ATSDR
AGENCY FOR TOXIC SUBSTANCES
AND DISEASE REGISTRY

Public Health Assessment for

GROUNDWATER, SURFACE WATER, AND SEDIMENTS AT THE ST. REGIS SUPERFUND SITE

CASS LAKE, CASS COUNTY, MINNESOTA
EPA FACILITY ID: MND057597940
DECEMBER 8, 2005

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

March 31 , 2006

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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CASS LAKE, CASS COUNTY, MINNESOTA

EPA FACILITY ID: MND057597940

Prepared by:

Minnesota Department of Health
Under cooperative agreement with the
Agency for Toxic Substances and Disease Registry

This information is distributed by the Agency for Toxic Substances and Disease Registry for public comment under applicable information quality guidelines. It does not represent and should not be construed to represent final agency conclusions or recommendations.

Foreword

This document summarizes health concerns associated with the St. Regis Superfund site in Cass Lake Minnesota. It is based on a formal site evaluation prepared by the Minnesota Department of Health (MDH) in collaboration with the Agency for Toxic Substances and Disease Registry (ATSDR) and Leech Lake Band of Ojibwe (LLBO). A number of steps are necessary to do such an evaluation:

- Evaluating exposure: MDH scientists begin a site evaluation by reviewing available information about environmental contamination at the site, or emitted from the site. The first task is to find out how much contamination is present, where it is found, and how people might be exposed to it. Usually, MDH does not collect its own environmental sampling data; instead MDH relies on information provided by the U.S. Environmental Protection Agency (EPA), Agency for Toxic Substances and Disease Registry (ATSDR) and Leech Lake Band of Ojibwe (LLBO), other government agencies, businesses, and the general public.

- Evaluating health effects: If there is evidence that people are being exposed—or could be exposed—to hazardous substances, MDH scientists will take steps to determine whether that exposure could be harmful to human health. The report focuses on public health i.e., the health impact on the community as a whole and is based on existing scientific information.

- Developing recommendations: In the evaluation report, MDH, ATSDR, and LLBO outline their conclusions regarding any potential health threat posed by a site and offers recommendations for reducing or eliminating human exposure to contaminants. The role of MDH in dealing with individual sites is primarily advisory. For that reason, the evaluation report will typically recommend actions to be taken by other agencies—including EPA, LLBO, or local government. However, if an immediate health threat exists, MDH will issue a public health advisory warning of the danger and will work to resolve the problem.

- Soliciting community input: The evaluation process is interactive. MDH starts by soliciting and evaluating information from various government agencies, the organizations responsible for cleaning up the site, and the community surrounding the site. Any conclusions about the site are shared with these groups and organizations that provided the information. Once an evaluation report has been prepared, MDH seeks feedback from the public. *If you have questions or comments about this report, you are encouraged to contact MDH.*

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Executive Summary

This report evaluates the findings related to contaminated groundwater, surface water, and sediments in the area of the St. Regis site. The purpose of this report is to provide a compilation and evaluation of the groundwater, surface water, and sediment sampling to date, as well as an assessment of the implications for public health. Earlier Public Health Consultations addressed contaminated soils and human health concerns associated with the site(ATSDR, MDH, and LLBO, 2004; ATSDR, MDH, and LLBO; in preparation). Subsequent reports will address exposure to site contaminants by ingestion of fish and exposure to indoor dust. A comprehensive ecological and human health risk assessment is being completed by the U.S. Environmental Protection Agency (EPA) and International Paper Company. That assessment will evaluate the cumulative effects of all site related exposures.

The St. Regis Paper Company Site (St. Regis site) is a former wood preserving facility that operated from 1957 through 1985. It is currently owned by International Paper Company, which purchased it in 1985. As a result of activities at the facility, large volumes of soil and groundwater were contaminated by pentachlorophenol (PCP), polynuclear aromatic hydrocarbons (PAHs), polychlorinated dibenzo-p-dioxins (PCDDs, or dioxins), polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), and metals. Sampling of groundwater, surface water, and sediments in water bodies near the St. Regis site indicate that these media have also been contaminated with these chemicals, at least in part by the activities at the wood preserving facility. Contaminated groundwater continues to discharge to surface water bodies near the facility.

A series of clean up actions were taken at the site. A total of 26,000 cubic yards of contaminated soil and sludge were excavated and placed in a lined, soil containment vault in a portion of the site known as the “Southwest Area”. A groundwater pump-out system was installed to capture contaminated groundwater and to prevent it from migrating away from the site. To date, the system has removed an estimated 10,031 kg of PCP and 3,584 kg of PAHs. However, subsequent sampling indicates that significant levels of contamination remain at the site and in nearby water bodies, and that the groundwater pump-out system is not adequately capturing or controlling the contamination.

A network of monitoring wells was installed and a large number of groundwater samples have been collected. However, because of inadequacies in the monitoring network, much remains unknown about the magnitude and extent of groundwater contamination, both vertically and horizontally. Nothing is known about where groundwater discharges to nearby water bodies, such as Fox Creek and Pike Bay, and sediment and surface water sampling have not been sufficient to evaluate human health hazards associated with this discharge.

Despite the shortcomings of the sampling to date, it is clear that sediment and surface water contamination represent on-going exposure pathways. The contaminant concentrations in many of the sediment samples exceed human health based screening guidelines. Frequent exposure to these sediments would represent a public health hazard, but information regarding the frequency of exposure is lacking. At this time, the human health hazard associated with sediments at the site is considered to be indeterminate, but actions are recommended to limit exposure to sediments in Fox Creek and the channel between Pike Bay and Cass Lake.

Contaminant concentrations in the surface water, where sampled, do not appear to pose a current public health hazard. However, more sampling is needed to determine contaminant concentrations in areas most frequently used for swimming and wading. Information regarding frequency of exposure to surface water is also needed. At this time, the public health hazard associated with surface water near the site is considered to be indeterminate.

Some residents were exposed, in the past, to contaminated groundwater through private wells and/or the city water supply, in some cases above the current drinking water standards. The duration of those exposures is unknown, but in some cases may have lasted as much as several decades. Currently, the groundwater does not appear to provide a completed exposure pathway; most of the contaminated wells were sealed, those that were not sealed currently are not used for drinking water, and the city water system has been reconfigured to eliminate sources of contamination. However, significant levels of contamination persist in the groundwater, making it a potential future exposure pathway, and at least one homeowner with an unsealed well indicated their individual circumstances might necessitate future use of their well. Also, as noted above, contaminated groundwater continues to discharge to nearby water bodies, creating an indirect exposure pathway. Currently, there is no public health hazard associated with the groundwater, but actions are recommended for additional investigation and cleanup of the groundwater to prevent future exposures and eliminate discharge of contaminants to nearby surface waters.

Other health assessment documents have detailed community health concerns / health outcome data and contaminated soils at the site. The community health concerns and health outcome data report (ATSDR, MDH, and LLBO, in preparation) concluded that workers at the St. Regis facility likely experienced high levels of exposure to wood treating chemicals used at the plant, including creosote, PCP, petroleum-based solvents (fuel oil), dioxins, furans, and PAHs and that worker reports of eye irritation and burns are consistent with known health effects of exposures to these chemicals. Residents of homes on and near the site, particularly children, also likely experienced long-term exposures to these wood treating chemicals, although at levels generally lower than workers. Residents have reported numerous and varied health concerns as a result of these exposures. The report found an excess of some cancers in the population living in the Cass Lake community. However, it cannot be determined if any of the increased cancer occurrence is site-related. More generally, health outcome data reviews are usually not helpful for identifying the impacts of site chemicals, even in a sensitive sub-population such as occurs in Cass Lake. The contaminated soil health consultation (ATSDR, MDH, and LLBO, 2005) concluded that soils on the site and in some residential yards in and near the site pose an on-going public health hazard to people in the Cass Lake community. The EPA is currently planning an interim response action to reduce on-going exposures to house dust originating from the contaminated soils (EPA, 2005a; EPA, 2005b). These past and current exposures point to the need to consider cumulative exposures when evaluating the significance of exposure pathways described in the present document.

I. Introduction

This Public Health Assessment (PHA) is a collaborative effort between the Agency for Toxic Substances and Disease Registry (ATSDR), Leech Lake Band of Ojibwe (LLBO), and the Minnesota Department of Health (MDH). This PHA is part of a series of health assessment documents focusing on the health impacts associated with environmental exposures to the St. Regis Superfund site contamination in Cass Lake, Minnesota. Each document will address a specific environmental medium (soil, sediment, water, and fish) or community health concern.

This document examines ground water, surface water, and sediment contaminants, transport mechanisms and routes of exposure (ingestion, inhalation and dermal contact) to determine the magnitude of exposure to residents living in the area surrounding the St. Regis site. It reviews data presented in the site investigation, annual site monitoring, Minnesota Pollution Control Agency (MPCA) five-year review, and EPA data evaluation reports. Health effects associated with dioxin exposure are also discussed.

This document does not evaluate ecological health risks, although these are occasionally discussed in the context of human exposures. The EPA is completing a comprehensive assessment of both human and ecological risk.

The EPA, ATSDR and MDH project files, along with electronic documents provided to MDH, were reviewed. These documents and two site visits form the basis for this Public Health Assessment.

II. Background

A. Site Description and History

The following summary is based on information contained in the following documents: ATSDR Public Health Assessment, St. Regis Paper Company National Priorities List (NPL) Site, April 1989; ATSDR Site Review and Update, July 1993; ATSDR Site Review and Update, April 1995; EPA NPL Fact Sheet, St. Regis Paper Co., February 1998; Minnesota Pollution Control Agency (First) Five-Year Review Report, March 1995; EPA Second Five-Year Review Report, September 2000; EPA Fact Sheet, July 2001; EPA Fact Sheet, October 2002; and EPA Field Sampling Plan For Removal Site Evaluation, March 2003. A more detailed description of site activities and waste disposal are included in Appendix C.

The St. Regis Paper Company site, also known as “St. Regis/Wheeler” or “Champion”, is a former wood preserving facility that operated from 1957 through 1985. In 1957, the Wheeler Division of St. Regis Corporation started a wood-treatment operation on land leased from the Great Northern Railroad, which through merger has become part of Burlington Northern Santa Fe (BNSF) Railroad. The St. Regis Corporation eventually expanded the site to its current boundaries by purchasing land south of the leased facility. Then in January 1985, Champion International Corporation assumed responsibility for the site when it acquired and merged with St. Regis Corporation. The wood preserving operation ceased in September 1985.

Groundwater, surface water, sediment, and soil on and in the vicinity of the site have been contaminated as a result of the wood preserving process and waste disposal activities. On September 21, 1984, the site was placed on the National Priorities List (NPL; Superfund), and classified as a high priority Superfund site.

The site consists of 125 acres on the Leech Lake Reservation within the Chippewa National Forest and is located in Section 15, Township 145N, Range 31W, in Cass County, in the City of Cass Lake, Minnesota. The entire site is located within the exterior boundaries of the Leech Lake Reservation. The approximate site boundaries are the BNSF Railroad tracks on the north, state Highway 371 on the west, Pike Bay and the channel between the Bay and Cass Lake on the east, and to the south, Fox Creek, which empties into Pike Bay (Figure 1, Appendix A). This area is part of the Mississippi River headwaters, and surface water drains into Pike Bay and Cass Lake. The site consists of three areas: the Former Operating Area (FOA), the Southwest Area (SWA), and the Cass Lake City Dump Area (Dump).

1) Facility Operations and On-site Waste Disposal

Beginning in 1957, creosote was used as a preservative to treat wood at the FOA. It continued to be used until the facility closed. Creosote is a flammable, heavy, oily liquid with a characteristic sharp, smoky smell, and caustic burning taste. It is composed of a mixture of chemicals that varies by source, but may include: polynuclear aromatic hydrocarbons (PAHs), guaiacol, creosols, phenol, and pyridine.

The use of pentachlorophenol (PCP) as a pressure treatment chemical for wood products began in 1960. PCP, like creosote, was used until the facility closed. PCP was generally combined with a carrier solvent, usually No. 2 fuel oil. When present as a free phase product in water, this mixture tends to float. In the latter years of facility operations, a mixture of PCP and ketone, was used. This mixture was denser than water, and would sink if present as a free phase product in water.

In 1969, treatment of wood with a water-soluble metal-salt solution, believed to be chromated copper arsenate (CCA), began.

Wastewater from the facility was sent through a separation tank, a filter system, and then discharged to unlined disposal ponds known as “Pond A”, “Pond B”, and “Pond C” (Figure 2, App. A).

In 1976, a 3,000-gallon spill of creosote was recovered by absorption with sawdust, which was later burned in a brush-burning project. During two occasions in 1976, sludge from the cleaning of tanks was hauled to a disposal site in the southwestern corner of the SWA property (Figure 3, App. A). Pond C was dredged on one occasion, and the dredged bottom material was placed on the south, east and north sides of the pond. Sawdust used for removing oil from the filters was deposited in a landfill area immediately northeast of Pond C.

In 1980, wastewater from Pond C was sprayed on the ground in various areas of the FOA and SWA properties (Figures 2 and 3). Timber, metal and other demolition wastes were deposited in the landfill area (Figure 2). Wastes were also burned in “Tee-Pee Burners” in the FOA (Figure 2).

Airborne ash from the tee-pee burners would have deposited on land and surface water areas downwind of the burners.

From 1980 until the facility closed in 1985, dewatered waste residue was transported to an out-of-state hazardous waste disposal facility. However, contaminated water from the ponds and other waste water were not transported out of state, but rather were disposed through the city sewage treatment plant and spray irrigated in other areas as described in the sections below. On August 6, 1985, Champion announced the planned closure of the Cass Lake facility. The facility was closed on August 31, 1985.

2) **Off-site Wastewater Disposal at City Sewage Treatment Plant**

In 1981, the MPCA received a complaint from Leech Lake Department of Natural Resources staff alleging that wastewater from the plant was discharged from tanker trucks through a hose into a manhole adjacent and leading to the city wastewater treatment plant (MPCA, 1981b). Sampling by MPCA staff confirmed the presence of PCP in the influent and effluent of the wastewater treatment plant. The treatment plant discharges to Fox Creek.

3) Off-site Sludge Disposal at Cass Lake City Dump

Between 1957 and 1960, wastewater from Pond A and sludge from storage tanks were hauled to a pit at the city dump and burned (Figure 4, App. A). This disposal occurred almost daily at an estimated rate of 500 gallons per day, for an estimated total of 547,500 gallons during those three years. From 1960 to 1975, unknown quantities of sludge were hauled to the pit. It is probable that the contents of the pit were burned during this time period as well. The pit containing the ash and unburned residuals was eventually covered. All three types of wood treatment chemicals; creosote, PCP, and CCA, were used at the facility during the time that waste was hauled to the pit.

4) Off-Site Disposal at Southwest Area

As noted earlier, significant volumes of wastewater and sludge were disposed in the SWA. In addition to the two events of waste disposal in a pit near the southwest corner of this property, and spraying of wastewater on the property, former workers have alleged significant volumes of wastewater and sludge were dumped near the southeast corner of the property (Figure 3). Interviews with former workers in 1994 and 2003 indicate that as much as 468,000 gallons of sludge may have been disposed in the area immediately north of Fox Creek and immediately west of Highway 147 (EPA, 1994; Figures 4 and 5, App. A). These employees also noted that north of the are now occupied by the soil containment vault, the company stored 55-gallon steel drums of copper arsenate (Figure 4). The drums reportedly were not sheltered; some reportedly were rusted and leaked their contents on the ground.

The wastewater sprayed in the SWA likely had high concentrations of PCP and other contaminants. In 1980, EPA collected samples of wastewater from Pond C, after the sand filter, and after the sawdust filter. High concentrations of PCP were detected in all of the samples, including 42,000 micrograms per liter (ug/L, or parts per billion) PCP in the sample collected after the sawdust filter (EPA, 1980b). This suggests that wastewater sprayed in the SWA could have resulted in significant contamination to soil, groundwater, and surface water.

Treated timber was stored at the SWA, which likely resulted in creosote and PCP dripping onto the ground surface. There are no reports of burying wood waste in this area, but a trench excavation northeast of former well MW-111 encountered black bark chips and “dark material” at depths of approximately 2 to 4 feet below grade and sloping to the west (St. Regis, 1983). It is likely that this area was excavated during the construction of the soil containment vault. It is not known whether the soil in this area was disposed in the vault, or used as “clean” fill in the FOA, along with other soils excavated during the vault construction.

5) Environmental Investigation

Investigation of the site began in 1981. The investigation determined that the groundwater beneath the site was contaminated with various PAHs, phenol, and PCP (Barr, 1982).

In September 1984 the site was placed on the National Priorities List (NPL) and in January 1985 Champion assumed responsibility for the site. In 1984-1985, a Remedial Investigation was conducted at both the former plant and the city dump, in which both the upper and lower aquifers beneath the site were evaluated for groundwater contamination and surface water was sampled. The study concluded that PCP and PAHs were present in the upper aquifer in the FOA, with the contamination originating in the area of the treating plant and extending eastward to the channel between Cass Lake and Pike Bay. Low concentrations of PCP were also detected on the east side of the channel.

Private wells interspersed with the facility property were found to have very low levels of some PAHs, PCBs, and PCP (Table 1, App. B; Figure 6, App. A), and other wells south of the facility were deemed to potentially be at risk for future contamination. Very low levels of PAHs were also detected in the Cass Lake municipal water supply wells, but PAHs did not exceed drinking water criteria (Table 2).

Samples from one well on the eastern portion of the FOA found low levels of polychlorinated dibenzo-p-dioxins (PCDDs) in the groundwater. PCDDs are a class of compounds, also called “dioxins”, that includes 75 individual compounds. These individual compounds are technically referred to as congeners. Five forms of these compounds are considered to be significantly toxic and will occasionally be discussed separately as tetrachlorodibenzo-p-dioxin (TCDD), pentachloro-dibenzo-p-dioxin (PeCDD), hexachlorodibenzo-p-dioxin (HxCDD), heptachlorodibenzo-p-dioxin (HpCDD), and octochlorodibenzo-p-dioxin (OCDD). More often, all of the dioxin congeners detected at the site will be referred to as PCDDs. For more information about dioxins, dioxin congeners, and their toxicity, please refer to Appendix D.

Investigations in the Dump area showed higher concentrations of PCDDs, PCP, other phenolic compounds, and PAHs in the shallow aquifer than at the FOA, and groundwater was found to be discharging to Fox Creek. Surface water sampling detected PCP in Fox Creek.

In 1985 and 1986, Champion excavated approximately 22,000 cubic yards of contaminated soil and 4,000 cubic yards of sludge. These were disposed in a lined soil containment vault constructed in the Southwest Area in 1986-1987 (Champion, 1988). The engineered life of the vault is reportedly 20 years. This has raised the concern that leachate from the vault (that is, water that has picked up contaminants as it leaches through the vault contents) could escape the leachate collection system and impact groundwater. Several nearby wells are used to supply water to the Leech Lake Band of Ojibwe's (LLBO) Division of Resource Management offices and fish hatchery.

A groundwater pump and treat system consisting of eleven extraction wells was constructed at the FOA in 1985 and became operational in 1987. Three pump-out wells were installed in the City Dump Pit Site in 1988. The treated water discharges to the channel (Figure 7, App. A).

All of the private properties interspersed with the facility property and south of it, except one (where the homeowner refused; labeled G on Figure 6), were connected to city water. However, not all of the wells were sealed. At least one business continues to use a private well for non-potable use (labeled HH on Figure 6). In addition, three homes in and near the FOA still have wells present on their property, although the wells are currently not in use and these homes are connected to city water (labeled J, EE, and JJ on Figure 6).

In March 1995, the Minnesota Pollution Control Agency (MPCA) submitted a 5-year review report of the clean-up actions implemented at the site. This first 5-year review revealed that some of the clean-up actions were not adequate and that further action was needed to ensure protection of human health and the environment. Based on the first 5-year review, EPA, MDH, and the Leech Lake Division of Resource Management (LLDRM) identified several areas that required further investigation.

As a result of the findings of the first 5-year review, LLDRM obtained an Environmental Justice grant and EPA Superfund pilot project grant to support their involvement in site assessment activities. These grants were used to collect fish tissue data in 2001, develop the LLDRM's subsistence exposure scenarios for the site (Leech Lake Band of Ojibwe, 2003), and to fund a Sea Grant evaluation of the site that concluded additional investigation was needed (Richards, et. al, 2002).

EPA began the second 5-year review process in 2000, as it was planning to implement sampling recommendations from the first 5-year review. In October 2001, Tetra Tech (EPA's contractor) conducted a field investigation of the site that included sampling of soil, surface water, groundwater, sediment and fish. The sampling results identified site-related contamination in all of these media (EPA, 2002a). ATSDR was provided a copy of the Final Data Evaluation Report for the St. Regis Paper Company site and was asked to provide a public health assessment to EPA, based on a review and analysis of the new environmental data.

B. Current Conditions

All of the St. Regis/Wheeler buildings have been demolished and most of the FOA was graded to nearly level. Portions of the site are fenced and there are signs posted to restrict access. There are forty-three residences on the site, one of which is a licensed day care facility. Sand and salt are stock piled by the City of Cass Lake near the corner of 3rd St. and Cedar. A building at 3rd St. and Elm is used for storage by Reimer's Marine, a boat and marina business. Cass Forest Products, located on the west side of state Highway 371, maintains two drying kilns on the site and stock piles newly kiln dried wood on the northwest corner of the site. Most of the site soils have been disturbed during remedial and removal activities in the former pond areas on the east end of the site and during the soil grading in the Northern Storage Area.

C. Site Visits

Representatives of Region 5 ATSDR, LLDRM, Minnesota Chippewa Tribe (MCT) water quality office, and MDH met in November 2002 at the St. Regis site to discuss co-authoring a series of media specific Health Consultations that would become a Public Health Assessment on the St. Regis site. Representatives from each agency also met in January 2003 to discuss the health assessment progress, tour the site, and take pictures of the site. During site visits, it was noted that some homes in the residential area adjacent to and south of the North Storage Area, as well as north of the railroad tracks, may still be using private wells for their drinking water source.

On March 20 and 21, 2003, representatives of LLDRM and MDH conducted a survey to determine where private wells may still be in use. This consisted of a door-to-door survey south of the railroad tracks and visits to residences north of the tracks identified by the city as not being billed for municipal water. This survey identified 23 homes and businesses (3 south of the railroad tracks, and 20 north of the tracks) where private wells were still in use or the building had not been connected to city water, and at least 3 homes (all south of the railroad tracks) where private wells had not been properly sealed after the home was connected to city water (Figure 6). One of the homes south of the tracks that had not been connected to city water was not occupied, and at two others the resident stated they were not using the well because the pump had stopped functioning (one of these homes has subsequently been demolished and the well sealed). One business south of the tracks uses a private well, but not for drinking water. A fourth home south of the tracks had a new well installed, completed in the lower sand aquifer, after the home was connected to city water, but the well is currently disconnected. South of Fox Creek, all single-family residences appear to be using private wells.

D. Demographics, Land Use, and Natural Resources Use

Cass Lake, has a population of 863 (2000 census). The St. Regis site is located in Cass Lake, on the Leech Lake Indian Reservation. The site contains homes, businesses, and vacant lots owned by tribal and non-tribal individuals. The City of Cass Lake also owns portions of the site. It is estimated that one half of the site population is Indian and the other half non-Indian. The site is located within the Leech Lake Band of Ojibwe (LLBO) Indian Reservation.

The land contains forests, wetlands, and large water bodies. Local residents, and tourists use lakes and channels near the site area for recreation. People also fish, hunt, and forage on the site and adjoining lands, and in the wetlands, streams, and lakes near the site (LLBO, 2003). By treaty, the members of the Leech Lake band retain resource use rights on public lands and all waters within the Leech Lake reservation, including the St. Regis site area.

E. Community Concerns Regarding Groundwater, Sediments, and Surface Water

The Cass Lake community is deeply concerned about the St. Regis Paper Company Superfund site contamination in and around the Cass Lake/Pike Bay area. Community members (Tribal and non-tribal) expressed concern about the potential health and environmental impacts and the health of the community residents who live on or utilize resources near the site. Community members have expressed concern that contaminated groundwater continues to migrate off-site into surface waters and residential wells. Residents have also expressed concerns about waste that was dumped into the Fox Creek area and whether it is contaminating the creek and fish. Residents who live on the site want to know if they are or will be sick from exposure to site related contamination. Community members have expressed concern about elevated incidence of cancers, and other health effects in families that live next to the site. The City of Cass Lake has expressed interest in fencing the site and posting warning signs. The City has also expressed interest in community education to help avoid site contamination.

Tribal members have additional concerns relating to treaty rights and traditional practices. They are concerned that their treaty rights to hunt, fish and gather resources will be limited by site related contamination. They are also concerned that some of their traditional ways of life are being threatened by degradation of natural resources. Some of their traditional practices, in fact, may increase their exposure to site contaminants. They want to know if exercising their treaty rights in and around the site jeopardizes their health. The LLBO have also expressed concerns regarding the potential for groundwater contamination and/or leachate from the vault in the SWA to contaminate the wells that supply water to their offices and the fish hatchery.

F. Agency For Toxic Substances and Disease Registry (ATSDR) Involvement

ATSDR is mandated by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA 1986**)** to conduct a public health assessment at each site proposed for or listed on the National Priorities List (NPL). In cooperation with ATSDR, the Minnesota Department of Health (MDH) and Leech Lake Band of Ojibwe (LLBO) have drafted several documents regarding the public health significance of St. Regis. For further background information on the site, the 1995 Site Review and Update (SRU; ATSDR,1995a), 1993 SRU (ATSDR, 1993), or the 1989 Public Health Assessment (ATSDR, 1989) should be consulted. In addition, the 2004 Health Consultation (ATSDR, et. al., 2004) contains information specifically about contaminated soils at the site.

III. Geologic and Hydrogeologic Setting

A. Geology

The site is located in a region of mixed sands, silts, and clays that were deposited by glaciers as they retreated at the end of the last Ice Age. These deposits collectively are referred to as Superior Lobe till. The glacial deposits are approximately 400 to 500 feet thick and are underlain by Precambrian age bedrock composed of slate, quartzite and iron formations and older granite and gneiss. The uppermost glacial deposits beneath the town of Cass Lake and the site are outwash sands that were deposited in former glacial melt-water stream channels (Oakes and Bidwell, 1968).

The geology at the site consists generally of four units: an upper glacial outwash sand (“upper sand”) overlying a silty clay till (“upper till”). Beneath the upper till is another layer of glacial outwash sand (“lower sand”), and a lower clay till. In some areas, the upper till unit is not present, so the upper sand unit lies directly above the lower sand unit. This is important because the clay till layers will act as a barrier to downward movement of both groundwater and contaminants. Where the till layer is not present, groundwater and contaminants may be able to migrate downward into the lower sand aquifer.

Figures 8 and 9 (App. A) are cross-sections that show the geology of the FOA (Figure 7 shows the location of these cross-sections). In the FOA, the upper sand ranges from 30 to 80 feet in thickness and, in the eastern portion of the area, is overlain by 5 to 23 feet of peat and fill material. The upper till layer, where present, ranges from 20 to 90 feet in thickness and slopes to the southeast. The upper till is not present in some areas, such as near well MW-3, located north of the railroad tracks.

Figures 11 and 12 (App. A) are cross-sections that show the geology in the SWA (Figure 10, App. A, shows the location of these cross-sections). The upper sand is up to 35 feet thick in the SWA. The upper till layer, where present, ranges from 10 – 95 feet thick and appears to slope to the south, toward Fox Creek. As Figure 11 shows, the upper till unit is not present in the western portion of the SWA, and may be absent elsewhere, but the limited number of monitoring wells makes it difficult to interpret the geology in this portion of the site.

In the City Dump area (Figures 13, 14 and 15, App. A), the upper sand is 33 to 56 feet in thickness. The till layer, where present, is 3 to 50 feet thick. The till layer is absent in the area of soil borings SB-2007 and SB-2028 and the sewage treatment plant well (unique number 228990) and may be absent in the area of well MW-2325.

B. Groundwater

Groundwater is generally encountered at relatively shallow depths across the site, ranging from 6 inches to 15 feet below the ground surface. The groundwater in the upper sand aquifer generally flows east and southeast, toward Pike Bay, although this varies locally. Little is known about the groundwater flow direction in the lower sand unit, as there are too few wells completed in this aquifer.

Groundwater can also flow vertically, as well as horizontally. This flow is measured in wells located next to each other, but screened at different depths, called “nested” wells. Vertical flow directions vary across the site and over time.

Former Operations Area

Water level data collected at the site since 1982 indicate that the ground water flow direction in the upper sand aquifer in the FOA is primarily to the east towards the channel between Pike Bay and Cass Lake (Figure 16, App. A). Water levels gathered from “nested” wells in the FOA prior to operation of the pump-out system indicate a slight downward component to flow within the upper sand aquifer for much of the FOA, but a slight upward component to flow was measured in nested wells near the channel, where some upward flow would be expected as groundwater discharges to the channel.

The groundwater flow direction in the lower sand aquifer is unknown, because only two wells are completed in this unit (Figure 8). Without three wells completed in the lower sand aquifer, it is impossible to calculate the groundwater flow direction.

The absence of the upper till layer in the northern portion of the FOA (and possibly elsewhere) means that groundwater and contamination in the upper sand aquifer could migrate downward into the lower sand aquifer. Comparison of water levels in nested wells completed in the upper and lower sand aquifers have been inconclusive, but suggest that upward and downward gradients have existed between the two aquifers at various times. A gradient between the upper and lower sand does not necessarily indicate groundwater flow between these units, particularly where the till layer separates them, but rather the potential for such flow to occur.

A pump test conducted on city well #3 in 1984 resulted in measurable water level reductions in deep monitoring well MW-302, but not MW-306 or the upper sand aquifer wells (Barr, 1985b). This means the city well was able to draw water from an area under the site at least as far away as MW-302, and perhaps further, although the scarcity of deep wells in the FOA makes it impossible to evaluate this. City well #3 was sold to Champion International and is now MW-3.

Southwest Area

In the SWA, near the soil containment vault, the ground water flow direction in the upper sand aquifer is to the east and southeast, towards Fox Creek (Figure 17, App. A). However, in at least one instance (May 1992), water levels in the monitoring wells indicated groundwater flow direction to the southwest (Barr, 1992). If groundwater does flow in that direction under certain conditions, then at least one Fish Hatchery well (#4) occasionally may be downgradient of the soil containment vault. All of the monitoring wells in this area are screened across the water table. There are no monitoring wells completed at the base of the upper sand, nor in the lower sand, in this area of the site, so it is not possible to evaluate whether any vertical component to groundwater flow exists (see Section IIIA).

City Dump

In the Dump area, the ground water flow direction in the upper sand aquifer is to the southeast, towards Fox Creek and Pike Bay (Figure 18, App. A), although occasionally it appears to flow in a more easterly direction. Flow directions are only generally known, as the relative location of monitoring wells in this area on site maps have changed over the course of the study, making it impossible to know which maps are accurate. Water levels in the Dump area were gathered only infrequently from nested wells in the upper sand, but appear to indicate slight vertical gradients, both upward and downward, that have switched directions over time.

The groundwater flow direction in the lower sand aquifer is usually to the east, and occasionally to the northeast (Figure 19, App. A). Water level elevation differences between the upper and lower sand aquifers indicate a primarily upward gradient between the two units. As noted earlier, the presence of this gradient does not mean that groundwater is flowing in that direction, particularly where the till separates the two sand units, but rather the potential exists for such flow to occur.

Discharge to Surface Waters

There is no direct information regarding where ground water from the site discharges to the lake. Generally, ground water discharge to surface waters may occur anywhere on a lake bottom, but may concentrate in particular areas of the lake bottom. There has not been sufficient study done at the site to determine where such areas may be. Additionally, there has been no assessment at the site to determine whether all the groundwater flowing from the city dump area discharges to Fox Creek, or if some of it passes under the creek bed.

C. Groundwater-Surface Water-Sediment System

For convenience sake, various components of the environment, such as groundwater, surface water, and stream and lake sediments are often described as discreet pieces, but this does not reflect reality. These components are interconnected, and contamination in one may migrate to another. Groundwater discharging to Fox Creek, Pike Bay, and the channel may contaminate sediment and surface water in these areas. Contaminated soils, eroding from the land, or airborne particles from the former teepee burners, may have settled to the bottom of the creek, bay or channel, contaminating the sediments and acting as a source of contaminants that may be released to either surface waters above the sediments or groundwater in the pore spaces of the sediment. Given the groundwater flow directions observed at the site, it is unlikely that surface water or sediments in the creek, bay or channel could contribute significantly to groundwater contamination at the site. It is possible that discharging groundwater may contribute to sediment and surface water contamination in those areas.

IV. Evaluation of Contamination and Exposure

A. Evaluation Criteria for Contaminants

This health assessment evaluates multiple contaminants in three media: groundwater, surface water, and sediment. Each media has its own set of established criteria, either standards or screening values, which are used to evaluate the level of contamination, based on either human or ecological health. A standard is an enforceable value that has been enacted either through legislation or rule-making, while a screening value is used only for comparison purposes to determine whether additional investigation is warranted. Human health based standards are generally available for most contaminants in drinking water, while generally there are only screening values for surface water and sediments, and these are often based on ecological, not human health, risk.

For the purposes of this report, which is intended to evaluate human health risks, preference is given first to human health based standards and then human health based screening values. Where neither are available, ecological standards and then ecological screening values are used. A discussion of the criteria used for this report and tables of the criteria for each medium are present in Appendix E.

A separate health consultation document (ATSDR, 2004) evaluated contamination and exposure levels related to soil at the St. Regis site. Another health consultation document will be prepared later evaluating contamination and exposure levels related to fish gathered near the St. Regis site.

B. Groundwater Contamination

Several potential sources of groundwater contamination exist or formerly existed, including:

- Original plant operations (leakage from waste ponds and underground piping, spills, dripping from treated lumber stored in the FOA and SWA storage areas, leaching of ashes deposited by the tee pee burners, etc.)
- Disposal pits at city dump and SWA
- Dumping of waste water and sludge in the SWA
- Spray irrigation of waste water in the FOA and SWA
- Continuing release of contaminants from soils in all of the areas
- Leakage from the soil containment vault in the SWA (there is no evidence to date that this is occurring, but it represents a potential source of contamination)

<u>Summary of Findings</u>:

Sporadic groundwater sampling began at the site in the 1970s, and annual groundwater monitoring began in 1985. Detailed descriptions of the sampling results are provided in the following sections for each area of the site (FOA, SWA, and City Dump). This section provides a summary of general findings with respect to groundwater, and is followed by sections with specific findings from each of the site areas.

The groundwater monitoring networks are not adequate. In the FOA, the monitoring well network does not fully define the extent of contamination in the upper sand aquifer. In the lower sand aquifer there are only two wells (a minimum of three wells are needed to determine groundwater flow directions), and they are located in areas unlikely to provide useful information regarding groundwater contamination. In the SWA, the monitoring well network in the upper sand aquifer does not provide coverage of areas where wastes were allegedly dumped and there are no monitoring wells completed in the lower sand aquifer, despite the fact that contaminants have been detected in deep wells supplying the fish hatchery. The monitoring well network is more complete in the City Dump area. However, it too fails to provide sufficient information regarding the vertical distribution of groundwater contaminants in the upper sand aquifer and is inadequate to define the magnitude and extent of contamination in the lower sand aquifer.

Despite the shortcomings of the monitoring networks, the sampling data indicate that significant groundwater contamination is present in the FOA and City Dump areas. High concentrations of

PAHs and pentachlorophenol remain in the areas shown on Figures 20, 21, 23, 24, and 25 (App. A). The FOA and City Dump areas not only have high dissolved concentrations of PCP and PAHs, but also oil floating on the water table. Several of the wells in the FOA and City Dump areas also have had high concentrations of various dioxin congeners (PCDDs). The presence of PCDDs in groundwater samples may be due to mixing with the oil floating on the water table or the presence of sediment particles in the samples, as PCDDs generally do not dissolve into water. Groundwater in the SWA has never been tested for PCDDs and no groundwater samples have not been analyzed for PCDDs since 1988, despite significant detections of PCDDs in groundwater samples from the FOA and Dump areas in 1985 and 1988 (Table 5).

The annual monitoring reports for the site have generally reported decreasing trends in contaminant concentrations (Tables 3, 6, 7 and 8). For total PAH concentrations, some of this decrease may be attributed to a decision in 1999 to discontinue analysis of nineteen individual PAHs from the set of "List 2", or non-carcinogenic, PAHs. In wells that exceeded the site action level of 0.3 ug/L for List 2 PAHs, those nineteen PAHs accounted for a significant portion of the total PAH value (Table 4, App. B). If the percent of total PAHs represented by the nineteen PAHs that were dropped from the analysis list remained approximately the same as the averages shown in Table 4, many of those wells might still exceed the site action level of 0.3 ug/L. However, naphthalene and PCP concentrations have decreased in most monitoring and pump-out wells (see Tables 3, 6, 7, and 8).

Samples from private wells and the city water supply collected in the 1980s indicate that some residents were exposed to low concentrations of PAHs and PCP. One private well also was found to have very low concentrations of PCDDs. Only one private well was found to exceed health standards for PAHs and PCP. These exposures appear to have been halted by sealing of private wells and changes in the city water supply system. Only one private well tested in 2003 was found to have any contaminants (PCDDs below drinking water standards), and it is not currently operable. Wells supplying the Leech Lake fish hatchery have also had low concentrations of PAHs, and occasionally the total nPAHs in well #4 has exceeded the drinking water standard. The potential for residents to be exposed to contaminated groundwater is very limited.

1) Former Operating Area

A total of 31 monitoring wells have been installed in the FOA (plus former city well #3, which is now used as a monitoring well), of which, 13 have been sealed. Of the remaining wells, six are screened at or near the surface of the water table in the upper sand aquifer (100-series wells), ten are screened at the base of the upper sand aquifer (200-series wells), one is screened in the upper till unit, and two are screened in the lower sand aquifer (300-series wells; including city well #3).

Contaminant concentrations in the upper sand aquifer are summarized in Table 3. As noted above, the concentrations generally have decreased following site clean-up activities. The end of operations at the facility and the excavation of large volumes of contaminated soils, the waste ponds, and leaking underground lines, not only eliminated the on-going releases of contamination, but also removed the bulk of the source material that was leaching contaminants into the groundwater. Groundwater extraction through the pump-out system has removed an estimated 10,031 kg of PCP and 3,584 kg of PAHs and continues to remove some of the contamination (Barr, 2004). However, contaminants remain trapped in the pore spaces of the upper sand aquifer, as evidenced by the continued high concentrations of groundwater contamination in the area (Figures 20 and 21, App. A).

The sampling data from the FOA indicates that a plume of PCP and PAHs covers an area of approximately 40 acres in the upper sand aquifer (Figures 20 and 21). PCP concentrations as high as 7,500 ug/L and total PAH concentrations as high as 1,628 ug/L persist in the FOA (Table 3). The actual size of the plume is not known, as the extent of PCP and PAH contamination in the upper sand aquifer has not been defined to the northwest or southeast. Sampling of many of the monitoring wells that would have helped define the extent of the plume was discontinued in the late 1980's or early 1990's.

Free-floating oil was observed on the groundwater surface in well MW-118 between 1985-1991, after which sampling of that well was discontinued. Such floating oil is referred to as a "light, non-aqueous phase liquid", or LNAPL. Pump-out well RW-401 was installed next to MW-118 to recover the LNAPL, which continues to be present in measurable thicknesses. There are no wells north, south, or west of MW-118, and the nearest well to the east (MW-104) is approximately 500 ft. away. This means the extent of the LNAPL also has not been adequately defined.

Sampling in 1985 detected significant concentrations of dioxin congeners HxCDD, HpCDD, and OCDD in well MW-118 (Table 3; Barr, 1985a). Lower HpCDD and OCDD concentrations were also detected in a composite sample from wells 107, 113, and 118 and lower OCDD concentrations were detected in composite samples from wells 104, 106, and 107 and wells 207, 213, and 218 (Table 5, App. B; Barr, 1985a). While there are no drinking water standards currently for PCDDs, there is a Maximum Contaminant Level (MCL) for 2,3,7,8-TCDD of 0.03ng/L. Using World Health Organization (WHO) 1998 TEQs (Toxic Equivalency Quotients), drinking water criteria for the other dioxin congeners can be derived, and a total TCDD equivalence value can be derived for the water samples (see Appendix D, page 5). Using this approach to evaluate the concentrations detected in the FOA indicates the groundwater in MW-118 significantly exceeds health criteria for HxCDD, HpCDD, and OCDD. The composite samples suggest there is OCDD contamination in one or more of the following wells: 104, 106, 107, 207, 213, and 218. However, there is no way to determine from the samples which of the wells were contaminated and at what concentrations, except to note that a 1985 sample from well 106 did not detect significant concentrations of OCDD (Table 3). The detection limits for TCDD and PeCDD in all of the samples were higher than the health criteria, making it impossible to evaluate the lab results in terms of human health standards.

The contaminant plume appears to "dive" down to the base of the upper aquifer, so that near the channel between Cass Lake and Pike Bay, contamination is primarily detected only in the wells completed at the base of the upper aquifer, but not in the water table wells (Figure 22, App. A). For example, PCP was detected at 45-47 ug/L in wells MW-212 and MW-215, both completed at the base of the upper sand aquifer, but their associated nested, water table wells, MW-112 and MW-115, were found to have no PCP present. These results also indicate that PCP continues to discharge to the channel area at concentrations in excess of the drinking water standard of 3 ug/L and the surface water standard of 5.5 ug/L.

PAHs also have been detected in the groundwater on the east side of the channel (well MW-219) at concentrations exceeding the site action levels (Figure 21). There are not enough wells on the east side of the channel to define the extent of PAH contamination in that area, and the source of the contamination is still unclear. It is not known if any waste materials from the wood treating facility were dumped in that area, although this seems unlikely, given its location. Champion International (1999) had suggested that creosote treated timbers may have been driven into the wetland areas to serve as pilings for the railroad grade, possibly acting as a source for the PAH contamination. While possible, no documentation has been provided to support this suggestion. If the PAHs are related to contamination at the FOA, their presence in MW-219 suggests that shallow groundwater does not entirely discharge to the channel, as some earlier reports have suggested. Instead, some of the groundwater from the site may migrate beneath the channel.

An exception to the general trend in decreasing concentrations is observed in well MW-104, located downgradient of pump-out well RW-401. MW-104 has exhibited a fairly steady trend of increasing PAH and PCP concentrations (Table 3), suggesting that perhaps well RW-401 is not adequately capturing the contaminant plume in this area. Concentrations in the pump-out wells have fluctuated and, in some cases, increased with time, but this is expected to occur as the plume is captured by these wells.

As noted earlier, nothing conclusive may be said regarding contamination in the deeper sand aquifer, due to the inadequate monitoring well network in this aquifer. Despite the shortcomings of the monitoring network, there is evidence of some contamination in the lower sand aquifer. Well MW-302 has shown persistent contamination by PAHs at low concentrations (see Table 6, App. B), and in both 1992 and 1994 the sum of the non-carcinogenic PAHs (also called “List 2 PAHs”) exceeded the site action level of 0.3 ug/L. Carcinogenic PAHs (also called “List 1 PAHs”) have only rarely been detected in MW-302 and never at concentrations above drinking water standards. This suggests that the deep sand aquifer may be contaminated, but without an adequate monitoring network, it is not possible to evaluate the magnitude, extent, discharge point(s), or potential environmental and human health effects associated with groundwater contamination in this aquifer.

In addition to monitoring wells, residential wells in and adjacent to the FOA were sampled in 1983, 1984, 1992 and 2003. Figure 6 shows the location and Table 1 records the results of residential well sampling. Fifteen wells were found to have low concentrations of PAHs in 1983 and 1985. Only one well (Well J) exceeded the site action level of 0.3 ug/L for total non-carcinogenic PAHs. Seven wells were also found to have PCP contamination in 1983 and 1985. Well J exceeded the MDH Health Risk Limit (HRL) for PCP. Most of the wells tested in 1983 and 1985 that were not sealed were sampled again in 2003 (except G and J, which could not be accessed). PAHs and PCP were not detected in any of the wells. Another well (Well JJ) was found to have dioxin/furan contamination, but the concentrations did not exceed the drinking water standard (this well was installed in 1999, so was only sampled in 2003).

In 1985, most of the residences in and adjacent to the FOA were connected to city water. Two residents refused to have their homes connected. Private wells at the properties connected to city water were to be sealed, but at least eight wells reportedly remain unsealed (including the two residences not connected to city water). Additionally, one business south of the FOA uses a private well as a non-potable water supply for cleaning equipment.

North of the FOA, there are 18 residences and one business that are not connected to city water. Three of the wells closest to the FOA were sampled in 1983, and five were sampled in 2003 for PAHs, PCP, and PCBs. Low concentrations of PAHs were detected in the three wells sampled in 1983 and 1984, but were not detected in any of the wells in 2003 (Figure 6, Table 1).

The city wells closest to the site, wells #1 and #3, were sampled in 1984 – 1989 (Table 2). Low concentrations of PAHs were detected in both wells during this time, but did not exceed individual drinking water standards, and the total concentrations of the cPAHs and nPAHs did not exceed site action levels. PCP was detected only once in well #1, at a concentration of 8.9 ug/L which exceeds the current HRL, but did not exceed the drinking water standard at that time, which was 220 ug/L. It is not clear whether the city wells exceeded the 3 ug/L PCP standard at other times, because the detection limit for all of the samples was either 5 or 6 ug/L.

Additional city water samples were collected from water taps at the St. Regis facility and at a private residence on January 24 and April 23, 1984 (Barr, 1985c). The January 1984 sample from the private residence contained 4.3 ug/L PCP, which exceeds the current HRL of 3 ug/L for that compound. The drinking water standard at the time the samples were collected was 220 ug/L, so the water was not considered to pose a threat to health, based on the knowledge of health risks associated with PCP at the time. No PAHs were detected in that sample, and the sample collected from the facility tap on that date contained no PCP, but did contain low concentrations of two PAHs (Table 2). The April 1984 samples from these two taps contained low concentrations of several PAHs, but no PCP. None of the PAHs exceeded their respective current HRLs, nor did the total concentrations of either cPAHs or nPAHs exceed the site action levels.

In 1980, the MPCA sampled a well on the FOA described as a “St. Regis well for employee consumption” and was further identified as having provided water to the “Peeler Building” (MPCA, 1981c). In later reports, this well was called “W-1”. The laboratory reported: 7.2 ug/L biphenyl, 24 ug/L pyrene, and 2.1 ug/L fluoranthene, none of which exceed the current individual or additive drinking water standards. All of these results were labeled “unconfirmed” and no additional sample results for this well, or other potable water sources for facility employees, were found in the site files.

It appears that the city water, monitoring wells in the FOA and the residential wells near the FOA were never tested for methyl ethyl ketone or methyl isobutyl ketone, despite the fact that the wood treatment process in later years of the facility’s operation used a mixture of PCP and ketone.

<u>Groundwater exposures</u>: Currently, no exposure to contaminated groundwater appears to be occurring in the FOA. Past exposures did occur.

Workers at the facility and some residents living in homes with private wells in the FOA were exposed to low concentrations of PAHs and PCP through both ingestion of drinking water and skin exposure to bath and wash water. Only one private well sample was found to exceed health criteria for these compounds in two samples in 1983.

The city water supply system had very low concentrations of PAHs detected from 1982 to 1989. In January 1984, one city water system sample contained PCP at concentrations exceeding the current HRL of 3 ug/L, but this was not confirmed by the city water system sample collected from the facility tap on that date. Without a confirmation sample, it is not possible to verify this detection. A sample from City well #1 in June 1987 also had a detection of PCP at levels above 3 ug/L. It appears probable that PCP exposures may have occurred through the city water supply system, but the sampling data is insufficient to allow any conclusions regarding the duration and level of exposures. City well #1 was sealed in 1990. City well #2, which was not in use during the time of the site investigation, was also sealed about that same time. City well #3 was taken out of use as a municipal well and now serves as a monitoring well for the site (MW-3).

The duration of the past groundwater exposures are unknown, because it is not known when the contaminants entered the groundwater and when they migrated into the affected drinking water or city wells. However, the facility began operations in 1957 and that most of the private wells and the affected city well were in use until the late 1980's and early 1990's. This suggests that exposures via groundwater could have occurred over a period as long as thirty years, but likely occurred over a shorter period of time as it would have taken some time for contaminants to reach the groundwater and migrate to the wells in question. As noted above, these exposures occurred in the past and no on-going exposures have been identified. However, at least one resident with an unsealed well indicated that their circumstances might necessitate using the well in the future.

2) South West Area (SWA) Samples

In 1982, the first well (MW-111) was installed in the area of the site to determine if groundwater contamination was migrating toward the fish hatchery wells. In 1986, three additional wells (MW-121, 122, and 123) were installed in the SWA, but apparently were sealed soon after (Figure 10). Well MW-122 apparently was never sampled. Wells 111, 121 and 123 contained low concentrations of List 1 and List 2 PAHs (Table 7, App. B). PCP was not detected in any of these wells, but the sample detection limits always exceeded the drinking water standard for this compound.

In 1988, following construction of the soil containment vault, five wells were installed around the vault, screened across the water table, to monitor for any contamination that may leach from the vault. Low concentrations of PAHs were routinely detected in these wells until 1995. Since then, PAHs have been detected only infrequently (Table 7). PCP has not been detected in any of the SWA monitoring wells, however the detection limit used often exceeds the drinking water standard. It appears that none of the monitoring wells in the SWA have ever been tested for PCDDs or PCDFs.

Leachate collected from within the containment vault was analyzed for PCP approximately weekly between October 1987 until June 1988. PCP concentrations ranged from 5,100 to 19,900 ug/L. Later leachate sampling, in March and July, 1992, detected concentrations of 3,500 to 8,000 ug/L PCP. Leachate samples were analyzed for PAHs, PCBs, dioxins and furans on May 23, 1988 and March 19, 1992. The 1988 sample contained only 5 ug/L acenaphthene, and no PAHs were detected in the 1992 sample, but the detection limits for the PAHs were generally much higher than the individual drinking water standards, so PAHs may have been present but not reported. PCBs, dioxins, and furans were not detected in either sample. The detection limits used for PCBs exceeded current drinking water standards for those compounds. The detection limits for dioxins and furans was below the drinking water standards for those compounds, so the data can be interpreted to mean that dioxins and furans were not present in the sample at levels of potential human health concern.

There has been no shallow groundwater monitoring along the northern or northwestern portions of the SWA, even though these areas were used for storage of treated wood. There has been only limited shallow groundwater monitoring using well MW-121 in the southeastern corner of the SWA. This area was used for spray irrigation of wastewater from the facility and dumping of sludges (Figure 3). Low concentrations of PAHs were detected, but the well was apparently sealed in 1987. PCP was not detected in this area, but the detection limit exceeded the drinking water standard. The well was never tested for PCBs, PCDDs, or PCDFs (Table 7).

There are no deep monitoring wells in the SWA. However, there are four wells that supply water to the Leech Lake Department of Resource Management building and fish hatchery wells, which are all completed in the lower sand aquifer. All were sampled in 1992 and 1995, and one well, “fish hatchery well #4”, continues to be sampled annually. Fish hatchery well #4 has had detections of a variety of List 2 PAHs since 1992, and exceeded the site response action level of 0.3 ug/L total List 2 PAHs at least seven times (see Table 7), but the individual PAHs did not exceed their respective drinking water standards. PAHs have not been detected in well #4 since 2000. PCP has not been detected in any of the fish hatchery wells. It appears that the fish hatchery wells have never been tested for PCDDs or PCDFs.

One private residence is located in the northeast corner of the SWA (Figure 10). Although this property is connected to city water, a private well was installed in 1997 and completed in the lower sand aquifer at 130 ft. below grade (#604780). A sample collected from this well in 2003 detected low levels of total TCDDs, PCDDs, and dibenzofurans (Well JJ, Table 1). The presence of PAHs in Fish Hatchery well #4 and dioxins and furans in the residential well suggests that contamination may have migrated to the lower sand aquifer in the SWA.

The only well apparently ever tested in this area for MEK and MIBK was the fish hatchery well #4 (FISH 4), which was tested in October 2001 by the EPA. Neither compound was detected. Leachate from the containment vault has never been tested for these compounds, even though ketones were known to be used in the later PCP formulations used at the St. Regis facility.

<u>Groundwater Exposures</u>: Currently, no exposures to contaminated groundwater are occurring in the SWA. There are very few private or public wells in the SWA, but some limited exposures may have occurred in the past. The private well located in the northwestern corner of the SWA was not in use for very long (less than 6 years) and because the home has a connection to city water it is not clear how often the well was actually used. The well is currently disconnected. Only one sample has been collected from that well, but it appears that low concentrations of dioxins and furans may be present in the water. The fish hatchery wells have had low concentrations of nPAHs detected and Fish Hatchery Well #4 exceeded the site action levels for total nPAHs, but none of the

individual PAHs exceeded their drinking water standards and PAHs have not been detected in that well for at least 3 years.

3) City Dump Area Samples

Eighteen wells have been installed in the upper sand aquifer. Fourteen of these were water table wells (2100-series wells; four of which have been sealed), and four were completed at the base of the upper sand aquifer (2200-series wells; three of which have been sealed). In addition, the three recovery wells (2400-series wells) are completed at the base of the upper sand aquifer. Six wells have been completed in the lower sand aquifer (2300-series wells).

Contaminant concentrations in the upper sand aquifer are summarized in Table 8. Contaminant concentrations generally have decreased significantly following site remedial activities. The cessation of dumping and excavation of the waste pits, removed the bulk of the source material that was leaching contaminants into the groundwater. Groundwater extraction through the pump-out system continues to remove some of the contamination. However, significant contamination apparently remains trapped in the pore spaces of the upper sand aquifer, as evidenced by the continued presence of LNAPL and high concentrations of groundwater contamination in the area.

A plume of PCP and PAHs is present covering an area of approximately 2 acres in the upper sand aquifer (Table 8, App. B; Figures 23 and 24, App. A). The area of the plume has decreased over time. The area outlined in red indicates the area of groundwater that still exceeds drinking water standards at the site for PCP and PAHs. The extent of contamination to the southeast has not been defined. Additionally, there are few nested well sets, and none were sampled together in the latest sampling event. This makes it impossible to evaluate what the three-dimensional shape of the plume currently looks like. Earlier sampling events in nested wells 2134/2234 indicated higher levels of PAHs near the base of the aquifer, but higher PCP concentrations near the top of the aquifer. While not actually nested, wells 2401 and 2106 are located near each other and both were sampled in 2001 (the only year in which both wells were sampled, although not in the same month). Those samples suggest the opposite – higher levels of PAH near the top of the aquifer, and higher levels of PCP near the base of the aquifer.

None of the monitoring wells completed at the base of the upper sand aquifer were constructed in areas downgradient of the pit where sludge from the facility was burned, except MW-2229, which was never sampled. Only one well (MW-2134) was constructed in an area where significant contamination was found at the water table. Recovery wells 2402 and 2403 are located to the south and southeast of the sludge pit and indicate fairly significant contaminant concentrations at the base of the upper sand aquifer at least 200 ft. from the sludge pit area. However, the recovery wells have 20 ft. long screens, making it difficult to determine where in the water column the contamination is present. In order to determine if the plume migrates downward, as has been observed in the FOA, basal upper sand aquifer wells would need to be located in the areas of wells MW-2104, 2128, and 2129.

Free-floating oil (LNAPL) has been observed on the groundwater surface in monitoring wells 2102, 2103, 2104, 2105 and extraction wells 2401 and 2402. This means LNAPL is present as far as 250 ft. south-southwest of the pit in which sludge from the facility was burned. Pump-out wells RW-2401 and 2401 were installed east of MW-2105 to recover LNAPL. The extent of the LNAPL has not been fully defined.

Sampling in 1985 detected significant concentrations of the dioxin congeners HxCDD, HpCDD, and OCDD in wells 2102, 2103, 2104, and 2105, and lower HpCDD and OCDD concentrations in well 2106 (Table 5; Barr, 1985a). Extrapolating from the MCL of 0.03 ng/L for 2,3,7,8-TCDD (as described in Appendix D), the groundwater in wells 2102, 2103, 2104, 2105, and 2106 significantly exceeded health criteria for HxCDD, HpCDD, and OCDD. The detection limits for TCDD and PeCDD were too high to discern whether they exceeded health criteria. LNAPL from well MW-2105 was analyzed and found to contain even higher PCDD concentrations.

PAHs are present, and PCP has been present, in the lower sand aquifer, but generally at lower concentrations than in the upper sand aquifer (Table 8; Figure 25, App. A). Nothing conclusive can be stated regarding the magnitude and extent of groundwater contamination in the deep aquifer. Four of the six deep monitoring wells in the City Dump area (MW-2301, 2325, 2326 and 2333) are located up-gradient or side-gradient to the main source area, the sludge pit (Figure 13). The other two wells, MW-2335 and MW-2329 may be located downgradient of the sludge pit (groundwater flow directions in this portion of the deep aquifer appear to be highly variable), but are more than 800 feet from the pit. This is too far away to provide good information regarding the contaminant plume. There are no monitoring wells immediately downgradient of the sludge pit or between the pit and Fox Creek. Despite the inadequacy of the deep-aquifer monitoring network, most of the wells have shown persistent low concentrations of List 2 PAHs and less frequent detections of List 1 PAHs at low concentrations (Table 8). In general, all PAH concentrations have decreased during the course of the site investigation. PCP has been detected only once in well MW-2329 (2.7 ug/L in 2001) and twice in well MW-2326 (at an unquantified concentration less than 5 ug/L in 1986 and 68 ug/L in 1992).

Ten wells in this area, both in the upper and lower sand aquifers (wells 2102, 2106, 2127, 2129, 2135, 2301, 2326, 2329, 2333, and 2335), were tested for MEK and MIBK. MEK was detected in one of the lower sand aquifer well, 2301, at a concentration of 5.3 ug/L.

Groundwater Exposures:

There are no residential wells in the CD area, or immediately south of Fox Creek. Therefore, exposure to contaminated groundwater in this area is unlikely given current site conditions, and it is unlikely that past drinking water exposures via groundwater have occurred.

Groundwater Conclusion:

Despite the inadequacies of the groundwater monitoring networks at the St. Regis site, there is sufficient information to conclude that high levels of PAH and PCP contamination persist in the FOA and City Dump areas. The full magnitude and horizontal and vertical extent of this contamination has not been defined. Additionally, sampling for PCDDs and ketones has been inadequate to evaluate the presence of these compounds.

Some residents were exposed in the past to contaminated water from private wells and the city water supply. The affected wells were either sealed or are currently inoperative, and the configuration of the city's water supply system has been changed. As a result, with the exception of the fish hatchery wells, it appears that no completed groundwater exposure pathway currently exists.

There is insufficient information regarding the duration of past exposures and the concentration levels to determine if those past exposures constituted a public health hazard. The one exception is well J in the FOA, where infrequent sampling in the 1980s detected non-carcinogenic PAHs and PCP at concentrations above their respective Health Risk Limits. The house was connected to city water, but the contaminated well was not sealed and could be put into use again in the future. It is not known how long the residents at this property were exposed to PAHs and PCP, but as their exposures could have been as much as several decades, those exposures may have constituted a health hazard for the residents in that home. Without knowing the duration of their exposures, it is not possible to state with any certainty what the potential health risks related to those exposures might be.

Residents have also raised concerns regarding the soil containment vault in the SWA. Sampling of monitoring wells near the vault does not indicate that any contaminants are currently leaching from the vault into the groundwater. However, it should be noted that the vault is approaching the limit of its engineered "lifetime", so it remains a potential source for groundwater contamination in the future.

C. Surface Water Contamination

Several potential sources of surface water contamination in Fox Creek, Pike Bay, and the Channel exist or formerly existed, including:

- Discharge of contaminated groundwater to the surface water
- Direct discharge of site chemicals of concern with primary treated city wastewater
- Runoff from areas with contaminated soils
- Leaching of contaminants from contaminated sediments
- Direct discharge of wastewater or sludges to the surface waters (this has been alleged, but not proven)

Summary of Surface Water Findings:

Detailed descriptions of the surface water sampling results are provided below for each area of the site (Fox Creek, Pike Bay, Channel, Cass Lake, and reference areas). This section provides a brief summary of the surface water findings.

Sporadic sampling of surface water in Fox Creek and Pike Bay occurred in the early 1980s, but poor documentation of the sample locations and sampling methods makes it difficult to interpret these data. These sampling events detected low concentrations of PCP, PAHs, and metals in Fox Creek and low concentrations of PAHs in Pike Bay. Annual surface water samples have been collected in the channel and analyzed for PCP, which were not detected. Two of the samples were analyzed for PAHs, which were detected at low concentrations. However, the sampling method was suspect.

A more thorough sampling event conducted by the EPA occurred in 2001. This sampling event detected low concentrations of PCP, PAHs, VOCs, and metals in Fox Creek, Pike Bay, and the channel, some of which exceeded surface water criteria. Samples from Cass Lake were found to have low concentrations of metals, one PAH, and one VOC. Samples were also collected from “reference areas” to evaluate possible background concentrations in the area near Cass Lake. Low concentrations of metals and PAHs were detected, generally at concentrations lower than those found in Fox Creek and Pike Bay.

1) Fox Creek Samples:

Early surface water sampling results from Fox Creek are sketchy. A memo in MPCA files (MPCA, 1984a) notes that samples were collected in 1980, 1982 and 1983. A review of the files did not locate documentation of these samples, so little is known regarding the sample locations, collection or analytical methods, or the detection limits used. The sample collected in 1980 at the mouth of Fox Creek was analyzed for PCP, but this compound was not detected. However, the samples collected in 1982 did detect PCP at concentrations ranging from 0.3 to 2.1 ug/L and low concentrations of chromium (less than 2.2 ug/L) and copper (less than 1.2 ug/L). The samples collected in 1983 were analyzed for phenols, PAHs, and pesticides; only acenaphthene was detected at concentrations below the reporting limit.

The only surface water sampling of Fox Creek for which sample collection and analysis methodology is available appears to have occurred in 2001 (EPA, 2002). Samples were collected near the Southwest Area and near the outlet of Fox Creek at Pike Bay, but not immediately downstream of the City Dump. The samples were gathered at the base of the water column, which would be most likely to reflect any impacts to water quality caused by discharge of contaminated groundwater to the surface water. Low concentrations of PAHs, PCP, metals, and VOCs were detected in those samples (see Figure 26, App. A and Table 9, App. B), but only copper, bis-(2-ethylhexyl)-phthalate, and benzo(a)pyrene exceeded surface water criteria.

2) Pike Bay Samples:

Early surface water sampling in Pike Bay appears to have been as poorly documented as those for Fox Creek. The MPCA file memo (MPCA, 1984a) notes that samples were collected in 1980 by both MPCA and MDH staff, but the sample locations were not documented and no information is provided regarding sample collection or analysis methods. The samples were analyzed for PAHs and PCP. Eight PAHs were detected at very low concentrations (3.8 to 85 ng/L), but the results were considered to be suspect. Another sample was collected for PCP analysis in January 1982 by MPCA staff, again without documenting the location, but no PCP was detected. In May 1982, samples were collected at the “National Park campground” (this probably refers to a National Forest campground on the east shore of Pike Bay). This sample was analyzed for phenols and PCP, but none were detected. In May 1983, samples were collected at the mouth of Fox Creek and at the “Cass Lake Inlet” (possibly the south end of the channel, but this is not clear). These samples were analyzed for phenols, PAHs, and pesticides, but none were detected.

In 2001, the EPA conducted a more systematic sampling effort, evaluating the surface water in Pike Bay, collecting water samples from near the base of the water column in both near-shore and "deep hole" areas (See Figure 26; EPA, 2002). The near-shore sample (PB-01-0102) was created by combining discreet water samples from five near-shore locations into one composite sample. Low concentrations of metals, PAHs, and VOCs were detected in both areas, while PCP was detected only in the near-shore sample (Table 10, App. B). Generally, higher concentrations were detected in the near-shore area, compared to the "deep hole" samples, although the small number of samples prevents the identification of any concentration trends. Only copper and bis-(2-ethylhexyl)-phthalate exceeded surface water criteria. It's important to note, however, that the composite sample could under-report any contaminants that are present, by up to as much as 80 percent. It is also important to note that no samples were collected from the beach area at the city park that is used by residents for swimming and wading (Figure 2).

3.) Channel Samples:

The channel connecting Pike Bay to Cass Lake is reportedly used by many residents for swimming. It is located immediately downgradient of the FOA and at least some of the groundwater contaminant plume discharges in the channel. The groundwater treatment system for the site also discharges to the channel. As a result, significantly more surface water sampling has been conducted in this area than elsewhere at the site.

Early sampling efforts were not well documented. According to the MPCA file memo (MPCA, 1984a), a sample was collected by MPCA staff from the "north end of the channel by [the] railroad trestle" in May 1982 and analyzed for phenols and PCP, with no detections.

Barr Engineering, on behalf of St. Regis/Wheeler and International Paper, has sampled the "north" and "south" ends of the channel at least annually (sometimes more often) since 1985. These samples were primarily analyzed for PCP, which was detected only once, in 1994, in both sampling locations and at concentrations exceeding the surface water criterion. In 1986 and 1990, the samples were analyzed for PAHs, eleven of which were detected at very low concentrations (see Table 11, App. B; only the sampling events where contaminants were detected are included in the table). The samples were collected by simply dipping open bottles into the water. This method would collect water samples primarily from the surface of the water and may not be representative of the water column, as groundwater discharge to the surface water would occur primarily through the sediment, with the highest concentrations anticipated near the bottom of the water column. Also, any volatile compounds that enter the surface water through groundwater discharge would likely evaporate from the near-surface water.

In 2001, the EPA sampled surface water in the channel at the railroad and highway crossings, as well as in the wetland immediately east of the channel (Figure 26; EPA, 2002). Those samples, which were collected near the bottom of the water column, had low concentrations of metals, PAHs, PCP, and VOCs (Table 11). Only copper and bis-(2-ethylhexyl)-phthalate exceeded surface water criteria.

4.) Cass Lake Samples:

Surface water from Cass Lake itself appears to have been sampled only once in 2001, when EPA collected samples from two “deep holes” in the lake (See Figure 26; EPA, 2002). No samples were collected from the near-shore zone. The “deep hole” samples were similar to those collected in the “deep hole” areas of Pike Bay. EPA collected the water samples from near the base of the water column. Low concentrations of metals, one PAH, and one VOC were detected, at levels very similar to those in Pike Bay (see Table 10). Only copper exceeded the surface water criterion.

5.) Reference Areas Samples:

Two reference areas, a creek and a lake, were selected by EPA for sampling, in an effort to identify background levels of surface water contamination that may be present in the environment of this region (Figure 27, App. A; EPA, 2002). Many metals are naturally occurring, and some other metals, PAHs, and VOCs are widely distributed in the environment, as a result of many industrial, power generation, and transportation emissions. Comparison of site samples to those from reference areas is needed in order to determine what additional contaminant load to the environment may have resulted from various releases at the St. Regis site.

Low concentrations of metals and PAHs were detected in the reference area surface water samples. No PCP or VOCs were detected. The arsenic concentrations detected were comparable to those found in the vicinity of the site, but the copper concentrations in the reference areas were lower than all but the “deep hole” samples from Cass Lake and Pike Bay and one Fox Creek sample. One PAH, bis(2-ethylhexyl)phthalate, was detected at higher concentrations than in the vicinity of the site, but the other PAH detected, phenanthrene, was detected at significantly lower concentrations (Table 12, App. B). This suggests that PCP, VOC, copper, and some of the PAH contamination detected in surface water near the site is not just “background” contamination, but may be related to activities that occurred nearby.

Surface Water Exposures:

Pike Bay, Cass Lake, and the channel that connects them, are all areas frequently used for swimming, wading, and gathering resources for traditional uses. Fox Creek is used less often, but children do wade and play in the creek and school classes occasionally visit it. No data is available regarding the frequency of use, either past or present. Anecdotal evidence suggests use of the channel may have decreased somewhat as a result of concerns by residents over contamination from the St. Regis site, while use of Fox Creek may have increased (compared to the 1970s and 1980s) as the aesthetic quality (odor, clarity, etc.) of water in the creek has improved over time. However, the beach at the town park on Pike Bay continues to be used for swimming. (Personal communication, Shirley Nordrum, LLBO, August 4, 2005).

The level of exposure is difficult to evaluate given the small number of surface water samples, the lack of health-based standards for surface water, and the absence of samples from the swimming beach at the city park. Residents also use Fox Creek and the channel area for swimming, where limited surface water sampling has shown the presence of contaminants at concentrations exceeding aquatic life standards, particularly PCP. However, aquatic life standards do not necessarily translate in any meaningful way that helps to clarify human health hazards.

Surface Water Conclusion:

Sampling of surface water near the site generally has not been systematic, but does indicate the presence of contamination in the surface waters in Fox Creek, Pike Bay, the channel, and Cass Lake. Comparison to the reference lake and stream samples indicates that a source in the area of the site has caused the contamination. This contamination represents an on-going exposure pathway for residents and others who use the creek, bay, channel, and lake for subsistence and recreational activities. Such recreational exposures to PCP and PAH could result in uptake of these chemicals both through absorption through the skin and ingestion of water during swimming (see Appendix D). Additional sampling and information on frequency and duration of exposures is needed to determine if these exposures pose an actual public health risk or contributes to cumulative risk from exposures through multiple pathways.

D. Sediment Contamination

Contamination of sediments in Fox Creek, Pike Bay, and the Channel could have occurred in a number of ways, including:

- Direct deposition of waste or contaminated materials,
- Groundwater discharge, and
- Airborne deposition of contaminated ash

Direct deposition of waste or contaminated materials – Interviews with former employees indicate that wastewater and sludge were dumped in the SWA immediately north of Fox Creek and some may have runoff into the creek. The site records show that wastewater and oil was discharged to the municipal wastewater treatment facility, located next to the city dump, and that contaminated water was discharged directly into Fox Creek. Sediment sampling activities encountered a deposit of woodchips in the waters of Pike Bay between the channel and Fox Creek. It is not known of those woodchips were treated. Former employees have also alleged that wastewater and oil occasionally discharged overland to the channel area.

Groundwater discharge – Contaminated groundwater discharging to any of these water bodies could result in contamination being adsorbed onto the sediment. This is most likely to occur in the channel and Fox Creek, because of their proximity to contaminant plumes of fairly high concentrations. However, it is possible that contaminated groundwater is also discharging to Pike Bay.

Airborne deposition - St. Regis, reportedly received PCP in a dry mixture that was mixed on-site and the bags along with scrap materials were burned in two “Tee-Pee” burners **(**see Figure 2**),** as has been discussed in ATSDR, et. al. (2004). The use of “Tee-Pee” burners could have contributed to wide spread distribution of ash and smoke containing dioxin and furans. The incomplete combustion of PCP packaging materials and PCP treated scrap materials could have provided the ingredients and temperatures for creation of dioxins and furans. These contaminants could be emitted from the top of the Tee-Pee along with the plume of smoke and ash and distributed downwind of the site during burning activities. The wind can blow in any direction, but the prevailing winds in Minnesota are generally from the northwest from November through approximately May and from the south in June through October. This suggests that ash from these burners could have settled in the channel and Pike Bay areas. Airborne surface soil eroding from the site may also be an on-going source of airborne deposition to the sediments near the site.

Summary of Sediment Findings:

Detailed descriptions of the sediment sampling results are provided below for each water body near the site (Fox Creek, Pike Bay, Channel, Cass Lake, and reference areas). This section provides a brief summary of the sediment findings.

Sediment samples were collected in 1983, 1995, and 2001. The 1983 samples detected PCBs and phenols in Fox Creek, Pike Bay and the channel. The concentrations of PCBs in several of the samples exceeded both human health and ecological sediment screening criteria. Only Fox Creek was sampled in 1995. The samples were analyzed for PCBs, which were not detected, but the higher detection limits used may have masked the presence of low concentrations of PCBs.

Samples collected in 2001 were analyzed for PCDDs, metals, and VOCs, and some samples were also tested for PAHs, PCP, PCBs and pesticides. In addition to sampling Fox Creek, Pike Bay, and the Channel, samples were also collected in Cass Lake and the reference area lake and creek. The results indicate PCDD, PCB, and benzo(a)pyrene contamination in most of the sediment samples at concentrations above the human health and ecological sediment screening value and above the background concentrations detected in the reference areas.

Sampling Results:

1.) Fox Creek Samples:

In May 1983, EPA consultants collected three sediment samples in Fox Creek (Figure 28, App. A): where County Road 146 crosses Fox Creek (EPA-1); "at [the] sewage plant" (EPA-2), presumably where the plant discharge point is located; and from the "delta" where Fox Creek empties into Pike Bay (EPA-3) (EPA, 1983). No information was provided regarding the sampling depth or sample collection or analytical methods, although a later document (Champion, 1996) indicates the samples were analyzed using a gas chromatograph/mass spectrometer (GC/MS). The samples were analyzed for phenols, PAHs, and pesticides (Table 13, App. B). Low concentrations of phenols and PAHs were detected in the samples collected from Fox Creek near the county road 146 crossing and near the sewage treatment plant. Only phenol in sample EPA-2 exceeded its sediment screening value. Pesticides were not detected. No contaminants were detected in the sample from the delta area.

In June 1983, MPCA staff collected sediment samples in Pike Bay, the Channel, and Cass Lake (Figure 28; MPCA, 1984b). They collected one sample (MPCA-1) from the "delta" at the mouth of

Fox Creek, where it enters Pike Bay (Figure 13). The samples were collected using a small dredge and were analyzed only for PCBs; sample depths are unknown. The highest concentration detected was from the Fox Creek delta sample, where 0.53 mg/kg total PCBs were detected (Table 13), which exceeds the human health based sediment screening value. According to a later document (Champion, 1996) these samples were analyzed using gas chromatography with electron capture detection (GC/ECD), which provides somewhat less conclusive results for PCBs than does GC/MS analysis, but has lower detection limits (0.05 mg/kg).

In 1995, Barr Engineering collected six sediment samples in a transect along Fox Creek, starting on the west side of Highway 371 (STA-1) and ending at the mouth of Fox Creek at Pike Bay (STA-6) (Figure 28; Champion, 1996). The samples were analyzed only for PCBs, with a detection limit of 0.5 mg/kg. PCBs were not detected, but the relatively high detection limits used may have masked the presence of low levels of PCBs.

In 2001, EPA collected thirteen samples from Fox Creek (FCSW-01 through –03; FCCD-01 through –05; and FCD-01 through –05; Figure 28, App. A). The samples were collected from the upper 10 to 15 centimeters of sediment, and were analyzed for total PCDDs/PCDFs, metals, PAHs, PCP, and VOCs. In addition, some of the samples were analyzed for PCBs and pesticides. All of the samples tested for total PCDD/PCDF had concentrations exceeding the human health based sediment screening value of 0.077 ng/kg, with the highest levels detected in the sediments near the city dump area (Table 13). The sediment samples collected near the southwest area and city dump, and one sample from the Fox Creek delta, also had elevated levels of metals and PAHs, most of which exceeded the sediment screening values, including many that exceeded human health based screening values. PCP was not detected in any of the samples, but many of the samples had very high detection limits.

The information currently available suggests the highest contaminant concentrations in the Fox Creek sediments are located near the discharge point of the city wastewater treatment plant and the City Dump. However, contaminants have been found at elevated concentrations in the delta at Pike Bay and near the containment facility in the SWA.

2.) Pike Bay Samples:

In May 1983, EPA staff collected a sediment sample (EPA-4) from Pike Bay, near the south end of the channel (Figure 29, App. A; EPA, 1983). The samples were analyzed for PAHs, phenols, and pesticides using GC/MS, but none were detected (MPCA, 1984a; Table 14, App. B).

In June 1983, MPCA staff collected sediment samples from five locations in Pike Bay (Figure 29; MPCA-2 through MPCA-6). Three of the samples were collected from relatively shallow areas of the bay, between 4 to 35 feet deep (MPCA-2, MPCA-5, and MPCA-6). The other two samples (MPCA-3 and MPCA-4) were collected in deeper areas of the bay, between 75 and 80 feet deep. All of the samples were analyzed for PCBs, which were detected in three of the samples at concentrations exceeding the sediment screening value (MPCA, 1984b; Table 14).

In 2001, EPA consultants collected sediment samples along five near-shore transects and two "deep hole" (PBDH-01 and PBDH-02) locations in Pike Bay (Figure 29). Five samples were collected along each transect and these were combined to form five composite samples (PB-A through PB-E), one from each transect. The samples were analyzed for total PCDDs/PCDFs, VOCs, and metals. The “deep hole” samples were also analyzed for PAHs, PCP, PCBs, and pesticides. All of the samples tested for total PCDD/PCDF had concentrations exceeding the human health based sediment screening value of 0.077 ng/kg, with the highest concentration detected in the deep hole sample. Metals were detected in samples from both areas, with generally higher concentrations in the deep hole samples, but none exceeded its sediment screening value. It’s important to note, however, that the composite samples could under-report any analytes that are present, by up to as much as 80 percent.

Generally low concentrations of PAHs were detected in the deep hole samples, but five exceeded their respective sediment criteria, and benzo(a)pyrene exceeded its human health based sediment screening value. Two VOCs (bromoform and carbon disulfide) were also detected in the deep hole samples. PCP, PCBs, and pesticides were not detected (EPA, 2002; Table 14). The levels of PCDDs/PCDFs, lead, PAHs, and VOCs generally exceeded those detected in samples from the reference lake (Figure 27; Table 17).

The small number of samples from Pike Bay are inadequate to evaluate contamination of sediments in that body of water. However, comparison to samples from a reference lake indicate that contamination of sediments has occurred more than 2 miles southeast of the former St. Regis facility.

3.) Channel Samples:

In 1983, MPCA staff collected sediment samples from three locations in the channel (MPCA-7 through MPCA-9), east of the FOA (Figure 29). The samples were analyzed only for PCBs, which were detected at concentrations exceeding the sediment screening value in all of the samples (MPCA, 1984b; Table 15, App. B).

In 2001, EPA consultants collected sediment samples from six locations in the channel (RR-01 through –03 and HWY-01 through –03;) and three locations in the wetland area immediately east of the channel (WL-01 through –03; Figure 29). The samples were analyzed for total PCDDs/PCDFs, metals, PAHs, PCP, and VOCs. All of the samples analyzed for PCDDs/PCDFs exceeded the human health based sediment screening value. Lead exceeded its sediment screening value in three samples and zinc exceeded its screening value in one sample. Fourteen PAHs exceeded their screening values in one or more samples, and many exceeded the human health based screening values (EPA, 2002; Table 15).

4.) Cass Lake Samples:

In 1983, MPCA staff collected sediment samples from two locations in Cass Lake (MPCA-10 and MPCA-11; Figure 29). The samples were analyzed only for PCBs, which exceeded the sediment screening value in both samples (MPCA, 1984b; Table 16, App. B).

In 2001, EPA consultants collected sediment samples from two “deep hole” locations in Cass Lake (CLDH-01 and CLDH-02; Figure 29). The samples were analyzed for total PCDDs/PCDFs, PAHs, PCBs, metals, pesticides, and VOCs. Total PCDDs/PCDFs exceeded the human health based sediment screening value in the sample analyzed for these compounds.

Four metals were also detected in samples from both locations at concentrations higher than those found in the reference lake areas, but none exceeded their screening value. Twelve PAHs were detected at levels elevated above background, but only two (acenaphthalene and benzo(a)pyrene) exceeded there sediment screening value. One pesticide, chlordane, was detected, but did not exceed its screening value. Only two VOCs (bromoform and methyl ethyl ketone) were detected. PCBs and PCP were not detected (EPA, 2002; Table 16). Most of the detection limits used for the pesticide and PCB analyses exceeded the screening value.

The small number of samples from Cass Lake are inadequate to evaluate contamination of sediments in that body of water. However, comparison to samples from a reference lake indicate that contamination of sediments has occurred up to 2 miles northeast of the former St. Regis facility.

5.) Reference Area Samples

Two reference areas, a creek and a lake, were selected for sampling by EPA, in an effort to identify the background levels of sediment contamination that may be present in the environment of this region (Figure 27; EPA, 2002). Many metals are naturally occurring, and some other metals, PAHs, PCBs, PCDDs, and VOCs are widely distributed in the environment, as a result of many industrial, power generation, and transportation emissions. Comparison of site samples to those from reference areas is needed in order to determine what additional contaminant load to the environment may have resulted from various releases at the St. Regis site.

Low concentrations of PCDDs/PCDFs, metals, pesticides, PAHs, and one VOC (1,2-dichloroethane) were detected in the reference area sediment samples. No PCBs or PCP were detected (Table 17, App. B).

The total PCDDs/PCDFs concentrations detected in the reference areas were generally lower than those detected in Fox Creek, Pike Bay (except the near-shore area), the channel, and Cass Lake, but all exceeded the human health based sediment screening value. Arsenic levels in the reference area samples tended to be higher than most areas near the site, except for Fox Creek near the city dump. Other metals in the reference area samples were generally present at lower concentrations than those collected from areas near the site. Similarly, the PAHs detected were generally present at much lower concentrations than in samples collected near the site. The pesticides detected, however, tended to be present at concentrations similar to or greater than those detected in sample locations near the site. This suggests that PCDDs/PCDFs, PCP, VOC, PCBs, and some of the PAH contamination detected in sediments near the site are most likely related to activities that occurred nearby.

<u>Sediment Exposures:</u>

As noted in the Surface Water section, above, Pike Bay, Cass Lake, the channel that connects them, and to a lesser degree Fox Creek, are used for swimming, wading, and gathering resources for traditional uses. These activities would also expose people to the sediments in these areas, both through dermal contact and ingestion. The actual frequency and duration of exposure events is not known, and would likely be largely weather dependant (more frequent in hot periods, less frequent in cold). However, it is likely that the exposure frequencies used to derive the sediment criteria (see Appendix E) are representative of exposures for at least some members of the population with respect to use of Cass Lake and Pike Bay for swimming and wading, based on anecdotal information regarding uses of those areas. Use of the channel and Fox Creek may be less frequent than the exposure frequencies used to develop the criteria. (Personal communication, Shirley Nordrum, LLBO, August 4, 2005).

Sediment Conclusion:

Generally, higher concentrations of contaminants were detected in sediments collected near the site compared to those from the reference areas. This suggests the contamination near the site is related to nearby activities.

Elevated concentrations of PCDDs were detected in most of the sediment samples, including those collected near the swimming beach. Higher concentrations of PCDDs than those reported may exist in "hot spots" in that area because the samples were made by compositing, which gives an averaged result. Elevated concentrations were also reported for most of the samples analyzed for PAHs, including several exceedences of human health based sediment screening values. These screening values consider the relative contribution of various exposure pathways related to various activities in the area of the contaminated sediments, such as fishing, wading, and swimming. The sediment-related exposure pathways include: ingestion of contaminated sediment and surface water, dermal contact with contaminated sediment and surface water, inhalation of volatile compounds, and consumption of fish from the contaminated area. The screening values are also derived based on several assumptions regarding frequency and duration of exposures (see Appendix E).

Fish consumption will be specifically addressed by MDH in a subsequent Health Consultation. However, it should be noted that fish consumption constitutes the bulk of the modeled exposure for dioxins, PCBs, and benzo(a)pyrene and the other carcinogenic PAHs based on their B(a)P equivalency. In comparing the sediment sample results to the screening values, with respect to decisions regarding access to swimming and wading areas, it is important to keep this in mind. Samples collected from Fox Creek and the Channel had dioxin and carcinogenic PAHs present at concentrations high enough that one percent of the measured dioxin concentrations and/or eighteen percent of the calculated B(a)P equivalent concentrations exceeded the human health screening values, suggesting that these sediments may not be safe for swimming and wading, even if no fish from the area are consumed.

The sediments represent an on-going human exposure pathway because of the recreational and subsistence uses of Fox Creek, Pike Bay and the channel that bring residents and visitors into contact with sediments in these areas. Some of these activities are detailed in the Leech Lake Band of Ojibwe's Pilot Superfund Project report (LLBO, 2003). There is insufficient, site-specific information regarding the duration and frequency of exposures to evaluate the significance for health of exceedences of the screening values for the site-related contaminants. However, all of the sediments tested near the site are between 5 to 2,200 times higher than the human health-based screening values for dioxin; most are between 1.7 to 70 times higher than the human-health based screening values for benzo(a)pyrene. Thus, while exceedences of a screening value does not in itself indicate a health hazard, and the public health hazard related to sediments is indeterminate at this time, actions to prevent further exposures until additional assessment of the human health hazards may be completed is warranted.

V. Remedial Actions

Efforts to clean up the contamination associated with the St. Regis facility operations included soil and sludge removal, demolition of the facility, and groundwater extraction and treatment. Additional soil removal was done in the summer of 2004. These activities have removed significant volumes of contamination from the site.

A. Soil Removal and Soil Containment Vault

In the mid-1980's, approximately 22,000 cubic yards of contaminated soil and 4,000 cubic yards of sludge were excavated from the FOA, SWA, and City Dump areas and placed in the soil containment vault in the SWA (Figure 3). In the early 1990's, the last of the facility was demolished and underground pipelines were removed. These activities removed large volumes of PCP, PAHs, and other contaminants that were leaching into the groundwater. Their removal limits the amount of contamination entering the groundwater and the amount of contamination that can potentially migrate to the channel, Pike Bay, Cass Lake, and Fox Creek, where it may contaminate sediments and surface water in those areas.

The vault contains a leachate collection system. In 1988, the vault was dewatered, and the leachate treated in a temporary carbon filtration system. The treated water was discharged to the channel, east of the FOA. In 1988, installation and operation of a water evaporation system for the vault allowed use of the vault leachate collection system to be discontinued. However, leachate samples continue to be collected and analyzed to evaluate levels of contamination in water within the vault.

B. Groundwater Extraction and Treatment

A groundwater extraction and treatment system was installed in 1985 and became operational in 1987. The system consists of ten extraction wells in the FOA and three in the City Dump area (an eleventh well was installed in the FOA, but has not operated since 1989). All of the extracted water is piped to a treatment building where the contaminants are removed by a granular activated carbon filter system. The filter system is housed in the FOA and consists of three carbon canisters in series. The treated water is discharged to the channel. The extraction system is intended to serve a dual purpose: removal and treatment of contaminated groundwater and control of the contaminant plumes to prevent them from migrating off-site.

The treatment plant influent samples are analyzed for PCP and HxCDDs and the discharge water is tested for PAHs and PCP. The treatment system appears to be effectively removing PCP, as the discharge water usually has no detectable levels of PCP. One exception to this was in December

1988 and January 1989, when the effluent contained 16 to 2,100 ug/L PCP. This was thought to be due to a problem in the sampling method that allowed untreated water to be mixed into the sample. The sampling method was revised; subsequent samples that same month and thereafter have exceeded the permitted discharge concentration of 8 ug/L only once (January 1990).

HxCDD has not been detected in the influent water samples, so the effluent water generally has not been tested for this compound. However, one effluent sample tested in April 1990 was found to contain 0.0041 ug/L of HxCDD (Table 18, App. B). Although HxCDD is one of the most toxic dioxin congeners found at the site, HpCDDs and OCDDs were the congeners detected at the highest concentrations at the site, and TCDD and PeCDD were detected in one well at the site (Table 5). However, TCDD, PeCDD, HpCDD, and OCDD are not tested for in the treatment plant influent. PAHs are tested for only in the discharge water, where they are generally present at low concentrations (Table 18).

The treatment system is removing significant amounts of contaminants from the ground water. To date, an estimated 10,031 kg of PCP and 3,584 kg of PAHs have been removed by the treatment system. Moreover, the total PAH concentrations in the discharge water has only once (April 7, 1997) exceeded the site action level of 0.3 ug/L (Table 18).

Although some additional information is needed, the system appears to be achieving to a large degree its goal of extracting contaminants from the groundwater. It is not clear that the system is effectively capturing the contaminant plumes and preventing them from migrating to the various water bodies near the site.

Extraction wells ought to create a cone-shaped depression in the surface of the groundwater as pumping of the well draws down the water table near it. However, water level data from the site actually shows groundwater “mounding” around the extraction wells on many occasions. It is unclear why there would be mounding of the water table, but it certainly raises concern that the wells may not be removing enough water to effectively capture the contaminant plumes.

A quick review of pumping rates, compared to groundwater flow volumes, at least in part supports this concern. The groundwater flow model produced by Barr Engineering (Barr, 1996) assumed a hydraulic conductivity of 46 to 100 ft/day. An earlier site investigation report (Barr, 1982) reported the hydraulic conductivity of the upper sand aquifer as $9x10^{-2}$ cm/sec. (or 255 ft/day), but the EPA noted that it may be as high as 1 cm/sec (or 2,832 ft/day) in the lower portion of the upper aquifer (EPA, 2002). This is not a measure of the speed at which groundwater is actually flowing. The speed at which groundwater moves depends on both the hydraulic conductivity and the hydraulic gradient (the slope) of the water table. The average hydraulic gradient at the site is 0.0009. Based on these values of hydraulic conductivity and gradient, the estimated groundwater flow velocity ranges from 0.04 to 2.5 ft/day.

Calculations of the volume of water flowing through the cross-sectional area of the pump-out system in the FOA, using the range of hydraulic conductivities described above, a range of cross-sectional area of 17,500 to 35,000 square feet, yields flow volumes of 5,402 to 667,800 gallons per day. At the higher ends of the ranges of flow volumes, the pump-out system could not possibly capture the contaminant plume migrating through the area of the pump-out system. Given that the contamination in the FOA appears to be present throughout the thickness of the upper sand aquifer, these larger flow volumes may be a reasonable assumption.

VI. Site Specific Community Concerns

Many of Cass Lake's residents and visitors enjoy the open spaces and lakes near the site for recreation, hunting, fishing, and foraging. Many residents near the site have or had vegetable gardens. As a Leech Lake Reservation community, Cass Lake also has a large Native American population who practice traditional uses of the natural resources found on or near the site. Many of these uses have been documented in the Leech Lake Band's Pilot Superfund Project report (LLBO, 2003).

In animals, PCP, PAHs, and dioxins are known to bioconcentrate (accumulate in an individual at concentrations above those found in their food source), and dioxins are known to biomagnify (increase in concentration up the food chain). There is also evidence of uptake of dioxins, PCP, and PAHs by plants, in addition to the potential for these compounds to be present in soil or dust particles on the exterior of the plants. (ATSDR, 1994; ATSDR, 1995b; ATSDR, 1998).

Traditional use of local plants, animals, soil, and sediments for ceremonial, medicinal, or dietary purposes could result in addition exposure to site related contamination (LLBO, 2003). Additional exposure to dioxins and other site contaminants above background may result from traditional practices like:

- Inhalation of steam from boiling plant materials for medicinal purposes
- Ingestion of various plant materials like roots, leaves, inner and outer plant barks, fruits, berries, nuts, and wild rice. Plant parts are sometimes boiled and drunk or are just chewed.
- Consumption of ducks, deer, rabbits, muskrat, grouse, fish, mussels, turtles, crawfish, and other animals that frequent the site and adjoining areas.
- Dermal exposure stemming from the preparations and use of traditional poultice materials or topical solutions; preparation and use of medicinal solutions for eye and ear conditions;
- Dermal exposure while harvesting plant or animal materials in areas with contaminated soils, water and sediments.
- Inhalation of soot from burning plant materials used in smudging ceremonies.

If these types of exposures produce increased TCDD, PCP, and PAH body burdens, standard health criteria may not be sufficiently protective. Furthermore, some local residents formerly worked at the St. Regis site and may have had high occupational exposures. Many people have lived in the community all of their lives and have raised children there. Exposures to fetuses and nursing infants have likely occurred, and could be especially high in worker families. These issues will be discussed further in another Health Consultation on community health outcomes and concerns (ATSDR, MDH, and LLBO, in preparation).

VII. Child Health Considerations

ATSDR, LLDRM, and MDH recognize that the unique vulnerabilities of infants and children make them of special concern to communities faced with contamination of their water, soil, air, or food. Children are at greater risk than adults from certain kinds of exposures to contaminants at hazardous waste sites. A child's behavior and lifestyle will influence exposure. Children often spend significant time outdoors and tend to play in contact with soil, water, and sediments to a larger degree than do adults. Children are also more likely to ingest soil, water, and sediment than are adults, both during outdoor activities and afterwards by hand-to-mouth contact. At the St. Regis site, children "…played in and around Site wastewater ponds, runoff puddles, log and woodpiles" (LLBO, 2003), which likely resulted in very high levels of exposure.

A child's exposure to dioxins and PCP starts during their gestational development and continues with the ingestion of contaminated breast milk. The developing body systems of children can sustain permanent damage if exposures occur during critical growth stages (Ginsberg, 2003). Children drink more fluids, eat more food, breath more air per kilogram of body weight than adults, resulting in higher chemical exposure per body weight. Children also have a larger skin surface in proportion to their body volume than adults, making dermal contact a potentially greater pathway for exposure.

Children have different eating habits and food preferences for milk, cheese and meat, which may expose them to relatively more dioxin and PCP in their diet. Children whose families are subsistence fisherman can be additionally exposed to dioxins from locally caught fish. Children living in Cass Lake have the potential to be exposed to one or more of the contaminants of concern, particularly through contact with contaminated surface water and sediment. Some children, in the past, may have been exposed to contaminated groundwater.

There is some evidence that children are more susceptible to the toxic effects of PCP than adults (Chapman and Robson, 1965) and that infants are even more susceptible than children, especially by the dermal contact exposure route (Armstrong, et. al, 1969; Barthel et. al., 1969; Smith, et. al, 1967).

Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care. They are not able to make informed decisions regarding exposure or personal protection. As noted above, the absorption of most PAHs across the placenta poses particular risks to developing fetuses of mothers exposed to PAHs.

VIII. Conclusions

ATSDR public health assessments categorize public health hazards as one of the following: no public health hazard, indeterminate public health hazard, or public health hazard. An indeterminate public health hazard is declared when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking. A classification of "indeterminate" does not mean that a public health hazard is not present, it merely means that there is insufficient information to declare a public health hazard.

The public health hazards associated with the St. Regis site may be characterized as follows, and are described in greater detail below:

Groundwater – Indeterminate public health hazard.

Surface Water – Indeterminate public health hazard

Sediment – Indeterminate public health hazard

Despite the large number of samples collected at this site to date, it is still difficult to draw many conclusions regarding the magnitude and extent of the contamination, the level of human exposure, and the risk to public health. The groundwater monitoring networks do not adequately define the extent of contamination in upper sand aquifer in the FOA and SWA, nor the lower sand aquifer in the FOA, SWA, and City Dump area. No information has been obtained regarding where groundwater discharges to the surface water bodies near the site. Additional information is needed to determine groundwater discharge locations in order to direct surface water and sediment sampling efforts.

Surface water sampling has been sporadic, and except for the EPA sampling in 2001, the methodology is either unknown or was not adequate for collecting accurate samples. Until 2004, no surface water and only limited sediment sampling had occurred in areas where children are most likely to swim. The results of the 2004 sampling have only become available in May 2005 and will be evaluated by MDH once the associated split sample data collected by EPA is available.

Sediment sampling suggests possibly significant levels of contamination in Fox Creek and the channel area, which are used by residents for swimming and wading, but samples collected from the swimming area at the city park were not analyzed for PCP and PAHs. Again, such samples were collected by International Paper in 2004, but the EPA split sample data has not been made available yet. Once all of the data are available, MDH will evaluate it.

Despite these and other shortcomings of the site assessment work to date, it is possible to conclude that many Cass Lake residents, particularly those living nearest the facility, may have been exposed to one or more of the contaminants of concern at the site through ingestion, dermal contact, and to a much lesser degree, inhalation (primarily as steam from contaminated water in showers and household appliances). These exposures include:

- Past exposure to contaminated groundwater via private wells and the city water supply system,
- On-going exposure to contaminated surface water in the Fox Creek, Pike Bay, Cass Lake, and channel area,
- On-going exposure to contaminated sediments in the Fox Creek, Pike Bay, Cass Lake, and channel area.

Appendix D provides a discussion of the possible public health risks related to exposure to PAHs, PCP, and PCDDs by various pathways. However, information regarding how often (frequency) and how long (duration) actual exposures to these contaminants actually occurred is needed to determine whether the exposures at the St. Regis site would be expected to pose an actual public health hazard.

Contaminated groundwater at and near the St. Regis is considered to pose an indeterminate public health hazard. It does not currently pose a public health hazard, as there are currently no known completed exposure pathways. However, it may have posed a public health hazard in the past, and potentially could pose a public health risk in the future.

One home had concentrations of PCP in excess of the current HRLs. The well at this home is still present, but is not currently in use and the home is connected to city water. The length of time the occupants of this home were exposed to contaminated water is unknown, because it is not known when the contaminants first entered the well. However, based on the period of operations of the facility, it is possible that exposures may have occurred for as much as twenty to thirty years. This exposure must be considered an indeterminant health risk, because the duration of exposure is unknown.

It is difficult to evaluate what risk might have been associated with the Cass Lake city water supply, in which PAHs and PCP were detected. The PAH concentrations were generally below the current HRLs, but the detection limits for PCP were generally higher than the current HRL. This means that some samples may have contained PCP at concentrations above the HRL, but the high detection limits “masked” its presence in the sample. Again, because there are no data recording when contamination entered the city wells, it is possible that residents were exposed to low concentrations of PAHs and PCP for up to twenty or thirty years. If the PAH or PCP concentrations exceeded the HRLs for significant periods of time, this could have represented a public health hazard for users of the affected wells or city water. There is simply no way to know this, based on the data that has been collected. Therefore, these exposures must also be classified as an indeterminant health hazard.

There are several private wells still present in the FOA and one in the SWA. All but one of the wells in the FOA are not currently used, and the one in use is not used for drinking water or bathing. A fish hatchery well in the SWA is still in use, but has not had contamination in samples collected in the past three years. However, future use of these wells for drinking water or bathing could pose a public health hazard.

The risk related to surface water near the St. Regis site is considered to be an on-going, indeterminate public health hazard. There is not sufficient information regarding frequency and duration of swimming and wading activities to allow the exposures to be evaluated. Also, sampling has not been conducted in the city park swimming area, and only minimal sampling has occurred in Fox Creek and the channel. Such samples were collected in the supplemental investigation completed by International Paper in 2004. These data have only just become available, but split samples collected by EPA have not yet been made available. Samples collected from Pike Bay, Fox Creek, and the channel, however, suggest that surface water may represent only a minor exposure pathway, as concentrations detected in those areas were generally low. It is unlikely that surface water poses a public health hazard, but additional sampling will be needed to confirm this.

The risk related to contaminated sediments near the St. Regis site is considered to be an on-going, indeterminate public health hazard. Sampling has not been sufficient to fully evaluate the levels of contamination in the swimming areas where dermal and ingestion exposures are most likely to occur. Nor is there sufficient information available regarding the frequency and duration of activities in which exposures might occur. However, the concentrations of dioxin, PCP, and PAHs detected in the sediment in Fox Creek and the channel areas indicate the potential for significant dermal contact exposures and may constitute a public health hazard, if exposures occur on a frequent basis. The sediment concentrations may be sufficient to also result in uptake by benthic organisms at the base of the food chain, providing an indirect exposure pathway that has not been evaluated. Evaluation of that potential exposure pathway is beyond the scope of this document, and will be undertaken as part of the human health and ecological risk assessment process led by EPA, based on the recently available 2004 sampling data.

IX. Recommendations

MDH and ATSDR recommend that International Paper or the EPA take the following actions:

1. Access to Fox Creek and the Channel Area should be restricted and signs should be posted warning residents and visitors to avoid contact with sediments and bottom-dwelling organisms in this area, until additional assessment of the human health hazards is completed and any necessary remedial actions taken to reduce the risk associated with exposure. (The data for the human health risk assessment has been collected, but is currently being evaluated).

2. In order to fully evaluate the potential human health risk associated with groundwater, both as a direct pathway for exposure to site contaminants, and as an indirect pathway via contamination of sediments and surface water, additional information about groundwater quality and flow directions is needed:
   - In both the upper and lower sand aquifers North of Fox Creek, in the southeast corner of the Southwest area where sludge was disposed of;
   - In the FOA, at the base of the upper sand aquifer, to define the southern and southeastern extent of the plume, and in the lower sand aquifer to provide information about the lateral extent of contamination in that aquifer and vertical groundwater flow between the two aquifers;
   - At the City Dump, to define the southeastern extent of groundwater contamination, and at the base of the upper sand aquifer to determine downward plume migration;
   - Downgradient of the former sludge pit in the City Dump, in the lower sand aquifer;
   - At the channel that connects Pike Bay and Cass Lake, to determine whether the plume is migrating beneath the channel; and
   - In Pike Bay, Fox Creek, and the channel to determine where groundwater discharges to these water bodies and what mass flux of site-related contaminants may be migrating to the sediments and surface water there.

3. Dioxin congener contamination should be evaluated in the upper and lower sand aquifers in the FOA, in the fish hatchery wells, and in the discharge of the water treatment plant.

4. The extent of the LNAPL in the vicinity of MW-118 should be investigated, and actions taken to ensure its removal.

5. Ensure that migration of PCP and PAHs to the channel is stopped, either by upgrading the recovery well network to completely capture the contaminant plume or by applying alternative technologies to prevent further contaminant migration.

6. Resample the private well in the SWA and if it is contaminated it should either be used as a monitoring well or sealed.

7. All PAH analyses should include the full California List in accordance with Minnesota policy.

8. Methyl ethyl ketone and methyl isobutyl ketone should be analyzed at the FOA, SWA and City Dump.

9. Resurvey the location of all monitoring wells to provide accurate location maps and elevations.

Public Health Action Plan:

1. MDH, ATSDR, and LLBO will evaluate the 2004 sample data, once all of the data are available for review.

2. MDH, ATSDR, LLBO will continue to work with Region 5 EPA, and the City of Cass Lake in addressing community concerns, assisting site investigations, evaluating site data, and mitigating exposures through community education. MDH/ATSDR and LLBO are available for reviewing any site sampling plans.

3. MDH and the city of Cass Lake should consider whether a Special Well Construction Area should be established to ensure that no wells are installed in areas of groundwater contamination in the future.

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CERTIFICATION

This St. Regis Public Health Assessment was prepared by the Minnesota Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). The Leech Lake Division of Resource Management, an agency of the Leech Lake Band of Ojibway, co-authored the Public Health Assessment. It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

Jeff Kellam
Technical Project Officer, CAT, SSAB, DHAC
ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

Sven Rodenbeck
Chief, Cooperative Agreement Team, SSAB, DHAC, ATSDR

Appendix A: Figures

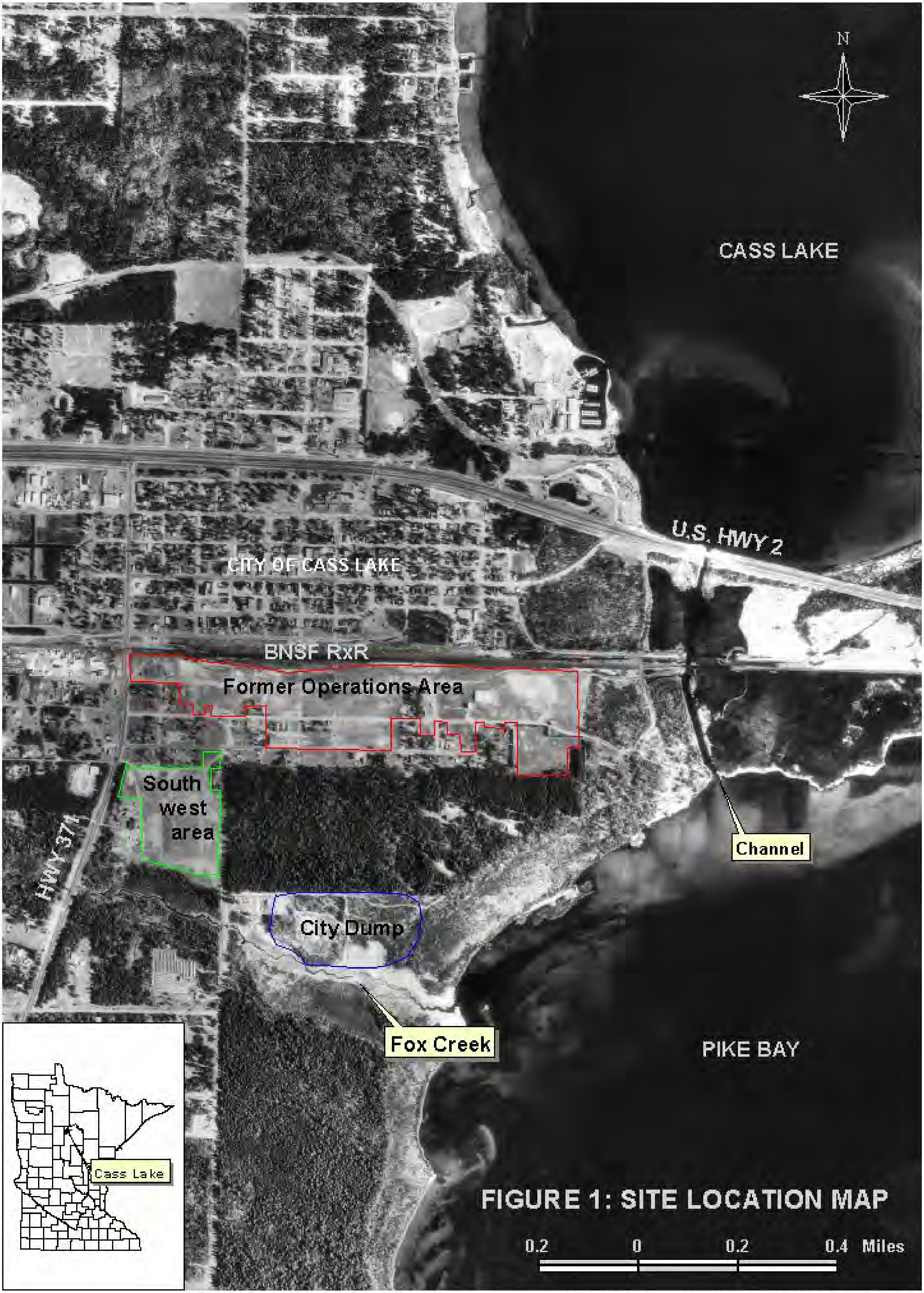

FIGURE 1: SITE LOCATION MAP

Figure 2: Former Operating Area

● Approximate location of "tee-pee" burners

Figure 3: Southwest Area

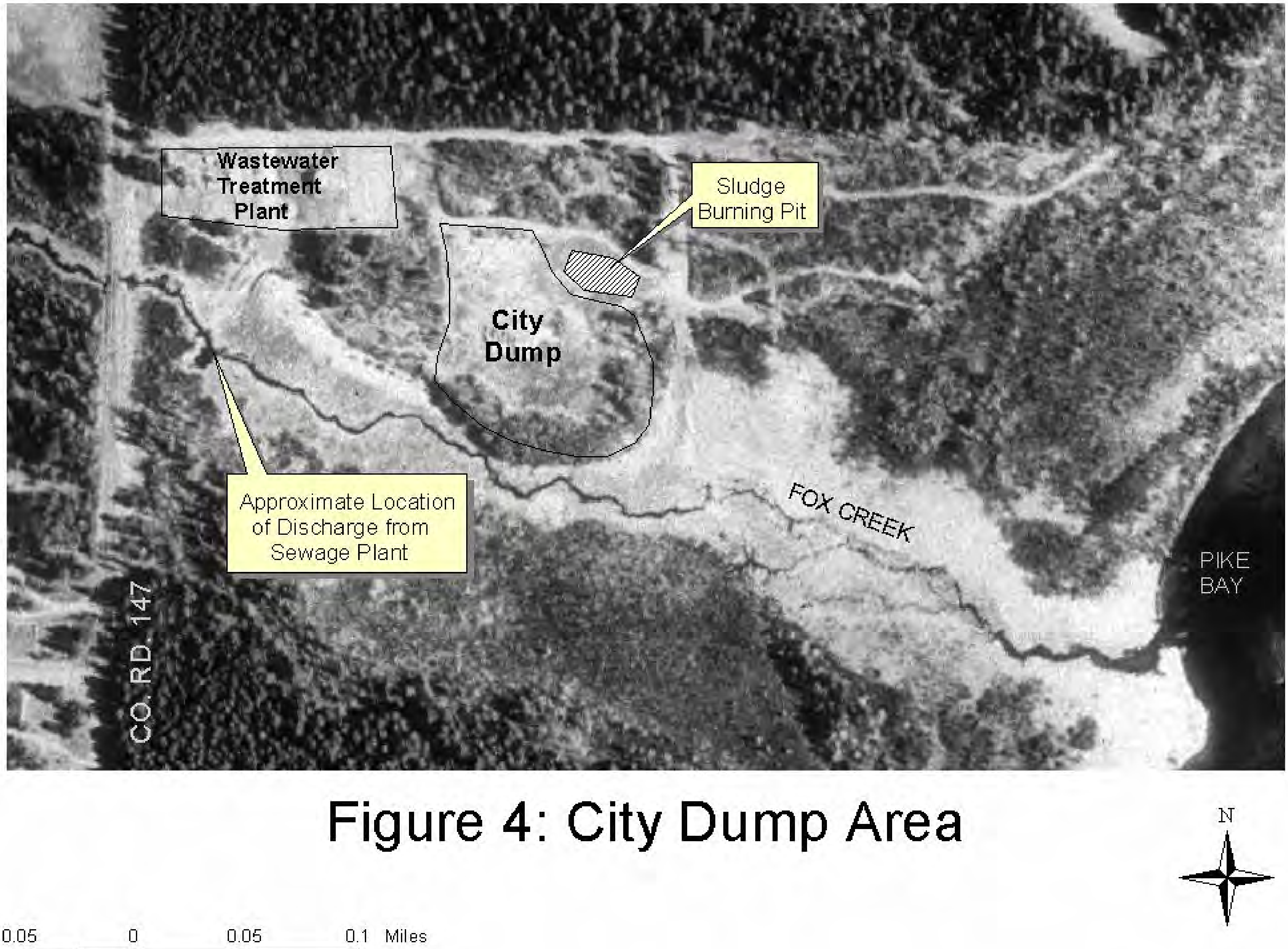

Figure 4: City Dump Area

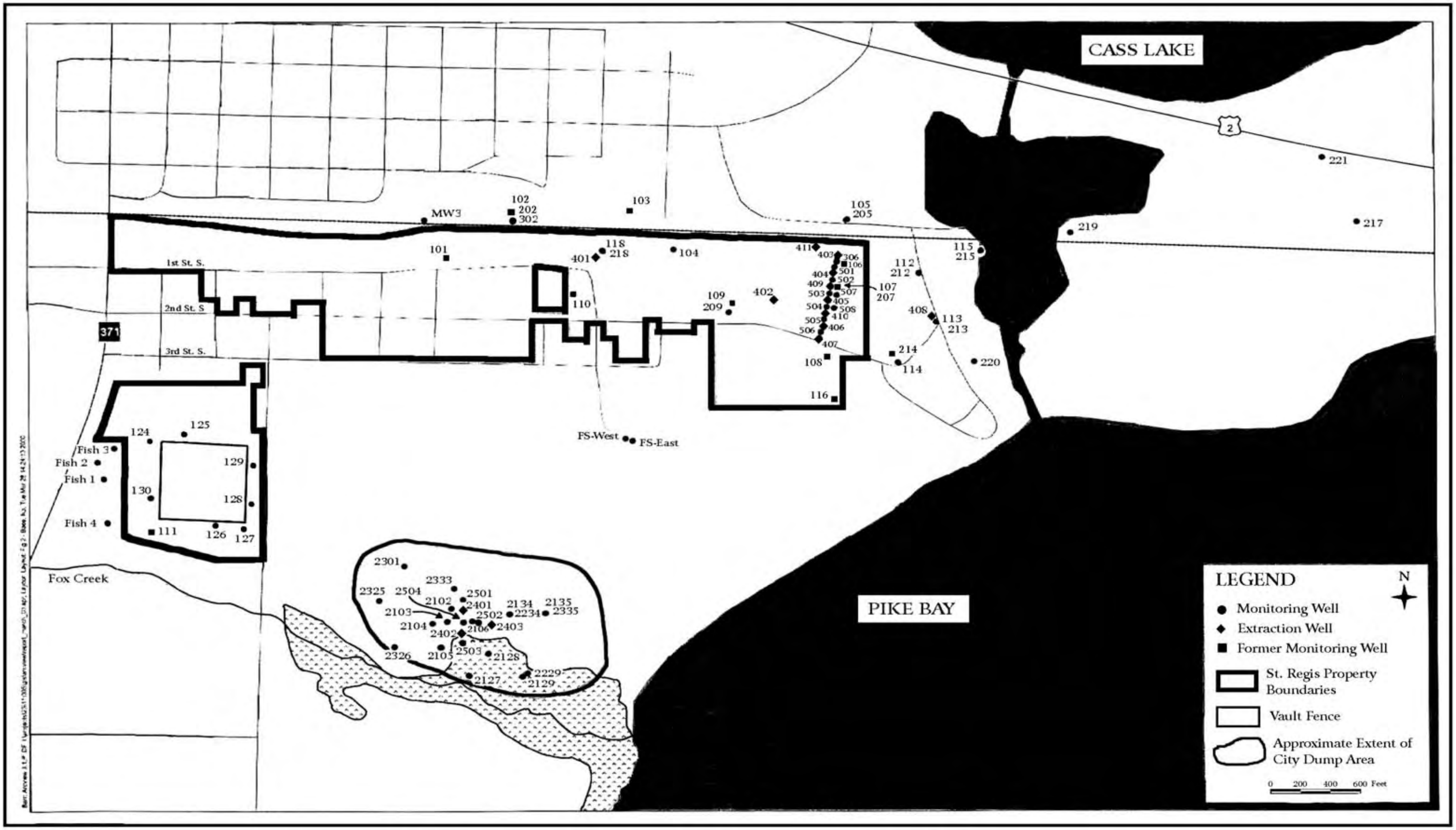

Figure 5: Monitoring and Extraction Well Locations

Modified from Fig. 2, Barr (2000)

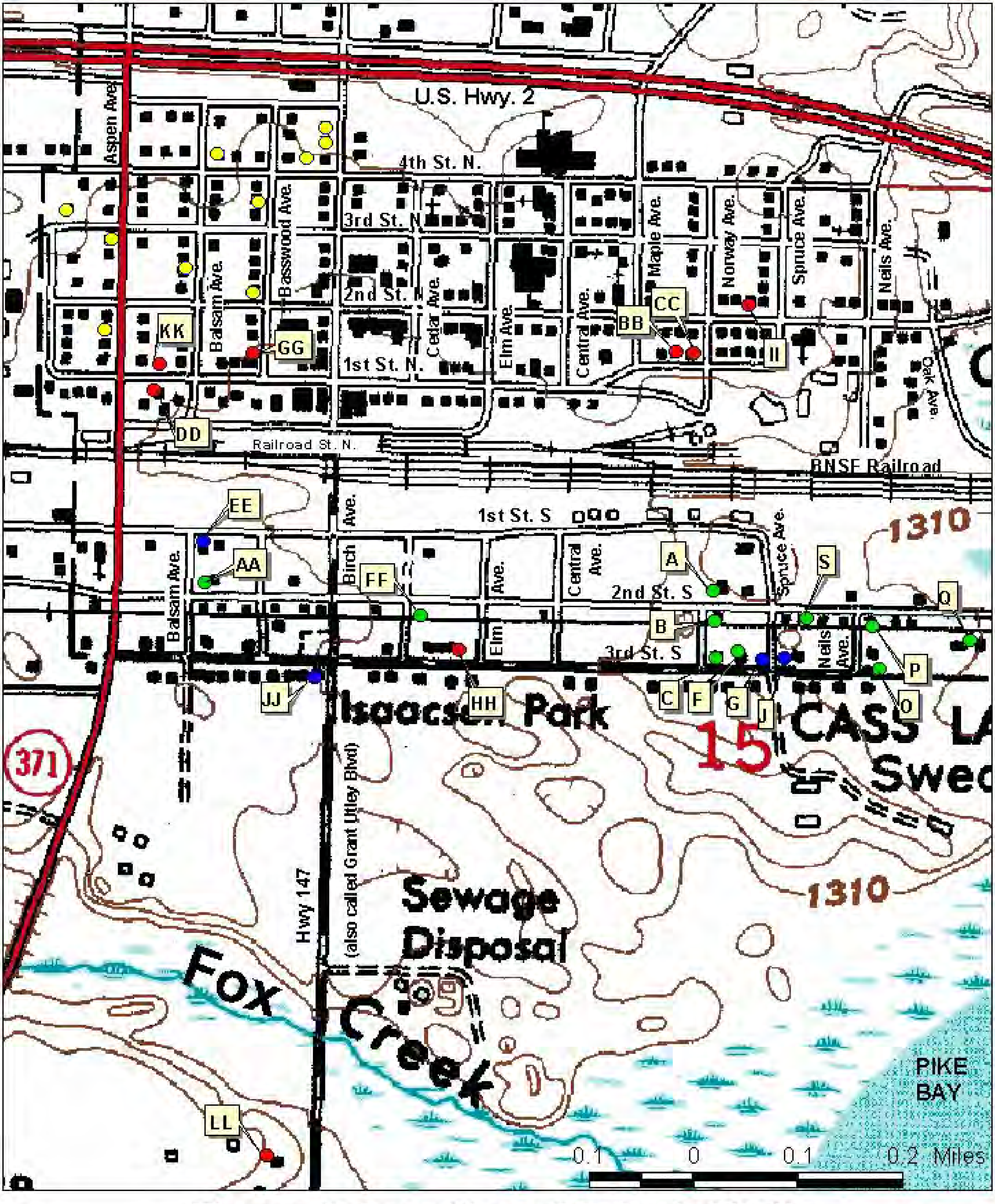

Figure 6: Location of Private Wells

● Well still in use, sampled

● Well still in use, not sampled

● Well still present, not currently in use

● Well sealed, previously sampled

A Well identification, corresponds to Table 1

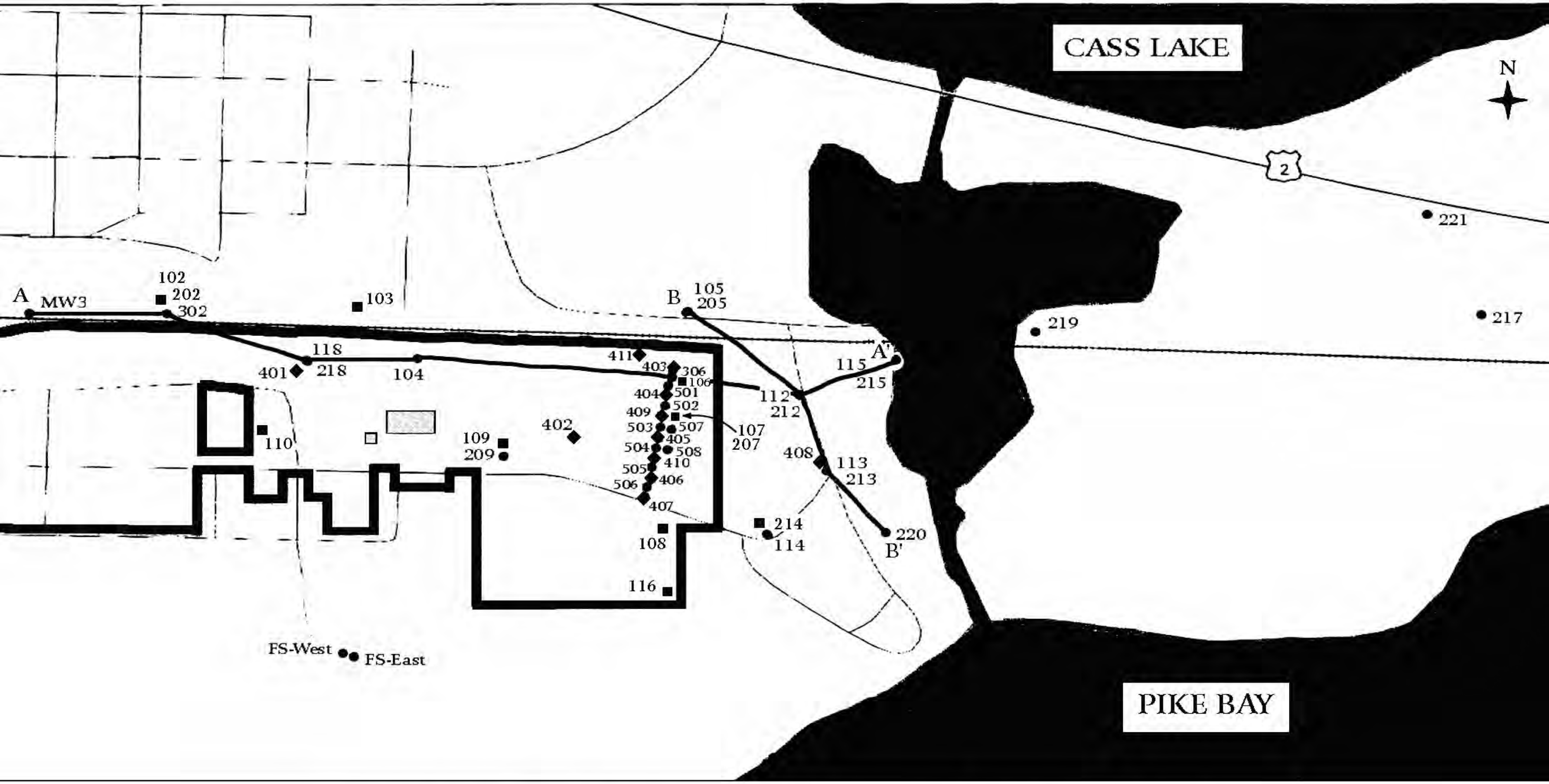

Figure 7: Former Operations Area

▨ Groundwater Treatment Buildings

● Monitoring Well

◆ Extraction Well

■ Former Monitoring Well

0 200 400 600 Feet

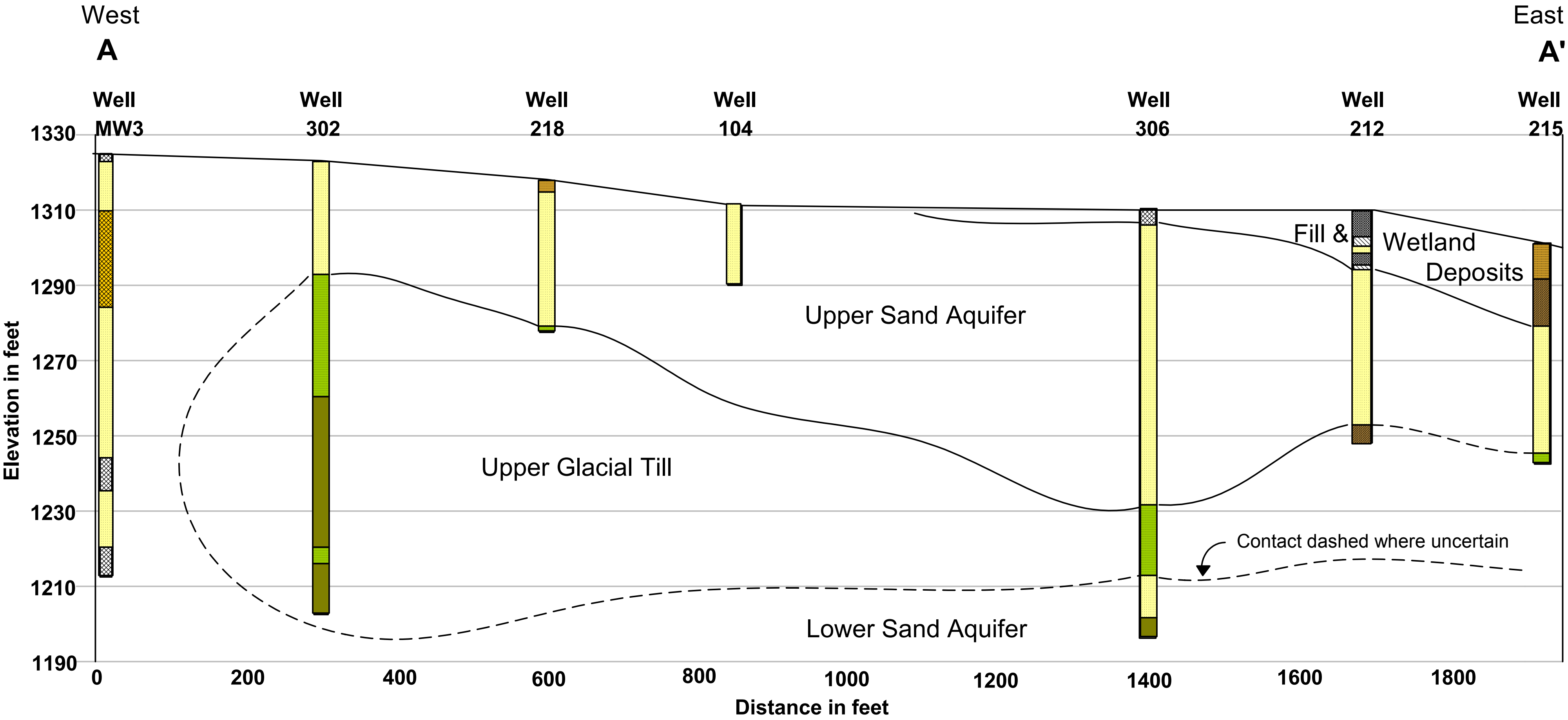

Figure 8: Cross Section A-A'

Geologic information for wells 302, 218, 104, 306, 212, and 215 taken from borings logs prepared by Barr Engineering; for well MW-3, from a boring prepared by Layne-Minn. Co.

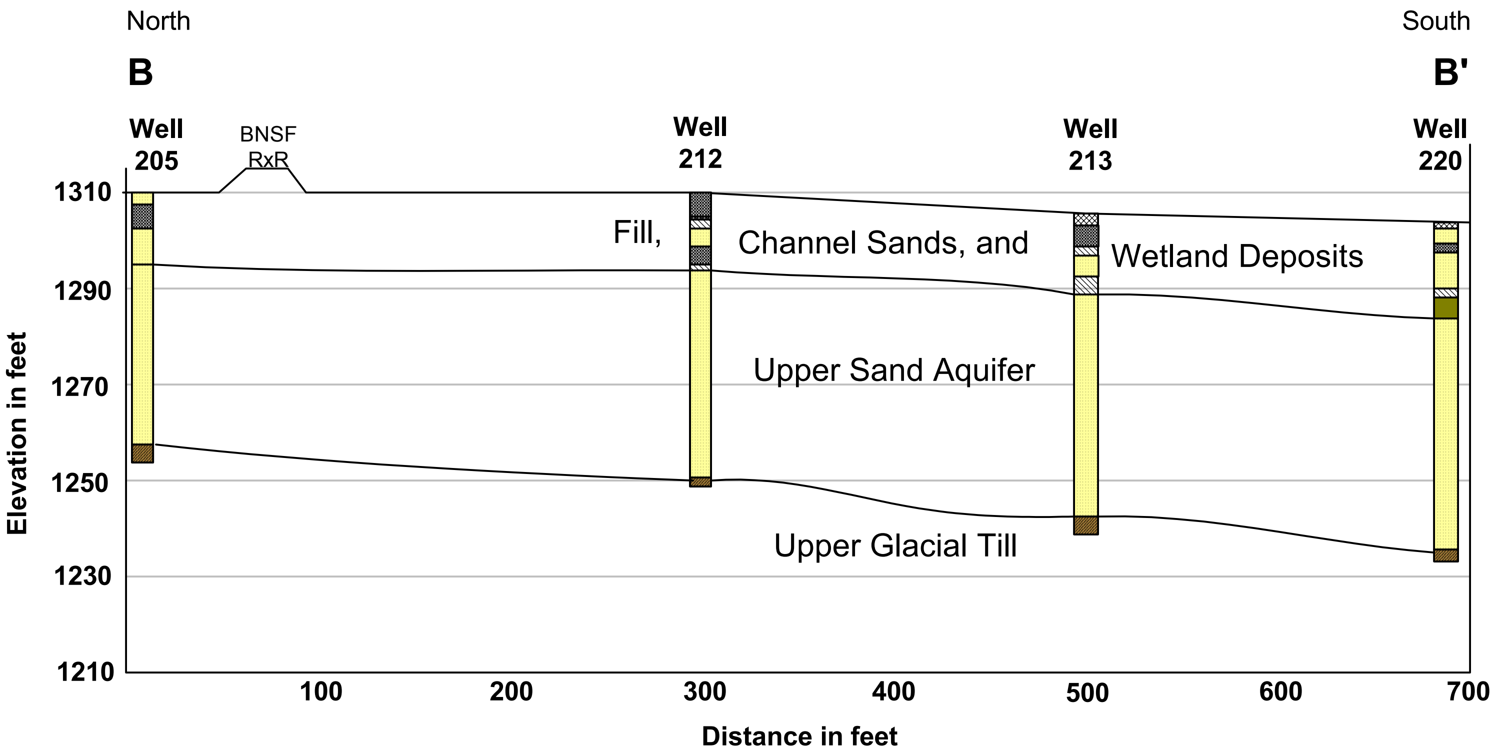

Figure 9: Cross Section B-B'

▩ Peat
▨ Sand
▧ Silt
■ Clay
▩ Silty Clay/Clayey Silt
▦ Fill

Geologic information for wells taken from borings logs prepared by Barr Engineering

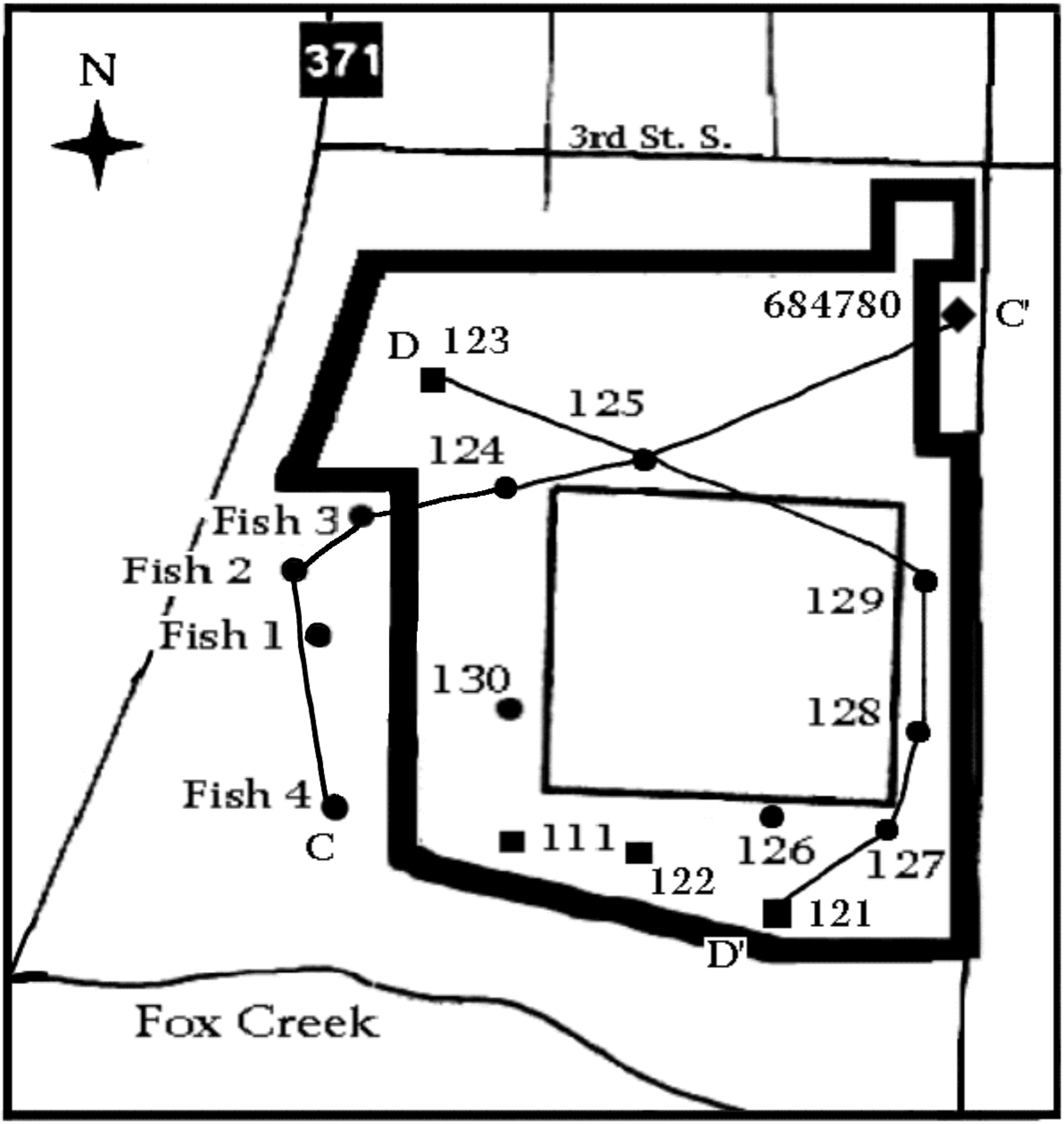

Figure 10: Southwest Area

▬ Champion property boundary

▬ Outline of containment vault

C —— C' Location of cross-section (Fig. 11)

D —— D' Location of cross-section (Fig. 12)

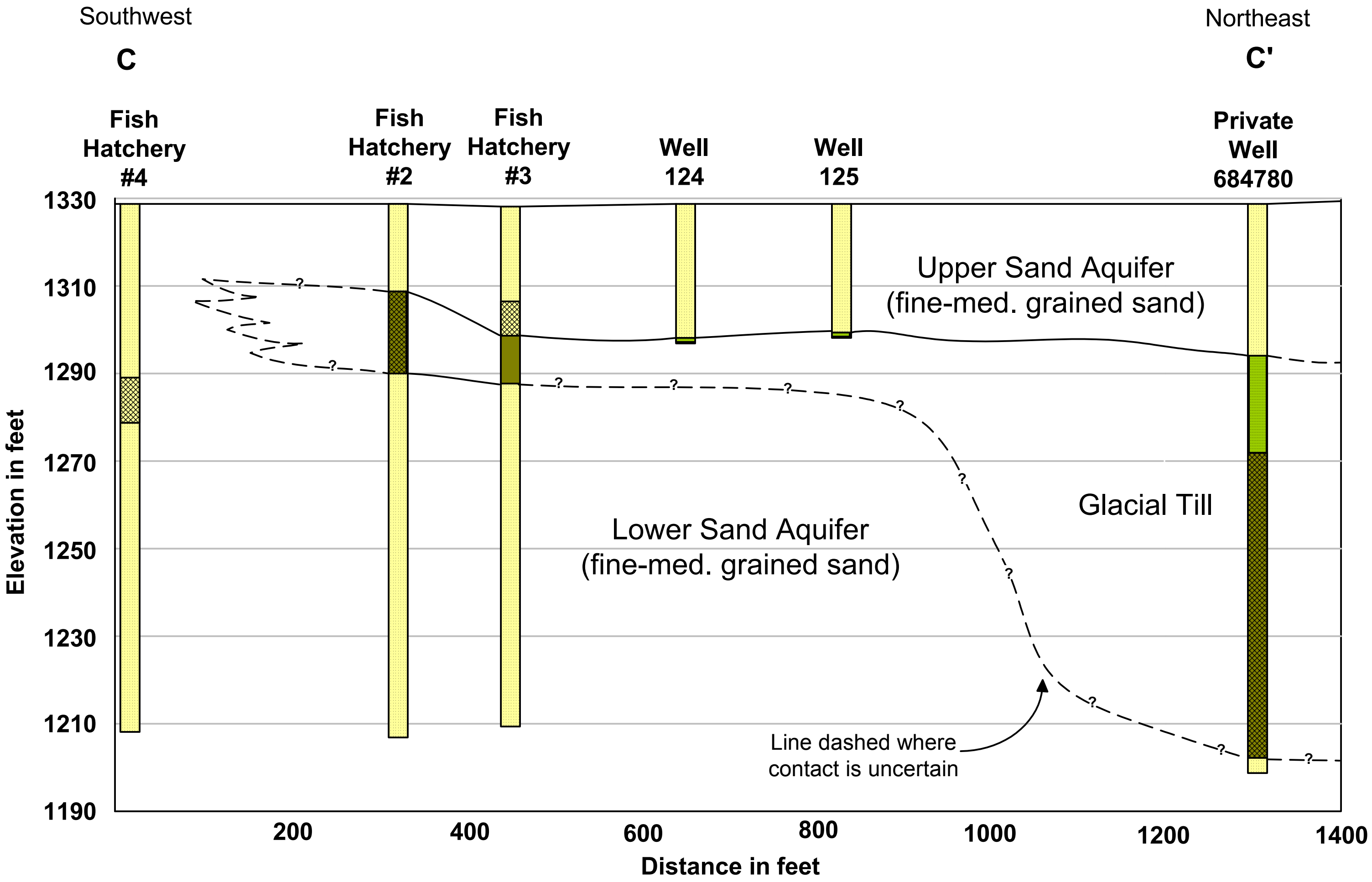

Figure 11: Cross Section C - C'

🟨	Sand	🟫	Clay	▨	Sand with Gravel
▨	Gravel	🟩	Sandy Clay	▨	Clay with Gravel

Geologic information for monitoring wells taken from borings logs prepared by Barr Engineering; for the Fish Hatchery wells from logs prepared by North Star Drilling

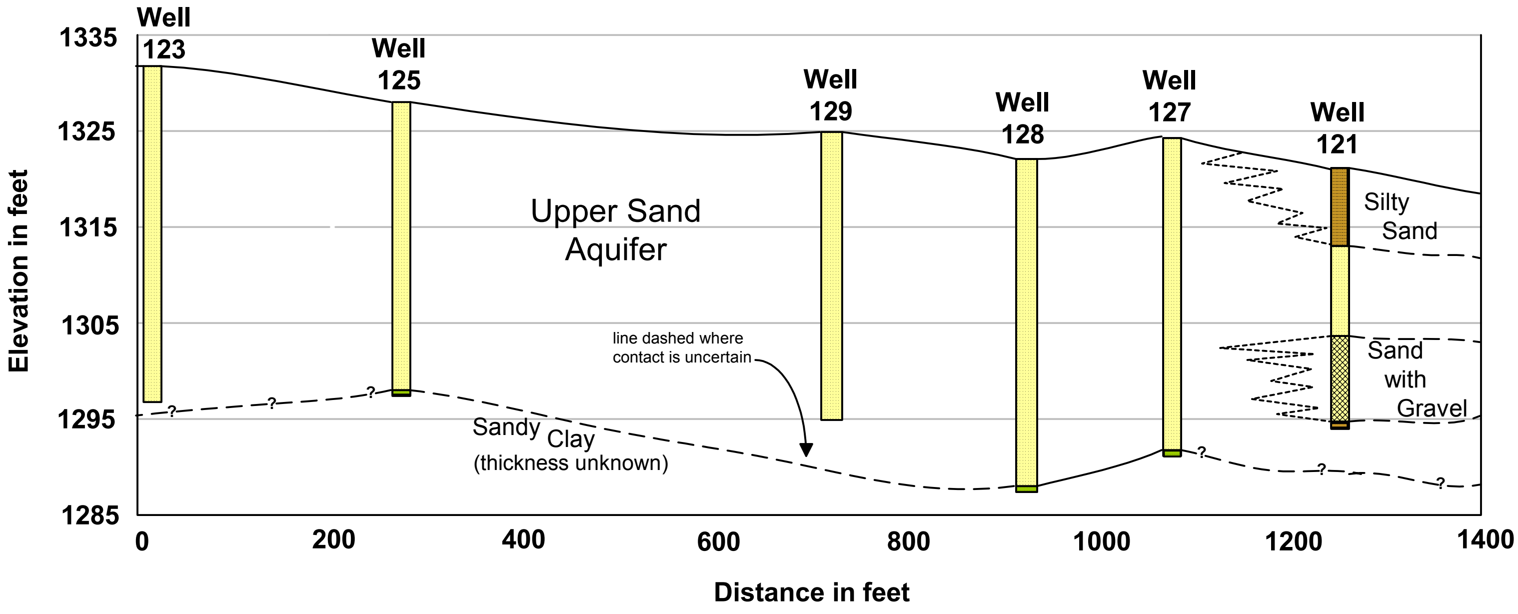

Figure 12: Cross Section D - D'

▨ Sand
▨ Sand with Gravel
🟩 Sandy Clay
▨ Gravel
🟫 Silty Sand

Geologic information for wells taken from borings logs prepared by Barr Engineering

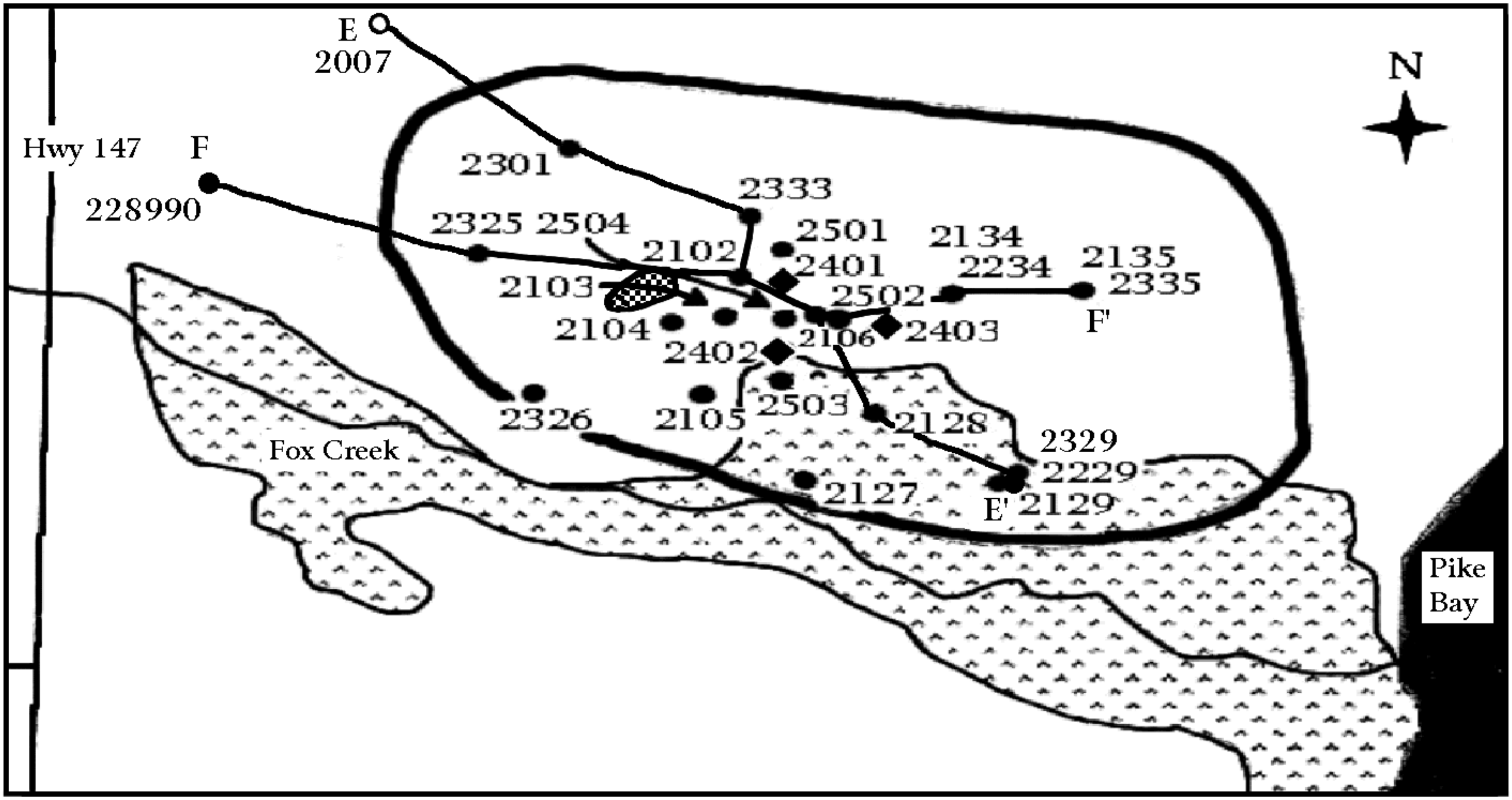

Figure 13: City Dump Area

Approximate boundary of City Dump Area

E —— E' Location of Cross Section E-E' (see Figure 14)

F —— F' Location of Cross Section F-F' (see Figure 15)

Note: locations approximate

Sludge Pit

Wetlands

● Monitoring well

◆ Extraction well

○ Soil boring

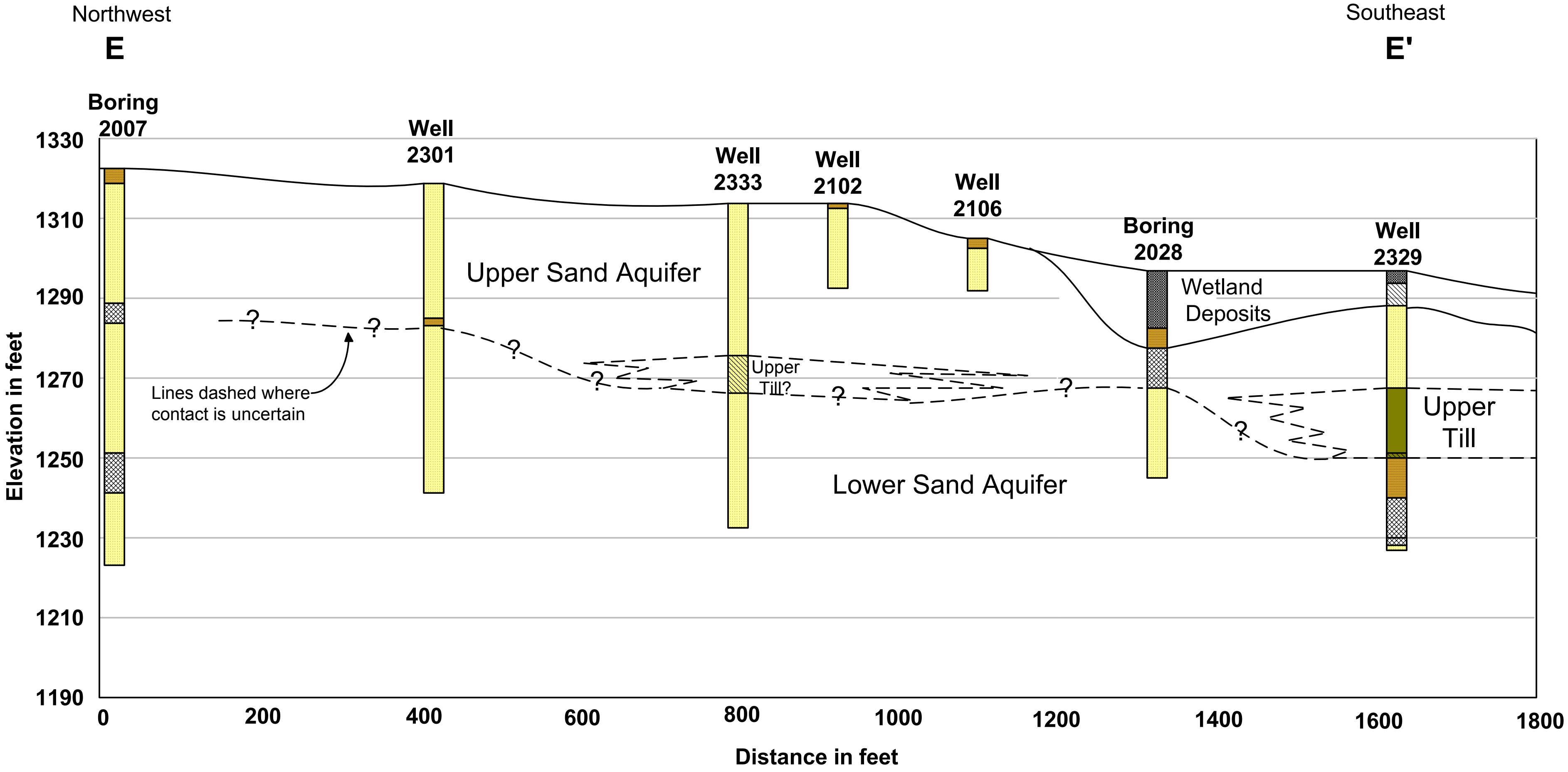

Figure 14: Cross Section E - E'

▩ Peat

🟨 Sand

▧ Silt

🟩 Clay

▦ Gravel

▦ Sand with Gravel

🟧 Silty Sand/Sandy Silt

Geologic information for wells taken from borings logs prepared by Barr Engineering

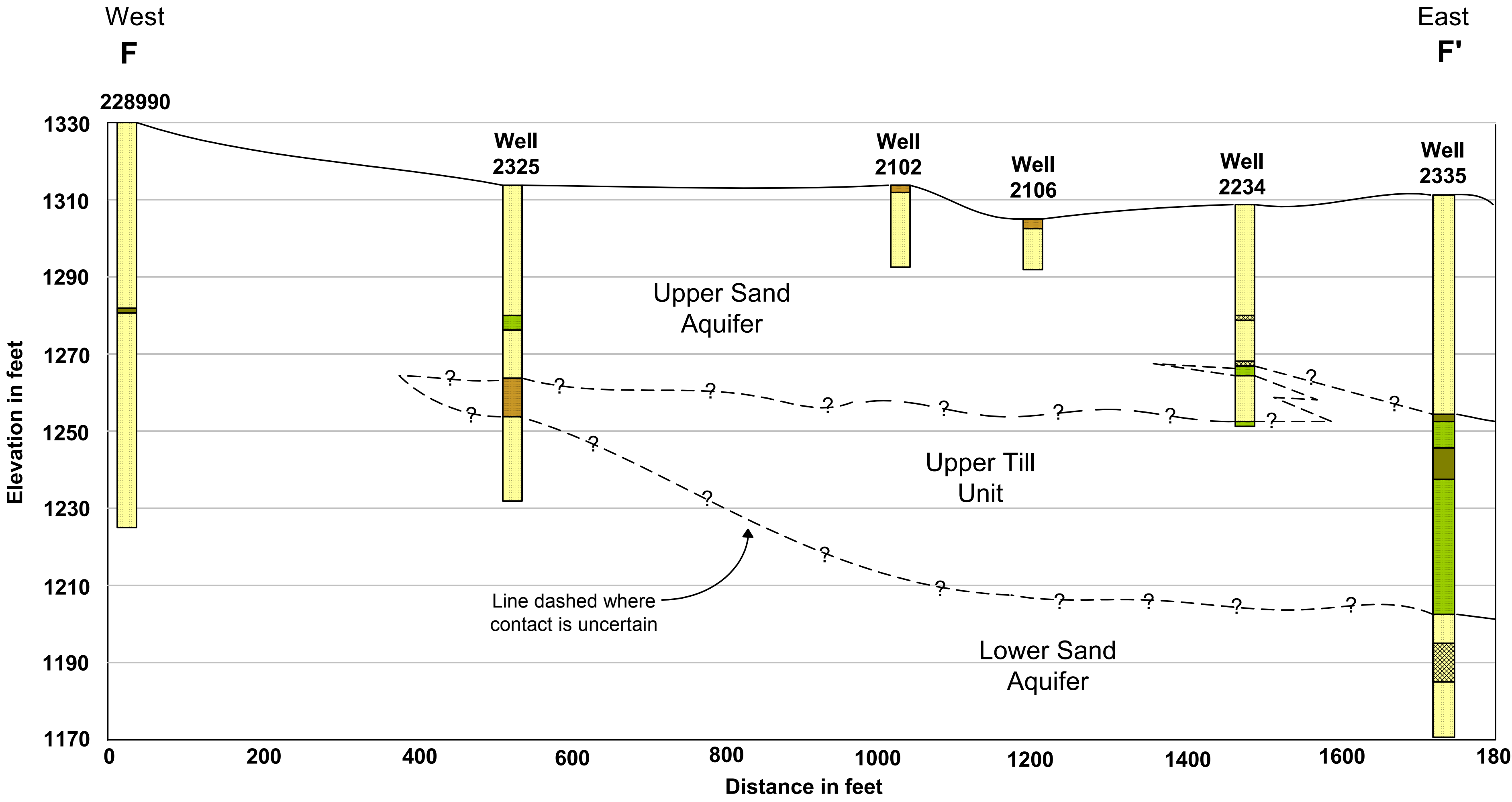

Figure 15: Cross Section F - F'

🟨 Sand
🟫 Clay
🟧 Silty Sand/Sandy Silt
▩ Gravel
🟩 Clayey Sand/Sandy Clay

Geologic information for monitoring wells taken from boring logs prepared by Barr Engineering; for well 228990 from well log prepared by Johnson Wells

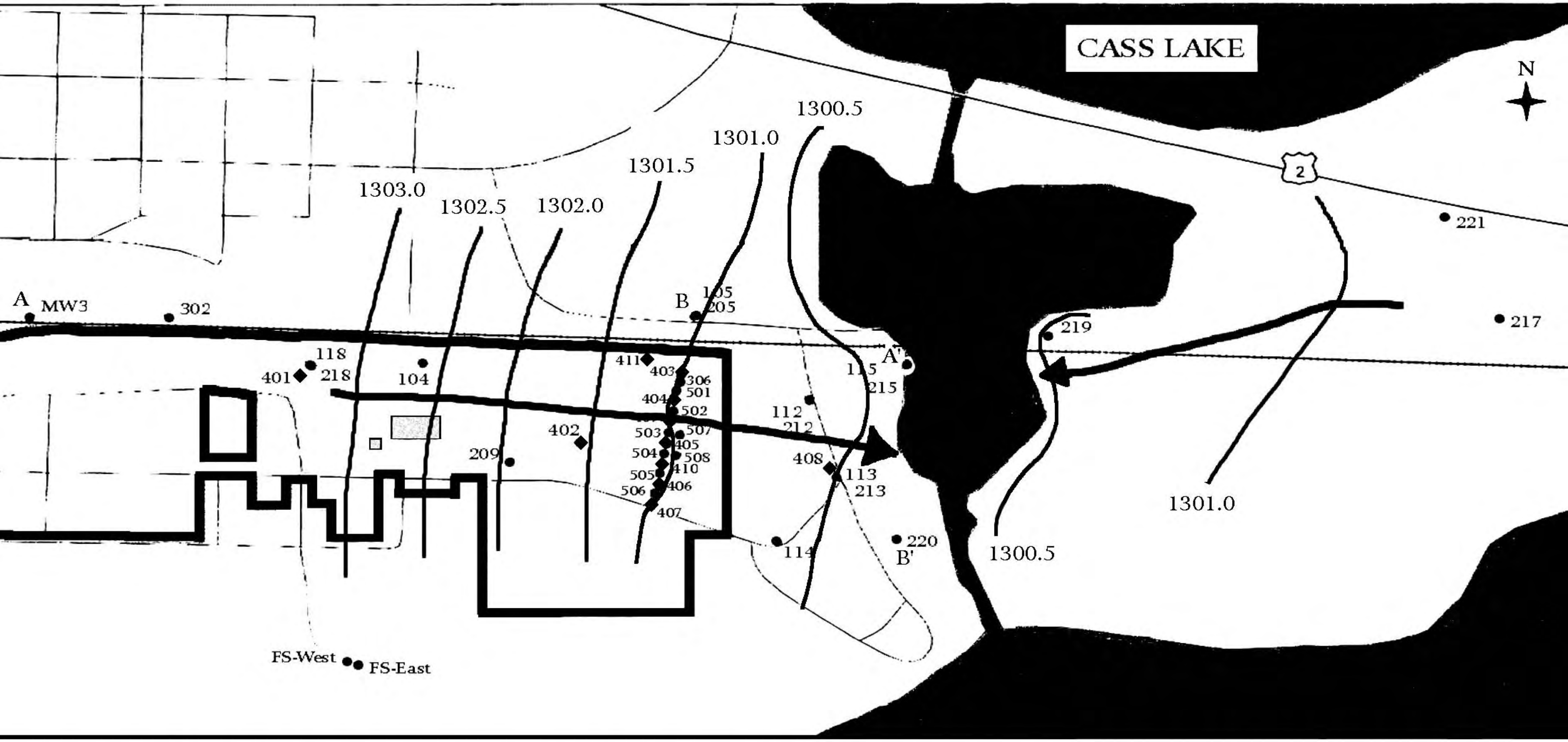

Figure 16: Groundwater Flow Direction in Former Operations Area

▨ Groundwater Treatment Buildings

1301.5 Water Level Elevation (in ft., based on 10/8/01 measurements)

→ General Groundwater Flow Direction

0 200 400 600 Feet

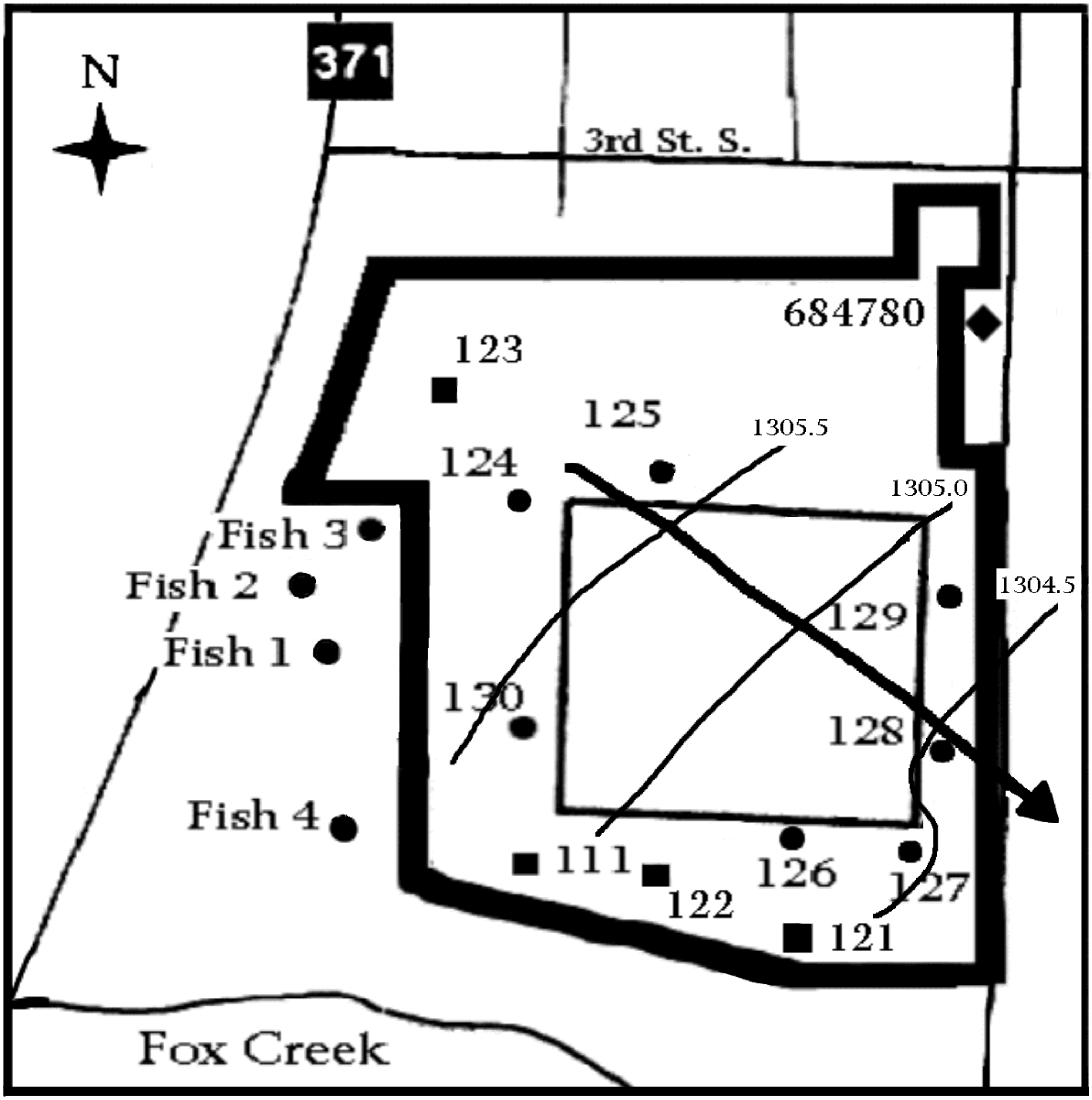

Figure 17: Groundwater Flow Direction in Southwest Area

1305.5 Water Level Elevation (in ft., based on 10/8/01 measurement)

Groundwater flow direction

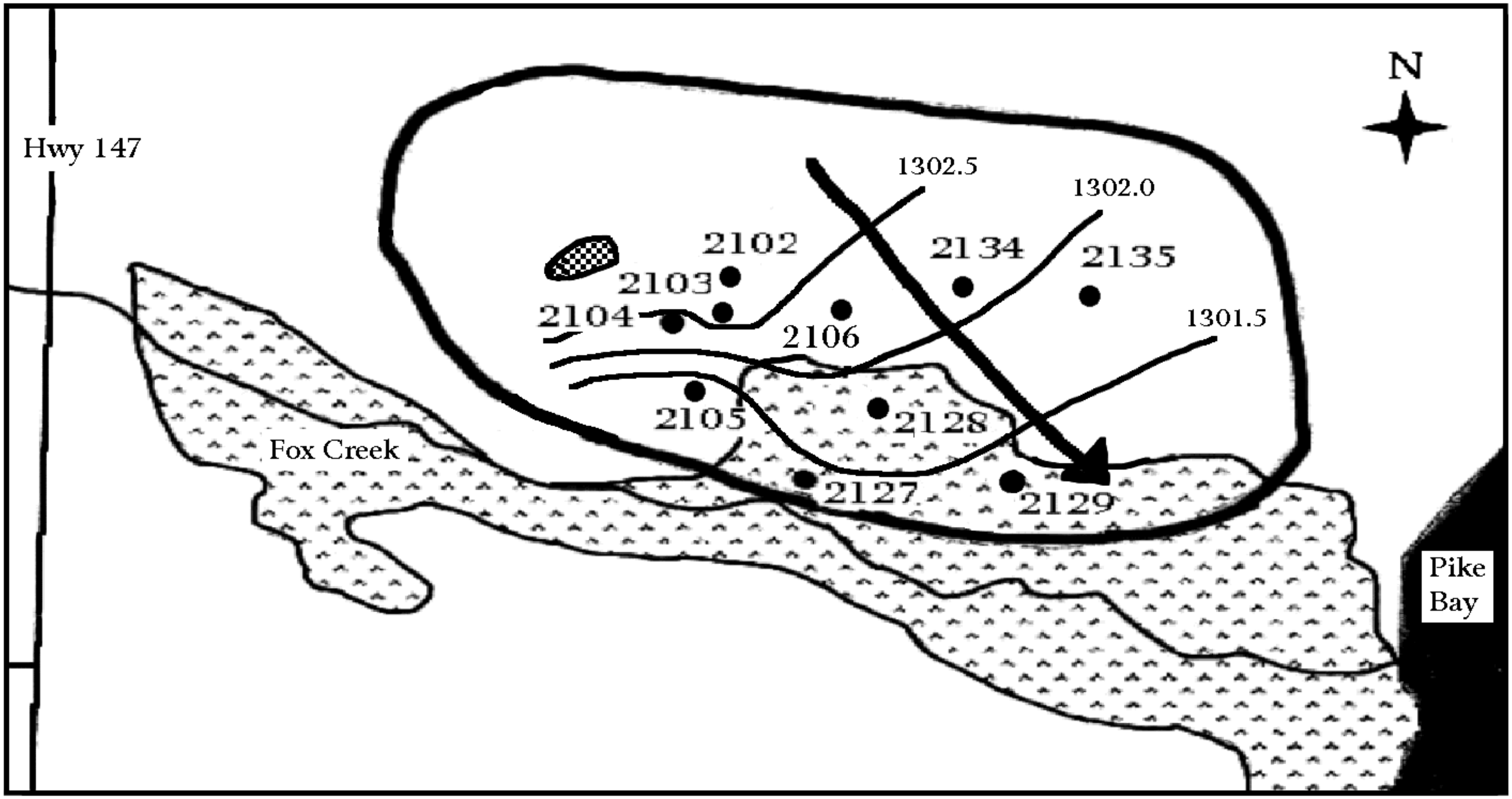

Figure 18: Groundwater Flow Direction, Upper Sand Aquifer, City Dump Area

1302.5 Water Level Elevation (in ft., based on 10/8/01 measurement)

→ Groundwater flow direction

Note: locations approximate

Wetlands

● Monitoring well

▨ Sludge Pit

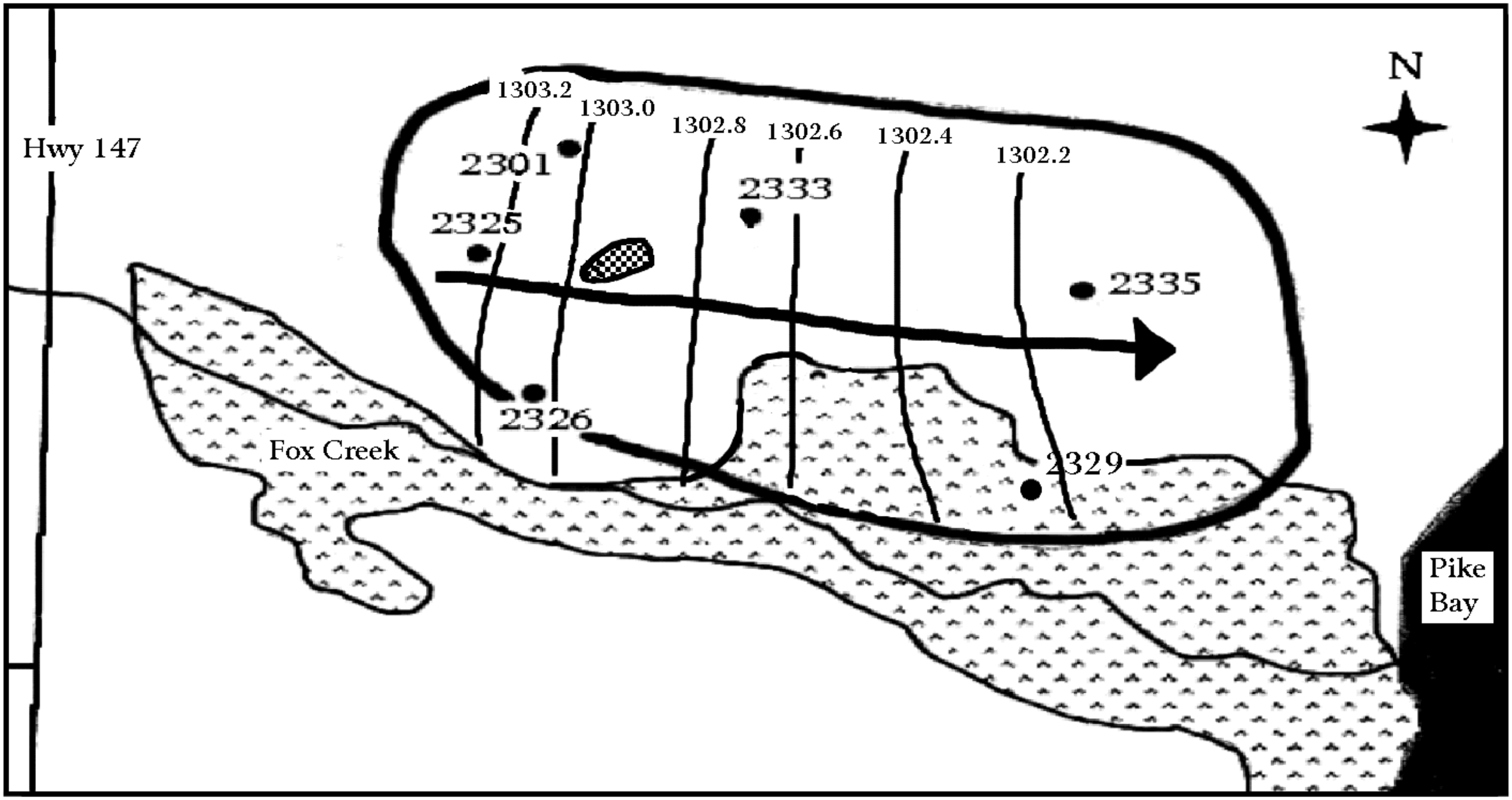

Figure 19: Groundwater Flow, Lower Sand Aquifer, City Dump Area

1302.4 Water Level Elevation (in ft., based on 10/8/01 measurement)

→ Groundwater Flow Direction

Note: locations approximate

▨ Wetlands

● Monitoring well

▨ Sludge Pit

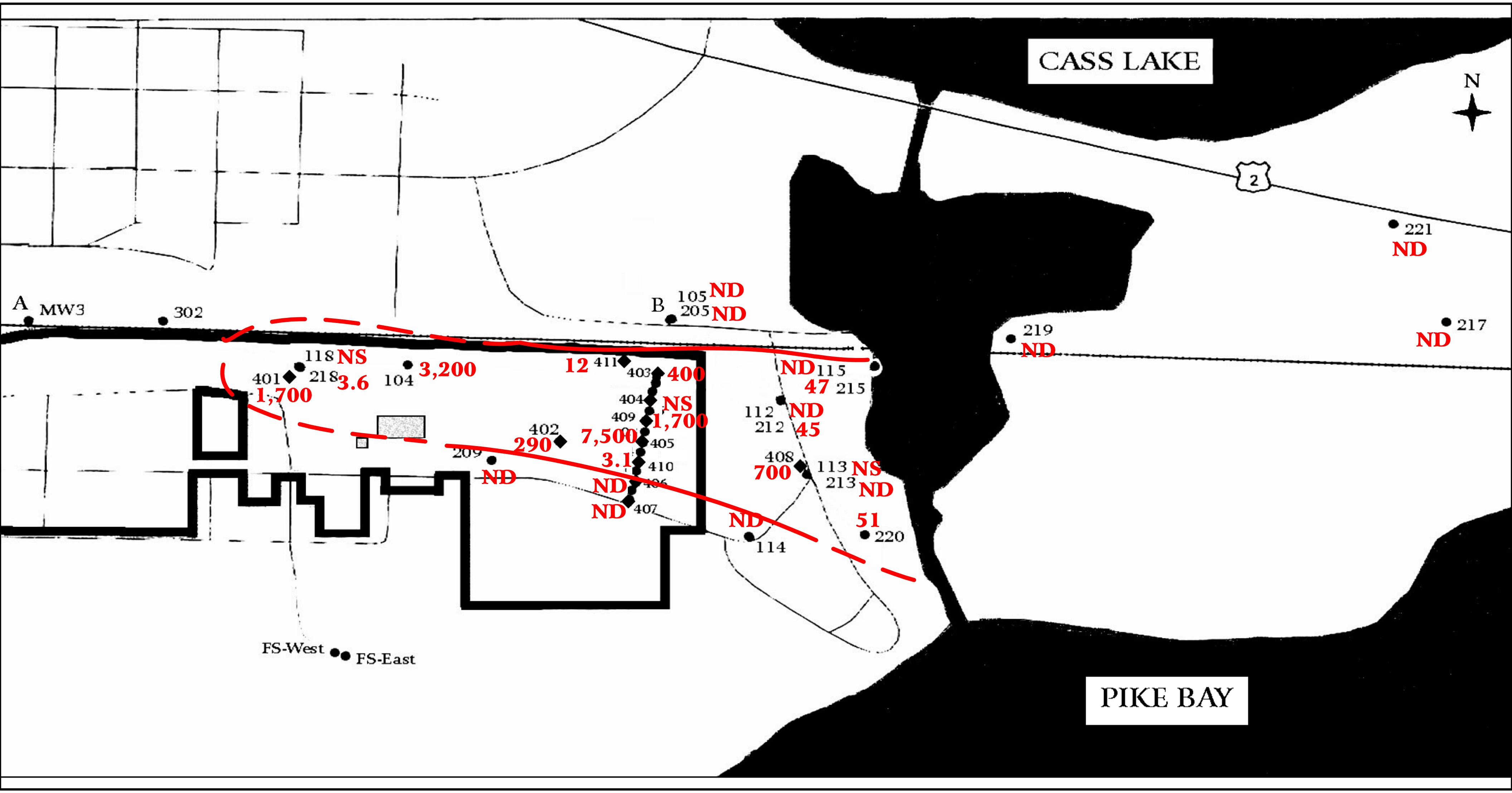

Figure 20: Extent of PCP Contamination in the upper sand aquifer, Former Operations Area

1,700 = PCP (ug/L)
ND = PCP not detected
NS = Well not sampled

— Edge of PCP contamination, dashed where data are insufficient to locate edge of plume

Based on sampling results from 2003 (Barr, 2004)

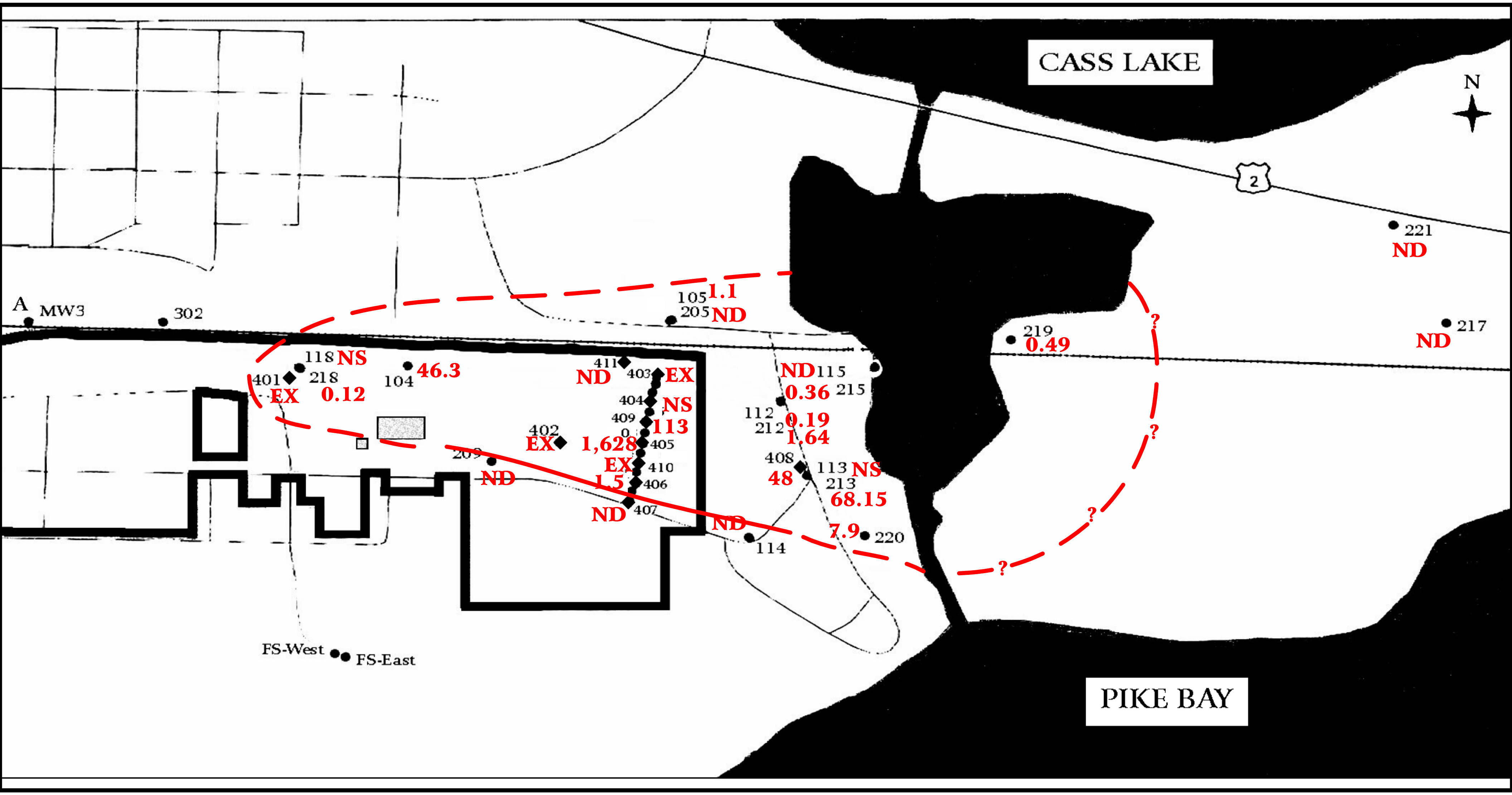

Figure 21: Extent of PAH Contamination in the upper sand aquifer, Former Operations Area

113 = total PAHs (ug/L)
ND = PCP not detected
NS = Well not sampled
EX = Detection limit exceeded drinking water standard

Edge of PCP contamination, dashed where data are insufficient to locate edge of plume

Based on sampling results from 2003 (Barr, 2004)

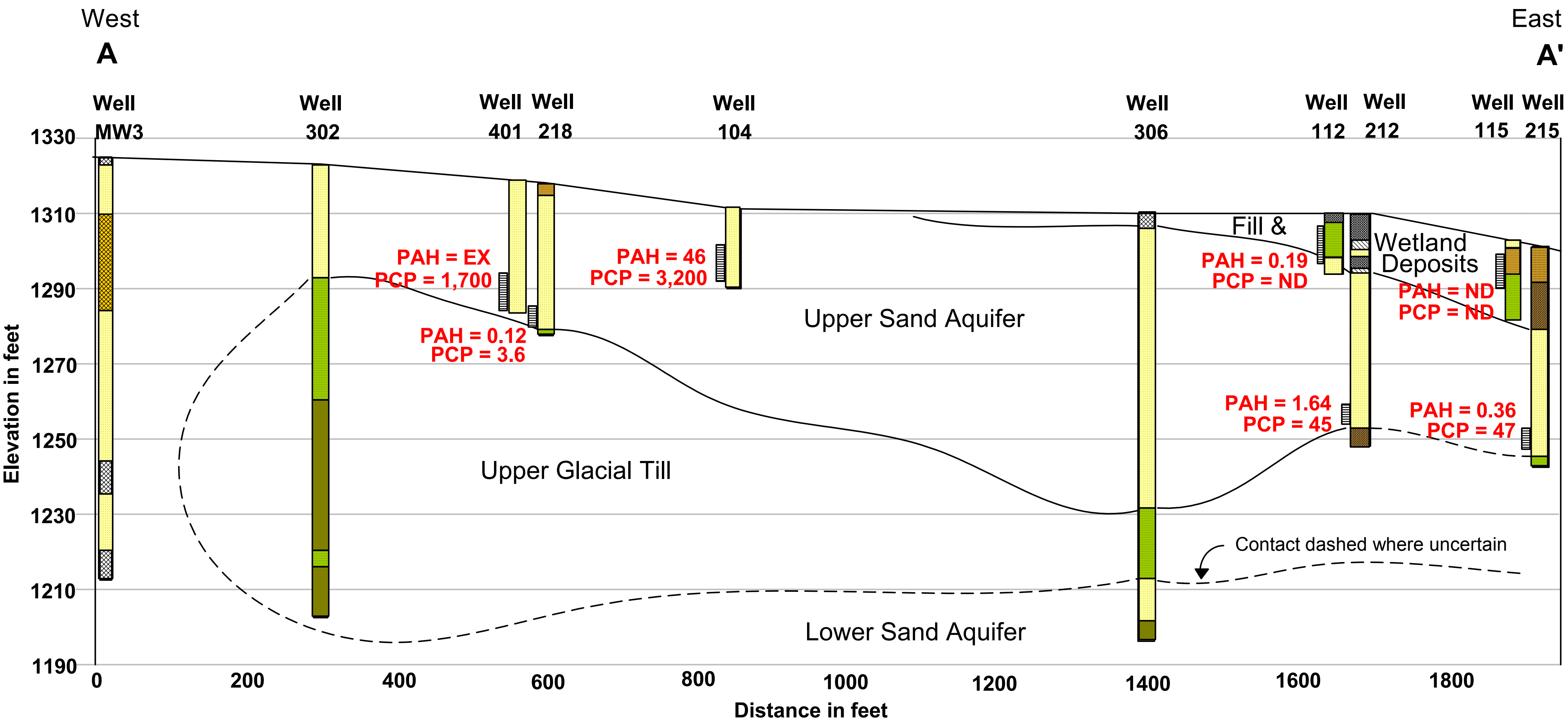

Figure 22: Cross Section of Plume in upper sand aquifer, FOA

▩ Peat
▨ Sand
▧ Silt
■ Clay
▦ Gravel
▩ Silty Clay/Clayey Silt
▨ Silty Sand/Sandy Silt
🟩 Clayey Sand/Sandy Clay
▦ Fill
▤ Well screen interval
47 Contaminant concentration in ug/L
ND Not detected
EX Detection limit exceeded the drinking water standard

Cross section location shown in Figure 7

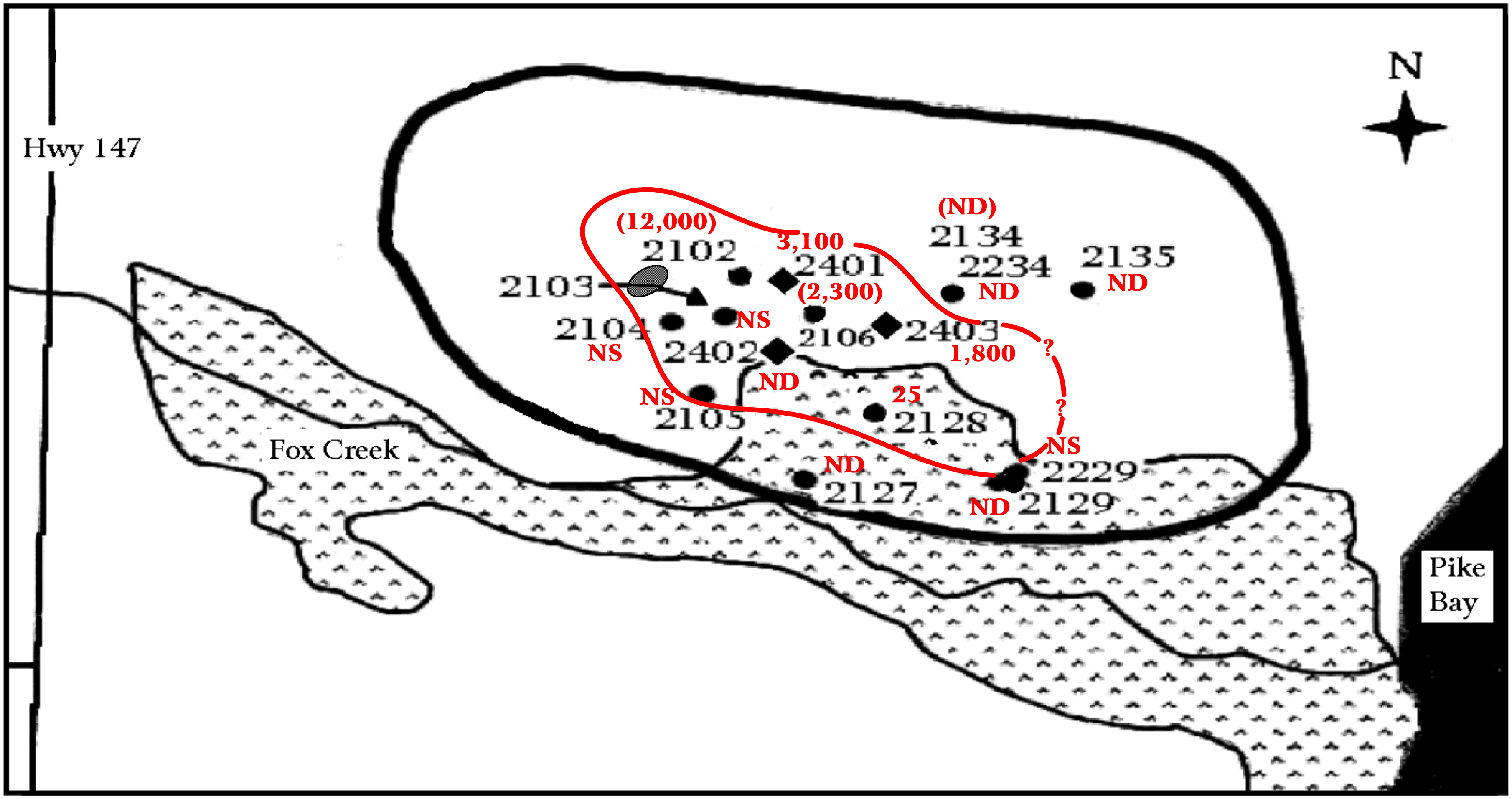

Figure 23: Extent of PCP Contamination in City Dump Area, Upper Sand Aquifer

1,800 = PCP (ug/L), 2003
(2,300) = PCP (ug/L), 2001
ND = PCP not detected
NS = Well not sampled - 2103, 2104, 2105 have LNAPL

— Edge of PCP contamination, dashed where data are insufficient to determine edge of plume

⬬ Sludge Pit

Based on sampling results from 2001 & 2003 (Barr, 2002; Barr, 2004)

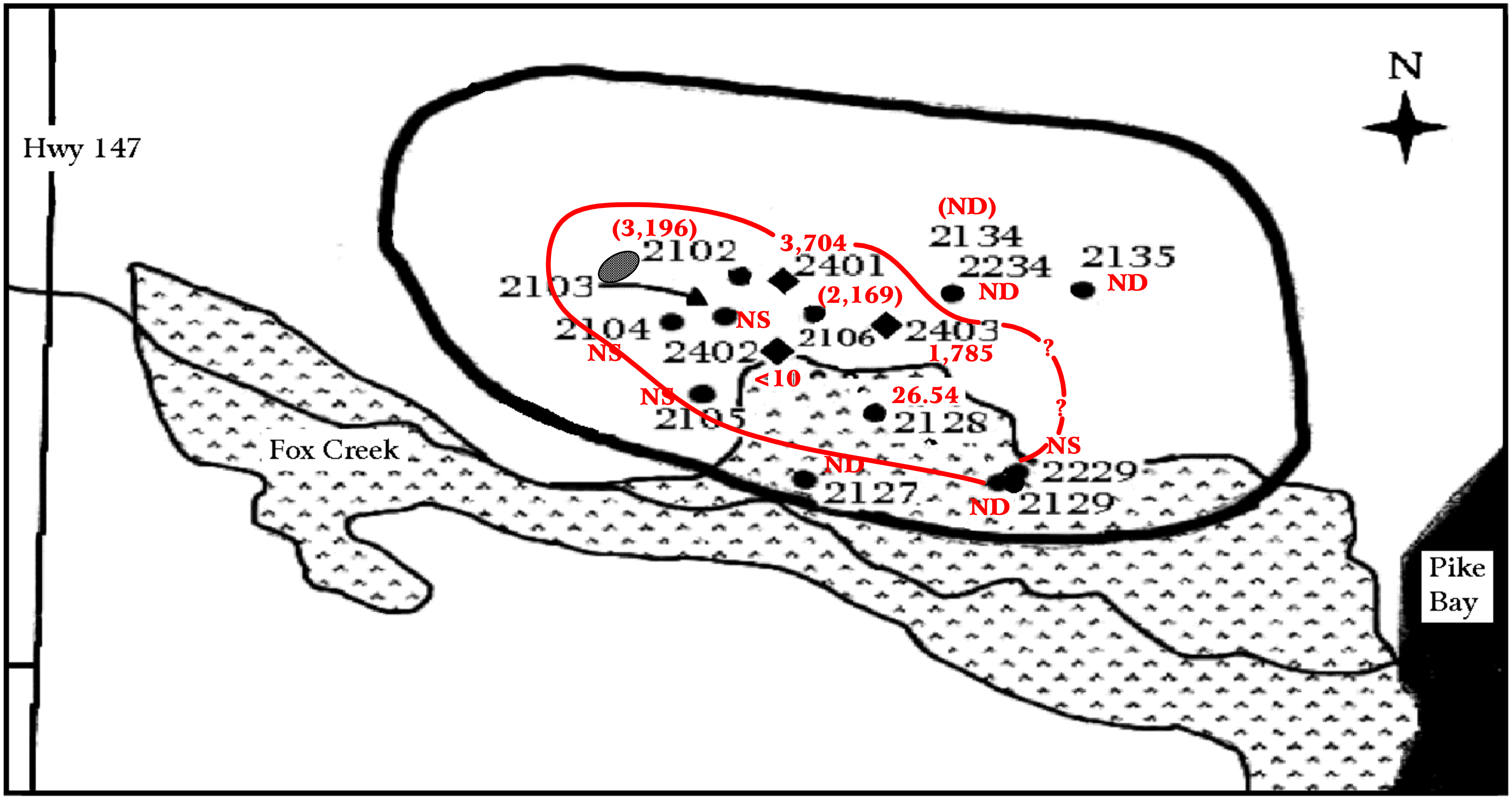

Figure 24: Extent of PAH Contamination in City Dump Area, Upper Sand Aquifer

⬮	Sludge Pit
1,800	Total PAH (ug/L), 2003
(2,300)	Total PAH (ug/L), 2001
ND	PAH not detected
NS	Well not sampled
<10	PAH detection limit greater than the drinking water criterion
―	Edge of PCP contamination, dashed where data are insufficient to determine edge of plume

Based on sampling results from 2001 & 2003 (Barr, 2002; Barr, 2004)

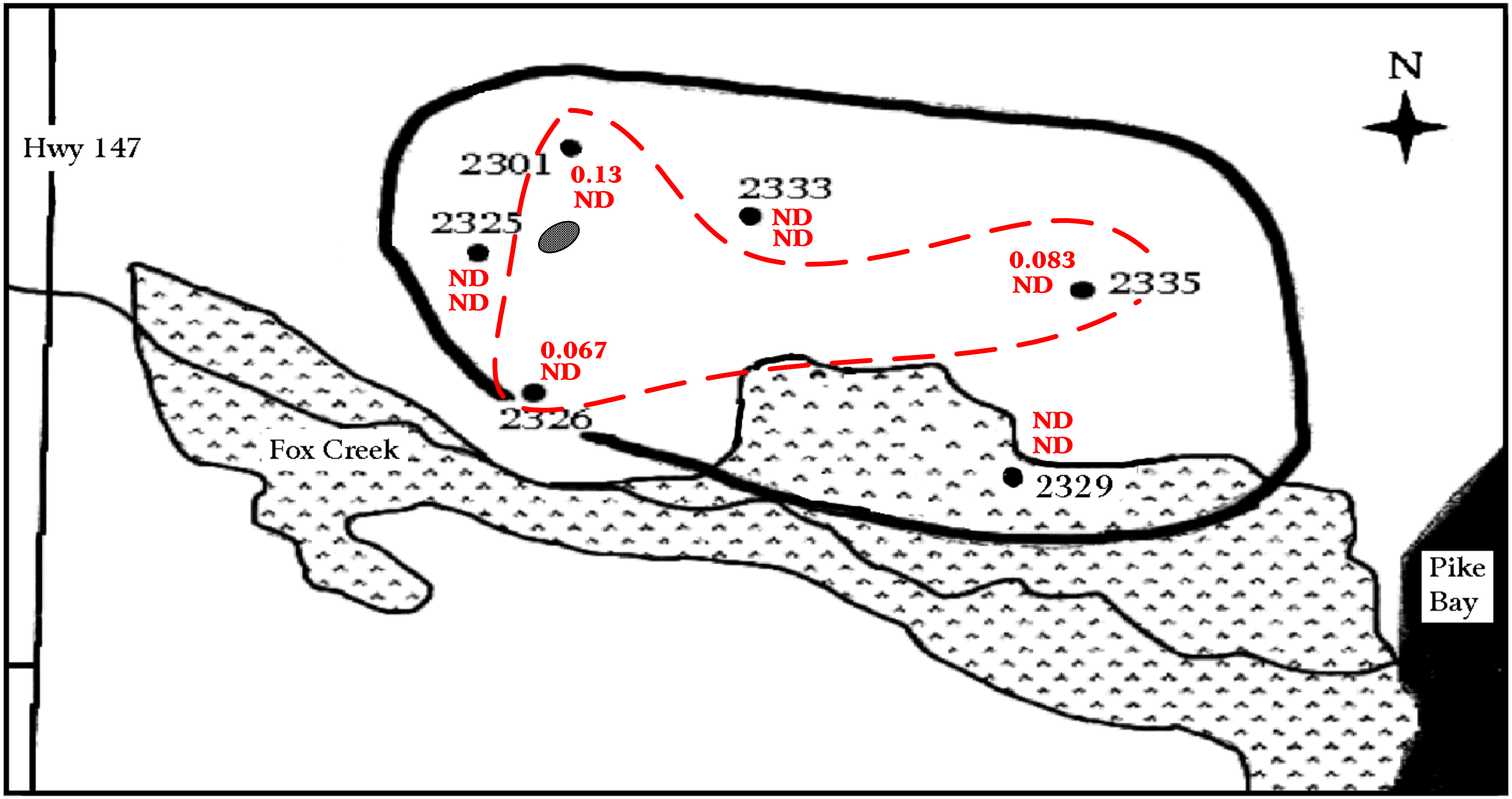

Figure 25: Extent of PAH & PCP Contamination in Lower Sand Aquifer, City Dump Area

0.067
ND **Contaminant concentrations, upper value is total PAHs, lower value is PCP (ug/L)**

▨ **Sludge Pit**

- - - **Outline of PAH contaminant plume, dashed as edge of plume is uncertain**

Based on sampling results from 2003 (Barr, 2004)

Figure 26: Location of Surface Water Samples

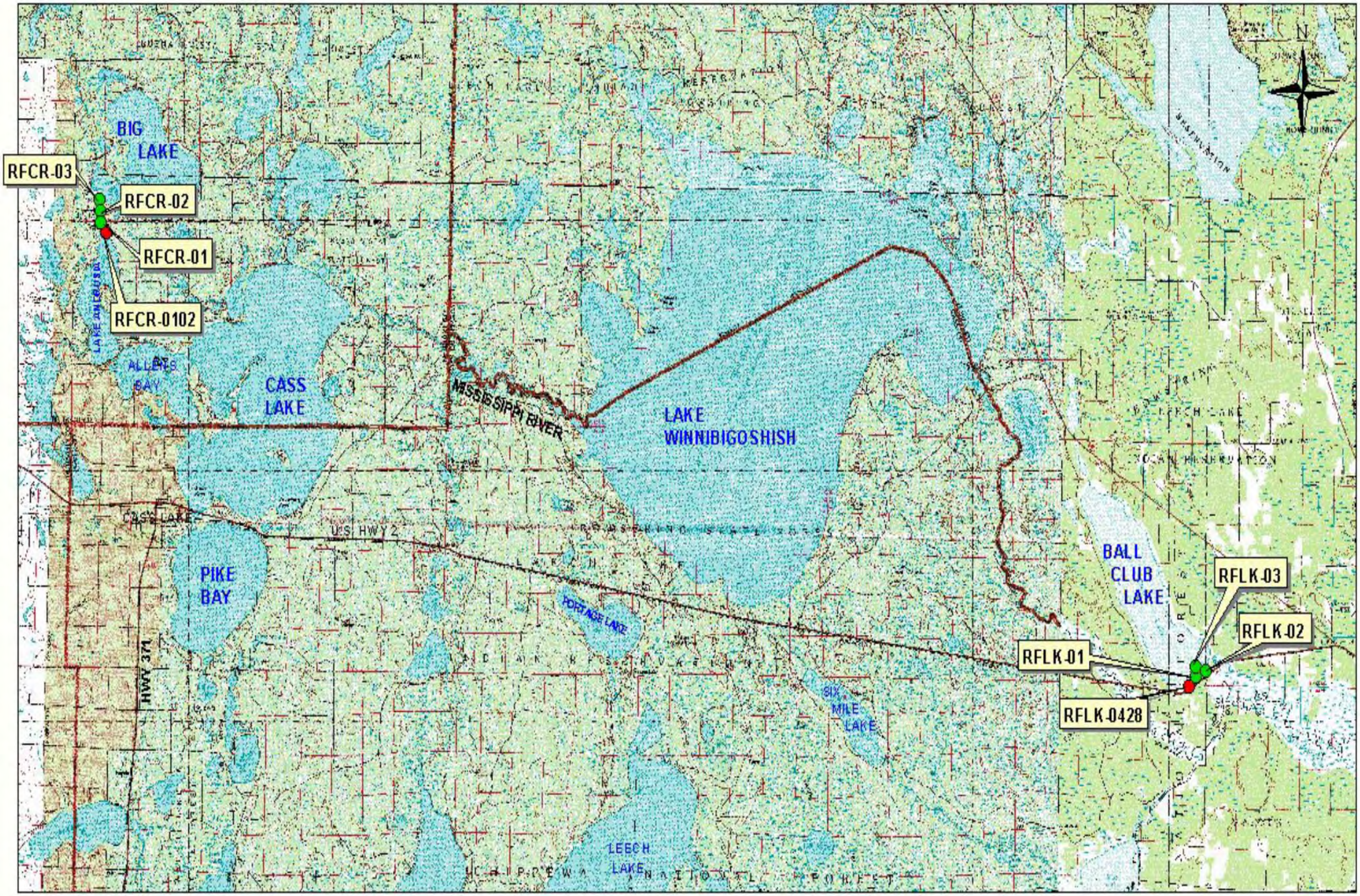

Figure 27: Surface Water and Sediment Reference Sample Locations

🟢 Reference sediment sample location

🔴 Reference surface water sample location

5 0 5 10 Miles

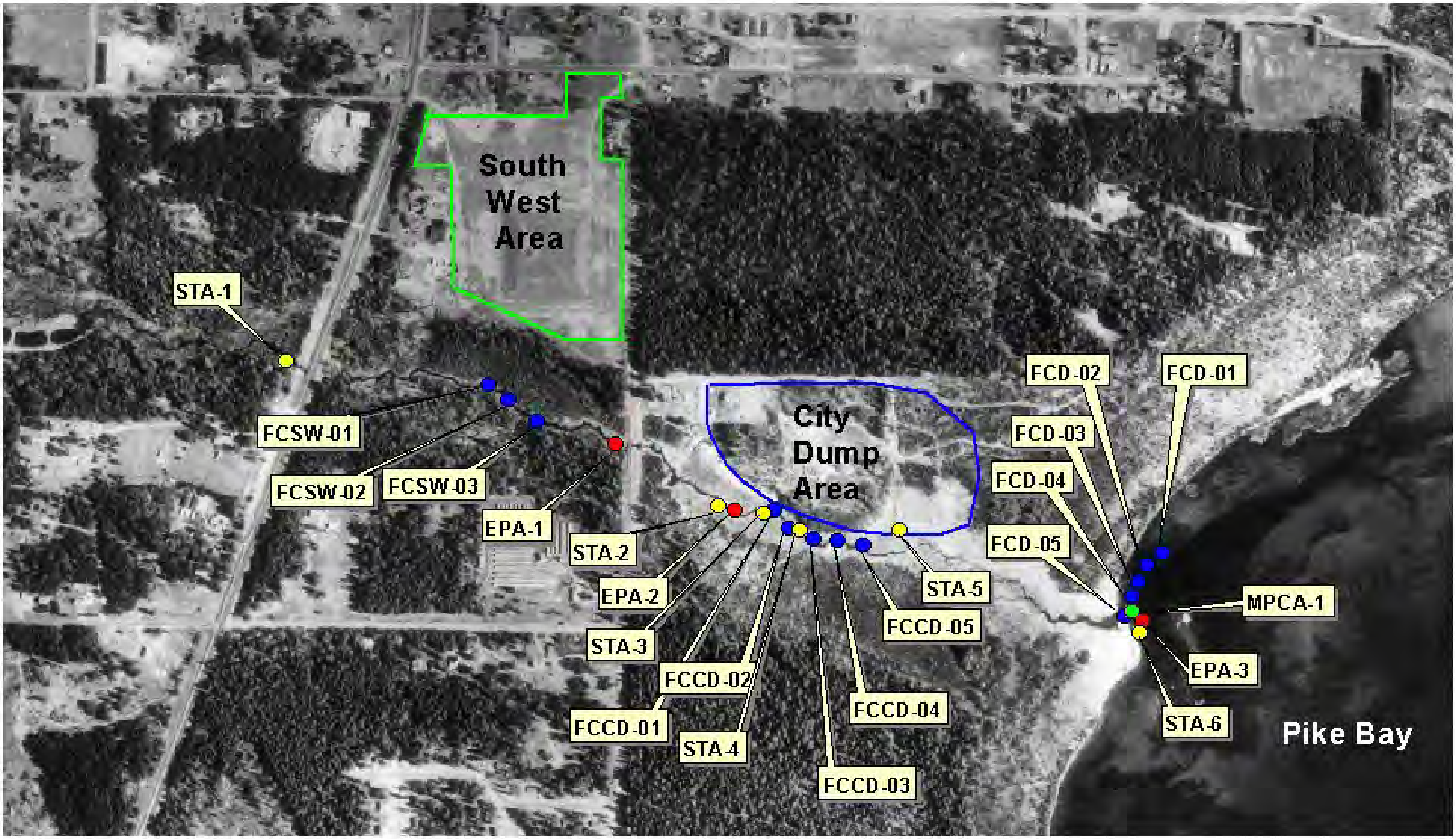

Figure 28: Fox Creek Sediment Sample Locations

🔵 EPA samples collected October, 2001

🟡 **Barr Engineering samples collected November, 1995**

🟢 **MPCA sample collected June 1983**

🔴 EPA samples collected May, 1983

NOTE: All locations approximate

Figure 29: Lake and Channel Sediment Sample Locations

🟢 MPCA Samples collected in June, 1983

🔵 EPA samples collected October, 2001

NOTE: All locations approximate

Appendix B: Tables

Table 1: Residential Sampling Results
(all values in ug/L)

Sample Location[a]	Date	Chrysene	Benzo(b) fluoranthene	Quinoline	2,3-Dihydro indene	Indene	Naphthalene	Tri-phenylene	Benzo(k) fluroanthene	2-Methyl-napthalene	1-Methyl-napthalene	Biphenyl
A	6/16/1983	ND	ND	ND	ND	ND	**0.0045**	---	ND	**0.0031**	**0.0016**	ND
	10/29/1984	ND	ND	ND	ND	ND	**0.0069**	ND	ND	**0.0029**	ND	ND
B	6/16/1983	ND	ND	ND	ND	**0.0025**	**0.0097**	ND	ND	**0.0064**	**0.0028**	ND
C	6/16/1983	ND	ND	ND	ND	ND	**0.005**	ND	ND	**0.0031**	**0.0016**	ND
F	6/16/1983	**0.0013**	ND	**0.0038**	ND	ND	**0.0032**	---	ND	**0.0026**	---	ND
G	1/6/1983	---	---	---	---	---	---	---	---	---	---	---
	6/16/1983	**0.0015**	ND	ND	**0.0022**	**0.0016**	**0.01**	---	ND	**0.008**	**0.004**	**0.003**
	5/28/1983	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	8/14/2003	could not sample, pump not operable and well not accessible										
J	6/16/1983	ND	ND	**0.0015**	**0.029**	**0.0087**	**0.0071**	---	ND	**0.004**	---	ND
	7/18/1983	---	---	---	---	---	---	---	---	---	---	---
	11/10/1983	ND	ND	---	---	---	ND	---	ND	---	---	---
	11/10/1983[b]	ND	ND	---	---	---	**0.05**	---	ND	---	---	---
	10/30/1984	**0.0032***	ND	ND	ND	**0.0052**	**0.0075**	ND	ND	**0.0031**	**0.0021**	**0.0014**
	5/28/1992	ND	ND	ND	ND	ND	ND	---	ND	ND	ND	ND
	8/14/2003	could not sample, pump not operable and well not accessible										
O	6/16/1983	**0.0046***	ND	ND	**0.0015**	ND	**0.0047**	ND	ND	**0.0041**	**0.0017**	ND
	11/10/1983	ND	ND	---	---	---	**0.05**	---	ND	---	---	---
	10/29/1984	**0.001**	ND	ND	ND	**0.004**	ND	ND	ND	**0.0031**	**0.0017**	ND
P	6/16/1983	ND	ND	**0.0016**	**0.0018**	ND	**0.0054**	---	ND	**0.0032**	**0.0016**	**0.001**
Q	6/16/1983	ND	ND	ND	**0.0015**	**0.0016**	**0.006**	---	ND	**0.0041**	**0.0012**	ND
	10/29/1984	ND	ND	ND	ND	**0.0034**	**0.0064**	ND	ND	**0.003**	**0.0021**	ND
S	6/16/1983	ND	ND	**0.0018**	ND	ND	**0.0057**	---	ND	**0.0032**	**0.002**	**0.0012**
	6/16/1983[b]	ND	ND	**0.0017**	**0.0019**	ND	**0.0055**	---	ND	**0.0038**	**0.002**	ND
	10/30/1984	ND	ND	ND	ND	**0.003**	**0.009**	ND	ND	**0.003**	**0.0021**	ND
	10/30/1984[b]	**0.001**	**0.001**	ND	ND	**0.0029**	**0.0084**	**0.001**	ND	**0.003**	**0.0021**	ND
Drinking Water Criterion		**5**	**0.5**	**NE**	**NE**	**NE**	**300**	**NE**	**0.5**	**NE**	**NE**	**NE**

Table 1: Residential Sampling Results
(all values in ug/L)

Sample Location[a]	Date	Acenapthylene	Anthracene	Phenanthrene	Carbazole	Fluoranthene	Pyrene	Phenol	PCP	Sum List 1[c]	Sum List 2[d]	Total PCBs	TCDD Equiv.
A	6/16/1983	ND	**0.0024**	ND	ND	ND	ND	---	ND	ND	**0.012**	---	---
	10/29/1984	ND	**0.002**	ND	ND	ND	ND	ND	<5	ND	**0.013**	---	---
B	6/16/1983	ND	**0.008**	**0.0018**	ND	ND	ND	---	ND	ND	**0.038**	---	---
C	6/16/1983	ND	**0.0029**	ND	ND	ND	ND	---	**0.4***	ND	**0.013**	---	---
F	6/16/1983	ND	**0.0052**	**0.0013**	ND	**0.001**	ND	---	ND	**0.0051**	**0.014**	---	---
G	1/6/1983	---	---	---	---	---	---	---	**0.3***	---	---	---	---
	6/16/1983	ND	**0.0066**	**0.0013**	**0.0014**	ND	ND	---	---	**0.002**	**0.04**	---	---
	5/28/1983	ND	ND	ND	ND	ND	ND	---	<6	ND	ND	---	---
	8/14/2003	could not sample, pump not operable and well not accessible											
J	6/16/1983	ND	**0.0079**	**0.0043**	ND	ND	**0.0023**	**---**	**20**	**0.002**	**0.42**	---	---
	7/18/1983	---	---	---	---	---	---	ND	**29**	---	---	---	---
	11/10/1983	ND	ND	ND	---	ND	ND	ND	**1.1***	<0.15	**0.05**	---	---
	11/10/1983[b]	ND	ND	ND	---	ND	ND	ND	ND	<0.15	ND	---	---
	10/30/1984	ND	**0.0085**	ND	ND	ND	**0.0018**	ND	<5	**0.003**	**0.055**	---	---
	5/28/1992	ND	ND	ND	ND	ND	ND	ND	<6	ND	ND	---	---
	8/14/2003	could not sample, pump not operable and well not accessible											
O	6/16/1983	ND	**0.0038**	ND	ND	ND	ND	**---**	**1***	**0.005**	**0.018**	---	---
	11/10/1983	ND	ND	ND	---	ND	ND	ND	ND	<0.15	**0.05**	---	---
	10/29/1984	**0.002**	**0.0055**	ND	ND	ND	**0.001**	ND	<5	**0.001**	**0.017**	---	---
P	6/16/1983	ND	ND	**0.001**	ND	ND	ND	---	**0.03***	**0.002**	**0.014**	---	---
Q	6/16/1983	ND	**0.0025**	**0.0013**	ND	ND	ND	---	**1.1***	ND	**0.03**	---	---
	10/29/1984	ND	**0.0053**	ND	ND	ND	ND	ND	<5	ND	**0.02**	---	---
S	6/16/1983	ND	**0.0058**	**0.0015**	ND	ND	ND	---	**0.8***	**0.002**	**0.03**	---	---
	6/16/1983[b]	ND	**0.0065**	**0.0013**	ND	ND	ND	---	---	**0.002**	**0.032**	---	---
	10/30/1984	ND	**0.0058**	ND	ND	ND	ND	ND	<5	0	**0.023**	---	---
	10/30/1984[b]	ND	**0.007**	ND	ND	ND	ND	ND	<5	**0.002**	**0.025**	---	---
Drinking Water Criterion		**NE**	**2,000**	**NE**	**20**	**300**	**NE**	**4,000**	**3**	**0.05**	**0.3**	**0.04**	**0.00003**

Table 1: Residential Sampling Results
(all values in ug/L)

Sample Location[a]	Date	Chrysene	Benzo(b) fluoranthene	Quinoline	2,3-Dihydro indene	Indene	Naphthalene	Tri-phenylene	Benzo(k) fluroanthene	2-Methyl-napthalene	1-Methyl-napthalene	Biphenyl
AA	11/10/1983	ND	ND	---	---	---	**0.008**	---	ND	---	---	---
BB	11/10/1983	ND	ND	---	---	---	**0.009**	---	ND	---	---	---
	10/29/1984	ND	ND	ND	ND	**0.0035**	**0.024**	ND	ND	**0.0066**	**0.0034**	**0.0031**
	8/9/2003	ND	ND	---	---	---	ND	---	ND	ND	---	ND
CC	11/10/1983	ND	ND	---	---	---	**0.026**	---	ND	---	---	---
	11/10/1983[b]	ND	ND	---	---	---	**0.004**	---	ND	---	---	---
	8/9/2003	ND	ND	---	---	---	ND	---	ND	ND	---	ND
DD	11/10/1983	ND	ND	---	---	---	ND	---	ND	---	---	---
	8/14/2003	ND	ND	---	---	---	ND	---	ND	ND	---	ND
EE	11/10/1983	ND	ND	---	---	---	**0.01**	---	ND	---	---	---
	11/10/1983[b]	ND	ND	---	---	---	**0.009**	---	ND	---	---	---
FF	11/10/1983	ND	ND	ND	---	---	**0.0057**	---	ND	---	---	---
	10/29/1984	ND	ND	ND	ND	**0.0026**	**0.0079**	ND	ND	**0.0035**	**0.0017**	ND
GG	8/9/2003	ND	ND	---	---	---	ND	---	ND	ND	---	ND
HH	8/9/2003	ND	ND	---	---	---	ND	---	ND	ND	---	ND
II	8/15/2003	ND	ND	---	---	---	ND	---	ND	ND	---	ND
JJ	8/26/2003	ND	ND	---	---	---	ND	---	ND	ND	---	ND
KK	8/9/2003	ND	ND	---	---	---	ND	---	ND	ND	---	ND
LL	8/1/2003	ND	ND	---	---	---	ND	---	ND	ND	---	ND
Drinking Water Criterion		**5**	**0.5**	**NE**	**NE**	**NE**	**300**	**NE**	**0.5**	**NE**	**NE**	**NE**

Table 1: Residential Sampling Results
(all values in ug/L)

Sample Location[a]	**Date**	**Acenapth-ylene**	**Anthracene**	**Phen-anthrene**	**Carbazole**	**Fluor-anthene**	**Pyrene**	**Phenol**	**PCP**	**Sum List 1[c]**	**Sum List 2[d]**	**Total PCBs**	**TCDD Equiv.**
AA	11/10/1983	ND	**0.002**	**0.002**	---	**0.002**	**PP <0.002**	ND	**1***	ND	**0.012**	---	---
BB	11/10/1983	**0.001**	ND	**0.003**	---	**0.002**	**PP <0.002**	ND	ND	ND	**0.015**	---	---
	10/29/1984	ND	ND	ND	ND	ND	ND	ND	<5	ND	**0.04**	---	---
	8/9/2003	ND	ND	ND	---	ND	ND	---	ND	ND	ND	ND	---
CC	11/10/1983	ND	ND	ND	---	ND	ND	ND	ND	ND	**0.026**	---	---
	11/10/1983[b]	ND	ND	ND	---	ND	ND	**0.2***	ND	ND	**0.004**	---	---
	8/9/2003	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND	---
DD	11/10/1983	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	---	---
	8/14/2003	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND	---
EE	11/10/1983	**PP <0.001**	**0.003**	**0.002**	---	**0.001**	**0.001**	---	ND	ND	**0.017**	---	---
	11/10/1983[b]	ND	**0.002**	**0.003**	---	**0.002**	ND	ND	**0.5***	ND	**0.016**	---	---
FF	11/10/1983	ND	ND	ND	---	ND	ND	**PP <0.1**	**0.5**	ND	**0.057**	---	---
	10/29/1984	ND	**0.0011**	ND	ND	ND	ND	ND	<5	ND	**0.017**	---	---
GG	8/9/2003	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND	---
HH	8/9/2003	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND	---
II	8/15/2003	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND	---
JJ	8/26/2003	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND	**6.81E-06**
KK	8/9/2003	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND	---
LL	8/1/2003	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	ND	---
Drinking Water Criterion		**NE**	**2,000**	**NE**	**20**	**300**	**NE**	**4,000**	**3**	**0.05**	**0.3**	**0.04**	**0.00003**

Footnotes:

ug/L = micrograms per liter, or parts per billion

PCP = pentachlorophenol

PCB = polychlorinated biphenyls

All drinking water criteria listed are MDH values, except the criterion for TCDD equivalents, which is based on WHO 1998 criteria for TCDD (see Appendix E)

ND = Compound not detected

b = Duplicate sample

PAH = polynuclear aromatic hydrocarbon

NE = No criterion has been established for this compound

c = Sum of all List 1 (carcinogenic) PAHs

░ = ND, but detection limit > drinking wtr criterion

a = Sample locations are shown on figure 6

d = Sum of all List 2 (non-carcinogenic) PAHs

▒ = concentration > the drinking water criterion

* compound exceeds LLBO groundwater cleanup level (which addresses both human and ecological health risks)

--- = compound not analyzed

Table 2: City Water Sampling Results

	List 1 PAHs (ug/L)					List 2 PAHs (ug/L)					
City Well #1	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Quinoline	Chrysene	Sum List 1 PAHs	Acenaphthene	2,3-Benzofuran	Benzo(b)-thiophene	Biphenyl	2,3-Dihydro-indene	Dibenzo-furan
4/23/1984	ND	ND	**0.0014**	ND	**0.0014**	---	---	---	**0.0013**	---	---
7/25/1984	---	---	---	---	---	---	---	---	---	---	---
11/7/1984	---	---	---	---	---	---	---	---	---	**0.0087**	ND
1/10/1985	ND	ND	ND	ND	ND	**0.0054**	**0.0077**	**0.004**	ND	**0.017000001**	ND
3/21/1985	ND	ND	ND	ND	ND	ND	ND	ND	**0.0015**	ND	ND
4/24/1985	ND	ND	ND	ND	ND	ND	**0.0021**	ND	ND	ND	ND
9/18/1985	ND	ND	ND	ND	ND	ND	**0.0019**	ND	ND	**0.0021**	ND
12/17/1985	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/4/1986	---	---	---	---	---	---	---	---	---	---	---
5/6/1986	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3/1986	---	---	---	---	---	---	---	---	---	---	---
12/16/1986	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/24/1987	ND	ND	**0.0026**	**0.0012**	**0.0038**	ND	ND	**0.0019**	ND	**0.0085**	ND
12/8/1987	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.0028**	ND
6/28/1988	ND	ND	ND	ND	ND	ND	**0.0048**	ND	ND	**0.0021**	ND
12/15/1988	ND	ND	ND	ND	ND	ND	**0.0069**	ND	ND	**0.0052**	ND
6/27/1989	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/13/1989	**0.0033**	**0.0033***	ND	**0.0011**	**0.0077**	ND	**0.0042**	ND	ND	ND	ND

	List 2 PAHs (ug/L)									Phenols
City Well #1 (cont.)	Fluorene	Fluoranthene	Indene	1-Methyl-naphthaler	2-Methyl-naphthalene	Naphthalene	Phenanthrene	Pyrene	Sum List 2 PAHs	PCP
4/23/1984	---	---	---	**0.0022**	**0.0037**	ND	**0.0013**	---		---
7/25/1984	---	---	---	**0.0013**	**0.0025**	**0.0049**	---	---		---
11/7/1984	ND	ND	**0.0031**	**0.0027**	**0.0042**	**0.014**	---	---		---
1/10/1985	ND	ND	**0.036**	**0.014**	**0.0067**	**0.15***	**0.0033**	ND		---
3/21/1985	ND	ND	ND	ND	ND	**0.03**	**0.0025**	**0.0016**		<5
4/24/1985	ND	ND	ND	0.0012	**0.0021**	ND	**0.0017**	ND		<5
9/18/1985	ND	ND	**0.0011**	**0.0012**	**0.0064**	**0.006**	ND	ND		<5
12/17/1985	ND	ND	ND	**0.0011**	ND	ND	ND	ND		<5
3/4/1986	---	---	---	---	---	---	---	---		<5
5/6/1986	ND	ND	ND	ND	ND	ND	ND	ND	ND	<5
7/3/1986	---	---	---	---	---	---	---	---		<5
12/16/1986	ND	ND	**0.0014**	**0.0014**	**0.0022**	ND	ND	ND	**0.005**	<5
6/24/1987	ND	ND	**0.0025**	**0.0017**	**0.0023**	**0.012**	ND	**0.0014**	**0.03**	**8.9**
12/8/1987	ND	ND	**0.0011**	**0.0012**	**0.002**	**0.023**	**0.0012**	ND	**0.031**	<6
6/28/1988	ND	ND	ND	**0.0013**	**0.0024**	**0.0037**	ND	ND	**0.014**	<6
12/15/1988	ND	ND	ND	**0.0032**	**0.0022**	**0.019**	**0.0022**	ND	**0.039**	<6
6/27/1989	ND	ND	ND	ND	ND	**0.0039**	ND	ND	**0.0039**	<6
12/13/1989	ND	**0.0078***	ND	**0.001**	ND	**0.0019**	**0.0028**	**0.0052**	**0.023**	<6

Table 2: City Water Sampling Results

	List 1 PAHs (ug/L)					**List 2 PAHs (ug/L)**					
City Well #3	**Benzo(b) fluoranthene**	**Benzo(k) fluoranthene**	**Quinoline**	**Chrysene**	**Sum List 1 PAHs**	**Acenaphthene**	**2,3-Benzofuran**	**Benzo(b)-thiophene**	**Biphenyl**	**2,3-Dihydro-indene**	**Dibenzo-furan**
7/25/1984	ND	ND	**0.003**	ND	**0.003**	---	---	---	---	---	---
11/7/1984	---	---	---	---	---	ND	---	---	**0.0013**	**0.0076**	ND
1/16/1985	ND	ND	ND	ND	ND	ND	**0.0051**	ND	ND	**0.0045**	ND
3/21/1985	ND	ND	ND	ND	ND	ND	**0.012**	ND	**0.0012**	**0.015**	ND
4/24/1985	ND	ND	ND	ND	ND	ND	ND	ND	**0.0014**	ND	ND
9/18/1985	ND	ND	ND	ND	ND	ND	**0.0013**	ND	ND	ND	ND
12/17/1985	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/4/1986	---	---	---	---	---	---	---	---	---	---	---
5/6/1986	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/3/1986	---	---	---	---	---	---	---	---	---	---	---
12/16/1986	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/24/1987	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.0063**	**0.0024**
12/8/1987	ND	ND	**0.0036**	ND	**0.0036**	ND	ND	ND	ND	**0.0043**	ND
6/28/1988	ND	ND	ND	ND	ND	ND	**0.0032**	ND	ND	ND	ND
12/14/1988	ND	ND	ND	ND	ND	ND	**0.0089**	ND	**0.0038**	**0.0071**	ND

	List 2 PAHs (ug/L)									**Phenols**
City Well #3 (cont.)	**Fluorene**	**Fluoranthene**	**Indene**	**1-Methyl-naphthaler**	**2-Methyl-naphthalene**	**Naphthalene**	**Phenanthrene**	**Pyrene**	**Sum List 2 PAHs**	**PCP**
7/25/1984	---	---	---	---	---	**0.0028**	---	---		---
11/7/1984	ND	ND	**0.0031**	**0.0027**	**0.005**	**0.017**	---	---		---
1/16/1985	ND	ND	ND	ND	ND	**0.0067**	ND	ND		---
3/21/1985	ND	ND	**0.0014**	**0.0033**	**0.0049**	**0.032**	**0.0025**	ND		<5
4/24/1985	ND	ND	ND	**0.0012**	ND	ND	**0.0017**	ND		<5
9/18/1985	ND	ND	ND	**0.0012**	**0.0024**	**0.0048**	ND	ND		<5
12/17/1985	ND	ND	ND	ND	ND	ND	ND	ND		<5
3/4/1986	---	---	---	---	---	---	---	---	---	<5
5/6/1986	ND	ND	ND	ND	ND	ND	ND	ND	ND	<5
7/3/1986	---	---	---	---	---	---	---	---	---	<5
12/16/1986	ND	ND	**0.0017**	**0.0013**	**0.002**	ND	ND	ND	**0.005**	<5
6/24/1987	**0.0016**	ND	**0.0015**	**0.0017**	**0.0029**	**0.013**	**0.0071**	ND	**0.037**	<6
12/8/1987	ND	**0.0018**	**0.0014**	**0.0065**	**0.011**	**0.037**	**0.004**	**0.0029**	**0.069**	<6
6/28/1988	ND	**0.0015**	ND	**0.0014**	**0.0021**	**0.0042**	**0.0031**	**0.0021**	**0.018**	<6
12/14/1988	ND	ND	**0.0027**	**0.0094**	**0.019**	**0.023**	**0.0036**	ND	**0.078**	<6

Table 2: City Water Sampling Results

	List 1 PAHs (ug/L)					**List 2 PAHs (ug/L)**					
Facility Tap	**Benzo(b) fluoranthene**	**Benzo(k) fluoranthene**	**Quinoline**	**Chrysene**	**Sum List 1 PAHs**	**Acenaphthene**	**2,3-Benzofuran**	**Benzo(b)-thiophene**	**Biphenyl**	**2,3-Dihydro-indene**	**Dibenzo-furan**
7/25/1984	ND	ND	---	ND	ND	ND	---	---	---	---	---
11/7/1984	ND	ND	**0.0036**	ND	**0.0036**	**0.0033**	---	**0.0046**	**0.0018**	**0.017**	ND

	List 2 PAHs (ug/L)									**Phenols**
Facility Tap (cont.)	**Fluorene**	**Fluoranthene**	**Indene**	**1-Methyl-naphthaler**	**2-Methyl-naphthalene**	**Naphthalene**	**Phenanthrene**	**Pyrene**	**Sum List 2 PAHs**	**PCP**
1/24/1984	ND	ND	---	---	---	**0.041**	**0.016**	ND	**0.06**	ND
4/23/1984	**0.0019**	**0.0017***	**0.041**	**0.0086**	**0.02**	**0.1***	---	**0.0017**	**0.2**	░ <5

	List 1 PAHs (ug/L)					**List 2 PAHs (ug/L)**					
Residential Tap	**Benzo(b) fluoranthene**	**Benzo(k) fluoranthene**	**Quinoline**	**Chrysene**	**Sum List 1 PAHs**	**Acenaphthene**	**2,3-Benzofuran**	**Benzo(b)-thiophene**	**Biphenyl**	**2,3-Dihydro-indene**	**Dibenzo-furan**
1/24/1984	ND	ND	---	ND	ND	ND	---	---	---	---	---
4/23/1984	ND	ND	**0.0038**	ND	**0.0038**	ND	---	ND	ND	**PP<0.0014**	ND

	List 2 PAHs (ug/L)									**Phenols**
Residential Tap (cont.)	**Fluorene**	**Fluoranthene**	**Indene**	**1-Methyl-naphthaler**	**2-Methyl-naphthalene**	**Naphthalene**	**Phenanthrene**	**Pyrene**	**Sum List 2 PAHs**	**PCP**
1/24/1984	ND	ND	---	---	---	ND	ND	ND	ND	▓ **4.3**
4/23/1984	ND	ND	**0.0017**	**0.0018**	**0.0042**	**PP<0.0029**	---	ND	**0.0077**	░ <5

ND	compound not detected
░	= compound not detected, but detection limit exceeded MDH drinking water criterion listed in Appendix E
▓	= compound detected at a concentration exceeding the MDH drinking water criterion listed in appendix E
---	= compound not analyzed

* Exceeds LLBO groundwater cleanup level (which evaluates both human and ecological risk)

ug/L = micrograms per liter, or parts per billion

PAH = polynuclear aromatic hydrocarbon

PCP = pentachlorophenol

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs (ug/L)					**Phenols** (ug/L)	**PCBs** (ug/L)	**Dioxins** (ng/L)
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**	***TCDD Equiv.*** [a]
Drinking Water Standard		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**0.04**	**0.03**
Monitoring Well	**Sample Date**								
101	2/22/1982	ND*	ND*	ND*	ND*	ND*	**1.1***	---	---
	5/6/1982	ND*	ND*	ND*	ND*	ND*	ND*	---	---
	6/15/1983	ND*	ND*	ND*	ND*	ND*	ND*	---	---
	11/11/1983	ND*	ND*	ND*	ND*	ND*	ND*	---	---
	1/25/1984	**0.086**	**0.033**	**0.123**	**0.21**	**0.019***	ND*	---	---
	4/25/1984	**0.213**	**0.078**	**0.59**	**0.8**	**0.036***	ND*	---	---
	11/5/1984	ND*	**0.11***	**0.33**	**0.33**	ND*	ND*	---	---
	4/26/1985	**0.011**	ND*	**0.098**	**0.11**	**0.0019***	ND	---	---
	12/17/1985	ND	**0.061**	**0.2287**	**0.2287**	ND	ND	---	---
	12/16/1986	**0.0034**	**0.013**	**0.0401**	**0.0435**	**0.000034**	ND	---	---
102	1/29/1982	ND*	ND*	ND*	ND*	ND*	**1.1***	---	---
	5/6/1982	ND*	ND*	ND*	ND*	ND*	**1.1***	---	---
	6/15/1983	**0.39**	ND*	ND*	**0.39**	**0.228**	ND*	---	---
	11/10/1983	**0.016**	**0.053**	**0.243**	**0.26**	**0.0038***	ND	---	---
	11/11/1983	ND	**0.014**	**0.09**	**0.09**	ND	ND	---	---
	1/25/1984	**0.0083**	ND*	**0.031**	**0.039**	**0.0019***	ND*	---	---
	4/25/1984	**0.0087**	**0.038**	**0.319**	**0.33**	**0.00009**	ND*	---	---
	11/6/1984	**0.0036**	**0.043**	**0.14**	**0.144**	**0.00004**	ND*	---	---
	4/24/1985	ND	**0.004**	**0.045**	**0.045**	ND	ND	---	---
	12/17/1985	ND	ND	**0.1066**	**0.1066**	ND	ND	---	---
	12/16/1986	**0.0034**	ND	**0.0123**	**0.0157**	**0.000013**	ND	---	---
103	2/22/1982	ND*	ND*	ND*	ND*	ND*	**0.05***	---	---
	5/6/1982	ND*	ND*	ND*	ND*	ND*	ND*	---	---
	6/15/1983	---	---	---	---	---	**0.6***	---	---
	11/11/1983	ND*	ND*	**0.044**	**0.044**	ND*	ND*	---	---
	1/25/1984	ND*	**0.11***	**0.288**	**0.288**	ND*	**4.3**	---	---
	4/25/1984	ND*	**0.14***	**6.3**	**6.3**	ND*	ND*	---	---
	11/6/1984	ND*	**0.18***	**1.44**	**1.44**	ND*	ND*	---	---
	4/25/1985	ND	ND	**4.85**	**4.85**	ND	ND	---	---
	12/20/1985	ND	**0.134***	**0.739**	**0.739**	ND	ND	---	---
	12/16/1986	ND	**0.088**	**0.367**	**0.367**	ND	ND	---	---
104	1/29/1982	ND*	ND*	ND*	ND*	ND*	**22,000**	---	---
	5/6/1982	**0.31**	ND*	**3.4**	**3.7**	**0.016***	**590**	---	---
	6/15/1983	**1.5**	ND*	**0.9**	**2.4**	**0.76**	**1,100**	---	---
	11/11/1983	ND*	**0.29***	**1.24**	**1.24**	ND*	**630**	---	---
	1/25/1984	ND*	**35***	**41.6**	**41.6**	ND*	**370**	---	---
	4/25/1984	**0.053**	**13***	**41**	**41**	ND*	**760**	---	---
	11/8/1984	ND*	**29***	**69.6**	**69.6**	ND*	**1,100**	---	---
	12/20/1985	ND	**0.22***	**6.87**	**6.87**	ND	**48**	---	---
	12/19/1986	ND	**1.7***	**24.1**	**24.1**	ND	**670**	---	---
	6/29/1988	<6	**28***	**61**	**61**	<6	**990**	---	---
	6/28/1989	<10	ND	**PP <10**	**PP <10**	<10	**330**	---	---
	6/27/1990	<10	ND	**53**	**53**	<10	**820**	---	---

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs (ug/L)					**Phenols (ug/L)**	**PCBs (ug/L)**	**Dioxins (ng/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**	***TCDD Equiv.*** [a]
Drinking Water Standard		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**0.04**	**0.03**
Monitoring Well	**Sample Date**								
104 (cont.)	6/19/1991	<10	ND	**2**	**2**	<10	**200**	---	---
	5/28/1992	ND	ND	ND	ND	ND	**84**	ND	---
	6/2/1993	0	ND	**15.469**	**15.469**	0	**250**	---	---
	6/14/1994	<0.12	**.244 B***	**19.7**	**19.7**	<0.12	**110**	---	---
	6/8/1995	<0.6	**3.8***	**69**	**69**	<0.6	**590**	---	---
	6/6/1997	<80	ND	**57**	**57**	<80	**740**	---	---
	5/20/1999	**0.02**	**0.94***	**17.75**	**17.77**	<0.2	**1,000**	---	---
	4/25/2001	<0.019	**14***	**23**	**23**	ND	**2,400**	---	---
	5/11/2003	**0.075**	**30***	**46.24**	**46.31**	ND	**3,200**	---	---
105	7/25/1984	**0.089**	**0.22***	**0.15**	**0.24**	**0.022***	ND	---	---
	11/2/1984	ND	**0.14***	**0.33**	**0.33**	ND	ND	---	---
	1/7/1985	**0.015**	**0.027**	**0.197**	**0.21**	**0.001**	ND	---	---
	4/25/1985	---	---	---	---	---	ND	---	---
	5/28/1985	**0.0399**	**0.051**	**0.31**	**0.35**	**0.0065***	ND	---	---
	12/17/1985	ND	**0.066**	**0.2501**	**0.2501**	ND	ND	---	---
	12/16/1986	ND	**0.023**	**0.0557**	**0.0557**	ND	ND	---	---
	6/14/1994	ND	**0.01 B**	**0.025**	**0.025**	0	<3	---	---
	5/20/1999	ND	ND	ND	ND	ND	<3	---	---
	4/25/2001	ND	ND	ND	ND	ND	<0.5	---	---
	5/5/2003	**0.44**	**0.03**	**0.66**	**1.1**	**0.1**	<0.5	---	---
	8/15/2003	ND	ND	ND	ND	ND	<0.5	---	---
106	9/18/1985	ND	ND	ND	ND	ND	ND	ND	<0.19
	12/18/1985	ND	**0.7***	**2.4**	**2.4**	ND	**47**	ND	---
	12/17/1986	ND	**2.2***	**5.2**	**5.2**	ND	**62**	---	---
107	12/18/1985	ND	ND	**3.5**	**3.5**	ND	**990**	---	---
	12/17/1986	**11**	ND	**123.2**	**134.2**	ND	**1600**	---	---
108	12/18/1985	ND	**PP <19**	**217**	**217**	ND	**11**	---	---
109	12/17/1985	ND	**0.051**	**0.3317**	**0.3317**	ND	ND	---	---
	12/16/1986	**0.0039**	**0.012**	**0.0298**	**0.0337**	**0.000017**	ND	---	---
110	12/17/1985	**0.0433**	**0.045**	**0.1834**	**0.2267**	**0.011512***	**PP <5**	---	---
	12/16/1986	**0.0715**	b	**0.0829**	**0.1544**	**0.0177***	**PP <6**	---	---
112	12/20/1985	**0.025**	**0.028**	**0.5881**	**0.6131**	**0.00133***	ND	---	---
	5/6/1986	**0.0123**	ND	**0.6029**	**0.6152**	**0.000735**	ND	---	---
	12/18/1986	**0.0096**	**0.016**	**0.2033**	**0.2129**	**0.000411**	ND	---	---
	6/28/1988	**0.0091**	**0.0064**	**0.2412**	**0.2503**	**0.000406**	ND	---	---
	6/28/1989	**0.03**	ND	**0.375**	**0.405**	**0.00015**	ND	---	---
	6/27/1990	**0.0131**	**0.0038**	**0.24846**	**0.26156**	**0.001157***	ND	---	---
	6/19/1991	ND	**1.1 B***	**0.25**	**0.25**	ND	ND	---	---
	5/27/1992	ND	ND	**0.1714**	**0.1714**	ND	ND	ND	---

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs (ug/L)					**Phenols (ug/L)**	**PCBs (ug/L)**	**Dioxins (ng/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**	***TCDD Equiv.***[a]
Drinking Water Standard		**0.05**	**300**	**0.3**[c]	**0.3**[c]	**0.05**	**3**	**0.04**	**0.03**
Monitoring Well	**Sample Date**								
112 (cont.)	6/2/1993	---	---	---	---	---	ND	---	---
	7/22/1993	ND	ND	**0.10996**	**0.10996**	0	---	---	---
	6/14/1994	**0.019**	**.011 B**	**0.2123**	**0.2313**	0.0013	<3	---	---
	6/8/1995	**0.01**	**.003 B**	**0.187**	**0.197**	0.00046	<3	---	---
	6/6/1997	<10	ND	<10	<10	<10	<50	---	---
	5/20/1999	ND	ND	**0.13**	**0.13**	ND	<3	---	---
	4/25/2001	<0.019	ND	**0.12**	**0.12**	ND	ND	---	---
	5/5/2003	ND	ND	**0.19**	**0.19**	ND	ND	---	---
113	12/16/1985	ND	**0.06**	**0.207**	**0.207**	ND	ND	---	---
	5/6/1986	ND	**0.045**	**0.4334**	**0.4334**	ND	ND	---	---
	12/16/1986	ND	**0.019**	**0.0483**	**0.0483**	ND	ND	---	---
	6/28/1988	**0.0117**	**0.0064**	**0.0622**	**0.0739**	**0.003357***	ND	---	---
	6/28/1989	ND	**0.006**	**0.0101**	**0.0101**	ND	ND	---	---
	6/27/1990	**0.0022**	ND	**0.01902**	**0.02122**	**0.00025**	ND	---	---
	6/19/1991		**1.9***	**1.9**	**1.9**	0	ND	---	---
	5/27/1992	**0.102**	**.021 B**	**0.7821**	**0.8841**	**0.02606***	ND	ND	---
	6/2/1993	---	---	---	---	---	ND	---	---
	7/22/1993	ND	**.0198 B**	**0.10053**	**0.10053**	ND	---	---	---
	6/14/1994	ND	**.034 B**	ND	ND	ND	<3	---	---
114	12/16/1985	ND	**0.028**	**0.1205**	**0.1205**	ND	ND	---	---
	5/6/1986	ND	ND	**0.0227**	**0.0227**	ND	ND	---	---
	12/16/1986	ND	**0.017**	**0.0682**	**0.0682**	ND	ND	---	---
	6/28/1988	ND	**0.0067**	**0.0483**	**0.0483**	ND	ND	---	---
	6/28/1989	ND	**0.0086**	**0.0315**	**0.0315**	ND	ND	---	---
	6/27/1990	ND	**0.002**	**0.0113**	**0.0113**	ND	ND	---	---
	6/19/1991	ND	**0.0094 B**	**0.031**	**0.031**	0	ND	---	---
	5/27/1992	ND	ND	ND	ND	ND	ND	ND	---
	6/2/1993	ND	**.0121 B**	**0.01321**	**0.01321**	0	ND	---	---
	6/14/1994	ND	**0.022**	**0.036**	**0.036**	ND	<3	---	---
	6/8/1995	ND	**.004 B**	**0.007**	**0.007**	<0.005	<3	---	---
	6/4/1996	<10	ND	<10	<10	<10	< 50	---	---
	6/6/1997	<10	ND	<10	<10	<10	<50	---	---
	4/29/1998	0	ND	ND	ND	0	<5	---	---
	5/20/1999	ND	ND	ND	ND	ND	<3	---	---
	4/4/2000	ND	ND	ND	ND	ND	<3	---	---
	4/25/2001	ND	ND	ND	ND	ND	<0.5	---	---
	5/2/2002	ND	ND	ND	ND	ND	<3	---	---
	5/5/2003	ND	ND	ND	ND	ND	<0.5	---	---
115	12/17/1985	ND	**0.028**	**0.1183**	**0.1183**	ND	ND	---	---
	5/6/1986	ND	ND	**0.0346**	**0.0346**	ND	ND	---	---
	12/17/1986	ND	ND	**0.0091**	**0.0091**	ND	ND	---	---
	6/28/1988	**0.0025**	**0.0074**	**0.0365**	**0.039**	**0.000025**	ND	---	---
	6/28/1989	ND	**0.0064**	**0.017**	**0.017**	ND	ND	ND	---

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs **(ug/L)**					**Phenols** **(ug/L)**	**PCBs** **(ug/L)**	**Dioxins** **(ng/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**	***TCDD Equiv.*** [a]
Drinking Water Standard		**0.05**	**300**	**0.3**[c]	**0.3**[c]	**0.05**	**3**	**0.04**	**0.03**
Monitoring Well	**Sample Date**								
115 (cont.)	6/27/1990	ND	ND	**0.0033**	**0.0033**	ND	ND	---	---
	6/19/1991	ND	**0.011 B**	**0.003**	**0.003**	ND	ND	---	---
	5/27/1992	ND	**.0086 B**	**0.0371**	**0.0371**	ND	ND	ND	---
	6/2/1993	ND	**.0122 B**	**0.02046**	**0.02046**	ND	ND	---	---
	6/14/1994	ND	**.011 B**	**0.009**	**0.009**	ND	<3	---	---
	6/8/1995	ND	**0.003**	**0.003**	**0.003**	<0.005	<3	---	---
	6/4/1996	<10	ND	<10	<10	<10	< 50	---	---
	6/6/1997	<10	ND	<10	<10	<10	<50	---	---
	4/29/1998	ND	ND	ND	ND	ND	<5	---	---
	5/20/1999	ND	ND	ND	ND	ND	<3	---	---
	4/4/2000	ND	ND	ND	ND	ND	<3	---	---
	4/25/2001	ND	ND	ND	ND	ND	ND	---	---
	5/5/2002	ND	ND	ND	ND	ND	<3.1	---	---
	5/5/2003	ND	ND	ND	ND	ND	ND	---	---
116	12/16/1985	ND	**0.035**	**0.1773**	**0.1773**	ND	ND	---	---
	12/16/1986	ND	**0.024**	**0.0702**	**0.0702**	ND	ND	---	---
118	9/18/1985						ND	ND	**198.9**
	12/20/1985	**608,000**	**2,000,000**	**22,361,000**	**22,969,000**	**68900**	**<30,600,000**	---	---
	6/30/1988		**9,000**	**51,000**	**51,000**	**PP <600**	**49,000**	---	---
	6/28/1989	**360**	**1,500**	**5,870**	**6,230**	**PP <200**	**46,000**	---	---
	6/27/1990	**470**	**1,300**	**5,300**	**5,770**		**54,000**	---	---
	6/19/1991	**1,500**	**6,700**	**45,000**	**46,500**	**56**	**60,000**	---	---
202	12/17/1985	**0.0042**	ND	**0.0549**	**0.0591**	ND	ND	---	---
	12/16/1986	ND	**18***	**94.5**	**94.5**		**1,500**	---	---
205	12/20/1985	ND	**0.049**	**0.1183**	**0.1183**	ND	ND	---	---
	12/18/1986	ND	**0.013**	**0.0602**	**0.0602**	ND	ND	---	---
	6/14/1994	<0.120	ND	<0.120	<0.120	<0.120	ND	---	---
	5/16/1999	ND	ND	ND	ND	---	<3	ND	---
	4/24/2001	ND	ND	ND	ND	ND	<0.50	---	---
	5/5/2003	ND	ND	ND	ND	ND	<0.50	---	---
207	12/21/1985	**1,100**	**2,200**	**3,883**	**4983**		**13,000**	---	---
	12/19/1986	**330**	**660**	**1,511**	**1841**		**9,300**	---	---
209	12/21/1985	**0.0409**	**0.096**	**0.3215**	**0.3624**	**0.00142***	**13**	---	---
	12/19/1986	**0.1414**	**0.075**	**0.4778**	**0.6192**	**0.01869***	ND	---	---
	5/16/1999	ND	ND	ND	ND	---	<3	ND	---
	4/24/2001	ND	ND	ND	ND	ND	<0.50	---	---
	5/5/2003	ND	ND	ND	ND	ND	<0.50	---	---

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs (ug/L)					**Phenols (ug/L)**	**PCBs (ug/L)**	**Dioxins (ng/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**	***TCDD Equiv.*** [a]
Drinking Water Standard		**0.05**	**300**	**0.3**[c]	**0.3**[c]	**0.05**	**3**	**0.04**	**0.03**
Monitoring Well	**Sample Date**								
212	12/19/1986	**47**	**980**	**1533**	**1580**	ND	**8,900**	---	---
	6/29/1988	<6	**550**	**855.9**	**855.9**	<6	**3,800**	---	---
	6/28/1989	<20	**230***	**380**	**380**	<20	**3,500**	---	---
	6/27/1990	<10	**52***	**150**	**150**	<10	**5,100**	---	---
	6/19/1991	<100	**28***	**28**	**28**	<100	**2,200**	---	---
	5/28/1992	ND	ND	ND	ND	ND	**2,200**	ND	---
	6/2/1993	<10	**13***	**42**	**42**	<10	**2,900**	---	---
	6/14/1994	<10	**10***	**46**	**46**	<10	**3,900**	---	---
	6/8/1995	<750	ND	<750	<750	<750	**2,300**	---	---
	6/4/1996	<10	**5***	**27**	**27**	<10	**1,300**	---	---
	6/6/1997	<70	ND	**13**	**13**	<70	**950**	---	---
	4/29/1998	<0.4	**1.6***	**8.16**	**8.16**	<0.4	**470**	---	---
	5/20/1999	ND	**2.4***	**2.47**	**2.47**	ND	**430**	ND	---
	4/4/2000	ND	**2.8***	**2.88**	**2.88**	ND	**60**	---	---
	4/25/2001	ND	**3.1***	**3.1**	**3.1**	ND	**110**	---	---
	5/5/2002	ND	**1.1***	**1.17**	**1.17**	ND	**19**	---	---
	5/10/2003	ND	**1.6***	**1.64**	**1.64**	**ND**	**45**	---	---
213	12/21/1985	**1400**	**1,600**	**2,575**	**3975**		**12,000**	---	---
	12/19/1986	**1700**	**1,300**	**2,571**	**4271**		**20,000**	---	---
	6/29/1988	**160**	**1,200**	**2,100**	**2260**	<6	**4,800**	---	---
	6/28/1989	**700**	**1,000**	**1,965**	**2665**	<20	**13,000**	---	---
	6/27/1990	**19**	**470**	**1,116**	**1135**	<10	**5,800**	---	---
	6/19/1991	<40	**810**	**1,120**	**1120**	<40	**830**	---	---
	5/28/1992	ND	**150***	**328**	**328**	ND	**300**	ND	---
	6/2/1993	<10	**170***	**250**	**250**	<10	<10	---	---
	6/14/1994	<20	**130***	**236**	**236**	<20	<20	---	---
	6/8/1995	<10	**67***	**154**	**154**	<10	<10	---	---
	6/4/1996	<10	**47***	**90**	**90**	<10	<50	---	---
	6/6/1997	<10	**36***	**72**	**72**	<10	<50	---	---
	4/29/1998	<1.0	**21***	**44.4**	**44.4**	<1.0	3	---	---
	5/16/1999	ND	**22***	**24.17**	**24.17**	ND	<3	ND	---
	4/4/2000	ND	**470**	**494.45**	**494.45**	ND	**1,900**	---	---
	4/25/2001	**0.15**	**64***	**68**	**68.15**	ND	<0.5	---	---
	5/5/2002	**0.042**	**36***	**39.15**	**39.19**	ND	<3	---	---
	5/10/2003	ND	**31***	**34.3**	**34.3**	ND	<0.5	---	---
214	12/20/1985	**0.0219**	ND	**0.0779**	**0.0998**	**0.00102***	<5	---	---
	12/18/1986	**0.0141**	**0.023**	**0.1189**	**0.133**	**0.000771**	<6	---	---
215	12/18/1985	ND	**16***	**78.685**	**78.685**	ND	**5,300**	---	---
	12/17/1986	ND	ND	**0.0199**	**0.0199**	ND	<6	---	---
	6/28/1988	<6	**8.6***	**63**	**63**	<6	**4,400**	---	---
	6/28/1989	<10	**PP <10**	**20**	**20**	<10	**2,700**	---	---
	6/27/1990	<10	**16***	**66**	**66**	<10	**4,200**	---	---
	6/19/1991	<100	ND	**22**	**22**	<100	**2,800**	---	---

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs (ug/L)					**Phenols (ug/L)**	**PCBs (ug/L)**	**Dioxins (ng/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**	***TCDD Equiv.*** [a]
Drinking Water Standard		**0.05**	**300**	**0.3**[c]	**0.3**[c]	**0.05**	**3**	**0.04**	**0.03**
Monitoring Well	**Sample Date**								
215 (cont.)	5/28/1992	ND	ND	**16**	**16**	ND	**1,900**	ND	---
	6/2/1993	<10	**5***	**29**	**29**	<10	**2,200**	---	---
	6/14/1994	<10	**4***	**46**	**46**	<10	**3,400**	---	---
	6/8/1995	<500	ND	<500	<500	<500	**1,600**	---	---
	6/4/1996	<10	**1***	**29**	**29**	<10	**1,100**	---	---
	6/6/1997	<100	ND	**20**	**20**	<100	**1,200**	---	---
	4/29/1998	<0.7	ND	**19.4**	**19.4**	<0.7	**700**	---	---
	5/20/1999	ND	**0.38***	**0.51**	**0.51**	---	**680**	ND	---
	4/3/2000	ND	**0.48***	**0.59**	**0.59**	ND	**68**	---	---
	4/24/2001	ND	**0.53***	**0.58**	**0.58**	ND	**360**	---	---
	5/5/2002	0.041	**0.55***	**0.66**	**0.7**	ND	**170**	---	---
	5/10/2003	ND	**0.3***	**0.36**	**0.36**	ND	**47**	---	---
217	12/20/1985	0	ND	**0.0189**	**0.0189**	ND	ND	---	---
	12/19/1986	0	**0.038**	**0.1278**	**0.1278**	ND	ND	---	---
	6/28/1988	0	**0.007**	**0.0261**	**0.0261**	ND	ND	---	---
	6/28/1989	0	**0.0094**	**0.0126**	**0.0126**	ND	ND	---	---
	6/27/1990	0	ND	**0.0048**	**0.0048**	ND	ND	---	---
	6/19/1991	0	**.011 B**	**0.0037**	**0.0037**	0	ND	---	---
	5/26/1992	**0.0038**	**0.019**	**0.0429**	**0.0467**	**0.0038***	ND	ND	---
	6/2/1993	ND	**.00682 B**	**0.00305**	**0.00305**	ND	<6	---	---
	6/14/1994	ND	**.015 B**	**0.025**	**0.025**	ND	<3	---	---
	6/8/1995	ND	**.003 B**	ND	ND	ND	<3	---	---
	6/6/1997	<10	ND	ND	ND	<10	< 50	---	---
	5/17/1999	ND	ND	ND	ND	ND	<3	ND	---
	4/20/2001	ND	ND	ND	ND	ND	<0.5	---	---
	5/4/2003	ND	ND	ND	ND	ND	<0.5	---	---
218	12/20/1985	ND	ND	**13.2**	**13.2**	ND	**2,600**	---	---
	6/29/1988	ND	**1.4***	**8.287**	**8.287**	ND	**860**	---	---
	6/28/1989	**PP <0.04**	**1.9***	**13**	**13**	**PP <0.004**	**78**	---	---
	6/27/1990	ND	**8.8***	**16.57**	**16.57**	ND	**570**	---	---
	6/19/1991	ND	ND	**3.378**	**3.378**	ND	**170**	---	---
	5/27/1992	ND	ND	**0.394**	**0.394**	ND	**14**	ND	---
	6/2/1993	---	---	---	---	---	**26**	---	---
	7/22/1993	0.02149	**.0823 B**	**0.86476**	**0.88625**	**0.0004691**	---	---	---
	6/14/1994	ND	ND	**0.355**	**0.355**	ND	**13**	---	---
	6/8/1995	ND	ND	**0.365**	**0.365**	ND	**26**	---	---
	6/6/1997	<10	ND	<10	<10	<10	**17**	---	---
	5/18/1999	ND	ND	ND	ND	ND	**45**	ND	---
	4/25/2001	ND	ND	ND	ND	ND	**34**	---	---
	5/11/2003	ND	**0.12***	**0.12**	**0.12**	ND	**3.6**	---	---

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs (ug/L)					Phenols (ug/L)	PCBs (ug/L)	Dioxins (ng/L)
		Sum List 1	Naphthalene	*Sum List 2*	*Total PAH*	B*(a)P Equiv.*	PCP	TOTAL PCBs	*TCDD Equiv.* [a]
Drinking Water Standard		**0.05**	**300**	**0.3**^{c}	**0.3**^{c}	**0.05**	**3**	**0.04**	**0.03**
Monitoring Well	**Sample Date**								
219	12/20/1985	ND	**0.043**	**1.5741**	**1.5741**	ND	ND	---	---
	3/4/1986	**0.35**	**0.22***	**12.95**	**13.3**	**0.07577**	ND	---	---
	5/5/1986	ND	**0.18***	**5.133**	**5.133**	ND	ND	---	---
	7/2/1986	ND	**0.19***	**1.631**	**1.631**	ND	ND	---	---
	12/19/1986	ND	**0.071**	**1.182**	**1.182**	ND	ND	---	---
	6/29/1988	ND	ND	**9.7**	**9.7**	ND	ND	---	---
	6/28/1989	ND	**0.69***	**18.1**	**18.1**	ND	**16**	---	---
	6/27/1990	<10	ND	**16**	**16**	<10	<10	---	---
	6/19/1991	<10	ND	**8**	**8**	<10	<10	---	---
	5/26/1992	ND	ND	**8**	**8**	ND	ND	ND	---
	6/2/1993	<0.096	**.246 B***	**6.04**	**6.04**	<0.096	<6	---	---
	6/14/1994	<0.36	**.276 B***	**8.27**	**8.27**	<0.36	<3	---	---
	6/8/1995	<0.45	ND	**7**	**7**	<0.45	<3	---	---
	6/6/1997	<10	ND	**8**	**8**	<10	< 50	---	---
	5/17/1999	ND	**0.14***	**0.472**	**0.472**	---	<3	ND	---
	4/5/2000	ND	**0.21***	**0.68**	**0.68**	ND	<3	---	---
	4/25/2001	ND	**0.22***	**0.58**	**0.58**	ND	<0.5	---	---
	5/2/2002	ND	**0.22***	**0.72**	**0.72**	ND	< 3.1	---	---
	5/4/2003	ND	**0.11***	**0.49**	**0.49**	ND	<0.5	---	---
220	6/14/1994	<3	**363**	**527**	**527**	<3	**1,000**	---	---
	12/1/1994	<30	**270***	**410**	**410**	<30	**350**	---	---
	6/8/1995	<200	**200***	**252**	**252**	<200	**570**	---	---
	6/4/1996	<10	**76***	**118**	**118**	<10	**180**	---	---
	6/6/1997	<40	**48***	**81**	**81**	<40	**200**	---	---
	4/29/1998	<1.2	**23***	**41.9**	**41.9**	<1.2	**98**	---	---
	5/16/1999	ND	**11***	**11.55**	**11.55**	ND	**72**	ND	---
	4/5/2000	**0.03**	**19***	**19.76**	**19.79**	ND	**73**	---	---
	4/24/2001	**0.044**	**18***	**18**	**18.044**	ND	<0.50	---	---
	5/5/2002	**0.037**	**16***	**16.48**	**16.52**	ND	**4.5**	---	---
	5/10/2003	**0.03**	**7.4***	**7.9**	**7.9**	ND	**51**	---	---
221	6/14/1994	ND	**.013 B**	**0.006**	**0.006**	0	<3	---	---
	12/1/1994	ND	**.012 B**	**0.026**	**0.026**	0	<3	---	---
	6/8/1995	ND	**.003 B**	ND	ND	0	<3	---	---
	6/6/1997	<10	ND	<10	<10	<10	< 50	---	---
	5/17/1999	ND	ND	ND	ND	ND	<3	ND	---
	4/25/2001	ND	ND	ND	ND	ND	<0.5	---	---
	5/4/2003	ND	ND	ND	ND	ND	<0.5	---	---
401	12/12/1985	---	---	---	---	---	---	---	ND
	5/16/1988	---	---	---	---	---	**2,000**	ND	---
	12/19/1989	---	---	---		---	**56**	ND	---
	6/26/1990	<100	**320**	**544**		<100	**2,500**	---	---
	12/4/1990	---	---	---	---	---	**1,500**	---	---
	6/18/1991	<20	ND	**17**		<20	**1,600**	---	---

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs (ug/L)					**Phenols** (ug/L)	**PCBs** (ug/L)	**Dioxins** (ng/L)
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**	***TCDD Equiv.***[a]
Drinking Water Standard		**0.05**	**300**	**0.3**[c]	**0.3**[c]	**0.05**	**3**	**0.04**	**0.03**
Monitoring Well	**Sample Date**								
401 (cont.)	12/17/1991	---	---	---	---	---	**3,900**	---	---
	5/26/1992	**15**	**31***	**398**	**413**	**0.44**	**1,500**	ND	---
	6/1/1993	<10	ND	**50**	**50**	<10	**970**	---	---
	6/13/1994	**4**	ND	**28**	**32**	**0.22**	**2,000**	---	---
	6/7/1995	**2**	ND	**301**	**303**	**0.022***	**890**	---	---
	6/4/1997	<100	ND	**400**	**400**	<100	**1,000**	---	---
	5/14/1999	**49**	ND	**693**	**742**	<10	**1,500**	---	---
	4/22/2001	<9.5	ND	<9.5	<9.5	<9.5	**1,700**	---	---
	5/9/2003	<10	ND	<10	<10	<10	**1,700**	---	---
402	12/12/1985	---	---	---	---	---	---	---	ND
	5/16/1988	---	---	---	---	---	**1,300**	ND	---
	12/19/1989	---	---	---	---	---	**1,200**	ND	---
	6/26/1990	<25	**26***	**173**	**173**	<25	**1,600**	---	---
	12/4/1990	---	---	---	---	---	**700**	---	---
	6/18/1991	**23**	ND	**82**	**105**	<50	**1,600**	---	---
	12/17/1991	---	---	---	---	---	**1,600**	---	---
	5/26/1992	**10**	ND	**141**	**151**	**0.32**	**1,100**	ND	---
	6/1/1993	**29**	ND	**191**	**220**	<10	**810**	---	---
	6/13/1994	**48**	**9***	**470**	**518**	**0.55**	**2,200**	---	---
	6/7/1995	**24**	**56***	**530**	**554**	**0.23**	**1,200**	---	---
	6/4/1997	**19**	ND	**152**	**171**	**19**	**950**	---	---
	5/14/1999	<10	ND	ND	ND	<10	**1,300**	---	---
	4/22/2001	<9.6	ND	**18**	**18**	<9.6	**1,900**	---	---
	5/9/2003	<10	ND	<10	<10	<10	**290**	---	---
403	5/16/1988	---	---	---	---	---	**2,200**	ND	---
	12/19/1989	---	---	---	---	---	**1,500**	ND	---
	6/26/1990	<25	**26***	**37**	**37**	<25	**1,100**	---	---
	12/4/1990	---	---	---	---	---	**790**	---	---
	6/18/1991	<40	**15***	**15**	**15**	<40	**1,200**	---	---
	12/17/1991	---	---	---	---	---	**1,200**	---	---
	5/26/1992	ND	ND	**7**	**7**	0	**560**	ND	---
	6/1/1993	<10	ND	**4**	**4**	<10	**300**	---	---
	6/13/1994	<10	ND	**4**	**4**	<10	**320**	---	---
	6/7/1995	<10	ND	**10**	**10**	<10	**190**	---	---
	6/4/1997	<60	ND	**13**	**13**	<60	**560**	---	---
	5/14/1999	<10	ND	0	<10	<10	**640**	---	---
	4/22/2001	<9.6	ND	0	<9.6	<9.6	**530**	---	---
	5/9/2003	<10	ND	<10	<10	<10	**400**	---	---
404	5/16/1988	---	---	---	---	---	**6,300**	ND	---
	12/19/1989	---	---	---	---	---	**9,000**	ND	---

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs (ug/L)					**Phenols** (ug/L)	**PCBs** (ug/L)	**Dioxins** (ng/L)
		Sum List 1	Naphthalene	*Sum List 2*	*Total PAH*	B*(a)P Equiv.*	PCP	TOTAL PCBs	*TCDD Equiv.*[a]
Drinking Water Standard		**0.05**	**300**	**0.3**[c]	**0.3**[c]	**0.05**	**3**	**0.04**	**0.03**
Monitoring Well	**Sample Date**								
405	5/16/1988	---	---	---	---	---	**4,500**	ND	---
	11/20/1989	---	---	---	---	---	**170**	ND	---
	12/19/1989	---	---	---	---	---	**7,000**	ND	---
	12/4/1990	---	---	---	---	---	**5,500**	ND	---
	6/18/1991	**5**	**61***	**110**	**115**	<20	**480**	---	---
	12/17/1991	---	---	---	---	---	**1,500**	---	---
	5/26/1992	**17**	**240***	**409**	**426**	0	**840**	ND	---
	6/1/1993	**210**	**770**	**1,265**	**1,475**	<10	**6,400**	---	---
	6/13/1994	**420**	**1,000**	**2,000**	**2,420**	<100	**6,500**	---	---
	6/7/1995	**570**	**1,400**	**3,188**	**3,758**	<200	**5,300**	---	---
	6/4/1997	<400	**1,000**	**1,728**	**1,728**	<400	**5,300**	---	---
	5/14/1999	**160**	**1,100**	**1,207**	**1,367**	<10	**7,000**	---	---
	4/22/2001	**270**	**1,900**	**2,300**	**2,570**	<9.6	**7,400**	---	---
	5/9/2003	**190**	**1,300**	**1,438**	**1,628**	0	**7,500**	---	---
406	5/16/1988	---	---	---	---	---	**12**	ND	---
	12/19/1989	---	---	---	---	---	<5	ND	---
	6/18/1991	<10	ND	ND	<10	<10	<10	---	---
	6/13/1994	<10	ND	ND	<10	<10	<5	---	---
	6/7/1995	<10	ND	ND	<10	<10	<5	---	---
	6/4/1997	**1**	**10***	**31**	**32**	<10	**58**	---	---
	5/14/1999	<10	ND	ND	<10	<10	<50	---	---
	4/22/2001	<9.5	ND	ND	<9.5	<9.5	<24	---	---
	5/9/2003	ND	**0.12***	**1.5**	**1.5**	ND	ND	---	---
407	5/16/1988	---	---	---	---	---	<5	ND	---
	12/19/1989	---	---	---	---	---	ND	ND	---
	6/18/1991	---	---	---	---	---	ND	ND	---
	6/13/1994	<10	ND	ND	<10	<10	<5	---	---
	6/7/1995	<10	ND	ND	<10	<10	<5	---	---
	6/4/1997	<10	ND	ND	<10	<10	<50	---	---
	5/14/1999	<10	ND	ND	<10	<10	<50	---	---
	4/22/2001	<9.6	ND	ND	<9.6	<9.6	<24	---	---
	5/9/2003	ND	ND	ND	ND	ND	ND	---	---
408	5/16/1988	---	---	---	---	---	**5,000**	ND	---
	12/19/1989	---	---	---	---	---	**5,600**	ND	---
	6/26/1990	**120**	**780**	**1,500**	**1,620**	<150	**6,200**	---	---
	12/4/1990	---	---	---	---	---	**4,800**	---	---
	6/18/1991	**120**	**710**	**1,200**	**1,320**	<180	**5,300**	---	---
	12/17/1991	---	---	---	---	---	**9,100**	---	---
	5/26/1992	**110**	**640**	**1,213**	**1,323**	0	**3,800**	ND	---
	6/1/1993	<10	**450**	**4,400**	**4,400**	<10	**4,400**	---	---
	6/13/1994	**50**	**350**	**650**	**700**	<50	**3,100**	---	---
	6/7/1995	**40**	**500**	**1,046**	**1,086**	<100	**1,300**	---	---
	6/5/1996	<40	**270***	**468**	**468**	<40	**2,000**	---	---

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs (ug/L)					Phenols (ug/L)	PCBs (ug/L)	Dioxins (ng/L)
		Sum List 1	Naphthalene	*Sum List 2*	*Total PAH*	B*(a)P Equiv.*	PCP	TOTAL PCBs	*TCDD Equiv.* [a]
Drinking Water Standard		0.05	300	0.3[c]	0.3[c]	0.05	3	0.04	0.03
Monitoring Well	**Sample Date**								
408 (cont.)	6/4/1997	<150	650	1,163	1,163	<150	2,000	---	---
	5/1/1998	<5	240*	378	378	<5	1,200	---	---
	5/14/1999	<10	150*	161	161	<10	1,800	---	---
	4/22/2001	<9.7	110*	122	122	<9.7	1,200	---	---
	5/2/2002	0.39	76*	81.6	82	0	440	---	---
	5/9/2003	<10	48*	48	48	<10	700	---	---
409	5/16/1988	---	---	---	---	---	18,000	ND	---
	12/19/1989	---	---	---	---	---	8,900	ND	---
	6/26/1990	560	1,600	2,900	3,460	<200	8,700	---	---
	12/4/1990	---	---	---	---	---	5,800	---	---
	6/18/1991	380	1,400	6,600	6,980	<200	6,600	---	---
	12/17/1991	---	---	---	---	---	11,000	---	---
	5/26/1992	240	810	1,534	1,774	0	5,400	ND	---
	6/1/1993	330	550	4,800	5,130	<10	4,800	---	---
	6/13/1994	200	400	840	1,040	<50	3,700	---	---
	6/7/1995	180	55*	394	574	<50	2,100	---	---
	6/4/1997	500	2,200	4,068	4,568	<400	5,000	---	---
	5/1/1998	0	240*	378	378	---	1,200	ND	---
	5/14/1999	19	190*	225	244	<10	2,900	---	---
	4/22/2001	54	370	465	519	<9.7	3,100	---	---
	5/9/2003	17	85*	96	113	0	1,700	---	---
410	5/16/1988	---	---	---	---	---	280	ND	---
	11/20/1989	---	---	---	---	---	12,000	ND	---
	12/19/1989	---	---	---	---	---	130	ND	---
	6/26/1990	<10	6*	6	6	<10	80	---	---
	12/4/1990	---	---	---	---	---	39	---	---
	6/18/1991	<10	ND	<10	<10	<10	<10	---	---
	5/26/1992	ND	ND	ND	ND	ND	<5	ND	---
	6/1/1993	<10	ND	<10	<10	<10	<5	---	---
	6/13/1994	<10	ND	<10	<10	<10	8	---	---
	6/7/1995	<10	ND	2	2	<10	14	---	---
	5/14/1999	<10	ND	<10	<10	<10	<50	---	---
	4/22/2001	<9.6	ND	<9.6	<9.6	<9.6	50	---	---
	5/9/2003	<10	ND	<10	<10	<10	3.1	---	---
411	5/14/1999	ND	ND	ND	ND	ND	350	---	---
	4/22/2001	ND	ND	ND	ND	ND	14	---	---
	5/9/2003	ND	ND	ND	ND	ND	12	---	---

TABLE 3 - SUMMARY OF GROUNDWATER SAMPLING RESULTS, UPPER SAND AQUIFER, FORMER OPERATIONS AREA

NOTES:

All criteria listed are MDH values, except for TCDD equivalent, which is based on WHO 1998 criteria (see App. E)
ND = not detected
ND* = not detected, but detection limit unknown
a = see Table 5 for individual dioxin congeners
░ = compound not detected, but detection limit exceeded drinking water criteria
▓ = compound detected at a concentration exceeding the drinking water standard
--- = compound not analyzed
* Exceeds LLBO groundwater cleanup level (which evaluates both human and ecological risk)
ug/L = micrograms per liter, or parts per billion
ng/L = nanograms per liter, or parts per trillion
PCP = pentachlorophenol
PAH = polynuclear aromatic hydrocarbon
PCB = polychlorinated biphenyls
B(a)P = benzo(a)pyrene

TABLE 4: Mean Percentage of List 2 PAHs and Total PAHs Represented by the Nineteen PAHs Excluded From Analysis After 1998 in Monitoring Wells Exceeding Site Action Level for PAHs*

Well Number	Mean Percentage of List 2 PAHs Represented by 19 PAHs Excluded from Analysis After 1998	Mean Percentage of Total PAHs Represented by 19 PAHs Excluded from Analysis After 1998
103	79	79
104	72	72
106	60	60
107	85	83
108	24	24
109	48	45
112	10	9
113	47	45
118	38	37
202	81	81
207	44	35
209	33	26
212	57	57
213	44	40
215	89	89
218	70	70
219	90	90
220	32	32
302	42	38
2128	48	48
2134	55	55
2234	34	32
2301	42	41
2335	51	51
Fish #4	56	56

*** Does not include pump out or residential wells**
“Fish #4” is well #4 at the LLDRM fish hatchery
PAH = polynuclear aromatic hydrocarbon

TABLE 5 - DIOXIN CONGENERS IN GROUNDWATER SAMPLES, FORMER OPERATIONS AREA AND CITY DUMP

		Dioxin congeners (ng/L)					
		TCDD	**PeCDD**	**HxCDD**	**HpCDD**	**OCDD**	**TCDD Equiv. (WHO 98)**
Drinking Water Criterion		**0.03**	**0.03**	**0.3**	**3**	**300**	**0.03**
Monitoring Wells	**Sample Date**						
FOA							
107, 113, 118*	7/16/1985	░	░	░	■	**183****	■
106	9/18/1985	░	░	<0.29	<1.7	░	░
104, 106, 107*	9/18/1985	░	░	<0.19	░	**11**	**0.0011**
118	9/18/1985	░	░	■	■	■	■
207, 213, 218*	7/16/1985	░	░	<0.13	<0.53	**6.5**	**0.00065**
207, 213, 218*	9/18/1985	░	░	<0.27	░	**19**	**0.0019**
City Dump							
2102	8/22/1985	░	░	■	■	■	■
2103	8/22/1985	░	░	■	■	■	■
2104	8/22/1985	░	░	■	■	■	■
2105	8/22/1985	░	░	■	■	■	■
2104 & 2105*	7/16/1985	░	░	■	■	■	■
2106	8/22/1985	░	░	░	■	**10**	■
2401	12/21/1988	░	░	■	■	■	■
2402	12/21/1988	■	■	■	■	■	■
2403	12/21/1988	---	░	■	■	■	■

NOTES: All criteria listed are based on WHO 1998 criteria (see Appendix E)

* composite samples

░ = compound not detected, but detection limit exceeded drinking water criteria

■ = compound detected at a concentration exceeding the drinking water standard

--- = compound not analyzed

** exceeds LLBO groundwater cleanup level (which evaluates both human and ecological risk)

ng/L = nanograms per liter, or parts per trillion

TCDD = tetrachlorodibenzo-p-dioxin

PeCDD = pentachloro-dibenzo-p-dioxin

HxCDD = hexachlorodibenzo-p-dioxin

HpCDD = heptachlorodibenzo-p-dioxin

OCDD = octochlorodibenzo-p-dioxin

TABLE 6: GROUNDWATER SAMPLING RESULTS, LOWER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs (ug/L)					**Phenols (ug/L)**	**PCBs (ug/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)*P *Equiv.***	**PCP**	**TOTAL PCBs**
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**0.04**
Monitoring Well	**Sample Date**							
302	12/20/1985	**0.02**	**0.014**	**0.0887**	**0.109**	0	ND	---
	3/4/1986	---	---	---	---	---	ND	---
	5/5/1986	**0.0071**	ND	**0.0253**	**0.0324**	0	ND	---
	7/2/1986	---	---	---	---	---	ND	---
	12/18/1986	**0.0019**	ND	**0.0261**	**0.028**	**0.000019**	ND	---
	6/28/1988	**0.127**	**0.049**	**0.2724**	**0.3994**	**0.02658***	ND	---
	12/14/1988	ND	**0.017**	**0.0409**	**0.0409**	0	ND	---
	6/27/1989	**0.0022**	**0.037**	**0.0918**	**0.094**	0	ND	---
	6/27/1990	**0.0131**	**0.018**	**0.0727**	**0.0858**	**0.000021**	ND	---
	6/19/1991	**0.016**	**0.037 B**	**0.0593**	**0.0753**	0	ND	---
	5/27/1992	ND	**0.019 B**	**0.2351**	**0.2351**	0	ND	ND
	6/2/1993	ND	**0.00947 B**	**0.0133**	**0.0133**	0	ND	---
	6/14/1994	ND	**0.092**	**0.883**	**0.883**	0	ND	---
	6/6/1995	ND	**0.016**	**0.059**	**0.059**	0	ND	---
	6/4/1997	<10	ND	ND	ND	<10	<50	ND
	5/13/1999	ND	ND	ND	ND	0	ND	---
	4/25/2001	ND	ND	ND	ND	0	ND	---
	5/8/2003		**0.043**	**0.043**	**0.043**	0	ND	---
306	12/17/1985	ND	ND	**0.014**	**0.014**	0	ND	---
	3/3/1986	---	---	---	---	---	ND	---
	5/5/1986	ND	ND	**0.0039**	**0.0039**	0	ND	---
	7/2/1986	---	---	---	---	---	ND	---
	12/17/1986	ND	ND	**0.0036**	**0.0036**	0	ND	---
	6/28/1988	**0.0101**	**0.013**	**0.0566**	**0.0667**	**0.000371**	ND	---
	12/14/1988	ND	**0.029**	**0.0792**	**0.0792**	0	ND	---
	6/28/1989	ND	**0.0047**	**0.0106**	**0.0106**	0	ND	---
	6/27/1990	ND	**0.003**	**0.0064**	**0.0064**	0	ND	---
	6/19/1991	ND	**0.32***	**0.3384**	**0.3384**	0	ND	---
	5/27/1992	ND	ND	**0.0159**	**0.0159**	0	ND	ND
	6/2/1993	ND	**.00923 B**	ND	ND	0	<6	---
	6/14/1994	**0.023**	**.01 B**	**0.0273**	**0.05**	**0.00625***	ND	---
	6/6/1995	ND	**0.007**	**0.018**	**0.018**	0	ND	---
	6/5/1996	<10	ND	ND	ND	<10	<50	---
	6/4/1997	<10	ND	ND	ND	<10	<50	ND
	4/30/1998	<0.1	ND	ND	ND	<0.1	<5	---
	5/13/1999	ND	**0.04**	**0.08**	**0.08**	0	ND	---
	4/4/2000	ND	ND	ND	ND	0	ND	---
	4/25/2001	ND	ND	ND	ND	0	ND	---
	5/4/2002	ND	**0.023**	**0.023**	**0.023**	0	ND	---
	5/7/2003	ND	**0.031**	**0.031**	**0.031**	0	ND	---

TABLE 6: GROUNDWATER SAMPLING RESULTS, LOWER SAND AQUIFER, FORMER OPERATIONS AREA

		PAHs **(ug/L)**					**Phenols** **(ug/L)**	**PCBs** **(ug/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P Equiv.***	**PCP**	**TOTAL PCBs**
Drinking Water Criterion		**0.05**	**300**	**0.3^c**	**0.3^c**	**0.05**	**3**	**0.04**
Monitoring Well	**Sample Date**							
MW3	6/28/1988	ND	ND	**0.0176**	**0.0176**	0	ND	---
	12/14/1988	ND	ND	**0.0775**	**0.0775**	0	ND	---
	6/27/1989	ND	ND	**0.0202**	**0.0202**	0	ND	---
	6/27/1990	**0.0022**	ND	**0.0507**	**0.0727**	0	ND	---
	6/19/1991	ND	ND	**0.0122**	**0.0122**	0	ND	---
	5/26/1992	ND	**0.019**	**0.0501**	**0.0501**	0	ND	ND
	6/1/1993	ND	**.00941 B**	**0.00924**	**0.00924**	0	<6	---
	6/14/1994	**0.01**	**.015 B**	**0.02**	**0.03**	**0.00406***	ND	---
	6/6/1995	ND	**0.017**	**0.048**	**0.048**	0	ND	---
	6/4/1997	<10	ND	ND	ND	<10	<50	ND
	5/15/1999	ND	ND	ND	ND	ND	ND	---
	4/25/2001	ND	ND	ND	ND	ND	ND	---
	5/7/2003	ND	ND	ND	ND	ND	ND	---

NOTES: All criteria listed are MDH values (see App. E)

ND = Compound not detected

▨ = compound not detected, but detection limit exceeded drinking water criteria

▩ = compound detected at a concentration exceeding the drinking water standard

--- = compound not analyzed

* exceeds LLBO groundwater cleanup level (which evaluates both human and ecological risk)

ug/L = micrograms per liter, or parts per billion

ng/L = nanograms per liter, or parts per trillion

PCP = pentachlorophenol

PAH = polynuclear aromatic hydrocarbon

PCB = polychlorinated biphenyls

B(a)P = benzo(a)pyrene

TABLE 7: GROUNDWATER SAMPLING RESULTS, SOUTHWEST AREA

		PAHs (ug/L)					**Phenols (ug/L)**	**PCBs (ug/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**0.04**
Monitoring Well	**Sample Date**							
111	1/29/1982	ND*	ND*	ND*	ND*	ND*	**0.03***	---
	5/6/1982	ND*	ND*	ND*	ND*	ND*	ND*	---
	6/15/1983	**0.46**	ND*	**0.04**	**0.5**	**0.145**	ND*	---
	11/11/1983	ND*	**0.015**	**0.24**	**0.24**	ND*	ND*	---
	1/25/1984	**0.009**	**0.026**	**0.081**	**0.09**	**0.0007**	ND*	---
	4/25/1984	**0.13**	**0.029**	**0.35**	**0.48**	**0.028***	ND*	---
	11/6/1984	**0.0095**	**0.28***	**0.82**	**0.83**	**0.0006**	ND*	---
	4/22/1986	**0.0011**	**0.019**	**0.0483**	**0.0494**	**0.000011**	ND	---
	12/18/1986	**0.0029**	**0.022**	**0.0642**	**0.0671**	**0.000029**	ND	---
121	4/22/1986	**0.0037**	**0.019**	**0.1156**	**0.1193**	**0.000136**	ND	---
	7/2/1986	ND	ND	**0.0274**	**0.0274**	0	ND	---
	12/19/1986	ND	ND	**0.0455**	**0.0455**	0	ND	---
123	4/21/1986	**0.0022**	ND	**0.174**	**0.1762**	**0.000022**	ND	---
	7/2/1986	**0.0019**	ND	**0.042**	**0.0439**	0	ND	---
	12/19/1986	ND	**0.013**	**0.0418**	**0.0418**	0	ND	---
124	10/20/1987	---	---	---	---	---	---	<0.1
	1/19/1988	ND	**0.003**	**0.0147**	**0.0147**	0	ND	---
	6/29/1988	ND	**0.028**	**0.0541**	**0.0541**	0	ND	---
	8/30/1988	**0.0021**	**0.003**	**0.0126**	**0.0127**	**0.000021**	ND	---
	12/15/1988	ND	**0.023**	**0.0531**	**0.0531**	0	ND	---
	3/28/1989	ND	**0.0021**	**0.0068**	**0.0068**	0	ND	---
	6/27/1989	ND	**0.0048**	**0.0071**	**0.0071**	0	ND	---
	8/31/1989	ND	**0.0031**	**0.0043**	**0.0043**	0	ND	---
	12/13/1989	ND	**0.0022**	**0.0102**	**0.0102**	0	ND	---
	3/5/1990	ND	**0.004**	**0.0103**	**0.0103**	0	ND	---
	6/28/1990	ND	**0.0047**	**0.0146**	**0.0146**	0	ND	---
	6/18/1991	ND	ND	ND	ND	0	ND	---
	12/18/1991	ND	**0.0069 B**	ND	ND	0	ND	---
	5/27/1992	ND	ND	ND	ND	0	ND	ND
	12/10/1992	ND	ND	ND	ND	0	ND	ND
	2/9/1993	ND	**0.00679**	**0.03044**	**0.03044**	0	---	---
	6/3/1993	ND	ND	ND	ND	0	ND	---
	11/2/1993	ND	**.00759 B**	ND	ND	0	ND	---
	6/15/1994	ND	**0.004**	**0.004**	**0.004**	0	ND	---
	12/1/1994	ND	**.006 B**	ND	ND	0	ND	---
	6/7/1995	ND	ND	**0.004**	**0.004**	0	ND	---
	11/7/1995	ND	ND	ND	ND	0	ND	---
	6/5/1996	<10	ND	ND	<10	<10	<50	---
	6/4/1997	<10	ND	ND	<10	<10	<50	---

TABLE 7: GROUNDWATER SAMPLING RESULTS, SOUTHWEST AREA

		PAHs (ug/L)					**Phenols (ug/L)**	**PCBs (ug/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**0.04**
Monitoring Well	**Sample Date**							
124 (cont.)	4/30/1998	<0.1	ND	ND	<0.1	<0.1	ND	---
	5/13/1999	ND	ND	ND	ND	0	ND	---
	4/3/2000	ND	ND	ND	ND	0	ND	---
	4/26/2001	ND	ND	ND	ND	0	ND	---
	5/4/2002	ND	ND	ND	ND	0	<3.1	---
	5/12/2003	ND	**0.021**	**0.021**	**0.021**	0	ND	---
125	10/20/1987	---	---	---	---	---	---	<0.1
	1/19/1988	**0.0024**	**0.0022**	**0.0215**	**0.0239**	**0.000024**	ND	---
	6/29/1988	ND	**0.0034**	**0.0127**	**0.0127**	0	ND	---
	8/30/1988	**0.0021**	**0.0031**	**0.0158**	**0.0179**	**0.000021**	ND	---
	12/15/1988	ND	ND	**0.0235**	**0.0235**	0	ND	---
	3/28/1989	ND	ND	**0.0069**	**0.0069**	0	ND	---
	6/27/1989	ND	**0.0047**	**0.0134**	**0.0134**	0	ND	---
	8/31/1989	ND	**0.0031**	**0.0099**	**0.0099**	0	ND	---
	12/13/1989	ND	**0.0022**	**0.011**	**0.011**	0	ND	---
	3/5/1990	ND	**0.0044**	**0.0207**	**0.0207**	0	ND	---
	6/28/1990	ND	ND	ND	ND	0	ND	---
	6/18/1991	ND	ND	ND	ND	0	ND	---
	12/18/1991	**0.0074**	**0.0057 B**	**0.1271**	**0.1345**	**0.11708**	ND	---
	5/27/1992	ND	ND	**0.0084**	**0.0084**	0	ND	ND
	12/10/1992	ND	ND	ND	ND	0	ND	ND
	2/9/1993	ND	ND	ND	ND	0	---	---
	6/3/1993	ND	**.0047 B**	ND	ND	0	ND	---
	11/2/1993	ND	**.00788 B**	ND	ND	0	ND	---
	6/15/1994	ND	**0.005**	**0.005**	**0.005**	0	ND	---
	12/1/1994	ND	**.005 B**	ND	ND	0	ND	---
	6/7/1995	ND	**.004 B**	**0.006**	**0.006**	0	ND	---
	11/7/1995	ND	ND	ND	ND	0	ND	---
	6/5/1996	<10	ND	ND	ND	<10	<50	---
	6/4/1997	<10	ND	ND	ND	<10	<50	---
	4/30/1998	<0.1	ND	ND	ND	<0.1	ND	---
	5/13/1999	ND	ND	ND	ND	0	ND	---
	4/3/2000	ND	ND	**0.05**	**0.05**	0	ND	---
	4/21/2001	ND	ND	ND	ND	0	ND	---
	5/4/2002	ND	ND	**0.023**	**0.023**	0	<3.1	---
	5/7/2003	ND	ND	ND	ND	0	ND	---
126	10/20/1987	---	---	---	---	---	---	<0.1
	1/19/1988	ND	**0.004**	**0.0282**	**0.0282**	0	ND	---
	6/29/1988	ND	**0.0029**	**0.0117**	**0.0117**	0	ND	---
	8/30/1988	**0.0023**	**0.0032**	**0.0197**	**0.022**	**0.000023**	ND	---

TABLE 7: GROUNDWATER SAMPLING RESULTS, SOUTHWEST AREA

		PAHs (ug/L)					**Phenols (ug/L)**	**PCBs (ug/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**0.04**
Monitoring Well	**Sample Date**							
126 (cont.)	12/15/1988	ND	**0.019**	**0.0419**	**0.0419**	0	ND	---
	5/9/1989	ND	**0.013**	**0.0299**	**0.0299**	0	ND	---
	6/27/1989	ND	**0.0062**	**0.015**	**0.015**	0	ND	---
	8/31/1989	ND	**0.0026**	**0.0131**	**0.0131**	0	ND	---
	12/13/1989	ND	**0.0023**	**0.0094**	**0.0094**	0	ND	---
	3/5/1990	ND	**0.0033**	**0.0116**	**0.0116**	0	ND	---
	6/28/1990	ND	**0.0029**	**0.0057**	**0.0057**	0	ND	---
	6/18/1991	ND	ND	ND	ND	0	ND	---
	12/18/1991	ND	**.0049 B**	ND	ND	0	ND	---
	5/27/1992	ND	ND	**0.0047**	**0.0047**	0	ND	ND
	12/10/1992	ND	ND	**0.0034**	**0.0034**	0	ND	ND
	6/3/1993	ND	**.00436 B**	ND	ND	0	ND	---
	11/2/1993	ND	**.00575 B**	**0.00435**	**0.00435**	0	ND	---
	6/15/1994	ND	**0.005**	**0.009**	**0.009**	0	ND	---
	12/1/1994	ND	**.005 B**	**0.003**	**0.003**	0	ND	---
	6/7/1995	ND	**.009 B**	**0.025**	**0.025**	0	ND	---
	7/28/1995	ND	ND	ND	ND	0	---	---
	11/7/1995	ND	ND	ND	ND	0	ND	---
	6/5/1996	<10	ND	ND	ND	<10	<50	---
	6/4/1997	<10	ND	ND	ND	<10	<50	---
	4/30/1998	<0.1	ND	ND	ND	<0.1	ND	---
	5/13/1999	ND	ND	ND	ND	0	---	---
	4/3/2000	ND	ND	**0.08**	**0.08**	0	ND	---
	4/21/2001	ND	ND	ND	ND	0	ND	---
	5/4/2002	ND	ND	**0.023**	**0.023**	0	ND	---
	5/7/2003	ND	ND	ND	ND	0	ND	---
127	10/20/1987	---	---	---	---	---	---	<0.1
	1/19/1988	ND	**0.0038**	**0.0196**	**0.0196**	0	ND	---
	6/29/1988	ND	**0.0039**	**0.0173**	**0.0173**	0	ND	---
	8/30/1988	**0.002**	**0.0031**	**0.021**	**0.023**	**0.00002**	ND	---
	12/15/1988	ND	**0.023**	**0.0601**	**0.0601**	0	ND	---
	3/28/1989	ND	**0.0027**	**0.0027**	**0.0027**	0	ND	---
	6/27/1989	ND	**0.0032**	**0.0055**	**0.0055**	0	ND	---
	8/31/1989	ND	**0.0059**	**0.0176**	**0.0176**	0	ND	---
	12/13/1989	ND	**0.0022**	**0.0099**	**0.0099**	0	ND	---
	3/5/1990	ND	**0.0039**	**0.0239**	**0.0239**	0	ND	---
	6/28/1990	ND	**0.0032**	**0.0087**	**0.0087**	0	ND	---
	6/18/1991	ND	**.004 B**	**0.0046**	**0.0046**	0	ND	---
	12/18/1991	ND	**.0042 B**	**0.0037**	**0.0037**	0	ND	---
	5/27/1992	ND	ND	**0.0097**	**0.0097**	0	ND	ND
	5/13/1999	ND	ND	ND	ND	0	ND	---

TABLE 7: GROUNDWATER SAMPLING RESULTS, SOUTHWEST AREA

		PAHs (ug/L)					Phenols (ug/L)	PCBs (ug/L)
		Sum List 1	Naphthalene	*Sum List 2*	*Total PAH*	B*(a)P Equiv.*	PCP	TOTAL PCBs
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**0.04**
Monitoring Well	**Sample Date**							
127 (cont.)	10/8/1999	ND	ND	ND	ND	0	ND	---
	4/3/2000	ND	ND	**0.04**	**0.04**	0	ND	---
	4/21/2001	ND	ND	ND	ND	0	ND	---
	5/4/2002	ND	ND	**0.024**	**0.024**	0	ND	---
	5/7/2003	ND	ND	ND	ND	0	ND	---
128	10/20/1987	---	---	---	---	---	---	<0.1
	1/19/1988	**0.0057**	**0.0045**	**0.0199**		0	ND	---
	6/29/1988	ND	**0.0027**	**0.0136**	**0.0136**	0	ND	---
	8/30/1988	**0.0049**	**0.0035**	**0.0211**	**0.026**	**0.000015**	ND	---
	12/15/1988	ND	**0.027**	**0.0587**	**0.0587**	0	ND	---
	3/28/1989	ND	**0.0026**	**0.0082**	**0.0082**	0	ND	---
	6/27/1989	ND	**0.0028**	**0.01**	**0.01**	0	ND	---
	8/31/1989	ND	**0.0031**	**0.0118**	**0.0118**	0	ND	---
	12/13/1989	ND	**0.0014**	**0.0076**	**0.0076**	0	ND	---
	3/5/1990	ND	**0.0049**	**0.0169**	**0.0169**	0	ND	---
	6/28/1990	ND	**0.0035**	**0.0072**	**0.0072**	0	ND	---
	6/18/1991	ND	ND	**0.003**	**0.003**	0	ND	---
	12/18/1991	ND	**.007 B**	**0.0072**	**0.0072**	0	ND	---
	5/27/1992	ND	ND	**0.004**	**0.004**	0	ND	ND
	12/10/92**	**0.0263**	ND	**0.0116**	**0.0379**	**0.007824***	ND	ND
	6/3/1993	ND	**.0414 B**	ND	ND	0	ND	---
	11/2/1993	ND	**.00759 B**	**0.00739**	**0.00739**	0	ND	---
	6/15/1994	ND	**0.018**	**0.033**	**0.033**	0	ND	---
	8/24/1994	ND	**.005 B**	**0.01**	**0.01**	0	---	---
	12/1/1994	ND	**.004 B**	**0.004**	**0.004**	0	ND	---
	6/7/1995	ND	**.003 B**	ND	ND	0	ND	---
	11/7/1995	ND	ND	ND	ND	0	ND	---
	6/5/1996	<10	ND	ND	ND	<10	<50	---
	6/4/1997	<10	ND	ND	ND	<10	<50	---
	4/30/1998	<0.1	ND	ND	ND	<0.1	ND	---
	5/13/1999	ND	ND	ND	ND	0	ND	---
	4/4/2000	ND	ND	ND	ND	0	ND	---
	4/21/2001	ND	ND	ND	ND	0	ND	---
	5/4/2002	ND	ND	ND	ND	0	ND	---
	5/7/2003	ND	ND	ND	ND	0	ND	---
129	8/27/1992	ND	**.012 B**	**0.0225**	**0.0225**	0	ND	ND
	12/10/1992	ND	ND	ND	ND	0	ND	ND
	6/3/1993	ND	**.00407 B**	ND	ND	0	ND	---
	11/2/1993	ND	**.00518 B**	ND	ND	0	ND	---
	6/15/1994	ND	**0.003**	**0.003**	**0.003**	0	ND	---

TABLE 7: GROUNDWATER SAMPLING RESULTS, SOUTHWEST AREA

		PAHs (ug/L)					**Phenols (ug/L)**	**PCBs (ug/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	**PCP**	**TOTAL PCBs**
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**0.04**
Monitoring Well	**Sample Date**							
129 (cont.)	12/1/1994	ND	**.003 B**	ND	ND	0	ND	---
	6/7/1995	ND	**.003 B**	**0.007**	**0.007**	0	ND	---
	11/7/1995	ND	ND	ND	ND	0	ND	---
	6/5/1996	<10	ND	ND	ND	<10	<50	---
	6/4/1997	<10	ND	ND	ND	<10	<50	---
	4/30/1998	<0.1	ND	ND	ND	<0.1	ND	---
	5/13/1999	ND	ND	ND	ND	0	ND	---
	4/3/2000	ND	ND	ND	ND	0	ND	---
	4/21/2001	ND	ND	ND	ND	0	ND	---
	5/4/2002	ND	ND	ND	ND	0	ND	---
	5/7/2003	ND	ND	**0.023**	**0.023**	0	ND	---
130	8/27/1992	ND	ND	ND	ND	0	ND	ND
	12/10/1992	ND	ND	ND	ND	0	ND	ND
	2/9/1993	ND	**0.00455**	**0.00856**	**0.00856**	0	---	---
	6/3/1993	ND	ND	ND	ND	0	ND	---
	11/2/1993	ND	**.00570 B**	ND	ND	0	ND	---
	6/15/1994	ND	**0.004**	**0.004**	**0.004**	0	ND	---
	12/1/1994	ND	**.005 B**	ND	ND	0	ND	---
	6/7/1995	ND	**.003 B**	ND	ND	0	ND	---
	11/7/1995	ND	ND	ND	ND	0	ND	---
	6/5/1996	<10	ND	ND	ND	<10	<50	---
	6/4/1997	<10	ND	ND	ND	<10	<50	---
	4/30/1998	<0.1	ND	ND	ND	<0.1	ND	---
	5/13/1999	ND	ND	ND	ND	0	ND	---
	4/3/2000	ND	ND	ND	ND	0	ND	---
	4/21/2001	ND	ND	ND	ND	0	ND	---
	5/4/2002	ND	ND	ND	ND	0	ND	---
	5/7/2003	ND	ND	ND	ND	0	ND	---
Fish #1	5/27/1992	ND	ND	**0.0041**	**0.0041**	0	ND	ND
	6/7/1995	ND	ND	ND	ND	0	ND	---
Fish #2	5/27/1992	ND	ND	**0.0054**	**0.0054**	0	ND	ND
	6/7/1995	ND	ND	ND	ND	0	ND	---
Fish #3	5/27/1992	ND	ND	**0.0042**	**0.0042**	0	ND	ND
	6/7/1995	ND	**.005 B**	**0.003**	**0.003**	0	ND	---
Fish #4	5/27/1992	ND	**0.62***	**1.362**	**1.362**	0	ND	ND
	12/10/1992	ND	**0.09**	**0.1902**	**0.1902**	0	---	ND
	6/2/1993	---	---	---	---	0	ND	---

TABLE 7: GROUNDWATER SAMPLING RESULTS, SOUTHWEST AREA

		PAHs (ug/L)					**Phenols (ug/L)**	**PCBs (ug/L)**
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P Equiv.***	**PCP**	**TOTAL PCBs**
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**0.04**
Monitoring Well	**Sample Date**							
Fish#4 (cont)	7/22/1993	ND	ND	ND	ND	0	---	---
	2/24/1994	<0.09	**0.67***	**1.3**	**1.3**	<0.09	ND	---
	6/15/1994	<0.09	**1.11***	**3.18**	**3.18**	<0.09	ND	---
	12/1/1994	ND	**.012 B**	**0.024**	**0.024**	0	ND	---
	6/7/1995	ND	ND	ND	ND	0	ND	---
	11/7/1995	ND	**2.6***	**5.2**	**5.2**	0	ND	---
	6/5/1997	<10	**3***	**6**	**6**	<10	<50	---
	5/1/1998	<0.1	**0.2***	**0.37**	**0.37**	<0.1	ND	---
	5/17/1999	ND	**0.32***	**0.35**	**0.35**	0	ND	---
	4/4/2000	ND	**0.03**	**0.03**	**0.03**	0	ND	---
	4/24/2001	ND	ND	ND	ND	0	ND	---
	5/6/2002	ND	ND	ND	ND	0	ND	---
	5/7/2003	ND	ND	ND	ND	0	ND	---

NOTES: All criteria listed are MDH values (see App. E)

ND = Compound not detected

░ = compound not detected, but detection limit exceeded drinking water criteria

▒ = compound detected at a concentration exceeding the drinking water standard

--- = compound not analyzed

ND* detection limit unknown

* exceeds LLBO groundwater cleanup level (which evaluates both human and ecological risk)

** data is suspect as it does not match historical data

ug/L = micrograms per liter, or parts per billion

ng/L = nanograms per liter, or parts per trillion

PCP = pentachlorophenol

PAH = polynuclear aromatic hydrocarbon

PCB = polychlorinated biphenyls

B(a)P = benzo(a)pyrene

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						**PCBs (ng/L)**	**Dioxins (ng/L)**	**Pesticides (ug/L)**		
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	***PCP (ug/L)***	***TOTAL PCBs***	***TCDD Equiv.***	***DDD***	***DDE***	***DDT***
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
Surficial Aquifer												
2101	12/7/1984	ND	**0.0062**	**0.24**	**0.24**	0	<5	---	---	---	---	---
	1/9/1985	**0.011**	**0.045**	**0.24**	**0.254**	**0.0008**	<5	---	---	---	---	---
	4/25/1985	**0.023**	ND	**0.051**	**0.074**	**0.0032***	<5	---	---	---	---	---
	9/17/1985	ND	**0.0049**	**0.014**	**0.014**	0	<5	---	---	---	---	---
	12/19/1985	ND	ND	**0.0084**	**0.0084**	0	<5	---	---	---	---	---
	6/24/1987	**0.0066**	**0.012**	**0.0296**	**0.0362**	0	<6	---	---	---	---	---
2102	12/6/1984	**3,300**	**6,800**	**15,060**	**18,360**	<100	**45,000**	---	---	---	---	---
	1/9/1985	**2,569**	**4,100**	**10,035**	**12,604**	**3.84**	**49,000**	---	---	---	---	---
	4/25/1985	**1,000**	**3,500**	**6,980**	**7,980**	<50	**32,000**	---	---	---	---	---
	8/22/1985	**97**	**3,300**	**9,339**	**9,436**	**5.65**	**27,000**	---	**9.25**	---	---	---
	10/10/2001*	**200**	**1,200**	**2,996**	**3,196**	**42.5**	**12,000**	**0.24**	---	**0.13***	**0.3***	ND
2103	12/6/1984	**370**	**2,600**	**6,917**	**7,287**	<50	**13,000**	---	---	---	---	---
	1/11/1985	**300**	**2,200**	**5,887**	**6,187**	<10	**1,300**	---	---	---	---	---
	4/25/1985	**180**	**1,600**	**4,568**	**4,648**	<25	**21,000**	---	---	---	---	---
	8/22/1985	**53**	**1,500**	**5,860**	**5,918**	**3**	**8,800**	---	**41.1**	---	---	---
2104	12/6/1984	**3,090**	**17,000**	**83,740**	**86,830**	**462**	**62,000**	---	---	---	---	---
	1/11/1985	**4,190**	**22,000**	**121,430**	**125,620**	**238**	**52,000**	---	---	---	---	---
	4/25/1985	**410**	**4,300**	**15,210**	**15,620**	**17**	**26,000**	---	---	---	---	---
	8/22/1985	**540**	**2,600**	**10,188**	**10,728**	**16**	**20,000**	---	**51.8**	---	---	---
2105	1/1/1985	**30,000**	**340,000**	**1,019,500**	**1,049,500**	**1,830**	**130,000**	---	---	---	---	---
	4/25/1985	**16,800**	**180,000**	**536,700**	**553,500**	**2,589**	**59,000**	---	---	---	---	---
	8/22/1985	**296,000**	**1,100,000**	**8,383,600**	**8,679,600**	**66,950**	**440,000**	---	**109.9**	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						**PCBs (ng/L)**	**Dioxins (ng/L)**	**Pesticides (ug/L)**		
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P Equiv.***	***PCP (ug/L)***	***TOTAL PCBs***	***TCDD Equiv.***	***DDD***	***DDE***	***DDT***
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
2106	1/10/1985	**1,300**	**2,100**	**4,038**	**5,338**	<10	**79,000**	---	---	---	---	---
	4/25/1985	<5	**590**	**1,233**	**1,233**	<5	**39,000**	---	---	---	---	---
	8/22/1985	<10	**1,500**	**3,470**	**3,470**	<10	**19,000**	---	**0.041**	---	---	---
	10/10/2001*	<73	**1,500**	**2,169**	**2,169**	<73	**2,300**	ND	---	ND	ND	**0.069***
2126	12/19/1986	**0.144**	ND	**0.1568**	**0.3**	**0.0266***	ND	---	---	---	---	---
2127	5/6/1986	ND	ND	**0.0031**	**0.0031**	0	ND	---	---	---	---	---
	6/30/1988	**0.0017**	**0.0074**	**0.0884**	**0.0901**	**0.00017**	ND	---	---	---	---	---
	6/28/1989	ND	**0.073**	**0.0892**	**0.0892**	0	ND	---	---	---	---	---
	6/28/1990	ND	**0.0019**	**0.0034**	**0.0034**	0	ND	---	---	---	---	---
	6/19/1991	ND	**.13 B***	**0.317**	**0.317**	0	ND	---	---	---	---	---
	5/27/1992	ND	ND	**0.0065**	**0.0065**	0	ND	ND	---	---	---	---
	6/2/1993	---	---	---	---	---	ND	---	---	---	---	---
	7/22/1993	ND	**.00882 B**	**0.009**	**0.009**	0	---	---	---	---	---	---
	6/15/1994	ND	ND	ND	ND	0	ND	---	---	---	---	---
	6/6/1995	ND	**0.003**	**0.003**	**0.003**	0	ND	---	---	---	---	---
	6/4/1996	<10	ND	<10	<10	0	<50	---	---	---	---	---
	6/5/1997	<10	ND	<10	<10	0	<50	---	---	---	---	---
	4/29/1998	ND	ND	ND	ND	0	<5	---	---	---	---	---
	5/17/1999	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/5/2000	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/20/2001	ND	ND	ND	ND	0	ND	---	---	---	---	---
	5/1/2002	ND	ND	ND	ND	0	ND	---	---	---	---	---
	5/4/2003	ND	ND	ND	ND	0	ND	---	---	---	---	---
2128	8/22/1985	ND	ND	ND	ND	0	ND	ND	---	---	---	---
	5/6/1986	ND	**1,200**	**1,720**	**1,720**	0	**1,700**	---	---	---	---	---
	4/27/1987	---	---	---	---	---	---	<200	---	---	---	---
	6/30/1988	ND	ND	**254.7**	**254.7**	0	**2,100**	---	---	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						PCBs (ng/L)	Dioxins (ng/L)	Pesticides (ug/L)		
		Sum List 1	Naphthalene	*Sum List 2*	*Total PAH*	B*(a)P Equiv.*	*PCP (ug/L)*	*TOTAL PCBs*	*TCDD Equiv.*	*DDD*	*DDE*	*DDT*
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
2128 (cont.)	6/28/1989	<120	**1,200**	**1,500**	**1,500**	<120	**760**	---	---	---	---	---
	6/28/1990	<10	ND	**5**	**5**	<10	**190**	---	---	---	---	---
	6/19/1991	<10	ND	ND	ND	<10	**99**	---	---	---	---	---
	5/27/1992	ND	ND	ND	ND	0	<10	ND	---	---	---	---
	6/2/1993	---	---	---	---	---	**130**	---	---	---	---	---
	7/22/1993	ND	**1.06 B***	**7.47**	**7.47**	0	---	---	---	---	---	---
	6/15/1994	ND	ND	**7.7**	**7.7**	0	**38**	---	---	---	---	---
	6/6/1995	ND	**13***	**40.08**	**40.08**	0	**120**	---	---	---	---	---
	6/5/1997	<10	**96***	**157**	**157**	<10	**79**	---	---	---	---	---
	5/17/1999	ND	**23***	**24.4**	**24.4**	0	**3.7**	---	---	---	---	---
	4/5/2000	ND	**23***	**24.95**	**24.95**	0	**4**	---	---	---	---	---
	4/20/2001	ND	**49***	**51**	**51**	0	**48**	---	---	---	---	---
	5/3/2002	ND	**43***	**44.85**	**44.85**	0	ND	---	---	---	---	---
	5/4/2003	ND	**25***	**26.54**	**26.54**	0	**25**	---	---	---	---	---
2129	5/6/1986	ND	ND	**0.0026**	**0.0026**	0	ND	---	---	---	---	---
	6/30/1988	ND	**0.0045**	**0.0211**	**0.0211**	0	ND	---	---	---	---	---
	6/28/1989	<10	ND	<10	<10	<10	ND	---	---	---	---	---
	6/28/1990	ND	**0.0028**	**0.0054**	**0.0054**	0	ND	---	---	---	---	---
	6/19/1991	**0.004**	**.0047 B**	**0.0073**	**0.0113**	**0.00004**	ND	---	---	---	---	---
	5/27/1992	ND	**.005 B**	ND	ND	0	ND	ND	---	---	---	---
	6/2/1993	---	---	---	---	---	ND	---	---	---	---	---
	7/22/1993	ND	**.0146 B**	ND	ND	0	---	---	---	---	---	---
	6/15/1994	ND	**.004 B**	ND	ND	0	ND	---	---	---	---	---
	6/6/1995	ND	**0.004**	**0.004**	**0.004**	0	ND	---	---	---	---	---
	6/4/1996	<10	ND	<10	<10	<10	<50	---	---	---	---	---
	6/5/1997	<10	ND	<10	<10	<10	<50	---	---	---	---	---
	4/29/1998	ND	ND	ND	ND	0	<5	---	---	---	---	---
	5/17/1999	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/6/2000	ND	ND	ND	ND	0	ND	---	---	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						**PCBs (ng/L)**	**Dioxins (ng/L)**	**Pesticides (ug/L)**		
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	***PCP (ug/L)***	***TOTAL PCBs***	***TCDD Equiv.***	***DDD***	***DDE***	***DDT***
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
2129 (cont.)	4/20/2001	ND	ND	ND	ND	0	**1.5***	---	---	---	---	---
	5/3/2002	ND	**0.034**	**0.034**	**0.034**	0	ND	---	---	---	---	---
	5/4/2003	ND	ND	ND	ND	0	ND	---	---	---	---	---
2133	12/19/1985	**0.0067**	ND	**0.00029**	**0.0069**	**0.00029**	ND	---	---	---	---	---
	12/17/1986	ND	ND	**0.0211**	**0.0211**	0	ND	---	---	---	---	---
	6/25/1987	**0.0039**	**0.012**	**0.0287**	**0.0326**	0	<6	---	---	---	---	---
2134	4/21/1986	ND	**4.7***	**15**	**15**	0	**610**	---	---	---	---	---
	7/2/1986	ND	ND	**0.33**	**0.33**	0	**470**	---	---	---	---	---
	12/18/1986	ND	ND	**1.2**	**1.2**	0	**1,600**	---	---	---	---	---
	4/27/1987	---	---	---	---		---	<200	---	---	---	---
	6/30/1988	ND	ND	ND	ND	0	**4,600**	---	---	---	---	---
	6/28/1989	ND	**0.013**	**6.513**	**6.513**	0	**74**	---	---	---	---	---
	6/28/1990	<10	**0.0028**	**0.0028**	**0.0028**	0	ND	---	---	---	---	---
	6/20/1991	<10	ND	<10	<10	<10	ND	---	---	---	---	---
	5/28/1992	ND	ND	ND	ND	0	ND	ND	---	---	---	---
	6/2/1993	---	---	---	---	---	ND	---	---	---	---	---
	7/22/1993	**0.0167**	**.0199 B**	**0.4367**	**0.4534**	**0.00091**	---	---	---	---	---	---
	6/15/1994	ND	ND	ND	ND	0	ND	---	---	---	---	---
	6/6/1995	ND	**0.004**	**0.004**	**0.004**	0	ND	---	---	---	---	---
	6/5/1997	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	5/15/1999	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/26/2001	ND	ND	ND	ND	0	ND	---	---	---	---	---
2135	3/26/1986	ND	**0.033**	**0.01465**	**0.01465**	0	ND	---	---	---	---	---
	4/25/1986	ND	**0.024**	**0.0692**	**0.0692**	0	ND	---	---	---	---	---
	7/2/1986	ND	ND	**0.0069**	**0.0069**	0	ND	---	---	---	---	---
	12/18/1986	ND	**0.11***	**0.2396**	**0.2396**	0	ND	---	---	---	---	---
	6/30/1988	ND	**0.009**	**0.0347**	**0.0347**	0	ND	---	---	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						PCBs (ng/L)	Dioxins (ng/L)	Pesticides (ug/L)		
		Sum List 1	Naphthalene	*Sum List 2*	*Total PAH*	B*(a)*P *Equiv.*	*PCP (ug/L)*	*TOTAL PCBs*	*TCDD Equiv.*	*DDD*	*DDE*	*DDT*
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
2135 (cont.)	6/28/1989	ND	**0.0036**	**0.0049**	**0.0049**	0	ND	---	---	---	---	---
	6/28/1990	ND	**0.0021**	**0.0038**	**0.0038**	0	ND	---	---	---	---	---
	6/20/1991	ND	ND	**0.01**	**0.01**	0	ND	---	---	---	---	---
	5/28/1992	ND	**.0048 B**	**0.0078**	**0.0078**	0	ND	ND	---	---	---	---
	6/2/1993	---	---	---	---	---	ND	---	---	---	---	---
	7/22/1993	**0.01626**	**.00847 B**	**0.1714**	**0.1877**	**0.00071**	---	---	---	---	---	---
	6/15/1994	ND	ND	ND	ND	0	ND	---	---	---	---	---
	6/6/1995	ND	**0.003**	**0.003**	**0.003**	0	ND	---	---	---	---	---
	6/4/1996	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	6/5/1997	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	4/29/1998	ND	ND	ND	ND	0	<5	---	---	---	---	---
	5/15/1999	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/5/2000	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/26/2001	ND	ND	ND	ND	0	ND	---	---	---	---	---
	5/5/2002	ND	**0.046**	**0.085**	**0.085**	0	ND	---	---	---	---	---
	5/8/2003	ND	ND	ND	ND	0	ND	---	---	---	---	---
Base of surficial aquifer												
2201	12/19/1985	ND	ND	ND	ND	0	ND	---	---	---	---	---
	12/17/1986	**0.0017**	ND	**0.0116**	**0.0133**	**0.000017**	ND	---	---	---	---	---
	6/25/1987	**0.0193**	**0.011**	**0.0321**	**0.0514**	**0.000215**	<6	---	---	---	---	---
2226	12/19/1985	**0.0835**	ND	**0.1022**	**0.1857**	**0.01835***	ND	---	---	---	---	---
	12/17/1986	**0.0015**	ND	**0.0289**	**0.0304**	**0.000015**	ND	---	---	---	---	---
2234	6/30/1988	ND	**0.056**	**0.1271**	**0.1271**	0	ND	---	---	---	---	---
	6/29/1989	**0.0044**	**0.002**	**0.1564**	**0.1608**	**0.00079**	ND	---	---	---	---	---
	6/20/1991	ND	**.0045 B**	ND	ND	0	ND	---	---	---	---	---
	5/28/1992	ND	ND	ND	ND	0	ND	ND	---	---	---	---
	12/10/1992	ND	ND	ND	ND	0	ND	---	---	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						**PCBs (ng/L)**	**Dioxins (ng/L)**	**Pesticides (ug/L)**		
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	***PCP (ug/L)***	***TOTAL PCBs***	***TCDD Equiv.***	***DDD***	***DDE***	***DDT***
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
2234 (cont.)	6/2/1993	---	---	---	---	---	ND	---	---	---	---	---
	7/22/1993	ND	ND	**4.628**	**4.628**	0	---	---	---	---	---	---
	11/2/1993	**0.0133**	**.0271 B**	**0.06623**	**0.07953**	0	ND	---	---	---	---	---
	6/15/1994	ND	ND	ND	ND	0	ND	---	---	---	---	---
	12/1/1994	**0.007**	**.014 B**	**0.04**	**0.047**	**0.00007**	ND	---	---	---	---	---
	6/6/1995	ND	**0.004**	**0.004**	**0.004**	0	ND	---	---	---	---	---
	6/4/1996	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	6/5/1997	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	4/29/1998	ND	ND	ND	ND	0	<5	---	---	---	---	---
	5/15/1999	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/5/2000	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/26/2001	ND	ND	ND	ND	0	ND	---	---	---	---	---
	5/3/2002	ND	ND	ND	ND	0	ND	---	---	---	---	---
	5/6/2003	ND	ND	ND	ND	0	ND	---	---	---	---	---
2401	12/21/1988	<1,000	**11,000**	**17,400**	**17,400**	<1,000	**16,000**	<5,000	**10.2**	ND	ND	ND
	6/2/1993	**560**	**890**	**2,076**	**2,636**	<20	**4,200**	---	---	---	---	---
	6/15/1994	**813**	**1,920**	**4,188**	**5,001**	**6**	**3,800**	---	---	---	---	---
	8/24/1994	---	---	---	---	---	---	<2,000	---	---	---	---
	6/7/1995	**380**	**550**	**2,509**	**2,889**	<100	**1,800**	---	---	---	---	---
	6/5/1997	**784**	**1,800**	**3,889**	**3,663**	<400	**5,700**	---	---	---	---	---
	5/14/1999	**383**	ND	**1,267**	**1,650**	**31**	**4,400**	---	---	---	---	---
	5/7/2001	**417**	ND	**819**	**1,236**	**2**	**3,200**	---	---	---	---	---
	5/9/2003	**424**	**2,400**	**3,280**	**3,704**	**1**	**3,100**	---	---	---	---	---
2402	12/21/1988	<500	**1,700**	**1,700**	**1,700**	<500	**17,000**	<50,000	**1,185**	<1.1	ND	<1.2
	12/19/1989	---	---	---	---	---	**2,500**	---	---	---	---	---
	6/28/1990	ND	**0.2***	**1.8**	**1.8**	ND	**1,100**					
	12/4/1990	---	---	---	---	---	**700**	---	---	---	---	---
	6/20/1991	<30	ND	<30	<30	<30	**720**	---	---	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						**PCBs (ng/L)**	**Dioxins (ng/L)**	**Pesticides (ug/L)**		
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	***PCP (ug/L)***	***TOTAL PCBs***	***TCDD Equiv.***	***DDD***	***DDE***	***DDT***
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
2402 (cont.)	12/17/1991	---	---	---	---	---	**820**	---	---	---	---	---
	5/27/1992	<10	ND	<10	<10	<10	**580**	---	---	---	---	---
	6/2/1993	<10	ND	<10	<10	<10	**450**	---	---	---	---	---
	6/15/1994	<0.06	**0.081**	**0.081**	**0.081**	<0.06	**280**	---	---	---	---	---
	8/24/1994	---	---	---	---	---	---	<1,000	---	---	---	---
	6/7/1995	<10	ND	<10	<10	<10	**220**	---	---	---	---	---
	6/5/1997	<80	<80	<80	<80	<80	**1,000**	---	---	---	---	---
	5/14/1999	<10	ND	<10	<10	<10	**1,400**	---	---	---	---	---
	4/16/2001	<10	ND	<10	<10	<10	**340**	---	---	---	---	---
	5/9/2003	<10	ND	<10	<10	<10	ND	---	---	---	---	---
2403	12/21/1988	<210	**820**	**820**	**820**	<210	**6,900**	<50,000	**7.5**	<1.1	ND	<1.2
	12/19/1989	---	---	---	---	---	**4,500**	---	---	---	---	---
	6/28/1990	**24**	**660**	**1,241**	**1,265**	<29	**3,000**	---	---	---	---	---
	12/4/1990	---	---	---	---	---	**2,600**	---	---	---	---	---
	6/20/1991	**43**	<100	**275**	**318**	<100	**3,000**	---	---	---	---	---
	12/17/1991	---	---	---	---	---	**3,800**	---	---	---	---	---
	5/27/1992	**32**	**720**	**1,204**	**1,236**	<50	**3,400**	---	---	---	---	---
	6/2/1993	**77**	**580**	**1,116**	**1,193**	<20	**2,800**	---	---	---	---	---
	6/15/1994	**76**	**880**	**1,670**	**1,746**	<100	**1,900**	<1,000,000	---	---	---	---
	6/7/1995	**41**	**78**	**550**	**591**	<50	**1,600**	---	---	---	---	---
	6/5/1997	<300	<300	<300	<300	<300	**2,200**	---	---	---	---	---
	5/14/1999	**58**	**1,300**	**1,460**	**1,518**	<10	**3,500**	---	---	---	---	---
	4/16/2001	<9.6	ND	**85**	**85**	<9.6	**3,000**	---	---	---	---	---
	5/9/2003	**16**	**1,600**	**1,769**	**1,785**	<10	**1,800**	---	---	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						**PCBs (ng/L)**	**Dioxins (ng/L)**	**Pesticides (ug/L)**		
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)*P *Equiv.***	***PCP (ug/L)***	***TOTAL PCBs***	***TCDD Equiv.***	***DDD***	***DDE***	***DDT***
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
Deep aquifer												
2301	12/19/1985	**0.0056**	ND	**0.0103**	**0.0159**	**0.000056**	ND	---	---	---	---	---
	12/17/1986	ND	ND	**0.0109**	**0.0109**	0	ND	---	---	---	---	---
	6/15/1987	---	---	---	---	---	---	**1**	---	---	---	---
	6/30/1988	ND	**0.0098**	**0.0458**	**0.0458**	0	ND	---	---	---	---	---
	12/15/1988	**0.0275**	**0.21***	**0.6803**	**0.7078**	**0.00795***	---	---	---	---	---	---
	3/28/1989	ND	**0.018**	**0.0851**	**0.0851**	0	ND	---	---	---	---	---
	6/29/1989	ND	**0.04**	**0.094**	**0.094**	0	ND	---	---	---	---	---
	12/14/1989	ND	ND	**0.024**	**0.024**	0	ND	---	---	---	---	---
	6/28/1990	ND	**0.0082**	**0.0292**	**0.0292**	0	ND	---	---	---	---	---
	12/4/1990	ND	**0.046**	**0.1099**	**0.1099**	0	ND	---	---	---	---	---
	6/20/1991	ND	**.004 B**	ND	ND	0	ND	---	---	---	---	---
	12/17/1991	**0.0137**	**.014 B**	**0.1105**	**0.1242**	**0.01047***	ND	---	---	---	---	---
	5/28/1992	ND	**.0062 B**	**0.024**	**0.024**	0	ND	ND	---	---	---	---
	6/2/1993	---	---	---	---	---	ND	---	---	---	---	---
	7/22/1993	ND	**.0135 B**	**0.026**	**0.026**	0	---	---	---	---	---	---
	6/15/1994	<10	<10	<10	<10	<10	<5	---	---	---	---	---
	6/7/1995	ND	**.01 B**	**0.022**	**0.022**	0	ND	---	---	---	---	---
	6/4/1997	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	5/15/1999	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/20/2001	ND	**0.058**	**0.164**	**0.164**	0	ND	---	---	---	---	---
	5/8/2003	ND	**0.13***	**0.13**	**0.13**	0	ND	---	---	---	---	---
2325	12/19/1985	**0.0058**	ND	**0.038**	**0.0438**	**0.00022**	ND	---	---	---	---	---
	3/4/1986	ND	ND	**0.0108**	**0.0108**	0	ND	---	---	---	---	---
	5/6/1986	**0.0011**	ND	**0.0191**	**0.0202**	**0.00011**	ND	---	---	---	---	---
	7/2/1986	ND	ND	**0.0086**	**0.0086**	0	ND	---	---	---	---	---
	12/17/1986	**0.0014**	ND	**0.0147**	**0.0161**	**0.000014**	ND	---	---	---	---	---
	6/15/1987	---	---	---	---	---	---	<2	---	---	---	---
	6/30/1988	ND	**0.007**	**0.0468**	**0.0468**	0	ND	---	---	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						**PCBs (ng/L)**	**Dioxins (ng/L)**	**Pesticides (ug/L)**		
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	***PCP (ug/L)***	***TOTAL PCBs***	***TCDD Equiv.***	***DDD***	***DDE***	***DDT***
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
2325 (cont.)	12/15/1988	ND	**0.044**	**0.1214**	**0.1214**	0	ND	---	---	---	---	---
	3/28/1989	ND	**0.022**	**0.0854**	**0.0854**	0	---	---	---	---	---	---
	6/29/1989	ND	**0.021**	**0.0634**	**0.0634**	0	ND	---	---	---	---	---
	12/14/1989	ND	**0.031**	**0.1603**	**0.1603**	0	ND	---	---	---	---	---
	6/28/1990	ND	**0.0099**	**0.0349**	**0.0349**	0	ND	---	---	---	---	---
	12/4/1990	ND	**0.0062**	**0.0127**	**0.0127**	0	ND	---	---	---	---	---
	6/20/1991	ND	**0.0047 B**	ND	ND	0	ND	---	---	---	---	---
	12/17/1991	ND	**.0094 B**	**0.1373**	**0.1373**	0	ND	---	---	---	---	---
	5/28/1992	ND	**.009 B**	**0.0108**	**0.0108**	0	ND	ND	---	---	---	---
	6/2/1993	---	---	---	---	---	ND	---	---	---	---	---
	7/22/1993	**0.014**	**.0113 B**	**0.217**	**0.231**	**0.00059**	---	---	---	---	---	---
	6/15/1994	<10	<10	<10	<10	<10	<5	---	---	---	---	---
	6/7/1995	ND	**0.004**	**0.004**	**0.004**	0	ND	---	---	---	---	---
	6/5/1997	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	5/18/1999	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/26/2001	ND	ND	ND	ND	0	ND	---	---	---	---	---
	5/5/2003	ND	ND	ND	ND	0	ND	---	---	---	---	---
2326	12/19/1985	ND	ND	**0.0143**	**0.0143**	0	ND	---	---	---	---	---
	3/4/1986	ND	ND	**0.0129**	**0.0129**	0	ND	---	---	---	---	---
	5/6/1986	**0.0021**	ND	**0.0813**	**0.0834**	**0.0855***	ND	---	---	---	---	---
	7/2/1986	ND	ND	ND	ND	0	**PP <5**	---	---	---	---	---
	6/30/1988	ND	**0.0071**	**0.0319**	**0.0319**	0	ND	---	---	---	---	---
	12/15/1988	ND	**0.47***	**1.95**	**1.95**	0	ND	---	---	---	---	---
	3/28/1989	**0.011**	**0.034**	**0.17**	**0.181**	**0.00021**	---	---	---	---	---	---
	6/29/1989	ND	**0.017**	**0.0464**	**0.0464**	0	ND	---	---	---	---	---
	6/28/1990	<10	<10	<10	<10	<10	ND	---	---	---	---	---
	6/20/1991	<10	<10	<10	<10	<10	ND	---	---	---	---	---
	5/28/1992***	ND	**10***	**16**	**16**	0	**68**	ND	---	---	---	---
	8/27/1992	ND	ND	ND	ND	0	ND	ND	---	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						**PCBs (ng/L)**	**Dioxins (ng/L)**	**Pesticides (ug/L)**		
		Sum List 1	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P* *Equiv.***	***PCP (ug/L)***	***TOTAL PCBs***	***TCDD Equiv.***	***DDD***	***DDE***	***DDT***
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
2326 (cont.)	6/2/1993	<10	---	---	---	---	ND	---	---	---	---	---
	7/22/1993	ND	**.0194 B**	**0.1538**	**0.1538**	0	---	---	---	---	---	---
	6/15/1994	ND	ND	ND	ND	0	ND	---	---	---	---	---
	6/7/1995	ND	**.014 B**	**0.035**	**0.035**	0	ND	---	---	---	---	---
	6/4/1997	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	5/15/1999	ND	**0.07**	**0.1**	**0.1**	0	ND	---	---	---	---	---
	4/26/2001	ND	**0.068**	**0.2**	**0.2**	0	ND	---	---	---	---	---
	5/8/2003	ND	**0.067**	**0.067**	**0.067**	0	ND	---	---	---	---	---
2329	6/15/1994	ND	ND	ND	ND	0	ND	---	---	---	---	---
	6/6/1995	ND	**0.004**	**0.004**	ND	0	ND	---	---	---	---	---
	6/5/1997	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	5/17/1999	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/20/2001	ND	ND	ND	ND	0	ND	---	---	---	---	---
	10/12/2001**	ND	ND	**0.038**	**0.038**	0	**2.7***	ND	ND	ND	ND	
	5/4/2003	ND	ND	ND	ND	0	ND	---	---	---	---	---
2333	12/19/1985	ND	ND	**0.011**	**0.011**	0	ND	---	---	---	---	---
	3/4/1986	ND	**0.019**	**0.0487**	**0.0487**	0	ND	---	---	---	---	---
	5/6/1986	ND	**0.079**	**0.1649**	**0.1649**	0	ND	---	---	---	---	---
	7/2/1986	ND	ND	ND	ND	0	ND	---	---	---	---	---
	12/17/1986	**0.0134**	ND	**0.1225**	**0.1359**	**0.0021***	**PP <6**	---	---	---	---	---
	6/30/1988	ND	**0.0028**	**0.0185**	**0.0185**	0	ND	---	---	---	---	---
	12/15/1988	ND	**0.23***	**0.735**	**0.735**	0	ND	---	---	---	---	---
	3/28/1989	ND	**0.03**	**0.1031**	**0.1031**	0	---	---	---	---	---	---
	6/29/1989	ND	**0.0067**	**0.0184**	**0.0184**	0	ND	---	---	---	---	---
	6/28/1990	<10	<10	<10	<10	<10	ND	---	---	---	---	---
	6/20/1991	<10	<10	<10	<10	<10	ND	---	---	---	---	---
	5/28/982	ND	ND	ND	ND	0	ND	ND	---	---	---	---
	6/2/1993	<10	---	---	---	---	ND	---	---	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						PCBs (ng/L)	Dioxins (ng/L)	Pesticides (ug/L)		
		Sum List 1	Naphthalene	*Sum List 2*	*Total PAH*	B*(a)*P *Equiv.*	*PCP (ug/L)*	*TOTAL PCBs*	*TCDD Equiv.*	*DDD*	*DDE*	*DDT*
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
2333 (cont.)	7/22/1993	ND	**.0123 B**	**0.02647**	**0.02647**	0	---	---	---	---	---	---
	6/15/1994	ND	ND	**0.146**	**0.146**	<0.15	ND	---	---	---	---	---
	6/5/1995	ND	**0.004**	**0.004**	**0.004**	0	ND	---	---	---	---	---
	6/5/1997	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	5/17/1999	ND	ND	ND	ND	0	ND	---	---	---	---	---
	4/26/2001	ND	ND	ND	ND	0	ND	---	---	---	---	---
	5/8/2003	ND	ND	ND	ND	0	ND	---	---	---	---	---
2335	4/25/1986	ND	**0.081**	**0.4677**	**0.4677**	0	**PP <5**	---	---	---	---	---
	7/2/1986	**0.0062**	**0.092**	**0.2779**	**0.284**	0	ND	---	---	---	---	---
	12/18/1986	**0.0023**	**0.021**	**0.0515**	**0.0538**	0	ND	---	---	---	---	---
	6/30/1988	ND	**0.0058**	**0.0195**	**0.0195**	0	ND	---	---	---	---	---
	12/15/1988	ND	**0.068**	**0.1821**	**0.1821**	0	ND	---	---	---	---	---
	3/28/1989	ND	**0.032**	**0.0933**	**0.0933**	0	ND	---	---	---	---	---
	6/29/1989	ND	**0.011**	**0.034**	**0.034**	0	ND	---	---	---	---	---
	12/14/1989	ND	**0.016**	**0.0637**	**0.0637**	0	ND	---	---	---	---	---
	6/28/1990	ND	**0.0035**	**0.0237**	**0.0237**	0	ND	---	---	---	---	---
	12/4/1990	ND	**0.014**	**0.0583**	**0.0583**	0	ND	---	---	---	---	---
	6/20/1991	ND	ND	**0.0112**	**0.0112**	0	ND	---	---	---	---	---
	12/17/1991	ND	ND	**0.0227**	**0.0227**	0	ND	---	---	---	---	---
	5/28/1992	ND	ND	**0.0239**	**0.0239**	0	ND	ND	---	---	---	---
	6/2/1993	---	---	---	---	---	ND	---	---	---	---	---
	7/22/1993	**0.00305**	**.0141 B**	**0.18**	**0.183**	**0.00031**	---	---	---	---	---	---
	6/15/1994	ND	ND	ND	ND	0	ND	---	---	---	---	---
	6/7/1995	ND	**.005 B**	ND	ND	0	ND	---	---	---	---	---
	6/5/1996	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	6/5/1997	<10	<10	<10	<10	<10	<50	---	---	---	---	---
	4/29/1998	ND	ND	ND	ND	0	<5	---	---	---	---	---
	5/15/1999	ND	**0.04**	**0.07**	**0.07**	0	ND	---	---	---	---	---
	4/5/2000	ND	ND	ND	ND	0	ND	---	---	---	---	---

TABLE 8: CITY DUMP AREA GROUNDWATER SAMPLING RESULTS

		PAHs (ug/L)						PCBs (ng/L)	Dioxins (ng/L)	Pesticides (ug/L)		
		Sum List 1	Naphthalene	*Sum List 2*	*Total PAH*	B*(a)P Equiv.*	*PCP (ug/L)*	*TOTAL PCBs*	*TCDD Equiv.*	*DDD*	*DDE*	*DDT*
Drinking Water Criterion		**0.05**	**300**	**0.3**	**0.3**	**0.05**	**3**	**40**	**0.03**	**1**	**1**	**1**
Monitoring Well	**Sample Date**											
2335 (cont.)	4/26/2001	ND	ND	ND	ND	0	ND	---	---	---	---	---
	5/5/2002	ND	ND	ND	ND	0	ND	---	---	---	---	---
	5/8/2003	ND	**0.06**	**0.083**	**0.083**	0	ND	---	---	---	---	---

NOTES: All criteria listed are MDH values, except for TCDD equivalent, which is based on WHO 1998 criteria (see App. E)

ND = not detected

░ = compound not detected, but detection limit exceeded drinking water criteria

▒ = compound detected at a concentration exceeding the drinking water standard

--- = compound not analyzed

* exceeds LLBO groundwater cleanup level (which evaluates both human and ecological risk)

ug/L = micrograms per liter, or parts per billion

ng/L = nanograms per liter, or parts per trillion

PCP = pentachlorophenol

PAH = polynuclear aromatic hydrocarbon

PCB = polychlorinated biphenyls

B(a)P = benzo(a)pyrene

TABLE 9: FOX CREEK SURFACE WATER SAMPLING RESULTS, 2001

		Metals (ug/L)			**PAHs (ug/L)**			**VOCs (ug/L)**			**Phenols (ug/L)**
		Arsenic	**Chromium**[a]	**Copper**[b]	**bis(2-Ethyl-hexyl) phthalate**	**Benzo(a) pyrene**	**Phen-anthrene**	**Benzene**	**cis-1,3-Dichloro-propene**	**Ethyl-benzene**	**PCP**
MN Surface Water Criterion		**53**	**11**	**12.3 - 15**	**2.1**	**0.00051**	**3.6**	**114**	**NE**	**68**	**5.5**
Sample Location*	**Sample Number**										
Near Soil Vault	FCSW-0102	**1.6**	**2**	**25**	ND	ND	ND	ND	**0.1**	ND	ND
Mouth of Fox Ck. At Pike Bay	FCCD-10-0102	**1.1**	ND	**4.7**	**2.3**	ND	**0.18**	ND	ND	ND	**0.35**
Mouth of Fox Ck. At Pike Bay	FCD-01-0102	**0.8**	ND	**21**	ND	**0.29**	ND	**0.28**	ND	**0.18**	**0.43**

Notes: only compounds that were detected in one or more samples are listed in the table

▨ = compound detected at a concentration exceeding the surface water criteria

a = criterion is for Cr-6, which is more toxic than the more common Cr-3

b = criterion depends upon hardness of water, range used is for hardness of 143-200 mg/L, based on measured hardness in Pike Bay & Fox Creek

ND = compound not detected

NE = no criterion established for this compound

* sample locations shown on Figure 26

ug/L = microgram per liter, or parts per billion

PAHs = polynuclear aromatic hydrocarbons

PCP = pentachlorophenol

The surface water criterion are from Minnesota Rules 7050.0222 subpart 4

TABLE 10: PIKE BAY AND CASS LAKE SURFACE WATER SAMPLING RESULTS, 2001

		Metals (ug/L)		PAHs (ug/L)			VOCs (ug/L)		Phenols (ug/L)
		Arsenic	Copper[a]	bis(2-Ethyl-hexyl) phthalate	Capro-lactum	Phen-anthrene	Benzene	Ethyl-benzene	PCP
MN Surface Water Criterion		**53**	**12.3 - 15**	**2.1**	**NE**	**3.6**	**114**	**68**	**5.5**
Sample Location*	**Sample Number**								
Pike Bay									
Nearshore	PB-01-0102	**1.2**	**44**	**2.4**	**4.4**	ND	**0.15**	ND	**0.34**
Deep Hole	PBDH-01-8081	**1.1**	**9.9**	**2.7**	ND	**0.44**	ND	**0.12**	ND
	PBDH-02-8081	**1.1**	**9.6**	**1.9**	ND	ND	ND	ND	ND
Cass Lake									
Deep Hole	CLDH-01-6566	**1.1**	**12**	**1.4**	ND	ND	ND	**0.11**	ND
	CLDH-02-8283	**1.1**	**9.8**	**1.7**	ND	ND	ND	ND	ND

Notes: only compounds that were detected in one or more samples are listed in the table

▨ = compound detected at a concentration exceeding the surface water criteria

a = criterion depends upon hardness of water, range used is for hardness of 143 - 200 mg/L, based on the measured hardness in Pike Bay & Fox Creek

NE = no criterion established

ND = compound not detected

* sample locations shown on Figure 26

ug/L = microgram per liter, or parts per billion

PAHs = polynuclear aromatic hydrocarbons

PCP = pentachlorophenol

The surface water criterion are from Minnesota Rules 7050.0222 subpart 4

TABLE 11: CHANNEL SURFACE WATER SAMPLING RESULTS, 2001

Sample Locations*

	North End			South End			RR Crossing RR-0102	Hwy 2 Crossing HWY-0102	Wetland WL-0102	Minnesota Surface Water Criterion (ug/L)
Compounds (in ug/L)	12/16/1986	12/4/1990	12/1/1994	12/16/1986	12/4/1990	12/1/1994	10/12/2001	10/12/2001	10/12/2001	
Arsenic	NA	NA	NA	NA	NA	NA	**1.1**	**1.1**	**1.6**	**53**
Copper	NA	NA	NA	NA	NA	NA	**21**	**25**	**26**	**12.3 - 15**[a]
2,3-Benzofuran	ND	**0.0072**	NA	ND	ND	NA	ND	ND	ND	**NE**
bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	**6.3**	ND	ND	**2.1**
Quinoline	**0.0029**	ND	NA	ND	ND	NA	ND	ND	ND	**NE**
Indene	**0.001**	ND	NA	ND	ND	NA	ND	ND	ND	**NE**
Naphthalene	ND	**0.0072**	NA	**0.0076**	ND	NA	ND	ND	ND	**81**
2-Methyl-naphthalene	ND	ND	ND	ND	**0.0025**	ND	ND	ND	ND	**NE**
1-Methyl-naphthalene	**0.0015**	**0.0021**	NA	**0.0015**	**0.0021**	NA	ND	ND	ND	**NE**
Phenanthrene	ND	**0.0046**	NA	ND	**0.004**	NA	**0.015**	ND	ND	**3.6**
Acenaphthene	**0.0017**	ND	NA	ND	ND	NA	ND	ND	ND	**20**
Carbazole	**0.0013**	ND	NA	ND	ND	NA	ND	ND	ND	**NE**
Pyrene	ND	**0.0025**	NA	ND	**0.0016**	NA	ND	ND	ND	**NE**
Fluoranthene	ND	**0.0036**	NA	ND	**0.0019**	NA	ND	ND	ND	**1.9**
Benzene	NA	NA	NA	NA	NA	NA	ND	ND	ND	**114**
Ethylbenzene	NA	NA	NA	NA	NA	NA	ND	ND	ND	**68**
PCP	ND	ND	**7**	ND	ND	**75**	**0.13**	ND	ND	**5.5**

Notes: only compounds that were detected in one or more samples are listed in the table

▓ = compound detected at a concentration exceeding the surface water criteria

░ = compound not detected, but method detection limited exceeded the surface water criteria

a = criteria depends upon hardness of water, range used is for hardness of 143 - 200 mg/L, based on measured hardness in Pike Bay & Fox Creek

ND = compound not detected

NE = no criterion established for this compound

* sample locations shown on Figure 26

ug/L = microgram per liter, or parts per billion

PAHs = polynuclear aromatic hydrocarbons

PCP = pentachlorophenol

The surface water criterion are from Minnesota Rules 7050.0222 subpart 4

TABLE 12: REFERENCE LAKE AND CREEK SURFACE WATER SAMPLING RESULTS, 2001

	Sample Locations*		Minnesota Surface Water Criterion (ug/L)
	Reference Lake	Reference Creek	
Compounds (in ug/L)	RFLK-0428	RFCR-0102	
Arsenic	1	0.95	53
Copper	15	17	12.3-15[a]
2,3-Benzofuran	ND	ND	NE
bis(2-ethylhexyl)phthalate	ND	9	2.1
Quinoline	ND	ND	NE
Indene	ND	ND	NE
Naphthalene	ND	ND	81
2-Methyl-naphthalene	ND	ND	NE
1-Methyl-naphthalene	ND	ND	NE
Phenanthrene	0.029	0.037	3.6
Acenaphthene	ND	ND	20
Carbazole	ND	ND	NE
Pyrene	ND	ND	NE
Fluoranthene	ND	ND	1.9
Benzene	ND	ND	114
Ethylbenzene	ND	ND	68
PCP	ND	ND	5.5

Notes: only compounds that were detected in one or more surface water samples are listed in the t

▨ = compound detected at a concentration exceeding the surface water criterion

a = criteria depends upon hardness of water, range used is for hardness of 143 - 200 mg/L, based on measured hardness in Pike Bay & Fox Creek

ND = compound not detected

NE = no criterion established for this compound

* sample locations shown on Figure 27

ug/L = microgram per liter, or parts per billion

PCP = pentachlorophenol

The surface water criterion are from Minnesota Rules 7050.0222 subpart 4

TABLE 13: FOX CREEK SEDIMENT SAMPLING RESULTS

	Sample Locations				Human Health Screening Value	Ecological Screening Value
	Near/Adjacent to Southwest Area					
	STA-1*	FCSW-01**	FCSW-02**	FCSW-03**		
	11/8/1995	10/11/2001	10/11/2001	10/11/2001		
Dioxin/Furan TEQ (ng/kg)	NA	**15.7**	**6.1**	**9.1**	**0.077**	**0.85**
Metals (in mg/kg)						
Arsenic	NA	**5.9**	ND	ND	**20**	**6**
Cadmium	NA	ND	ND	ND	**97**	**0.6**
Chromium	NA	**24.7**	**18**	**12.7**	**1,700**	**37.3**
Copper	NA	**15.2**	**8.6**	**8.4**	**10,000**	**35.7**
Lead	NA	**29.4**	**12.7**	**11.8**	**100**	**35**
Mercury	NA	ND	ND	ND	**0.14**	**0.174**
Silver	NA	ND	ND	ND	**NE**	**4.5**
Zinc	NA	**69.6**	**51.5**	**43.1**	**84,000**	**123**
PAHs (ug/kg)						
Acenaphthene	NA	**27**	**17**	**21**	**7,900**	**6.71**
Acenapthylene	NA	**94**	**48**	**33**	**24,000**	**5.87**
Anthracene	NA	**100**	**50**	**34**	**170,000**	**46.9**
Benzaldehyde	NA	<500	<620	<810	**NE**	**NE**
Benzo(a)anthracene	NA	**440**	**220**	**140**	**NE**	**31.7**
Benzo(a)pyrene	NA	**630**	**330**	**250**	**77**	**3.19**
B(a)P equivalents		**911**	**490**	**344**	**77**	**3.19**
Benzo(b)fluoranthene	NA	**620**	**380**	**210**	**NE**	**NE**
Benzo(g,h,i)perylene	NA	**380**	**200**	**180**	**NE**	**300**
Benzo(k)fluoranthene	NA	**700**	**330**	**230**	**NE**	**13,400**
Bis(2-ethylhexyl)phthalate	NA	ND	ND	ND	**NE**	**750**
Chrysene	NA	**730**	**370**	**230**	**NE**	**57.1**
Dibenz(a,h)anthracene	NA	**130**	**77**	**43**	**NE**	**6.22**
1,2-Dichlorobenzene	NA	<240	<300	<400	**NE**	**13**
1,4-Dichlorobenzene	NA	<290	<360	<470	**NE**	**110**
Diethyl phthalate	NA	ND	<220	<290	**NE**	**6**
Di-n-octylphthalate	NA	NA	NA	NA	**NE**	**61**
Fluoranthene	NA	**1,500**	**710**	**440**	**48,000**	**111**
Fluorene	NA	**56**	**33**	**26**	**18,000**	**21.2**
Indeno(1,2,3-cd)pyrene	NA	**370**	**190**	**130**	**NE**	**330**
Phenanthrene	NA	**680**	**350**	**220**	**130,000**	**41.9**
Pyrene	NA	**1,200**	**630**	**410**	**41,000**	**53**
Pesticides (ug/kg)						
g-Chlordane	NA	NA	NA	NA	**NE**	**4.5**
4,4'-DDD	NA	NA	NA	NA	**NE**	**3.54**
4,4'-DDE	NA	NA	NA	NA	**NE**	**1.42**
4,4'-DDT	NA	NA	NA	NA	**NE**	**6.98**
Dieldrin	NA	NA	NA	NA	**NE**	**2.85**
Endrin	NA	NA	NA	NA	**NE**	**2.67**
Total PCBs (mg/kg)	<0.5	NA	NA	NA	**0.013**	**0.034**
Phenols (mg/kg)						
PCP	NA	<2,500	<3,100	<4,400	**NE**	**NE**
Phenol	NA	NA	NA	NA	**NE**	**0.048**

TABLE 13: FOX CREEK SEDIMENT SAMPLING RESULTS

	Sample Locations					Human Health Screening Value	Ecological Screening Value
	Near/Adjacent to City Dump						
	EPA-1**	**EPA-2****	**STA-2***	**STA-3***	**STA-4***		
	5/11/1983	5/11/1983	11/8/1995	11/8/1995	11/8/1995		
Dioxin/Furan TEQ (ng/kg)	NA	NA	NA	NA	NA	**0.077**	**0.85**
Metals (in mg/kg)							
Arsenic	NA	NA	NA	NA	NA	**20**	**6**
Cadmium	NA	NA	NA	NA	NA	**97**	**0.6**
Chromium	NA	NA	NA	NA	NA	**1,700**	**37.3**
Copper	NA	NA	NA	NA	NA	**10,000**	**35.7**
Lead	NA	NA	NA	NA	NA	**100**	**35**
Mercury	NA	NA	NA	NA	NA	**0.14**	**0.174**
Silver	NA	NA	NA	NA	NA	**NE**	**4.5**
Zinc	NA	NA	NA	NA	NA	**84,000**	**123**
PAHs (ug/kg)							
Acenaphthene	ND	ND	NA	NA	NA	**7,900**	**6.71**
Acenapthylene	ND	ND	NA	NA	NA	**24,000**	**5.87**
Anthracene	**0.28**	**0.7**	NA	NA	NA	**170,000**	**46.9**
Benzaldehyde	ND	ND	NA	NA	NA	**NE**	**NE**
Benzo(a)anthracene	**0.4**	ND	NA	NA	NA	**NE**	**31.7**
Benzo(a)pyrene	ND	ND	NA	NA	NA	**77**	**3.19**
B(a)P equivalent	**0.042**	ND	NA	NA	NA	**77**	**3.19**
Benzo(b)fluoranthene	ND	ND	NA	NA	NA	**NE**	**NE**
Benzo(g,h,i)perylene	ND	ND	NA	NA	NA	**NE**	**300**
Benzo(k)fluoranthene	**0.2**	ND	NA	NA	NA	**NE**	**13,400**
Bis(2-ethylhexyl)phthalate	**0.48**	ND	NA	NA	NA	**NE**	**750**
Chrysene	**0.4**	ND	NA	NA	NA	**NE**	**57.1**
Dibenzo(a,h)anthracene	ND	ND	NA	NA	NA	**NE**	**6.22**
1,2-Dichlorobenzene	ND	**3**	NA	NA	NA	**NE**	**13**
1,4-Dichlorobenzene	ND	**4.4**	NA	NA	NA	**NE**	**110**
Diethyl phthalate	ND	ND	NA	NA	NA	**NE**	**6**
Di-n-octylphthalate	ND	**0.32**	NA	NA	NA	**NE**	**61**
Fluoranthene	**0.64**	ND	NA	NA	NA	**48,000**	**111**
Fluorene	ND	ND	NA	NA	NA	**18,000**	**21.2**
Indeno(1,2,3-cd)pyrene	ND	ND	NA	NA	NA	**NE**	**330**
Phenanthrene	**0.28**	**0.7**	NA	NA	NA	**130,000**	**41.9**
Pyrene	**0.52**	ND	NA	NA	NA	**41,000**	**53**
Pesticides (ug/kg)							
g-Chlordane	ND	ND	NA	NA	NA	**NE**	**4.5**
4,4'-DDD	ND	ND	NA	NA	NA	**NE**	**3.54**
4,4'-DDE	ND	ND	NA	NA	NA	**NE**	**1.42**
4,4'-DDT	ND	ND	NA	NA	NA	**NE**	**6.98**
Dieldrin	ND	ND	NA	NA	NA	**NE**	**2.85**
Endrin	ND	ND	NA	NA	NA	**NE**	**2.67**
Total PCBs (mg/kg)	NA	NA	<0.5	<0.5	<0.5	**0.013**	**0.034**
Phenols (mg/kg)							
PCP	NA	NA	NA	NA	NA	**NE**	**NE**
Phenol	ND	**0.8**	NA	NA	NA	**NE**	**0.048**

TABLE 13: FOX CREEK SEDIMENT SAMPLING RESULTS

	Sample Locations						Human Health Screening Value	Ecological Screening Value
	Near/Adjacent to City Dump							
	STA-5*	FCCD-01**	FCCD-02**	FCCD-03**	FCCD-04**	FCCD-05**		
	11/8/1995	10/10/2001	10/10/2001	10/10/2001	10/10/2001	10/10/2001		
Dioxin/Furan TEQ (ng/kg)	NA	175.7	154.4	155.8	47	123.7	0.077	0.85
Metals (in mg/kg)								
Arsenic	NA	11.8	14.9	29.1	9	18.2	20	6
Cadmium	NA	4.8	6.1	12.6	1.8	5.3	97	0.6
Chromium	NA	27.3	30.8	43.4	14.9	34.5	1,700	37.3
Copper	NA	230	307	523	87.7	192	10,000	35.7
Lead	NA	201	260	493	113	247	100	35
Mercury	NA	2.8	3.4	10.2	0.94	10	0.14	0.174
Silver	NA	32.9	42.2	80.7	10.8	21.3	NE	4.5
Zinc	NA	1,100	1,630	4,090	791	1,210	84,000	123
PAHs (ug/kg)								
Acenaphthene	NA	120	93	120	14	71	7,900	6.71
Acenapthylene	NA	280	300	690	49	140	24,000	5.87
Anthracene	NA	250	250	540	33	160	170,000	46.9
Benzaldehyde	NA	<580	<580	<430	1,600	4,700	NE	NE
Benzo(a)anthracene	NA	970	990	2,600	110	440	NE	31.7
Benzo(a)pyrene	NA	1,100	1,100	3,100	130	510	77	3.19
B(a)P equivalent		1,777	1,808	4,217	192	789	77	3.19
Benzo(b)fluoranthene	NA	1,400	1,600	3,800	170	610	NE	NE
Benzo(g,h,i)perylene	NA	890	890	2,500	120	430	NE	300
Benzo(k)fluoranthene	NA	1,400	1,200	3,800	150	550	NE	13,400
Bis(2-ethylhexyl)phthalate	NA	10,000	4,800	1,400	ND	3,200	NE	750
Chrysene	NA	1,500	1,600	4,000	170	650	NE	57.1
Dibenzo(a,h)anthracene	NA	340	350	870	22	130	NE	6.22
1,2-Dichlorobenzene	NA	<290	<270	480	<110	<320	NE	13
1,4-Dichlorobenzene	NA	<340	<320	460	<130	<380	NE	110
Diethyl phthalate	NA	<220	<210	710	ND	<240	NE	6
Di-n-octylphthalate	NA	NA	NA	NA	NA	NA	NE	61
Fluoranthene	NA	2,400	2,200	4,900	220	1,100	48,000	111
Fluorene	NA	190	190	310	26	150	18,000	21.2
Indeno(1,2,3-cd)pyrene	NA	840	850	2,400	99	380	NE	330
Phenanthrene	NA	1,000	930	2,000	110	890	130,000	41.9
Pyrene	NA	2,300	2,000	4,500	260	1,000	41,000	53
Pesticides (ug/kg)								
g-Chlordane	NA	NA	NA	NA	NA	NA	NE	4.5
4,4'-DDD	NA	NA	NA	NA	NA	NA	NE	3.54
4,4'-DDE	NA	NA	NA	NA	NA	NA	NE	1.42
4,4'-DDT	NA	NA	NA	NA	NA	NA	NE	6.98
Dieldrin	NA	NA	NA	NA	NA	NA	NE	2.85
Endrin	NA	NA	NA	NA	NA	NA	NE	2.67
Total PCBs (mg/kg)	<0.5	NA	NA	1.45	NA	NA	0.013	0.034
Phenols (mg/kg)								
PCP	NA	<2,900	<2,700	<27	<2,100	<3,200	NE	NE
Phenol	NA	NA	NA	NA	NA	NA	NE	0.048

TABLE 13: FOX CREEK SEDIMENT SAMPLING RESULTS

	Sample Locations				Human Health Screening Value	Ecological Screening Value
	Delta at Pike Bay					
	MPCA-1***	STA-6*	FCD-01**	FCD-02**		
	6/9/1983	11/8/1995	10/9/2001	10/9/2001		
Dioxin/Furan TEQ (ng/kg)	NA	NA	**46.5**	**0.55**	**0.077**	**0.85**
Metals (in mg/kg)						
Arsenic	NA	NA	ND	ND	**20**	**6**
Cadmium	NA	NA	**1.4**	ND	**97**	**0.6**
Chromium	NA	NA	**10.3**	**1.4**	**1,700**	**37.3**
Copper	NA	NA	**47.1**	**0.82**	**10,000**	**35.7**
Lead	NA	NA	**32.1**	**0.96**	**100**	**35**
Mercury	NA	NA	**1**	ND	**0.14**	**0.174**
Silver	NA	NA	**7.7**	ND	**NE**	**4.5**
Zinc	NA	NA	**205**	**5.1**	**84,000**	**123**
PAHs (ug/kg)						
Acenaphthene	NA	NA	**23**	ND	**7,900**	**6.71**
Acenapthylene	NA	NA	**47**	ND	**24,000**	**5.87**
Anthracene	NA	NA	**37**	ND	**170,000**	**46.9**
Benzaldehyde	NA	NA	**5,200**	<480	**NE**	**NE**
Benzo(a)anthracene	NA	NA	**100**	**1.3**	**NE**	**31.7**
Benzo(a)pyrene	NA	NA	**140**	**1.6**	**77**	**3.19**
B(a)P equivalent	NA	NA	**223**	**2**	**77**	**3.19**
Benzo(b)fluoranthene	NA	NA	**160**	**1.6**	**NE**	**NE**
Benzo(g,h,i)perylene	NA	NA	**120**	**0.72**	**NE**	**300**
Benzo(k)fluoranthene	NA	NA	**150**	**1.5**	**NE**	**13,400**
Bis(2-ethylhexyl)phthalate	NA	NA	ND	ND	**NE**	**750**
Chrysene	NA	NA	**170**	**1.8**	**NE**	**57.1**
Dibenzo(a,h)anthracene	NA	NA	**44**	ND	**NE**	**6.22**
1,2-Dichlorobenzene	NA	NA	<5,400	<480	**NE**	**13**
1,4-Dichlorobenzene	NA	NA	<5,400	<480	**NE**	**110**
Diethyl phthalate	NA	NA	<5,400	<480	**NE**	**6**
Di-n-octylphthalate	NA	NA	NA	NA	**NE**	**61**
Fluoranthene	NA	NA	**290**	**3.3**	**48,000**	**111**
Fluorene	NA	NA	**41**	ND	**18,000**	**21.2**
Indeno(1,2,3-cd)pyrene	NA	NA	**110**	**1.1**	**NE**	**330**
Phenanthrene	NA	NA	**170**	**1.8**	**130,000**	**41.9**
Pyrene	NA	NA	**300**	**2.9**	**41,000**	**53**
Pesticides (ug/kg)						
g-Chlordane	NA	NA	**3**	ND	**NE**	**4.5**
4,4'-DDD	NA	NA	<17	ND	**NE**	**3.54**
4,4'-DDE	NA	NA	<17	ND	**NE**	**1.42**
4,4'-DDT	NA	NA	**3**	ND	**NE**	**6.98**
Dieldrin	NA	NA	<17	ND	**NE**	**2.85**
Endrin	NA	NA	<17	ND	**NE**	**2.67**
Total PCBs (mg/kg)	**0.53**	<0.5	**0.17**	<20	**0.013**	**0.034**
Phenols (mg/kg)						
PCP	NA	NA	<33	<1,200	**NE**	**NE**
Phenol	NA	NA	NA	NA	**NE**	**0.048**

TABLE 13: FOX CREEK SEDIMENT SAMPLING RESULTS

	Sample Locations			Human Health Screening Value	Ecological Screening Value
	Delta at Pike Bay				
	FCD-03**	FCD-04**	FCD-05**		
	10/9/2001	10/9/2001	10/9/2001		
Dioxin/Furan TEQ (ng/kg)	**0.6**	**0.4**	**0.5**	**0.077**	**0.85**
Metals (in mg/kg)					
Arsenic	ND	ND	ND	**20**	**6**
Cadmium	ND	ND	ND	**97**	**0.6**
Chromium	**1.4**	**1.2**	**1.3**	**1,700**	**37.3**
Copper	**0.64**	**0.69**	**0.76**	**10,000**	**35.7**
Lead	**0.65**	ND	**0.98**	**100**	**35**
Mercury	ND	ND	ND	**0.14**	**0.174**
Silver	**0.38**	ND	**0.25**	**NE**	**4.5**
Zinc	**3.7**	**2.8**	**2.7**	**84,000**	**123**
PAHs (ug/kg)					
Acenaphthene	ND	ND	ND	**7,900**	**6.71**
Acenapthylene	ND	ND	ND	**24,000**	**5.87**
Anthracene	ND	ND	ND	**170,000**	**46.9**
Benzaldehyde	<450	<440	<490	**NE**	**NE**
Benzo(a)anthracene	ND	**0.88**	ND	**NE**	**31.7**
Benzo(a)pyrene	**1**	**1.2**	**97**	**77**	**3.19**
B(a)P equivalent	**2.4**	**2.5**	**98**	**77**	**3.19**
Benzo(b)fluoranthene	**0.93**	**0.94**	**0.67**	**NE**	**NE**
Benzo(g,h,i)perylene	**0.74**	**0.83**	**0.62**	**NE**	**300**
Benzo(k)fluoranthene	ND	**1**	ND	**NE**	**13,400**
Bis(2-ethylhexyl)phthalate	ND	ND	ND	**NE**	**750**
Chrysene	**1.2**	**1**	**0.8**	**NE**	**57.1**
Dibenzo(a,h)anthracene	**1.2**	**1**	**0.8**	**NE**	**6.22**
1,2-Dichlorobenzene	<450	<450	<450	**NE**	**13**
1,4-Dichlorobenzene	<440	<440	<440	**NE**	**110**
Diethyl phthalate	<490	<490	<490	**NE**	**6**
Di-n-octylphthalate	NA	NA	NA	**NE**	**61**
Fluoranthene	**1.9**	**1.9**	**1.5**	**48,000**	**111**
Fluorene	ND	<440	ND	**18,000**	**21.2**
Indeno(1,2,3-cd)pyrene	**0.6**	**0.78**	**0.54**	**NE**	**330**
Phenanthrene	**0.95**	ND	**0.74**	**130,000**	**41.9**
Pyrene	**1.6**	**1.6**	**1.8**	**41,000**	**53**
Pesticides (ug/kg)					
g-Chlordane	ND	**0.85**	**0.42**	**NE**	**4.5**
4,4'-DDD	ND	**1.5**	ND	**NE**	**3.54**
4,4'-DDE	ND	**0.56**	ND	**NE**	**1.42**
4,4'-DDT	ND	ND	**0.64**	**NE**	**6.98**
Dieldrin	ND	ND	ND	**NE**	**2.85**
Endrin	ND	ND	ND	**NE**	**2.67**
Total PCBs (mg/kg)	<22	<21	<21	**0.013**	**0.034**
Phenols (mg/kg)					
PCP	<1,100	<1,100	<1,200	**NE**	**NE**
Phenol	NA	NA	NA	**NE**	**0.048**

TABLE 13: FOX CREEK SEDIMENT SAMPLING RESULTS

NOTES:

note: only compounds that were detected in one or more surface water samples are listed in the table

▓ = concentration exceeds the human health screening value

▒ = concentration exceeds the ecological criterion

░ = compound not detected, but detection limit exceeds the sediment criteria

ND = not detected

NE = no criterion established

NA = not analyzed

* sample collected by Barr Engineering for Champion International

** sample collected by EPA or their consultants

*** sample collected by MPCA staff

ng/kg = nanograms per kilogram, or parts per trillion

mg/kg = milligrams per kilogram, or parts per million

ug/kg = micrograms per kilogram, or parts per billion

TEQ = Toxic Equivalency Quotient

PAH = polynuclear aromatic hydrocarbon

PCB = polychlorinated biphenyls

PCP = pentachlorophenol

Human health screening values are derived from previous work at the U.S. Steel contaminated sediment site in Duluth, Minnesota (U.S. Steel (2003) Former Duluth Works Sediment Characterization and Tier I Risk Assessment Work Plan, Prepared by URS Corporation for US Steel, September 5, 2003.)

Ecological screening values were derived from a variety of sources, primarily Threshold Effect Levels (TEL) (TEL) from Buchmann, 1999; Leech Lake Band of Ojibwe clean-up goals (LLBO, 2000) and Interim Sediment Quality Guidelines (ISQGs) from Environment Canada, 2003.

TABLE 14: PIKE BAY SEDIMENT SAMPLING RESULTS

	Sample Locations				Human Health Screening Value	Ecological Screening Value
	Deep Areas of the Bay					
	MPCA-3**	MPCA-4**	PBDH-01*	PBDH-02*		
	6/9/1983	6/9/1983	10/13/2001	10/13/2001		
Dioxin/Furan TEQ (ng/kg)	NA	NA	6.9	NA	0.077	0.85
Metals (in mg/kg)						
Arsenic	NA	NA	<17.9	<14.2	20	6
Cadmium	NA	NA	<1.8	<1.4	97	0.6
Chromium	NA	NA	6.1	4.7	1,700	37.3
Copper	NA	NA	10.2	8.2	10,000	35.7
Lead	NA	NA	31.8	26.2	100	35
Mercury	NA	NA	<0.74	<0.58	0.14	0.174
Silver	NA	NA	ND	ND	NE	4.5
Zinc	NA	NA	51.7	34	84,000	123
PAHs (ug/kg)						
Acenaphthene	NA	NA	ND	ND	7,900	6.71
Acenapthylene	NA	NA	ND	ND	24,000	5.87
Anthracene	NA	NA	16	5.7	170,000	46.9
Benzaldehyde	NA	NA	<580	<520	NE	NE
Benzo(a)anthracene	NA	NA	33	8	NE	31.7
Benzo(a)pyrene	NA	NA	31	15	77	3.19
B(a)P equivalent	NA	NA	45	23	77	3.19
Benzo(b)fluoranthene	NA	NA	26	13	NE	NE
Benzo(g,h,i)perylene	NA	NA	23	15	NE	300
Benzo(k)fluoranthene	NA	NA	28	14	NE	13,400
Bis(2-ethylhexyl)phthalate	NA	NA	1,600	<320	NE	750
Chrysene	NA	NA	36	13	NE	57.1
Dibenzo(a,h)anthracene	NA	NA	5.7	4	NE	6.22
1,2-Dichlorobenzene	NA	NA	<290	<260	NE	13
1,4-Dichlorobenzene	NA	NA	<340	<300	NE	110
Diethyl phthalate	NA	NA	<210	<190	NE	6
Di-n-octylphthalate	NA	NA	NA	NA	NE	61
Fluoranthene	NA	NA	120	28	48,000	111
Fluorene	NA	NA	6.1	<4.2	18,000	21.2
Indeno(1,2,3-cd)pyrene	NA	NA	21	13	NE	330
Phenanthrene	NA	NA	62	89	130,000	41.9
Pyrene	NA	NA	13	23	41,000	53
Pesticides (ug/kg)						
g-Chlordane	NA	NA	<12	<11	NE	4.5
4,4'-DDD	NA	NA	<24	<21	NE	3.54
4,4'-DDE	NA	NA	<24	<21	NE	1.42
4,4'-DDT	NA	NA	<24	<21	NE	6.98
Dieldrin	NA	NA	<24	<21	NE	2.85
Endrin	NA	NA	<24	<21	NE	2.67
Total PCBs (mg/kg)	0.21	0.19	<0.13	<0.24	0.013	0.034
Phenols (mg/kg)						
PCP	NA	NA	<2,900	<2,600	NE	NE
Phenol	NA	NA	NA	NA	NE	0.048

TABLE 14: PIKE BAY SEDIMENT SAMPLING RESULTS

	Sample Locations					Human Health Screening Value	Ecological Screening Value
	Shoreline Near City Park						
	PB-A*	PB-B*	PB-C*	PB-D*	PB-E*		
	10/9/2001	10/9/2001	10/9/2001	10/9/2001	10/9/2001		
Dioxin/Furan TEQ (ng/kg)	**0.4**	NA	**0.43**	**0.45**	NA	**0.077**	**0.85**
Metals (in mg/kg)							
Arsenic	ND	ND	ND	**0.49**	NA	**20**	**6**
Cadmium	ND	ND	ND	ND	NA	**97**	**0.6**
Chromium	**1.5**	**1.5**	**1.8**	**1.8**	NA	**1,700**	**37.3**
Copper	**0.5**	**0.61**	**0.65**	**0.78**	NA	**10,000**	**35.7**
Lead	**0.98**	**0.9**	**0.89**	**1.3**	NA	**100**	**35**
Mercury	ND	ND	ND	ND	NA	**0.14**	**0.174**
Silver	ND	ND	**0.24**	**0.27**	NA	**NE**	**4.5**
Zinc	**2.9**	**2.7**	**3**	**4**	NA	**84,000**	**123**
PAHs & VOCs (ug/kg)							
Acenaphthene	NA	NA	NA	NA	NA	**7,900**	**6.71**
Acenapthylene	NA	NA	NA	NA	NA	**24,000**	**5.87**
Anthracene	NA	NA	NA	NA	NA	**170,000**	**46.9**
Benzaldehyde	NA	NA	NA	NA	NA	**NE**	**NE**
Benzo(a)anthracene	NA	NA	NA	NA	NA	**NE**	**31.7**
Benzo(a)pyrene	NA	NA	NA	NA	NA	**77**	**3.19**
B(a)P equivalents	NA	NA	NA	NA	NA	**77**	**3.19**
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	**NE**	**NE**
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	**NE**	**300**
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	**NE**	**13,400**
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	**NE**	**750**
Chrysene	NA	NA	NA	NA	NA	**NE**	**57.1**
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	**NE**	**6.22**
1,2-Dichlorobenzene	<12	<14	<11	<21	NA	**NE**	**13**
1,4-Dichlorobenzene	<12	<14	<11	<21	NA	**NE**	**110**
Diethyl phthalate	NA	NA	NA	NA	NA	**NE**	**6**
Di-n-octylphthalate	NA	NA	NA	NA	NA	**NE**	**61**
Fluoranthene	NA	NA	NA	NA	NA	**48,000**	**111**
Fluorene	NA	NA	NA	NA	NA	**18,000**	**21.2**
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	**NE**	**330**
Phenanthrene	NA	NA	NA	NA	NA	**130,000**	**41.9**
Pyrene	NA	NA	NA	NA	NA	**41,000**	**53**
Pesticides (ug/kg)							
g-Chlordane	NA	NA	NA	NA	NA	**NE**	**4.5**
4,4'-DDD	NA	NA	NA	NA	NA	**NE**	**3.54**
4,4'-DDE	NA	NA	NA	NA	NA	**NE**	**1.42**
4,4'-DDT	NA	NA	NA	NA	NA	**NE**	**6.98**
Dieldrin	NA	NA	NA	NA	NA	**NE**	**2.85**
Endrin	NA	NA	NA	NA	NA	**NE**	**2.67**
Total PCBs (mg/kg)	NA	NA	NA	NA	NA	**0.013**	**0.034**
Phenols (mg/kg)							
PCP	NA	NA	NA	NA	NA	**NE**	**NE**
Phenol	NA	NA	NA	NA	NA	**NE**	**0.048**

TABLE 14: PIKE BAY SEDIMENT SAMPLING RESULTS

	Sample Locations				Human Health Screening Value	Ecological Screening Value
	Near Channel		"Shallow" Bay			
	EPA-4*	MPCA-6**	MPCA-2**	MPCA-5**		
	5/11/1983	6/9/1983	6/9/1983	6/9/1983		
Dioxin/Furan TEQ (ng/kg)	NA	NA	NA	NA	**0.077**	**0.85**
Metals (in mg/kg)						
Arsenic	NA	NA	NA	NA	**20**	**6**
Cadmium	NA	NA	NA	NA	**97**	**0.6**
Chromium	NA	NA	NA	NA	**1,700**	**37.3**
Copper	NA	NA	NA	NA	**10,000**	**35.7**
Lead	NA	NA	NA	NA	**100**	**35**
Mercury	NA	NA	NA	NA	**0.14**	**0.174**
Silver	NA	NA	NA	NA	**NE**	**4.5**
Zinc	NA	NA	NA	NA	**84,000**	**123**
PAHs (ug/kg)						
Acenaphthene	ND	NA	NA	NA	**7,900**	**6.71**
Acenapthylene	ND	NA	NA	NA	**24,000**	**5.87**
Anthracene	ND	NA	NA	NA	**170,000**	**46.9**
Benzaldehyde	ND	NA	NA	NA	**NE**	**NE**
Benzo(a)anthracene	ND	NA	NA	NA	**NE**	**31.7**
Benzo(a)pyrene	ND	NA	NA	NA	**77**	**3.19**
B(a)P equivalent	ND	NA	NA	NA	**77**	**3.19**
Benzo(b)fluoranthene	ND	NA	NA	NA	**NE**	**NE**
Benzo(g,h,i)perylene	ND	NA	NA	NA	**NE**	**300**
Benzo(k)fluoranthene	ND	NA	NA	NA	**NE**	**13,400**
Bis(2-ethylhexyl)phthalate	ND	NA	NA	NA	**NE**	**750**
Chrysene	ND	NA	NA	NA	**NE**	**57.1**
Dibenzo(a,h)anthracene	ND	NA	NA	NA	**NE**	**6.22**
1,2-Dichlorobenzene	ND	NA	NA	NA	**NE**	**13**
1,4-Dichlorobenzene	ND	NA	NA	NA	**NE**	**110**
Diethyl phthalate	ND	NA	NA	NA	**NE**	**6**
Di-n-octylphthalate	ND	NA	NA	NA	**NE**	**61**
Fluoranthene	ND	NA	NA	NA	**48,000**	**111**
Fluorene	ND	NA	NA	NA	**18,000**	**21.2**
Indeno(1,2,3-cd)pyrene	ND	NA	NA	NA	**NE**	**330**
Phenanthrene	ND	NA	NA	NA	**130,000**	**41.9**
Pyrene	ND	NA	NA	NA	**41,000**	**53**
Pesticides (ug/kg)						
g-Chlordane	ND	NA	NA	NA	**NE**	**4.5**
4,4'-DDD	ND	NA	NA	NA	**NE**	**3.54**
4,4'-DDE	ND	NA	NA	NA	**NE**	**1.42**
4,4'-DDT	ND	NA	NA	NA	**NE**	**6.98**
Dieldrin	ND	NA	NA	NA	**NE**	**2.85**
Endrin	ND	NA	NA	NA	**NE**	**2.67**
Total PCBs (mg/kg)	NA	<0.08	**0.24**	<0.08	**0.013**	**0.034**
Phenols (mg/kg)						
PCP	ND	NA	NA	NA	**NE**	**NE**
Phenol	ND	NA	NA	NA	**NE**	**0.048**

TABLE 14: PIKE BAY SEDIMENT SAMPLING RESULTS

NOTES:

note: only compounds that were detected in one or more surface water samples are listed in the table
▓ = concentration exceeds the human health screening value
▒ = concentration exceeds the ecological criterion
░ = compound not detected, but detection limit exceeds the sediment criteria
ND = not detected
NE = no criterion established
NA = not analyzed
* sample collected by Barr Engineering for Champion International
** sample collected by EPA or their consultants
*** sample collected by MPCA staff
ng/kg = nanograms per kilogram, or parts per trillion
mg/kg = milligrams per kilogram, or parts per million
ug/kg = micrograms per kilogram, or parts per billion
TEQ = Toxic Equivalency Quotient
PAH = polynuclear aromatic hydrocarbon
PCB = polychlorinated biphenyls
PCP = pentachlorophenol

Human health screening values are derived from previous work at the U.S. Steel contaminated sediment site in Duluth, Minnesota (U.S. Steel (2003) Former Duluth Works Sediment Characterization and Tier I Risk Assessment Work Plan, Prepared by URS Corporation for US Steel, September 5, 2003.)

Ecological screening values were derived from a variety of sources, primarily Threshold Effect Levels (TEL) (TEL) from Buchmann, 1999; Leech Lake Band of Ojibwe clean-up goals (LLBO, 2000) and Interim Sediment Quality Guidelines (ISQGs) from Environment Canada, 2003.

TABLE 15: CHANNEL SEDIMENT SAMPLING RESULTS

	Sample Locations					Human Health Screening Value	Ecological Screening Value
	South of RxR Crossing						
	MPCA-7**	MPCA-8**	RR-01*	RR-02*	RR-03*		
	6/9/1983	6/9/1983	10/12/2001	10/12/2001	10/12/2001		
Dioxin/Furan TEQ (ng/kg)	NA	NA	35.97	23.3	NA	0.077	0.85
Metals (in mg/kg)							
Arsenic	NA	NA	<14.9	<11.5	<12.6	20	6
Cadmium	NA	NA	<1.5	<1.1	<1.2	97	0.6
Chromium	NA	NA	8.1	6.5	7.3	1,700	37.3
Copper	NA	NA	19.5	13.9	15.3	10,000	35.7
Lead	NA	NA	57.1	33.5	33.5	100	35
Mercury	NA	NA	<0.61	<0.41	<0.52	0.14	0.174
Silver	NA	NA	<2.4	<1.9	<2.1	NE	4.5
Zinc	NA	NA	144	88.9	83.7	84,000	123
PAHs (ug/kg)							
Acenaphthene	NA	NA	62	17	16	7,900	6.71
Acenapthylene	NA	NA	150	68	65	24,000	5.87
Anthracene	NA	NA	270	78	90	170,000	46.9
Benzaldehyde	NA	NA	<510	<450	<390	NE	NE
Benzo(a)anthracene	NA	NA	810	340	240	NE	31.7
Benzo(a)pyrene	NA	NA	640	320	230	77	3.19
B(a)p equivalent	NA	NA	989	493	352	77	3.19
Benzo(b)fluoranthene	NA	NA	1,100	360	240	NE	NE
Benzo(g,h,i)perylene	NA	NA	380	210	170	NE	300
Benzo(k)fluoranthene	NA	NA	1,000	370	260	NE	13,400
Bis(2-ethylhexyl)phthalate	NA	NA	<350	1,200	<260	NE	750
Chrysene	NA	NA	1,900	610	480	NE	57.1
Dibenz(a,h)anthracene	NA	NA	110	79	56	NE	6.22
1,2-Dichlorobenzene	NA	NA	<250	<220	<190	NE	13
1,4-Dichlorobenzene	NA	NA	<300	<260	<230	NE	110
Diethyl phthalate	NA	NA	<190	<170	<150	NE	6
Di-n-octylphthalate	NA	NA	<310	<280	<240	NE	61
Fluoranthene	NA	NA	4,100	750	700	48,000	111
Fluorene	NA	NA	110	36	41	18,000	21.2
Indeno(1,2,3-cd)pyrene	NA	NA	360	200	150	NE	330
Phenanthrene	NA	NA	850	260	260	130,000	41.9
Pyrene	NA	NA	3,200	660	630	41,000	53
Pesticides (ug/kg)							
g-Chlordane	NA	NA	NA	NA	NA	NE	4.5
4,4'-DDD	NA	NA	NA	NA	NA	NE	3.54
4,4'-DDE	NA	NA	NA	NA	NA	NE	1.42
4,4'-DDT	NA	NA	NA	NA	NA	NE	6.98
Dieldrin	NA	NA	NA	NA	NA	NE	2.85
Endrin	NA	NA	NA	NA	NA	NE	2.67
Total PCBs (mg/kg)	0.15	0.35	NA	NA	NA	0.013	0.034
Phenols (mg/kg)							
PCP	NA	NA	<2.5	<2.2	<1.9	NE	NE
Phenol	NA	NA	NA	NA	NA	NE	0.048

TABLE 15: CHANNEL SEDIMENT SAMPLING RESULTS

	Sample Locations			Human Health Screening Value	Ecological Screening Value
	Wetland Areas				
	WL-01*	WL-02*	WL-03*		
	10/12/2001	10/12/2001	10/12/2001		
Dioxin/Furan TEQ (ng/kg)	**45.6**	NA	NA	**0.077**	**0.85**
Metals (in mg/kg)					
Arsenic	ND	ND	ND	**20**	**6**
Cadmium	<1.1	<1.1	<1.2	**97**	**0.6**
Chromium	**6.5**	**6**	**8.1**	**1,700**	**37.3**
Copper	**20.8**	**12.5**	**16**	**10,000**	**35.7**
Lead	**35.6**	**25.7**	**35.6**	**100**	**35**
Mercury	<0.7	<0.7	<0.8	**0.14**	**0.174**
Silver	<2.5	<2.5	<2.8	**NE**	**4.5**
Zinc	**79.3**	**81.9**	**79.1**	**84,000**	**123**
PAHs (ug/kg)					
Acenaphthene	<37	**50**	<48	**7,900**	**6.71**
Acenapthylene	<370	**76**	**45**	**24,000**	**5.87**
Anthracene	<370	**100**	**48**	**170,000**	**46.9**
Benzaldehyde	<3,700	<4,100	<4,700	**NE**	**NE**
Benzo(a)anthracene	**340**	**510**	**230**	**NE**	**31.7**
Benzo(a)pyrene	**450**	**500**	**290**	**77**	**3.19**
B(a)P equivalent	**537**	**707**	**364**	**77**	**3.19**
Benzo(b)fluoranthene	**450**	**640**	<4,700	**NE**	**NE**
Benzo(g,h,i)perylene	**390**	**200**	**140**	**NE**	**300**
Benzo(k)fluoranthene	**380**	**510**	**280**	**NE**	**13,400**
Bis(2-ethylhexyl)phthalate	NA	NA	NA	**NE**	**750**
Chrysene	**480**	**870**	**330**	**NE**	**57.1**
Dibenz(a,h)anthracene	<370	**78**	**48**	**NE**	**6.22**
1,2-Dichlorobenzene	NA	NA	NA	**NE**	**13**
1,4-Dichlorobenzene	NA	NA	NA	**NE**	**110**
Diethyl phthalate	NA	NA	NA	**NE**	**6**
Di-n-octylphthalate	<3,700	<4,100	<4,700	**NE**	**61**
Fluoranthene	**960**	**1,800**	**570**	**48,000**	**111**
Fluorene	**1,200**	**2,100**	**660**	**18,000**	**21.2**
Indeno(1,2,3-cd)pyrene	**35**	**81**	<48	**NE**	**330**
Phenanthrene	**400**	**580**	**190**	**130,000**	**41.9**
Pyrene	**890**	**1,700**	**570**	**41,000**	**53**
Pesticides (ug/kg)					
g-Chlordane	NA	NA	NA	**NE**	**4.5**
4,4'-DDD	NA	NA	NA	**NE**	**3.54**
4,4'-DDE	NA	NA	NA	**NE**	**1.42**
4,4'-DDT	NA	NA	NA	**NE**	**6.98**
Dieldrin	NA	NA	NA	**NE**	**2.85**
Endrin	NA	NA	NA	**NE**	**2.67**
Total PCBs (mg/kg)	NA	NA	NA	**0.013**	**0.034**
Phenols (mg/kg)					
PCP	<9.2	<10	<12	**NE**	**NE**
Phenol	NA	NA	NA	**NE**	**0.048**

TABLE 15: CHANNEL SEDIMENT SAMPLING RESULTS

	Sample Locations				Human Health Screening Value	Ecological Screening Value
	Between Hwy 2 and RxR Crossings					
	MPCA-9**	HWY-01*	HWY-02*	HWY-03*		
	6/9/1983	10/12/2001	10/12/2001	10/12/2001		
Dioxin/Furan TEQ (ng/kg)	NA	**25.6**	NA	NA	**0.077**	**0.85**
Metals (in mg/kg)						
Arsenic	NA	<10.2	<11.8	<10.4	**20**	**6**
Cadmium	NA	<1.0	<1.2	<1.0	**97**	**0.6**
Chromium	NA	**5.5**	**5.6**	**6.1**	**1,700**	**37.3**
Copper	NA	**9.1**	**8.9**	**12.8**	**10,000**	**35.7**
Lead	NA	**27.2**	**25.4**	**26.3**	**100**	**35**
Mercury	NA	<0.42	<0.49	<0.43	**0.14**	**0.174**
Silver	NA	ND	ND	ND	**NE**	**4.5**
Zinc	NA	**64.8**	**74**	**83.2**	**84,000**	**123**
PAHs (ug/kg)						
Acenaphthene	NA	**26**	**30**	**120**	**7,900**	**6.71**
Acenapthylene	NA	**150**	**240**	**590**	**24,000**	**5.87**
Anthracene	NA	**110**	**190**	**1,000**	**170,000**	**46.9**
Benzaldehyde	NA	<310	<410	<410	**NE**	**NE**
Benzo(a)anthracene	NA	**380**	**620**	**4,000**	**NE**	**31.7**
Benzo(a)pyrene	NA	**510**	**800**	**3,800**	**77**	**3.19**
B(a)P equivalent	NA	**735**	**1,152**	**5,456**	**77**	**3.19**
Benzo(b)fluoranthene	NA	**510**	**830**	**3,600**	**NE**	**NE**
Benzo(g,h,i)perylene	NA	**360**	**560**	**1,900**	**NE**	**300**
Benzo(k)fluoranthene	NA	**440**	**720**	**4,100**	**NE**	**13,400**
Bis(2-ethylhexyl)phthalate	NA	ND	**1,200**	**1,100**	**NE**	**750**
Chrysene	NA	**480**	**860**	**5,400**	**NE**	**57.1**
Dibenz(a,h)anthracene	NA	**99**	**150**	**670**	**NE**	**6.22**
1,2-Dichlorobenzene	NA	<150	<200	<200	**NE**	**13**
1,4-Dichlorobenzene	NA	<180	<240	<240	**NE**	**110**
Diethyl phthalate	NA	ND	ND	ND	**NE**	**6**
Di-n-octylphthalate	NA	ND	ND	ND	**NE**	**61**
Fluoranthene	NA	**1,100**	**1,800**	**8,500**	**48,000**	**111**
Fluorene	NA	**45**	**70**	**210**	**18,000**	**21.2**
Indeno(1,2,3-cd)pyrene	NA	**320**	**490**	**1,800**	**NE**	**330**
Phenanthrene	NA	**390**	**710**	**2,300**	**130,000**	**41.9**
Pyrene	NA	**920**	**1,600**	**6,400**	**41,000**	**53**
Pesticides (ug/kg)						
g-Chlordane	NA	NA	NA	NA	**NE**	**4.5**
4,4'-DDD	NA	NA	NA	NA	**NE**	**3.54**
4,4'-DDE	NA	NA	NA	NA	**NE**	**1.42**
4,4'-DDT	NA	NA	NA	NA	**NE**	**6.98**
Dieldrin	NA	NA	NA	NA	**NE**	**2.85**
Endrin	NA	NA	NA	NA	**NE**	**2.67**
Total PCBs (mg/kg)	**0.23**	NA	NA	NA	**0.013**	**0.034**
Phenols (mg/kg)						
PCP	NA	<1,500	<2,100	<2,000	**NE**	**NE**
Phenol	NA	NA	NA	NA	**NE**	**0.048**

TABLE 15: CHANNEL SEDIMENT SAMPLING RESULTS

NOTES:

note: only compounds that were detected in one or more surface water samples are listed in the table

▓ = concentration exceeds the human health screening value
▒ = concentration exceeds the ecological criterion
░ = compound not detected, but detection limit exceeds the sediment criteria
ND = not detected
NE = no criterion established
NA = not analyzed
* sample collected by Barr Engineering for Champion International
** sample collected by EPA or their consultants
*** sample collected by MPCA staff
ng/kg = nanograms per kilogram, or parts per trillion
mg/kg = milligrams per kilogram, or parts per million
ug/kg = micrograms per kilogram, or parts per billion
TEQ = Toxic Equivalency Quotient
PAH = polynuclear aromatic hydrocarbon
PCB = polychlorinated biphenyls
PCP = pentachlorophenol

Human health screening values are derived from previous work at the U.S. Steel contaminated sediment site in Duluth, Minnesota (U.S. Steel (2003) Former Duluth Works Sediment Characterization and Tier I Risk Assessment Work Plan, Prepared by URS Corporation for US Steel, September 5, 2003.)

Ecological screening values were derived from a variety of sources, primarily Threshold Effect Levels (TEL) (TEL) from Buchmann, 1999; Leech Lake Band of Ojibwe clean-up goals (LLBO, 2000) and Interim Sediment Quality Guidelines (ISQGs) from Environment Canada, 2003.

TABLE 16: CASS LAKE SEDIMENT SAMPLING RESULTS

	Sample Locations				Human Health Screening Value	Ecological Screening Value
	"Shallow"	Deep				
	MPCA-10**	MPCA-11**	CLDH-01*	CLDH-02*		
	6/9/1983	6/9/1983	10/12/2001	10/12/2001		
Dioxin/Furan TEQ (ng/kg)	NA	NA	7.14	NA	0.077	0.85
Metals (in mg/kg)						
Arsenic	NA	NA	<14.2	<13.1	20	6
Cadmium	NA	NA	<1.4	<1.3	97	0.6
Chromium	NA	NA	ND	ND	1,700	37.3
Copper	NA	NA	11.6	6.8	10,000	35.7
Lead	NA	NA	24	20.1	100	35
Mercury	NA	NA	<0.58	<0.54	0.14	0.174
Silver	NA	NA	ND	ND	NE	4.5
Zinc	NA	NA	32.2	29.4	84,000	123
PAHs (ug/kg)						
Acenaphthene	NA	NA	ND	ND	7,900	6.71
Acenapthylene	NA	NA	6.3	ND	24,000	5.87
Anthracene	NA	NA	ND	ND	170,000	46.9
Benzaldehyde	NA	NA	<460	<460	NE	NE
Benzo(a)anthracene	NA	NA	15	6	NE	31.7
Benzo(a)pyrene	NA	NA	22	11	77	3.19
B(a)P Equivalent	NA	NA	32.3	17	77	3.19
Benzo(b)fluoranthene	NA	NA	20	9	NE	NE
Benzo(g,h,i)perylene	NA	NA	22	11	NE	300
Benzo(k)fluoranthene	NA	NA	18	9	NE	13,400
Bis(2-ethylhexyl)phthalate	NA	NA	ND	ND	NE	750
Butylbenzylphthalate	NA	NA	<14	<680	NE	NE
Chrysene	NA	NA	20	9	NE	57.1
Dibenz(a,h)anthracene	NA	NA	4.7	3.5	NE	6.22
1,2-Dichlorobenzene	NA	NA	<24	<220	NE	13
1,4-Dichlorobenzene	NA	NA	ND	<270	NE	110
Diethyl phthalate	NA	NA	ND	ND	NE	6
Fluoranthene	NA	NA	38	19	48,000	111
Fluorene	NA	NA	ND	ND	18,000	21.2
Indeno(1,2,3-cd)pyrene	NA	NA	19	10	NE	330
Phenanthrene	NA	NA	14	7	130,000	41.9
Pyrene	NA	NA	36	16	41,000	53
Pesticides (ug/kg)						
g-Chlordane	NA	NA	3.7	2.6	NE	4.5
4,4'-DDD	NA	NA	<18	<18	NE	3.54
4,4'-DDE	NA	NA	<18	<18	NE	1.42
4,4'-DDT	NA	NA	<18	<18	NE	6.98
Dieldrin	NA	NA	<18	<18	NE	2.85
Endrin	NA	NA	<18	<18	NE	2.67
Total PCBs (mg/kg)	0.23	0.13	<0.11	<0.18	0.013	0.034
Phenols (mg/kg)						
PCP	NA	NA	<0.0023	<2.3	NE	NE
Phenol	NA	NA	ND	NA	NE	0.048

TABLE 16: CASS LAKE SEDIMENT SAMPLING RESULTS

NOTES:

note: only compounds that were detected in one or more surface water samples are listed in the table

▓ = concentration exceeds the human health screening value
▒ = concentration exceeds the ecological criterion
░ = compound not detected, but detection limit exceeds the sediment criteria
ND = not detected
NE = no criterion established
NA = not analyzed
* sample collected by Barr Engineering for Champion International
** sample collected by EPA or their consultants
*** sample collected by MPCA staff
ng/kg = nanograms per kilogram, or parts per trillion
mg/kg = milligrams per kilogram, or parts per million
ug/kg = micrograms per kilogram, or parts per billion
TEQ = Toxic Equivalency Quotient
PAH = polynuclear aromatic hydrocarbon
PCB = polychlorinated biphenyls
PCP = pentachlorophenol

Human health screening values are derived from previous work at the U.S. Steel contaminated sediment site in Duluth, Minnesota (U.S. Steel (2003) Former Duluth Works Sediment Characterization and Tier I Risk Assessment Work Plan, Prepared by URS Corporation for US Steel, September 5, 2003.)

Ecological screening values were derived from a variety of sources, primarily Threshold Effect Levels (TEL) (TEL) from Buchmann, 1999; Leech Lake Band of Ojibwe clean-up goals (LLBO, 2000) and Interim Sediment Quality Guidelines (ISQGs) from Environment Canada, 2003.

TABLE 17: REFERENCE CREEK AND LAKE SEDIMENT SAMPLING RESULTS

	Sample Locations						Human Health Screening Value	Ecological Screening Value
	Reference Creek			Reference Lake				
	RFCR-01*	RFCR-02*	RFCR-03*	RFLK-01*	RFLK-02*	RFLK-03*		
	10/15/2001	10/15/2001	10/15/2001	10/16/2001	10/16/2001	10/16/2001		
Dioxin/Furan TEQ (ng/kg)	0.6	1.04	1.06	0.16	0.12	0.92	0.077	0.85
Metals (in mg/kg)								
Arsenic	ND	3.3	13.1	ND	ND	6.3	20	6
Cadmium	ND	ND	<0.98	<1.6	<1.5	ND	97	0.6
Chromium	3.5	3.6	9.5	2.4	1.5	4.2	1,700	37.3
Copper	2.6	1.8	5.9	3.1	0.42	0.51	10,000	35.7
Lead	2.5	3.1	11.2	1.4	1.5	12.8	100	35
Mercury	ND	ND	<0.41	ND	ND	<0.22	0.14	0.174
Silver	ND	ND	ND	ND	ND	ND	NE	4.5
Zinc	9.3	11.3	29.2	4.4	3.8	19.6	84,000	123
PAHs (ug/kg)								
Acenaphthene	ND	ND	ND	1.2	1.6	ND	7,900	6.71
Acenapthylene	ND	ND	ND	ND	ND	ND	24,000	5.87
Anthracene	ND	ND	ND	ND	ND	ND	170,000	46.9
Benzaldehyde	<97	<170	<240	<58	<58	<160	NE	NE
Benzo(a)anthracene	2	3	5.5	ND	ND	2.2	NE	31.7
Benzo(a)pyrene	2.5	2.9	6.2	ND	ND	3.1	77	3.19
B(a)P equivalent	3.3	4.1	8.4	ND	ND	3.9	77	3.19
Benzo(b)fluoranthene	3.3	4.3	8.1	ND	ND	2.9	NE	NE
Benzo(g,h,i)perylene	2.8	4.9	6.6	ND	ND	2.8	NE	300
Benzo(k)fluoranthene	2.9	3.5	6.9	ND	ND	2.8	NE	13,400
Bis(2-ethylhexyl)phthalate	280	ND	ND	ND	ND	ND	NE	750
Chrysene	3.3	4	8.3	ND	ND	2.9	NE	57.1
Dibenz(a,h)anthracene	ND	ND	ND	ND	ND	ND	NE	6.22
1,2-Dichlorobenzene	<48	<84	<120	<28	<28	<77	NE	13
1,4-Dichlorobenzene	ND	ND	<140	ND	ND	ND	NE	110
Diethyl phthalate	ND	ND	ND	<140	<140	ND	NE	6
Fluoranthene	8.5	10	19	6	ND	ND	48,000	111
Fluorene	1.7	2.4	2.7	ND	ND	ND	18,000	21.2
Indeno(1,2,3-cd)pyrene	2.8	4.6	7.4	ND	ND	2.8	NE	330
Phenanthrene	4.5	5.5	6.9	ND	ND	2.9	130,000	41.9
Pyrene	5.9	8.3	14	ND	ND	5.8	41,000	53
Pesticides (ug/kg)								
g-Chlordane	3	ND	<5.7	ND	ND	ND	NE	4.5
4,4'-DDD	<4.1	ND	<11	ND	ND	<6.6	NE	3.54
4,4'-DDE	2.4	<3.1	4.4	0.55	0.59	1.8	NE	1.42
4,4'-DDT	1.1	1.2	<11	ND	ND	ND	NE	6.98
Dieldrin	1.1	<3.1	<11	ND	ND	<6.6	NE	2.85
Endrin	1.2	<3.1	<11	ND	1	<6.6	NE	2.67
Total PCBs (mg/kg)	<0.041	ND	ND	ND	ND	ND	0.013	0.034
Phenols (mg/kg)								
PCP	<0.48	<0.85	<6.7	<0.29	ND	<0.29	NE	NE
Phenol	NA	NA	17	NA	15	NA	NE	0.048

TABLE 17: REFERENCE CREEK AND LAKE SEDIMENT SAMPLING RESULTS

NOTES:

note: only compounds that were detected in one or more surface water samples are listed in the table

▓ = concentration exceeds the human health screening value
▒ = concentration exceeds the ecological criterion
░ = compound not detected, but detection limit exceeds the sediment criteria
ND = not detected
NE = no criterion established
NA = not analyzed
* sample collected by Barr Engineering for Champion International
** sample collected by EPA or their consultants
*** sample collected by MPCA staff
ng/kg = nanograms per kilogram, or parts per trillion
mg/kg = milligrams per kilogram, or parts per million
ug/kg = micrograms per kilogram, or parts per billion
TEQ = Toxic Equivalency Quotient
PAH = polynuclear aromatic hydrocarbon
PCB = polychlorinated biphenyls
PCP = pentachlorophenol

Human health screening values are derived from previous work at the U.S. Steel contaminated sediment site in Duluth, Minnesota (U.S. Steel (2003) Former Duluth Works Sediment Characterization and Tier I Risk Assessment Work Plan, Prepared by URS Corporation for US Steel, September 5, 2003.)

Ecological screening values were derived from a variety of sources, primarily Threshold Effect Levels (TEL) (TEL) from Buchmann, 1999; Leech Lake Band of Ojibwe clean-up goals (LLBO, 2000) and Interim Sediment Quality Guidelines (ISQGs) from Environment Canada, 2003.

Table 18: Effluent Water Sampling Results

	PAHs (ug/L)					**Phenols**	**Dioxins**
	Sum *List 1*	**Naphthalene**	***Sum List 2***	***Total PAH***	**B*(a)P Equiv.***	***PCP (ug/L)***	***HxCDD (ug/L)***
Surface Water Criterion	**NE**	**81**	**NE**	**NE**	**0.00051**	**5.5**	**0.00038**
Sample Date							
1/19/1988	ND	**0.0036**	**0.012**	**0.012**	ND	---	---
4/18/1988	ND	ND	**0.0084**	**0.0084**	ND	---	---
7/19/1988	ND	**0.0031**	**0.016**	**0.016**	ND	---	---
12/5/1988	---	---	---	---	---	**16**	---
12/15/1988	---	---	---	---	---	**530**	---
12/29/1988	**0.0023**	**0.013**	**0.049**	**0.051**	**0.0001**	---	---
1/9/1989	---	---	---	---	---	**2,100**	---
1/12/1989	---	---	---	---	---	**60**	---
1/16/1989	---	---	---	---	---	**150**	---
1/30/1989	ND	**0.03**	**0.14**	**0.14**	ND	<5	---
4/10/1989	**0.023**	**0.0046**	**0.039**	**0.062**	**0.0056**	<5	---
7/5/1989	**0.01**	**0.041**	**0.081**	**0.091**	**0.0004**	<5	---
10/2/1989	**0.0023**	ND	**0.043**	**0.045**	**0.0001**	<5	---
12/18/1989	---	---	---	---	---	**5**	---
1/2/1990	**0.005**	**0.0062**	**0.027**	**0.032**	**0.0003**	**9**	---
4/9/1990	ND	**0.0055**	**0.021**	**0.021**	ND	<5	**0.0041**
7/2/1990	ND	**0.011**	**0.027**	**0.027**	ND	<5	---
9/4/1990	ND	**0.009**	**0.026**	**0.026**	ND	<5	---
9/12/1990	ND	**0.0034**	**0.0085**	**0.0085**	ND	<5	---
10/1/1990	ND	**0.0065**	**0.0019**	**0.0019**	ND	<5	---
1/7/1991	**0.008**	**0.11**	**0.26**	**0.27**	ND	<5	---
4/1/1991	**0.0012**	**0.015**	**0.18**	**0.18**	ND	**7**	---
7/1/1991	ND	**0.0054**	**0.0096**	**0.0096**	ND	<5	---
10/7/1991	**0.0047**	ND	ND	**0.0047**	ND	<5	---
1/6/1992	*	*	*	*	*	<5	---
4/6/1992	*	*	*	*	*	<5	---
7/6/1992	*	*	*	*	*	<5	<0.0041
10/5/1992	*	*	*	*	*	<5	---
1/4/1993	ND	**0.13**	**0.24**	**0.24**	ND	<5	---
4/5/1993	**0.003**	**0.01**	**0.018**	**0.021**	**0.0003**	<5	---
7/6/1993	ND	ND	ND	ND	ND	<5	---
10/4/1993	ND	**0.069**	**0.051**	**0.051**	ND	<5	---
1/3/1994	ND	**0.131**	**0.274**	**0.274**	ND	<5	---
4/21/1994	ND	ND	**0.003**	**0.003**	ND	<5	---
7/11/1994	ND	**0.02**	**0.02**	**0.02**	ND	<5	---
10/3/1994	ND	**0.077**	**0.088**	**0.088**	ND	<5	---
1/2/1995	**0.009**	ND	**0.12**	**0.12**	**0.0045**	---	---
1/23/1995	---	---	---	---	---	<5	---
4/3/1995	ND	**0.04**	**0.13**	**0.13**	ND	<5	---
10/3/1995	ND	ND	ND	ND	ND	<5	---
12/4/1995	ND	**0.01**	**0.012**	**0.012**	ND	<5	---
1/8/1996	ND	ND	ND	ND	ND	<5	---
4/1/1996	ND	**0.01**	**0.035**	**0.035**	ND	<5	---
10/7/1996	ND	**0.01**	**0.019**	**0.019**	ND	<5	---
1/2/1997	ND	ND	ND	ND	ND	<5	---
2/3/1997	ND	**0.017**	**0.041**	**0.041**	ND	<5	---
4/7/1997	**0.23**	ND	**0.18**	**0.41**	**0.038**	<5	---
7/7/1997	ND	**0.01**	**0.018**	**0.018**	ND	<5	---

Table 18: Effluent Water Sampling Results

		PAHs (ug/L)					**Phenols**	**Dioxins**
		Sum ***List 1***	**Naphthalene**	***Sum*** ***List 2***	***Total*** ***PAH***	**B*(a)P*** ***Equiv.***	***PCP*** ***(ug/L)***	***HxCDD*** ***(ug/L)***
Surface Water Criterion		**NE**	**81**	**NE**	**NE**	**0.00051**	**5.5**	**0.00038**
	Sample Date							
	10/3/1997	ND	**0.023**	**0.074**	**0.074**	ND	<5	---
	1/8/1998	ND	**0.012**	**0.033**	**0.033**	ND	<5	---
	4/8/1998	ND	ND	ND	ND	ND	<5	---
	8/6/1998	ND	**0.009**	**0.012**	**0.012**	ND	<5	---
	10/20/1998	**0.109**	**0.01**	**0.099**	**0.3**	**0.022**	<5	---
	3/15/1999	ND	ND	ND	ND	ND	**0.3**	---
	5/11/1999	**0.0007**	**0.02**	**0.015**	**0.016**	**0.00009**	**0.08**	---
	7/21/1999	ND	**0.065**	**0.11**	**0.11**	ND	**0.08**	---
	8/19/1999	---	---	---	---	---	**0.07**	---
	10/8/1999	ND	ND	ND	ND	ND	ND	---
	1/7/2003	ND	ND	ND	ND	ND	ND	---
	4/8/2003	ND	ND	ND	ND	ND	ND	---
	7/8/2003	ND	ND	ND	ND	ND	ND	---
	10/6/2003	ND	**0.04**	**0.04**	**0.04**	ND	ND	---

NOTES:

1. The effluent is sampled twice monthly for PCP, but only those sampling events where PCP was detected are included in this table in the interest of saving space.

2. All surface water criterion in the table are Minnesota state surface water criterion

* 1992 data missing from MDH's copy of 1992 Annual Monitoring Report

ND = not detected
NE = no surface water criterion established for this compound
░ = compound not detected, but detection limit exceeded surface water criterion
▒ = compound detected at a concentration exceeding the surface water criterion
--- = not analyzed
ug/L = micrograms per liter, or parts per billion
ng/L = nanograms per liter, or parts per trillion
PCP = pentachlorophenol
PAH = polynuclear aromatic hydrocarbon
B(a)P = benzo(a)pyrene
HxCDD = hexachlorodibenzo-p-dioxin

Appendix C: Detailed Description of St. Regis Operations and Waste Disposal Activities

1) Facility Operations and On-site Waste Disposal

Beginning in 1957, creosote was used as a preservative to treat wood at the FOA. It continued to be used until the facility closed. Creosote is a flammable, heavy, oily liquid with a characteristic sharp, smoky smell, and caustic burning taste. The chemical composition is determined by the source and may contain guaiacol, creosols, phenol, cresols, pyridine, and numerous other aromatic compounds. Pressure treatment of lumber with creosote occurred in a pressure cylinder in the wood treating plant located in the north central portion of the site. Wastewater discharged from the cylinder passed through a separator tank and charcoal filter before discharging into an unlined disposal pond adjacent to the treating plant, called "Pond A" (Figure 2).

The use of pentachlorophenol (PCP) as a pressure treatment chemical for wood products began in 1960. PCP, like creosote, was used until the facility closed. Two underground tanks were installed to further separate the water from the PCP in the treatment discharge. Beginning in about 1960, wastewater was discharged into a series of three unlined disposal ponds collectively called "Pond B" (Figure 2). PCP was generally combined with a carrier solvent, usually No. 2 fuel oil. When present as a free phase product in water, this mixture tends to float. In the latter years of facility operations, a water dispersible PCP concentrate, in a proprietary mixture of PCP and ketone, was used. This PCP concentrate was denser than water, and would sink if present as a free phase product in water.

A second cylinder was added in 1969 to treat wood with a water-soluble metal-salt solution, believed to be chromated copper arsenate (CCA). The small amount of water that was routinely generated in this process was generally returned as makeup water for preparing the treating solution; however, some cylinder wash water was discharged to the disposal ponds.

In 1971, Pond B was covered with sand and replaced with a new unlined pond, "Pond C". In 1972, the cylinder that had been used for treating wood with CCA was added, as an expansion tank, to the original cylinder and a new cylinder was installed for treating wood with PCP and CCA. In addition, a 20,000-gallon underground wastewater separation tank was added for each cylinder.

In 1974, improvements were made to the wastewater treatment system. With these improvements, wastewater from each cylinder was routed to a primary separation tank. The oil that accumulated on top of the wastewater was skimmed from the top of the tank and recycled. The water was then pumped to a mixing station, a settling tank, and a sand filter. Water from the sand filter was carried to a sawdust filter located next to Pond C.

In 1976, a 3,000-gallon spill of creosote was recovered by absorption with sawdust, which was later burned in a brush-burning project. During two occasions in 1976, sludge from the cleaning of tanks was hauled to a disposal site in the southwestern corner of the SWA property (Figure 3). Pond C was dredged on one occasion, and the dredged bottom material was placed on the south, east and north sides of the pond. Sawdust used for removing oil from the filters was deposited in a landfill area immediately northeast of Pond C.

From 1974 to 1980, the average wastewater flow to Pond C was estimated to be 12,000 gallons per day, with a maximum flow rate of 17,000 gallons per day (totaling approximately 30 to 43 million gallons). Water in Pond C was aerated and nutrients were added to improve the treatment of the wastewater. Most of this wastewater likely infiltrated into the soils and groundwater beneath the pond. In 1980, an algal bioassay of the St. Regis effluent determined that even at a 0.01% dilution, the effluent inhibited algal growth, and at a 50% dilution all of the algae was killed (U.S. EPA, 1980a).

In 1980, wastewater from Pond C was sprayed on the ground in various areas of the FOA and SWA properties (Figures 2 and 3). Timber, metal and other demolition wastes were deposited in the landfill area (Figure 2). A letter dated October 14, 1981, from the MPCA to St. Regis Paper Company, reported that during a site inspection, MPCA staff observed "…various wood wastes, penta [i.e. PCP] and creosote treated scrap and other related by-products from [St. Regis'] operation…" in a lowland area on St. Regis property, adjacent to Pike Bay that is referred to in the letter as "Wheeler Division Wood Waste Dump (CS-55)" (MPCA, 1981a). Empty containers that once contained water-soluble, wood preserving chemicals were also reportedly placed in the landfill area or were burned in "Tee-Pee Burners" (Figure 2). Airborne ash from the tee-pee burners would have deposited on land and surface water areas downwind of the burners.

From 1980 until the facility closed in 1985, water was evaporated from the waste and the residue placed in barrels and transported to an out-of-state hazardous waste disposal facility. However, contaminated water from the ponds and other waste water were transported out of state and properly disposed, but rather were disposed through the city sewage treatment plant and spray irrigated in other areas as described in the sections below. On August 6, 1985, Champion announced the planned closure of the Cass Lake facility. The facility was closed on August 31, 1985.

2) **Off-site Wastewater Disposal at City Sewage Treatment Plant**

In 1981, the MPCA received a complaint from Leech Lake Department of Natural Resources staff alleging that wastewater from the plant was discharged from tanker trucks through a hose into a manhole adjacent and leading to the city wastewater treatment plant (MPCA, 1981b). The treatment plant discharges to Fox Creek. Reportedly, a tanker truck from the St. Regis facility would discharge approximately 1,000 to 1,500 gallons of waste into the manhole. The memo states this happened "…between the hours of 4:00 p.m. to 9:00 p.m. (usually on Mondays)", but did not describe how long the practice had been occurring.

In July and August 1981, MPCA staff sampled wastewater found in the hose and the effluent from the treatment plant. They detected 28-76 mg/L (ppm) PCP in the hose sample and 5.3 ug/L (ppb) PCP in the treatment plant effluent. The samples were collected approximately four to twelve hours after discharge to the manhole. An undated MPCA letter to the Leech Lake Reservation Business Committee (stamped received January 8, 1982) noted that no standards existed for discharge of PCP to a publicly owned wastewater treatment works, but that the oil and grease standard of 100 mg/L was "…designed to limit sewer discharges of PCP to 15 mg/L". The letter states that additional composite samples were collected in November 1981, to conduct a static bioassay (MPCA, 1982). A search of MPCA files did not locate the results of that bioassay.

3) Off-site Disposal at Cass Lake City Dump

Between 1957 and 1960, wastewater from Pond A and sludge from the storage tanks were hauled to a pit at the city dump and burned (Figure 4). This disposal occurred almost daily at an estimated rate of 500 gallons per day, for an estimated total of 547,500 gallons for those three years. From 1960 to 1975, unknown quantities of sludge were hauled to the pit. It is probable that the contents of the pit were burned during this time period as well. The pit containing the ash and unburned residuals was eventually covered. All three types of wood treatment chemicals; creosote, PCP, and CCA, were used at the facility during the time that waste was hauled to the pit. The facility regularly dumped site-related waste and materials in the city dump.

4) Off-Site Disposal at Southwest Area

As noted earlier, significant volumes of wastewater and sludge were disposed in the SWA. In addition to the two events of waste disposal in a pit near the southwest corner of this property, and spraying of wastewater on the property, former workers have alleged significant volumes of wastewater and sludge were dumped near the southeast corner of the property (Figure 3).

An EPA memo dated July 9, 1994 reports a former St. Regis employee's allegation that for a period of at least three years, sludge from the plant was disposed in the Southwest Area (EPA, 1994). According to the memo, the former employee indicated "…he would haul a 3,000 gallon tanker of sludge at least once a week and dispose of its contents upon the open ground. The sludge was identical to those he had placed within the city's landfill." The location indicated by the former employee is north of Fox Creek and west of Highway 147 (Figure 4). The area where the dumping occurred slopes southward toward Fox Creek; the employee recalled seeing the sludge moving downhill but did not recall actually seeing the sludge enter the water of the creek. The memo states that the same employee also noted that north of the current RCRA vault, the company stored 55-gallon steel drums of copper arsenate (Figure 4). The drums reportedly were not sheltered and he recalled that some were rusted and leaked their contents on the ground. He also recalled on one occasion lifting a drum that ruptured and spilled all of its contents onto the ground.

The information in the EPA memo is consistent with information provided to MDH staff by former employees in a conversation prior to a public meeting held on July 7, 2003. However, in that conversation, the former employees indicated that sludge was observed entering the creek. If the former employees' estimates are correct, as much as 468,000 gallons of sludge may have been disposed in the area immediately north of Fox Creek and immediately west of Highway 147. Currently there are no monitoring wells located in the area identified by the memo and by the former employees (Figure 5).

The wastewater sprayed in the SWA likely had high concentrations of PCP and other contaminants. In 1980, EPA collected samples of wastewater from Pond C, after the sand filter, and after the sawdust filter. High concentrations of PCP were detected in all of the samples, including 42,000 ug/L PCP in the sample collected after the sawdust filter (U.S. EPA, 1980b). This suggests that wastewater sprayed in the SWA could have resulted in significant contamination to soil, groundwater, and surface water.

Treated timber was stored at the SWA, which likely resulted in creosote and PCP dripping onto the ground surface. There are no reports of burying wood waste in this area, but a trench excavation northeast of former well MW-111 encountered black bark chips and "dark material" at depths of approximately 2 to 4 feet below grade and sloping to the west (St. Regis, 1983). It is likely that this area was excavated during the construction of the soil containment vault. It is not known whether the soil in this area was disposed in the vault, or used as "clean" fill in the FOA, along with other soils excavated during the vault construction.

5) Environmental Investigation

Investigation of the site began in 1981 and a report titled "Groundwater Investigation – Cass Lake Wood Treating Facility" was issued in October 1982 by St. Regis' consultant, Barr Engineering. The investigation determined that the upper aquifer beneath the site was contaminated with various PAHs, phenol, and PCP.

In September 1984 the site was placed on the National Priorities List (NPL) and in January 1985 Champion assumed responsibility for the site. In 1984-1985, a Remedial Investigation was conducted at both the former plant and the city dump, in which both the upper and lower aquifer were evaluated for groundwater contamination and surface water was sampled. The study concluded that PCP and PAHs were present in the upper aquifer in the FOA, with the plume originating in the area of the treating plant and extending eastward to the channel between Cass Lake and Pike Bay.

Samples from one well on the eastern portion of the FOA found low levels of polychlorinated dibenzo-p-dioxins (PCDDs) in the groundwater. PCDDs are a class of compounds, also called "dioxins", that includes 75 individual compounds. These individual compounds are technically referred to as congeners. Five forms of these compounds are considered to be significantly toxic and will occasionally be discussed separately as tetrachlorodibenzo-p-dioxin (TCDD), pentachloro-dibenzo-p-dioxin

(PeCDD), hexachlorodibenzo-p-dioxin (HxCDD), heptachlorodibenzo-p-dioxin (HpCDD), and octochlorodibenzo-p-dioxin (OCDD). More often, all of the dioxin congeners detected at the site will be referred to as PCDDs. For more information about dioxins, dioxin congeners, and their toxicity, please refer to Appendix B.

Contamination in the upper aquifer was found both at the surface of the water table and near the base of the aquifer, indicating that the contamination has migrated downward through the aquifer. Low concentrations of PCP were also detected at the base of the aquifer on the east side of the channel. Investigations in the Dump area showed higher concentrations of PCDDs, PCP, other phenolic compounds, and PAHs in the shallow aquifer than at the FOA, and groundwater was found to be discharging to Fox Creek. Evaluations of the lower aquifer were inconclusive, due to the few wells installed.

Private wells interspersed with the facility property were found to have very low levels of some PAHs, PCBs, and PCP (Table 1, Figure 6), and other wells south of the facility were deemed to potentially be at risk for future contamination. Very low levels of PAHs were also detected in the Cass Lake municipal water supply wells, but PAHs did not exceed drinking water criteria (Table 2). Surface water sampling detected PCP in Fox Creek at concentrations of 2.1 ug/L in an upstream sample collected near Highway 371 and 0.3 ug/L in sample collected immediately west of Highway 149.

In 1985 and 1986, Champion excavated approximately 22,000 cubic yards of contaminated soil and 4,000 cubic yards of sludge. These were disposed of in the vault constructed in the Southwest Area in 1986-1987 (Champion, 1988). The engineered life of the vault is reportedly 20 years. This has raised the concern that leachate from the vault (that is, water that has picked up contaminants as it leaches through the vault contents) could escape the leachate collection system and impact groundwater. Several nearby wells are used to supply water to the Leech Lake Band of Ojibwe's (LLBO) Division of Resource Management offices and fish hatchery.

A groundwater pump and treat system consisting of eleven extraction wells was constructed at the FOA in 1985 and became operational in 1987. Three pump-out wells were installed in the City Dump Pit Site in 1988. Pipelines carry the contaminated groundwater from the wells to a carbon treatment plant located in the FOA. The treated water discharges to the channel (Figure 7). The combined water extraction rate is approximately 1,200 gallons per minute, but not all of the wells operate at all times.

All of the private properties interspersed with the facility property and south of it, except one (where the homeowner refused; labeled G on Figure 6), were connected to city water. However, not all of the wells were sealed. At least one business continues to use a private well for non-potable use (labeled HH on Figure 6). In addition, three homes in and near the FOA still have wells present on their property, although the wells are currently not in use and these homes are connected to city water (labeled J, EE, and JJ on Figure 6).

In March 1995, the Minnesota Pollution Control Agency (MPCA) submitted a 5-year review report of the clean-up actions implemented at the site. This first 5-year review revealed that some of the clean-up actions were not adequate and that further action was needed to ensure protection of human health and the environment. The first 5-year review recommended that if significant soil, sediment, or surface water contamination related to the groundwater treatment plant or former city dump pit is found, a risk assessment should be performed to assess existing and potential impacts of site-related contaminants on potential human, terrestrial, and aquatic receptors.

In 1995, upon completion of the first 5-year review, USEPA assumed the lead oversight role for the site. The LLBO provides local oversight personnel. Based on the first 5-year review, US EPA, MDH, and the Leech Lake Division of Resource Management (LLDRM) identified several areas that required further investigation.

As a result of the findings of the first 5-year review, LLDRM obtained an Environmental Justice grant and U.S. EPA Superfund pilot project grant to support their involvement in site assessment activities. These grants were used to collect fish tissue data in 2001, develop the LLDRM’s subsistence exposure scenarios for the site (Leech Lake Band of Ojibwe, 2003), and to fund a Sea Grant evaluation of the site that concluded additional investigation was needed (Richards, et. al, 2002).

US EPA began the second 5-year review process in 2000, as it was planning to implement sampling recommendations from the first 5-year review. In October 2001, Tetra Tech (US EPA’s contractor) conducted a field investigation of the site that included sampling of soil, surface water, groundwater, sediment and fish. The sampling results identified site-related contamination in all of these media (US EPA, 2002a). ATSDR was provided a copy of the Final Data Evaluation Report for the St. Regis Paper Company site and was asked to provide a public health assessment to USEPA, based on a review and analysis of the new environmental data.

Based on the October 2001 sample data, EPA mailed soil sample results to all the current owners and residents whose properties were sampled. ATSDR, LLBO, and MDH co-authored a letter sent February 2003 to 40 residents south of the site advising them to avoid contact with contaminated soils.

Appendix D: Health Risks Related to Contaminants of Concern at the St. Regis Site

A. Properties of the Contaminants of Concern

1) Pentachlorophenol

Pentachlorophenol (PCP) was recognized and used as an insecticide, fungicide, herbicide, molluscicide, and algicide in a wide variety of applications (ATSDR 1994). PCP was used as preservative for utility poles, fence posts, railroad ties, and other common industrial wood products. PCP is common in the environment, and is found across the United States in surface waters, sediments, rainwater, groundwater, soils, food, and living organisms, including humans (ATSDR 1994).

At the St. Regis site, PCP contaminated waste was directly disposed in ponds that likely were in direct communication with the groundwater and this would hasten the transfer of PCP into the groundwater. Moreover, the presence of LNAPL on the surface of the water table provides a continuing source for PCP to disperse into the groundwater. Microorganisms in the soil, groundwater, surface water, and sediments metabolize PCP, and biodegradation is thought to be the major pathway of PCP degradation in the environment.

In surface water, PCP will degrade when exposed to sunlight (Wong and Crosby, 1981; Pignatello, et. al., 1983). However, this process is limited by increasing water depth. At greater water depths, microbes play the greater role in breaking down PCP in the environment (Pignatello, et. al., 1983). Similarly, PCP will be degraded by bacteria in soil, sediment, and groundwater, where sunlight plays no role in the breakdown of the chemical.

Studies of fish and freshwater mussels indicate that PCP will accumulate in their tissues, but is eliminated rapidly if subsequently exposed to clean water (Pruitt, et. al., 1977; Makela, et. al., 1991). Human studies indicate PCP has a relatively short half-life (i.e. the amount of time it takes for half of the PCP that entered the body to be eliminated), approximately 33 hours, with most of the PCP being eliminated through the urine (ATSDR, 1994).

Short-term exposure to high concentrations of PCP is associated with adverse effects to the kidneys, blood, lungs, nervous system, immune system, and gastrointestinal tract (ATSDR, 1994). It can also cause a potentially serious increase in body temperature as the body attempts to metabolize it. Animal studies also indicate PCP ingestion by female rats resulted in slight changes in the formation of the bones of their offspring, but it is not known whether PCP causes birth defects in humans. PCP has also been shown to decrease the number of offspring born to animals that were exposed to it during pregnancy, but again it is not known whether PCP has the same effect in humans.

Dermal contact can irritate the skin, eyes, and mouth. These types of exposures and concentrations are usually only seen in the workplace. Former St. Regis employees have described skin, eyes, mouth, and nose irritation from handling or breathing vapors from PCP treated materials.

Long-term exposure to lower levels of PCP can cause damage to the liver, kidneys, blood, and nervous system. PCP is considered a probable human carcinogen. Some of the adverse effects associated with exposure to PCP may be caused by impurities present in commercially produced PCP, such as dioxins and furans.

2) Polynuclear Aromatic Hydrocarbons

Polynuclear aromatic hydrocarbons (PAHs) are produced by the incomplete combustion of organic materials such as coal, oil, wood, tobacco, and even food products (ATSDR 1995). They are also found in petroleum products such as asphalt, coal tar, creosote, and roofing tar. As a result, they are very common in the environment from such processes as volcanic eruptions, forest fires, home wood burning, and vehicle exhaust. Over 100 PAHs have been identified, and they are usually found in the environment as mixtures. PAHs generally fall into two groups based on their potential health effects: those that are carcinogenic (cancer causing, known as cPAHs), and those that are not (non-carcinogenic PAHs, or nPAHs). The PAHs found on the site (a mixture of cPAHs and nPAHs) are likely present as a result of the use of creosote in wood treatment. Creosote itself is usually derived from coal tar, and is described as a thick, oily liquid that is amber or black in color, and contains hundreds or even thousands of different chemicals including PAHs and phenols (ATSDR 1996). It has been in use as a wood preservative and waterproofing agent for over 100 years.

PAHs tend to bind to soil particles, especially organic matter, and therefore tend to remain in soils and sediments. Because of their affinity for organic matter, PAHs can accumulate in aquatic and terrestrial organisms, but unlike PCP can become concentrated as they move up the food chain (ATSDR 1995). This effect is somewhat balanced by the ability of many organisms, such as fish, to metabolize PAHs. In soil, microorganisms can metabolize PAHs. Environmental factors like soil nutrients, types of microbes present, and the properties and concentrations of PAHs present influence the extent and rate of decomposition (ATSDR 1995).

Individual cPAHs are classified as probable or possible human carcinogens by the International Agency for Research on Cancer (IARC) (ATSDR 1995). MDH uses information developed by the California Environmental Protection Agency to evaluate the carcinogenicity of cPAHs, and the list of cPAHs of concern has been expanded from prior lists typically reported by EPA (MDH 2001). Exposure to high levels of PAHs in general has also been associated in animals with reproductive difficulties and adverse effects on the skin and immune system. Most PAHs and their metabolites cross the placenta readily, and pre- and post-natal exposure to PAHs could produce adverse reproductive and developmental effects in human fetuses. The offspring of mice fed high levels of benzo(a)pyrene during pregnancy had birth defects and decreased body weight. It is not known whether similar effects occur in humans (ATSDR, 1995b). Moreover, animal studies suggest delayed effects may occur to offspring born to mothers exposed to PAHs during pregnancy, including sterility, immune suppression, and possible alteration of endocrine function (ATSDR, 1995b). Adverse effects on the liver and gastro-intestinal tract have also been noted.

3) Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs)

The polychlorinated dibenzo-p-dioxins (PCDDs) include 75 individual compounds, and the polychlorinated dibenzofurans (PCDFs) include 135 individual compounds. These compounds are referred to as congeners. Only 7 of the 75 congeners of PCDDs are thought to have dioxin-like toxicity; these are ones with chlorine substitutions in, at least, the 2,3,7, and 8 positions. Only 10 of the 135 possible congeners of PCDFs are thought to have dioxin-like toxicity; these also are ones with substitutions in the 2,3,7, and 8 positions. The 17 PCDD and PCDF congeners with dioxin-like toxicity (i.e. chlorine in the 2,3,7, 8 positions) are collectively referred to as dioxins.

Dioxins and furans are formed as a result of the incomplete combustion of fossil fuels, organic matter, and waste materials, during the bleaching of paper in pulp and paper mills, and as a by-product in the production of other chemicals such as the wood preservative PCP, and the herbicide 2,4,5-T (ATSDR 1998). In the environment, dioxins and furans always occur as various combinations of all the possible congeners.

In soil, dioxins tend to bind to small particles or organic matter. They tend to settle out of the air or water as they attach to organic particulate and end up in soils or sediments. However, as seen at the St. Regis site, dioxins can be present in groundwater, particularly in areas where LNAPL is present to act as a continuing source of dioxin to the dissolve into the groundwater.

In sediments, dioxins are taken up by microscopic organisms. Dioxins then pass through the foodchain and become concentrated in the tissues of larger aquatic animals, especially in the fatty tissue. Dioxins accumulate in organisms (bioconcentration effect) because they do not metabolically breakdown and they are lipophilic (dissolve into fat). Dioxins in soil can be transported to surface water bodies via runoff, where humans and animals may be exposed to them through indirect ingestion or dermal contact. Plants do not efficiently take up dioxins through their roots, but may have dioxins on their surfaces as a result of particle deposition (ATSDR 1998). Animals (e.g. cows, chickens) or humans that eat the plants or ingest soils may then ingest the dioxins.

On the surface of soil and sediments in very shallow water, and in surface water, dioxins may be broken down by sunlight, a process known as photodegradation. The half-life of TCDD on soil may be on the order of 15 years at the soil surface (Paustenbach et al, 1992). This process is only effective in the top few millimeters of soil where ultraviolet light can penetrate (EPA, 2000), and likely even less in sediments, as much of the ultraviolet light would be filtered by the overlying water. Burial in place (by the constant accumulation of airborne dust and dirt, erosion, and the buildup of organic matter) or erosion to surface water bodies are likely the main environmental fate of dioxins in soil and sediment. Once buried, TCDD has been shown to have a half-life of up to 100 years, and becomes tightly bound to soil organic matter (EPA 2000).

As a result of natural and man-made processes, dioxins are found nearly everywhere in the environment. Dioxins have been found in the fat tissue of humans across the U.S., even in those who have no known exposure to dioxins. This indicates that exposure is widespread, and is likely occurring through the food supply. Foods containing animal fat, such as meat, fish, and dairy products are the most common dietary sources. Dioxins may also be passed from mother to fetus via maternal blood and to the infant through breast milk.

According to an EPA summary, background levels of dioxins in soils in rural areas in North America average 2.5 parts per trillion (ppt, or 0.0025 ppb) as expressed using TEFs (see next section), with a range of between 0.1 to 6 ppt (EPA 2000). Background soil dioxin levels measured for the St. Regis site are 1ppt TEQ. In urban areas, the average cited by EPA is 9.4 ppt (0.0094 ppb), with a range of between 2 and 21 ppt. Background levels in sediments average 5.31 ppt (0.00531 ppb) with a range of from less than 1 ppt to 20 ppt. There has been little testing of surface waters. Based on these limited studies, EPA estimates a "typical" TEF of 0.00056 ppq in water, for the purpose of estimating background exposures for the general population.

Toxic Equivalency Factors (TEFs) for Dioxin

Not all dioxins and furans are as toxic as TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin), but all are thought to cause adverse effects through the same mechanisms. To estimate the toxicity of dioxin and furan mixtures, a series of toxicity equivalency factors (TEFs) have been developed that compare the toxicity of other dioxin and furan congeners to TCDD. The overall toxicity of a mixture can then be calculated in terms of total TCDD equivalents. The TEFs used in this Health Consultation were published by the World Health Organization (WHO) in 1998 (EPA, 2000). The TEFs are based on existing toxicological data on individual dioxins and furans, or are estimated using a number of different methodologies. They are intended to be used pending additional research on specific dioxin and furan compounds. The current WHO TEFs are listed in the table below (EPA, 2000):

Dioxin/Furan TEFs, WHO 1998			
Dioxin (D) Congener	TEF	Furan (F) Congener	TEF
2,3,7,8-TCDD	1.0	2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDD	1.0	1,2,3,7,8-PeCDF	0.05
1,2,3,4,7,8-HxCDD	0.1	2,3,4,7,8-PeCDF	0.5
1,2,3,6,7,8-HxCDD	0.1	1,2,3,4,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDD	0.1	1,2,3,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDD	0.01	1,2,3,7,8,9-HxCDF	0.1
1,2,3,4,6,7,8,9-OCDD	0.0001	2,3,4,6,7,8-HxCDF	0.1
		1,2,3,4,6,7,8-HpCDF	0.01
		1,2,3,4,7,8,9-HpCDF	0.01
		1,2,3,4,6,7,8,9-OCDF	0.0001

B. Exposure Routes

Area residents have to come into physical contact or “be exposed” to the hazardous materials disposed of at the St. Regis site for these toxic chemicals to cause the development of adverse health effects. For the residents to come into contact with these chemicals, there must be the development of a completed exposure pathway. A completed exposure pathway consists of five main parts that must be present for exposure to the chemicals to occur. These include:

- A source of the toxic chemicals of concern (chemical releases and spills);
- Environmental transport which allows the chemical to move from the site and bring it into contact with a person (receptor);
- A point of exposure which is the place where the receptor comes into direct contact with the chemical;
- A route of exposure which is how the receptor comes into contact with the chemical (drinking it, eating it, breathing it, touching it); and
- A population at risk which are people near the site who could possibly come into physical contact with site-related chemicals.

Physical contact with a chemical contaminant in and by itself does not necessarily result in adverse health effects. Exposure pathways can also be characterized by when the exposure occurred or might occur in the past, present, or future.

A chemical’s ability to affect health is also controlled by a number of other factors including:

- How much of the chemical a person is exposed to (the dose).
- How long and how often a person is exposed to the chemical (duration and frequency of exposure).
- The chemical’s toxicity and how it impacts the body.

Other factors affecting a chemical's likelihood of causing adverse health effects upon contact include the resident's:

- History of past exposure to chemicals;
- Smoking, drinking alcohol, or taking certain medicines or drugs;
- Current health status;
- Sensitivity to certain substances;
- Age and sex; and,
- Family medical history.

The potential routes of exposure to the contaminants of concern at St. Regis include:

- Ingestion of contaminated ground water, surface water, or sediment
- Dermal (skin) exposure to contaminated ground water, surface water, or sediment
- Inhalation of contaminated water droplets (especially from steam in showers or sweat lodges, or from dishwashers or washing machines) or contaminants that evaporate from the soils and/or groundwater and accumulate inside buildings.

NOTE: There are other exposure pathways, most notably ingestion or dermal exposure to contaminated soil and ingestion of fish, which are discussed in other site health assessment documents, but which add to the cumulative exposure of residents and others in this area.

1) Ingestion

a) Contaminant concentrations in accessible ground water

Exposures to the contaminants of concern at the site, via ingestion of groundwater, appear to have occurred in the past, but this does not appear to be a current exposure pathway. Some residents were exposed by drinking water from their wells. Concentrations of PAHs and PCP were generally low and below drinking water criteria. One residential well (well J, see figure 6), however, exceeded the drinking water standard for PCP twice and the site action level for total PAHs once, although no individual PAH appears to have exceeded a drinking water criterion. Only one residential well (JJ, see figure 6) was tested for dioxins, which were detected at very low concentrations. Workers at the facility may have also been exposed by drinking water from a well at the facility. Although sampling of this well was extremely limited, 7.2 ug/L biphenyl, 24 ug/L pyrene, and 2.1 ug/L fluoranthene were detected in 1980.

Other residents may have been exposed to the contaminants of concern by drinking water from the city water supply system prior to removal from service of city wells #1 and #3. Low levels of PAHs were detected in both of these wells, but levels did not exceed drinking water criteria. PCP was generally not detected in the wells, but the detection limit was always higher than the current drinking water standard of 3 ug/L. One exception was the detection of 8.9 ug/L PCP in well #1 in 1986 (see table 2). Samples from two taps (residential and at the facility), drawing water from the city water system, provided comparable results. Low concentrations of PAHs were detected, below drinking water standards, and PCP was generally not detected but the detection limit was above 3 ug/L. In one instance, in 1984, 4.3 ug/L PCP was detected in water from the residential tap.

b) Contaminant concentrations in other media

Ingestion of the contaminants of concern may also occur during wading, swimming, scouting, or foraging in areas with contaminated surface water or sediments. Although these activities would occur infrequently and would be mostly limited to summer and early autumn, they still may constitute a significant exposure, particularly for children who are likely to spend more time playing in shallow water and are more likely to swallow water when they swim.

Unfortunately, the sediment and surface water sampling have not focused on the swimming area at the city park on Pike Bay, where most wading and swimming is likely to occur. The few sediment samples collected from that area (Table 14) indicated low concentrations of dioxins (below the sediment standard), but samples were not analyzed for PAHs, PCBs, or PCP. Surface water samples have not been collected from the swimming area (Figure 26). Surface water and sediment samples elsewhere in Pike Bay indicate contamination by PCP and PAHs.

Sediment samples from the channel area and Fox Creek indicate significant PAH contamination is present (Tables 13 and 15). PCPs generally were not detected, but the detection limits were quite high. While the channel area is not likely to have much swimming or wading activity, it is reported that children frequently wade in Fox Creek, and local school groups have even visited it for field trips.

c) Oral Bio-availability

PCP is readily and completely absorbed following oral exposure (ATSDR, 1994).

PAHs are absorbed at different rates, depending upon the specific chemical and the vehicle on which it is ingested. Oral absorption of benzo(a)pyrene is estimated to be 40-80 percent. Higher rates of absorption (65-90 percent) have been observed with ingestion of chrysene, dibenzanthracene, and pyrene. Studies suggest high rates of absorption of fluoranthene and benz(a)anthracene as well (ATSDR, 1995b).

No information is available regarding the oral bio-availability of dioxins in water. The oral bio-availability of dioxins in soil and sediment is partially dependent on the soil organic content, and for TCDD has been found to range from 0.5% to 50% in animals (EPA, 2000). The bio-availability of other dioxin compounds, such as the octa-CDDs may be less, perhaps 10% of the absorption rate of TCDD (Duff and Kissel, 1996).

2) Dermal Exposure

a) Dermal Contact

The area of skin available for contact with ground water, surface water, and sediments will vary according to season and personal habits. When the affected homes were connected to city water the primary dermal contact route with groundwater, bathing or showering, was eliminated. However, the potential remains for Cass Lake residents and visitors to contact contaminated surface water and sediments. Typically, it is assumed that skin contact involves the hands and lower arms, but can include the legs, feet, or other body parts. Skin available for contact with surface water and sediments increases in warmer weather when individuals may wade, swim, or engage in foraging activities that involve entering shallow water.

The area where dermal contact with contaminated sediment and surface water is most likely to occur, the swimming beach at the city park, has had almost no sampling, as noted above. Samples collected there indicate minor contamination by dioxins, but nothing is known of PAH or PCP contamination in this area. However, PCP and PAHs were detected in surface water and sediment samples elsewhere in Pike Bay. Significant concentrations of PAHs have been detected in sediment samples from Fox Creek and the channel. Surface water samples in these areas are less conclusive, but suggest elevated PCP concentrations in the channel and moderate contamination by PAHs in both areas.

b) Dermal Bioavailability

PCP is readily and completely absorbed following dermal exposure (ATSDR, 1994).

Dermal absorption can play a major role in PAH exposure. Some PAHs, such as phenanthrene, antrhacene, pyrene, and fluoranthene, are readily absorbed by humans following dermal exposure, while others, such as benzo(a)pyrene, are much less readily absorbed (ATSDR, 1995b).

Dioxins appear to be absorbed slowly through the skin, indicating that if the exposed area is adequately washed within a reasonably short time after exposure, much of the absorption can be prevented (47).

3) Inhalation

a) Inhalation exposures

Prior to connection to the city water system, inhalation of the chemicals of concern may have occurred in homes with contaminated water, primarily through steam or water particles in showers, kitchens, and laundry areas. However, the low volatility of most of the chemicals of concern, and the low concentrations detected in the water of most of the homes, would have made this a minor exposure pathway. Contaminant vapors could also enter homes by evaporating from contaminated soils and groundwater. Only naphthalene appears to be present at high enough concentrations at the site for this transport mechanism to pose a potential risk, and it does not appear to be present at such high concentrations in areas where there currently are residences.

Residents and workers near the wood treating facility likely were exposed to significant ambient levels of PCP in the air, related to operations at the facility. For example, workers in the vicinity of the cooling tower may have been exposed to 14.4 mg/day and workers elsewhere in the plant may have been exposed to 0.9-14 mg/day (US EPA, 1980c). Indoor air of structures built with industrially dipped, non-pressure treated wood were reported to contain levels of PCP ranging from 34 to 104 ug/m^3 (EPA, 1984). Given the proximity of some homes to the facility and wood storage areas, similar exposures may have also occurred to residents.

Inhalation of dioxins, aside from those carried on airborne particles, is likely to represent a very minor exposure pathway. The low solubility and low vapor pressure values for dioxins make it very unlikely to be present at significant concentrations in steam droplets or as a vapor. However, during the period when the wood treating facility was in operation, this exposure pathway may have been more significant for some residents, particularly workers at the facility or those living nearest to it. During the 2003 site visit, former workers related to MDH staff how steam would “pour out” of the pressurized treatment vessels. These exposures may have been significant.

b) Inhalation Bioavailability

PCP is readily and completely absorbed following inhalation exposure (ATSDR, 1994).

Animal studies suggest that PAHs absorption may be partial or complete depending upon the mechanism by which the inhalation occurs (i.e. particles, steam droplets, or vapor; ATSDR, 1995b).

Studies suggest that inhaled TCDD will be absorbed; however the degree and rate of absorption is dependant on the vehicle (usually particles), and percent chlorination of the particular dioxin congener (US EPA, 2000).

C. Background Exposure

Studies in the 1970s found PCP in the urine, blood, and fat tissue of the general population at concentrations far below the levels found in people exposed occupationally (ATSDR, 1994). The primary exposure route for the general population appears to be through the food supply (Coad and Newhook, 1992; Wild and Jones, 1992). However, use of PCP has decreased significantly since the 1970s and it is likely that general population exposures and body burdens have also decreased. In 1984, the FDA estimated dietary intake for various populations based on a study of foods from 1982-1984. The intake per body weight was highest for infants (6-11 months) at 59 ng/kg/day and lowest for women ages 60-65 years, at 13.9 ng/kg/day. In 1988, when the FDA conducted a similar study, they estimated much lower dietary intakes, with infants receiving just 0.4 ng/kg/day and 60-65 year old females receiving 0.3 ng/kg/day (FDA, 1989).

Although it is difficult to generalize about PAHs, it appears that the primary exposure pathway for the general population is inhalation. Ambient air concentrations of benzo(a)pyrene tend to be higher in urban areas (0.2 to 19.3 ng/m^3) than in non-urban areas (0.1 to 1.2 ng/m^3) (ATSDR, 1990). The average ambient air concentration of naphthalene in urban and suburban areas has been reported as 0.95 ug/m^3 (ATSDR, 1995b). Smokers and those exposed to second-hand smoke have significantly higher exposures to PAHs than the rest of the general population(ATSDR, 1995b). Smoking one pack per day has been estimated to result in exposure to cPAHs of up to 5 ug/day (Menzie, et. al, 1992). Estimated background concentrations of PAHs in food range from 1.6 – 16 ug/day, although there is considerable uncertainty in these estimates (Sandtodonato, et. al., 1981).

The mean daily exposure in the general U.S. population to dioxins is approximately one picogram per kilogram of body weight per day (1 pg/kg/day) of TCDD equivalents (Mocarelli, et. al., 1991). A picogram is one-trillionth of a gram (0.000000001 gram). Estimates of the 95th and 99th percentile intake rates are two times the mean and three times the mean, respectively. Intake rates may be as much as three times higher for children. The vast majority of this exposure is through the diet. Studies have shown that levels of dioxins and furans measured in human body fat have declined from the early 1980s to the present as a result of the increased regulation of emission sources and the subsequent decrease in levels measured in the environment (Mocarelli, et. al., 1991).

Dioxin and dioxin like compounds readily enter the food chain and it is estimated that approximately 90% of exposure occurs through food for the general population (ATSDR, 1997, 1998). The main sources of background exposure to dioxins are foods like meat, cheese, dairy products, and fish. Fruits and vegetables generally have much lower levels of dioxin. The amount of background exposure is dependant on the amount and types of food consumed and the level of contamination. Certain sub-populations, such as those who eat a particularly fatty diet, subsistence fishermen, and nursing infants may have a higher daily intake.

Appendix E: Evaluation Criteria for Groundwater, Surface Water, and Sediment

1. Groundwater

Drinking water criteria, primarily those developed by the Minnesota Department of Health, are used in this report for evaluating groundwater contamination (see table on page 55). Site specific "response action levels" (RAL) developed by the Minnesota Pollution Control Agency were used for total List 2 (non-carcinogenic) PAHs. Groundwater cleanup levels developed by the Leech Lake Band of Ojibwe (LLBO) were used where HRLs or HBVs were not available (Leech Lake Band of Ojibwe, 2000). These values were developed to be protective of both human health and the environment. All of the LLBO clean up levels are included in the table below.

The main drinking water criteria used by MDH are Health Risk Limits (HRLs) and Health Based Values (HBVs). A HRL is the concentration of a groundwater contaminant, or a mixture of contaminants, that can be safely consumed daily for a lifetime. MDH has established HRLs for 120 contaminants that are most commonly found in Minnesota's groundwater. These criteria were formally adopted into Minnesota State rules through a public rule-making process. They may be found in the Health Risk Limits for Groundwater Rule (Minnesota Rules, Parts 4717.7100 to 4717.7800). The HRLs were developed using risk assessment methods and toxicological data from the U.S. Environmental Protection Agency (U.S. EPA). U.S. EPA's risk assessment methods undergo extensive review by U.S. EPA scientists and a public review process. A more detailed discussion of HRLs can be found at MDH's website:
http://www.health.state.mn.us/divs/eh/groundwater/hrlrule.html

A HBV is developed using the same method for developing a HRL, but the value has not been formally adopted through a public rule-making process. Like a HRL, a HBV is the concentration of a groundwater contaminant, or a mixture of contaminants, that poses little or no risk to health, even if consumed daily over a lifetime. The Minnesota Department of Health (MDH) develops HBVs in response to requests from other Minnesota agencies that have found a contaminant in Minnesota groundwater for which no HRL exists (MDH, 2004). Toxicological data used to develop an HBV may be held to less rigorous standards than are data used to develop a HRL. Differences may include the number of studies and the quality of those studies. Because of these differences, HBVs may have less certainty than HRLs. MDH is currently in the process of revising the HRLs, and some HBVs may be included in the future list of HRLs.

As noted above, site specific response action levels (RALs) were established by the MPCA for total List 2 (non-carcinogenic) PAHs. RALs for total PAHs are often applied at Superfund sites to trigger some kind of action when contaminants exceed the RAL.

DRINKING WATER CRITERIA

Contaminant	**Value (ug/L)**	**Criteria**	**Source**	**LLBO Clean-up Level (ug/L)**
List 1 PAHs				
Benzo(a)pyrene	0.05		MDH, 2004	0.001
Chrysene	5	B(a)P equiv.*	MDH, 2004	0.002
Benzo(b)fluoranthene	0.5	B(a)P equiv.*	MDH, 2004	NE
Quinoline	NE			NE
Benzo(k)fluoranthene	0.5	B(a)P equiv.*	MDH, 2004	0.001
Sum List 1	0.05	HBV	MDH, 2004	NE
List 2 PAHs				
Acenaphthylene	NE			400
Anthracene	2,000	HRL	MDH, 1994	0.02
Benzo(b)thiophene	NE			NE
Biphenyl	NE			NE
Carbazole	20	HBV	MDH, 2001a	NE
Dibenzofuran	20	HBV	MDH, 2004	NE
2,3-Dihydroindene	NE			NE
Fluoranthene	300	HRL	MDH, 1994	0.005
Fluorene	300	HRL	MDH, 1994	NE
Indene	NE			NE
2-methyl-naphthalene	NE			NE
1-methyl-naphthalene	NE			NE
Naphthalene	300	HRL	MDH, 1994	0.1
Phenanthrene	NE			0.03
Pyrene	200	HRL	MDH, 1994	200
Triphenylene	NE			NE
Sum List 2	0.3	RAL	MPCA	NE
Phenolics				
Phenol	4,000	HRL	MDH, 1994	0.2
PCP	3	HRL	MDH, 1994	0.02
PCBs	0.04	HRL	MDH, 1994	0.01
Dioxins				
TCDD	0.00003	MCL	U.S. EPA, 2002b	0.000003
PeCDD	0.00003	TEQ*	WHO, 1998	0.000003
HxCDD	0.0003	TEQ*	WHO, 1998	0.00003
HeCDD	0.003	TEQ*	WHO, 1998	0.0003
OCDD	0.3	TEQ*	WHO, 1998	0.03
Pesticides				
DDD	1	HRL	MDH, 1994	0.01 (for total DDD/DDE/DDT)
DDE	1	HRL	MDH, 1994	
DDT	1	HRL	MDH, 1994	

* These criteria are calculated based on toxic equivalency (see discussion above)

NE = no drinking water criterion established

B(a)P Equiv = Benzo(a)pyrene equivalency

The U.S. EPA is currently reassessing the standards for dioxins, so there are no Minnesota drinking water criteria for this class of compounds. The only standard that does exist is the federal public water supply criterion, called a Maximum Contaminant Level (MCL), of 0.03 ng/L (or 0.00003 ug/L) for 2,3,7,8-TCDD. While no criteria exist for the other dioxin congeners, the World Health Organization (WHO) has calculated Toxic Equivalency Quotients (TEQs) that allow an estimation of the relative toxicity of these compounds compared to 2,3,7,8-TCDD (see Appendix B for further discussion of dioxins and TEQ calculations). Using this approach, we may calculate relative criterion for drinking water.

Similarly, several of the PAH criterion are derived based on their relative toxicity when compared to benzo(a)pyrene, for which a HBV of 0.05 ug/L has been established.

2. Surface Water:

Surface water criteria developed by the MPCA were used to evaluate contaminant concentrations at the site (see table on page 57). Surface water criteria are established through rulemaking (Minnesota Rules Chapter 7050) and vary depending upon the classification of the use of the water. The most restrictive classification is “drinking water” or “Class 1”. The next most restrictive classification, under which most water bodies in Minnesota are classified, is “Class 2”. Class 2 criteria are intended to protect aquatic organisms from long-term (chronic) exposure to the contaminant of concern, as well as to protect human health for recreational purposes (i.e. swimming, fishing, etc.).

Cass Lake and Pike Bay are classified as part of the Mississippi River, with the highest use category being Class 2B (i.e. “cool and warm water fisheries, not protected for drinking water”; MPCA, 2004). Surface water criteria for Class 2B waters are promulgated under Minnesota Rules 7050.0222 subpart 4. More information about the surface water criteria can be found on the MPCA’s website: http://www.pca.state.mn.us/water/standards/index.html

Where no MPCA criteria were available, LLBO surface water cleanup levels were used (Leech Lake Band of Ojibwe, 2000). These values were developed to be protective of both human health and the environment. All of the LLBO values are shown in the table below.

Although no surface water samples have been analyzed for dioxin, the treatment plant discharge water is analyzed for the HxCDD congener, so it is included in the table below. MPCA has developed site specific surface water criteria for all of the dioxin and dioxin-like compound congeners (MPCA, 2004), as provided for under Minnesota Rule chapter 7050.0217 and 7050.0218.

SURFACE WATER CRITERIA

Contaminant	**Value (ug/L)**	**Criteria**	**LLBO Cleanup Levels (ug/L)**
List 1 PAHs			
Benzo(a)pyrene	0.00051	Class 2B Chronic std.	0.014
Quinoline	NE		NE
Sum List 1	NE		NE
List 2 PAHs			
Acenaphthene	20	Class 2B Chronic std.	12
2,3-Benzofuran	NE		NE
Bis-(2- Ethylhexyl)-Phthalate	2.1	Class 2B Chronic std.	NE
Caprolactum	NE		NE
Carbazole	NE		NE
Fluoranthene	1.9	Class 2B Chronic std.	20
Indene	NE		NE
1-Methyl-naphthalene	NE		NE
2-Methyl-naphthalene	NE		NE
Naphthalene	81	Class 2B Chronic std.	81
Phenanthrene	3.6	Class 2B Chronic std.	2.1
Pyrene	NE		NE
Sum List 2	NE		NE
Metals			
Arsenic	53	Class 2B Chronic std.	53
Copper	11	Class 2B Chronic std.	12
Chromium	12.3-15*	Class 2B Chronic std.	11-207**
Volatile Organic Compounds			
Benzene	114	Class 2B Chronic std.	700
Ethyl benzene	68	Class 2B Chronic std.	NE
Cis-1,3-dichloropropene	NE		NE
Phenols			
PCP	5.5	Class 2B Chronic std.	5.5
Dioxins			
HxCDD	0.00038	Site specific criteria	
PCDDs/PCDFs	NE		0.000001

* The chromium criterion is dependent on the hardness of the water; these values are based on measured hardness levels in Fox Creek and Pike Bay.

** The lower value is for chromium VI; the higher value is for chromium III

3. Sediment:

Three sets of values for evaluating sediment contaminant concentrations are shown in the table on page 60. The first column (human health values) and the third column (ecological value) are not standards, but rather screening values developed through a variety of methods, as discussed below. The second column in the table (LLBO clean-up levels) are clean-up standards that have been adopted by the Leech Lake Band of Ojibwe to be protective of both human and ecological health. With the exception of the values developed by LLBO, these screening values are intended only to indicate when contaminant concentrations warrant further investigation. In this document, preference is given to using the human health screening values, where they exist. In instances where there are no human health screening values, the LLBO clean-up levels were used. If there were also no LLBO values, then the ecological screening values were used.

The ecological screening values are significantly lower than those for human health because the animals they were developed for live in and near the sediments, potentially being exposed for their entire lives, while human exposures are assumed to be infrequent and of short duration.

Human health based sediment screening values for some compounds were developed by MDH for sediment characterization and risk assessment at the U.S. Steel site in Duluth, Minnesota (US Steel, 2003; see Appendix F). MDH has determined that these values may also be applied, for screening purposes, at other sites, including the St. Regis site. They are listed in the table below as “human health values”.

These human health screening values take into account the relative contribution of various routes of exposure related to contaminated sediments: sediment ingestion, surface water ingestion, sediment and surface water dermal contact, and consumption of fish from areas with contaminated sediments. They are based on a number of assumptions, which are described at length in the supporting documents from the U.S. Steel site (US Steel, 2003). These assumptions include: the frequency of exposure events for differing age groups and at different times of the year; the duration of the exposure events; the number of years during a life-time over which the exposures are likely to occur; rates of sediment ingestion for differing age groups engaged in various activities; the area of skin exposed during various activities; and the volume of fish ingested by various age groups.

The assumptions used for these values specifically are:

a) 1 wading event per day (0.5 hrs/event), 2 days per week, during the months of May and September for all age groups
b) 2 swimming events per day (0.5 hrs/ event), 4 days per week, during the months of June, July, August for age groups 1-6 yrs. and 7-17 yrs.
c) 1 swimming event per day (0.5 hrs/event), 2 days per week, during the months of June, July, August for age group 18-33 yrs.
d) skin adherence for wading = 1 mg/cm^2 over 20% of the total body surface area for all age groups*
e) skin adherence for swimming = 0.2 mg/cm^2 over 90% of the total body surface area for age groups 1-6 yrs. and 7-17 yrs.; and 0.07 mg/cm^2 over 90% of the total body surface area for age group 18-33 yrs.**

f) ingested surface water for wading = 25 mL/hr for age groups 1-6 yrs. and 7-17 yrs.; and 0.5 mL/hr for age group 18-33 yrs.
g) ingested surface water for swimming = 250 mL/hr for age groups 1-6 yrs. and 7-17 yrs.; and 50 mL/hr for age group 18-33 yrs.***
h) ingested sediment for wading = 250 mg/event-day for age groups 1-6 yrs. and 7-17 yrs.; and 0.093 mg/event-day for age group 18-33 yrs.**
i) ingested sediment for swimming = 250 mg/event-day for age groups 1-6 yrs. and 7-17 yrs.; and 9.3 mg/event-day for age group 18-33 yrs.**
j) suspended sediment concentration is assumed to be 370 mg/L (milligrams per liter, or parts per million)

(* Massachusetts DEP, 2002; **EPA, 1997; ***EPA 1989)

Fish consumption will be specifically addressed by MDH in a subsequent Health Consultation. However, it should be noted that fish consumption constitutes most of the modeled exposure for dioxins, PCBs, and benzo(a)pyrene and the other carcinogenic PAHs based on their B(a)P equivalency. In comparing the sediment sample results to the screening values, with respect to decisions regarding access to swimming and wading areas, it is important to keep this in mind.

The LLBO have developed sediment cleanup levels that are considered to be protective of both human health and the environment (Leech Lake Band of Ojibwe, 2000). With the exception of TCDDs, the LLBO cleanup levels are identical to the TEL and ISQG values (discussed below). Also, the LLBO developed a value for PCP, which is used in this report.

Many of the chemicals of concern at the site have no human health based screening values. In that case, the primary sediment screening value used in this report is the Threshold Effect Level (TEL), which represents a concentration below which adverse effects to bottom-dwelling (or benthic) organisms are expected to occur only rarely. TELs are based on evaluation of studies of the toxic effects of the particular chemical on a variety of freshwater, benthic organisms.

Interim Sediment Quality Guidelines (ISQG) values were used when TELs were not available. ISQGs were developed by Environment Canada using an approach similar to TELs (Environment Canada, 1995). They represent a concentration below which adverse effects to freshwater, benthic organisms are not expected to occur.

Upper Effect Threshold (UET) values were used when TELs and ISQGs were not available. These are values derived from studies of the toxic effects on a single species of freshwater, benthic organism. UET values also assume that the sediment contains 1% total organic carbon. If the actual organic carbon content varies, the actual toxic effects may also vary. Adverse effects are always expected for the species for which the UET was derived if the contaminant concentration measured exceeds the UET value.

Apparent Effects Threshold (AET) values were used only when freshwater sediment screening values were not available. These are values are species-specific values derived in similar manner to UETs, but for marine, benthic organisms. As with UETs, adverse effects are always expected for the species for which the AET was derived if the contaminant concentration measured exceeds the

SEDIMENT CRITERIA

Contaminant	**Human Health Value***	**LLBO Clean-up Level***	**Ecological Value***	**Eco-Screening Value Type**	**Ecological Screening Value Source**
PAHs					
Acenaphthene	7.9	0.00671	0.00671	ISQG	Env. Canada, 2003
Acenaphthylene	24	0.00587	0.00587	ISQG	Env. Canada, 2003
Anthracene	170	0.00469	0.00469	ISQG	Env. Canada, 2003
Benzaldehyde	NE	NE	NE		
Benzo(a)anthracene	NE	0.00317	0.00317	TEL	Buchman, 1999
Benzo(a)pyrene	0.077	0.00319	0.00319	TEL	Buchman, 1999
Benzo(b)fluoranthene	NE	NE	NE		
Benzo(g,h,i)perylene	NE	NE	0.3	UET	Buchman, 1999
Benzo(k)fluoranthene	NE	NE	13.4	UET	Buchman, 1999
Bis(2-ethylhexyl)phthalate	NE	NE	0.75	UET	Buchman, 1999
Butylbenzylphthalate	NE	NE	NE		
Chrysene	NE	0.0571	0.0571	TEL	Buchman, 1999
Dibenz(a,h)anthracene	NE	0.00622	0.00622	ISQG	Env. Canada, 2003
1,2-Dichlorobenzene	NE	NE	0.013	AET	Buchman, 1999
1,4-Dichlorobenzene	NE	NE	0.11	AET	Buchman, 1999
Diethyl phthalate	NE	NE	0.006	AET	Buchman, 1999
Di-n-octylphthalate	NE	NE	0.061	AET	Buchman, 1999
Fluoranthene	48	0.111	0.111	TEL	Buchman, 1999
Fluorene	18	0.0212	0.0212	ISQG	Env. Canada, 2003
Indeno(1,2,3-cd)pyrene	NE	NE	0.33	UET	Buchman, 1999
Phenathrene	130	0.0419	0.0419	TEL	Buchman, 1999
Pyrene	41	0.053	0.053	TEL	Buchman, 1999
Dioxins (in ng/kg)					
TCDD Equivalent	0.077	1.0	0.85	ISQG	Env. Canada, 2003
PCBs	0.013	0.023	0.034	TEL	Buchman, 1999
Phenolics					
PCP	NE	0.360	NE		LLBO, 2000
Phenol	NE	NE	0.048	UET	Buchman, 1999
Metals					
Arsenic	20	5.9	6	TEL	Buchman, 1999
Cadmium	97	0.6	0.6	TEL	Buchman, 1999
Chromium VI	1,700	37.3**	37.3	TEL	Buchman, 1999
Copper	10,000	35.7	35.7	TEL	Buchman, 1999
Lead	100	35	35	TEL	Buchman, 1999
Mercury	0.14	0.17	0.174	TEL	Buchman, 1999
Silver	NE	NE	4.5	UET	Buchman, 1999
Zinc	84,000	NE	123	TEL	Buchman, 1999
Pesticides (ug/kg)					
Chlordane	NE	NE	4.5	TEL	Buchman, 1999
DDD	NE	3.54	3.54	TEL	Buchman, 1999
DDE	NE	1.42	1.42	TEL	Buchman, 1999
DDT	NE	1.19	6.98	TEL	Buchman, 1999
Dieldrin	NE	NE	2.85	TEL	Buchman, 1999
Endrin	NE	NE	2.67	TEL	Buchman, 1999

* all values in mg/kg, except dioxins, which are in ng/kg, and pesticides, which are in ug/kg

** this value is for total chromium

NE = no screening value has been established

AET value. It is not clear how they relate to freshwater ecosystems and are the least reliable screening values used in this report.

Among the ecological screening values, TELs and ISQGs were given priority over UETs and AETs, because TELs and ISQGs were developed to evaluate potential risk to the range of organisms likely to be present in the benthic community. UETs and AETs are based on potential risk only to specific species.

Appendix F: Human Health Sediment Screening Values Used At The US Steel / St. Louis River NPL Site

FINAL REPORT

FORMER DULUTH WORKS SEDIMENT CHARACTERIZATION AND TIER I RISK ASSESSMENT WORK PLAN

Prepared for
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3.1.2 Human Health

3.1.2.1 Tier I

Human health COIs for the St. Louis River will be selected based on comparison of risk-based screening concentrations (SCs) to measured concentrations of chemicals in surface sediments. For sediments, conservative human health SCs have been developed by the MDH for sediments in the St. Louis River that will be applied in Tier I. These SCs are based on conservative exposure assumptions representing a carcinogenic risk of 1 x 10^{-5}, or a noncarcinogenic hazard of 0.2. For surface water, SCs were developed based, in order of preference, on 1) Minnesota water quality standards for the Lake Superior Basin or Class 2B waters; 2) national recommended water quality criteria from USEPA (2002); and 3) drinking water standards (USEPA, 2001a). Human health Tier I SCs for surface water and sediments are presented in Table 2. Note that following the Tier I screening step, site-specific exposure parameters will be used in Tier II to further evaluate the COIs identified.

Chemicals measured during Tier I sampling will be compared to the Tier I sediment SCs. The goal of this process is to identify human health COIs. A COI is a chemical, based on an initial screening of its maximum concentration in applicable media (i.e., surface sediment or surface water), that may present a potential for risk to human health. Specifically, the following criteria will be used in selecting COIs:

- If a chemical is not detected, and the detection limit is below the SC or there is no human health SC, then the chemical will not be selected as a COI.
- If the maximum concentration of a chemical is less than the human health SC, then the chemical will not be selected as a COI.
- If the maximum concentration of a chemical exceeds the human health SC, then the chemical will be selected as a COI in Tier I.
- If a chemical is detected, and there is no human health SC, then the chemical will be included as a COI in Tier I, but identified as an uncertainty, and discussion provided to assess whether, based on other information (e.g., frequency of detection, toxicity of related chemicals, co-occurrence with other COIs), the chemical should be carried forward to Tier II of the evaluation.

The results of this process will also be considered in the context of other supporting information. For carcinogenic chemicals, a decision to classify specific chemicals as COIs will be based on the cumulative screening risk estimate of 1 x 10^{-5}. For noncarcinogenic chemicals, a decision to classify chemicals as COIs will also be based on the cumulative screening hazard estimate of 1. However, if the maximum concentration of a chemical or chemicals only slightly exceeds the respective screening concentration in one or few samples, the 95% UCL is below the SC, and/or there is supporting information to suggest limited bioavailability, then it will be recommended that the chemical(s) not be evaluated further. This will be examined on a case-by-case basis, and recommendations with clear rationale presented to MPCA. The outcome of Tier I will be a list of COIs that warrant further evaluation in Tier II.

If no COIs are identified, it will be concluded that there are no unacceptable human health risks or hazards, and no further human health evaluation is warranted.

3.1.2.2 Tier II

The second tier of human health risk evaluation will consist of refining the Tier I assumptions to develop site-specific risk estimates for individual COIs. In Tier II, Site COI data will be compared to reference area concentrations. The purpose of this comparison is based on the understanding that naturally occurring chemicals (inorganics), or low levels of ubiquitous organic chemicals, cannot be remediated to levels lower than their reference area concentrations, even if such reference area concentrations exceed theoretical conservative risk thresholds. Chemicals that are lower than or equal to ambient concentrations will not be considered further in the human health-based evaluation.

Under MPCA guidance, the total target carcinogenic risk is 1×10^{-5}. Chemicals with the same toxicity endpoints will be summed into specific hazard indexes with targets of 0.2 for the non-carcinogenic hazard quotient, or a hazard index of 1.0.

Site-specific human health exposure assumptions and COI exposure concentrations in sediment will be developed. Examples of site-specific assumptions include using the 95% upper confidence limit (UCL) of the mean as a Reasonable Maximum Exposure (RME) concentration rather than the maximum concentration, and median exposure assumptions that correspond to the Most Likely Exposure (MLE) outlined in USEPA Risk Assessment Guidance (USEPA 1989). Exposure assumptions will be provided to MPCA in a Human Health Exposure Assessment Memorandum prior to implementation of the Tier II risk evaluation.

At the end of the Tier II evaluation, if all of the retained chemicals, pathways, and exposure scenarios do not exceed target carcinogenic risk or noncarcinogenic hazard levels, then no further evaluation of human health will be necessary. If, chemicals, pathways, or exposure scenarios do exceed the target risk levels, they will be identified, discussed, and recommendations for either remedial goals, or additional analyses at the Tier III level will be made.

3.1.2.3 Tier III

If there are still COIs present following the Tier II risk evaluation, further evaluation may be conducted, i.e., a Tier III risk evaluation. In a Tier III human health risk evaluation, exposure assessment, and risk characterization may be refined using several techniques. Fish tissue analyses may be used to provide actual measurements for the fish pathway. Exposure parameters may be estimated as probability density functions, using Monte Carlo Analysis (MCA), rather than point estimates. The resultant risk characterization would express risks and hazards as a range of probabilities rather than as deterministic point estimates.

3.1.3 Ecological Risk Evaluation – Tier I

As with the human health risk evaluation, the ecological risk evaluation will be carried out in a tiered manner. Chemicals measured during Tier I sampling will be compared to conservative, ecologically protective SCs. SCs will be developed for ecologically relevant components of the ecosystem identified through the Preliminary Problem Formulation process. Problem formulation is a systematic planning step that identifies major factors to be considered (USEPA 1992a). The following subsections discuss the ecological components of the AOIs, and culminates in the selection of screening-level assessment endpoints. Assessment endpoints are the relevant ecological values to be protected.

3.1.3.1 Biological Characteristics and Ecological Structure

The following subsections describe the study area in the context of habitat, biological composition (structure), and system function. Habitat and biological composition are presented in the context of aquatic and terrestrial, or semiaquatic, *communities*. A detailed evaluation of the habitat types and species specific to the Site has not been conducted. However, general observations regarding the types of communities present can be made as discussed below.

Aquatic Communities

Aquatic biotic communities are typically distinguished in the context of two basic physical macrohabitats (or media); that is, the water column versus submerged substrates (e.g. sediments or the surfaces of submerged plants and debris). In most systems there are further important subdivisions (e.g., neuston and nekton of the water column). Some algae and many of the animals are actually members of two or more communities. For example, most fish are nektonic as juveniles and adults, but their larvae (and some case fertilized eggs) are planktonic. "Aquatic" insects generally include species that are part of the benthos, aufwuchs, and/or "drift" communities while in various immature phases, but upon achieving adulthood some leave the water for a terrestrial phase and others do not. A discussion of aquatic communities in general, and potential relevance to the AOIs based on limited information and site observations, are provided in the following subsections.

Water-Column Communities

Three distinct water-column communities are discussed below:

Neuston

The neuston is an assemblage of organisms associated with the surface film at the air/water interface (Thorp and Covich 1991). The neuston of most lakes and ponds consists mainly of bacteria, algae, protozoans, microcrustaceans (especially certain cladocerans), water mites, spiders, and a variety of insects. Neustonic organisms are sometimes selectively preyed upon by certain fishes and higher vertebrates (e.g., birds). In terms of potential vulnerability to exposures to chemicals, the neustonic forms would only come into direct contact with surface water. Therefore, neustonic organisms (phytoplankton and zooplankton) are considered assessment endpoints in the St. Louis River ecological evaluation. For practical purposes, neustonic organisms will be evaluated as part of the plankton community.

Plankton

Though the study area is in a river, it represents a transition zone that may have the characteristics of both lotic (riverine) and lentic (lake) environments. The plankton community in the water column is generally divisible into an algal subdivision (phytoplankton), and assemblages of mainly invertebrate animals referred to here collectively as zooplankton. Phytoplankton are responsible for virtually all of the primary production in the "open," or limnetic, portions of lakes and are regarded as the "base" of the food chain for limnetic animals.

TABLE 7
PHYSIOCHEMICAL PARAMETERS

Constituent	Molecular Wt (g/mol)	Melting Point (°C)	Vapor Pressure (mm of Hg)	Solubility (mg/L) @20-25°C	Log K_{oc}	K_{oc}	Log K_{ow}	Henry's constant (atm/m^3/mole)	Species	Water BCF	Log BCF	Comments
Halogenated Methanes/Alkanes												
Bromodichloromethane	163.8	-57	64.4	3110	2.48		2.09	0.00447	FM	1.80E+01		ASTER/QSAR (1998)
Bromodichloromethane	163.8	-57.1	50	4700	2.06	53-251	2.1	0.0016			0.72-1.37	HSDB
Bromoform	252.7	8	6.3	2270	2.63		2.37	0.000923	FM	3.00E+01		ASTER/QSAR (1998)
Bromoform	252.73	8.3	40	3190			2.372	0.00066		3.74E+01		HSDB
Bromomethane	94.94	-94	1630	27200	1.92		1.08	0.00749	FM	3.00E+00		ASTER/QSAR (1998)
Bromomethane	94.95	-93.66	1620	902	1.19		2.1	0.00624		4.70E+00		HSDB
Carbon tetrachloride (Tetrachloromethane)	153.8	-23	110	361	2.9		2.88	0.0617	FM	7.40E+01		ASTER/QSAR (1998)
Carbon tetrachloride (Tetrachloromethane)	153.24	-23	108	1160	1.85	71	2.83	0.0304	RT		1.24-1.48	HSDB
Chloroform (Trichloromethane)	119.4	-64	197	3290	2.4		1.95	0.0094	FM	1.40E+01		ASTER/QSAR (1998)
Chloroform (Trichloromethane)	119.39		197	7950	1.53	34	1.97	0.00367		1.00E+00		HSDB
Chloromethane	50.49	-98	4310	21000	1.85		0.936	0.0136	FM	2.00E+00		ASTER/QSAR (1998)
Chloromethane	50.49	-97	4300	5320			0.91	0.0882				HSDB
Methylene chloride	84.93	-95	436	15300	2.02		1.25	0.00318	FM	4.00E+00		ASTER/AQUIRE/QSAR (1998)
Methylene chloride			400		1.68		1.25	0.00318		5.00E+00		HSDB
Halogenated Ethanes												
1,1-Dichloroethane	98.96	-97	228	4340	2.3		1.78	0.00683	FM	1.00E+01		ASTER/QSAR (1998)
1,1-Dichloroethane	98.97	-96.9	234	5500	1.63	43	1.9			1.30E+00		HSDB
1,1,1-Trichloroethane	133.4	-31	121	896	2.69		2.48	0.0237	FM	3.60E+01		ASTER/QSAR (1998)
1,1,1-Trichloroethane	133.42	-30.4	124	4400	1.28	2-183	2.49	0.008	BG	8.90E+00		HSDB
1,1,2-Trichloroethane	133.4	-37	22.5	2820	2.45		2.05	0.0014	FM	1.70E+01		ASTER/QSAR (1998)
1,1,2-Trichloroethane	133.42	-36.6	23.25	4500	2.05	70-183	2.17	0.000824		1.00E+00		HSDB
1,1,2,2-Tetrachloroethane	167.8	-44	5.95	729	2.78		2.64	0.0018	FM	4.90E+01		ASTER/QSAR (1998)
1,1,2,2-Tetrachloroethane	167.85	-43.8	4.62	2962	1.90	79	2.39	0.000455			0.9-1	HSDB
1,2-Dichloroethane	98.96	-35	80.3	10200	2.13		1.46	0.00102	FM	6.00E+00		ASTER/AQUIRE/QSAR (1998)
1,2-Dichloroethane	98.96	-35.3	87	8690	1.52	33	1.48		BG		0.3	HSDB
Chloroethane	64.51	-136	1200	6540	2.13		1.47	0.0156	FM	6.00E+00		ASTER/QSAR (1998)
Chloroethane	64.52	-138.7	1010	5710	1.84	33-143	1.43	0.00848			0.67-0.86	HSDB
Halogenated Propanes												
1,2-Dichloropropane	113	-100	49.7	2840	2.42		1.99	0.0026	FM	1.50E+01		ASTER/AQUIRE/QSAR (1998)
1,2-Dichloropropane	112.99	-100.4	50	260000	1.67	47	2.28	0.00207			1.26	HSDB
Halogenated Alkenes												
1,1-Dichloroethene	96.94	-122	600	866	2.63		2.37	0.0883	FM	3.00E+01		ASTER/QSAR (1998)
1,1-Dichloroethene	96.94	-122.5	591	6300	2.18	150	2.13	0.0261				HSDB
1,2-Dichloroethene (total)	96.95	-50	324		1.62	36-49				15-22		HSDB
1,2-Dichloroethene (cis)	96.94	-81	209	4300	2.3		1.77	0.00621	FM	1.00E+01		ASTER/QSAR (1998)
1,2-Dichloroethene (cis)	96.94	-80.5	24 (mpa)	3500	1.69	49	1.86	0.00307		1.50E+01		HSDB
1,2-Dichloroethene (trans)	96.94	-50	330	4300	2.3		1.77	0.00978	FM	1.00E+01		ASTER/QSAR (1998)
1,2-Dichloroethene (trans)	96.95	-50	395	6300	1.56	36	2.06	0.00672		2.20E+01		HSDB
1,3-Dichloropropene (total)	110.98	<-50	0.02775	150000			1.36			7.00E+00		HSDB
1,3-Dichloropropene (cis)	110.97		43	2700	2.65	450	1.36	0.0024		7.00E+00		HSDB
1,3-Dichloropropene (trans)	111	N/A	24.9	4640	2.3		1.76	0.000782	FM	1.00E+01		ASTER/QSAR (1998)
1,3-Dichloropropene (trans)	110.98		2.47(kpa)	2800	2.87	740	1.41	0.0018		7.00E+00		HSDB
Tetrachloroethene	165.8	-19	17.8	77.2	3.23		3.48	0.0503	FM	2.23E+02		ASTER/QSAR (1998)
Tetrachloroethene	165.83	-19	18.47	150	2.80	238-1685	3.4	0.0177		2.26E+02		HSDB
Trichloroethene	131.4	-87	74.3	597	2.77		2.63	0.0215	FM	4.70E+01		ASTER/QSAR (1998)
Trichloroethene	131.4	-73	19.9	1100	2	87-150	2.61	0.01	BG	17-39		HSDB
Vinyl chloride	62.5	-154	2660	5450	2.16		1.52	0.0401	FM	6.00E+00		ASTER/QSAR (1998)

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PHYSIOCHEMICAL PARAMETERS

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Vinyl chloride	62.5	-153.8	2660	2700	1.75	56	0.6	0.056		7.00E+00		HSDB
Benzene and Derivatives												
Benzene	78.11	6	95.2	1790	2.5		2.14	0.00547	FM	2.00E+01		ASTER/AQUIRE/QSAR (1998)
Benzene	78.11	5.5	95.2	1800	1.82	31-143	2.13	0.0053		3.5-24		HSDB
Chlorobenzene	112.6	-46	11.7	409	2.89		2.86	0.00424	FM	7.20E+01		ASTER/QSAR (1998)
Chlorobenzene	112.56	-45.2	12	502	1.59	4.8-313.1	2.89	0.00377		3.9-2187		HSDB
1,2-Dichlorobenzene	147	-17	1.28	144	3.21		3.45	0.00172	FM	2.11E+02		ASTER/QSAR (1998)
1,2-Dichlorobenzene	147	-16.7	1.36	156	4.00	280-320	3.43	0.0015		90-560		HSDB
1,2,4-Trichlorobenzene	181.2	17	0.291	45.5	3.6		4.16	0.00153	FM	1.77E+03		ASTER/AQUIRE (1998)
1,2,4-Trichlorobenzene	181.45	17	0.46	31.3	3.1-5		4.02	0.00142		91-3200		HSDB
1,3-Dichlorobenzene	147	-25	1.89	125	3.28		3.57	0.00292	FM	2.62E+02		ASTER/AQUIRE/QSAR (1998)
1,3-Dichlorobenzene	147	-24.8	2.15	125	2.48	300	3.53	0.0028		60-740		HSDB
1,4-Dichlorobenzene	147	53	1.76	30.7	3.28		3.57	0.0111	FM	2.62E+02		ASTER/AQUIRE/QSAR (1998)
1,4-Dichlorobenzene	147	52.7	1.74	76	4.8	273-390	3.44	0.0027		57-720		HSDB
Hexachlorobenzene	284.8	230	0.00000435	0.00461	4.7		6.18	N/A	Scud	4.12E+04		ASTER/AQUIRE (1998)
Hexachlorobenzene	284.78	231.8	0.000049	0.0047	4.55		5.73	0.00058		1600-4800	3.1-4.3	HSDB
Methylated Benzenes												
Toluene	92.14	-95	28.4	518	2.77		2.64	0.00665	FM	4.90E+01		ASTER/AQUIRE/QSAR (1998)
Toluene	92.13	-95	36.7		1.87	37-151	2.69	0.00664		9.00E+01		HSDB
Xylenes (total)	N/A	N/A	5.87	N/A	N/A		N/A	N/A	N/A	N/A		ASTER (1998)
Xylenes (total)	106.16		7.99	0	2.08	39-365	3.12-3.2	0.007		2.00E+01		HSDB
Other Substituted Benzenes												
Ethylbenzene	106.2	-95	9.57	153	3.06		3.17	0.00874	FM	1.27E+02		ASTER/QSAR (1998)
Ethylbenzene	106.16	-95	10	140	2.94	164	3.15	0.00844			0.67-2.16	HSDB
Styrene	104.2	-31	6.06	250	2.9		2.87	0.00332	FM	7.30E+01		ASTER/QSAR (1998)
Styrene	104.15	-31	6.12	310	2.73	520-555	2.95	0.00275		13.5-100		HSDB
Chlorinated Dienes												
Hexachlorobutadiene	260.8	-21	0.329	2.74	4		4.9	0.0413	FM	2.96E+03		ASTER/QSAR (1998)
Hexachlorobutadiene	260.76	-21	0.15	2.548	3.71	5181	4.9	0.0103		5800-17000		HSDB
Ketones (Carbonyl Compounds)												USEPA 2002
2-Butanone	72.11	-86	95.1	223000	1.51		0.321	0.0000405	FM	1.00E+00		ASTER/QSAR (1998)
2-Butanone	72.11	-86	91	353000(10oC)	1.50	29-34	0.29	0.000047		1.00E+00		HSDB
Acetone	58.08	-95	227	513000	1.22		-0.208	0.0000338	FM	1.00E+00		ASTER/QSAR (1998)
Acetone	58.08	-94.8	231		0.00	1	-0.24	0.0000187		1.00E+00		HSDB
Low Molecular Weight PAHs												USEPA 2002
2-Methylnaphthalene	142.2	35	0.08	25.9	3.41		3.81	0.000578	FM	4.11E+02		ASTER/QSAR (1998)
2-Methylnaphthalene	142.2	34.6	0.0681	24.6	3.93	8500	3.86	0.000518		40-23500		HSDB
2-Methylnaphthalene				25	3.79		3.857					USEPA 2002
Acenaphthene	154.2	96	0.000719	4.44	3.39		3.77	0.0000328	FM	3.79E+02		ASTER/AQUIRE/QSAR (1998)
Acenaphthene	154.2	95	10	3.9	3.41	2065-3230	3.92	0.000155		387-397	2.59	HSDB
Acenaphthene				3.8	3.94		4.012					USEPA 2002
Acenaphthylene	152.2	92	0.00548	12.3	3.3		3.62	0.0000892	FM	2.86E+02		ASTER/QSAR (1998)
Acenaphthylene	152.2	92-93	0.000912	16.1	3.25	950-3315	4.07	0.0000113			2.11-2.76	HSDB
Acenaphthylene				16.314	3.17		3.223					USEPA 2002
Anthracene	178.2	215	0.000179	0.0743	3.78		4.49	N/A	FM	5.63E+02		ASTER/AQUIRE (1998)
Anthracene	178.23	218	0.00000267	0.0434	5.30	70000-130000	4.45	0.0000488		759-17000		HSDB
Fluorene	166.2	116	2.80E-04	1.99	3.55		4.07	3.08E-05	FM	6.60E+02		ASTER/QSAR (1998)
Fluorene	166.21	116-117	3.20E-04	0	3.96			1.00E-04			3.02-3.35	HSDB

TABLE 7
PHYSIOCHEMICAL PARAMETERS

Constituent	Molecular Wt (g/mol)	Melting Point (°C)	Vapor Pressure (mm of Hg)	Solubility (mg/L) @20-25°C	Log K_{oc}	K_{oc}	Log K_{ow}	Henry's constant (atm/m^3/mole)	Species	Water BCF	Log BCF	Comments
Fluorene				1.9	4.137		4.208					USEPA 2002
Naphthalene	128.2	81	0.213	38.7	3.14		3.32	9.28E-04	FM	1.66E+02		ASTER/QSAR (1998)
Naphthalene	128.16	80.2	0.01(kpa)	30	3.26	812-4100	3.3				1.6-3	HSDB
Naphthalene				30.995	3.30		3.356					USEPA 2002
Phenanthrene	178.2	100	1.35E-06	1.26	3.78		4.49	2.50E-07	FM	1.40E+03		ASTER/QSAR (1998)
Phenanthrene	178.22	101	6.80E-04	1.29	4.36		4.57	1.24E-04				HSDB
Phenanthrene				1.1	4.494		4.571					USEPA 2002
High Molecular Weight PAHs												
Benzo(a)anthracene	228.3	159	1.81E-10	0.0141	4.42		5.66	N/A	FM	1.19E+04		ASTER/QSAR (1998)
Benzo(a)anthracene	228.29	160	0.000000005	0.0094	4.49	545000-1870000	5.79	0.000008		350-18000		HSDB
Benzo(a)anthracene				0.011	5.58		5.673					USEPA 2002
Benzo(a)pyrene	252.3	179	6.46E-13	0.00381	4.67		6.12	N/A	FM	2.74E+04		ASTER/QSAR (1998)
Benzo(a)pyrene	252.32	179-179.3	5.49E-09	0.0016	6.14	930-1700000	5.97	0.000000457		0.2-55000		HSDB
Benzo(a)pyrene				0.00381	6.003		6.107					USEPA 2002
Benzo(ghi)perylene	276.3	277	3.9E-11	0.000264	4.92		6.58	N/A	FM	6.33E+04		ASTER/QSAR (1998)
Benzo(ghi)perylene	276.34	277	1E-10	0.00026	4.98	96000	6.63	0.000000266		6.40E+04		HSDB
Benzo(ghi)perylene				0.00026	6.397		6.507					USEPA 2002
Benzo(b,k)fluoranthene	252.3	217	1.39E-09	7.62E-04	4.67		6.12	N/A	FM	2.74E+04		ASTER/QSAR (1998)
Benzo(b,k)fluoranthene	252.32	217	9.7E-10	7.60E-04	5.82	330000-1300000	6.84	0.000000584		27000-310000		HSDB
Benzo(b)fluoranthene				1.50E-03	6.16		6.266					USEPA 2002
Benzo(k)fluoranthene				7.99E-04	6.184		6.291					USEPA 2002
Chrysene	228.3	250	6.64E-11	1.99E-03	4.42		5.66	N/A	FM	1.19E+04		ASTER/QSAR (1998)
Chrysene	228.29	258.2	6.23E-09	1.89E-03	5.13	31000-580000	5.73	0.00000099		0.3-20280		HSDB
Chrysene				2.00E-03	5.616		5.713					USEPA 2002
Dibenzo(a,h)anthracene	278.4	266	3.41E-14	5.07E-04	5.06		6.84	N/A	FM	1.00E+05		ASTER/QSAR (1998)
Dibenzo(a,h)anthracene	278.33	266	1E-10	5.99E-04	6.12	570000-3100000	6.5	0.00000012		652-11000		HSDB
Dibenzo(a,h)anthracene				6.00E-04	6.599		6.713					USEPA 2002
Fluoranthene	202.3	111	0.000000947	0.243	4.03		4.95	1.04E-06	FM	3.24E+03		ASTER/QSAR (1998)
Fluoranthene	202.26	111	0.00000922	0.26	4.97		5.16	9.45E-06		5.7-76696	2.58-4.09	HSDB
Fluoranthene				0.2399	4.998		5.084					USEPA 2002
Indeno(1,2,3-cd)pyrene	276.3	163	3.9E-11	1.85E-03	4.92		6.58	N/A	FM	6.33E+04		ASTER/QSAR (1998)
Indeno(1,2,3-cd)pyrene	276.34	163.6	1.3E-10	6.20E-02	6.82	110000	6.7	0.000000348		1.00E+04		HSDB
Indeno(1,2,3-cd)pyrene					6.608		6.722					USEPA 2002
Pyrene	202.3	156	4.3E-09	0.134	4.03		4.95	N/A	FM	3.24E+03		ASTER/QSAR (1998)
Pyrene	202.26	151.2	0.0000892	0.135	5.2	59675-169000	4.88	0.000012		72-970		HSDB
Pyrene				0.1319	4.839		4.922					USEPA 2002
PCBs (mg/kg)												
Aroclor 1016			0.0004	0.225-0.25	4.97	52100-171000	4.38	0.000343		13000-43100	4.53-4.63	HSDB
Aroclor 1221	192	1	0.0067	2	4.46		4.09	0.000228			2.98-4.14	HSDB
Aroclor 1248	288		0.000494	0.054			6.11			52000-120000		HSDB
Aroclor 1254	327		0.000077	0.012	5.58	110000-1330000	6.3	0.000283		3800-340000	3.0-5.66	HSDB
Aroclor 1260	375.7		0.0000405	0.027	5.83	61000-7400000	6.8	0.000336		2.70E+05	5.28-5.57	HSDB
Dioxins/Furans (mg/kg)												
2,3,7,8-TCDD	322	305-306	7.4E-10	19300	7.39		6.8	0.0000162		5840-29200	3.2-3.9	HSDB

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Total Petroleum Hydrocarbons (mg/kg)												
TPH-Gasoline range organics												
TPH-Diesel range organics												

Note:
BG=Bluegill sunfish
FM=Fathead Minnow

TABLE 2
MINNESOTA DEPARTMENT OF HEALTH HUMAN HEALTH-BASED SCREENING VALUES

Chemical	Surface Water SC (ug/L)		Sediments	
			Cancer SC (mg/kg)	NonCancer SC (mg/kg)
Inorganics				
Arsenic	53	a	**20**	**35**
Cadmium	5	b		**97**
Chromium III	100	b		**420000**
Chromium VI	NA			**1700**
Copper	1300	c		**10000**
Cyanide	30240	d		**5600**
Lead *	15	b		**100**
Mercury (inorganic in sediment/SW; methylmercury in fish)	0.00153	d		**0.014**
Nickel	610	c		**5600**
Zinc	7400	c		**84000**
VOCs				
Benzene	2.2	c	**0.0035**	**0.0094**
Ethyl benzene	3100	c		**0.37**
Styrene	100	b		**4.3**
Toluene	45679	d		**0.21**
Xylenes (mixed)	10000	b		**0.063**
PAHs (Polynuclear Aromatic Hydrocarbons)				
Acenaphthene	20	a		**7.9**
Acenaphthylene (toxicity surrogate - acenaphthene)	NA			**24**
Anthracene	8300	c		**170**
Benzo(a)pyrene Equivalents	0.0038	c	**0.077**	
Fluoranthene	130	c		**48**
Fluorene	1100	c		**18**
Methylnaphthalene (toxicity surrogate - naphthalene)	NA			**0.3**
Naphthalene	NA			**0.1**
Perylene (toxicity surrogate - pyrene)	NA			**33**
Phenanthrene (toxicity surrogate - anthracene)	NA			**130**
Pyrene	830	c		**41**
Polychlorinated Biphenyls				
PCBs (Polychlorinated Biphenyls)	0.000029	a	**0.013**	**0.0032**
Dioxins/Furans				
2,3,7,8-TCDD (or 2,3,7,8-TCDD equivalents)	0.0014 pg/L	d	**7.7E-08**	**9.5E-07**
Other Organics				
Carbazole	NA		**2.6**	
Dibenzofuran (unsubstituted)	NA			**1.3**
Hexachlorobenzene	0.00024	a	**0.15**	**1**
Octachlorostyrene	NA			**0.013**

* The lead sediment screening value is not based on a direct evaluation of hazard, but it is equivalent to the Minnesota bare-soil standard of 100 ppm. (Minn

Cancer SCs based on $1x10^{-5}$ risk.

NonCancer SCs based on hazard quotient of 0.2.

[a] Minnesota Water Quality Standards for Class 2B waters, Minnesota Rule 7050.0222

[b] National Primary Drinking Water Standard EPA-816-F-01-007

[c] National Recommended Water Criteria: 2002 EPA-822-R-02-047

[d] Minnesota Water Quality Standards for the Lake Superior Basin, Minnesota Rule 7052.0100

NA = No values available

Appendix G: MDH Cancer Risk Assessment Guidance

Cancer Risk Assessment

Human exposure to TCDD is thought to be associated with an increased risk of soft tissue cancers, rather than increased risk of specific types of cancers. TCDD is believed to be a cancer promoter, rather than an initiator (Schlummer, et. al., 1998). Cancer initiators cause direct genetic damage that can also lead to mutations. The initial mechanism by which dioxins are thought to induce adverse health effects, including cancer promotion, is by binding with a cellular protein known as the aryl hydrocarbon receptor (AhR). The AhR protein is part of a family of cellular proteins that is thought to play an important role in normal physiological function. The AhR mediated response to dioxin and dioxin like compounds has been established in several species, but how its induction leads to potential adverse health effects is poorly understood (EPA, 2000; ATSDR, 1997).

PAHs, in contrast, appear to be cancer initiators. The types of cancers associated with PAH exposure depends upon the type of PAH involved and the route of exposure. Inhalation is generally associated with tumors of the lungs and upper respiratory system. Animal studies suggest dermal contact may induce some forms of skin cancer and ingestion may induce tumors in the fore-stomach, esophagus, and larynx (ATSDR, 1995b).

The carcinogenicity of PCP is less well understood. One occupational study suggested a possible association between inhalation of PCP and cancer (Hodgkin's disease, acute leukemia, and soft tissue sarcoma), but other studies do not support these findings (ATSDR, 1994). Animal studies involving ingestion of PCP are more conclusive, suggesting a link to cancers of the liver, adrenal gland, and spleen. There have been few studies of dermal exposure and these do not appear to indicate a connection between PCP and cancer (ATSDR, 1994).

The potency of a carcinogen is typically estimated using mathematical models. In general, cancer potency is estimated from the linear term in the equation used to describe the observed data. The resulting number is known as a cancer slope factor, and describes the cancer risk per unit dose. For ingestion, it is expressed in terms of the risk per milligrams of contaminant ingested per kilogram of body weight per day (mg/kg/day). MDH uses EPA potency slopes to evaluate cancer risks. A discussion of the risk assessment for dioxins appears on the MDH website at: www.health.state.mn.us/divs/eh/risk/guidance/dioxinmemo1.html.

In the evaluation of safe levels of cancer-causing chemicals, MDH uses a negligible excess lifetime cancer risk of 1 in 100,000, or 1×10^{-5}. This means that a person exposed to a concentration of a carcinogen equal to the lifetime risk level of 1×10^{-5} for a lifetime would have up to a 1 in 100,000 chance of developing cancer from this exposure. MDH regards an incremental risk from a single source as negligible at this level, and it is a very small risk compared to the overall existing lifetime cancer rate in Minnesota of approximately 40%.

The cancer slope factor, the MDH negligible lifetime excess cancer risk number, and standard default exposure parameters are used to generate environmental screening criteria such as MDH's Health Risk Limits (HRLs) and Health Risk Values (HRVs). Site-specific information may be used where appropriate to develop more refined criteria. The common use of conservative exposure assumptions means that the actual risk from exposure to levels of contaminants at the various screening levels lies somewhere between zero and 1 in 100,000.

A possible shortcoming in this approach is the typical use of a 70-year lifetime exposure model. Chemical exposures are often unequally distributed over a lifetime, despite the fact that there are critical periods of susceptibility at varying times, especially during pregnancy and childhood. Children may be especially susceptible during periods of rapid tissue growth and development, and have a longer time in which to develop adverse health effects. Ginsberg (2003) estimated that early childhood exposure to carcinogens may have as much as ten times the impact as the same exposure duration later in life. A significant portion of lifetime risk may therefore be accumulated in a relatively short time. Traditional risk assessment methods do not adequately address the issue of the proportion of cancer risk accrued during different time periods when exposures are for less than a lifetime.