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United States Department of Energy

Savannah River Site

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Second Explanation of Significant Differences (ESD) for the Revision 1 TNX Area Operable Unit Record of Decision (U)

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SRNS-RP-2012-00205

Revision 1

February 2013

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Aiken, South Carolina

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LIST OF ABBREVIATIONS AND ACRONYMS

ac	acre
ARAR	applicable or relevant and appropriate requirements
ARF	Administrative Record File
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CCL_4	carbon tetrachloride
CVOC	chlorinated volatile organic compound
EOS™	Edible Oil Substrate
ESD	Explanation of Significant Differences
ft	feet/foot
ha	hectares
HGCA	Hybrid Groundwater Correction Action
RAO	remedial action objective
RGO	remedial goal option
IROD	Interim Record of Decision
kg	kilogram
lb	pound
µg/l	microgram per liter
m	meter
MCL	Maximum Contaminant Level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NTSB	New TNX Seepage Basin
OTSB	Old TNX Seepage Basin
PCE	tetrachloroethylene
ppb	parts per billion
PTSM	Principal Threat Source Material
ROD	Record of Decision
SCDHEC	South Carolina Department of Health and Environmental Control
SRNS	Savannah River Nuclear Solutions, LLC
SRS	Savannah River Site
SVE	soil vapor extraction
TCE	trichloroethylene
TNXOU	TNX Operable Unit
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
WSRC	Westinghouse Savannah River Company

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I. INTRODUCTION

This Explanation of Significant Differences (ESD) is being issued by the United States Department of Energy (USDOE), the lead agency for the Savannah River Site (SRS) remedial activities, with concurrence by the United States Environmental Protection Agency (USEPA) – Region 4 and the South Carolina Department of Health and Environmental Control (SCDHEC). The purpose of this ESD is to announce the remedial change from the selected remedial action for groundwater documented in the *Record of Decision Remedial Alternative Selection for the TNX Area Operable Unit (U), WSRC-RP-2003-4017, Revision 1, August 2003.*

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) §117(c), SRS is required to publish an ESD whenever there is a significant change to a component of a remedy specified in a Record of Decision (ROD). Sections 300.435(c)(2)(i) and 300.825(a)(2) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) require the lead agency to provide an explanation of the differences and to make the information available to the public in the Administrative Record File (ARF) and information repositories.

The groundwater and vadose zone at the TNX Area Operable Unit (TNXOU) have been contaminated with volatile organic compounds (VOCs) as a result of past operations within the TNX Area. In 2003, the TNXOU ROD was issued that outlined the selected remedy for the vadose zone and groundwater (WSRC 2003). The selected remedy for the TNX Groundwater subunit was Extraction in High Chlorinated Volatile Organic Compound (CVOC) Area with Monitoring/Mixing Zone and Institutional Controls. This remedy entailed soil vapor extraction (SVE) at high VOC concentration areas, operation of the existing pump-and-treat system and T-1 air stripper until groundwater monitoring determined that passive remediation (mixing zone) and continued monitoring and land use controls would be appropriate.

In December 2007, the T-1 air stripper was placed in standby mode to accommodate a pilot treatability study for the deployment of edible oils onto the water table surface and into the water table aquifer to reduce VOC concentrations. The SVE system remained operational. The treatability study was initiated in February 2008 and completed in May 2010 (SRNS 2009). Per agreement with the USEPA and SCDHEC, the pump and treat system (recovery well network and T-1 air stripper) was not returned to service during the subsequent groundwater sampling period in order to evaluate the overall effectiveness of the edible oil injections.

Given the success as evidenced by monitoring results and modeling predictions, it is believed that a transition to a passive remediation is appropriate at this time. Due to the effectiveness of the edible oil treatability study, edible oil treatment as needed is deemed an appropriate remedy action for the groundwater. The USDOE, SCDHEC, and USEPA agreed that an ESD to the TNX ROD would be required to implement a change to the groundwater remedy. Issuance of this ESD to the ROD is in fulfillment of that agreement.

This ESD documents the following modifications of the remedy selected in the ROD for the TNXOU groundwater component:

- Permanent removal of service of the T-1 air stripper.
- Addition of edible oil treatment as needed. A sustained rebound lasting over 1 year in excess of 75 μg/L (ppb) of trichloroethylene (TCE), tetrachloroethylene (PCE), or carbon tetrachloride in any well will represent a viable trigger for injection of edible oil if determined appropriate by the USDOE, USEPA and SCDHEC.

Based on the demonstrated effectiveness of the edible oil treatability study of groundwater VOC contamination at TNXOU, this ESD documents a remedy change that is still protective of the groundwater.

The ESD is part of the ARF and is available for public review during normal business hours at the following repositories.

US Department of Energy
Public Reading Room
Gregg-Graniteville Library
University of South Carolina – Aiken
171 University Parkway
Aiken, South Carolina 29801
(803) 641-3465

Thomas Cooper Library
Government Documents Department
University of South Carolina
Columbia, South Carolina 29208
(803) 777-4866

Reese Library
Augusta State University
2100 Walton Way
Augusta, GA 30910
(706) 737-1744

Asa H. Gordon Library
Savannah State University
Thompkins Road
Savannah, GA 31404
(912) 356-2183

II. SITE HISTORY AND SELECTED REMEDY

The TNXOU is situated in the southwestern portion of SRS, approximately one quarter-mile east of the Savannah River (Figure 1). The TNXOU consists of four waste units: the Old TNX Seepage Basin (OTSB), New TNX Seepage Basin (NTSB); TNX Burying Ground; and the TNX Groundwater beneath the surface units (Figure 2). The TNXOU has been deactivated and decommissioned with a soil cap placed over the area.

Site History

The TNX Area was a pilot-scale testing and evaluation facility that supported nuclear fuel and target manufacturing chemical processes and the Defense Waste Processing Facility. Past operations within the TNX Area resulted in contamination of the vadose zone and groundwater. Potential sources of groundwater contamination included seepage from unlined basins (OTSB, NTSB), leakage from the process sewers, leachate from contaminated media in the TNX Burying Ground, and leachate from other sources at TNX (e.g., a temporary storage facility for 208 liters (55-gallon [gal]) drums during the 1950s, and an equipment staging area).

The OTSB was an unlined liquid-waste disposal area that operated from the mid 1950's until 1980 and received radioactive organic and inorganic contaminated process wastewaters generated from TNX facilities. From 1981 to 1988, non-hazardous and non-radioactive process wastewater was sent to an unlined earthen basin known as the NTSB. In August 1988, the NTSB was removed from operation, at which time wastewaters were routed to the TNX Effluent Treatment Facility.

The TNX Burying Ground, which consisted of four trenches at 1.8- to 2.4-meters (m, 6- to 8-feet [ft]) below land surface, received contaminated debris from a 1953 explosion of an experimental evaporator containing 590 kilogram (kg, 1,300 pounds [lb]) of uranyl nitrate. Between 1982 and 1984, during an expansion of the TNX facilities, the majority of the buried waste was excavated and sent to the SRS Radioactive Waste Burial Ground. Five known areas and one suspect area of contamination were not excavated. These areas potentially contain an estimated 60 pounds of uranyl nitrate.

The TNX Groundwater is the groundwater beneath the TNX Area units described above and extending all the way to the Savannah River. Groundwater at TNX can be divided into two main aquifer systems, a shallow and deep aquifer system. The shallow system can be further subdivided into an upper unconfined water table aquifer 11- to 12-m (35- to 40-ft) thick that outcrops in the TNX floodplain and a lower semi-confined aquifer. Groundwater flows progressively from deep to shallow aquifers (i.e., upward hydraulic gradient) and to the Savannah River.

<u>Summary of Contamination</u>

The nature and extent of contamination in soil, sediment, surface water, and groundwater at the TNXOU were characterized with the results summarized in the *RCRA Facility Investigation/Remedial Investigation Report with Baseline Risk Assessment for the TNX Area Operable Unit* (WSRC 1996). To support the change to the remedial decision described in this ESD, discussion of contamination will focus only on the VOC contamination in the vadose zone and groundwater.

Groundwater VOC contamination consists primarily of TCE, and to a lesser extent, PCE and carbon tetrachloride (CCl_4). The hydrogeological conditions at TNXOU have contained the VOCs to the water table aquifer, resulting in a plume extending from the TNX facility toward the adjacent floodplain and the Savannah River. VOCs have not been detected in the semi-confined or deep aquifers. The extent of the VOC contamination has been determined under the TNX floodplain, and recently installed monitoring wells indicate that the plume is not currently discharging into the Savannah River or offsite groundwater.

Secondary source VOC contamination is present in the sediments within the vadose zone and uppermost portion of the water table beneath the TNX Burying Ground and continues to impact groundwater at concentrations above maximum contaminant levels (MCLs). Soil gas characterization identified the approximate location of the vadose zone VOC source material.

A VOC "smear zone" of source material within the capillary fringe 4.5 m (15 ft, above and below the water table) was identified and likely resulted from leaching of vadose zone source material (WSRC 1999a). The lateral extent of the vadose zone and smear zone source material has not been fully determined, but appears to have been within the area delineated by the 500 parts-per-billion (ppb) TCE groundwater plume contour prior to edible oil treatment. Following the USEPA guidance, *A Guide to Principal Threat and Low Level Threat Wastes* (OSWER 9380.3-06FS), this source material prior to edible oil treatment would be considered principal threat waste (i.e., identified as principal threat source material [PTSM] at SRS) because it is highly mobile and is contaminating groundwater at concentrations above Safe Drinking Water standards (USEPA 1991) and poses a risk to human receptors. USEPA guidance places priority on treatment of principal threat waste wherever practicable, with early actions favored.

Previous Regulatory Decisions and Studies

To control and remediate VOC source material and the groundwater plume, an interim ROD (IROD) for the TNXOU Groundwater was authorized by USEPA, SCDHEC, and USDOE on November 16, 1994 (WSRC 1994). The interim remedial action served as an incremental step in part of an overall final remedy to address TNX groundwater contamination. The following interim Remedial Action Objectives (RAOs) were developed:

- Prevent further aquifer degradation
- Maintain risk at acceptable levels to the onsite worker at the seep line
- Reduce potential risk to human health and the environment in general

To successfully achieve the interim RAOs, the following interim Remedial Goal Options (RGOs) were agreed upon for the interim action:

- Mitigate migration of VOCs to the floodplain by stabilizing the 500 ppb TCE plume core
- Remove VOC contamination in the groundwater near the TCE plume core

The interim remedy selected in the IROD was the Hybrid Groundwater Correction Action (HGCA) which consisted of (1 a pump and treat system (recovery well network and T-1 air stripper) to treat and inhibit further migration of the 500 ppb TCE plume core, and (2 an airlift recirculation well, located at the heart of the plume to expedite remediation. Testing performed in 1996 demonstrated that the recirculation well system was ineffective in the TNX Burying Ground area because of geological factors and the nature of the contamination. Furthermore, it was determined that the pump and treat system (recovery well network and T-1 air stripper) could adequately achieve the RGOs. The recirculation well was later shown to be ineffective and the IROD was modified via an ESD in 1997 to remove it from the HGCA system (WSRC, 1997a). The performance of the remaining recovery well network and T-1 air stripper system was evaluated through an effectiveness monitoring program that required submittal of semi-annual monitoring reports to USEPA and SCDHEC for the duration of the interim action.

A SVE treatability study was performed in the vadose zone near the TNX Burying Ground in 1997 (Phase I) and in 1999 (Phase II) (WSRC 1997, WSRC 1999b). During a 180-day period of intermittent operation, a very small scale SVE unit was able to remove 8.2 kg (18 lb) of TCE and 3.6 kg (8 lb) of CCl_4 (pumping rates between 0.1 and 0.6 cubic meter (5 and 20 cubic feet) per minute with an estimated radius of influence between 12.2 and 33.5 m (40 and 110 ft). Based on these results, addition of SVE was shown to be an effective and cost efficient approach at reducing the mass of VOCs at TNX (i.e., removing vadose zone secondary source VOCs near the plume core) and minimizing future VOC groundwater concentrations in the TNX floodplain.

In October 2001, an ESD to the IROD (WSRC 2001a) was approved to add SVE to the HGCA system and to modify the effectiveness monitoring reporting requirements from two semi-annual reports to one annual report. In 2002, a portable SVE unit and twelve wells were installed at the TNXOU. In 2006, the SVE wells were shutdown to accommodate the placement of a 4-ha (10-ac) engineered cover system over the former TNX Area as part of the final T-Area Closure. After completion of the engineered cover, the conventional active SVE system was replaced with five 24V passive (MicroBlower™) SVE wells. The twelve wells, in addition to previously existing wells provide 22 available wells for the five MicroBlowers™. Location of the current SVE system wells are presented in Figure 3.

In 2003, a final ROD for the TNXOU was issued with the following RAOs for the groundwater component:

- Protect future industrial workers and return groundwater to beneficial uses within a reasonable time period by remediating carbon tetrachloride, PCE, and TCE to applicable or relevant and appropriate requirements (ARARS) (i.e., MCLs).

- Protect future industrial workers from exposure to groundwater contaminated with radiological constituents and mercury at levels exceeding MCLs.

- Prevent, minimize, or eliminate discharge of contaminated groundwater to surface water that would result in unacceptable risk to human or ecological receptors.

- Minimize adverse impact to the wetland ecosystem of the TNX Area flood plain through careful consideration and implementation of remedial actions.

The ROD selected extraction in high VOC concentration areas with monitoring/mixing zone and institutional controls as the final remedial action for groundwater (WSRC 2003).

In December 2007, the T-1 air stripper was temporarily placed in standby mode to accommodate an edible oil treatability study (SRNS 2009). The SVE system remained operational during the treatability study, except when several SVE wells with screens near the top of the water table where used to deploy neat oil. The two-phase edible oil treatability study was conducted with the initial deployment of amendments occurring in February 2008 and completed in April 2008, and the second

phase occurred in May 2010. The purpose of the treatability study was to determine how effective edible oil deployment was on the treatment zones. Edible oil treatment is an enhanced degradation technology that alters the site conditions such that the contaminant plume will passively stabilize and shrink. The design of the remedy is derived from two mechanisms, partitioning and degradation, combined with standard hydrology and engineering calculations. The design process utilized the T-Area configuration of existing wells and piezometers for access to the top of the water table and into the water table aquifer. The edible oil treatment technology consists of 1) deployment of neat (pure) vegetable oil at the top of the water table in the residual source area (vicinity of the smear zone); and 2) deployment of emulsified vegetable edible oil substrate (EOS™) in the core of the groundwater VOC plume. Figure 4 depicts the schematic of the TCE concentration reduction processes via edible oils.

The water table aquifer was first treated with base solutions made with site groundwater injected through existing monitoring wells. EOS™ emulsion was then mixed with site groundwater and injected through the same wells. A small portable air stripper was used to remove VOCs from the groundwater prior to using the water in injection mixtures. Groundwater from the site was used for base and emulsion treatments so that the net water balance in the plume would not be altered. The neat oil was gravity fed using deep vadose zone wells TVX-3L, TVX-5L, TVX-6L. Figure 5 depicts the map of edible oil injection wells.

Groundwater contaminant data indicates that TCE concentrations are decreasing rapidly in the treatment area. Additionally, the presence of reductive daughter products (cis-dichloroethene and vinyl chloride) have been observed in some wells and thus indicates that reductive dechlorination is occurring. These daughter products are prone to oxidation outside of the reductive zone formed by the edible oil, and data indicates no significant accumulation of daughter products in the groundwater from the treatment.

<u>Selected Remedy</u>

The selected remedy for groundwater as documented in the TNXOU ROD consists of extraction in high VOC concentration areas with monitoring/mixing zone and institutional controls. As supported by the results of the edible oil treatability study and groundwater monitoring data, this ESD documents modification to the current remedy as follows:

- Permanent removal from service of the T-1 air stripper. (The TNX Air Stripper is permitted under state regulations and it will be closed in accordance with a state approved closure plan.)

- Addition of edible oil treatment as needed. A sustained rebound lasting over 1 year in excess of 75 μg/L (ppb) of TCE, PCE, or carbon tetrachloride in any well will represent a viable trigger for injection of edible oil if determined appropriate by the USDOE, USEPA and SCDHEC.

Modifications to the remedy via this ESD do not impact any other components of the selected remedy as described in the TNXOU ROD including operation

of the passive SVE system, groundwater monitoring, and institutional controls.

III. BASIS FOR THE EXPLANATION OF SIGNIFICANT DIFFERENCE

The combination of technologies that emerged for the TNX OU included: 1) neat (pure) vegetable oil deployment in the deep vadose zone in the former source area, and 2) emulsified vegetable oil deployment within the footprint of the groundwater plume. Neat oil spreads laterally forming a thin layer on the water table to intercept and reduce future VOC loading (via partitioning) and reduce oxygen inputs (via biostimulation). Emulsified oil forms active bioremediation reactor zones within the plume footprint to degrade the existing groundwater contamination (via reductive dechlorination and/or cometabolism) and stimulates long-term degradation capacity in the distal plume (via cometabolism).

The overall effectiveness of edible oil injection is discussed in terms of lines of evidence. Three lines of evidence were evaluated.

The first line of evidence pertains to groundwater data that demonstrate a clear and meaningful trend in decreasing contaminant mass and/or concentration over time and the presence of daughter products at appropriate monitoring points. Degradation remedies are fundamentally based on a mass balance. The estimated TCE mass in the plume decreased by approximately 90%, from 2.73 kg (6 lb) in 4Q07 (prior to edible oil treatment) to 0.27 kg (0.6 lb) in 4Q11. Table 1 provides the areas measured from the plume maps and the corresponding estimated total mass. TCE concentrations decreased immediately after injections, likely due to partitioning and dilution and remained near or below the MCL of 5 µg/L (ppb) throughout most of the treatment zone. An estimate of total TCE mass reduction and rate in the plume during five time periods is depicted in Figure 6. Figures 7 and 8 depict graphical trends of TCE concentration in TNXOU wells. Additionally, Table 2 provides a summary of trend analysis of 36 wells derived from statistical software results. A rate constant calculation was also performed to determine the estimated time to reach a remediation goal. Modeling of the preliminary results indicate TCE mass is decreasing and that the TCE concentrations throughout the plume will be below 5 ppb within 7 to 10 years.

The second line of evidence entails evaluation of hydrogeologic and geochemical data that can be used to demonstrate indirectly if degradation processes are occurring. Daughter products (cis-DCE, vinyl chloride, and ethene) were detected proving full reductive dechlorination is occuring. Some measurements that are indicative of redox conditions that are being observed in the treatment area include: low oxidation-reduction potential, low dissolved oxygen, high dissolved iron concentrations, and increasing ammonia concentrations.

The third line of evidence is the use of data from field or microcosm studies which directly demonstrate or quantify the occurrence of a particular degradation process and/or the ability to degrade contaminants of concern. Strong anaerobic conditions are present and are ideal for the microorganisms such as *Dehalococcoides* that possess reductive dechlorination capability. Reductive dechlorination of TCE generally requires conditions reducing enough to promote methanogenesis. Methanogenic

and methanotrophic bacteria were quite abundant in groundwater prior to edible oil deployment. Activity dependent enzymes were detected and show active degradation. Cometabolism is likely occurring in the distal aerobic treatment zone based on activity dependent enzyme testing and the presence of methanotrophic bacteria. Cometabolites (e.g. methane, ammonia, TOC) are being generated and distributed to stimulate aerobic degradation in the distal plume zone and are expected to increase.

In summary, the edible oil treatability study has demonstrated the ability to decrease the TCE contaminant plume in less time and lower cost than the remedy selected in the TNXOU ROD and still be protective of the groundwater. This ESD does not result in changes to the groundwater monitoring frequency and reporting requirements outlined in the ROD. Action-specific ARARs associated with the edible oil treatment remedy are provided in Table 3.

IV. DESCRIPTION OF SIGNIFICANT DIFFERENCES

A significant change to a selected remedy generally involves a change or modification to a component of a remedy that does not fundamentally alter the overall cleanup approach. A significant change does not involve an appreciable change in the scope, performance, and/or cost of the selected remedy. A significant change often involves implementation of a secondary or alternative technology to the selected remedy.

Remedial actions selected for the TNXOU groundwater through a series of decision documents included in situ treatment, in situ biodegradation, pump and treat technology (extraction well network), soil vapor extraction (SVE), air stripping, monitoring/mixing zone, and institutional controls. The initial remedy selected in the IROD included extraction wells, an air stripper, and a recirculation well that recharged the contaminated aquifer with treated groundwater containing amendments (i.e., nutrients) to stimulate in situ biodegradation (WSRC 1994). As conditions within the TNXOU groundwater changed, two ESDs were issued in 1997 and 2001 to replace the recirculation well with a SVE system (WSRC 1997, WSRC 2001). A final ROD was issued in 2003 to continue operation of the SVE system and to introduce a mixing zone and institutional controls as components of the final remedy (WSRC 2003). In 2009, the air stripper and pump and treat system were placed in standby while a treatability study was conducted to evaluate an edible oil emulsion technology as an enhancement to the ongoing in situ biodegradation.

Monitoring and groundwater model results confirm that a modification to the selected remedy to replace the T-1 air stripper with the edible oil emulsion technology is appropriate as a final remedy to support the transition to passive remediation.

The current TNXOU groundwater remedial actions include the pump and treat system, T-1 air stripper, SVE system, monitoring/mixing zone and institutional controls. This ESD modifies a component of the selected remedy to permanently remove the T-1 air stripper and replace with the edible oil emulsion treatment technology as needed. As previously discussed, reinjection of treated groundwater to stimulate in situ cleanup through biodegradation was a component of the remedy selected in the IROD. Similarly, the edible oil

emulsion injection employs extraction of a discrete amount of groundwater from the existing well network, treats the extracted groundwater ex situ with the edible oil emulsion, and uses the same well network for reinjection of treated groundwater back into the aquifer. The method of treatment is modified by introducing the edible oil emulsion to the groundwater ex situ prior to reinjection, but is consistent with using amendments to support in situ biodegradation.

An example of a significant change provided in USEPA guidance (USEPA 1999) describes the use of a biological treatment method as an alternate technology in place of air stripping (which was specified in the example ROD) for treatment of extracted groundwater. The USEPA example mirrors the modification to the selected remedy described in this ESD because the basic remedy for the TNX OU groundwater (i.e., pump and treat) remains unaltered, and the cleanup level specified in the ROD will be met by the alternative technology. The scope, performance goals, and consistency with ARARs are unchanged and the cost of the remedy modification is not greater than the known operational costs of the original remedy. Figure 9 depicts the schematic cross section of TNX Area operable units and remedial action.

SRS recognizes that additional edible oil injections may be necessary. A good example is well TBG-4 which had a rebound of over 200 ug/L of TCE after edible oil injection. This increase seemed sustained and caused SRS to inject additional edible oil emulsion in TBG-4. The addition of the oil emulsion resulted in a rapid degradation of TCE that has persisted for approximately 2 years. The details of the rebound and injection are documented in the TNX Area Groundwater Annual Report (SRNS 2012a) and Table 5 of the Edible Oil Treatability Study (SRNS 2012b). A sustained rebound lasting over 1 year in excess of 75 µg/L of TCE, PCE, or carbon tetrachloride in any well will represent a viable trigger for injection of edible oil if determined appropriate by the USDOE, USEPA and SCDHEC.

V. STATUTORY DETERMINATIONS

The modified remedy meets the requirements specified in CERCLA Section 121 to: 1) be protective of human health and the environment; 2) comply with (or waive) ARARs; 3) be cost-effective; 4) utilize permanent solutions and alternative treatment technologies to the maximum extent practicable; and 5) satisfy the preference for treatment as a principal element of the remedy which permanently and significantly reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants.

Because this remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a review will be conducted within five years after initiation of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

VI. PUBLIC PARTICIPATION

The public will be informed of the change to a component of the selected remedy as specified in this ESD through the *Environmental Bulletin*, a newsletter sent to approximately 3,500 citizens in South Carolina and Georgia, and through the *Aiken*

Standard, the *Allendale Citizen Leader*, the *Barnwell People Sentinel, The State,* and the *Augusta Chronicle* newspapers. To obtain more information concerning this ESD contact:

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VII. REFERENCES

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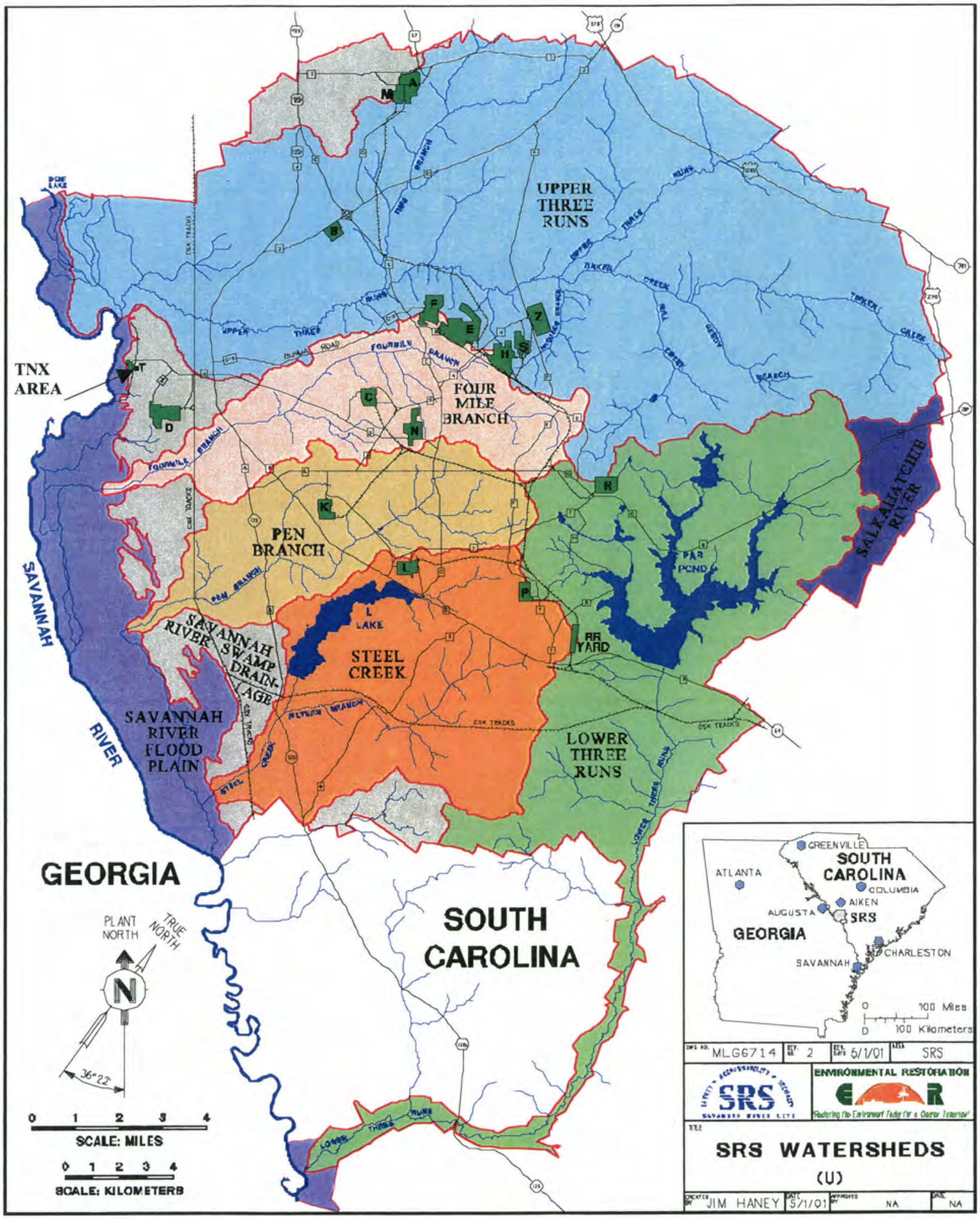

Figure 1. Location of the TNX Area at the Savannah River Site

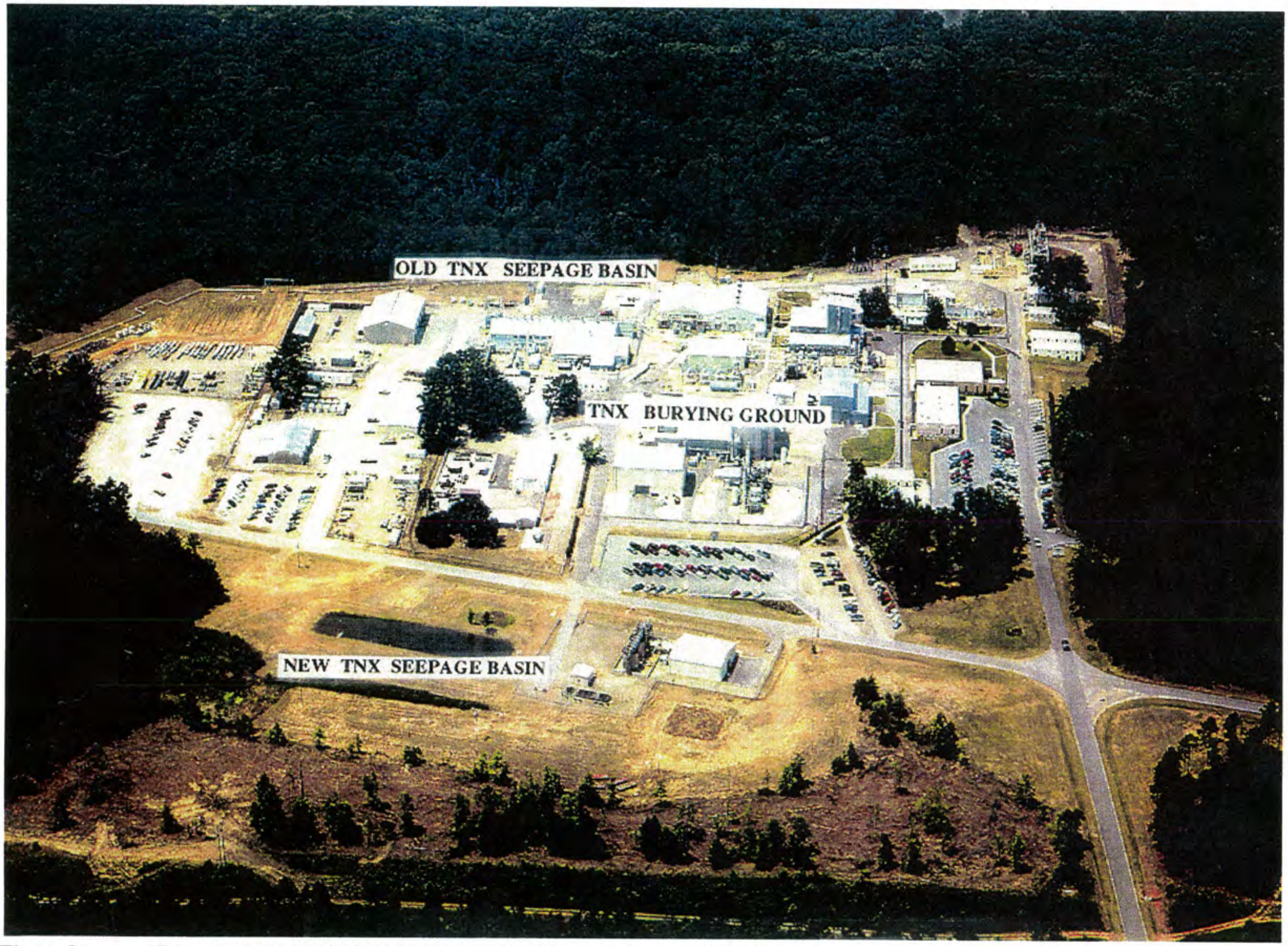

Figure 2. Layout of the TNXOU Prior to Deactivation and Decommissioning

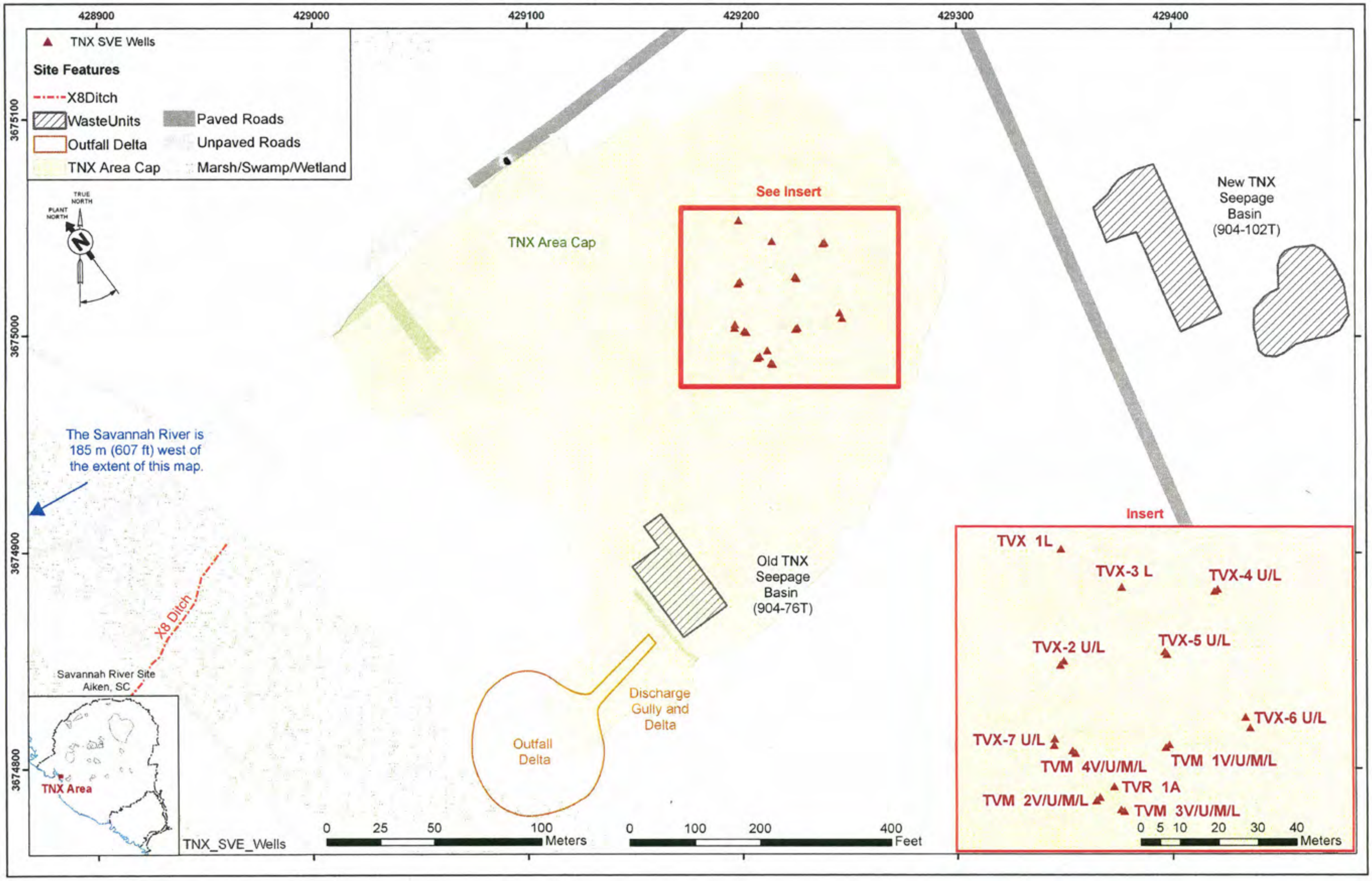

Figure 3. **Location of the Remedial Action SVE Well System**

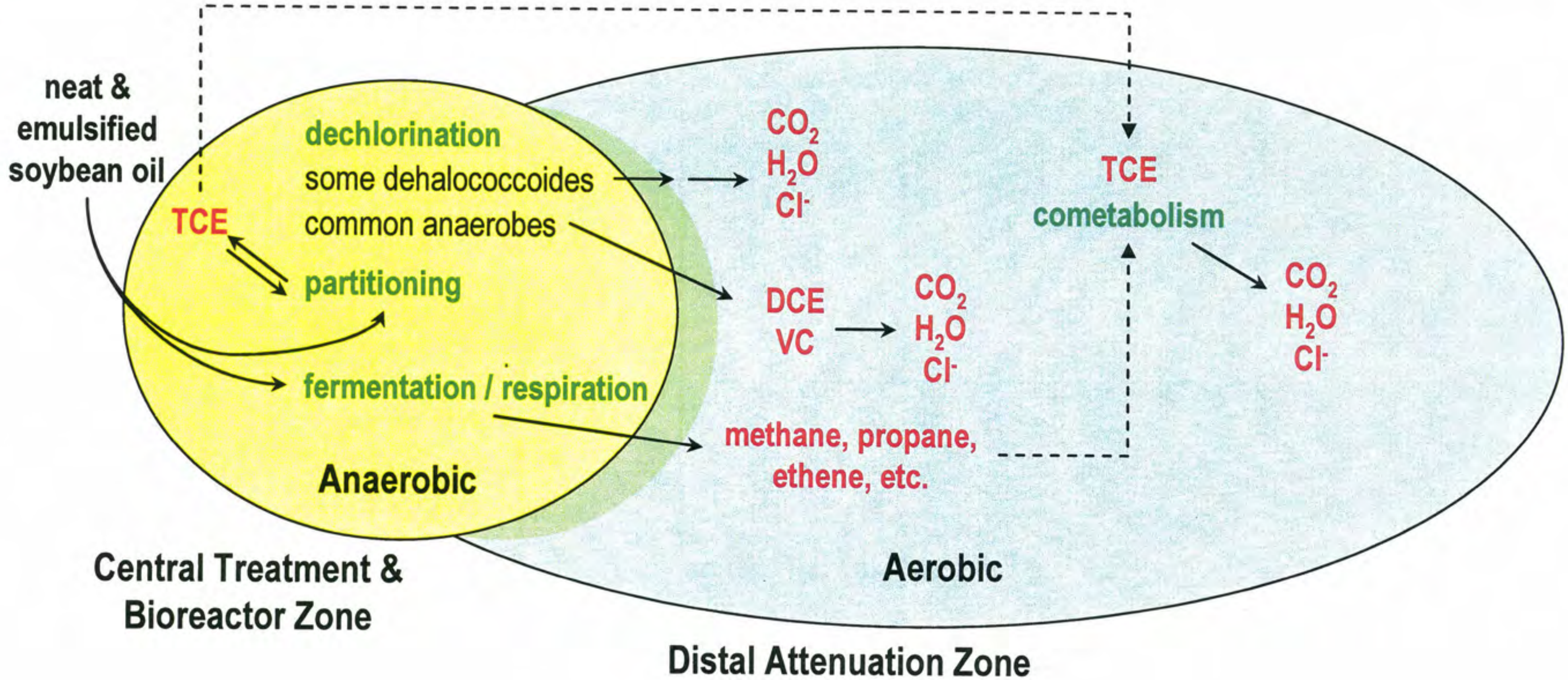

Figure 4. **Schematic of Edible Oil Reduction Processes**

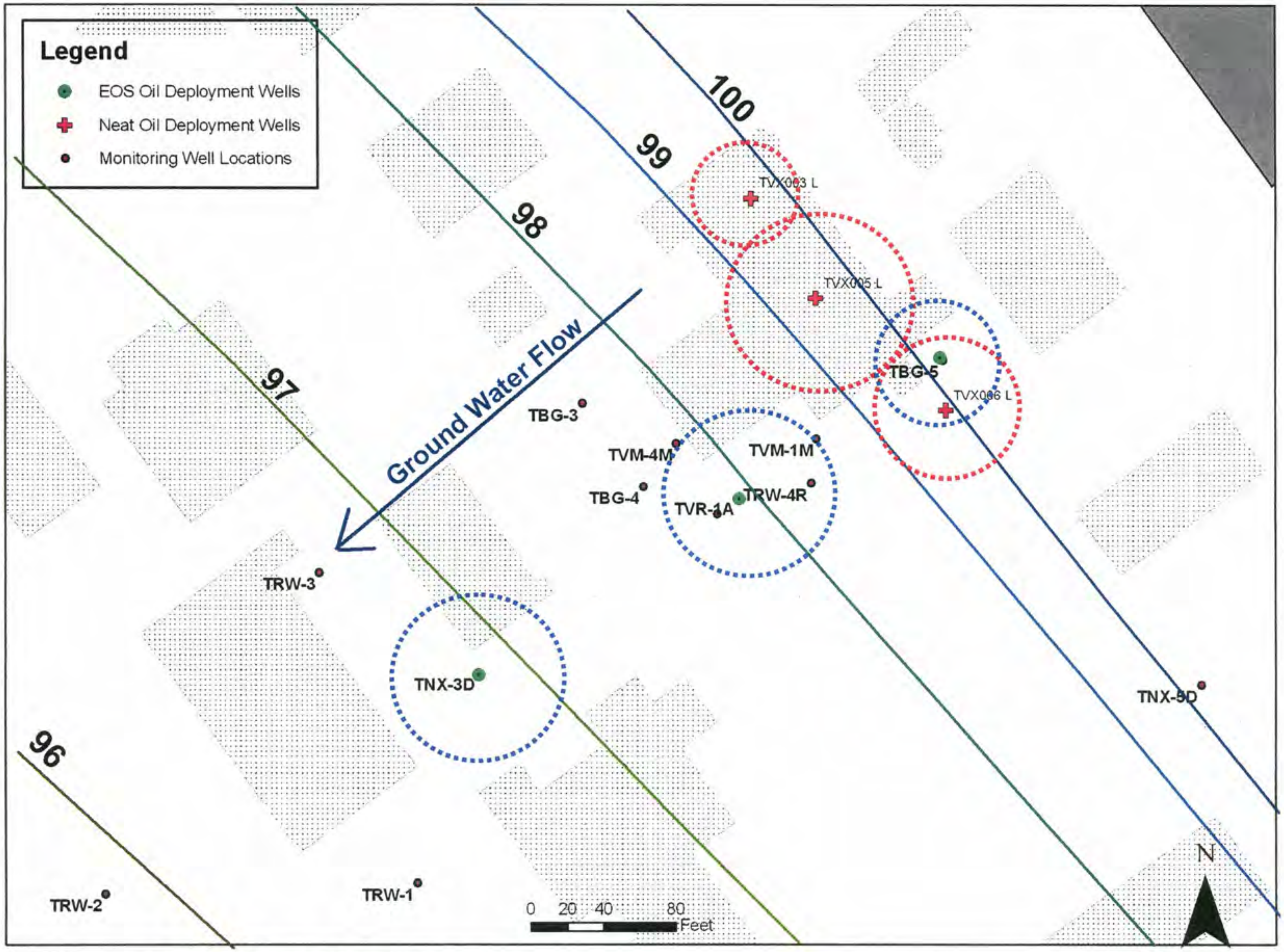

Figure 5. Location of Edible Oil Injection Wells

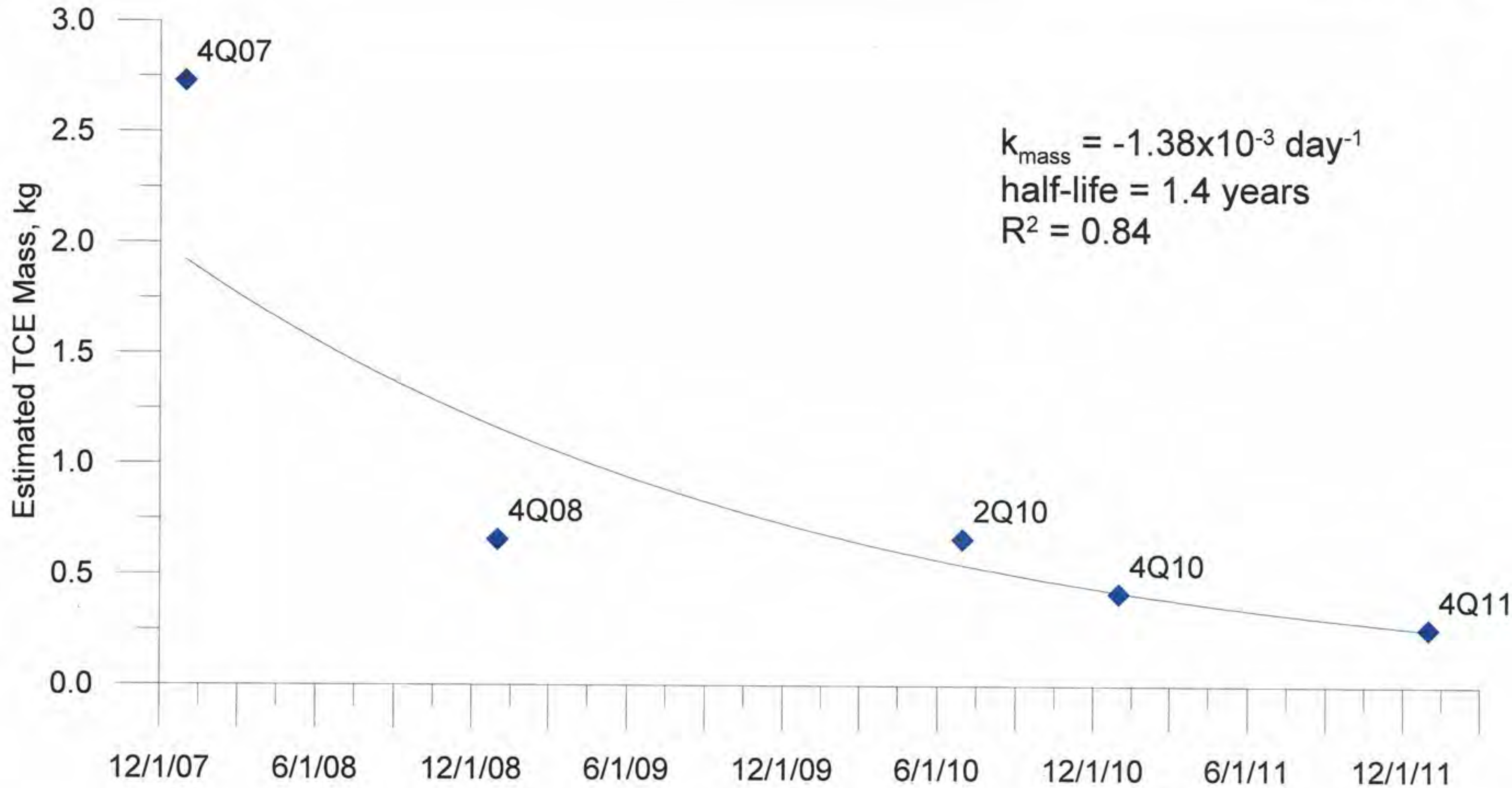

Figure 6. **Estimate of TCE Plume Mass Reduction and Rate**

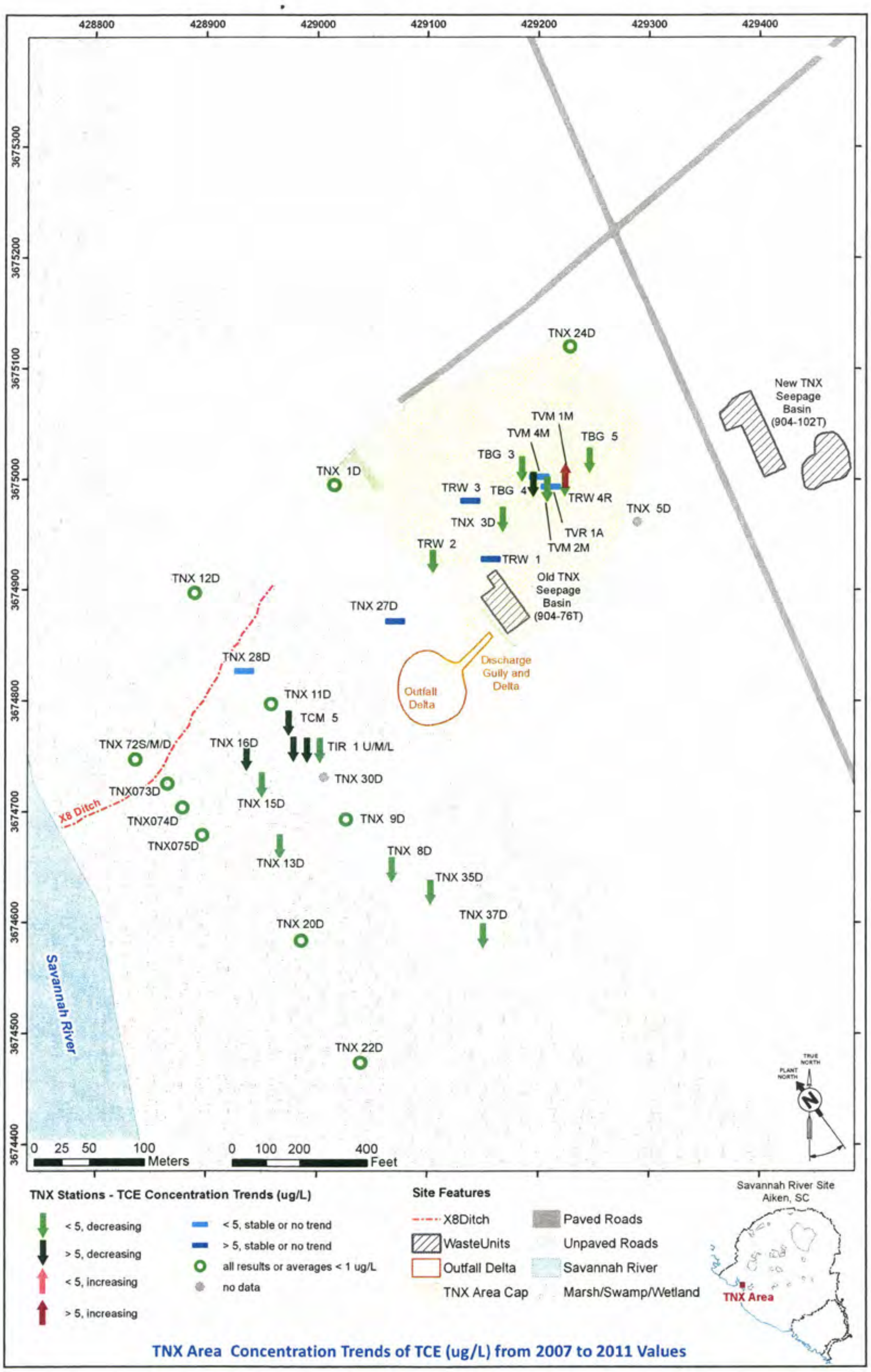

Figure 7. Graphical Trends of TCE Concentration Between 4Q07 to 4Q11

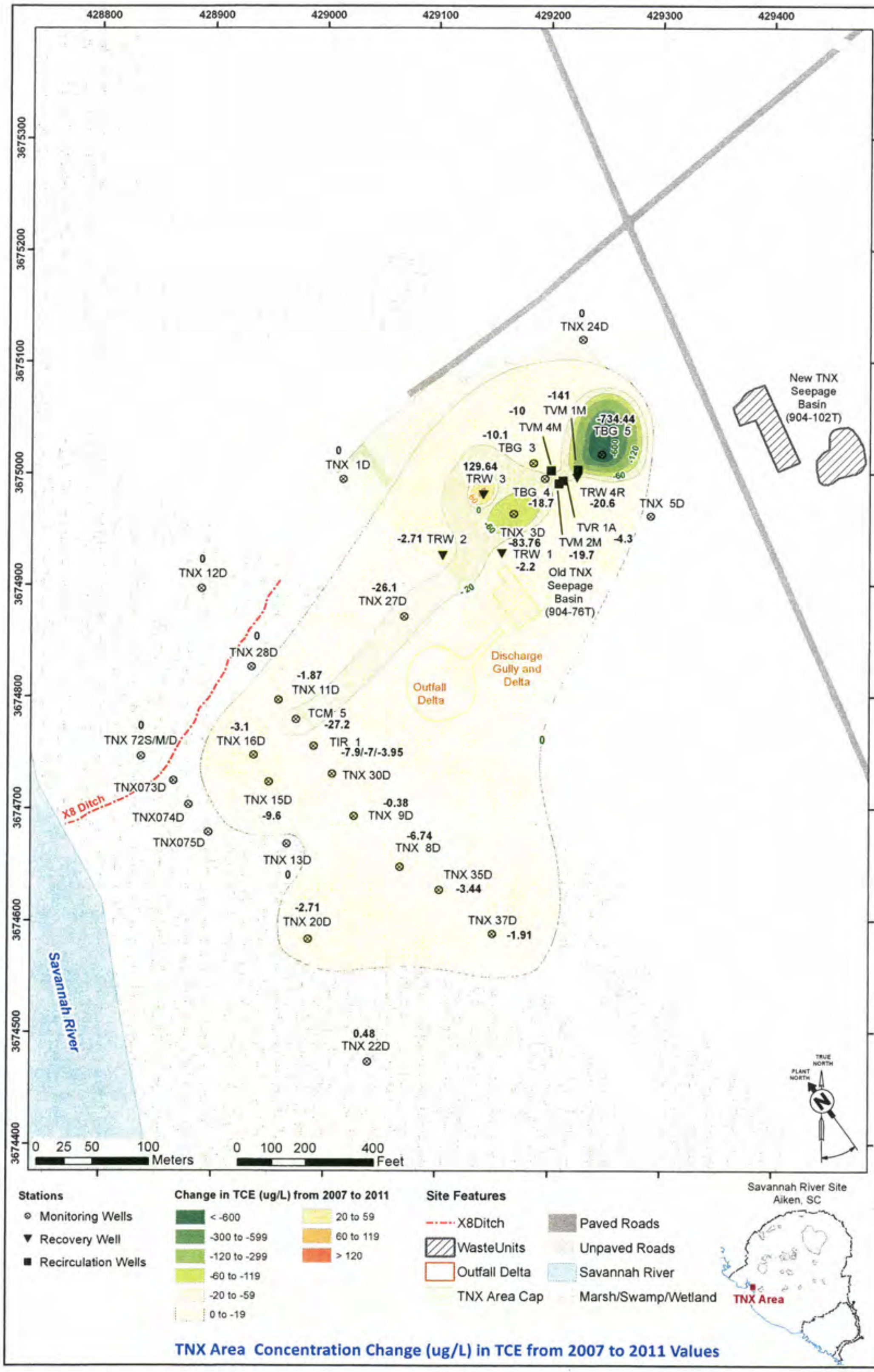

Figure 8. Change in TCE Concentration Between 4Q07 to 4Q11

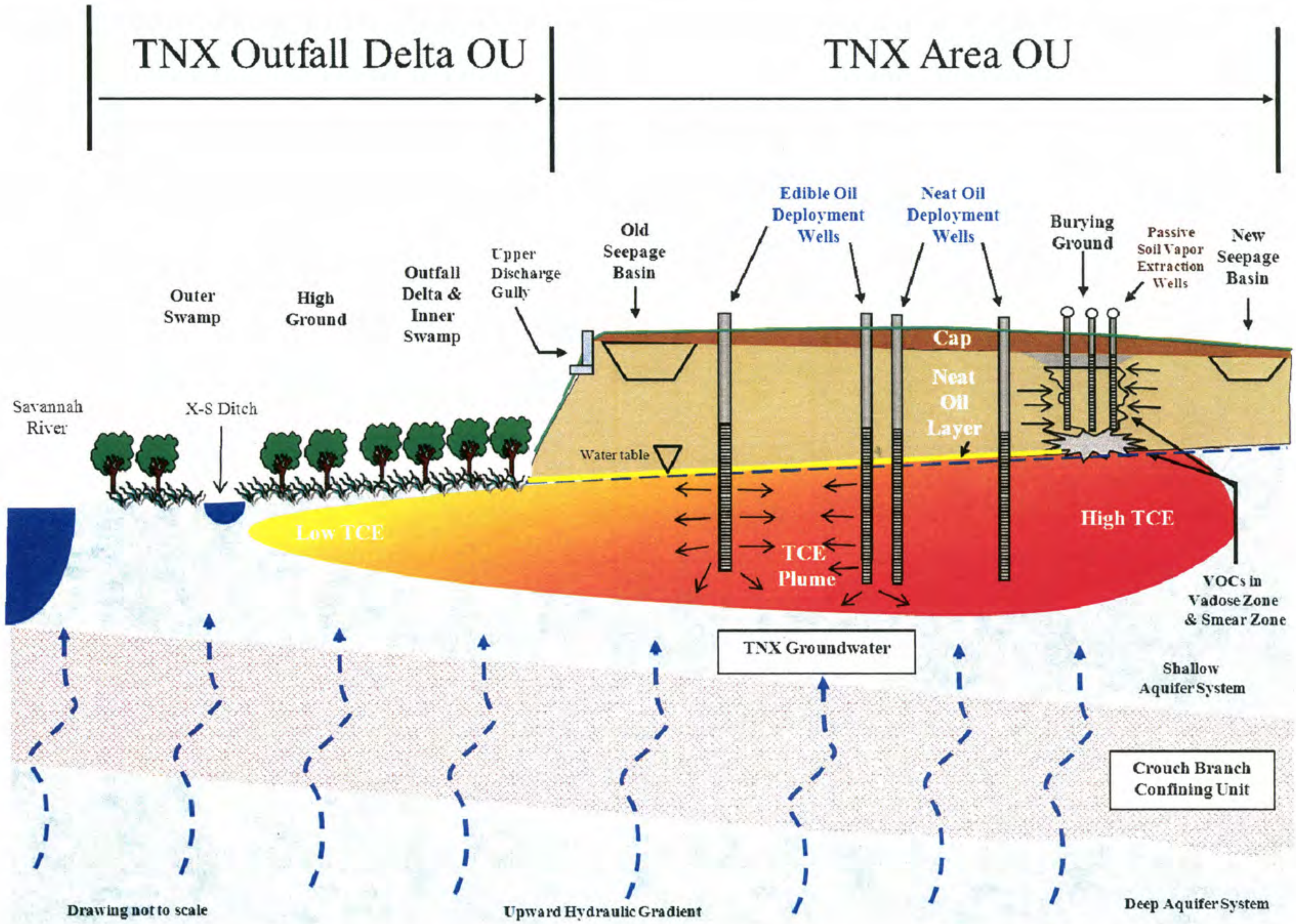

Figure 9. **Schematic Cross Section of TNX Area Operable Units and Remedial Action**

Table 1. Contoured Areas Used to Calculate Mass from the Plume Maps

Date	Area (ft^2) 5 µg/L	Area (ft^2) 50 µg/L	Area (ft^2) 100 µg/L	Area (ft^2) 500 µg/L	TCE Mass (kg)
9Q07	316,262	37,512	72,826	2,637	2.733
4Q08	28,693	7,208	4,958	NA	0.662
2Q10	402,129	31,837	NA	NA	0.667
4Q10	289,151	NA	NA	NA	0.422
4Q11	81,627	NA	NA	NA	0.265

Table 2. Summary of Statistical Trend Analyses

Well ID	Trend	4Q07 TCE µg/L	4Q11 TCE µg/L	Difference µg/L	Average µg/L	Median µg/L	% Change
TBG 3	PD	12.7	2.6	-10.1	25	12	-79.5%
TBG 4	D	33.9	15.2	-18.7	120	36	-55.2%
TBG 5	D	735	0.56	-734.44	41	4	-99.9%
TCM 5	PD	37.2	10	-27.2	14	13	-73.1%
TIR 1L	D	4.36	0.41	-3.95	1.1	0.96	-90.6%
TIR 1M	D	13.5	5.6	-7.9	9.6	10	-58.5%
TIR 1U	D	15.5	8.5	-7	19	20	-45.2%
TNX 1D	D	0	0	0	0.34	0.25	N/A
TNX 3D	D	84.4	0.64	-83.76	2.4	0.27	-99.2%
TNX 8D	D	7.64	0.9	-6.74	1.6	1.5	-88.2%
TNX 9D	S	0.38	0	-0.38	0.29	0.25	-100.0%
TNX 11D	PD	1.87	0	-1.87	0.39	0.37	-100.0%
TNX 12D	ND	0	0	0	0	0	N/A
TNX 13D	PD	0	0	0	0.97	0.76	N/A
TNX 15D	PD	14	4.4	-9.6	11	10	-68.6%
TNX 16D	PD	11.2	8.1	-3.1	15	15	-27.7%
TNX 20D	D	2.71	0	-2.71	0.87	0.94	-100.0%
TNX 22D	PI	0.34	0.82	0.48	0.59	0.71	141.2%
TNX 24D	ND	0	0	0	0	0	N/A
TNX 27D	NT	40.1	14	-26.1	6.5	2.7	-65.1%
TNX 28D	NT	0	0	0	1.4	0.54	N/A
TNX 35D	D	3.44	0	-3.44	0.64	0.71	-100.0%
TNX 37D	PD	5.61	3.7	-1.91	4.2	4.4	-34.0%
TNX 72D	ND	0	0				N/A
TNX 72M	ND	N/S	N/S				N/A
TNX073D	ND	N/S	0				N/A
TNX074D	TR	N/S	0.31				N/A
TNX075D	ND	N/S	0				N/A
TRW 1	S	16.2	14	-2.2	9.6	8.6	-13.6%
TRW 2	D	5.21	2.5	-2.71	16	3.8	-52.0%
TRW 3	NT S	0.36	130	129.64	67	55	36011.1%
TRW 4R	D	20.6	0	-20.6	3.1	1.3	-100.0%
TVM 1M	I	260	119	-141	61	57	-54.2%
TVM 2M	D	20.2	0.5	-19.7	2.1	0.45	-97.5%
TVM 4M	I?	10.3	0.3	-10	1.2	0.54	-97.1%
TVR 1A	I?	6.7	2.4	-4.3	3.6	1.4	-64.2%

Increasing	I	No Trend	NT
Probably Increasing	PI	Not Sample	N/S
Stable	S	Not Applicable	N/A
Probably Decreasing	PD	No Detectable Concentration	ND
Decreasing	D	Trace - J value	TR

Table 3. Action-Specific ARARs – TNX Area Operable Unit

Action	Requirements	Prerequisite	Citation
Underground Injection Well Installation, Operation, and Abandonment			
Reinjection of treated contaminated groundwater, or injection of bioamendments, surfactants, or reagents	Your injection activity cannot allow the movement of fluid containing any contaminant into USDW, if the presence of that contaminant may cause a violation of the primary drinking water standards under 40 *CFR* Part 142 or may otherwise adversely affect the health of persons. This prohibition applies to well construction, operation, maintenance, conversion, plugging, closure, or any other injection activity.	Injection of contaminants into underground source of drinking water – **applicable**	40 CFR 144.82(a)(1) *[Class V wells]*
	The movement of fluids containing wastes or contaminants into underground sources of drinking water as a result of injection is prohibited if the presence of the waste or contaminant: (A) may cause a violation of any drinking water standard under R61-58.5; or (B) may otherwise adversely affect the health of persons.	Injection of contaminants into underground source of drinking water – **applicable**	SCDHEC R.87.5
Monitoring of Class V underground injection wells	An appropriate number of monitoring wells shall be completed into the injection zone and into any underground sources of drinking water which could be affected by the injection operation. These wells shall be located in such a fashion as to detect any excursion of injection fluids, process byproducts, or formation fluids outside the injection area or zone. If the operation may be affected by subsidence or catastrophic collapse the monitoring wells shall be located so that they will not be physically affected.	Operation of well for underground injection of any fluids into the subsurface or ground waters of the State of South Carolina – **applicable**	SCDHEC R.61-87.14(G)(1)
	In determining the number, location, construction and frequency of monitoring of the monitoring wells the following criteria shall be considered: (a) The population relying on the USDW affected or potentially affected by the injection operation; (b) The proximity of the injection operation to points of withdrawal of drinking water; (c) The local geology and hydrology; (d) The operating pressures and whether a negative pressure gradient is being maintained; (e) The nature and volume of the injected fluid, the formation water, and the process byproducts; and (f) The injection well density.		SCDHEC R.61-87.14(G)(2)

Table 3. Action-Specific ARARs – TNX Area Operable Unit *(Continued/End)*

Action	Requirements	Prerequisite	Citation
Underground Injection Well Installation, Operation, and Abandonment			
Monitoring of Class V underground injection wells *(Contd)*	Monitoring requirements shall, at a minimum, specify: (a) Monitoring of the nature of injected fluids with metering and daily recording of injected and produced fluid volumes as appropriate; (b) Monitoring of injection pressure and either flow rate or volume semimonthly, or metering and daily recording of injected and produce fluid, volumes as appropriate; (c) Demonstration of mechanical integrity at least once every five years during the life of the well; (d) Monitoring of the fluid level in the injection zone semimonthly, where appropriate and monitoring of the parameters chosen to measure water quality in the monitoring wells semimonthly		SCDHEC R.61-87.14(G)(3)
Operation and maintenance of Class V underground injection wells	Shall at all times properly operate and maintain all facilities and systems of treatment and controls which are installed or used.	Operation of well for underground injection of any fluids into the subsurface or ground waters of the State of South Carolina – **applicable**	SCDHEC R.61-87.13(X)
	Shall report malfunction of injection system which may cause fluid migration into or between underground sources of drinking water; shall immediately stop injection upon determination that the injection system has malfunctioned and could cause fluid migration into or between underground sources of drinking water; shall not restart the injection system until the malfunction has been corrected.		SCDHEC R.61-87.13(EE)
Closure of Class V underground injections wells	Wells must be closed in a manner that complies with the prohibition of fluid movement in 40 CFR 144.82(a)(l). Also, any soil, gravel, sludge, liquids, or other materials removed from or adjacent to the well must be disposed or otherwise managed in accordance with substantive applicable Federal, State, and local regulations and requirements.	Closure of Class V wells [as defined in 40 CFR 144.6(e)] – **applicable**	40 CFR 144.82(b)
Construction and abandonment of all underground injection wells	Minimum standards for construction and abandonment of injection wells are as those stated for all wells in the SC Well Standards and Regulations (SCDHEC R.61-71).	Operation of well for underground injection of any fluids into the subsurface or ground waters of the State of South Carolina – **applicable**	SCDHEC R.61-87.3

ARAR = applicable or relevant and appropriate requirement
EPA = U.S. Environmental Protection Agency
CERCLA =Comprehensive Environmental Response Compensation and Liability Act, 42 U.S.C. §9601 et seq.
SCDHEC =South Carolina Department of Health and Environmental Control
USDW = Underground Source of Drinking Water
CFR = *Code of Federal Regulations*

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