LUST Site in Cadillac: Institutional Controls and Evaluation of Residual LNAPL

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Leaking Underground Storage Tank (LUST) Site

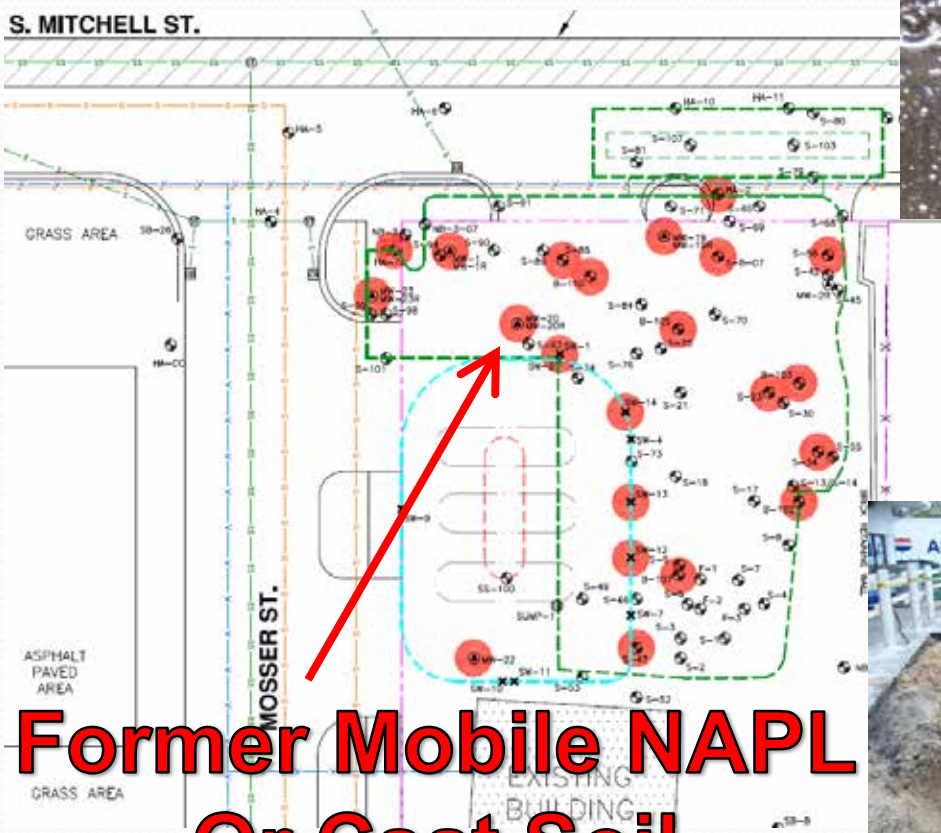
- 1992 and 2006 releases of gasoline from UST system
- Property ownership changed between 1992 and 2006
- Different parties completing corrective action
- Non-aqueous phase liquids (NAPL) measured in monitoring wells
- Soil concentrations above soil saturation screening levels (Csat)
- Maximum historic total BTEX in groundwater >50,000 µg/L

LUST SITE

LUST Site

- Excavation completed in 2006 and 2009
- All impact could not be excavated
- Residual non-aqueous phase liquids (NAPL) remained
- Impact remained under utilities and road rights of way (ROW)
- ROW institutional controls implemented for MDOT ROW and city ROW
- NAPL addressed in accordance with MDEQ guidance
- MDEQ (Steve Kitler) met with us to discuss closure report, provided us opportunity to answer questions and make correction
- Site closed

LUST Site



Former Mobile NAPL Or Csat Soil

CSM Element - Maximum Remaining Soil Concentrations Post-Excavation

Chemical	Soil Concentration [µg/kg]
Benzene	28,790
Toluene	50,630
Ethylbenzene	9,890
Xylene	76,600
1,2,4-Trimethybenzene	98,640
1,3,5-Trimethylbenzene	31,120
Naphthalene	10,200
2-Methylnaphthalene	28,300

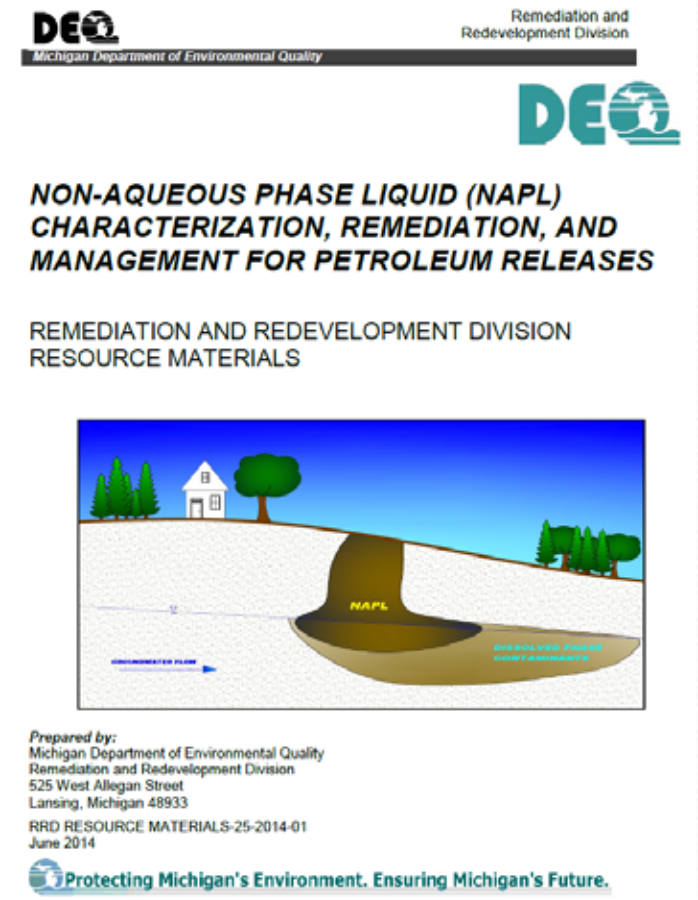
- Remaining soil concentrations may have been indicative of residual NAPL
- Additional lines of evidence showing NAPL absent was needed or NAPL would be assumed present
- Additional soil sampling challenging due to presence of utilities, roads and other structures

Old School NAPL Risk Assessment

- Part 201 generic criteria/Part 213 Tier 1 risk based screening levels assume NAPL not present
- Guidelines for assessing NAPL risk not developed
- NAPL addressed through presumptive remedy and/or exposure control

New School NAPL Risk Assessment

- MDEQ's 2014 Guidance provides approaches to assess risk when NAPL present
- Allows Part 201 generic criteria/Part 213 Tier 1 risk based screening levels to be used for some sites
- Remedy or exposure control for each pathway not always required for No Further Action or Closure when NAPL present



DEQ Michigan Department of Environmental Quality

Remediation and Redevelopment Division

NON-AQUEOUS PHASE LIQUID (NAPL) CHARACTERIZATION, REMEDIATION, AND MANAGEMENT FOR PETROLEUM RELEASES

REMEDIATION AND REDEVELOPMENT DIVISION RESOURCE MATERIALS

Prepared by:
Michigan Department of Environmental Quality
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525 West Allegan Street
Lansing, Michigan 48933

RRD RESOURCE MATERIALS-25-2014-01
June 2014

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CSM Element- Relevant Exposure Pathways

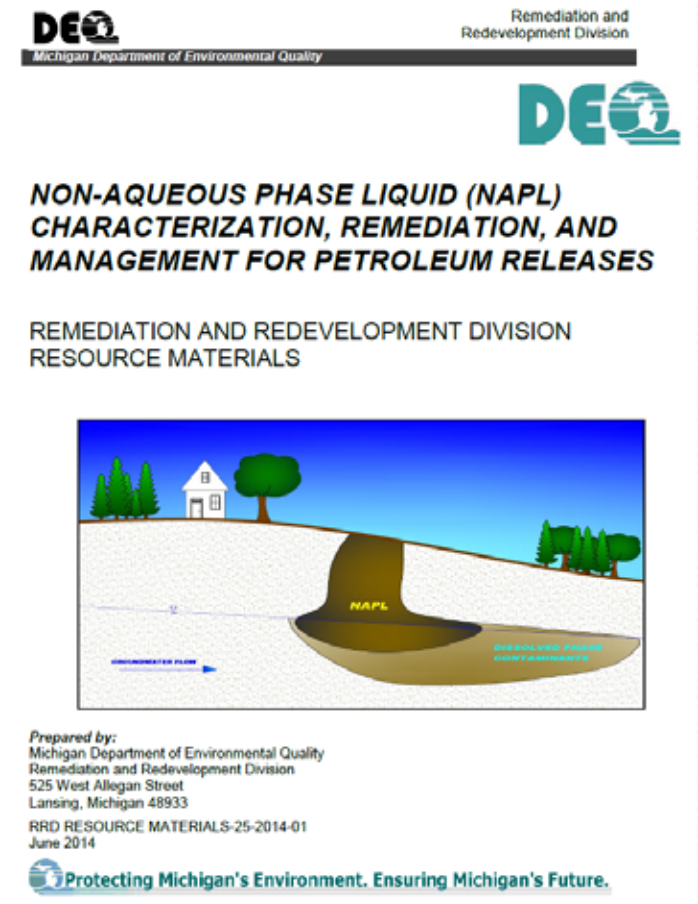
- Due to potential presence of NAPL at Cadillac site, MDEQ expressed concern with on-site exposure
- This included concern related to soil direct contact and soil leaching to groundwater pathways
- Exposure control for these pathways more burdensome for property owner than control of other exposures (for example drinking water exposure or exposure due to vapor intrusion)

Soil Direct Contact

- MDEQ's 2014 Guidance allows for generic criteria/Tier 1 RBSLs to be used to asses soil direct contact risk when:

  1) The NAPL saturation is less than 0.5% or the TPH-GRO is less than 900 mg/kg (or TPH-DRO < 1,050 mg/kg for diesel releases) AND

  2) Mobile NAPL is not present
- Guidance states if TPH data not available assume TPH GRO = 40 x BTEX



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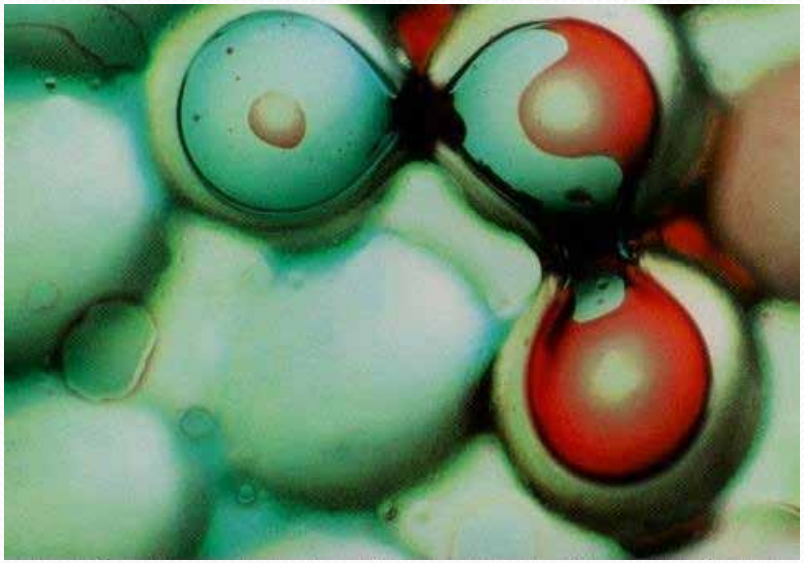
Application of Guidance to Site

- All soil samples not analyzed for TPH or otherwise analyzed for NAPL presence/absence
- Some soil samples analyzed for BTEX and TPH
- Data used to calculate a site-specific factor as alternative to the 40x factor in guidance (TPH = BTEX x ?)
- NAPL saturations calculated from TPH concentrations



Site-Specific BTEX/TPH

Sample	Depth [feet bg]	TPH-GRO [µg/kg]	Total BTEX [µg/kg]	TPH/BTEX
HA-1	5-5.5	589,300	20,045	29.4
HA-7	6.5	5,733,430	1,217,960	4.7
SB-8-07	4.5-5	5,627,980	1,134,600	5.0
B-102	3.5-4	581,440	66,960	8.7
B-108	6.5-7	339,390	28,487	11.9
			Average	**11.9**

NAPL Saturation from TPH Calculation

$$S_n = \frac{\rho_b \times \text{TPH}}{\rho_n \times \eta \times 10^6}$$

S_n = NAPL saturation or % porosity containing NAPL

ρ_b = dry bulk density of soil [g/cm^3] – assumed to be 1.6

TPH = TPH soil concentration [mg/kg]

ρ_n = NAPL density [g/cm^3] – assumed to be 0.77 for gasoline

η = soil porosity – assumed to be 0.4

NAPL Saturation from TPH Calculation

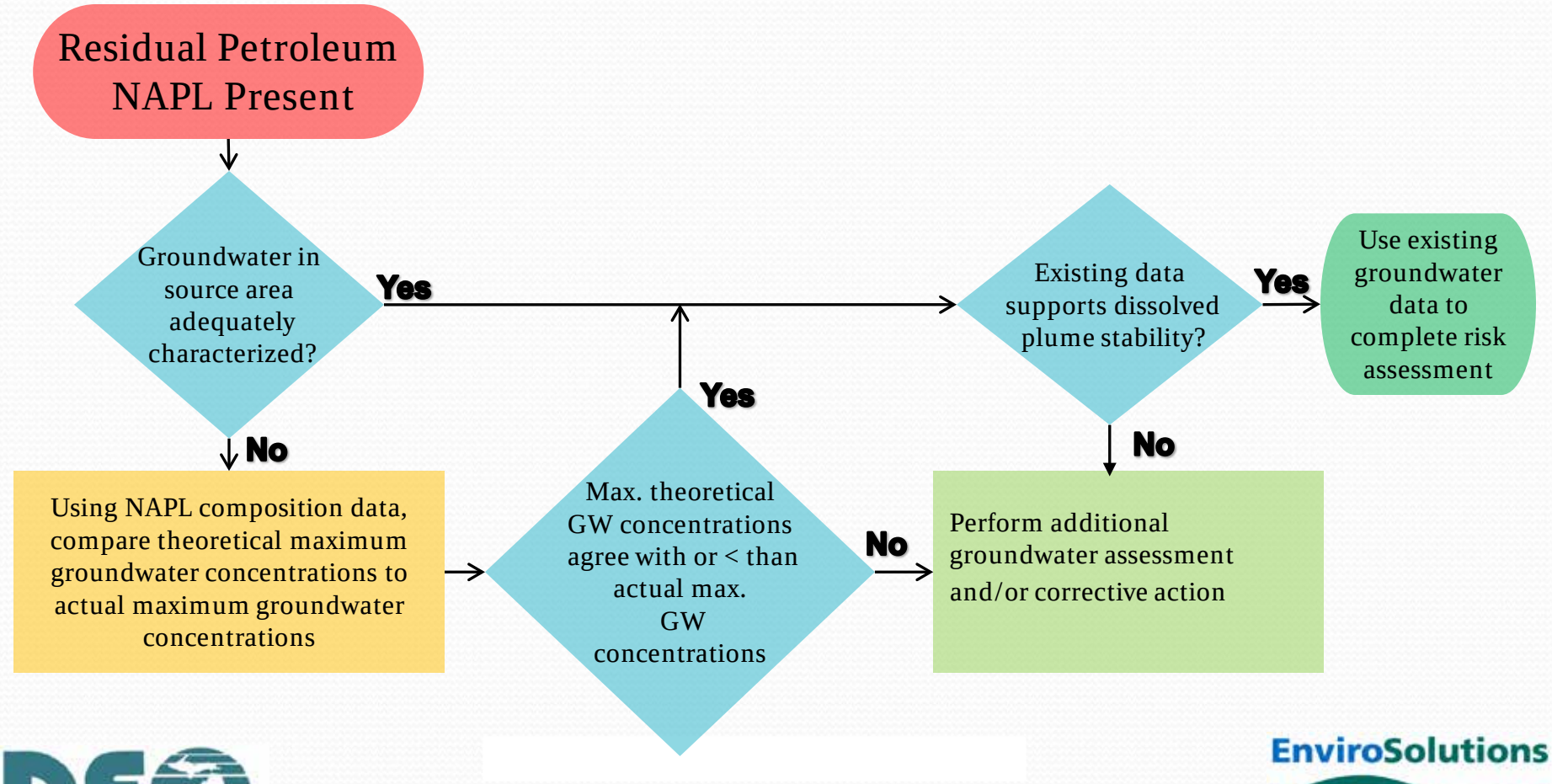
Soil Sample	Depth [feet bg]	Total BTEX in Soil [µg/kg]	TPH-GRO in Soil [mg/kg]	NAPL Saturation
S-2	5	51,280	431	0.22%
F-3	7	82,207	691	0.36%
S-14	5	25,083	211	0.11%
S-18	11	30,154	253	0.13%
S-21	8	80,250	674	0.35%
S-42	9	46,307	389	0.20%
S-69	7	27,635	232	0.12%
S-73	9	43,350	364	0.19%
S-75	11.5	38,640	325	0.17%
S-76	11.5	36,893	310	0.16%
S-84	13	88,990	748	0.39%
S-89	13.5	29,662	249	0.13%

MDEQ Maximum NAPL Saturation for Use of Soil Direct Contact Generic Criteria/RBSLs = 0.5%

Soil Direct Contact
Risk Assessment Conclusion – No Risk

Chemical	Soil Concentration [µg/kg]	Non-Residential Generic Criteria/Tier 1 RBSL [µg/kg]
Benzene	28,790	840,000
Toluene	50,630	160,000,000
Ethylbenzene	9,890	71,000,000
Xylene	76,600	1,000,000,000
1,2,4-Trimethybenzene	98,640	100,000,000
1,3,5-Trimethylbenzene	31,120	100,000,000
Naphthalene	10,200	52,000,000
2-Methylnaphthalene	28,300	26,000,000

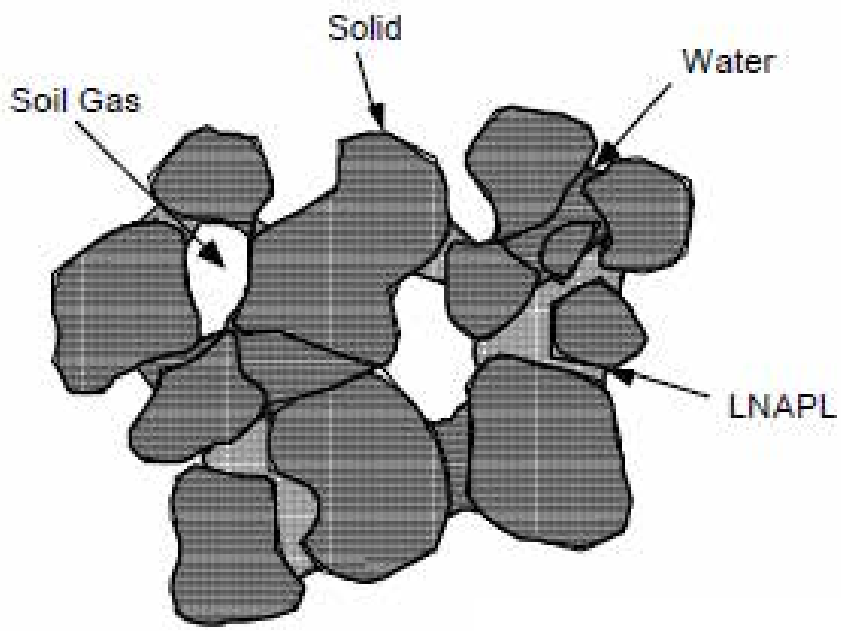
Example NAPL Leaching to Groundwater Site-Specific Evaluation



ASSESSING LEACHING TO GROUNDWATER WHEN NAPL PRESENT

- NAPL composition helps us evaluate if we have characterized the maximum groundwater concentrations – is characterization adequate to make site decisions?
- NAPL composition also helps us evaluate if the maximum known concentrations in groundwater will or can be exceeded due to the NAPL
- Maximum groundwater concentrations can be used in modeling risk assessment and fate/transport and for remediation evaluation/design.

Example NAPL Leaching to Groundwater Site-Specific Evaluation



- Assumes equilibrium between NAPL and other mass phases
- Groundwater concentration of a chemical when NAPL is present can be related to the amount of the chemical present in the NAPL
- Similar to an “effective solubility” calculation

Example NAPL Leaching to Groundwater Site-Specific Evaluation

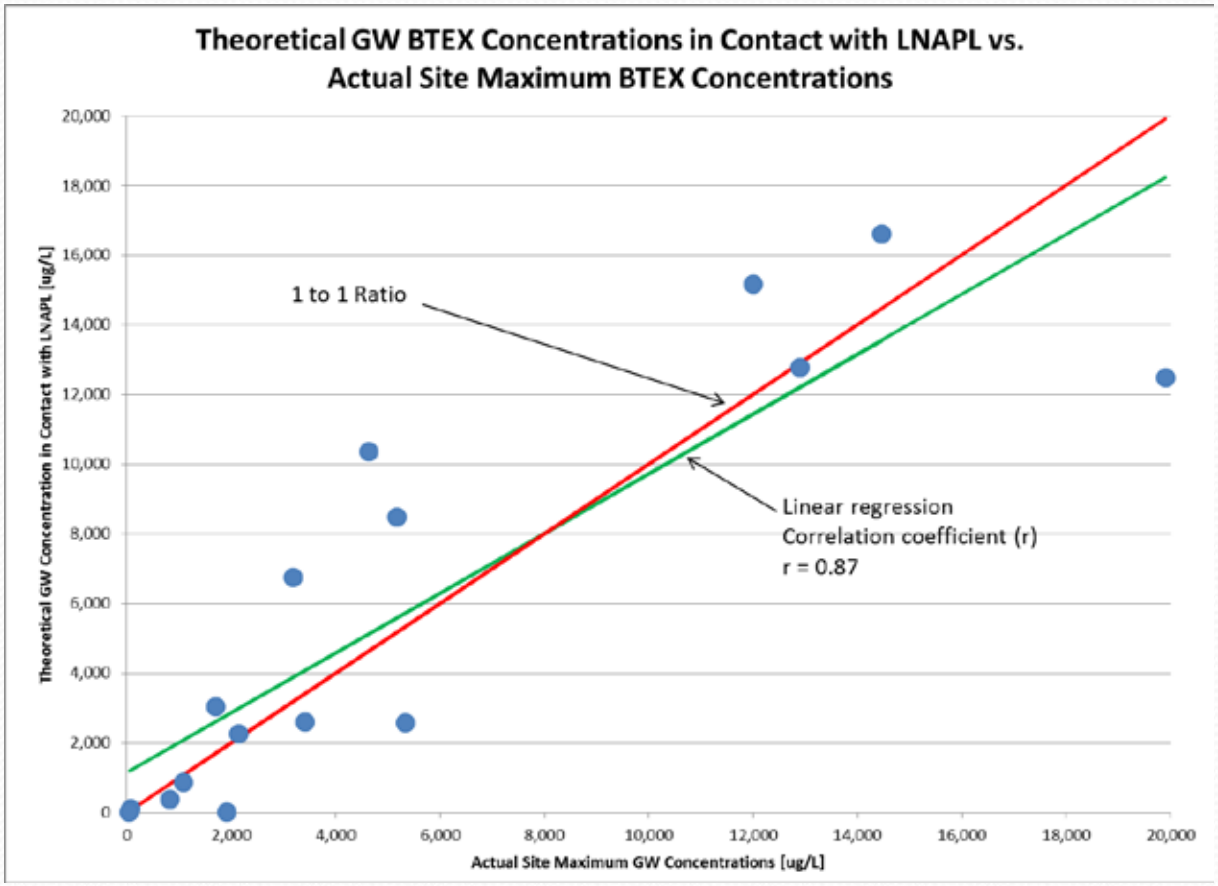
Determined maximum potential groundwater concentrations from:

- Mole fraction of chemical in NAPL at a site (determined from NAPL analysis or estimated from soil sample analysis)
- Chemical solubility

Cadillac Site Analysis

Compound	Mole Fraction in NAPL	Solubility [µg/L]	Maximum Theoretical Groundwater Concentration [µg/L]	Maximum Actual Groundwater Concentration [µg/L]
Benzene	3.9×10^{-3}	1.75×10^{6}	6,760	3,180
Toluene	2.4×10^{-2}	5.26×10^{5}	12,500	19,900
Ethylbenzene	1.5×10^{-2}	1.69×10^{5}	2,590	3,410
Xylenes	8.9×10^{-2}	1.86×10^{5}	16,600	14,460
MTBE	1.6×10^{-5}	4.68×10^{7}	737	72
1,2,4-TMB[2]	8.0×10^{-2}	5.59×10^{4}	4,460	1,420
1,3,5-TMB[2]	3.0×10^{-2}	6.12×10^{4}	1,850	392
Naphthalene	5.3×10^{-3}	3.10×10^{4}	164	284
2-Methyl-naphthalene	1.2×10^{-2}	2.46×10^{4}	306	49

Example – Leaching to Groundwater More Site-Specific Method Data

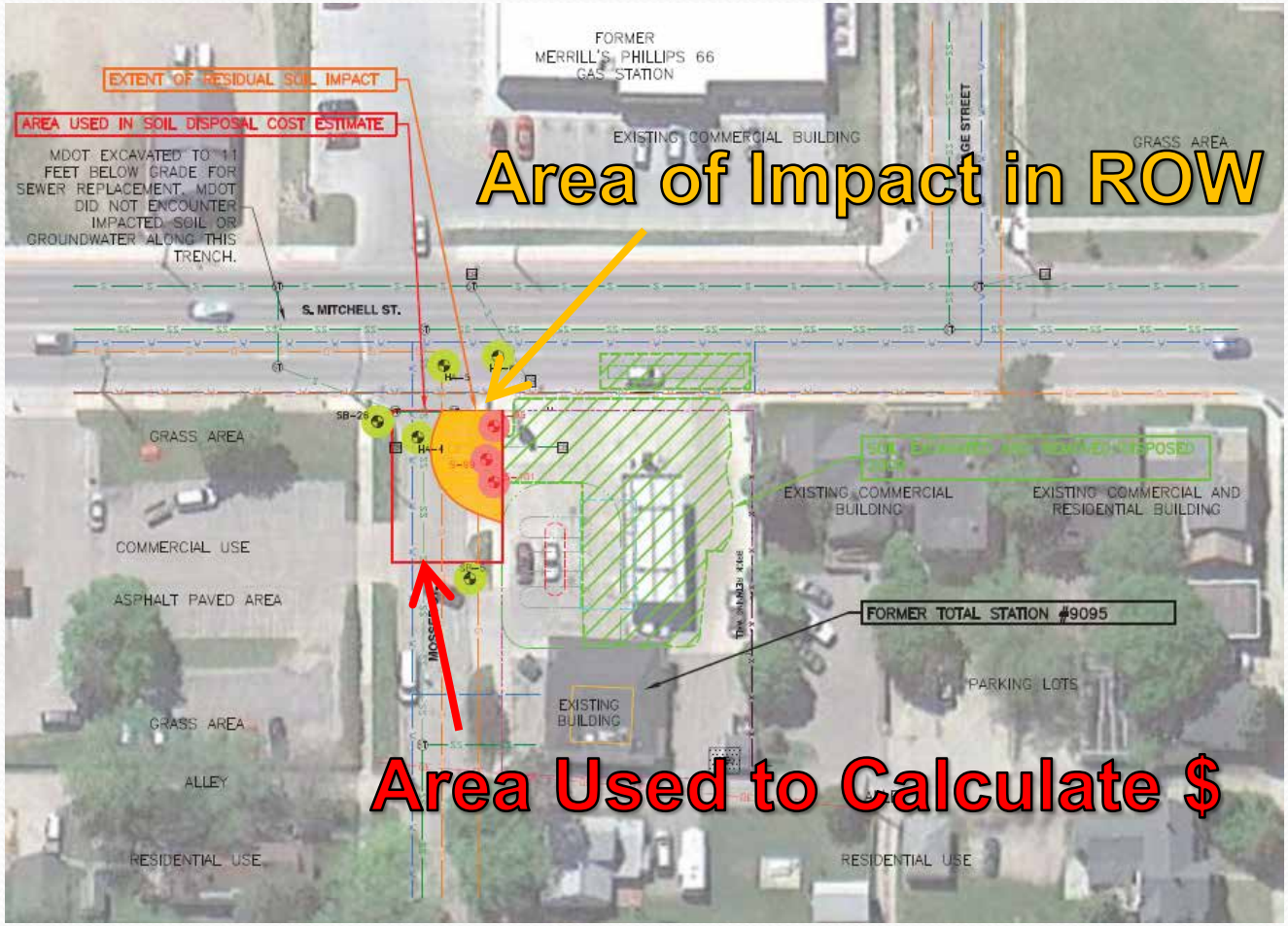


Residual Impact in City Street ROW Addressed with MDEQ Alternate Institutional Control (RROW AIC)

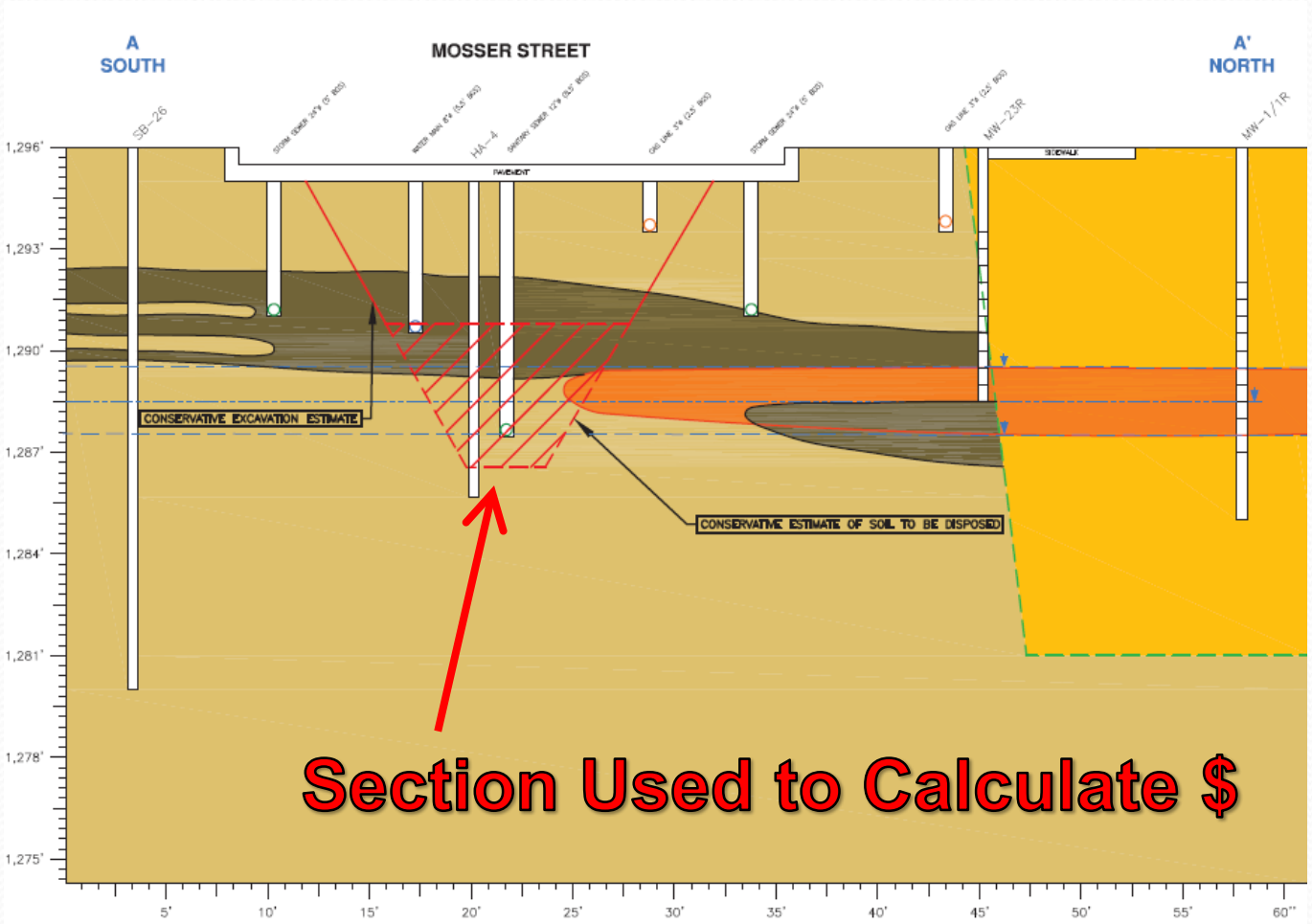
RROW AIC Implementation

- Offered to reimburse City for incremental cost associated with remaining impact that could be incurred during a future construction project
- Initially contacted City Engineer
- Engineer sold idea to City Manager
- MDEQ staff (Brian Flickinger) sold idea to City Manager (critical step)
- MDEQ also told City impacted soil could be returned to excavation (as long as soil handled properly)
- City Manager sold idea to City Council
- City Council approved execution of RROW AIC

Residual Impact in City Street ROW



Residual Impact in City Street ROW



RROW AIC Implementation Incremental Cost Assumptions

- The sanitary sewer is present from approximately 8 to 9 feet (ft) below grade (bg)
- If the sanitary sewer was replaced, the excavation would be 9 ft bg, 4 ft wide at the bottom, have sidewalls with a 1:1 slope, and would be 60 ft long
- The top 5 ft of soil is clean backfill and does not require special handling or disposal
- The soil between 5 and 9 ft bg was assumed to be disposed and replaced with suitable backfill (sand)
- One cubic yard of soil (in place) weighs approximately 2.6 tons
- To determine loose cubic yards, one cubic yard of soil (in place) was assumed to expand by a factor of 1.4 upon excavation
- Soil transportation and disposal costs and backfill sand costs \$66.60/ yd^3
- Groundwater may be present from 7 to 9 ft bg
- A total of 100 cubic yards of soil may require disposal and replacement with backfill at a total cost of \$6,700
- A total of 1,300 gallons of groundwater may require disposal at a total cost of \$300

THANK YOU!

Michigan Department of Environmental Quality

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