CASE STUDY

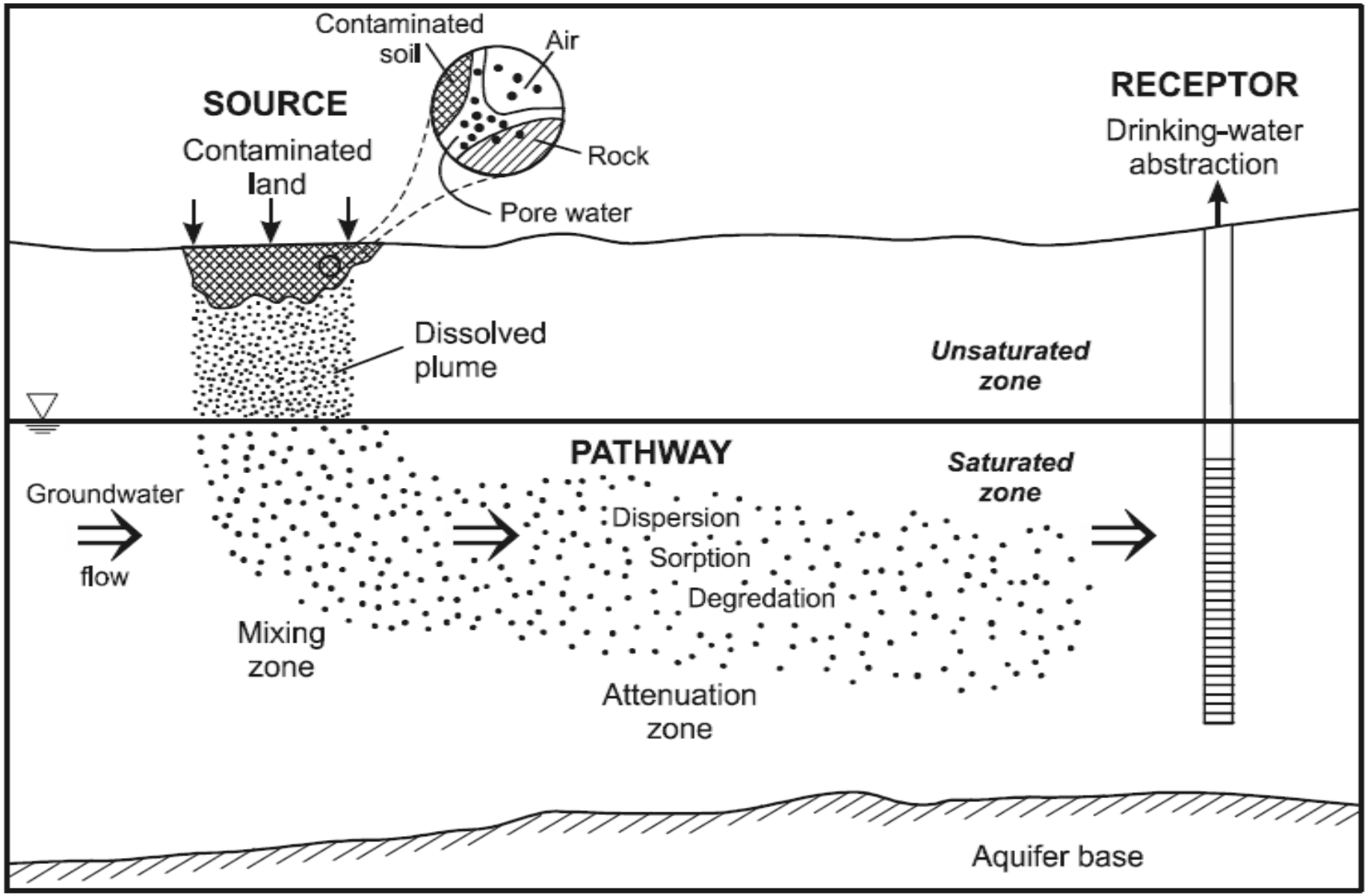
In my thirty years of consulting, conducted Environmental and Social Impact assessments, Environmental, Health and Safety Audits, Soil and Ground Water Quality investigations and Remediation projects as well as Waste Management Studies. In particular:

Soil and Ground Water Investigations: Performed numerous soil and ground water investigations for multinational oil and gas companies, Turkish refinery sector. Conducted several remedial projects to clean up soil and groundwater contaminated media.

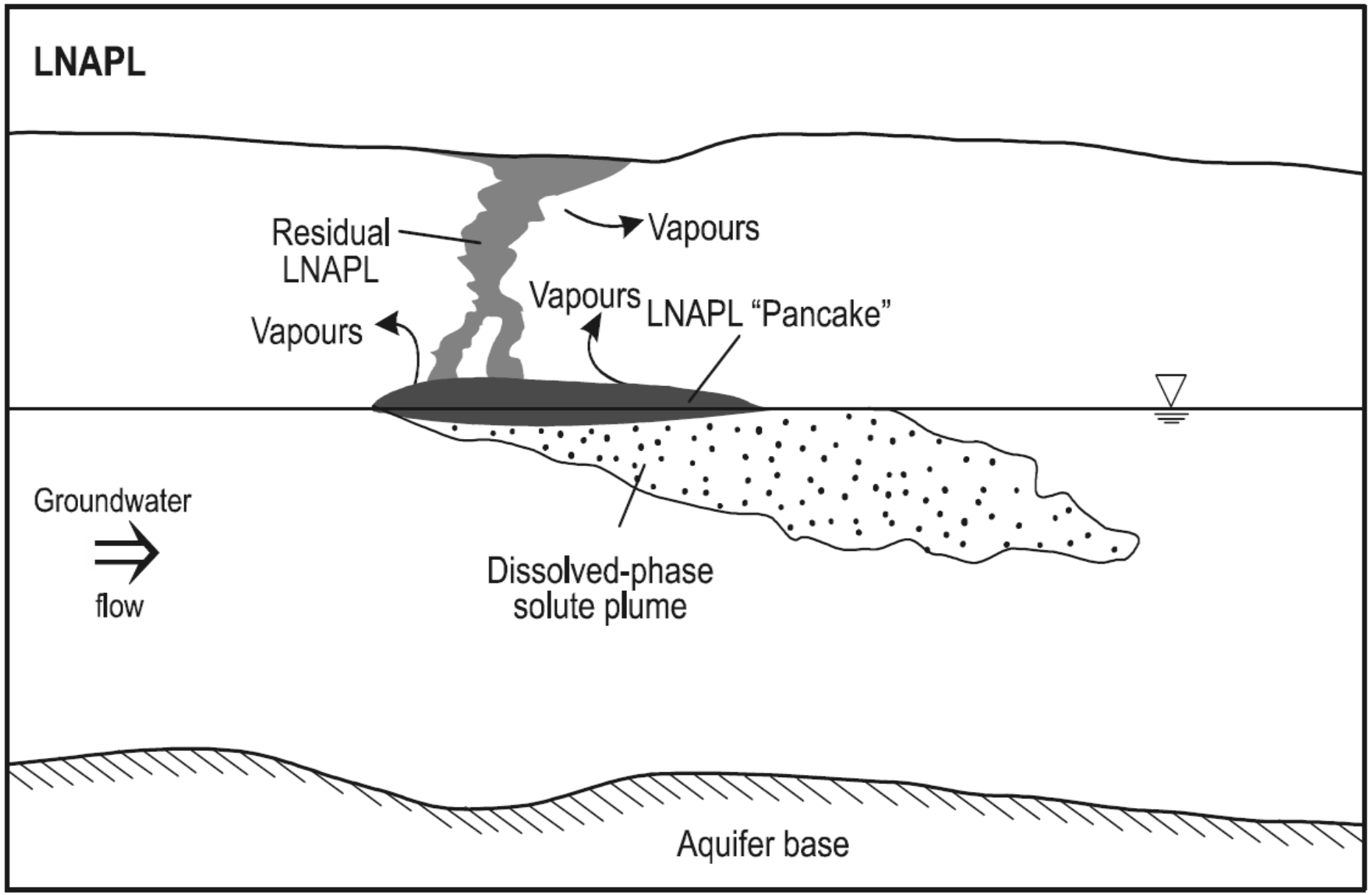
Worked on Superfund Projects in the US for 5 years on soil and ground water remediation

Full Professor, Civil Engineering Department
Hydraulics Division, Boğaziçi University
Istanbul, Turkey

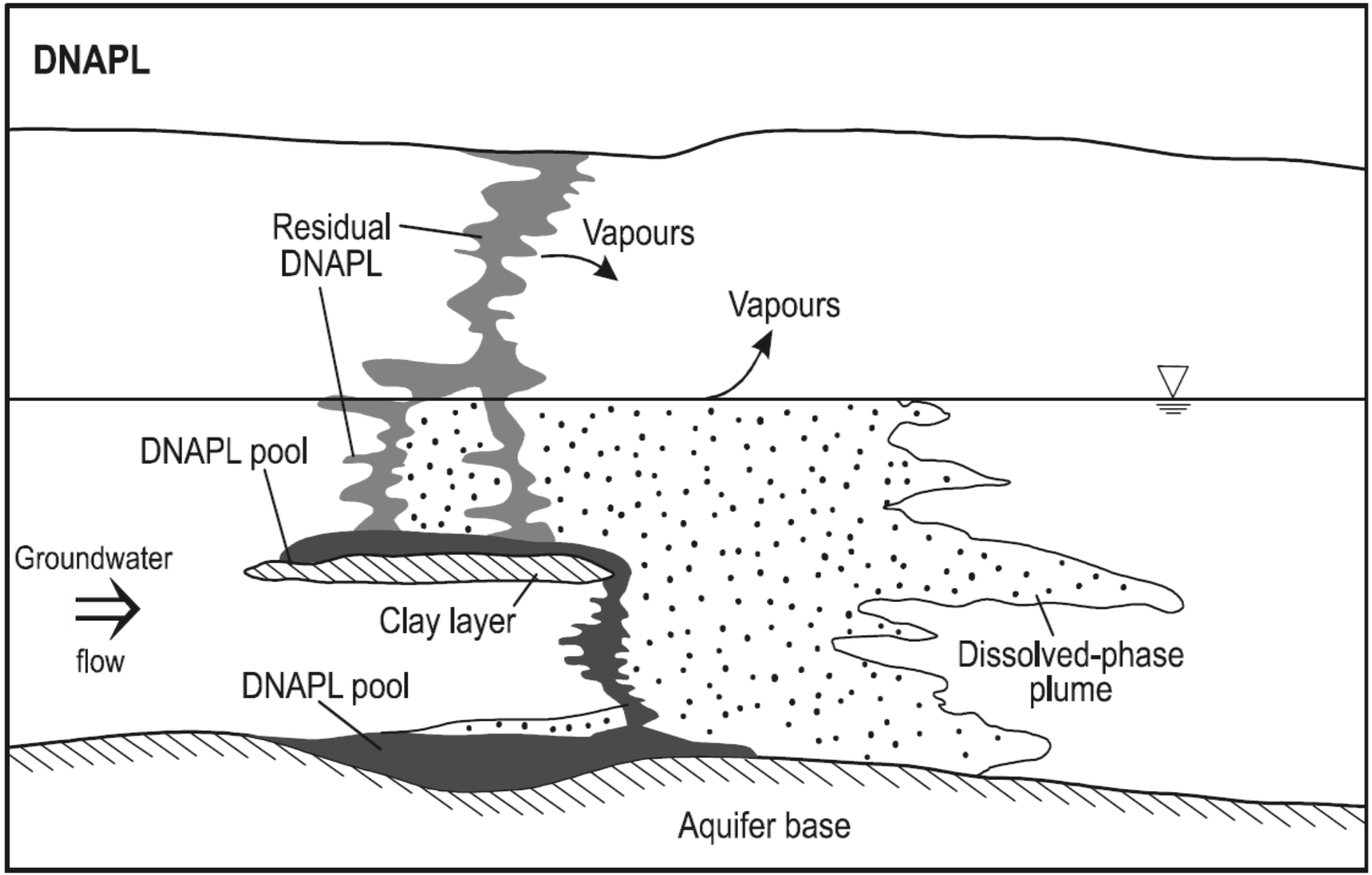
Classical contaminant conceptual model



LNAPL (light non-aqueous phase liquid; *e.g.* petrol, benzene)

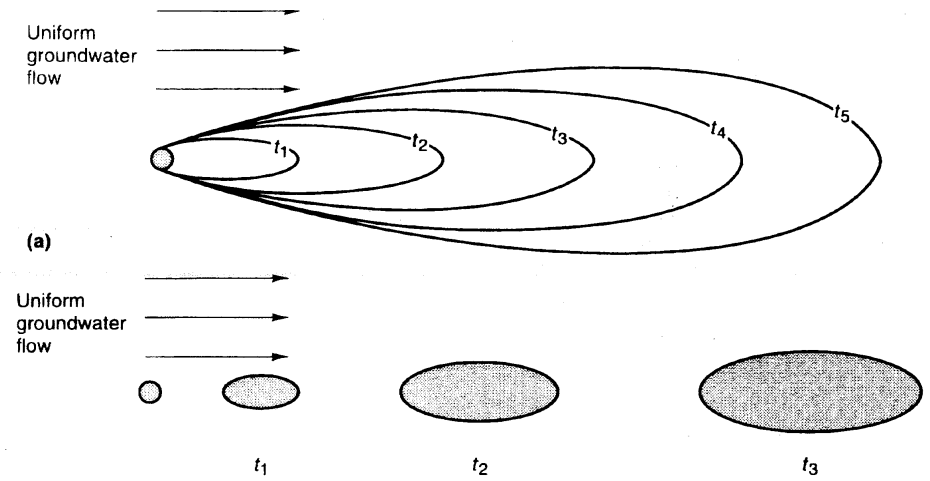


DNAPL (Dense non-aqueous phase liquid, e.g. heavy oils)



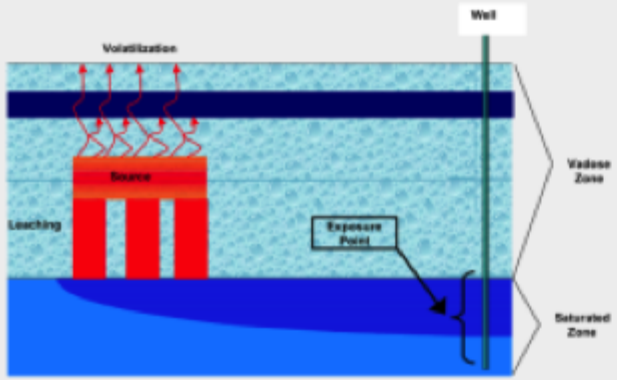
FATE OF POLLUTANTS IN GROUNDWATER

Groundwater flow cm's/day (much less in clay)



- Adsorption/precipitation (but for *e.g.* NO_3^- unhindered flows)
- Microbiological degradation (*e.g.* BOD; also die-off of bacteria)
- Complexation, redox reactions, *etc.* (*e.g.* $Fe^{2+} \rightarrow Fe^{3+} \rightarrow Fe(OH)_{3\downarrow}$)

Problem Modeling Type



Type of release

- (●) A1 - Continuous in Unsatured

RISC van Genuchten and Alves (1982) Eq. (A-5)

UNLU- Steady State
Unlu et al 1992 . A screening model for effects of land-disposed wastes on groundwater quality. Journal of Contaminant Hydrology 11 (1-2), 27-49

ASTM - Steady State - Equilibrium Partitioning

Van Genuchten, M. Th., and W. J. Alves. 1982. Analytical solutions of the one-dimensional convective-dispersive solute transport equation. Tech. Bulletin 1661. Washington, D.C.: USDA-ARS

- ( ) B1 - Continuous in Satured

Domenico, P.A. 1987. An analytical model for multidimensional transport of a decaying contaminant species. Journal of Hydrology 91, no. 1-2: 49-58

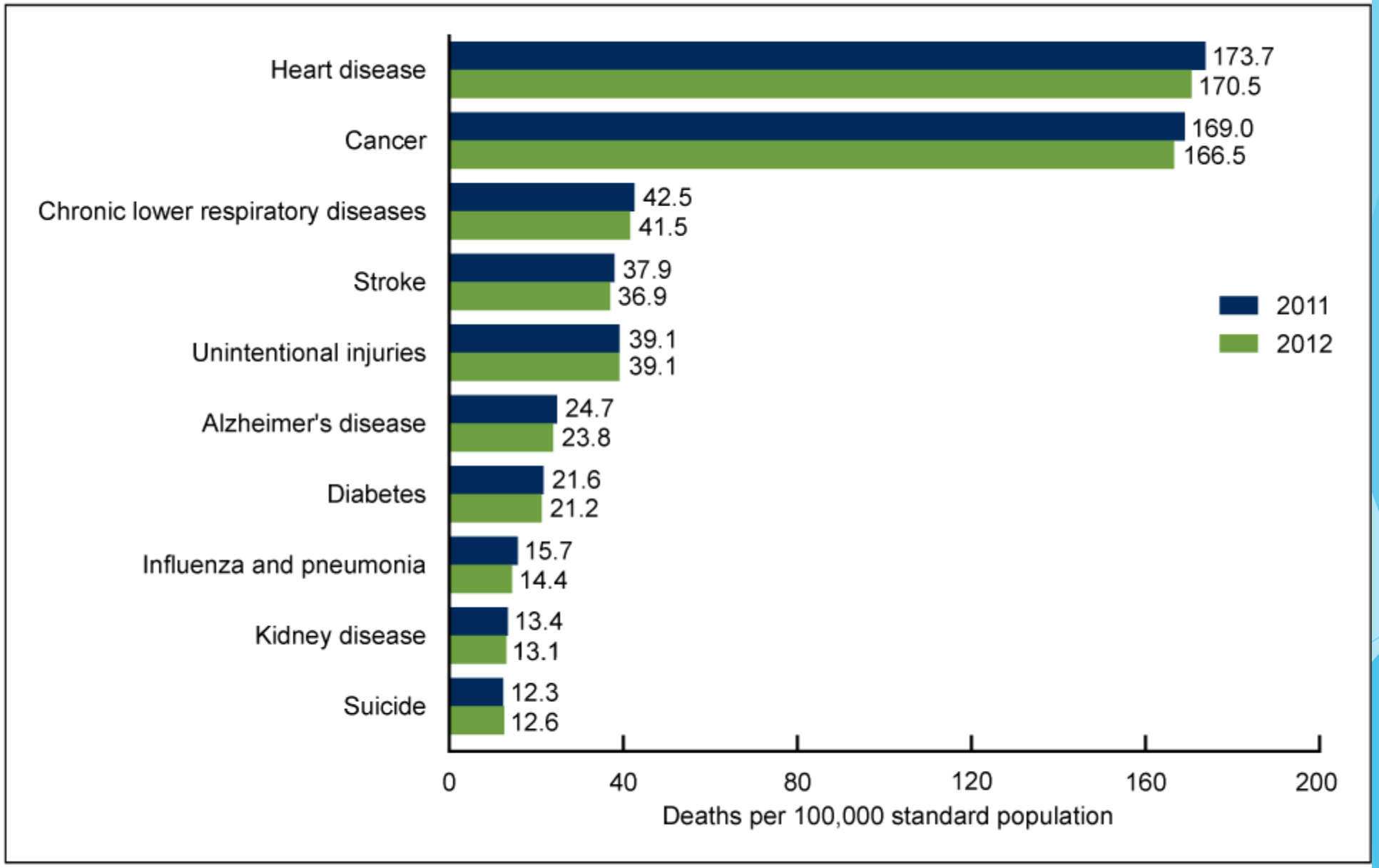
- ( ) A2 - Instantaneous in Unsatured

- ( ) B2 - Instantaneous in Satured

Baestlé, quoted in Domenico, P.A., Schwartz, F.W., Physical and Chemical Hydrogeology, Wiley, New York,

Ok Cancel

Figure 3. Age-adjusted death rates for the 10 leading causes of death in 2012: United States, 2011–2012



NOTE: Access data table for Figure 3 at: http://www.cdc.gov/nchs/data/databriefs/db168_table.pdf#1.
SOURCE: CDC/NCHS, National Vital Statistics System, Mortality.

PRODUCT SPILL IMPACTED HSE ABATTEMENT PROJECT

SCOPE OF PRESENTATION

Retail Store Site Setting

Spill Event

Spill Mechanism

Chronology up to Spill Confirmation

Site Survey

Contaminant Migration

HSE Abbatement Program

Situation Overview

RETAIL STORE SITE SETTING

RETAIL STORE SITE SETTING

RETAIL STORE SITE SETTING

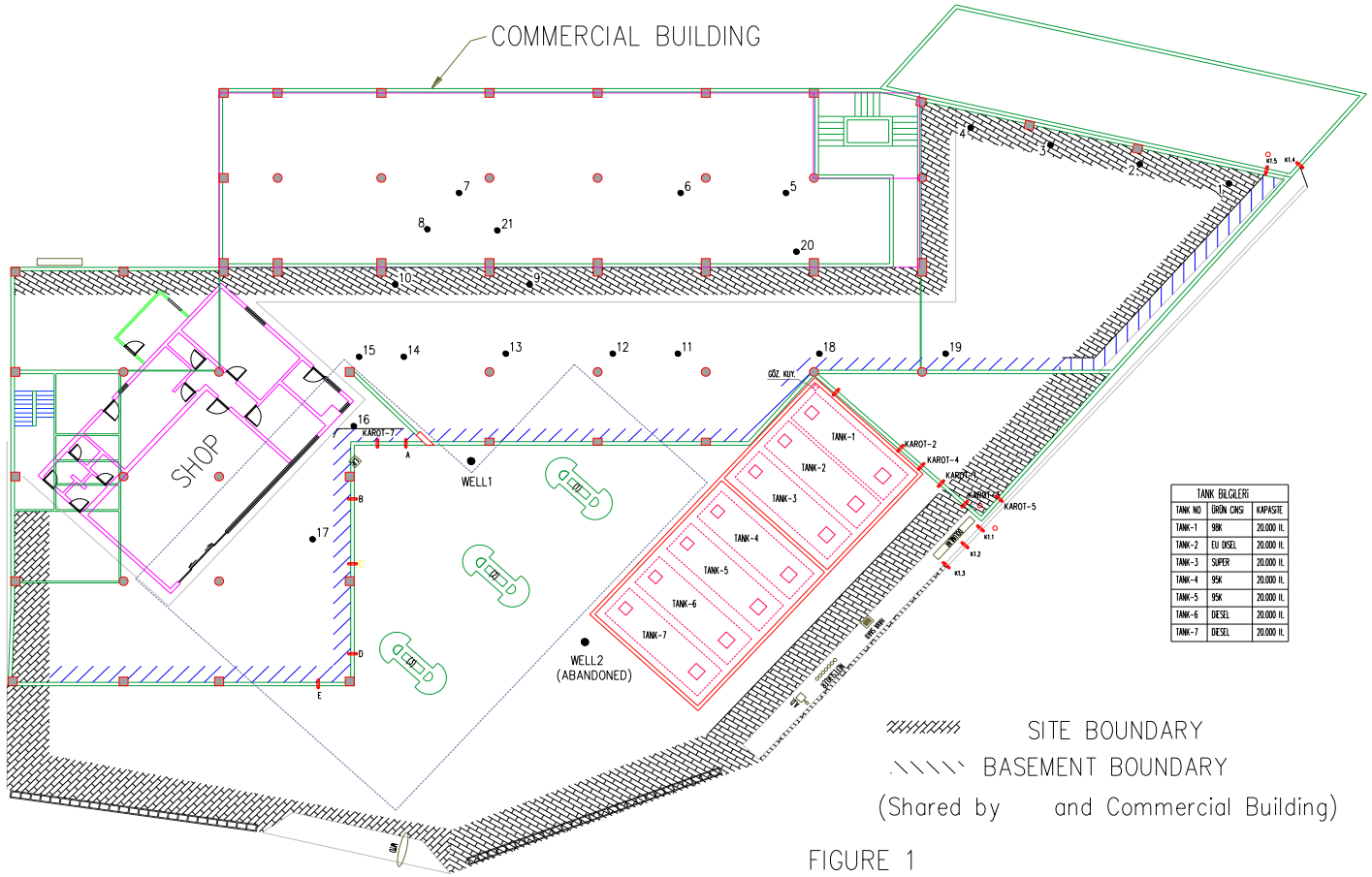
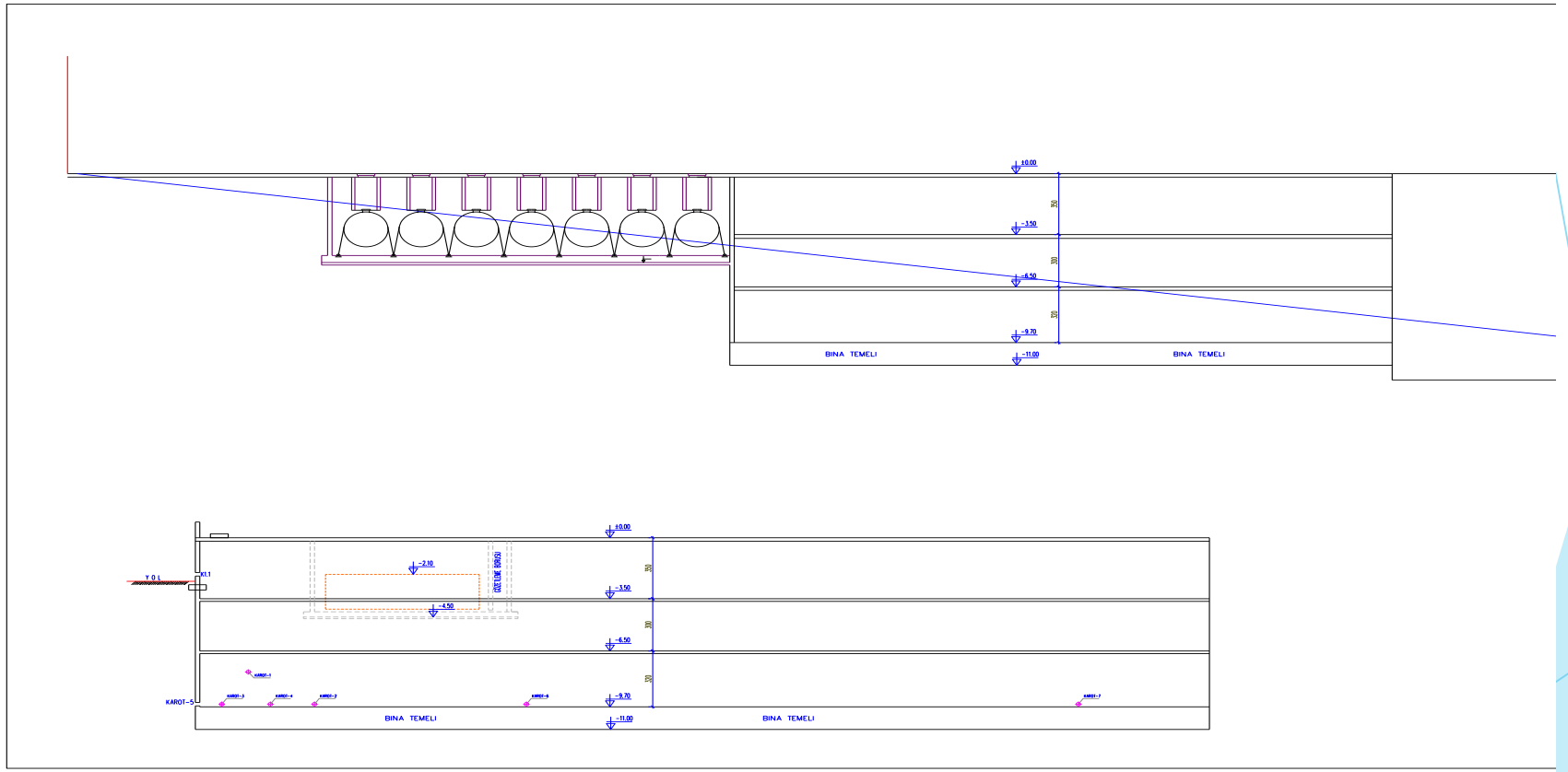


FIGURE 1

RETAIL STORE SITE SETTING

RETAIL STORE SITE SETTING



SPILL EVENT

Overfill into Single Underground Tank

8920 ltr Gasoline (95 Octane)

Secondary Transport 29 May 2005 Night Shift

Mechanism:

- Overfill into Tank
- Filling of Tank Manhole
- Overspill into tank farm
- Escape into surrounding soil

SPILL EVENT

Preventative Mechanism Performance

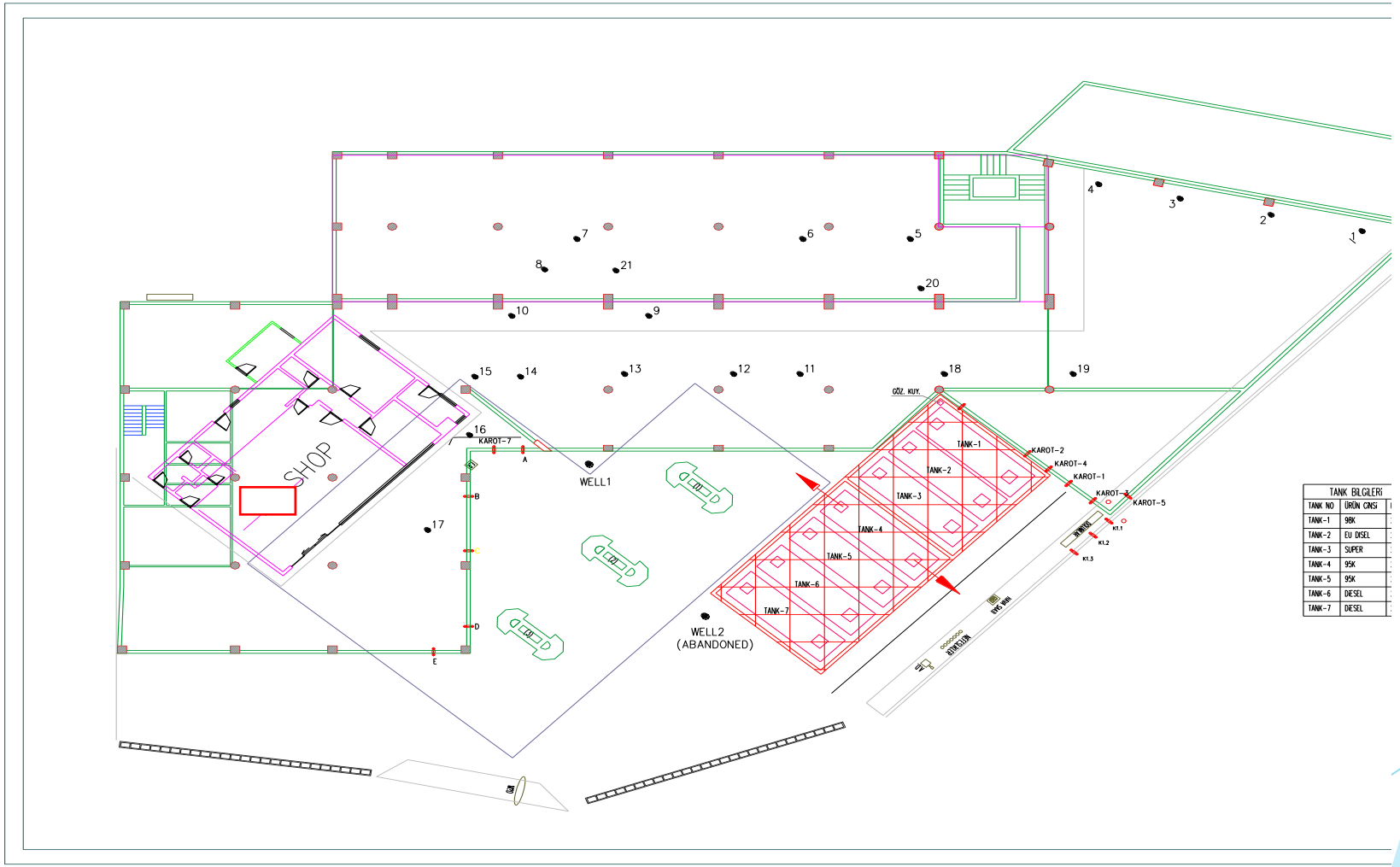
Overfill Protection Valve: malfunction

Audible Alarm on forecourt: chip missing

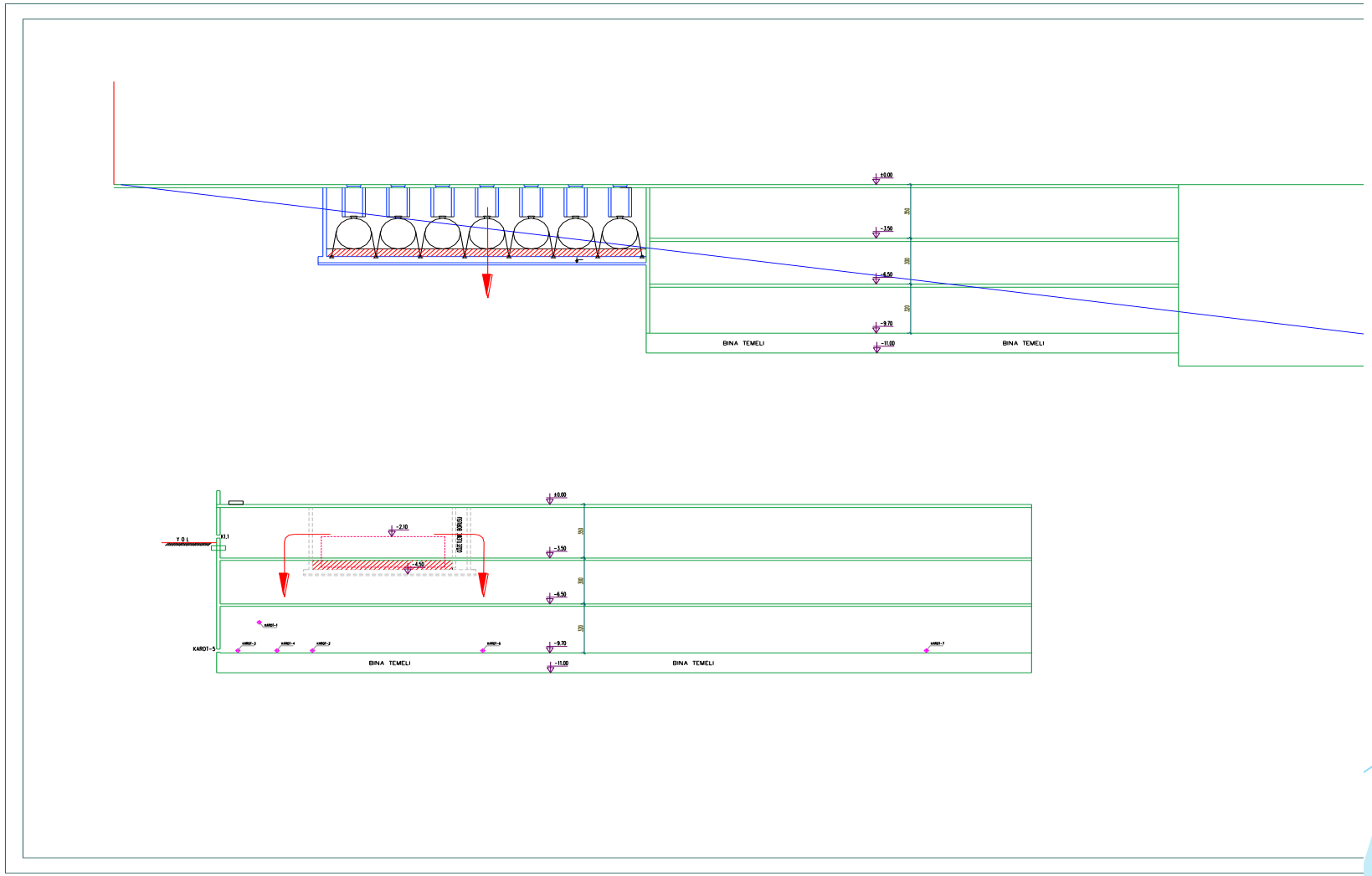
Tank Manhole Integrity: breached

Tank Farm Integrity: breached

SPILL MECHANISM



SPILL MECHANISM



SPILL MECHANISM

SPILL MECHANISM

SPILL MECHANISM

CHRONOLOGY UP TO SPILL CONFIRMATION

Dealer indicated mismatch of 9000 liters with ST on product delivery

18 June : Investigation started on potential spill check preventive measures

Found product in tank farm

Analyzed product found in basement and basement

Tested integrity of tanks, integrity of manhole OPV system

Established contaminated fill presence within tank farm area

6 July : Decision to close site and renovate

7 July-3August: Site renovation work performed

SITE SURVEY SUMMARY

Drilling of six soil deep boreholes in forecourt and side road

Installing four monitoring wells capable of ground water extraction

Drilling of twenty five shallow vertical boreholes in second level basement

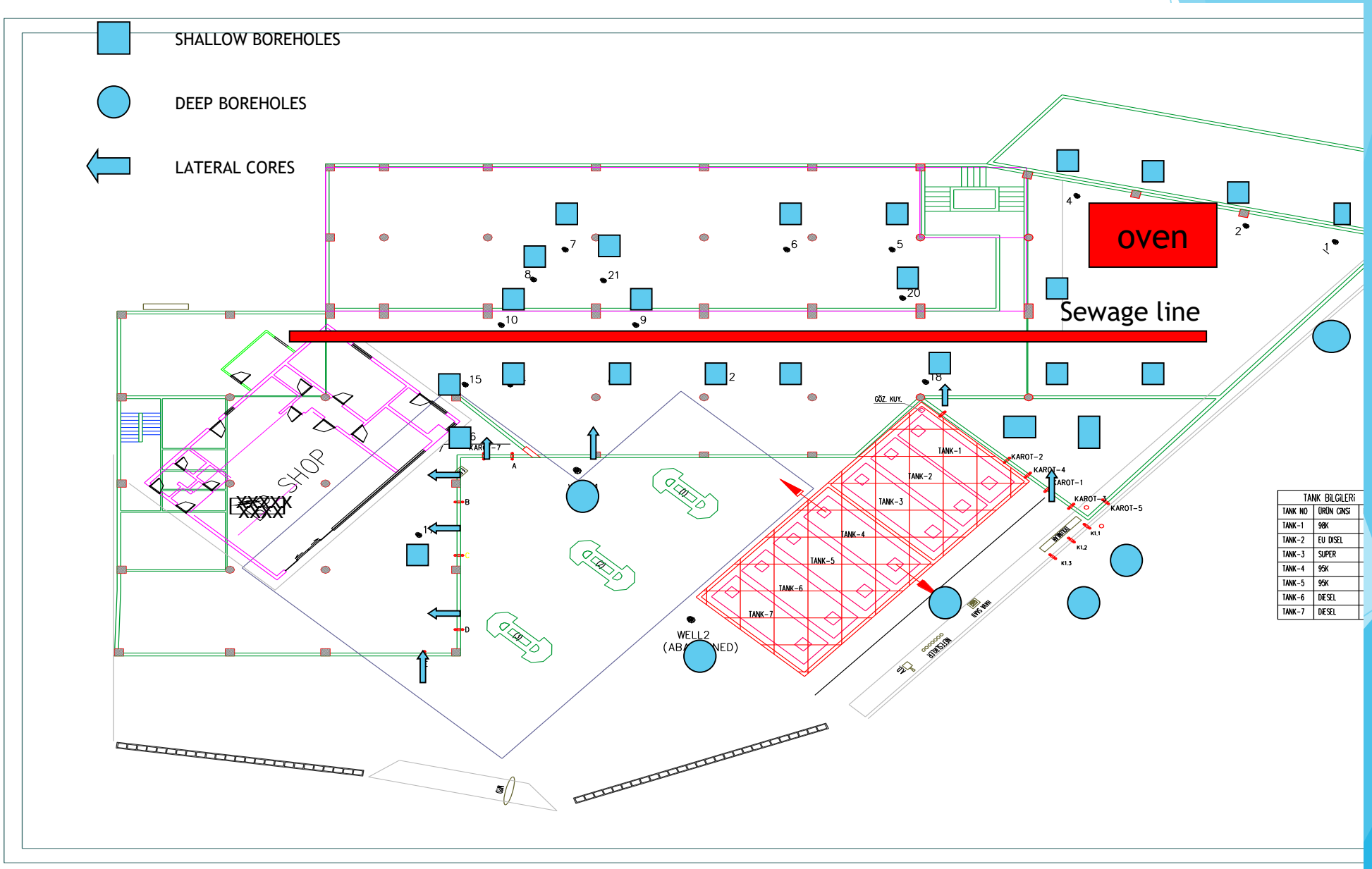
Drilling of eight lateral cores into retaining wall

Drilling of three inclined cores into building basement

Pumping tests performed in forecourt and side road wells

TPH and soil gas measurements in all sampling locations

Pumping tests for SVE systems


SHALLOW BOREHOLES
DEEP BOREHOLES
LATERAL CORES
oven
Sewage line
SHOP
WELL2
TANK-1
TANK-2
TANK-3
TANK-4
TANK-5
TANK-6
TANK-7
KAROT-1
KAROT-2
KAROT-3
KAROT-4
KAROT-5
TANK BİLGİLERİ
TANK NO
ÜRÜN CİNSİ
TANK-1 98K
TANK-2 EU DİSEL
TANK-3 SUPER
TANK-4 95K
TANK-5 95K
TANK-6 DİESEL
TANK-7 DİESEL

SITE SURVEY

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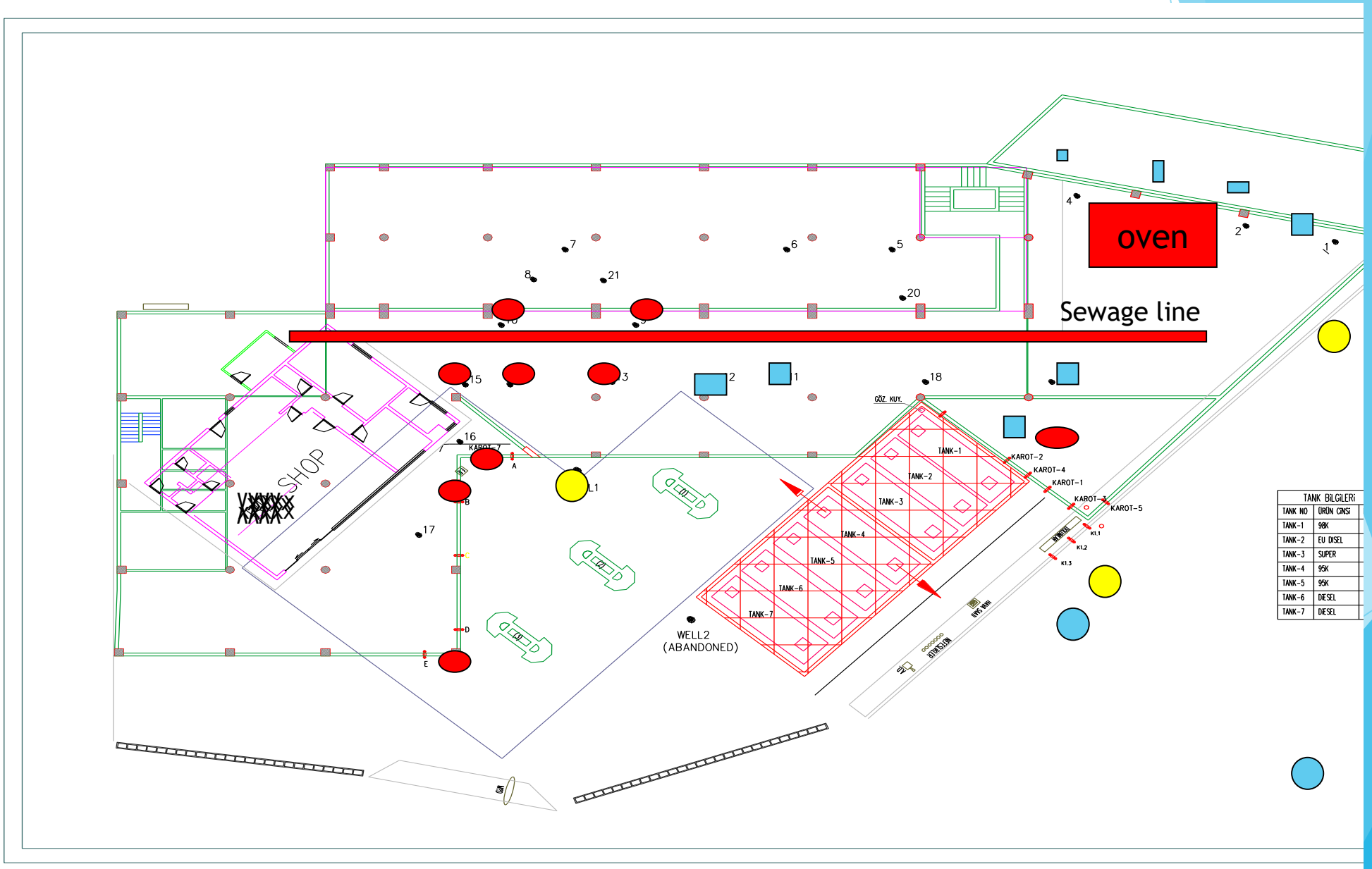
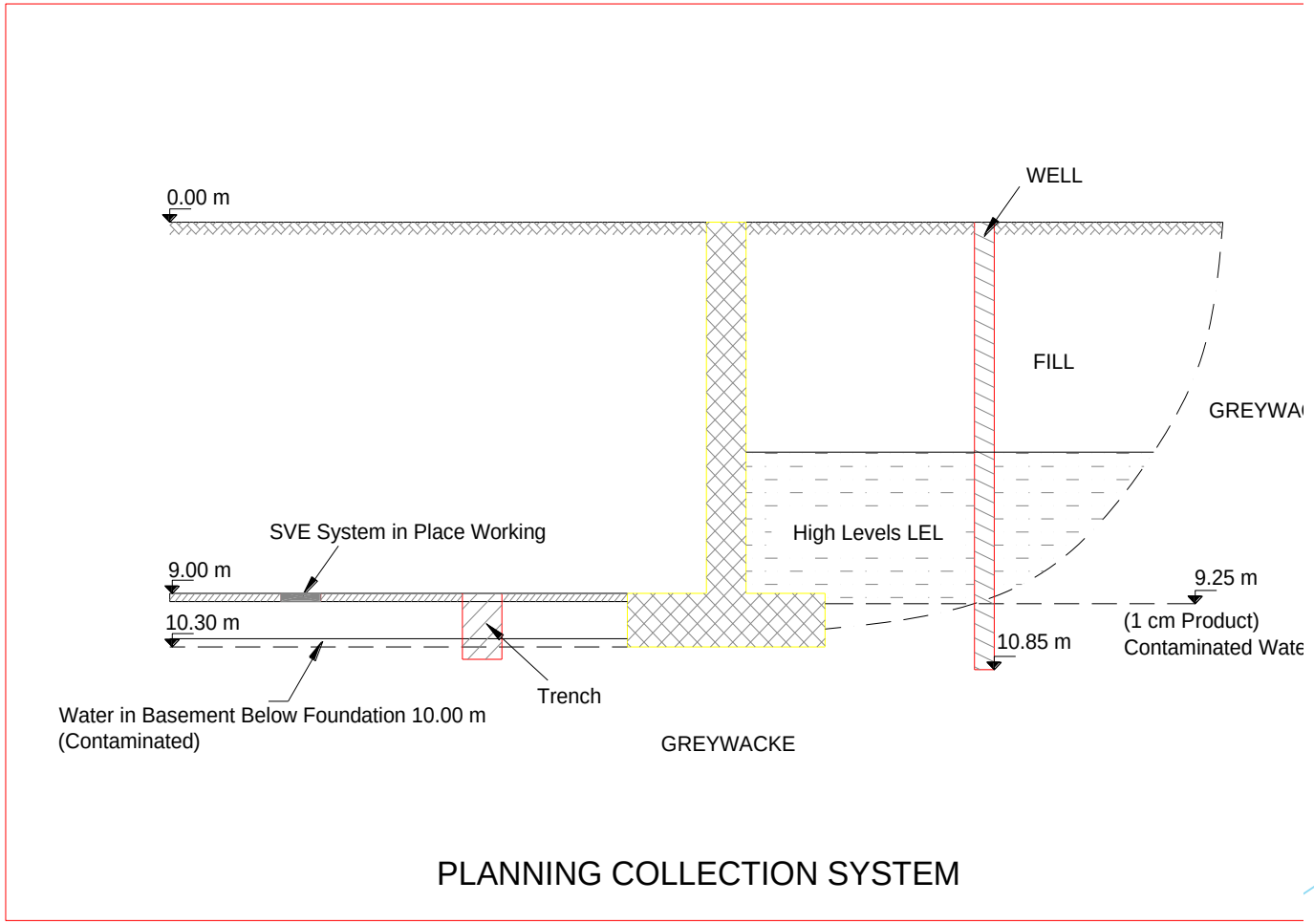
SITE SURVEY


oven
Sewage line
SHOP
WELL2
(ABANDONED)
TANK-1
TANK-2
TANK-3
TANK-4
TANK-5
TANK-6
TANK-7
KAROT-1
KAROT-2
KAROT-3
KAROT-4
KAROT-5
GÖZ. KUY.
TANK BİLGİLERİ
TANK NO
ÜRÜN CİNSİ
TANK-1 98K
TANK-2 EU DİSEL
TANK-3 SUPER
TANK-4 95K
TANK-5 95K
TANK-6 DİESEL
TANK-7 DİESEL

CONTAMINATION MIGRATION

CONTAMINANT MIGRATION

SPILL MECHANISM



PLANNING COLLECTION SYSTEM

MASS BALANCE ESTIMATIONS

Company has requested an explanation of the fate of the 9000 litres spill that has occurred in the retail store.

To be able to do this in a scientific and technically sound manner, one should have had the chance to collect detailed information on the subsoil of the retail store, taken detailed information on the level of saturation within the fill in the tank farm area, have detailed monitoring wells in the forecourt area with identification of free product thickness.

None of the above has been collected due a number of reasons including the need to conduct emergency excavation of the tank farm and tank replacement as well as rehabilitation of the forecourt. However, an educated approach would include the following four major conditions where the product was/is stored following the spill:

Condition 1: as free liquid in the tank farm area (evidence found)
Condition 2: absorbed in the fill material in the tank farm area (evidence found)
Condition 3: suspended in the fill material unsaturated zone (zone above the water table) underneath the forecourt area (evidence found)
Condition 4: free product above the water table in the fill material underneath the forecourt area (evidence found)
Condition 5: product located within the natural soil (greywacke) underneath the retail store

MASS BALANCE ESTIMATIONS

The distribution of the 9000 litres in the above mentioned conditions is very difficult to guess. One scenario could be as follows:

Condition 1: Up to 200 litres were collected as free product from the tank farm area

Condition 2: Up to 40 cm of fill material thickness was seen to be soaked with gasoline product during the tank excavation area. Let us say that an average 20 cm thickness of the fill material was to contain the gasoline product within its pore space. The tank farm area would hold 7200 liters

Condition 4: free product accumulation in the monitoring well may be equivalent to 2-4 cm of actual free product in the fill material. Porosity may be taken as 0.3 and the areal extent of the product may be 30-50 m2. The resulting 180- 600 litres may be on top of the water table in the fill material.

The rest of the material is likely to be in the Condition 3 and Condition 5 conditions. Condition 3 which is the free product suspended in the unsaturated zone (zone above the fill water table) is known to be present. An estimate is difficult to provide at this point.

ABATEMENT PROGRAM

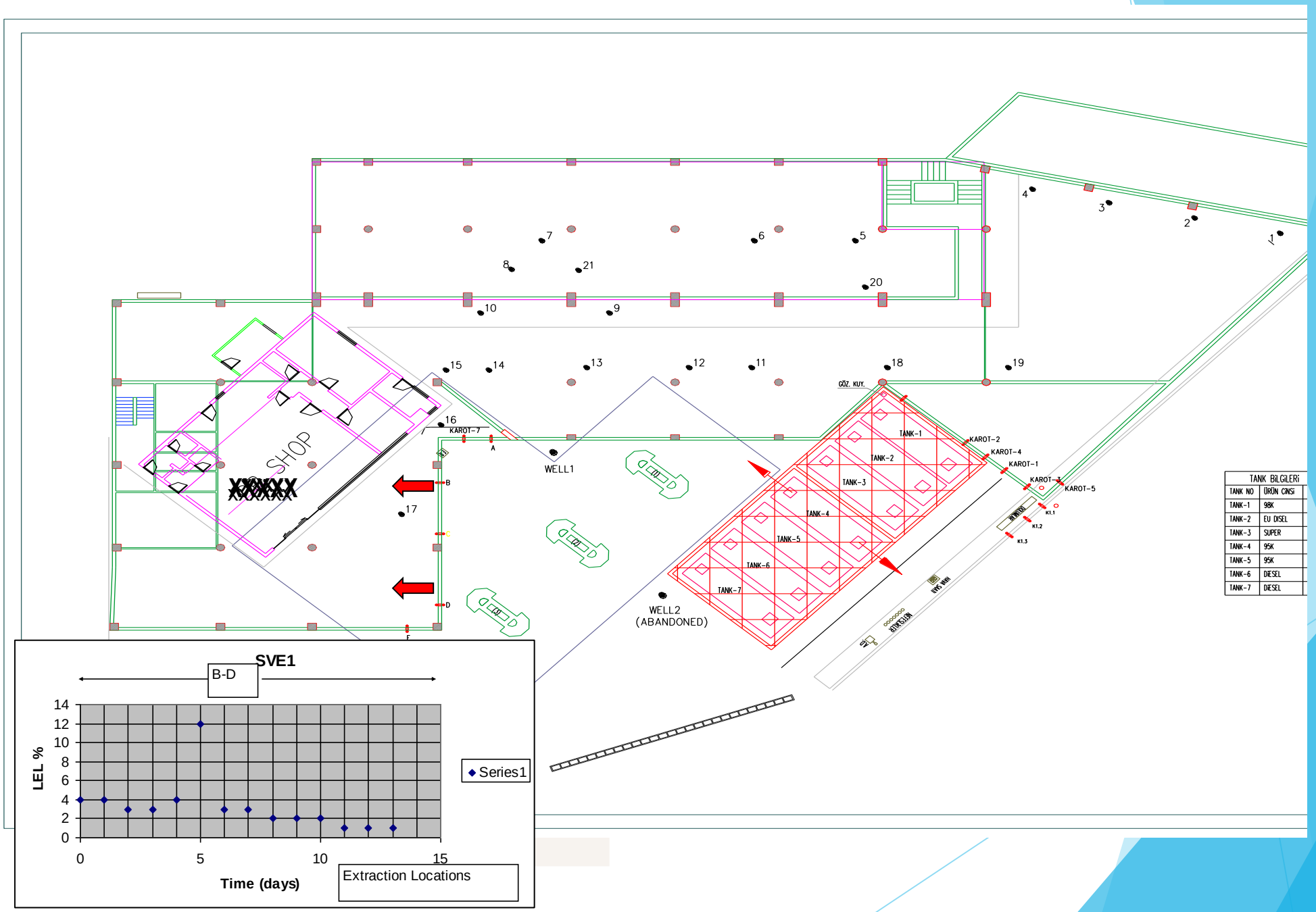
Soil Vapor Extraction System Operations

Free Product and Ground water Extraction in Fill Material

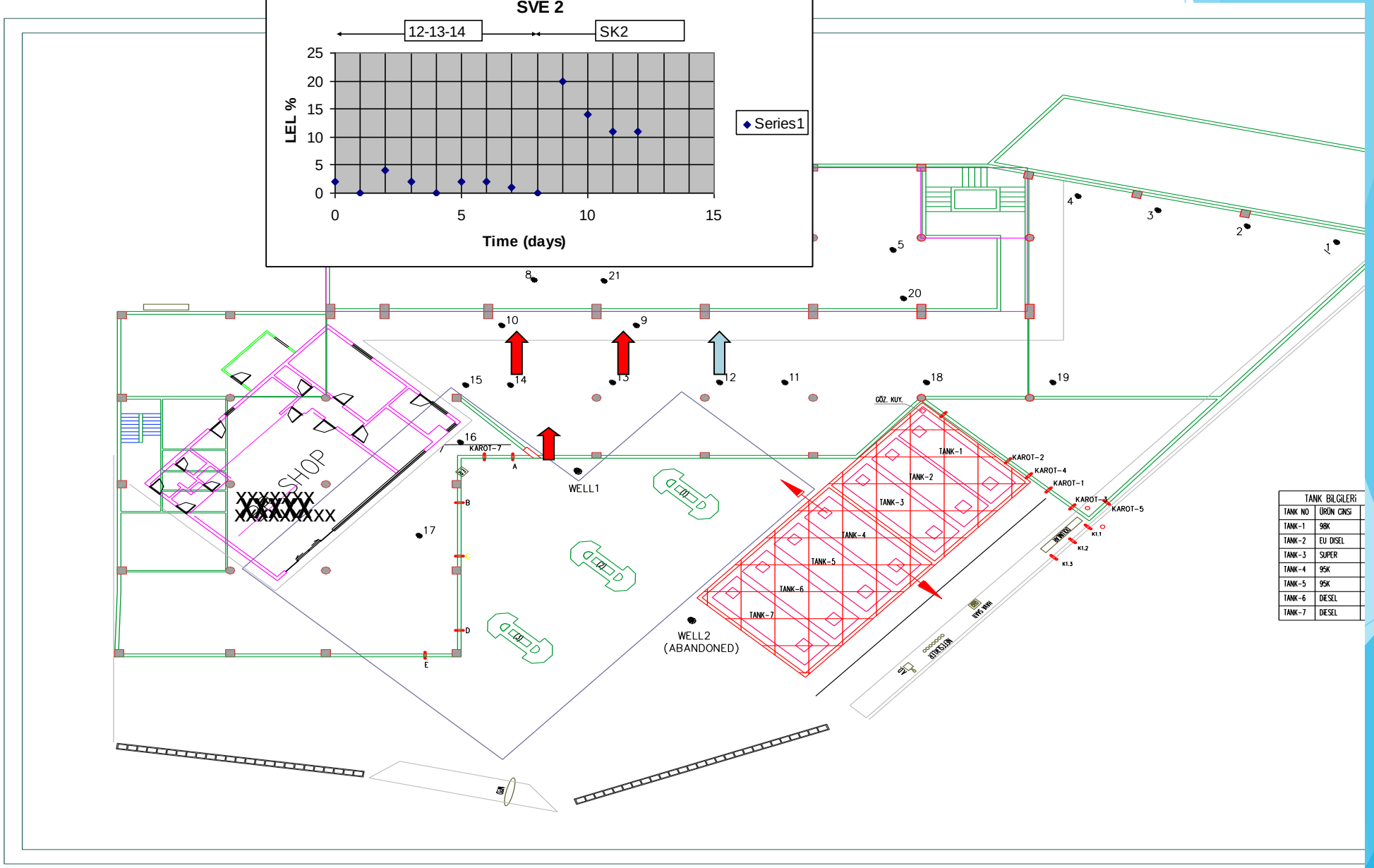
Off-site Ground Water Extraction Installation

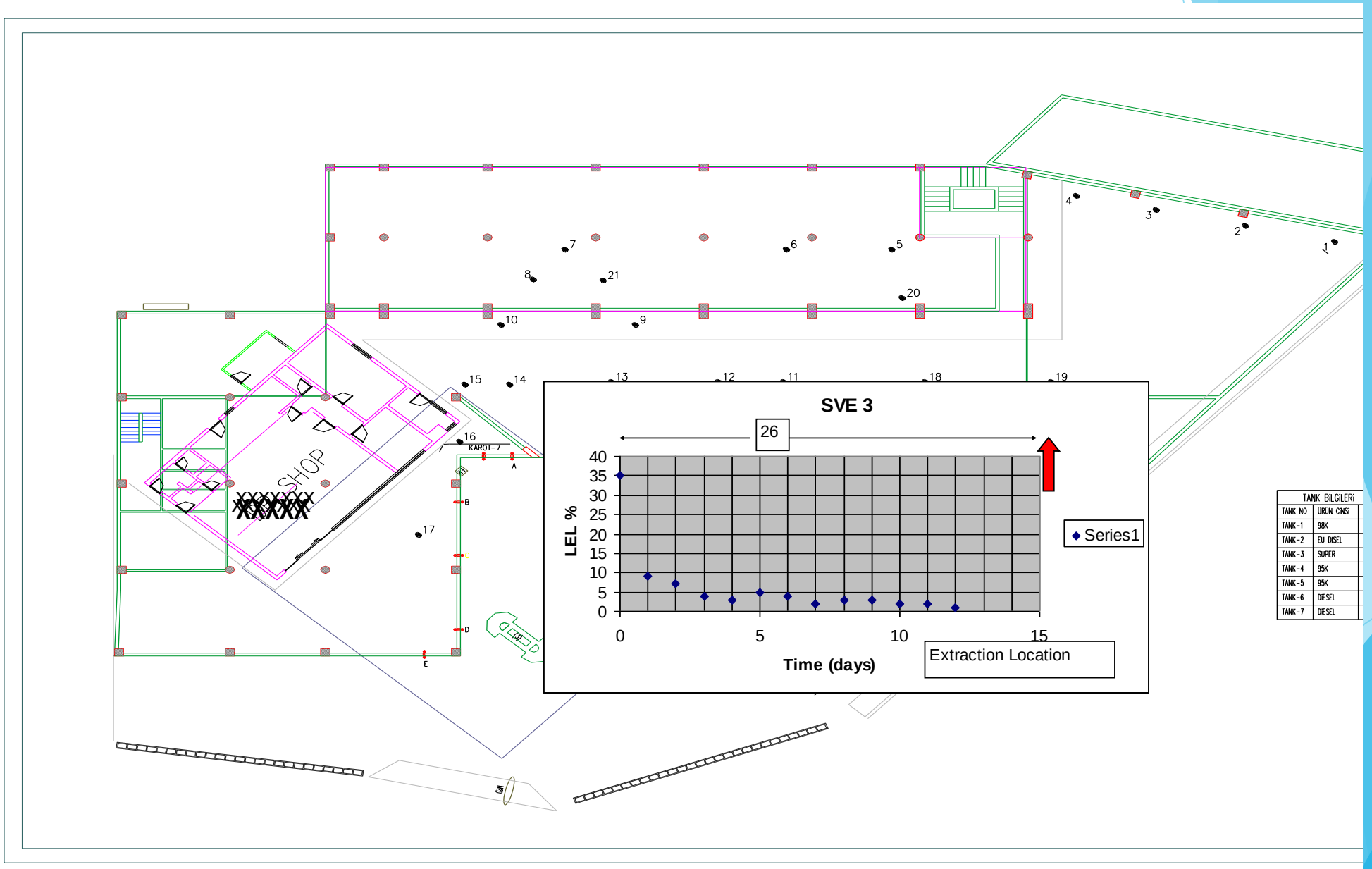
ABATEMENT PROGRAM: SOIL VAPOR EXTRACTION SYSTEM

- There are three soil vapor extractions being operated at the site: SVE1, SVE2 and SVE3. Each is aimed at reducing the accumulation of hydrocarbon contamination gases generated due to leakage spill at the facility. All use activated carbon to treat off-site gases
- SVE1 has been operated to extract the soil vapors in the back of the retaining wall in the BP shop and the commercial building. The flow rate out of the system is approximately110 m3/hour.
- SVE 2 is being used to reduce the accumulation of hydrocarbon gases underneath the slab foundation. The air flow rate out of the SVE 2 system is approximately130 m3/hour. The locations where soil gases are being extracted were initially from soil boreholes 12-13-14 located in the foundation slab. The extraction point was then placed on SK2 which is a concrete core into the foundation tapping the fill material behind the retaining wall.
- SVE3 has been installed in the basement towards the boundary of the nearby road. The system is extracting directly from behind the retaining wall from a core in the retaining wall. The flow rate out of the system is approximately130 m3/hour.


SHOP
XXXXX
WELL1
WELL2
(ABANDONED)
GÖZ. KUY.
KAROT-7
KAROT-1
KAROT-2
KAROT-3
KAROT-4
KAROT-5
TANK-1
TANK-2
TANK-3
TANK-4
TANK-5
TANK-6
TANK-7
TANK BİLGİLERİ
TANK NO
ÜRÜN CİNSİ
TANK-1 98K
TANK-2 EU DİSEL
TANK-3 SUPER
TANK-4 95K
TANK-5 95K
TANK-6 DİESEL
TANK-7 DİESEL
SVE1
B-D
LEL %
Time (days)
Series1
Extraction Locations

SVE 2
12-13-14
SK2
LEL %
25
20
15
10
5
0
0
5
10
15
Time (days)
Series1

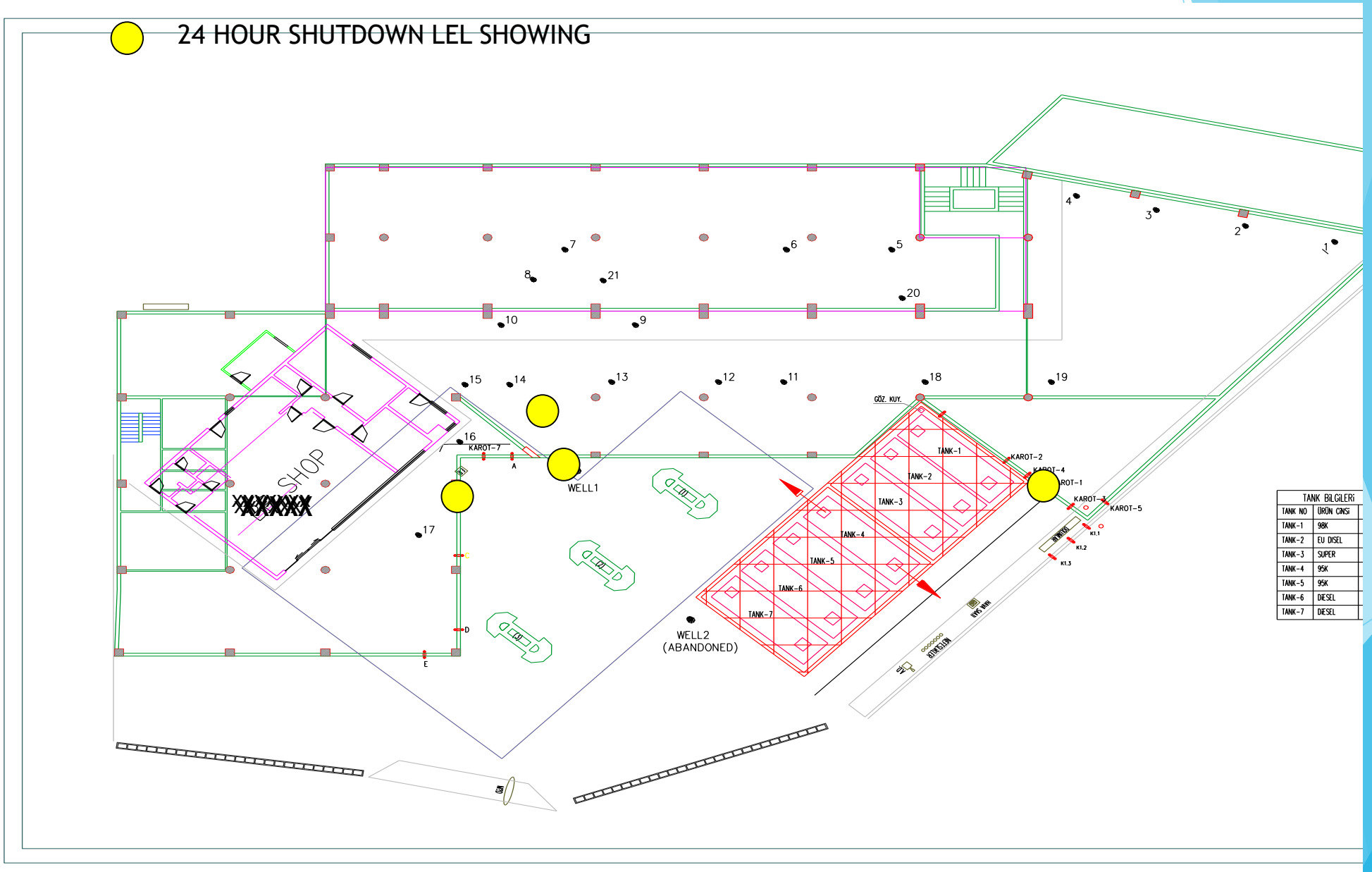

SHOP
XXXXXXX
XXXXXXXXX
WELL1
WELL2
(ABANDONED)
KAROT-7
KAROT-2
KAROT-4
KAROT-1
KAROT-3
KAROT-5
TANK-1
TANK-2
TANK-3
TANK-4
TANK-5
TANK-6
TANK-7
GÖZ. KUY.
TANK BİLGİLERİ
TANK NO | ÜRÜN CİNSİ
TANK-1 | 98K
TANK-2 | EU DİSEL
TANK-3 | SUPER
TANK-4 | 95K
TANK-5 | 95K
TANK-6 | DİESEL
TANK-7 | DİESEL


SVE 3
26
LEL %
40
35
30
25
20
15
10
5
0
0
5
10
15
Time (days)
Series1
Extraction Location
SHOP
KAROT-7
TANK BİLGİLERİ
TANK NO
ÜRÜN CİNSİ
TANK-1 98K
TANK-2 EU DİSEL
TANK-3 SUPER
TANK-4 95K
TANK-5 95K
TANK-6 DİESEL
TANK-7 DİESEL

ABATTEMENT PROGRAM:
SVE SYSTEM SVE1

ABATTMENT PROGRAM: SVE EXTRACTİON LOCATIONS

24 HOUR SHUTDOWN LEL SHOWING

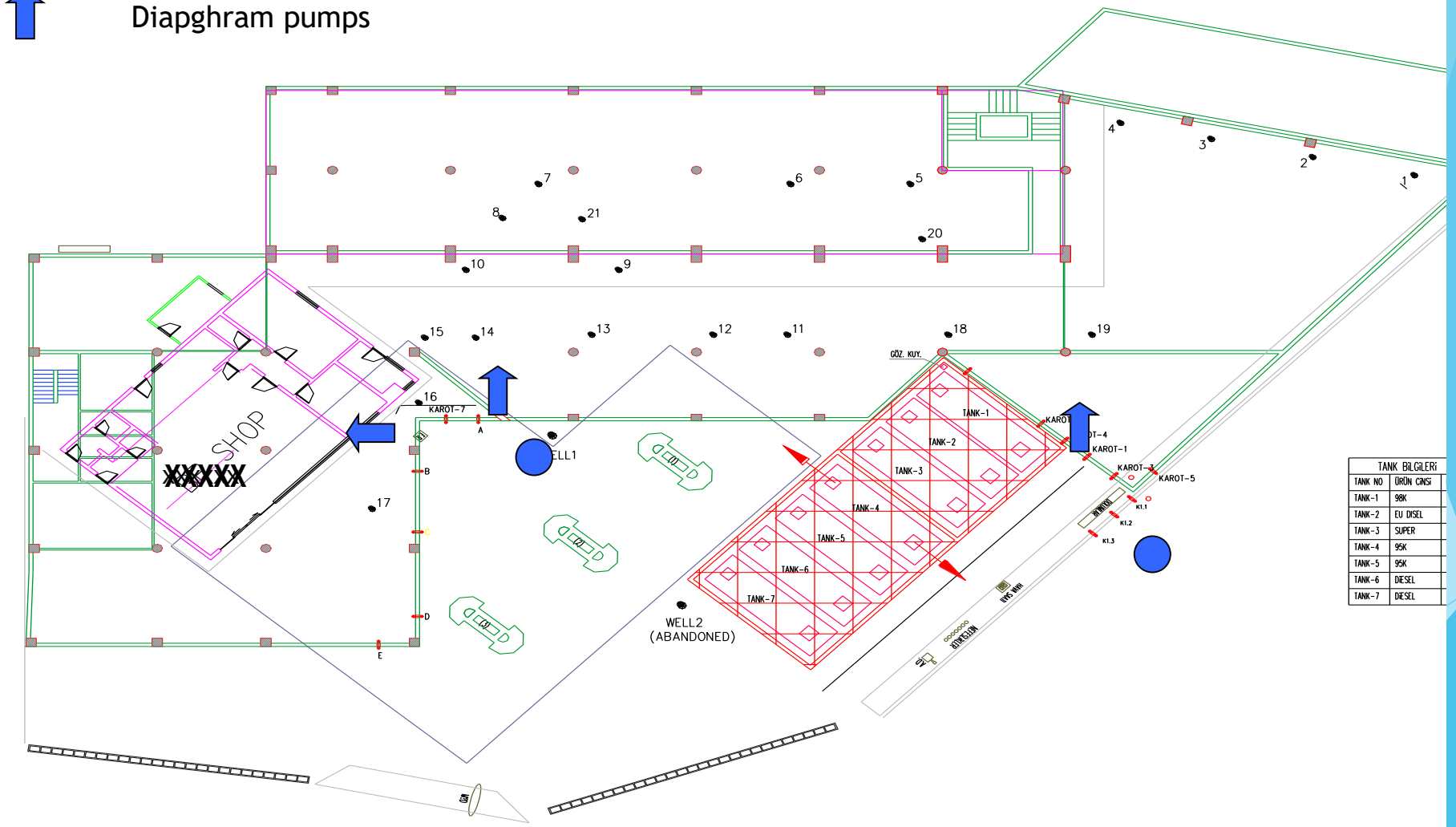


ABATEMENT PROGRAM:GROUND WATER EXTRACTION

- Two deep wells have been used to extract ground water-free product from the forecourt fill material and off-site ground water. Pneumatic total fluid removal pumps are used.
- Inclined boreholes drilled through the foundation has been used to extract ground water-free product from the fill material. Diaphgram pumps are used for this purposed.
- Purpose of extraction program:
  - Remove contaminated ground water and free product
  - Decrease hydraulic load for migration underneath building
  - Improve efficiency of soil vapor extraction system

Contaminated water extraction locations-total fluid pneumatic pumps

Diapghram pumps



ABATEMENT PROGRAM:
GROUND WATER EXTRACTION

ABATEMENT PROGRAM:GROUND WATER EXTRACTION

- Total amount of fluid removed to date is approximately 35,000 liters
  - Fill material yield 33,000 liters
  - Off-site well yield 2,000 liters
- Temporary solution forwarding to Izaydas-costly
- Air strippers requirement-ordered

SITUATION OVERVIEW

Station geometry and infrastructure

-data collection

- remediation techniques

Terrain conditions

Proximity-encroachment of basement from nearby building

Time lag in spill confirmation

Receptors

Abatement performed non-optimal conditions

Geology-hydrogeology

Roles-responsibilities

CHALLENGES-OPPORTUNITES

- Tens of thousands of Registered Sites
- Billion dollar remedial industry
- Most Complex Branch within the Environmental Protection Sector
- Multi-Disciplinary Team
  - Geologists, Hydrogeologists, Chemists, Mechanical Engineers, Toxicologists, Project Managers, Lawyers
- Multiple Players
  - Polluter, Consultant, Government, Receptors,
- Knowledge Base
- Learning Curve
- Resources of Parties
- Laboratories
- Consultants