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# A PUBLIC HEALTH ANALYSIS OF EXPOSURE TO CONTAMINATED MUNICIPAL WATER SUPPLIES AT SOUTHINGTON, HARTFORD COUNTY, CONNECTICUT

ATSDR - GA TECH
Exposure-Dose Reconstruction Project

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by

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# FOREWORD

The Agency for Toxic Substances and Disease Registry (ATSDR)[1] and the Connecticut Department of Health Services (CDHS) are collaborating in a study of cancer incidence in the Town of Southington, Hartford County, Connecticut. As part of the study, ATSDR is determining population exposure to contaminated groundwater that was distributed in the town's water distribution system. To address the complex issues associated with exposure assessment, ATSDR relied on the resources of the Exposure-Dose Reconstruction Project (EDRP). The EDRP, a cooperative research effort between ATSDR and the Georgia Institute of Technology (GATECH), is responsible for developing methods and computational tools to quantify levels of contaminants transported through the environment from the source of contamination to the receptor populations. Geographic Information Systems (GIS) is also incorporated in this analysis in order to establish spatial relationships between contaminant sources and receptor populations.

This report summarizes the methods used to estimate the extent and location of contamination in the Southington Water Company's water distribution system and to estimate the potentially exposed population. Results of the analysis described herein are based solely on data available to ATSDR and GATECH at the time of the study. At the conclusion of the report, methods by which the current analysis might be enhanced are discussed.

[1] A Glossary of Acronyms used in this report is provided on page vi.

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## LIST OF ILLUSTRATIONS

*Illustrations are located in Appendix A*



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## Conversion from English to S.I. Units and Abbreviations

*Listed below are factors to be used for converting from the English units used in the text to S.I. units and the accompanying abbreviations.*

| | | |
|---|---|---|
| *Length* | | |
| 1.0 foot (ft) | = | 0.3048 meter (m) |
| 1.0 mile (mi) | = | 1.609 kilometers (km) |
| *Area* | | |
| 1.0 square mile ($mi^2$) | = | 2.590 square kilometers ($km^2$) |
| *Volume* | | |
| 1.0 million gallons (Mgal) | = | $3.785 \times 10^3$ cubic meters ($m^3$) |
| | | $3.785 \times 10^6$ liters (L) |
| *Flow* | | |
| 1.0 gallon per minute (gal/min) | = | $6.309 \times 10^{-5}$ cubic meter per second ($m^3/s$) |
| 1.0 cubic foot per second ($ft^3/s$) | = | $2.832 \times 10^{-2}$ cubic meter per second ($m^3/s$) |
| *Mass* | | |
| 1.0 pound (lb avoirdupois) | = | 0.4536 kilogram (kg) |
| *Concentration* | | |
| 1 part per billion (ppb) | = | 1.0 microgram per liter (µg/L) |

# Glossary of Acronyms

*Listed below are acronyms and their definitions that are used throughout this report.*

| Acronym | Definition |
|---|---|
| ATSDR | Agency for Toxic Substances and Disease Registry |
| CDHS | Connecticut Department of Health Services |
| DHAC | Division of Health Assessment and Consultation, ATSDR |
| DHS | Division of Health Studies, ATSDR |
| EDRP | Exposure-Dose Reconstruction Project |
| EPA | United States Environmental Protection Agency |
| GATECH | Georgia Institute of Technology |
| GIS | Geographical Information System |
| NPL | National Priorities List |
| STF1BX | Summary Tape File 1B Extract |
| SWC | Southington Water Company |
| TCA | 1,1,1 trichloroethane |
| TIGER | Topologically Integrated Geographic Encoding and Referencing System |
| TCE | 1,1,2 trichloroethylene |
| VOC | volatile organic compounds |

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By Mustafa M. Aral and Morris L. Maslia

## INTRODUCTION

The Connecticut Department of Health Services (CDHS) is conducting a study of cancer incidence near the Solvents Recovery Services of New England (SRSNE) site, located in the Town of Southington, Hartford County, Connecticut (Figure 1). This study is funded through a grant from the Division of Health Studies (DHS) of the Agency for Toxic Substances and Disease Registry (ATSDR). Part of the study methodology involves assessment of exposure to contaminated groundwater that is distributed to residents of the town through the Southington Water Company's (SWC) distribution system. CDHS has requested that ATSDR determine the location and distribution of the census subdivisions that may have been served by contaminated water supplied by the SWC's water distribution system.

### Purpose and Scope

The purpose of this study is: (1) to determine the extent and location of contamination from 1,1,1 trichloroethane (TCA), 1,1,2 trichloroethylene (TCE), and total volatile organic compounds (VOCs) in the SWC's water distribution system; and (2) to determine the location of census blocks that may have been exposed to the contaminated water delivered by the water distribution system. The residents of the Town of Southington are supplied potable water from a municipal water distribution system that extracts groundwater which is pumped from 9 wells located throughout the town (Figure 2). Water from all wells are blended together and, depending on demand conditions, either pumped into the distribution system or routed to three water reservoirs (Figure 2) for future use. Water samples from wells 4, 5, and 6 have indicated significant groundwater contamination [ATSDR, 1992]. For this study, the subsurface migration of contaminants from the source of contamination (the SRSNE site) to the municipal wells is not analyzed. However, contamination of the water distribution system is assessed from the point of withdrawal (municipal wells) to the extent of the SWC's distribution system.

### Background and Previous Studies

The SRSNE site (Figures 1 and 2) has been listed by the U.S. Environmental Protection Agency (EPA) as a National Priorities List (NPL) site. The site operated as a hazardous waste treatment and handling facility from 1955 to March 1991 [ATSDR, 1992]. The facility processed 3 to 5 Mgal of liquid hazardous wastes and 100,000 lb of solid hazardous wastes annually. Groundwater contamination resulting from the operations at SRSNE have been documented as far back as 1965 when an SRSNE bedrock well was reported to be contaminated with VOCs [ATSDR, 1992]. A review of groundwater sampling data and hydrogeologic investigations suggest that most of the contaminated groundwater in the surficial aquifer (overburden) has migrated towards the south and southeast [Warzyn Engineering, Inc., 1980; Werhan Engineering, 1982; YWC, Inc., 1986; YWC, Inc. and ERM-Northeast, Inc., 1986; YWC, Inc., 1989; Roy F. Weston, Inc., 1988; Roy F. Weston, Inc., 1990; NUS Corporation, 1990]. SWC's production wells 4 and 6 are located about 1,200 feet south of the SRSNE. Well 4 was installed in 1966 and well 6 in 1976. Well 5, installed in 1972, is located approximately 4 mi south of the SRSNE site (Figure 2) and its contamination has not been directly linked to the site but, as reported, probably is a result of landfill operations and disposal practices at the Old Southington Landfill. Groundwater samples from wells 4, 5, and 6 were identified as contaminated with VOCs and possibly heavy metals in 1976 and 1977. Water from all three wells was blended and distributed through the town's water supply system, thereby potentially exposing a large population to contaminated water. A more complete description of the site and evaluation of its public health implications is presented in a public health assessment of the SRSNE site [ATSDR, 1992].

## STUDY APPROACH

Assessing the distribution of contaminants in the SWC's drinking water distribution system and estimating the population exposure from drinking contaminated water is a complex problem whose analysis requires a multidisciplinary approach. For this particular study area, the following components are involved: (1) analysis of the stress placed on the groundwater resources by the SWC's groundwater extraction wells, (2) the fate and transport of contaminants in the subsurface and their movement in response to groundwater pumpage, (3) the hydraulic characteristics of the water distribution system, (4) water quality distribution within a drinking water distribution system, and (5) spatial analysis with respect to the location of census subdivisions as they relate to the water distribution network. In order to simplify the number and complexity of the analysis, we have made several simplifying assumptions: (1) transient effects owing to turning on and off of different pumping wells are negligible and that the groundwater flow system, no matter which wells are pumping, is at steady state, (2) the contamination measured in water samples from wells 4, 5, and 6 represent sources of contamination that do not vary over time and that measured concentrations represents maximum values, and (3) the distribution of contaminants in the SWC's drinking water network is at steady state after 24 hours from initial contamination. This last assumption was made based on sensitivity analyses conducted on the hydraulics of the SWC's water distribution system.

The implications of the assumptions described above are: (1) the SWC's water distribution system has a constant supply of water that will not vary over time, (2) the movement of the contaminant plume from the source of contamination to the extraction wells is ignored, thereby resulting in the contamination of wells (4, 5, and 6) being independent of spatial and temporal distributions that characterize the contaminant plume (this eliminates the need to conduct a fate and transport analysis of contaminants from the sources of contamination to the pumping municipal wells), and (3) simulation of the water distribution system over a 24-hour period can be used to represent any 24-hour operational time period a long as information about which extraction wells were operating is known.

The objective of the study was to determine the location of census subdivisions that may have been exposed to contaminated drinking water. Owing to the massive quantity of data required for an analysis of this type, we have chosen to use a geographical information system (GIS) to help manage, manipulate, analyze, and query the data. A GIS provides a platform in which layered, spatially distributed databases can be manipulated easily and whereby certain topological attributes, which may not be known *a priori*, can be queried to obtain the spatial relationship between environmental and infrastructure parameters and demographic distributions. For this study, we are using the GisPlus® software package [Caliper Corporation, 1992][2] that runs on a personal computer platform. This software package combines the spatial analysis capabilities of a traditional GIS database with:

- A menu-driven interface,
- A spreadsheet view of databases,
- Graphic display and manipulation of databases,
- Geographic editing and querying,
- Statistical analysis and cross tabulations,
- Integration of user customized analysis routines,
- Automatic TIGER/Line file translation,
- Automatic translation of U.S. Bureau of Census demographic databases, and
- Automatic translation of other GIS software file formats such as ARC/Info® export and AUTOCAD® DXF file formats.

Illustrations referenced in this report have been prepared using this GIS software.

## APPLICATION OF ANALYSIS TO SOUTHINGTON, CONNECTICUT

A three-step process was used to assess exposure of the Southington, Connecticut area due to contamination of the SWC's water distribution system. These steps were: (1) hydraulic and chemical fate modeling of the water distribution system to determine the distribution of contaminants within the system, (2) retrieval of demographic data and location of census subdivisions, and (3) conducting a spatial analysis to determine which census subdivisions may have been exposed to the contaminated water in the distribution system network and the estimated magnitude of the contaminant concentrations within the census subdivisions. This three-step approach used the simplifying assumptions described above. Specifically, that the movement of groundwater and the distribution and fate of contaminants in the underlying aquifer were not modeled and that the measured concentrations of contaminants in wells 4, 5, and 6 were assumed to represent maximum concentration values in the SWC's water distribution system. In the following sections, activities pertaining to each step of this analysis are described.

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[2]Use of brand or trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Government.

## Hydraulic and Chemical Fate Modeling

Hydraulic and chemical fate modeling of the Southington Water Company's water distribution system was conducted by use of a computational program that simulates hydraulic and water quality behavior within water distribution systems. The computer program, EPANET, tracks the flow of water within each pipe segment, the pressure at each pipe junction or node, the height of water in each reservoir or storage tank, and the concentration of a substance (contaminant) throughout a distribution system during a multi-time period simulation. EPANET runs on a personal computer under the DOS and WINDOWS™ operating systems. For a detailed explanation on the use of EPANET and on the mathematical theory supporting the hydraulic and water quality modeling capabilities of the code, refer to Rossman [1994] and Rossman and Clark [1994].

Configuration of the SWC's water distribution system (Figure 2) and data pertaining to the physical characteristics of pipes (length, diameter, resistance coefficient, hydraulic grade line, location of pipe junctions, elevation of pipe junctions, and water demand) were obtained from information supplied by the CDHS and the SWC. Pipe and junction locations were digitized into a GIS database from a water distribution system map supplied by the SWC (Figure 2). Data on pipe resistance coefficients (Hazen-Williams C) , pipe junction elevation, and water demand were not available for the system shown in Figure 2, but rather for an equivalent network system, which was not useful for our analysis. Therefore, average values for the resistance coefficient, pipe junction elevation, and water demand of 99.2, 203.7 ft, and 5 gal/min, respectively, determined from the equivalent pipe network data, were used for the input data to the water distribution system shown in Figure 2. The implication of using average values for the water distribution system characteristics instead of actual values is that simulated results (pressures and chemical concentrations) will be correct over larger areas or longer pipe lengths, but may vary from actual system performance on a pipe by pipe and junction by junction basis.

The SWC obtains its water supply by pumping 9 municipal wells which extract groundwater at varying rates. The water extracted from these wells is then blended and pumped into the distribution system. Thus, when wells 4, 5, and 6 became contaminated with TCA, TCE, and VOCs, the contaminated groundwater was mixed with water pumped from other wells and distributed in the water distribution system. For the purposes of our analysis, we conducted four different simulations in order to represent as closely as possible (based on available data) the configuration of the water distribution system and operation of the pumping wells during the period of contamination. These scenarios represented the following pumping configurations and contaminated wells (Table 1): (1) Scenario I, 1970 conditions, well 4 contaminated; (2) Scenario II, 1974 conditions, wells 4 and 5 contaminated; (3) Scenario III, 1979 conditions, wells 5 and 6 contaminated; and (4) Scenario IV, maximum pumping (peak demand) conditions, wells 4, 5, and 6 contaminated.

Using the data described above, the EPANET model was run for each of the four scenarios. The output from EPANET was retrieved and placed into a point database (coverage) for used with our GIS. The point database contains information on pipe junction elevation, water demand, hydraulic grade, pressure, and chemical concentration. By use of the querying and selection capability of the GIS, the pipe junctions that were simulated as contaminated (chemical concentrations greater than 0 ppb) were selected and displayed for each simulation scenario. Figures 3, 4, 5, and 6 show the SWC's water distribution system and those pipe junctions where total VOC concentrations were simulated as greater than 0 ppb for Scenarios I, II, III, and IV, respectively (blue points on Figures 3, 4, 5, and 6).

**Table 1. Simulation scenarios, pumping and chemical parameter values**

| Scenario<br>Pumping Condition | I<br>1970 | II<br>1974 | III<br>1979 | IV<br>Peak<br>Demand |
|---|---|---|---|---|
| Groundwater Pumpage, in gallons per minute* | | | | |
| Well Number 1 | 391.3 | 389.3 | 381.9 | 466.4 |
| Well Number 2 | 397.1 | 115.5 | 436.7 | 467.0 |
| Well Number 3 | 185.8 | 205.0 | 383.7 | 510.7 |
| Well Number 4 | 576.6 | 283.2 | 0. | 580.0 |
| Well Number 5 | 0. | 463.0 | 261.2 | 518.0 |
| Well Number 6 | 0. | 0. | 102.7 | 103.3 |
| Well Number 7 | 0. | 0. | 0. | 818.5 |
| Well Number 8 | 0. | 0. | 0. | 608.2 |
| Well Number 9 | 0. | 0. | 289.3 | 692.2 |
| Chemical Concentration, in parts per billion** | | | | |
| Well Number 4 | | | | |
| Total VOCs | 6,700. | 6,700. | 0. | 6,700. |
| TCA | 0. | 0. | 0. | 3,500. |
| TCE | 0. | 0. | 0. | 120. |
| Well Number 5 | | | | |
| Total VOCs | 0. | 319.4 | 319.4 | 319.4 |
| TCA | 0. | 0. | 0. | 300. |
| TCE | 0. | 0. | 0. | 4.5 |
| Well Number 6 | | | | |
| Total VOCs | 0. | 0. | 151. | 151. |
| TCA | 0. | 0. | 0. | 120. |
| TCE | 0. | 0. | 0. | 0. |

*Data from D. Aye, Connecticut Department of Health Services, December 2, 1993.
**Data from ATSDR, 1992.

## Census Subdivisions and Demographic Data

The smallest census subdivision of reportable demographic data occurs at the block level. The 1990 census data at the block level are available for the Southington area. These data were obtained by using the Summary Tape File 1B Extract (STF1BX) for the area [U.S. Bureau of Census, 1991a]. Because contamination of the SWC's wells 4, 5, and 6 occurred during the 1970s, census data and subdivisions are needed for 1970 and 1980. To assess potential population exposure over time requires linking past census data with current area boundaries and estimating area migration [White, 1984]. Census tracts are most suitable for this type of small area longitudinal analysis because tracts are relatively stable statistical area boundaries [Shyrock and Siegel, 1976]. Census block and tract area boundaries for 1990 were obtained by using the 1990 TIGER/Line census files for Hartford County, Connecticut [U.S. Bureau of Census, 1991b] in conjunction with the internal TIGER/Line translator available with our GIS software. The census block and tract boundaries and tract numbers for 1990 for the Town of Southington are shown in Figure 7. Demographic data for 1970, 1980, and 1990 [U.S. Bureau of Census, 1971; 1981; 1991a] on total population for census tracts in the Town of Southington are listed in Table 2. Note that the 1990 census data reflect a subdivision of the 1970 and 1980 data for tract numbers 4302, 4303, and 4306.

**Table 2. Area statistics and data for census tracts in the Southington, Connecticut, area**

| Census Tract Number | Tract Area (square miles) | Total Population | | |
|---|---|---|---|---|
| | | 1970 | 1980 | 1990 |
| 4301 | 1.28 | 4,488 | 4,216 | 3,873 |
| 4302 | 11.35 | 7,191 | 9,808 | -- |
| 430201<br>430202<br>430203 | 2.54<br>6.80<br>2.01 | --<br>--<br>-- | --<br>--<br>-- | 3,167<br>4,142<br>3,708 |
| 4303 | 5.40 | 4,553 | 5,671 | -- |
| 430301<br>430302 | 3.69<br>1.71 | --<br>-- | --<br>-- | 2,878<br>2,987 |
| 4304 | 3.84 | 3,812 | 3,398 | 4,162 |
| 4305 | 4.79 | 4,796 | 5,522 | 5,703 |
| 4306 | 9.92 | 6,106 | 8,264 | -- |
| 430601 | 8.81 | -- | -- | 4,370 |
| 430602 | 1.41 | -- | -- | 3,511 |

30,946 36,879 3850

## Spatial Analysis

Spatial analysis involves evaluations that examine data characterized by location, shape, and relationship among geographic features, usually stored as coordinates and topology, with the intent of extracting or creating new data that fulfill some required condition or conditions [ESRI, 1991]. Applying this definition to the current study would indicate that we would like to identify those census blocks that were served by contaminated municipal water from the SWC's water distribution system. In other words, we would like to relate the location of contaminated pipe junctions (Figures 3, 4, 5, and 6) to the location of the 1990 census block (Figure 7) in which the pipe junction is located. Additionally, we would like to determine the distribution of contaminants (range of TCA, TCE, and total VOCs) within the census block areas served by the water distribution system pipe junctions that were simulated as being contaminated.

To begin our analysis, we made use of the querying and aggregating operations of our GIS and aggregated all 1990 census blocks that contained pipe junctions that were simulated as having contaminant concentrations greater than 0 ppb. The results of this analysis, which are the census blocks served by the SWC's contaminated pipe junctions, are shown in Figures 8, 9, 10, and 11 for simulation scenarios I (1970 conditions), II (1974 conditions), III (1979 conditions), and IV (peak demand conditions), respectively. Table 3 lists the number of 1990 census blocks that were estimated to have been served by contaminated water from the SWC water distribution system. Additionally, the total population for those census blocks (1990 data) is also listed in the table. Identification of individual census block and tract numbers, census block areas, and total 1990 population for each block that was served by contaminated water is listed Tables B-1 through B-4 (Appendix B) for Scenarios I through IV, respectively. The simulated range of VOC contamination (mean, maximum, and minimum values) is also listed in these tables.

**Table 3. Census blocks and total population served by contaminated water**

| Scenario Number | Pumping Conditions | Number of Census Blocks Served by the Contaminated Water Distribution System | Total Population 1990 |
|---|---|---|---|
| I | 1970 | 30 | 4,465 |
| II | 1974 | 75 | 11,591 |
| III | 1979 | 75 | 11,591 |
| IV | Peak Demand | 70 | 11,337 |

The distribution of contaminant concentrations for each census block can also be displayed graphically by use of a GIS. For the present study we chose to display the results for Scenario IV (peak demand conditions). Figures 12, 13, and 14 represent the distribution of maximum simulated values of TCA, TCE, and total VOCs (in ppb) for conditions of Scenario IV. Additionally, the simulated ranges of concentration for each contaminant (TCA, TCE, and VOCs) are listed in Table B-4.

## Discussion of Results

In order to estimate the population that may have been exposed to contaminated municipal water supplies in Southington, Connecticut, we conducted four simulations of the SWC's water distribution system. The simulations represented pumping conditions for 1970, 1974, 1979, and peak demand based on data supplied by the CDHS. Results of these simulations indicate that identification of areas of contamination are sensitive to and may be a function of the location and number of wells that are pumping. For example, in Scenario I, only four wells are pumping and only well 4 is contaminated (Table 1). This results in the smallest area of contamination (Figures 3 and 8) of the four simulations. However, maximum pumping demand, Scenario IV, with all of the wells pumping and wells 4, 5, and 6 contaminated (Table 1), does not produce the largest area of exposure when compared with Scenarios II and III (compare Figure 11 with Figures 9 and 10). An explanation for this can be seen by reviewing the illustrations that show the location of contaminated pipe junctions in relation to the wells that are contaminated, and by reviewing Table 1 that lists the wells that are pumping for each scenario. In Scenarios II and III, wells 7 and 8 are not being used (Table 1, Figures 4 and 5). These wells are located in the southeastern part of Southington. In order to supply the demand for water in that part of Southington, the water distribution system must deliver water from the more western and northern parts of the distribution system. Thus contaminated water from wells 4, 5, or 6 is routed to the southeastern part of Southington, thereby delivering contaminated water to that area of the town. On the other hand, when all wells are pumping (Scenario IV, peak demand conditions, Table 1 and Figure 6), wells 7 and 8 supply the water demand to the southeastern part of town. Because these wells are providing water that is not contaminated, and the demand in the southeastern part of town is satisfied by wells 7 and 8, there is no need for the water distribution system to deliver contaminated water from the part of the distribution system located in the more western and northern parts of the town.

The analyses we have provided indicate that using the procedures described above, an improved and more definitive estimate of population exposure can be obtained as opposed to assuming, for example, average exposure over a 1-mile radius or over the areal extent of the water distribution system. Results for Scenario IV indicate that the distribution of contaminant concentrations in the water distribution system is not necessarily uniform, but can vary by several orders of magnitude (Figures 12, 13, and 14). Thus, techniques that we have used in this study should be applied in conjunction with other approaches to exposure assessment studies if improved and definitive exposure estimates are needed.

## Refined Exposure Estimates and Additional Data Needs

The analysis described above estimated human exposure that resulted from ingestion of TCA, TCE, VOC contaminated groundwater in the SWC's water distribution system. A more comprehensive assessment of these conditions requires a detailed study and analysis of each mechanism of exposure. In order to reduce the complexity of the analysis owing to time, budgetary constraints, and insufficient data, simplifying assumptions were made (see section on Study Approach). Even with these assumptions, we believe, the results described herein are reasonable and defensible. However, given the opportunity to improve the results, or if additional resolution of exposure estimates are necessary, we describe below activities that could be undertaken that would result in improved exposure estimates.

(1) Obtaining data on daily and monthly pumping cycles and when wells were put into and taken out of service would yield information required to conduct a transient analysis of the underlying groundwater system and information on the daily operation of the water distribution system.

(2) Modeling the groundwater flow and the transport of contaminants from the source of contamination to the points of withdrawal under steady-state and transient conditions would yield information on the spatial and temporal distribution of the contaminant plume and when in time each extraction well became contaminated.

(3) Obtaining detailed data on pipe and junction elevations, water demand at pipe junctions, hydraulic grades, pump rating curves, and minimum and maximum reservoir water levels for the distribution system shown in Figure 2 would allow us to calibrate the hydraulic and chemical fate distribution model against actual field conditions and judge the reliability of simulated results along each pipe length and at each pipe junction in the water distribution system.

(4) Obtaining data on SWC's distribution system zones and historical data on when valves may have been turned on and off during the periods of contamination and exposure would allow us to model more precisely the operation of the water distribution system during the periods of contamination and exposure.

(5) Data on the number of households served by each pipe junction and more definitive data on the demographics for Southington would allow us to identify which households were served by contaminated water (as opposed to entire census blocks) and which age-sensitive populations (e.g., infants, women of child-bearing age) may have been exposed to municipal water contaminated with TCA, TCE, VOCs, or other contaminants of concern.

## CONCLUSIONS

This analysis estimated: (1) the extent and location of the SWC's water distribution system that distributed groundwater contaminated with TCA, TCE, and total VOCs, and (2) the location of census blocks that may have been serviced by contaminated water supplies delivered through the SWC's water distribution system. To determine the extent and magnitude of contamination, hydraulic and chemical fate modeling of the water distribution system was conducted. Flow within each pipe segment and the contaminant concentration at each pipe junction was simulated. Four simulation scenarios representing pumping conditions for 1970, 1974, 1979, and peak demand periods were conducted for the water distribution system. Results of the simulation were then integrated with census subdivisions and demographics for the Town of Southington through the use of a GIS. Applying spatial analysis techniques through the use of the GIS enabled us to determine which census blocks were served by contaminated municipal water supplies under the four simulation scenarios and also the range of contaminant concentrations, in parts per billion, for the exposed census block areas. Depending on the simulation scenario, total exposed population ranged from 4,465 for Scenario I (1970 conditions) to 11,591 people for Scenarios II and III (1974 and 1979 conditions). Because of the location of the wells pumping fresh (uncontaminated) water, the scenario representing peak pumping demand (Scenario IV), resulted in fewer census blocks and people (11,337) being potentially exposed to contaminants in the water distribution system than did results for Scenarios II and III. Thus, based on our analysis of the Town of Southington, maximum pumping and demand conditions in the water distribution system, is not necessarily an indicator of maximum exposure distribution.

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# APPENDIX A

## ILLUSTRATIONS

Figures 1 - 14

Figure 1. Location of Southington, Hartford County, CT

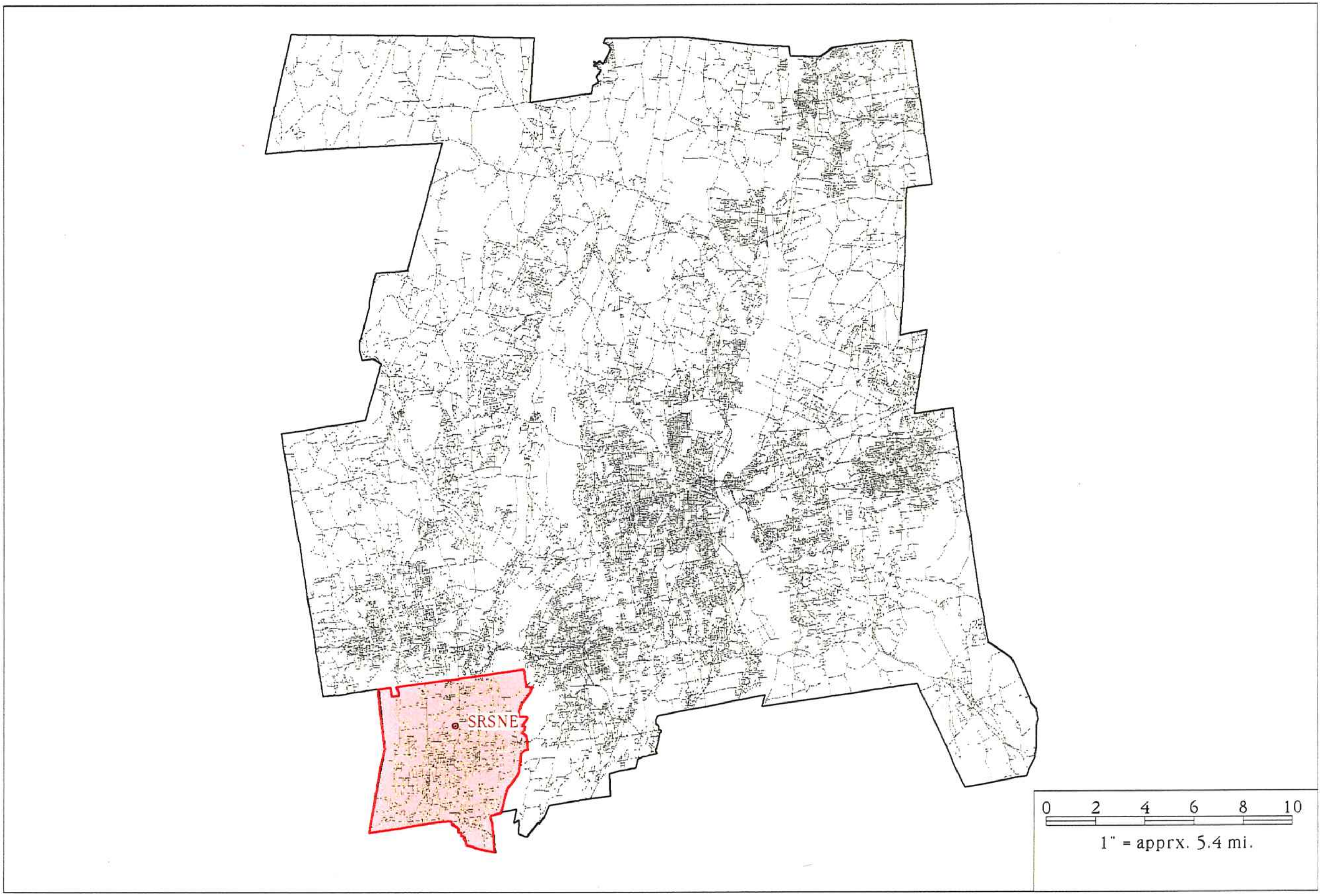


Figure 2. Hydrography and Water Distribution System

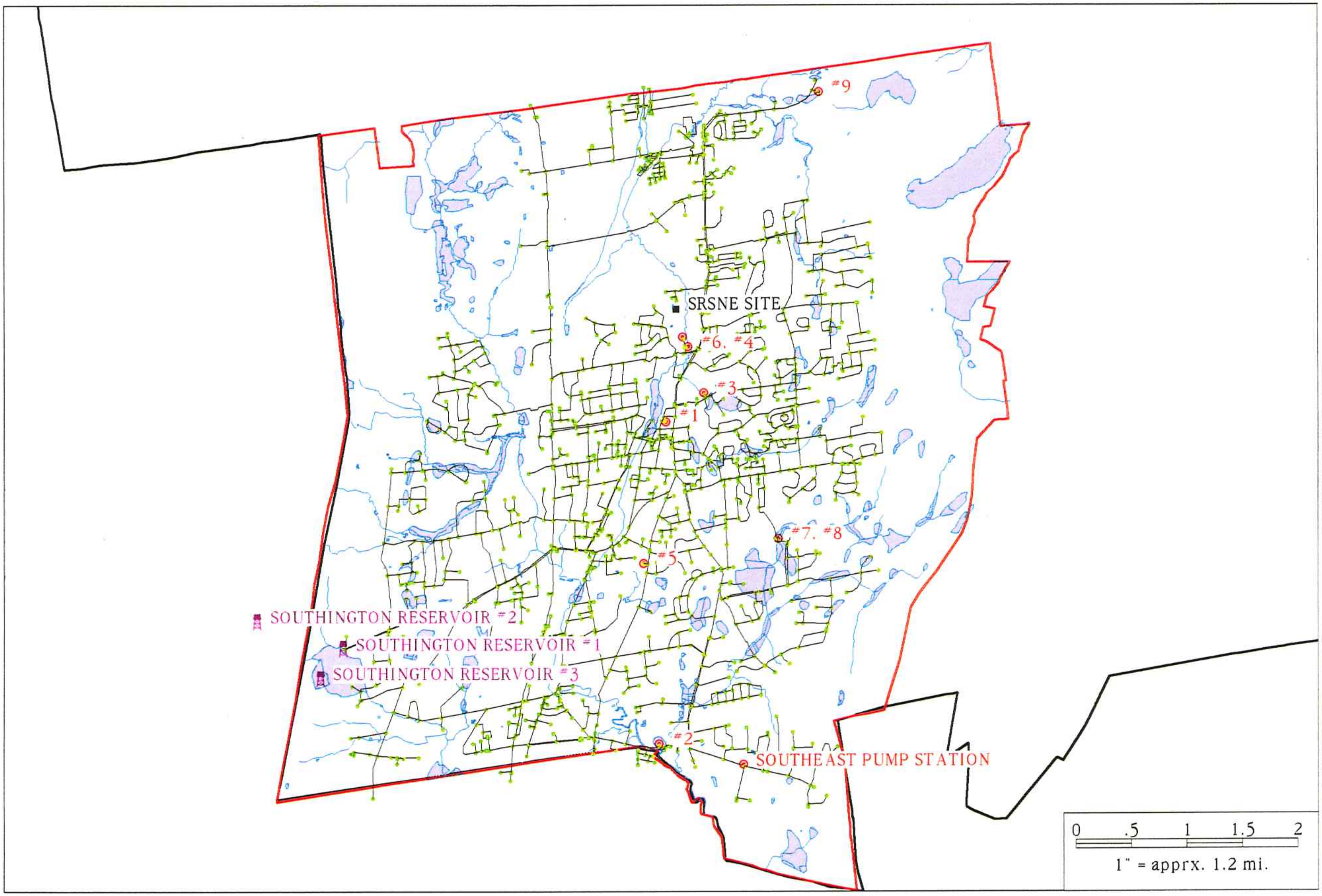


Figure 3. VOC–Contaminated Pipe Junctions, Scenario I

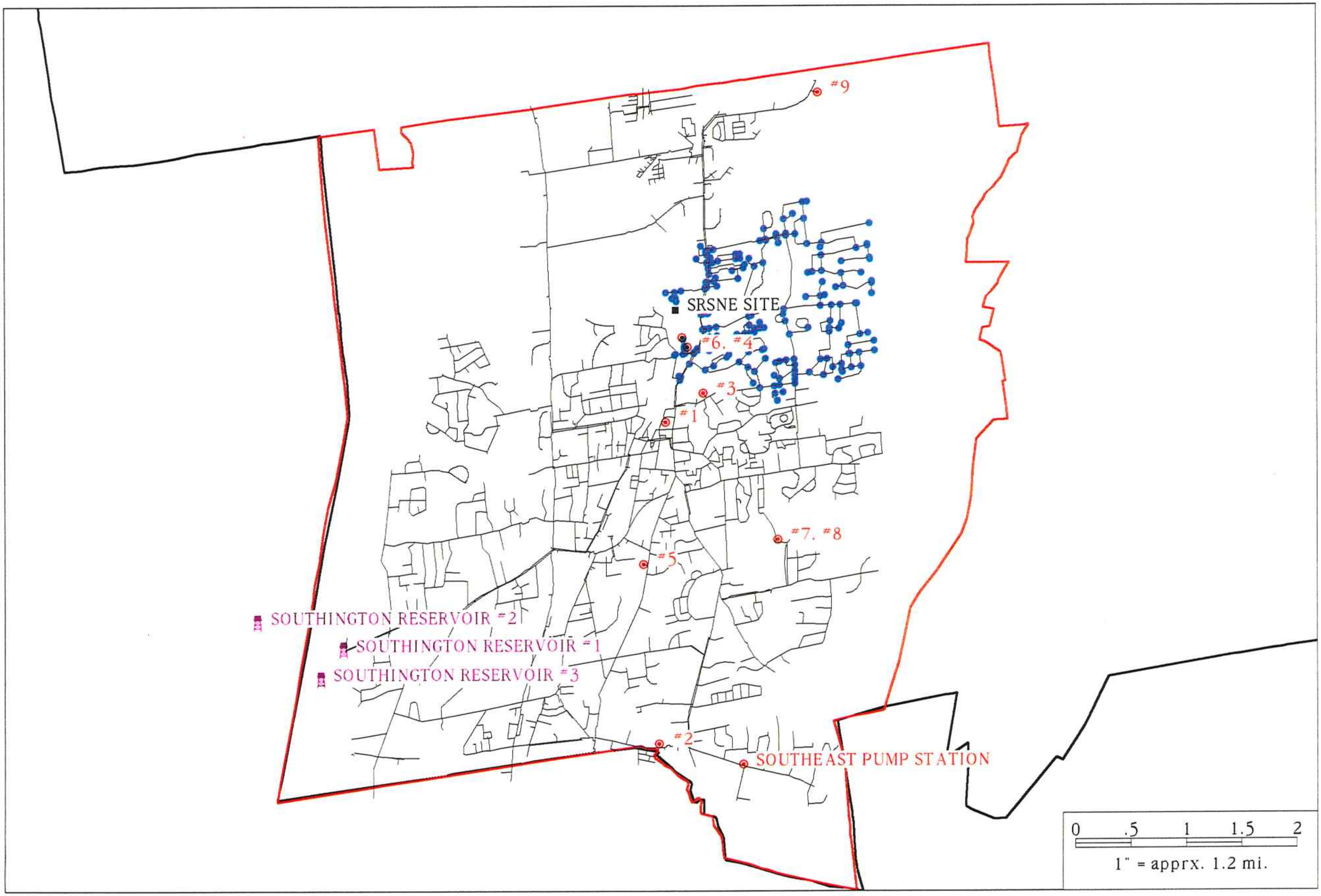


Figure 4. VOC-Contaminated Pipe Junctions, Scenario II

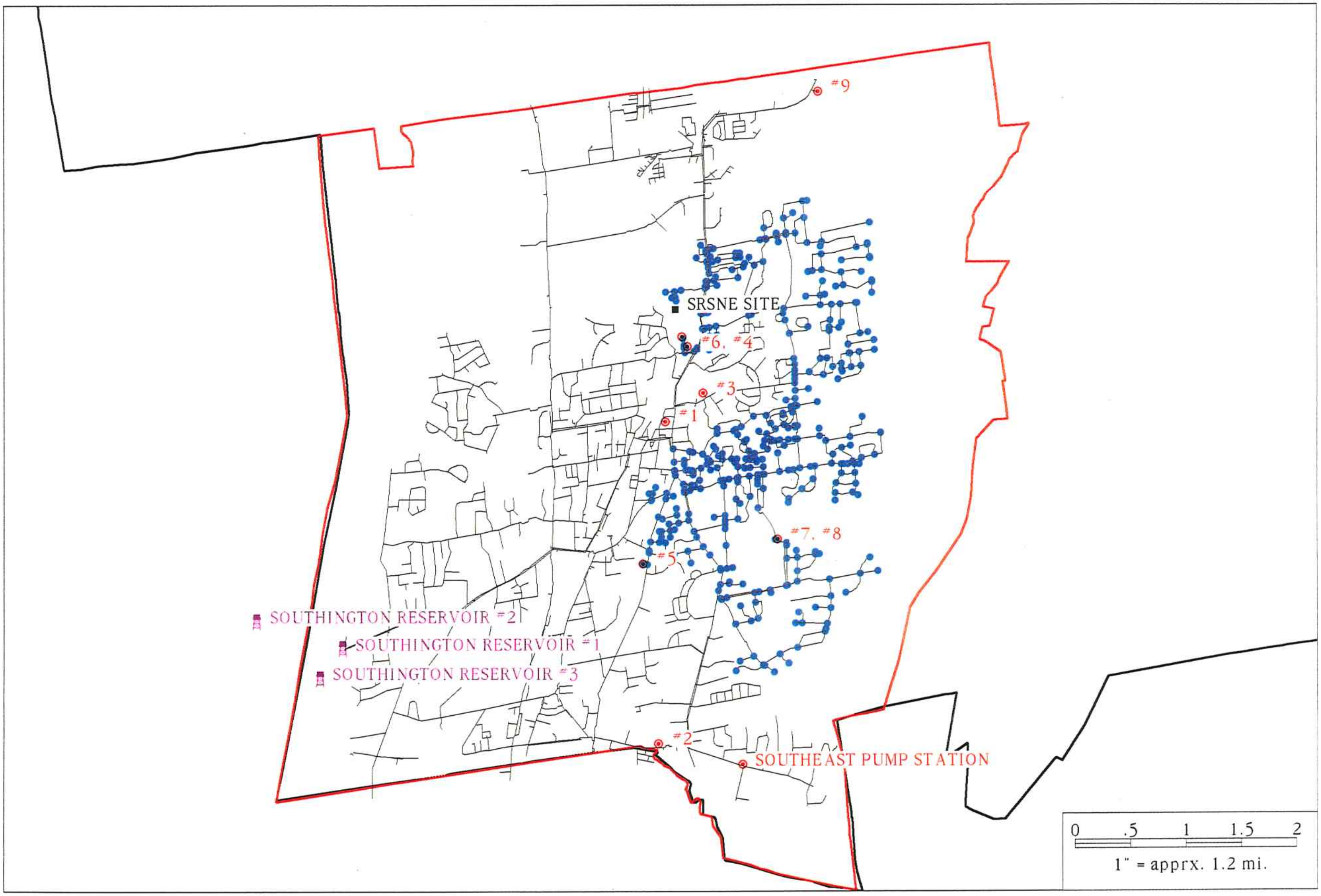


Figure 5. VOC-Contaminated Pipe Junctions, Scenario III

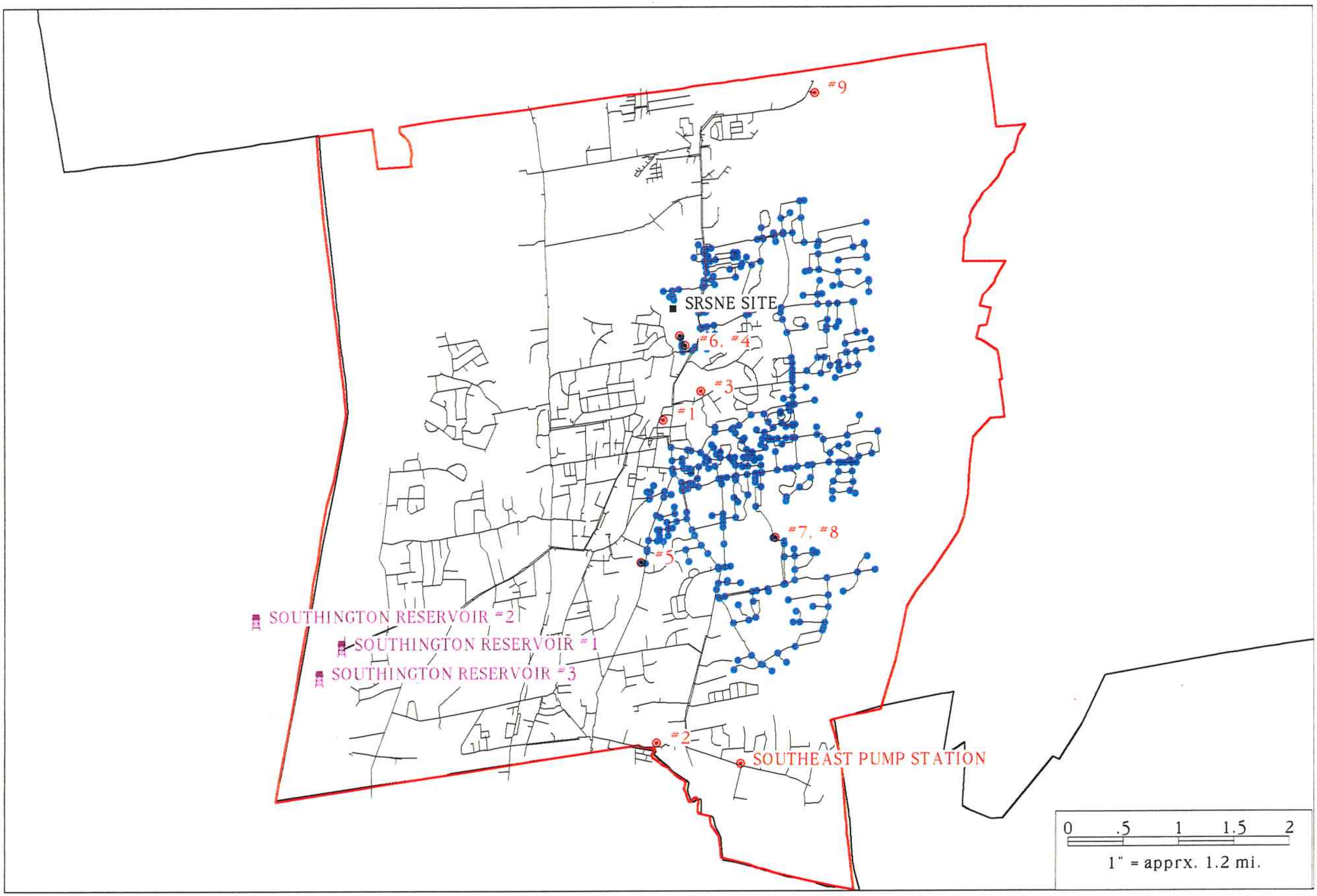


Figure 6. VOC–Contaminated Pipe Junctions, Scenario IV

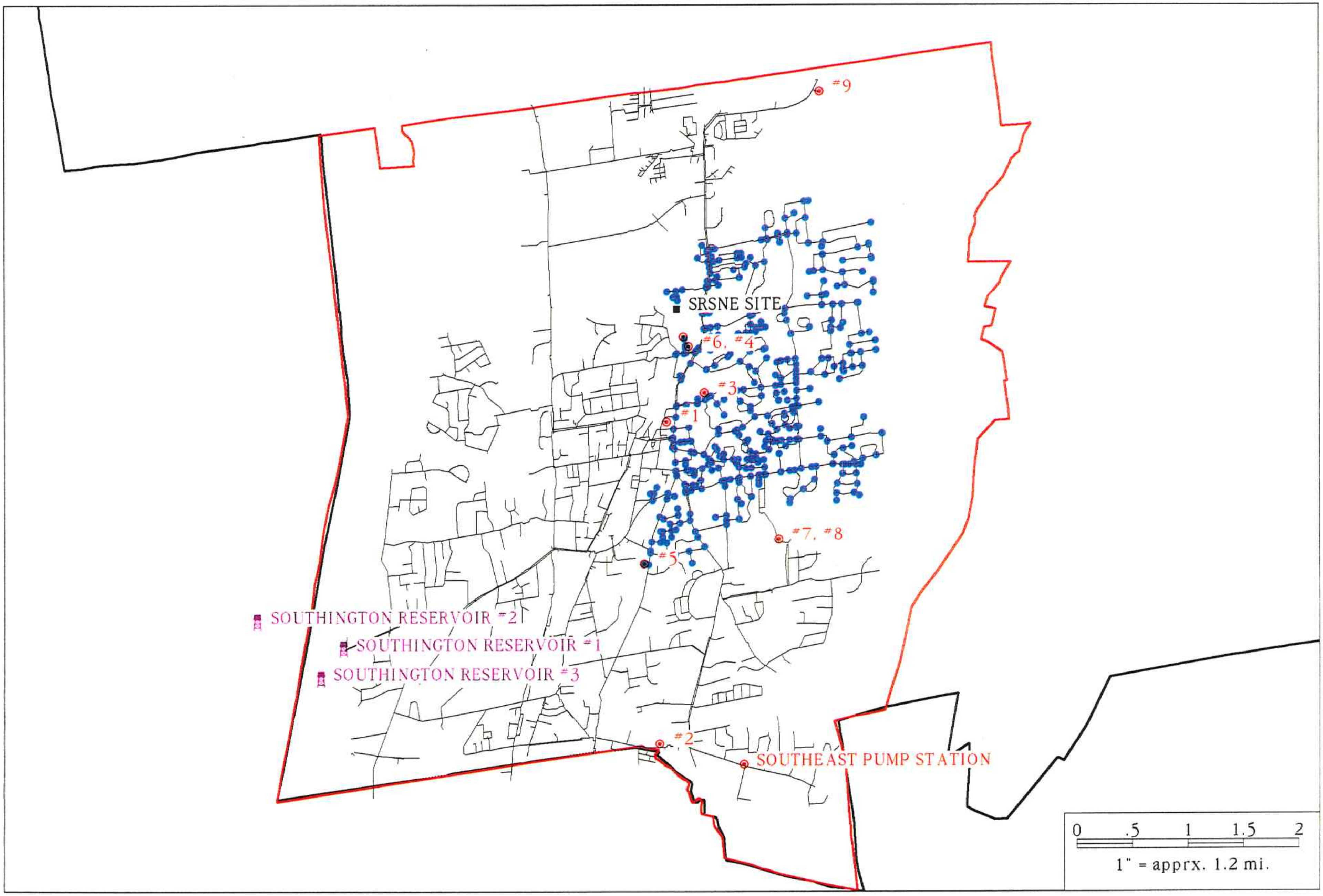


Figure 7. 1990 Census Tracts (Black) and Blocks (Purple)

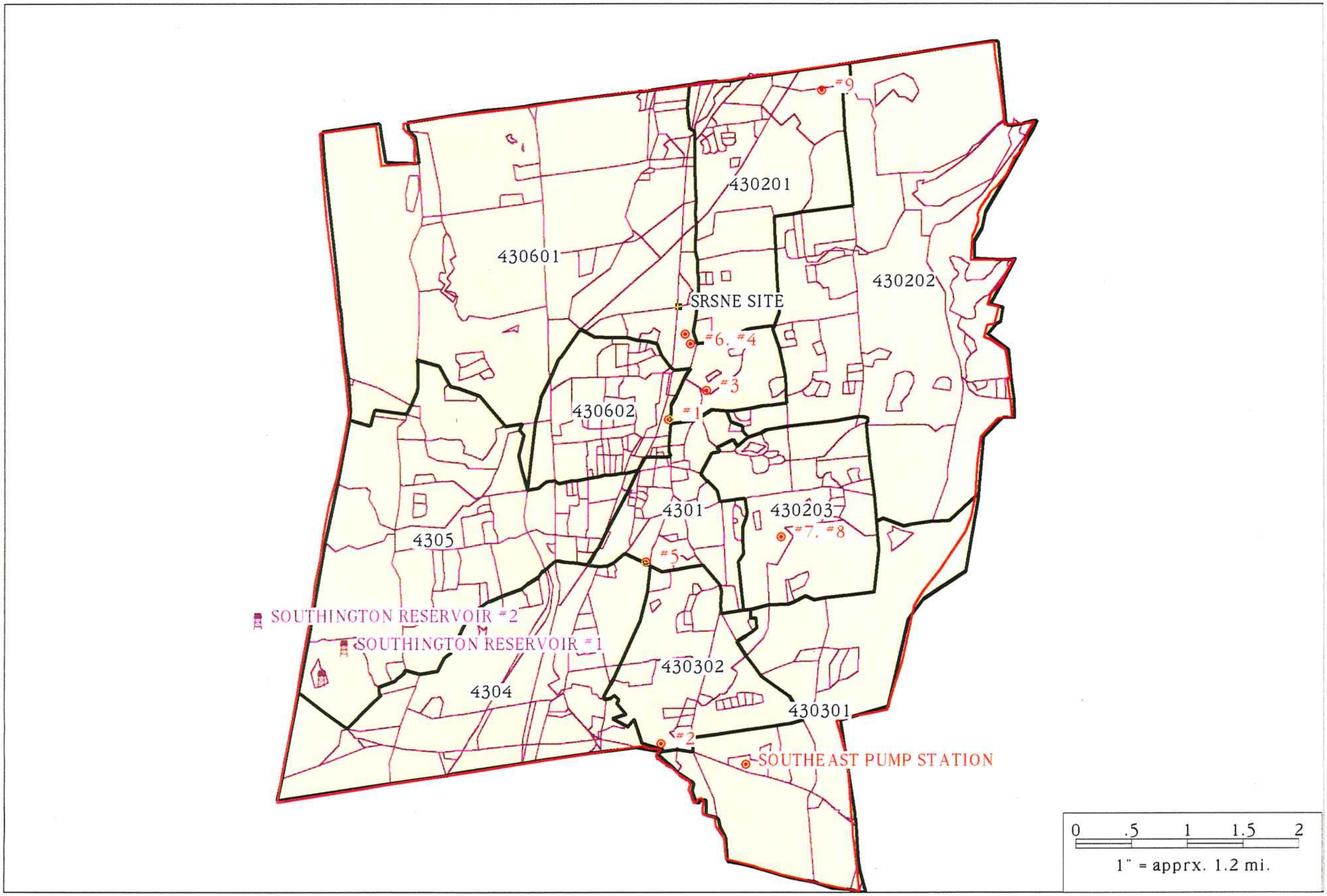


Figure 8. Census Blocks Served by VOC-Cont. Water, Scen. I

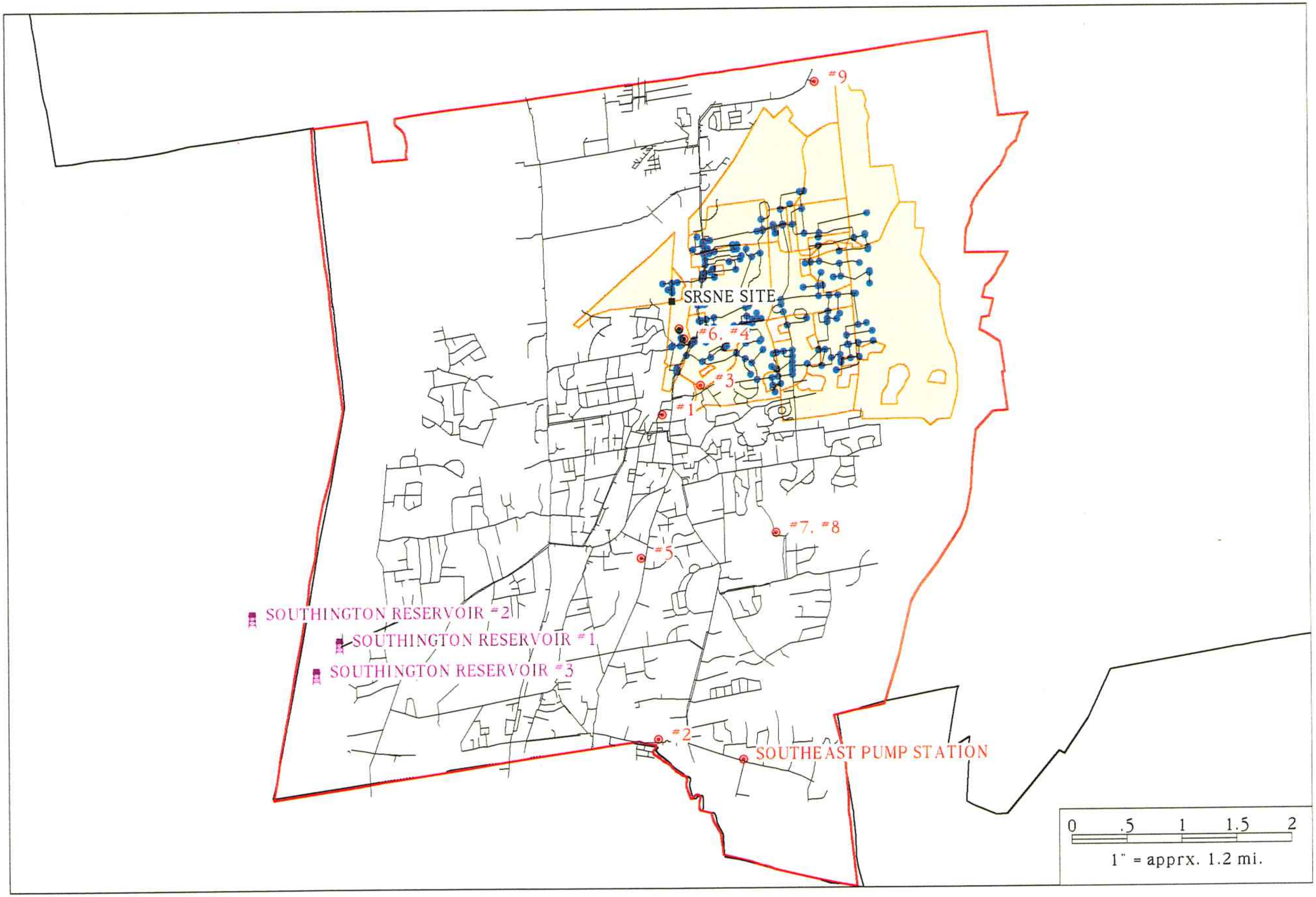


Figure 9. Census Blocks Served by VOC-Cont. Water, Scen. II

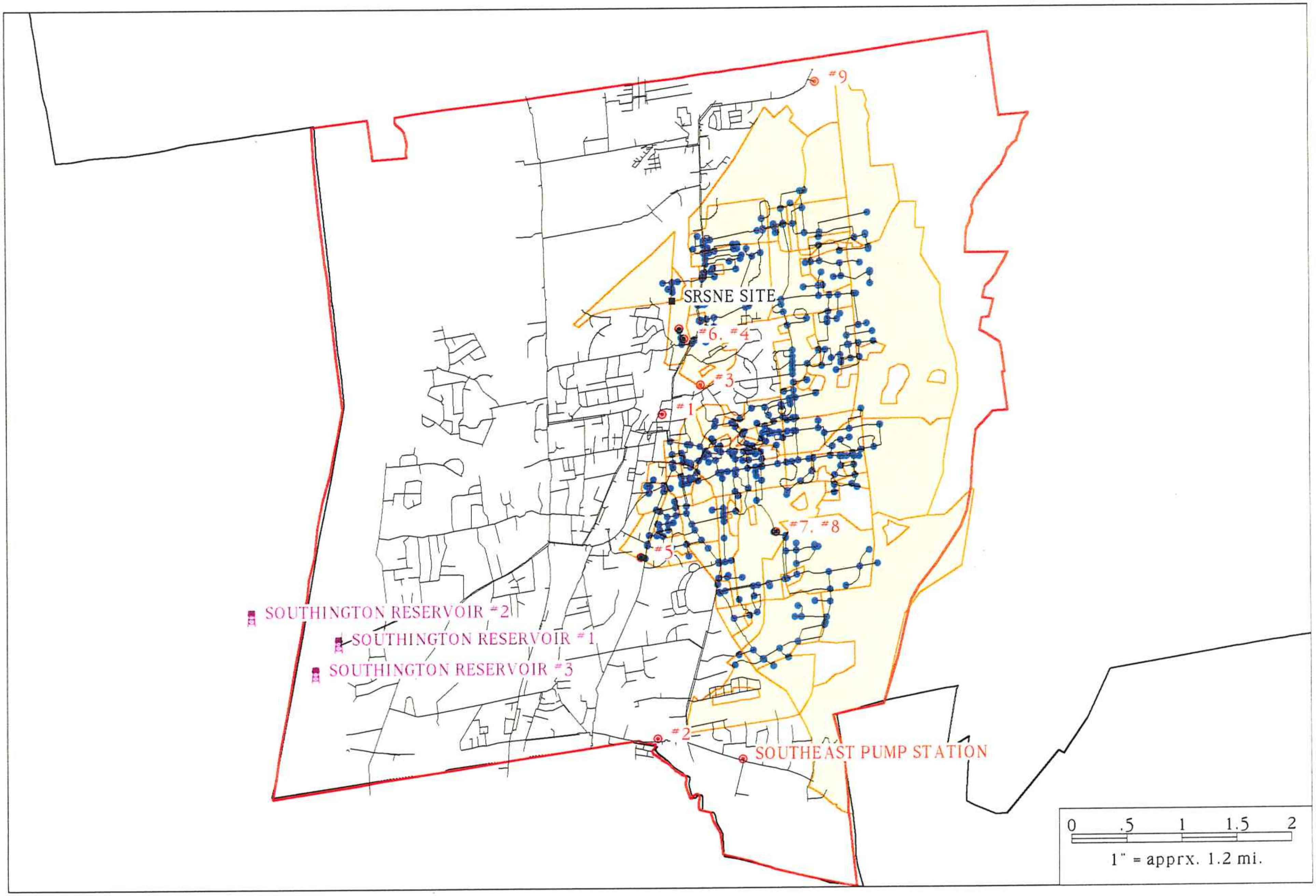


Figure 10. Census Blocks Served by VOC–Cont. Water,Scen. III

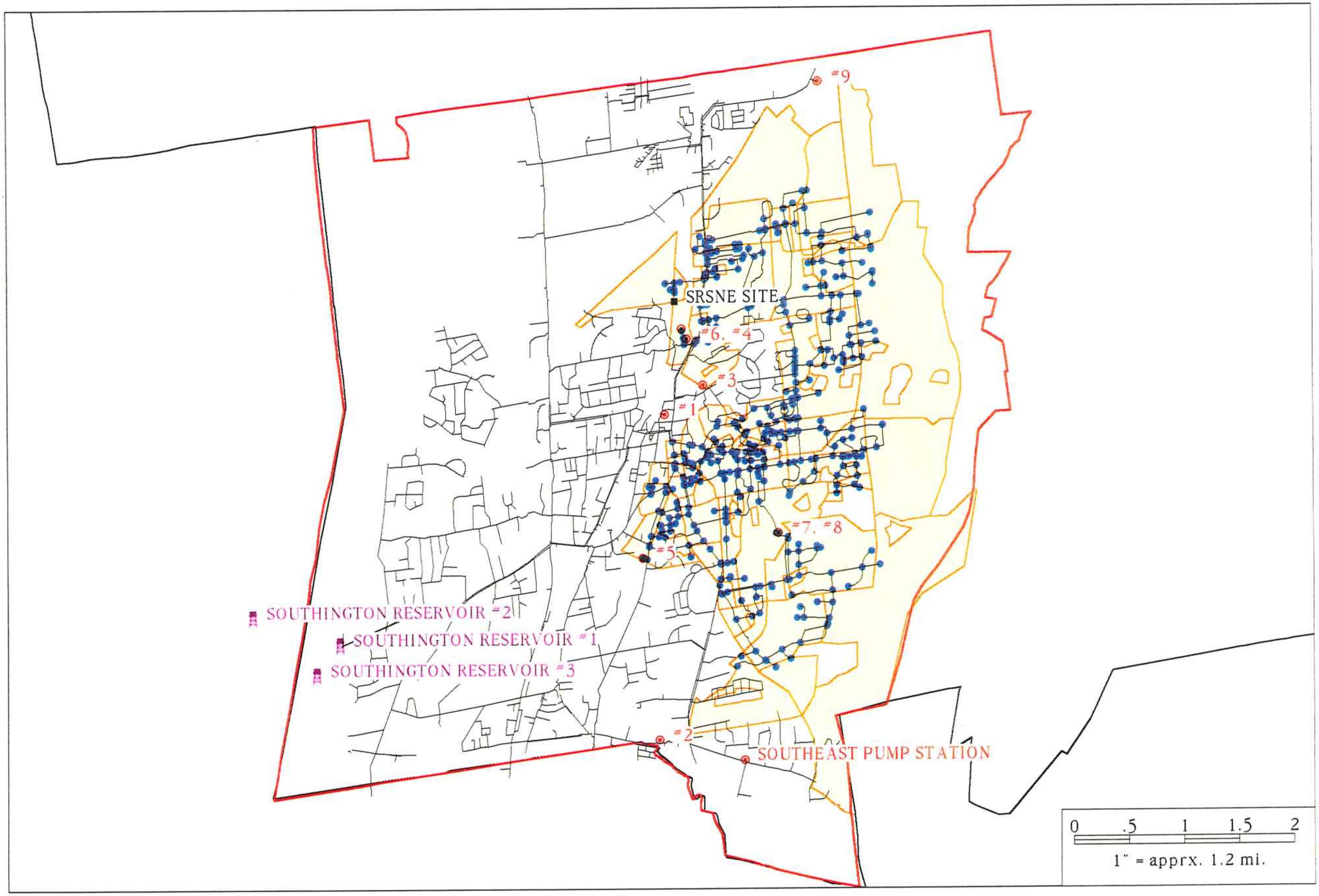


Figure 11. Census Blocks Served by VOC–Cont. Water, Scen. IV

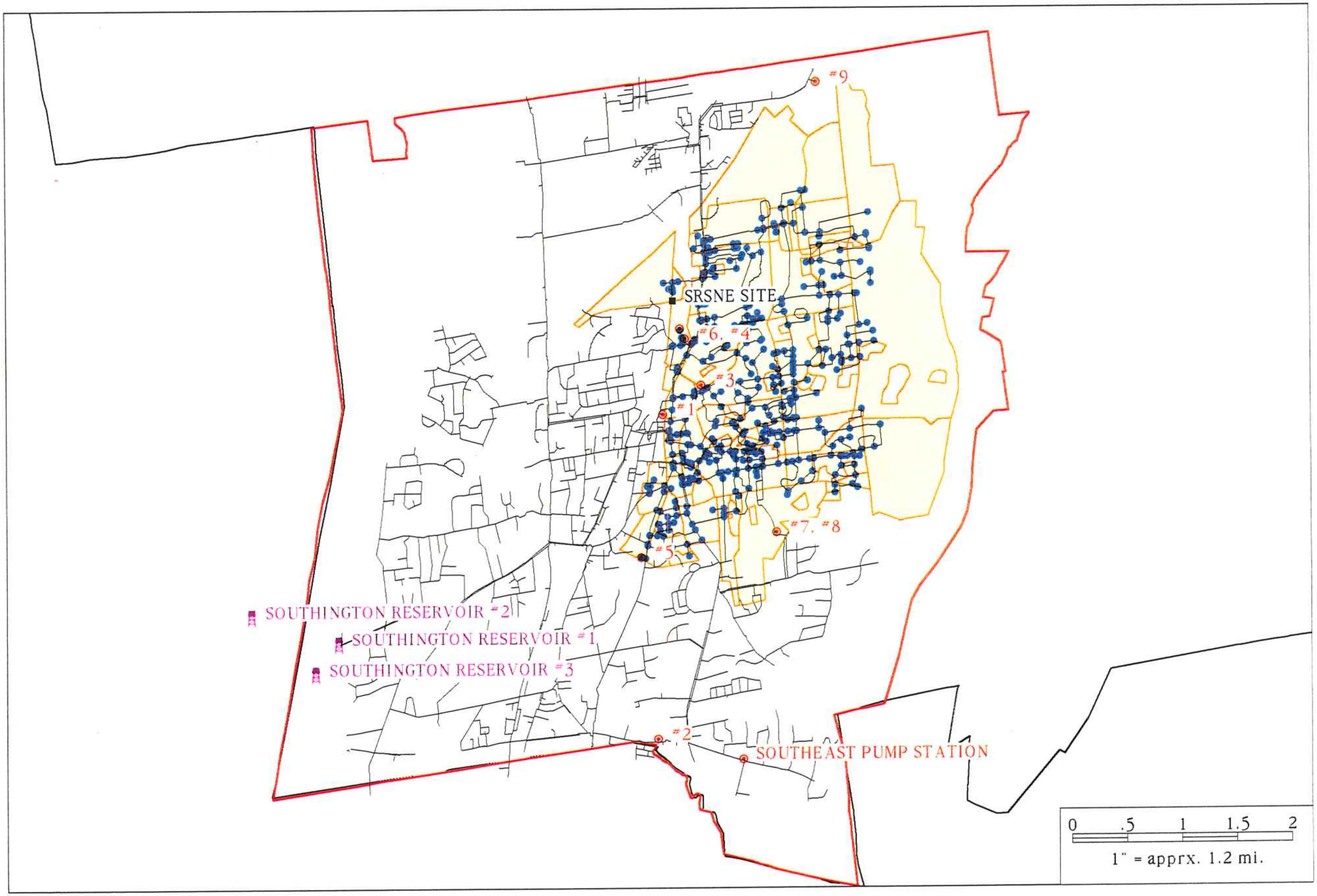


Figure 12. Distribution of TCA Contamination (ppb), Scen. IV

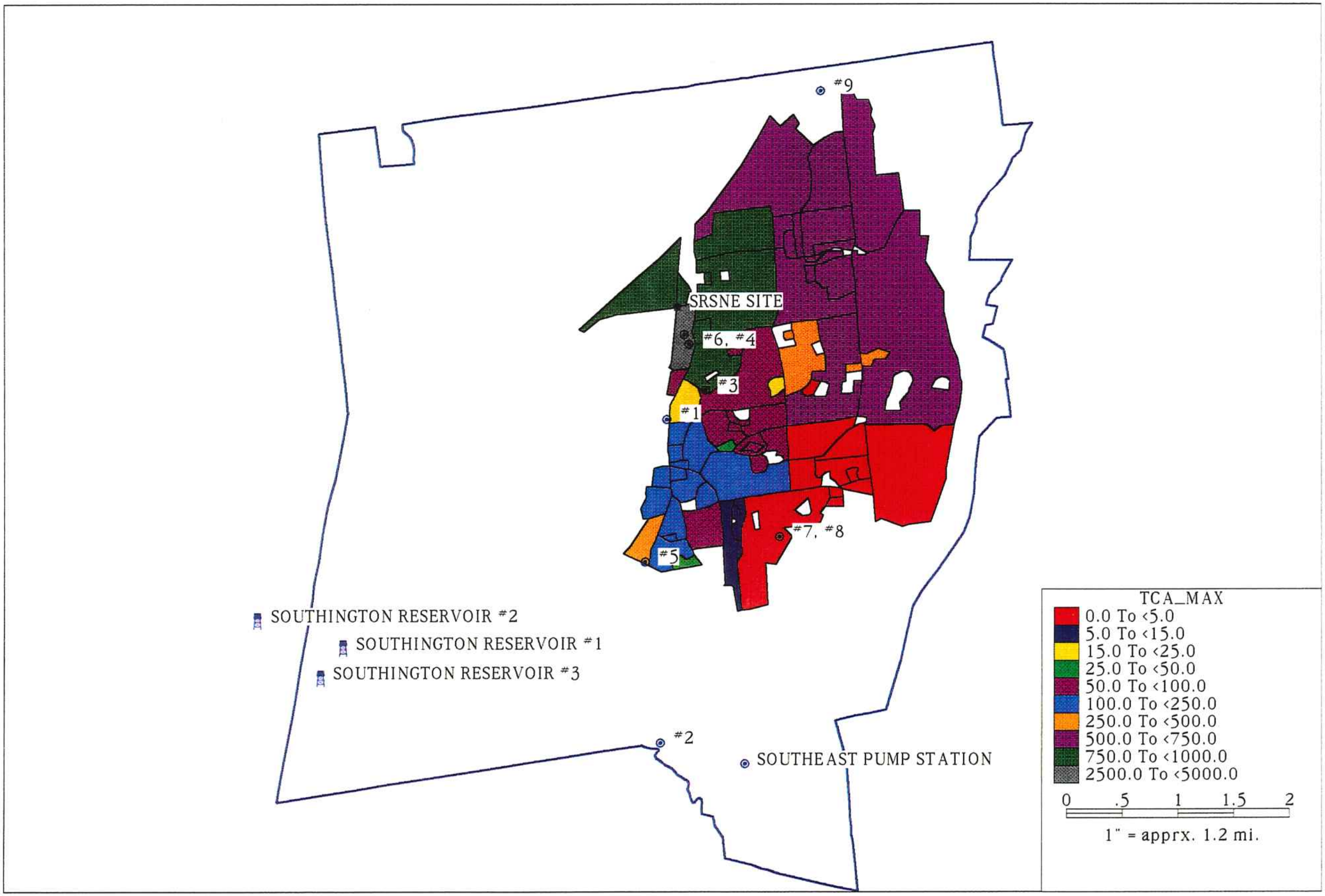


Figure 13. Distribution of TCE Contamination (ppb), Scen. IV

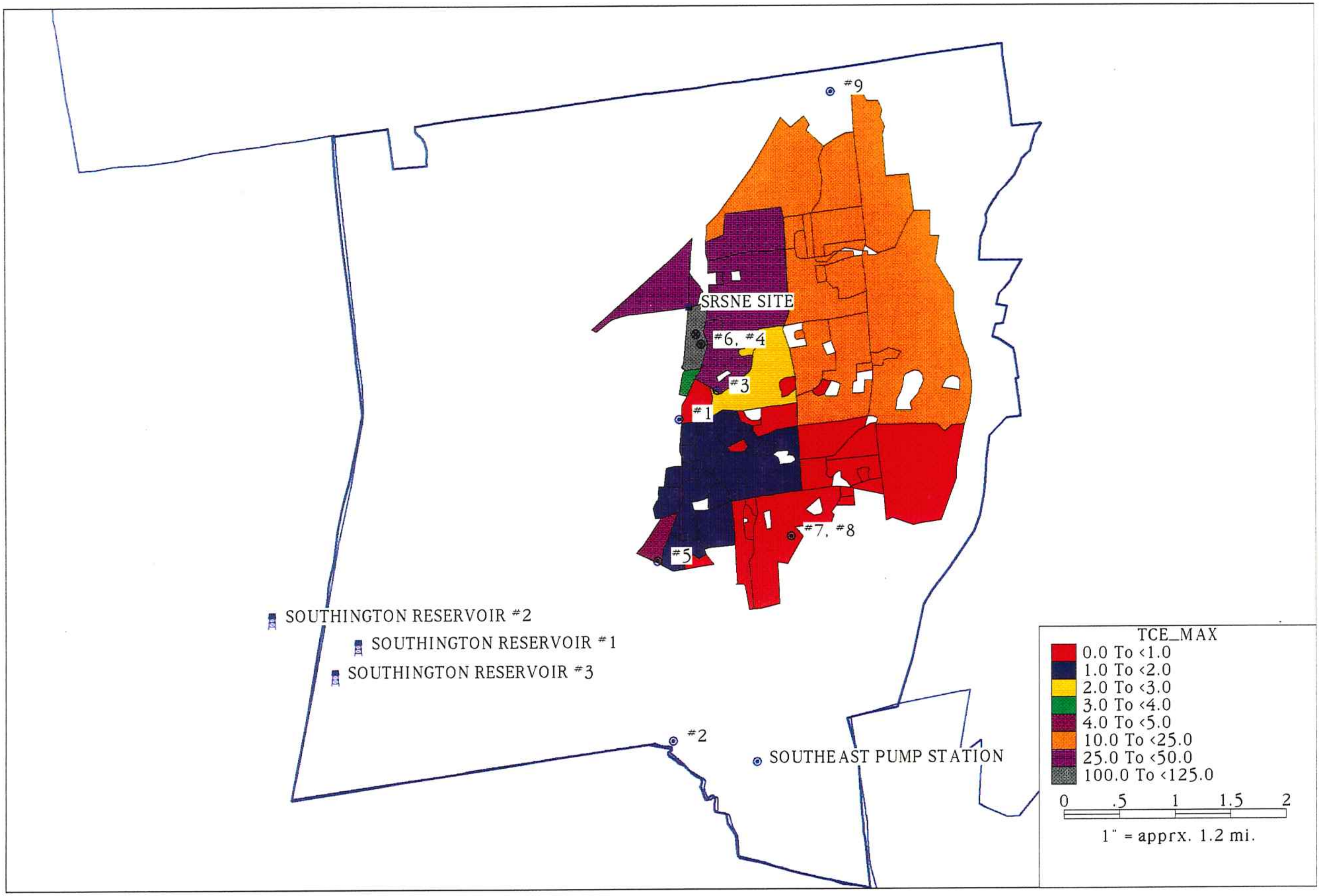
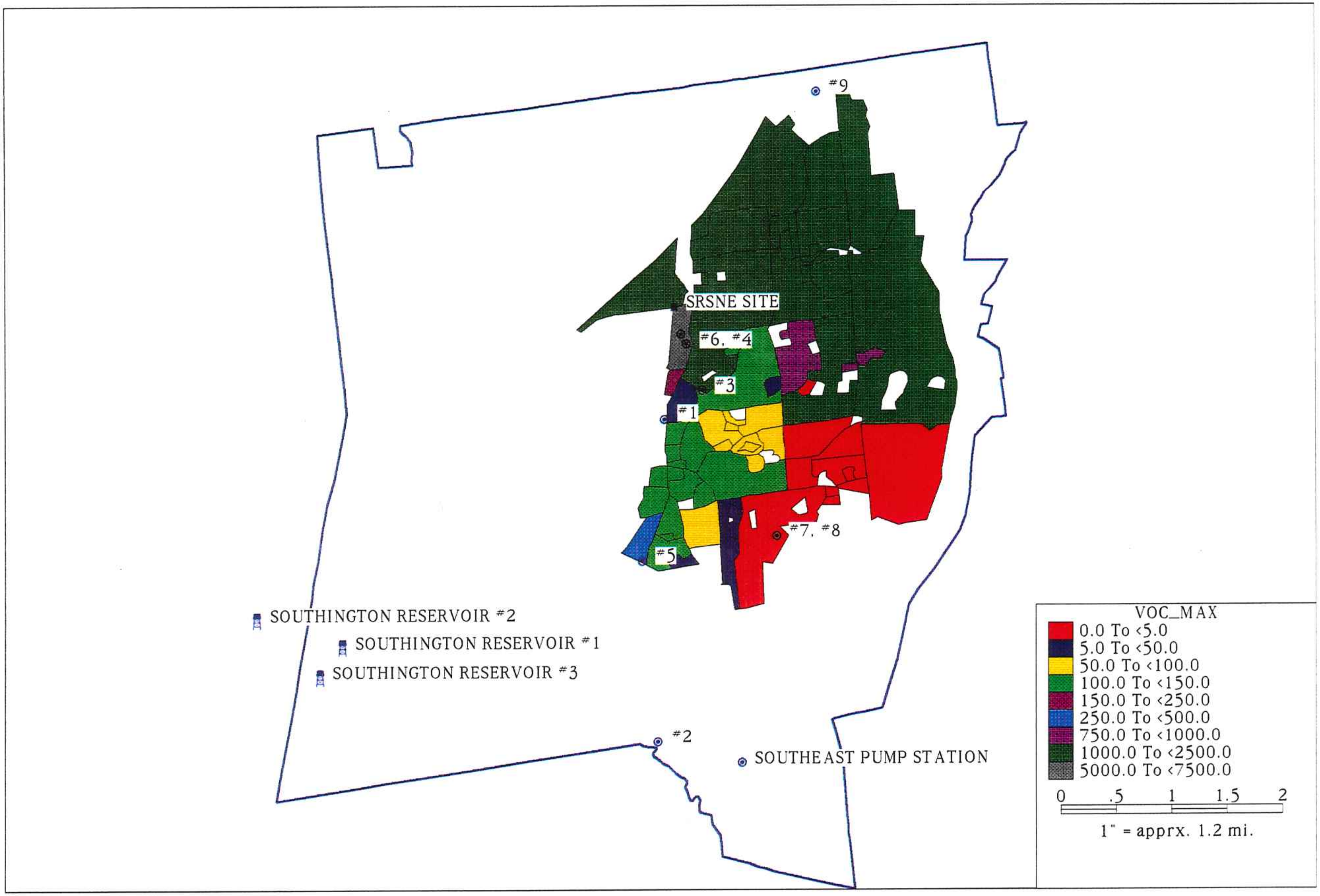


Figure 14. Distribution of VOC Contamination (ppb), Scen. IV



# APPENDIX B

## TABLES

## B-1, B-2, B-3, B-4

**Table B-1. Area statistics, census data, and simulated VOC concentration, Scenario I***

| Area Statistics and 1990 Census Data | | | | Simulated VOC Concentration, in ppb | | |
|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value |
| 0.10289 | 430601 | 105 | 3 | 4573.4 | 6700.0 | 220.8 |
| 0.17143 | 430601 | 109 | 641 | 749.0 | 1916.7 | 148.0 |
| 0.02405 | 430601 | 104 | 1 | 1916.7 | 1916.7 | 1916.7 |
| 0.02578 | 430602 | 908 | 27 | 202.6 | 220.8 | 148.0 |
| 0.23921 | 430601 | 102 | 0 | 1916.7 | 1916.7 | 1916.7 |
| 0.31097 | 430601 | 111 | 481 | 116.6 | 148.0 | 41.0 |
| 0.01039 | 430601 | 112 | 0 | 148.0 | 148.0 | 148.0 |
| 0.17650 | 430202 | 212 | 182 | 102.0 | 873.7 | 25.7 |
| 0.37451 | 430202 | 211 | 454 | 739.7 | 1581.4 | 25.7 |
| 1.28388 | 430202 | 907 | 0 | 1446.6 | 1581.7 | 712.4 |
| 0.02428 | 430202 | 911 | 45 | 151.0 | 151.0 | 151.0 |
| 0.02063 | 430601 | 113 | 117 | 41.0 | 41.0 | 41.0 |
| 0.01061 | 430202 | 218 | 71 | 194.0 | 194.0 | 194.0 |
| 0.46233 | 430202 | 902 | 0 | 1581.4 | 1581.4 | 1581.4 |
| 0.53891 | 430201 | 203 | 145 | 1581.4 | 1581.4 | 1581.4 |
| 0.29110 | 430202 | 205 | 384 | 1581.4 | 1581.4 | 1581.4 |
| 0.23754 | 430201 | 205 | 222 | 1769.1 | 1916.7 | 1581.4 |
| 0.03912 | 430202 | 203 | 124 | 1581.4 | 1581.4 | 1581.4 |
| 0.02771 | 430202 | 202 | 63 | 1581.4 | 1581.4 | 1581.4 |
| 0.15333 | 430202 | 201 | 81 | 1581.4 | 1581.4 | 1581.4 |
| 0.47961 | 430201 | 206 | 1113 | 1572.1 | 1916.7 | 148.0 |
| 0.03251 | 430201 | 208 | 0 | 1772.9 | 1916.7 | 1474.2 |
| 0.00657 | 430201 | 209 | 4 | 1916.7 | 1916.7 | 1916.7 |
| 0.00897 | 430202 | 208 | 0 | 1581.4 | 1581.4 | 1581.4 |

**Table B-1 -- continued. Area statistics, census data, and simulated VOC concentration, Scenario I***

| Area Statistics and 1990 Census Data | | | | Simulated VOC Concentration, in ppb | | |
|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value |
| 0.02881 | 430202 | 207 | 60 | 1581.4 | 1581.4 | 1581.4 |
| 0.00633 | 430202 | 215 | 26 | 873.7 | 873.7 | 873.7 |
| 0.02382 | 430202 | 204 | 63 | 1581.4 | 1581.4 | 1581.4 |
| 0.01244 | 430202 | 210 | 41 | 1581.4 | 1581.4 | 1581.4 |
| 0.22709 | 430201 | 204 | 158 | 1581.4 | 1581.4 | 1581.4 |

*Scenario I represents 1970 pumping conditions.

**Table B-2. Area statistics, census data, and simulated VOC concentration, Scenario II***

| Area Statistics and 1990 Census Data | | | | Simulated VOC Concentration, in ppb | | |
|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value |
| 0.53891 | 430201 | 203 | 145 | 768.7 | 768.7 | 768.7 |
| 0.00657 | 430201 | 209 | 4 | 978.0 | 978.0 | 978.0 |
| 0.47961 | 430201 | 206 | 1113 | 908.3 | 978.0 | 531.3 |
| 0.10289 | 430601 | 105 | 3 | 6267.1 | 6700.0 | 4535.3 |
| 0.03251 | 430201 | 208 | 0 | 880.0 | 978.0 | 676.6 |
| 0.17143 | 430601 | 109 | 641 | 678.9 | 978.0 | 375.6 |
| 0.08870 | 4301 | 103 | 208 | 72.5 | 137.5 | 10.3 |
| 0.07961 | 4301 | 101 | 175 | 68.6 | 137.5 | 24.4 |
| 0.24742 | 430203 | 206 | 815 | 98.2 | 137.5 | 13.8 |
| 0.01279 | 430203 | 205 | 39 | 137.5 | 137.5 | 137.5 |
| 0.29110 | 430202 | 205 | 384 | 768.7 | 768.7 | 768.7 |
| 0.17650 | 430202 | 212 | 182 | 62.1 | 405.8 | 10.5 |
| 0.01314 | 430202 | 224 | 65 | 37.6 | 37.6 | 37.6 |
| 0.08033 | 430202 | 222 | 183 | 48.8 | 55.7 | 31.5 |
| 0.00761 | 4301 | 102 | 26 | 56.2 | 56.2 | 56.2 |
| 0.03086 | 430203 | 204 | 107 | 56.2 | 56.2 | 56.2 |
| 0.02261 | 430203 | 207 | 115 | 59.7 | 83.1 | 55.7 |
| 0.37451 | 430202 | 211 | 454 | 180.9 | 768.7 | 24.1 |
| 0.05050 | 430203 | 203 | 261 | 55.8 | 56.2 | 55.7 |
| 0.15001 | 430203 | 202 | 190 | 55.2 | 55.7 | 54.1 |
| 0.06963 | 430203 | 210 | 103 | 55.7 | 55.7 | 55.7 |
| 0.05441 | 4301 | 108 | 183 | 137.5 | 137.5 | 137.5 |
| 0.03438 | 4301 | 109 | 116 | 137.5 | 137.5 | 137.5 |
| 0.11620 | 4301 | 111 | 251 | 91.8 | 137.5 | 62.3 |

**Table B-2 -- continued. Area statistics, census data, and simulated VOC concentration, Scenario II***

| Area Statistics and 1990 Census Data | | | | Simulated VOC Concentration, in ppb | | |
|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value |
| 0.06374 | 4301 | 116B | 73 | 44.6 | 62.3 | 38.7 |
| 0.07980 | 4301 | 224 | 338 | 109.3 | 137.5 | 62.3 |
| 0.02253 | 4301 | 201 | 86 | 62.3 | 62.3 | 62.3 |
| 0.10562 | 4301 | 114 | 166 | 49.0 | 69.5 | 38.7 |
| 0.01071 | 4301 | 113 | 91 | 69.5 | 69.5 | 69.5 |
| 0.02432 | 4301 | 117 | 170 | 69.5 | 69.5 | 69.5 |
| 0.42686 | 430203 | 106 | 760 | 23.6 | 55.7 | 13.7 |
| 0.03438 | 4301 | 116A | 10 | 13.8 | 13.8 | 13.8 |
| 0.04880 | 430302 | 201 | 125 | 13.8 | 13.8 | 13.8 |
| 0.05842 | 430301 | 202 | 60 | 13.8 | 13.8 | 13.8 |
| 0.00630 | 430302 | 202 | 33 | 13.8 | 13.8 | 13.8 |
| 0.33435 | 430302 | 204 | 497 | 13.8 | 13.8 | 13.8 |
| 0.30719 | 430301 | 201 | 243 | 13.8 | 13.8 | 13.8 |
| 0.55199 | 430203 | 109 | 229 | 13.6 | 13.8 | 10.3 |
| 0.01921 | 430203 | 110 | 62 | 13.8 | 13.8 | 13.8 |
| 0.01244 | 430202 | 210 | 41 | 768.7 | 768.7 | 768.7 |
| 0.10690 | 430202 | 209 | 259 | 768.7 | 768.7 | 768.7 |
| 1.28388 | 430202 | 907 | 0 | 647.6 | 768.9 | 49.7 |
| 0.00633 | 430202 | 215 | 26 | 405.8 | 405.8 | 405.8 |
| 0.01061 | 430202 | 218 | 71 | 70.5 | 70.5 | 70.5 |
| 0.02428 | 430202 | 911 | 45 | 24.3 | 24.3 | 24.3 |
| 0.01457 | 430202 | 216 | 56 | 55.5 | 55.5 | 55.5 |
| 0.08148 | 430203 | 211 | 167 | 55.7 | 55.7 | 55.6 |

**Table B-2 -- continued. Area statistics, census data, and simulated VOC concentration, Scenario II***

| Area Statistics and 1990 Census Data | | | | Simulated VOC Concentration, in ppb | | |
|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value |
| 0.08572 | 430203 | 212 | 198 | 55.7 | 55.7 | 55.7 |
| 0.01136 | 430203 | 213 | 59 | 55.7 | 55.7 | 55.7 |
| 0.58327 | 430202 | 913 | 0 | 55.7 | 55.7 | 55.7 |
| 0.01055 | 430203 | 102 | 18 | 55.7 | 55.7 | 55.7 |
| 0.02594 | 430203 | 214 | 22 | 55.7 | 55.7 | 55.7 |
| 0.01066 | 430203 | 103 | 47 | 55.7 | 55.7 | 55.7 |
| 1.43467 | 430301 | 902 | 0 | 13.1 | 13.8 | 10.3 |
| 0.15064 | 430301 | 204 | 141 | 13.8 | 13.8 | 13.8 |
| 0.23921 | 430601 | 102 | 0 | 978.0 | 978.0 | 978.0 |
| 0.02405 | 430601 | 104 | 1 | 978.0 | 978.0 | 978.0 |
| 0.23754 | 430201 | 205 | 222 | 897.7 | 978.0 | 768.7 |
| 0.03912 | 430202 | 203 | 124 | 768.7 | 768.7 | 768.7 |
| 0.02382 | 430202 | 204 | 63 | 768.7 | 768.7 | 768.7 |
| 0.05916 | 4301 | 203 | 66 | 137.5 | 137.5 | 137.5 |
| 0.07399 | 4301 | 207 | 301 | 183.0 | 319.4 | 137.5 |
| 0.03024 | 4301 | 223 | 78 | 137.5 | 137.5 | 137.5 |
| 0.01954 | 4301 | 107 | 97 | 13.5 | 17.3 | 9.7 |
| 0.01012 | 4301 | 105 | 72 | 77.4 | 137.5 | 17.3 |
| 0.01656 | 4301 | 106 | 54 | 97.4 | 137.5 | 17.3 |
| 0.06043 | 4301 | 206 | 259 | 137.5 | 137.5 | 137.5 |
| 0.00630 | 4301 | 205 | 36 | 137.5 | 137.5 | 137.5 |
| 0.22709 | 430201 | 204 | 158 | 768.7 | 768.7 | 768.7 |
| 0.46233 | 430202 | 902 | 0 | 768.7 | 768.7 | 768.7 |

**Table B-2 -- continued. Area statistics, census data, and simulated VOC concentration, Scenario II***

| Area Statistics and 1990 Census Data | | | | Simulated VOC Concentration, in ppb | | |
|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value |
| 0.02771 | 430202 | 202 | 63 | 768.7 | 768.7 | 768.7 |
| 0.15333 | 430202 | 201 | 81 | 768.7 | 768.7 | 768.7 |
| 0.00897 | 430202 | 208 | 0 | 768.7 | 768.7 | 768.7 |
| 0.02881 | 430202 | 207 | 60 | 768.7 | 768.7 | 768.7 |
| 0.01060 | 430203 | 299 | 0 | 56.2 | 56.2 | 56.2 |

*Scenario II represents 1974 pumping conditions

**Table B-3. Area statistics, census data, and simulated VOC concentration, Scenario III***

| Area Statistics and 1990 Census Data | | | | Simulated VOC Concentration, in ppb | | |
|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value |
| 0.53891 | 430201 | 203 | 145 | 5.7 | 5.7 | 5.7 |
| 0.00657 | 430201 | 209 | 4 | 7.2 | 7.2 | 7.2 |
| 0.47961 | 430201 | 206 | 1113 | 6.7 | 7.2 | 3.9 |
| 0.10289 | 430601 | 105 | 3 | 129.2 | 151.0 | 41.8 |
| 0.03251 | 430201 | 208 | 0 | 6.5 | 7.2 | 5.1 |
| 0.17143 | 430601 | 109 | 641 | 5.0 | 7.2 | 2.8 |
| 0.08870 | 4301 | 103 | 208 | 42.4 | 80.6 | 5.5 |
| 0.07961 | 4301 | 101 | 175 | 40.2 | 80.6 | 11.8 |
| 0.24742 | 430203 | 206 | 815 | 54.0 | 80.6 | 5.5 |
| 0.01279 | 430203 | 205 | 39 | 80.6 | 80.6 | 80.6 |
| 0.29110 | 430202 | 205 | 384 | 5.7 | 5.7 | 5.7 |
| 0.17650 | 430202 | 212 | 182 | 10.3 | 27.2 | 4.6 |
| 0.01314 | 430202 | 224 | 65 | 21.0 | 21.0 | 21.0 |
| 0.08033 | 430202 | 222 | 183 | 26.6 | 30.6 | 17.2 |
| 0.00761 | 4301 | 102 | 26 | 34.3 | 34.3 | 34.3 |
| 0.03086 | 430203 | 204 | 107 | 34.3 | 34.3 | 34.3 |
| 0.02261 | 430203 | 207 | 115 | 31.5 | 42.9 | 27.2 |
| 0.37451 | 430202 | 211 | 454 | 15.5 | 27.2 | 5.7 |
| 0.05050 | 430203 | 203 | 261 | 29.5 | 34.3 | 27.2 |
| 0.15001 | 430203 | 202 | 190 | 27.2 | 27.2 | 27.2 |
| 0.06963 | 430203 | 210 | 103 | 27.2 | 27.2 | 27.2 |
| 0.05441 | 4301 | 108 | 183 | 80.6 | 80.6 | 80.6 |
| 0.03438 | 4301 | 109 | 116 | 80.6 | 80.6 | 80.6 |
| 0.11620 | 4301 | 111 | 251 | 52.1 | 80.6 | 35.0 |

**Table B-3 -- continued. Area statistics, census data, and simulated VOC concentration, Scenario III***

| Area Statistics and 1990 Census Data | | | | Simulated VOC Concentration, in ppb | | |
|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value |
| 0.06374 | 4301 | 116B | 73 | 22.4 | 35.0 | 18.1 |
| 0.07980 | 4301 | 224 | 338 | 63.5 | 80.6 | 35.0 |
| 0.02253 | 4301 | 201 | 86 | 35.0 | 35.0 | 35.0 |
| 0.10562 | 4301 | 114 | 166 | 24.1 | 36.0 | 18.1 |
| 0.01071 | 4301 | 113 | 91 | 36.0 | 36.0 | 36.0 |
| 0.02432 | 4301 | 117 | 170 | 36.0 | 36.0 | 36.0 |
| 0.42686 | 430203 | 106 | 760 | 10.6 | 27.2 | 5.5 |
| 0.03438 | 4301 | 116A | 10 | 5.5 | 5.5 | 5.5 |
| 0.04880 | 430302 | 201 | 125 | 5.5 | 5.5 | 5.5 |
| 0.05842 | 430301 | 202 | 60 | 5.5 | 5.5 | 5.5 |
| 0.00630 | 430302 | 202 | 33 | 5.5 | 5.5 | 5.5 |
| 0.33435 | 430302 | 204 | 497 | 5.5 | 5.5 | 5.5 |
| 0.30719 | 430301 | 201 | 243 | 5.5 | 5.5 | 5.5 |
| 0.55199 | 430203 | 109 | 229 | 5.5 | 5.5 | 5.3 |
| 0.01921 | 430203 | 110 | 62 | 5.5 | 5.5 | 5.5 |
| 0.01244 | 430202 | 210 | 41 | 5.7 | 5.7 | 5.7 |
| 0.10690 | 430202 | 209 | 259 | 5.7 | 5.7 | 5.7 |
| 1.28388 | 430202 | 907 | 0 | 6.3 | 8.7 | 5.7 |
| 0.00633 | 430202 | 215 | 26 | 5.2 | 5.2 | 5.2 |
| 0.01061 | 430202 | 218 | 71 | 10.2 | 10.2 | 10.2 |
| 0.02428 | 430202 | 911 | 45 | 10.2 | 10.2 | 10.2 |
| 0.01457 | 430202 | 216 | 56 | 27.2 | 27.2 | 27.2 |
| 0.08148 | 430203 | 211 | 167 | 27.2 | 27.2 | 27.2 |

**Table B-3 -- continued. Area statistics, census data, and simulated VOC concentration, Scenario III***

| Area Statistics and 1990 Census Data | | | | Simulated VOC Concentration, in ppb | | |
|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value |
| 0.08572 | 430203 | 212 | 198 | 27.2 | 27.2 | 27.2 |
| 0.01136 | 430203 | 213 | 59 | 27.2 | 27.2 | 27.2 |
| 0.58327 | 430202 | 913 | 0 | 27.2 | 27.2 | 27.2 |
| 0.01055 | 430203 | 102 | 18 | 27.2 | 27.2 | 27.2 |
| 0.02594 | 430203 | 214 | 22 | 27.2 | 27.2 | 27.2 |
| 0.01066 | 430203 | 103 | 47 | 27.2 | 27.2 | 27.2 |
| 1.43467 | 430301 | 902 | 0 | 5.5 | 5.5 | 5.5 |
| 0.15064 | 430301 | 204 | 141 | 5.5 | 5.5 | 5.5 |
| 0.23921 | 430601 | 102 | 0 | 7.2 | 7.2 | 7.2 |
| 0.02405 | 430601 | 104 | 1 | 7.2 | 7.2 | 7.2 |
| 0.23754 | 430201 | 205 | 222 | 5.8 | 7.2 | 4.4 |
| 0.03912 | 430202 | 203 | 124 | 5.7 | 5.7 | 5.7 |
| 0.02382 | 430202 | 204 | 63 | 5.7 | 5.7 | 5.7 |
| 0.05916 | 4301 | 203 | 66 | 80.6 | 80.6 | 80.6 |
| 0.07399 | 4301 | 207 | 301 | 140.3 | 319.4 | 80.6 |
| 0.03024 | 4301 | 223 | 78 | 80.6 | 80.6 | 80.6 |
| 0.01954 | 4301 | 107 | 97 | 7.1 | 9.1 | 5.2 |
| 0.01012 | 4301 | 105 | 72 | 44.9 | 80.6 | 9.1 |
| 0.01656 | 4301 | 106 | 54 | 56.8 | 80.6 | 9.1 |
| 0.06043 | 4301 | 206 | 259 | 80.6 | 80.6 | 80.6 |
| 0.00630 | 4301 | 205 | 36 | 80.6 | 80.6 | 80.6 |
| 0.22709 | 430201 | 204 | 158 | 5.7 | 5.7 | 5.7 |
| 0.46233 | 430202 | 902 | 0 | 5.7 | 5.7 | 5.7 |

**Table B-3 -- continued. Area statistics, census data, and simulated VOC concentration, Scenario III***

| Area Statistics and 1990 Census Data | | | | Simulated VOC Concentration, in ppb | | |
|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value |
| 0.02771 | 430202 | 202 | 63 | 5.7 | 5.7 | 5.7 |
| 0.15333 | 430202 | 201 | 81 | 5.7 | 5.7 | 5.7 |
| 0.00897 | 430202 | 208 | 0 | 5.7 | 5.7 | 5.7 |
| 0.02881 | 430202 | 207 | 60 | 5.7 | 5.7 | 5.7 |
| 0.01060 | 430203 | 299 | 0 | 34.3 | 34.3 | 34.3 |

*Scenario III represents 1979 pumping conditions

**Table B-4. Area statistics, census data, and simulated concentrations, Scenario IV***

| Area Statistics and 1990 Census Data | | | | Simulated TCA Concentration, in ppb | | | Simulated TCE Concentration, in ppb | | | Simulated VOC Concnetration, in ppb | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value | Mean Value | Maximum Value | Minimum Value | Mean Value | Maximum Value | Minimum Value |
| .53891 | 430201 | 203 | 145 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.00657 | 430201 | 209 | 4 | 838.2 | 838.2 | 838.2 | 28.6 | 28.6 | 28.6 | 1601.4 | 1601.4 | 1601.4 |
| 0.47961 | 430201 | 206 | 1113 | 699.4 | 838.2 | 69.4 | 23.8 | 28.6 | 2.3 | 1335.8 | 1601.5 | 129.9 |
| 0.10289 | 430601 | 105 | 3 | 1408.2 | 3500.0 | 99.4 | 62.8 | 120.0 | 3.4 | 2672.6 | 6700.0 | 151.0 |
| 0.03251 | 430201 | 208 | 0 | 803.9 | 838.2 | 730.3 | 27.4 | 28.6 | 24.9 | 1535.8 | 1601.4 | 1394.9 |
| 0.17143 | 430601 | 109 | 641 | 358.6 | 838.2 | 69.4 | 12.2 | 28.6 | 2.3 | 683.7 | 1601.4 | 129.9 |
| 0.31097 | 430601 | 111 | 481 | 37.5 | 69.4 | 5.2 | 1.2 | 2.3 | 0.1 | 67.8 | 129.9 | 5.5 |
| 0.08192 | 430601 | 114 | 454 | 12.3 | 15.4 | 9.6 | 0.2 | 0.2 | 0.1 | 13.1 | 16.4 | 10.2 |
| 0.08870 | 4301 | 103 | 208 | 111.9 | 128.5 | 22.9 | 1.7 | 1.9 | 0.3 | 119.1 | 136.8 | 24.4 |
| 0.07961 | 4301 | 101 | 175 | 54.3 | 88.4 | 5.2 | 0.8 | 1.3 | 0.1 | 57.8 | 94.1 | 5.5 |
| 0.24742 | 430203 | 206 | 815 | 33.2 | 127.5 | 2.5 | 0.5 | 1.9 | 0.0 | 35.4 | 135.7 | 2.7 |
| 0.01279 | 430203 | 205 | 39 | 48.0 | 48.0 | 48.0 | 0.7 | 0.7 | 0.7 | 51.1 | 51.1 | 51.1 |
| 0.01039 | 430601 | 112 | 0 | 69.4 | 69.4 | 69.4 | 2.3 | 2.3 | 2.3 | 129.9 | 129.9 | 129.9 |
| 0.29110 | 430202 | 205 | 384 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.17650 | 430202 | 212 | 182 | 83.4 | 477.5 | 2.5 | 2.8 | 16.3 | 0.0 | 156.2 | 910.8 | 2.7 |

**Table B-4 -- continued. Area statistics, census data, and simulated concentrations, Scenario IV***

| Area Statistics and 1990 Census Data | | | | Simulated TCA Concentration, in ppb | | | Simulated TCE Concentration, in ppb | | | Simulated VOC Concnetration, in ppb | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value | Mean Value | Maximum Value | Minimum Value | Mean Value | Maximum Value | Minimum Value |
| 0.01314 | 430202 | 224 | 65 | 61.5 | 61.5 | 61.5 | 0.9 | 0.9 | 0.9 | 65.5 | 65.5 | 65.5 |
| 0.08033 | 430202 | 222 | 183 | 35.1 | 50.1 | 5.2 | 0.5 | 0.8 | 0.1 | 37.3 | 53.3 | 5.5 |
| 0.00761 | 4301 | 102 | 26 | 88.4 | 88.4 | 88.4 | 1.3 | 1.3 | 1.3 | 94.1 | 94.1 | 94.1 |
| 0.03086 | 430203 | 204 | 107 | 88.4 | 88.4 | 88.4 | 1.3 | 1.3 | 1.3 | 94.1 | 94.1 | 94.1 |
| 0.02261 | 430203 | 207 | 115 | 28.1 | 88.4 | 2.5 | 0.4 | 1.3 | 0.0 | 29.9 | 94.1 | 2.7 |
| 0.02063 | 430601 | 113 | 117 | 23.5 | 23.5 | 23.5 | 0.7 | 0.7 | 0.7 | 41.0 | 41.0 | 41.0 |
| 0.37451 | 430202 | 211 | 454 | 246.5 | 715.2 | 2.3 | 8.2 | 24.4 | 0.0 | 461.1 | 1366.1 | 2.5 |
| 0.05050 | 430203 | 203 | 261 | 27.8 | 88.4 | 2.5 | 0.4 | 1.3 | 0.0 | 29.6 | 94.1 | 2.7 |
| 0.15001 | 430203 | 202 | 190 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |
| 0.06963 | 430203 | 210 | 103 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |
| 0.05441 | 4301 | 108 | 183 | 114.2 | 128.5 | 85.2 | 1.7 | 1.9 | 1.3 | 121.6 | 136.8 | 90.8 |
| 0.03438 | 4301 | 109 | 116 | 111.9 | 111.9 | 111.9 | 1.7 | 1.7 | 1.7 | 119.1 | 119.1 | 119.1 |
| 0.11620 | 4301 | 111 | 251 | 39.3 | 85.2 | 9.6 | 0.6 | 1.3 | 0.1 | 41.8 | 90.8 | 10.2 |
| 0.07980 | 4301 | 224 | 338 | 91.3 | 128.5 | 29.3 | 1.4 | 1.9 | 0.4 | 97.2 | 136.8 | 31.1 |
| 0.02253 | 4301 | 201 | 86 | 29.3 | 29.3 | 29.3 | 0.4 | 0.4 | 0.4 | 31.1 | 31.1 | 31.1 |

**Table B-4 -- continued. Area statistics, census data, and simulated concentrations, Scenario IV***

| Area Statistics and 1990 Census Data | | | | Simulated TCA Concentration, in ppb | | | Simulated TCE Concentration, in ppb | | | Simulated VOC Concnetration, in ppb | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value | Mean Value | Maximum Value | Minimum Value | Mean Value | Maximum Value | Minimum Value |
| 0.10562 | 4301 | 114 | 166 | 9.6 | 9.6 | 9.6 | 0.1 | 0.1 | 0.1 | 10.2 | 10.2 | 10.2 |
| 0.01071 | 4301 | 113 | 91 | 9.6 | 9.6 | 9.6 | 0.1 | 0.1 | 0.1 | 10.2 | 10.2 | 10.2 |
| 0.02432 | 4301 | 117 | 170 | 9.6 | 9.6 | 9.6 | 0.1 | 0.1 | 0.1 | 10.2 | 10.2 | 10.2 |
| 0.42686 | 430203 | 106 | 760 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |
| 0.01244 | 430202 | 210 | 41 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.10690 | 430202 | 209 | 259 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 1.28388 | 430202 | 907 | 0 | 664.2 | 715.3 | 2.1 | 22.6 | 24.4 | 0.0 | 1268.6 | 1366.2 | 2.3 |
| 0.00633 | 430202 | 215 | 26 | 405.9 | 405.9 | 405.9 | 13.8 | 13.8 | 13.8 | 773.7 | 773.7 | 773.7 |
| 0.01061 | 430202 | 218 | 71 | 407.4 | 407.4 | 407.4 | 13.9 | 13.9 | 13.9 | 776.7 | 776.7 | 776.7 |
| 0.02428 | 430202 | 911 | 45 | 454.1 | 454.1 | 454.1 | 15.4 | 15.4 | 15.4 | 866.2 | 866.2 | 866.2 |
| 0.01457 | 430202 | 216 | 56 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |
| 0.08148 | 430203 | 211 | 167 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |
| 0.08572 | 430203 | 212 | 198 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |
| 0.01136 | 430203 | 213 | 59 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |
| 0.58327 | 430202 | 913 | 0 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |

**Table B-4 -- continued. Area statistics, census data, and simulated concentrations, Scenario IV***

| Area Statistics and 1990 Census Data | | | | Simulated TCA Concentration, in ppb | | | Simulated TCE Concentration, in ppb | | | Simulated VOC Concnetration, in ppb | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value | Mean Value | Maximum Value | Minimum Value | Mean Value | Maximum Value | Minimum Value |
| 0.01055 | 430203 | 102 | 18 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |
| 0.02594 | 430203 | 214 | 22 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |
| 0.01066 | 430203 | 103 | 47 | 2.5 | 2.5 | 2.5 | 0.0 | 0.0 | 0.0 | 2.7 | 2.7 | 2.7 |
| 0.23921 | 430601 | 102 | 0 | 838.2 | 838.2 | 838.2 | 28.6 | 28.6 | 28.6 | 1601.4 | 1601.4 | 1601.4 |
| 0.02405 | 430601 | 104 | 1 | 838.2 | 838.2 | 838.2 | 28.6 | 28.6 | 28.6 | 1601.4 | 1601.4 | 1601.4 |
| 0.23754 | 430201 | 205 | 222 | 619.6 | 838.2 | 361.7 | 21.1 | 28.6 | 12.3 | 1183.8 | 1601.4 | 691.2 |
| 0.03912 | 430202 | 203 | 124 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.02382 | 430202 | 204 | 63 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.05916 | 4301 | 203 | 66 | 128.5 | 128.5 | 128.5 | 1.9 | 1.9 | 1.9 | 136.8 | 136.8 | 136.8 |
| 0.07399 | 4301 | 207 | 301 | 171.4 | 300.0 | 128.5 | 2.6 | 4.5 | 1.9 | 182.4 | 319.4 | 136.8 |
| 0.02578 | 430602 | 908 | 27 | 91.9 | 99.4 | 69.4 | 3.1 | 3.4 | 2.3 | 175.0 | 190.0 | 129.9 |
| 0.03024 | 4301 | 223 | 78 | 128.5 | 128.5 | 128.5 | 1.9 | 1.9 | 1.9 | 136.8 | 136.8 | 136.8 |
| 0.03435 | 4301 | 104 | 140 | 81.2 | 124.7 | 22.9 | 1.2 | 1.9 | 0.3 | 86.5 | 132.7 | 24.4 |
| 0.01954 | 4301 | 107 | 97 | 124.7 | 124.7 | 124.7 | 1.9 | 1.9 | 1.9 | 132.7 | 132.7 | 132.7 |
| 0.01012 | 4301 | 105 | 72 | 126.6 | 128.5 | 124.7 | 1.9 | 1.9 | 1.9 | 134.8 | 136.8 | 132.7 |

**Table B-4 -- continued. Area statistics, census data, and simulated concentrations, Scenario IV***

| Area Statistics and 1990 Census Data | | | | Simulated TCA Concentration, in ppb | | | Simulated TCE Concentration, in ppb | | | Simulated VOC Concnetration, in ppb | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area (square miles) | Tract Number | Block Number | Total Population | Mean Value | Maximum Value | Minimum Value | Mean Value | Maximum Value | Minimum Value | Mean Value | Maximum Value | Minimum Value |
| 0.01656 | 4301 | 106 | 54 | 127.2 | 128.5 | 124.7 | 1.9 | 1.9 | 1.9 | 135.4 | 136.8 | 132.7 |
| 0.06043 | 4301 | 206 | 259 | 128.5 | 128.5 | 128.5 | 1.9 | 1.9 | 1.9 | 136.8 | 136.8 | 136.8 |
| 0.00630 | 4301 | 205 | 36 | 128.5 | 128.5 | 128.5 | 1.9 | 1.9 | 1.9 | 136.8 | 136.8 | 136.8 |
| 0.22709 | 430201 | 204 | 158 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.46233 | 430202 | 902 | 0 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.02771 | 430202 | 202 | 63 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.15333 | 430202 | 201 | 81 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.00897 | 430202 | 208 | 0 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.02881 | 430202 | 207 | 60 | 715.2 | 715.2 | 715.2 | 24.4 | 24.4 | 24.4 | 1366.1 | 1366.1 | 1366.1 |
| 0.01060 | 430203 | 299 | 0 | 88.4 | 88.4 | 88.4 | 1.3 | 1.3 | 1.3 | 94.1 | 94.1 | 94.1 |

*Scenario IV represents peak demand pumping conditons