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VOLUME I OF IV

REMEDIAL INVESTIGATION

NORTH BRONSON INDUSTRIAL AREA
BRONSON, MICHIGAN

JULY 1993

PREPARED FOR:
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
LANSING, MICHIGAN

...

PREPARED BY:
WARZYN INC.
NOVI, MICHIGAN

PROJECT
7005100

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BRONSON, MICHIGAN

JULY 1993

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DISCLAIMER

Please note that for purposes of discussing the results of this Remedial Investigation (RI), the North Bronson Industrial Area Superfund site (site) has been subdivided into areas and subareas identified by major landmarks. Several of these subareas have been named for companies that are operating or historically have operated within the confines of the site. These designations are in no way to be construed to imply the level of responsibility attributed to any one company or to preclude the future identification of companies not specifically identified as contributors to the contamination at this site.

[mad-605-67L]

EXECUTIVE SUMMARY

The North Bronson Industrial Area RI report was written from data collected between September 1988 and December 1991. There is sufficient data of acceptable quality to support the summaries and conclusions found in this report and the Baseline Risk Assessment (published separately). For purposes of discussion only the site has been divided into five areas of interest as follows (see Figure 5-1): Eastern Lagoons; Western Lagoons; County Drain #30 (CD#30); Industrial Complex (LA Darling subarea, Scott Fetzer subarea, and abandoned industrial sewer line); Background Areas (upgradient and/or apparently unaffected by site activities). These areas do not necessarily specify definitive areas of contamination but instead were defined in an attempt to logically present the large amount of data collected.

Contaminants at the site are found in several media (soils, groundwater, surface water, sediments, lagoon water, and lagoon sludge) at numerous locations, and varying concentrations. Predominant contaminants at the site can be placed in two major categories - chlorinated ethene compounds (trichloroethene (TCE), 1,2-dichloroethene (1,2-DCE), and vinyl chloride and metals (cadmium, total chromium, copper, nickel, and zinc) and cyanide.

The contamination detected at the site is the result of industry operating practices since the early 1900's, possibly as early as 1910. Industries in the site area include plating operations, machine shops, agricultural supply, bulk petroleum storage, and manufacturing plants producing various products.

The following source areas of potential organic compound and metal contamination have been identified at the site. These include:

- Abandoned Industrial Sewer
- LA Darling subarea
- Scott Fetzer subarea
- Western lagoon area
- Eastern lagoon area
- Douglas Components Corp. (Plant #2)
- Bronson Specialties
- Bronson Precision Products

See Figure 5-3 for the approximate distribution of total chlorinated ethene compounds in the upper aquifer at the site. Chlorinated ethene compounds were detected in exceedance of federal maximum contaminant levels (MCLs) and/or Michigan Act 307 Type B criteria in groundwater at the site. See Table 5-6. TCE and vinyl chloride also exceed Act 307 Type B groundwater/surface water interface values at several wells near CD#30. See Table 5-21.

TCE is commonly used as an industrial solvent for cleaning and degreasing and was likely in the waste streams of facilities which discharged to the eastern and western lagoons. Facilities in the area which have at this point been identified as having used TCE are: Bronson Specialties (Plastics, Tool, and Fiberglass Divisions), Bronson Plating Company, Scott Fetzer, Douglas Components Plant #2 (DCC Plant #2), Bronson Precision Products, LA Darling and Bronson Reel. The DCC Plant #2 facility, however was not connected to the industrial sewer.

High metal concentrations were detected in subsurface soils, lagoon berm soils, lagoon sludge, and groundwater at the eastern and western lagoons. The predominant metals detected: cadmium, total chromium, copper, lead, nickel, and zinc are common to the metal plating industry as well as other heavy industry. Cadmium is detected at Resource Conservation and Recovery Act (RCRA) hazardous concentrations in lagoon sludge at the eastern and western lagoons and some subsurface soils at the eastern lagoons. See Figure 5-2 for the approximate distribution of metals detected above background concentrations in soils at the site. Several metals were detected at concentrations in exceedance of MCLs and/or Act 307 Type B criteria in groundwater (upper aquifer) near the eastern and western lagoons but there are few exceedances outside the immediate influence of the eastern and western lagoons. Figure 5-4 illustrates the approximate distribution of metal contaminants in groundwater at the site.

Although chlorinated ethene compounds and metals are the predominant contaminants at the site, polyaromatic hydrocarbon (PAH) compounds and polychlorinated biphenyls (PCBs) were also detected. PAH compounds were detected at relatively high concentrations in soils and sludges at the eastern lagoons and in soils (SB15) at LA Darling. PCBs were detected at relatively high concentrations in CD#30 sediments downstream of the western lagoons and at relatively low concentrations in eastern lagoon sludge.

Contaminants are entering CD#30 via Bronson Plating outfall OF1 (PAHs), and stormwater sewer outfall OF5, (chlorinated ethenes), and contaminated groundwater discharges to CD#30.

Contaminants at the site (predominantly chlorinated ethene compounds and metals) have migrated (following groundwater flow) to the west - northwest from

source areas, and downward within the upper aquifer to at least the top of the aquitard. Chlorinated ethene compounds have mid-range to high solubilities (compared to metals, SVOCs, and PCBs), low Koc values, and low retardation factors. This indicates a high migration potential, which is observed at the site. Metals have relatively low solubilities in groundwater at North Bronson and have not migrated to the extent chlorinated ethene compounds have migrated.

Contaminant transport in groundwater, at the site, is likely driven by horizontal and vertical gradients. These gradients are affected by many factors including permeability of the geologic material of the upper aquifer and of the material underlying it. The upper aquifer is a relatively permeable sand and gravel mix. Based on drilling activities that took place at the site, it appears it is possible that an aquitard, which is potentially continuous, underlies the upper aquifer. This conclusion was based on data collected while drilling 29 soil borings on the 220-acre site, examination of residential well logs from the area, and information from a regional geologic atlas. The material underlying the upper aquifer is a silty sand and clay layer which appears to vary in thickness form 17 ft to 50 ft. This underlying layer is relatively impermeable and may serve as a barrier to the downward migration of contaminants located in the upper aquifer into the lower aquifer. Data from the lower aquifer were not collected during the remedial investigation.

Although references are made throughout this report to "the aquitard" underlying the upper aquifer, it should be kept in mind that the presence of a continuous aquitard at the site has not been confirmed.

Contaminated groundwater is likely discharging to CD#30. This conclusion is based upon the observed upward vertical gradients in wells near CD#30. It is also likely that contaminated groundwater is entering the Bronson storm sewer which flows into CD#30. Once contaminants are in CD#30, the VOCs are likely volatilized to the atmosphere, while metals likely precipitate into the sediment. VOC and metal contamination were not detected in the surface water/sediment sample collected in Swan Creek (downstream from CD#30). PCBs, however, were detected in the sediments collected in Swan Creek.

At this time, conditions remain favorable for contaminant releases by infiltration and percolation of precipitation through the relatively porous sandy soils at the site. Once in groundwater, contaminant transport is driven by horizontal and vertical gradients. It is expected that contaminants will follow groundwater flow to the west - northwest at the site. Contaminant releases from soils, lagoon sludges, and groundwater are expected to continue at the North Bronson site until remedial action is undertaken at the source areas.

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1

INTRODUCTION

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) established a fund (Superfund) to finance cleanup of uncontrolled hazardous waste sites. CERCLA requires procedures to be established to evaluate remedial measures, determine the appropriate extent of these measures, and to provide cost-effective measures.

The U.S. Environmental Protection Agency (U.S. EPA) has the responsibility and authority to implement the provisions of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). Either the State or the U.S. EPA may take the lead in this process. Under SARA, the remedial process is comprised of two major analytical components. In the first component, the Remedial Investigation (RI), data is collected to determine and evaluate the characteristics of the site and the wastes encountered. Findings of the RI facilitate the Feasibility Study (FS), the second component of the remedial process. In the FS, a number of potential remedial alternatives are developed and screened; the most promising alternatives are evaluated against a range of critical factors. The process results in selection of a remedy which, when implemented, will address the hazards associated with the site.

Warzyn Inc. (formerly Warzyn Engineering Inc.) (Warzyn) was retained by the Michigan Department of Natural Resources (MDNR) under Contract Number 3644 to conduct a Remedial Investigation/Feasibility Study (RI/FS) of the North Bronson Industrial Area (site) located in Bronson, Michigan (Figure 2-1).

This RI Report is submitted in partial fulfillment of MDNR Contract Number 3644. The RI was conducted in accordance with the project Work Plan, Quality Assurance Project Plan (QAPP), and the Site Health and Safety Plan. These documents are addressed in greater detail in Section 3.0. Chemical analyses performed during this RI were conducted under the U.S. EPA Contract

Laboratory Program (CLP). Data validation was conducted by the U.S. EPA Central Regional Laboratory (CRL) and Warzyn.

1.1 RI PURPOSE AND OBJECTIVES

The purpose of the RI was to determine the nature and extent of contamination on site. The primary objectives of the site investigation were as follows:

- Evaluate the extent of contamination in the upper aquifer in the vicinity of two sets of industrial lagoons and evaluate the general groundwater quality in the North Bronson Industrial Area

- Evaluate the nature and extent of environmental contamination due to the industrial lagoons and associated discharges in CD#30 which discharges to Swan Creek, a tributary to the St. Joseph River

- Provide data to evaluate the threat of contamination to public health

- Provide data to evaluate remedial alternatives for alleviating the environmental contamination in the Site area

To achieve these objectives, a variety of field activities were performed. These activities are discussed in Section 3.0. The data collected during the RI will be used to assess the potential risks to human health and the environment if no remedial action is taken. This assessment will be published in the Baseline Risk Assessment and will form the basis for preparation of the Feasibility Study (FS) report. The objective of the FS is to develop, evaluate, and select remedial measures for reducing environmental and public health hazards related to contamination within the site area. The FS report is a separately published document.

1.2 REPORT ORGANIZATION

This RI report is comprised of four volumes consisting of the following:

Volume 1 - RI Text with Tables, and Figures
Volume 2 - Appendices A through H
Volume 3 - Appendix I
Volume 4 - Appendices J and K

This report describes the work performed and the findings of the RI. Data collected prior to initiation of the RI have been considered, however, the assessment of site conditions relies primarily on the data collected during this RI. Section 3.0 of this report presents a summary of the field activities used to collect data. Section 4.0 contains a detailed characterization of the physical site setting, including topography, geology, hydrology, and hydrogeology. Section 5.0 presents the analytical results and provides discussion of the nature and extent of contamination at the site. The actual or potential migration of contaminants and the transport and transfer of contaminants within and between media are evaluated in Section 6.0. The summary of the RI and conclusions are presented in Section 7.0. The references cited throughout the RI report are included in Section 8.0.

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2

SITE BACKGROUND

A number of isolated studies have been conducted at the site by, and for, the MDNR since 1975 (Section 2.2). In June, 1984, the site received a Hazard Ranking System (HRS) score from the United States Environmental Protection Agency (U.S. EPA). In June, 1986 as a result of the HRS score, the site was included on the National Priorities List (NPL) for investigation and potential remediation under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The site also received a Michigan Site Assessment System Score of 38 (on a scale of 1 to 48) and, consequently, appears on the State Act 307 List.

2.1 SITE DESCRIPTION

The North Bronson Industrial Area (site) is located in southern Michigan, adjacent to the City of Bronson, in Branch County (Figure 2-1). The site is located in portions of the northeast quarter of Section 11 and the northwest quarter of Section 12, Township 7 South, Range 8 West (Figure 2-1) and occupies the northern (industrial) area of the City of Bronson (Figure 2-2). Land use in the larger area around the site consists of a mixture of industrial, residential, and agricultural activity. The site is bounded to the east by Lincoln Street as projected northward to CD#30, to the south by Fillmore and Union Streets, to the west by Burr Oak Road as projected northward to CD#30, and to the north by CD#30, itself. These boundaries reflect the general area that was studied during the remedial investigation. Two predominant site features and potential contaminant source areas of concern are the two sets of lagoons located in the northeast and northwest sections of the site, south of and adjacent to CD#30.

The western lagoons, also referred to as the "old" lagoons, are comprised of five lagoons, most of which contain standing water year-round. The eastern lagoons, also referred to as the "new" lagoons, had once been comprised of five lagoons as

noted on historical aerial photographs of Bronson, Michigan. Currently, the remnants of two dry eastern lagoons are visually discernible in this area. The two lagoon systems (eastern and western) were the focus of the Phase I investigation.

As a result of the Phase I investigation, a Phase II investigation was conducted which extended the site south to include the former L.A. Darling property, a portion of the abandoned industrial sewer, and the former Scott Fetzer Components Corporation (Scott Fetzer) Buildings, including a cyanide destruction facility (CDF) (labeled on Figure 2-2 as SFCC (vacant)). The investigation area was expanded during Phase II based upon locations of the contaminants detected during Phase I, assessment of potential sources from the industrial survey, and the Phase I geophysical survey. The area included during the Phase II investigation encompassed presumed potential contaminant sources and background areas at the site.

2.2 PREVIOUS INVESTIGATIONS

In the fifteen year period from 1975 to 1990, several studies were conducted to evaluate lagoon sludges and surface water, CD#30 sediments and surface water, and groundwater and soils at the site. Investigations performed at the site prior and during this RI effort are as follows:

- *1978; McNamee, Porter, and Seeley Inc., Hydrogeological Investigation of the "Old"* [Western] *Lagoon Area*
- *1979; MDNR, Water Quality Study of County Drain #30*
- *1980; MDNR, Study of Sediments and Fish in County Drain #30 and Swan Creek*
- *1981; Keck Consultants, Inc., Hydrogeologic Study of the "New"* [Eastern] *Lagoon Area*
- *1982; Snell Environmental Group, "New"* [Eastern] *Lagoon Sludge Sampling Program*
- *1984; U.S. EPA, Site Inspection at the Bronson Plating Company Facility by Ecology and Environment*
- *1985; County Drain #30 Sediment Removal and Sampling Conducted, Bronson Plating Co.*

- *1985; Lagoon Sludge Sampling Program Conducted, Bronson Plating Co.*

- *1990; WW Engineering and Science, Inc., Bronson Precision Products - Subsurface Investigation*

2.3 SITE HISTORY

Several companies operated at various times and under various names in the North Bronson Industrial Area from the early 1900s to the present. A brief history of industrial activity and operations at the site is summarized below. This historical summary is based primarily upon information collected during the RI Phase I Industrial Survey (December 1988), historical aerial photographs provided and interpreted by the U.S. EPA, and local newspaper articles.

Western Lagoons

In the 1930's deaths of cattle and fish kills were reported from ingestion of cyanide contaminated water from CD#30. The contaminated water was reportedly due to direct discharge of industrial waste to CD#30. This prompted the City of Bronson to excavate the western lagoons in an effort to reduce the amount of contaminants entering CD#30 from direct discharges. The City of Bronson were the owners and operators of the western lagoons during the time they were used. Currently, the City still owns the lagoons.

Three lagoons were excavated between 1938 and 1950. In 1949, as a result of overtaxing the three western lagoons, two new lagoons were excavated approximately 1,500 ft to the east (see Eastern Lagoon discussion, below). At this time, only Bronson Reel, reportedly, continued to use the western lagoons.

By 1955 a fourth western lagoon had been added. Between 1938 and 1955 the western lagoons were interconnected with piping and valves to control water levels and discharges to CD#30 (see Figure 2-2).

From approximately 1939 to 1949 the following companies reportedly discharged wastes to the western lagoons:

- Bronson Reel
- Douglas Components Corp. (DCC Plant #1 (Scott Fetzer))
- LA Darling
- Bronson Plating

Bronson Reel reportedly discharged wastes to the western lagoons until approximately 1968. Note that three of the four companies listed above operated

prior to construction of the western lagoons in 1939. Waste disposal practices used by these companies prior to this time are not known (Douglas components began operations in 1910, LA Darling in the early 1900s, and Bronson Reel in 1922).

In November 1978, McNamee, Porter & Seeley, Consulting Engineers (McNamee), Ann Arbor, Michigan, performed a hydrogeologic investigation in the vicinity of the western lagoons. The study was conducted for Douglas Division - Scott Fetzer Company to assess replacing the four existing western lagoons with two large lagoons and a smaller settling pond. Ten borings, six of which were finished as monitoring wells (MWs), were installed by Sterling Drilling Company. Boring logs can be found in Appendix C. The corresponding well designations are noted below:

Former Designation	RI Designation
78-1	MW1
78-2	MW2
78-3	MW3
78-4	MW4
78-5	MW5
78-6	MW6
78-7 (Test Boring (TB))	Not shown (NS)
78-8 (TB)	NS
78-9 (TB)	NS
78-10 (TB)	NS

The locations of the six MWs, noted as MW-1 through MW-6, are depicted as pre-RI wells on Figure 2-2. Although the report concluded the site suitable for the renovation, the reconstruction did not take place and by 1980, the western lagoons were, reportedly, no longer being used by local industry.

Eastern Lagoons

As noted, by 1949, overtaxing of the western lagoons resulted in the City of Bronson constructing two new lagoons 1,500 ft due east of the western lagoons. LA Darling, Bronson Plating, and Douglas Division - Scott Fetzer Company were reportedly connected to the new eastern lagoons via an industrial sewer line. LA Darling, Bronson Plating, and Scott Fetzer reportedly ceased use of the eastern lagoons in 1967, 1981, and 1951, respectively.

Review of aerial photos reveal that by 1955 a third eastern lagoon east of the two original eastern lagoons, by 1958 a fourth eastern lagoon was evident north of the

three existing lagoons and by 1967 a fifth eastern lagoon can be seen due east of the other four lagoons (see Figure 2-2).

In 1970 Bronson Plating Company purchased the eastern lagoons from the City (Bronson Plating had moved its operations to this location in 1953). Between 1970 and 1974, Bronson Plating expanded by constructing a building which apparently was located where three of the five eastern lagoons had previously been. By 1981, Bronson Plating reportedly stopped discharging waste to the two original eastern lagoons, and by 1988 expanded again, covering more of the area where the other three eastern lagoons had been. An unconfirmed source indicated, during the industrial survey, that sludge and waste material was removed from the three eastern lagoons and the lagoons backfilled prior to Bronson Plating constructing buildings over them. At the time of the RI, only the remnants of two original (now) dry eastern lagoons could be observed.

LA Darling

The LA Darling Company (LA Darling) located at Matteson and Railroad Streets operated from the early 1900s until 1967 when it closed (see Figure 2-2). LA Darling manufactured display fixtures and retail shelving, which reportedly included chromium and cadmium plating operations. It was also reported in the industrial survey that LA Darling disposed of liquid wastes in their own lagoons until 1939, at which time LA Darling was connected via an industrial sewer line to the western lagoons operated by the City of Bronson. Location of the disposal lagoons on LA Darling property were not identified during the RI effort.

LA Darling switched disposal to the eastern lagoons (via an industrial sewer line) in 1949 which continued until 1967 when they ceased operations in Bronson. The facility reportedly remained vacant from 1967 until 1983 when the City bought the property from LA Darling for back taxes. The City, reportedly, wanted the property for the water tower, which LA Darling had constructed in 1960. As part of the purchase agreement, LA Darling demolished the existing structures leaving only the foundations in place.

Douglas Component Corporation (DCC)

In 1910 Harry A. Douglas began operations of HA Douglas Manufacturing in Bronson. This company designed and manufactured automobile electrical parts. Metal plating operations were part of the manufacturing process which included cadmium, chromium, silver, tin, and zinc. At this time, the company was located at the southwest corner of West Railroad and Matteson Streets and was referred to as Plant No. 1 (see Figure 2-2).

In 1939, the City established the western lagoons, and Plant No. 1 was connected to them via the industrial sewer line. In 1940 HA Douglas Manufacturing merged with Kingston Products and became Kingston Products-Douglas Division.

In the late 1940s, the Bronson Plant of Kingston Products manufactured automobile electrical products, military products, including track links and electrical switches, and consumer products, including appliance timers and vacuum cleaners. Additions to Plant No. 1 were made in the 1940s and 1950s. In 1949, Plant No. 1, reportedly, ceased discharging wastes to the western lagoons and began discharging to the eastern lagoons via a separate sewer line.

In 1951, the CDF, located on State Street, was constructed. At this time, the Douglas Division, reportedly, ceased discharging to the eastern lagoons because wastewater was being treated at the CDF and discharged directly to the storm sewers. The CDF operated until 1973.

In 1968, Kingston Products was sold to the Scott Fetzer Corporation, Cleveland, Ohio, and in 1969 the Bronson Plant became the Douglas Division.

Beginning in 1973, Plant No. 1 plating processes included zinc and tin. Consequently, cyanide destruction processes ended and the facility was modified to remove metals and phosphate from the waste stream. In 1977 or 1978 the acid-tin process line was stopped, and in 1981 the alkaline-zinc process line was stopped.

In January 1984, investors representing the Douglas Component Corporation bought Douglas Division from the Scott Fetzer Corporation, and began operations. By 1987, the zinc phosphate line stopped, which meant all plating at Plant No. 1 had ceased. According to DCC employees at the time of the industrial survey, Plant No. 1 had been used for storage of equipment and supplies. In 1988 approximately 325 gallons of PCB oil (from electric transformers) was, reportedly, removed from the site by Great Lakes Environmental Services, Inc. No documentation was available to confirm this removal.

Douglas Division, Plant No. 2, was built in 1953, at a location west of Plant No. 1, on Mill Street. This facility had a paint line, and reportedly produced machined metal parts but did not have any plating operations. Building additions to Plant No. 2 were constructed in 1965 and 1987. A shed was constructed at Plant No. 2 in 1975 which was used to store oil covered metal chips.

In December 1977, the Douglas Division of Scott Fetzer Corporation contracted with A&B Sewer Cleaning of Kalamazoo, Michigan, to clean, TV inspect and, if necessary, pressure grout the industrial sewer line from Plant No. 1 to the western

lagoons. McNamee, Porter, and Seeley Consulting Engineers were hired by the Douglas Division to evaluate the inspection report and to recommend appropriate action. (A copy of this report is contained in Appendix A). Repairs were made to several manholes, but pressure grouting was deemed unnecessary.

In November 1978, Douglas Division-Scott Fetzer Company sponsored a hydrogeologic study in the vicinity of the western lagoons to assess renovating the existing four small lagoons to two larger lagoons. The study was conducted by McNamee, Seeley & Porter Consulting Engineers and is discussed in greater detail under Section 2.3, Site History, by 1980 the western lagoons were no longer in use by local industry.

In October 1985 a crack in the floor of the shed reportedly allowed oil from the chips to seep into the ground. As a result, DCC hired EDI Engineering and Science consultants to study the suspected release. A report was submitted to MDNR by EDI in 1986. In 1987 a Field Investigation Team (FIT) from U.S. EPA identified an 80 to 100 ft oil plume on groundwater at DCC. The disposition of this investigation is not known. Eight monitoring wells existed on DCC Plant #2 prior to the RI. These are presumed to be part of the EDI investigation. No boring logs were available for these wells. Corresponding monitoring well designations are noted below:

Former Designation	RI Designation
DC3	MW7
DC2	MW8
DC5	MW9
DC4	MW10
DC6	MW11
DC8	MW12
DC7	MW13
DC1	MW14

The above wells are located on Figure 2-2. A number of these wells were sampled during the RI. These results are reported in Section 5.0

Bronson Reel Company

The Bronson Reel Company (BRC) was established in June 1922. BRC which produced fishing reels, was originally located at 123 North Matteson. In need of more space, a new building was constructed at Douglas and State Streets (see Figure 2-2) between 1928 and 1929. During the 1940s, several additions were made to this building. BRC had a machine shop to make their own dies, tools,

and fixtures. They also did their own plating and anodizing. In 1945, BRC stopped making reels and began making bomb sight parts.

BRC, reportedly, discharged liquid wastes to the western lagoons via the industrial sewer line from 1939 until 1968, but not to the eastern lagoons. In 1963 BRC was purchased by Bronson Specialties. Bronson Specialties sold BRC in 1968 to True Temper, which moved operations to Anderson, South Carolina. Successor companies at the BRC building reportedly continued to use the industrial sewer, which discharged to the western lagoons, for small amounts of non-plating waste through 1980.

Bronson Plating Company

Bronson Plating Company (BPC), established in 1946, was originally located at West Matteson Street and Railroad Street. BPC moved its operation in 1953 to their present location at 135 Industrial Avenue (also the site of the eastern lagoons) (see Figure 2-2).

BPC performs nickel and chrome plating, buffing, and polishing operations. Liquid wastes from BPC were, reportedly, discharged via the industrial sewer line to the western lagoons from 1946 to 1949. After the first two eastern lagoons were constructed in 1949, BPC switched over their waste discharge to them.

In 1970 BPC purchased the eastern lagoons (now five) from the City of Bronson. Between 1970 and 1974 BPC expanded and constructed a building which covered over where three of the five eastern lagoons had been located. BPC stopped using the eastern lagoons in 1980.

In 1981, seven monitoring wells were installed in the vicinity of the eastern lagoons as part *of Keck Consultants Hydrogeologic Study of the New (eastern) Lagoon Area*. Results of the investigation indicated VOC and metals contamination in groundwater. Boring logs for this investigation are found in Appendix C. These wells were resampled by Warzyn at the beginning of the RI. The following wells were relabeled for the RI:

Former Designation	RI Designation
BP1S	MW15S
BP1D	MW15D
BP2S	MW16S
BP2D	MW16D
BP3S	MW17S
BP3D	MW17D
BP4	MW18

These monitoring wells are located on Figure 2-2.

By 1988, BPC had expanded again, covering more of the eastern lagoons. Remnants of the remaining two eastern lagoons, still visible, are becoming overgrown with vegetation. Bronson Plating currently discharges liquid to CD#30 via two outfalls under one NPDES permit (see Appendix K).

Branch County Road Commission

The Branch County Road Commission, located at the corner of West Matteson and Industrial streets, was built in 1945 (see Figure 2-2). The garage is used for maintenance of county vehicles. The following underground storage tanks (USTs) are located at this facility:

1 - 5,000 gallon gasoline tank installed 1947
1 - 10,000 gallon gasoline tank installed 1947
1 - 4,000 gallon fuel oil furnace tank installed in the 1950s
1 - 6,000 gallon diesel fuel tank installed 1974
1 - 500 gallon used oil tank

The integrity of the USTs are unknown at this time. Four floor drains in the garage area were, reportedly, connected to the storm sewer. The status of the floor drains is also unknown at this time.

Bronson Specialties

Bronson Specialties Inc. located at 404 Union Street, was established in 1956 (see Figure 2-2). Three divisions were identified: Bronson Plastics; Bronson Tool; and Bronson Products.

The building occupied by Bronson Specialties, Inc. was built in the 1940s. Bronson Specialties purchased the building in 1958. Ownership history prior to Bronson Specialties in unknown.

The Bronson Plastics Division was formerly Bronson Fiberglass, which produced fiberglass seats and front end parts for commuter trains. Bronson Plastics started blow-molding operations in the late 1960s, which continued to, at least, the time of the industrial survey (1988). They produced custom molded products including fuel tanks for pick-up trucks. Bronson Plastics had used and stored methylethyl ketone (MEK) as well as other chemicals (undefined) at this location.

Bronson Tool Division began in 1956 as a tool and die shop. At the time of the survey they manufactured specialty machines. Degreaser chemicals were provided by Safety-Kleen, which supplied and disposed of the solvent. It is not

known when Safety-Kleen began supplying this service. Prior to Safety-Kleen providing this service it is not identified how they handled their degreaser chemicals.

Bronson Products operations included screw machines, casting machines, and a metal turning shop.

Bronson Specialties purchased Bronson Reel in 1963. In 1968, Bronson Specialties sold Bronson Reel to True Temper. At that time, True Temper moved Bronson Reel operations to South Carolina. The subsequent operations at the former Bronson Reel building are not known.

The Bronson Products Division was sold to Bronson Precision Products in 1985. As of 1988, Bronson Precision Products continued to lease space from Bronson Specialties, who still owned the building and land.

Bronson Specialties, Inc., the parent, had one National Pollutant Discharge Elimination System (NPDES) permit for two outfalls. Bronson Plastics and Bronson Tool are reportedly listed under the same permit. (Copy of the permit was not available).

In 1974 acetone and methyl ethyl ketone (MEK) (5 mg/L) were detected in a private well owned by James Blaskie located at 442 Mill Street, approximately 1,100 ft south of the western lagoons and 300 ft west of the Access Road to the City's Wastewater Treatment Plant (Figure 2-2). During that time, construction dewatering wells were being used at the wastewater treatment plant located 800 ft northeast of the Blaskie well. Elevated levels of acetone and MEK (1 mg/L) were also detected in the dewatering wells. Bronson Specialties was identified as a potential source of these contaminants because of their proximity to the Blaskie well (approximately 200 ft south (side gradient) of the well). MEK was reportedly used by Bronson Fiberglass, and drums of MEK were stored at Bronson Specialties. However, this was not investigated any further at the time.

As a result of the contamination detected, the Blaskie well was abandoned and the residence was connected to the City of Bronson water supply in 1974. Subsequently, several studies which have been conducted at the site by and for MDNR, including the RI, have not determined the source of MEK found in the Blaskie well.

Two investigations of groundwater and soils were conducted at Bronson Precision Products by WW Engineering & Science, Inc. (1990) and EDI Science and Engineering Inc. (1988). As a result of these studies a 250 ft x 200 ft x 5 ft deep area of contaminated soil was excavated and disposed of by Bronson Specialties

at a TYPE II Landfill (unnamed), as the soils were tested and determined at the time not to be hazardous. Analytical results were previously reported in the North Bronson Technical Memorandum (Warzyn October 1989). Boring logs for these investigations are contained in Appendix C.

H.G. Geiger Manufacturing

H.G. Geiger Manufacturing Company, located at 416 Mill Street, was established in 1972 (see Figure 2-2). Additions to the building were made in 1978 and 1984. A residential dwelling formerly occupied the site.

H.G. Geiger Manufactures machine parts, using lathes and screw machines. Safety-Kleen has been contracted for the supply and disposal of degreaser solvents. Metal scrap is removed by Tri-State Industrial.

G&W Display Fixtures Inc.

G&W Display Fixtures, Inc. located at 804 Matteson Street, was established in 1982 (see Figure 2-2). They manufactured display fixtures from tubular steel. Prior to G&W Display Fixtures, the building was occupied by a machine shop until 1957. A beer distributor occupied this location between 1957 and 1982. At the time of the industrial survey (1988), cutting oils and kerosene were noted on-site in 55 gallon drums. Two USTs existed on-site in 1988 but were, reportedly, empty. The USTs had been used to fuel delivery trucks when the beer distributor occupied the building. Solvents are, reportedly, not used at G&W Display Fixtures, Inc.

Anderson Farm Services

Anderson Farm Service had two locations in the North Bronson Industrial Area, until the business closed in 1984 (see Figure 2-2). There is little information about these facilities. The Mill Street location contains offices and a garage. At the time of the industrial survey, various equipment was stored outdoors and repaired at the Mill Street location.

The Union Street location distributed bulk fertilizers. This location closed in 1984 and burned in 1986. Eight above-ground storage tanks (ASTs) located at the Union Street location were used to store liquid fertilizer (nitrogen). Reportedly, only 1 of 8 storage tanks still contained liquid fertilizer in 1988 (at the time of the industrial survey). One UST was located at the Union Street location. It contained regular gasoline and was, reportedly, empty at the time of the industrial survey. The current status of this tank is unknown.

Putnam Manufacturing

Putnam Manufacturing Company (Putnam) has two facilities: Plant No. 1, located at 211 Industrial Avenue, and Plant No. 2, located at 735 Matteson Street (see Figure 2-2).

Plant No. 1 was purchased in 1983. Modular homes had been built at that location prior to Putnam purchasing the site. Plant No. 2, which was purchased in 1976, had been a foundry for two years prior to Putnam's purchase. Both Plant No. 1 and Plant No. 2 manufacture screw machine parts. In the past, some painting had been done on-site but at the time of the industrial survey, this work was reportedly subcontracted and performed off-site. Scrap metal is removed by Sturgis Iron and Metal. Cutting oil is used on-site, as is mineral spirits. There were no USTs noted at this location and no floor drains were observed.

County Drain #30

CD#30 begins in a marsh area/wetland about ½ mile north east of the site. It flows in a westerly direction and empties into the Swan Creek approximately 1½ mi northwest of the site. CD#30 defines the northern boundary of the site (see Figure 2-2).

In the 1930s and then again in the 1950s, events appeared in the local newspapers describing cattle dying after drinking the water from CD#30. The western lagoons were, reportedly, constructed in response to the 1930's events, in an effort to reduce the amounts of contaminants from local industry entering CD#30.

There are currently six outfalls discharging into CD#30 within the site boundaries. These include: 2-Bronson Plating outfalls, the wastewater treatment plant outfall, the city of Bronson stormwater discharge, and two agricultural field outfalls on the north side of the drain. Three of the six outfalls were sampled during the RI and are located on Figure 2-2.

In 1983/1984, Bronson Plating was responsible (at their own cost) for dredging CD#30 from their most eastern outfall (not shown on Figure 2-2) to the Matteson Street overpass. Bronson Plating, reportedly, contacted an unnamed waste hauler to remove the dredged material. Within the same general time frame, Branch County dredged CD#30 from the Matteson Street overpass to the wastewater treatment plant outfall. This dredged material was, reportedly, left stockpiled on the north bank of CD#30 and not removed. Dredging of CD#30 was, reportedly, undertaken to improve its flow.

General Information

The following paragraphs summarize miscellaneous information gathered during the industrial survey.

The vacant block structure located on Matteson Street between the Branch County Road Commission and the former LA Darling facilities (see Figure 2-2) was used in the 1960s by Roberts Motors, which built electric motors. After Robert Motors ceased operations, the facility was occupied by a specialty screw machine manufacturer. The facility has been vacant since that operation left (dates unknown).

There are two bulk oil terminal facilities in the area. Mobil Oil Company, shown as Hooker Oil Company, is located on the east side of Matteson Street (see Figure 2-2) and Standard Oil Company (not shown on Figure 2-2) is located off of Albers Road. Mobil Oil is still active but the Standard Oil facility is no longer operating.

The vacant SJD Industries building on Mill Street located between Anderson Farm Service and the Wheeler Residence (see Figure 2-2) was a metal shear factory, which also housed a grinding operation.

The City of Bronson Wastewater Treatment Plant was constructed in 1957 and expanded in 1978. Phosphate removal was added to plant operations in 1978. The Wastewater Treatment Plan has an NPDES permit to discharge to CD#30 (see Appendix K).

The area near city well PW-03, was a dill pickle facility consisting of six to eight vats. The pickle facility was owned by Kehoe from 1936 to approximately 1945/1946.

Assembly Service, Inc. located on Industrial Street (see Figure 2-2) across from Putnam Manufacturing Co. was started about 1986. At the time of the industrial survey, they performed copper brazing and production welding operations for several components in ovens.

Several vacant buildings are (ruins) located on the north side of West Railroad Street. The remains of an old Grain Mill building stands on the northwest corner of West Railroad Street and Matteson Street. A lumber yard occupied the vacant wood structure located on West Railroad Street, west of the old Grain Mill. And, remnants of the old railroad depot are located on West Railroad Street west of the lumber yard (see Figure 2-2).

Additional information from the industrial survey can be found in the North Bronson Technical Memorandum (Warzyn, October 1989).

2.4 STATUS OF PRIVATE AND PUBLIC WELLS

The majority of the residences in the vicinity of the site are thought to be connected to the City of Bronson water supply system. The following five residential (private) wells located within or close to the boundaries of the site (Figure 2-2) were identified for sampling during the RI. (Information obtained since the RI was completed indicates that at least two additional residential wells in the area may be present.)

Private Well Owners (as of 1989)	Location	Depth (ft)	Round 1 Sample Designation	Round 2 Sample Designation
Losinski	231 Albers Road	35	PW1	PW2
Wheeler	204 Mill Street	22	PW2	PW5
Borgert	216 Matteson Lake Road	78	PW4	PW3
Eichler	220 Matteson Lake Road	90	PW5	PW6
Himes	425 Union Street	Unknown	PW7	PW4
City of Bronson	City Supply Well #3	100	PW3	PW1

Based on the reported well depths, the Losinski and Wheeler wells appear to be screened in the shallow aquifer and the Borgert and Eichler wells screened in the deeper aquifer (see Section 4.3 for a complete discussion of site geology). Except for the City Supply Well #3 and the Borgert Well, boring logs are not available to confirm this. Boring logs for the City Supply Well #3, Borgert well, and other private wells in the area but not within site boundaries are found in Appendix C3. Sample designations for private wells were inadvertently redefined between Rounds 1 and 2. Table 5-1 includes a corresponding reference to private well designations by round.

Independent of the RI effort, the Michigan Department of Public Health (MDPH) collected water samples from several private wells at and near the site. Many of these wells were not sampled as part of the RI effort. In October 1984, the Losinski, Wheeler, Borgert and Eichler wells (also sampled during the RI) were sampled and tested by the MDPH for bacteria, Volatile Organic Compounds (VOCs), and Target Analyte List (TAL) inorganics. Results showed no detectable levels of these parameters. These wells were in use when the October 1984 sampling was conducted and are presumed to still be in use.

In 1989 MDPH sampled and analyzed the following wells:

Private Well Owners (as of 1989)	Location
G. Blaskie	422 Mill Street
Wheeler	204 Mill Street
Himes	425 Union Street
Gieber	115 Union Street
Meyer	426 Franklin Street
Smoker	417 Franklin Street
Williams/Kane	853 Albers
Yenor/Prough	208 Mill Street

These samples were analyzed for VOCs, selected metals, and indicator parameters. VOC contamination was detected at the Yenor/Prough well (208 Mill Street), only. MDPH reports this residence was connected to the Bronson municipal water supply in January 1989 and the private well abandoned at that time.

The City of Bronson water supply system consists of three wells (Figure 2-2). The two primary supply wells (Wells No. 4 and No. 5) are located approximately 4,000 to 5,000 ft east of the site and are screened in the upper aquifer. The third well (Well No. 3) is a backup well located approximately 1,000 ft southeast of the eastern lagoons and is screened in the lower aquifer.

Water samples are collected annually from Bronson municipal wells #3, #4, and #5 by the MDPH and analyzed for VOCs, synthetic organic compounds, selected metals, and indicator parameters. Analytical results indicate these contaminants are not present in the Bronson municipal water supply (see Appendix I11 for MDPH 1990 and 1992 analytical results).

Well status has not been determined for all private wells within and around the site. MDPH in coordination with MDNR is pursuing a separate survey to further determine if there may be impacts to private wells which are still in use in and around the site.

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3

REMEDIAL INVESTIGATION ACTIVITIES

3.1 OVERVIEW OF RI PROJECT PLANS

In order to address the objectives of the RI, several documents that detail how this would be accomplished were prepared as part of the contract requirements for MDNR review and approval. The documents which comprised the project plans are noted below.

Each of these documents was amended or revised during the course of the contract, on an "as needed basis", to incorporate unforeseen developments necessary to meet the project objectives.

- North Bronson Industrial Area RI/FS Work Plan (Warzyn, September 1988)
- Work Plan Addendum (Warzyn, September 23, 1991)
- Quality Assurance Project Plan (QAPP) (Warzyn, July 1988)
- QAPP Addendum (Warzyn, September 26, 1991, Revised December 2, 1991)
- Health and Safety Plan (Warzyn, July 1988)
- Health and Safety Plan Addendum (Warzyn, September 23, 1991)

The Work Plan describes the purpose of the investigation and the activities to be performed in the RI to meet those objectives. The basic Work Plan tasks designed for the RI were as follows:

- Project Plans and Site Map

- Site Investigation Activities
- Data Assessment and Validation
- Community Relations Support
- Remedial Investigation Report
- RI Project Management

The QAPP was developed to address the specific requirements of field sampling activities, sample management, laboratory analytical work, and data handling aspects of the site investigation. The QAPP was prepared in accordance with U.S. EPA guidelines.

The Sampling Plan is an integral part of the QAPP. It addressed such details as sample location selection, sampling procedures, sample preservation, chain of custody procedures, and other required documentation. This plan was also developed in accordance with U.S. EPA guidance documents.

The Health and Safety Plan was developed to address specific hazards that on-site activities may present to the investigating team and/or the community at large. This plan was prepared in accordance with applicable requirements specified by U.S. EPA and other regulatory agencies, including the Occupational Safety & Health Administration (OSHA), Michigan Occupational Safety & Health Administration (MIOSHA), and the National Institute of Occupational Health & Safety (NIOSH).

3.2 OVERVIEW OF RI ACTIVITIES

Two phases of field activities were conducted during the RI. The complete site sampling effort (sample locations) is shown on Figure 3-1.

The field activities for the first phase were approved as part of the Work Plan (Warzyn, September 1988) and conducted during the period December 1988 through February 1989. See Table 5-1 for a summary of samples collected and the parameters which were analyzed.

Phase I investigative activities included the following:

- Industrial Site Survey (Subtask 3.1)
- Initial Elevation and Location Survey (Subtask 3.2)
- Site Office Set-up (Mobilization) (Subtask 4.1)
- Existing Well Sampling (Subtask 4.2)
- Surface Geophysical Survey (Subtask 4.3)
- Waste Characterization (Subtask 4.4)

- Drilling and Well Installation (Subtask 4.5)
- Surface Water and Sediment Sampling (Subtask 4.6)
- Groundwater Sampling and Aquifer Testing (Subtask 4.7)
- Groundwater Level Monitoring (Subtask 4.8)
- Location and Elevation Survey (Subtask 4.9)

Following Phase I field activities, an Interim Draft Technical Memorandum was published (Warzyn March 1989).

Phase II field activities were approved as part of the Work Plan Addendum (Warzyn, September 23, 1991) and conducted during the period October through December 1991. See Table 5-1 for a summary of samples collected and parameters which were analyzed. These activities included:

- Drilling and Well Installation (Task 5.3)
- Waste Characterization (Task 5.4)
- Location and Elevation Survey (Task 5.5)
- County Drain #30 Sampling (Task 5.6)
- Groundwater Sampling and Aquifer Testing (Task 5.7)
- Groundwater Level Monitoring (Task 5.8)
- Surface and Background Soil Sampling (Task 5.9)

The following sections contain a general description of activities performed during the RI. Although two phases of activities were conducted, Warzyn will discuss each specific type of investigation activity (e.g., Groundwater Sampling, Waste Characterization, etc.) as a single unit, discussing phases in terms of time and sample events where it aids the discussion.

3.3 INDUSTRIAL SURVEY

The Industrial Site Survey was conducted between December 7 and 9, 1988. It was conducted in an attempt to obtain information pertaining to present and past industrial activities within the site boundary to identify possible contaminants and potential source areas. Much of the information obtained during the industrial survey is presented in Site Background (Section 2.0). A copy of the information collected during the Industrial Site Survey is contained in Appendix A2.

3.4 SURFACE GEOPHYSICAL SURVEY

A surface geophysical survey was conducted by Fromm Applied Technology (Fromm) between October 17 through October 22, 1988.

The purpose of the geophysical program was to:

- Conduct an electromagnetic conductivity survey in both the eastern and western lagoon areas and along the industrial sewer line in order to assess areas of high conductivity, estimate boundaries of the filled lagoons, and delineate lateral extent of contamination.

- Identify areas of high conductivity with surface electrical resistivity profiles at the former L.A. Darling property.

- Aid in selecting locations for monitoring wells and soil borings at the Bronson Plating Co. property.

The geophysical survey investigation was conducted by dividing the site into three areas (Figure 3-2). The western lagoons, the eastern lagoons, and the L.A. Darling site (Figure 3 of the Fromm Report, Appendix B). The abandoned industrial sewer line was initially included in the geophysical survey investigation but interferences from such things as buried pipes would not allow sensitive measurements to be obtained. Figures 4, 5 and 6 (of the Fromm Report, Appendix B) depict the approximate locations of the surveyed areas, EM profile lines, and orientation of each Cartesian coordinate system used. Resistivity sounding locations are shown on their appropriate base maps, which are also contained in Appendix B.

The survey consisted of a guided electromagnetic (EM) survey, nine EM profiles, and six electrical resistivity soundings. In general, EM readings (stations) were taken throughout a survey area on a 15 ft by 15 ft grid system. In addition, individual transects were conducted in areas that were not fully accessible or not contiguous to the main survey areas (Figure 3-2).

A Geonics EM 31D Electromagnetic Terrain Conductivity Meter was used to take conductivity measurements. EM readings were recorded on a TRS Model 100 portable computer and later loaded into a mainframe system.

The resistivity soundings were strategically located to enhance the known EM data or to provide data at locations where the electromagnetic readings were distorted by cultural features (fences, pipelines, cables, etc.). Six soundings were completed throughout the site. Each sounding used a Sintrex IPC-9 Resistivity

Transmitter and a Sintrex IPR-8 Receiver with Wenner electrode arrays, using spacings of 1, 2, 3, 5, 7, 8.5, 10, 15, 25, and 50 meters (where possible).

Station numbers are referenced in most of the diagrams and the distance between stations is 15 ft, unless otherwise noted. Resistivity profile data was generated along five lines, however the results were poor and led to inconclusive findings. These data were not directly used in the geophysical report. Details concerning the geophysical survey are presented in the Fromm Applied Technology Geophysical Survey Report (Appendix B).

3.5 DRILLING, SOIL SAMPLING, AND WELL INSTALLATION

3.5.1 Drilling and Sampling Procedures

A site office trailer was set up as a base of operations for field activities.

The site trailer provided on site storage and office facilities for coordination of field activities including field GC operations and sample paperwork preparation.

Two rounds of exploratory drilling were performed during this RI. The first round of drilling was conducted as part of the Phase I investigation and was performed between July 31 and August 9, 1989. Nineteen monitoring wells (5 deep and 14 shallow) were drilled and installed at 14 locations across the site. These wells include:

MW1S	MW6S	MW10D
MW2S	MW7S	MW11S
MW3S	MW8S	MW12S
MW4S	MW8D	MW12D
MW5S	MW9S	MW13S
MW5D	MW10S	MW13D
		MW14S

See Figure 3-1 for locations and Table 3-1 for survey coordinates and well elevations. The monitoring wells were located to delineate subsurface geology, provide hydrogeologic data, and assess water quality upgradient of the site, immediately downgradient of potential source areas, and directly adjacent to potential source areas. Vertical profiling (groundwater sampling to determine the zone of highest VOC contamination) was not part of the Phase I drilling work scope. Thus wells were not necessarily screened in the zone of highest contamination. Drilling was performed by John Mathes & Associates, Columbia City, Illinois, under the direct supervision of a Warzyn hydrogeologist. MDNR

representatives were on site during much of the drilling activities. Drilling activities were performed in Level D protection.

Shallow and deep monitoring well borings were performed using 4.25-in. inside diameter (I.D.) hollow stem augers (HSA). Split-spoon soil samples were obtained at each drilling location using 2-in. stainless steel split-spoons according to ASTM D-1586 protocols. Where multiple wells were installed at the same location, soil samples were only obtained from the deep boring. Split-spoon samples were collected at 5-ft intervals to 20 ft and 10-ft intervals thereafter to the terminus of the boring or at lithology changes. Shallow well borings were drilled to approximately 15 ft and deep well borings were drilled and installed to what was assumed to be the top of the aquitard underlying the aquifer.

Split-spoon soil samples were monitored with an HNu photoionization detector (HNu or PID) and a HCN monotox single gas indicator. Samples were then logged for lithology using the Unified Soil Classification System (USCS). Soil boring logs, well construction details, and residential well logs are contained in Appendix C. Soil samples were collected for grain size, grain size with hydrometer, permeability, and TAL inorganics using CLP protocols, and were submitted to the Contract Laboratory for analysis (see Appendix I for results). Grain size and grain size with hydrometer analysis results are contained in Appendix D. Laboratory permeability analysis results are contained in Appendix E.

Phase II drilling activities were performed between November 4 and 27, 1991. Eleven monitoring wells at 11 locations and nine piezometers (six shallow and three deep) at six locations were installed at the site (Figure 3-1). These wells include:

MW19	MW25	PZ1D
MW20	MW26	PZ2
MW21	MW27	PZ4
MW22	MW28	PZ5
MW23	MW29	PZ6S
MW24	PZ1S	PZ6D
		PZ7S
		PZ7D

Boring logs and well construction details are found in Appendix C.

Monitoring wells were located to delineate subsurface geology, provide hydrogeologic data and assess water quality upgradient, immediately

downgradient, adjacent, and further downgradient of known and potential source areas. Drilling was performed by John Mathes & Associates (Mathes), Columbia City, Illinois, under the direct supervision of a Warzyn hydrogeologist. MDNR representatives were on site during the drilling activities. Drilling was performed under Level D protection guidelines.

Monitoring well borings were drilled using 4.25-in. I.D. HSA. During Phase II, vertical groundwater profiling (sampling) was conducted at each monitoring well boring at 5 ft intervals to establish vertical VOC contaminant distribution in the aquifer. The sampling procedure in the Work Plan Addendum (Warzyn, September 23, 1991), called for the use of a screened lead auger and a stainless steel knockout plug to conduct vertical sampling during downward drilling, but after attempting this procedure at monitoring well location MW21, the method was abandoned due to the failure of equipment to perform as expected (well MW21 was sampled continuously as indicated on the boring log). The screened lead-auger used by Mathes would not allow sufficient water volume into the augers, to accomplish the amount of purging necessary before the well could be sampled. After MW21 was completed, the vertical sampling procedure was modified with MDNR approval and consisted of drilling to the base of the upper aquifer with either a center plug or a knockout plug in the lead auger. Split-spoon samples were not collected from the borings. Soil descriptions are included on the boring logs in Appendix C for wells MW19 through MW29, from field observation of drill cuttings and known geology from other site borings. The boring was then geophysically logged for gamma rays through the drill stem (see Appendix F for Gamma Ray Logs), and a 2-in. temporary well equipped with a stainless steel well screen and galvanized steel riser pipe was set at the aquitard/aquifer contact. The HSA was then pulled from the borehole.

The rig pump was used to purge the temporary well. Approximately 60 to 75 gallons were purged at each sampling interval (over three well volumes) with pH, conductivity, and temperature readings being recorded in the field notebooks at approximate 20- to 25-gallon intervals. After purging the temporary well, a groundwater sample was collected using a stainless steel bailer with stainless steel cable. The sample was placed in 2-40 ml glass vials and analyzed for chlorinated organic compounds using the on-site field GC, supplied and operated by MDNR personnel. Total VOC area counts are included on the boring logs for wells MW19 through MW29. Individual compound concentrations were not calculated due to limitations of the field GC and intended use of the data. The data was intended to be used as an indicator to aid in setting well screens in the zone of highest VOC contamination.

After collection of the groundwater sample from this interval, the temporary well was raised 5 ft, purged again, and sampled. Note, for well MW29, the temporary

well was raised in 10 ft sections instead of 5 ft sections. (This was done to expedite well construction as this was the last well at the end of a 10 day shift, therefore eliminating the need to mobilize to the site to complete one well.) This action was conducted with MDNR approval. This procedure was continued from the total depth of the borehole to the water table. Once the groundwater samples from a given boring were collected and analyzed, the monitoring well screen was to be set at the zone of highest VOC contamination. Three wells, MW19, MW23, and MW29 were not set in the zone of highest total VOC readings from the field GC because Warzyn and MDNR field personnel determined some compound peaks may be masking other peaks (due to extremely high concentrations). Consequently in these cases the total VOC area counts were not considered to be representative. For example, an unidentified compound which eluted before the target compounds may have been off-scale, thus masking the target compounds on the chromatogram. Screen placements were determined using target compound peaks and best professional judgement of the GC operator and geologist.

In addition to monitoring wells, nine piezometers (including three nested shallow and deep piezometer sets) (Figure 3-5) were installed during the Phase II drilling activities at six locations. Piezometers were installed in order to provide additional water level measuring points, vertical and horizontal hydraulic gradient data, and to evaluate the extent and to nature of the aquitard.

Borings for piezometer installation were accomplished using 4.25-in. HSA techniques and continued until the aquitard was reached and penetrated at least 3 ft. Split spoon samples were collected at each drilling location according to ASTM D-1586 protocols. Split-spoon samples (2-in.) were taken at 5 ft intervals to a depth of 20 ft, at 10 ft intervals from 20 ft to the aquitard layer, or at changes in lithology, as noted by inspection of cuttings or by drill rig performance. Split-spoon samples were screened for the presence of VOCs with a PID and were visually inspected in order to establish stratigraphy using the USCS. Detailed boring logs were noted in the hard bound field notebooks by the hydrogeologist. Shelby tube samples of the aquitard layer were taken at each of the three nested piezometer locations. Laboratory permeability tests were conducted on each of the Shelby tube samples. In addition, split-spoon samples from each of the three deep piezometer borings were taken to conduct grain size analysis of the aquitard (one each) and the aquifer (two each) for a total of nine grain size analyses. Total organic carbon (TOC) samples were also collected at each nested piezometer location. One sample was taken from the unsaturated zone and two samples were taken from the saturated zone (aquifer) at each nested piezometer location. Nine TOC samples, plus one duplicate sample from each of the unsaturated and saturated zones, for a total of eleven samples were taken. Permeability, grain size, and TOC analyses were conducted by Warzyn's Analytical Laboratory.

3.5.2 Monitoring Well and Piezometer Installation and Development Procedures

Nineteen monitoring wells were installed during the Phase I investigation. See Figure 3-1 for well locations. Monitoring wells were constructed through (inside) the auger using 2-in. I.D. PVC well screens and PVC riser. The well screen for each well was 5 ft in length and had 0.010 in. (#10) slots. Shallow wells were constructed to intersect the groundwater table. The annular space around the well screen was backfilled with coarse sand to at least a 2-ft above the screen, followed by a 2 ft bentonite pellet seal above the sand pack. Fine granular bentonite was placed above the bentonite pellet seal to the ground surface. The riser was cut 2.5 ft above grade and a cap was threaded to the riser pipe. Each well was outfitted with a vented well cap and a locking steel protective casing was placed over the well and was pushed into place through the fine granular bentonite. The protective casing was locked to secure the well.

Deep wells were installed to what was assumed to be the top of the aquitard at each location. Deep monitoring wells were constructed following the same procedure as the shallow wells, except that a bentonite slurry was placed above the bentonite pellets to within 5 ft of the ground surface. Fine granular bentonite was then placed, to the ground surface. Construction details for each monitoring well are located in Appendix C.

The monitoring wells were developed by purging water from each well using the drilling rig suction pump and a 1 in. PVC hose. At least 10 well volumes were purged from each well. pH, conductivity, and temperature measurements were recorded during well development and are found in field notebooks. Wells were purged until water appeared clear, with no turbidity.

Eleven monitoring wells and nine piezometers were installed during the Phase II investigation (Figures 3-1 and 3-5). Monitoring wells were constructed, through the augers, using 2-in. I.D. stainless steel risers and 5-ft, 0.006-in. slot well screens. Monitoring well screens were placed at a depth corresponding to the zone of highest VOC contamination (as previously described) during the vertical groundwater profiling. See the well construction details in Appendix C for screened intervals. Natural formation collapse was allowed to backfill the borehole to the appropriate total depth where the well screen was to be set. Natural materials were allowed to collapse to 2 ft above the top of the well screen. A 2 to 3-ft coarse (3/4 in.) bentonite chip seal was placed above the natural pack. The remainder of the annular space to the water table was sealed with a thick bentonite slurry. Granular bentonite was then placed above the slurry to the surface.

A tremie pipe was used to place the slurry in deep wells. Above the water table, fine granular bentonite was used to seal the borehole to the ground surface. The well riser was cut 2.5 ft above grade. Each well was outfitted with a vented well cap and a locking steel protective casing was placed over the well and pushed into place through the fine granular bentonite. The protective casing was locked to secure the well. Monitoring well construction details are located in Appendix C.

Piezometers were constructed using 3-ft, 0.006-in. slot, 1-in. I.D., flush-threaded, Schedule 80, PVC well screens, and 1-in. I.D., flush threaded, Schedule 80 PVC riser. The piezometer materials were suspended within the borehole during well construction to maintain plumb within the borehole. Both shallow and deep piezometers were installed in a single borehole. Once in place, the annular space around the deep piezometer screen was backfilled by allowing natural materials to collapse to at least 2 ft above the top of the well screen. A 2 to 3 ft coarse (3/4 in.) bentonite chip seal was placed directly above the natural pack. Bentonite slurry was pumped down on top of the lower seal and natural formation collapse was also allowed to fill the annular space from above the lower seal of the deep piezometer to where the shallow piezometer was to be set. Natural formation was allowed to collapse around and to 2 ft above the top of the well screen. A 2 to 3 ft coarse (3/4 in.) bentonite chip seal was then placed above the natural pack followed by fine granular bentonite to the ground surface. Nested piezometers were finished above the ground surface with stickups of varying heights. For identification purposes, the deep piezometer was given a slightly lower stickup than the shallow piezometer in the nested locations. Both piezometers were marked and fitted with vented well caps. A single locking steel protective casing was placed over both piezometers and pushed into the fine granular bentonite.

Single piezometers were constructed by allowing natural formation collapse to fill the annular space of the borehole to the appropriate depth for setting the shallow piezometer. The well materials were then lowered into the borehole and natural material was allowed to collapse to at least 2 ft above the top of the well screen. A 2 to 3 ft coarse (3/4 in.) bentonite chip seal was placed directly over the natural pack followed by fine granular bentonite to the ground surface. The single piezometer riser was cut-off above the ground to form a 2.5 ft stickup. Each well was outfitted with a vented well cap and a steel protective casing was placed over the piezometer and pushed into the fine granular bentonite.

Each Phase II monitoring well (MW19 through MW29) and piezometer (PZ1 through PZ7 (no PZ3)) was developed using the drilling rig suction pump. The suction pump was used to remove multiple well volumes (typically 10 to 20 volumes), then the pump was reversed and approximately 5 to 10 well volumes were surged back into the formation surrounding the well screen. This process was normally repeated three times or until the water removed from the well was

clear with no visible turbidity. Conductivity, pH, and temperature readings were taken during monitoring well development and are found in the field log books. Development continued until these readings stabilized. Piezometer PZ4 was the only well that was not developed in this manner. PZ4 recovered excessively slow and therefore was surged with a bailer for 30 minutes and was bailed for 30 minutes to remove approximately 10 well volumes. Monitoring wells installed in Phase I were developed differently than wells installed in Phase II due to a change in development methods in consultation with MDNR.

3.5.3 Location and Elevation Survey

Three location and elevation surveys were performed during the RI by Kapur and Associates, Inc. The initial survey was performed in February 1989 to provide locations and elevations of existing on-site wells (existing wells) (Figure 2-2). A topographic base map of the site was also developed. Permanent benchmarks were established for vertical and horizontal control, with elevations based on the U.S. Geological Survey datum.

A second survey was conducted in September 1989. Phase I monitoring well locations and elevations were surveyed at this time. The third survey was conducted in December 1991 and included Phase II monitoring wells, soil borings, and piezometer locations. Surveyed points are shown on Figure 3-5.

3.6 WASTE CHARACTERIZATION

Waste characterization activities were conducted in September and October 1988, August and September 1989, and November 1991. Waste characterization was conducted to evaluate the nature and extent of contamination in various media at both western and eastern lagoon areas. The waste characterization investigation consisted of sampling lagoon water, lagoon berm soils, lagoon sludge, and soil boring sampling. See Appendix G for sample identification and control information.

The first waste characterization sampling event included sampling of lagoon water, lagoon berm soils, and lagoon sludge (September - October, 1988). Eight lagoon water samples were collected from the four western lagoons (Figure 3-3). Lagoon water samples were collected in pairs. The first sample was collected near the bank of each lagoon by submerging the sample bottle in the lagoon water. The second sample was collected further out in the lagoon by using a stainless steel dipper with a 10 ft extension pole. Each sample was collected from below the water surface to minimize the collection of surface materials (e.g., duckweed). Lagoon water samples were not filtered.

Following collection of surface water from the western lagoons, three lagoon berm soils samples were collected from the western lagoon berms and three lagoon berm soils were collected from the eastern lagoon berms (Figures 3-3 and 3-4). Lagoon berm soil samples were collected using a stainless steel hand auger and were collected at a depth of 2 to 3 ft below the ground surface.

Lagoon sludge samples were collected at 12 sampling locations in the western and eastern lagoons (Figure 3-5). Three borings were hand augered approximately 2 ft from each other at each sludge sample location. Samples from each of these borings were collected at depths of 6 in. and 36 in. At each of the three borings within one lagoon sludge sample location, the sample depth intervals were denoted as "S" - Shallow for the 6 in. interval and "D" - Deep for the 36 in. interval. The three borings were then denoted by a "A", "B", or no letter following the lagoon sludge sample location number and the sample depth indicator to indicate a VOC subsample. VOC grab samples were collected from each boring at both sample intervals (shallow and deep). A total of six VOC samples were collected at each of the 12 sludge sampling locations for a total of 72 VOC samples. After the collection of each VOC grab sample, extra volume was collected from each of the six sampling points and were composited in stainless steel bowls according to sampling depth; therefore, a total of 24 composite samples, two from each location to correspond with each sampling depth, were collected and analyzed for TAL inorganics, TCL organics, and RCRA characteristics (corrosivity, EP toxicity, reactivity, and ignitability).

The second waste characterization sampling event (August - September 1989) included resampling western lagoon sludges and the collection of soil samples from three soil borings (SB1, SB2, and SB3). Lagoon sludges were resampled in the western lagoons (Figure 3-4) due to CLP laboratory problems during analysis of samples from the first round of sampling. Six VOC subsamples were collected at each of the eight new soil boring locations. At each location three VOC subsamples were collected at the 6 in. depth(s) and at the 36 in. depth(s). For example, at location S5 these are the following samples for VOCs: S5SA, S5SB, S5SC, S5DA, S5DB, S5DC. The remaining composite parameters are labeled S5S and S5D. To avoid confusion with the first round of sampling, the new soil boring VOC subsamples were designated "A", "B", or "C". Lagoon sludge samples were analyzed for TCL, VOCs, SVOCs, P/PCBs, TAL inorganics, and RCRA characteristics. Forty-eight VOC samples and 16 composite samples (plus QA/QC samples) were collected. In addition to the resampling of lagoon sludge, three soil borings near the eastern lagoons (Figure 3-5) were sampled to assess the extent of buried sludge and contaminated soils at the eastern lagoons and to assess soil and sludge chemical characteristics in this area of the site. The three soil borings were drilled using 4.25 in. HSA. Three-in. diameter split-spoon samples were collected at 2 ft intervals (continuously) from 0 to 10 ft and a final split-

spoon was collected at 15 ft (end of boring). Split-spoon samples were screened for the presence of VOCs with a PID. Samples were collected for TCL organics, TAL inorganics, and RCRA characteristics analyses.

The drilling rig and associated equipment used during drilling was moved to the decontamination pad, where the rig and equipment were steam cleaned. Split-spoon samplers were washed in a TSP solution and were thoroughly rinsed with distilled water between each sampling interval and were steam cleaned between boreholes. Boring logs for SB1, SB2, and SB3 are presented in Appendix C.

The third waste characterization sampling event was conducted during the Phase II investigation (November 1991) and included soil borings SB4 through SB15. Four soil borings (SB4 through SB7) were located in the eastern lagoon areas, and two soil borings (SB8 and SB9) were located in the western lagoon area (Figure 3-5). Because the eastern lagoons are inaccessible to a truck mounted drilling rig, soil borings SB4 and SB5 were hand augered. SB4 and SB5 were augered to establish the thickness of sludge in the two eastern lagoons. Cuttings from these borings were visually inspected and observations were recorded in field notes. No samples were submitted for analysis.

Borings SB6, SB7, SB8, and SB9 were drilled to establish aquifer thickness in the vicinity of each set of lagoons, to determine natural soil chemical characteristics, and to aid in estimating the amount of contaminated soils on site. These soil borings were drilled and sampled using 4.25 in. HSA. Split spoon samples were collected according to ASTM D-1586 protocols. Split-spoons were collected at 2.5 ft intervals to a depth of 10 ft and at 5 ft intervals from 10 ft to the top of the aquitard.

Nineteen samples collected from SB6 and SB7 (in the vicinity of the eastern lagoons Figure 3-5) were submitted for TAL inorganic and TCL organic analysis.

Soil cuttings from borings SB8 and SB9 (in the vicinity of the western lagoons Figure 3-4) were visually inspected only, no samples were submitted for analysis. Boring logs for soil borings SB4 through SB7 are presented in Appendix C.

Soil borings SB10 through SB15 (Figure 3-5) were drilled using 4.25 in. HSA. Split spoon samples were collected at each drilling location according to ASTM D-1586 protocols. Split-spoon samples were taken at 5 ft intervals from ground surface to 30 ft. An additional surface sample (at 0 to 0.5 ft) was taken for analytical analysis at soil borings SB13 through SB15. Soil borings SB10, SB11, and SB12 were drilled adjacent to the abandoned industrial sewer (Figure 2-2) to determine if the sewer is a possible source of contamination. Additionally, the borings were intended to supplement data already collected along the length of the

abandoned industrial sewer. Soil samples were collected for TAL inorganics and TCL organics (VOCs, SVOCs), and pesticides/PCBs (P/PCBs) analysis. A total of 21 soil samples were collected, including two duplicate samples, and one MS/MSD sample.

Soil borings SB13, SB14, and SB15 were drilled on the vacant former L.A. Darling property (Figure 3-5). These borings were located based on results of the geophysical survey conducted during the Phase I field investigation and/or information provided by individuals familiar with the history of the site (reportedly, there were lagoons or waste pits located in this area). The borings were drilled to determine whether drums, underground storage tanks (USTs), or buried materials were present on the property, and to determine if the soil on this property was a possible source of contamination. Samples collected from soil borings SB13, SB14, and SB15 were analyzed for TAL inorganics and TCL organics. A total of 25 samples were collected, including two duplicates and one MS/MSD. Sample interval, time of sampling, blow counts, lithology (using the Unified Soil Classification System (USCS)), sampling personnel, and other pertinent information were recorded in a bound field notebook. This information was used to prepare field boring logs, which were converted to computer generated boring logs (Appendix C) using gINT (gEOTECHNICAL INTegrator) software (GCA, Santa Rosa, California).

In addition to performing soil borings, a second round of lagoon water samples were collected during the third waste characterization sampling event. Lagoon water samples were collected from the approximate center of the two largest western lagoons (Figure 3-4) A flat-bottom boat and a depth specific bulk water sampler (e.g., Kemmerer Sampler) was used to collect the lagoon water samples. The second round of lagoon water samples were collected at the mid-depth and at the bottom of the lagoons, just above the lagoon sludges to determine if contaminant concentrations at depth within the lagoon waters were significantly different than those from the upper lagoon waters. There was between 3 and 5 ft of standing water in two largest western lagoons. Lagoon water samples collected during the first waste characterization event were taken near the lagoon surface.

Sampling from the flat bottom boat was conducted by lowering a weighted water level tape into the lagoon until it rested on the lagoon bottom sediments. The tape was then slowly drawn taut and the depth of the lagoon was recorded. The mid-point (depth) of the lagoon was determined and the Kemmerer Sampler was lowered to the mid-depth of the lagoon and a sample was collected. After the mid-depth sample was collected, the Kemmerer sampler was decontaminated using a TSP wash followed by a thorough distilled water rinse, and the lagoon water sample was then collected from the bottom. Sampling depths were 2 ft and 4 ft for the mid-point and bottom depths, respectively. A total of seven samples

were collected including four lagoon water samples, one duplicate, one equipment blank, and one MS/MSD sample. Samples were analyzed for TCL organics, TAL inorganics, CLP special analytical service (SAS) indicators, and CRL hexavalent chromium. Lagoon water samples were not filtered, as surface water samples are generally never filtered.

3.7 SURFACE WATER, SEDIMENT, AND OUTFALL SAMPLING

Two rounds of surface water and sediment sampling were conducted during the RI. The first round was conducted in September 1988 during the Phase I investigation and included the collection of ten surface water and sediment samples (SW/SD1 through SW/SD10). The purpose of the surface water and sediment sampling program was to determine impacts local industrial processes may have had on CD#30. Surface water and sediment samples were collected at the locations shown on Figure 3-1. Surface water and sediment samples were collected upstream and downstream of each outfall and lagoon area in an attempt to establish background conditions and to determine the affect each outfall and/or lagoonal area may have had on the CD#30. Initially, sample SW/SD1 was considered as background because of its location upstream of the Bronson Plating outfall.

Sampling proceeded from downstream to upstream (west to east). The surface water sample was collected first at each location. The sample was collected by submerging the sample bottle below the water surface. After the surface water sample was collected, the corresponding sediment sample was collected using a stainless steel spoon. Sediment samples were collected from 0 to 6 in. Surface water and sediment samples were collected for analysis of TAL inorganics and TCL organics. Surface water samples were also analyzed for water quality indicator parameters and hexavalent chromium; measurements of pH, conductivity, and temperature readings were recorded in the field and are found in Appendix I.

The second round of surface water, sediment and outfall sampling was conducted in November 1991 during the Phase II investigation and included the collection of seven surface water and sediment samples (SW/SD11 through SW/SD17) and three outfall samples (OF1, OF3, and OF5). Sediment samples were not collected with outfall samples. This sampling program was conducted to confirm selected data from Phase I results, to "spot-check" outfall effluents for contaminants, and to further establish background conditions at the site.

Surface water, sediment and outfall samples were collected using the same procedures used during the first round and were analyzed for the same analytes. Surface water and outfall samples were not filtered prior to analysis.

Originally, five outfalls were to be sampled during Phase II, but the two farmland outfalls (OF2 and OF4) were dry and could not be sampled. Only the Bronson Plating, Bronson Wastewater Treatment Plant (WWTP), and Bronson Storm Sewer outfalls (OF1, OF3, and OF5, respectively) were sampled (Figure 3-1). A second Bronson Plating outfall east of OF5 was also not sampled.

The outfall samples were treated as surface water samples and were collected by allowing the outfall water to pour directly into the sample bottles. Outfall samples were analyzed for the same analytes as surface water samples.

3.8 SURFACE AND SUBSURFACE SOIL SAMPLING

Surface and subsurface soil samples were collected during the Phase II investigation in November 1991. Surface (0 to 6 in.) and subsurface (3 to 5 ft) soil samples were collected around the site to evaluate potential contamination associated with the previously operated cyanide destruction facility, other potential contaminant sources identified from selected historic and industrial activities, and to establish background soil conditions at the site. In addition, the surface and subsurface soil samples were collected to aid in the evaluation of potential health risks associated with direct contact with site soils. (See North Bronson Baseline Risk Assessment, Warzyn, July 1993.)

Soil samples SS1, SS2, SS13, and SS14 collected from two baseball fields at either end of the site, and SS15 and SS16 collected in close proximity to the two existing background wells MW1S and MW11S, respectively, were taken to establish background surface and subsurface soil conditions at the site (Figure 3-1). Sixteen surface and subsurface soil samples were collected at 16 locations. Samples were obtained by hand augering and submitted for analyses of TAL inorganics and TCL VOCs. Soil boring logs were not prepared for these shallow soil borings; however, a brief description of the soils at each sampling location was recorded in the field notebook for this activity. The soil borings were backfilled with cuttings. Decontamination between samples was accomplished by washing sampling equipment in a TSP solution followed by a thorough distilled water rinse.

3.9 GROUNDWATER SAMPLING

Three rounds of groundwater sampling were conducted during the RI. The first round of groundwater sampling was conducted in September and October 1988 during the Phase I investigation, and consisted of sampling 16 existing monitoring wells (six at the western lagoon area, six at the eastern lagoon area, and four at Douglas Components Corporation (DCC Plant #2)), one city water supply well (PW3) and five private wells (Losinski, 231 Albers; Wheeler, 204 Mill; Borgert, 216 Matteson; Eichler, 220 Matteson, Himes, 425 Union) (Figure 2-2). In consultation with MDNR, monitoring wells MW9 through MW12 (at DCC Plant #2) were not sampled because of the presence of approximately four feet of oil in the wells. Remediation of the oil spill, presumed to account for the free product found in the DCC monitoring wells, is being addressed at this time as a separate action by DCC with oversite by the Jackson District office of MDNR. Well MW15S (at the eastern lagoons) was not sampled because it was dry.

The monitoring wells were purged and sampled with a stainless steel bailer and stainless steel cables, with the exception of wells MW15D, MW16D, and MW17D which were purged and sampled with a submersible pump. Groundwater samples obtained from the four DCC Plant #2 wells were split with DCC's consultant, EDI Engineering & Science Inc., while groundwater samples obtained in the eastern lagoon area were split with Bronson Plating Company's consultant, Environmental Resources Management, Inc. (ERM).

At each monitoring well location, the well cap was removed and breathing zone organic vapor monitoring was conducted using a photoionization detector. After determining the proper level of protection to be worn, a water level reading was taken to the nearest 0.01 ft using an electric water level indicator. Plastic sheeting was placed around the monitoring well to minimize contact of sampling equipment with the ground. Three to five well volumes were then purged from each well before sampling; pH, conductivity, and temperature readings were taken (see Appendix I). Immediately upon completing purging, the wells were sampled. When splitting samples with the consultants representing DCC and Bronson Plating, the sample bottles were alternately filled, one sample bottle to support the RI and one sample bottle for others. Each consulting company provided their own bottles. Samples were filtered and preserved according to the procedures outlined in the 1988 QAPP. Groundwater samples were analyzed for TAL inorganics, TCL organics, water quality indicator parameters, and hexavalent chromium. Samples were placed in coolers and were cooled to approximately 4°C with ice. Samples were shipped daily to the CLP laboratory.

In addition to existing monitoring well sampling, residential (private) wells were sampled during the round of groundwater sampling. Residential (private) well

sampling consisted of sampling city water supply well (City Well #3) and five private wells (Figure 2-2). Residential wells were sampled by purging the well which consisted of running the cold water tap closest to the well head for a minimum of fifteen minutes after the pump was turned on. No sampling downline from water softeners or other water treatment systems occurred. Temperature, pH, and conductivity readings were taken prior to sampling. Samples were collected, preserved, and shipped in the same manner as groundwater samples, and were analyzed for the same parameters as the existing monitoring wells.

The second groundwater sampling round (September 1989) was also conducted during the Phase I investigation, after installation of the 19 Phase I monitoring wells. During this round of groundwater sampling, the 19 new Phase I monitoring wells were sampled, and 13 previously existing monitoring wells and 6 private (residential) wells were resampled. DCC property monitoring wells were not sampled. Warzyn, under the direction of MDNR, excluded DCC property wells from the RI because the oil spill on the DCC property was being handled under a separate cooperative investigation. Sampling procedures were identical to those used during the first round of groundwater sampling, as were the chemical analyses performed on these groundwater samples.

A third round of groundwater samples were collected (December 1991) after the installation of the 11 Phase II monitoring wells. This round of groundwater sampling consisted of resampling 18 selected Phase I monitoring wells and sampling the 11 newly installed Phase II monitoring wells (MW19 through MW29). Residential wells and several existing monitoring wells were not resampled because two complete rounds of sampling had already been conducted on these wells. Groundwater samples obtained during this round of sampling were collected using the same procedures applied during the first two rounds of sampling. However, samples were not analyzed for SVOCs, P/PCBs, and hexavalent chromium due to the absence of these analytes during previous rounds of sampling. Groundwater samples were analyzed for TAL inorganics, TCL VOCs, and water quality indicator parameters.

3.10 GROUNDWATER LEVEL MONITORING

Groundwater levels were measured by Warzyn at the completion both the Phase I and II well installation programs, prior to but concurrent with the three rounds of groundwater sampling. Additionally, groundwater levels were measured by MDNR personnel on February 7, 1990, April 24, 1992, and June 25, 1992. Groundwater levels were collected to determine seasonal fluctuations in groundwater levels and flow directions, and to establish horizontal and vertical

gradients. Groundwater elevations were analyzed by Warzyn and were used to construct groundwater contour maps and other pertinent data to help characterize site conditions. See Table 4-3 for a summary of groundwater elevations and Figures 3-6, 3-7, and 3-8 for the groundwater table contour maps.

3.11 HYDRAULIC CONDUCTIVITY (AQUIFER) TESTING

Two rounds of hydraulic conductivity testing were performed during the RI. The first round was performed in September 1989 during the Phase I investigation. Ten of the Phase I monitoring wells were tested. A Hermit Data Logger (In-Situ Inc., Laramie, WY) with a pressure transducer was used for in-situ hydraulic conductivity aquifer testing. To perform an aquifer test, the static water level was first measured and recorded. The transducer was then lowered into the well and the water level was entered into the Hermit Data Logger. The slug was then lowered into the well and the water level was allowed to return to static conditions. The slug was then removed from the well, and the changes in water levels over time were recorded by the Hermit Data Logger. The transducer and other equipment was decontaminated between wells, using a TSP and water wash followed by a thorough distilled water rinse. Results are found in Table 4-1 and Appendix H.

The second round of hydraulic conductivity tests was performed in December 1991 during the Phase II investigation. The eleven Phase II monitoring wells (MW19 through MW29) plus Phase I monitoring wells MW5D and MW10D were tested. In-situ hydraulic conductivity aquifer tests were performed on each of the wells by using air pressure to depress the water levels. To perform this aquifer test, the static water level was measured and recorded. The transducer and an electric water level indicator were lowered into the well and the water level was entered in the Hermit Data Logger. A sealed cap assembly with a pressure release valve was fitted to the top of the monitoring well. The water level in the well was depressed (using compressed air), between 2.5 ft and 10 ft depending on the water column above the top of the screen (determined by the water level indicator in the well) and this level was held until the level was stable. Simultaneously, the pressure was released and the test was started. The changes in water levels over time were recorded by the Hermit Data Logger. The transducer and other equipment was decontaminated between wells as described above. Care was taken to avoid introducing air into the aquifer by setting a water level indicator above the top of the screen. By doing this, the geologist was able to depress the water to a point above the top of the well screen but not intersecting the well screen.

Results of both rounds of hydraulic conductivity tests were used to calculate hydraulic conductivity values for the aquifer. Hydraulic conductivity results are presented in Appendix H and are summarized in Table 4-1.

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4

PHYSICAL CHARACTERISTICS OF STUDY AREA

4.1 SURFACE FEATURES AND TOPOGRAPHY

The site encompasses an area of approximately 220 acres with a maximum topographic relief of approximately 12 ft (see Figures 2-1 and 2-2). Topography varies little between the northern and southern portions of the site. The topography across the site is relatively flat, ranging from a high of 915 ft above mean sea level (MSL) to a low of approximately 903 ft above MSL. The highest points are attributed to the lagoon berms surrounding both the eastern and western lagoons. The lowest point on-site is the bottom of CD#30. The topography north of CD#30 (off-site) gently rises to the north.

4.2 HYDROLOGY

CD#30 is the major surface water feature within the site and defines the northern site boundary (Figure 3-1). The drain flows from east to west, eventually discharging to Swan Creek, approximately 1.5 miles, northwest of the site. Swan Creek is a tributary of the St. Joseph River which flows to the southwest (Figure 2-1).

CD#30 is a channel, approximately 6-8 ft wide and 3-6 ft deep, widening and deepening from east to west across the site. Water depth was observed to vary from 1-2 inches with stagnant flow, in the eastern reach, to 8-10 inches with surface flow of approximately 1-2 feet per second (fps), in the western reach.

The origin of CD#30 is a small marsh area (wetland) located about one half mile to the northeast of the site. Six outfalls discharge to CD#30 along its reach within the site (Figure 3-1). On the north side of CD#30 are two farm outfalls. On the

south side of the drain are the following four outfalls: Bronson Plating Company (2), Bronson Water Treatment Plant, and the City of Bronson storm sewer discharge. The Bronson storm sewer discharge is a 36 inch concrete pipe which discharges into CD#30 just north of the western lagoons. Annual average precipitation for the years 1951 through 1980 is 33.43 inches, recorded at the Coldwater State School Station. The heaviest average precipitation has been in July, the lowest in February. Surface water drainage in the immediate vicinity and on-site is toward CD#30. There are no lakes or reservoirs in the immediate vicinity of the site.

4.3 SITE GEOLOGY

The site is located in an area underlain by glacial outwash. Quaternary deposits in the south-central part of Michigan are approximately 150 ft thick. A prominent northeast-southwest oriented terminal moraine is located to the north of the site. This terminal moraine is composed of poorly sorted sand, silt and clay. The general stratigraphy beneath the site, based on data gathered from borings made on the site and on information from the Hydrogeologic Atlas of Michigan (1981), consists of the following:

- Surficial silt, clay and sands to a depth of 0 to 17 ft
- 7 to 63 ft of a fine to coarse sand and gravel layer (referred to as the upper or shallow aquifer)
- 17 to 50 ft of a silt and clay layer (assumed aquitard)
- 50 ft of a sand and gravel layer (lower aquifer)

The glacial deposits are underlain by bedrock of the Coldwater Shale Formation at a depth of approximately 150 ft. The Coldwater Shale is a blue-gray to green shale with sandstone and limestone lenses and is approximately 500 to 700 ft thick in this region (Hydrogeologic Atlas of Michigan, 1981). Data collected at the site generally supports the site geology as described above and is discussed in the following paragraphs. Considering the large site area (220 acres), there is limited data available confirming the continuity and thickness of the aquitard at the site.

A number of grain size and grain size hydrometer analyses were conducted on site soils during the RI (Appendix D). These results indicate that the upper sand unit (aquifer) observed across the entire site area is a loose to dense, coarse to fine sand with trace to some gravel and trace to little silt and clay. An aquifer is

defined as a saturated geologic unit that has sufficient permeability to permit water to flow through it with relative ease. The USCS classification for this unit is SP. This sand unit is not completely homogeneous and has several seams or layers of sand and gravelly sand with trace amounts of silt and clay. A few gravel and cobble seams or layers were encountered just above the aquitard and may indicate a high-energy alluvial deposit (e.g., a fast moving stream deposit typical of glacial outwash). According to the grain size results, the sand unit is comprised of between 0.6% - 35.5% gravel, 62.2% - 98.7% sand, and 0.7% - 6.5% silt and clay. The sand unit ranges between 7 - 63 ft thick and thins and possibly pinches out to the north of the site.

An aquitard layer was observed to exist under the upper sand unit across the site. A confining unit or aquitard is characterized by low permeability that does not readily permit water to pass through it despite the fact that it stores large quantities of water (U.S. EPA Ground Water Handbook). Figure 4-1 presents a contour map of the aquitard based on interpretation of the data collected during the RI. The existence of the aquitard was based on emplacement of 26 soil borings during the RI which extended to the silt and clay layer, grain size analyses, plus information on soil borings drilled by others before and/or during the RI (i.e., Bronson Plating Company wells and residential well logs).

Grain size (sieve and hydrometer) results indicate that this unit is dense, silty, coarse to fine sand, with some clay and trace to little fine gravel, classified as SM using the USCS. According to grain size results, this unit is comprised of between 2.0 - 10.8% gravel, 49.6 - 53.5% sand, 21.1 - 31.6% silt, and 6.5 - 20.5% clay. This unit appears to be a glacial till, well graded, and uniformly mixed, with a coarse-grained sand and gravel held in placed within a fine-grained silt and clay matrix. No stratification of sand or gravel was observed in this unit.

The aquitard has been presented in Figure 4-1 as a continuous layer based upon professional interpretation of the data available. However, the site covers nearly 220 acres, and thus the data used to make this interpretation is considered to be limited. Consequently, although discontinuities in the aquitard were not observed during drilling activities, it is possible that the aquitard may not be continuous across the site. In the remainder of the report, the aquitard is sometimes discussed without reference to the possibility that it may be discontinuous, however, the reader is advised to keep this possible condition in mind.

At piezometer PZ6 a hard, gray, lean clay, with trace sand and no gravel, was observed instead of the silty sand. According to the grain size results, this unit or layer is comprised of 0% gravel, 3.5% sand, 29.8% silt, and 66.7% clay and is classified as CL. This clay layer appears to be at least 8 ft thick at the PZ6 location and from area residential well logs may be extensive. Residential well

logs in the immediate vicinity of the site indicate that this clay layer may be as thick as 21 ft and that the combination of the silty sand layer and the clay layer may be as thick as 50 ft (see Appendix C-2 for residential well logs)(See Figure 2-2 for residential well locations). An aquitard surface contour map (Figure 4-1) has been constructed from available information (Table 4-2) and presents the interpreted surface contour of the aquitard. Four cross sections of the site have also been prepared to aid in the determination and interpretation of site geology. The four cross sections along these lines are shown in Figures 4-3, 4-4, 4-5, and 4-6. The lines of geological cross sections are presented on Figure 4-2.

The aquitard surface contours indicate that the site may be located on the edge of a large erosional valley present on the aquitard surface. The surface of the aquitard appears to be gently sloping toward the south. PZ6 is located in a depression on the edge of this erosional feature. It appears that the aquitard is actually composed of two distinct units but at PZ6 it appears that the first layer, the silty sand, has been eroded away, leaving the underlying clay layer exposed.

North of CD#30 is a predominant northeast-southwest oriented terminal moraine. This moraine appears to overlie the upper sand unit and forms a gentle sloping ridge north of CD#30. Monitoring well MW11S appears to be positioned within this unit. The terminal moraine is composed of poorly sorted sand, silt, and clay. At piezometer PZ4, this morainal material was encountered from the ground surface to a depth of 17 ft, below which the upper sand layer was observed. The morainal material is described as a loose to dense, brown to gray, silty, coarse to fine sand, with some clay and trace gravel. One grain size analysis was conducted on this material (MW11S at 15 ft) and the results indicate that this material (unit) is comprised of 7.9% gravel, 49.6% sand, 24.5% silt, and 18.0% clay. Based on this analysis, the USCS classification for this unit is SM.

The geologic characteristics of the lower sand and gravel aquifer, which lies below the aquitard, have not been defined. This lower aquifer has been identified in a number of residential well logs and is reported to be comprised of sand and gravel in about equal quantities, but no geotechnical data exists for this unit. This second sand and gravel layer is approximately 50 ft thick based on residential well logs and published reports. Bedrock reportedly underlies this sand and gravel layer.

4.4 SITE HYDROGEOLOGY

Based on the hydrogeologic information for the area (site boring logs and residential well logs), it appears there are two sand and gravel aquifers separated by an aquitard at the site. The aquitard is assumed to be continuous at the site but

there is limited information to confirm its continuity and thickness. The depth to the water table at the site ranges from 3 to 9 ft below ground surface.

The upper sand unit described previously is saturated at depths of 3 to 9 ft below the ground surface. The saturated zone of the upper sand unit comprises an unconfined aquifer referred to as the upper aquifer at this site. Groundwater elevation data is presented in Table 4-3. Three groundwater surface contour maps (Figures 3-6, 3-7, and 3-8) have been constructed to aid in the interpretation of groundwater elevation and hydrogeologic data. Groundwater elevations vary from a high of approximately 905 ft above MSL in the southeastern area of the site (MW1S, MW29, PZ1S, and MW14S) to a low of approximately 903 ft above MSL adjacent to the drain in the northwest area of the site (MW28, MW4, MW5, and MW6). Groundwater elevations north of CD#30 also appear to vary from a high of 905 ft above MSL at PZ4, to a low at CD#30 of approximately 903 ft above MSL. The water table is higher on the east side of the site, indicating that regional groundwater flow direction is toward the west.

Local groundwater flow is affected by the presence of CD#30 within the site area. Groundwater flow direction immediately south of the drain appears to be north-northwest. Groundwater flow direction immediately north of CD#30 appears to be south-southwest, (Figures 3-6, 3-7, and 3-8). This localized groundwater flow effect caused by CD#30 appears to only affect groundwater within 600 ft north and south of CD#30, with regional flow patterns (to the west) dominating away from CD#30.

Horizontal groundwater gradients (Table 4-4) vary across the site. The gradients adjacent to CD#30 (within 300 ft of the drain) are moderate, ranging from 0.001 ft/ft to 0.004 ft/ft and averaging 0.003 ft/ft. Horizontal gradients further away (300 to 600 ft) from CD#30 are relatively more gentle, ranging from 0.0001 ft/ft to 0.001 ft/ft and averaging 0.0003 ft/ft. The steepening of gradients toward CD#30 is the result of the influence of the drain on groundwater flow at the site.

Vertical groundwater gradients are presented in Table 4-5. Vertical gradients vary in magnitude and direction (upward or downward) across the site and in individual well nests. A few trends are observed in the vertical gradient data. The first trend is that vertical gradients close to CD#30 appear to be consistently upward. Vertical gradients furthest from CD#30 (in the southern portion of the site) appear to be predominantly downward, while vertical gradients in the central portion of the site (in the areas of MW5S and D, MW10S and D, and PZ7S and D) away from the county drain are not consistently upward or downward. Variations between upward and downward vertical gradients within well nests may be seasonaly related. The upward gradients observed adjacent to CD#30 indicate that groundwater discharges to the drain.

Hydraulic conductivity results are presented in Appendix H and are summarized in Table 4-1. Hydraulic conductivity results for wells in the upper aquifer vary from a high of 2.70×10^{-3} ft/sec (8.24×10^{-2} cm/sec) at MW6S to 5.37×10^{-4} ft/sec (1.64×10^{-2} cm/sec) at MW13S. The geometric mean hydraulic conductivity for the upper aquifer is 1.38×10^{-3} ft/sec (4.21×10^{-2} cm/sec). No trends in hydraulic conductivity results for the upper aquifer appear to exist. Hydraulic conductivities may vary slightly across the site due to variations in the soils in the screened intervals of each well.

Groundwater flow rates at the site were calculated using the average linear flow equation:

$$v = \frac{Ki}{n}$$

Where:
v = average linear flow velocity
K = hydraulic conductivity (ft/sec)
i = hydraulic gradient (unitless)
n = porosity of the aquifer (unitless)

The calculated estimate of groundwater velocity is 34 ft/yr for the southern part of the site. Groundwater velocity was calculated using the geometric mean of the hydraulic conductivities from wells MW19, MW20, MW21, MW10D, and MW29, where K = $1.64e^{-3}$ ft/sec (4.99×10^{-2} cm/sec), I (hydraulic gradient in the southern part of the site) = 0.0002 and n=0.3 (assumed porosity for a typical sandy aquifer) (Freeze and Cherry, 1979)(Note groundwater velocities are estimated, using reasonable assumptions made about the aquifer).

The calculated groundwater velocity is 450 ft/yr for the northern part of the site near CD#30. Groundwater velocity was calculated using the geometric mean of the hydraulic conductivities from wells MW8S, MW8D, MW13S, MW13D, MW25, and MW28. Where K=$1.07e^{-3}$ ft/sec (3.26×10^{-2} cm/sec), I (hydraulic gradient in the northern part of the site) = 0.004, and n=0.3.

The greatest horizontal gradients and estimated flow velocities are observed in the area adjacent to CD #30. This is attributed to the thinning of the aquifer from approximately 50 to 60 feet thick in the southern portion of the site to 10 to 20 feet near CD#30. As the aquifer becomes thinner, gradients and velocity increase to maintain volume of flow.

The other important hydrogeologic unit at site is the aquitard. Five laboratory permeability tests were conducted on five Shelby tube samples of this unit. Four of these permeability tests were conducted on samples from the silty sand and one

test was conducted on a sample from the clay layer portion of the aquitard. Laboratory permeability test results are contained in Appendix E and are summarized below:

Sample Location	Depth	Layer	Permeability	
MW6S	15 ft	Silty sand	2.6×10^{-7} cm/sec	8.53×10^{-9} ft/sec
MW12D	28 ft	Silty sand	1.2×10^{-7} cm/sec	3.93×10^{-9} ft/sec
PZ1S, D	58 ft	Silty sand	9.3×10^{-9} cm/sec	2.95×10^{-10} ft/sec
PZ6S, D	68 ft	Clay	2.4×10^{-9} cm/sec	6.56×10^{-11} ft/sec
PZ7S, D	42 ft	Silty sand	3.2×10^{-7} cm/sec	1.05×10^{-8} ft/sec

The geometric mean vertical permeability of the silty sand layer is 3.2×10^{-9} ft/sec (9.8×10^{-8} cm/sec). Due to the geologic nature and the relatively low permeability of the silty sand layer and the underlying clay layer, this combined unit (silty sand and clay) is considered an aquitard. If the clay layer which underlies the silty sand layer is continuous throughout the site area, as is indicated by residential well logs (Appendix C), then the silty sand and clay layers should form a geologic unit which will act as a semi-confining layer to separate the upper and lower aquifers identified at the site. It is assumed this semi-confining layer is continuous at the site but there is limited data to confirm its extent.

The terminal moraine described in Section 4.3 is saturated at depths ranging from 8 to 10 ft. One laboratory permeability test was conducted on a Shelby tube from MW11S and a slug test was also conducted in this well. The laboratory permeability test yielded a permeability of 2.75×10^{-9} ft/sec (8.4×10^{-8} cm/sec) while the slug test yielded a hydraulic conductivity of 4.06×10^{-6} ft/sec (1.24×10^{-4} cm/sec). The results indicate that this unit has a low to moderate permeability and could be classified as an aquitard. Due to the relatively low permeability and the fact that the terminal moraine overlies the thin upper aquifer in the very northern portion of the site (e.g., north of the county drain), the upper aquifer in this area of the site may be locally confined. The morainal deposits may act as a leaking or partial confining layer, but may affect groundwater water levels locally.

Very little is known about the hydrogeology of the second sand and gravel unit which underlies the aquitard and comprises the lower aquifer on site. The lower aquifer according to residential well logs, is sand and gravel. This unit may be more gravelly than the upper aquifer, and possibly may have a higher hydraulic conductivity. The piezometric surface, hydraulic gradient and conductivity, and groundwater flow direction and velocity are not known for the lower aquifer.

4.5 DEMOGRAPHY AND LAND USE

According to the 1990 census, 2342 persons reside within a one-mile radius of the site. A number of private wells and one public water supply well are located within or adjacent to the site (Figure 2-2). Two of the wells (the Losinski and Wheeler wells) are thought to be screened in the upper aquifer (no boring logs are available to confirm this), while three wells (the Borgert and Eichler wells, and City supply well #3) are known to be screened in the lower aquifer. The depth and aquifer penetrated by the Himes well is not known. Several residential wells in the site area, which were apparently affected by site contamination, were disconnected and abandoned. City water was supplied to the affected residences. The MDPH is conducting a survey in the site area to further determine which private wells may still may be in use in and around the site.

Several businesses and industries are located within the site boundary (Figure 2-2); most of these businesses were interviewed during the industrial survey. Findings of the Industrial Survey can be found in Appendix A. Several small businesses are located along US Highway 12 (West Chicago Street) approximately 1/2 mile south of the site.

4.6 CLIMATOLOGY

The North Bronson Industrial Area site is located in southern Michigan approximately 8 miles north of the Indiana state line. The nearest weather station is in Coldwater, Michigan, about 13 miles east of the site.

Monthly norms of temperature and precipitation recorded at the Coldwater State School Station based upon readings taken for years 1951 through 1980 are shown below.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Precipitation (in.)	1.72	1.56	2.36	3.48	3.03	3.67	4.01	3.40	3.03	2.60	2.38	2.19	33.43
Temperature (Deg. F)													
Max	30.1	33.7	43.7	57.8	69.4	78.9	82.4	80.8	74.1	62.3	47.2	35.2	58.0
Mean	14.5	16.3	25.2	36.1	46.2	55.6	59.3	57.6	50.7	40.4	30.7	20.2	37.7
Min	22.4	25.0	34.5	47.0	57.8	67.3	70.9	69.2	62.4	51.4	39.0	27.7	31.7

For comparative purposes, mean annual temperature extremes for the State of Michigan during the same 30 yr period ranged from 49.9^{o}F to 38.2^{o}F. Precipitation extremes for the State of Michigan during this period ranged from 38.37 in. to 26.02 in.. Wind speed and direction vary greatly but, in general, predominate from the west and northwest.

[mad-605-67f]

5

NATURE AND EXTENT OF CONTAMINATION

5.1 INTRODUCTION

The primary purpose of this section is to develop an understanding of the nature and extent of the contaminants at the site. Documentation of the chemical constituents of the contaminants, specific locations of those contaminants and potential contaminant migration mechanisms are important for the preparation of the Baseline Risk Assessment and critical in selecting the appropriate remedy in the Feasibility Study.

Data validation was performed for all analytical results received from Contract Laboratory Program (CLP) laboratories. Data validation procedures and data quality are discussed below.

5.2 EVALUATION OF DATA QUALITY

Data quality is assessed based on the laboratory and field quality control (QC) criteria as described in the North Bronson Industrial Area RI/FS (site) Quality Assurance Project Plan (QAPP) (Warzyn, July 1988). Qualified data are identified by the performing laboratory, Warzyn, U.S. EPA and/or the Central Regional Laboratory (CRL). Warzyn performed data validation for samples collected during Phase I (Rounds 1 and 2), except hexavalent chromium data which was validated by the CRL. U.S. EPA performed data validation for Phase II (Round 3) data, except hexavalent chromium data which was validated by the CRL. Assessment of organics data was performed using guidelines developed by the U.S. EPA in Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses, February 1988. Inorganics data assessment was performed based on guidelines in Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses, July 1988. Indicator parameter data were

assessed using guidelines established in the special analytical services request forms.

Data use and limitations are based on laboratory and field QC criteria described in the North Bronson QAPP. The discussion below briefly summarizes the North Bronson data qualifiers.

Based on data validation, the following data are qualified (R), unusable (compound may or may not be present) when not detected. This means if laboratory QC was poor and no compounds were detected, that analysis is unusable, (R). If the compound(s) were detected (even with poor laboratory QC) it is estimated, (J) and included in the data summary.

- EP Toxicity for Selenium and silver are qualified (R), unusable, in Round 1 lagoon sludges due to low spike recoveries.

- Most 2-butanone data for groundwater, private wells, lagoon water and surface water/sediments are qualified (R), unusable, due to failure of initial and continuing calibration criteria (low response factors).

- Most hydrogen cyanide and hydrogen sulfide data for Round 1 lagoon sludge are qualified (R), unusable, due to low spike recoveries.

- Most total cyanide data for Round 2 lagoon sludge are qualified (R), unusable, due to hold time exceedances and poor spike recoveries.

- All SVOCs for the following samples are qualified (R) unusable, due to hold time exceedances.

SSSB06-30	SB07-03
SB07-08	SB07-20
SB10-05 DUP	SB15-01 DUP
OF05-92	

- Several semi-volatile organic compounds (SVOCs) including: 4-nitroaniline, 2-nitroaniline, 3-nitroaniline, 4,6-dinitro-2-methylphenol, N-nitrosodiphenylamine, and 3,3-dichlorobenzidine are qualified (R), unusable due to failure of initial and continuing calibration criteria (low response factors).

- Silver, cyanide, and thallium are qualified (R), unusable, in most Round 1 lagoon water samples due to low spike recoveries.

- Cadmium, cobalt, and silver are qualified (R), unusable, in Round 1 private well samples due to low spike recoveries.

The following compounds were detected in laboratory method blanks:

- methylene chloride
- acetone
- bis(2-ethylhexyl)phthalate

The following compounds were detected in field or trip blanks:

- Acetone was detected in the Round 2 surface water and lagoon water field blanks. Acetone is qualified (U), not detected, in Round 2 surface water and lagoon water samples.

- Toluene was detected in the Round 2 surface water trip blank. Toluene is qualified (U), not detected in Round 2 surface water samples.

- Di-n-butylphthalate and bis(2-ethylhexyl)phthalate were detected in the Round 2 lagoon water blank and are qualified (U), not detected in Round 2 lagoon water samples when the 10x criteria is not met (described below).

The compounds detected in blanks listed above are qualified (U), not detected, and have elevated detection limits in associated samples that do not meet the 10x criteria for common laboratory contaminants. To be considered positive, the concentration of the compound in a sample must be greater than ten times the concentration detected in the method blanks, field blanks, or trip blanks.

It should also be noted that a number of samples and analyses results were lost by the contract laboratory or QC was outside acceptable limits and the data was never received by Warzyn. The "lost" data includes:

- All Round 1 private well organics data.

- Organics data for lagoon berm samples LB4 and LB6.

- Organics data for Round 1 lagoon sludge samples S5 (S,D) through S12 (S,D).

- Hexavalent chromium data collected during Round 3 for surface water sample SW17 and outfall samples OF1, OF3, and OF5.

Only the above data have been considered unusable or qualified as not detected. The remaining data are of sufficient quality to be used for interpretation and will support the conclusions contained in this report, and no additional sampling is required for the RI.

A complete discussion of data validation and laboratory validation qualifiers is found with the data set in Appendix I.

5.3 DISCUSSION OF PRESENTATION APPROACH

The following sections describe the nature and extent of contaminants at North Bronson. The discussion of contaminants has been divided into 5 areas of interest identified during the RI which include (Figure 5-1):

- Background Areas (upgradient and/or unaffected by site activities)
- Industrial Complex (majority of site excluding background, eastern lagoons, western lagoons and County Drain #30 (CD#30))
- Eastern Lagoons
- Western Lagoons
- CD#30

Discussion areas were divided in this way due to the following considerations: size of the study area, physical features present, distribution of contaminants, and groundwater flow direction at the site. These areas do not necessarily specify definitive and known areas of contamination but instead were defined in order to logically organize the data.

Contaminants will be presented within each discussion area according to media. For example, industrial complex contaminants will be discussed in the following order:

- Surface Soils (0-0.5 ft)
- Subsurface Soils (greater than 0.5 ft)
- Groundwater

Within each media, analytical results will be discussed in the following order:

- Organic Results (VOCs, SVOCs, pesticides, and PCBs)

- Inorganic Results
- Indicator Parameter Results (when applicable)

Organic compounds have been grouped based on their similar chemical characteristics and behaviors in the environment. In addition, there are certain organic compounds associated with degradation sequences (i.e., the formation of breakdown products from the parent compound) which have been grouped separately, such as chlorinated ethenes and chlorinated ethanes. Specific groups are discussed below and examples of compounds within each group are given.

Table 5-2 contains a summary of compounds detected at the site as divided into constituent groups. Compounds identified are of interest at this site.

- BETX Compounds - Partially water soluble compounds typically found as constituents in gasoline, oil and/or hydrocarbon products (i.e., benzene, ethylbenzene, toluene, xylene).

- Chlorinated Ethenes - Chlorinated ethenes include tetrachloroethene, trichloroethene, 1,1-dichloroethene, total 1,2-dichloroethenes (cis- and trans-), and vinyl chloride. These compounds represent a potential degradation sequence and are common industrial solvents.

- Chlorinated Ethanes - Chlorinated ethanes include 1,1,2,2-tetrachloroethane, 1,1,1-trichloroethane and 1,1,-dichloroethane. These compounds represent a potential degradation sequence and are common industrial solvents.

- Ketone Compounds - Compounds found in resins, paint removers, cements, adhesives, and cleaning fluids (e.g., 2-butanone, acetone); methylene chloride, while not a ketone, was included in this group.

- Phenol Compounds - A group of chemicals of similar composition used in adhesives, epoxies, plastics, and a variety of synthetic fibers and dyes. Compounds in the group include chlorinated, methylated, and nitrated phenols.

- Polynuclear Aromatic Hydrocarbons (PAHs) - A group of compounds associated with and derived from coal, oil, and tars, or the incomplete combustion of carbonaceous materials. Examples are naphthalene, pyrene, and fluorene.

- Phthalates - Compounds associated with plastics and plastic making processes, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, and di-n-octyl phthalate.

- Chlorinated Aromatics - Compounds used as solvents and raw materials in a variety of chemical manufacturing processes. Compounds in this group include: chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, and 1,2,4-trichlorobenzene.

- PCBs - Mixtures of chlorinated biphenyls identified as Aroclors, formerly used extensively in industrial applications.

- Pesticides - Common organochlorine based pesticides formerly used in agricultural applications, including gamma-chlordane, alpha-chlordane, and aldrin.

Where warranted, a summary is included at the end of each analytical result section listed above. In addition, an overview of contaminants is provided at the end of the analytical results section for each area.

Each sampling location at the site is discussed in association with at least one of the areas identified above. The location of a sample in a specific study area does not imply the associated area is necessarily the sole source of contamination detected in the samples, nor does it imply the party associated with the facility after which the subarea is named is the only potentially responsible party. Hence, several samples are discussed in more than one subarea. For example, well MW28 is included in the discussion of the western lagoons even though it is approximately 450 ft west of the western lagoons, because it is downgradient of groundwater flow from the western lagoons. Also soil boring SB10 is discussed with the Scott Fetzer subarea data and the abandoned industrial sewer subarea data because of its proximity to both subareas. See Figure 5-1 for area designations.

The analytical data discussed below was from samples collected by Warzyn and its subcontractors and analyzed by CLP laboratories (designated by the U.S. EPA Sample Management Office) between September of 1988 and December 1991 as part of each field event in Phases I and II of the RI. Table 5-1 contains a summary of field sampling activities and analyses.

Analytical results are discussed in relation to contaminant concentrations and locations, exceedances of federal maximum contaminant levels (MCLs), State of Michigan Act 307 Type B Criteria and/or background concentrations. The Act 307 Type B Criteria for soils and sludges is 20x the drinking water value, but the

eastern and western lagoon sludges and soils are also discussed, where applicable, in relation to the 20x the groundwater/surface water interface (GSI) value for the soils (see the MDNR - MERA Operational Memorandum #8, Revision 1, March 16, 1992, Appendix J for Act 307 Type B Criteria values). Surface water and lagoon water are discussed in relation to Ambient Water Quality Criteria (AWQC) exceedances, and groundwater, near CD#30, is also discussed in relation to Act 307 Type B GSI Criteria, because of the likely discharge of groundwater to CD#30.

Although Michigan Act 307 is an Applicable or Relevant and Appropriate Requirement (ARAR) which will be taken into account in selecting the remedy for this site, the Criteria Type that will be considered to be an ARAR will be determined by the U.S. EPA in consultation with the State of Michigan (State). References to Type B Criteria that occur throughout this report are for comparison purposes only.

The use of Ambient Water Quality Criteria (AWQC) values as a type of cleanup criteria will also be considered by U.S. EPA to determine whether they should be included as ARARs. The final determination of which values are used as final clean-up criteria for groundwater and surface water will be made by U.S. EPA in consultation with the State.

5.4 BACKGROUND SAMPLES

Background surface soils, subsurface soils, surface water, sediments, and groundwater samples were collected at the site for the purpose of providing analytical data for analytes which may be found naturally occurring in the environment (inorganics and indicators). Establishing local background concentrations enables a discussion of impacts on the environment attributable to site activities.

When possible, local background concentrations were calculated according to MDNR's - "Waste Management Division - Cleanup Verification Guidance Document, November 1991". Summaries of background calculations and the aforementioned document are found in Appendix J. The following conditions were used in determining background concentrations when MDNRs guidance did not apply. When an analyte was detected in just one background sample, this concentration was used as the background concentration. While an analyte detection in just one background sample may not be indicative of natural background, this value is useful for comparison purposes but not necessarily clean up values, as stated above. If an analyte was not detected in background samples, subsequent detection in downgradient samples is considered an exceedance of

background conditions. Background sample locations are discussed below. See Figure 3-1 for sample locations.

5.4.1 Background Surface Soils

Background surface soils were collected from the surface to 6 in. below ground surface, from similar soil types, in areas assumed to be unaffected by site activities. Background surface soils were analyzed for TCL VOCs and TAL inorganics. Background surface soil samples included:

SS1-0.5 ft	SS14-0.5 ft
SS2-0.5 ft	SS15-0.5 ft
SS13-0.5 ft	SS16-0.5 ft

See Figure 3-1 for sample locations and Appendices I and J for analytical results.

Organic Compounds

No VOCs were detected in background surface soil samples.

Inorganic Analytes in Background Surface Soils

TAL metals and cyanide were detected in one or more background surface soil samples, with the exception of selenium, thallium, and silver. The following metals were detected in 1 sample, only:

antimony	sodium
cadmium	cyanide
mercury	

5.4.2 Background Subsurface Soils

Background subsurface soils were collected at 3.5 ft and 5.0 ft sample depths from similar soil types, in areas unaffected by site activities. Each sample was analyzed for TAL inorganics and six background subsurface soils were analyzed for TCL VOCs. Background subsurface soil samples included:

SS1-3.5 ft	SS15-3.5 ft
SS2-3.5 ft	SS16-3.5 ft
SS13-3.5 ft	MW1S-5.0 ft
SS14-3.5 ft	MW11S-5.0 ft

See Figure 3-1 for sample locations and Appendices I-1, I-2, and J-1 for analytical results.

Organic Compounds in Background Subsurface Soils
Background subsurface soils were analyzed for VOCs only.

VOCs
Acetone at 50 ug/kg in SS14-3.5 was the only VOC detected in background subsurface soils.

Inorganic Analytes in Background Subsurface Soils
As with surface soil inorganics, many TAL metals were detected in background subsurface soil samples. The following metals and cyanide were not detected in background surface soil samples:

selenium
silver
thallium
cyanide

5.4.3 Background Groundwater Wells
Background groundwater samples were collected from 5 wells upgradient of the site and analyzed for TCL organics, TAL inorganics, and indicator parameters. The wells included:

MW1S	MW23
MW11S	MW29
MW14S	

See Figure 3-1 for well locations and Appendices I-3 and J-1 for analytical results.

Organic Compounds in Background Wells
Two VOCs were detected in 1 background well (MW11S), only.

VOCs
Methylene chloride at 5 ug/L and 2-butanone at 3 ug/L were the only VOCs detected in background well MW11S. VOCs were not detected in other background wells.

SVOCs
Well MW11S is the only background well where SVOCs were detected and include:

Phenol Compounds
Constituent phenol compounds detected at well MW11S included:

- phenol at 4 ug/L
- 4-methylphenol at 8 ug/L
- benzoic acid at 22 ug/L

Phthalate Compounds

- Bis(2-ethylhexyl)phthalate was detected at 11 ug/L at MW11S. Phthalate compounds were not detected in other background wells.

Pesticides/PCBs

Pesticides/PCBs were not detected in background wells.

Summary of Organic Compounds in Background Wells
The VOC, phthalate, and phenol compounds detected at MW11S are not likely site related because well MW11S is upgradient of the site and phenol compounds are not found frequently or in large concentrations in the site monitoring wells.

Inorganic Analytes in Background Groundwater Wells
Eleven metals were detected in background wells. There were no exceedances of federal MCL or Act 307 Type B Criteria for metals and cyanide in any of the 5 background wells. Arsenic, total chromium, copper, lead, and mercury were detected in only one background well, and sample concentrations greater than these values are considered in exceedance of background. The remaining background metal concentrations were calculated as described in MDNRs guidance document (Appendix J). Background concentrations and sample exceedances of background will be discussed in subsequent sections.

5.4.4 Private Wells
Although not all private well locations are considered background to the site, private wells will be discussed in this background section.

The data included in the following discussion includes six private well samples collected during Rounds 1 and 2. See Table 5-1 for sample locations and analyses. Round 1 organic analysis results for private wells are not included in the discussion because the laboratory indicated to Warzyn the data was lost. Private well status has not been determined for all private wells which still may be in use within and around the site. MDPH in coordination with MDNR and U.S. EPA is pursuing a separate survey to further determine if there may be impacts to private wells which are still in use in and around the site.

Organic Compounds in Private Wells
Toluene at 2 ug/L in wells PW3 and PW4 (Round 2) was the only organic compound detected in private well samples. Toluene at 2 ug/L is not in exceedance of any MCLs or Act 307 Type B Criteria.

Inorganic Analytes in Private Wells
Five TCL metals were detected in private wells in exceedance of federal MCLs (primary or secondary) and/or Act 307 Type B - Groundwater Criteria (health based). The following metals were detected in exceedance:

- Arsenic exceeded Act 307 Type B Criteria at 4 private wells.
- Beryllium exceeded MCLs at PW2 and PW5, Round 2 only.
- Manganese exceeded secondary MCLs at 5 wells.
- Zinc exceeded secondary MCLs at PW5, Round 1 only.
- Iron exceeded secondary MCLs at 5 wells.

See Table 5-6 for a summary of MCL and/or Act 307 Type B Criteria exceedances in private well samples.

Ten metals were detected in private wells in exceedance of background concentrations. These metals included:

Metals	No. of Exceedances
aluminum	1
arsenic	1
beryllium	2
copper	3
iron	7
selenium	3
silver	1
sodium	1
zinc	6

See Table 5-7 for a summary of metal exceedances of background in private wells. The concentrations of the metals detected in exceedance of background are relatively low and do not indicate impact from the site.

Indicator Parameters in Private Wells
No private well indicator parameters were detected in exceedance of MCL or Act 307 Type B Criteria. Sulfate was detected in each private well at concentrations slightly greater than background. In addition, ammonia was detected in

exceedance of background in private wells PW1 and PW2. Table 5-8 summarizes indicator exceedances of background concentrations.

The elevated sulfate and ammonia levels do not necessarily indicate impact from site contaminants but may be due to natural variation in groundwater.

Summary of Contaminants in Private Wells
Data collected during the RI did not seem to indicate that private wells were being impacted by site contamination. Although beryllium was detected in the Wheeler well, located in the middle of the study area, beryllium was not identified in groundwater on-site at elevated levels.

5.4.5 Background Surface Water in CD#30

Background surface water samples were collected from 3 locations upstream of the site area and the Bronson plating outfall. The samples were analyzed for TCL organics, TAL inorganics, indicators and hexavalent chromium. The samples included: SW1, SW11, and SW12. See Figure 3-1 for sample locations.

Organic Compounds in Background Surface Water
Few organic compounds were detected in background surface water and those compounds detected were at relatively low concentrations.

VOCs
No VOCs were detected in background surface water samples.

SVOCs
Three SVOCs were detected in background surface water samples SW1 and/or SW12.

Phenol Compounds:

- Benzyl alcohol was detected at 5 ug/L in SW1.
- Benzoic acid was detected at 210 ug/L in SW1.

Phthalates
Diethylphthalate was detected at 1 ug/L in SW12.

Pesticides
Two pesticides were detected in background sample SW12.

- Heptachlor was detected at 0.003 ug/L.
- Methoxychlor was detected at 0.024 ug/L.

PCBs
PCBs were not detected in background surface water samples.

Inorganic Analytes in Background Surface Water
Several metals and cyanide were detected in background surface water samples. While several of these metals may be naturally occurring, a few are in exceedance of AWQC. The exceedances included:

Metal	Location(s) and Concentration(s)
copper	SW1 - 85.7 ug/L
lead	SW1 - 33.3 ug/L, SW12 - 28 ug/L
cyanide	SW11 - 16 ug/L, SW12 - 21 ug/L

The copper and lead exceedances at location SW1 and the lead and the cyanide detected at SW12 may or may not be site related, because there may have been backflow from downstream (Bronson plating outfalls), or surface water run-off from the area. The cyanide detected in SW11 is not likely site-related as the sample was collected well upstream from the site.

Indicator Parameters in Background Surface Water
Alkalinity, chloride, COD, Nitrate + Nitrite, sulfate, and TOC were (with a few exceptions) detected at higher concentrations in one or more background surface water samples than downstream samples. This is likely due to impacts from the surrounding agricultural fields and possibly run-off from the Branch County Salt Storage located nearby. The indicator parameters become more dilute as flow increases downstream.

5.4.6 Background Sediments
Background sediment samples were collected from 3 locations. However, based upon analytical results it was determined that two samples (SD1 and SD12) were not representative of background. Samples SD1 and SD12 had elevated levels of cadmium, chromium, copper, lead, nickel, and zinc, which were the predominant waste metals detected in the nearby, eastern lagoons. Therefore, sample location SD11 is considered the only sediment sample representative of background conditions. SD11 was analyzed for TCL organics, and TAL inorganics.

Organic Compounds in Background Sediments
Although VOCs, SVOCs, pesticides, and PCBs were analyzed in SD11, only acetone was detected.

VOCs
Acetone at 11 ug/kg was the only VOC detected in SD11.

SVOCs
No SVOCs were detected in SD11.

Pesticides/PCBs
No pesticides or PCBs were detected in SD11.

Inorganic Analytes in Background Sediments
Thirteen metals were detected in SD11 but most at relatively low concentrations. Background metal and cyanide concentrations and comparisons to downstream sediment concentrations are presented in Section 5.7, overview of contaminants in CD#30.

5.5 INDUSTRIAL COMPLEX AREA

The industrial complex represents a study area quite different from the eastern and western lagoons and CD#30. This area has different physical features and/or history of waste deposition than the western and eastern lagoons and CD#30. Within the industrial complex, three study subareas have been defined to assist in the discussion of results. These include:

- LA Darling Subarea
- Scott Fetzer Subarea
- Abandoned (western) Industrial Sewer Line Route

The three areas are delineated in Figure 5-1. The delineating lines on Figure 5-1 do not necessarily imply distinct contaminant source areas but rather are for grouping samples to aid in the understanding and evaluation of site conditions. The areas have also been defined to include sampling locations downgradient of potential source areas but there is likely overlap of contaminant plumes downgradient.

The LA Darling subarea contains the former location of LA Darling and part of the eastern industrial sewer line. The Scott Fetzer subarea contains the former Scott Fetzer, the former Bronson Reel, and portions of the western industrial sewer line. Bronson Specialties (Plastics, Tool, and Fiberglass Divisions), Bronson Precision Products, and DCC Plant #2 were not included in any of the subareas studied during the RI. However, this does not indicate that these facilities are not potential sources of contamination at the site.

The DCC Plant #2 should also be included as a potential source of contaminants at the site. Samples were collected at DCC Plant #2 during Round 1, only. Compounds detected included TCE, 1,1-DCE, and 1,1,1-trichloroethane. Subsequent to Phase I activities, DCC property wells were removed from the RI because an oil spill was being investigated as a separate effort, lead by DCC, in conjunction with the MDNR Jackson District Office.

In addition, Bronson Specialties and Bronson Precision Products may also be included as potential source areas of contaminants because of the chemicals used at these sites and the past environmental problems at these sites.

5.5.1 LA Darling Subarea

The following media were analyzed at the LA Darling subarea: surface soils, subsurface soils, and groundwater. Analyses included TCL organics, TAL inorganics, and indicator parameters. See Figure 5-1 for the delineation of the subarea.

Surface Soils in the LA Darling Subarea

Five surface soil samples were collected at the LA Darling subarea. These included:

SS3-0.5 ft	SS6-0.5 ft
SS4-0.5 ft	SS7-0.5 ft
SS5-0.5 ft	

See Figure 3-1 for sample locations.

The sample designation SS3-0.5 ft indicates a surface soil sample collected at location 3 from a depth of 0 to 6 in. All surface soils were analyzed for TCL VOCs and TAL inorganics. Since metals may be naturally occurring in soils, metal concentrations are compared to background surface soil concentrations.

Organic Compounds in Surface Soils at LA Darling Subarea

VOCs - TCE at 4 ug/kg in SS6-0.5 ft and acetone at 30 ug/kg in SS5-0.5 ft were the only 2 VOCs detected.

Inorganic Analytes in Surface Soils at LA Darling Subarea

As stated previously, metals are naturally occurring in soils. Since background surface soils have been collected, surface soil data will be compared to background concentrations.

Between 8 and 13 metals, and cyanide, were detected in exceedance of background concentrations in surface soils at the LA Darling subarea. The

following metals and cyanide were detected in exceedance of background concentrations.

Metal	No. of Exceedances of Background
Arsenic	2
Barium	1
Beryllium	2
Cadmium	4
Calcium	1
Copper	4
Total Chromium	4
Cobalt	1
Iron	3
Lead	1
Magnesium	3
Nickel	4
Selenium	1
Thallium	1
Sodium	4
Zinc	3
Cyanide	4

Cadmium, copper, total chromium, nickel, sodium, and cyanide were the predominant metals detected above background in surface soils at the LA Darling subarea. There is no apparent spatial distribution pattern of metals in surface soils at the LA Darling subarea but several of the highest contaminant concentrations were detected in sample SS3-0.5 ft. Sample SS3-0.5 ft was collected from a pile of soil in the LA Darling subarea. See Table 5-3 for a summary of metals in exceedance of background and Figure 5-2 for an approximate extent of metal contaminants in soil at the LA Darling subarea.

Subsurface Soils - LA Darling Subarea

Subsurface soils were collected from depths of 1 ft to 30 ft. Twenty six subsurface soil samples were collected in the LA Darling subarea from borings SB13, SB14, SB15, SS3, SS4, SS5, SS6, and SS7. Samples from borings SB13, SB14, and SB15 were analyzed for TCL organics and TAL inorganics. Samples from borings SS3, SS4, SS5, SS6, and SS7 were analyzed for TCL VOCs and TAL inorganics.

Sample locations are identified using the following designations. Sample identification "SB13-5" indicates a soil sample from soil boring 13 collected at a

depth of 5 ft. Sample identification for "SS" samples are similar to the surface soils identification except subsurface soils were collected at a depth of 3.5 ft. See Figure 3-1 for sample locations.

Organic Compounds in Subsurface Soils at the LA Darling Subarea
Relatively few VOCs were detected and most were detected at relatively low concentrations. However, numerous PAH compounds and many at high concentrations were detected in subsurface soils at the LA Darling subarea.

VOCs
Relatively low concentrations of toluene and TCE were detected infrequently (5 samples) in subsurface soils at the LA Darling subarea.

BETX Compounds
Toluene was detected at 2 ug/kg in sample SB13 at 5 ft and SB13 at 10 ft.

Chlorinated Ethene Compounds
TCE was detected at 1 ug/kg at SS3 at 3.5 ft, 10 ug/kg at SS6 at 3.5 ft, and 1 ug/kg at SS7 at 3.5 ft.

SVOCs
Numerous SVOCs were detected at relatively high concentrations in each soil boring. The highest concentrations were detected in the samples collected at a depth of 1 ft.

PAH Compounds
PAHs were the SVOCs detected most frequently and at the highest concentrations of the SVOCs. The following 11 PAHs were detected at the LA Darling subarea:

Compound	Range of Concentration (ug/kg)
phenanthrene	59 to 4,700
fluoranthene	73 to 70,000
pyrene	38 to 57,000
benzo(a)anthracene	45 to 71,000
chrysene	76 to 74,000
benzo(b)fluoranthene	46 to 290,000
benzo(k)fluoranthene	46 to 290,000
benzo(a)pyrene	50 to 35,000
indeno(1,2,3-cd)pyrene	120 to 42,000
dibenz(a,h)anthracene	1,200 to 15,000
benzo(g,h,i)perylene	110 to 37,000

Total PAH concentrations are as follows:

Sample	Total PAHs (ug/kg)
SB13 at 1 ft	163,900
SB13 at 5 ft	38
SB13 at 10 ft	330
SB14 at 1 ft	3,050
SB15 at 1 ft	986,000
SB15 at 5 ft	410
SB15 at 15 ft	92
SB15 at 20 ft	560

Phthalate Compounds
Constituent phthalate compounds included:

- Bis(2-ethylhexyl)phthalate was detected in 4 samples ranging in concentration from 41 ug/kg in SB13 at 15 ft, to 6,100 ug/kg in SB15 at 1 ft.

- Diethylphthalate was detected at 9,800 ug/kg in SB15 at 1 ft, only.

- Di-n-butylphthalate was detected in 2 samples; 1,600 ug/kg in SB13 at 20 ft and 18,000 ug/kg in SB15 at 1 ft.

Phenol Compounds
Pentachlorophenol was detected at 19,000 ug/kg in SB15 at 1 ft, only.

Pesticides
Numerous pesticides at relatively low concentrations were detected predominantly at the 1 ft depth samples in borings SB13, SB14, and SB15. Pesticides detected include:

Compound	Concentrations (ug/kg)
beta-BHC	0.95
delta-BHC	0.24 and 2.2
gamma-BHC	0.22
heptachlor	0.11 and 1.2
aldrin	0.43
endosulfan I	0.26 to 3.4
dieldrin	0.19 and 0.60

Compound	Concentrations (ug/kg)
endrin	0.21 to 19
endosulfan II	0.37
4,4'-DDE	0.58 to 2.3
4,4'-DDD	3.2
4,4'-DDT	1.7 to 8.0
endosulfan sulfate	1.6
methoxychlor	0.67 to 120
alpha-chlordane	0.74 and 2.8
gamma-chlordane	0.42
endrin aldehyde	1.1 and 2.9

It should be noted, the majority of the pesticides detected are at very low concentrations and many are well below contract required detection limits.

PCBs
Aroclor 1248 at 79 ug/kg in SB15 at 1 ft was the only PCB detected in soils in the LA Darling subarea.

Summary - Organics in Subsurface Soils in the LA Darling Subarea
The concentrations of toluene and TCE near ground surface may indicate contaminants were disposed of at the surface in the LA Darling subarea, or the concentrations may be a result of volatilization and diffusion from a relatively large subsurface contaminant source.

Soil borings SB13, SB14, and SB15 are located northeast of the former LA Darling building. The boring logs indicate the samples were predominantly sand and gravelly sand, but the samples at a depth of 1 ft (highest PAH concentrations) were collected in black to dark brown sandy, gravelly topsoil. Apparently, there is surficial contamination in this area from PAH containing coal, coal tars, asphalt, or oils and low level pesticides.

Several SVOCs and pesticides are in exceedance of Act 307 Type B criteria for soils. See Table 5-4 for a summary of compounds in exceedance.

Inorganic Analytes in Subsurface Soils at the LA Darling Subarea
As discussed previously, 26 subsurface soil samples were collected from 8 soil borings. The borings included SB13, SB14, SB15, SS3, SS4, SS5, SS6, and SS7.

Metal concentrations were detected in exceedance of background in 22 of 26 samples. Thirteen metals and cyanide were detected in exceedance of background and included the following:

Metal	No. of Exceedances of Background	Metal	No. of Exceedances of Background
beryllium	1	nickel	2
barium	2	magnesium	3
cadmium	7	mercury	12
total chromium	7	sodium	9
cobalt	1	selenium	1
copper	6	zinc	6
lead	5	cyanide	1

See Table 5-5 for a summary of metal exceedances and Figure 5-2 for the distribution metals in soils at the LA Darling subarea. Beryllium, barium, cobalt, nickel, magnesium, selenium, and cyanide had relatively few exceedances and those concentrations were relatively low.

Cadmium, total chromium, copper, lead, mercury, and zinc were detected most frequently and at the highest concentrations. These metals, except mercury, are common to the plating industry but are also commonly found in other heavy industry.

Samples from borings SS4 and SS6 (at 3.5 ft) had the most metal exceedances. Sample SS4 is located between the remnants of the LA Darling building foundation and the railroad tracks directly to the north. Sample SS6 is located at the southeast corner of the building foundation remains.

Groundwater - LA Darling Subarea

The following four wells: MW21, MW22, MW24, and MW25 are included in the discussion of groundwater at the LA Darling subarea. Wells MW21 and MW22 are on the former LA Darling property. Wells MW24 and MW25 are sidegradient to downgradient of the LA Darling subarea. It should be noted that indication of variable groundwater flow and due to its location, well MW25 is likely impacted by other sources in addition to the LA Darling subarea. TCL VOCs, TAL inorganics and indicator parameters were analyzed at these four wells.

Organic Compounds in Groundwater at the LA Darling Subarea

Few VOCs were detected in the LA Darling subarea monitoring wells, but concentrations of these VOCs were relatively high.

VOCs
TCE and 1,2-DCE were the only compounds detected in wells MW21, MW22, and MW24. Vinyl chloride was detected in well MW25, only.

Chlorinated Ethene Compounds

- TCE was detected at 2,700 ug/L in well MW21, 9 ug/L in well MW22, and 320 ug/L in well MW24.
- 1,2-DCE was detected at 130 ug/L in well MW22, and 290 ug/L in well MW24.
- Vinyl chloride was detected at 2 ug/L in well MW25, only.

Summary - Organics in Groundwater in the LA Darling Subarea
The high concentration of TCE at well MW21 indicates the LA Darling subarea may be a potential source of VOC contamination at the site. Well MW21 is located upgradient and crossgradient of the Scott Fetzer subarea (an additional potential contaminant source) and there are no wells upgradient of well MW21 with VOCs detected.

Contamination at the LA Darling subarea appears to migrate with groundwater flow (see Figure 3-8) to the west-northwest as evidenced by the contaminants present in wells MW24 and MW25, 600 ft and 1,200 ft downgradient of well MW21, respectively. Due to the variable nature of groundwater flow at the site, wells MW24 and MW25 may also be impacted from other sources.

Table 5-6 summarizes MCL and Act 307 Type Criteria exceedances in groundwater. Each well had at least 1 VOC in exceedance. Figure 5-3 shows the approximate distribution of chlorinated ethene compounds in groundwater at the site.

Inorganic Analytes in Groundwater in the LA Darling Subarea
There were no metals detected in wells MW21, MW22, MW24, and MW25 in exceedance of MCLs or Act 307 Type B Criteria.

Table 5-7 summarizes metal concentrations in exceedance of background at the LA Darling subarea, and includes the following:

Metal	No. of Exceedances of Background
arsenic	1
iron	1
nickel	1
potassium	1
selenium	1
zinc	1
cyanide	1

There were no metals in exceedance of background at well MW22 and only arsenic was detected in exceedance of background at well MW25. Well MW21 had 4 metal exceedances and well MW24 had two metal exceedances.

The metals detected at well MW21 are likely due to contamination at the LA Darling subarea. The metals detected at downgradient well MW24 (nickel and zinc) are not likely related to LA Darling subarea because they exceeded levels in groundwater samples from well MW21 at the LA Darling subarea. If the metals detected at downgradient well MW24 had come from an upgradient source (LA Darling subarea), the concentrations at the source area (MW21) would be expected to be higher than what was detected in well MW24. See Figure 5-4 for the approximate distribution of metals in exceedance of background in groundwater.

Indicator Parameters in Groundwater at the LA Darling Subarea
Few indicator parameters were detected in exceedance of background at the LA Darling subarea. Each well at the LA Darling subarea had at least 1 indicator parameter with concentrations elevated above background concentrations and included the following:

Indicator Parameter	No. of Exceedances of Background
ammonia-N	1
COD	2
sulfate	4

Table 5-8 summarizes background exceedances. The elevated COD level at well MW25 is over 4 times greater than background and indicates localized impact to groundwater, but the remaining elevated indicator parameters may be due to natural variations in groundwater quality.

Overview of Contaminants at the LA Darling Subarea
TCE and 1,2-DCE were detected at relatively high concentrations in wells at and downgradient of the LA Darling subarea. See Figure 5-3 for the distribution of total chlorinated ethenes in groundwater. The concentration of TCE indicates the LA Darling subarea is a source of chlorinated ethene compounds at the site. In addition, high concentrations of PAH compounds were detected in soils near the surface at the LA Darling subarea. Cadmium, total chromium, copper, mercury, zinc, and cyanide were detected most frequently above background concentrations in soils (see Figure 5-2 for the distribution of elevated metal concentrations in soils), whereas zinc, cyanide, selenium, potassium, nickel, iron, and arsenic were detected above background in groundwater at the LA Darling subarea. See Figure 5-4 for the distribution of elevated metal concentrations in groundwater.

5.5.2 Scott Fetzer Subarea
Surface soils, subsurface soils, and groundwater samples were collected at the Scott Fetzer subarea. All samples were collected on the perimeter of the Scott Fetzer buildings and facilities in the Scott Fetzer subarea, because we were not provided access to the facilities. Analytical results are discussed below. See Figure 5-1 for the delineation of the Scott Fetzer subarea.

Surface Soils in the Scott Fetzer Subarea
Five surface soil samples were collected in the Scott Fetzer subarea and include the following:

SS8-0.5 ft	SS11-0.5 ft
SS9-0.5 ft	SS12-0.5 ft
SS10-0.5 ft	

See Figure 3-1 for sample locations.

All surface soil samples were analyzed for TCL VOCs and TAL inorganics. Since metals are naturally occurring in soils, metal concentrations will be compared to background concentrations.

Organic Compounds in Surface Soils at the Scott Fetzer Subarea
TCE was the only organic compound detected in surface soils at the Scott Fetzer subarea.

VOCs
Chlorinated Ethene Compounds
TCE was detected at 7 ug/kg in SS9 at 0.5 ft, only. Sample SS9 is located near the former Scott Fetzer CDF (located south of State Street and labeled on figures as SFCC (vacant)).

Inorganic Analytes in Surface Soils at the Scott Fetzer Subarea
Between 2 and 14 metals were detected in each of the five surface soil samples from the Scott Fetzer subarea at concentrations exceeding background concentrations. The following metals were detected in exceedance of background:

Metal	No. of Exceedances of Background
Aluminum	1
Arsenic	1
Barium	1
Beryllium	2
Cadmium	1
Copper	2
Total Chromium	1
Iron	1
Lead	2
Magnesium	1
Nickel	2
Potassium	1
Selenium	2
Thallium	2
Sodium	2
Zinc	3
Cyanide	3

Table 5-3 summarizes exceedances of background concentrations in surface soils at the Scott Fetzer subarea. Figure 5-2 indicates the distribution of metals in exceedance of background in soils at the Scott Fetzer subarea.

Zinc and cyanide were detected most frequently in exceedance of background. In addition, several metals were detected at SS9, only. Sample SS9-0.5 ft had the most metals detected in exceedance of background (14) and at the highest concentrations. Sample SS9 is located east of the CDF at Scott Fetzer.

Subsurface Soils in the Scott Fetzer Subarea
Twelve subsurface soil samples were collected at depths from 3.5 ft to 30 ft at seven soil boring locations at the Scott Fetzer subarea. The soil borings include:

MW10D	SS10
SB10	SS11
SS8	SS12
SS9	

Samples collected from boring SB10, were analyzed for TCL organic and TAL inorganic parameters. Samples collected from borings SS8, SS9, SS10, SS11, and

SS12 were analyzed for TCL VOCs and TAL inorganics. Samples collected from boring MW10D were analyzed for TAL inorganics. See Figure 3-1 for sample locations. Note: sample MW10D was collected approximately 450 ft northwest of the Scott Fetzer buildings while the remaining samples were collected within the immediate vicinity of the Scott Fetzer buildings.

Organic Compounds in Subsurface Soils at the Scott Fetzer Subarea
Several organic compounds were detected at varying concentrations in subsurface soils at the Scott Fetzer subarea. Organic compounds detected are discussed below.

VOCs
Three VOCs were detected in subsurface soils at the Scott Fetzer subarea and included:

1,1,1-trichloroethane
trichloroethene
1,2-dichloroethene

Chlorinated Ethane Compounds
1,1,1-trichloroethane was detected at 4 ug/kg in SB10 at 15 ft, only.

Chlorinated Ethene Compounds
Constituent chlorinated ethene compounds were detected in 14 soil samples from borings SB10, SB11, and SB12.

- TCE was detected in soil samples collected below the water table only. TCE concentrations, detected in samples from SB10, ranged from 2 ug/kg at 20 ft to 29 ug/kg at 30 ft. TCE was not detected in boring SB11. TCE detected in boring SB12 ranged from 200 ug/kg at 20 ft to 4 ug/kg at 30 ft.

- 1,2-DCE was also only detected in 1 soil sample collected from below the water table. 1,2-DCE concentrations in boring SB10 were 9 ug/kg at 15 ft and 14 ug/kg at 30 ft. 1,2-DCE was detected in four samples from boring SB11 with concentrations of 2 ug/kg at 15 ft and 30 ft and 3 ug/kg at 20 ft and 25 ft. 1,2-DCE was not detected in boring SB12.

SVOCs
Eight SVOCs were detected at relatively low concentrations in soil samples from boring SB10 and SB11. The majority of the compounds were detected at the 5 ft depth in borings SB10 and SB11.

PAH Compounds
Constituent compounds include:

Compound	Range of Concentrations (ug/kg)	
	SB10 at 5 ft	SB11 at 5 ft
phenanthrene	---	78
benzo(a)anthracene	---	70
chrysene	---	74
benzo(b)fluoranthene	42	150
benzo(k)fluoranthene	42	150
fluoranthene	41	120
pyrene	36	110
benzo(a)pyrene	---	43

Total PAH concentrations were 257 ug/kg at SB10 at 5 ft and 797 ug/kg at SB11 at 5 ft.

Phthalates
Constituent phthalate compounds detected included:

- Butylbenzylphthalate detected at 70 ug/kg in SB10 at 5 ft.
- Di-n-octylphthalate was detected at 81 ug/kg in SB10 at 5 ft and 54 ug/kg at SB11 at 5 ft.
- Bis(2-ethylhexyl)phthalate was detected at 57 ug/kg at SB11 at 5 ft.

Phenols
Pentachlorophenol was detected at 42 ug/kg in SB10 at 30 ft.

Pesticides
Three pesticides were detected at relatively low concentrations in subsurface soil samples at the Scott Fetzer subarea. The following compounds were detected:

4,4'-DDE	heptachlor
4,4'-DDT	heptachlor epoxide
endosulfan II	endrin ketone

- 4-4'-DDE, 4,4'-DDT and endosulfan II were detected in sample SB10 at 5 ft at 3.5, 3.0 and 0.28 ug/kg, respectively.

- Heptachlor epoxide was detected in SB11 at 0.26 ug/kg at 5 ft, heptachlor was detected in SB11 at 0.29 ug/kg at 5 ft, 0.16 ug/kg at 10 ft, and 0.17 ug/kg at 20 ft.

PCBs

PCBs were not detected in subsurface soil samples at the Scott Fetzer subarea.

Summary - Organic Contaminants in Subsurface Soils at the Scott Fetzer Subarea

No organic compounds were detected in samples SS8, SS9, SS10, SS11, and SS12 at 3.5 ft. The VOCs detected in this area were found below the water table which may indicate the soil was contaminated by a source deeper than 3.5 ft below the ground surface, or that soils may have been impacted from leaks in the nearby abandoned industrial sewer line (to western lagoons). With the high concentration of contaminants in well MW20 (to be discussed in the next section) it is likely the source of contaminants in subsurface soils is from the Scott Fetzer subarea.

SVOCs detected in the vicinity of the Scott Fetzer subarea may be the result of fill material and/or some surface disposal of coal, asphalt and/or oils.

The pesticides detected near the Scott Fetzer subarea may be the result of surface application of pesticides.

VOCs, SVOCs, and pesticides were detected at concentrations in exceedance of Act 307 Type B criteria for soils at the Scott Fetzer subarea. See Table 5-4 for a summary of these compounds.

Inorganic Analytes in Subsurface Soils at the Scott Fetzer Subarea

Twelve subsurface soil samples were collected from 7 soil borings at the Scott Fetzer subarea. The borings included:

MW10D
SB10
SS8
SS9
SS10
SS11
SS12

See Figure 3-1 for sample locations. Note sample MW10D was collected approximately 450 northwest of the Scott Fetzer buildings while the remaining samples were collected in the immediate vicinity of the Scott Fetzer buildings.

Metal concentrations in exceedance of background concentrations were detected in 9 of 12 soil samples. Ten metals were detected in exceedance of background concentrations at least once. The following metals and cyanide were detected in exceedance of background:

Metal	No. of Exceedances of Background	Metal	No. of Exceedances of Background
antimony	2	lead	4
barium	1	magnesium	2
calcium	1	sodium	1
total chromium	1	thallium	1
copper	1	zinc	3
		cyanide	2

See Table 5-9 for a summary of exceedances of background. See Figure 5-2 for the distribution of metals in exceedance of background concentrations in subsurface soils at the Scott Fetzer subarea.

There is no particular spatial distribution pattern to metals concentrations, but high lead and zinc concentrations were detected at SS12 - 3.5 ft near the former Scott Fetzer cyanide destruction facility (CDF) and high copper, lead and zinc concentrations were detected at SB10 at a depth of 5 ft located at the northeast corner of State Street and North Walker. It is likely the soil contamination is a result of the former plant operations.

Groundwater in the Scott Fetzer Subarea

Due to their proximity to the Scott Fetzer subarea, the following 4 wells are included in the discussion of groundwater at Scott Fetzer:

MW10S
MW10D
MW19
MW20

See Figure 3-1 for well locations.

Organic Compounds in Groundwater at the Scott Fetzer Subarea

Several VOCs (many at high concentrations) were detected in groundwater at the Scott Fetzer subarea. No SVOCs, pesticides, or PCBs were detected in groundwater at the Scott Fetzer subarea.

VOCs
VOCs were detected in each monitoring well (MW10S, MW10D, MW19, and MW20). The VOCs detected included:

TCE	1,1,1-TCA
1,2-DCE	1,1,-DCA
vinyl chloride	PCE

Chlorinated Ethene Compounds
Constituent chlorinated ethene compounds included:

- TCE, detected in each well, ranged in concentration from 170 ug/L in well MW19 to 30,000 ug/L in well MW20.
- 1,2-DCE, detected in each well, ranged in concentration from 6 ug/L in well MW10S to 35,000 ug/L in well MW20.
- Vinyl chloride, detected at 5,200 ug/L in well MW20, only.
- PCE, detected at 3 ug/L in well MW19, only.

Chlorinated Ethane Compounds
Constituent chlorinated ethane compounds included:

- 1,1,1-TCA, detected at 14 ug/L in well MW19, only.
- 1,1-DCA, detected at 4 ug/L in well MW19, only.

SVOCs
SVOCs were not detected in the groundwater wells at the Scott Fetzer subarea.

Pesticides
Pesticides were not detected in groundwater wells at the Scott Fetzer subarea.

PCBs
PCBs were not detected in groundwater wells at the Scott Fetzer subarea.

Summary - Organic Compounds in Groundwater at the Scott Fetzer Subarea
High concentrations of TCE, 1,2-DCE, and vinyl chloride were detected at well MW20 located at the northwest corner of the vacant Scott Fetzer building. The concentrations at this location and in surrounding wells indicate this is a potential source area for VOCs in groundwater at the site.

Groundwater flows west-northwest from the Scott Fetzer subarea (see Figure 3-8) and contaminants appear to migrate with groundwater flow. See Figure 5-3 for the approximate distribution of chlorinated ethenes at the site. Wells downgradient of the Scott Fetzer subarea MW10S, MW10D, MW5S, MW5D, and MW27 also show high concentrations of TCE, 1,2-DCE, and vinyl chloride. As contaminants flow horizontally to the west-northwest, they are also migrating downward as evidenced by concentrations in wells screened at depth MW5D (46 ft) and MW10D (49 ft). Well MW19 located in the Scott Fetzer subarea also has high concentrations of TCE and 1,2-DCE and low level concentrations of 1,1,1-TCA, 1,1-DCA, and PCE. The chlorinated ethane compounds detected may indicate a separate source of contamination at the Scott Fetzer subarea different than what is detected at well MW20. Well MW27 is located approximately 1,600 ft downgradient from the Scott Fetzer subarea and may be impacted by other sources including DCC Plant #2 (located 300 ft south), the abandoned industrial sewer line (western), or Bronson Precision Products. Well MW5S may also be impacted by the abandoned industrial sewer line (western) and/or Bronson Precision Products.

Table 5-6 summarizes MCL and Act 307 Type B Criteria exceedances in groundwater at the Scott Fetzer subarea. Each well had at least 1 organic compound in exceedance. TCE was detected in exceedance in each well, 1,2-DCE and vinyl chloride were detected in exceedance in well MW20, only.

Inorganic Analytes in Groundwater at the Scott Fetzer Subarea
There were no metal concentrations in wells MW10S, MW10D, MW19, and MW20 in exceedance of MCLs or Act 307 Type B Criteria.

Table 5-7 summarizes metal concentrations in exceedance of background at the Scott Fetzer subarea. Figure 5-4 illustrates the area of metals in exceedance of background at the Scott Fetzer subarea. The following metals were detected in exceedance of background:

Metals	No. of Exceedances of Background
aluminum	1
iron	4
manganese	1
nickel	1
selenium	1
cyanide	1

Although the above metals and cyanide do not exceed MCLs or Act 307 Type B Criteria, their presence above background concentrations may indicate impact from site operations. See Figure 5-4 for the approximate distribution of elevated metal concentrations in groundwater at the Scott Fetzer subarea.

Indicator Parameters in Groundwater at the Scott Fetzer Subarea
Three of four wells at the Scott Fetzer subarea had at least 2 indicator parameters with elevated concentrations and included the following:

Indicator Parameter	No. of Exceedances of Background
ammonia-N	2
COD	1
nitrate + nitrite-N	1
sulfate	3

Table 5-8 summarizes exceedances of background concentrations. No MCLs or Act 307 Type B Criteria were exceeded. Some indicator parameters are elevated compared to background but the relatively low concentrations may indicate natural variation in groundwater.

Overview of Contaminants Detected at the Scott Fetzer Subarea
TCE, 1,2-DCE, and 1,1,1-TCA were detected in soils at the Scott Fetzer subarea. However, most compounds were detected in samples collected from below the water table. TCE, 1,2-DCE, and vinyl chloride concentrations in well MW20 were the highest concentrations detected in groundwater at any location at the site. The Scott Fetzer subarea is a potential source area for chlorinated ethenes at the site. See Figure 5-3 for the approximate distribution of total chlorinated ethenes in groundwater at the site. While metals in groundwater at the Scott Fetzer subarea did not exceed MCLs or Act 307 Type B Criteria, several were detected in soils and groundwater above background concentrations. See Figures 5-2 and 5-4, respectively, for the distribution of metals in soils and groundwater at the Scott Fetzer subarea.

5.5.3 Abandoned Industrial Sewer (Western) Subarea
Only subsurface soils and groundwater samples were collected at the abandoned industrial sewer subarea. See Figure 5-1 for the delineation of the abandoned industrial sewer subarea.

Surface Soils at the Abandoned Industrial Sewer Subarea
No surface soils were collected along the route of the abandoned industrial sewer line (western).

Subsurface Soils at the Abandoned Industrial Sewer Subarea
Sixteen subsurface soil samples were collected from 5 soil borings located along the route of the abandoned industrial sewer line (western). The borings included the following:

MW2S	SB11
MW4S	SB12
MW5D	

The samples collected ranged in depth from 5 ft to 30 ft. All samples were analyzed for TAL inorganics but samples from borings SB11 and SB12 were also analyzed for TCL organics. Sample identification for "SB" samples is the same as previously discussed. The sample identification for MW2S indicates a soil sample collected while drilling monitoring well MW2S. Sample results from soil boring SB10 may also be included in the discussion of the abandoned industrial sewer subarea. These results have been previously discussed in the Scott Fetzer subarea section.

Organic Compounds in Subsurface Soils Along the Abandoned Industrial Sewer Subarea
Several organic compounds were detected in subsurface soils at the abandoned industrial sewer (western) subarea. VOCs, SVOCs, and pesticides were detected and are discussed below. Refer to the subsurface soils in the Scott Fetzer Subarea section pages 5-24 and 5-25 for the discussion of organic compounds detected in soil boring SB10 (the Scott Fetzer subarea). Boring SB10 may also be impacted by the abandoned industrial sewer (western).

VOCs
Three VOCs were detected in subsurface soils from the borings. The VOCs included: toluene, TCE, and 1,2-DCE.

BETX Compounds
Toluene was detected in 2 ug/kg at SB12 at 5 ft, only.

Chlorinated Ethene Compounds
Constituent chlorinated ethene compounds included:

- TCE, detected in 5 samples, in boring SB12 with concentrations ranging from 4 ug/kg at 30 ft to 200 ug/kg at 20 ft.

- 1,2-DCE, detected in 4 samples, in boring SB11 which ranged in concentration from 2 ug/kg at 15 ft and 30 ft to 3 ug/kg at 20 ft and 25 ft.

SVOCs
Ten SVOCs were detected at relatively low concentrations in 3 of 12 subsurface soil samples. The SVOCs detected included PAHs and phthalates.

PAH Compounds
Constituent PAH compounds were detected in SB11 at 5 ft, only and included:

Compound	Concentration (ug/kg)
phenanthrene	78
fluoranthene	120
pyrene	110
benzo(a)anthracene	70
chrysene	74
benzo(b)fluoranthene	150
benzo(k)fluoranthene	150
benzo(a)pyrene	43

Total PAHs in SB11 at 5 ft are 795 ug/kg.

Phthalate Compounds
Constituent phthalate compounds included:

- Bis (2-ethylhexyl)phthalate, detected at 57 ug/kg in SB11 at 5 ft, 53 ug/kg at SB12 at 10 ft, 67 ug/kg in SB12 at 25 ft, and 44 ug/kg in SB12 at 30 ft.

- Di-n-octylphthalate, detected at 54 ug/kg in SB11 at 5 ft and 56 ug/kg in SB12 at 5 ft.

Pesticides
Six pesticides were detected at relatively low concentrations in subsurface soils collected near the abandoned industrial sewer line (western). The pesticides included:

- Heptachlor, detected in 3 samples - 0.29 ug/kg in SB11 at 5 ft, 0.16 ug/kg at SB11 at 10 ft, and 0.17 ug/kg at SB11 at 20 ft.

- Heptachlor epoxide, detected at 0.38 ug/kg in SB11 at 5 ft only.

- Endosulfan sulfate, endrin, and endrin ketone, detected in SB11 at 5 ft at concentrations of 0.45, 2.9, and 0.32 ug/kg, respectively.

- Methoxychlor, detected at 0.54 ug/kg in SB12 at 25 ft, only.

PCBs
No PCBs were detected in subsurface soils at the abandoned industrial sewer (western) subarea.

Summary - Organic Compounds Along the Abandoned Industrial Sewer (Western) Subarea
TCE, heptachlor, heptachlor epoxide, and bis(2-ethylhexyl)phthalate were detected at concentrations in exceedance of Act 307, Type B criteria for soils. See Table 5-4 for a summary of organic compound exceedances in subsurface soils.

The organic compounds and concentrations detected along the abandoned industrial sewer line (western) do not give a clear indication as to whether or not the sewer line had leaked in the past and contributed to contamination at the site but this is a possible scenario. The TCE and 1,2-DCE detected in the soils found at or below the water table may be attributable to an upgradient source (i.e., the Scott Fetzer subarea).

Inorganic Analytes in Subsurface Soils Along the Abandoned Industrial Sewer (Western) Subarea
Sixteen subsurface soil samples were collected from 5 soil borings. The borings included:

MW2S	SB11
MW4S	SB12
MW5D	

See Figure 3-1 for boring locations.

Metals in exceedance of background were detected in 7 of 15 samples. Ten metals were detected in exceedance at least once. The metals included:

Metal	No. of Exceedances of Background	Metal	No. of Exceedances of Background
arsenic	1	iron	1
beryllium	1	magnesium	5
cadmium	2	manganese	1
calcium	2	sodium	6
nickel	2	vanadium	1

See Table 5-10 for a summary of metals in exceedance of background in subsurface soils along the abandoned industrial sewer line. See Figure 5-2 for the area of metals in subsurface soils in exceedance of background concentrations along the abandoned industrial sewer. The sample from boring MW4S at 10 ft had 10 metals at relatively high concentrations exceeding background and sample SB12 at 5 ft had 5 metals in exceedance of background. The metals detected may be attributed to the abandoned industrial sewer (if the sewer line leaked), or may be due to an upgradient source.

Groundwater at Abandoned Industrial Sewer Subarea
Five wells are located near or adjacent to the abandoned industrial sewer line. See Figure 3-1 for well locations. These wells include:

MW2S	MW5S
MW3S	MW5D
MW4S	

Each well was sampled on two occasions and analyzed for TCL organics, TAL inorganics, and indicator parameters.

Wells MW19 and MW20 were discussed in the Scott Fetzer subarea section but may also be included in the discussion of the abandoned industrial sewer (western) since both wells are also adjacent to the abandoned industrial sewer line. See inorganic analytes in subsurface soils at the Scott Fetzer subarea, pages 5-27, 5-28, and 5-29 for analytical results from wells MW19 and MW20 and Figure 3-1 for well locations.

Organic Compounds in Groundwater Along the Industrial Sewer Subarea
Several VOCs were detected at varying concentrations in wells along the abandoned industrial sewer (western) subarea. One SVOC was also detected but no pesticides or PCBs were detected.

VOCs
Each well had at least 1 VOC detected. Four chlorinated ethene compounds were the only VOCs detected.

Chlorinated Ethene Compounds
Constituent chlorinated ethene compounds detected in groundwater included:

- TCE detected in each well with concentrations ranging from 7 ug/L in well MW4S to 310 ug/L in well MW5D.

- 1,2-DCE detected at 280 ug/L in well MW5S and 1,600 ug/L in well MW5D.

- Vinyl chloride detected at 16 ug/L in well MW5S and 86 ug/L in well MW5D.

- 1,1-DCE detected at 3 ug/L in well MW5D, only.

SVOCs
Bis(2-ethylhexyl)phthalate was the only SVOC detected at 1 ug/L in well MW5S.

Pesticides and PCBs
Neither pesticides nor PCBs were detected in these wells.

Summary - Organic Compounds in Groundwater Along the Abandoned Industrial Sewer (Western) Subarea
Each well along the abandoned industrial sewer line showed some degree of contamination, with the highest concentrations of contaminants detected at wells MW5S and MW5D (wells MW19 and MW20 could also be discussed in this section but have been included in the Scott Fetzer subarea discussion).

It cannot be determined if the industrial sewer line to the western lagoons leaked at a point or points along its route causing the contamination detected, because these same contaminants were detected at potential upgradient sources (at the Scott Fetzer and LA Darling subareas). The concentrations of contaminants present at well MW5D are high enough that they may be from the abandoned industrial sewer line rather than an upgradient source. This is because 1,2-DCE in well MW5D, located downgradient of MW10D, is twice the concentration of 1,2-DCE detected at MW10D. With such a high concentration of contaminants at the Scott Fetzer subarea, the closest downgradient well, MW10D, would be expected to have a higher concentration than MW5D which is further downgradient. Hence, an additional source of contamination near well MW5D may be the abandoned industrial sewer line. It should be noted the aforementioned Phase I wells were not necessarily screened at depths of highest organic compound contamination in the aquifer because vertical profiling was not part of the Phase I drilling operations. This makes discussion of source areas more difficult but the above discussion remains valid.

Table 5-6 summarizes MCL and Act 307 Type B Criteria exceedances in groundwater. Each well had at least 1 organic compound in exceedance. Wells MW5S and MW5D had 3 organic compounds in exceedance.

Inorganic Analytes in Groundwater at the Abandoned Industrial Sewer (Western) Subarea

Mercury at well MW4S is the only metal in exceedance of an MCL and Act 307 Type B Criteria along the abandoned industrial sewer line subarea. Mercury may be present due to leakage from the industrial sewer line (western).

Table 5-7 summarizes metal concentrations in exceedance of background concentrations at the abandoned industrial sewer line (western) subarea. Figure 5-4 illustrates metals in groundwater in exceedance of MCL, Act 307 Type B Criteria and background along the abandoned industrial sewer line. The following metals were detected in exceedance of background concentrations:

Metal	No. in Exceedances of Background
aluminum	1
barium	1
total chromium	3
iron	1
lead	1
mercury	1
zinc	1
cyanide	1

Well MW5D had the most compounds in exceedance of background concentrations (5) and the metals present may be attributable to leakage from the abandoned industrial sewer line to the western lagoons because metals do not appear to be migrating to any great extent elsewhere on site.

Indicator Parameters at the Abandoned Industrial Sewer (Western) Subarea

Each well had at least 2 indicator parameters which exceeded background concentrations, as follows:

Indicator Parameter	No. of Exceedances of Background
ammonia-N	2
Nitrate + Nitrite-N	1
sulfate	4
total kjeldahl-N	1
TOC	1

Table 5-8 summarizes exceedances of background concentrations. No MCLs or Act 307 Type B Criteria were exceeded. The parameters which exceeded background are detected at concentrations which may be attributable to natural variation in groundwater.

Overview of Contaminants Detected Along the Abandoned Industrial Sewer (Western) Subarea

Relatively high concentrations of TCE, 1,2-DCE, and vinyl chloride were detected in subsurface soils and groundwater along the route of the abandoned industrial sewer line to the western lagoons. In addition, relatively high concentrations of several metals were detected in subsurface soils. It is difficult to determine if contaminants are present due to potential leakage from the abandoned industrial sewer line or from an upgradient source. The contamination present is likely due to a combination of sources.

5.5.4 Overview and Summary of the Industrial Complex Area

The three subareas within the industrial complex each had high concentrations of chlorinated ethenes (TCE, 1,2-DCE, and vinyl chloride) in groundwater and soils (below the water table). The contaminants detected at the LA Darling and Scott Fetzer subareas are likely from separate sources while the contaminants at the abandoned industrial sewer line may have migrated from the Scott Fetzer subarea and/or may be due to potential leakage from the abandoned industrial sewer line. It should also be noted that Bronson Specialties, Bronson Precision Products, and DCC Plant #2 may also be potential sources of contamination in the industrial complex area. Contaminants from the LA Darling subarea appear to migrate with groundwater flow (advection) to the north and northwest, while contaminants from Scott Fetzer migrate west and northwest. See Figures 3-6, 3-7, and 3-8 for groundwater flow direction. Contaminants also appear to be migrating downward as they move horizontally. The downward migration is likely due to slight downward gradients observed in wells in the industrial complex area (Table 4-5).

Numerous metals were detected in soils and groundwater above background concentrations at each of the three subareas within the industrial complex. Metals do not appear to have migrated to the extent organic contaminants have.

The high TCE, 1,2-DCE and vinyl chloride concentrations at well MW20 at the Scott Fetzer subarea, and the high TCE concentration detected at well MW21 at the LA Darling subarea, indicate large amounts of contaminants remain at these source areas. This indicates that contamination of the upper aquifer will likely continue at the site due to probable sources at the industrial complex. No wells were placed in the lower aquifer during the RI because there was no indication of contamination in lower aquifer from sampling of public and private wells, the assumed continuity of aquitard, and the possibility of contaminating the lower

aquifer by drilling through the semi-confining layer. It has not been conclusively determined if contamination has migrated to the lower aquifer, but based on limited private well results, contamination does not appear to have migrated to the lower aquifer.

5.6 WASTE LAGOONS

Plating and other industrial wastes were deposited historically in two separate sets of lagoons located at the northeast and northwest corners of the site. The western lagoons were constructed in 1939 and indications are that many companies in Bronson deposited wastes in the western lagoons via the abandoned industrial sewer line. Currently, the four western lagoons each hold between 2 and 4 ft of water and 2 to 3 ft of sludge. Approximately 16,000 cy of contaminated material are found in the western lagoons (total of all lagoons). In 1949 disposal in the western lagoons exceeded capacity which lead to the construction of two eastern lagoons by the City of Bronson. Between 1950 and 1967, three additional lagoons were constructed - making a total of five eastern lagoons. These lagoons were identified by aerial photographs and topographic maps. During the RI Warzyn identified only two eastern lagoons located at Bronson Plating which contain 4 to 5 ft of plating waste sludge, but no standing water. Approximately 8,000 cy of contaminated material are found in the two eastern lagoons (total of the two lagoons).

Reportedly, Scott Fetzer, LA Darling, and Bronson Plating were all connected to the eastern lagoons via an industrial sewer line. Scott Fetzer reportedly stopped discharging to the eastern lagoons in 1951. LA Darling stopped discharging to the eastern lagoons in 1967. Bronson Plating purchased the eastern lagoons in 1970 and continued using the lagoons until 1981. In 1980, use of the western lagoons by other business was also discontinued. Due to the position of the buildings at Bronson Plating, Warzyn was not able to determine the exact locations of the three additional lagoons, which had subsequently been backfilled. See Section 2.0 for further historical information. See Figures 3-1, 3-3, and 3-4 for lagoon locations and Figure 5-1 for the delineation of the eastern and western lagoon study areas.

Identification for lagoon samples is as follows:

Matrix	Sample ID
lagoon water	LW1 through LW12 (western lagoons, only)
lagoon sludge	S1S (shallow sample) sludge from location 1 at 0 to 6 in. S1D (deep sample) sludge from location 1 at 36 in. S5SA sludge at location 5, 0 to 6 in., subsample A
lagoon berm soils	LB1 through LB6 collected at 2 to 3 ft

Lagoon water samples LW1 through LW8 were collected during Round 1 (Phase I), one sample was collected near shore and 1 sample was collected at least 10 ft from shore in each lagoon. Samples LW1 through LW8 were collected just beneath the surface of the water. Samples LW9 through LW12 were collected during Round 3 (Phase II). Samples were collected at mid-depth (2 ft) (LW9 and LW11) and near the bottom (4 ft) (LW10 and LW12) in the 2 largest western lagoons.

Sample identification for remaining soils and groundwater samples at the lagoons are the same as previously discussed. The eastern and western lagoons were both used for deposition of industrial wastes, consequently, the discussion of contaminants will in effect, be a waste characterization.

5.6.1 Eastern Lagoons

The following media were sampled at the eastern lagoons and will be discussed in this order:

lagoon sludge
lagoon berm soils
subsurface soils
groundwater

Please note there are no lagoon water samples for the eastern lagoons (lagoons were dry) and there were also no surface soil samples collected at the eastern lagoons.

Eastern Lagoon Sludge
The term lagoon sludge refers to a composite of waste material which was collected from the bottom of the waste lagoons.

A total of 8 sludge samples were collected from 4 borings in the eastern lagoons. The samples include:

S1S	S3S
S1D	S3D
S2S	S4S
S2D	S4D

Lagoon sludge samples were analyzed for TCL organics, TAL inorganics, and RCRA characteristics. See Figure 3-4 for sample locations.

Organic Compounds in the Eastern Lagoons
Many organic compounds were detected in the eastern lagoon sludge samples and many of these compounds were detected at relatively high concentrations.

VOCs
VOCs were detected in 6 of 8 eastern lagoon sludge samples. Five compounds were detected at relatively low concentrations and include the following:

benzene	2-butanone
toluene	carbon disulfide
acetone	

BETX Compounds
Constituent BETX compounds included:

- Benzene, detected at 3 ug/kg, in samples S4S and S4D.
- Toluene, detected in 6 samples, with concentrations ranging from 3 ug/kg in S3D to 330 ug/kg in S3S.

Ketone Compounds
Constituent ketone compounds included:

- Acetone, detected at 240 ug/kg in S4D, only.
- 2-butanone, detected at 23 ug/kg in S4D, only.

Miscellaneous VOCs

- Carbon disulfide was detected at 69 ug/kg in S4D, only.

SVOCs

A variety of SVOCs were detected at relatively high concentrations in eastern lagoon sludge. At least 1 SVOC was detected in each of the 8 samples.

PAH Compounds

Most of the SVOCs detected in eastern lagoon sludge were PAH compounds. The following PAH compounds were detected:

Compound	Range of Concentrations (ug/kg)
acenaphthylene	110
phenanthrene	190
anthracene	100
fluoranthene	1,500
benzo(a)anthracene	1,100
chrysene	1,100
benzo(b)fluoranthene	1,100
benzo(k)fluoranthene	680
pyrene	51 to 1,200

Total PAH concentrations are listed below:

Sample	Total PAHs (ug/kg)
S3S	79
S4S	51
S4D	7080

Sample S4D contained the most SVOCs at the highest concentrations.

Phthalate Compounds

Constituent phthalate compounds found in the eastern lagoons included:

- Bis(2-ethylhexyl)phthalate detected in 6 of 8 samples which ranged in concentration from 4700 ug/kg in S4D to 25,000 ug/kg in S2D.

- Di-n-butylphthalate detected at 84 ug/kg in S3S and 67 ug/kg in S4D.

- Di-n-octylphthalate detected at 170 ug/kg in S1S, only.

Chlorinated Aromatics
Only 1 chlorinated aromatic compound was detected in eastern lagoon sludge.

- 1,2-dichlorobenzene was detected in 3 samples; 250 ug/kg in S2D, 150 ug/kg in S3D, and 48 ug/kg in S4S.

Phenol Compounds
Only 1 phenol compound was detected in eastern lagoon sludge.

- Benzoic acid was detected at 150 ug/kg in S3S, 190 ug/kg in S3D, and 99 ug/kg in S4S.

Pesticides
Only 1 pesticide was detected in eastern lagoon sludge.

- Heptachlor epoxide was detected at 20 ug/kg in S2S, only.

PCBs
Constituent PCB compounds include:

- Aroclor 1254 detected in 5 of 8 samples which ranged in concentration from 48 ug/kg in S3S to 1200 ug/kg in S2D.

Summary of Organics Found in the Eastern Lagoons Sludge
Toluene was the VOC detected most frequently and at the highest concentrations in eastern lagoon sludge samples. Bis(2-ethylhexyl)phthalate was the SVOC detected most frequently and at the highest concentrations, and aroclor 1254 was the PCB detected most frequently. It appears the highest contaminant concentrations were detected in the deep samples at each boring. This indicates contaminants may be migrating downward, but the organic compounds detected in sludge have not migrated from the sludge into the groundwater. Table 5-11 summarizes organic compound exceedances of Act 307 Type B-Criteria (20x drinking water, 20x GSI, and acceptable detection limits) for soils in eastern lagoon sludges.

Inorganic Analytes in Eastern Lagoon Sludge
A total of 8 sludge samples were collected from 4 borings in the eastern lagoons. Each sample had at least 9 metals in exceedance of background and, in total, 17 of 23 metals and cyanide were detected in exceedance of background concentrations. The metals included:

Metal	No. of Exceedances of Background	Metal	No. of Exceedances of Background
antimony	8	lead	8
arsenic	2	magnesium	5
barium	8	nickel	8
cadmium	8	vanadium	4
calcium	3	sodium	5
total chromium	8	mercury	2
cobalt	8	silver	2
copper	8	zinc	8
iron	6	cyanide	8

Arsenic, calcium, mercury, and silver were detected less frequently and at lower concentrations than other metals.

Calcium, total chromium, iron, magnesium, and nickel were detected at such high concentrations that they could be represented in percentage amounts. For example, chromium at S1D has a concentration of 79,700 mg/kg or 7.9% by weight. See Table 5-12 for a summary of metal exceedances of background and/or Act 307 Type B 20x drinking water or 20x GSI values in the eastern lagoons. In addition, cadmium is considered RCRA hazardous in 5 of 8 samples. Table 5-13 summarizes RCRA exceedances at the eastern lagoons.

Summary of Inorganics in the Eastern Lagoons Sludge

Cadmium, total chromium, iron, magnesium, and nickel were detected at extremely high concentrations in eastern lagoon sludge, but only cadmium is considered RCRA hazardous. There is no apparent spatial distribution pattern of metals and cyanide in the eastern lagoon sludge as the entire lagoons are highly contaminated. Metal contamination likely exists in natural soils below the sludge, but analytical samples were not collected below the sludge to confirm this.

Eastern Lagoon Berm Soils

Lagoon berm soil samples LB1, LB2, and LB3 were collected from depths of 2 to 3 ft at the eastern lagoons. Lagoon berm soil samples were analyzed for TCL organics and TAL inorganics. Pesticides were not detected in eastern lagoon berm soil samples.

Organic Compounds in Eastern Lagoon Berm Soils
Relatively few organic compounds were detected in eastern lagoon berm soil samples and these compounds were at relatively low concentrations.

VOCs
Benzene and toluene were detected in each lagoon berm sample. Acetone was detected in sample LB1, only.

BETX Compounds
Constituent BETX compounds include:

- Benzene detected at 3 ug/kg, 1 ug/kg, and 2 ug/kg in LB1, LB2, and LB3, respectively.

- Toluene detected at 16 ug/kg, 2 ug/kg, and 1 ug/kg in LB1, LB2, and LB3, respectively.

Ketone Compounds
Only acetone was detected at 31 ug/kg in LB1.

SVOCs
PAH Compounds
Three PAH compounds were detected in lagoon berm samples. These compounds included: naphthalene, 2-methylnaphthalene, and phenanthrene which were detected in LB1 at 68 ug/kg, 220 ug/kg, and 130 ug/kg, respectively.

PCBs
Aroclor 1254 was detected in each lagoon berm sample at 480 ug/kg, 98 ug/kg, and 67 ug/kg in LB1, LB2, and LB3, respectively.

Summary - Organics in Eastern Lagoon Berm Soils
Relatively few organic compounds were detected in lagoon berm soil samples. 2-methylnaphthalene was the only organic compound in exceedance of Act 307 Type B Criteria, see Table 5-4.

Inorganic Analytes in Eastern Lagoon Berm Soils
At least 6 metals and cyanide were detected in exceedance of background concentrations in lagoon berm samples LB1, LB2, and LB3. LB1 contained the most metals in exceedance (10) and at the highest concentrations. See Table 5-14 for a summary of metals and cyanide in exceedance of background concentrations and/or Act 307 Type B Criteria (20x drinking water and 20x GSI).

Arsenic, barium, lead, and silver were detected in exceedance of background at LB1, only, and at relatively low concentrations.

Antimony, cadmium, chromium, copper, nickel, zinc, and cyanide were detected most frequently and at the highest concentrations. These metals and cyanide are expected, considering the known deposition of plating and other industrial wastes in the lagoons.

Subsurface Soils at the Eastern Lagoons Area

Thirty-six subsurface soil samples were collected from 5 soil borings at depths ranging from 2 ft to 40 ft in the area of the eastern lagoons. Soil borings included SB1, SB2, SB3, SB6, SB7. See Figure 3-4 for boring locations. TCL organics and TAL inorganics analysis were performed on the subsurface soil samples. In addition, two soil borings SB4 and SB5 were hand augered (one in each of the two visible lagoons). These borings were performed only to determine the depth of sludge in each of the lagoons. Analytical samples were not collected from either boring, because analytical samples had been previously collected from these areas.

Organic Compounds in Subsurface Soils at the Eastern Lagoons

Numerous organic compounds were detected in subsurface soils at the eastern lagoons. Many compounds were detected in each organic fraction (VOCs, SVOCs, pesticides, and PCBs).

VOCs

The following VOCs were detected in the subsurface soils at the eastern lagoons:

methylene chloride	chloroform
toluene	1,1,2,2-tetrachloroethane
2-butanone	tetrachloroethene
trichloroethene	chlorobenzene
ethylbenzene	xylenes
carbon disulfide	acetone
	benzene

Ketone Compounds

Constituent ketone compounds detected in subsurface soils included the following:

- Methylene chloride, detected at varying concentrations in 13 samples from borings SB1, SB2, and SB3. Methylene chloride concentrations ranged from 2 ug/kg throughout boring SB2 to 90 ug/kg in boring SB1 at 4 ft.

- 2-butanone, detected in 8 samples at borings SB1, SB2, and SB7. The 2-butanone concentrations ranged from 8 ug/kg in sample SB2 at 15 ft to 25 ug/kg in sample SB1 at 8 ft.

- Acetone, detected in 5 samples, which ranged in concentration from 4 ug/kg in SB2 at 6 ft to 11 ug/kg at SB3 at 10 ft.

BETX Compounds
Constituent BETX compounds detected in subsurface soil samples included the following:

- Benzene, detected at 2 samples, which include 1 ug/kg in SB7 at 5 ft; and 1 ug/kg in SB7 at 8 ft.

- Ethylbenzene, detected at 5 ug/kg in SB1 at 6 ft, only.

- Toluene, detected in 21 subsurface soil samples and at all borings except SB6. Toluene ranged in concentration from 1 ug/kg in SB1 at 15 ft and SB7 at 15 ft to 46 ug/kg in SB3 at 4 ft.

- Xylenes were detected at 24 ug/kg in SB1 at 6 ft, only.

Chlorinated Ethene Compounds
Constituent chlorinated ethene compounds detected in subsurface soil samples included the following:

- TCE, detected in 16 subsurface soil samples and in each soil boring. These detections were identified in samples collected below the water table and ranged from 2 ug/kg in SB7 at 8 ft to 83 ug/kg in SB3 at 15 ft.

- Tetrachloroethene (PCE), detected at 1 ug/kg in SB7 at 15 ft, only.

Chlorinated Ethane Compounds
1,1,2,2-tetrachloroethane was detected at 1 ug/kg in SB7 at 3 ft, only.

Miscellaneous VOCs
The following miscellaneous VOCs were detected in eastern lagoon subsurface soil samples:

- Chlorobenzene, detected at 9 ug/kg in SB1 at 10 ft and 2 ug/kg in SB6 at 10 ft.

- Chloroform, detected at 78 ug/kg in SB7 at 35 ft.

- Carbon disulfide, detected at 14 ug/kg in SB2 at 8 ft and 8 ug/kg in SB2 at 10 ft.

SVOCs
SVOCs were detected in all soil borings.

PAH Compounds
Numerous PAHs, at relatively high concentrations, were detected at several borings. The following PAHs were detected:

Compound	Range of Concentrations (ug/kg)
naphthalene	44 to 110
2-methylnaphthalene	230 to 400
acenaphthylene	370
dibenzofuran	67 to 420
phenanthrene	67 to 3,800
anthracene	52 to 350
benzo(a)anthracene	230 to 1,700
chrysene	160 to 2,100
benzo(b)fluoranthene	42 to 3,000
benzo(k)fluoranthene	42 to 560
benzo(a)pyrene	200 to 910
fluoranthene	220 to 3,100
dibenz(a,h)anthracene	82 to 83
indeno(1,2,3-cd)pyrene	190 to 1,700
fluorene	91
acenaphthene	49
pyrene	45 to 3,200
benzo(g,h,i)perylene	220 to 1,800

Total PAH concentrations by location are listed below:

Sample	Total PAHs (ug/kg)
SB1-4	22,700
SB1-6	510
SB2-8	400
SB6-3	37
SB6-5	3,740
SB6-8	2,640
SB6-10	860
SB6-15	44

Phthalate Compounds
Constituent phthalate compounds detected at the eastern lagoons included the following:

- Bis(2-ethylhexyl) phthalate, detected in 5 soil samples, which ranged in concentration from 210 ug/kg in SB6 at 8 ft to 6,200 ug/kg in SB2 at 8 ft.

- Di-n-octylphthalate, detected in two soil samples - 130 ug/kg in SB7 at 3 ft and 41 ug/kg in SB6 at 30 ft.

- Di-n butylphthalate was detected in LB2 at 43 ug/kg.

Chlorinated Aromatics
Constituent chlorinated aromatic compounds detected in subsurface soils included the following:

- 1,2-dichlorobenzene, detected in 10 soils samples from 5 borings. Concentrations ranged from 50 ug/kg in SB6 at 30 ft to 840 ug/kg in SB6 at 15 ft.

- 1,4-dichlorobenzene, detected at 860 ug/kg in SB6 at 10 ft and 70 ug/kg in SB6 at 15 ft.

- 1,2,4-trichlorobenzene, detected at 48 ug/kg in SB7 at 3 ft and 1,500 ug/kg in SB6 at 10 ft.

Phenols
4-nitrophenol was detected at 35 ug/kg in SB6 at 30 ft, only.

Pesticides
Eighteen of thirty-six subsurface soil samples, in 5 of 8 borings at the eastern lagoons had detectable levels of pesticides. The following pesticides were detected in soil samples at the eastern lagoons:

Compound	Range of Concentrations (ug/kg)
beta-BHC	3.1
gamma-BHC (lindane)	0.29 to 0.44
heptachlor	0.16 to 0.31
aldrin	0.58
heptachlor epoxide	0.24 to 0.39
endosulfan I	0.29 to 0.63
4,4'-DDE	0.45 to 3.8

Compound	Range of Concentrations (ug/kg)
4,4'-DDD	1.4 to 78
4,4'-DDT	2.8
endrin	1.4
endrin ketone	0.55 to 11
methoxychlor	0.83 to 9.4
alpha-chlordane	0.69 to 1.1
gamma-chlordane	0.47
endrin aldehyde	0.84 to 0.89
dieldrin	0.96

Soil boring samples at SB6 from 3 ft to 10 ft depth contained the greatest number and highest concentrations of pesticides at the eastern lagoons - 11 compounds. However, the concentrations detected in the eastern lagoons were generally less than 1 ug/kg.

PCBs

PCBs were detected in each soil boring at varying concentrations throughout the subsurface soils at the eastern lagoons. The following PCBs were detected:

- Aroclor 1248, at 79 ug/kg in SB1 at 15 ft, only.
- Aroclor 1254 in 2 samples which ranged in concentration from 210 ug/kg in SB6 at 5 ft to 180 ug/kg in SB6 at 8 ft.
- Aroclor 1260, (most frequently) in subsurface soils - 10 samples. Concentrations ranged from 27 ug/kg in SB2 at 2 ft to 550 ug/kg in SB3 at 6 ft.

Summary of Organic Compounds in Subsurface Soils at the Eastern Lagoons

Most VOCs detected in subsurface soil samples at the eastern lagoons were detected at varying depths throughout the borings. However, TCE and PCE were detected at or below groundwater, only. Based upon this observation, TCE and PCE may not have been part of the waste deposited in the two eastern lagoons that were investigated but may have contaminated the subsurface soils at the eastern lagoons by migration of contaminated groundwater from an upgradient source. A possible upgradient source would be one or more of the eastern lagoons which formerly existed in the area now covered by the building additions.

The types of SVOCs detected in subsurface soils are not normally associated with plating operations. However, many of the same SVOCs detected in eastern lagoon subsurface soils were also detected in the Bronson Plating outfall, OF1,

(see Section 5-7). It is likely Bronson Plating is a source of these SVOCs, since they used the eastern lagoons from 1949-1981 (see Industrial Survey Results - Appendix A).

PCBs were detected at various depths in the subsurface soils but their source is not determined at this time.

Several VOCs, SVOCs, and pesticides were detected at concentrations in exceedance of ACT 307 Type B criteria for soils at the eastern lagoons. See Table 5-4 for a summary of these compounds. Note, many of the SVOCs and pesticides found on Table 5-4 are in exceedance of Act 307 Type B Criteria - 20x drinking water values, and 20x groundwater/surface water interface (GSI), but less than the currently identified Act 307 Type B acceptable detection limits. The Act 307 Type B acceptable detection limits may be the clean-up level required during remediation.

Inorganic Analytes in Subsurface Soils Near the Eastern Lagoons

Forty subsurface soil samples were analyzed for TAL inorganics from 7 soil borings at depths ranging from 2 ft to 40 ft, in the area of the eastern lagoons. The borings included:

SB1	SB6
SB2	SB7
SB3	MW12D
	MW13D

See Figure 3-4 for boring locations. (As previously noted borings SB4 and SB5 were hand-augered and used for visual description only. No analytical samples were collected from either boring.)

Metal concentrations in exceedance of background concentrations were detected in each soil sample. Fifteen metals and cyanide were detected in exceedance of background and included the following:

Metals	No. of Exceedances of Background	Metals	No. of Exceedances of Background
arsenic	6	mercury	1
antimony	2	magnesium	9
barium	2	nickel	31
cadmium	37	silver	8
total chromium	35	sodium	11
cobalt	2	thallium	1
copper	20	zinc	19
lead	13	cyanide	21

See Table 5-14 for a summary of metal background exceedances at the eastern lagoons. Table 5-14 also lists Act 307 Type B 20x drinking water and 20x GSI values. The GSI values are included because of the proximity of the contaminated soils to groundwater and CD#30. When an analyte is not detected in a background sample, the comparative standard becomes the lesser value of Act 307 Type B 20x drinking water or 20x GSI values. Arsenic, antimony, barium, cobalt, mercury, silver and thallium were detected in exceedance rather infrequently and at relatively low concentrations. While these metals are not considered a large component of the plating wastes deposited in the eastern lagoons, they will be considered during remediation.

Cadmium, total chromium, copper, lead, magnesium, nickel, zinc, and cyanide are normally associated with plating wastes and obviously constitute a large fraction of the wastes generated by Bronson Plating and deposited in and around the eastern lagoons. See Figure 5-2 for the distribution of metals in soils at the eastern lagoons.

The following soil borings contained high concentrations of numerous metals:

- SB1 from 2 ft to 10 ft
- SB2 at 8 ft
- SB3 at 2 ft
- SB6 from 3 to 10 ft
- SB7 at 3 ft

Summary Inorganic Analyte Contaminants in Eastern Lagoons

Cadmium, total chromium, copper, lead, magnesium, nickel, zinc, and cyanide were detected most frequently and at the highest concentrations in eastern lagoon soil samples. There is no particular spatial distribution pattern of contaminants in the 10 borings at the eastern lagoons that have exceedances. Metal exceedances were detected at depths from 2 ft to 40 ft at the eastern lagoons. Generally, metal concentrations decreased with increased depth in soils, more specifically concentrations decreased markedly after the 10 ft sample in most borings.

Groundwater at the Eastern Lagoons

The following 11 wells are included in the discussion of groundwater at the eastern lagoons:

MW12S	MW15S	MW17S
MW12D	MW15D	MW17D
MW13S	MW16S	MW18
MW13D	MW16D	

Samples were analyzed for TCL organics, TAL inorganics, hexavalent chromium, and groundwater quality indicator parameters. See Table 5-1 for a summary of wells sampled and parameters analyzed during each sampling round. See Figure 3-4 for well locations. Analytical results are compared to MCLs and Act 307 Type B Criteria, when applicable.

Organic Compounds in Groundwater at the Eastern Lagoons
Relatively few organic compounds were detected in wells near the eastern lagoons. Chlorinated ethene compounds were the predominant compounds detected.

VOCs
VOCs were detected in 9 of 11 monitoring wells at varying concentrations. VOCs were not detected in wells MW12S and MW15S. Chlorinated ethene compounds were the only VOCs detected in groundwater in the eastern lagoon wells.

Chlorinated Ethene Compounds
Constituent chlorinated ethene compounds detected include:

- TCE in 9 well samples which ranged in concentration from 3 ug/L in well MW12D to 390 ug/L in well MW16D.
- 1,2-DCE in 8 well samples which ranged in concentration from 3 ug/L in wells MW15D, MW13D, and MW17S to 120 ug/L in well MW17D.
- Vinyl chloride at 5 ug/L in well MW17D, Round 2 only.

SVOCs
Bis(2-ethylhexyl)phthalate was the only SVOC detected but it was detected in 8 of 11 wells near the eastern lagoons.

Phthalate Compounds

- Bis(2-ethylhexyl)phthalate ranged in concentration from 1 ug/L in wells MW16D and MW17D to 18 ug/L in well MW16S.

Pesticides/PCBs
Pesticides and PCBs were not detected in groundwater in eastern lagoon area wells.

Summary of Organic Groundwater Contaminants in the Eastern Lagoon Area

TCE and 1,2-DCE were the predominant VOCs detected in groundwater in eastern lagoon wells. Total chlorinated ethene concentrations ranged from no detections (MW12S) to 409 ug/L detected at MW16D. Monitoring wells in the eastern lagoon area are in relatively close proximity which makes it difficult to determine the extent of contamination in this area. Contamination extends north to at least MW12D (north of CD#30), south to at least MW15D, east to an area between well MW17D (relatively high VOC concentrations) and well MW23 (no VOC detections) and west to at least wells MW16S, MW16D, and MW18. See Figure 5-3 for the approximate distribution of total chlorinated ethenes in groundwater.

Total depths in eastern lagoon wells ranged from 12 ft (wells MW16S and MW17S) to 42 ft at wells MW16D and MW15D. The highest contaminant concentrations were detected in deep wells MW13D, MW16D, and MW17D.

As previously discussed in the subsurface soil and lagoon sludge sections, chlorinated ethene compounds (TCE, 1,2-DCE, and vinyl chloride) were not detected in subsurface soil samples or sludge samples collected above the water table at the eastern lagoons. It should be noted only two of the five eastern lagoons were sampled due to the physical constraints of Bronson Plating's buildings. It is possible, the three eastern lagoons not sampled due to inaccessibility may contain TCE, 1,2-DCE, and/or vinyl chloride because known users of these compounds (Scott Fetzer and LA Darling) used the eastern lagoons along with Bronson Plating. Bronson Plating officials have indicated, however, that waste material was excavated from the lagoons and the lagoons were backfilled prior to construction. Regardless of this, residual contaminants may remain. Thus, the source of the organics detected in groundwater at the eastern lagoons may be from an on-site source and/or may be from an undetermined upgradient off-site source (via groundwater flow).

Table 5-6 summarizes MCL and Act 307 Type B exceedances in groundwater. Nine of eleven wells had at least one compound in exceedance at the eastern lagoons. TCE was detected in exceedance most frequently (9 wells). 1,2-DCE and vinyl chloride were in exceedance at well MW17D, only.

Inorganic Analytes in Groundwater at the Eastern Lagoon Area

Five of eleven wells at the eastern lagoons had exceedances of MCLs and/or Act 307 Type B Criteria for metals and/or cyanide. The following analytes were detected in exceedance in groundwater at the eastern lagoons.

Metal	No. of Exceedances
cadmium	3
manganese	1
nickel	2
sodium	2
cyanide	2

See Table 5-6 for a summary of metal exceedances in groundwater in the eastern lagoon area. Well MW13S had the greatest number of exceedances (4). Wells in the immediate vicinity of the eastern lagoons had the highest number of exceedances at the greatest concentrations. Based upon the RI results, metal contaminants do not appear to have migrated north of CD#30 (MW12S, MW12D), or south of MW15S/15D in concentrations in exceedance of MCLs or Act 307 Type B Criteria. These wells do however show metal concentration in excess of background. See Figure 5-4 for the distribution of metals in groundwater.

See Table 5-7 for a summary of metal concentrations in excess of background in groundwater at the eastern lagoons. Thirteen metals and cyanide were detected in exceedance of background. Each well had at least 3 metals in exceedance of background concentrations. Metals were detected at elevated concentrations in both shallow and deep wells at the eastern lagoons. It appears there are more metals at higher concentrations in the shallow wells, but the deep wells also showed impact at the eastern lagoons.

Summary - Inorganic Contaminants in Groundwater at the Eastern Lagoons
Cadmium, manganese, nickel, sodium, and cyanide were detected in exceedance of MCLs and/or Act 307 Type B Criteria in eastern lagoon wells. Elevated background metal concentrations were detected north of CD#30 at wells MW12S and MW12D and south of the eastern lagoons at MW15S and MW15D. Contaminants at wells MW12S and MW12D may be attributable to the eastern lagoons, while the contaminants at wells MW15S and MW15D may be attributable to the eastern lagoons and/or an upgradient source (see Figure 5-4).

Indicator Parameters in Groundwater Near the Eastern Lagoons
At least 1 indicator parameter was detected in exceedance of background at each well at the eastern lagoons. The following indicator parameters were detected in exceedance:

Indicator Parameters	No. of Exceedances of Background
ammonia-N	7
chloride	2
COD	1
sulfate	11
nitrate + nitrite - N	1
total kjeldahl - N	1

Table 5-8 summarizes indicator parameter exceedances in groundwater at the eastern lagoons. Sulfate had elevated concentrations compared to background in each well and sulfate concentrations exceeded MCLs and Act 307 Type B Criteria at well MW17D Round 1, only. In addition, chloride concentrations exceeded MCLs and Act 307 type B in wells MW16D and MW17D. As stated above, elevated sulfate levels are likely the result of sulfuric acid in plating wastes, whereas, the elevated ammonia nitrate + nitrite and TKN levels may be naturally occurring or a result of fertilizer application to agricultural fields in the area.

Summary of Indicator Parameters in Groundwater near the Eastern Lagoons

Elevated indicator parameters at each well near the eastern lagoons indicate probable impact from wastes deposited in the eastern lagoons. Contamination was found to range north of CD#30 (to at least MW12S and MW12D) and south of the lagoons (wells to at least MW15S and MW15D).

Overview and Summary of Contaminants at the Eastern Lagoons

There were many VOCs, SVOCs, pesticides, and PCBs detected in soils and sludges at the eastern lagoons, but chlorinated ethene compounds and bis(2-ethylhexyl) phthalate were the only organic compounds detected in groundwater at the eastern lagoons. Although chlorinated ethene compounds were not detected in soils or eastern lagoon sludge above the water table from the two accessible lagoons, it is possible the chlorinated ethene compounds were in the waste stream deposited in the three inaccessible lagoons. Thus, the chlorinated ethene compounds detected in groundwater at the eastern lagoons may be from an on-site source and/or an upgradient off-site source yet to be investigated.

Many metals and cyanide were detected in soils, sludges, and groundwater at the eastern lagoons. The analytes detected are associated with the plating wastes deposited in the eastern lagoons.

5.6.2 Western Lagoons

The following media were sampled at the western lagoons and are discussed in this order:

- lagoon water
- lagoon sludge
- lagoon berm soils
- subsurface soils
- groundwater

No surface soils were collected at the western lagoons.

See Figure 5-1 for the delineation of the western lagoon study area.

Western Lagoon Water

Lagoon water samples were collected from the western lagoons, (eastern lagoons are dry). Eight samples were collected during Round 1, and 4 samples were collected during Round 2. Lagoon water samples were analyzed for TCL organics, TAL inorganics, hexavalent chromium and indicator parameters. Lagoon water samples collected for analysis of TAL inorganics and indicator parameters were not filtered (TCL organics are never filtered). Contaminant concentrations are compared to Ambient Water Quality Criteria (AWQC) - Freshwater Chronic Criteria from the Federal Register, December 3, 1986. See Table 5-15.

The four western lagoons have been designated A (LW3, LW4), B (LW1, LW2, LW9, and LW10), C (LW5, LW6), and D (LW7, LW8, LW11, LW12). See Figure 3-3 for lagoon designations and sample locations within the lagoons.

Organic Compounds in Lagoon Water Near the Western Lagoons

No VOCs, SVOCs, pesticides, or PCBs were detected in lagoon water samples collected from Lagoons A and C. The organic compounds in Lagoons B and D were detected at relatively low concentrations.

VOCs

Relatively few VOCs were detected in lagoon water from Lagoons B and D and the compounds detected were at relatively low concentrations.

BETX Compounds

Constituent BETX compounds included:

- Benzene, detected at 1 ug/L in LW9 (Lagoon B), only.

- Toluene, detected in 3 samples (all in Lagoon B), at 3 ug/L in LW1, LW9, and LW10.

Chlorinated Ethene Compounds
Constituent chlorinated ethene compounds included:

- TCE, detected in 2 samples (Lagoon B), at 4 ug/L in LW9 and 3 ug/L in LW10.

- 1,2-DCE, detected in 2 samples (Lagoon B), at 5 ug/L in LW9 and 4 ug/L in LW10.

Ketone Compounds
Constituent ketone compounds included:

- Methylene chloride, detected in 2 samples, at 2 ug/L in LW2 (Lagoon B) and 8 ug/L in LW7 (Lagoon D).

- Acetone, detected at 5 ug/L in LW8 (Lagoon D), only.

- 2-butanone, detected at 3 ug/L in LW8 (Lagoon D), only.

SVOCs
Three SVOCs were detected in seven lagoon water samples at low concentrations. These are identified below.

Phenol Compounds

- 4-methylphenol was detected at 16 ug/L in LW1 (Lagoon B), only.

Phthalate Compounds
Constituent phthalate compounds included:

- Bis(2-ethylhexyl)phthalate, detected in LW9 at 54 ug/L (Lagoon B), 2 ug/L in LW7, and 3 ug/L in LW8 (Lagoon D).

Pesticide Compounds
Gamma-BHC(lindane) was detected in LW9 (lagoon B) at 0.01 ug/L, only.

Summary of Organic Contaminants in Lagoon Water in the Western

Lagoons
As stated above, no organic compounds were detected in lagoon water in Western Lagoons A and C. Also, PCBs were not detected in any lagoon water sample. Of the few compounds detected, most were found in Lagoon B. There were no AWQC exceedances for organic compounds in lagoon water.

Inorganic Analytes in Lagoon Water Western Lagoons
At least 2 metals were detected in each lagoon water sample in exceedance of AWQC. Sample LW5 (Lagoon C) had 6 metals and cyanide in exceedance.

The following metals and cyanide were detected in exceedance:

Metal	No of. Exceedances of AWQC
cadmium	11
total chromium	4
copper	7
lead	5
mercury	2
nickel	6
zinc	5
cyanide	8
hexavalent chromium	1

Table 5-15 summarizes metal concentrations in exceedance of AWQC in western lagoon surface water. Cadmium and cyanide were detected most frequently in exceedance of AWQC although copper and nickel were also detected in exceedance in half of the lagoon water samples.

Summary of Inorganic Contaminants in Lagoon Water - Western Lagoons
The metal concentrations in Lagoon C (samples LW5 and LW6) were 2 to 3 times higher (when detected) than in the other lagoons. It is likely however that elevated metal concentrations are due to increased sediments in each sample (lagoon water samples collected for TAL inorganics analyses were not filtered). Sediments affect surface water metal concentrations when samples are not filtered (elevated concentrations), but run for total metals. Sediments in the metals sample is also the reason samples LW10 and LW12 (collected near the bottom and turbid) have concentrations 10 times greater than the samples collected at the mid-depth of the lagoons.

Indicator Parameters in Lagoon Water - Western Lagoons
There are few AWQC for indicator parameters and no lagoon surface water samples in exceedance of these AWQC. Table 5-16 summarizes minimum, maximum, and mean concentrations and frequency of detection of indicator parameters in western lagoon water samples.

There are a wide range of concentrations of indicator parameters between lagoon water samples. The indicator parameters provide little insight into water quality because the maximum concentrations were detected in a sample with more sediments than the other samples. Sediments in the water samples tend to elevate indicator parameter concentrations.

Western Lagoon Sludge
A total of 16 sludge samples were collected from 8 locations at the western lagoons. The samples include:

S5S	S9S
S5D	S9D
S6S	S10S
S6D	S10D
S7S	S11S
S7D	S11D
S8S	S12S
S8D	S12D

Samples were analyzed for TCL organics, TAL inorganics, and RCRA characteristics. There are 2 rounds of data for TAL inorganics and RCRA characteristics, but only 1 round of data for TCL organics. See Figure 3-3 for sample locations.

Organic Compounds in Western Lagoon Sludge
Many organic compounds were detected in western lagoon sludge samples. Several organic compounds were detected at relatively high concentrations.

VOCs
VOCs were detected in each of the 16 western lagoon sludge samples. Concentrations appear to be higher in shallow samples although there is great variability in concentrations between shallow and deep samples. Eleven VOCs were detected in western lagoon sludge and included the following compounds:

benzene	PCE
toluene	acetone
vinyl chloride	2-butanone
TCE	carbon disulfide
1,2-DCE	chlorobenzene

BETX Compounds
Constituent BETX compounds included:

- Benzene, detected at 5 ug/kg in S12D, only.
- Toluene, detected in 15 of 16 samples, which ranged in concentration from 3 ug/kg in S8S to 3040 ug/kg in S10S.

Chlorinated Ethene Compounds
Constituent chlorinated ethene compounds included:

- TCE, detected in 11 of 16 samples, which ranged in concentration from 6.5 ug/kg in S12D to 2460 ug/kg in S10S.
- 1,2-DCE, detected in 8 of 16 samples, which ranged in concentration from 3 ug/kg in S7D to 128 ug/kg in S10S.
- Vinyl chloride, detected in 3 samples - 24 ug/kg in S5S; 29 ug/kg in S10S; and 12 ug/kg in S12S.
- PCE was detected in 2 samples - 8 ug/kg in S10D and 15 ug/kg in S10S.

Ketone Compounds
Constituent ketone compounds included:

- Methylene chloride, detected in 4 of 16 samples, which ranged in concentration from 51 ug/kg in S11D to 400 ug/kg in S9S.
- Acetone, detected at 10 ug/kg in S9S, only.
- 2-butanone, detected at 21 ug/kg in S11S and 37 ug/kg in S12S.

Miscellaneous VOCs
The following miscellaneous VOCs were also detected in sludge samples:

- Carbon disulfide detected in 4 of 16 samples, which ranged in concentration from 4.5 ug/kg in S12D to 58 ug/kg in S9S.
- Chlorobenzene detected at 10 ug/kg in S8D and 16 ug/kg in S9S.

SVOCs
Four SVOCs were detected at relatively low concentrations in western lagoon sludge samples. SVOCs were detected in 8 of 16 samples.

Phthalate Compounds
Constituent phthalate compounds included:

- Bis(2-ethylhexyl)phthalate, detected in 7 of 16 samples, which ranged in concentration from 140 ug/kg in S10D to 790 ug/kg in S5S.

- Diethylphthalate, detected at 220 ug/kg in S5D, only.

PAH Compounds
Constituent PAH compounds included:

- Fluoranthene, detected at 36 ug/kg in S10D.
- Pyrene, detected at 120 ug/kg in S10D.

Pesticides
Constituent pesticides detected included 4-4'-DDT detected at 37 ug/kg in S6D, only.

PCBs
No PCBs were detected in western lagoon sludge samples.

Summary of Organic Contaminants in Western Lagoon Sludges
TCE, 1,2-DCE, and toluene were the predominant VOCs detected in western lagoon sludge. The highest concentrations of these compounds were detected at S10S (shallow sample). Bis(2-ethylhexyl)phthalate was the SVOC detected most frequently. Table 5-11 summarizes organic compound exceedances of Act 307 Type B Criteria in the western lagoon sludge samples.

Inorganic Analytes in Western Lagoon Sludge
Two rounds of TAL inorganic data (16 sludge samples per round) were collected at the four western lagoons. Seventeen of twenty-three metals and cyanide were detected in one or more sludge samples in exceedance of background concentrations. Each sample had at least 8 metal and cyanide exceedances and included the following:

Metal	No. of Exceedances of Background
arsenic	8
antimony	16
barium	3
calcium	4
cadmium	16
total chromium	16
cobalt	10
copper	16
lead	11
magnesium	4
mercury	3
nickel	16
silver	13
selenium	6
zinc	16
vanadium	1
iron	3
cyanide	16

Antimony, cadmium, total chromium, copper, lead, nickel, silver, zinc, and cyanide were detected most frequently and at the highest concentrations of metals detected. Table 5-17 summarizes western lagoon sludge metals in exceedance of background concentrations and/or Act 307 Type B Criteria (20x drinking water or 20x GSI value). When an inorganic analyte is not detected in background samples, the comparative criteria becomes the lesser value of Act 307 Type B 20x drinking water or 20x GSI values. The 20x GSI values are included because of the proximity of soil and sludge contaminants to groundwater and CD#30 at the western lagoons.

Cadmium is at RCRA hazardous concentrations in each of the western lagoon sludge samples. Table 5-13 summarizes RCRA exceedances in the western lagoons. See Figure 5-2 for an illustration of metals in exceedance of background concentrations in soils, subsurface soils, and sludges.

Summary of Inorganics in Western Lagoon Sludges

The metals and cyanide detected in the western lagoons are consistent with plating and other industrial wastes deposited in the lagoons. There is no apparent spatial distribution pattern of metals in sludge at the western lagoons as contamination is found independent of depth (0.5 ft and 3 ft depths). The sludge appeared to be 3 ft to 4 ft thick and contamination likely exists below the sludge, but samples were

not collected beneath the sludge to confirm this. Follow-up sampling below the sludge will likely be conducted as part of the feasibility study.

Western Lagoon Berm Soils

Three lagoon berm soil samples were collected at the western lagoons:

LB4 (north end of Lagoon A)
LB5 (between Lagoons B and C)
LB6 (northwest corner of Lagoon D)

The lagoon berm samples were collected at a depth of 2-3 ft and analyzed for TCL organics and TAL inorganics. Due to laboratory error (hold time exceedances), the TCL organics for samples LB4 and LB6 are not available, but were not resampled because sufficient information existed for this area of the site.

Organic Compounds in Western Lagoon Berm Soils

VOCs

Benzene at 6 ug/kg and toluene at 37 ug/kg were the only VOCs detected in sample LB5.

SVOCs, pesticides, and PCBs were not detected in LB5.

Inorganic Analytes in Western Lagoon Berm Soils

Eleven metals and cyanide were detected in exceedance of background concentrations in lagoon berm samples LB4, LB5, and LB6. Table 5-18 summarizes metals and cyanide in exceedance of background subsurface soil concentrations.

Cadmium, chromium, copper, nickel, zinc, and cyanide were detected in exceedance at the greatest concentrations. This is to be expected considering the type of industrial waste deposited in the lagoons.

Arsenic, antimony, silver, and lead were also detected in exceedance of background but less frequently and at relatively lower concentrations than other metals.

Summary of Contaminants in Lagoon Berm Soils near the Western Lagoons

Although there are few lagoon berm samples, analysis indicated the existence of similar contaminants to that of the lagoon sludge, and to a lesser extent lagoon water.

Western Lagoon Subsurface Soils
Five subsurface soil samples were collected from 3 borings in the area of the western lagoons. The borings included MW6D, MW7S, and MW8S. The samples were analyzed for TAL inorganics, only. See Figure 3-3 for boring locations.

Organic Compounds in Subsurface Soils - Western Lagoons
Organic analysis was not performed on the western lagoon subsurface soil samples listed above, due to hold time exceedances.

Inorganic Analytes in Subsurface Soils From the Western Lagoon Area
Each soil sample from near the western lagoons had at least one exceedance of background concentrations. Eleven metals and cyanide were detected in exceedance of background concentrations in subsurface soils at the western lagoons and include the following:

Metals	No. of Exceedances of Background	Metals	No. of Exceedances of Background
barium	1	magnesium	2
cadmium	2	nickel	2
calcium	1	selenium	1
total chromium	3	sodium	1
copper	2	zinc	2
lead	1	cyanide	2

Barium, calcium, lead and selenium were detected in exceedance infrequently and do not appear to be a major contaminant in soils at the western lagoons. Cadmium, total chromium, copper, magnesium, nickel, zinc, and cyanide had the highest concentrations and most detections greater than background. See Table 5-18 for a summary of metal exceedances of background concentrations in subsurface soils at the western lagoons. See Figure 5-2 for an illustration of the area with elevated metal concentrations at the western lagoons.

Summary of Inorganic Contamination in Subsurface Soils Near the Western Lagoons
Soil samples from boring MW7S at depths of 5 ft and 10 ft contained the greatest number of metals in exceedance of background concentrations. Soil samples from boring MW7S were collected in the same material as the lagoon berm soil samples, but MW7S samples were collected during well installation, hence the different sample identification. Soil samples collected beyond the lagoon berms have few metal exceedances. Metal contamination in subsurface soils at the

western lagoons is likely attributable to the contaminated water discharged to the lagoons during industrial use and subsequent migration to the adjacent soils. The metals detected are consistent with metals associated with plating wastes.

Groundwater Near the Western Lagoons
The following 14 wells are included in the discussion of groundwater at the western lagoons:

MW1	MW5	MW8S	MW27
MW2	MW6	MW8D	MW28
MW3	MW6S	MW9S	
MW4	MW7S*	MW26	

* Submitted to the lab as MW7D but the sample identification was subsequently changed on laboratory paperwork and boring logs, to MW7S. Initially, two wells were to be installed at this location (MW7S and MW7D), but a decision was made to install only one well after the samples were collected and sent to the laboratory.

Groundwater samples were analyzed for TCL organics, TAL inorganics, hexavalent chromium, and indicators with the exception of wells MW26, MW27, and MW28, which were analyzed during Round 3 (Phase II), only, for TCL VOCs, TAL inorganics, and indicator parameters.

See Figures 3-3 and 5-1 for well locations.

Organic Compounds in Groundwater Near the Western Lagoons
Several organic compounds were detected in most wells near the western lagoons. VOCs were the predominant compounds detected.

VOCs
Six VOCs were detected in wells at the western lagoons. The VOCs included:

methylene chloride	toluene
TCE	benzene
1,2-DCE	vinyl chloride

Chlorinated Ethene Compounds
Constituent chlorinated ethene compounds included:

- TCE, detected in 11 of 14 samples, which ranged in concentration from 3 ug/L in well MW5 to 450 ug/L in well MW26.

- 1,2-DCE, detected in 12 of 14 samples, which ranged in concentration from 6 ug/L in well MW6S to 960 ug/L in well MW8D.

- Vinyl chloride, detected in 6 of 14 samples, which ranged in concentration from 3 ug/L in well MW28 to 100 ug/L in wells MW4 and MW6.

BETX Compounds

- Benzene was detected at 1 ug/L in well MW8D, Round 1 only.
- Toluene was detected at 5 ug/L in well MW4, Round 1 only.

Ketone Compounds

- Methylene chloride was detected at 3 ug/L in well MW9S, Round 2 only.

SVOCs

Bis(2-ethylhexyl)phthalate and 1,2-dichlorobenzene were the only SVOCs detected in groundwater at the western lagoons.

Phthalate Compounds

- Bis(2-ethylhexyl)phthalate was detected at 3 ug/L in wells MW4, MW6S, and MW7S and at 4 ug/L in well MW5.

Chlorinated Aromatics

- 1,2-dichlorobenzene was detected at 2 ug/L in well MW7S and 4 ug/L in well MW8S, Round 1 only.

Pesticides/PCBs

No pesticides or PCBs were detected in groundwater at the western lagoons.

Summary of Organic Groundwater Contaminants Near the Western Lagoons

TCE, 1,2-DCE, and vinyl chloride were the predominant organic compounds detected (most frequently and at the highest concentrations) in groundwater at the western lagoons. Contamination exists from an area at least 400 ft south of the western lagoons (well MW27) (likely due to an upgradient source(s) and not the western lagoons) to at least 450 ft northwest of the western lagoons (well MW28). VOCs were also detected north of CD#30 at MW6S (likely due to contamination from groundwater flow under CD#30). See Figure 5-3 for the distribution of total chlorinated ethenes near the western lagoons.

Shallow groundwater flow is north-northwest beneath and likely through the western lagoons (see Figure 3-8) and is found at depths between approximately 6 ft and 10 ft (from top of well casing) in wells at the western lagoons. Total depths of the wells at the western lagoons ranged from 9.5 ft at well MW4 to 52 ft at well MW27.

Most wells at the western lagoons have some degree of VOC contamination (no VOCs detected at well MW7S), and although the majority of wells are shallow (less than or equal to 17 ft total depth) some of the highest contaminant concentrations were detected in wells screened at depth - 960 ug/L of 1,2-DCE at well MW8D (29 ft total depth) and 45 ug/L of 1,2-DCE at well MW27 (52 ft total depth). Thus, VOCs have migrated downward (to at least the top of the aquitard (MW27 and MW8D)) and outward to the north (MW6S), to the west (MW28) and to the south (MW26 and MW27). It is likely the contaminants detected at and downgradient of the western lagoons originate at the western lagoons and other upgradient sources (the Scott Fetzer subarea and the LA Darling subarea, abandoned industrial sewer (western) line, DCC Plant #2, and possibly Bronson Precision Products and Bronson Specialties).

Table 5-6 summarizes MCL and Act 307 Type B Criteria exceedances in groundwater. Exceedances were detected in 11 of 14 wells at or near the western lagoons. TCE was the predominant VOC detected in exceedance of noted standards. Benzene, 1,2-DCE, and vinyl chloride were also detected in exceedance but less frequently. See Figure 5-3 for the approximate distribution of total chlorinated ethenes in groundwater.

Inorganic Analytes in Groundwater Near the Western Lagoons

Five metals and cyanide were detected in exceedance of MCLs and/or Act 307 Type B Criteria in groundwater at the western lagoons. Eleven of fourteen wells at the western lagoons had metal exceedances as noted below:

Metals	No. of Exceedances
cadmium	6
lead	2
manganese	2
nickel	7
zinc	5
cyanide	1

Table 5-6 summarizes metal and cyanide exceedances of MCL and Act 307 Type B Criteria. Wells in the immediate vicinity of the western lagoons, (MW1

through MW7S, and MW26) had the highest concentrations and most metals detected in exceedance of standards.

Well MW28 located approximately 450 ft downgradient (west) of the western lagoons had an exceedance of manganese at 742 ug/L. However manganese was not detected in exceedance of standards near the western lagoons, and the concentration at well MW28 is less than the local background concentration of background 778 ug/L.

Table 5-7 summarizes metal and cyanide exceedances of background concentrations. Figure 5-4 illustrates the distribution of metal concentrations in exceedance of background, MCLs and/or Act 307 Type B concentrations in groundwater. Sixteen metals and cyanide were detected in exceedance of background concentrations in groundwater at the western lagoons. Each well, except well MW28, had at least 2 metals in exceedance of background concentrations. The wells in closest proximity to the western lagoons had the most exceedances and at the highest concentrations (as would be expected) while the wells further from the lagoons had markedly fewer exceedances at lower concentrations (wells MW6S, MW26, and MW27).

Metals	No. of Exceedances of Background	Metals	No. of Exceedances of Background
aluminum	3	magnesium	6
arsenic	3	mercury	1
barium	3	nickel	12
cadmium	7	selenium	1
calcium	3	silver	1
total chromium	10	sodium	1
copper	2	zinc	12
iron	7	cyanide	3
lead	2		

Summary - Inorganic Contaminants in Groundwater Near the Western Lagoons

Groundwater in the vicinity of the western lagoons is impacted by metal contaminants but these contaminants have not migrated horizontally to any great extent as evidenced by the relatively few detections at low concentrations at wells downgradient and side gradient to the western lagoons, (wells MW6S, MW26, and MW28). Metals have migrated downward in the upper aquifer in the vicinity of the western lagoons to at least 29 ft which is the total depth of well MW8D.

Indicator Parameters in Groundwater at the Western Lagoons
At least 2 indicator parameters exceeded background concentrations in each well at or near the western lagoons. The following parameters were detected in exceedance:

Indicator Parameters	No. of Exceedances of Background
ammonia - N	11
COD	6
nitrate + nitrite - N	5
total kjeldahl - N	4
sulfate	12
TOC	1

Table 5-8 summarizes indicator parameters in exceedance of background concentrations. Nitrate + nitrite exceeded MCLs and Act 307 Type B Criteria in wells MW2, MW8D, and MW8S. Sulfate exceeded Act 307 Type B Criteria at wells MW1 and MW9S.

It is apparent groundwater is impacted by wastes deposited in the western lagoons because several indicator parameters detected at high concentrations in lagoon water (Table 5-16) were also detected at elevated concentrations in groundwater. The elevated nitrate + nitrite may be the result of fertilizer application to the adjacent agricultural fields or may be from spills at the Anderson Farm Service facility which stores liquid nitrogen (from the Industrial Survey - Appendix A). The elevated sulfate concentrations are likely the result of plating wastes such as sulfuric acid and sulfate salts which were by-products of manufacturing processes at Bronson Specialties (see the Industrial Survey - Appendix A).

Elevated indicator parameters were detected at least as far as well MW28 (approximately 450 ft) downgradient (west of the western lagoons), north of CD#30 (MW6S), south of the lagoons (MW26 and MW27), and east of the lagoons (MW9S). It is likely that contamination exists beyond the wells described above. In addition, elevated indicator parameter concentrations were detected to depths of 29 ft (total depth of well MW8D) and 49 ft (total depth of well MW27).

5.6.3 Summary and Overview of Contamination in and Near the Eastern and Western Lagoons

Relatively high concentrations of TCE, 1,2-DCE, and vinyl chloride were detected in groundwater wells at and downgradient of the western lagoons, and in the immediate vicinity of the eastern lagoons (see Figure 5-3). The same

chlorinated ethenes detected in groundwater at the western lagoons were also detected in the western lagoon sludge. While the western lagoons are a likely source of chlorinated ethene contamination, it is likely that similar contaminants from the Scott Fetzer subarea, the LA Darling subarea, abandoned industrial sewer line, DCC Plant #2, and possibly Bronson Specialties, and Bronson Precision Products have migrated in groundwater to the downgradient western lagoons. There are a number of other possible sources that were not part of the RI.

At the eastern lagoons, chlorinated ethenes were detected in groundwater and in subsurface soils at or below the water table only and were not detected in sludge samples from the two accessible lagoons. It is likely chlorinated ethenes would be detected in the three inaccessible lagoons since the eastern lagoons were used by known users of these compounds (DCC Plant #2, LA Darling, and Bronson Plating). Thus, the source of chlorinated ethenes at the eastern lagoons may be both on-site and upgradient. While several other organic compounds (PAHs and PCBs) were detected in eastern lagoon sludge, none of these compounds were detected in groundwater at the eastern lagoons.

High concentrations of metals were detected in lagoon sludge and subsurface soils at both the eastern and western lagoons. Metals appear to have migrated downward and horizontally. Wells in the immediate vicinity of the eastern and western lagoons show exceedances of MCL and/or Act 307 Type B Criteria. In addition, many metals show exceedances of local background concentrations in the immediate vicinity of the eastern and western lagoons.

5.7 COUNTY DRAIN #30 (CD#30)

Two rounds of surface water/sediment (SW/SD) and a single round of outfall (OF) samples were collected from CD#30. Seventeen surface water and 3 outfall samples were collected for analysis for TCL/TAL parameters, indicator parameters, and hexavalent chromium. Seventeen sediment samples were collected and analyzed for TCL/TAL parameters, only. See Figures 3-1 and 5-1 for sample locations. Note the Work Plan Addendum identified that 5 outfall samples be collected during Round 3 (Phase II), but at the time the samples were collected outfall samples OF2 and OF4 (farm outfalls) were dry, hence no samples were collected. The outfall samples collected included:

OF1 - Bronson Plating
OF3 - Bronson Wastewater Treatment Effluent
OF5 - Bronson Storm Sewer

Outfall Organics
VOC
Chlorinated Ethene Compounds
TCE, 1,2-DCE, and vinyl chloride were the only VOCs detected in outfall samples and each was detected at sample OF5, (Bronson storm sewer outfall), only. Chlorinated ethene compounds detected in sample OF5 included:

- TCE, detected at 72 ug/L.
- 1,2-DCE, detected at 370 ug/L.
- Vinyl chloride, detected at 34 ug/L.

SVOCs
SVOCs were detected in each outfall sample. A total of 11 different SVOCs were identified. PAH compounds were the predominant SVOCs detected in outfall samples. Phenol was detected in 1 sample, only.

PAH Compounds
Constituent PAH compounds included:

Compounds	Range of Concentration (ug/L)
naphthalene	9 to 25
2-methylnaphthalene	4 to 8
acenaphthylene	1 to 3
fluorene	1
phenanthrene	1 to 3
anthracene	1
fluoranthene	1
pyrene	2
benzo(b)fluoranthene	2
benzo(k)fluoranthene	2
benzo(a)pyrene	1

Total PAH concentrations are listed below:

Sample	Total PAHs (ug/kg)
OF1	49
OF3	7
OF5	13

Phenol Compounds
Phenol was detected at 1 ug/L in OF1 (Bronson plating outfall), only.

Pesticides
Gamma-BHC (lindane) was detected at 0.029 ug/L in OF3 (waste treatment plant outfall), only.

Summary of Organic Contaminants Detected From Outfalls to CD#30
The storm sewer outfall (OF5) had the only VOCs detected in outfall samples. It is possible the chlorinated ethenes detected in OF5 are from the storm sewer intercepting contaminated groundwater because these compounds were found to be distributed in groundwater across the site. See Figure 5-3. The PAHs detected in OF1 have relatively low concentrations and are allowed under Bronson Plating's National Pollutant Discharge Elimination System (NPDES) permit. Current NPDES permits for the Bronson waste water treatment plant and Bronson Plating are found in Appendix K. There were no organics detected in exceedance of Ambient Water Quality Criteria (AWQC) in the outfall samples.

Outfall Inorganic Analytes
Several metals at varying concentrations were detected in outfall samples. Two of the three outfall samples had 1 metal in exceedance of AWQC. Note, hexavalent chromium data for one round of outfall samples is not available due to laboratory error (data was never received from CRL). Resampling was deemed unnecessary because there is one round of hexavalent chromium data. Cadmium - 3.3 ug/L at OF5 and mercury 0.27 ug/L at OF1 were detected in exceedance of AWQC (Table 5-19).

Outfall Indicator Parameters
Indicator parameter concentrations detected in the outfall samples are compared to the highest concentration detected in 3 background samples collected from surface water in CD#30 (Table 5-20). Ammonia and TKN in OF3 (wastewater treatment plant outfall) were the only parameters detected in outfalls which exceeded background concentrations. Elevated ammonia and TKN values are typically found in wastewater treatment effluent and within the NPDES permit limits.

Overview and Summary of Contaminants from Outfall Samples
Outfalls OF1 and OF5 are contributing low concentrations of VOCs, SVOCs, and/or metals to CD#30, but only the metals exceeded AWQC. Ammonia and TKN exceeded background concentrations but these are typically found in wastewater treatment effluent.

Surface Water in CD#30
Seventeen surface water samples were collected over the course of the RI. This included background surface water samples.

Organic Compounds in Surface Water in CD#30
Numerous organic compounds were detected in surface water in CD#30 and most were at relatively low concentrations.

VOCs
Seven VOCs were detected in CD#30 surface water at relatively low concentrations. Nine of seventeen surface water samples contained VOCs.

BETX Compounds:
Constituent BETX compounds include:

- Benzene, detected at 1 ug/L in SW15 and SW16.
- Toluene, detected at 1 ug/L in SW8, only.

Chlorinated Ethene Compounds:

- Vinyl chloride was detected at 3 ug/L in SW14.
- TCE was detected in 4 surface water samples - 4 ug/L in SW8, 3 ug/L in SW14, 2 ug/L in SW15 and 2 ug/L in SW16.

- 1,2-DCE was detected in 7 surface water samples where concentrations ranged from 6 ug/L in SW7, SW15, and SW17 to 19 ug/L in SW4.

Chlorinated Ethane Compounds:

- 1,1,1-Trichloroethane (1,1,1-TCA) was detected at 2 ug/L in SW13, only.

Ketone Compounds

- 2-Butanone was detected at 3 ug/L in SW14, only.

SVOCs
Six SVOCs were detected in 6 of 17 surface water samples. Phenol compounds were the predominant compounds detected in surface water, although 2 phthalates and 1 PAH compound were also detected.

PAH Compounds
Naphthalene at 1 ug/L in SW3 was the only PAH compound detected.

Phthalate Compounds
Constituent phthalate compounds included:

- Bis(2-ethylhexyl)phthalate, detected in 6 ug/L at SW7, only.

- Diethylphthalate, detected at 1 ug/L in SW12, only.

Phenol Compounds
Constituent phenol compounds included:

- Benzyl alcohol, detected in 3 samples - 5 ug/L in SW1, 19 ug/L in SW3 and 6 ug/L in SW4.

- Benzoic acid, detected in 4 samples, which ranged in concentration from 18 ug/L in SW2 to 380 ug/L in SW3.

- 4-Chloro-3-methylphenol was detected at 7 ug/L in SW2 and 4 ug/L in SW3.

Pesticides
Four pesticides were detected in three surface water samples at relatively low concentrations. These included:

- Gamma-BHC (lindane), detected at 0.009 ug/L in SW17, only.
- Heptachlor, detected at 0.003 ug/L in SW12, only.
- Heptachlor epoxide, detected at 0.006 ug/L in SW17, only.
- Methoxychlor, detected at 0.024 ug/L in SW12, only.

Summary of Organic Contaminants Detected in CD#30 Surface Water
Few VOCs, which are at relatively low concentrations, were detected in CD#30 surface water. The chlorinated ethenes detected in SW8, SW14, SW15, SW16, and SW17, which are downstream of OF5, may be attributed to the storm sewer outfall (OF5). VOCs were also detected in CD#30 between Matteson Road and location SW7 (upstream of the storm sewer outfall). The source of these VOCs may be groundwater discharge into the CD#30. VOCs were not detected in SW10, collected in Swan Creek 100 ft downstream of the confluence of CD#30 and Swan Creek.

The source of phenol compounds in CD#30 surface water is undetermined, but the phenols may be breakdown components of naturally occurring organic matter.

Pesticides were detected upstream (background sample SW12) and downstream (SW17) of the site. The wastewater treatment plant outfall (OF3) contributes a relatively small concentration of lindane to CD#30, and the other pesticides detected in surface water are likely attributable to run-off from the agricultural fields around the site. It should be stated, the pesticide concentrations are very low (generally less than 10% of the required detection limits). Although not

qualified during data validation, these results are of questionable quality at such low concentrations.

Heptachlor epoxide in sample SW17 is the only organic compound in exceedance of AWQC. Table 5-19 summarizes AWQC exceedances at CD#30.

Inorganic Analytes in Surface Water in CD#30
Several metals were detected in surface water samples at varying concentrations. Many of the metals detected may be naturally occurring, but 5 metals and cyanide were detected at concentrations greater than AWQC. Eight of seventeen surface water samples had at least 1 analyte in exceedance of AWQC. Hexavalent chromium data for sample SW17 is not available, (analytical data was never received from CRL).

The following metals and cyanide were detected in exceedance of AWQC:

Metal	No. of Exceedances of AWQC
cadmium	1
copper	1
lead	2
selenium	1
cyanide	4
hexavalent chromium	1

Table 5-19 summarizes AWQC exceedances in CD#30 surface water. Background samples SW1, SW11, and SW12 each had metal and/or cyanide exceedances of AWQC. Copper was in exceedance in SW1, lead was in exceedance in SW1 and SW12, and cyanide was in exceedance at SW11 and SW12. Hence, there may be upgradient sources and surface water runoff which contribute metals and/or cyanide to CD#30.

Indicator Parameters in Surface Water in CD#30
Seventeen surface water samples were collected for indicator parameter analyses. Indicator parameter concentrations are compared to the highest of the background (SW1, SW11, SW12) indicator concentrations. Most indicator parameters were detected at greater concentrations in the background samples than in the downstream samples.

The following indicator parameters were detected in exceedance of background concentrations:

Analyte	No. of Exceedances of Background
chloride	1
ammonia-N	6
total kjeldahl-N (TKN)	5
sulfate	2

See Table 5-20 for a summary of indicator parameters in exceedance of background. The chloride concentration in the background sample appears to be high and there is an exceedance of chloride at SW3 which was collected near Matteson Road. The elevated chloride concentration in the background samples may be attributed to impacts from the salt storage facility at the Branch County Road Commission. It is likely sample SW3 may be impacted by road salt. Ammonia-N and TKN were detected in surface water in exceedance most frequently. SW6 was collected near the wastewater treatment plant outfall and the elevated ammonia-N and TKN values are typical at this location, as well as downstream samples SW7, SW8, SW16, and SW17. The elevated sulfate levels at samples SW1 and SW3 may be related to contaminants at the eastern lagoons.

Summary of Contaminants in Surface Water in CD#30

The source of VOCs detected in surface water is likely from the storm sewer outfall (OF5) and groundwater discharge directly to CD#30. There is no clear source of the phenols detected in surface water in CD#30 but they are typical breakdown constituents of naturally occurring organic matter. Pesticides are likely present in CD#30 due to runoff from agricultural fields in the area. Metals detected above AWQC in CD#30 may be attributable to groundwater and outfall discharge into CD#30.

The following wells were located adjacent to or near CD#30 to monitor the discharge of groundwater to CD#30. The Act 307 Type B criteria concerning contaminated groundwater discharges to a surface water body (groundwater/surface water interface (GSI)) may or may not be determined to be a cleanup standard.

MW4	MW8S
MW5	MW17S
MW6	MW18
MW7S	MW25

Table 5-21 summarizes groundwater exceedances of GSI values for organics, vinyl chloride and TCE were detected in exceedance.

Table 5-22 summarizes groundwater exceedances of GSI values for metals. The following metals and cyanide were detected in exceedance:

Metal	No. of Exceedances of GSI values
cadmium	4
lead	1
nickel	4
zinc	3
cyanide	4

According to Act 307 Type B GSI values, several organic and inorganic contaminants in groundwater are impacting CD#30 surface water.

Sediments in CD#30

Seventeen sediment samples were collected in conjunction with surface water samples in CD#30. Sediment samples were analyzed for TCL organics and TAL inorganics. There is little correlation between the types and concentration of compounds detected in sediments and those detected in surface water in CD#30.

Organic Compounds in Sediments in CD#30

Few VOCs were detected in CD#30 sediments but numerous SVOCs at relatively high concentrations were detected, as were pesticide and PCB compounds.

VOCs

Six VOCs were detected in sediment samples. Nine of seventeen sediment samples had at least one VOC detected.

Ketone Compounds

Constituent ketone compounds included:

- Acetone was detected in 7 sediment samples and ranged in concentration from 10 ug/L in SD2 to 120 ug/kg in SD7.
- Methylene chloride was detected at 6 ug/kg in SD1, only.
- 2-Butanone was detected at 21 ug/kg in SD14, only.

BETX Compounds

Toluene was detected at 9 ug/kg in SD4 and 200 ug/kg in SD7.

Chlorinated Ethene Compounds

1,2-DCE was detected at 2 ug/kg in SD14 and 5 ug/kg in SD15.

Miscellaneous VOCs

Carbon disulfide was detected at 87 ug/kg in SD7.

SVOCs

Twenty SVOCs (predominantly PAHs) were detected at relatively high concentrations throughout CD#30 sediments. The samples collected furthest upstream (SD11 and SD12 east of the site) and downstream (SD9 and SD10 in and near Swan Creek) were the only samples with no SVOCs detected.

PAH Compounds

Constituent PAH compounds included:

Compound	Range of Concentrations (ug/L)
anthracene	160 to 830
fluoranthene	95 to 14,000
pyrene	48 to 9,800
acenaphthene	87 to 150
phenanthrene	62 to 4,800
acenaphthylene	280
naphthalene	670
chrysene	88 to 5,800
benzo(b)fluoranthene	280 to 12,000
benzo(k)fluoranthene	280 to 12,000
benzo(a)pyrene	100 to 4,200
carbazole	91
benzo(a)anthracene	75 to 5,300
2-methylnaphthalene	170
indeno(1,2,3-cd)pyrene	89 to 3,700
dibenz(a,h)anthracene	1,200
benzo(g,h,i)perylene	160

Total PAH concentrations were as follows:

Sample	Total PAHs (ug/kg)
SD1	700
SD2	143
SD3	8,290
SD7	11,530

Sample	Total PAHs (ug/kg)
SD8	37,230
SD13	535
SD14	4,630
SD15	1,930
SD16	76,570
SD17	4,180

PAH compounds were not detected in samples SD4, SD5, SD6, SD9, SD10, SD11, and SD12.

Phthalate Compounds
Constituent phthalate compounds included:

- Bis(2-ethylhexyl)phthalate, detected in 9 sediment samples, which ranged in concentration from 260 ug/kg in SD4 to 29,000 ug/kg in SD7.
- Di-n-octylphthalate, detected at 230 ug/kg in SD14 and 720 ug/kg in SD16.
- Butylbenzylphthalate was detected in 3 samples, 130 ug/kg in SD15, 820 ug/kg in SD16, and 150 ug/kg in SD17.

Pesticides
Pesticides were not detected in Round 1 sediment samples SD1 through SD10 whereas 6 of 7 Round 2 sediment samples contained pesticides at low concentrations. Pesticides detected in Round 2 are likely due to the lower detection limits and reporting requirements for Round 2 data. In addition, many of the pesticides were detected in background sediments at similar concentrations as downstream sediments. The following pesticides were detected:

Compounds	Range of Concentrations (ug/kg)
beta-BHC	26
delta-BHC	0.2 to 1.1
gamma-BHC	0.17 to 0.92
dieldrin	0.25 to 0.71
endrin	0.34 to 1.1
4,4'-DDT	0.38
4,4'-DDE	0.99 to 24
4,4'-DDD	0.71 to 11
endrin aldehyde	1.4 to 18

Compounds	Range of Concentrations (ug/kg)
endosulfan II	16
aldrin	0.45
endosulfan sulfate	1.0
alpha-chlordane	0.44 to 26

Sample SD15 had the highest concentration of pesticides detected in CD#30 sediments. There is no apparent reason that concentrations are greater at this location.

PCBs

PCBs were detected in 6 of 17 sediment samples (SD7, SD8, SD9, SD10, SD16 and SD17). PCBs detected included:

- Aroclor 1248, detected at 1,400 ug/kg in SD17, only.
- Aroclor 1254, detected in 6 samples which ranged in concentration from 55 ug/kg in SD9 to 1,600 ug/kg in SD17.

PCBs were detected at and downstream of the western lagoons and in the Swan Creek.

Summary of Organic Contaminants Detected in CD#30 Sediments

Few VOCs were detected in sediment samples. PAH compounds were the predominant contaminants detected in sediments, and were detected at various concentrations throughout CD#30. The highest concentrations of PAHs were detected directly north and west (downstream) of the western lagoons. Pesticides were detected in 6 of 7 Round 2 sediment samples (including the background sample), over the length of CD#30. Sample SD17 had the highest concentration of pesticides. PCBs were detected in sediment samples located directly north of the western lagoons (SD7) and west (downstream) of the western lagoons. The highest PCB concentration was detected at SD17 located in CD#30 approximately 75 ft from the confluence of CD#30 and Swan Creek. PCBs were also detected in sample SD10 which was collected in Swan Creek 100 ft downstream from the confluence of CD#30 and Swan Creek. Since PCBs were also detected in CD#30 between the site and Swan Creek it is likely the PCBs detected in Swan Creek are attributable to the site and have migrated to Swan Creek. Table 5-23 summarizes organic compounds in exceedance of Act 307 Type B criteria (direct contact values) in CD#30 sediments.

Inorganic Analytes in CD#30 Sediments
Metals detected in CD#30 sediments will be discussed in relation to the concentrations in background sample SD11. Although SD1, SD11, and SD12 were collected for background, it was determined that SD1 and SD12 were likely impacted by site activity and should not be used for background comparisons. Sediment samples SD1 and SD12 each had elevated levels of cadmium, chromium, copper, lead, nickel, and zinc which are the predominant waste metals associated with the eastern lagoons. Twenty-two metals and cyanide were detected in exceedance of background in at least one sediment sample. Only, thallium was not detected in CD#30 sediments.

Summary of Inorganic Analytes in CD#30 Sediments
Table 5-24 summarizes minimum and maximum metal concentrations, frequency of detection and frequency of exceedance of background in sediments. Most metals were detected frequently and at relatively high concentrations in CD#30 sediments. Only, antimony, beryllium, mercury, selenium, sodium, silver, and cyanide were detected infrequently (4 or less detections) and at relatively low concentrations.

Samples at SD7 and SD8 located north and northeast respectively, of the western lagoons indicate the greatest site impact on sediments. Each sample contained 6 inorganic analytes at their maximum concentrations. CD#30 sediments may also be impacted by run-off from agricultural fields located north and along the length of CD#30.

Summary of Contaminants Detected in CD#30 Sediments
Relatively high concentrations of PAHs, PCBs, and metals were detected in CD#30 sediments. There is little doubt contaminants from the eastern and western lagoons have impacted CD#30 sediments. The types of compounds detected in sediments (PAHs, PCBs, and metals) are more readily bound to sediments and less mobile than VOCs, and are expected to be found in sediments rather than surface water.

5.7.1 Overview of Contaminants in CD#30
Numerous organic compounds were detected in CD#30 surface water but most compounds were detected at relatively low concentrations and no organic compounds exceeded AWQC. Contaminants are entering CD#30 via storm sewer outfall (OF5), Bronson Plating outfall (OF1), and groundwater discharge to CD#30. (Bronson Plating was not in exceedance of allowable concentrations under their NPDES permit at the time of sampling.) Surface water runoff from the agricultural fields and land adjacent to CD#30 may also be impacting surface water and sediments in CD#30.

Cadmium and mercury are entering CD#30 surface water via outfalls OF5 and OF1, respectively. The remaining metals detected in surface water in exceedance of AWQC may be attributable to release from contaminated sediments in CD#30 and/or groundwater discharge to CD#30.

Relatively high concentrations of PAHs, PCBs, and metals were detected in CD#30 sediments, but only PCBs exceeded Act 307 Type B Criteria (direct contact values). The PAHs, PCBs, and metals were detected at greatest concentrations at and downstream of the western lagoons. PCBs and to a lesser extent metals were detected in Swan Creek and are likely attributable to the site. PCBs were not detected in western lagoon sludge samples but PCBs were detected in subsurface soils and sludge at the eastern lagoons. Thus a likely source of PCBs is (or was) the storm sewer and the eastern lagoons. Surface water runoff from the area may have also contributed to the PCBs detected in CD#30.

5.8 OVERVIEW OF THE NORTH BRONSON SITE

Contaminants at North Bronson are found at numerous locations and at varying concentrations but can be put into two major categories - chlorinated ethene compounds (TCE, 1,2-DCE, and vinyl chloride) and metals (cadmium, total chromium, copper, nickel, and zinc).

The following source areas of organic compounds have been identified at North Bronson and include:

- LA Darling Subarea
- Scott Fetzer Subarea
- Western Lagoons
- Eastern Lagoons
- Abandoned Industrial Sewer (Western) Subarea
- DCC Plant #2

There are other possible sources that were not part of this RI. TCE and 1,2-DCE were the predominant compounds detected in groundwater and soil, with vinyl chloride detected at lesser concentrations. TCE is likely the parent compound and 1,2-DCE and vinyl chloride may be degradation products of TCE (to be discussed in Section 6). TCE is a common industrial solvent and was likely in the waste stream deposited in the western lagoons. Chlorinated ethene contamination is found downgradient of the source locations and at depth in the upper aquifer (to the top of the aquitard) at concentrations in exceedance of MCLs and/or Act 307

Type B Criteria. See Figure 5-3 for the approximate distribution of chlorinated ethene compounds in groundwater at North Bronson.

High metal concentrations were detected in subsurface soils, lagoon berm soils, lagoon sludge and groundwater at the eastern and western lagoons. The predominant metals detected; cadmium, total chromium, copper, lead, nickel, and zinc are common to the plating industry as well as other heavy industry. Cadmium is detected at RCRA hazardous concentrations in lagoon sludge at the eastern and western lagoons and some subsurface soils at the eastern lagoons. As opposed to the chlorinated ethene compounds which have migrated hundreds of feet, metals have not migrated very far from source areas. Metals are detected at elevated concentrations, compared to background (see Figure 5-4), however there are few exceedances of MCLs or Act 307 Type B Criteria outside the immediate influence of the eastern and western lagoons.

Although chlorinated ethene compounds and metals are the predominant contaminants at North Bronson, PAH compounds and PCBs were also detected at relatively high concentrations in certain areas. PAH compounds were detected at relatively high concentrations in soils and sludges at the eastern lagoons, CD#30 and in soils (SB15) at LA Darling. PCBs were detected at relatively high concentrations in CD#30 sediments downstream of the western lagoons, Swan Creek, and in eastern lagoon sludge. PAH compounds and PCBs have not migrated from the contaminated sludges and soils into groundwater.

Contaminants are also entering CD#30 via outfalls OF1 (PAHs) and OF5 (chlorinated ethenes), and contaminated groundwater discharges to CD#30.

Migration of contaminants at the site has been discussed briefly in Section 5 but will be the focus of Section 6.0. Fate and migration of contaminants is important when developing the Baseline Risk Assessment and remediation alternatives. Chapter 6 will discuss the general physical and chemical processes affecting transport of contaminants, specific migration pathways of contaminants at North Bronson, and fate and persistence of contaminants at North Bronson.

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6

CONTAMINANT FATE AND MIGRATION

The release of hazardous substances from sources at the site and the subsequent transport and transformation in the surrounding environment are dependent on properties of the transporting media, specific properties of the chemical contaminants, climatic conditions, and site-specific features. Several contaminant transport processes affect the migration and subsequent fate of a contaminant in the environment.

Migration pathways define the route and method by which a contaminant moves from the source(s) to potential receptors at or near the site. Three migration pathways are present at the site: air and wind, surface water and sediments, and groundwater. Review of the data collected at the site indicates that sufficient quantity and quality of data has been gathered to evaluate the fate and migration of contaminants at the site.

The contaminant fate and migration section of this report is divided into 4 sections. These include:

- Section 6.1 - Processes affecting Contaminant Transport
- Section 6.2 - Site Contaminant Migration Pathways
- Section 6.3 - Fate and Persistence of Site Contaminants
- Section 6.4 - Summary

Section 6.1 discusses generic processes affecting contaminant transport. The processes listed do not necessarily indicate these are actually occurring at the site. This information is presented as background for the reader. Section 6.2 discusses potential migration pathways at the site. Section 6.3 discusses specific migration pathways, fate and persistence of contaminants at the site. Section 6.4 summarizes the entire Section 6, as it pertains to the site.

6.1 PROCESSES AFFECTING CONTAMINANT TRANSPORT

Physical and chemical processes affecting contaminant transport include the following:

- Sorption/desorption (organic analytes) - the retention or dissolution of a solute (contaminant) in the geologic media by means of partitioning between groundwater and the surfaces of the aquifer geologic matrix

- Sorption/desorption (inorganic analytes) - the retention or dissolution of metals, which is dependent on the geologic matrix, hydrochemical environment, and the specific valence state of the element

- Volatilization - the loss of contaminants from soils by desorption from soils, diffusion from water, dissolution into infiltration water, interphase mass transfer, and diffusion in air

- Leaching - the transfer of contaminants by infiltration and percolation of precipitation through waste or contaminated soils

- Degradation - the biological decomposition or chemical reaction of the solute

- Advection - the transport of a contaminant at a velocity proportional to that of groundwater flow. Dispersion, or the spreading of contaminants, occurs during transport due to variations in aquifer permeability, fluid mixing, and molecular diffusion

- Dilution - a non-reactive species introduced into groundwater or surface water will decrease in concentration as it is transported away from the source

- Overall mobility - the mobility of contaminants in soils is dependent on several physical and chemical properties of the contaminants (refer to Table 6-1)

- Precipitation - the control of aqueous phase metal concentrations, by binding metals out of solution through the formation of solids, which is dependent on the pH of groundwater and the presence of carbonated hydroxides in the aquifer

6.1.1 Sorption/Desorption (Organic Analytes)

Dissolved organic compounds tend to adsorb onto or desorb from solid phases that come in contact with water. Because a large solid surface area is available in most soils, the mass of solute adsorbed may be substantial. The amount of contaminant that is adsorbed by a soil is dependent on soil grain size, mineral composition, organic content, solute composition, and solute concentration. The adsorption capacity relationship is frequently expressed by the soil/water partition coefficient or distribution coefficient (K_d). K_d values for specific compounds can be estimated from the organic carbon partition coefficient (K_{oc}) (refer to Table 6-1) and the organic carbon content (Karickhoff, 1984; Schwarzenbach and Westall, 1982; and Wilson, et al., 1981). K_{oc} may be used to describe the relative affinity of a contaminant for soil organic matter and water. In general, compounds with relatively high K_{oc} values also have high K_d values. These substances are more easily adsorbed than compounds with low K_{oc} and therefore low K_d values, and many also desorb or leach from solid surfaces more readily.

K_d may be applied to saturated zone contaminant transport to estimate the retardation factor (R_f) for a contaminant. The retardation factor is related to the K_d value according to the following equation:

$$R_f = 1 + (P_b/N) \times K_d$$

Where: P_b = Aquifer bulk density (g/cm^3)
N = Total porosity of the aquifer (unitless)
K_d = Distribution coefficient (mL/g)
K_d = (K_{oc} x organic carbon fraction in soils)

Retardation factors have been calculated for compounds detected at the Site and are found on Table 6-1. Table 6-1 also contains the assumptions for porosity and natural organic content of soils used to compute the retardation factor.

The retardation factor describes how sorption decreases the rate of contaminant transport in the liquid phase, relative to nonreactive species (R_f=1). The retardation factor represents the ratio of groundwater velocity to contaminant velocity, or the ratio of total contaminant mass in the aquifer to the mass in solution. For example, a contaminant with a retardation factor of 2 moves at one-half the groundwater velocity and would have 1 gram adsorbed for each gram in solution.

6.1.2 Sorption/Desorption (Inorganic Analytes)

Sorption/desorption reactions involving inorganic species are dependent on the geologic matrix, the hydrochemical environment, and the specific valence state

and ionic radii of the adsorbed element. Important adsorbent media include the following:

- Hydrous oxides of aluminum, iron, and manganese
- Amorphous aluminosilicates
- Organic matter
- Lattice silicates or clay minerals

The hydrochemical environment controls ion speciation, provides ions that compete for adsorption sites affecting the net surface charge on amphoteric adsorbents (e.g., Fe and Mn oxides, amorphous aluminosilicates), and affects base saturation and exchangeable acidity of cation exchange materials. Element speciation is controlled primarily by solution pH, eH, and ion composition. In general, research indicates only uncomplexed ions (e.g., Cd^{2+}), rather than complexed ions (e.g., CdSO, CdCO), are adsorbed. Hydrochemical conditions in groundwater favoring complexation may reduce adsorption. Similarly, solution redox potential controls the valence of redox sensitive elements. For some elements (e.g., Cr), different valence states exhibit different adsorption behavior. Major anions (e.g., SO^{2-}) affecting solution speciation of cations via complexation may compete for available sorption sites with contaminants of similar chemical behavior (e.g., SeO^{2-}, CrO^{2-}). This reduces the sorption of each individual constituent. Most specific adsorbents (e.g., Fe, Mn oxides, amorphous aluminosilicates) have a pH-dependent surface charge. These constituents are positively charged at pH values below their point of zero charge (PZC), and negatively charged above. Thus, decreasing groundwater pH increases positive charge and favors anion retention, while increasing pH encourages cation retention.

The cationic elements are sorbed specifically and by ion exchange. With the exception of Na and Ba, the specific sorption process predominates for most trace constituents at lower concentrations ($<10^{-5}$ M [molarity]). Ion exchange is favored when the specific sorption capacity is exceeded. The affinity of adsorbed cations for hydrous oxides decreases in the following order: Pb > Cu > Zn > Ni ≥ Cd. Some cationic elements, notably Cu and Hg, are strongly complexed by particulate organic materials. The sorption of most cationic elements increases with increases in pH, and the cations are more mobile in acidic conditions (Battelle, 1984).

Ligands (e.g., Cl^-, SO^{2-}, F^-, and organics) forming stable aqueous complexes with cations (e.g., Pb^{2+}, Cu^{2+}, Ni^{2+}, Hg^{2+}) reduce free cation activity and element adsorption. The presence of macro ions (e.g., Ca^{2+}, Na^+) and specifically absorbing ions (e.g., Cu, Zn, Cd) in solution reduces absorption by competition for cation exchange and specific adsorption sites.

6.1.3 Volatilization

Volatilization may be a significant process for reducing some contaminant levels in soils (Lyman and Reehl, 1981; Swallow and Gschwend, 1983). Factors controlling volatilization include soil porosity, soil moisture content, surface wind speed, temperature, surface characteristics (e.g., hard packed, vegetative cover, paved, tilled, etc.), and contaminant properties, including Henry's Law constant and diffusivity. Volatilization involves several steps, including desorption from soils, diffusion in water, interphase mass transfer, and diffusion in air.

Volatilization is an important process to examine in unsaturated soils, due to the presence of an air phase. The air phase acts as a pathway for gas phase diffusion of VOCs through the unsaturated zone to the atmosphere. A volatile solute tends to partition between either water and air phases, or solid and air phases. The water/air equilibrium situation is described by the Henry's Law constant (refer to Table 6-1). The air/solid situation would be described by an air/solid partition coefficient. However, little published information is available to estimate the partition coefficient. In natural soils, sufficient soil moisture will be present to maintain a thin water film most of the time. Therefore, the air/solid equilibrium is neglected and Henry's Law constant is used to describe the air/water solute distribution.

The substances with relatively high Henry's Law constants (refer to Table 6-1) readily partition into the air phase, and higher volatilization losses will be observed for these substances. Substances with relatively high diffusivities in air also exhibit higher volatilization losses. Although no simple relationship between the Henry's Law constants and molecular diffusivity exists, there are greater difference(s) in Henry's Law constants than in diffusivities between different substances. Therefore, the magnitude of the Henry's Law constants may be used as the primary semi-quantitative indicator for contamination loss through volatilization.

Volatilization of organic compounds from surface water is a significant process for losses of VOCs to air. The vapor pressure of VOCs indicates which VOCs are more susceptible to volatilization losses. Compounds with higher vapor pressures (vinyl chloride, 1,2-DCE) tend to volatilize to air from surface water more rapidly than other VOCs, SVOCs, pesticides, or PCBs.

6.1.4 Leaching

Leaching of compounds from saturated and unsaturated zones can be a mechanism transferring contaminants to groundwater. The leachability of hydrophobic chemicals depends on several factors, including the flow rate of water through the contaminants and the solubility of the specific chemicals in water. Table 6-1 indicates solubilities are variable for the chemicals listed.

Generally, the compounds with the high to mid-range solubilities in water also have the greatest potential for leaching into the groundwater system. These compounds include: chlorinated ethanes, chlorinated ethenes, and phenol compounds. Whereas, metals and PAH, pesticide, and PCB compounds have relatively low solubilities and the least potential for leaching into groundwater.

6.1.5 Degradation

Biodegradation may be an important attenuation process, under the proper conditions. In laboratory studies, Bouwer and McCarty (1983), Parsons, et al. (1984), and Kloepfer, et al. (1985), have demonstrated that microbially mediated reductive dehalogenation of chlorinated alkanes and alkenes occurs in environments similar to those found in groundwater systems. Cline and Viste (1984) presented chemical data from several hydrogeologic investigations demonstrating field trends are consistent with the predictions of laboratory studies.

In general, the referenced investigations suggest chlorinated parent compounds, such as tetrachloroethene, trichloroethene, and 1,1,1-trichloroethane can be converted sequentially through the loss of a chlorine atom to tri-, di-, or mono-chlorinated species by reductive dechlorination. This reaction appears to be microbially mediated, although the precise reaction mechanisms are not well understood. The degradation reactions are favored under anaerobic or anoxic conditions, with a nonhalogenated carbon source present for sustaining the bacterial community. The typical degradation pathway is:

$$\text{tetrachloroethene} \rightarrow \text{trichloroethene} \rightarrow \left[\begin{array}{l} \rightarrow \text{cis 1,2-dichloroethene} \\ \rightarrow \text{trans 1,2-dichloroethene} \\ \rightarrow \text{1,1,-dichloroethene} \end{array}\right] \rightarrow \text{vinyl chloride} \rightarrow \text{carbon dioxide}$$

Microbially mediated degradation of aromatic hydrocarbons (BETX compounds) is also an important process determining fate and migration of contaminants. Olsen and Davis (1990) and Barker, Patrick and Major (1987), have demonstrated degradation of BETX compounds occurs in laboratory experiments and groundwater systems. Oxygen is likely the limiting factor for biotransformation of aromatic hydrocarbons. Anaerobic biotransformation likely occurs, but rates appear extremely slow. BETX compounds degrade to non-hazardous compounds.

Degradation under aerobic conditions without another carbon source is slow or nonexistent (Bouwer, et al., 1981). Transformation of chlorinated alkanes and alkenes is expected to be slow in the upper unsaturated zone, where the exchange of atmospheric and soil gases normally creates aerobic conditions. Under anoxic or anaerobic conditions, degradation will be slow due to the lack of a carbon source supporting normal bacterial metabolism.

6.1.6 Overall Mobility

The mobility of organic chemicals in soil is controlled by several chemical properties. These properties must be considered together, along with Site factors, to develop an accurate depiction of contaminant movement in soils and groundwater. See Table 6-1 for a summary of physical and chemical properties of contaminants found at the site. Solubility describes the extent to which a pure chemical dissolves in water. Henry's Law constant describes the partitioning between water and air. K_d describes the partitioning between water and soil. Vapor pressure describes the volatility of a pure substance. Density indicates whether a pure substance will sink or float in water. Melting and boiling points indicate the state or phase of a pure substance at the prevailing temperature. Therefore, contaminant fates depend on which phases are present. In unsaturated soils, there are solid, gas, and liquid phases present. At a high soil moisture content, volatilization losses are reduced due to the lower volume available for gas porosity and permeability. In saturated soils, only liquid and solid phases are present, so sorption and residual saturation become important. Biodegradation may be significant in saturated and unsaturated soils, depending on the prevailing environmental factors relevant to biological activity.

6.1.7 Precipitation (Inorganic Analytes)

Precipitation is generally controlled by solubility. Therefore, the thermodynamic behavior of various species may be used to predict the most stable phase that will form in a geologic environment. However, the thermochemical behavior of numerous trace elements (e.g., Pb, Cd, Ni, etc.) are not adequately described in the literature. Evidence for the existence of solubility-controlling solid phases is often indirect, such as the comparison of ion activity products to solubility products. The observed and speculated solid/mineral phases that may control the aqueous concentrations of priority pollutant metals are shown in Table 6-2.

Hydroxide and carbonate solids are more soluble at low pH values, and these phases are important in alkaline geologic materials ($pH \geq 7.0$). Previous investigations indicate that precipitation is a primary attenuation mechanism for Fe, Al, and Mn. These elements form a variety of compounds, which limit their concentration in groundwater. Crystalline and amorphous oxides of Fe are common in geologic materials. Previous investigations (Battelle, 1984) suggest that formation of Fe containing solids (e.g., FeMoO, $NiFeO_4$, Fe(SeO) may be a significant chemical attenuation mechanism for trace constituents.

6.1.8 Advection

Advection is the primary mechanism for contaminant movement during transport by flowing groundwater. As groundwater passes through the sand and gravel deposits in the upper aquifer at the site, contaminants are dissolved and carried off. Contaminant migration within groundwater is a function of the chemical

properties listed in Table 6-1 and aquifer characteristics including porosity, permeability (Table 4-1), and horizontal and vertical gradients (Table 4-4 and 4-5, respectively).

6.1.9 Dilution

A non-reactive species introduced into groundwater or surface water will decrease in concentration as it is transported from the source. Dilution attenuation of an analyte is independent of other chemical mechanisms affecting concentration over distance from the source. Nonreactive species such as chloride are affected primarily by dilution.

6.2 SITE CONTAMINANT MIGRATION PATHWAYS

Three potential contaminant migration pathways have been identified at North Bronson. The migration pathways include:

- Air and wind
- Surface water and sediments
- Groundwater

The air and wind migration pathway includes potential transport of contaminants by volatilization from surface soils, and wind erosion of contaminated surface soils. The surface water and sediment pathway involves transport of contaminated surface soils off site and transport of contaminants in surface water and sediments off site. The groundwater migration pathway involves the transport of contaminants from surface and subsurface sources to groundwater and the vertical and horizontal distribution of contaminants in groundwater.

6.2.1 Air and Wind

Industrial Complex - Based on the types of contaminants and concentrations present at the LA Darling subarea and the Scott Fetzer subarea, (TCE, 1,2-DCE, and vinyl chloride) volatilization of contaminants through soils into surrounding air may be a contributing transport process. Since current cover in these areas is generally a porous, silty, sand and gravel with areas of sparse vegetation (LA Darling subarea) and grass (Scott Fetzer subarea), it is likely some volatilization of contaminants into the surrounding air is occurring. Soil gas and/or air data was not collected for the site, as part of the RI scope of work. Thus there is no way to determine the amount of volatilization occurring.

Contaminants in the surface and subsurface soils at the Scott Fetzer subarea and the abandoned industrial sewer line (western) have relatively low potential for

release to the air as particulates because of the depths of contaminants below ground surface and because the area is generally covered with grasses.

Approximately 40% of the LA Darling area is covered by concrete (foundation remains). However, contaminants in surface soils at LA Darling not covered by the concrete have a relatively higher potential for release to the air as particulates where there is little vegetative cover. The silty sand and gravel is porous and susceptible to wind erosion so any metals or organic compounds within the first 6 in. of surface soil may be subject to wind erosion.

Eastern and Western Lagoons - Contaminated materials within the lagoon areas have relatively low potential for release to the air as particulates because the eastern lagoons are covered with soils and dense vegetation and are generally lower than surrounding areas, while the western lagoons have 3 to 4 ft of water or dense vegetation over contaminated sludges. The cover soils on the eastern lagoons are a loose silty sand, and the abundant vegetative cover is dominated by grasses, trees, and bushes. The depressed area of the eastern lagoons and abundant vegetation make wind erosion of contaminated soils and sludge an unlikely occurrence. Areas at the western lagoons susceptible to wind erosion are the top of the lagoon berms and higher ground between lagoons. These areas have loose, sandy silt loam with little vegetative cover.

Based on the types of contaminants present in the eastern and western lagoons (metals and VOCs), volatilization of contaminants through the soils into the surrounding air is not likely a major contributing transport process. If physical conditions at the Site change (e.g., an unvegetated or poorly vegetated, eroded, porous soil cover) volatilization could become a greater contributing process. Since the current cover at the eastern lagoons consists of a moderately porous silty sand covered by dense vegetative growth and the current geologic processes acting on the eastern lagoons are dominated by sedimentation (see Section 6.2.2 for a discussion on sediments), rather than erosion, it is unlikely that significant volatilization of contaminants into the surrounding air is occurring.

VOCs in groundwater may migrate into the vadose zone and then, during periods of precipitation and infiltration, may be redissolved and contaminate additional soils.

CD#30 - Release of contaminants from CD#30 sediments via airborne particulates is not likely because there is, generally, surface water in CD#30, which would inhibit wind erosion.

VOCs detected in CD#30 surface water (vinyl chloride, 1,2-DCE, and TCE) are likely volatilized directly into the air because of the relatively high vapor pressures of these compounds.

6.2.2 Surface Water and Sediments

Based on the RI analytical results (Appendix I), surface water and sediments in CD#30, adjacent to and downgradient of the site contain organic compounds and elevated concentrations of metals. There are continuous releases of contaminants to surface water and sediments in CD#30 by groundwater and outfall discharges to CD#30. There is little correlation between contaminants detected in surface water (VOCs) and sediments (PAHs, phthalates, PCBs and metals). This is expected as PAHs, phthalates, PCBs and metals are preferentially adsorbed to sediments and organic matter. Surface water is likely transporting contaminants (dissolved and bound to sediments) from the site. Contaminated surface water and sediments are being carried downstream and off-site. PCBs were detected in Swan Creek 100 ft downstream of the confluence of CD#30 and Swan Creek.

Transport of contaminants by surface water run-off from the eastern and western lagoons is not likely because the lagoon areas are generally lower than surrounding areas; thus, surface water preferentially runs onto the lagoons rather than off the lagoons. Sedimentation from surface water running onto the lagoons is a more likely occurrence than erosion. Sedimentation may actually decrease the potential for air and wind transport of contaminants in these areas.

There is little potential for surface water runoff at the Industrial Complex because of the combination of a relatively flat gradient and porous, sandy surface soil.

6.2.3 Groundwater

Groundwater is the migration pathway with the greatest potential for release of contaminants from site sources at present and in the future. Transport of contaminants in the groundwater flow system at the site is presently occurring.

Eastern and Western Lagoons - Leaching of contaminants from subsurface soils and lagoon sludge in the eastern and western lagoons likely occurs by the infiltration of precipitation through the existing cover, and percolation through the sludge and contaminated soils, thus releasing contaminants to groundwater. Once in contact with groundwater, contaminants have varying potential to migrate off-site. Migration of individual contaminants will be controlled by the respective retardation factors. However, VOCs will tend to migrate to the greatest extent.

The primary directions for migration of contaminants in the groundwater flow system at the eastern lagoons is north (toward the county drain) where groundwater is believed to discharge into CD#30. Groundwater flows to the north

and northwest at the western lagoons, toward Swan Creek (see Figure 3-8), as evidenced by the contaminants detected at well MW28 (located between the western lagoons and Swan Creek.

Industrial Complex (Scott Fetzer Subarea and LA Darling Subarea) - Leaching of contaminants from source areas at the Scott Fetzer and LA Darling subareas likely occurs by infiltration of precipitation through the porous surface soils and percolation through the contaminated soils. This transport mechanism releases VOCs to groundwater. If the contaminant source is at or below the water table, contaminant transport would follow groundwater flow (advection) to the west-northwest. Once in contact with groundwater, the contaminants have a relatively high potential for migration, as supported by downgradient analytical data. (See groundwater results in wells MW10S, MW10D, MW5S, MW5D, MW24, and MW25).

The upper aquifer at the site is composed primarily of glacial silty sands and gravels. The rate at which contaminant migration will occur by groundwater flow in the sand and gravel aquifer is dependent on several hydrogeologic factors. These include: the silt and clay content in the sand and gravel matrix, porosity and permeability of the underlying aquitard unit and the hydraulic characteristics of the groundwater flow system. See Table 4-1 for hydraulic conductivities in groundwater wells. The geometric mean hydraulic conductivity in the upper aquifer is 1.38×10^{-3} ft/sec (4.21×10^{-2} cm/sec) which means the upper aquifer is relatively permeable and contaminants would be expected to migrate at a relatively high rate.

The extent of chemical migration in the aquitard is dependent upon factors related to the hydrochemical environment, the physical and chemical properties related to the contaminants, and the relative amount of contaminants present. The physical and chemical properties which influence the rate and extent of contaminant migration within the upper aquifer include solubility, vapor pressure, organic carbon partition coefficient (K_{oc}), and the octanol water partition coefficient (K_{ow}).

Each contaminant present has varying tendencies for migration depending on individual properties (Table 6-1). Contaminants in shallow groundwater have been detected approximately 600 ft downgradient of the western lagoon area (well MW28). See Figure 5-3 for the approximate distribution of total chlorinated ethene compounds and Figure 5-4 for the approximate distribution of metals in groundwater.

Contaminants at the site have also migrated vertically downward. Vertical gradients are presented in Table 4-5.

Vertical gradients are variable within the site but, generally, near CD#30 appear to be consistently upward, which indicates contaminated groundwater discharges to CD#30. Vertical gradients furthest to the south (industrial complex) appear to be predominantly downward, while vertical gradients in the central area of the site (wells MW5S and MW5D) vary between upward and downward. Downward vertical gradients have carried contaminants down through the upper aquifer to at least the top of the aquitard. Two private wells, the Borgert and the Eichler wells are reportedly screened in the lower aquifer. Manganese and iron were detected in the Eichler well at concentrations exceeding the secondary MCLs in Round 1 and 2 and in the Borgert well in Round 1, only. Zinc exceeded secondary MCLs in the Eichler well in Round 1, only. Results from samples from these two private wells did not seem to indicate that contaminants from south of the drain have migrated into the lower aquifer in this area. However, because the lower aquifer was not investigated as part of the RI, this cannot be stated conclusively.

There is apparently another groundwater migration pathway. It appears contaminated groundwater is intercepted by the Bronson storm sewer which in turn flows into CD#30. Groundwater in the area of the storm sewer contains TCE, 1,2-DCE, and vinyl chloride, the same compounds detected in the storm sewer outfall, OF5.

6.3 FATE AND PERSISTENCE OF SITE CONTAMINANTS

This section discusses the persistence of site contaminants associated with the three contaminant migration pathways, air and wind, groundwater, and surface water and sediments. Specific fate and migration processes likely occurring at the site are discussed below.

6.3.1 Air and Wind

Contaminated transport may occur via air or wind by the following mechanisms:

- Windborne soil
- Volatilization of organic compounds through soils

Windborne Soil Eastern and Western Lagoons - The typical ground cover in the eastern lagoon area consists of a silty sand soil of variable thickness, with a relatively flat slope and vegetated with grasses. Generally, the eastern lagoon area is hummocky and lower than surrounding areas. Although the surface soils are a loose silty sand, the relatively abundant vegetative cover, and relatively flat slope presently make wind erosion an unlikely occurrence at the eastern lagoons.

The western lagoons have between 2 and 4 ft of standing water in them. This fact plus the abundant vegetative cover along side slopes and banks make wind erosion an unlikely occurrence. As stated previously, the only places wind erosion may be a problem is the top of the lagoon berms and the areas between lagoons which have little or no vegetation.

Industrial Complex - There is some potential for windborne soil contaminant transport in the unvegetated areas at the LA Darling subarea. The porous, loose, sand and gravel soils and sparse vegetation make wind erosion a likely occurrence. There are also soil piles of silty sand and gravel with little or no vegetative cover located on-site which are highly susceptible to wind erosion. The source of these soil piles is unknown, but they were found to be contaminated with various metals.

There is little potential for windborne soil contaminant transport at the Scott Fetzer or the abandoned industrial sewer line subareas as there is abundant vegetative cover and relatively few contaminants in surface soils.

Volatilization - VOCs in soils may volatilize into surface soils and be emitted to ambient air by diffusion. In unsaturated soils, the compounds with relatively high Henry's Law constants (refer to Table 6-1) TCE, 1,2-DCE, and vinyl chloride readily partition into the air phase, so relatively higher volatilization losses should be observed for these compounds. Generally, the deeper the contaminants are located in soil or sediments, the less likely volatilization will occur directly to air. Saturated conditions in soils also limits volatilization of VOCs to the air. VOCs are generally detected at or below the water table at the LA Darling subarea, the Scott Fetzer subarea, the eastern lagoons, and the western lagoons. Volatilization of VOCs to the air is unknown because soil gas and ambient air sampling were not part of the RI effort. Thus there is no way to know the actual amount of volatilization occurring at the site.

6.3.2 Groundwater

Based on results of sampling activities, TCE, 1,2-DCE, and vinyl chloride are the most prevalent compounds detected in soils and groundwater at and downgradient of the industrial complex, and the eastern and western lagoons. Cadmium, total chromium, copper, lead, nickel, zinc, and cyanide were also detected at high concentrations in the eastern and western lagoons subsurface soils, sludges, and groundwater. Specific contaminant transport processes for groundwater at the site are discussed below.

Leaching - The primary transport mechanism of contaminants from soils and lagoon sludges to groundwater at the site is through leaching.

TCE, 1,2-DCE, and vinyl chloride were the predominant compounds detected in soils and groundwater at and downgradient of the LA Darling subarea and the Scott Fetzer subarea, DCC Plant #2, and the eastern and western lagoons. Cadmium, total chromium, copper, lead, nickel, zinc, and cyanide were the predominant contaminants detected in subsurface soils and lagoon sludge at the eastern and western lagoons (source areas). Because background wells (MW1S, MW11S, MW14S, MW23, and MW29) were uncontaminated, the contaminants detected in groundwater have been attributed to leaching of contaminants from the source areas into groundwater.

Because the lagoon areas are generally lower than surrounding areas, they are susceptible to pooling of rainfall and snowmelt. This increases infiltration and percolation through the contaminated subsurface soils and lagoon sludge. This is more prevalent at the eastern lagoons because the western lagoons, generally, have 2 to 4 ft of water at all times. The water in the western lagoons is likely due to the lagoons intersecting groundwater flow, however, staff gauges were not installed in the western lagoons to confirm this.

The Industrial Complex area (LA Darling subarea, Scott Fetzer subarea, and the abandoned industrial sewer line (western)) is relatively flat with few depressions. Infiltration and percolation of precipitation is not enhanced by surface features in this area, but because of the porous, silty sand and gravel soils, infiltration and percolation of precipitation during rainfall and snowmelt events is likely rapid. Thus, precipitation will not likely runoff from this area.

Examination of the data in Table 6-1 indicates that the solubilities of TCE, 1,2-DCE, and vinyl chloride are mid-range to high compared to metals, SVOCs, and PCBs. In general, compounds with the greatest solubilities in water are expected to exhibit the greatest losses by leaching. Groundwater analytical results indicate TCE, 1,2-DCE, and vinyl chloride have been conveyed to groundwater from sources at the LA Darling subarea, Scott Fetzer subarea, western lagoons, the abandoned industrial sewer and possibly other unidentified source areas. The approximate extent of chlorinated ethene contamination in groundwater is shown on Figure 5-3. In contrast, PAH, phthalate, pesticide, and PCBs have relatively low solubilities in water and are therefore less susceptible to losses by leaching. This is supported by the analytical results, which indicate only low concentrations of phthalates detected in groundwater at the site.

Conditions in the aquifer do not favor increased solubility. Increased solubilities of metals may occur if groundwater pH was low and reducing conditions existed, but this does not appear to be the case at the site. See Figure 5-4 for distribution of metals in groundwater. Metals have not migrated to the extent that VOCs have migrated.

Advection - Advection is the major migration process at the site for contaminant movement once contaminants are in groundwater. Groundwater at the site flows generally west-northwest at the Industrial Complex and north-northwest near CD#30. Contaminants tend to follow groundwater flow (see Figure 3-8) and contaminant migration within groundwater is a function of several properties listed in Table 6-1.

Solubility describes the extent to which a pure chemical compound dissolves in water. If the concentration of a compound exceeds the solubility limit, the contaminant will be present within the aquifer as a non-aqueous phase liquid (NAPL). See Table 6-1 for the solubilities of the organic compounds detected on-site.

The migration of a NAPL is influenced by the compound density relative to the density of water, the volume of NAPL released, and the NAPL's residual saturation in the soils at the site. A NAPL formed by compounds with a composite density greater than the density of water (1.0 g/cc at 20°C) will tend to sink within the aquifer until all the NAPL is trapped as residual saturation or encounters a lower permeability layer. The density of compounds detected at the site are: TCE - 1.46 g/cc; 1,2 DCE - 1.26 g/cc; and vinyl chloride - 1.37 g/cc. The complete list of densities for compounds detected on-site is found on Table 6-1. Therefore, if these compounds were present at concentrations exceeding the solubility limit, they could be expected to sink in the aquifer, be trapped as residual saturation, or be adsorbed on the organic fraction of soils.

Since TCE, 1,2-DCE, and vinyl chloride have densities greater than water, it is possible these compounds are present in the aquifer as a dense non-aqueous phase liquid (DNAPL) (EPA Publication 9355.407 FS, Estimating Potential for occurrence of DNAPL at Superfund Sites). After these liquids have entered the subsurface a DNAPL may be present in the aquifer when the concentration of a compound (or mixture of compounds) is only 1% of its maximum solubility. However, vertical concentration gradients show decreasing concentrations with depth, suggesting the volume of DNAPL released was trapped in residual saturation or pooled on shallow, small, low permeability lenses.

A DNAPL may migrate downward in the aquifer until a change of as little as 10^{-1} difference in hydraulic conductivity is encountered so a DNAPL would not necessarily be found at the bottom of the aquifer. At this point, the DNAPL may pool as a free liquid phase. As a DNAPL moves downward small globules or ganglia are trapped in the pores of the aquifer. Therefore, a portion or the entire volume of DNAPL may be trapped within the aquifer, as residual saturation in the soil.

The high concentrations detected at well MW20 are likely the result of a dissolved phase emitted from the immiscible phase of the DNAPL. The concentration of total chlorinated ethenes detected at well MW20 (70,200 ug/L) (screened in the zone of highest VOC contamination) indicates a high probability of the existence of a DNAPL in the aquifer because the maximum solubility of TCE in water is approximately 1,000 mg/L and the concentration of chlorinated ethenes at well MW20 is 70,200 ug/L (70.2 mg/L) is well above the 1% guidelines. The existence of a DNAPL in the aquifer may affect remedial alternative options.

Contaminants may also move downward in the aquifer as they migrate outward from the source areas due to horizontal and vertical hydraulic gradients in the aquifer (Tables 4-1 and 4-5, respectively).

Generally, horizontal groundwater flow is to the west-northwest at the industrial complex and to the north and northwest near CD#30. Vertical hydraulic gradients are, generally, downward at the Industrial Complex, upward near CD#30, and variable in the center of the site (wells MW5S and MW5D). Because of the migration processes, contaminants (predominantly chlorinated ethenes) have been detected in wells downgradient of the Industrial Complex (MW2S, MW3S, MW4S, MW5S, MW5D, MW6S, MW10S, MW10D, MW24, MW25, MW27, and MW28) and most wells at the eastern and western lagoons (based on residential well logs).

As contaminated groundwater migrates horizontally away from the source areas, it also migrates vertically downward (with downward vertical gradients) to at least the top of the aquitard (wells MW5D, MW10D, MW27, and MW28). The aquitard (estimated to be between 17 and 50 ft thick and assumed continuous at the site), while not impermeable, has relatively low permeability which should inhibit the migration of contaminants to the lower aquifer. The geometric mean vertical permeability in the silty sand is 3.2×10^{-9} ft/sec (9.8×10^{-8} cm/sec), while the geometric mean vertical permeability in the clay part of the aquitard is 7.9×10^{-11} ft/sec (2.4×10^{-9} cm/sec). See Table 4-2 for a summary of aquitard elevation data and Figure 4-1 for the aquitard map. It should be noted, the assumption of the presence and continuity of the aquitard beneath the site is based on review of 5 logs from borings advanced to the base of the aquifer during previous investigations, 26 borings drilled to the base of the aquifer during the RI, numerous residential well logs from the area, and a review of the Hydrogeologic Atlas of Michigan (1981) encompassing the site. Physical testing of soil samples as well as visual observation of soil samples were both used to map the aquitard. Professional judgement was used when assuming the continuity of the aquitard at the site. Due to the large site area (220 acres) and limited data available, it cannot be stated with certainty that the aquitard is continuous at the site.

As stated previously, samples from the two private wells, Borgert and Eichler, screened in the lower aquifer did not indicate the presence of TCL/TAL contaminants. These two wells are north of CD#30 and not necessarily representative of the lower aquifer near the area of highest contamination. Since there are no monitoring wells in the lower aquifer near the contaminant sources, it is not known, with certainty, whether there is contamination in the lower aquifer.

Sorption of Organic Compounds - Based on the organic carbon partition coefficients (K_{oc}) in Table 6-1, TCE, 1,2-DCE, and vinyl chloride have moderate K_{oc} values and are expected to be relatively mobile within the aquifer. The computed retardation factors (R_f) 1.78, 1.35, and 1.34 for TCE, 1,2-DCE, and vinyl chloride, respectively, indicate that little attenuation of chlorinated ethene compounds occurs in the aquifer. In contrast, PAH, pesticide, and PCB compounds have relatively high retardation factors and are not expected to be mobile within the aquifer. This is supported by the analytical data. See Table 6-1 for assumptions used to calculate R_f values.

Biodegradation of Organic Compounds - Higher molecular weight chlorinated ethene compounds, such as trichloroethene, may biodegrade into lower order chlorinated ethene compounds through reductive dehalogenation. Degradation by reductive dehalogenation is favored under anoxic or anaerobic conditions. Degradation products such as vinyl chloride, and 1,2-DCE were detected in most wells at the eastern and western lagoons and wells downgradient of the Scott Fetzer and LA Darling subareas. Although 1,2-DCE may also be detected as a parent compound, vinyl chloride is not commonly used in the type of industry, historically, located at the site.

Although the shallow aquifer at the site is considered an unconfined aquifer (aerobic), ammonia levels at several wells indicate reducing conditions are present in parts of the aquifer. In addition, anaerobic conditions likely exist at the microscopic level at the biodegradation sites.

Coarse-grained soils typically offer a relatively low specific surface area for the attachment of microorganisms for biodegradation compared to fine-grained soils. However, given the appropriate nutrients found in groundwater at the site, (nitrogen series, phosphorous, available carbon) even with medium- to coarse-grained soils biodegradation may be occurring. Evidence of biodegradation is seen by the high concentrations of 1,2-DCE and vinyl chloride found in the aquifer. This biodegradation may be taking place at the source areas or in the aquifer as the contaminants migrate.

Sorption of Inorganic Compounds - Groundwater in the immediate vicinity of the eastern and western lagoons have metal concentrations in exceedance of

MCLs and/or Act 307 Type B criteria. The metals include: cadmium, lead, manganese, nickel, and zinc. Several other areas at the site have elevated levels of metals in groundwater (compared to background). It may appear there is little migration of metals in groundwater from the source areas, but looking at concentrations compared to background concentrations gives a good indication that metals are migrating in groundwater although not to the same extent as VOCs (which is expected), see Figure 5-4.

Generally, the presence of silt, clay, and naturally occurring organic matter will enhance the sorptive capacity of soils for organic and inorganic analytes. At the site, attenuation of metals in groundwater by sorption is limited due to the relatively low amount of organic matter, silt, and clay in the sand and gravel aquifer, but due to decreased concentrations detected in downgradient wells some attenuation is occurring.

6.3.3 CD#30 Surface Water and Sediments

As stated previously, there is little correlation between the types and amounts of contaminants detected in CD#30 surface water and those detected in sediments. PAHs, phthalates, PCBs, and metals were detected more often and at much higher concentrations in sediments than in surface waters where VOCs were the predominant compounds detected.

Contaminant fate and migration in surface water and sediments is generally a function of:

- Stream morphology/surface water movement; and
- Physical, chemical and biological processes.

These are discussed below.

Stream Morphology/Surface Water Movement - The horizontal gradient of CD#30 is relatively flat, the channel width and depth is fairly consistent, and the stream channel is relatively straight with a smooth stream bed. As long as the velocity of flow in CD#30 is not inhibited, sediments would likely be carried downstream in CD#30, until, at some point, flow velocity is reduced and sedimentation occurs. Rate of flow was not measured in CD#30, but flow was observed to increase from east to west in CD#30. The flow in CD#30 is stagnant at the eastern end of CD#30 but flow increases from each outfall as CD#30 flows west.

Because the stream bed is relatively smooth, there is little agitation of the water and oxygenation which enhances volatilization of contaminants in surface water is

limited. Downstream surface water sample results do indicate, however, that VOC concentrations in surface water are reduced by dilution and volatilization.

Physical, Chemical and Biological Processes - The capacity of a sediment to bind contaminants and retard migration is dependent on both chemical and physical properties of the sediment and contaminant, and the biological activity in the sediment. Retention of organic and inorganic chemicals by sediment is typically attributed to sorption of these chemicals to particulates composed of organic matter, and their subsequent precipitation to sediments. Carbonates and oxides of iron, aluminum, and manganese have the capacity to retain contaminants through sorption and ion exchange reactions (due to an electrostatic attraction to ion charged mineral surfaces). Because reactions take place at the surface of particulates, particle size influences adsorption capacity. Silts, clays, and organic matter have larger effective surface areas thus greater sorption capacities than sands and gravels. Also, compounds with high K_{oc} values (SVOCs, pesticides/PCBs) tend to be adsorbed to a greater extent than compounds with lower K_{oc} values (VOCs). See Table 6-1. Metals may be complexed with organic matter, adsorbed by metal oxides, and/or retained by ion exchange reactions.

High adsorption capacity is generally associated with decomposed organic matter (i.e., peat) because of the small particle size and large amounts of surface area. The capacity of decomposed organic matter to bind contaminants is related to its high adsorption capacities. Clay soils, generally, have high cation exchange capacities. Many contaminants, such as metals, are tightly bound to constituents in clay soils. Sandy soils low in silt and clay have much larger particles and tend to have relatively low surface area for adsorption.

The pH of CD#30 is a very important factor controlling the mobility and subsequent migration of contaminants in the sediments by influencing the adsorbing properties. pH may be impacted by water entering the system, biological activity, and the buffering capacity of stream bed materials. The pH levels reported in CD#30 ranged from 6.93 to 7.93. The consistent pH levels in the surface water indicate surface water mixing will not significantly alter pH levels and cause increased solubilizing of contaminants from sediments. Thus, contaminants bound to sediments are likely to remain bound and not be released to surface water.

6.4 SUMMARY

Contaminants at the site are found in subsurface soils, eastern and western lagoon sludges, lagoon water, CD#30 surface water and sediment, and groundwater. The main contaminants detected on-site are TCE, 1,2-DCE, vinyl chloride, metals (cadmium, total chromium, copper, lead, nickel, zinc), and cyanide.

TCE, 1,2-DCE, and vinyl chloride are the most mobile contaminants present and are likely to migrate the furthest from source areas regardless of the media they are in (soils, sediments, sludges, or groundwater). Groundwater, however, is the migration pathway with the greatest potential for spreading of contaminants. TCE, 1,2-DCE, and vinyl chloride have mid-range to high solubilities (relative to metals and PCBs), low K_{oc} values and low retardation factors. The high migration potential for VOCs in groundwater has been confirmed by high concentrations in downgradient wells and wells screened at the top of the aquitard at the site.

Metals are also migrating in groundwater. However, due to the relatively low solubilities of metals in groundwater they have not migrated to the extent VOCs have.

Contaminants from the LA Darling subarea, the Scott Fetzer subarea, the eastern lagoons, and the western lagoons have migrated and appear to continue to be released from sources in subsurface soils (possibly a DNAPL of chlorinated ethenes) and sludges from these areas. Other unidentified source areas also likely exist at the site. The cover soils in these areas are a porous, silty sand and the infiltration and percolation from rainfall and snowmelt events will likely continue to carry contaminants from subsurface sources to groundwater.

Once contaminants are in groundwater they will follow groundwater flow (advection). Contaminant transport in groundwater is driven by horizontal and vertical gradients which are affected by many factors including permeability of the upper and lower aquifer. An aquitard of silty sand and clay beneath the upper aquifer is assumed to be between 17 ft and 50 ft thick and continuous at the site (from residential well logs, on-site borings, and the Hydrogeologic Atlas of Michigan (1981)). Due to the large site area (220 acres) and limited data available regarding the aquitard, its continuity and thickness cannot be stated with certainty. The aquitard has relatively low permeability and, if it is continuous contaminants from the site are not likely to migrate through the aquitard to the lower aquifer, but there are no known wells in the lower aquifer located at or downgradient of the source areas at the site to confirm this.

Contaminated groundwater is likely discharging to CD#30 directly and contaminated groundwater is likely intercepted by the Bronson storm sewer which flows into CD#30. Once contaminants are in CD#30, the VOCs are volatilized directly into the air and metals likely precipitate out into the sediment.

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CONCLUSIONS

This North Bronson Industrial Area RI report has been written from data collected between September 1988 and December 1991. There is sufficient data of acceptable quality to support the summaries and conclusions found in this report. The following paragraphs summarize the contaminants present on-site and the likely fate and migration of these contaminants in the environment.

Contaminants at the site are found in several media (soils, groundwater, surface water, lagoon water, sediments, and lagoon sludges), at numerous locations, and varying concentrations. Contaminants at the site can be put into two major categories - chlorinated ethene compounds (TCE, 1,2 - DCE, and vinyl chloride) and metals (cadmium, total chromium, copper, nickel, and zinc).

The following areas have been identified as potential source areas of organic compounds and metals and cyanide at the site and include:

- LA Darling subarea
- Scott Fetzer subarea (Scott Fetzer, CDF, and Bronson Reel)
- Western Lagoons
- Eastern Lagoons
- Abandoned Industrial Sewer (western)
- DCC Plant #2

It is not clear how many of these areas have contributed to groundwater contamination at the site, and it is possible other unidentified source areas exist at the site. TCE and 1,2 - DCE were the predominant compounds detected in groundwater and soils at source areas but vinyl chloride was also detected. See Figure 5-3 for the approximate distribution of total chlorinated ethene compounds in groundwater at the site. TCE is a common industrial solvent and was likely used as a parts cleaner/degreaser at LA Darling, Scott Fetzer, DCC Plant #2, Bronson Reel, Bronson Plating, and was likely in the waste stream deposited in

the western lagoons. Chlorinated ethene compounds were detected in exceedance of MCLs and/or Act 307 Type B criteria in groundwater at the site. TCE and vinyl chloride also exceed Act 307 Type B - groundwater/surface water interface (GSI) values at several wells near CD#30.

High metal concentrations were detected in subsurface soils, lagoon berm soils, lagoon sludge, and groundwater at the eastern and western lagoons. The predominant metals detected - cadmium, total chromium, copper, lead, nickel, and zinc are common to the metal plating industry as well as other heavy industry of the type currently and historically found at the site.

Cadmium is detected at RCRA hazardous concentrations in lagoon sludge at the eastern and western lagoons and some subsurface soils at the eastern lagoons. See Figure 5-2 for the approximate distribution of metals detected above background concentrations in soils at the site.

Several metals are in exceedance of MCLs and/or Act 307 Type B criteria in groundwater near the eastern and western lagoons but there are few exceedances outside the immediate influence of the eastern and western lagoons. Figure 5-4 illustrates the approximate distribution of metal contaminants in groundwater at the site.

Although chlorinated ethene compounds and metals are the predominant contaminants at the site, PAH compounds and PCBs were also detected at relatively high concentrations in certain areas. PAH compounds were detected at relatively high concentrations is soils and sludges at the eastern lagoons and in soils (SB15) at LA Darling. PCBs were detected at relatively high concentrations in CD#30 sediments downstream of the western lagoons and in eastern lagoon sludge and subsurface soils. PCBs were also detected in sediments collected in Swan Creek.

Contaminants are also entering CD#30 via Bronson Plating outfall OF1 (PAHs), stormwater outfall OF5 (chlorinated ethenes), and contaminated groundwater discharges to CD#30.

The following paragraphs will discuss the observed major contaminant migration pathways and fate in the environment.

Contaminants at the site (predominantly chlorinated ethene compounds and metals) have migrated (following groundwater flow) to the west - northwest from source areas and downward in the upper aquifer to at least the top of the aquitard. The chlorinated ethene compounds have mid-range to high solubilities (compared to metals, SVOCs, and PCBs), low K_{oc} values, and low retardation factors which

indicates a high migration potential, which is observed at the site. Metals have relatively low solubilities in groundwater at the site and have not migrated to the extent VOCs have. See figures 5-3 and 5-4 for the distribution of chlorinated ethenes and metals in groundwater, respectively, at the site.

Contaminant transport in groundwater at the site is driven by horizontal and vertical gradients which are affected by many factors including permeability of the upper and lower aquifer geologic material. There is also a strong possibility that a DNAPL of chlorinated ethene compounds exists at the site in the vicinity of MW20 in the Scott Fetzer subarea. The upper aquifer is a relatively permeable sand and gravel. An aquitard of silty sand and clay beneath the upper aquifer is assumed to vary in thickness from 17 ft to 50 ft. This aquitard has relatively low permeability and if continuous, contaminants are not likely to migrate through it to the lower aquifer. However, there are no known wells screened in the lower aquifer near the contaminant source areas at the site to confirm this.

Contaminated groundwater is likely discharging to CD#30 (upward vertical gradients in wells near CD#30). Contaminated groundwater is also likely intercepted by the Bronson storm sewer which flows into CD#30. Once contaminants are in CD#30, the VOCs likely volatilize directly into the air and metals likely precipitate into the sediment.

At this time, conditions remain favorable for contaminant releases by infiltration and percolation of precipitation through the relatively porous sandy soils at the site. As stated above, once in groundwater contaminant transport is driven by horizontal and vertical gradients and contaminants will follow groundwater flow to the west - northwest at the site. Contaminant release from soils, lagoon sludges, and groundwater are expected to continue at the site until remedial action at the source areas is undertaken.

[mad-605-67q]

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SGW/CSY/JLV/RJK/BJH/DJB/JDD/JAH/ms/JMK
[mad-605-67j]
7005172/159

TABLE 3-1

Location and Elevation
Survey Data
North Bronson Industrial Area
Bronson, Michigan

Existing Monitoring Wells				
Well ID	Survey Coordinates		Ground Elev.	TOC Elev.
	Northing	Easting		
MW1	10201.14	8601.23	909.3	910.48
MW2	10198.99	8420.28	911.7	912.40
MW3	10201.85	8036.39	912.8	914.32
MW4	10436.51	8032.39	908.3	909.61
MW5	10430.27	8436.84	911.8	914.05
MW6	10428.29	8600.44	908.1	910.31
MW7	9276.99	7921.87		912.97
MW8	9430.80	7839.88		912.99
MW9	9414.30	7923.95		914.64
MW10	9406.60	7964.28		913.81
MW11	9437.82	7933.21		914.63
MW12	9428.45	7977.37		915.01
MW13	9443.70	7974.19		914.90
MW14	9449.41	7994.39		913.60
MW15S	10033.52	10369.86	911.8	915.69
MW15D	10033.57	10370.15	911.5	915.58
MW16S	10235.71	10156.22	912.0	914.81
MW16D	10235.71	10156.22	912.0	915.63
MW17S	10502.28	10356.51	909.8	912.47
MW17D	10502.57	10356.25	909.8	913.03
MW18	10461.07	10165.05	910.4	914.16

Phase I Monitoring Wells				
Well ID	Survey Coordinates		Ground Elev.	TOC Elev.
	Northing	Easting		
MW1S	8087.82	8859.85	913.30	915.44
MW2S	9167.43	8846.03	911.84	914.15
MW3S	8978.54	8206.72	912.54	915.05
MW4S	9413.82	8644.18	911.36	913.74
MW5S	9692.41	8644.71	910.77	912.97
MW5D	9685.22	8645.23	910.77	913.04
MW6S	10477.31	8154.58	907.89	910.31
MW7S	10424.65	8438.02	911.77	913.64
MW8S	10432.87	8034.98	908.29	910.78
MW8D	10438.03	8038.52	908.39	910.59
MW9S	10198.21	8712.92	909.36	911.74
MW10S	9432.37	9254.10	912.18	914.62
MW10D	9434.40	9258.88	912.20	914.53
MW11S	12059.62	9933.17	927.60	930.19
MW12S	10523.41	10163.15	910.29	912.84
MW12D	10524.63	10167.48	910.58	912.94
MW13S	10375.42	10309.83	910.77	913.20
MW13D	10377.91	10314.49	910.52	912.74
MW14S	9521.34	11030.14	912.29	914.00

Phase II Monitoring Wells and Piezometers				
Well ID	Survey Coordinates		Ground Elev.	TOC Elev.
	Northing	Easting		
MW19	8883.37	9674.28	913.0	915.47
MW20	9118.58	9531.96	914.1	915.94
MW21	9382.79	10141.43	916.6	919.06
MW22	9612.79	10608.91	913.3	915.38
MW23	10596.50	10815.60	911.5	913.75
MW24	9782.59	9677.86	911.6	913.93
MW25	10390.02	9395.99	909.0	911.57
MW26	10178.70	8305.76	909.5	911.74
MW27	9827.75	8024.26	910.8	913.33
MW28	10569.55	7682.80	908.0	910.47
MW29	8474.45	9608.93	914.2	916.37
PZ1D	9079.29	10229.68	913.7	915.89
PZ1S	9079.29	10229.68	913.7	916.02
PZ2	9261.97	10841.78	913.8	916.21
PZ4	10979.07	9882.51	915.1	917.19
PZ5	10035.42	9165.32	909.4	911.90
PZ6D	9756.97	9211.39	910.4	912.84
PZ6S	9756.97	9211.39	910.4	912.92
PZ7D	9949.47	8026.01	910.3	912.62
PZ7S	9949.47	8026.01	910.3	912.73

Note:

1) Survey information provided by Kapur and Associates, Milwaukee, Wisconsin

SGW/jlv/MWK
[Bronson\3-1]

TABLE 4-1

Summary of Hydraulic Conductivity Test Results
North Bronson Industrial Area
Bronson, Michigan

Well Identification	Hydraulic Conductivity (ft/sec)	(cm/sec)
Aquifer tests conducted during Phase I Investigation		
MW6S	2.70e-3	8.24e-2
MW8S	6.81e-4	2.07e-2
MW8D	9.03e-4	2.75e-2
MW11S*	4.06e-6	1.24e-4
MW12S	1.54e-3	4.70e-2
MW12D	1.78e-3	5.43e-2
MW13S	5.37e-4	1.64e-2
MW13D	1.52e-3	4.64e-2
Aquifer tests conducted during Phase II Investigation		
MW19	1.72e-3	5.23e-2
MW20	1.57e-3	4.78e-2
MW21	1.78e-3	5.41e-2
MW22	1.36e-3	4.16e-2
MW23	8.33e-4	2.54e-2
MW24	1.80e-3	5.49e-2
MW25	1.58e-3	4.80e-2
MW26	7.78e-4	2.37e-2
MW27	1.79e-3	5.45e-2
MW28	1.96e-3	5.97e-2
MW29	1.38e-3	4.20e-2
MW5D	1.54e-3	4.68e-2
MW10D	1.78e-3	5.42e-2
Geometric Mean	1.38e-3	4.21e-2

Note:
1) *MW11S is screened within the surficial silt layer (terminal moraine), not the aquifer and is therefore not included in the geometric mean hydraulic conductivity calculation.

CSY/jlv/SGW
[lot-301-37]
70051.72-dt
[Bronson\4-1]

TABLE 4-2

Depth to Aquitard Elevation Data
North Bronson Industrial Area
Bronson, Michigan

Boring ID	Depth to Aquitard (ft)	Ground Elevation (ft MSL)	Aquitard Elevation (ft MSL)
EXISTING WELLS			
MW5	14.0	911.8	897.8
MW15D	41.0	911.5	870.5
MW16D	40.0	912.0	872.0
MW17D	24.0	909.8	885.8
MW18	15.0	910.4	895.4
PHASE I MONITORING WELLS			
MW5D	> 51.0	910.8	< 859.8
MW6S	12.5	907.9	895.4
MW7S	14.0	911.8	897.8
MW8D	27.0	908.4	881.4
MW10D	50.0	912,2	862.2
MW12D	26.0	910.6	884.6
MW13D	26.0	910.5	884.5
PHASE II MONITORING WELLS, PIEZOMETERS, and SOIL BORINGS			
MW19	57.0	913.0	856.0
MW20	54.0	914.1	860.1
MW21	54.0	916.6	862.6
MW22	55.0	913.3	858.3
MW23	31.0	911.5	880.5
MW24	49.0	911.6	862.6
MW25	24.0	909.0	885.0
MW26	27.5	909.5	882.0
MW27	55.0	910.8	855.8
MW28	21.0	908.0	887.0
MW29	56.0	914.2	858.2
PZ1S,D	57.0	913.7	856.7
PZ2	61.5	913.8	852.3
PZ4	30.5	915.1	884.6
PZ5	54.0	909.4	855.4
PZ6S,D	63.5	910.4	846.9
PZ7S,D	41.0	910.3	869.3
SB6	41.0	911.4	870.4
SB7	47.0	910.9	863.9
SB8	27.0	908.8	881.8

Note:
1) Only sampling locations where the aquitard was encountered are listed, but well MW5D is also listed to indicate that the aquitard must be deeper than the total depth of the boring at this location.

CSY/jlv/SGW
[lot-301-38]
7005100/159-dt
[Bronson\4-2]

TABLE 4-3

Groundwater (GW) Elevation Data
North Bronson Industrial Area
Bronson, Michigan

Well ID	TOC Elevation	February 7, 1990		December 9, 1991		April 22, 1992		June 25, 1992	
		Depth to GW	GW Elevation	Depth to GW	GW Elevation	Depth to GW	GW Elevation	Depth to GW	GW Elevation
EXISTING MONITORING WELLS									
MW1	910.48	5.89	904.59	5.78	904.70	5.60	904.88	5.86	904.62
MW2	912.40	7.85	904.55	7.75	904.65	7.53	904.87	7.85	904.55
MW3	914.32	9.96	904.36	9.80	904.52	9.62	904.70	9.86	904.46
MW4	909.61	6.44	903.17	6.00	903.61	6.02	903.59	5.61	904.00
MW5	914.05	10.61	903.44	10.34	903.71	10.36	903.69	9.88	904.17
MW6	910.31	6.78	903.53	6.50	903.81	6.45	903.86	6.04	904.27
MW15S	915.69	10.57	905.12	10.58	905.11	10.28	905.41	10.67	905.02
MW15D	915.58	10.57	905.01	10.66	904.92	10.37	905.21	10.74	904.84
MW16S	914.81	10.10	904.71	10.14	904.67	9.97	904.84	10.10	904.71
MW16D	915.63	10.84	904.79	well is broken off		well is broken off		well is broken off	
MW17S	912.47	7.72	904.75	8.02	904.45	8.01	904.46	7.78	904.69
MW17D	913.03	8.30	904.73	8.59	904.44	8.57	904.46	8.36	904.67
MW18	914.16	9.90	904.26	9.86	904.30	9.82	904.34	9.53	904.63
PHASE I MONITORING WELLS									
MW1S	915.44	10.55	904.89	10.50	904.94	10.07	905.37	10.70	904.74
MW2S	914.15	9.50	904.65	9.22	904.93	8.90	905.25	9.36	904.79
MW3S	915.05	10.06	904.99	10.20	904.85	9.85	905.20	10.38	904.67
MW4S	913.74	8.88	904.86	8.86	904.88	8.55	905.19	9.00	904.74
MW5S	912.97	8.15	904.82	8.13	904.84	7.84	905.13	8.25	904.72
MW5D	913.04	8.25	904.79	8.19	904.85	7.90	905.14	8.32	904.72
MW6S	910.31	7.10	903.21	6.72	903.59	6.77	903.54	6.25	904.06
MW7S	913.64	10.21	903.43	9.94	903.70	9.95	903.69	9.48	904.16
MW8S	910.78	7.60	903.18	7.20	903.58	7.20	903.58	6.80	903.98
MW8D	910.59	6.68	903.91	6.43	904.16	6.36	904.23	6.30	904.29
MW9S	911.74	7.15	904.59	7.06	904.68	6.87	904.87	7.14	904.60
MW10S	914.62	9.70	904.92	9.68	904.94	9.35	905.27	9.80	904.82
MW10D	914.53	9.67	904.86	9.57	904.96	9.26	905.27	9.71	904.82
MW11S	930.19	3.85	926.34	3.14	927.05	4.27	925.92	6.11	924.08
MW12S	912.84	8.70	904.14	8.60	904.24	8.60	904.24	8.24	904.60
MW12D	912.94	8.75	904.19	8.68	904.26	8.69	904.25	8.32	904.62
MW13S	913.20	8.45	904.75	dry	sediment filled	dry		dry-sediment filled	
MW13D	912.74	7.95	904.79	8.11	904.63	8.02	904.72	7.95	904.79
MW14S	914.00	9.07	904.93	8.72	905.28	8.34	905.66	9.22	904.78

TABLE 4-3 Continued

Well ID	TOC Elevation	February 7, 1990		December 9, 1991		April 22, 1992		June 25, 1992	
		Depth to GW	GW Elevation	Depth to GW	GW Elevation	Depth to GW	GW Elevation	Depth to GW	GW Elevation
PHASE II MONITORING WELLS AND PIEZOMETERS									
MW19	915.47	Phase II wells not installed		10.40	905.07	10.02	905.45	10.54	904.93
MW20	915.94	until November 1991		10.88	905.06	10.52	905.42	11.01	904.93
MW21	919.06			13.92	905.14	13.55	905.51	14.05	905.01
MW22	915.38			10.15	905.23	9.77	905.61	10.30	905.08
MW23	913.75			8.70	905.05	8.69	905.06	8.85	904.90
MW24	913.93			8.97	904.96	8.66	905.27	9.06	904.87
MW25	911.57			7.27	904.30	7.20	904.37	7.05	904.52
MW26	911.74			7.11	904.63	6.87	904.87	7.21	904.53
MW27	913.33			8.62	904.71	8.35	904.98	8.78	904.55
MW28	910.47			7.35	903.12	7.28	903.19	6.96	903.51
MW29	916.37			11.30	905.07	10.87	905.50	11.45	904.92
PHASE II MONITORING WELLS AND PIEZOMETERS Continued									
PZ1D	915.89	Phase II wells not installed		10.74	905.15	10.34	905.55	10.85	905.04
PZ1S	916.02	until November 1991		10.84	905.18	10.47	905.55	10.99	905.03
PZ2	916.21			10.92	905.29	10.54	905.67	11.09	905.12
PZ4	917.19			11.90	905.29	12.12	905.07	12.10	905.09
PZ5	911.90			7.10	904.80	6.87	905.03	7.19	904.71
PZ6D	912.84			7.92	904.92	7.64	905.20	8.03	904.81
PZ6S	912.92			8.00	904.92	7.72	905.20	8.12	904.80
PZ7D	912.62			7.91	904.71	7.66	904.96	7.82	904.54
PZ7S	912.73			8.01	904.72	7.76	904.97	8.20	904.53

Notes:

1) Groundwater elevation taken prior to 1990 not shown on this graph due to data gaps.
2) December 9, 1991 groundwater elevations are plotted on Figure 3-6.
3) April 22, 1992 groundwater elevations are plotted on Figure 3-7.
4) June 25, 1992 groundwater elevations are plotted on Figure 3-8.

CSY/jlv/SGW
[lot-301-36]
7005100/159-dt
[Bronson/4-3]

TABLE 4-4

Summary of Horizontal Gradients
North Bronson Industrial Area
Bronson, Michigan

Well I.D.	Groundwater Elevation (H)	Elevation Difference (dH) (ft)	Distance between Wells (dl) (ft)	Horizontal Gradient In = dH/dl (ft/ft)
MW14S MW22	905.28 905.23	0.05	431	1.16 x 10-4
MW14S MW15S	905.28 905.11	0.17	833	2.04 x 10-4
PZ2 MW21	905.29 905.14	0.15	708	2.12 x 10-4
PZ1S PZ6S	905.18 904.92	0.26	1214	2.14 x 10-4
PZ1S MW10S	905.18 904.94	0.24	1025	2.34 x 10-4
MW19 MW3S	905.07 904.85	0.22	1472	1.49 x 10-4
MW19 MW2S	905.07 904.93	0.14	876	1.60 x 10-4
MW20 MW5S	905.06 904.84	0.22	1052	2.09 x 10-4
MW20 MW4S	905.06 904.88	0.18	933	1.93 x 10-4
MW21 MW24	905.14 904.96	0.18	605	2.98 x 10-4
MW24 MW25	904.96 904.30	0.66	665	9.92 x 10-4
PZ6S PZ5S	904.92 904.80	0.12	282	4.26 x 10-4
MW10S MW5S	904.94 904.84	0.10	669	1.49 x 10-4
MW5S MW27	904.84 904.71	0.13	632	2.06 x 10-4
MW5S PZ7S	904.84 904.72	0.12	674	1.78 x 10-4
MW5S MW3	904.84 904.52	0.32	792	4.04 x 10-4
MW5S MW26	904.84 904.63	0.21	593	3.54 x 10-4
MW15S MW18	905.11 904.30	0.81	477	1.69 x 10-3
MW18 MW12S	904.30 904.24	0.06	63	9.52 x 10-4
MW9S MW6	904.68 903.81	0.87	257	3.39 x 10-3
MW1 MW6	904.70 903.81	0.89	228	3.90 x 10-3

TABLE 4-4 Continued

Well I.D.	Groundwater Elevation (H)	Elevation Difference (dH) (ft)	Distance between Wells (dl) (ft)	Horizontal Gradient In = dH/dl (ft/ft)
MW2 MW5	904.65 903.71	0.94	240	3.92 x 10-3
MW26 MW7S	904.63 903.70	0.93	270	3.44 x 10-3
MW26 MW6S	904.63 903.59	1.04	332	3.13 x 10-3
MW3 MW8S	904.52 903.58	0.94	231	4.07 x 10-3
MW3 MW4	904.52 903.61	0.91	237	3.84 x 10-3
PZ7S MW28	904.72 903.12	1.60	708	2.26 x 10-3

Notes:

1) dH is the difference in groundwater elevation between the two given wells
2) dL is the horizontal distance between the two wells.
3) Groundwater elevations are from 12-9-91 measurements.

CSY/jlv/SGW
[lot-301-12]
7005100/159-dt
[Bronson\4-4]

TABLE 4-5

Summary of Vertical Gradients
North Bronson Industrial Area
Bronson, Michigan

Well I.D.	(1) Total Depth (TD) of Well (ft) Below Ground Level (Bgl)	(2) Groundwater (GW) Level Elev. (El)	(3) Date of (GW) Measurement	(4) Difference in TD (ft) (from Row 1)	(5) Difference in GW El (ft) (from Row 2)	(6) Vertical Gradient Diff GW El Diff TD (Row 5/Row 4) (ft/ft)	
MW5S	12.1	905.00	8/9/89				
MW5D	45.7	905.01	8/9/89	33.6	0.01	0.000298	Upward
MW8S	10.5	903.74	8/9/89				
MW8D	26.8	904.18	8/9/89	16.3	0.44	0.0270	Upward
MW10S	12.1	905.15	8/9/89				
MW10D	49.2	905.15	8/9/89	37.1	0.00	—	—
MW12S	10.9	904.17	8/9/89				
MW12D	25.6	904.17	8/9/89	14.7	0.00	—	—
MW13S	10.0	904.78	8/9/89				
MW13D	24.9	904.77	8/9/89	14.9	0.01	0.000671	Downward
MW5S	12.1	904.82	2/7/90				
MW5D	45.7	904.79	2/7/90	33.6	0.03	0.000893	Downward
MW8S	10.5	903.18	2/7/90				
MW8D	26.8	903.91	2/7/90	16.3	0.73	0.0448	Upward
MW10S	12.1	904.92	2/7/90				
MW10D	49.2	904.86	2/7/90	37.1	0.06	0.00162	Downward
MW12S	10.9	904.14	2/7/90				
MW12D	25.6	904.19	2/7/90	14.7	0.05	0.00340	Upward
MW13S	10.0	904.75	2/7/90				
MW13D	24.9	904.79	2/7/90	14.9	0.04	0.00268	Upward
MW15S	8.3	905.12	2/7/90				
MW15D	38.2	905.01	2/7/90	29.9	0.11	0.00368	Downward
MW16S	9.1	904.71	2/7/90				
MW16D	38.1	904.79	2/7/90	29.0	0.08	0.00276	Upward
MW17S	9.4	904.75	2/7/90				
MW17D	23.8	904.73	2/7/90	14.4	0.02	0.00139	Downward
MW5S	12.1	904.84	12/9/91				
MW5D	45.7	904.85	12/9/91	33.6	0.01	0.000298	Upward
MW8S	10.5	903.58	12/9/91				
MW8D	26.8	904.16	12/9/91	16.3	0.58	0.0356	Upward
MW10S	12.1	904.94	12/9/91				
MW10D	49.2	904.96	12/9/91	37.1	0.02	0.000539	Upward
MW12S	10.9	904.24	12/9/91				
MW12D	25.6	904.26	12/9/91	14.7	0.02	0.00136	Upward
MW15S	8.3	905.11	12/9/91				
MW15D	38.2	904.92	12/9/91	29.9	0.19	0.00635	Downward
MW17S	9.4	904.45	12/9/91				
MW17D	23.8	904.44	12/9/91	14.4	0.01	0.000694	Downward
PZ1S	13.7	905.18	12/9/91				
PZ1D	57.0	905.15	12/9/91	43.3	0.03	0.000693	Downward

TABLE 4-5 Continued

Well I.D.	(1) Total Depth (TD) of Well (ft) Below Ground Level (Bgl)	(2) Groundwater (GW) Level Elev. (El)	(3) Date of (GW) Measurement	(4) Difference in TD (ft) (from Row 1)	(5) Difference in GW El (ft) (from Row 2)	(6) Vertical Gradient Diff GW El Diff TD (Row 5/Row 4) (ft/ft)	
PZ6S	12.2	904.92	12/9/91				
PZ6D	59.9	904.92	12/9/91	47.7	0.00	0.00	—
PZ7S	10.1	904.72	12/9/91	30.0	0.01	0.000333	
PZ7D	40.1	904.71	12/9/91				Downward
MW5S	12.1	905.13	4/22/92	33.6	0.01	0.000298	Upward
MW5D	45.7	904.14	4/22/92				
MW8S	10.5	903.58	4/22/92	16.3	0.65	0.0399	
MW8D	26.8	904.23	4/22/92				Upward
MW10S	12.1	905.27	4/22/92	37.1	0.00	0.00	
MW10D	49.2	905.27	4/22/92				—
MW12S	10.9	904.24	4/22/92	14.7	0.01	0.000680	Upward
MW12D	25.6	904.25	4/22/92				
MW15S	8.3	905.41	4/22/92	29.9	0.20	0.00669	Downward
MW15D	38.2	905.21	4/22/92				
MW17S	9.4	904.46	4/22/92	14.4	0.00	0.00	—
MW17D	23.8	904.46	4/22/92				
PZ1S	13.7	905.55	4//22/92	43.3	0.00	0.00	—
PZ1D	57.0	905.55	4//22/92				
PZ6S	12.2	905.20	4/22/92	47.7	0.00	0.00	—
PZ6D	59.9	905.20	4/22/92				
PZ7S	10.1	904.97	4/22/92	30.0	0.01	0.000333	Downward
PZ7D	40.1	904.96	4/22/92				

Note:

1) — = No vertical gradient.

CSY/jlv/SGW
[lot-301-13]
7005100/159-dt
[Bronson\4-5]

Table 5-1
Summary of Field Sampling Activities
North Bronson Industrial Area
Bronson, Michigan

Round 1 - September 25 through October 5, 1988

Sampling Locations:		Parameters
Groundwater Wells (16):		
	MW1, MW2, MW3, MW4, MW5, MW6, MW7, MW8, MW13, MW14, MW15D, MW16S, MW16D, MW17S, MW17D, MW18	TCL Organics, TAL Inorganics, Hexavalent Chromium, Indicators, pH, Specific Conductivity and Temperature
Private Wells (6):		
	PW1 Losinski 231 Albers[1] PW2 Wheeler 204 Mill St.[1] PW3 City Well#3[1] PW4 Borgert 216 South Matteson[1] PW5 Eichler 220 Matteson[1] PW7 Himes 425 Union Street [1]	TCL Organics, TAL Inorganics, Hexavalent Chromium, Indicators, pH, Specific Conductivity and Temperature
Surface Water/Sediment (10):		
	SW1/SD1, SW2/SD2, SW3/SD3, SW4/SD4, SW5/SD5, SW6/SD6, SW7/SD7, SW8/SD8, SW9/SD9, SW10/SD10	TCL Organics, TAL Inorganics, Hexavalent Chromium [2], Indicators,[2] pH[2], Specific Conductivity[2] and Temperature[2]

Table 5-1
Summary of Field Sampling Activities
(continued)

Lagoon Water (8):

LW1	LW5		TCL Organics, TAL Inorganics, Hexavalent Chromium, Indicators, pH, Specific Conductivity and Temperature
LW2	LW6		
LW3	LW7		
LW4	LW8		

Lagoon Sludge:
(72-VOCs, 24 remaining parameters)

S1S	S4S	S7S	S10S	TCL Organics[3], TAL Inorganics, and RCRA Characteristics
S1D	S4D	S7D	S10D	
S2S	S5S	S8S	S11S	
S2D	S5D	S8D	S11D	
S3S	S6S	S9S	S12S	
S3D	S6D	S9D	S12D	

Lagoon Berm (6):

LB1	LB4[1]	TCL Organics, TAL Inorganics
LB2	LB5	
LB3	LB6[1]	

Round 2 - September 6 through 12, 1989

Sampling Locations:					Parameters
Groundwater Wells (32):					
MW1	MW1S	MW7S	MW11S	MW15S	TCL Organics, TAL Inorganics, Indicators, pH, Specific Conductivity, Temperature and Hexavalent Chromium
MW2	MW2S	MW8S	MW12S	MW15D	
MW3	MW3S	MW8D	MW12D	MW16S	
MW4	MW4S	MW9S	MW13S	MW16D	
MW5	MW5S	MW10S	MW13D	MW17S	
MW6	MW5D	MW10D	MW14S	MW17D	
	MW6S			MW18	

Table 5-1
Summary of Field Sampling Activities
(continued)

Private Wells (6):

PW1	City Well #3	PW4	Himes 425 Union	TCL Organics, TAL Inorganics, Indicators, pH, Specific Conductivity, Temperature and Hexavalent Chromium
PW2	Losinski 231 Albers	PW5	Wheeler 204 Mill Street	
PW3	Borgert 216 Matteson	PW6	Eichler 220 Matteson	

Lagoon Sludge (48-VOCs, 16 remaining parameters):

S5S	S8S		TCL Organics, TAL Inorganics, RCRA Classification
S5D	S8D		
S6S	S9S	S11S	
S6D	S9D	S11D	
S7S	S10S	S12S	
S7D	S10D	S12D	

Round 3 - November 10-14, 1991 and December 9-11, 1991

Sampling Locations:					Parameters
Groundwater (29):					
MW1S	MW6S	MW10D	MW19	MW25	TCL VOCs, TAL Inorganics, pH, Specific Conductivity, and Temperature
MW2S	MW7S	MW11S	MW20	MW26	
MW3S	MW8D	MW12D	MW21	MW27	
MW4S	MW8S	MW12S	MW22	MW28	
MW5S	MW9S	MW13D	MW23	MW29	
MW5D	MW10S	MW14S	MW24		
Surface Water and Sediments (7):					
SW11/SD11		SW15/SD15			TCL Organics, TAL Inorganics, Indicators(2), Hexavalent Chromium(2), pH(2), Specific Conductivity(2), and Temperature(2)
SW12/SD12		SW16/SD16			
SW13/SD13		SW17/SD17			
SW14/SD14					

Table 5-1
Summary of Field Sampling Activities
(continued)

Outfalls (3):							
	OF1						TCL Organics, TAL Inorganics, Indicators, Hexavalent Chromium, pH, Specific Conductivity, and Temperature
	OF3						
	OF5						
Lagoon Water (4):							
	LW9						TCL Organics, TAL Inorganics, Indicators, Hexavalent Chromium, pH, Specific Conductivity, and Temperature
	LW10						
	LW11						
	LW12						
Surface Soils (32)							
	SS1-0.5	SS4-0.5	SS7-0.5	SS10-0.5	SS13-0.5	SS16-0.5	TCL VOCs, TAL Inorganics
	SS1-3.5	SS4-3.5	SS7-3.5	SS10-3.5	SS13-3.5	SS16-3.5	
	SS2-0.5	SS5-0.5	SS8-0.5	SS11-0.5	SS14-0.5		
	SS2-3.5	SS5-3.5	SS8-3.5	SS11-3.5	SS14-3.5		
	SS3-0.5	SS6-0.5	SS9-0.5	SS12-0.5	SS15-0.5		
	SS3-3.5	SS6-3.5	SS9-3.5	SS12-3.5	SS15-3.5		

Table 5-1
Summary of Field Sampling Activities
(continued)

Sample Collection During Drilling Activities - August 2 through 9, 1989

Sample Locations:			Parameters
Soil borings (18):			
	SB1-2	SB2-10	TCL Organics, TAL Inorganics, and RCRA Characteristics
	SB1-4	SB2-15	
	SB1-6	SB3-2	
	SB1-8	SB3-4	
	SB1-10	SB3-6	
	SB1-15	SB3-8	
	SB2-2	SB3-10	
	SB2-4	SB3-15	
	SB2-6		
	SB2-8		
Monitoring Wells (15):			
	MW1-5	MW6D-10	MW10D-5	TAL Inorganics, Grain Size,* and Permeability
	MW2S-15	MW7D-5	MW11D-5	
	MW4S-10	MW7D-10*	MW12D-5	
	MW5D-5	MW8S-5	MW13D-5	
	MW5D-15*	MW8S-20*	MW13D-27*	

Table 5-1
Summary of Field Sampling Activities
(continued)

Sampling During Drilling Activities November 18-20, 1991

Sample Locations:								Parameters
Soil Borings (58)								
	SB06-3	SB06-40	SB07-35	SB11-15	SB12-30	SB14-5	SB15-15	TCL Organics, TAL Inorganics
	SB06-5	SB07-3	SB10-5	SB11-20	SB13-1	SB14-10	SB15-20	
	SB06-8	SB07-5	SB10-10	SB11-25	SB13-5	SB14-15	SB15-25	
	SB06-10	SB07-8	SB10-15	SB11-30	SB13-10	SB14-20	SB15-30	
	SB06-15	SB07-10	SB10-20	SB12-5	SB13-15	SB14-25		
	SB06-20	SB07-15	SB10-25	SB12-10	SB13-20	SB14-30		
	SB06-25	SB07-20	SB10-30	SB12-15	SB13-25	SB15-1		
	SB06-30	SB07-25	SB11-5	SB12-20	SB13-30	SB15-5		
	SB06-35	SB07-30	SB11-10	SB12-25	SB14-1	SB15-10		

NOTES:

1. TCL organics are missing due to laboratory error. Also, note the Blaskie well (442 Mill Street) was identified in the sampling plan to be sampled but had been abandoned in 1974.

2. Hexavalent chromium, indicators, pH, specific conductivity, and temperature were run on surface water, only.

3. TCL organics for sludge samples S5 (S,D) through S12 (S,D) were never received due to laboratory error. These samples were re-collected in September of 1989.

SGW/vlr/CAW
[mad-405-266]
7005100/159

TABLE 5-2
Listing of Constituent Organic Groups
North Bronson Industrial Area RI/FS
Bronson, Michigan

Volatiles

BETX	Chlorinated Ethenes	Clorinated Ethanes	Ketones	Miscellaneous VOCs
Benzene	Vinyl chloride	1,1,2,2-Tetrachloroethane	Methylene chloride	Chloroform
Toluene	1,1-Dichloroethene	1,1,1-Trichloroethane	Acetone	Carbon disulfide
Total Xylenes	Trichloroethene	1,1-Dichloroethane	2-butanone	Chlorobenzene
Ethylbenzene	1,2-Dichloroethenes			
	Tetrachloroethene			

Semi-Volatiles

PAH	Phenols	Phthalates	Chlorinated Aromatics
Naphthalene	Phenol	Bis(2-ethylhexyl)phthalate	1,2-dichlorobenzene
2-Methylnaphthalene	Pentachlorophenol	Di-n-octylphthalate	1,2,4-trichlorobenzene
Acenaphthylene	4-Nitrophenol	Butylbenzylphthalate	1,4-dichlorobenzene
Benzo(a)anthracene	4-Methylphenol	Di-n-butylphthalate	
Phenanthrene	Benzoic acid	Diethylphthalate	
Anthracene	Benzyl alcohol	Dimethylphthalate	
Fluoranthene	4-Chloro-3-methylphenol		
Pyrene			
Chrysene			
Benzo(b)fluoranthene			
Benzo(k)fluoranthene			
Benzo(a)pyrene			
Indeno(1,2,3-cd)pyrene			
Benzo(g,h,i)perylene			
Dibenz(a,h)antracene			
Carbazole			
Dibenzofuran			
Fluorene			
Acenaphthene			

Pesticides	PCBs
Aldrin	Aroclor-1248
Dieldrin	Aroclor-1254
Endrin	Aroclor-1260
Endrin aldehyde	
delta-BHC	
Endrin ketone	
alpha-Chlordane	
gamma-Chlordane	
4,4'-DDT	
4,4'-DDD	
4,4'-DDE	
Methoxychlor	
Heptachlor epoxide	
Heptachlor	
Endosulfan sulfate	
gamma-BHC (Lindane)	
Endosulfan I	
EndosulfanII	
beta-BHC	

SGW/jlv/CAW
[Bronson/5-2]

TABLE 5-3

Summary of Metal Concentrations (mg/kg) in Exceedance of Local Background Concentrations - Surface Soils North Bronson Industrial Area Bronson, Michigan

	LA Darling Area				*Scott Fetzer Area*					Local Background Concentration (2)	Act 307 Type B (20xDrinking Water)
	SS3-0.5	SS4-0.5	SS5-0.5	SS6-0.5	SS8-0.5	SS9-0.5	SS10-0.5	SS11-0.5	SS12-0.5		
Aluminum						11,100				9,976	1.0
Arsenic	9.2		10.7			30.4				8.93	0.0004
Barium		252				447				95.5	40
Beryllium	0.69	1.6				2.4	0.65			0.55	--
Cadmium	76.3	4.4	12.1	2.0		1.8				0.79	0.08
Calcium	34,100									30,379	--
Copper	200	399	183	54.4	64.8	114				45.2	20
Total Chromium	102(D)	65(D)	64.9(D)	29.5(D)			25.3(D)			24.9	140
Cobalt		21								8.02	--
Iron		31,900	33,500	28,900		25,200				21,684	6.0
Lead		193				279		61.5		49.2	0.08(6)
Magnesium	6,290	5,870	3,550						5,170	3,442	--
Nickel	273	52.7	58.6	21.2		20.7	18			12.06	2.0
Potassium						1,010				1,009	--
Selenium		3.1			1.0	1.0				N.D.	0.80
Thallium	0.58				0.28	0.56				N.D.	0.01
Sodium	92.7(D)	152(D)	170(D)	120(D)	68.7(D)	245(D)				47.8	3000
Zinc	145	456	198		83.8	418		109		82	20
Cyanide	3.5	0.98(D)	0.89(D)	0.21(D)		0.89(D)	0.2(D)	0.28(D)		0.19	2.0

Notes:

1) All concentrations are in mg/kg.
2) Local background concentrations were calculated from surface soil samples SS1, SS2, SS13, SS14, SS15 and SS16 (at 0.5 ft). The local background values are the sum of the mean value plus 3 standard deviations. The standard deviation was calculated as suggested in MDNRs Waste Management Division - Clean-up Verification Guidance Document, November, 1991 (see Appendix J-1). The calculated background values are generally less restrictive than Act 307 Type B criteria.
3) Sample SS7-0.5 was omitted from this table as there were no exceedances at this sample location. Metals with no exceedances were also omitted from this table.
4) D = use local background if higher than Act 307 criteria and representative of background as defined in Rule 701. (Values with (D) are greater than local background but less than Act 307 Type B criteria (20x groundwater) and are therefore not at concentrations of concern).
5) -- = no Act 307 Type B criteria.
6) The finalized Act 307 Type B criteria for lead is taken from MDNR's August 18, 1992 Supplement to Operational Memorandum #8.

SGW/jlv/JAH
[Bronson/5-3]

TABLE 5-4

Summary of Organic Compound Exceedances (ug/kg)
of Act 307 Type B-Criteria
Subsurface Soils
North Bronson Industrial Area
Bronson, Michigan

LA Darling	SB13-1	SB13-5	SB13-15	SB13-20	SB13-10	SB14-1	SB15-1	Act 307 Type B Criteria(3) (20xDrinking Water)	Act 307 Type B Acceptable Detection Limits
Fluoranthene	11,000						70,000	6,000	330
Pyrene	15,000						57,000	4,000	330
Benzo(a)anthracene	12,000					200*	71,000	200	330
Chrysene	11,000						74,000	200	330
Benzo(b)fluoranthene	43,000					780	290,000	200	330
Benzo(k)fluoranthene	43,000					780	290,000	200	330
Benzo(a)pyrene	15,000					220*	35,000	200	330
Indeno(1,2,3-cd)pyrene	5,900						42,000	200	330
Dibenz(a,h)anthracene	2,000						15,000	200	330
Bis(2ethylhexyl)phthalate			41*	57*	43*		6,100	40	330
Pentachlorophenol							19,000	6	1700
Di-n-butylphthalate							18,000	14,000	330
Heptachlor						1.2*		0.16	1.7
Dieldrin		0.19*				0.6*		0.04	3.3
4,4'-DDE						2.0*	2.3*	2.0	3.3
4,4'-DDD	3.2*							2.0	3.3
4,4'-DDT	8.0					5.7	1.7*	2.0	3.3
Alpha Chlordane						2.8	0.74*	0.6	1.7
Scott Fetzer	**SB10-5**	**SB10-30**						**Act 307 Type B Criteria(3) (20xDrinking Water)**	**Act 307 Type B Acceptable Detection Limits**
Pentachlorophenol		42*						6	1700
4,4'-DDE	3.5							2	3.3
4,4'-DDT	3.0*							2	3.3

TABLE 5-4 Continued

Abandoned Industrial Sewer	SB11-5	SB11-10	SB12-25	SB11-20	SB12-20											Act 307 Type B Criteria(3) (20xDrinking Water)	Act 307 Type B Acceptable Detection Limits
bis(2-ethyl hexyl)phthalate	57*		67*													40	330
Heptachlor	0.29*	0.16*		0.17*												0.16	1.7
Heptachlor Epoxide	0.38*															0.08	1.7
Trichloroethene					200											60	10
Eastern Lagoons	SB1-4	SB1-6	SB1-8	SB1-15	SB2-2	SB2-8	SB2-15	SB3-2	SB3-15	SB6-5	SB6-8	SB6-10	SB7-3	LB-1	Act 307 Type B (20xGSI)	Act 307 Type B Criteria(3) (20xDrinking Water)	Act 307 Type B Acceptable Detection Limits
Trichloroethene				61					83						1900	60	10
bis(2-ethylhexyl)phthalate						6,200		260*		280*	210*	550			–	40	330
1,2,4-trichlorobenzene												1,500			440	180	330
Benzo(a)anthracene	1,700									240*	230*				–	200	330
Benzo(b)fluoranthene	3,000					400				560	480				–	200	330
Benzo(k)fluoranthene										560	480				–	200	330
Benzo(a)pyrene	910									230*	200*				–	200	330
Chrysene	2,100									220*					–	200	330
2-methylnaphthalene	230*	400												220*	–	200	330
Aldrin													0.58*		–	0.04	1.7
4,4'-DDD		11						3.7		78	65	3.3			–	2	3.3
4,4'-DDE		3.7	3.8		2.2*	3.8	3.8								–	2	3.3
4,4'-DDT							2.8*								0.0046	2	3.3
Dieldrin			0.96*												0.00064	0.04	3.3
Heptachlor										0.31*	0.16*				0.032	0.16	1.7
Heptachlor-expoxide												0.39*			–	0.08	1.7
Gamma-BHC										0.44*	0.35*				–	0.03	1.7
Chlordane												0.69*			0.011	0.60	1.7

Notes:

1) All concentrations are in ug/kg.
2) Act 307 Type B criteria is taken from MDNR's MERA Operational Memorandum #8, Revision 1, March 16, 1992.
3) Soil borings with no exceedances are omitted from this table. There were no exceedances at the Western lagoons, thus it does not appear on this table.
4) * = Concentrations are greater than Act 307 Type B criteria but less than the Act 307 Type B acceptable detection limit requirements. The acceptable detection limit values will likely drive any remediation actions.

SGW/jlv/JAH
[Bronson/5-4]

TABLE 5-5

Summary of Metal Concentrations (mg/kg) in Exceedance of Local Background Concentrations of Subsurface Soils at LA Darling North Bronson Industrial Area Bronson, Michigan

	SS3-3.5	SS4-3.5	SS5-3.5	SS6-3.5	SS7-3.5	SB13-1	SB13-5	SB13-10	SB13-15	SB13-20	SB13-25	SB13-30	Local Background Concentration(2)	Act 307 Type B (20x Drinking Water)
Beryllium		0.98											0.92	–
Barium		81.4											75.8	40
Cadmium	13.5	1.7	5.2	0.95	0.75	1.4							0.71	0.08
Total Chromium	82.1(D)	37.3(D)	24.1(D)	28.8(D)	34(D)	46.6(D)							21.9	140
Cobalt		19.7											8.6	–
Copper	190	147	105	121		55.4							28.8	20
Lead		91.3		29.7		138							13.6	0.08(6)
Magnesium								21,800					17,136	–
Mercury		0.31				0.19	0.2	0.16		0.21			0.08	0.04
Nickel	251			29.7									28.4	2.0
Sodium		126(D)		160(D)	115(D)	97.3(D)			146(D)			107(D)	95.6	3000
Selenium		0.59(D)											N.D.	0.80
Zinc	70.7	186		88		91.6							62.4	20
Cyanide	7.7												N.D.	2.0

TABLE 5-5 Continued

	SB14-1	SB14-5	SB14-10	SB14-15	SB14-20	SB14-25	SB14-30	SB15-1	SB15-5	SB15-10	Local Background Concentration(2)	Act 307 Type B (20x Drinking Water)
Beryllium											0.92	--
Barium								88			75.8	40
Cadmium	1.8										0.71	0.08
Total Chromium									24.5(D)		21.9	14.0
Cobalt											8.6	--
Copper								48.1			28.8	20
Lead	88.3							42.1			13.6	0.08(6)
Magnesium			18,200		110,000						17,136	--
Mercury		0.14	0.23	0.25	0.13	0.42	0.21			0.25	0.08	0.04
Nickel											28.4	2.0
Sodium				112(D)	152(D)					94.7(D)	95.6	3000
Selenium											N.D.	0.80
Zinc	93.5							63.9			62.4	20
Cyanide											N.D.	2.0

Notes:

1) All concentrations are in mg/kg.
2) Local Background concentrations were calculated from subsurface soil samples SS1, SS2, SS13, SS14, SS15, SS16 (at 3.5 ft), MW1S, and MW11S (at 5.0 ft). The local background values are equal to the sum of the mean plus three standard deviations. The standard deviation was calculated as suggested in MDNRs Waste Management Division - Clean-up Verification Guidance Document, November, 1991 (see Appendix J-1).
3) Soil samples with no metal exceedances were omitted from this table, as were metals with no exceedances.
4) D = use local background if higher than Act 307 criteria and representative of background as defined in Rule 701. (Values with (D) are greater than local background but less than Act 307 Type B criteria (20x Drinking Water) and are therefore not at concentrations of concern).
5) -- = no Act 307 Type B criteria.
6) The finalized Act 307 Type B criteria for lead is taken from MDNR's August 18, 1992 Supplement to Operational Memorandum #8.

SGW/jlv/JAH
[Bronson/5-5]

TABLE 5-6

Summary of Maximum Contaiminant Levels (MCLs) and/or
Act 307 Type B Criteria Exceedances
Groundwater
North Bronson Industrial Area
Bronson, Michigan

Private Wells		PW1	PW2	PW3	PW4	PW5	PW6	Maximum Contaminant Level (MCL)(2)	Act 307 Type B Criteria(3)
Arsenic	R1			3.6	6	2.7		50	0.02
	R2	6.1		8.3					
Beryllium	R1							1	---
	R2		2.1			3.3			
Manganese	R1			97	111	113		50(6)	700
	R2	123					122		
Zinc	R1					595		500(6)	1000
	R2								
Iron	R1			526	3,200	2,680		300(6)	---
	R2	1,050					2,690		

TABLE 5-6 Continued

L.A. Darling		MW21	MW22	MW24	MW25	MCLs	Act 307 Type B Criteria
Trichloroethene	R1	2,700	9	320		5	3
	R2						
1,2-dichloroethene	R1		130	290		70	100
	R2						
Vinyl Chloride	R1				2	2	0.02
	R2						

Scott Fetzer Area		MW10S	MW10D	MW19	MW20	MCLs	Act 307 Type B Criteria(3)
Trichloroethene	R1	160	700	170	30,000	5	3
	R2	200	640				
1,2-dichloroethene	R1				35,000	70	100
	R2						
Vinyl Chloride	R1				5,200	2	0.02
	R2						

Abandoned Industrial Sewer Line		MW2S	MW3S	MW4S	MW5S	MW5D	MCLs	Act 307 Type B Criteria
Trichloroethene	R1	10	28	7	21	66	5	3
	R2	11			24	310		
1,2-dichloroethene	R1				130	1,600	70	100
	R2				280	1,500		
Vinyl Chloride	R1				11	86	2	0.02
	R2				16	48		
Mercury	R1						2	2
	R2			2.3				
Lead	R1					7.8	15	4
	R2							
Background Wells		**MW1S**	**MW11S**	**MW14S**	**MW23**	**MW29**		
No exceedances								

TABLE 5-6 Continued

Eastern Lagoons		MW12S	MW12D	MW13S	MW13D	MW15S	MW15D	MW16S	MW16D	MW17S	MW17D	MW18	Maximum Contaminant Level (MCL)(2)	Act 307 Type B Criteria(3)
Trichloroethene	R1(5)		4	16	160		8	36	320	130	12	61	5	3
	R2		3		150		5	18	400	110		43		
1,2-dichloroethene	R1										83		70	100
	R2										120			
Vinyl Chloride	R1												2	.02
	R2										5			
Cadmium	R1			301	50							120	5	4
	R2				58							151		
Manganese	R1			834									--(4)	700
	R2													
Nickel	R1			1,100								424	100	100
	R2											460		
Sodium	R1								610,000		331,000		--	150,000
	R2								397,000					
Cyanide	R1			102									200	100
	R2				531									

TABLE 5-6 Continued

Western Lagoons		MW1	MW2	MW3	MW4	MW5	MW6	MW6S	MW7S	MW8S	MW8D	MW9S	MW26	MW27	MW28	Maximum Contaminant Level (MCL)(2)	Act 307 Type B Criteria(3)
Trichloroethene	R1	8		190	34	3	43	12		38	29		450		72	5	3
	R2			440	20		33	15		43	25						
1,2-dichloroethene	R1			140			270				680		340		100	70	100
	R2										960						
Vinyl Chloride	R1				100	31	100			59	45				3	2	0.02
	R2								12	36	23						
Benzene	R1										1					5	1
	R2																
Cadmium	R1			5.7		4.2			36.3		22.7		5.2			5	.4
	R2			9.5					30.2	6							
Lead	R1				24					26						15	4
	R2									6.6							
Manganese	R1											730			742		700
	R2															50(6)	
Nickel	R1		193	130	576		110		194		479		110			100	100
	R2		197	116	280		159		247	667							
Zinc	R1	3,780	1310	2,840	8,800	1,410	1,380									500(6)	1,000
	R2		626														
Cyanide	R1								2,960							200	100
	R2								250								

Notes:

1) All concentrations are in ug/L.
2) MCLs are taken from Drinking Water Regulations and Health Adviseries by the U.S. EPA Office of Water, November 1991.
3) Act 307 Type B criteria are Health-Based Drinking Water Criteria and are taken from MDNRs - MERA Operational Memo randum #8, Revision 1, March 16, 1992 and the August 18, 1992 Supplement to Operational Memorandum #8.
4) =--Indicates no established maximum contaminant level.
5) RI = Round 1, R2 = Round 2
6) MCLs are secondary standards.

SGW/jlv/JAH
[Bronson/5-6]

TABLE 5-7

Summary of Metal Concentrations (ug/L)
in Exceedance of Local Background Concentrations
Groundwater
North Bronson Industrial Area
Bronson, Michigan

Private Wells		PW1	PW2	PW3	PW4	PW5	PW6	PW7	Local Background Concentrations
Aluminum	R1								
	R2	27.6							N.D.
Arsenic	R1								
	R2			8.3					8.2
Beryllium	R1								
	R2		2.1			3.3			N.D.
Copper	R1	19	22			15			14.7
	R2								
Iron	R1	92	72	526	3,200	2,680		87	
	R2	1,050		58.8			2,690		N.D.
Selenium	R1		1.7						
	R2				2.9	2.2			N.D.
Silver	R1	8							
	R2								N.D.
Sodium	R1								
	R2			122,000					77,567
Zinc	R1	434	433	345	377	595		367	
	R2		69.1		34.2	40			N.D.

TABLE 5-7 Continued

L.A. Darling		MW21	MW24	MW25		Local Background Concentrations
Arsenic	R1			12.8		8.2
Iron	R1	22.6				N.D.
Nickel	R1		10.4			N.D.
Potassium	R1	11,300				9,571
Selenium	R1	4.9				N.D.
Zinc	R1		40.1			N.D.
Cyanide	R1	13.5				N.D.
Scott Fetzer		MW10D	MW10S	MW19	MW20	Local Background Concentrations
Aluminum	R1			69.1		
	R2					N.D.
Iron	R1	100		14.5	16.1	
	R2	68.2	13.4			N.D.
Manganese	R1				1,010	
	R2					874
Nickel	R1				7.4	
	R2					N.D.
Selenium	R1					
	R2		2.3			N.D.
Cyanide	R1		11.3			
	R2					N.D.

TABLE 5-7 Continued

Abandoned Industrial Sewer Line		MW2S	MW4S	MW5D	MW5S	Local Background Concentrations
Aluminum	R1				1150	
	R2					N.D.
Barium	R1			244		
	R2			198		158
Total Chromium	R1		27.2	27	26.5	
	R2					13.4
Iron	R1			682		
	R2			825		N.D.
Lead	R1			7.8		
	R2					3.3
Mercury	R1					
	R2		2.3			0.59
Zinc	R1					
	R2			26.5		N.D.
Cyanide	R1	15.8				
	R2					N.D.

TABLE 5-7 Continued

Eastern Lagoons		MW12D	MW12S	MW13D	MW13S	MW15D	MW15S	MW16D	MW16S	MW17D	MW17S	MW18	Local Background Concentrations
Aluminum	R1				29.7	38.4	39.8		280	112	74.3	66.9	
	R2					32.7		22	29.7	26.7	39.2		N.D.
Barium	R1						198			203			
	R2												158
Cadmium	R1			50.3	301							120	
	R2			58								151	N.D.
Calcium	R1				141,000					217,000			
	R2												134,182
Total Chromium	R1								28				
	R2								19				13.4
Copper	R1								14.8	18.9	18.7	10.2	
	R2												14.7
Iron	R1	339			955	224		42.9	711	1,260	433	89.8	
	R2	572	22.4			424				224	318		N.D.
Magnesium	R1									46,100			
	R2	36,700										36,800	29,133
Manganese	R1												
	R2												874
Nickel	R1	17.9		79.4	1,100			11.1	37.8	11.8	54	424	
	R2			55			18.6	17.7	38.9		44	460	N.D.
Selenium	R1												
	R2		2.4										N.D.
Sodium	R1			86,900	89,000			610,000		331,000			
	R2							406,000				80,000	77,567
Zinc	R1				53.4	29.4	111	43.2	39.6	48	127.0	48.6	
	R2								70.7	41.3	132.0	47.4	N.D.
Cyanide	R1		17.4	22.6	102		10.6		28				
	R2			531					47.5		12.1		N.D.

TABLE 5-7 Continued

Western Lagoons		MW1	MW2	MW3	MW4	MW5	MW6	MW6S	MW7S	MW8D	MW8S	MW9S	MW26	MW27	Local Background Concentrations
Aluminum	R1				143	44.4	30.3								
	R2														N.D.
Arsenic	R1				9.9				9.2	8.3					
	R2														8.2
Barium	R1										206			204	
	R2									192					158
Cadmium	R1		3.3	5.7		4.2			36.3	22.7			5.2		
	R2			9.5					30.2		6				N.D.
Calcium	R1											168,000			
	R2	171,000					177,000					134,000			134,182
Total Chromium	R1				32				26.9	25.3	26.9	37.3			
	R2	40.4	26.1	25.9	21.8	27	41.9								13.4
Copper	R1				14.8										
	R2							19.1							14.7
Iron	R1				2,670	2,100	460		142		700			565	
	R2	213			930	2,370	278		1530						N.D.
Lead	R1				24						26				
	R2										6.6				3.3
Magnesium	R1	32,700				31,200						32,200			
	R2	44,400					37,200				30,400				29,133
Mercury	R1														
	R2								1.0						0.59
Nickel	R1	10	193	130	576	35.5	110		194	479			110		
	R2		197	116	280		159	8.2	247		627	10			N.D.
Selenium	R1														
	R2		3.6												N.D.
Silver	R1					4.1									
	R2														N.D.
Sodium	R1				467,000										
	R2														77,567
Zinc	R1	3,780	1,310	2,840	8,800	1,410	1,380		70	102	93.4	81.7	41.1		
	R2	999	626	857	847	468	510	14.3	8.1		33.2	13.3			N.D.
Cyanide	R1					10.7			2,960						
	R2		5.4			45.7			250						N.D.

TABLE 5-7 Continued

Notes:

1) All concentrations are in ug/L.
2) Local background concentrations were calculated by the same formula as background soils. Refer to Appendix J-1 for a summary of calculations used to calculate background concentrations.
3) The maximum value between a sample and a duplicate was used in calculations.
4) If values existed for two rounds of data, the values were averaged and this average was used in the background calculation. If only one value was detected for all background samples; this value was used as the background concentration. If an analyte was not detected (N.D.) in a background sample, any subsequent detection is considered an exceedance.
5) R1 indicates Round 1 data, R2 indicates Round 2 data.
6) If a metal was not detected in exceedance, it was omitted from this table as were wells with no exceedances of local background.
7) For private well locations please refer to Table 5-1, as well designations and locations were not consistent between Rounds 1 and 2.

SGW/jlv/JAH
[Bronson\5-7]

TABLE 5-8

Summary of Indicator Parameter Concentrations (mg/L)
in Exceedance of Local Background, MCL and/or Act 307
Type B Criteria - Groundwater
North Bronson Industrial Area
Bronson, Michigan

Private Wells		PW1	PW2	PW3	PW4	PW5	PW6	PW7	Local Background Concentrations	MCL	Act 307 Type B
Ammonia-N	R1									--	--
	R2	1.35	0.34						0.26	0.26	
Sulfate	R1		31.7	49.9	30.2	44.2		44.8			
	R2	55		33	45	30	45		29.8	400	250
L.A. Darling		MW21	MW22	MW24	MW25				Local Background Concentrations	MCL	Act 307 Type B
Ammonia-N	R1				0.802					--	--
									0.26		
COD	R1	140			420					--	--
									93.7		
Sulfate	R1	59	31.5	63	65						
									29.8	400	250
Scott Fetzer		MW10D	MW19	MW20					Local Background Concentrations	MCL	Act 307 Type B
Ammonia-N	R1	0.56		0.781						--	--
	R2	0.45							0.26		
COD	R1			116						--	--
	R2								93.7		
NO3+NO2-N	R1		5.14							--	--
	R2								3.77		
Sulfate	R1	52	31.5	32							
	R2	41							29.8	400	250

TABLE 5-8 Continued

Abandoned Industrial Sewer Line		MW2S	MW4S	MW5D	MW5S								Local Background Concentrations	MCL	Act 307 Type B
Ammonia-N	R1			3.69										–	–
	R2			2.6	0.658								0.26		
NO3+NO2-N	R1		8.24												
	R2												3.77	10	10
Sulfate	R1	57	30	52	45										
	R2	35		48.5	31								29.8	400	250
Total Kjeldahl-N	R1			5.01										–	–
	R2												3.23		
TOC	R1													–	–
	R2	35.4											34.9		
Eastern Lagoons		MW12S	MW12D	MW13S	MW13D	MW15D	MW15S	MW16D	MW16S	MW17S	MW17D	MW18	Local Background Concentrations	MCL	Act 307 Type B
Ammonia-N	R1		0.32	4.28	1.08			0.45		1.4	1.4	1.7		–	–
	R2				0.688			0.44		1.82	0.62	2.11	0.26		
Chloride	R1							1020			537				
	R2							504					122	250	250
COD	R1	155												–	–
	R2												93.7		
Sulfate	R1	51	126	114	114	57.7		68.4	28.9	84.2	602	77.5			
	R2	102	114		62	63	30	70	33	100	100	100	29.8	400	250
Total Kjeldahl-N	R1													–	–
	R2											5.36	3.23		
NO3+NO2-N	R1	14													
	R2												3.77	10	10

TABLE 5-8 Continued

Western Lagoons		MW1	MW2	MW3	MW4	MW5	MW6	MW6S	MW7S	MW8D	MW8S	MW9S	MW26	MW27	MW28	Local Background Concentrations	MCL	Act 307 Type B
Ammonia	R1	0.37		0.68	4.5	7.3	2.5		1.85	1.91	2.6	1.42	0.716	0.273			--	--
	R2	0.31		0.8	2.94	5.5	2.6		3.33	1.75	2.3					0.26		
COD	R1							522	227		171	183	216		192		--	--
	R2															93.7		
NO3+NO2-N	R1		11.6															
	R2		17.52	4.6				5.2		357	395					3.77	10	10
Sulfate	R1	134	51.7	48.1	40.4		133	57		52	45	260	50	52.5	124			
	R2	295	45	55	45		195	71.5		55	31	168				29.8	400	250
Total Kjeldahl-N	R1				4.5	7.3											--	--
	R2				4.16	6.7			3.7							3.23		
TOC	R1											85					--	--
	R2															34.9		

Notes:

1) All concentrations are in mg/L.
2) When possible, local background concentrations were calculated by the same formula as background soils. Refer to Appendix J-1 for a summary of calculations.
3) The maximum value between a sample and a duplicate was used in calculations.
4) If values existed for two rounds of data, the values were averaged and this average was used in the background calculations. If only one value was detected for all background samples, this value was used as the background concentration.
5) -- = No MCL or Type 307 Type Criteria.

TABLE 5-9

Summary of Metal Concentrations (mg/kg) in Exceedance of Local Background Concentrations in Subsurface Soils at Scott Fetzer North Bronson Industrial Area Bronson, Michigan

	MW10D-5	SB10-5	SB10-10	SB10-15	SS8-3.5	SS9-3.5	SB10-3.5	SS11-3.5	SS12-3.5	Local Background Concentrations(2)	Act 307 Type B (20x Drinking Water)
Antimony		4.6		3.8						3.2	0.06
Barium									148	75.8	40
Calcium			161,000							108,475	--
Total Chromium								27.9(D)		21.8	140
Copper		60.2								28.8	20
Lead		34.4				19.6	16.2		1,500	13.6	0.08(9)
Magnesium	29,200		20,400							17,136	--
Sodium	156(D)									95.9	3000
Thallium					0.31					N.D.	0.01
Zinc		70.3						62.9	77.3	62.4	20
Cyanide			0.26(D)			0.22(D)				N.D.	2.0

Notes:

1) All concentrations are in mg/kg.
2) Local background concentrations were calculated from subsurface soil samples SS1, SS2, SS13, SS14, SS15, SS16 (at 3.5 ft), MW1S and MW11S (at 5 ft). The local background values are equal to the sum of the mean value plus three standard deviations. Whenever possible, the standard deviation was calculated as suggested in MDNRs Waste Management Division - Clean-up Verification Document, November, 1991. Refer to Appendix J-1 for a summary of the methods used to calculate background values. When an analyte was not detected in any background sample, subsequent detections in samples are considered exceedances.
3) Soil samples with no metal exceedances were omitted from this table as were metals with no exceedances.
4) The maximum value between a sample and its duplicate was included in this table.
5) Sample identification is as follows:
   MW10D-5 - Soil boring at monitoring well MW10D at 5 ft depth.
   SB10-5 - Soil boring No. 10 at a depth of 5 ft.
6) ND = nothing detected in background samples.
7) -- = no Act 307 Type B criteria.
8) D = use local background if higher than criteria and representative of background as defined in Rule 701. (Values with (D) are greater than background but less than Act 307 Type B criteria (20x groundwater) and are therefore not at concentrations of concern).
9) The finalized Act 307 Type B criteria for lead is taken from MDNR's August 18, 1992 Supplement to Operational Memorandum #8.

SGW/jlv/MWK
[Bronson/5-9]

TABLE 5-10

Summary of Metal Concentrations (mg/kg) in Exceedance of Local Background Concentrations in Subsurface Soils Abandoned Industrial Sewer Line North Bronson Industrial Area Bronson, Michigan

	MW2S-15	MW4S-10	MW5D-15	SB11-10	SB11-15	SB12-5	SB12-25	Local Background Concentrations	Act 307 Type B (20xDrinking Water)
Arsenic		95.9						14.8	0.0004
Beryllium		157						0.92	–
Cadmium		3.7				20.5		0.71	0.08
Calcium		127,000	114,000					108.475	–
Iron		85,900						28,563	6.0
Magnesium		30,900	19,400	17,300	22,000	25,400		17,136	–
Manganese		5,160						701	1.0
Nickel		52.4				40.8		28.4	2.0
Sodium	104(D)	137(D)	101(D)	108(D)		162(D)	118(D)	95.9	3000
Vanadium		84.9						40.8	–

Notes:

1) All concentrations are in mg/kg.
2) Local background concentrations were calculated from subsurface soils samples SS1, SS2, SS13, SS14, SS15, SS16 (at 3.5ft), MW1S, and MW11S (at 5.0 ft). The local background values are equal to the sum of the mean value plus three standard deviations. Whenever possible, the standard deviation was calculated as suggested in MDNRs Waste Management Division - Clean-up Verification Document, November, 1991. Refer to Appendix J-1 for a summary of the method used to calculate background values.
3) Soil samples with no exceedances were omitted from this table as were metals with no exceedances.
4) The maximum value between a sample and its duplicate was included in this table.
5) D = use local background if higher than criteria and representative of background as defined in Rule 701. (Values with (D) are greater than local background but less than Act 307 Type B criteria (20x groundwater) and are therefore not of concern).
6) – = no Act 307 Type B criteria.

SGW/jlv/MWK
[Bronson/5-10]

TABLE 5-11

Summary of Organic Compound Exceedances (ug/kg) of Act 307 Type B Criteria
Lagoon Sludge
North Bronson Industrial Area
Bronson, Michigan

Eastern Lagoons	S1D	S1S	S2S	S2D	S3S	S3D	S4S	S4D					Act 307 Type B Criteria (20xDrinking Water)	Act 307 Type B Acceptable Detection Limits	Act 307 Type B (20xGSI)
bis(2-ethylhexyl)phthate	24,000	13,000	15,000	25,000		8,600		4,700					40	330	--
benzo(a)anthracene								1,100					200	330	--
Chrysene								1,100					200	330	--
benzo(b)fluoranthene								1,100					200	330	--
benzo(k)fluoranthene								680					200	330	--
Aroclor 1254				1,200									1,000	33	0.0004
Heptachlor Epoxide			20										0.08	1.7	--
Western Lagoons	**S5S**	**S5D**	**S6S**	**S6D**	**S7D**	**S7S**	**S10D**	**S10S**	**S11S**	**S11D**	**S12S**	**S12D**	**Act 307 Type B Criteria (20xDrinking Water)**	**Act 307 Type B Acceptable Detection Limits**	**Act 307 Type B (20xGSI)**
Trichloroethene	83	183			136	117	860	2,460					60	10	1900
Vinyl Chloride	24							29			12	20	0.4	10	62
Methylene Chloride									130		213		100	10	1200
bis(2-ethylhexyl)phthalate	790		240*	200*	380		140*		240*	320			40	330	--
4,4'-DDT				37									2	3.3	0.0046

Notes:

1) All concentrations are in ug/kg.
2) The values for trichloroethene, vinyl chloride, and methylene chloride are mean values calculated from the three VOC subsamples collected at each location during Round 2.
3) Sample identification is as follows:
   S5S - Lagoon sludge sample S5 at a 0.5 ft depth.
   S5D - Lagoon sludge sample S5 at a 3.0 ft depth
4) * = Concentrations greater than Act 307 Type B but less than acceptable detection limit requirements for soils.
5) -- = no Act 307 Type B criteria.

SGW/jlv/JAH
[Bronson/5-11]

TABLE 5-12

Summary of Metal Concentrations (mg/kg) in Exceedance of Local Background Concentrations and/or Act 307 Type B Criteria in Lagoon Sludge - Eastern Lagoons North Bronson Industrial Area Bronson, Michigan

	S1D	S1S	S2D	S2S	S3D	S3S	S4D	S4S	Local Background Concentrations(2)	Act 307 Type B (20xDrinking Water)	Act 307 Type B (20xGSI)
Antimony	1,920	1,140	2,280	1,390	591	121	224	52	6.6	0.06	--
Arsenic	15		16						14.8	0.0004	3.6
Barium	1,670	3,200	1,320	5,920	738	2,240	3,450	363	95.5	40	--
Cadmium	131	68	3,060	38	775	128	554	654	0.79	0.08	0.012
Calcium	112,000	124,000		147,000					108,475	--	--
Total Chromium	79,700	53,600	97,800	71,600	27,100	18,600	13,100	3,850	24.9	140	1.5
Cobalt	69	58	107	71	33	50	35	10	8.6	--	--
Copper	1,270	1,360	2,330	2,250	1,210	1,090	1,040	529	45.2	20	0.36
Iron	29,700		31,900	41,800	29,500	58,300	27,900		28,563	6.0	--
Lead	1,730	2,440	635	1,770	354	1,140	314	91	49.2	0.08(9)	0.16
Mercury			0.76		0.30				0.14	0.04	0.000026
Magnesium	31,800	39,000	21,000	20,300			27,900		17,136	--	--
Nickel	51,500	42,100	71,800	75,000	26,100	49,500	22,700	9,080	28.4	2.0	1.1
Silver				12			19		N.D.	0.8	0.002
Sodium	3,410	1,490	7,320	3,700	799(D)				95.9	3000	--
Vanadium	601	51	100	57					40.8	--	--
Zinc	707	537	2,670	1,180	1,320	1,090	1,170	462	82.1	82.1	1.6
Cyanide	126	106	317	16	8.60	5.10	18	26	0.19	2.0	0.072

Notes:

1) All concentrations are in mg/kg.
2) Local background concentrations were calculated from subsurface soil samples SS1, SS2, SS13, SS14, SS15, SS16 (at 3.5 ft), MW1S, and MW11S (at 5.0 ft). Local background surface soil concentrations were calculated from samples SS1, SS2, SS13, SS14, SS15, and SS16 (at 0.5 ft). The local background values are equal to the sum of the mean value plus three standard deviations. The standard deviation was calculated as suggested in MDNRs Waste Management Division - Clean-up Verification Document, Novermber, 1991. Refer to Appendix J-1 for a summary of calculations and methods used to determine background concentrations. For this table the higher background value between background surface soils, background subsurface soils, or sediment sample, SD11 is used to compare to eastern lagoon sludge concentrations.
3) The maximum value between a sample and its duplicate is included in this table.
4) Metals not in exceedance of background concentrations are omitted from this table.
5) Sample identification is as follows:
   S1D - Lagoon sludge sample 1 at 3.0 ft
   S1S - Lagoon sludge sample 1 at 0.5 ft
6) N.D. = not detected in any background sample.
7) D = use local background if higher than criteria and representative of background as defined in Rule 701. In the absence of a background value (N.D.), an exceedance is determined by a value greater than the lesser of either Act 307 Type B 20x Drinking Water or Act 307 Type B 20x GSI Criteria. (Values with (D) are greater than background but less than Act 307 Type B criteria (20x groundwater) and are therefore not at concentrations of concern).
8) -- = no Act 307 Type B criteria.
9) The finalized Act 307 Type B criteria for lead is taken from MDNR's August 18, 1992 Supplement to Operational Memorandum #8.

SGW/jlv/JAH
[Bronson/5-12]

TABLE 5-13

Summary of RCRA Hazardous Waste Characteristics Exceedances (ug/L) - Lagoon Sludge North Bronson Industrial Area Bronson, Michigan

Eastern Lagoons	S2D	S3D	S3S	S4D	S4S												RCRA Maximum Concentration
Cadmium	4,140	4,330	2,480	4,410	12,900												1,000
Western Lagoons	S5D	S5S	S6D	S6S	S7D	S7S	S8D	S8S	S9D	S9S	S10D	S10S	S11D	S11S	S12D	S12S	RCRA Maximum Concentration
Cadmium R1	7,710	11,600	4,510	4,240	5,970	14,400	6,460	5,850		4,450	2,140	3,650	22,200	5,890	3,200	1,560	
R2	2,440	6,040	4,460	5,050	9,740	6,510	5,970	5,990	2,670	2,360	2,800	4,800	2,940	3,710	22,940	30,900	1,000

Notes:

1) All concentrations are in ug/L.
2) The maximum value between a sample and the duplicate is included in this table.
3) Samples with no exceedances are omitted from this table.
4) Two values for a given sample indicate two rounds of data. R1 indicates Round 1, R2 indicates Round 2.

SGW/jlv/MWK
[Bronson/5-13]

TABLE 5-14

Summary of Metal Concentrations (mg/kg) in Exceedance of Local Background Metal Concentrations and/or Act 307 Type B in Subsurface Soils and Lagoon Berm Samples
Eastern Lagoon Area
North Bronson Industrial Area
Bronson, Michigan

	SB1-2	SB1-4	SB1-6	SB1-8	SB1-10	SB1-15	SB2-2	SB2-4	SB2-8	SB2-10	SB2-15	SB3-2	Local Background Concentrations	Act 307 Type B (20xDrinking Water)	Act 307 Type B (20xGSI)
Antimony													3.2	0.06	–
Arsenic			18.3	16	17.8							17.4	14.8	0.0004	3.6
Barium					138				594				75.8	40	–
Cadmium	1,400	1,970	747	924	4,900	88.4	69.2	4.4	259	197	66	2,070	0.71	0.08	0.012
Total Chromium	1,770	1,200	1,030	1,520	14,500	257	325		4,300	272	190	2,070	21.8	140	1.5
Cobalt					19.9								8.6	–	–
Copper	539	709	315	458	2,110		92.6		387	37.4	36.3	654	28.8	20.0	0.36
Lead	67.7	132	47	44.1	110				93.7			58.8	13.6	0.08(9)	0.16
Magnesium						17,400		23,900			22,100		17,136	–	–
Mercury													0.08	0.04	.000026
Nickel	1,410	1740	1,010	1,520	14,400	208	210		10,100	307	187	1,450	28.4	2.0	1.1
Silver	0.56	8.8		13	2.8								N.D.	0.80	0.002
Sodium	95.7(D)	148(D)		114(D)	204(D)	126(D)			190(D)				95.9	3000	–
Thallium													N.D.	0.01	–
Zinc	724	397	397	593	2,480	64	70.7		299	91.4		686	62.4	20	1.6
Cyanide	21.6	84.8	15.3	29.4	55.5	3.2	1.3		9.5			37.7	N.D.	2.0	0.072

TABLE 5-14 Continued

	SB3-4	SB3-8	SB3-10	SB6-3	SB6-5	SB6-8	SB6-10	SB6-15	SB6-20	SB6-25	SB6-30	SB6-35	SB6-40	SB7-3	Local Background Concentrations	Act 307 Type B (20xDrinking Water)	Act 307 Type B (20xGSI)
Antimony				16.5			19.8								3.2	0.06	--
Arsenic														14.8	14.8	0.0004	3.6
Barium															75.8	40	--
Cadmium	58.9	104	22.5	2,210	48.8	311	313	69.9	56.7	66.3	30.6	13.4	6.6	1,260	0.71	0.08	0.012
Total Chromium	57.7	300	21.2	2,570	232	656	3,000	308	196	155	95.1	82.1	57.9	1,440	21.8	140	1.5
Cobalt				9.6											8.6	--	--
Copper		61.9	34.1	765	74.2	176	882	34.8						515	28.8	20.0	0.36
Lead		24.8		53.8	15.0	22.2	99.6							43.7	13.6	0.08(9)	0.16
Magnesium								18,800							17,136	--	--
Mercury															0.08	0.04	.000026
Nickel		273	61.2	2,150	537	1,010	914	145	87.6	81.3	48.2	38.9		1,210	28.4	2.0	1.1
Silver				2.4			1.9								N.D.	0.80	0.002
Sodium								102(D)						162(D)	95.9	3000	--
Thallium														0.23	N.D.	0.01	--
Zinc		68.7		915	65.9	246	497	88.7	64.6					576	62.4	20	1.6
Cyanide		15.2		171	25.6	24.3	584	36.9	20.3	25.1	7.9				N.D.	2.0	0.072

TABLE 5-14 Continued

	SB7-5	SB7-8	SB7-10	SB7-15	SB7-20	SB7-25	SB7-30	SB7-35	LB1	LB2	LB3	MW12D-5	MW13D-5	MW13D-27	Local Background Concentrations	Act 307 Type B (20xDrinking Water)	Act 307 Type B (20xGSI)
Antimony									42	15	15				3.2	0.06	--
Arsenic	16.5								15						14.8	0.0004	3.6
Barium									67						75.8	40	--
Cadmium	33.3	13.7	2.2	3.6	10.7	12.7	3.8	1.4	1,900	215	236	0.97	233	4.3	0.71	0.08	0.012
Total Chromium	29	26.9	98.9	160	177	172	131	68.3	1,930	435	215		540	29.6	21.8	140	1.5
Cobalt															8.6	--	--
Copper	35.3								437	132	124		257		28.8	20.0	0.36
Lead									30						13.6	0.08(9)	0.16
Magnesium			18,900		19,500							22,800	23,300	18,300	17,136	--	--
Mercury					0.18										0.08	0.04	.000026
Nickel	204	74.1	28.5	50.3	63.4	68.1	40		1,700	437	185		328		28.4	2.0	1.1
Silver					1.0				5.7				2.1		N.D.	0.80	0.002
Sodium	105(D)												113(D)	193(D)	95.9	3000	--
Thallium															N.D.	0.01	--
Zinc									1,010	283	85		125		62.4	20	1.6
Cyanide					9.4	9.3			43	20	10		4.4		N.D.	2.0	0.072

Notes:

1) All concentrations are in mg/kg.
2) Local background concentrations were calculated from the following subsurface soils - SS1, SS2, SS13, SS14, SS15, SS16 (at 3.5 ft), MW1S, MW11S (at 5 ft). The local background value is equal to the sum of the mean plus three standad deviations. Whenever possible, the standard deviation was calculated using MDNRs Waste Mangement Division - Clean-up Verification Document, November, 1991. Refer to Appendix J-1 for a summary of the methods used to calculate background values. When an analyte was not detected in any of the background samples, any subsequent detection in subsurface soils is generally considered an exceedance.
3) The maximum value between a sample and its duplicate was used in all calculations.
4) Samples with no metal exceedances are omitted from this table as are the metals with no corresponding exceedances.
5) Sample identification is as follows:
   SB1-2 = soil boring 1 at the 2 ft depth
   MW12D-5 = soil boring for monitoring well MW12D at the 5 ft depth
   LB1 = Lagoon berm sample No. 1
6) ND = not detected in background samples.
7) D = use local background if higher than criteria and representative of background as defined by Rule 701. In the absence of local background, an exceedance is determined by values greater than the lesser of Act 307 Type B 20x Drinking Water or Act 307 Type B 20x GSI criteria. (Values with (D) are greater than local background but less than Act 307 Type B (20x groundwater) criteria and are therefore not of concern).
8) -- = no Act 307 Type B criteria.
9) The finalized Act 307 Type B criteria for lead is taken from MDNR's August 18, 1992 Supplement to Operational Memorandum #8.

SGW/jlv/MWK
[Bronson/5-14]

TABLE 5-15

Summary of Ambient Water Quality Criteria Exceedances (ug/L) - Western Lagoons
North Bronson Industrial Area
Bronson, Michigan

	Lagoon A		Ambient Water Quality(1)	*Lagoon B*				Ambient Water Quality(1)	*Lagoon C*		Ambient Water Quality(1)	*Lagoon D*				Ambient Water Quality
	LW3	LW4	Criteria	LW1	LW2	LW9	LW10	Criteria	LW5	LW6	Criteria	LW7	LW8	LW11	LW12	Criteria(1)
Cadmium(2)	7.4	7.7	2.6	75.6	12	20	206	2.6	544	500	5	143		17	136	2.2
Chromium(2)			482				663	484	1750	2080	964				725	418
Copper(2)			29	82			290	29	711	766	58	166		38	256	25
Lead(2)			12				23	12	72	45	35	14.7			29	9.5
Mercury			0.012			0.68		0.012			0.012			0.23		0.012
Nickel(2)			377				801	377	3280	3420	772	409		446	1120	326
Zinc(2)			254				541	255	2080	2220	520	407			629	219
Cyanide	18	23	5.2	45	66			5.2	27	23	5.2	52	35			5.2
Hexavalent Chromium			11			21		11			11					11

Notes:

1) Ambient water quality criteria values are reported in ug/L.
2) Ambient water quality criteria values for cadmium, chromium, copper, lead, nickel, and zinc were calculated based on mean hardness of each lagoon using chronic criterion equations from the Federal Register, December 3, 1986.
3) Hardness = 2.497 [(Ca-mg/L)] + 4.118[Mg-mg/L]
   EXP(a * LN(hardness) + b) where

Chronic Criterion

Metal	a	b
Cd	0.7852	-3.4900
Cr	0.8190	1.5610
Cu	0.8545	-1.4650
Pb	1.2730	-4.7050
Ni	0.8460	1.1645
Zn	0.8473	0.7614

Average Hardness

Lagoon A - 282
Lagoon B - 281
Lagoon C - 654
Lagoon D - 236

SGW/jlv/JAH
[Bronson/5-15]

TABLE 5-16

Summary of Indicator Parameters (mg/L)
Lagoon Water
North Bronson Industrial Area
Bronson, Michigan

	Minimum Concentration	Location	Maximum Concentration	Location	Mean Concentration	Frequency of Detection
Akalinity	205	LW12	344	LW5	236	12/12
Chloride	21.9	LW3	80.1	LW5	44.8	12/12
Chemical Oxygen Demand	40.1	LW4	737	LW5	158	12/12
Nitrite+Nitrate-N	0.10	LW7	0.11	LW1	0.10	2/12
Ammonia-N	0.11	LW4	2.0	LW5	0.59	11/12
Total Kjeldahl-N	1.4	LW4	31	LW5	6.55	12/12
Sulfate	8	LW9	246	LW6	53	10/12
Total Organic Carbon	7.8	LW3	63.9	LW5	22.6	12/12
pH (S.U.)	6.38	LW2	7.6	LW11	6.91	12/12
Spec. Conductivity (umohs/cm)	430	LW4	1010	LW6	583	12/12

Notes:

1) All concentrations are in mg/L, unless otherwise noted.
2) S.U. = Standard Units
3) Specific conductivity is corrected to 25 deg. C.

SGW/jlv/MWK
[Bronson/5-16]

TABLE 5-17

Summary of Metal Concentrations in Exceedance of Local Background Concentrations (mg/kg) and/or 307 Type B Criteria in Sludges - Western Lagoons North Bronson Industrial Area Bronson, Michigan

		S5S	S5D	S6S	S6D	S7S	S7D	S8S	S8D	S9S	S9D	S10S	S10D	S11S	S11D	S12S	S12D	Local Background Concen-tration(2)	Act 307 Type B (20xDrinking Water)	Act 307 Type B (20xGSI)
Arsenic	R1	19		28		28	17.2							21	29	32		14.8	0.0004	3.6
	R2	46.4												17.6	18.9		18.1			
Antimony	R1	186	30	107	48	118	40	31	53	46	22	20	24	386	368	111	74	6.6	0.06	--
	R2	185	15.1	42.9	24.1	18.9	43	22	15.1					48.4	31	42.7	20.1			
Barium	R1													330	358			95.5	40	--
	R2	150																		
Calcium	R1						112,000	243,000							116,000			108,475	--	--
	R2							110,000									115,000			
Cadmium	R1	2,230	225	1,340	371	1,030	315	298	512	436	46	192	61	4,490	9,280	716	380	0.79	0.08	0.012
	R2	2,200	256	824	444	692	837	309	318	325	183	494	106	468	297	1,470	790			
Total Chromium	R1	11,200	1,250	8,220	2,760	3,930	1,260	1,220	1,600	2,670	500	1,200	408	19,600	17,100	4,400	3,030	24.9	140	1.5
	R2	15,700	1,870	3,670	2,200	2,320	4,190	1,400	1,710	2,590	1,460	3,090	966	4,100	2,930	3,690	2,220			
Cobalt	R1	31		30	8.3	24				12		9.7		117	105	24	12	8.6	--	--
	R2	8.7																		
Copper	R1	2,710	282	2,480	664	1,710	390	492	698	674	76	352	98	7,850	11,100	1,940	768	45.2	20	0.36
	R2	4,100	422	1,070	514	788	1,330	699	721	733	420	958	244	1,110	719	2,450	1,320			
Iron	R1	33,400												37,300	40,800			28,563	6.0	--
	R2																			
Lead	R1	234		179	53	69								2,150	2,600	119	78	49.2	0.08(9)	0.16
	R2	316		120	64.9	53.2	82.5			51.7		71.2		61	52.5	574	464			
Magnesium	R1						19,100											17,136	--	--
	R2					21,200							32,500		21,500					
Mercury	R1	0.24									0.15				0.63			0.14	0.04	.000026
	R2	0.16																		
Nickel	R1	7,220	715	7,600	1,720	4,860	855	1,220	1,500	2,690	296	1,360	387	16,100	15,300	4,470	2,190	28.4	2.0	1.1
	R2	11,100	1,400	2,970	1,440	1,760	2,640	1,170	1,290	2,250	1,370	3,900	830	2,780	2,040	2,810	1,320			
Silver	R1	28	5.5	42	9.7	15	6.1	4.0	7.3	4.6		3		15		30	7.3	N.D.	0.80	0.002
	R2	59.5		19.9			14.3									135	94.2			

TABLE 5-17 Continued

		S5S	S5D	S6S	S6D	S7S	S7D	S8S	S8D	S9S	S9D	S10S	S10D	S11S	S11D	S12S	S12D	Local Background Concen-tration(2)	Act 307 Type B (20xDrinking Water)	Act 307 Type B (20xGSI)
Selenium	R1					3.6												N.D.	0.80	0.40
	R2	1.0		0.38(D)		0.73	0.89	0.31(D)								0.43				
Vanadium	R1			58														40.8	--	--
	R2																			
Zinc	R1	5,110	555	4,360	1,410	2,400	466	658	1,060	1,500	203	714	239	11,700	12,000	2,260	2,020	82.1	20	1.6
	R2	9,670	988	1,950	1,010	1,350	2,260	820	924	1,500	1,000	2,180	468	2,470	1,890	2,610	1,270			
Cyanide	R1	254	38	81.2	13	18	14	26	40	6.3	37.4	6.0	14.5	547	831	95.1	221	0.19	2.0	0.072
	R2	197	11.9		62.4	36.3	51	18.2	18.6	35.4	101	75		80.5	72.5		137			

Notes:

1) All concentrations are in mg/kg.
2) Local background concentrations were calculated from subsurface soil samples SS1, SS2, SS13, SS14, SS15, SS16 (at 3.5ft), MW1S, and MW11S (at 5.0 ft).
   Local background concentrations were calculated from surface soil samples SS1, SS2, SS13, SS14, SS15, and SS16 at (0.5 ft).
   Background values are equal to the sum of the mean value plus three standard deviations. The standard deviation was calculated as suggested in MDNRs Waste Management Division Clean-up Verification Document, Novermber, 1991. Refer to Appendix J-1 for a summary of methods used to calculate background concentrations. For this table the higher background value between the background subsurface soils, background surface soils, or background sediment sample SD11 was used to compare sludge results. When an analyte was not detected (N.D.) in a background sample, any subsequent detection is generally considered an exceedance.
3) The maximum value between a sample and duplicate sample is used in this table.
4) Metals not detected in exceedance of background concentrations are omitted from this table.
5) Sample identification is as follows:
   S5S - Lagoon sludge sample 5 at 0.5 ft
   S5D - Lagoon sludge sample 5 at 3.0 ft
6) RI = Round 1 sample results
   R2 = Round 2 sample results
7) -- = no Act 307 Type B criteria.
8) D = use local background if higher than criteria and representative of background as defined in Rule 701. In the absence of a background value (N.D.) an exceedance determined by values greater than the lesser of the Act 307 Type B 20x Drinking Water or Act 307 Type B 20x GSI criteria. (Values with (D) are greater than local background by less than Act 307 Type B (20x groundwater) and are therefore not of concern).
9) The finalized Act 307 Type B criteria for lead is taken from MDNR's August 18, 1992 Supplement to Operational Memorandum #8.

SGW/jlv/MWK
[Bronson/5-17]

TABLE 5-18

Summary of Metal Concentrations (mg/kg) in Exceedance of Local Background Metal and/or Act 307 Type B Concentrations in Subsurface Soils and Lagoon Berm Samples
Western Lagoons
North Bronson Industrial Area
Bronson, Michigan

	LB4	LB5	LB6	MW6D-10	MW7S-5	MW7S-10	MW8S-5	MW8S-20	Local Background Concentration(2)	Act 307 Type B (20xDrinking Water)	Act 307 Type B (20xGSI)
Antimony		20	60						3.2	0.06	--
Arsenic	23	28	18						14.8	0.0004	3.60
Barium					81.7				75.8	40	--
Cadmium	105	138	1,450		204	89.3			0.71	0.08	0.012
Calcium						115,000			108,475	--	--
Total Chromium	206	462	2,870		461	342	41.9		21.8	140	1.5
Cobalt			16						8.6	--	--
Copper	301	191	1,380		261	57.4			28.8	20	0.36
Lead	17	20	106		16.4				13.6	0.08(7)	0.160
Magnesium		17,800		17,600		24,800			17,136	--	--
Nickel	269	342	2,340		356	202			28.4	2.0	1.1
Selenium					0.64				N.D.	0.80	0.400
Silver		5.8	18						N.D.	0.80	.002
Sodium						114(D)			95.9	3000	--
Zinc	120	197	903		362	122			62.3	20	1.60
Cyanide	10	31	58		83.4	8.6			N.D.	2.0	0.072

Notes:

1) All concentrations are in mg/kg.
2) Local background concentrations were calculated from subsurface soils samples SS1, SS2, SS13, SS14, SS15, SS16 (at 3.5ft), MW1S, and MW11S (at 5.0 ft). The local background values are equal to the sum of the mean value plus three standard deviations. The standard deviation was calculated as suggested in MDNRs Waste Management Division - Clean-up Verification Guidance Document, November, 1991. See Appendix J-1 for calculations. Background values are generally less restrictive than Act 307 Type B criteria.
3) Sample identification is as follows:
   LB4 - Lagoon berm No. 4 location
   MW6D-10 - Soil boring for monitoring well MW6S at a 10 ft depth.
4) ND = Nothing detected in background samples.
5) -- = no Act 307 Type B criteria.
6) D = use local background if higher than criteria and representative of background as defined in Rule 701. In the absence of a background value (N.D.) an exceedance is determined by values greater than the lesser of Act 307 Type B - 20x Drinking Water Act 307 Type B - 20x GSI criteria. (Values with (D) are greater than local background but less than Act 307 Type B criteria (20x groundwater) and are therefore not of concern.)
7) The finalized Act 307 Type B criteria for lead is taken from MDNR's August 18, 1992 Supplement to Operational Memorandum #8.

SGW/jlv/MWK
[Bronson/5-18]

TABLE 5-19

Summary of Ambient Water Quality Criteria (AWQC) Exceedances (ug/L)
County Drain #30
North Bronson Industrial Area
Bronson, Michigan

	SW1	AWQC Chronic	SW2	AWQC Chronic	SW5	AWQC Chronic	SW8	AWQC Chronic	SW11	AWQC Chronic	SW12	AWQC Chronic	SW14	AWQC Chronic	SW17	AWQC Chronic	OF1	AWQC Chronic	OF5	AWQC Chronic
Cadmium					13.3	3.1													3.3	2.9
Copper	85.7	43.3																		
Lead	33.3	22.0									28	21.8								
Mercury																	0.27	0.012		
Selenium			7.7	5.0																
Cyanide			94	5.2			28.9	5.2	16	5.2	21	5.2								
Heptaclor Expoxide															0.006	0.0038				
Hexavalent Chromium													17	11						

Notes:

1) All concentrations are in units of ug/L.
2) Exceedance criteria are hardness dependant for cadmium, total chromium, copper, lead, nickel and zinc and were calculated using chronic hardness equations.
   Hardness = 2.497 [(Ca-mg/L)] + 4.118[Mg-mg/L]
   EXP(a * LN(hardness) + b) where

Chronic Criterion

Metal	a	b
Cd	0.7852	-3.4900
Cr	0.8190	1.5610
Cu	0.8545	-1.4650
Pb	1.2730	-4.7050
Ni	0.8460	1.1645
Zn	0.8473	0.7614

Hardness

SW1	456.6	SW7	341	SW13	281.7	OF2	283.2
SW2	462.8	SW8	342.6	SW14	212.9	OF3	324.3
SW3	426.6	SW9	356.4	SW15	230.5		
SW4	332.6	SW10	334.4	SW16	243		
SW5	362.7	SW11	553.6	SW17	276.2		
SW6	327.3	SW12	452.8	OF1	146.9		

SGW/jlv/JAH
[Bronson/5-19]

TABLE 5-20

Summary of Indicator Parameters (mg/L) in Exceedance of Local Background Concentrations Surface Water North Bronson Industrial Area North Bronson, Michigan

	OF3	SW2	SW3	SW6	SW7	SW8	SW16	SW17	Maximum Concentration of Local Background Range(2)
Chloride			2,170						1,940
Ammonia-N	44		9.6	41.5	22.6	16.4	13	11	9.3
Total Kjeldahl-N	42.7		12.3	45.1	33.6	17.2	12.8		9.8
Sulfate		3,140	2,320						1,830

Notes:

1) All concentrations are in mg/L.
2) Local background samples included SW1, SW11, and SW12.

SGW/jlv/MWK
[Bronson/5-20]

TABLE 5-21

Summary of Groundwater Exceedances of Act 307 Type B Groundwater/Surface Water Interface (GSI) Values-Near CD #30 North Bronson, Michigan

		MW4	MW5	MW6	MW7S	MW8S	MW17S	Act 307 Type B GSI Value
Trichloroethene	R1						130	94
	R2						110	
Vinyl chloride	R1	100	31	100	12	59		3.1
	R2					36		

Notes:

1) All concentrations are in ug/L.

SGW/jlv/JAH
[Bronson\5-21]

TABLE 5-22

Summary of Metal Concentrations (ug/L) in Exceedance of Act 307 Type B Criteria-GSI Values Groundwater Wells Near CD #30 North Bronson Industrial Area Bronson, Michigan

	MW4	Chronic Value(2)	MW5	Chronic Value	MW6	Chronic Value	MW7S	Chronic Value	MW8S	Chronic Value	MW17S	Chronic Value	MW18	Chronic Value
Cadmium		1	4.2	1.2		1.7	36.3	1.2	6.0	1.2		1.3	151	1.2
Lead	24	19		32.4		65.4		30.3		31.2		38.8		32.8
Nickel	576	89.7		118.9		172	247	114.8	627	116.6		130.7	460	119.7
Zinc	8800	123.7	1410	160.4	1380	225.8				157.6		179		161.5
Cyanide		3.6	45.7	3.6		3.6	2960	3.6		36	12.1	3.6		3.6

Notes:

1) All concentrations are in ug/L.
2) Chronic criteria equations are from Michigan DNR, Surface Water Quality Division-Rule 57 guideline levels, 1/27/92.
3) Exceedance criteria are hardness dependant for cadmium, chromium, copper, lead, nickel, and zinc, and were calculated using chronic hardness equations.
   Hardness = 2.497[Ca(mg/L)] + 4.118[Mg(mg/L)]
   EXP(a x LN(hardness) + b) where

Metal	a	b	Hardness
Cadmium	0.7852	-4.51	MW4 - 293.3
Chromium	0.82	0.097	MW5 - 398.2
Copper	0.94	-1.957	MW6 - 595.2
Lead	1.75	-7.00	MW7S - 383.3
Nickel	0.92	-0.73	MW8S - 389.9
Zinc	0.85	-0.011	MW17S - 441.6
			MW18 - 401.2

JAH/jlv/SGW
[Bronson\5-22]

4) Well MW25 is omitted from this table because there were no exceedances at this well. Metals with no exceedance in these wells were also omitted from this table.

TABLE 5-23

Summary of Organic Compounds (ug/kg) in Exceedance of Act 307 Type B Criteria
County Drain #30 Sediments
North Bronson Industrial Area
Bronson, Michigan

	SD17	Act 307 Type B Direct Contact Value
Aroclor 1248	1,400	1000
Aroclor 1254	1,600	1000

Note:
1) All concentrations are in ug/kg.

SGW/jlv/MWK
[Bronson/5-23]

TABLE 5-24

Minimum, Maximum, and Mean Concentrations (mg/kg) and Frequency of Detection of Metals in Sediments County Drain #30 North Bronson Industrial Area Bronson, Michigan

	Minimum Concentration	Location of Minimum	Maximum Concentration	Location of Maximum	No. of Detections No. of Samples	Local Background Concentration SD11(2)	No. of Detections in Exceedance of Local Background
Aluminum	1,660	SD10	14,000	SD12	16/16	1,480	15/16
Antimony	6.2	SD12	6.4	SD17	2/16	N.D.	2/16
Arsenic	1.5	SD2	31.4	SD16	16/16	1.3	16/16
Barium	7.7	SD2	260	SD7	16/16	10.4	14/16
Beryllium	0.48	SD12	0.48	SD12	1/16	N.D.	1/16
Cadmium	0.95	SD10	231	SD7	15/16	N.D.	15/16
Calcium	3,170	SD4	187,000	SD5	16/16	41,000	8/16
Total Chromium	22.6	SD10	2,220	SD7	16/16	3.7	16/16
Cobalt	1.9	SD5	19	SD8	11/16	N.D.	11/16
Copper	10	SD9	802	SD7	16/16	N.D.	16/16
Iron	3,710	SD5	59,500	SD8	16/16	3,880	15/16
Lead	4	SD9	690	SD16	16/16	5.5	14/16
Magnesium	1,820	SD4	28,400	SD8	16/16	9,600	11/16
Manganese	53	SD4	605	SD8	16/16	96.5	13/16
Mercury	0.19	SD17	0.19	SD17	1/16	N.D.	1/16
Nickel	10.6	SD10	1,310	SD7	16/16	4.0	16/16
Potassium	177	SD5	1,300	SD12	16/16	226	14/16
Selenium	0.25	SD5	5	SD16	3/16	N.D.	3/16
Sodium	1,130	SD3	2,270	SD1	4/16	N.D.	4/16
Silver	1.4	SD6	30	SD7	4/16	N.D.	4/16
Vanadium	5.3	SD5	37	SD8	16/16	5.4	15/16
Zinc	17.7	SD5	1,440	SD8	16/16	14.1	16/16
Cyanide	9.4	SD7	9.4	SD7	1/16	N.D.	1/16

Notes:

1) All concentrations are in mg/kg.
2) It was determined sample SD11 is the only true local background sediment sample.
3) Thallium was not detected in County Drain #30 sediments and is omitted from this table.
4) N.D. = not detected in sample SD11.

SGW/jlv/JAH
[Bronson/5-24]

TABLE 6-1

Physical/Chemical Properties of Target Compound List Chemicals

VOCs	Density[2] (g/cc)	Molecular Weight (g/mole)	Water Solubility[3] (mg/L)	Vapor Pressure[4] (mm Hg)	Henry's Law Constant[5] (atm-m^3/mole)	Organic Carbon Partition Coefficient[6] (ml/g)	Octanol Water Partition Coefficient[7] (log_{10})	Retardation factor[9]
Vinyl Chloride	1.37	63	2.67E+03	2.66E+03	8.19E-02	5.7E+01	1.38	1.34
Methylene Chloride	1.33	85[1]	2.00E+04[1]	3.60E+02[1]	2.03E-03	8.8E+00	1.30	1.05
Acetone	0.79	58	1.00E+06	2.70E+02	2.06E-05	2.2E+00	-0.24	1.01
1,1-Dichloroethene	1.22	97	2.25E+03	6.00E+02	3.40E-02	6.5E+01	1.84	1.39
1,1-Dichloroethane	1.18	99	5.50E+03	1.82E+02	4.31E-03	3.0E+01	1.79	1.18
1,2-Dichloroethene	1.26	97	6.30E+03	3.24E+02	6.56E-03	5.9E+01	0.48	1.35
Chloroform	1.48	119	8.20E+03	1.51E+02	2.87E-03	3.1E+01	1.97	1.19
2-Butanone	0.81	72[1]	3.5E+05[1]	7.8E+01[1]	2.74E-05	4.5E+00	0.26[1]	1.02
1,1,1-Trichloroethane	1.34	133	1.50E+03	1.23E+02	1.44E-02	1.5E+02	2.5	1.90
Trichloroethene	1.46	131	1.10E+03	5.79E+01	9.10E-03	1.3E+02	2.38	1.78
Benzene	0.88	78	1.75E+03	9.52E+01	5.59E-03	8.3E+01	2.12	1.50
Tetrachloroethene	1.62	166	1.50E+02	1.78E+01	2.59E-02	3.6E+02	2.6	3.16
Toluene	0.87	92	5.35E+02	2.81E+01	6.37E-03	3.0E+02	2.73	2.80
Chlorobenzene	1.11	113	4.66E+02	1.17E+01	3.72E-03	3.3E+02	2.84	2.88
Ethylbenzene	0.87	106	1.52E+02	7.00E+00	6.43E-03	1.1E+03	3.15	7.60
Xylenes (total)	0.90	106	1.98E+02	1.00E+01	7.04E-03	2.4E+02	3.26	2.44
1,1,2,2-tetrachloroethane	1.60	168	2.90E+03	5.00E+00	3.81E-04	1.18E+02	2.39	1.71
Carbon Disulfide	1.26	76	2.94E+03	3.60E+02	1.23E-02	5.4E+01	2.00	1.32

TABLE 6-1
(Continued)

Semivolatile	Density[2] (g/cc)	Molecular Weight (g/mole)	Water Solubility[3] (mg/L)	Vapor Pressure[4] (mm Hg)	Henry's Law Constant[5] (atm-m^3/mole)	Organic Carbon Partition Coefficient[6] (ml/g)	Octanol Water Partition Coefficient[7] (log_{10})	Retardation factor[9]
Phenol	1.07*	94	9.30E+04	3.41E-01	4.54E-07	1.4E+01	1.46	1.08
1,2-Dichlorobenzene	1.30	147	1.00E+02	1.00E+00	1.93E-03	1.7E+03	3.60	11.2
4-Methylphenol	1.02	108[1]	2.40E+04[1]	1.10E-01[1]	4.95E-04	1.7E+01[8]	1.92[1]	1.10
Benzoic Acid	1.27*	122[1]	2.90E+04[1]	9.52E+01	--	5.44E+01	1.87[1]	1.09
Naphthalene	0.96	128[1]	3.00E+01[1]	2.60E-04	1.11E-0.3	6.7E+02[8]	3.01[1]	1.40
2-Methylnaphthalene	1.01	142[1]	2.50E-02[1]	5.9E-02[1]	--	7.12E+02[1]	--	--
Acenaphthylene	0.90*	152	3.93E+00	2.90E-02	1.48E-03	2.5E+03	3.7	16.0
Acenaphthene	1.02*	154	3.42E+00	1.55E-03	9.20E-05	4.6E+03	4.00	28.6
Dibenzofuran	1.09*	220[1]	--	--	--	--	--	--
Fluorene	1.20*	116	1.69E+00	7.10E-04	6.42E-05	7.3E+03	4.20	44.8
Pentachlorophenol	1.98	266	1.40E+01	1.10E-04	2.75E-06	5.3E+04	5.01	319
Phenanthrene	0.98*	178	1.00E+00	6.80E-04	1.59E-04	1.4E+04	4.46	85
Anthracene	1.28*	178	4.50E-02	1.95E-04	1.02E-03	1.4E+04	4.45	85
Fluoranthene	1.25*	202	2.06E-01	5.00E-06	6.46E-06	3.8E+04	4.90	229
Pyrene	1.27*	202	1.32E-01	2.50E-06	5.04E-06	3.8E+04	4.88	229
Butylbenzylphthalate	1.10	312[1]	2.9E+00[1]	8.6E-06[1]	--	--	4.78[1]	--
Benzo(a)anthracene	--	228	5.70E-03	2.20E-08	1.16E-06	1.4E+06	5.60	8,400
Bis(2-Ethylhexyl)Phthalate.	--	391	2.85E-01[1]	8.60E+06[1]	--	6.92E+02[1]	--	5.15
Chrysene	1.27	228	1.80E-03	6.30E-09	1.05E-06	2.0E+05	5.61	1,200
Di-n-octylphthalate	0.99	390[1]	2.85E-01[1]	1.34E+01[1]	--	--	--	--
Benzo(b)fluoranthene	--	252	1.40E-02	5.00E-07	1.19E-05	5.5E+05	6.06	3,300
Benzo(k)fluoranthene	--	252	4.30E-03	5.10E-07	3.94E-05	5.5E+05	6.06	3,300
Benzo(a)pyrene	--	252	1.20E-03	5.60E-09	1.55E-06	5.5E+06	6.06	33,000
Indeno(1,2,3-cd)pyrene	--	276	5.30E-04	1.00E-10	6.86E-08	1.6E+06	6.50	9,600
Dibenz(a,h)anthracene	--	278	5.00E-04	1.00E-10	7.33E-08	3.3E+06	6.80	19,800
Benzo(g,h,i,)perylene	--	276	7.00E-04	1.03E-10	5.34E-08	1.6E+06	6.51	9,600
1,4-Dichlorobenzene	1.46	147	7.90E+01	1.18E+00	2.89E-03	1.7E+03	3.60	11.2
Dimethylphthalate	--	194	5.00E+03	1.00E-02	--	4.03E+01	--	1.24
Diethylphthalate	--	222	8.96E+02	3.50E-03	--	1.42E+02	--	1.85
Di-n-butylphthalate	--	278	1.30E+01	1.00E-05	--	1.70E+05	--	1020

TABLE 6-1
(Continued)

	Density[2] (g/cc)	Molecular Weight (g/mole)	Water Solubility[3] (mg/L)	Vapor Pressure[4] (mm Hg)	Henry's Law Constant[5] (atm-m^3/mole)	Organic Carbon Partition Coefficient[6] (ml/g)	Octanol Water Partition Coefficient[7] (log_{10})	Retardation factor[9]
Carbozole	1.10	167	--	4.00E+02	--	--	3.29	--
Benzyl alcohol	1.05	108	4.00E+04	1.00E+00	--	--	1.10	--
4-Chloro-3-Methylphenol	--	143	3.85E+03[1]	5.90E-02[1]	--	4.70E+01[1]	3.10[1]	1.28
1,2,4-Trichlorobenzene	1.57	181	3.00E+01	2.90E-01	2.31E-03	9.20E+03	4.3	56.2
Pesticides								
Aldrin	--	365	1.8E-01	6.00E-06	1.60E-05	9.60E+04	5.3	576
Dieldrin	--	381	1.95E-01	1.78E-07	4.58E-07	1.7E+03	3.5	11.2
Endrin	--	--	--	2.0E-07	--	--	5.6	--
Endrin Ketone	--	381[1]	1.95E-01[1]	1.78E-07[1]	--	1.70E+03[1]	--	11.2
Alpha-Chlordane	--	410	--	1.0E-05	--	--	--	--
Gamma-Chlordane	--	410	--	1.0E-05	--	--	--	--
4,4'-DDT	--	355	5.00E-03	5.50E-06	5.13E-04	2.43E+05	6.19	1,458
4,4'-DDD	--	320	1.00E-01	1.89E-06	7.96E-06	7.70E+05	6.20	4,620
4,4'-DDE	--	318	4.00E-02	6.50E-06	6.80E-05	4.40E+06	7.00	26,400
Methoxychlor	--	--	--	--	--	--	--	--
Heptachlor Epoxide	--	389	3.50E-01	3.00E-04	4.39E-04	2.2E+02	2.70	2.32
Heptachlor	--	374	1.80E-01	3.00E-04	8.19E-04	1.2E+04	4.40	73
Endosulfan I	--	407	5.00E-03	5.5E-06	--	2.43E+06	--	1.458E+04
Endosulfan II	--	--	--	--	--	--	--	--
Endosulfan Sulfate	--	--	--	--	--	--	--	--
Beta-BHC	--	291	2.4E-01	2.80E-07	4.47E-07	3.8E+03	3.90	23.8
Gamma BHC	--	291	7.80E+00	1.60E-04	7.85E-06	1.08E+03	3.90	7.48
PCBs								
Polychlorinated biphenyls		328	3.10E-02	7.70E-05	1.07E-03	5.3E+05	6.04	3180

TABLE 6-1
(Continued)

NOTES:

1. All values were obtained from the U.S. EPA Superfund Public Health Evaluation Manual (SPHEM), 1986 unless otherwise referenced. (--) indicates property not identified. Below are descriptions of chemical properties.

2. Density of VOCs generally recorded at a temperature of 20°C relative to water at 4°C. However, "*" values were recorded at a different temperature (refer to reference #3).

3. Water Solubility is the maximum concentration of a chemical that dissolves in pure water at a specific temperature and pH. Values are given for a neutral pH and a temperature range of 20 to 40°C. The rate at which a chemical is leached from a waste by infiltrating precipitation is a function of its solubility in water. The more soluble compounds are expected to be leached much more readily and rapidly than less soluble chemicals. The water solubilities presented in the literature indicate that the volatile organic chemicals are usually several orders of magnitude more water soluble than the base/neutral organic compounds (e.g., PAHs, PCBs).

4. Vapor pressure provides an indication of the pressure exerted by a pure vapor when in equilibrium with its liquid phase (i.e., the pressure at which a chemical in its pure state volatilizes). Values are given for a temperature range of 20 to 30°C. It is of primary significance where environmental interfaces such as surface soil/air and surface water/air occur. Volatilization is not as important when evaluating groundwater and subsurface soils. Chemicals with higher vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Vapor pressures for monocyclic aromatic (toluene) and chlorinated aliphatics (TCE) are generally many times higher than vapor pressures for phthalate esters (bis(2-ethylhexyl)phthalate), polynuclear aromatic hydrocarbons (PAHs), and pesticides.

5. Henry's Law Constant, or the compounds' air-water partition coefficient, is important in evaluating air exposure pathways. Values for Henry's Law Constant (H) were calculated using the following equation and the values previously recorded for solubility, vapor pressure, and molecular weight:

$$H(\text{atm-m}^3/\text{mole}) = \frac{\text{Vapor Pressure (atm) x Mole Weight (g/mole)}}{\text{Water Solubility (g/m}^3)}$$

6. Organic Carbon Partition Coefficient (Koc) is a measure of the tendency for organics to be adsorbed by soil and sediment and is expressed as:

$$Koc = \frac{\text{mg chemical adsorbed/kg organic carbon}}{\text{mg chemical dissolved/liter of solution}}$$

The Koc is chemical specific and is largely independent of soil properties. In general, the Koc is inversely related to its environmental mobility. Refer to SPHEM for sources of the values.

TABLE 6-1
(Continued)

7. The Octanol/Water Partition Coefficient is used to estimate bioconcentration factors in aquatic organisms. A linear relationship between the octanol/water partition coefficient and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor) has been determined. It is also useful in estimating the sorption and desorption of compounds by organic soils, where experimental values are not available.

8. When Koc values were not given in SPHEM they were calculated by the following equation log Koc = (-0.55 x log Solubility) + 3.64).

9. Retardation factors (R_F)are calculated by the following equation:

$$R_F = 1+(_{Pb}/n)\ Kd$$

Where: P_b = aquifer bulk density (g/cm^3), assumed 1.8 g/cm^3
n = total porosity of the aquifer, assumed 0.3 (unitless)
K_d = distribution coefficient (mL/g) is calculated by Koc x Foc (organic carbon content of soils), assuming the Foc is 0.1%.

References:

(1) Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, 1983.

(2) Mackay, D. and Shire, W. Y. A critical review of Henry's Law constants for chemicals of environmental interest. J. Phys. Chem. Ref. Data. 10(4):1175-1199, 1981.

(3) Weast, R.C. (ed) Handbook of Chemistry and Physics 54th Edition. CRC Press, Cleveland, 1973.

SGW/ccf/JAH
[mad-405-266a]
7005100/159

TABLE 6-2

Summary of Important Solubility-Controlling Solids Reported In The Literature[a]

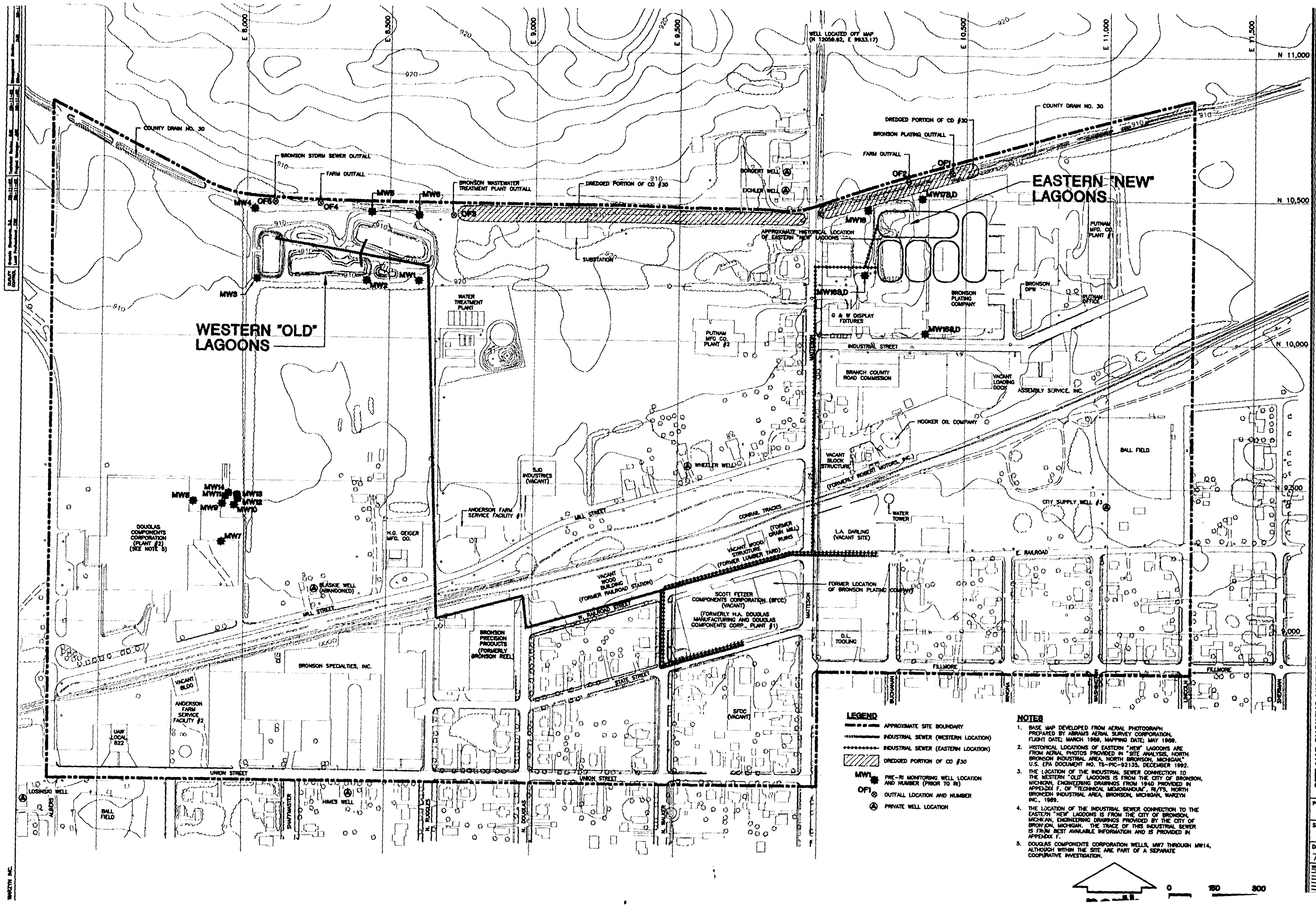
Element	Observed/Predicted[b]	Speculated[c]
Al	$Al(OH)_3$,$KAl_3(SO_4)_2(OH)_6$, $AlOHSO_4$, Kaolinite, Montmorillonite	
As		$FeAsO_4$,AsS or As_2S_3
Ba	$BaSO_4$	
Be		$Be(OH)_2$
Cd	$CdCO_3$, $Cd_3(PO_4)_2$	$(Ca,Cd)CO_3$
Cr	$Cr(OH)_3$	$FeCr_2O_4$
Cu	$Cu(OH)_2$	$Cu_2(PO_4)_3$, $Cu_2(OH)_2CO_3$
Fe	$Fe(OH)_3$,$Fe_3(OH)_8$,$FeCO_3$	
Hg	HgS	
Pb	$Pb(OH)_2$,$PbCO_3$,$Pb_3(PO_4)_2$,$Pb_4O(PO_4)_2$, $Pb_5(PO_4)_3OH$	
Mn	$MnCO_3$,Mn-oxides	
Mo	$PbMoO_4$	$FeMoO_4$,$Fe_2(MoO_4)_3$
Ni	NiS	$NiFe_2O_4$
Se		$Fe_2(SeO_3)_3$
S	$CaSO_4$,$Al_4(OH)_{10}SO_4 \cdot 5H_2O$,$KAl_3(SO_4)_2(OH)_6$	
V		$Fe_2(VO_3)_2$,$VO(OH)_2 \cdot H_2O$
Zn	$Zn(OH)_2$,$ZnCO_3$,$ZnSiO_4$	$ZnFe_2O_4$

(a) After Battelle, Pacific Northwest Laboratories, 1984. All solid phases are not expected in all environments; e.g., hydroxides and carbonate solids are expected only under near neutral to alkaline conditions and sulfides (e.g., HgS, NiS) are expected only under very reducing conditions.

(b) Solids whose presence has been established through physical observations of geologic materials or through similarities in ion activity products with the solubility products.

(c) The formation and presence of Fe-containing compounds are speculated primarily based on adsorption experiments or observed association of other elements with iron oxides.

SGW/ccf/JAH
[mad-405-266b]
7005100/159



LEGEND

- APPROXIMATE SITE BOUNDARY
- INDUSTRIAL SEWER (WESTERN LOCATION)
- INDUSTRIAL SEWER (EASTERN LOCATION)
- DREDGED PORTION OF CD #30
- MW1 PRE-RI MONITORING WELL LOCATION AND NUMBER (PRIOR TO RI)
- OF1 OUTFALL LOCATION AND NUMBER
- PRIVATE WELL LOCATION

NOTES

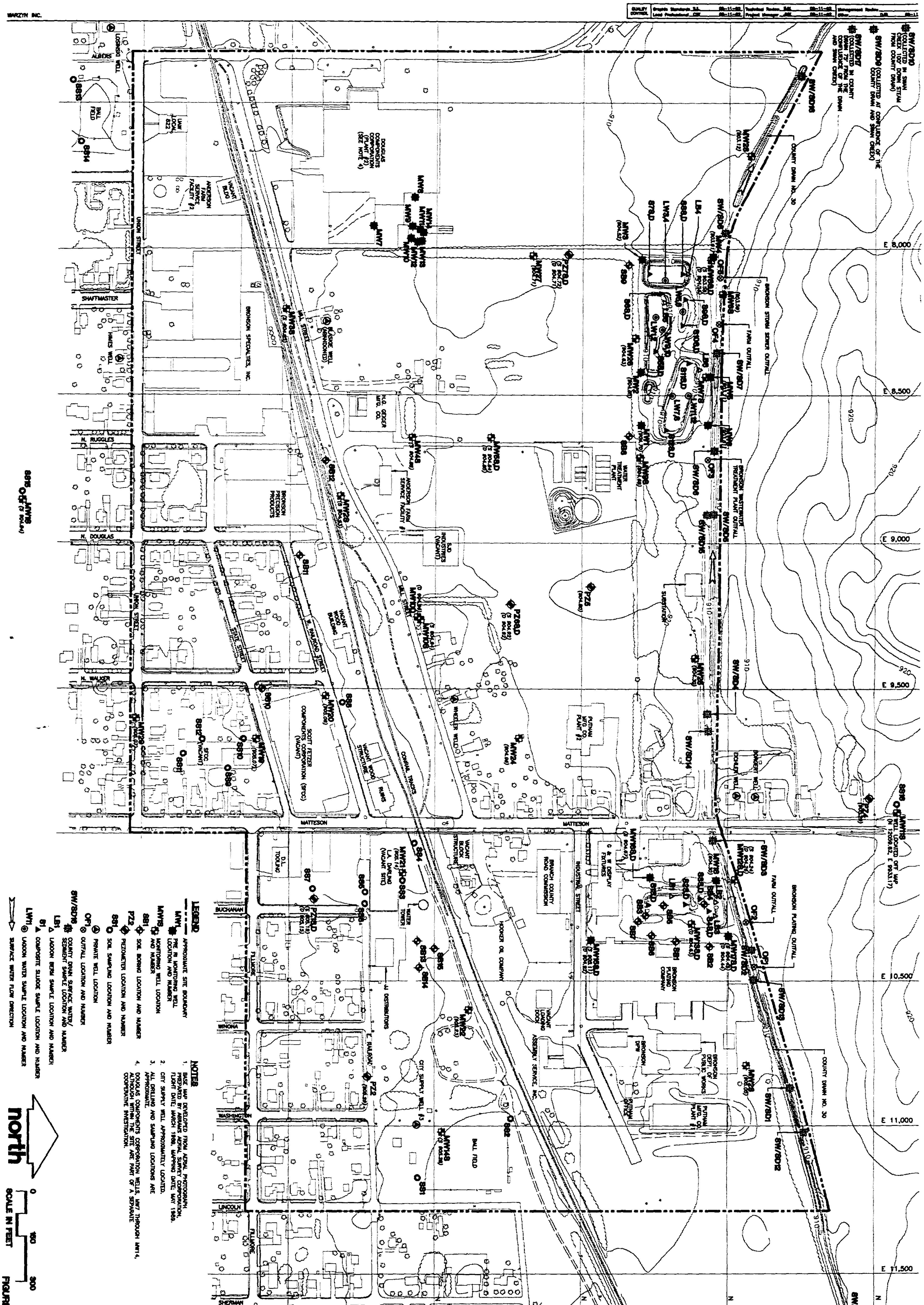
1. BASE MAP DEVELOPED FROM AERIAL PHOTOGRAPH PREPARED BY ABRAMS AERIAL SURVEY CORPORATION, FLIGHT DATE: MARCH 1989, MAPPING DATE: MAY 1989.
2. HISTORICAL LOCATIONS OF EASTERN "NEW" LAGOONS ARE FROM AERIAL PHOTOS PROVIDED IN "SITE ANALYSIS, NORTH BRONSON INDUSTRIAL AREA, NORTH BRONSON, MICHIGAN," U.S. EPA DOCUMENT NO. TS-PIC-92135, DECEMBER 1992.
3. THE LOCATION OF THE INDUSTRIAL SEWER CONNECTION TO THE WESTERN "OLD" LAGOONS IS FROM THE CITY OF BRONSON, MICHIGAN, ENGINEERING DRAWINGS FROM 1940 PROVIDED IN APPENDIX F, OF "TECHNICAL MEMORANDUM", RI/FS, NORTH BRONSON INDUSTRIAL AREA, BRONSON, MICHIGAN, WARZYN INC., 1989.
4. THE LOCATION OF THE INDUSTRIAL SEWER CONNECTION TO THE EASTERN "NEW" LAGOONS IS FROM THE CITY OF BRONSON, MICHIGAN, ENGINEERING DRAWINGS PROVIDED BY THE CITY OF BRONSON, MICHIGAN. THE TRACE OF THIS INDUSTRIAL SEWER IS FROM BEST AVAILABLE INFORMATION AND IS PROVIDED IN APPENDIX F.
5. DOUGLAS COMPONENTS CORPORATION WELLS, MW7 THROUGH MW14, ALTHOUGH WITHIN THE SITE ARE PART OF A SEPARATE COOPERATIVE INVESTIGATION.

SITE MAP SHOWING HISTORICAL SITE FEATURES EXISTING PRIOR TO REMEDIAL INVESTIGATION

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Developed By: CSY
Drawn By: SJL
Approved By: JMK
Date: 7/12/93
Reference:
Revisions:

Printed
Sheet Number
Drawing Number 7005100 D1



SITE MAP SHOWING PHASE I AND PHASE II RI SAMPLING POINTS	
Developed By: CSY	Drawn By: SJL
Approved By: JMK	Date: 7/12/93
Reference:	
Revisions:	

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Printed

Sheet Number

Drawing Number 700500 D2

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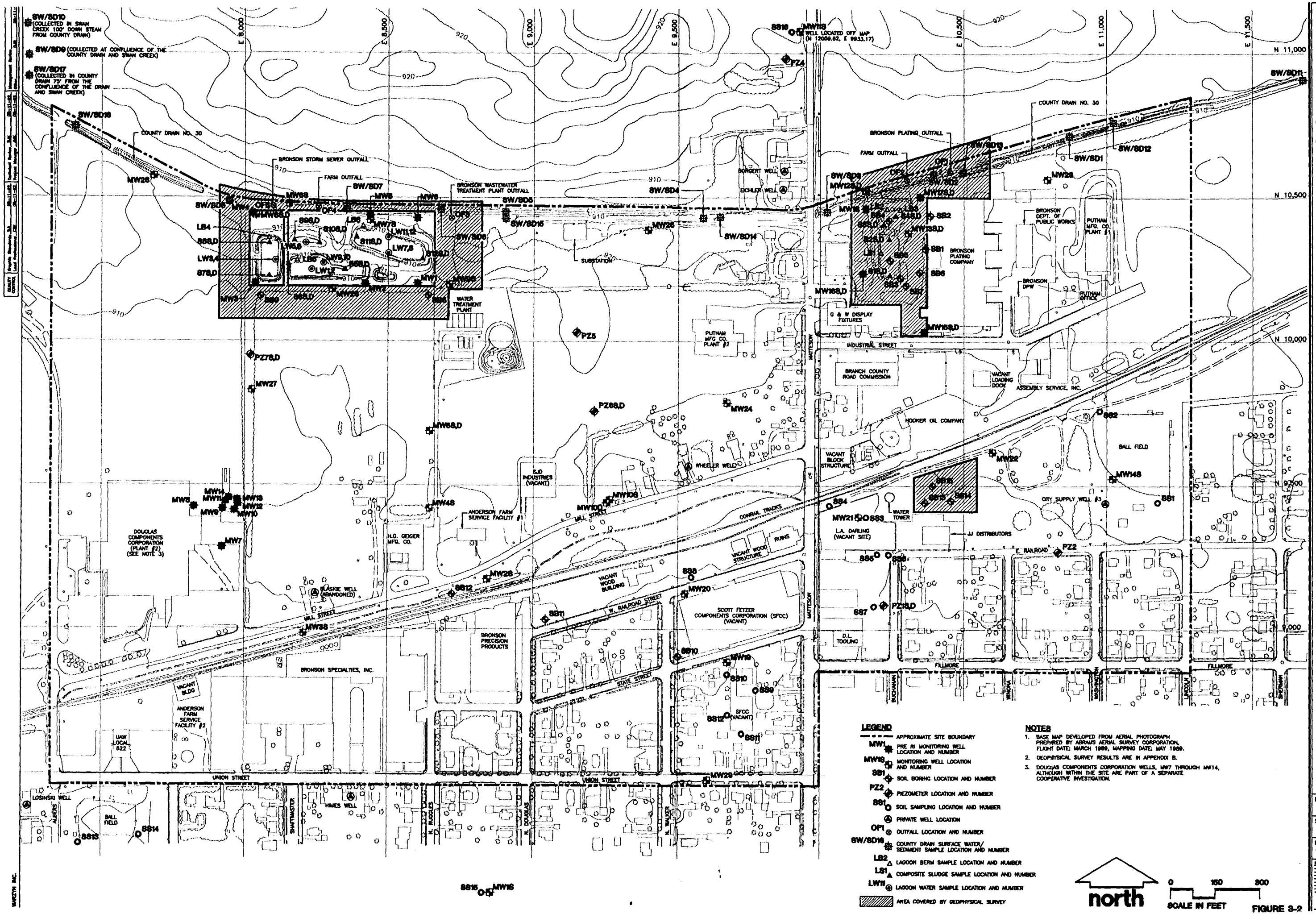

FIGURE 3-2

AREAS COVERED BY GEOPHYSICAL SURVEYS

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawn By: SJL
Date: 7/13/93
Developed By: CSY
Approved By: JMK
Reference:
Revisions:

Printed
Sheet Number
Drawing Number 7005100 D3

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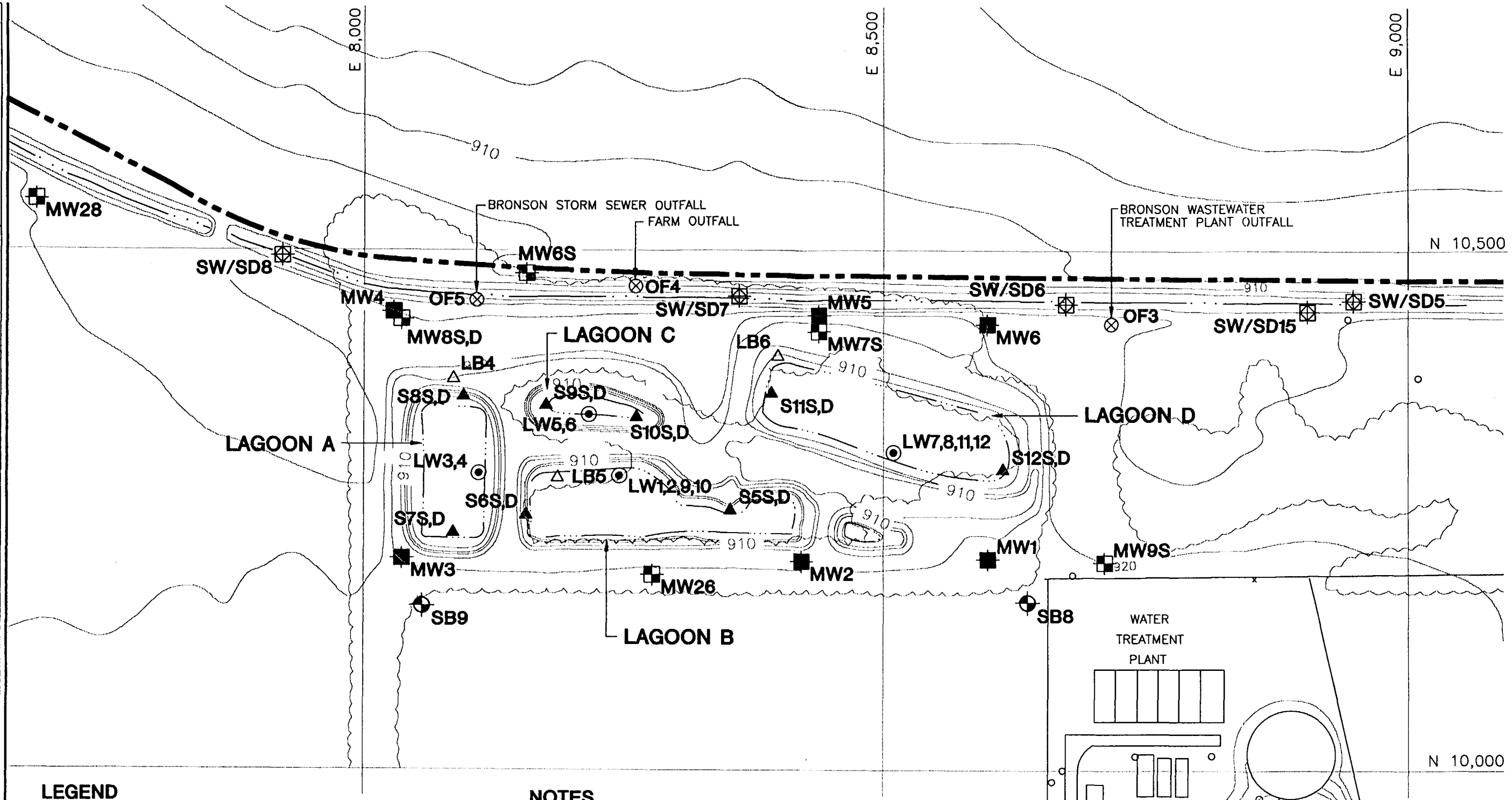
WARZYN INC.



LEGEND

- APPROXIMATE SITE BOUNDARY
- MW1 — MONITORING WELL LOCATION AND NUMBER (IN EXISTENCE PRIOR TO RI)
- MW8S — MONITORING WELL LOCATION AND NUMBER
- SW/SD6 — COUNTY DRAIN SURFACE WATER/ SEDIMENT SAMPLE LOCATION AND NUMBER
- SB8 — SOIL BORING LOCATION AND NUMBER
- OF3 — APPROXIMATE OUTFALL LOCATION AND NUMBER
- L6S — LAGOON BERM SAMPLE LOCATION AND NUMBER
- S6S — COMPOSITE SLUDGE SAMPLE LOCATION AND NUMBER
- LW11 — LAGOON WATER SAMPLE LOCATION AND NUMBER

NOTES

1. BASE MAP DEVELOPED FROM AERIAL PHOTOGRAPH PREPARED BY ABRAMS AERIAL SURVEY CORPORATION, FLIGHT DATE; MARCH 1989, MAPPING DATE; MAY 1989.
2. THIS DRAWING IS INTENDED TO SHOW ONLY THOSE SAMPLING POINTS IN AND ADJACENT TO THE WESTERN LAGOONS.

north

0 100 200

SCALE IN FEET

FIGURE 3-3

QUALITY CONTROL
Graphic Standards SJL 08-11-92 | Technical Review BJH 08-11-92 | Management Review
Lead Professional SGW 08-11-92 | Project Manager JMK 08-11-92 | Other JDD 08-11-92

WARZYN INC.

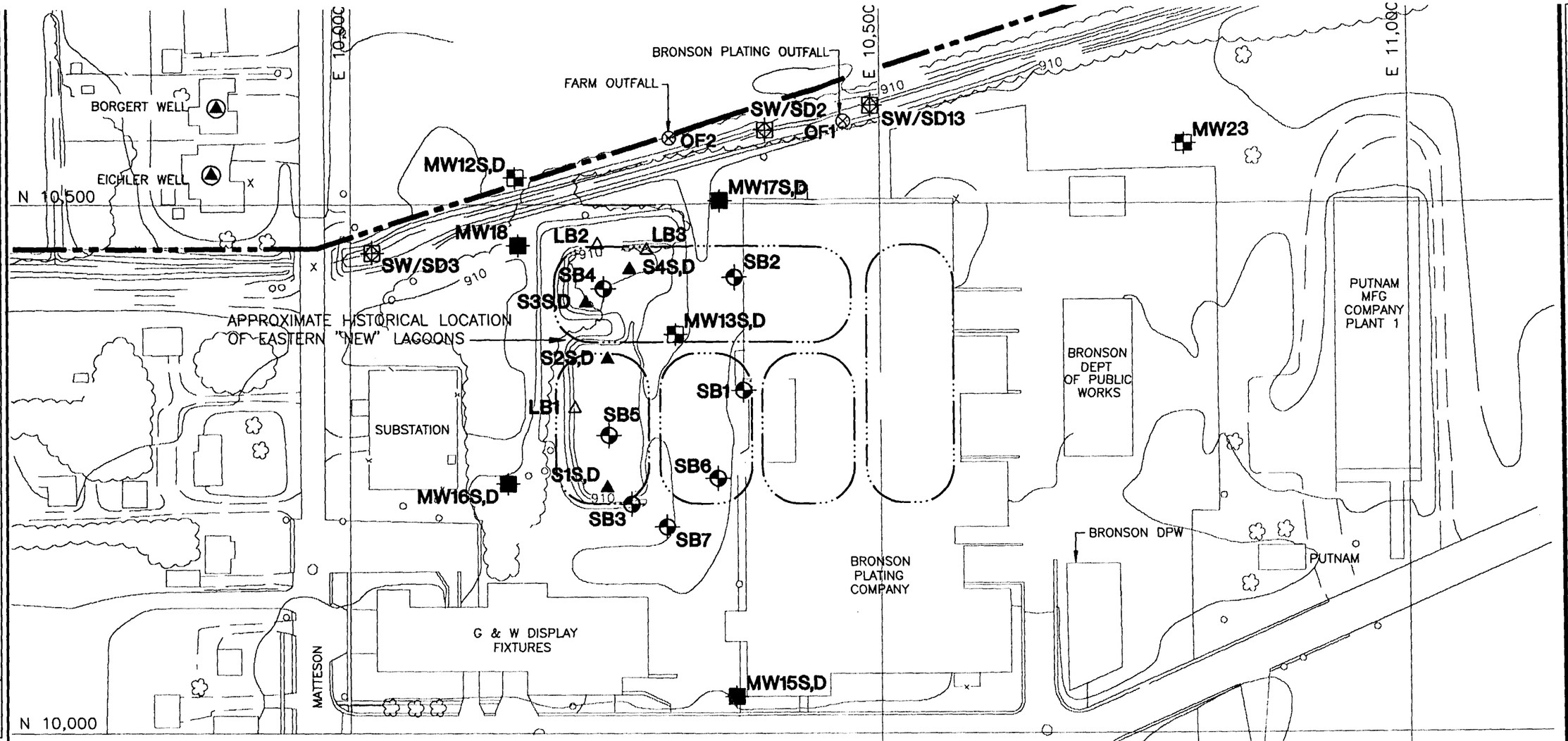
Developed By: CSY
Drawn By: SJL
Approved By: JMK
Date: 7/13/93
Reference:
Revisions:

FURTHER DEFINITION OF WESTERN LAGOONS

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawing Number
7005100 B17

WARZYN



LEGEND

- APPROXIMATE SITE BOUNDARY
- MW15S — MONITORING WELL LOCATION AND NUMBER (IN EXISTENCE PRIOR TO RI)
- MW12S — MONITORING WELL LOCATION AND NUMBER
- SW/SD3 — COUNTY DRAIN SURFACE WATER/ SEDIMENT SAMPLE LOCATION & NUMBER
- SB1 — SOIL BORING LOCATION AND NUMBER
- PRIVATE WELL LOCATION
- OF1 — APPROXIMATE OUTFALL LOCATION AND NUMBER
- LB1 — LAGOON BERM SAMPLE LOCATION AND NUMBER
- S1S — COMPOSITE SLUDGE SAMPLE LOCATION AND NUMBER

NOTES

1. BASE MAP DEVELOPED FROM AERIAL PHOTOGRAPH PREPARED BY ABRAMS AERIAL SURVEY CORPORATION, FLIGHT DATE; MARCH 1989, MAPPING DATE; MAY 1989.
2. THIS DRAWING IS INTENDED TO SHOW ONLY THOSE SAMPLING POINTS IN AND ADJACENT TO THE EASTERN LAGOONS.
3. HISTORICAL LOCATIONS OF EASTERN "NEW" LAGOONS ARE FROM AERIAL PHOTOGRAPHS PROVIDED IN "SITE ANALYSIS, NORTH BRONSON INDUSTRIAL AREA, NORTH BRONSON, MICHIGAN," U.S. EPA DOCUMENT NO. TS-PIC-92135, DECEMBER 1992.

north

0 100 200

SCALE IN FEET

FIGURE 3-4

QUALITY CONTROL | Graphic Standards SJL | Lead Professional SGW | 08-11-92
Technical Review BJH | Project Manager JMK | 08-11-92 | 08-11-92
Management Review JDD | Other | 08-11-92

Developed By: CSY
Drawn By: SJL
Approved By: JMK
Date: 7/13/93
Reference:
Revisions:

FURTHER DEFINITION OF EASTERN LAGOONS

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawing Number
7005100 B18

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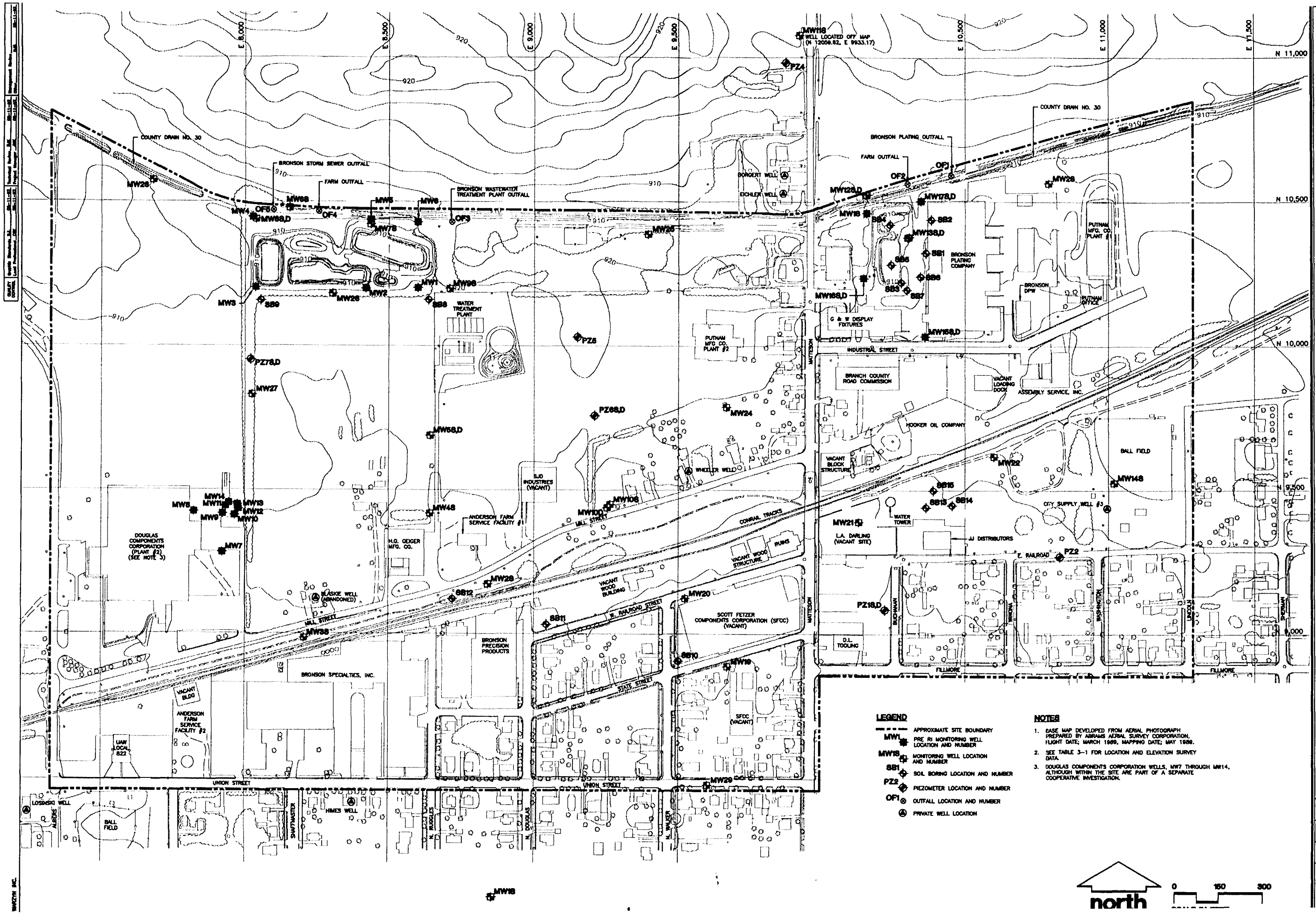

Drawn By: SJL
Date: 7/13/93
Developed By: CSY
Approved By: JMK
Reference:
Revisions:

SITE MAP SHOWING SURVEYED SAMPLING LOCATIONS

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

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Sheet Number
Drawing Number 7005100 D4

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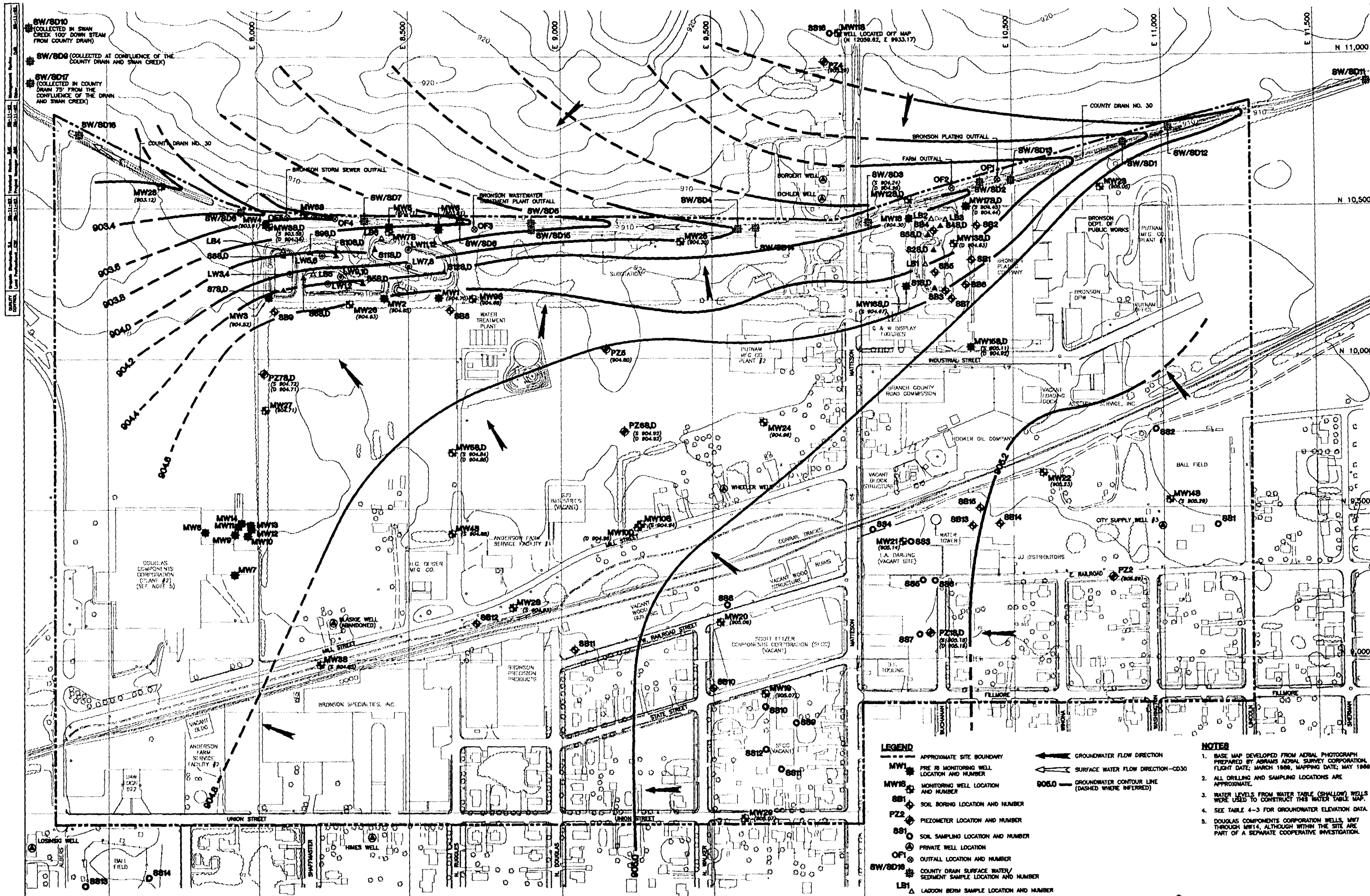


FIGURE 3-6

WINTER WATER TABLE CONTOUR MAP (12-09-91)

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Developed By: CSY
Drawn By: SJL
Approved By: JMK
Date: 7/13/93
Reference:
Reference:
Revisions:

Printed
Sheet Number
Drawing Number 7005100 D6

WARZYN

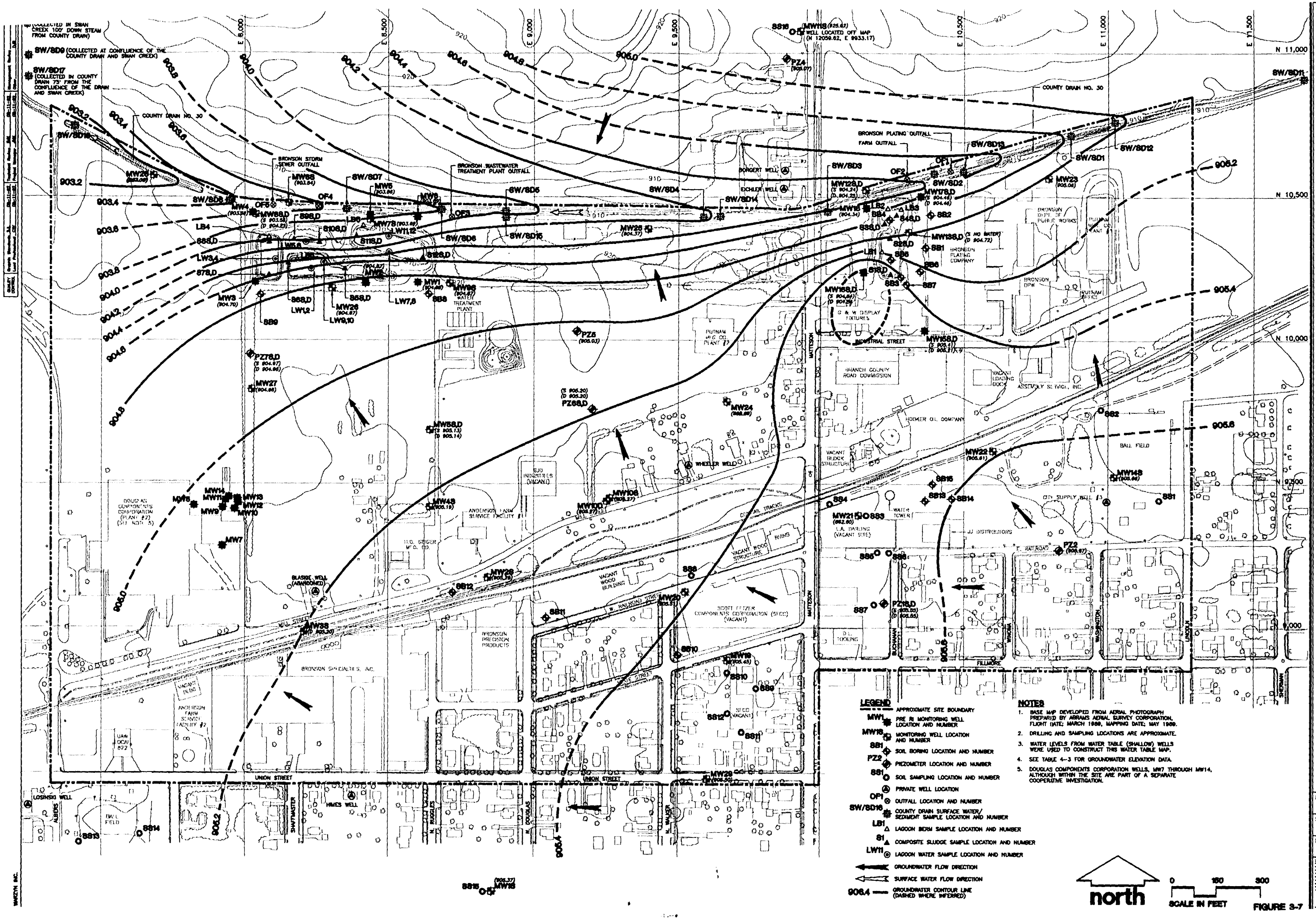


FIGURE 3-7

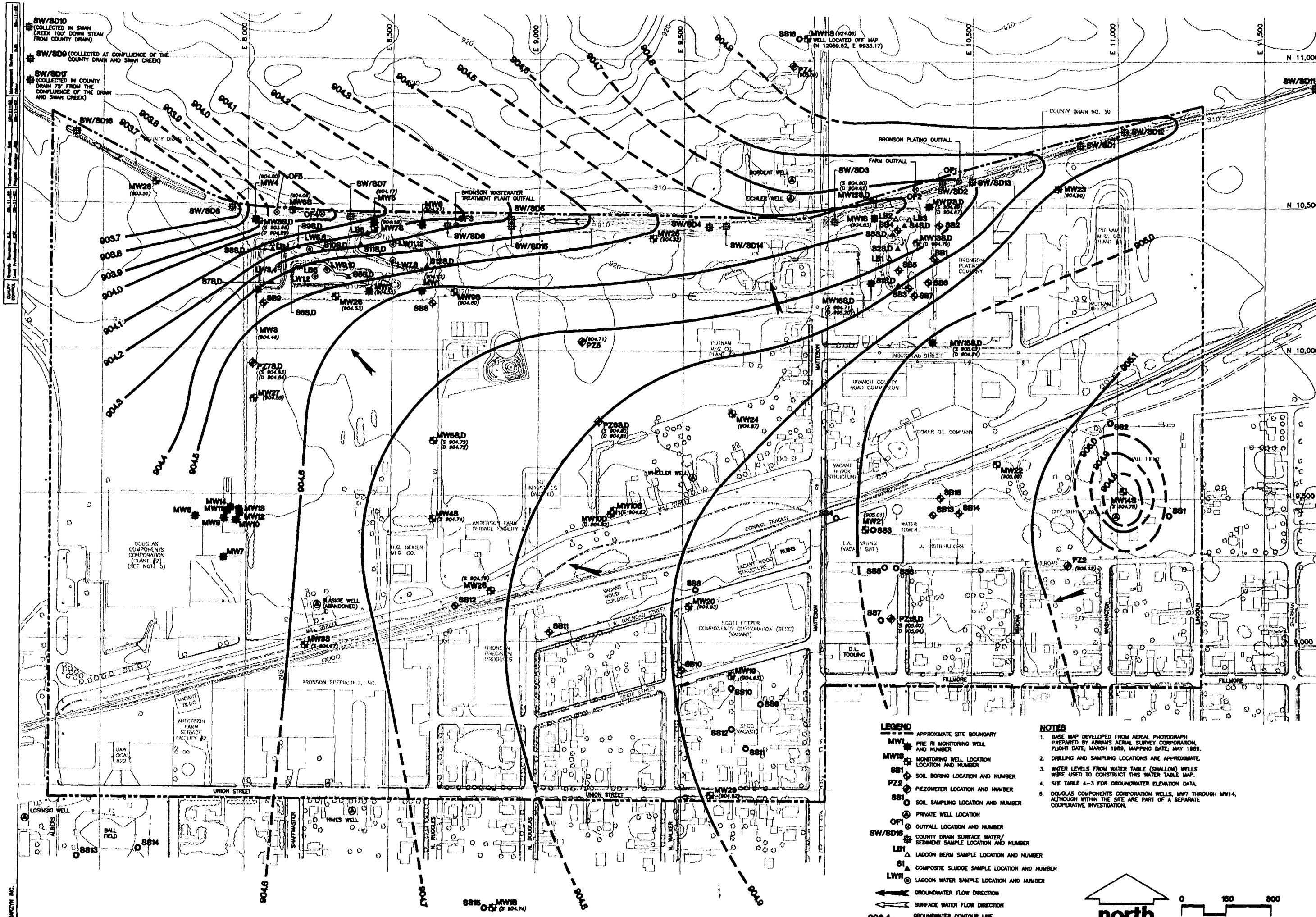
SPRING WATER TABLE CONTOUR MAP (04-22-92)

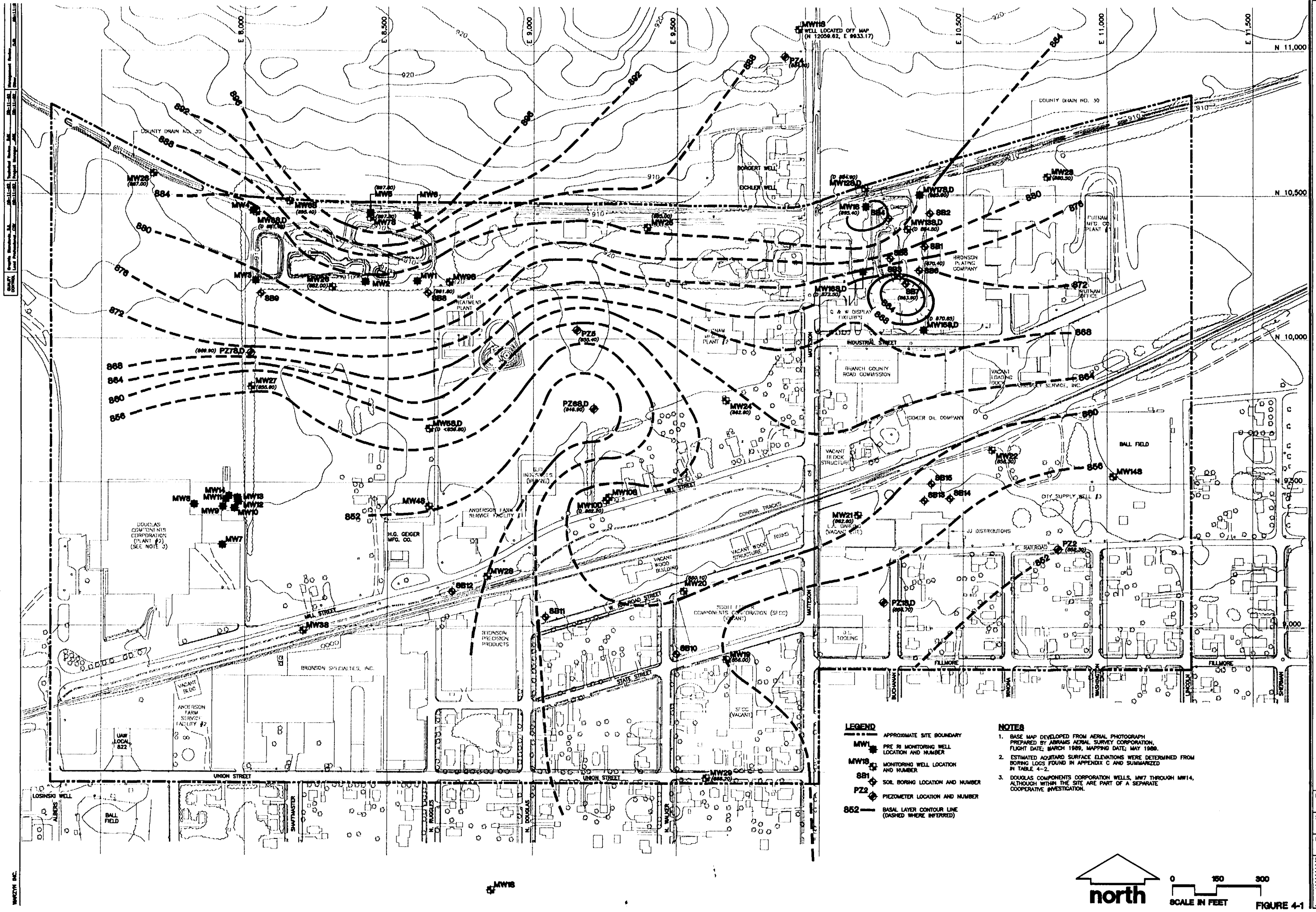
REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawn By: SJL
Date: 7/13/93
Developed By: CSY
Approved By: JMK
Reference:
Revisions:

Printed
Sheet Number
Drawing Number 7005100 D6

WARZYN


SUMMER WATER TABLE CONTOUR MAP (06-25-92)
REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN
LEGEND
APPROXIMATE SITE BOUNDARY
PRE RI MONITORING WELL AND NUMBER
MONITORING WELL LOCATION LOCATION AND NUMBER
SOIL BORING LOCATION AND NUMBER
PIEZOMETER LOCATION AND NUMBER
SOIL SAMPLING LOCATION AND NUMBER
PRIVATE WELL LOCATION
OUTFALL LOCATION AND NUMBER
COUNTY DRAIN SURFACE WATER/ SEDIMENT SAMPLE LOCATION AND NUMBER
LAGOON BERM SAMPLE LOCATION AND NUMBER
COMPOSITE SLUDGE SAMPLE LOCATION AND NUMBER
LAGOON WATER SAMPLE LOCATION AND NUMBER
GROUNDWATER FLOW DIRECTION
SURFACE WATER FLOW DIRECTION
GROUNDWATER CONTOUR LINE (DASHED WHERE INFERRED)
NOTES
1. BASE MAP DEVELOPED FROM AERIAL PHOTOGRAPH PREPARED BY ABRAMS AERIAL SURVEY CORPORATION, FLIGHT DATE; MARCH 1989, MAPPING DATE; MAY 1989.
2. DRILLING AND SAMPLING LOCATIONS ARE APPROXIMATE.
3. WATER LEVELS FROM WATER TABLE (SHALLOW) WELLS WERE USED TO CONSTRUCT THIS WATER TABLE MAP.
4. SEE TABLE 4-3 FOR GROUNDWATER ELEVATION DATA.
5. DOUGLAS COMPONENTS CORPORATION WELLS, MW7 THROUGH MW14, ALTHOUGH WITHIN THE SITE ARE PART OF A SEPARATE COOPERATIVE INVESTIGATION.
north
0 150 300
SCALE IN FEET
Developed By: CSY
Drawn By: SJL
Approved By: JMK
Date: 7/13/93
Reference:
Revisions:
Printed
Sheet Number
Drawing Number
7005100 D7
WARZYN
WARZYN INC.



LEGEND

- APPROXIMATE SITE BOUNDARY
- MW1 — PRE RI MONITORING WELL LOCATION AND NUMBER
- MW18 — MONITORING WELL LOCATION AND NUMBER
- SB1 — SOIL BORING LOCATION AND NUMBER
- PZ9 — PIEZOMETER LOCATION AND NUMBER
- 852 — BASAL LAYER CONTOUR LINE (DASHED WHERE INFERRED)

NOTES

1. BASE MAP DEVELOPED FROM AERIAL PHOTOGRAPH PREPARED BY ABRAMS AERIAL SURVEY CORPORATION, FLIGHT DATE: MARCH 1989, MAPPING DATE: MAY 1989.
2. ESTIMATED AQUITARD SURFACE ELEVATIONS WERE DETERMINED FROM BORING LOGS FOUND IN APPENDIX C AND SUMMARIZED IN TABLE 4-2.
3. DOUGLAS COMPONENTS CORPORATION WELLS, MW7 THROUGH MW14, ALTHOUGH WITHIN THE SITE ARE PART OF A SEPARATE COOPERATIVE INVESTIGATION.

north

0 150 300
SCALE IN FEET

FIGURE 4-1

ESTIMATED AQUITARD SURFACE CONTOUR MAP

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawn By: SJL
Date: 7/13/93
Developed By: CSY
Approved By: JMK
Reference:
Revisions:

Printed
Sheet Number
Drawing Number 7005100 D8

WARZYN

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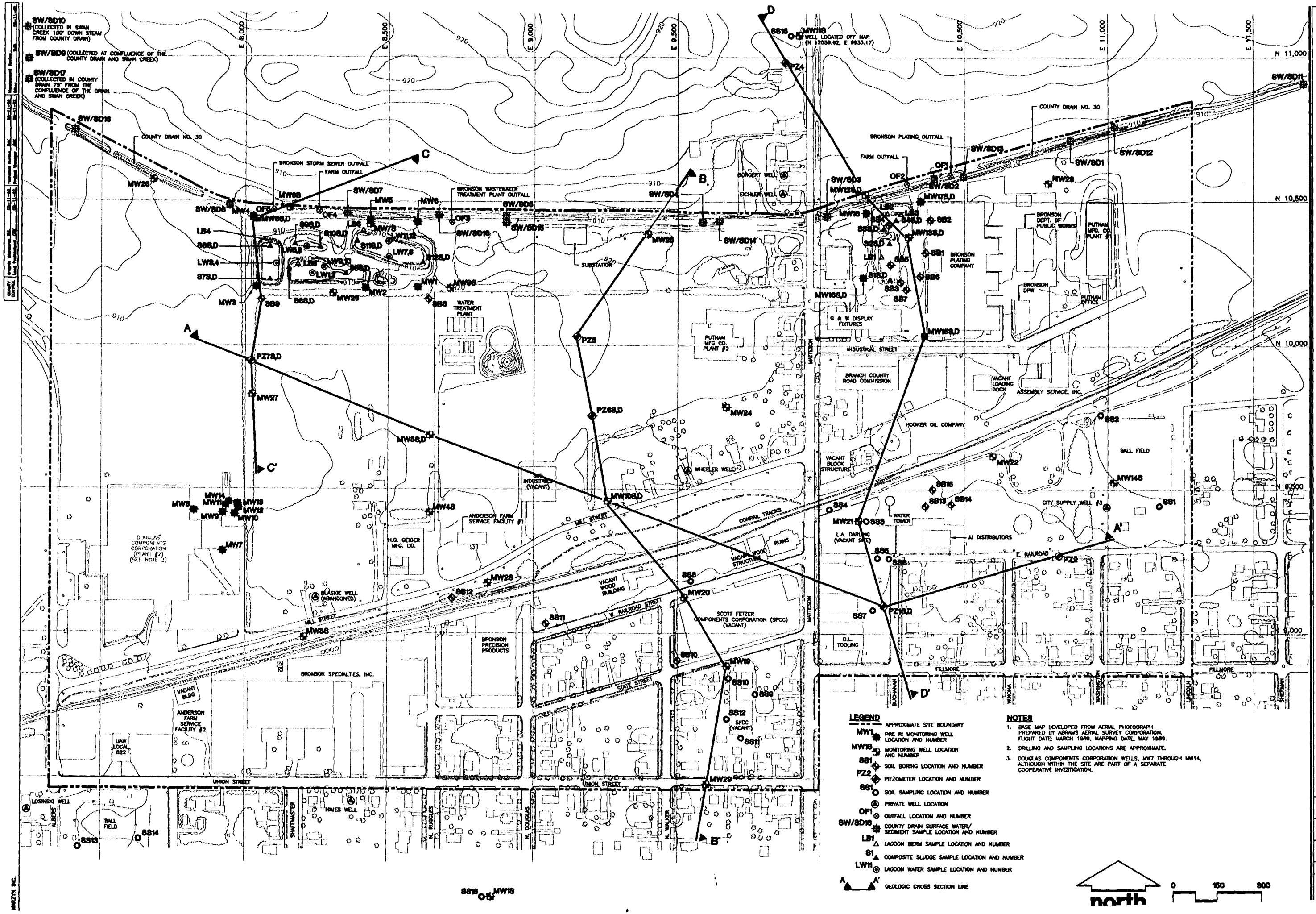

Developed By: CSY
Approved By: JMK
Drawn By: SJL
Date: 7/13/93
Reference:
Revisions:

LINES OF GEOLOGIC CROSS SECTION

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Printed
Sheet Number
Drawing Number 7005100 D9

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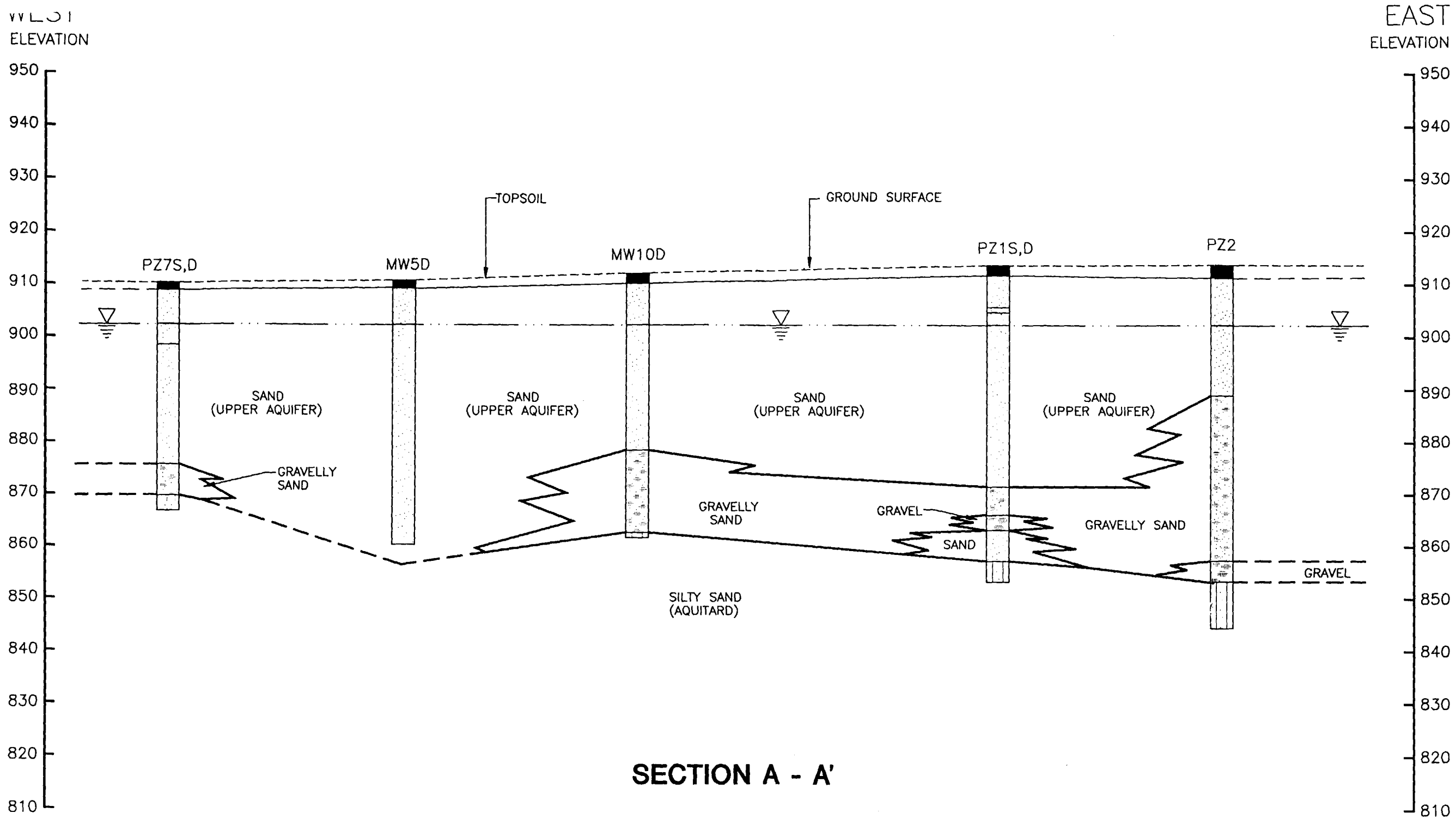

SECTION A - A'

LEGEND

- TOPSOIL
- CLEAN SAND
- CLEAN GRAVEL
- SILTY SAND
- GRAVELLY SAND
- WATER TABLE
- INFERRED

NOTES

1. STRATUM LINES ARE BASED ON INTERPOLATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.
2. CROSS SECTION LOCATIONS ARE SHOWN ON DRAWING FIGURE 4–2.
3. VERTICAL SCALE HAS BEEN EXAGGERATED FIFTEEN TIMES.
4. HORIZONTAL DISTANCES ARE MEASURED WITH RESPECT TO THE CENTER OF EACH SOIL BORING LOCATION.
5. ELEVATIONS ARE SHOWN IN REFERENCE TO U.S.G.S. DATUM.
6. SEE APPENDIX C FOR WELL CONSTRUCTION DETAILS & SOIL BORING LOGS.

CROSS SECTION SCALE

20

0

0 300 600

SCALE IN FEET

VERTICAL EXAGGERATION: FIFTEEN TIMES

FIGURE 4-3

Developed By: CSY
Drawn By: SJL,TBK
Approved By: JMK
Date: 7/13/93
Reference:
Revisions:

GEOLOGIC CROSS SECTION A - A'

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawing Number
7005100 **B13**

WARZYN

QUALITY CONTROL
Graphic Standards
Lead Professional
Technical Review
Project Manager
Management Review
Other

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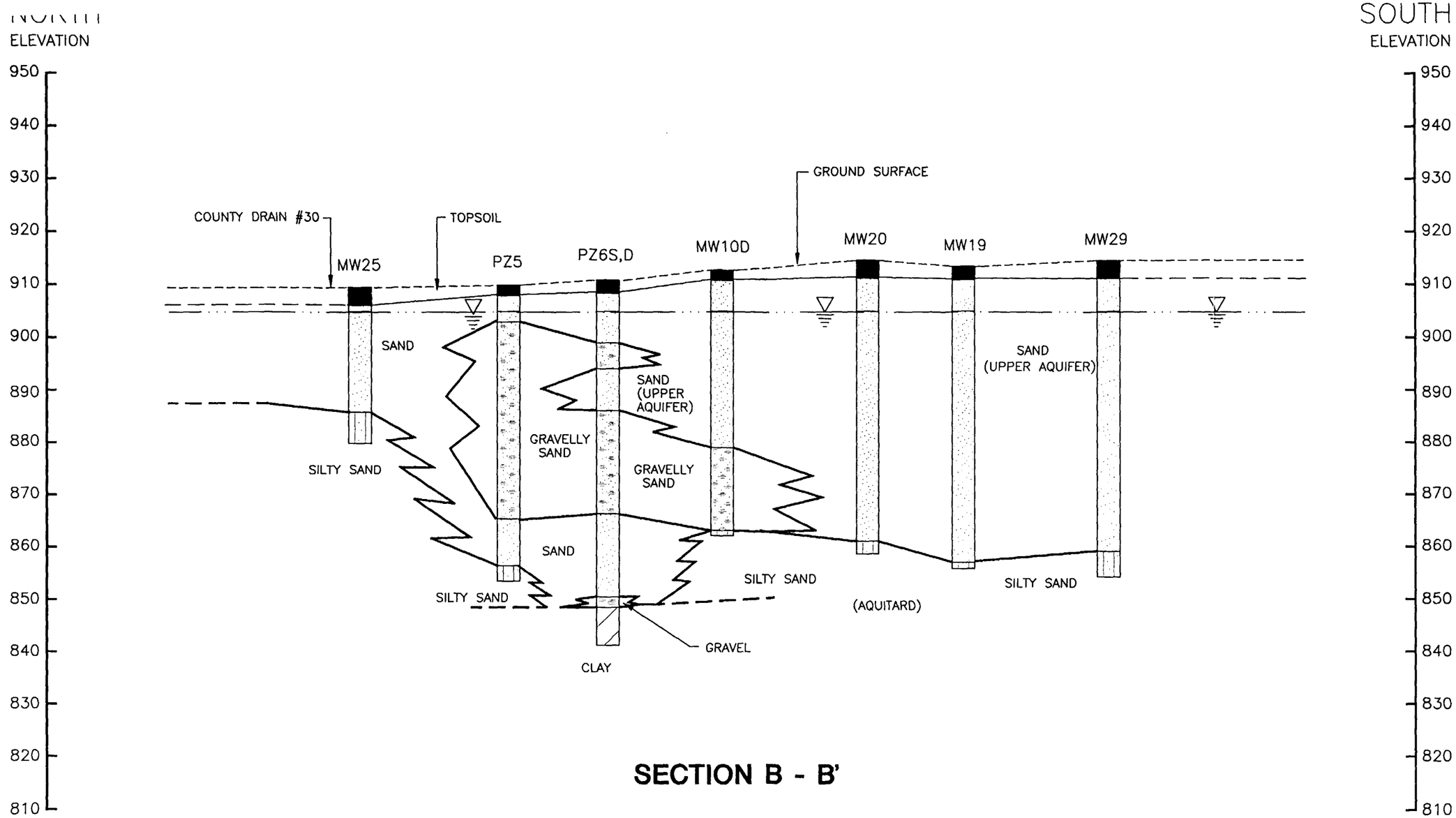

SECTION B - B'

LEGEND

- TOPSOIL
- CLEAN SAND
- CLEAN GRAVEL
- SILTY SAND
- GRAVELLY SAND
- WATER TABLE
- INFERRED

NOTES

1. STRATUM LINES ARE BASED ON INTERPOLATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.
2. CROSS SECTION LOCATIONS ARE SHOWN ON DRAWING FIGURE 4–2.
3. VERTICAL SCALE HAS BEEN EXAGGERATED FIFTEEN TIMES.
4. HORIZONTAL DISTANCES ARE MEASURED WITH RESPECT TO THE CENTER OF EACH SOIL BORING LOCATION.
5. ELEVATIONS ARE SHOWN IN REFERENCE TO U.S.G.S. DATUM.
6. SEE APPENDIX C FOR WELL CONSTRUCTION DETAILS & SOIL BORING LOGS.
7. STRATIGRAPHY FOR WELLS MW19, MW20, MW25, AND MW29 IS BASED ON DRILL CUTTINGS, GAMMA–LOGGING, AND OBSERVED CHANGES IN DRILLING EFFORT.

CROSS SECTION SCALE

20

0

0 300 600

SCALE IN FEET

VERTICAL EXAGGERATION: FIFTEEN TIMES

FIGURE 4-4

Management Review
Other
Technical Review
Project Manager
Graphic Standards
Lead Professional
QUALITY CONTROL

WARZYN INC.

Developed By: CSY
Drawn By: SJL,TBK
Approved By: JMK
Date: 7/13/93
Reference:
Revisions:

GEOLOGIC CROSS SECTION B - B'

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawing Number
7005100 **B14**

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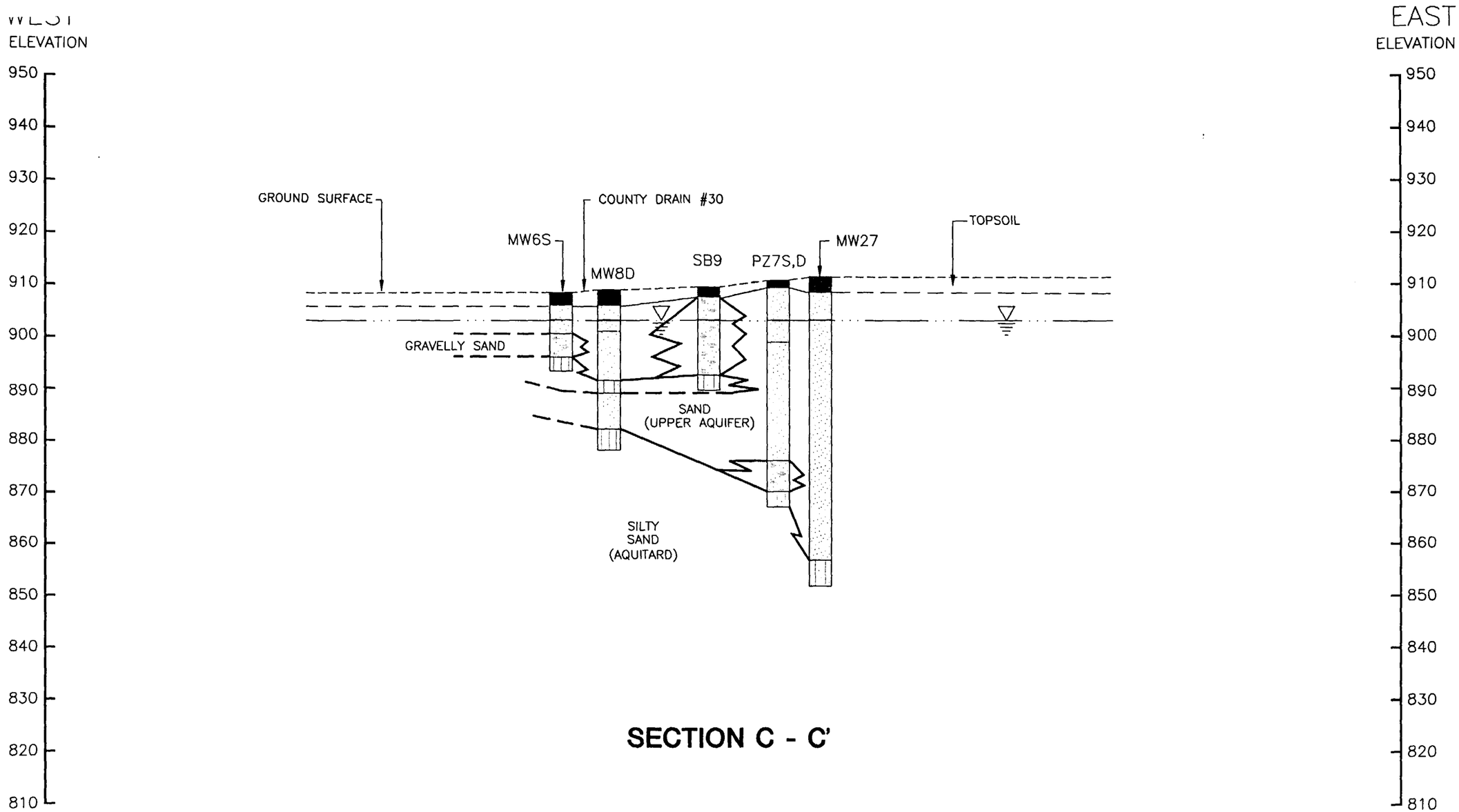


SECTION C - C'

LEGEND

- TOPSOIL
- CLEAN SAND
- CLEAN GRAVEL
- SILTY SAND
- GRAVELLY SAND
- WATER TABLE
- INFERRED

NOTES

1. STRATUM LINES ARE BASED ON INTERPOLATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.
2. CROSS SECTION LOCATIONS ARE SHOWN ON DRAWING FIGURE 4-2.
3. VERTICAL SCALE HAS BEEN EXAGGERATED FIFTEEN TIMES.
4. HORIZONTAL DISTANCES ARE MEASURED WITH RESPECT TO THE CENTER OF EACH SOIL BORING LOCATION.
5. ELEVATIONS ARE SHOWN IN REFERENCE TO U.S.G.S. DATUM.
6. SEE APPENDIX C FOR WELL CONSTRUCTION DETAILS & SOIL BORING LOGS.
7. STRATIGRAPHY FOR WELL MW27 IS BASED ON DRILL CUTTINGS, GAMMA-LOGGINGS, AND OBSERVED CHANGES IN DRILLING EFFORT.

CROSS SECTION SCALE

20

0

0 300 600

SCALE IN FEET

VERTICAL EXAGGERATION: FIFTEEN TIMES

FIGURE 4-5

QUALITY CONTROL
Graphic Standards
Lead Professional
Technical Review
Project Manager
Management Review
Other

WARZYN INC.

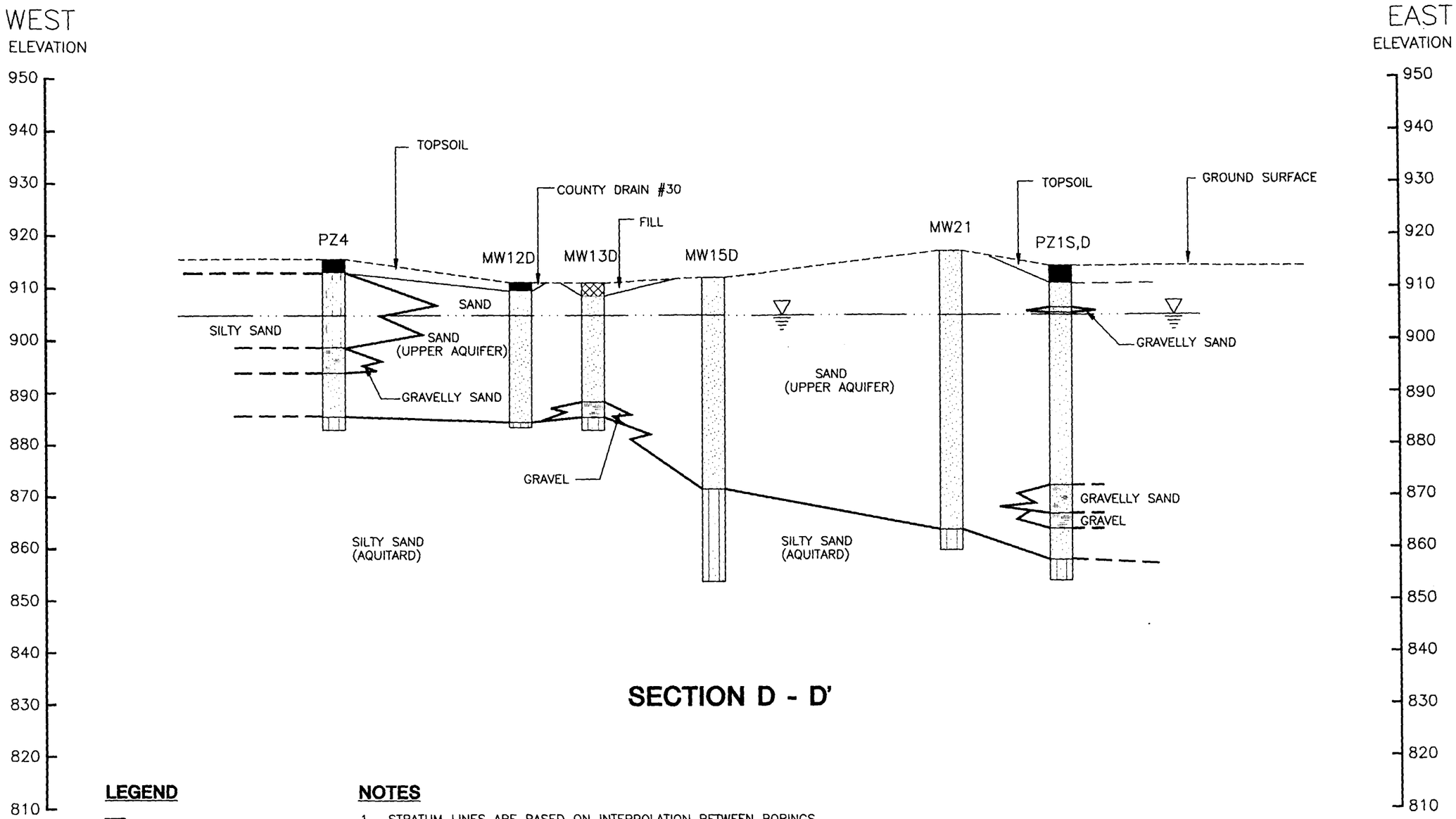
Developed By: CSY
Drawn By: SJL,TBK
Approved By: JMK
Date: 7/13/93
Reference:
Revisions:

GEOLOGIC CROSS SECTION C - C'

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawing Number
7005100 **B15**

WARZYN



SECTION D - D'

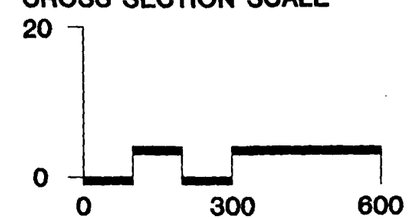
LEGEND

- TOPSOIL
- FILL
- CLEAN SAND
- CLEAN GRAVEL
- SILTY SAND
- GRAVELLY SAND
- WATER TABLE
- INFERRED

NOTES

1. STRATUM LINES ARE BASED ON INTERPOLATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.
2. CROSS SECTION LOCATIONS ARE SHOWN ON DRAWING FIGURE 4–2.
3. VERTICAL SCALE HAS BEEN EXAGGERATED FIFTEEN TIMES.
4. HORIZONTAL DISTANCES ARE MEASURED WITH RESPECT TO THE CENTER OF EACH SOIL BORING LOCATION.
5. ELEVATIONS ARE SHOWN IN REFERENCE TO U.S.G.S. DATUM.
6. SEE APPENDIX C FOR WELL CONSTRUCTION DETAILS & SOIL BORING LOGS.
7. STRATIGRAPHY FOR MW21 IS BASED ON DRILL CUTTINGS, GAMMA–LOGGINGS, AND OBSERVED CHANGES IN DRILLING EFFORT.

CROSS SECTION SCALE



SCALE IN FEET
VERTICAL EXAGGERATION: FIFTEEN TIMES

FIGURE 4-6

QUALITY CONTROL | Graphic Standards | Lead Professional | Technical Review | Project Manager | Management Review | Other

Developed By: CSY
Drawn By: SJL,TBK
Approved By: JMK
Date: 7/13/93
Reference:
Revisions:

GEOLOGIC CROSS SECTION D - D'

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawing Number
7005100 B16

WARZYN INC.

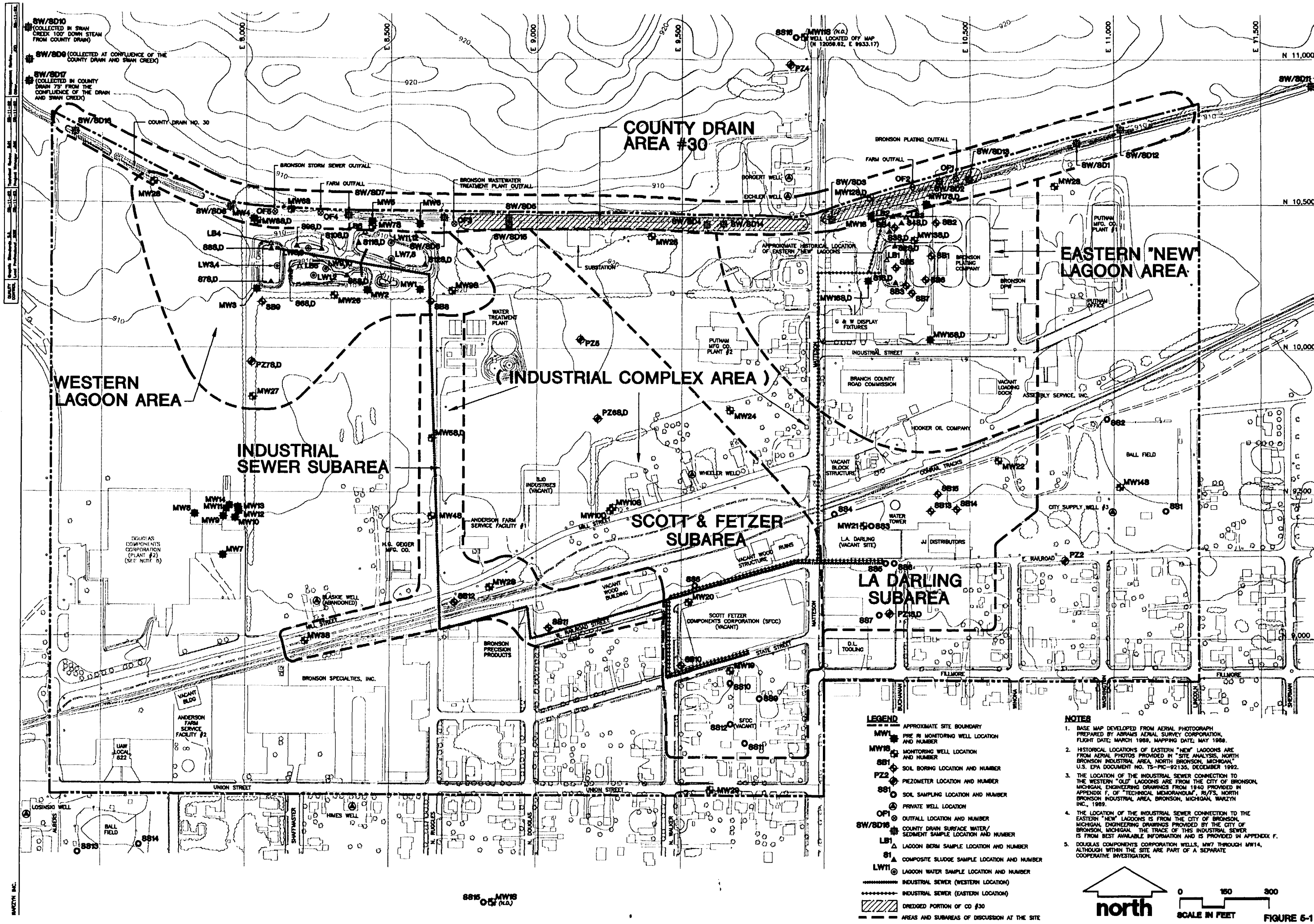


FIGURE 5-1

DELINEATION OF DISCUSSION AREAS

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawn By: SJL
Date: 7/13/93
Developed By: SGW
Approved By: JMK
Reference:
Revisions:

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Sheet Number
Drawing Number 7005100 D10

WARZYN

WARZYN INC.

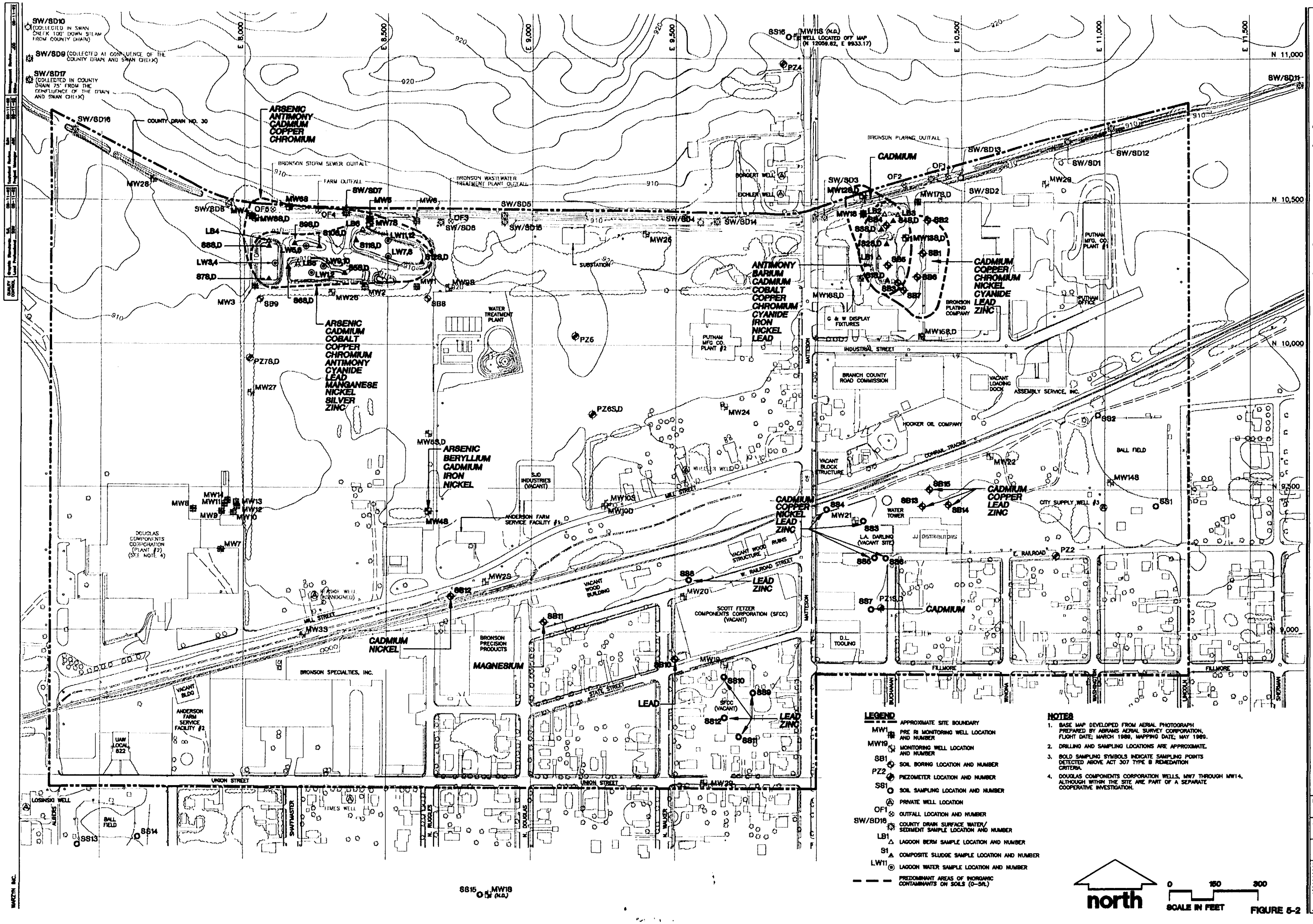


FIGURE 5-2

PREDOMINANT AREAS OF INORGANIC CONTAMINATION IN SOIL (0 - 5 FEET) ABOVE MICHIGAN ACT 307 TYPE B REMEDIATION CRITERIA

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Developed By: SGW
Drawn By: SJL
Approved By: JMK
Date: 7/13/93
Reference:
Revisions:

Printed
Sheet Number
Drawing Number 7005100 D11

WARZYN

WARZYN INC.

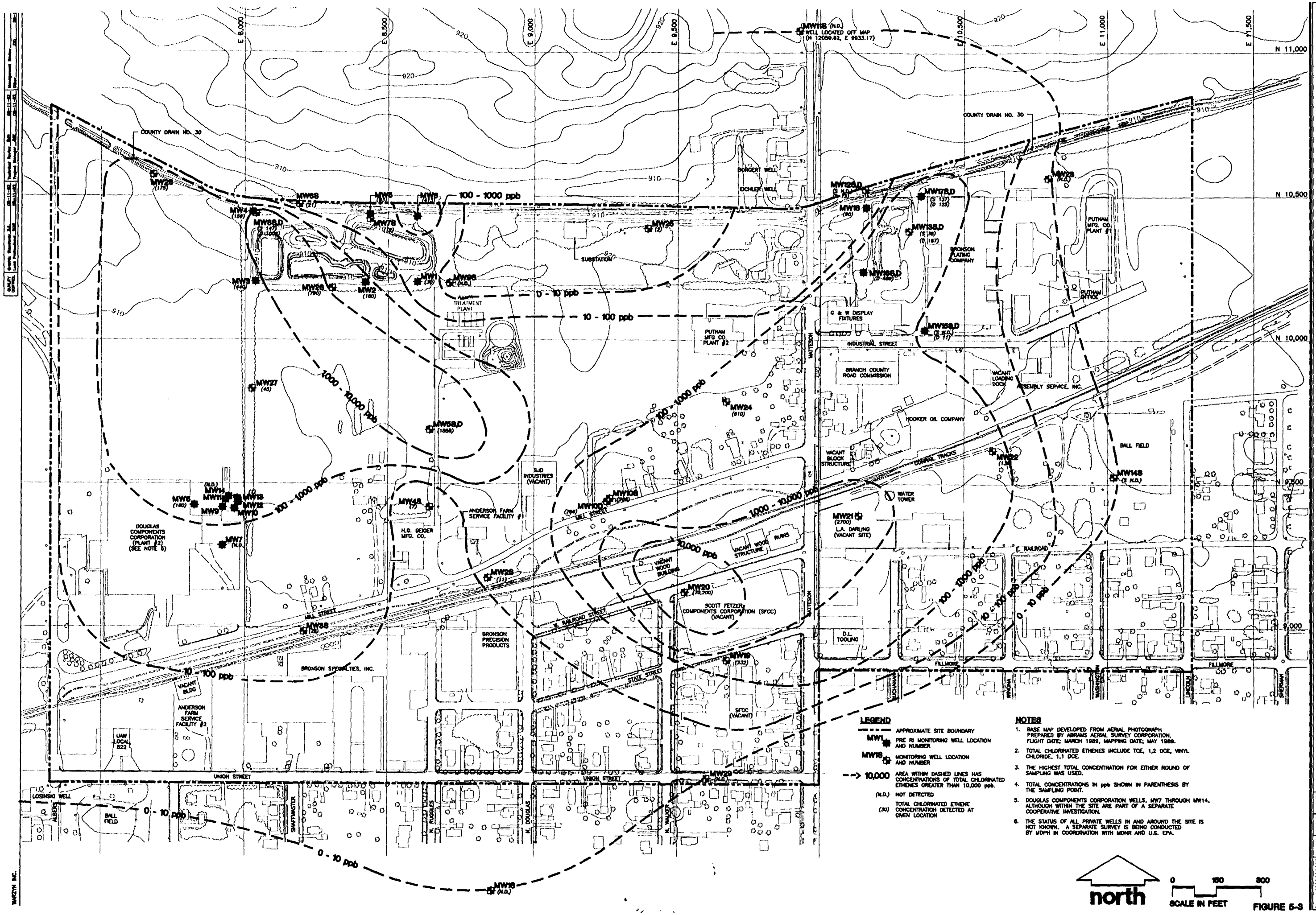


FIGURE 5-3

ESTIMATED TOTAL CHLORINATED ETHENE CONCENTRATIONS OF IN GROUNDWATER

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Developed By: SGW
Approved By: JMK
Drawn By: SJL
Date: 7/13/93
Reference:
Revisions:

Printed
Sheet Number
Drawing Number 7005100 D12

WARZYN

WARZYN INC.

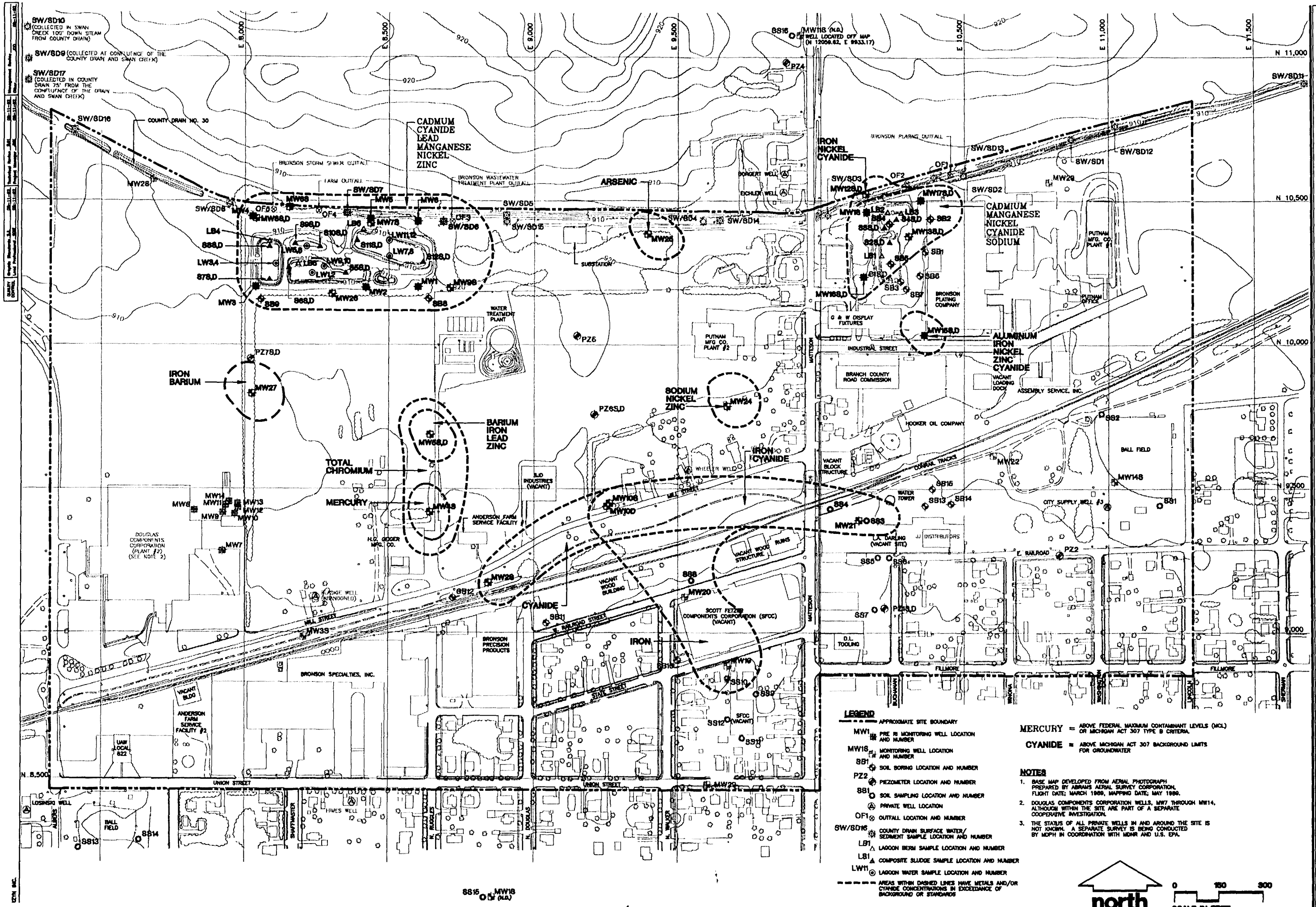


FIGURE 5-4

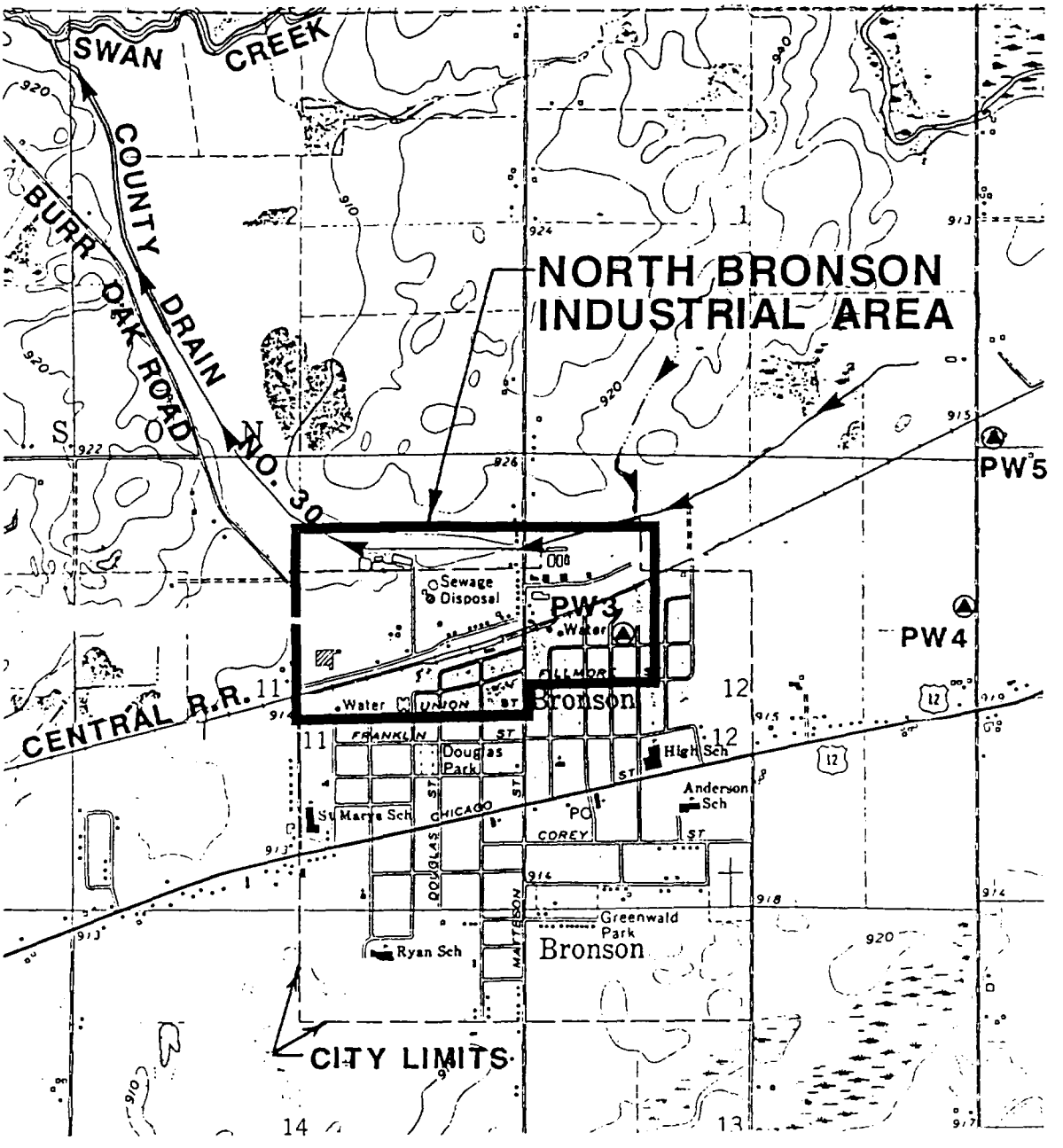
ESTIMATED LOCATIONS OF PREDOMINANT METALS AND CYANIDE IN GROUNDWATER ABOVE BACKGROUND AND/OR MCLs AND MICHIGAN ACT 307 TYPE B CRITERIA

REMEDIAL INVESTIGATION
NORTH BRONSON INDUSTRIAL AREA
BRANCH COUNTY
BRONSON, MICHIGAN

Drawn By: SJL
Date: 7/13/93
Developed By: SGW
Approved By: JMK
Reference:
Revisions:

Printed
Sheet Number
Drawing Number 7005100 D13

WARZYN



LEGEND

EXISTING PUBLIC WATER SUPPLY WELL

NOTES

1. BASE MAP DEVELOPED FROM THE BRONSON NORTH AND SOUTH 7.5 MINUTE U.S.G.S. TOPOGRAPHIC QUADRANGLE MAP, DATED 1960.
2. CONTOUR INTERVAL IS 10 FEET.
3. BOUNDARIES OF THE NORTH BRONSON INDUSTRIAL AREA SITE ARE APPROXIMATE.
4. LOCATIONS OF THE WATER SUPPLY WELLS ARE APPROXIMATE.

QUADRANGLE LOCATION

north

0 2000 4000

SCALE IN FEET

FIGURE 2-1

Developed By: CSY	Drawn By: DLF,SJL	SITE LOCATION MAP	Drawing Number 7005100 A1
Approved By: JMK	Date: 7.13.93	REMEDIAL INVESTIGATION NORTH BRONSON INDUSTRIAL AREA BRANCH COUNTY BRONSON, MICHIGAN	WARZYN
Reference:			
Revisions:			

WARZYN INC.

QUALITY CONTROL
Graphic Standards SJL 08-11-92
Lead Professional CSY 08-11-92
Technical Review RJK 08-11-92
Project Manager JMK 08-11-92
Management Review
Other DJB 08-11-92