GROUNDWATER USE AND CONTAMINANT ASSESSMENT

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY

Prepared by

TETRA TECH EM INC.

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EXECUTIVE SUMMARY

The City of Dickson, Dickson County, Tennessee, and the surrounding area contains numerous manufacturers, some of which have been operation for 30 years or more. Printing, boat building, and metal fabrication industries have historically been prevalent in the area. Each of these industries used, and continues to use, various types of industrial solvents. A number of these types of facilities in Dickson County have had documented releases of such chemicals to the environment. In addition to the presence of manufacturing facilities, the City of Dickson and Dickson County operated a landfill that reportedly received industrial wastes, including solvents. A municipal well field located adjacent to the landfill has been contaminated with trichloroethene (TCE). Investigations by state and federal agencies have been performed in an effort to link the landfill with documented TCE contamination in both private water supplies and the municipal water system.

The Birth Defect Research for Children organization believes that documented TCE contamination in the drinking water supply has caused an unusually high number of orofacial cleft birth defects in Dickson County. The organization also believes, based on its research, the toluene as an airborne contaminant may also have contributed to the high incidence of orofacial defects.

The scope of this Tetra Tech EM, Inc. (TtEMI) investigation was to summarize work completed by multiple local, state, and federal agencies relative to environmental permitting and site cleanups and the work performed relative to evaluating the potential cause and effect of environmental exposures and orofacial clefts (cleft palate and/or cleft lip). The investigation was designed to result in recommendations for responses appropriate to protect human health and the environment. Specifically, the investigation focused on (1) the use of a municipal groundwater well that has been used to supply potable water not only to the residents of the City of Dickson, but to others throughout Dickson County and (2) the operation of the Dickson County Landfill.

Data collected by the Centers for Disease Control and Prevention (CDC) indicates that the number of Dickson County birth defects is greater than Tennessee and national averages, without an explanation of the cause. Between 1997 and 2000, 18 families in Dickson County were identified as having cases of orofacial cleft birth defects. Dye trace efforts by the county and the U. S. Geological Survey (USGS) in connecting the Dickson County Landfill with the municipal well field were unsuccessful and the results inconclusive. The continued reliance on groundwater for private, commercial, recreational, and public water supply uses and the sensitive nature of the geology and hydrogeology only enhance the possibility of exposures to groundwater that might be contaminated. The extreme karst nature of the geology, which is largely undefined in the area, complicates the ability to protect the groundwater resource and to provide reliable, uncontaminated groundwater as a potable water source. The area geologic conditions and the location of the municipal well field adjacent to the Dickson County Landfill require a clear understanding of the geologic conditions of the area in the event groundwater is relied upon as a potable water source. Investigations performed by the USGS indicate those wells installed in conduits up to approximately 20 feet in height, produce the most water.

The following summarizes areas identified for further assessment:

Incidence of Orofacial Defects

- The summary of information presented herein indicates that additional investigation is warranted regarding the link between potential environmental exposure and the incidence of orofacial defects in Dickson County. Potential contaminants identified through this assessment include

trihalomethanes (THM), TCE, and toluene. Further investigation could evaluate the potential ingestion of water other than through residential exposure, the specific utility district(s) that provide water to the residences and workplaces, water intake sources, water treatment processes, and documented TCE concentrations in the public water supply in 1996 and 1997. Investigation could also evaluate other routes of exposure, such as swimming pools, lakes, and streams that might be affected.

- Further inquiry regarding the pending Tennessee Department of Health (TDH) air modeling study and subsequent information regarding concentrations in relation to the 18 case families identified in Dickson County.

- Further inquiry regarding the results of a public inquiry that was announced in The Dickson Herald on September 22, 2000.

Regional Geologic/Hydrogeologic Investigation

- An investigation should be conducted to define the geologic structure, joint patterns, groundwater discharges pathways, groundwater-to-surface water pathways, groundwater recharge effects on base surface stream flows, and contaminant source identification and their effect on the City of Dickson municipal well field.

Manufacturing/Commercial Facility Assessments

- Files from the Tennessee Department of Environment and Conservation (TDEC) and U. S. Environmental Protection Agency (EPA) files should be reviewed to determine all enforcement actions and waste management activities for each facility listed herein with a history of toluene, perchloroethene, and TCE use. Perchloroethene breaks down in the environment into trichloroethene and C15-1,2-dichloroethene, both of which have been reported in the municipal water supply, private wells, and springs.

- A site inspection should be performed for facilities with a history of using toluene, perchloroethene, and TCE. Specific attention should focus on facilities located near raw water sources.

- Assessment and corrective action measures being conducted at the Dickson County Landfill should be closely monitored to ensure technical competence and a timely completion of work.

Private Well/Spring Use Assessment

- Wells and springs surrounding the Dickson County Landfill and manufacturing facilities identified herein should be evaluated for routine quarterly or semi-annual monitoring.

- The specifics of the Baptist Church Camp spring contamination should be determined. The results should be evaluated as a potential exposure route relative to reported orofacial cleft cases.

- An investigation should be completed to determine if the wells at Goodlark Hospital, Tanbark Campground, the Ice Plant, Buckner Park, and the Mt. Sinai Community are used or have been used, particularly by the families with reported orofacial clefts. The well construction specifics

should be evaluated. Groundwater samples should also be collected and analyzed for constituents of concern.

- The installation of future private and municipal wells in the Dickson area should be closely scrutinized given the karst nature of the geology and the presence of contaminants in the subsurface.

Public Water Use Assessment

- Details should be determined regarding the raw water source, treatment methods, distribution, and storage methods of the Turnbull Utility District. Specific attention should be given to the results of volatile organic compound (VOC), THM, and total haloacetic acid within the system and at its entrance into the City of Dickson water system.

- The City of Dickson system should be monitored for THMs, TCE, and toluene, particularly at the residences of reported orofacial clefts and other areas known to be dead-end lines, stagnant lines, small lines with little flow, and with long contact time. The quality of the water should also be evaluated at the point the water enters other districts being supplied water from the city.

- The removal efficiency and performance of the draft-induced aerator relative to TCE and other VOC removal should be determined for the city water system. Although the aerator may be effective in removing TCE, it must also effectively remove common breakdown components of TCE, such as vinyl chloride. Vinyl chloride has a lower maximum contaminated level (MCL) than TCE and is a reported carcinogen.

- The backflow preventor program of the Turnbull Utility District and the City of Dickson water distribution system should be evaluated. The history of failures and chemical use at appropriate portions of the water system should be determined.

- Specifics should be determined regarding the reported pumping test conducted in 1997 by the city on well DK-21. The test does not seem to correlate with the dye trace test conducted in early 1998. No information relative to pumping duration, water discharge, or drawdown monitoring was available.

- The City of Dickson and Turnbull Utility Districts should be evaluated relative to any operational modifications, repairs, or other changes in the distribution and treatment system. Of specific interest, are the 1997 to 2000 period; and the years 1993, 1995, and 1996, when orofacial cases were not reported; and in 1989, when a high number of cases were reported.

- The City of Dickson and surrounding utility districts should consider initiating the proposed plan to obtain raw water from the Cumberland River to the north because of the following: the intensive karst nature of the hydrogeology and its undefined characteristics, the nature and extent of groundwater contamination in the Dickson area, the city's history of using groundwater as a raw water source, and the inability of the Piney Rivers to supply year-round raw water.

Well Head Protection Plan Modifications

- The city's well head protection plan should be updated to include a comprehensive evaluation of contaminant sources (including manufacturers), and bedrock jointing and structure analyses to

determine likely zones of recharge and the flow boundary for each well point. The plan should include City Lake as a "wellhead" because the lake is supplied water primarily from groundwater. The plan should be developed by either a Tennessee-licensed professional engineer or by a Tennessee-licensed professional geologist with a demonstrated expertise in karst conditions and contaminant fate and transport.

- The city should submit a preliminary evaluation report, plans, and specifications (as required by TDEC) for the new well at the West Piney River and well DK-15. This information should be submitted to the TDEC and EPA for approval prior before these or other new wells are used. The design and use of the wells should be certified by a Tennessee-licensed professional engineer and a Tennessee-licensed professional geologist, both with a demonstrated expertise in karst hydrogeologic conditions.

1.0 INTRODUCTION

This report has been prepared under provisions of Technical Direction Document (TDD) No. 4T-01-11-A-004, which the U. S. Environmental Protection Agency (EPA) assigned to the Tetra Tech EM Inc. (EMI) Superfund Assessment and Response Team (START). The overall scope of the TDD was to assist in conducting a groundwater use and contaminant evaluation that would summarize work performed to date in identifying the cause of contaminants in private and public potable water supplies in Dickson,. Dickson County, Tennessee. This section presents background information concerning the project and describes the project approach.

1.1 BACKGROUND

Volatile organic compounds (VOC) have been detected in private residential wells and springs, and one municipal water supply well (well DK-21) that has been used by the City of Dickson for its potable water supply. The results of groundwater sampling and analysis for private residential wells and springs indicated the presence of one or more VOCs, including trichloroethene (TCE) and cis-1, 2-dichloroethene (DCE). Sampling of raw and treated water by the City of Dickson also indicated the presence of TCE in the public potable water distribution system.

The Dickson County Landfill, which is located near impacted private wells, springs, and the municipal well field that includes well DK-21, has been identified as a potential source of contaminants. The landfill property includes an active landfill, an active Subtitle D balefill, and areas considered closed that have not received wastes in recent years. These closed areas include the portions operated by the city and county, as illustrated on Figure 1. The city operated the landfill from 1968 to 1977, and the county assumed operations in 1977.

The City of Dickson and the surrounding area have been home to manufacturing facilities that conducted metal cleaning operations using various solvents, degreasers, and other VOCs. Boat building, printing, and metal fabrication facilities have operated in Dickson County dating back at least to the 1960s. Some of these manufactures, particularly metal fabricators and printers, were known to have used TCE, and at least one manufacturer is implementing corrective actions for a release of TCE to the soil and groundwater. Several of these facilities operated both permitted and unpermitted sites for the disposal of industrial wastes. The Tennessee Department of Environment and Conservation (TDEC) and EPA have completed investigations that identified several possible contaminant sources or areas, including the Dickson County Landfill and manufacturing facilities that may have contributed VOCs to the potable water supply.

The presence of VOCs in the groundwater supply and treated municipal drinking water has been attributed by one public advocacy group as the possible cause of increased birth defects in Dickson County. The Birth Defect Research for Children organization based in Orlando, Florida, believes that the occurrence of cleft palates and cleft lips (collectively referred to as "orofacial clefts") is higher than normal in Dickson County. The organization has concluded that TCE may cause such birth defects when mothers ingest drinking water contaminated with TCE during the first trimester of pregnancy. The organization further believes that toluene can also cause similar effects.

Insert Figure 1
City of Dickson

Environmental investigations of the former Dickson County Landfill have been conducted to determine if the landfill is a source of contaminants the public and private groundwater supply. These investigations have been overseen or performed by EPA, the TDEC, the U.S. Geological Survey (USGS), and the Centers for Disease Control and Prevention (CDC). An attempt by the USGS to link the landfill to the VOCs detected in well DK-21 included a dye trace study performed as a joint effort with the county; however, the USGS determined that the results of the study were inconclusive. The TDEC Division of Solid and Hazardous Waste Management (DSWM) have provided regulatory oversight of groundwater assessment activities at the landfill, including review and approval of the dye trace study. Activities performed by the TDEC Division of Water Supply (DWS) have included an initial evaluation of groundwater data for contaminated water wells and recommendations for remedies; an evaluation of the operational performance of the municipal well field as a potable water supply; review and approval of water treatment plant upgrades to address the presence of TCE in the water; and review of the dye trace study. Work performed by EPA has focused on investigations to score the site for possible inclusion on the National Priorities List (NPL) of hazardous waste sites.

The Dickson County area is located in a karst geologic and hydrogeologic setting. This setting is sensitive to releases to the environment because of the potential for rapid contaminant migration over long distances. The conduit-type flow pattern characteristic of karst settings and the associated jointing and bedding planes of the underlying bedrock can facilitate contaminant transport and make source identification difficult. Pumping of the water and the associated groundwater table within a karst setting can further facilitate contaminant fate and transport.

1.2 PURPOSE AND SCOPE

Based on investigative work performed by federal and state regulatory agencies, the known presence of TCE, toluene, and 1,2-DCE in groundwater, and the possible increased occurrence of orofacial cleft cases, EPA is reevaluating industrial activities in the Dickson area and their effect on local water supplies. EPA requested that TtEMI assist by conducting a groundwater use and contaminant evaluation summarizing work performed to date.

The approved project approach was developed so that relevant facts from various regulatory agencies, knowledgeable individuals, and other sources could be combined into a single, summary document that EPA could use to make regulatory decisions designed to be protective of human health and environment. The major tasks associated with the TtEMI project included regulatory file reviews concerning the Dickson County Landfill and other industrial facilities; interviews of persons knowledgeable of the water distribution system; interviews with TDEC officials; an assessment of the occurrence of orofacial cleft birth defects; an evaluation of regulatory actions for assessment and corrective actions; a review of the area geology and hydrogeology; and an assessment of potential sources of contaminants in the public and private water supply.

This report presents the results of the groundwater use and contaminant assessment. Section 2.0 summarizes studies conducted concerning the occurrence of orofacial defects in the Dickson area. Section 3.0 summarizes information on the environmental setting of Dickson County, including the area geology and hydrogeology, groundwater studies, surface water conditions, water use and supply, and operations of the public water system. Section 4.0 summarizes the Dickson County Landfill. Section 5.0 summarizes the results of the regulatory file review, and Section 6.0 presents a summary and recommendations for further assessment. References are provided at the end of the report.

Also included in this document are three appendices and several attachments. Appendix A summarizes documents regarding the City of Dickson public water system; Appendix B provides a list of files

reviewed and a chronology of events for the Dickson County Landfill; and Appendix C summarizes regulatory files reviewed for sites identified through TtEMI's regulatory database review.

2.0 OROFACIAL STUDIES

The incidence of orofacial defects within Dickson County has been investigated by Tennessee Department of Health (TDH), the CDC, and by the Birth Defect Research for Children organization. The following are summaries of the information obtained from these sources.

2.1 TENNESSEE DEPARTMENT OF HEALTH/CENTERS FOR DISEASE CONTROL AND PREVENTION OROFACIAL STUDY

The TDH was contacted in June 2000 by a local early intervention center regarding a potential cluster of orfacial clefts in Dickson County, Tennessee. The TDH, in coordination with the CDC, performed a cluster investigation to identify the risk factors contributing to the increased rate of orfacial clefts in Dickson County. The scope of the investigation included a case definition, additional case-finding activities, a case review, and case mother interviews (CDC 2001). A copy of the CDC report is presented in Attachment A.

The investigation defined a case as an "infant with either cleft lip and palate (CLP) or cleft palate only (CPO) born between January 1997 and October 2000 to a mother whose residence was in Dickson County at the time of birth. The diagnosis of CLP or CPO was determined by a medical professional, usually at birth or at the time of surgical repair." Several cases were identified by the local early intervention center. The TDH also requested that the local hospitals search discharge data for ICD-9-CM codes 749.00 through 749.25 and birth certificate records for the period of January 1997 through October 2000. The cluster investigation identified 18 cases in Dickson County, including 11 CLP and 7 CPO cases. The rate of CLP and CPO cases is consistent with nationwide incidence data (CDC 2001).

The CDC report indicated that Tennessee does not have an established statewide birth defects monitoring system. Information from the Department of Energy (DOE)-funded birth defects registry was used to establish statewide baseline rates for 1991 through 1993. Vital statistic data from 1989 through 1996 was also used to determine the rates of orofacial defects for Tennessee. Prior to 1989, clefting defects were not reported on birth certificates in Tennessee. In 1989, a box was added to birth certificates for clefting, but the box does not allow for the differentiation between CPO and CLP. Due to the limitations of the DOE and vital statistic data, the CDC also used information from the Metropolitan Atlanta Congenital Defects Program (MADCP) and the National Birth Defects Prevention Network (NBDPN) was also used. Based on these data resources, the CDC report concluded the following (CDC 2001):

- For the period 1989 through 1996, the Tennessee state average for combined orofacial clefts was 0.97 per 1,000 versus 1.6 per 1,000 reported in Dickson County. The incidence of CPO was higher in Dickson County (0.60 per 1,000 live births versus State of Tennessee rate of 0.30) for the period 1991 to 1993, while rates for CLP were lower (0.60 per 1,000 live births versus 0.76) over the same time period.

- While the rates for orofacial clefts in the state remained relatively constant from 1989 to 1996, the rates for Dickson County varied considerably, with a high of 5.42 per 1,000 recorded in 1989 and a low of 0.0 in 1993, 1995, and 1996. The CDC reported that the variance was expected given the relative low number (500 to 600) of live births per year in the county.

- A comparison of county data to the MACDP data indicated that the Dickson County rates from 1997 through October 2000, were five-fold greater than expected for both CLP and CPO.

- Interviews were completed for 15 of the 18 case mothers. The information obtained through the maternal interviews indicated that among the 11 infants with CLP, 2 (18%) had other significant anomalies reported; and among the infants with 7 CPO, 3 (43%) had other anomalies reported. None of the infants had a recorded chromosomal abnormality; however only 17% had chromosomal analysis documented. The report indicated that due to the nature of the phenotypes, these types of clefts are likely to be underasertained in both Dickson County and most reference surveillance systems, including MACDP and NBDPN.

- The scope of the investigation could not determine whether the drinking water for the case mothers was contaminated with TCE during the first trimester of pregnancies. However, the study noted that most case mothers (87%) used water provided by the City of Dickson for drinking and cooking at home.

- The results indicated Dickson County's baseline rates for orofacial clefts may be elevated compared to statewide or national rates. However, baseline rates for Dickson County could not be established with certainty. The report indicated that increased rates for clefting in Dickson County could be due to an undetermined teratogenic exposure, elevated baseline rates, or statistical fluctuation. Further, the report concluded that any one factor examined in the investigation was unlikely to account for the increased rates in the county.

- The report indicated that a cluster is a greater-than-expected number of cases in a population for a defined geographic area and period of time, and that the cases described within the report during the period of January 1997 to October 2000 met the definition of a cluster.

- The report indicated that the scope of the investigation could not determine the contents of the landfill or how they relate to the cluster of orofacial clefts in Dickson County.

- The report recommended continued monitoring to determine if the increased rates were due to elevated baseline rates or statistical fluctuations. In the event they were elevated, the CDC recommended that "more formal case-control study" be conducted to quantify the risks with the known risk factors.

2.2 TENNESSEE DEPARTMENT OF HEALTH FORM LETTER

In February 2001, the TDH sent a form letter to parties interested in the occurrence of orofacial clefts. The letter enclosed a copy of the CDC report and provided an opinion and summary of the CDC findings. The letter stated that for the period January 1, 1997 to October 31, 2000, the rates of cleft lip and palate had increased, without an identified cause. The letter indicated that most of the case families used water supplied by the Cities of Dickson, Charlotte, or Vanleer; that 2 families had private wells; and that sampling of drinking water supplies for 10 families had shown no evidence of contamination. The letter offered to sample drinking water supplies for anyone interested and stated that the Environmental Assistance Office had sampled other wells in Dickson County; the well and spring in the immediate vicinity of the landfill were the only areas outside the landfill to have shown any contamination. The letter also indicated that results of air modeling by the Tennessee Division of Air Pollution Control were pending (TDH 2001). A copy of the form letter is presented in Attachment B. A TDH representative

stated in November 2001, that the results of the referenced air modeling study are pending further sampling. The representative also indicated that one CLP case was identified in Dickson County from November 2000 to November 2001 (Tetra Tech 2001f). No additional information was identified concerning the scope of work or purpose of the air modeling study.

2.3 BIRTH DEFECT RESEARCH FOR CHILDREN INVESTIGATION

In obtaining background information on the project, TtEMI contacted the Birth Defect Research for Children organization. Ms. Mekdeci of the organization stated that the organization became involved in approximately March 2000 when a relative of a child with an orofacial cleft contacted them concerning what they thought was an unusually high occurrence of these birth defects in the area. The organization agreed to investigate the matter; initial efforts included the collection of data from the National Birth Defects Registry. The families of the 18 cases identified were contacted by the organization to gather information on maternal and paternal genetics and other factors (Tetra Tech 2001a and 2001e). Ms. Mekdeci indicated that the Birth Defect Research for Children organization sent a questionnaire to each of the case families; however, she indicated that the organization does not release that information to the public. The case information provided to TtEMI is included in Attachment C. The information provided consisted of addresses for all 18 case families, and the names of families 6 through 18. Water use was indicated by the families as "well" or "public." A summary of these case families by location, birth and conception dates, and water use is presented in Table 1. The locations of the family residences relative to the City of Dickson are illustrated on Figure 2. Ms. Mekdeci was extensively quoted in an article written by Ms. Kim Conner that appeared in The Dickson Herald on September 22, 2000. A copy of the article is included in Attachment D.

TABLE 1
SUMMARY OF OROFACIAL CLEFT CASES IN DICKSON COUNTY

Family Number	Address	Home Water Supply	Work Water Supply	Date of Conception
1	495 Baker Road, Dickson, TN	Well	Public	8/97
2	304 Lovell Avenue, Dickson, TN	Well	Public	9/97
3	14355 Tidwell Switch Road, Dickson, TN	Public	Public	1/98
4	400 Log Wall Road, Dickson, TN	Public	Public	1/97
5	220 Shoulder Strap Branch Lane, Town of Vanleer, TN	Well	Public	7/97
6	Hummingbird Lane, Dickson, TN	Public	Well	5/96
7	743 Nels Adams Road, Dickson, TN	Public	Public	3/98
8A	121 Brookside Drive, Dickson, TN	Public	Public	10/97
8B	1862 Rock Church Road Charlotte, TN (Foster Home)	Not Given	Not Given	
9	513 Pleasant Valley Drive, Dickson, TN	Well	Public	8/97
10	McCreary Heights Dickson, TN	Public	Unknown	5/99
11	221 Oak Hill Drive, Town of Vanleer, TN	Public	Public	3/99
12	110 Red Oak Circle, Dickson, TN	Public	Public	1/99
13	4377 Highway 70 West, Dickson, TN	Public	Public	5/99
14A	1005 Harmon Springs Road, Dickson, TN	Public	Public (Nashville)	1/00
14B	North Eno Road Dickson, TN (Grandparent's Home)	Not Given	Not Given	
15	122 South 3rd Street, Dickson, TN	Public	Public	6/99
16	200 Plantation Court, Dickson, TN	Unknown	Unknown	6/98
17	123 Payne Springs Road Dickson, TN	Public	Work (Memphis)	8/98
18	No Local Address Given	Not Given	Not Given	10/96

Note:
Source: Birth Defect Research for Children 2001

Insert Figure 2

Location of Orofacial Cleft Residences with Groundwater District Boundaries

3.0 DICKSON COUNTY ENVIRONMENTAL SETTING

The following sections summarize the environmental setting of Dickson County, Tennessee, including general information, published geology and hydrogeology information, information obtained from groundwater studies, information on surface water conditions, water use and supply, and water system operations.

3.1 GENERAL INFORMATION

Dickson County is located in the central part of Tennessee. Based on the Dickson, Tennessee USGS topographic quadrangle map, elevations within the county appear to range from 600 feet above mean sea level (amsl) along river and creeks to 900 feet amsl at ridge tops. The major surface water drainage feature in the county is the West Piney River, which flows south. The Tennessee Valley Divide, which is a local drainage divide, bisects the region. Surface drainage north of the divide generally flows north to northeast, while surface drainage to the south of the divide generally flows south.

3.2 PUBLISHED GEOLOGY AND HYDROGEOLOGY SUMMARY

TtEMI reviewed available geologic information to define the regional geology and hydrogeology. Available sources included published information from the USGS, the TDEC DWS, and consultants. The sections below describe the area geology and hydrogeology. A copy of the USGS document, "Ground Water in the Dickson Area of the Western Highland Rim of Tennessee," is included in Attachment E.

3.2.1 Geologic Conditions

Dickson County and the surrounding area lie on the rolling plateau of the Western Highland Rim, a section of the Interior Low Plateau physiographic province (USGS 1984). The Dickson area also lies along the drainage divide below the Tennessee and Cumberland River Basins and is characterized by rolling terrain that has been cut by numerous streams.

Formations exposed on the northwestern Highland Rim in the Dickson area include, in descending order, the Tuscaloosa Gravel of the Cretaceous Period, and the St. Louis Limestone, the Warsaw Limestone, and the Fort Payne Formation of the Mississippian Period. According to the USGS, the regional dip of the formations is toward the northwest. Local structural features include lows to the southwest and northeast parts of the study area, separated by an east-west trending anticline under the City of Dickson (USGS 1984).

The Tuscaloosa Gravel consists of chert gravel, sand, silt, and clay. The chert gravel is composed of well-rounded fragments up to 6 inches in diameter derived from the Camden Chert of Devonian age or locally from the St. Louis, Warsaw, and Fort Payne Formations. Because of its isolated nature and limited distribution, the Tuscaloosa Gravel is not a significant source of groundwater (USGS 1984).

The St. Louis Limestone, which caps most of the uplands, is generally represented at land surface by a residual clay soil containing blocks and nodules of chert. The St. Louis formation is a yellowish-brown fine-grained cherty limestone that locally includes beds of medium- to coarse-grained fossil-fragmental silty limestone similar to the underlying Warsaw Limestone. The St. Louis regolith contains chert that is dark, very dense, and brittle, and in places is characterized by round chert "cannonballs." Regolith is the mantle of unconsolidated material that overlays the bedrock. The regolith in the uplands is generally 50

to more than 150 feet thick, and in the valleys of major streams, the regolith is less than 50 feet thick (USGS 1984).

The Warsaw Limestone is typically a thick-bedded, light colored, medium- to coarse-grained, fossil-fragmental limestone. In the Dickson area, it is approximately 100 feet thick. The sand-size fossil fragments were derived primarily from crinoids and bryozoans. Quartz and calcite are the main minerals present, but glauconite and pyrite occur locally in very small amounts. Locally, the Warsaw Limestone contains fine-grained, cherty beds that are typical of the underlying Fort Payne Formation. The Warsaw-Fort Payne contact is generally conformable with gradation and possible intertonguing occurs between the two formations (USGS 1984).

The Fort Payne Formation is typically a calcareous, dolomitic, very cherty siltstone. The maximum thickness in the Dickson area is approximately 250 feet. Chert occurs throughout the formation in distinct beds, as irregular discontinuous beds or nodules, and within the matrix of the limestone and dolomite. Small cavities (less than 2 inches in diameter) contain quartz or calcite. Gypsum occurs in the lower part of the Fort Payne Formation, with glauconite and pyrite also occurring in small quantities. Some beds in the Fort Payne are medium- to coarse-grained, fossil fragmental limestone similar to the typical Warsaw Limestone (USGS 1984).

3.2.2 Hydrogeologic Conditions

Groundwater primarily occurs in the Warsaw Formation, which is characteristically reliant upon secondary permeability (fractures and joints in the bedrock) to produce varying amounts of groundwater discharge. The Fort Payne Formation is regarded as the base of the aquifer. The regolith thickness and lithology of the bedrock are the main factors influencing the development of high-yielding solution-enlarged bedrock openings. High-yielding openings are more likely to occur in areas where a thick regolith and fine-grained limestone is present at the top of bedrock (USGS 1984).

The St. Louis Limestone and the upper part of the Warsaw Formation have weathered to a clay regolith. The regolith has a low permeability but stores a large amount of water and slowly releases it to the solution openings in the underlying limestone. Springs in the area, except Payne Spring, discharge from the Warsaw Limestone Formation (USGS 1984).

A review of the geologic maps and documents indicates several springs in the Dickson area. The following springs were identified by the USGS as Grassy Spring, Walnut Grove Spring, Tide Spring, Payne Spring, Donegan Spring, Redden Spring, Bruce Spring, and Fielder Spring (USGS 1984). Additional research has identified at least one other spring in the vicinity of the Dickson County Landfill (Sullivan Spring).

TtEMI reviewed county information on well yields, groundwater elevations and groundwater flow directions from "Ground Water in the Dickson Area of the Western Highland Rim of Tennessee" (USGS 1984). Well yields in the county range from less than 1 gallon per minute (gpm) to approximately 100 gpm. Groundwater elevations in the county range from approximately 600 to 900 feet amsl. A groundwater drainage divide runs generally east to west through Dickson County. The highest groundwater elevations occur in the northwest portion of the county, north of the drainage divide. Groundwater flow north of the drainage divide is generally north to northeast, with minor components of flow to the south and west. Groundwater flow south of the drainage divide is generally south to southwest.

TtEMI obtained site-specific groundwater flow information from "Construction, Lithologic, and Water-level Data for Wells Near the Dickson County Landfill, Dickson County, Tennessee, 1995" (USGS 1996). Groundwater elevations at the site range from 750.04 to 800.17 feet amsl.

3.3 GROUNDWATER STUDIES

TtEMI reviewed two reports by the USGS and one report by Griggs and Maloney, consultant for the City of Dickson, on groundwater within the county. The reports are summarized below.

3.3.1 Groundwater in the Dickson Area of the Western Highland Rim of Tennessee-USGS Study

The USGS installed 26 wells in Dickson area in the 1980s. The wells, identified as DK1 through DK26, were installed in cooperation with the City of Dickson and the Tennessee Division of Water Resources as Phase 2 of a groundwater evaluation of the area. Phase 1 described the groundwater hydrology, and Phase 3 evaluated the quantity and quality of groundwater in the study area of Dickson County. According to the well logs, the depths of the 26 wells ranged from 21 to 400 feet, and the observed regolith thickness ranged from 4 feet in the valleys to 331 feet in the uplands. The wells were drilled west of the City of Dickson and east of the Dickson Landfill (USGS 1984).

As part of Phase 3, the USGS performed pumping tests on 10 of the 26 wells to determine well yield characteristics. Test data for the wells indicated that well DK-21 had a specific capacity of 12.7 gallons per minute per foot [(gal/min)/ft] of drawdown compared to the average specific capacity of 4.1 (gal/min)/ft; thus well DK-21 is able to transmit water more readily than the other wells. Additional pumping tests were performed by the USGS on wells DK-17 and DK-21 in 1980 and 1981. The pumping test for well DK-17, pumped at a rate between 140 and 150 gal/min, indicated a drawdown of up to 75 feet in a well located approximately 200 feet from well DK-17; the total distance of influence (where at least some amount of drawdown was recorded at 10 feet) was at least 850 feet from the pumping well (USGS 1984).

The pumping test for well DK-21, pumped at 350 gal/min, indicated a drawdown response (20.52 feet) at least 552 feet from the pumping well. Well DK-21 reportedly intersects a 17-foot-high solution-enlarged, water-bearing zone in the bedrock that is reported to be 4 feet thick at a well 330 feet away. Wells that are poorly connected to well DK-21 are believed to intersect thin water-bearing fractures in the bedrock (USGS 1984).

3.3.2 1996 USGS Study

A USGS study was conducted in 1995 in cooperation with the Dickson County Solid Waste Management authority to determine local groundwater altitudes and determine if Sullivan Spring is hydraulically downgradient of the Dickson County Landfill. Five monitoring wells (MW-6 through MW-10) were installed at the northwest corner of the landfill at points between the landfill and Sullivan Spring (USGS 1996).

The following summarizes the activities and findings of the USGS study (USGS 1996):

- Two wells were screened in the first water-bearing zone in the regolith (wells MW-7 and MW-9 of the on-site monitoring system) to a depth of 103 and 84 feet below ground surface (bgs) respectively.

Three wells (MW-6, MW-8, and MW-10) were screened in a water-bearing zone in the bedrock and had total depths of 183, 174, and 162 feet, respectively.

- According to the well records from the USGS study, the surface casing in MW-6 was not sealed at the bedrock-soil interface to the ground surface.
- The water-bearing intervals for wells MW-6 and MW-10 were undetermined, and the yields were less than or equal to 1 gpm.
- Fine-grained limestone was the uppermost bedrock unit at each bedrock well location.
- Sullivan Spring was determined to be at a lower altitude than and hydraulically downgradient of the water-level altitudes of the landfill monitoring wells.
- Groundwater levels in the eastern portion of the study area were higher than those in the western portion (USGS 1996).

3.3.3 Groundwater Quality Assessment Plan-Griggs and Maloney

Griggs and Maloney completed a Groundwater Quality Assessment Plan of the Dickson County Landfill for the City of Dickson in November 1994. The document included information on the regional geology and hydrogeology of the Dickson area, as well as more specific information related to the Dickson County Landfill and Sullivan Spring. A copy of the report is provided as Attachment F.

3.3.3.1 Regional Information

The groundwater system in the Dickson area is primarily recharged from precipitation in the uplands where the regolith is thick. Recharge enters the regolith, which stores the water and transmits it slowly downward to points where it can enter the bedrock system or flow along the bedrock-residuum contact. Groundwater flow within the regolith may be discontinuous across the site and controlled by the presence of pinnacles, regolith thickness, or variable rates of recharge to solution openings in bedrock. Although the regolith stores large quantities of water, in most cases it will yield little water due to the low permeability of the clay (Griggs and Maloney 1994).

The groundwater quality assessment plan included a regional water level contour map, which indicated water levels in the Dickson area based on 1960 measurements in wells and springs. Based on TtEMI's review of the regional water level contour map, it appears that groundwater flow patterns are similar to surface flow patterns, as groundwater generally flows from the uplands toward the valleys. In the valleys, groundwater is discharged at springs or seeps. Based on the map, the general groundwater flow in Dickson County is west-southwesterly.

3.3.3.2 Dickson County Landfill Information

Existing monitoring wells at the landfill are screened immediately above the bedrock surface and show widely varying water levels, and 2 of the 10 wells are periodically dry. The direction of groundwater flow cannot be determined based on information from the existing wells (Griggs and Maloney 1994).

Based on the thickness of regolith, the primary aquifer beneath the landfill should occur in solution-enlarged openings in the Warsaw Limestone. When test wells were drilled into the Warsaw Limestone in

the Dickson area, solution openings were noted ranging from less than 1 foot to more than 40 feet thick. In general, the smaller openings were clean, water-bearing zones, while the larger openings were partially or completely filled with clay. Solution openings that occurred below fine-grained "cap rock" near the top of bedrock were more likely to yield large amounts of water. The size and number of the solution openings decreased with depth (Griggs and Maloney 1994).

Sullivan Spring appears to be recharged from the Warsaw Limestone, which outcrops along the valley wall of Worley Furnace Branch. The bedrock solution openings that recharge Sullivan Spring would most likely be at altitudes above or equal to the altitude at Sullivan Spring. Surface water from landfill drains primarily to the southwest, west, and northwest toward Worley Furnace Branch and its tributaries, including Sullivan Spring. Worley Furnace Branch is located approximately 0.3 mile north-northwest of the landfill. The altitude of the spring is near the 720-foot elevation. The spring appears to issue from the limestone bedrock that outcrops along the valley wall of Worley Furnace Branch (Griggs and Maloney 1994).

The regolith in the uplands of the Dickson area is generally from 50 to more than 150 feet thick. A comparison of depths to bedrock for residential wells and test wells in the area near the landfill found the actual regolith thickness to be highly variable within short distances, which indicates that the bedrock surface is likely pinnacled. One test well drilled at the southeastern corner of the landfill was drilled to 331 feet before bedrock was encountered. The top of the Warsaw Limestone was estimated to be near the 740-foot contour in the area of the landfill. This would place the top of the Warsaw Limestone at about 60 to 130 feet beneath the landfill site. Locally, the upper part of the Warsaw may be weathered to clay regolith at some locations in the landfill vicinity. The unit is approximately 100 feet thick in the area. The Fort Payne Formation is typically a calcareous, dolomitic, very cherty siltstone. It is estimated to have a maximum thickness of approximately 250 feet in the Dickson area (Griggs and Maloney 1994).

3.4 SURFACE WATER CONDITIONS

Surface water in Dickson County includes lakes, ponds, springs and rivers. The area surface water drains primarily to the southwest, west, and northwest. Large tributary streams of the Piney River enter the main stream at nearly right angles, suggesting a fracture origin for the stream bed. Fractures along the regional surface water divide are not easily observed due to the lack of stream incision and the masking of fracture patterns by a thick residuum overburden (IT Group 2001).

3.5 WATER USE AND SUPPLY

The primary aquifer and the source of drinking water in the Dickson area occurs in the solutionally-enlarged fractures and bedding plane openings in the St. Louis and Warsaw Limestones. Most wells in the area are screened in the Warsaw Limestone, and, with one exception, all springs recharge from the Warsaw. The dense cherty Fort Payne Formation is generally an underlying confining layer, but does yield water in some wells (Griggs and Maloney 1994).

Potable water supplies in Dickson County are obtained from surface water or bedrock wells through either public utilities or private wells. Five public utilities were identified, including the Harpeth Utility District, Harpeth/Charlotte Water District, Dickson Water District, Turnbill/White Bluff Utility District, and the Sylvia-Tennessee City Utility District. The following summarizes information obtained by TtEMI from the TDEC DWS, which regulates drinking water supplies.

3.5.1 Division of Water Supply Database

TtEMI reviewed and summarized information regarding public and private water wells identified by the TDEC DWS for the Dickson Quadrangle, in which the landfill and well DK-21 are located. The USGS Dickson, Tennessee, topographic quadrangle map includes wells registered with the DWS by the responsible installer or owner. The list may not be complete for the area given that some owners or installers may not have registered their wells. Wells were required to be registered by the driller as of 1963 (USGS 1984). The database obtained from the TDEC DWS in April 2001, sorted by well use, is included as Attachment G. The estimated well locations, plotted by latitude and longitude coordinates provided within the database are shown on Figure 3.

An analysis of the DWS data by 5-year periods indicates that 17 percent of the wells (58 of 334) included on the list were logged since 1995. The data indicated that 282 (84%) of the registered wells were greater than 100 feet deep and that 52 wells (16%) were 100 feet or less.

3.5.2 Private Groundwater Wells

A review of the DWS database indicated that 274 (82%) of the 334 registered wells on the Dickson Quadrangle were reportedly used for residential purposes.

3.5.3 Commercial Groundwater Wells

The DWS database included one well listed for commercial use. The owner for the well was listed as the Mt. Sinai Community.

3.5.4 Irrigation Wells

Private individuals, the Dickson County Landfill, and the Goodlark Hospital were listed as owners of seven irrigation wells. It is assumed that the irrigation wells are primarily used for agricultural purposes and landscaping maintenance.

3.5.5 Municipal Wells

Eighteen wells were listed for municipal use. The City of Dickson, Dickson County, and the Dickson County Airport were listed as owners of the municipal wells.

3.5.6 Miscellaneous Listing

Three wells owned by the City of Dickson were listed as used for "other" purposes, and two additional wells did not note a use. The Tanbark Campground located on Highway 48 South was also listed as an owner of a well, with no purpose indicated.

3.6 PUBLIC WATER SYSTEM OPERATION

TtEMI reviewed and summarized information in DWS files to obtain information about the City of Dickson public water system. TtEMI also reviewed the wellhead protection plan developed by the City of Dickson, which is included in this report as Attachment H. The purpose of the review was to identify the location of public water supply wells and springs, determine well construction specifics, locate potential contaminant sources, estimate groundwater flow patterns under pumping and baseline conditions, and estimate well pumping rates and the zones of influence. City of Dickson officials were

Insert Figure 3
Water Supply Wells-Dickson Quadrangle

interviewed to discuss their understanding of the water supply and distribution system. Interviews were conducted with former and current City of Dickson public works officials and a representative from their consultant, James C. Haley & Co. Consulting Engineers. The DWS files for the City of Dickson were reviewed at the NEAC and the TDEC Central Office. The documents that pertain to the City of Dickson public water system are summarized in Appendix A.

The following summarizes significant operational information regarding the City of Dickson public water supply system:

A hydrologic study of the Dickson area was performed by the USGS in the early 1980s, in cooperation with the City of Dickson and the TDEC Division of Water Resources. Twenty-six wells were drilled in the area to identify potential sources of water to supplement existing sources. Eight wells yielded more than 100 gpm. Aquifer tests were conducted on wells DK-17 and DK-21 (USGS 1984)

City Lake is reportedly used as a primary source of water from April 1 to June 1 each year. Well DK-21 was formerly used to supplement that source from April 1 to June 1, and water from the well was mixed with raw water from City Lake. Mixed, the lake supply was 0.90 million gallons per day (MGD) and DK-21 supplied 0.25 MGD (City of Dickson, Water Department 1992, Attachment I). Well DK-21 was used from 1984, its date of its installation, until April 1997, when sampling indicated the presence of TCE in the well. According to a city official, the well was turned off on April 18, 1997, after TCE was detected during sampling events in December 1996, February 1997, and April 1997. The well was turned off at the request of the DWS upon its review of the monthly monitoring report (TtEMI 2001d, TDEC 2000, Attachment J). Well DK-17 reportedly produced large quantities of sand that caused pump shaft bearing failures, which led to terminating its use in approximately 1989 (City of Dickson, Water Department 1992).

The city has supplemented supply by obtaining water from the Turnbull Utility District, and began purchasing approximately 250,000 gpd from Turnbull Utility District in 1964. Although the city paid for the water, it did not actually start receiving water until 1978, after which the city used the source when the water demand increased and when filters at the city water plant were repaired. The Turnbull Utility District can reportedly supply up to 1.0 MGD on a continuous basis (City of Dickson, Water Department 1992)

The West Piney River surface water intake was brought on-line in 1986, and most of the river flow at the intake point, which is located at the confluence of the East and West Piney Rivers, is due to spring discharges along the rivers. The Piney River intake pump capacity was reported as 2.1 MGD with a safe yield of 4.4 MGD (City of Dickson, Water Department 1992).

The city sold treated water to the West Piney Utility District located south of the city (3.5 MG per month) and to the Sylvia-Tennessee City-Pond Utility District northwest of the city (5.0 MG per month). Other county utility districts supplying water to county residents included the Harpeth Utility District (serving Charlotte and Northeast Dickson County by spring and water supplied by the Turnbull Utility District); the White Bluff Utility District (serving White Bluff and areas north of town with water purchased from Turnbull), and the Town of Vanleer (serving Vanleer and areas nearby from a spring with lines linked to Sylvia-Tennessee City-Pond Utility District for emergency supply). The City of Dickson purchased the West Piney Utility District in 1998. In addition, the city currently provides potable water to the Harpeth Utility District. As a

result, water produced by the city is distributed throughout most of Dickson County (City of Dickson, Water Department 1992).

The wellhead protection plan reviewed by TtEMI identified three wells as being used as potable water supplies for the City of Dickson. These wells are DK-21 located northeast of the Dickson County Landfill, DK-17 located southeast of the landfill, and well DK-1 located at the Water Treatment Plant. Potential contaminant sources that were identified in the plan consisted of the landfill, the Brannon Trailer Park to the east, a sludge-spreading site located between the landfill and well DK-21, and urbanized residential and commercial areas to the north (City of Dickson, Water Department 1996).

In a June 7, 2001, meeting with TtEMI, City of Dickson officials and their consultants discussed operational plans for the municipal water system. Specific portions of the proposed plans include the following (TtEMI 2001c):

- The city did not expect to use City Lake as a water source until a 4.0 MGD upgrade of the existing treatment plant was completed. Water from the lake is reportedly high in iron and manganese and is difficult to treat without dilution. Well DK-21 had previously been used to dilute the water obtained from City Lake.
- The city had installed a well near the West Piney River intake and was considering using the well as raw water source.
- The city considered using well DK-15, located southeast of the landfill, as a potable water source. The well is reportedly installed in a sand aquifer.
- The city considered joining other utility districts in developing a new utility district to obtain raw water from the Cumberland River, located along the northern portion of the county.

3.6.1 Public Water System Treatment

The following section is based primarily on verbal information provided to TtEMI through interviews and meetings. According to the information, the City of Dickson water treatment plant was upgraded in 1986 with the addition of two filters. The total filtration capacity prior to the upgrade was 1,400 GPM. In 1999, the city reportedly installed an aerator to treat TCE-contaminated water, after which well DK-21 was used regularly as a raw water source.

Recent information collected from the TDEC file indicates that the city provides approximately 2 MGD to city and county residences. Currently, the plant is reportedly operating near the 2.0 MGD design capacity. The water treatment plant is classified as "Water Treatment –4" by the TDEC based on the design capacity, the nature of the raw water, the treatment operations, chemical feed operations, and laboratory practices (TDEC 2001a). The city applied for and received approval from the TDEC on April 14, 1999, to expand the water plant to 4 MGD, upgrade the West Piney River intake to 4.0 MGD, and develop an additional well supply (TDEC April 14, 1999). The current, pre-expansion design filter rate is 4.0 GPM per square foot, with an anticipated increase to 6.0 GPM per square foot. The filter rate was approved during repair periods in 1996 and 1997 to operate at up to 6.0 gallons per minute (GPM) even though its design capacity was 4.0. The facility uses chlorine to disinfect the raw water; as a result, trihalomethanes (THMs) are produced and monitored at perimeter locations in the system.

The treatment processes include chemical feed to initiate flocculation, and a coagulation chamber, sedimentation basins, and sand filtration. When well DK-21 is used, the raw water is passed though a

draft-induced aerator before chemicals are added for flocculation. The TDEC DWS approved the aerator for installation in October 1998 (TDEC 1998); prior to that, the system had no treatment capability designed to remove VOCs from the water supply. Disinfection with chlorine gas is the last process before the treated water enters the distribution system. The aerator was reportedly tested for a 2-week period in March 2000. Well DK-21 was restarted during this testing period and was pumped 24 hours a day, 7 days a week, for 30 days. City representatives stated that no analytical testing was performed on the raw water obtained from the well, nor were samples collected to indicate the ability of the treatment system to remove TCE or other VOCs.

3.6.2 Public Water System Sampling

The City of Dickson Water Utility has routinely collected and analyzed for VOCs or other parameters during the operation. Instead, sampling the following summarizes available information and analytical results for samples collected.

3.6.2.1 Well Sampling

Analytical data for various well points and locations throughout Dickson County were obtained from the TDEC DWS for sampling events occurring in 1994 and 1996 to 2001. Copies of data are included in Attachment L. Analytical results for raw water from City Lake and well DK-21 were obtained for the period April 1997 to May 2001. TCE was detected at 0.032 milligrams per liter (mg/L) in well DK-21 on April 21, 1997, and methyl ethyl ketone was detected at 12 micrograms per liter (µg/L) on October 9, 2000. No information was available for other wells and water supply sources (DK-1, DK-17, West Piney River).

3.6.2.2 Treated Water Sampling

Analytical results were obtained for groundwater samples collected in 1996 through 2000. A finished water sample (treated and entering the distribution system) collected on February 24, 1997, indicated the presence of TCE at 0.0013 mg/L. Analysis of a sample identified as City Lake "A," collected on April 7, 1997, detected TCE at 0.0021 mg/L.

THMs, chloroform, bromodichloroethane, and chlorodibromomethane are routinely detected in the treated water at four locations (the north, south, east, and west extent) in the distribution system. These chemicals are by-products of disinfection with chlorine. The EPA maximum contaminant level (MCL) for total trihalomethanes (TTHMs) is 0.10 mg/L. Information provided by the City of Dickson Water Plant for the period 1983 to 1998 indicates that the TTHM concentrations in treated water exceeded the established MCL on August 3, 1984, and September 8, 1987. However, on several occasions, TTHM concentrations approached the established MCL. Copies of analytical data are presented in Attachment L.

3.6.3 Backflow Prevention Program

The City of Dickson provided information to TtEMI on its backflow prevention program dating back to 1988. The backflow prevention tests and results are summarized in Table 2. No testing was performed during the period 1998 to 1999; when the testing resumed in 2000, the number of inspections increased substantially. Table 3 lists those facilities that failed the tests, most of which were manufacturing facilities. The water treatment plant failed the test in 2000. No information was obtained from the Turnbull Utility District regarding its backflow program.

TABLE 2
BACKFLOW PREVENTER PROGRAM SUMMARY
CITY OF DICKSON, PUBLIC WATER SUPPLY

Year	Number of Tested Facilities	Number Passed	Percent Passed	Number Failed	Percent Failed
1988	2	0	0	2	100
1989	27	23	85.2	4	14.8
1990	9	9	100	0	0
1991	35	34	97.1	1	2.9
1992	10	10	100	0	0
1993	15	15	100	0	0
1994	33	33	100	0	0
1995	2	2	100	0	0
1996	31	31	100	0	0
1997	32	28	87.5	4	12.5
1998	No Testing				
1999	No Testing				
2000	144	91	63.1	53	36.8
2001	25	18	72.0	7	28.0
Total	365	294	81	71	19

TABLE 3
BACKFLOW DEVICE FAILURE SUMMARY
CITY OF DICKSON

Year	Facility	Number of Devices	Retested and Passed (after 30 days)
1988	VOCATIONAL SCHOOL	1	1
	DICKSON FAIRGROUNDS	1	1
1989	PINEY WWTP	1	1
	LONG JOHN SILVERS	1	1
	PICTURE PERFECT	1	1
	MR. GATTIS	1	1
1991	XANADU RECORDS	1	1
1997	GREEN VALLEY NURSING HOME	1	1
	ROBO CAR WASH	1	1
	PINEY WWTP	1	1
	SIR PIZZA	1	1
2000	TRAILS APARTMENTS	3	3
	POP'S CAR WASH	1	1
	DR. PHILLIP GREENE	1	1
	KROGERS	1	1
	WAL-MART	1	1
	DICKSON FUNERAL HOME	1	1
	HORIZON MEDICAL CENTER	4	4
	TAYLOR FUNERAL HOME	2	2
	TEXACO MKT. 70 WEST	2	2
	TEXACO MKT. 46 SOUTH	1	1
	TEXACO MKT. 70 EAST	1	1
	COUNTY NURSING HOME	6	6
	GREEN VALLEY HEALTHCARE	1	1
	WENDY'S	1	1
	WAFFLE HOUSE	1	1
	TACO BELL	1	1
	McDONALDS	1	1
	KRYSTAL	1	1
	KENTUCKY FRIED CHICKEN	1	1
	PIZZA HUT	1	1
	LONG JOHN SILVERS	1	1
	CHINA PLACE	1	1
	OAKMONT ELEMENTARY SCHOOL	3	3
	MIDDLE SCHOOL	2	2
	HIGH SCHOOL	5	5
	DISCOVERY SCHOOL	2	2

TABLE 3 (continued)
BACKFLOW DEVICE FAILURE SUMMARY
CITY OF DICKSON

Year	Facility	Number of Devices	Retested and Passed (after 30 days)
2000 (cont.)	CENTENNIAL ELEMENTARY SCHOOL	2	2
	DICKSON FAIRGROUNDS	2	2
	JACKSON ACADEMY	1	1
	JIMS STYLE SHOP	1	1
	MUNICIPAL BUILDING	1	1
	WATER TREATMENT PLANT	1	1
2001	TRAILS APARTMENTS	1	1
	FOOD LION	1	1
	ECKERD DRUGS	1	1
	WALGREENS	1	1
	TAYLOR FUNERAL HOME	1	1
	WAFFLE HOUSE	1	1
	PONDEROSA	1	1

Note:
WWTP = Wastewater Treatment Plant

4.0 DICKSON COUNTY LANDFILL

The Dickson County Landfill consists of approximately 74 acres off Eno Road, 1.5 miles southwest of the City of Dickson, Dickson County, Tennessee. The landfill is described as containing three parts, the City of Dickson Landfill, the County Landfill Expansion, and the Balefill (see Figure 1). The City of Dickson Landfill consists of approximately 5 acres located on the eastern portion of the landfill and was operational from 1968 to 1977. The County Landfill initially started as a 41.6-acre expansion to the original City of Dickson Landfill, of which 28.6 acres was to be used for waste disposal. The expansion occurred after the county purchased the original City of Dickson Landfill, as well as 45 additional acres in 1977. The balefill was established as part of the 1987 expansion.

According to a site description in an EPA site inspection report (SIR), the entire landfill property includes a steep hill at the northern end of the property that drops to a perimeter road and a pond. The property slopes gently toward the southern end of the landfill, and a drainage ditch is constructed through the eastern portion of the landfill. The drainage ditch was constructed by the U. S. Department of Agriculture (USDA) Soil Conservation Service (SCS) to control erosion of cover soil. The north end of the property includes a small wetland and pond. A retention pond located on the western edge of the landfill drains into an unnamed creek west of the landfill and feeds into Worley Furnace Creek (Haliburton 1991).

The landfill has been identified by the TDEC and EPA as a potential source of TCE in groundwater because of its location relative to impacted springs and groundwater supply wells. As part of this investigation, TtEMI reviewed available information regarding the landfill, including construction and operational data, results of environmental investigations, and information from dye trace studies and groundwater sampling conducted at the site. The following describes the landfill, summarizes investigations, and presents regulatory timeline of significant events associated with the landfill. A full listing of the files reviewed and chronology of events is included in Appendix B.

4.1 CONSTRUCTION, OPERATION AND HISTORY, AND ACCEPTED WASTE STREAMS

The following summarizes available information on the construction and operation of the landfill.

4.1.1 Construction

The landfill is situated at an approximate elevation of 840 feet amsl, with topography within the area ranging from 700 to 900 feet amsl. The City of Dickson Landfill was originally a dumpsite starting in 1968, prior to the development of Solid Waste Regulations. Construction details for the City of Dickson Landfill and county-operated landfill were not available. However, an environmental assessment plan prepared by Gresham, Smith and Partners references the original 5- and 45-acre portions of the landfill as unlined. No information was available on construction of the balefill.

The 1992 EPA SIR for the landfill indicated that runoff collected in a pond at the northern end of the property. Runoff was reported as flowing from the property through the drainage ditch and a small potential wetland at the southern end of the landfill.

In 1987, the SCS designed and supervised the construction of a sediment basin located in a drain below the Dickson County Landfill. The sediment basin was designed to drain the Dickson County Landfill and the 1987 expansion of the landfill.

4.1.2 Operation and History

Information collected from the TDEC file indicates that the landfill property first operated as a formal city dump in 1968. The initial area of filling was in the southeast portion of the property, as illustrated on Figure 1. The landfill operated as an unregulated disposal area until 1972, when the state accepted its construction and operation plan (Dynamac 1992).

The approximately 5-acre landfill was originally operated by the county and owned and used by the city until it reached capacity in 1977 and was closed. The county purchased the landfill property and an additional 45 acres in 1977 to continue using the facility as a sanitary landfill. After the sanitary landfill was opened, the landfill reportedly accepted only domestic wastes and industrial wastes permitted by the TDEC Division of Solid Waste Management (DSWM).

In 1987, the county considered expansion plans for the landfill. The TDEC approved the request for the expansion in October 1987. The approval included a requirement for sampling of wells for pH, specific conductance, total organic carbon (TOC), nitrate nitrogen, chloride, lead, chromium (total), cadmium, iron, and manganese.

In 1988, the TDEC issued a permit to Dickson County for the operation of a sanitary landfill. The general terms of the operation of the sanitary landfill included the following:

- No liquids, industrial special wastes or wastes requiring special handling shall be accepted at the facility unless prior approval for each individual waste is obtained from the Division of Solid Waste Management.

- Groundwater monitoring shall be conducted at the frequency and for the parameters specified by the Division of Waste Management. The location of groundwater monitoring wells shall be approved by a Division geologist.

- No hazardous waste, as regulated by the Tennessee Hazardous Waste Management Act and the Rules adopted pursuant to that Act, shall be accepted at the facility.

In 1988 and 1990, a balefill permit was granted, and the fill area was operated until October 1996 (Griggs and Maloney 1996). The county submitted a revised closure and post-closure plan to the TDEC in June 30, 1997, describing the anticipated closure and post-closure care activities for the balefill. The balefill was reported by county officials to have been capped beginning in the summer of 1997, with borrow soils obtained from an adjacent property to the east. According to 1992 plans the landfill, the balefill operation consisted of approximately 14 acres of the site

4.1.3 Accepted Waste

Waste identified as being accepted and disposed of at the landfill included industrial waste such as solvents and paint residues, special wastes, and domestic wastes. Information gathered from the landfill operations manual prepared in 1988 indicate that disposal volume was approximately 1,572 tons per week and that the filling was initially done in trenches, with three additional lifts added. The following summarizes available information regarding materials disposed of at the landfill. No information was available on wastes received when the property was used as a city dump.

Industrial Wastes, Solvents and Paints: According to a potential hazardous waste site preliminary assessment, the Ebbtide Corporation located in the area reportedly disposed of trailer loads of drums containing industrial wastes. According to the report, Ebbtide disposed of drummed wastes every week for 3 to 4 years (Dynamac 1992). The contents of the drums were suspected to be spent solvents used to harden fiberglass.

Special Waste-State Supervise-Cleanup Waste: According to the Tennessee potential hazardous waste site preliminary assessment and the review of TDEC files, the Ebbtide Corporation removed material from an on-site dump and transferred it to the Dickson County Landfill for disposal (HWSPA, no date). Additional information obtained from files specific to Ebbtide Corporation is included in Appendix B.

Schrader Automotive Group also reportedly disposed of drums containing waste solids used to degrease automotive parts and wastes generated from a state-enforced cleanup at the facility. Additional information specific to Schrader Automotive Group is included in Section 4 (EPA 1992).

In 1988, the Tennessee Department of Health and the Environment (TDHE) approved the disposal of 275 to 300 cubic yards of solid waste from the CSX White Bluff derailment cleanup. (TDHE 1988)

In 1990, the TDHE approved the disposal of soil excavated during an underground storage tank (UST) removal at the National Convenience Store 1356 and Smith & Whitfield Phillips 66 on Highway 70 West. (TDHE 1990)

In 1990, the TDHE approved the disposal of waste powder coatings from the Tennsco Corporation. According to the material safety data sheets, the powder coatings were primarily calcium carbonate, titanium dioxide, and acrylic oligomer. The powder coating was used to coat various metal shelving and related items. According to the Special Waste Approval Form, the powder coating was generated when color changes were made. The estimated disposal was 50 to 100 pounds per month with up to 600 pounds per month being generated twice per year.

In 1991, the TDHE approved the disposal of waste material and filters generated from the paint line at Tennsco Plant and dried sludge from the White Bluff wastewater treatment facility.

4.1.4 Leachate Issues

Leachate outbreaks at the landfill have been identified as early as 1983 (Dynamac 1992). To date, several consultants (Gardiner Engineering, Gresham Smith and Partners, Griggs and Maloney, and Ferguson Harbor) have assisted the Dickson County Landfill in evaluating leachate problems and providing alternative treatment options. Analytical results are available for leachate samples collected during a 1991 EPA site inspection and on September 6, 1994. The leachate samples collected during the EPA site inspection identified zinc, potassium, magnesium, lead and aluminum and unidentifiable extractable organics. The results for the 1994 sampling indicate that TCE and DCE constituents were present at concentrations below the detection limits. The following summarizes the available information from the TDHE files related to leachate issues.

In 1992, Gardiner Engineering prepared a report discussing the specifications of the liner and leachate collection system at the balefill portion of the landfill. Limited information was available about the leachate systems. Maps indicated up to five leachate withdrawal wells were installed ranging from 4 inches to 16 inches in diameter.

An inspection on December 17, 1993, identified numerous major and minor leachate seeps and flow on both the closed and active portions of the landfill. A notice of violation was issued on December 29, 1993, with required compliance by January 18, 1994. Follow-up inspections by the DSWM in March, April, and May 1994 indicated continued leachate and erosion problems at the landfill. The county submitted a remediation plan to address the leachate issues to the TDEC during a show-cause meeting in July 1994. The TDHE approved the plan for implementation (DSWM, NEAC).

In January 1996, Gresham, Smith and Partners, consultants for the landfill, conducted leachate treatment pilot tests to examine alternatives to the pump and haul method. The proposed approach for treating leachate included the use of a dual-phased extraction system to withdraw and aerate the leachate from leachate sumps and wells. The system would include ultraviolet treatment of the water and discharge to a constructed wetland area. According to the proposed approach, the system was expected to treat 14,000 gallons per day.

In March 1996, Ferguson-Harbor was contracted to perform a second treatability study. The response from the DSWM indicated full support of the proposed leachate system. In November 1996, the county requested additional time to comply with the DSWM requirement to terminate leachate outbreaks. In June 1997, the DSWM provided a "formal request" inquiring about the status of the remedial activities to address the landfill leachate problems (DSWM, NEAC)

In August 1997, the proposed leachate treatment scheme was revised by the county, which requested approval to conduct a pilot-scale wetland treatability study. In April 1998, the county received a notice of violation for discharge of leachate at one of the landfill outfalls (Outfall 003) without a permit. The violation also indicated a failure to implement and modify the facility's Stormwater Pollution Prevention Plan. The county was requested to provide an outline of the corrective actions to fully comply with the regulations (DSWM, NEAC).

The remedial approach for leachate collection and treatment was revised in March 1999 when plans were made to dispose of the leachate into the City of Dickson sewer system. In June 2000, an industrial user permit application was submitted to the City of Dickson sewer department requesting approval for leachate discharge into the sewer system (DSWM, NEAC). Documentation in the TDEC files includes correspondence with contractors concerning easement issue for the installation of the leachate system discharge line. No further information was available in the TDHE on the status, completion, or closure of leachate issues.

4.1.5 Notices and Violations

Available information indicates that the landfill received numerous unsatisfactory operational notices during 1983 and 1991. Table 4 summarizes the results of solid waste management sanitary landfill evaluations conducted at the landfill.

TABLE 4
SUMMARY OF COMMENTS FROM
SANITARY LANDFILL EVALUATIONS

Date	Comment (taken directly from sanitary landfill evaluation form)
12/30/83	Unsatisfactory intermediate cover.
6/10/83	Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage. Leachate observed at the site.
3/16/83	Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage.
3/2/84	Unsatisfactory intermediate cover.
6/19/84	Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage.
12/7/84	Waste not confined to manageable area. Unsatisfactory daily cover.
5/28/85	Unsatisfactory litter control. Unsatisfactory daily cover. Evidence of insects and vectors.
7/26/85	Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage. Operation does not correspond with engineering plans.
11/5/85	Access not limited to operating hours. Waste not confined to manageable area. Unsatisfactory litter control. Unsatisfactory intermediate cover. Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage. Leachate observed at the site. Evidence of insects and vectors.
12/17/85	Access not limited to operating hours. Unsatisfactory litter control. Unsatisfactory daily cover. Unsatisfactory intermediate cover. Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage. Leachate observed at the site. A Notice of Violation of Section 68-31-104 of Tennessee Code Annotated was submitted to the landfill 12/23/86.
2/3/86	Two drums of waste paint/acetone/rainwater from Winner Boats Corp will be picked up this afternoon.
5/8/86	Unsatisfactory litter control. Unsatisfactory daily cover. Unsatisfactory intermediate cover.
6/19/86	Unsatisfactory daily cover. Unsatisfactory intermediate cover. Unapproved salvaging of waste. Evidence of insects and vectors.
8/14/86	Unsatisfactory daily cover. Pooling of water, cover soil cracking, soil erosion, improper slope, poor drainage Leachate observed at the site. A Notice of Violation of Section 68-31-104 of Tennessee Code Annotated was submitted to the landfill 8/19/86.

TABLE 4 (continued)
SUMMARY OF COMMENTS FROM
SANITARY LANDFILL EVALUATIONS

Date	Comment (taken directly from sanitary landfill evaluation form)
9/24/86	Waste not confined to manageable area. Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage. Leachate observed at the site.
11/13/86	Unsatisfactory daily cover.
1/7/87	Unsatisfactory daily cover. Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage. Leachate observed at the site. Leachate entering a watercourse.
5/7/87	Waste not confined to manageable area. Unsatisfactory daily cover. Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage. Leachate observed at the site.
7/14/87	Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage.
9/1/87	Site in good shape; SCS doing major drainage development, silt pond construction (finished) reseeding, erosion control etc.
11/3/87	Waste not confined to manageable area. Unsatisfactory daily cover.
2/23/88	Unsatisfactory litter control. Unsatisfactory daily cover. Leachate observed at site.
4/15/88	Unsatisfactory daily cover. Leachate observed at site. Improper handling of special waste.
7/14/88	Unsatisfactory daily cover. A Notice of Violation of Section 68-31-104(3) of Tennessee Code Annotated was submitted to the landfill 7/18/88.
10/19/88	Evidence of open burning. Letter sent 10/25/88 to remedy open burning.
1/5/89	Unsatisfactory intermediate cover. Pooling of water; cover soil cracking, soil erosion, improper slope, and poor drainage. Leachate observed at the site.
4/13/89	Unsatisfactory daily cover. Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage. Leachate observed at the site.
7/13/89	Unsatisfactory daily cover. Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage.
8/10/89	Unsatisfactory daily cover.
3/20/90	Unsatisfactory litter control. Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage.
6/14/91	Unsatisfactory intermediate cover. Pooling of water, cover soil cracking, soil erosion, improper slope, and poor drainage. Leachate observed at site.

Available information indicates that five notices of violation (NOV) have been issued to the Dickson County Landfill. The NOVs include the following:

Date	Notice of Violation
August 19, 1996	Inadequate daily cover.
July 18, 1988	Inadequate daily cover.
September 9, 1994	Violation of Groundwater Protection Standards.
October 14, 1996	Violation of Groundwater Protection Standards Cadmium detected in groundwater and springs at concentrations exceeding MCLs.
April 12, 1999	Violation for inadequate depth of cover and pooling of water on landfill cover.

4.2 ENVIRONMENTAL INVESTIGATIONS

During the operation of landfill, various environmental investigations were conducted to evaluate the geologic and hydrogeologic conditions related to construction and expansion of the landfill, required landfill monitoring as part of solid waste permit, and potential sources of contamination in identified wells and springs adjacent to the landfill. The following summarizes available information on these investigations.

4.2.1 Landfill Expansion Investigations

The landfill has undergone three expansions since the city dump was originally approved as a landfill in 1972. The initial expansion was in 1977, when the county took over operations of the city-run landfill and added an additional 45 acres to the property. The next expansions were conducted in 1987 and 1992. The county has obtained assistance from several consultants (Law Engineering, ATEC Engineers, and Gardiner Engineering) in the investigations related to expansion projects.

As part of its initial geologic evaluation of the site for expansion, the TDHE reported, "most of the site appears suitable for use as a sanitary landfill" (DWSM). The 1975 report recommended landfilling under the following conditions:

- No liquid wastes were to be disposed of.
- No cuts were to be made below 820 feet amsl until the possibility of perched groundwater was disproved.
- The maximum cut depth was not to exceed 20 feet due to an increase of chert content in the soil.
- Water wells within a 0.5-mile radius were to be sampled to determine background quality.
- Wastes were to be covered and compounded; drainage control was to be maintained; cuts were allowable to 800 feet amsl if no perched groundwater was present.
- A 20-foot soil buffer was to be maintained above any perched groundwater (DSWM).

A geologic evaluation of the site was completed in 1987, when the county was considering expanding the landfill. The evaluation included the advancement of six borings using hollow-stem augers and mud-

wash drilling techniques. The reports indicated groundwater at less than 50 feet bgs in all cases. Sand or gravelly chert was prevalent in all borings, and the borings were terminated prior to refusal on bedrock. A report summarizing the investigation stated that the first water-bearing zone was a perched zone that "could be from a large perched system over the site..."(DSWM, NEAC). The initial review by the DSWM concluded "the water levels at present rule out the use of this site for a landfill" unless further investigations distinguish between a perched system and "actual groundwater conditions." The SCS conducted a review of soil types and submitted information to the DSWM. In 1987, the TDHE approved the expansion of the landfill with restrictions.

In preparation for an additional expansion of the landfill (the proposed balefill), a geotechnical and hydrogeological investigation report was prepared by ATEC Associates. The landfill was proposed as a Class I balefill as defined by DSWM rules. The report discusses the results of six borings installed on a 35-acre site and concludes the following:

- Soil was suitable as the landfill buffer zone.
- The uppermost aquifer occurred within 20 to 50 feet of the Warsaw Limestone Formation.
- Three existing wells on site were suitable to monitor the water moving through the overburden recharging the underlying bedrock.
- Existing groundwater monitoring wells indicate an indefinable groundwater flow in the overburden.
- Private well and stream monitoring points should be added to the monitoring scheme.

The report concluded that the site was suitable for expansion. No wells or borings advanced during the investigation penetrated into the bedrock (ATEC 1992). In 1990, the TDHE granted a permit for operation of the balefill.

4.2.2 Required Landfill Monitoring

The following summarizes available data on groundwater and other sampling required during the operation and closure of the landfill.

4.2.2.1 Groundwater Monitoring

In 1989, four monitoring well (MW-1 through MW-4) were installed at the landfill. MW-1 is located at the northeast corner of the landfill, and MW-2, MW-3, and MW-4 are located along the southwest corner. In 1995, an additional five monitoring wells (MW6, MW7, MW8, MW9, and MW10) were installed in the northwest corner of the property, topographically between the landfill and off-site springs. Of the five wells, three were installed to bedrock, and two were identified as "shallow".

According to a groundwater assessment plan, the site was using the existing 10 monitoring wells (MW-1, MW-1A, MW-2, MW-4, MW-6, MW-7, MW-8, MW-8A, MW-9, and MW-10), three private wells (Harry Holt Well, Lavenia Holt Well, and R. Holt Well), two USGS wells (DK-9 and DK-21), and one spring (Sullivan Spring) (Griggs and Maloney 1994). The additional wells were installed on the property as previously discussed in USGS investigations (DK-9 and DK-21) and other investigations.

Monitoring well MW-8A was installed in 1997 for use in groundwater pumping tests at the landfill. No information is available on the installation of well MW-1A.

Sampling and analysis of the groundwater monitoring wells has been performed on a sporadic basis from 1989 to 2000. Groundwater samples were initially collected from wells MW-1, MW-2, MW-3, and MW-4; well MW-3 eventually was removed from the sampling due to insufficient quantity of water. Additional monitoring wells were added to the sampling scheme as they were installed. Table 5 summarizes the sampling conducted at the site.

TDEC files regarding the landfill-related groundwater sampling and analysis included reports describing the results of sporadic sampling events and limited information on potentiometric groundwater surface diagrams. In 1994, the DSWM required that groundwater assessment and monitoring be completed, and in 1996, the DSWM requested that the county outline the steps to be taken to bring the landfill into compliance. In addition, the DSWM requested the following information:

- Submit a groundwater monitoring plan
- Resume Appendix I monitoring
- Inventory domestic water supply wells within a 1-mile radius of the landfill
- Sample existing monitoring wells at the landfill and Sullivan Spring

The first sampling of the monitoring wells in 1996 for Appendix I parameters indicated cadmium at concentration above the MCLs in all groundwater samples and Sullivan Spring. Based on these results, the DSWM requested a revised monitoring program to include the following:

- Quarterly sampling for Appendix II constituents
- Corrective actions to be initiated within 90 days
- Sampling of wells MW-7, MW-8, and MW9.
- Construction details for wells MW 2 and MW-4.

Well MW1 was eliminated from the sampling because it did not provide adequate sample volume.

Evidence in the file indicates that the county and its consultant recognized shortcomings of the monitoring system in determining the groundwater quality and flow direction. The current county consultant, Gresham, Smith and Partners, concluded that two aquifers are present at the landfill: one at the top of bedrock and one within the bedrock (GSP 2000). For the Class I balefill, the report states, "it is unlikely that any of the monitoring wells are upgradient of waste." The report states that for the Class IV landfill, "a background monitoring point has not been established." Monitoring well MW-6 continues to be used as a bedrock monitoring point even though the well casing is suspected of leaking water from the upper aquifer. The improper well casing can result in groundwater elevations being artificially high. Information also suggests that the on-site wells are not ideally situated in a triangular manner to determine the direction of groundwater flow.

Additional information in the file indicates that the current consultant never purges well MW-8 during sampling events, but rather purges an adjacent well, MW-8A. Sampling results for well MW-8 and adjacent wells indicated the presence of cadmium in 1996 at concentrations greater than the MCL. Well MW-8A is purged by removing approximately 25,000 gallons of water (versus the 40 gallons for three well volumes at well MW-8). The purge water is apparently discharged to the ground surface. Concentrations in a pre-purge sample collected from well MW-8 exceeded the MCL for cadmium, lead, mercury, and thallium.

TABLE 5
SUMMARY OF SAMPLING EVENTS FOR LANDFILL MONITORING

Date	Consultant	Wells Sampled	Constituents Analyzed		
			pH, Specific Conductance, TCL, TOC Nitrates	Metals	VOCs
November 7, 1989	Gardner Engineering	MW-2 and MW-4	Yes	No	No
October 18, 1990	Gardner Engineering	MW-1	Yes	No	No
November 24, 1990	Gardner Engineering	MW-1	Yes	No	No
March 6, 1990	Gardner Engineering	MW-1	Yes	No	No
February 8, 1990	Gardner Engineering	MW-2, MW-4, and Donegan Spring	Yes	No	No
March 16, 1991	Gardner Engineering	MW-1, MW-2 and MW-4	Yes	No	No
March 1993-First Semi-Annual Report for 1993	Gardner Engineering	MW-2, MW-4, Donegan Spring, and Sullivan Spring	Yes	No	No
March 1994-First Semi-Annual Sampling	Gardner Engineering	MW-2, MW-4, Donegan Spring, and Sullivan Spring	Yes	Yes	Yes
June 27, 1994	Gardner Engineering	MW-2, MW-4, Donegan Spring, and Sullivan Spring	No	Yes	Yes
September 28, 1994	Gardner Engineering	MW-2, MW-4, and Sullivan Spring	Yes	Yes	Yes
December 26, 1994	Gardner Engineering	MW-2, MW-4, and Sullivan Spring	Yes	Yes	Yes
July 25-26, 1995	Griggs and Maloney	MW-1, MW-6, MW-7, MW-8, MW-9, and MW-10	Yes	Yes	Yes
December 3, 1996	Griggs and Maloney	Sullivan Domestic Well	No	Yes	Yes

TABLE 5 (continued)
SUMMARY OF SAMPLING EVENTS FOR LANDFILL MONITORING

Date	Consultant	Wells Sampled	Constituents Analyzed		
			pH, Specific Conductance, TCL, TOC Nitrates	Metals	VOCs
February 12 and 19, 1997	Griggs and Maloney	MW-2, MW-4, MW-6, MW-7, MW-8, MW-9, MW-10, and Sullivan Domestic Well	No	Yes	Yes
May 14, 1997	Griggs and Maloney	Sullivan Spring	No	Yes	Yes
August 1999	Gresham, Smith and Partners	MW-1a, MW-2, MW-4, MW-6, MW-7, MW-8, MW-9, and Sullivan Spring	No	Yes	Yes
September 2000	Gresham, Smith and Partners	MW-1a, MW-2, MW-4, MW-6, MW-7, MW-8, MW-9, and Sullivan Spring	No	Yes	Yes

Notes:
VOC = Volatile organic compounds
TCL = Target Compound List
TOC = Total organic carbon

Although required by the DSWM, no statistical analyses of the groundwater sampling results were found in the DSWM file for any sampling event.

4.2.2.2 Landfill Closure

The city dump landfill was closed in 1977. No information was available on the specifics of the closure activities. A closure/post-closure plan was prepared for the balefill in 1997. The balefill reportedly stopped operations in 1996. The closure plan approach included the following:

- Groundwater monitoring
- Quarterly methane gas monitoring

In June 1997, a closure/post-closure plan was prepared for the landfill and balefill operations. The plan reported that at the landfill's current operation rate, the site would have approximately 15 years of operation and a projected closure of 2011. However, the county discontinued operation of the Class I landfill in October 1996; it is continuing to operate the Class IV landfill. The plan divides the site into areas that received wastes before and after March 1990. The portion that was before 1990 was considered closed, although ponding of water and erosion were reported as problems. As a result, areas will be filled in and a vegetative cover established. The plan proposed closure in accordance with current Tennessee regulations for the post-1990 area of the site. Closure would include placement of a 30-millimeter geomembrane and placement of soil in 6-inch lifts, compacted to a dry density of at least 85 percent of maximum dry density, and the installation of gas vents. No additional information was available on the closure activities.

4.2.3 Evaluations of Landfill as a Source of Groundwater Contamination.

In 1988, Ms. Ann Sullivan, a resident living near the landfill, requested that the TDHE sample a spring on her property. There is no indication in the files of sampling; however, the spring was referenced as being contaminated during a 1988 public meeting on the expansion of the landfill. In 1988, several residents in the area requested sampling of springs and private water supplies. The TDHE sampled three water supplies in October 1988: Dale Donegan Spring, Harry Holt well, and Lavenia Holt well. TCE was detected in the Harry Holt well at 3.5 mg/L and methylene chloride was detected in the Holt wells and Donegan Spring.

The next available data for springs and private water supplies in the area is from 1994, when eight residences were sampled. The sampling and analysis of water from kitchen sinks did not indicate concentrations of TCE or DCE. The following summarizes available groundwater analytical results.

4.2.3.1 Spring and Groundwater Sampling

From 1988 through 2000, private springs and groundwater wells near the landfill have been sampled by EPA, the TDHE, and landfill consultants. The following summarizes available information on the spring sampling. Table 6 lists the names, addresses, and dates of sampling activities. According to the data, TCE and DCE have been detected at four locations: Harry Holt well, Lavenia Holt well, Linda Gorley well, and Sullivan Spring. Table 6 also summarizes the analytical results for the Holt wells, Gorley well, and Sullivan Spring.

TABLE 6
SUMMARY OF TCE AND DCE RESULTS, SPRINGS AND PRIVATE WATER SUPPLIES
DICKSON COUNTY, TENNESSEE

Owner	Address	Date	TCE (mg/L)	DCE (mg/L)
Gorley, Linda	710 Eno Road	October 25, 2000	0.6	BDL
Gorley, Linda	710 Eno Road	October 31, 2000	0.5J	BDL
Holt, H.	340 Eno Road	October 9, 2000	120.0	6.6
Holt, H.	340 Eno Road	January 28, 1990	26.0	BDL
Holt, H.	340 Eno Road	August 17, 1990	3.9	BDL
Holt, H.	340 Eno Road	August 23, 1991	3.7	BDL
Holt, H.	340 Eno Road	October 12, 1988	3.5	BDL
Holt, H.	340 Eno Road	October 25, 1988	145.0	8.6
Holt, L.	Not Provided	October 25, 2000	0.2J	BDL
Sullivan Spring	738 Furnace Hollow Road	March 5, 1994	18	5
Sullivan Spring	738 Furnace Hollow Road	June, 25, 1994	83	19
Sullivan Spring	738 Furnace Hollow Road	September 1, 1994	59	9.8
Sullivan Spring	738 Furnace Hollow Road	September 28, 1994	84	17
Sullivan Spring	738 Furnace Hollow Road	May 22, 1995	31	6.8
Sullivan Spring	738 Furnace Hollow Road	August 19, 1996	<5	<5
Sullivan Spring	738 Furnace Hollow Road	December 3, 1996	<5	<5
Sullivan Spring	738 Furnace Hollow Road	May 14, 1997	230	31
Sullivan Spring	738 Furnace Hollow Road	August 26, 1999	160	39
Sullivan Spring	738 Furnace Hollow Road	September 20, 2000	160	25

Notes:
TCE = Trichloroethylene
DCE = Dichloroethene
µg/L = microgram per liter
BDL = Below detection limit; laboratory reports no provided
J = Estimate value
< = Less than

In addition, toluene was detected in the J. Holt well and Tices Spring. A summary table prepared by the TDHE indicates that bromodichloroethane and chloromethane were detected at the DeLoach and Herkimer properties, and methyl ethyl ketone was detected at the Donegan and McKenny locations. Antimony, barium, and zinc were also detected at the Petty property.

According to a 2001 environmental assessment plan (EAP), additional sampling of residential wells and springs was conducted in October and November 2000, and January and February 2001. The analytical results were not provided in the report, but the text indicated that the Holt well contained TCE in October and November 2000, and January 2001; the Sullivan Spring contained TCE in February 2001.

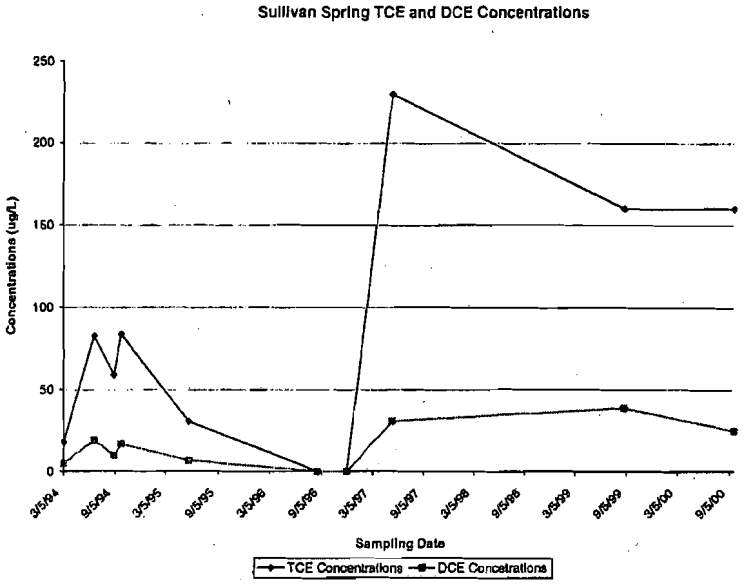
The following summarizes additional information about sampling conducted near the landfill.

Bruce Spring Evaluation: The TDHE investigated a complaint from a local resident concerning excess algae growth at the Bruce Spring, located approximately 4.5 miles downstream of the landfill. The complaint was the result of a Public Notice in 1988 relating to the proposed landfill expansion. The TDHE conducted sampling and determined that the aquatic community was consistent with those identified at other springs. The TDHE concluded that nutrients from the landfill, failing septic systems, and/or agricultural runoff were probably entering the spring during rainfall events (EPA 1992).

Harry and Lavenia Holt Wells and Donegan Spring Sampling: According to analytical reports from the TDHE laboratory, methylene chloride was detected in a 1988 sample of water from the Donegan Spring (0.003 parts per billion [ppb]) and the Lavenia Holt well (0.5 ppb). The reports also indicate TCE was detected in the Harry Holt well at 3.5 ppb. In December 1988, a letter from EPA to Harry Holt indicated that, "there were no constituents detected which exceeded EPA's National Primary Drinking Water Regulations or any other health-based criteria.

The DSWM file indicates that internal TDEC and EPA conversations regarding the Holt well were continuing into January, February, and March 1992. A January 6, 1992, memorandum to file from the DWS references a discussion with EPA where EPA had determined the field investigation to be complete. An internal DSWM memorandum dated February 12, 1992, regarding Holt well results stated "no substantial evidence was found in our files" that the well had been contaminated by the landfill. Another internal DSWM memorandum dated March 13, 1992, stated that because EPA had already completed a site investigation, EPA should continue with "their chosen course of action," and that "if Mr. Holt is concerned about possible health risks in using his well water between now and June (when EPA's priority decision is made), he should rely on bottled or city water for cooking and drinking purposes until he is convinced that his well water is safe." Correspondence related to the Holt well is included in Attachment N.

Sullivan Spring Sampling: In July 1988, Ms. Ann Sullivan, whose residence is located on Furnace Hollow Road topographically downgradient of the landfill, requested that the DSWM sample the spring on her property used for drinking water and cattle watering. No evidence of spring sampling was located in the TDEC files. However, the spring was sampled on six separate occasions between 1994 and 2000 and an additional four times in late 2000 and early 2001. Concentrations of TCE ranged from 18 to 160 µg/L, and DCE concentrations ranged from 5 to 25 µg/L based on the 1994 to 2000 data. Because of the September 1994 sampling, the TDHE sent a letter to the Sullivans recommending discontinued use of the spring as their drinking water supply. A new potable water supply was installed at the Sullivan residence. The following graph presents historic TCE and DCE concentrations in Sullivan Spring.



Notes:
µg/L = micrograms per liter

4.2.3.2 Dickson County Landfill Dye Trace Summary

A dye trace was proposed by consultants to evaluate a possible hydraulic connection between the landfill and impacted springs. Proposals for dye trace studies associated with the Dickson County Landfill were submitted to the DSWM by Gresham, Smith and Partners in August 1997, and the USGS in December 1997. The proposal prepared by Gresham, Smith and Partners focused on providing a system for managing leachate at the Dickson County Landfill. The proposal stated that a previous study confirmed the presence of a large mound of leachate beneath older sections of the landfill and that the leachate posed a significant potential to impact groundwater and surface water resources (Gresham, Smith and Partners 1997).

The dye trace registration form for the landfill trace investigation listed the purpose as follows: "Contaminants were detected in a production well near the Dickson County Landfill. The Trace could help us evaluate whether contaminants could migrate from the landfill to the well" (USGS 1997). The USGS proposed the use of three dyes to be injected into two leachate recovery wells and one abandoned landfill monitoring well, located northeast of the landfill. The anticipated injection date was indicated as January 6, 1998. The locations of the injection points and the information as submitted to the DWS and DSWM are presented in Attachments D1 and D2. Results of the proposed dye trace studies were not found in the DWS files at the time of TtEMI's review.

DSWM files included the results of the landfill trace performed by the USGS and Gresham, Smith and Partners. The landfill trace results were provided in Appendix B of the TCE investigation report prepared by Gresham, Smith and Partners on behalf of the county (Attachment E). The report stated that the background phase of the investigation was performed from December 2, 1997, to January 13, 1998. After the background phase was completed, cotton and coal dye detectors were placed at 25 sites in the landfill area. These sites included streams, springs, municipal wells, private wells, wetlands, and ponds. Three dyes were injected on January 13, 1998, and the test was concluded on September 29, 1998.

Tinopal CBS-X, an optical brightener, was injected into a groundwater well, rhotamine WT was injected into a leachate well located at the former county portion of the landfill property, and Eosien OJ was injected into a leachate well in the city portion of the landfill property. The cotton and coal dye detectors were collected and replaced every 1 to 2 weeks (Gresham, Smith and Partners 2000). The results of the landfill dye trace study are summarized below.

- The Executive summary of the Appendix B indicated that DK-21 is upgradient of from the landfill, although TtEMI could not find supporting data for this statement.

- Well DK-21 was apparently pumped intermittently during the first half of the study and not pumped during the second half. TtEMI was unable to identify pumping rates, drawdown or other information from the dye trace.

- A positive trace was declared for the optical brightener injection. The dye was reportedly identified in at a well identified at well Di:F-91, monitoring well on the west side of the landfill.

- The report indicated that although negative tracer recovery does not conclusively disprove the lack of hydraulic connection between the dye-injection and dye-detection sites, none of the tracer tests provided evidence that the landfill is hydraulically connected to springs and well included in the study.

4.3 FEDERAL INVESTIGATIONS

Complaints by local residents have prompted investigations of the landfill by EPA and the State of Tennessee. The following summarizes available information obtained concerning these federal and state investigations.

1992 Site Inspection Prioritization Report

The 1992 SIP report recommended that a limited further investigation be performed, focusing primarily on the additional characterization of the "possible southern drainage pathway." The attached scoring sheets showed that under one scenario, the overall score was 15.40. The scenario assumed a "low waste quantity value, a low Level I population value for the groundwater pathway, and the lack of an observed release to a perennial surface water body." The second scenario was less than the cutoff score (28.5) because of the limited number of people using the well for drinking water. Both scenarios assumed that a population of six was exposed to constituents at concentrations above the MCL, that the municipal water well only served 3 percent of the annual yield, and that the Piney River intake served the majority of the population. The scenario did not consider that the municipal water well was used (along with City Lake) during certain six-month periods.

1991 Potential Hazardous Waste Site Preliminary Assessment

The 1991 preliminary assessment report was prepared to investigate alleged improper waste disposal at the Dickson County Landfill. Specifically cited in the report is the alleged acceptance of drummed wastes from Ebbtide Corporation, White Bluff, Tennessee. According to the report, the drum was suspected to contain solvents, and the drum "exploded" as an employee tried to remove a top from a drum.

A medium priority was recommended based on city water being obtained from Dickson Lake and residential use of groundwater. The preliminary assessment identified the potential for surface water, groundwater and soil contamination from the disposal of questionable wastes from Ebbtide Corporation.

1991 EPA Site Inspection Report

The 1991 site inspection was conducted to determine the nature of contaminants present and to determine if a release of site substances had occurred or may occur. The inspection also identified the possible pathways for contaminant migration, as well as the population and environment it would affect.

In summary, the inspection identified the following:

- Wastes dumped by Ebbtide Corporation (Winner Boats) are known to have contained acetone and paint thinner.
- Waste dumped by Schrader Automotive Group was thought to be a degreaser used to clean automotive parts.
- Wastes accepted by the sanitary landfill included waste oil and coolants from Tekside Aluminum Foundry.
- Empty containers of Spotleak (a mercaptan-sulfur compound mixture) were brought to the landfill.
- Soil containing benzene, toluene, ethylbenzene, xylenes, and petroleum hydrocarbons from underground storage tank cleanups were brought to the landfill.
- A population within a 4-mile radius of the landfill was estimated at 8,072, primarily residential.
- Three surface water drainage patterns were identified on the landfill property. Most of the surface water drains through the swale in the middle of the landfill and travels west to a retention pond, then to an unnamed intermittent stream into Worley Furnace Creek. Worley Furnace Creek eventually flows into the West Piney River. South of the swale, surface water flows to the southwest, where it forms a small, potential wetland, then to Baker Branch before entering the West Piney River. Surface water from the northern end of the property flows north to a small wetland area.
- A geophysical study was performed to aid in selecting sampling locations at the old City Landfill. Electromagnetic "highs" were detected, suggesting that the observed readings were the result of buried waste.
- A soil gas survey was also conducted to aid in the selection of sampling locations. The soil gas probes were placed to 3 feet bgs in locations of leachate breaks, suspected disposal areas, and geophysical screened areas. Based on the readings, seven soil samples were collected (three from the drainage pathway, one from the northern edge of the landfill near a leachate outbreak, one from southwest berm of the drainage ditch, and two from the center of the landfill).
- A total of 224 samples (soil, surface water, sediment, and groundwater) were collected during the inspection. The samples were analyzed for all organic and inorganic parameters on the Target Compound List (TCL). The results are as follows:

- One subsurface sample contained pesticide/polychlorinated biphenyl (PCB) compounds
- One leachate sample contained pesticide/PCB compounds
- One groundwater sample from a private well contained trichloroethylene
- One sediment sample contained chloroform, evidence of petroleum hydrocarbons and polyaromatic hydrocarbons

4.4 PROPOSED ASSESSMENT AND CORRECTIVE ACTIONS

Dickson County developed a plan to address groundwater and leachate concerns at the landfill. The environmental assessment plan (EAP), which describes the proposed approach, was submitted to the DSWM on May 31, 2001, for review and approval. The EAP was prepared "pursuant to the requirements established within the Remedial Action Notice received by the City of Dickson and Dickson County." The plan described proposed groundwater assessment activities and plans for a remedial cap over portions of the landfill, consistent with the cover requirements established in the Resource Conservation and Recovery Act (RCRA) Subtitle D. The groundwater assessment portion of the plan is included in Attachment Q.

The groundwater assessment plan stated that the "site" includes 10 groundwater monitoring wells located on the landfill property, three private wells (owned by Harry Holt, Lavenia Holt, and R. Holt), two municipal wells (DK-21 and DK-9), and one spring (Sullivan Spring). Well DK-9 is located on the southeast portion of the landfill property, reportedly in a 380-foot plus area of residuum soil cover. The plan states that to date, none of the 10 on-site groundwater wells have indicated the presence of VOCs.

The proposed groundwater assessment approach includes installation of 2-inch piezometer well nests with gas monitoring and groundwater wells at varying depths, installation of bedrock wells located based on lineation patterns, development of a conceptual site model, development of an aquifer characterization plan, and completion of a water use survey. No assessment activities were proposed for the northwest portion of the landfill, nor were any actions proposed to close improperly installed wells. Specifically, the components of these proposed assessment activities included the following:

- **Borings and Gas/Groundwater Wells:** The proposed assessment approach includes the advancement of 14 soil borings on or very near the landfill property. All of these borings are adjacent to the closed portions of the city and county landfills. The borings will be advanced to bedrock refusal. The plan states that each water-bearing zone will be independently monitored by proper screening and borehole sealing. No proposed construction details were included, but will be submitted in the well installation plan (WIP) within 30 days after DSWM acceptance of the EAP. The approach does not indicate whether the piezometers will be sampled as groundwater monitoring points.

- **Groundwater Monitoring Well Installation:** The wells will be field-sited in an attempt to intercept the lineation pattern reportedly observed in Worley Furnace Branch northwest of the landfill. The reported lineation trend is 123 and 135 degrees. The site is possibly connected to Sullivan Spring and the Harry and R. Holt wells along this trend line. All of the proposed wells are located along the eastern portion of the property. The proposed approach includes advancing soil borings to bedrock and continuous rock core drilling until the Chattanooga Shale formation is reached. The top of the shale formation is estimated to be 450 feet below the landfill surface. The boring will be over-drilled with an air rotary drill rig, and a well nest will be installed to monitor all water-bearing zones in the Warsaw, St. Louis, and Fort Payne Formations. The

construction protocol, decontamination procedures, and other such information that were not included in the EAP will be included in the WIP within 30 days of DSWM approval of the concept.

- **Conceptual Site Model:** The EAP proposes that a conceptual geologic and hydrogeologic model be developed once the analytical testing and verification sampling is completed. Additional wells and monitoring points can then be evaluated. Upon completion of those monitoring points, a groundwater sampling program will be developed and submitted to the DSWM.

- **Aquifer Characterization Plan:** An aquifer characterization plan (ACP) will be submitted to the DSWM within 45 days after completion of the conceptual site model. The plan will "address all contaminated or potentially contaminated aquifers determined during the initial sampling and analysis."

- **Water Use Survey:** The EAP states that provisions to address additional water use surveys will be made to augment the existing 1.5-mile radius survey. The EAP proposes that a 2.0-mile radius be included in the ACP.

As part of the EAP, the county also developed a remedial work plan design that includes capping the entire City of Dickson/Dickson County Landfill site that received wastes until 1990. The proposed approach to address leachate outbreaks and related issues of noncompliance include installing and enhancing the leachate collection system, installing a geocomposite clay liner (GCL) cap system, and providing passive gas venting. The cap, proposed for a 40-acre area, is to consist of a minimum 6-inch soil layer beneath the GCL, minimum 12-inch soil layer above the GCL, and a 6-inch vegetative support layer. Leachate collected from the landfill will be pumped from the site into the City of Dickson sewage system, pending city approval.

4.5 REGULATORY SUMMARY AND TIMELINE

This section provides a timeline of events associated with the Dickson County landfill.

1972-Landfill Receives Approval for Operation

1977-City Landfill Closed

1977-County Landfill Expands

1986 EPA Preliminary Assessment

EPA completed a preliminary assessment (PA) of the site on January 17, 1986. The report described historical waste disposal practices, geologic conditions, water supplies, and populations served. The report noted that the Turnbill Utilities district sold potable water to the City of Dickson; the City of Dickson which had one active well and one in reserve, also utilized Dickson Lake (also known as City Lake) as a source; the West Piney Utilities served the area around the landfill with potable water. The West Piney Utilities district bought water directly from the City of Dickson. According to a representative of the West Piney Utilities, most of the water supplied to the West Piney Utility district came from Dickson Lake. The PA report concluded that "due to the fact that the city water southwest of Dickson is taken from Dickson Lake and the residents in the area (i.e. the landfill) use groundwater, this site should be given a medium priority" as a potential hazardous waste site.

1987 Soil Boring Investigation for Landfill Expansion-Law Engineering
A soil boring investigation was performed to assess the conditions of the soil and groundwater present for a landfill extension. Six borings were advanced using hollow-stem augers and mud/wash drilling techniques. The reports indicated that groundwater was present at less than 50 feet bgs in all cases. Sand and/or gravelly chert was prevalent in all borings. The borings were terminated prior to refusal

1988-Balefill Expansion Approved by TDHE

1988 Spring and Private Water Supply Sampling
In October 1988, samples were collected from spring and well locations near the landfill. The sampling results indicated that methylene chloride was detected in the Donegan Spring (0.003 ppb); TCE was detected in the Harry Holt well (3.5 ppb); and methylene chloride was detected in the Lavenia Holt well (0.5 ppb).

In December 1988, a letter from EPA to Harry Holt discussed the results of well sampling and analysis for VOCs. Although the TCE concentration in one sample was above the MCL (0.26 mg/L) and in a second sample was slightly below (0.0039 mg/L), EPA concluded that "there were no constituents detected which exceeded EPA's National Primary Drinking Water Regulations or any other health-based criteria. As such, use of your well water should not result in any adverse health effects." (EPA)

The TDHE sampled the Holt well and indicated that the water was of good quality. TDHE notes indicate that methylene chloride and TCE were detected but were probably a result of laboratory error.

1989-Landfill First Quarterly Groundwater Sampling
The first quarterly groundwater sampling of the four monitoring wells (MW-1, MW-2, MW-3, and MW-4) at the landfill was conducted and the results reported by Gardiner Engineering to the TDHE.

1989-Landfill Second Quarterly Groundwater Sampling
The second quarterly groundwater sampling of the four monitoring wells (MW-1, MW-2, MW-3, and MW-4) at the landfill was conducted and the results reported by Gardiner Engineering to the TDHE.

1991 Potential Hazardous Waste Investigation
EPA completed a potential hazardous waste site inspection in January 1991. The report described known industrial wastes that were reportedly disposed of in the landfill and described leachate outbreak areas that entered the surface water pathway. The report concluded that the total population potentially affected was 30,615 that the dumping of questionable material occurred prior to 1973, that a private well was contaminated with TCE, and that two municipal wells were within 4,000 feet of the landfill. The area was not fenced, and pedestrian traffic was possible. As a follow-up to that inspection, the final report was completed in October 1991. Analytical results indicated that elevated levels of pesticides were detected in a sample collected from the middle portion of the landfill, that unidentified extractables were found in all of the surface soil samples, that pesticides were also detected in a subsurface sample, and that methyl ethyl ketone, chloroform, petroleum products, and polyaromatic hydrocarbons were detected in samples. Unidentified extractables were found in all sediment samples. An elevated concentration of TCE was detected in a private well sample collected at the home of Mr. Harry Holt. The report recommended that the site be evaluated using the Hazard Ranking System (HRS).

The presence of TCE in the Holt well became a focal point for TDEC and EPA discussions in 1992. These discussions were based on EPA's conclusions in a December 3, 1998, letter to Mr. Harry Holt that discussed the results of well sampling for VOCs. Although TCE was detected in one sample at a

concentration above the MCL (0.26 mg/L) and in a resample at a concentration slightly below the MCL (0.0039 mg/L), EPA concluded that "there were no constituents detected which exceeded EPA's National Primary Drinking Water Regulations or any other health-based criteria. As such, use of your well water should not result in any adverse health effects." (see 1988 Spring and Private Water Supply Sampling above). The TDEC also responded in a December 17, 1991, letter to EPA expressing concern that the sampling of the Holt well may not have been representative of the actual conditions or health threat. Specifically, the TDEC stated that "our program is concerned that sampling twice with one considerably above the MCL and one slightly below the MCL in a karst area such as Dickson, is in no way an assurance that Mr. Holt's well water will stay below the MCLs." EPA agreed that the well should continue to be sampled, but that EPA "was not in a position to sample Mr. Holt's well again even though it had sporadically shown TCE contamination above MCLs." The letters are included in Attachment N.

1992 Geotechnical and Hydrogeological Investigation Report- ATEC

A geotechnical and hydrogeological investigation report was prepared for the proposed landfill site. The report discusses the results of six borings on a 35-acre site. The purpose of the investigation and report was to meet the required "Hydrogeologic Report" requirements outlined in TDHE DSWM Rule 1200-1-7-.04(9)(a). Notable report conclusions include the following: the soil was suitable as the landfill buffer zone; the uppermost aquifer occurs within 20 to 50 feet of the Warsaw Limestone Formation; the three on-site existing wells are suitable to monitor the water moving through the overburden recharging the underlying bedrock; and additional private well and stream monitoring points should be added.

1992 Site Inspection Prioritization Report

The SIP report for the landfill was submitted to EPA in August 1992. A copy of the HRS section of the report is included in Attachment O. The report concluded that a limited further investigation should be performed, focusing primarily on the additional characterization of the "possible southern drainage pathway". The attached scoring sheets for one scenario resulted in an overall score of 15.40. The scenario assumed a "low waste quantity value, a low Level I population value for the groundwater pathway, and the lack of an observed release to a perennial surface water body." The second scenario resulted in a score less than the threshold score (28.5) because of the "limited number of people utilizing the well for drinking water." Both scenarios assumed that six people were exposed to constituents at concentration above the MCL; that the municipal water well only served 3 percent of the annual yield; and that the Piney River intake served most of the population. Neither scenario considered that water mixed from the municipal well and City Lake was used as the exclusive source for 6 months per year. Follow-up internal TDEC correspondence dated October 1, 1992, indicated that since the HRS "scoring was based on Dickson's City Lake and wells being used for the city's drinking water supply" and that "approximately 2 years ago, the city discontinued using the lake and wells, relying on a water intake on the Piney River several miles away." It was TDEC's belief that "the site will be referred back to the state since it won't come close to ranking on the NPL."

1992 Modification for Synthetic Liner and Leachate Collection Report

A report was prepared to discuss the specifications of the liner and leachate collection system at the new balefill. The portion of the design that addresses the geologic buffer references the previous ATEC geotechnical Report (May 13, 1992). A maximum 20-foot cut was included in the design "so that there will be a minimum of 20 feet of soil above the bedrock," based upon ATEC's conclusion that the first water-bearing zone is in the bedrock.

1993-Remedial Site Assessment Decision Re-evaluated

In February 1993, EPA re-evaluated the 1992 landfill score after an effort to determine the additional waste volume. The re-evaluation did not score by the primary threat, which was reported to be the groundwater pathway (US EPA file).

1994 Notification of Groundwater Contamination to Division of Water Pollution Control

On September 2, 1994, the Division of Water Pollution Control received information from Gardiner Engineering, Dickson County consultant, that the landfill was adversely impacting groundwater quality at and around the site (DSWM, NEAC). Sampling data collected in May and June 1994 indicated that organic contamination was detected in a spring (Sullivan Spring) being used as a drinking water supply.

The TDHE issued an NOV on September 9, 1994, and directed the county to initiate an assessment monitoring program and corrective measures. The county was also levied a civil penalty of $34,200. The NOV indicated that the Dickson County Landfill shall immediately institute a monitoring program and that the landfill shall comply with the following rules: Assessment of Corrective Measures; Selection of a Remedy and Implementation of Corrective Action (DSWM, NEAC)

1994 Sampling

In September 1994, water samples were collected from kitchen sinks and springs in and around the landfill. In September 1994, a letter was sent from the TDHE to Ms. Sullivan and Ms. Kay Stewart recommending discontinuing use of the spring as a drinking water source. Additional sampling events were conducted in March, April, June, July, September, and October.

1994 Groundwater Quality Assessment Plan

A groundwater quality assessment plan was developed to determine if "solid waste constituents have entered the groundwater, and to characterize the concentrations and rate and extent of migration of waste constituents in the groundwater." The work proposed the installation of three wells between the landfill and Sullivan Spring and the identification of springs, streams, and domestic and commercial wells in the area. The report concluded that the direction of groundwater flow in regolith "may be discontinuous." The proposed well installation method was the use of hollow-stem augers through the soil, with split-spoon samples being collected every 10 feet. In the event bedrock drilling was necessary, air rotary drilling would be performed and a surface casing would be placed "in order to seal off the soil aquifer."

1995 Commissioner's Order

Operational issues relative to leachate outbreaks and the county's failure to terminate the discharges resulted in a Commissioner's Order being issued on January 23, 1995. Numerous leachate seeps and flow on both the closed and active portions of the facility were reported by the DSWM. Furthermore, intermediate cover was not being applied every 30 days as required by the permit, rainwater was being allowed to pool on the facility, and erosion on the slopes had exposed wastes.

1995 Groundwater Assessment Report- Griggs and Mahoney and USGS

A groundwater assessment report was submitted to the DSWM in August 1995. The report summarized the sampling results for five new wells (MW-5 through MW-9) installed in the northwest corner of the landfill. The wells were installed as a joint effort between the county, the USGS, and Gresham, Smith and Partners. Three "deep rock" wells were installed into bedrock, and two "shallow" wells are assumed to be in the residuum. The report summarized the monitoring of the five new wells and the results of Monitoring well 1 (MW-1), the only previously existing well that was sampled. Wells MW-2 and MW-4 were not sampled. Details of the well installation protocol or boring conditions were not available for review. The report concluded following:

- The direction of groundwater flow for the shallow wells was to the southwest and the direction for the rock wells was to the northwest.

1995-Removal of Site From EPA CERCLIS List

EPA issued a memo on August 15, 1995, to Dickson County notifying the county that the landfill had been removed from the EPA CERCLIS list as part of the EPA Brownfields initiative (DSF, NEAC).

1996 Notice of Violation

An NOV was issued in October 1996 because groundwater data had indicated that the MCL for cadmium had been exceeded. Another letter was issued again requiring that the county establish an assessment-monitoring program, conduct quarterly sampling for Appendix II constituents, and initiate corrective actions within 90 days of having found any constituent with a statically significant increase. Furthermore, the TDEC issued a June 12, 1997, letter inquiring about the status of remedial activities. The letter stated that leachate outbreaks "from time to time" move into the surface water runoff ditch that flows into the silt pond and that a remediation plan should be submitted no later than August 1, 1997.

1997 Groundwater Monitoring Report-Griggs and Maloney

A groundwater monitoring report was received by the DSWM for the February 12 and 19, 1997, sampling event. The report summarized the sampling results for wells MW-2, MW-4, MW-6, MW-7, MW-8, MW-9, MW-10, and the Sullivan Spring. Water levels and samples were collected on two separate days. The results indicated that five inorganic parameters (Be, Cd, Cr, Pb, and Ni) were detected at concentrations above regulatory limits. The report stated that the groundwater flow direction for the shallow wells is to the northwest and for the bedrock wells is to the southwest.

1997 Dye Trace Work Plan

In 1997, the USGS provided to the DSWM a work plan for a proposed dye study with the dye trace registration form attached. The work plan proposed that the dye trace be conducted in two phases, with the first beginning on December 2, 1997, and the second beginning January 6, 1998. The proposed dye trace suggested the use of three wells: Di: F-86 (unknown well), and two landfill wells (also unknown identification). The study proposed the use of three dyes.

1998 Dye Trace

In January 1998, the USGS began a dye study in cooperation with Dickson County. Three known dyes were introduced into the subsurface at two discreet locations within the footprint of the landfill and in well MW-1A. Monitoring of the study continued for approximately 1 year after the injection of the dyes. Although the USGS claims to have a positive detection of the dyes within monitoring well MW-8, it did not proclaim any proof or disproof of a hydraulic connection between the landfills and Sullivan Spring.

1998 Notice of Violation

An NOV was issued to Dickson County for the violation of the Tennessee Multi-Sector General Permit. The violation was observed during a compliance evaluation inspection and included leachate being discharged through Outfall 003 without a permit. The letter required that Dickson County "immediately take action to terminate the discharge." The facility also was in violation for failing to "properly implement and/or modify the facility Storm Water Pollution Prevention Plan." An outline of corrective actions to meet "full compliance" was due within four weeks of receipt of the letter.

1998 Groundwater Sampling Events

Groundwater and spring sampling was conducted in June 1998. VOCs were not detected in groundwater monitoring wells or the Sullivan domestic water well. Results for Sullivan Spring indicated 22 ppb of 1,2-DCE and 140 ppb of TCE.

1999 Notice of Violation

An NOV was given to the City of Dickson in 1999 for inadequate depth of cover and pooling of water on the cover. The violation required the City of Dickson to prepare a plan of corrective actions by June 1, 1999.

1999 Installation of Well MW-8

Monitor well MW-8A was drilled at the landfill to allow for a pumping test of the aquifer. A video log of the well was taken.

1999 Groundwater Sampling

The groundwater monitoring report for the groundwater sampling event conducted on August 26 and 27, 1999, was submitted to the TDHE. Samples were collected from wells MW-1A, MW-2, MW-4, MW-6, MW-7, MW-8, and MW-9, and Sullivan Spring. The samples were analyzed for Appendix I parameters. The TCE concentration (0.16 mg/L) in the Sullivan Spring sample exceeded the MCL, and cis-1,2-dichloroethene was detected in the spring sample at 0.039 mg/L. A statistical analysis of the sample results was not performed.

2000 Pumping Test of Well MW-8A

A pumping test of landfill monitoring well MW-8A was conducted in 2000. Groundwater analytical results for samples indicated the presence of TCE below detection limits. The Sullivan Spring sample contained TCE at 130 ppb and cis-1,2-Dichloroethene at 28 ppb. A second pumping test was conducted in February 2000, and samples from well MW-8A indicate TCE below detection limits. The Sullivan Spring sample contained TCE at 81 ppb and cis-1,2-Dichloroethene at 18 ppb.

In April 2000, the results of the dye study for the landfill were included in Appendix B of a report prepared by Gresham, Smith and Partners and USGS. The report states that well DK-21 is used as a municipal water supply from "generally December to April of each year." During that time, there "may be as much as 40 feet of drawdown in the well." Background dye receptors were placed from December 2, 1997, to January 13, 1998, to aid in choosing dyes for injection. Dye detectors were retrieved every 1 to 2 weeks. The dye injection phase was conducted from January 13 to September 29, 1998. Three dyes were injected into three wells at the landfill. Cotton and charcoal detectors placed at 25 sites were initially collected and analyzed "every couple of days," but were collected every 3 weeks at the end of the study. The detection sites generally consisted of the municipal well DK-21, numerous springs, at least one private well, and on-site wet areas and sumps. No receptors were installed at either of the Holt wells located to the southeast. Tinopal CBS-X (an optical brightener), Rhotamine WT, and Eosine OJ were the three dyes. The three injection points were as follows: Well Di:F-91 (an unknown well location), a county landfill leachate well (LW-4) installed in the waste, and a City landfill leachate well. The USGS reported a positive detection in Site 8 (presumed to be well MW-8) on January 14 from the optical brightener that was injected into Well Di:F-91. No other dyes were detected at the other 24 sites.

In 2000, groundwater sampling occurred at Sullivan Spring and the landfill monitoring wells. However, no information was available on sampling dates or results.

5.0 REGULATORY FILE REVIEW

TtEMI accessed the EPA Envirofacts Warehouse web database (www.epa.gov/enviro/html/qmr.html) and contacted the TDEC to perform a database search for Dickson County. The following databases were searched for Dickson County information:

- Resource Conservation and Recovery Information System (RCRIS)
- Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS)
- Toxic Chemical Release Inventory System (TRIS)
- Biennial Reporting System (BRS)
- TDEC State Remediation Program (SRP)

TtEMI then reviewed TDEC files for the identified facilities to gather information on potential contaminant sources, groundwater investigations, and groundwater corrective actions. Additional facilities were researched based on discussions with the TDEC. Files reviewed included DSWM files at the Central Office, DWS files at the NEAC and Central Office, and DSF files in the NEAC. Given the voluminous files to review, only those portions of the files that discussed contaminant sources, regulatory actions, waste generation and disposal, and significant raw material usage were copied. A summary of regulatory files reviewed for each facility is provided in Appendix C. Copies of files obtained through TtEMI's regulatory file review are provided in Attachment M. Selected industrial facilities identified through TtEMI's database review are shown on Figure 4. The following sections summarize the results of TtEMI's database search.

5.1 RCRIS DATABASE SEARCH

As a result of the RCRIS Database search conducted by TtEMI, several facilities were identified as large quantity generator (SQG), small quantity generators (SQG), or conditionally exempt small quantity generators (CESQG).

5.1.1 RCRIS Large Quantity Generators

The following four facilities were identified as LQGs of hazardous waste:

Facility Name	Address
Premedor Entry Systems	1 Premedor Drive Dickson, TN
Teksid Aluminum Foundry	1635 Old Columbia Road Dickson, TN
Quebecor Printing Corporation	1665 Old Columbia Road Dickson, TN
Tennsco Corporation Plants 2 and 3	1st and Pickett Street Dickson, TN

Insert Figure 4
Industrial/Commercial Facility Location Map

Quebecor Printing Corporation was listed as a former SQG and subsequently was designated as a LQG of hazardous waste.

5.1.2 RCRIS Small Quantity Generators

The following six facilities were identified as SQGs of hazardous waste:

Facility Name	Address
Carl's Certified Collision Center (formerly Carl's Body Shop)	525 Highway 46 Dickson, TN 37055
Dickson Electric Corporation	East Chestnut St. Dickson, TN
Lexalite International	1 Bumbranch Road Dickson, TN
Classic Cleaners	112 Sylvis St. Dickson, TN
Interstate Packaging	2885 Highway 47 N White Bluff, TN
Murphy Oil USA	508 Hensley Drive Dickson, TN

5.1.3 RCRIS Conditionally Exempt Small Quantity Generators

The following facility was identified as a CESQG:

Facility Name	Address
Gene's Body Shop	3604 Highway 48 P.O. Box 142 Charlotte, TN

5.1.4 Other RCRIS Sites Identified

The following additional facilities were identified as a result of TtEMI's RCRIS database search:

Facility Name	Address
Allstate Termite and Pest Control	P.O. Box 621 Dickson, TN
American Industrial Waste	Industrial Drive White Bluff, TN

Facility Name	Address
Brad Ragan Tire and Appliance	110 Villa Circle Dickson, TN
Community Newspaper	104 S. Church St. Dickson, TN
Crossville Ceramics	17 Ceco Drive Dickson, TN
Custom Marine	2545 Jones Creek Rd. White Bluff, TN
Dickson County Nursing Home	901 N. Charlotte St. Dickson, TN
Dickson General Hospital	222 Church St. Dickson, TN
Dickson Printing	East College St. Dickson, TN
Disser Enterprises	Highway 46 Dickson, TN
Ebbtide Corporation	2545 Jones Creek Road White Bluff, TN
Exxon USA	1-40 and Route 48 Dickson, TN
Fiberglass Works	2111 Highway 47 East Dickson, TN
Gad-A-Bout Campers	Highway 70 and Route 2 White Bluff, TN
Goodlark Hospital Foundation	Unknown
Graham Ford Lincoln Mercury	531 Highway 46A Dickson, TN
Green Valley, Inc.	Highway 48 Dickson, TN
Harbour, Inc. (formerly Winner Boats)	Highway 46 Dickson, TN

Facility Name	Address
Howell Enterprises	Highway 70 East White Bluff, TN
Jackson Clinic	111 Highway 70 East Dickson, TN
Kerr McGee Chemical Corp.	108 Bryan Avenue Dickson, TN
Larry's Body Shop	316 Westview White Bluff, TN
Leathers A H Manufacturing	East Walnut Street Dickson, TN
Martin Cabinet Shop	Route 1 White Bluff, TN
Mid-Tenn Aviation	Route 3 Sylvia Road Dickson, TN
Printwood	Printwood Place Dickson, TN
Progressive Ink Co.	4815 Highway 70 East White Bluff, TN
Sage Racing Team	Bells Wood Heights Dickson, TN
Sumiden Wire	710 Marshall Stuart Drive Dickson, TN
James R. Taylor	109 No Mulberry St. Dickson, TN
Tennessee Casting Company	Tennsco Drive Dickson, TN
Tennesco Corporation Plant 5	Tennsco Drive Dickson, TN
Wabash Alloys	600 Printwood Dr. Dickson, TN
Winner Corporation (now Harbour, Inc.)	1st and Prickett St. Dickson, TN

5.2 CERCLIS DATABASE SEARCH

The following facility was identified through TtEMI's CERCLIS database search:

Facility Name	Address
Mid-Tenn Paving Co.	Jones Creek Road Dickson, TN

5.3 TRIS DATABASE SEARCH

The following 13 facilities were identified through TtEMI's TRIS database search:

Facility Name	Address	Product Manufactured or Activity
Crossville Ceramics	17 Ceco Drive Dickson, TN	Ceramic wall and floor tile
Ebbtide Corporation	2545 Jones Creek Road White Bluff, TN	Boat building and repairing
Fiberglass Works, Inc.	2111 Highway 47 East Dickson, TN	Boat building and repairing
Premedor Entry Systems	1 Premedor Drive Dickson, TN	Metal doors, sash, frames, molding, and trim
Quebecor Printing Corp.	1665 Old Columbia Road Dickson, TN	Commercial printing and gravure
Sumiden Wire Products	710 Marshall Stuart Drive Dickson, TN	Steel wiredrawing and steel nails and spikes, miscellaneous fabricated wire products
Sun Chemical GPI	1667 Old Columbia Road Dickson, TN	Printing ink
Teksid Aluminum Foundry	1635 Old Columbia Road Dickson, TN	Aluminum foundries
Tennsco Corporation, Plant 1	404 East Broad Street Dickson, TN	Office and store fixtures, partitions, shelving and lockers, except wood
Tennsco Corporation, Plants 2 and 3	1st and Pickett Street Dickson, TN	Office and store fixtures, partitions, shelving and lockers, except wood
Tennsco Corporation, Plant 4	Marshall Stuart Blvd. Dickson, TN	Office and store fixtures, partitions, shelving and lockers, except wood

5.4 BRS DATABASE SEARCH

The following four facilities were identified through TtEMI's BRS database search:

Facility Name	Address
Quebecor Printing Corp.	1665 Old Columbia Road Dickson, TN
Sumiden Wire Products	710 Marshall Stuart Drive Dickson, TN
Teksid Aluminum Foundry	1635 Old Columbia Road Dickson, TN
Tennsco Corporation, Plants 2 and 3	1st and Pickett Street Dickson, TN

5.5 TDEC SRP DATABASE SEARCH

The following facility was listed identified through TtEMI's TDEC SRP database search:

Facility Name	Address
Ryder Truck Rental	199 Printwood Drive Dickson, TN

6.0 SUMMARY AND RECOMMENDATIONS

The purpose of this Groundwater Use and Contaminant Assessment was to summarize work that has been completed by multiple local, state, and federal agencies relative to environmental permitting and site cleanups and work performed relative to evaluating the potential cause and effect of environmental exposures and orofacial clefts. Based on information reviewed and summarized herein, the following provides a summary of issues regarding cleft palate/cleft lip occurrence, geologic/hydrogeologic conditions, potable water supply (private and municipal water supplies and sampling), municipal water treatment, wellhead protection, and the Dickson County Landfill. Recommendations regarding key issues are also provided.

6.1 CLEFT PALATE/CLEFT LIP OCCURENCE

Available information was reviewed for the occurrence of CLP and CPO for Dickson County from January 1997 to October 2000, a period during which 18 residents with orofacial clefts were identified. The investigation performed by the TDH and CDC indicated that the cases identified during that period met the definition of a cluster.

The Birth Defect Research for Children organization has noted the incidence of orofacial clefting for live Caucasian births is expected to be 1 birth in 1,000. For the period in question, the organization stated that the 18 identified cases were for approximately 1,700 births. This equates to over 10 cases per 1,000 births for an approximate 4-year period.

The CDC defined normal rates of CLP and CPO (based on national averages) to be 1 to 2 and 0.7 per 1,000 live births, respectively. The CDC report noted the high degree of variability in the reported cases in Dickson County. Historical data from 1989 to 1996 indicated 5.42 reported cases per 1,000 births in 1989 and 0 cases reported in 1993, 1995, and 1996.

The information collected by TtEMI indicated that although the cases were located in various portions of the county, environmental links between the cases can be extrapolated. Raw and treated water from the City of Dickson is provided to the Harpeth Utility District (one reported case during the above-referenced time period), the Sylvia-Tennessee City-Pond Utility District (four reported cases), and the town of Vanleer (one reported case). Nine cases reported were in the City of Dickson water district. Although analyses of end-water supplies are not available, TCE was detected in two water supply sources (City Lake and well DK-21) in 1997. The City of Dickson routinely buys treated water from the Turnbull Utility District (two reported cases); water from the City of Dickson and Turnbull Utility District has the potential to affect residents beyond the Dickson city limits. Any water quality issues that might affect the Dickson or Turnbull supplies, either raw or finished, have the potential to affect a large portion of the population and a large area of the county. Two of the cases are located near the industrial park southeast of the Dickson County Landfill, and five of the eight with City water district are located near surface water lakes and existing manufacturers.

Research conducted during this investigation indicated that in addition to TCE, THMs produced during disinfection of potable water also have the potential to cause cleft palates. The Agency for Toxic Substances and Disease Registry (ATSDR) has published information that THMs in drinking water have also been linked to adverse birth outcomes such as spontaneous abortion, small size for gestational age, neural tube defects (NTD), oral cleft defects, and heart defects. A review of the Dickson Water Department file indicated that THM concentrations have in the past approached or exceeded the existing MCL for total THMs. THMs are known to be at their highest concentrations where the contact time of the treated or chlorinated water is the longest. Such locations include the furthest extent of the

distribution system, areas of low water use, areas with "dead end" pipes, and areas of small-diameter pipes. The extent of these water distribution characteristics relative to the 18 cases was not assessed during this investigation.

6.2 GEOLOGIC/HYDROGEOLOGIC CONDITIONS

The karst geologic and hydrogeologic conditions in Dickson County are characteristically sensitive to releases to the environment because of the potential for rapid contaminant migration and the ability for contaminants to travel long distances. The conduit-type flow pattern characteristic of karst settings and the associated jointing and bedding planes of the underlying bedrock can quicken contaminant transport and make source identification more difficult. Information on such conditions was available in the Dickson County Landfill, Dickson Water Department, and Scovill/Schrader Automotive files. Groundwater monitoring programs in the area typically involve many wells (Scovill/Schrader), include dye traces that are sometimes inconclusive (Dickson County Landfill), access conduit-type zones in the bedrock (the 17-foot-tall conduit of well DK-21 and the conduit in well MW-8A at the landfill), and wells in multiple water-bearing zones (Scovill/Schrader). The geology in the Dickson area is further complicated by the existence of a surface drainage divide, the regional structural dip of the rock, and numerous spring discharges that feed most streams in the area. Perennial streams in the area, most notably the East and West Piney Rivers, are all recharged primarily from spring discharges.

The Tuscaloosa Gravel, the St. Louis Limestone, the Warsaw Limestone, and the Fort Payne Formations all have the potential to supply groundwater. The gravel formation is present in the soils above the bedrock, and reports prepared on behalf of Dickson County indicate that the amount of water stored is a function of the soil thickness. More water is available where the soil is the thickest. Griggs and Maloney reported that the top of the Warsaw Limestone Formation is approximately 60 to 130 feet beneath the landfill ground surface. Therefore the soil beneath the landfill would be expected to supply large amounts of recharge to the underlying bedrock.

The USGS concluded that groundwater occurs primarily in the Warsaw Formation, which is characteristically reliant upon fractures and joints in the bedrock to produce varying amounts of groundwater discharge. The report concluded that the regolith thickness and lithology of the bedrock are the main factors influencing the development of high-yielding solution-enlarged bedrock openings. High-yielding openings are more likely to occur in areas with a thick regolith and fine-grained limestone at the top of bedrock. As a result, the area beneath the Dickson County Landfill would be expected to have high-yielding solution openings. The USGS concluded that the Fort Payne Formation is regarded as the base of the aquifer. According to the USGS, the regional dip of the formations is toward the northwest, with local structural features including lows to the southwest and northeast and an east-west trending anticline under the City of Dickson. Most springs in the area reportedly discharge from the Warsaw Limestone Formation. The USGS reports that well yields in the area range from 1 to 100 gpm, and that there is no clear pattern to well yield and location. All of these conditions further complicate environmental investigations in karst areas.

A review of the geologic and hydrogeologic conditions in the area of the Dickson County Landfill indicated substantial karst conditions. Conceptual diagrams that illustrate the localized and regional conditions and wells are included as Figures 5 and 6. Conduit flow conditions were noted in at least two wells located at the landfill and well DK-21 east of the landfill. Although pumping tests indicated a widespread radius of influence, the connection is reportedly poor when a large conduit zone is pumped and compared to residuum or non-conduit zone bedrock wells in the immediate vicinity. This suggests that preferential pathways exist in the secondary porosity of the bedrock and are most likely related to the

Insert Figure 5
Conceptual Geologic Profile A to A^1

Insert Figure 6
Conceptual Geologic Profile B to B'

joints (lineation) and bedrock dip. As a result, pumping large quantities of water from well MW-8A during well purging, for example, is not guaranteed to evacuate groundwater from well MW-8 or even draw water from the landfill area toward it, as theorized by Gresham, Smith and Partners. Water pumped toward wells MW-8A and DK-21 is drawn from the conduit that extends into undetermined lengths and directions.

Contaminant fate and transport in such a conduit flow regime is a function of the size of the water-bearing zones, the direction of the bedrock joints, and the dip of the localized bedrock. Groundwater flow is a function of the type of bedrock, with conduit-type flow being more prevalent in coarse-grained limestones. Figures 5 and 6 illustrate the geologic and hydrogeologic conditions based on reported information. As the figures indicate, the conduit conditions are more prevalent in the deeper limestone. Given that these are multiple water-bearing zones in the soil and bedrock, cross-contaminate can result in different zones from uncased wells completed at various depths and when well surface casings are not properly grouted into place.

Sullivan Spring, which is reported to be present in the Warsaw Limestone, outcrops along the valley wall of Worley Furnace Branch. The conceptual geologic diagram developed from actual data and illustrated on Figures 5 and 6 indicate that the spring emanates from a coarser limestone layer. Surface water in the landfill area drains primarily to the southwest, west, and northwest toward Worley Furnace Branch. Large tributary streams of the Piney River enter the main stream at nearly right angles, suggesting a fracture origin for the stream bed. As a result, both stream course and groundwater transport are likely related to bedrock jointing and lineation. Joint patterns in the Dickson area are not easy to determine because the soil masks the jointing patterns. A connection of one or more joints is the likely reason that the upper portion of City Lake (north of U.S. 70) cannot be impounded with water and that the water from the upper lake discharges at Payne Spring (a source of water to City Lake). A secondary joint pattern could be the origin of another spring that discharges into City Lake from property to the east with the Tennsco 2 and 3 plants (and former Winner Boat plant).

Hydrogeologic investigations at the Dickson County Landfill and the Scovill and Schrader sites indicate that groundwater occurs at multiple zones. Geologic evaluations of the landfill have indicated that the first groundwater zone is present in the soil at depths less than 50 feet bgs. One report concluded that the first water-bearing zone was a perched zone. As a result, groundwater wells that are required to monitor the first water-bearing zone will mostly likely be installed in the soil, not bedrock. However, a report prepared for the landfill during planning stages for the now-closed Class I balefill concluded that three existing on-site wells (installed into bedrock) were suitable to monitor water moving through the overburden and recharging the underlying bedrock. However, this is not likely given the conclusions made by the USGS and an understanding of karst transport mechanisms. The existing groundwater monitoring system at the landfill includes several wells; however, most are installed into bedrock. Wells at the Scovill/Schrader site monitor at least two zones in the soil (a perched zone and a zone at the top of bedrock) and various depths within the bedrock.

6.3 MANUFACTURER CHEMICAL USE

Regulatory files were reviewed for sites previously identified in Section 5.0. As indicated in the files reviewed, boat building, metal fabricating, and printing industries have been prevalent in Dickson County. TtEMI's regulatory file review attempted to identify users of TCE, perchloroethene, toluene, or halogenated solvents. None of the facilities reported using TCE in quantities large enough to trigger TRI reporting. Other solvents noted in the files for numerous facilities included methyl ethyl acetone, methyl isobutyl ketone (MIBK), acetone, and xylene. Lexalite International also reported the use of 1,1,1-trichloroethane and methyl ethyl icetone, which has been reported in well DK-21.

Perchloroethene was noted in the files for the following facilities:

- Classic Cleaners
- Disser Enterprises
- Graham Ford Lincoln Mercury
- Interstate Packaging
- Lexalite International

TCE use was noted in the files for the following facilities:

- Graham Ford Lincoln Mercury
- Scovill/Schrader Automotive
- Ryder Truck Rental

Toluene use was noted in the files for the following facilities:

- Carl's Certified Collision Center
- Gene's Body Shop
- Larry's Body Shop
- Murphy Oil
- Premdor Entry Systems
- Quebecor Printing Corporation
- Tennsco Plant 1
- Tennsco Plants 2 and 3

6.4 POTABLE WATER SUPPLY - PRIVATE WELL USE AND SAMPLING

TtEMI reviewed information on private water wells identified by the DWS from the USGS Dickson, Tennessee, topographic quadrangle. The Dickson Quadrangle was selected because the initial focus of TtEMI's investigation was in the area of the Dickson County Landfill, which is in that quadrangle. Of the 334 wells identified, 274 were listed for residential use. A comparison of the residential wells to the 18 case families indicated that one of the families was included in the database. Information from the CDC interviews indicates four families use private water. As a result, additional private wells may exist that are not included in the DWS database. The water quality of private wells and other identified water sources (Mount Sinai commercial well, Goodlark Hospital irrigation well), as well as their influence on hydrogeologic conditions, are unknown. Further evaluation of the data indicated that approximately 17 percent of the wells were installed after 1995, indicating that individuals are still installing wells, possibly in areas served with potable water.

The DWSM has required for many years that wells and off-site springs be sampled as part of the routine monitoring. Contamination has been documented in Sullivan Spring and the Holt family wells.

6.5 POTABLE WATER SUPPLY – MUNICIPAL WATER SUPPLY AND SAMPLING

Information collected from the TDEC files and from interviews with current and former City of Dickson employees confirmed that groundwater obtained from municipal well DK-21, and at times well DK-17, has been used as a primary raw water source for potable water to the City of Dickson, the West Piney Utility District, the Sylvia-Tennessee City-Pond Utility District, the Harpeth Utility District, and the Town of Vanleer through its connection with the Sylvia-Tennessee City-Pond Utility District. Water

from well DK-21 was mixed with water from the spring-fed City Lake. As a result, much of Dickson County relied on groundwater as the primary potable water source up until 1986, when the West Piney River surface water intake was installed; the city used the intake as a water source 6 months per year.

Laboratory analytical data for various well points and locations throughout Dickson County was obtained from TDEC DWS for sampling events in 1994 and 1996 to 2001. TCE was detected at 0.032 mg/L in well DK-21 on April 21, 1997, and methyl ethyl ketone was detected at 12 µg/L on October 9, 2000. Correspondence from the TDEC NEAC indicated that chlorinated hydrocarbons, dichloromethane, and trichloroethylene were also detected in well DK-21 in December 1996. A finished water sample (treated and entering the distribution system) collected on February 24, 1997, indicated the presence of TCE at 0.0013 mg/L. A sample identified as City Lake "A," collected on April 7, 1997, containing TCE at 0.0021 mg/L.

THMs, chloroform, bromodichloroethane, and chlorodibromomethane are routinely detected in the treated water at four locations (north, south, east, and west extent) in the distribution system. These chemicals are by-products of disinfection with chlorine. The EPA MCL for TTHMs is 0.10 mg/L. Information provided by the City of Dickson Water Plant for the period 1983 to 1998 indicates that the TTHM concentrations in treated water exceeded the established MCL on August 3, 1984, and September 8, 1987. However, on several occasions, TTHM concentrations approached the established MCL.

According to information obtained through the TDEC file review and interviews with city officials, the city was experiencing an increased water demand in 1997 at the time when repairs were being made at the Dickson Water Plant. This is also the period for which the reported cases of orofacial clefts were evaluated by the CDC. During this time, the allowable filter rate was exceeded with DWS approval. The city purchased more water than normal from the Turnbull Utility District to meet local water demands. Also during this period in 1997, TCE was known to be present in the raw and treated city water, which would have distributed to the residents of the city, the West Piney Utility District (now owned by the City of Dickson), the Sylvia-Tennessee City-Pond Utility District, and possibly the town of Vanleer.

The 1996 well head protection plan indicated that three wells were used as the water supply. The use and water quality of wells DK-1 or D-17 has not been fully defined.

The city is considering joining other utility districts in developing a new utility district to obtain raw water from the Cumberland River, located along the northern portion of the County

6.6 MUNICIPAL WATER TREATMENT

In October 1998, the DWS approved the installation of the draft-induced aerator to treat the water collected from well DK-21. Prior to the installation of the draft-induced aerator, there was no treatment capability to remove VOCs. The DWS stated that treatment of water obtained from well DK-21 is required whenever the well is used for raw water. Furthermore, the city is required to sample raw water quarterly for VOCs if the well is used and otherwise sample annually.

THMs exist in the treated water within the city's distribution network, often approaching and on two occasions exceeding, the established EPA MCL. Documents reviewed by TtEMI contained no indication of THMs or haloacetic acids in areas beyond the city's system.

6.7 WELL HEAD PROTECTION

TtEMI reviewed the well head protection plan that the city submitted to the DWS most recently on September 4, 1998. Potential contaminant sources identified in the plan included the Dickson County Landfill, the Brannon Trailer Park to the east, a sludge spreading site located between the landfill and well DK-21, and urbanized residential/commercial areas to the north. The well head protection plan indicated that the direction of groundwater flow was determined by static water levels measured from numerous municipal wells, industrial monitoring wells, one municipal well at Buckner Park, a well at an "Ice House," and at Tice's Spring. The plan did not state whether these wells were located in the same water-bearing zone or aquifer. Since submittal of the plan and its most recent update, the city has reportedly drilled an additional well near the surface water intake at the West Piney River for use as a potable water source. The city is also reportedly evaluating well DK-15 as a raw water source. Preliminary evaluation reports (PER) for the potential water sources were not obtained through TtEMI's regulatory file review.

6.8 DICKSON COUNTY LANDFILL

Information indicates that portions of the landfill are unlined and industrial wastes including solvents were disposed of in the landfill. As a result, the landfill may be a source of contaminants to groundwater. Investigations have been conducted at the landfill, although information on activities is incomplete. The following summarizes information obtained for the Dickson County Landfill.

6.8.1 Regulatory Status

The county has a long history of noncompliance related to groundwater and leachate violations since at least 1983. These violations have resulted in fines, Commissioner's Orders, and NOVs. These violations were related to such issues as major and minor leachate seeps and flows, failure to provide intermediate cover, failure to provide erosion control, exceedance of groundwater standards for cadmium and TCE, discharge of leachate from the property without a permit, failure to maintain a storm water pollution prevention plan, and implementation of required corrective actions.

The county was required to implement groundwater assessment and corrective actions starting in September 1994. Remedial actions for leachate violations were required in July 1994. Available information indicates that the county has not met the DSWM requirements for fully assessing the extent of groundwater contamination or for applying corrective actions relative to groundwater and leachate control. The county has employed a several consulting firms over time, each with its own idea for addressing leachate and groundwater problems. Relevant conclusions and actions related to groundwater monitoring assessment since 1994 are summarized below:

- The USGS installed groundwater monitoring wells in 1995 northwest of the landfill to assess the potential effect of the landfill on Sullivan Spring. The USGS concluded that the spring was hydraulically downgradient of the landfill. A review of the geologic and groundwater information available for the site indicates that the wells may not monitor the first water-bearing zone (as required by DSWM rules), and at least one well (DK-6) may not be installed correctly.

- Evidence in the file and interviews with the county have indicated that the county and its consultants Gresham, Smith and Partners, recognize the inadequacy of the monitoring system in determining the groundwater quality and the direction of flow, both of which have been

requirements in the DSWM rules since 1994. The downgradient extent of TCE and cadmium have yet to be determined.

- Current groundwater sampling activities are not conducted in full compliance with EPA protocol. One well for example, is used to represent the groundwater conditions of another well located nearby. The well is purged of almost 25,000 gallons of water rather than purging approximately 40 gallons from the well required to be sampled. The well purge water is discharged to the groundwater surface without measuring its chemical quality, even though concentrations in samples from the well have exceeded one or MCL(s) in the past.

- Groundwater monitoring reports have been routinely submitted without Appendix II sampling and reporting, without performing statistical analyses, without determining the direction of groundwater flow from the landfill areas, and without monitoring background conditions for the Subtitle D area.

- An off-site spring (Sullivan Spring) and at least two wells (the Holt wells) are contaminated with TCE. In response to the spring contamination, which was formerly used to supply water to two families, a well was installed; however, that well was later also found to be contaminated. Concentrations in groundwater samples from the area are known to exceed the MCLs for trichloroethene and cadmium.

The county's currently proposed approach to mitigate leachate outbreaks and discharges is to construct a geocomposite cap on approximately 40 acres of the old city and county landfills. Leachate will be extracted and pumped to the City of Dickson wastewater treatment plant when the City approves the application to discharge

6.8.2 Dye Trace Evaluation

The purpose of the dye trace study performed was to determine whether contaminants could migrate from the landfill to well DK-21. The study attempted to mimic the use of the well as a water supply. The USGS report was inconclusive relative to the hydraulic connection between well DK-21 and the landfill. The trace seems to have been a logical request given the location of the landfill and the municipal well field. The test apparently tried to duplicate pumping rates in 1997 during the test conducted in 1998. The test could not, however, duplicate rainfall and groundwater recharge or possibly groundwater quality that was present in 1997. Past USGS reports suggested that during the pumping of well DK-21, the well was only "poorly" connected to wells installed in soil nearby. Given that the well provides up to 300 gpm (based on pump size), it is located in a 17-foot cavern, and it is most likely in a wide bedrock joint, there is only a slight possibility that dyes injected into wastes at the landfill will be detected in the pumped water. Water pumped from the well will flow along its most preferred pathway, which is the large, unobstructed conduit of unknown direction and origin, and will be less influenced by groundwater in the soil.

Future dye traces in the landfill area should consider the lineation/jointing patterns. A dye trace should consider ramifications of pumping a well for a long period of time, where pumped water of unknown quality and origin is discharged to the ground surface. The most likely opportunity for a positive trace from the landfill is if dye is injected into a bedrock joint that is linked to the cavern in which well DK-21 installed.

6.8.3 Modified Ranking Score

A revised HRS score for the site based on the updated information would reflect an overall groundwater migration pathway score of 100, and overall HRS site score of 50. The following score reflects a waste quantity value of the groundwater pathway. TCE has not been found in any surficial or subsurface soil samples collected during previous sampling investigations; however, PCE was disposed of at the landfill. TCE is a degradation product of PCE. This updated information supports the documented observed release to the aquifer of concern, the actual contamination of municipal well DK-21, and the large number of actual contamination (Level I) target values.

6.9 RECOMMENDATIONS

The following summarizes areas identified for further assessment:

Incidence of Orofacial Defects

- The information presented herein indicates that the link between potential environmental exposure and the incidence of orofacial defects in Dickson County warrants further investigation. Potential exposure contaminants identified through this assessment include THMs, TCE, and toluene. Further investigation could evaluate the potential ingestion of water other than through residential exposure, the specific utility districts that provide water to the residences and workplaces, water intake sources, water treatment processes, and documented TCE concentrations in the public water supply in 1996 and 1997. The investigation could also include an evaluation of other exposure routes, such as swimming pools, lakes, and streams that might be affected by contaminants.

- Further inquiry is recommended regarding the pending TDH air modeling study and contaminant concentrations in relation to the eighteen case families identified in Dickson County.

- Further inquiry is recommended regarding the results of the public inquiry announced in The Dickson Herald on September 22, 2000.

Regional Geologic/Hydrogeologic Investigation

- An investigation should be conducted to define the geologic structure, joint patterns, groundwater discharges pathways, groundwater-to-surface water pathways, groundwater recharge effects on base surface stream flows, and contaminant source identification relative to the City of Dickson municipal wells and water supplies.

Manufacturing/Commercial Facility Assessments

- The TDEC and EPA files should be reviewed to determine all enforcement actions and waste management activities for each facility listed herein with a history of toluene, perchloroethene, and TCE use. Perchloroethene breaks down in the environment to trichloroethene and 1,2-DCE, both of which have been reported in the municipal water supply, private wells, and springs.

- A site inspection should be performed for facilities with a history of toluene use (eight facilities), perchloroethene use (five facilities), and TCE use (five facilities including the Dickson County Landfill). Specific attention should focus on facilities near raw water sources.

- Assessment and corrective action measures being conducted at the Dickson County Landfill should be closely monitored to ensure technical competence and timely completion of work.

Private Well/Spring Use Assessment

- Wells and springs surrounding the Dickson County Landfill and manufacturing facilities identified herein, should be evaluated for routine quarterly or semi-annual monitoring.

- The specifics of the Baptist Church Camp spring contamination should be determined. The results should be evaluated as a potential exposure route to reported orofacial cleft cases.

- An investigation should be completed to determine if the wells at Goodlark Hospital, Tanbark Campground, the Ice Plant, Buckner Park, and the Mt. Sinai Community are being or have been used, and if so, such use was by the families with reported orofacial clefts. The well construction specifics should be evaluated. Samples should be collected and analyzed for constituents of concern.

- The installation of future private and municipal wells in the Dickson area should be closely scrutinized given the karst nature of the geology and the presence of contaminants in the subsurface.

Public Water Use Assessment

- The specifics of the raw water source, treatment methods, distribution, and storage of the Turnbull Utility District should be determined. Specific attention should be made to determine the results of VOC sampling, THM, and total haloacetic acid sampling within the system and at its entrance into the City of Dickson water system.

- The City of Dickson system should be monitored for THMs and VOCs at the residences of reported orofacial clefts and at other areas known to be dead-end lines, stagnant lines, and small lines with little flow, and areas with long contact time. The quality of the water should also be evaluated at the point the water enters into other districts being supplied water from the city.

- The removal efficiency and performance of the draft-induced aerator relative to TCE and other VOC removal should be determined for the city water system. Although the aerator may be effective in removing TCE, it also must also be effective in removing common breakdown components of TCE, such as vinyl chloride. Vinyl chloride has a lower MCL than TCE and is a reported carcinogen.

- The backflow preventor program of the Turnbull Utility District and the City of Dickson water distribution system should be evaluated. A history of failures and chemical use in portions of the water system should be determined.

- The specifics of the reported pumping test conducted by the city on well DK-21 in 1997 should be determined. The test does not seem to correlate with the dye trace test conducted in early 1998. Therefore, no information relative to pumping duration, water discharge, or drawdown monitoring was available.

- The City of Dickson and Turnbull Utility Districts should be evaluated relative to any operational modifications, repairs, or changes in the distribution and treatment system. Specific periods of interest include 1997 to 2000, 1993, 1995, and 1996 when orofacial cases were not reported, and 1989 when a high number of cases were reported.

- The City of Dickson and surrounding utility districts should consider initiating the plan to obtain raw water from the Cumberland River to the north because of the following: the intensive karst nature of the hydrogeology and its undefined characteristics, the nature and extent of groundwater contamination in the Dickson area, the city's history of using groundwater as a raw water source, and the inability of the East and West Piney Rivers to supply raw water year-round.

- The City of Dickson should consider a monitoring program to evaluate all existing water supply sources, including wells DK-1, DK-15, DK-17, and DK-21, City Lake, West Piney River, and any other wells or sources considered for its groundwater supply.

Well Head Protection Plan Modifications

- The city's wellhead protection plan should be updated to include a comprehensive evaluation of contaminant sources (including manufacturers), a bedrock jointing and structure analyses to determine likely zones of recharge and the flow boundary for each well point. The plan should include City Lake as a "wellhead," because the lake is supplied water primarily from groundwater. The plan should be developed by either a Tennessee-licensed P.E. or by a Tennessee-licensed P.G. with demonstrated expertise in karst conditions and contaminant fate and transport.

- The city should submit to the TDEC and EPA the preliminary evaluation report, plans, and specifications (as required by TDEC rule) for the new well at the West Piney River and well DK-15 before these or any new wells are used. The design and use of the wells should be certified by a Tennessee-licensed P.E. and a Tennessee-licensed P.G. both with a demonstrated expertise in karst hydrogeologic conditions.