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# Soil Gas Sampling for Natural Gas Pipeline Releases from Condensate Drips

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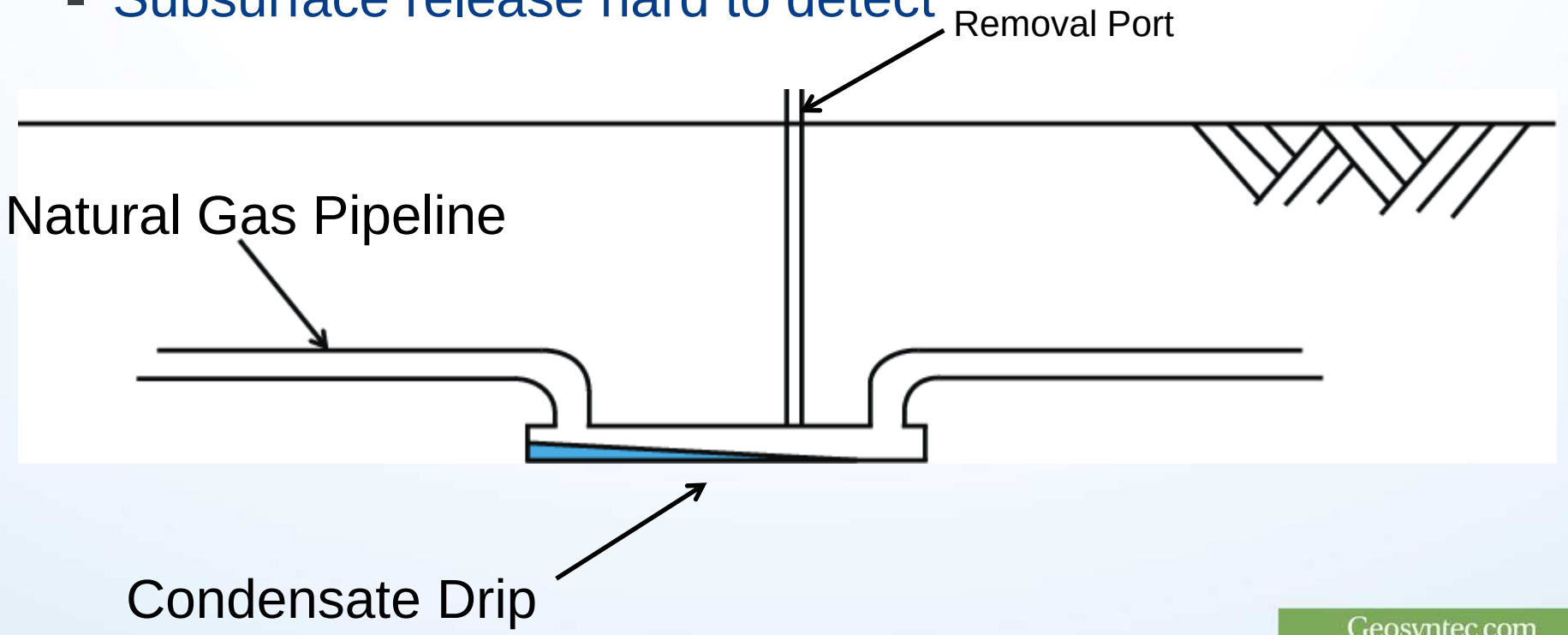
# Investigation of Condensate Drips

- Thousands of drips in natural gas field
- Spread over more than 1,000 square miles
- Possible preferential failure at drips
- Field under vacuum – leak detection more difficult
- Planned on excavating drips to inspect for failures

# Natural Gas Pipeline Condensate

- Forms as a result of natural gas extraction/compression
- Liquid removed periodically
- Surface and subsurface releases observed
- Subsurface release hard to detect



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# Natural Gas Pipeline Condensate

- API Gravity: 65
- SP Gravity: 0.72
- Benzene: 0.2 %
- Toluene: 0.9 %
- Ethylbenzene: 0.2%
- Xylenes: 1.4%
- Paraffins: 30%
- Isoparaffins: 32%
- Naphthenics: 31%
- Aromatics: 5%
- Olefins: 0.5%

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# Failure Concerns

- Environmental Concerns (original concern)
  - Soil, Groundwater, Surface Water, Ecologic impacts
- H&S Concerns
  - Employee exposure
  - Physical damage/fire
- Operational Concerns
  - Elevated oxygen concentrations (on vacuum lines)
  - Preferential corrosion (increased oxygen)
  - Well shut in for line failures
- Economic Concerns
  - Lost revenue
  - Cleanup costs
  - Public relations concerns

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# Original Investigation Strategy

- Landowner Contact/Compensation
- Utility Locate
- Drip Excavation
- Soil Sampling
- Backfill & Restoration
- Sample Analysis
- Reporting

- Approximately one man-day per site

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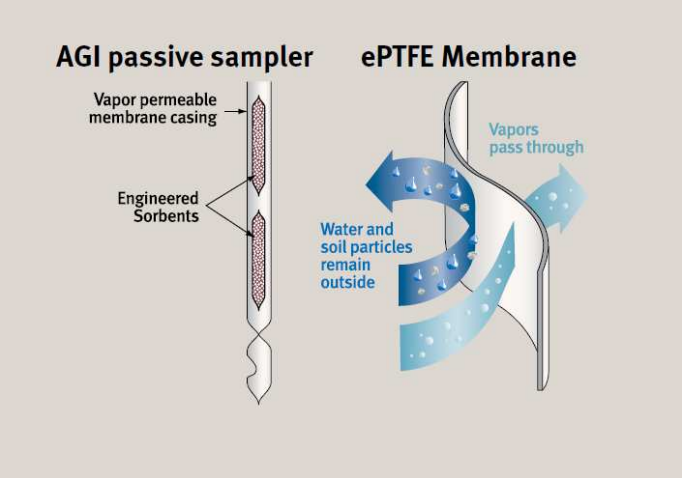
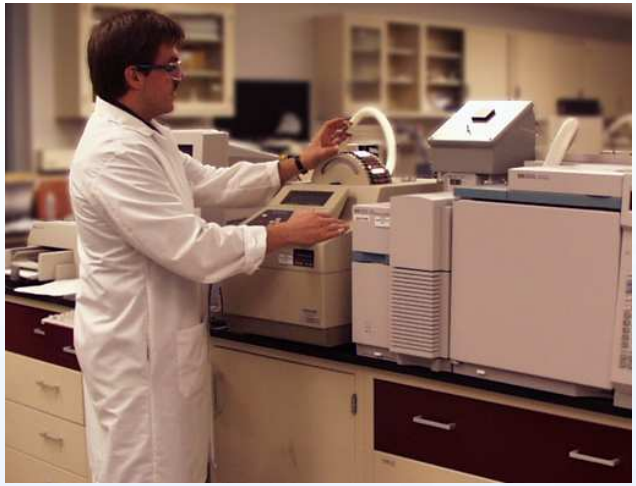
# Original Implementation Costs

- Utility Locate: $50/drip
- Investigation (excavation/restoration): $650/drip
- Soil Analytical: $250/drip
- Landowner: $250/drip
- Management: $50/drip
- Reporting: $100/drip
- **Estimated Cost per Drip: $1,350/drip**


# THE AGI SGM Module


- Universal – sample soil gas, air, sediment and groundwater
- > 50 Presentations and published papers
- >4,000 surveys worldwide
- Federal, state regulator acceptance/international acceptance



Note: GORE Survey and GORE Modules were acquired by Amplified Geochemical Imaging, LLC. in May 2013

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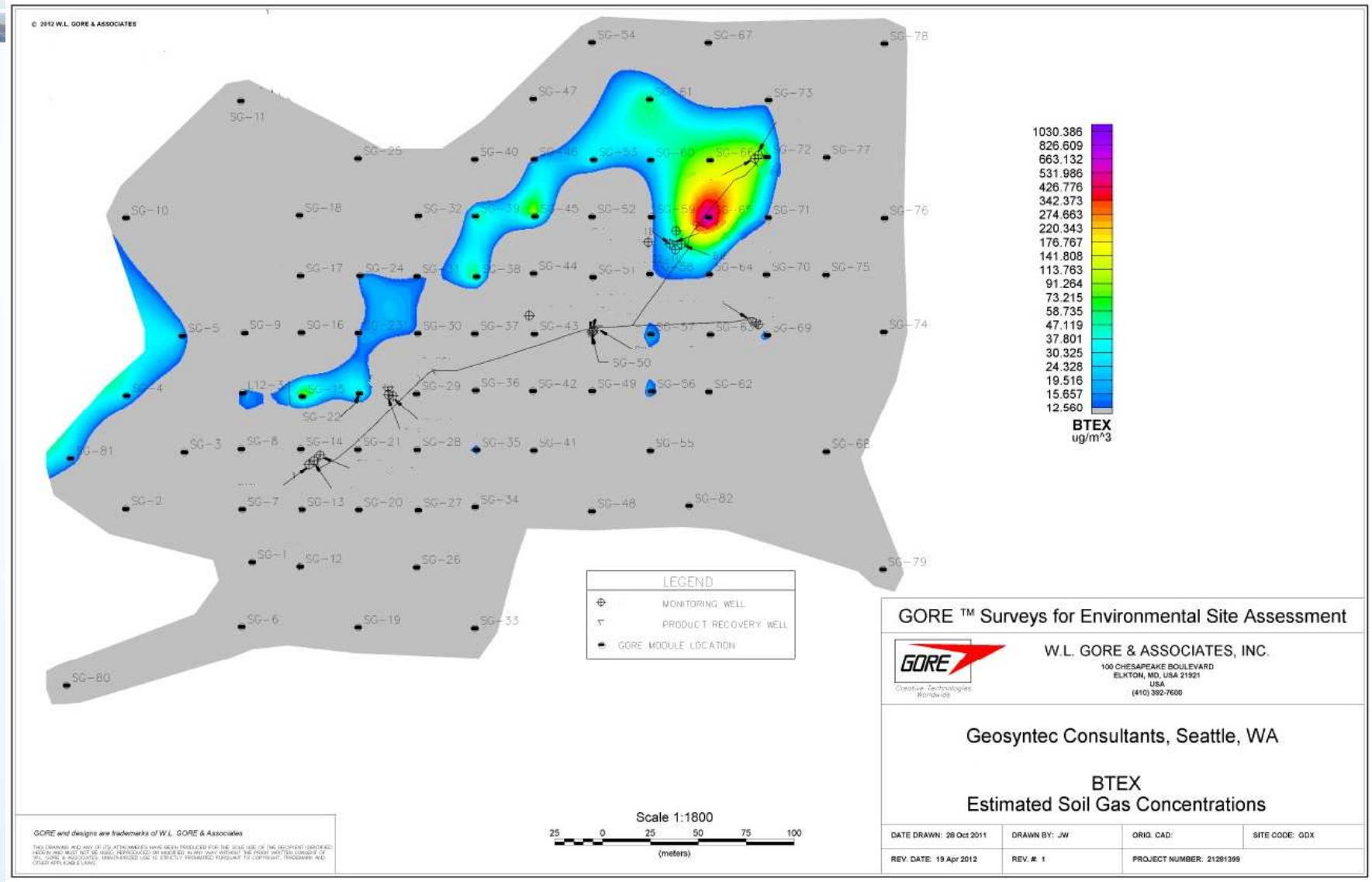
# Successful Grid Application
# AGI Soil Gas Survey



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# Revised Investigation Strategy

- Use Passive SGMs
  - Avoid landholder issues, utility locates, excavation, and site restoration
- Install SGMS at 10% of sites per year
- One SGM per drip, 18-inch burial depth, 3 days
- Innovative data management
- Analyze for BTEX, $C_4$-$C_8$, and $C_9$-$C_{14}$ alkanes
- Soil sampling for chlorides (brine release)
- Compare data to select soil sampling results to develop correlation

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# AGI Soil Gas Module Deployment

- Rapid, unobtrusive
- Use of hand tools
- 1.5 foot install depth
- 5-15 minutes to place
- 3 day exposure time
- 20-40 placed per day

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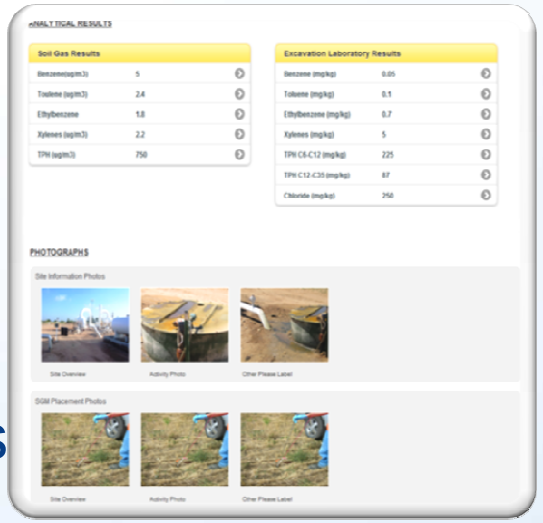
# Data Collection & Management

- iPad App created for data collection and management
  - SGM Placement Data
  - Physical Site Data
  - Soil Sampling Data
  - Photographs
  - GPS Coordinates
  - Real-time Project Progress
  - Auto Report Generation




- 450,00 data points/60,000 photographs

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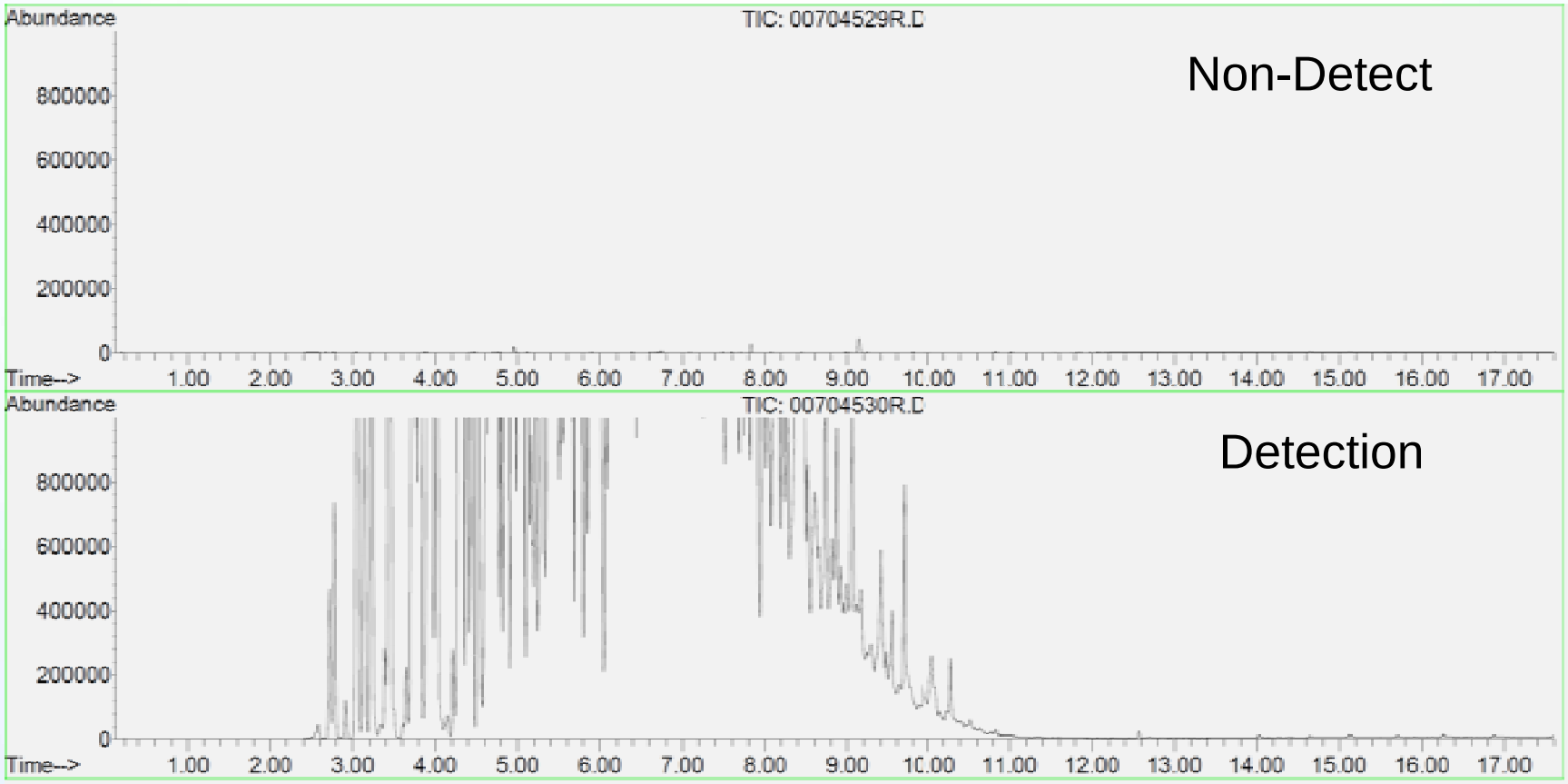
# SGM Analytical Results Indicative of Condensate



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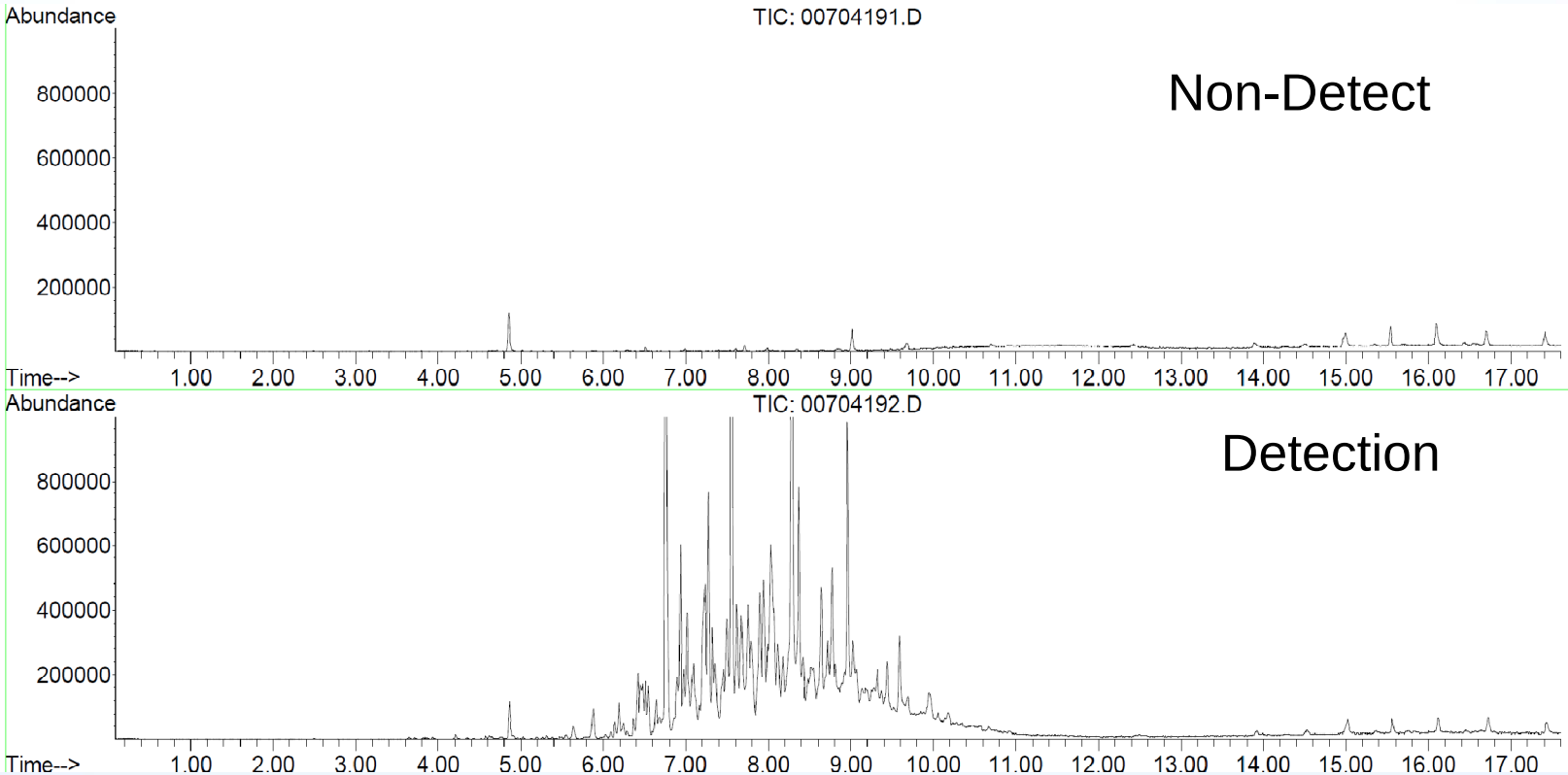
# SGM Analytical Results Indicative of Lube Oil



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# SGM/Soil Sampling Correlation

- Conducted during first year only
- Soil sampled at 71 drips
  - 58 drip line sites based on high petroleum constituents (above 85$^{th}$ percentile in TPH concentration)
  - 13 drip line sites that were non-detect for petroleum constituents were sampled to ensure no false negatives
- Benzene determined to be driver/indication of release
- False negatives/positives not observed

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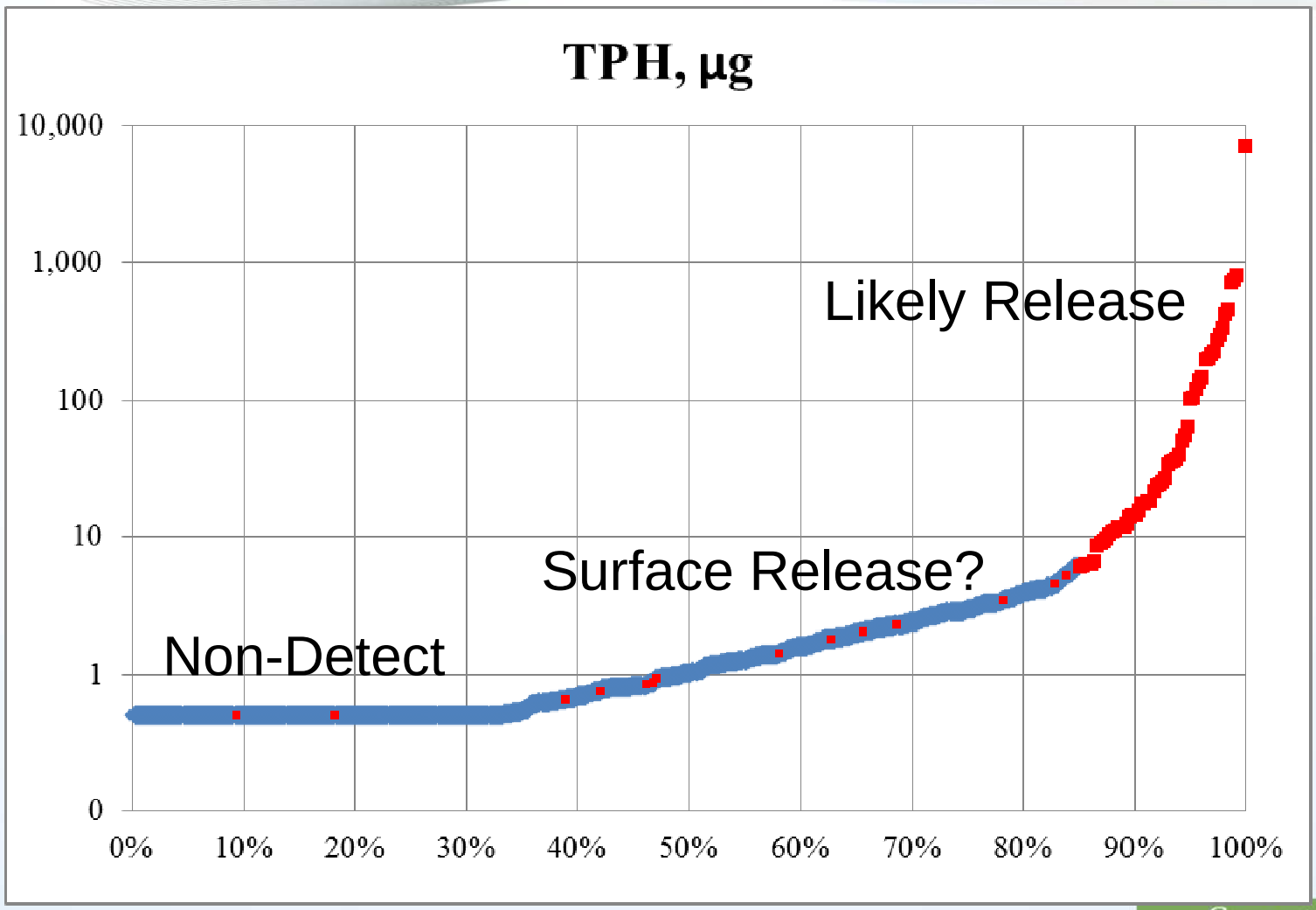
# Year 1 SGM Results
# Soil Sampling Sites in Red



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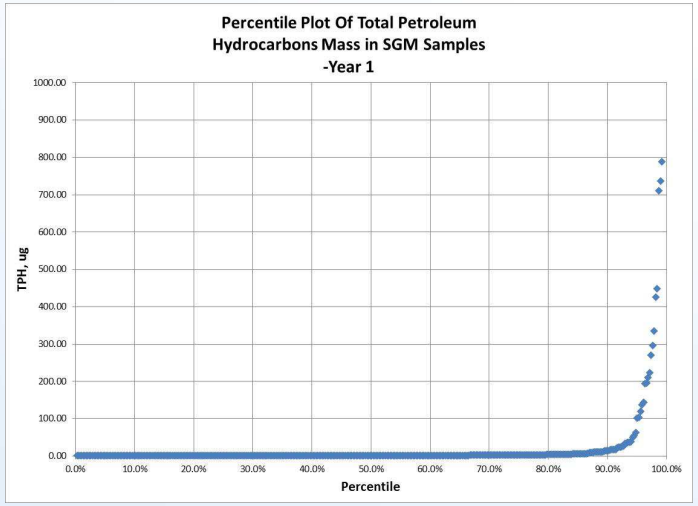
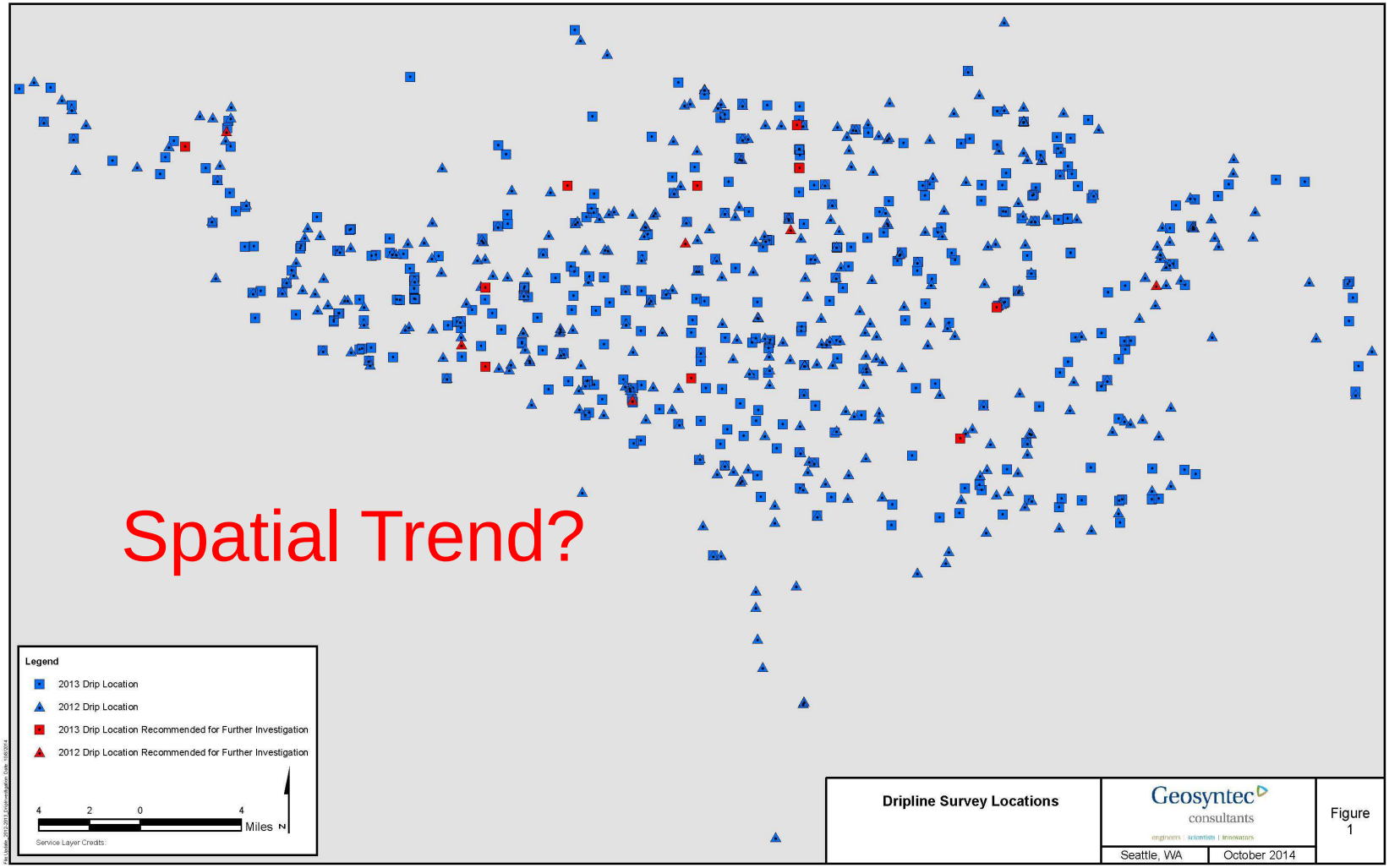
# Year 1 & 2 Results

- Total TPH sites investigated: 1150
- Total Chloride sites investigated: 377
- Sites with TPH detections: 928
- Sites with Chloride exceedances: 8 (2%)
- Sites recommended for investigation: 23 (2%)

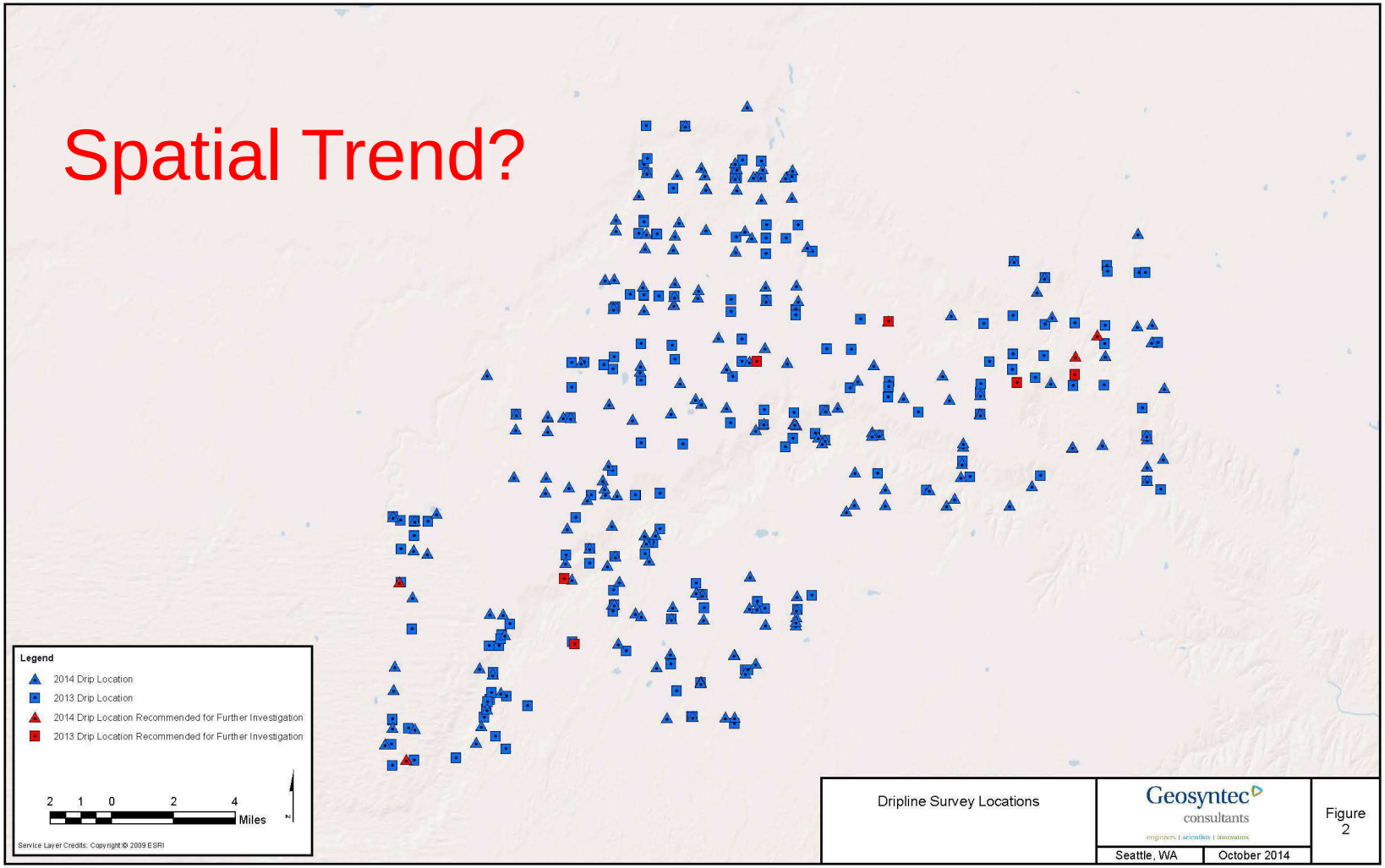



Failure identified before release!

# Field 1 Investigation Locations



# Field 2 Investigation Locations



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# Actual Implementation Costs

| | |
|---|---|
| Utility Locate: | $0/drip |
| SGM Placement/Removal: | $125/drip |
| SGM Analytical (plus QA/QC): | $250/drip |
| Landowner: | $0/drip |
| Management: | $25/drip |
| Reporting: | $50/drip |
| **Actual Cost per Drip:** | **$450/drip** |


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# Cost Savings

- Original Program Cost: $8,100,000
- Revised Program Cost: $2,700,000
  - Cost Savings per Drip: $900
  - Total Project Savings: $5,400,000

- Reduction of ~3,500 man-hours per year


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# Summary and Conclusions

- PSG process:
  - Simple and easily implemented
  - Avoids landowner involvement, utility locates, excavation and site restoration
  - Effective at identifying drip failures
  - Useful at differentiating condensate from lube oils
  - Accurate predictor of line failures
  - Reduced investigation costs by 67%
- Most releases small (<500 $yd^3$)
- One large cleanup (>25,000 $yd^3$)

# Questions

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