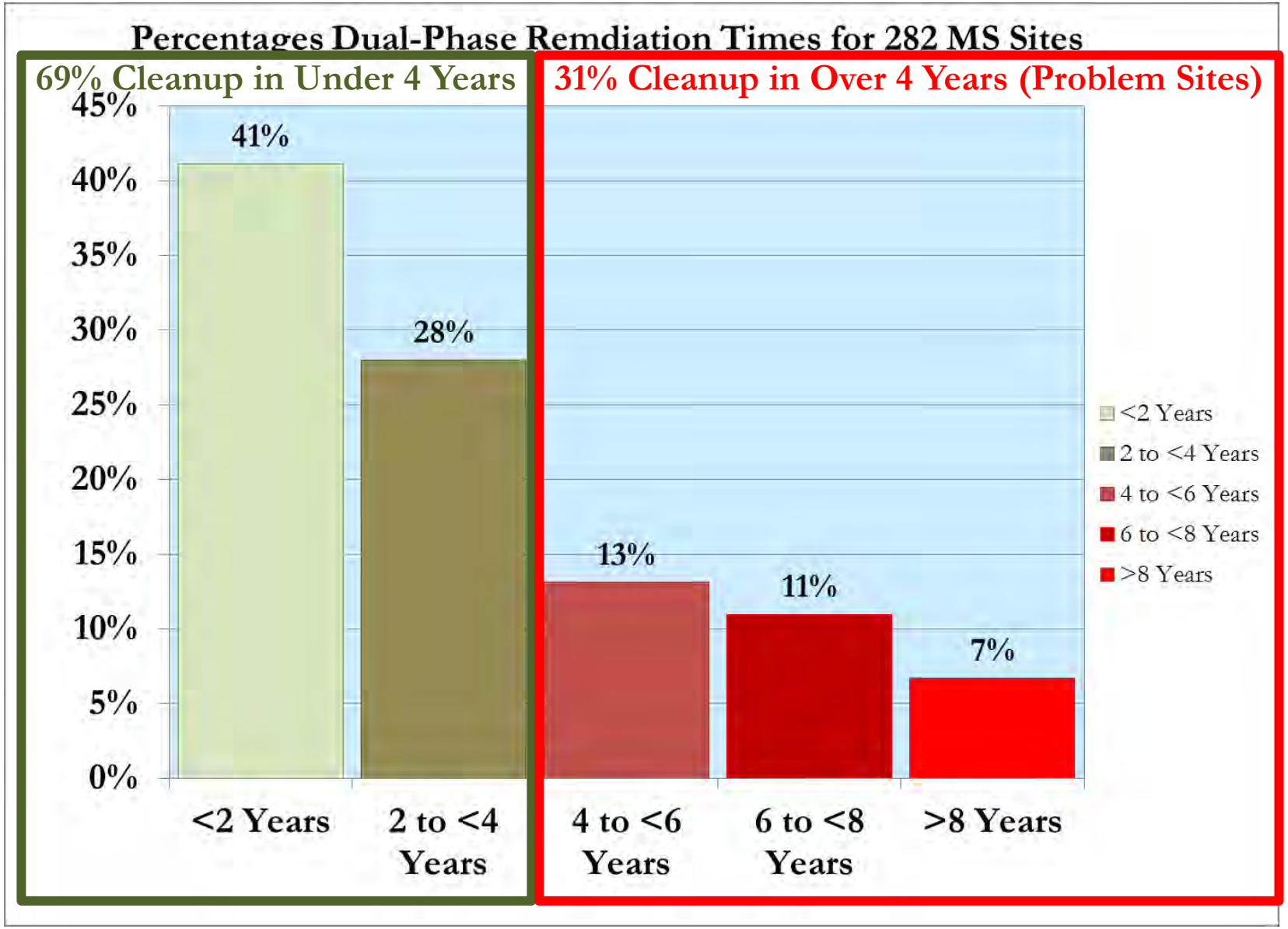
Advanced Data Analysis (ADA)

Guiding Mississippi Sites to More Effective Cleanups

William Benni

Duration Distribution of Dual-Phase Systems Operations at 282 MS Sites



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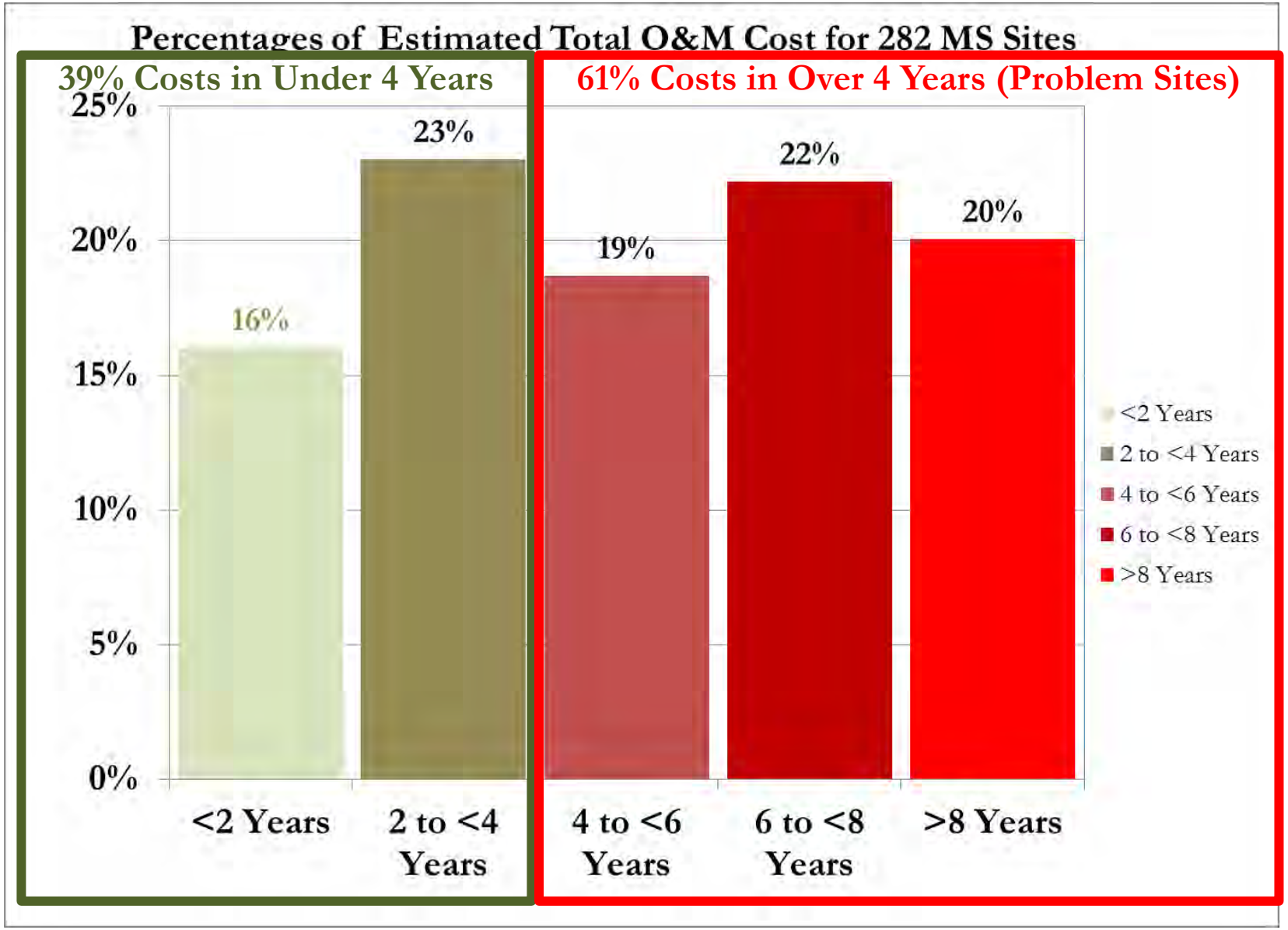
Estimated Distribution of Operational Costs at 282 MS Sites



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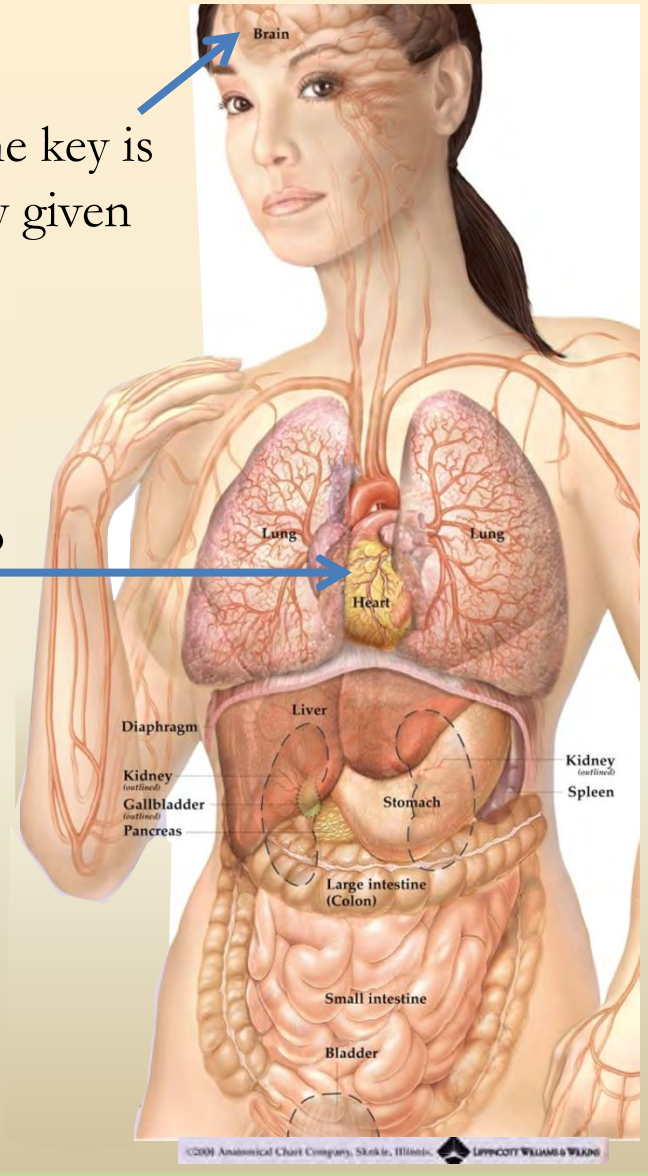
IAtM's Advanced Data Analysis (ADA)

A unique system of "data analysis organs" that transforms existing information into an understanding that guides sites to closure.

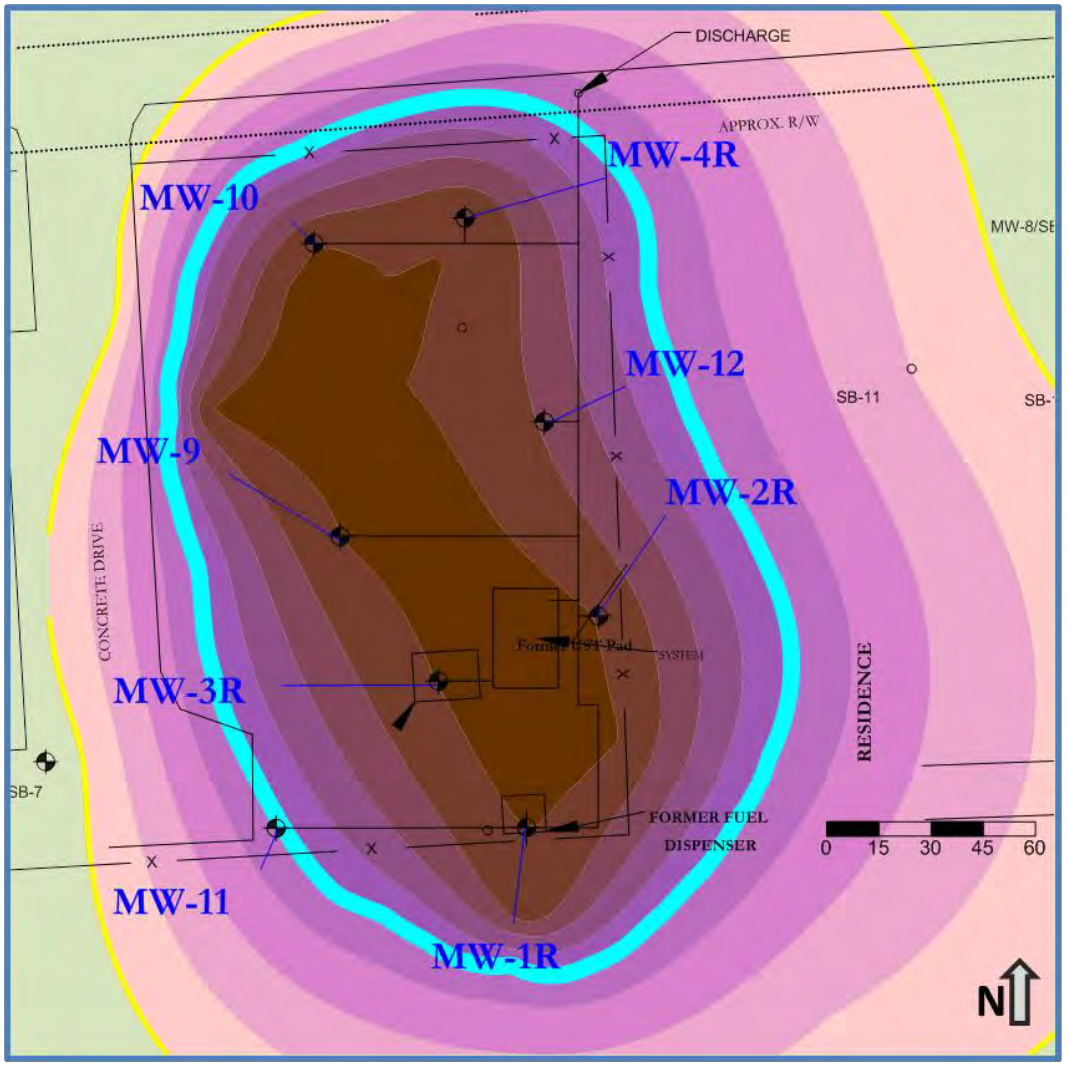
Strategic Ideation from Connectedness (brain): The key is to link datasets to create alternative ways to proceed in any given situation by quickly spotting relevant patterns and issues.

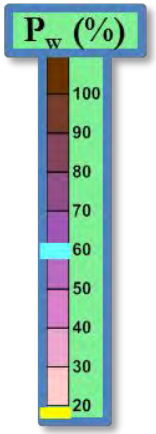
SOURCE LOCATOR (heart): Translates site data into plots of residual source mass using **IAtM**'s developed metric (P_w- percent equilibrium)



SOURCE LOCATOR "heart": Estimated Initial Extent of Residual Source Mass in Lower Layer

AI 78318
Monroe, LA





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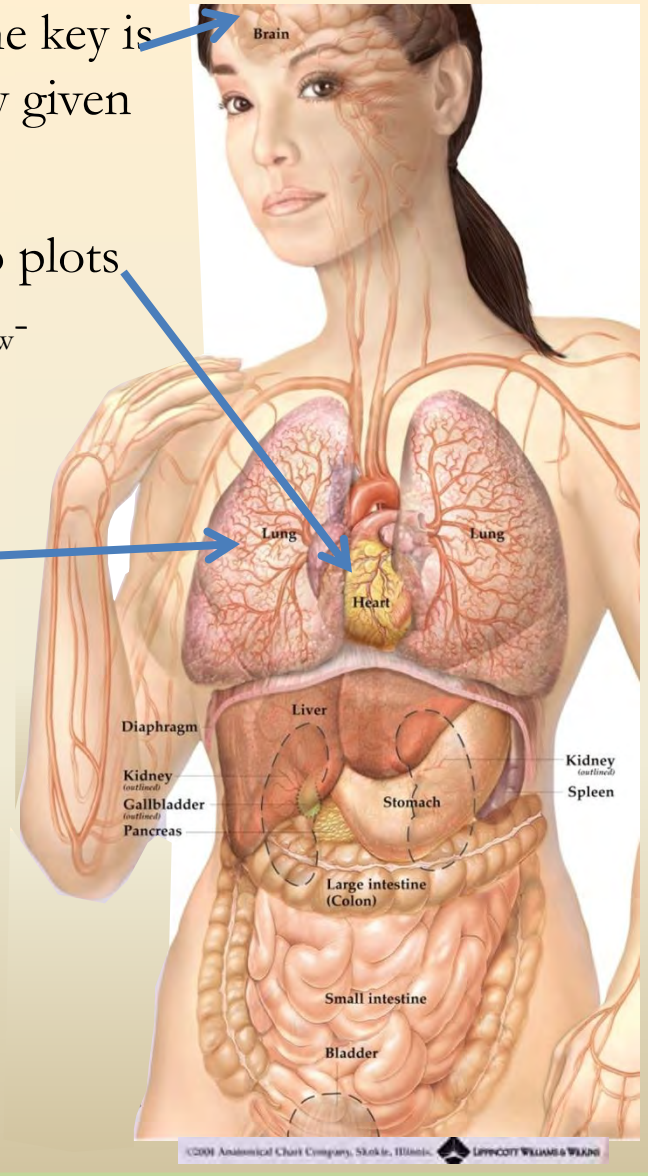
Strategic Ideation from Connectedness (brain): The key is to link datasets to create alternative ways to proceed in any given situation by quickly spotting relevant patterns and issues.

SOURCE LOCATOR (heart): Translates site data into plots of residual source mass using **IAtM**'s developed metric (P_w-percent equilibrium)

System Efficiency Evaluation (SEE) (lungs): **IAtM** estimates radius of effective mass reduction to identify areas of missed source mass and site-specific factors affecting mass removal



System Efficiency Evaluation "lung": Estimated Radius of Influence (ROI of Mass Reduction) with Initial Source Extent from SOURCE LOCATOR "heart"

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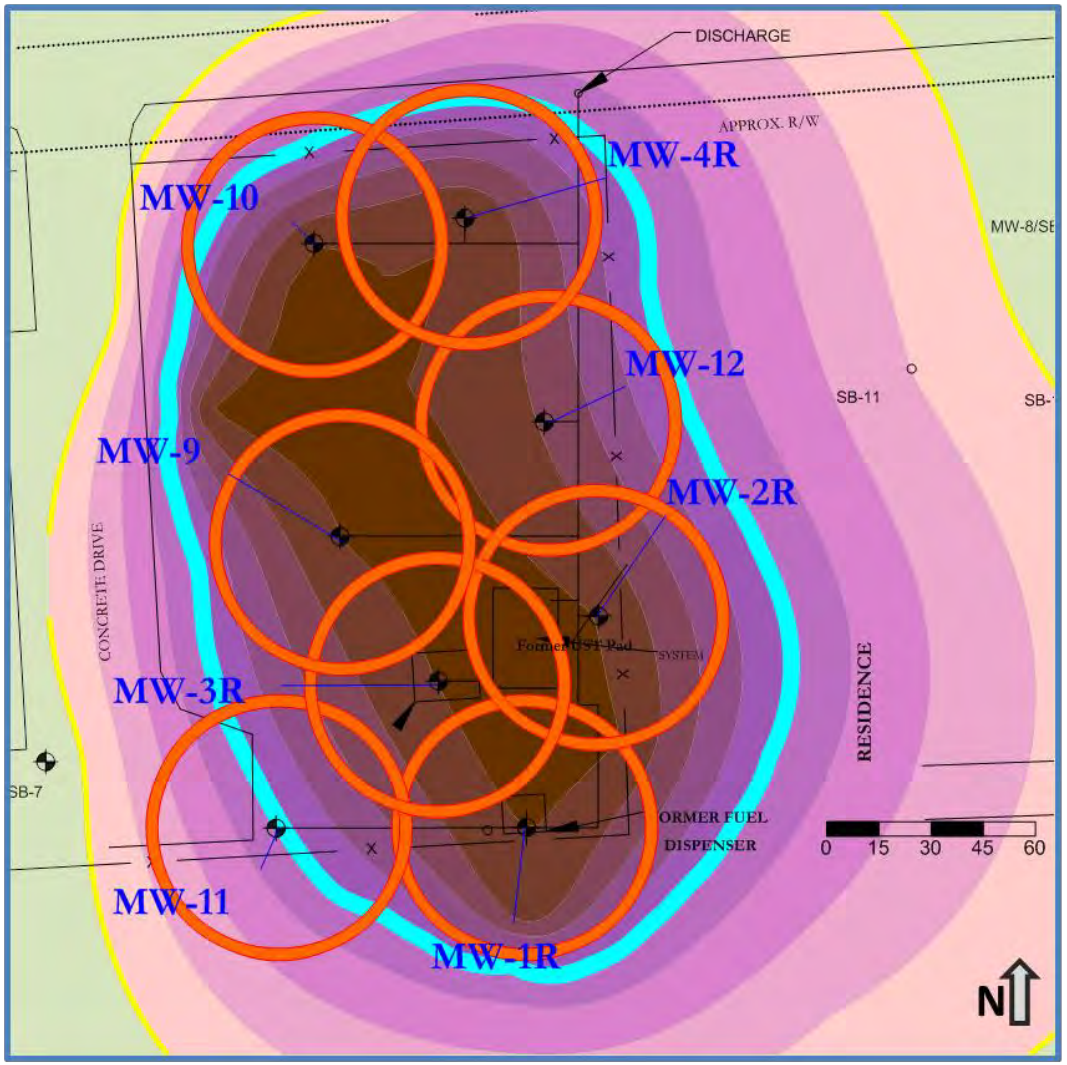

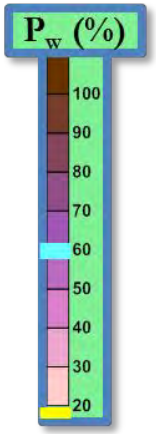

SOURCE LOCATOR "heart": Returns 2010 Source Mass Estimate Using Later Data and After Infusion from the System Efficiency Evaluation ROIs "lungs"

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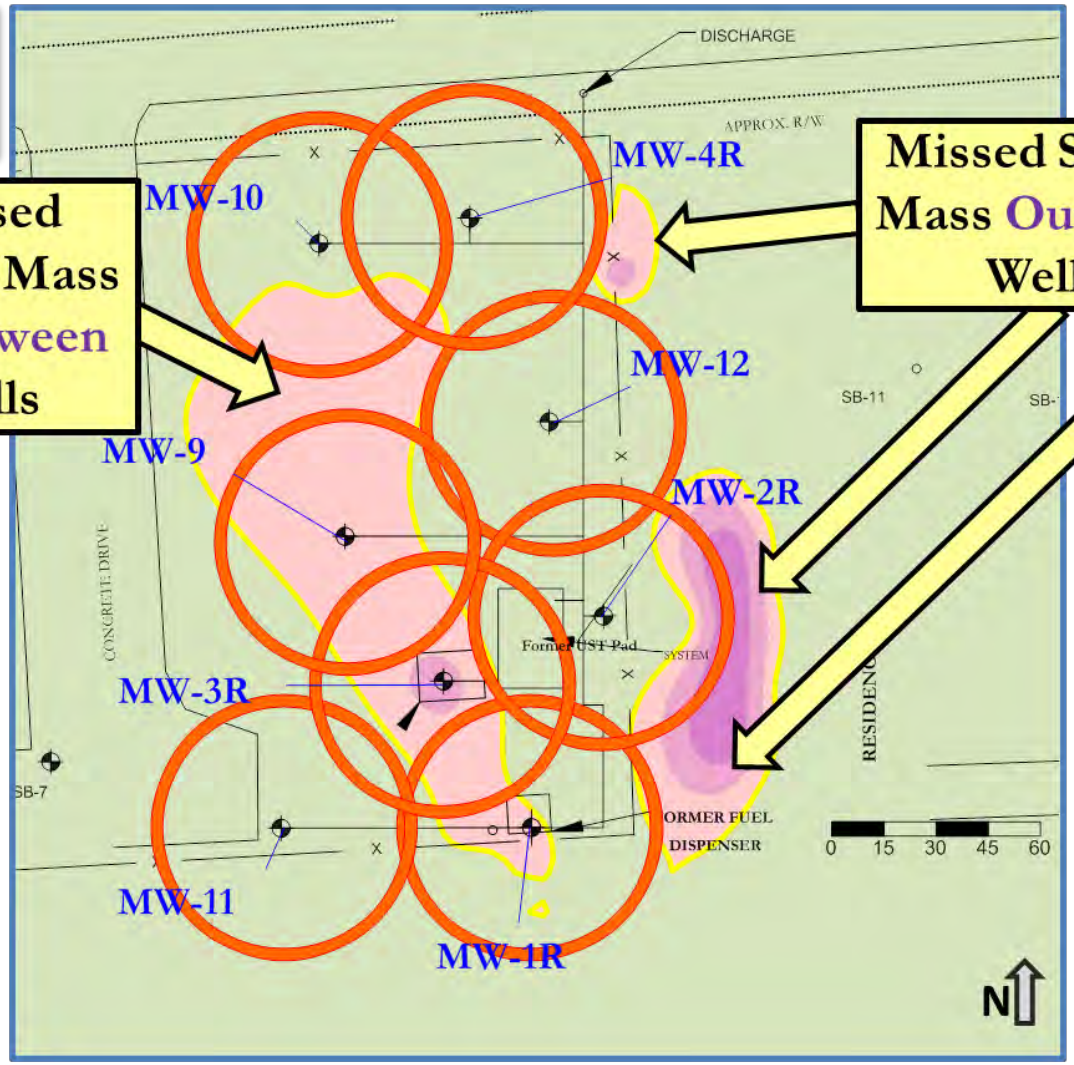
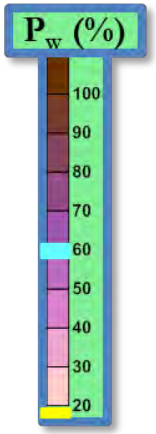
Monroe, LA



Missed Source Mass In Between Wells

Missed Source Mass OutSIDE Wells

WARNING!
Very small amounts of un-located missed mass can cause intermittent exceedances of low cleanup standards



IAtM's Advanced Data Analysis (ADA)

A unique system of "data analysis organs" that transforms existing information into an understanding that guides sites to closure.

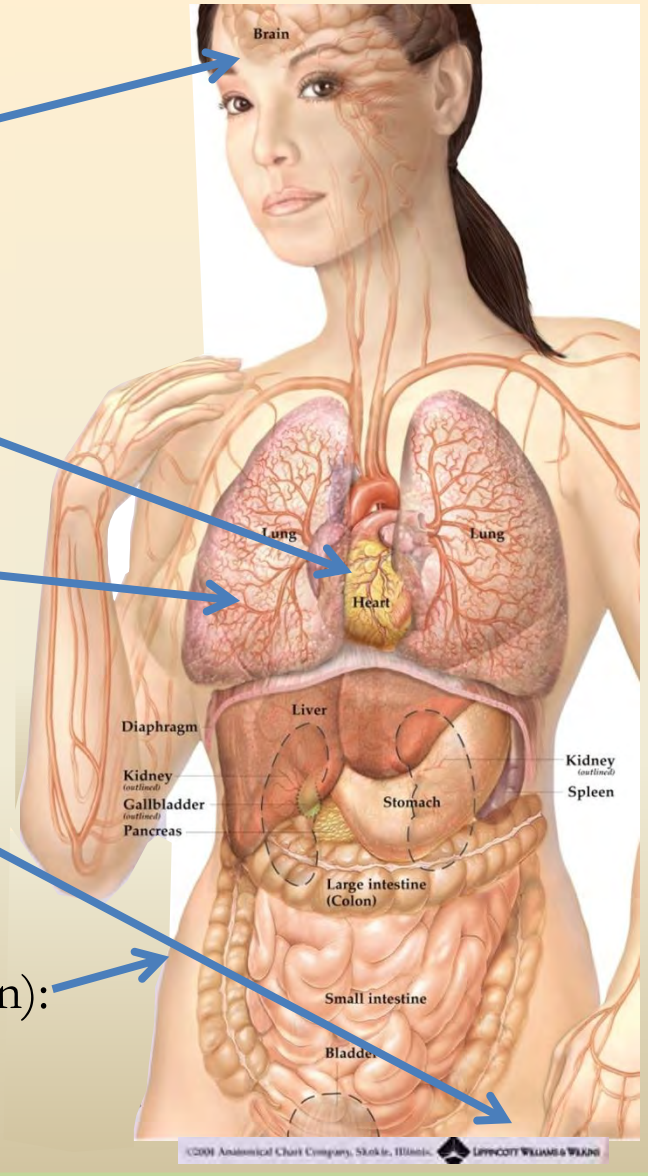
Strategic Ideation from Connectedness (brain)

SOURCE LOCATOR (heart)

System Efficiency Evaluation (SEE) (lungs)

SOURCE TRACKER: (legs): **IAtM** assessment to find missed source mass where no data exist and to assess the likelihood of rebound.

Reports with Clear Figures and Suggestions: (Skin): **IAtM** wraps up analysis with clear slides and suggestions.



SOURCE TRACKER "legs": : Follows Computer Generated Flow Directions from Observed Water Elevations and Color Codes them Based on Exceedances

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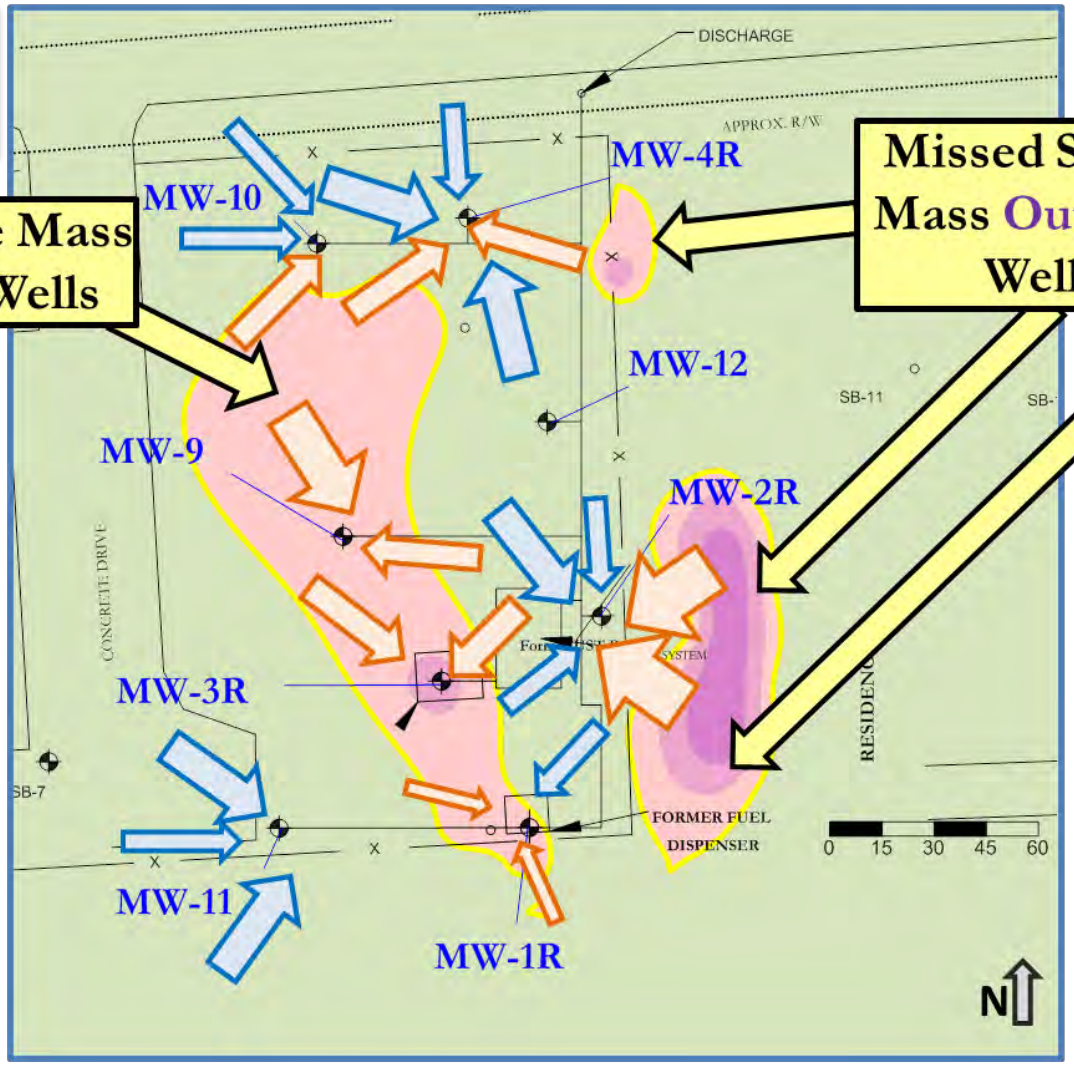
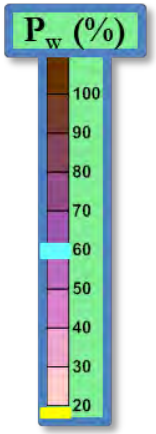
Missed Source Mass In Between Wells

Missed Source Mass OutSIDE Wells



Flow Directions with exceedance in Orange
(larger arrow = larger gradient)

Flow Directions without exceedance in Blue
(larger arrow = larger gradient)



Slide 10

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Suggestion: Add Four New Wells to DPE System in Areas of SOURCE TRACKER Verified Missed Mass: Result – Rapid Site Closure

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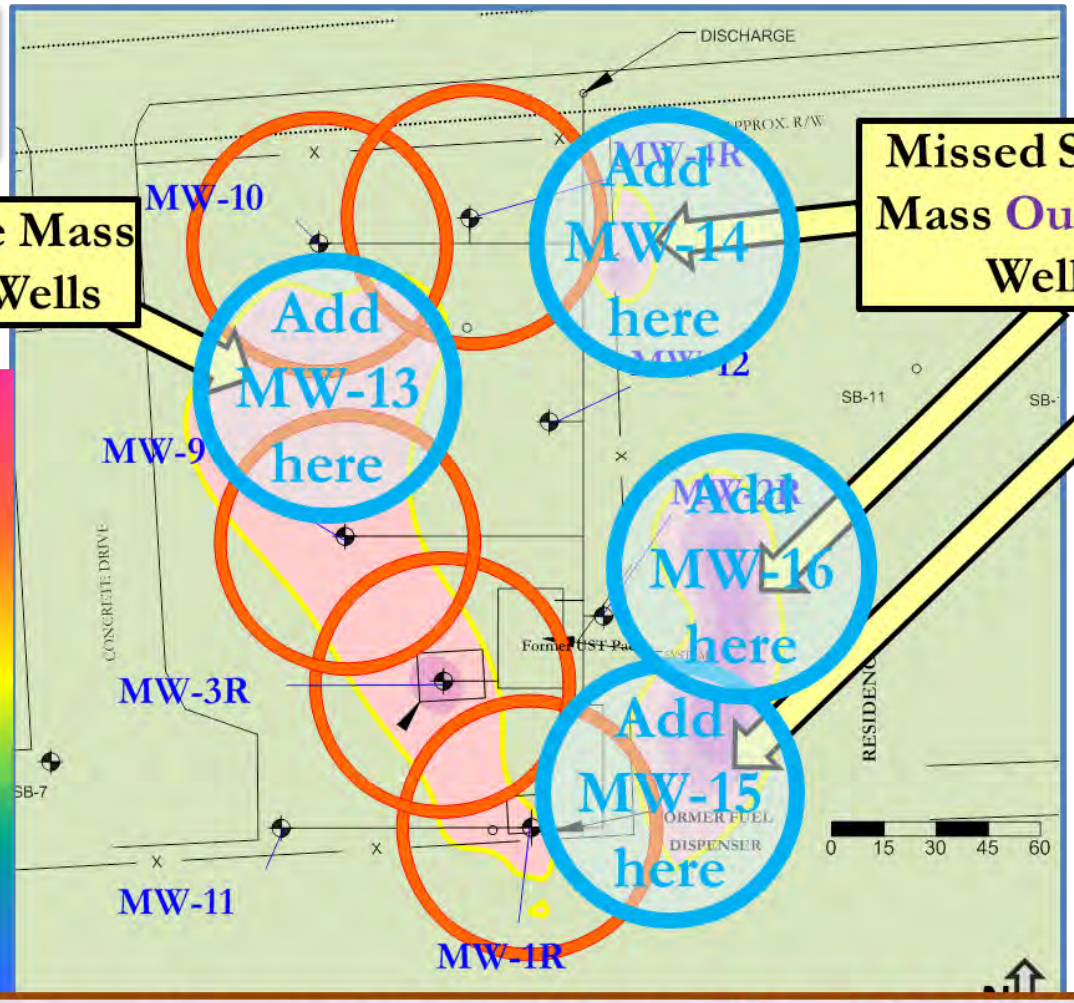
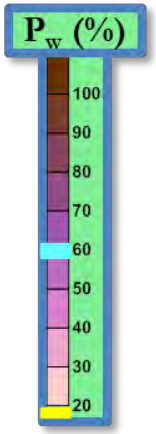
Missed Source Mass In Between Wells

Missed Source Mass OutSIDE Wells





Finding the mass with existing data led to quick

Site Closure!

If only three wells were installed site would not have fully cleaned up

- All four wells exceeded standard by **20x to 33x fold**
- Odds of occurring based on previous 13 rounds: **1 in 2055**
- Other 12 wells only had 1 slight exceedance (<2x vs. >20x)

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Consistent Causes for Failure to Cleanup in 4 Years Identified by ADA

Advanced Data Analysis (ADA) has Eyes to See Root Causes for Failure to Cleanup in Nine States				
Missed Source Mass	Spatially			Waste (action without mass reduction)
	In Between recovery/ injection wells	OutSIDE treatment area		
Dual-Phase (32 Evaluations)	74%	68%		71%

Estimated 23% of all MS sites and 45% of O&M Costs

Cause: ROI Overestimated or Possibility of Gaps not Checked

Suggested Solution: Begin with following Design ROI Maximums:

- ✓ 20 to 25 feet in asphalt covered areas with typical DTWs
- ✓ 12 to 15 feet in grass areas, or shallow DTWs relative to soil type (critical shallow depth greater for sands) [short-circuiting]
- ✓ 10 to 15 feet in very tight materials

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Monitoring Program Design Flaw: Wells Not Installed to Confirm Design ROI

Advanced Data Analysis (ADA) has Eyes to See Root Causes for Failure to Cleanup in Nine States

Missed Source Mass	Spatially			Waste (action without mass reduction)
	In Between recovery/ injection wells	OutSIDE treatment area		
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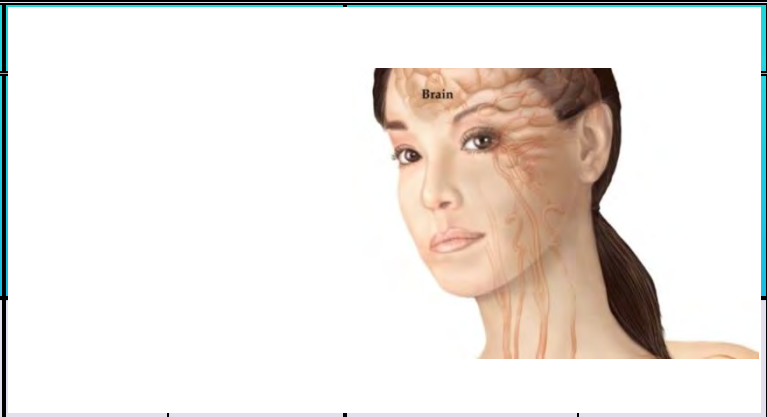

Estimated 21% of all MS sites and 41% of O&M Costs

Cause: No Monitoring Wells within one Design ROI Distance Outside recovery wells installed

Suggested Solution: Include Monitoring Wells Outside Recovery Well Network at 12, 17 and 22 feet in the three most impacted flow direction to monitor for vacuum response

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Critical Metric for Dual-Phase System Evaluation: If minimal vapors and exceedances persist, Waste is occurring: ADA and system mod required

Advanced Data Analysis (ADA) has Eyes to See Root Causes for Failure to Cleanup in Nine States				
Missed Source Mass	Spatially			Waste (action without mass reduction)
	In Between recovery/ injection wells	OutSIDE treatment area		
Dual-Phase (32 Evaluations)	74%	68%		71%

Estimated 22% of all MS sites and 43% of O&M Costs

Cause: Dual-phase System Continued to be Operated when No Vapors are Being Recovered

Suggested Solution: Monitor PID Exhaust during every site visit, if entire triannual has low PID readings after 2 years of operation, consider contacting IAtM for Advanced Data Analysis

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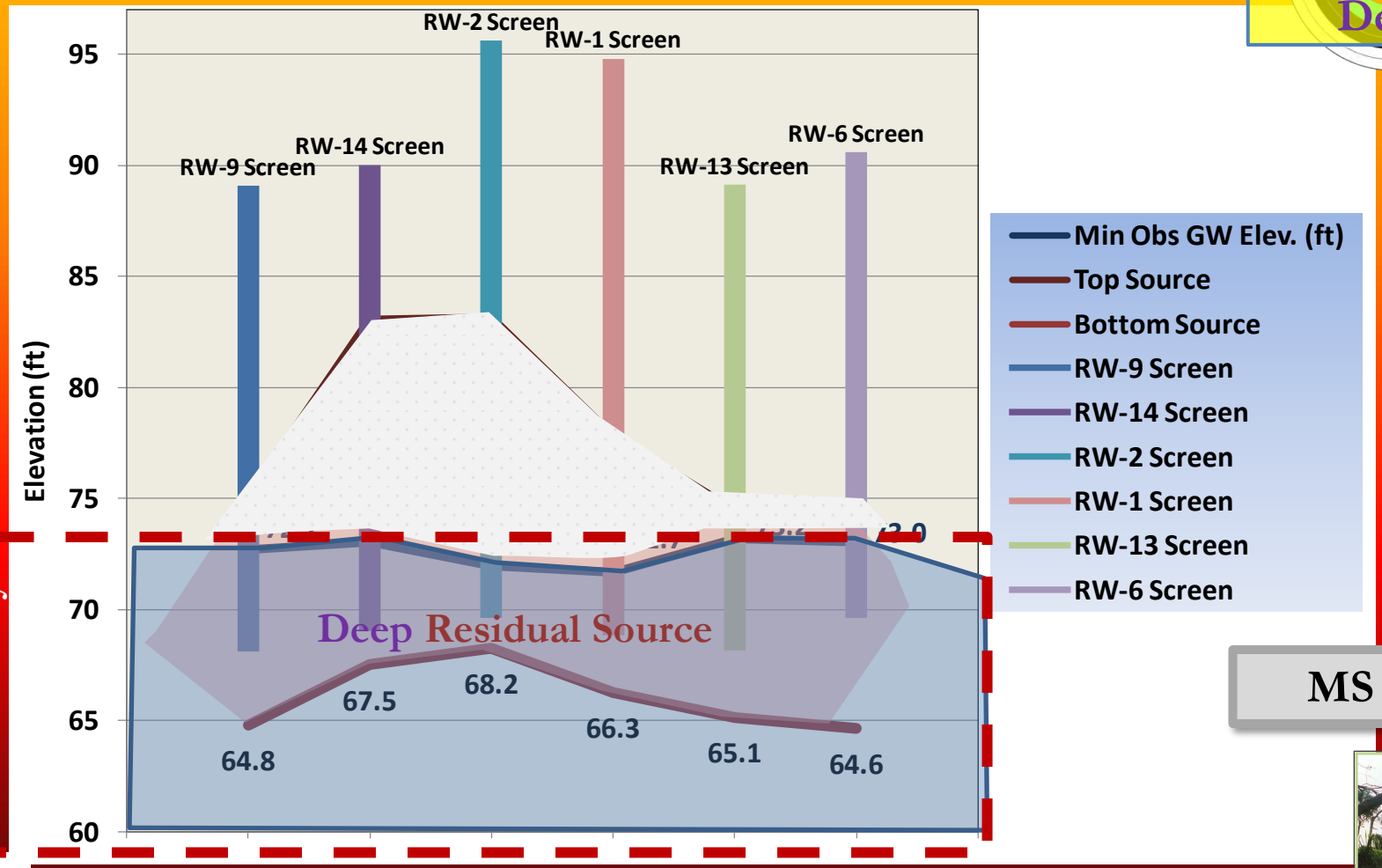
Improved Analysis through Modeling, LLC

Critical Dual-Phase Remedy Vulnerability: Deep Mass Below Remedy's Reach

65% of Dual-Phase problem sites



Critical Vulnerability

MS Site

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IAtM's Advanced Data Analysis (ADA)

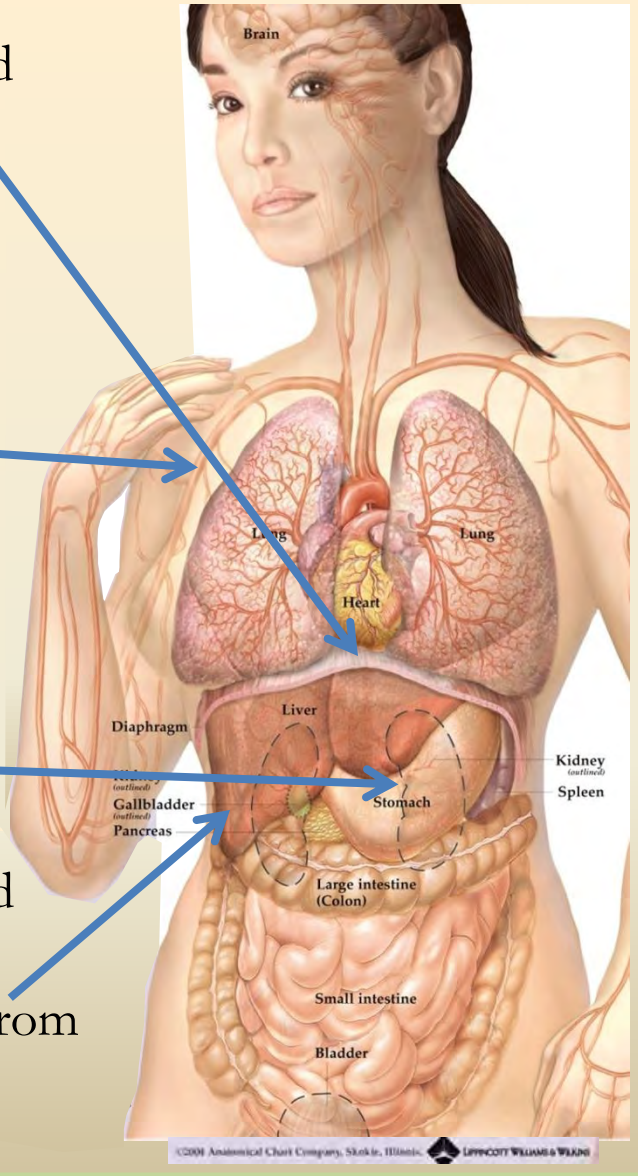
A unique system of "data analysis organs" that transforms existing information into an understanding that guides sites to closure.

SOURCE BOTTOM: (diaphragm): **IAtM** tool to find missed deeper source mass that is not exposed to vapor recovery or is below injections.

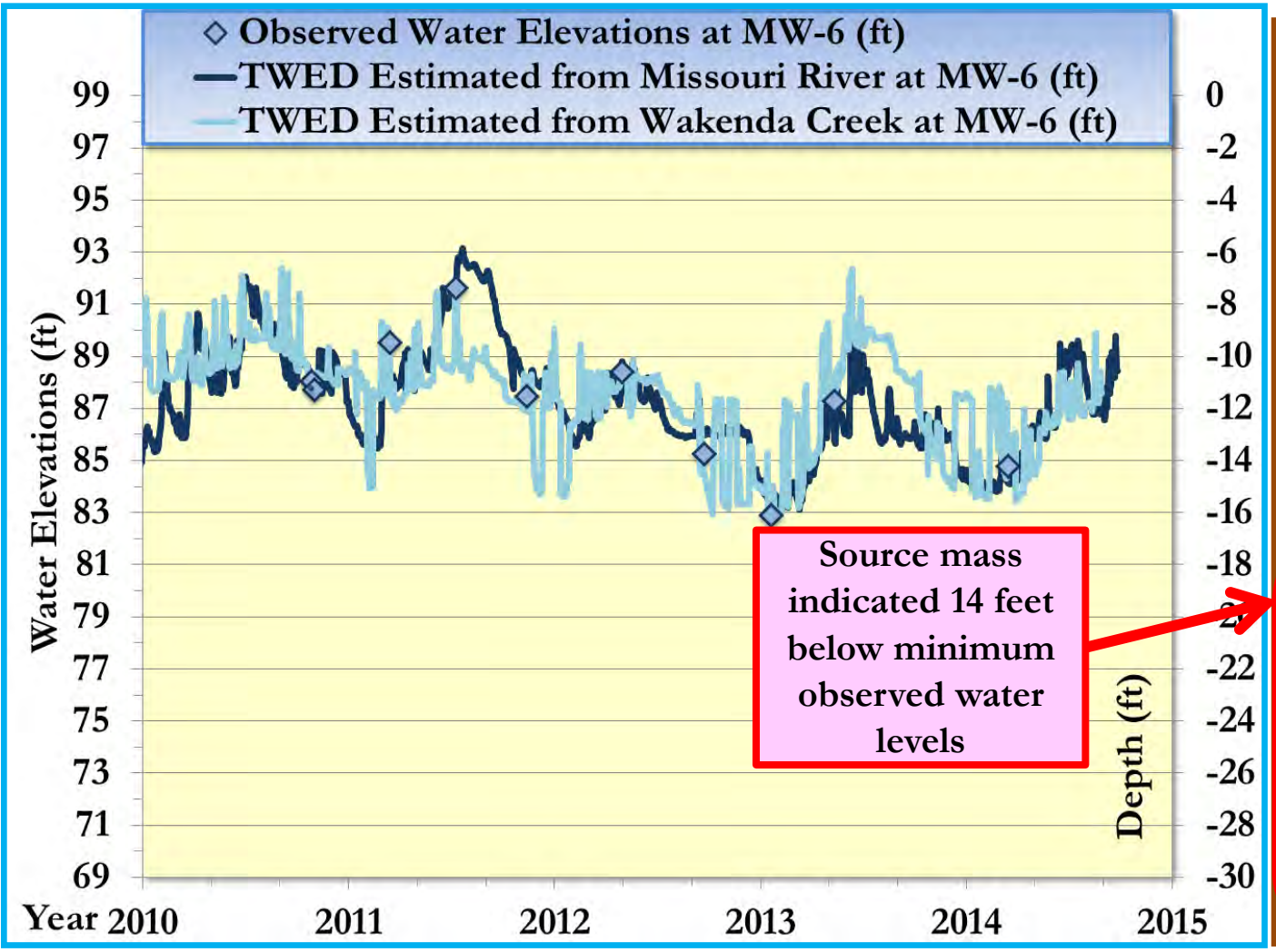
Transient Water Elevation Determination (TWED): (circulatory system): **IAtM**'s multi-variable adaptive regression model that estimates daily water elevations even before well installation from daily river discharge data.

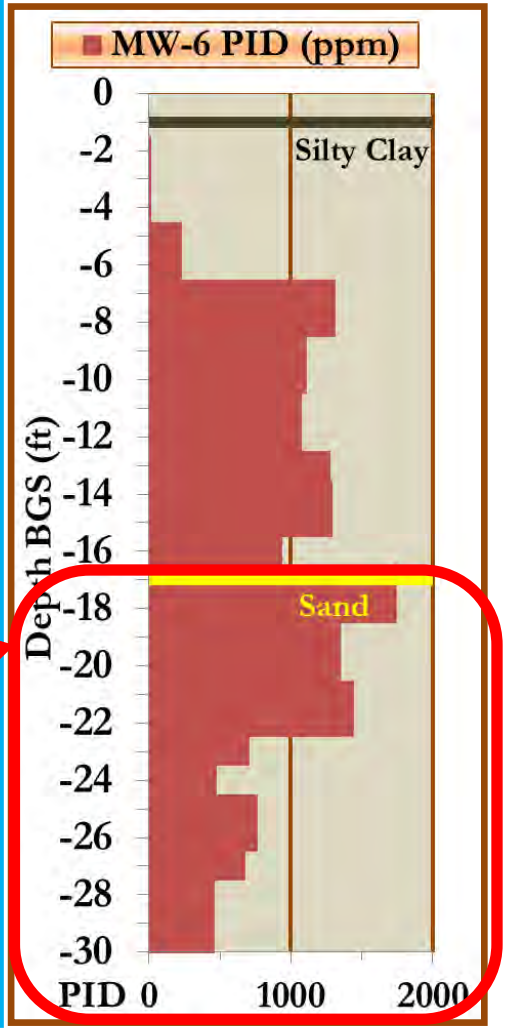
Product Occurrence Analysis (POA): (stomach): **IAtM** digests all available data and provides client with a clear explanation of why product rebounded at the site.

Drought Analysis: (Liver): A complex assessment offered only by **IAtM** as a means to estimate the optimal times to operate possible remedies based on probabilities derived from review of historic **TWED** estimated DTWs.



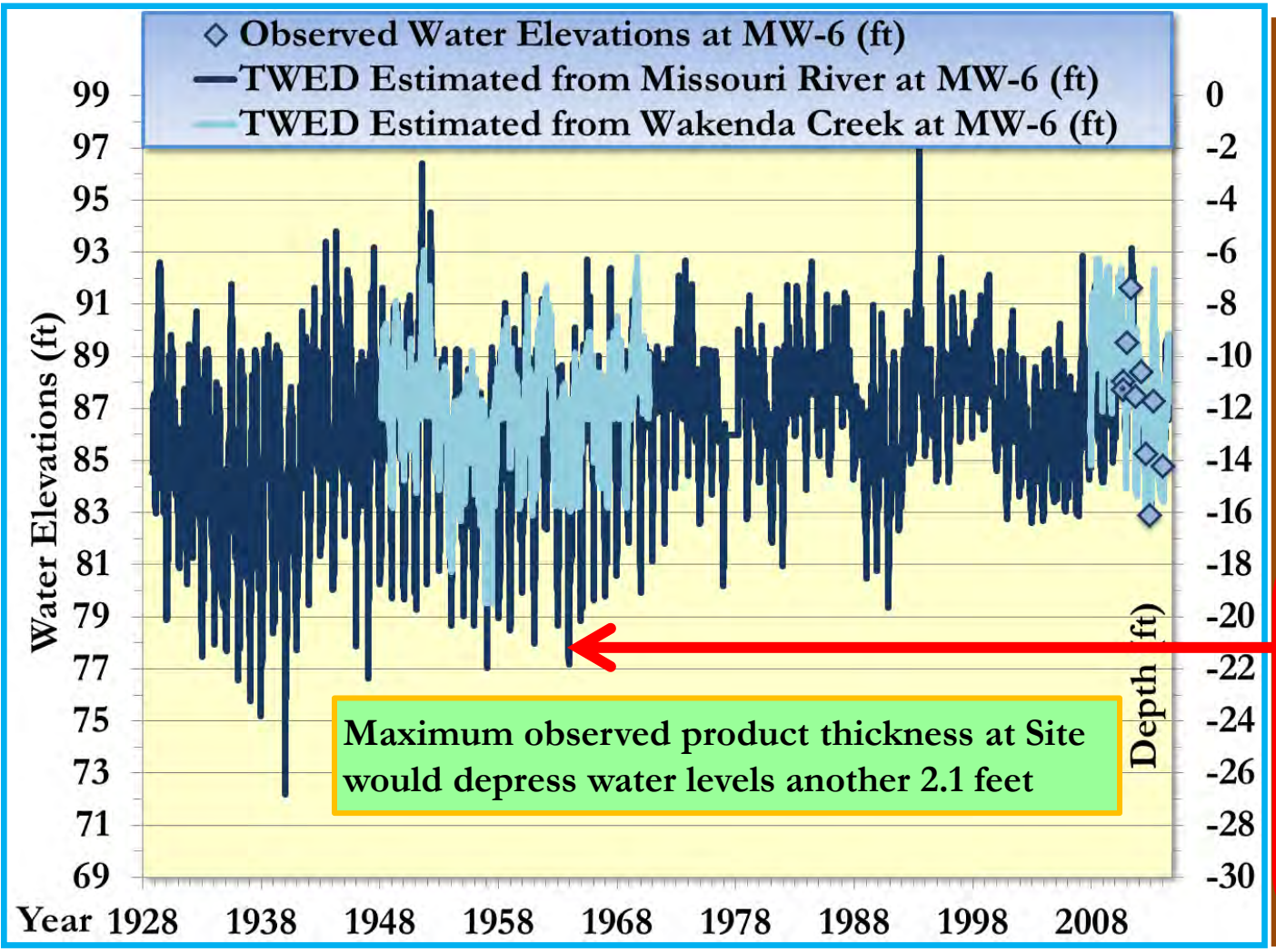
SOURCE BOTTOM: Observed and TWED Water Elevations from Missouri River and Wakenda Creek at MW-6: Maximum Depth of -16 ft During Observed Period

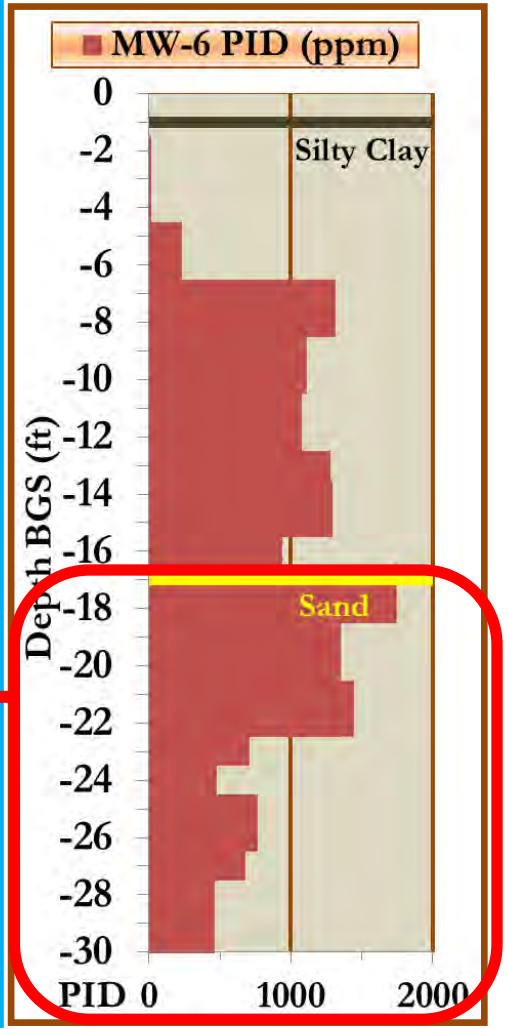




Carrollton, MO

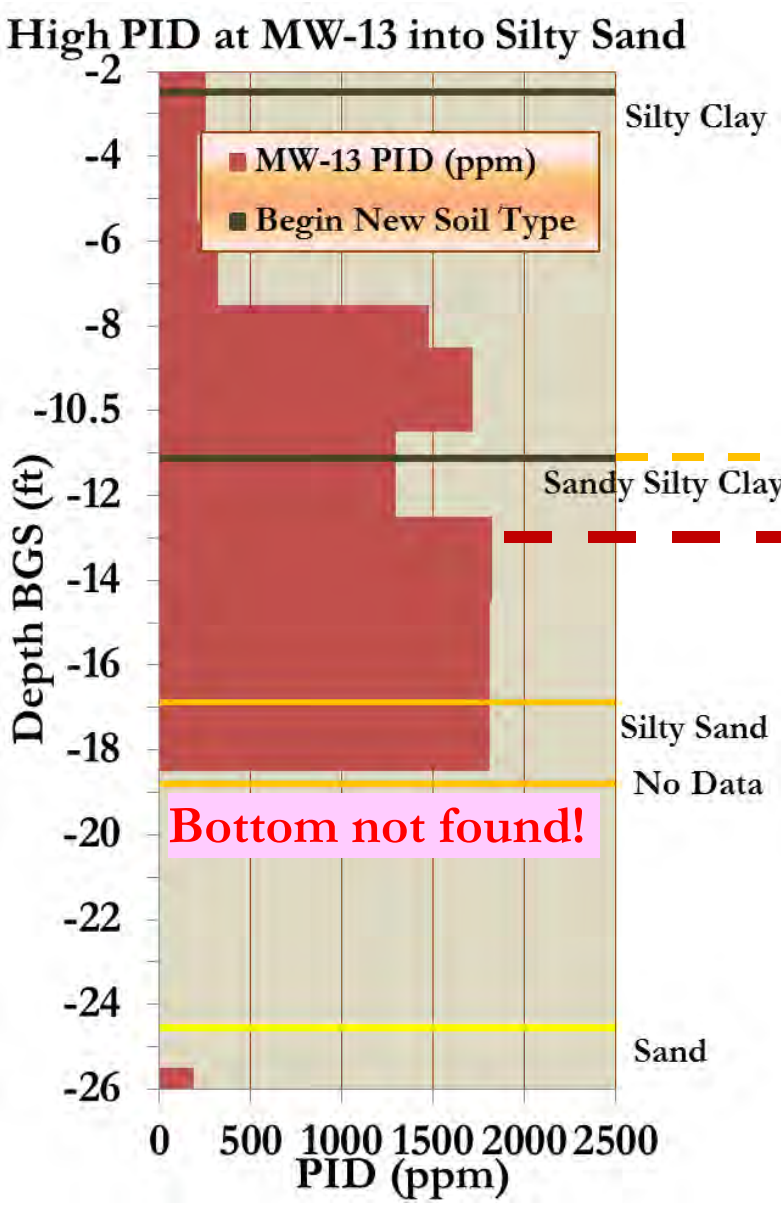
SOURCE BOTTOM: 87 Years of River Data Yields Greater Maximum Depth of -27.1 ft Based on TWED Correlation: High PIDs at this Depth Confirm TWED

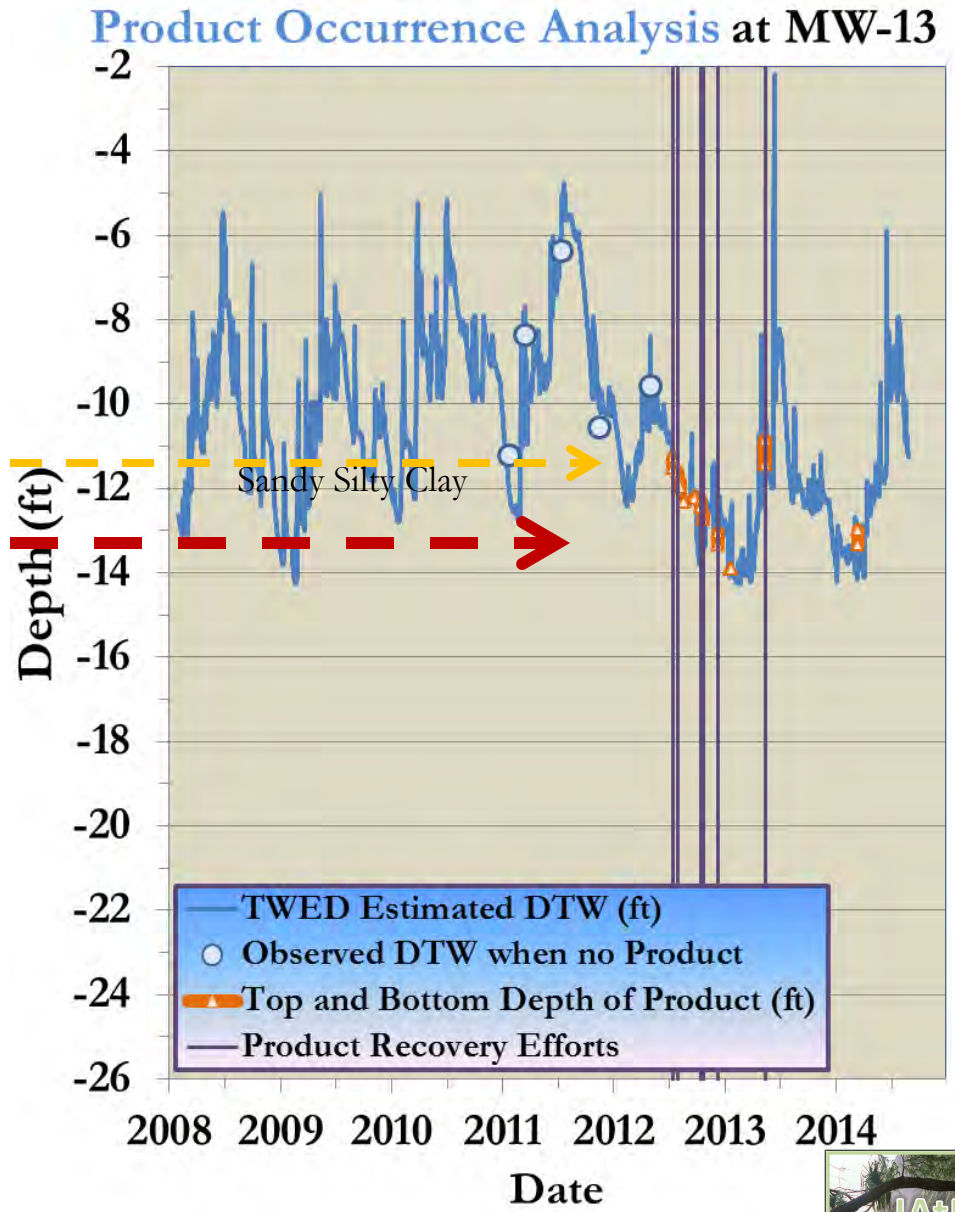




Carrollton, MO

Product Occurrence Analysis: Product with Greater DTWs at Sandy Silty Clay





Carrollton, MO

Critical Dual-Phase Remedy Vulnerability: Deep Mass Below Remedy's Reach

Advanced Data Analysis (ADA) has Eyes to See Root Causes for Failure to Cleanup in Nine States

Missed Source Mass	Spatially		Vertically			Waste (action without mass reduction)
	In Between recovery/ injection wells	OutSIDE treatment area	Deep (below remedy's reach)	Shallow (above remedy's reach)		
Dual-Phase (32 Evaluations)	74%	68%	65%	13%		71%

Estimated 20% of all MS sites and 40% of O&M Costs

Multiple Causes: Source Bottom Not Found During Initial Investigation

Suggested Solution: Continue Drilling Soil Boring Until Confirmed Significant Decline in Measured PIDs

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Critical Dual-Phase Remedy Vulnerability: Deep Mass Below Remedy's Reach

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Estimated 20% of all MS sites and 40% of O&M Costs

Multiple Causes: Dual-phase unable to lower water table without aid of pumps

Suggested Solution: If large initial product thicknesses or PIDs below water levels, install deeper wells with pumps from start

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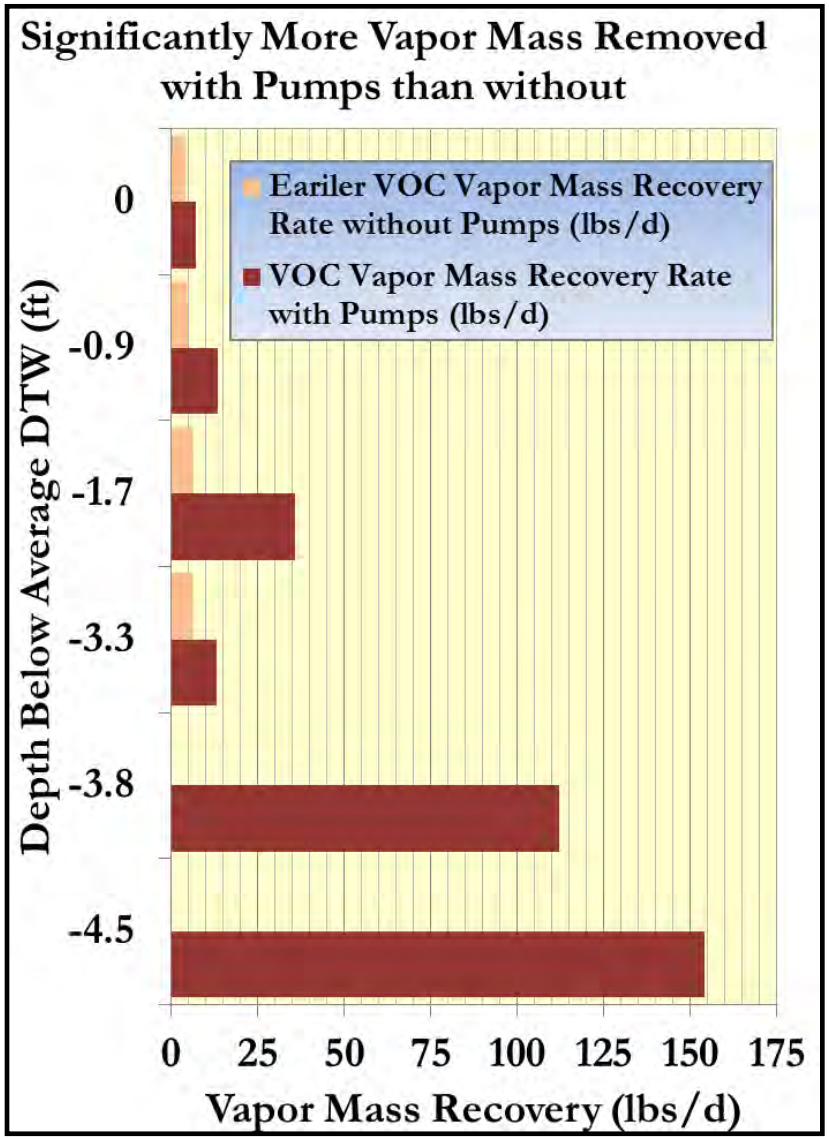
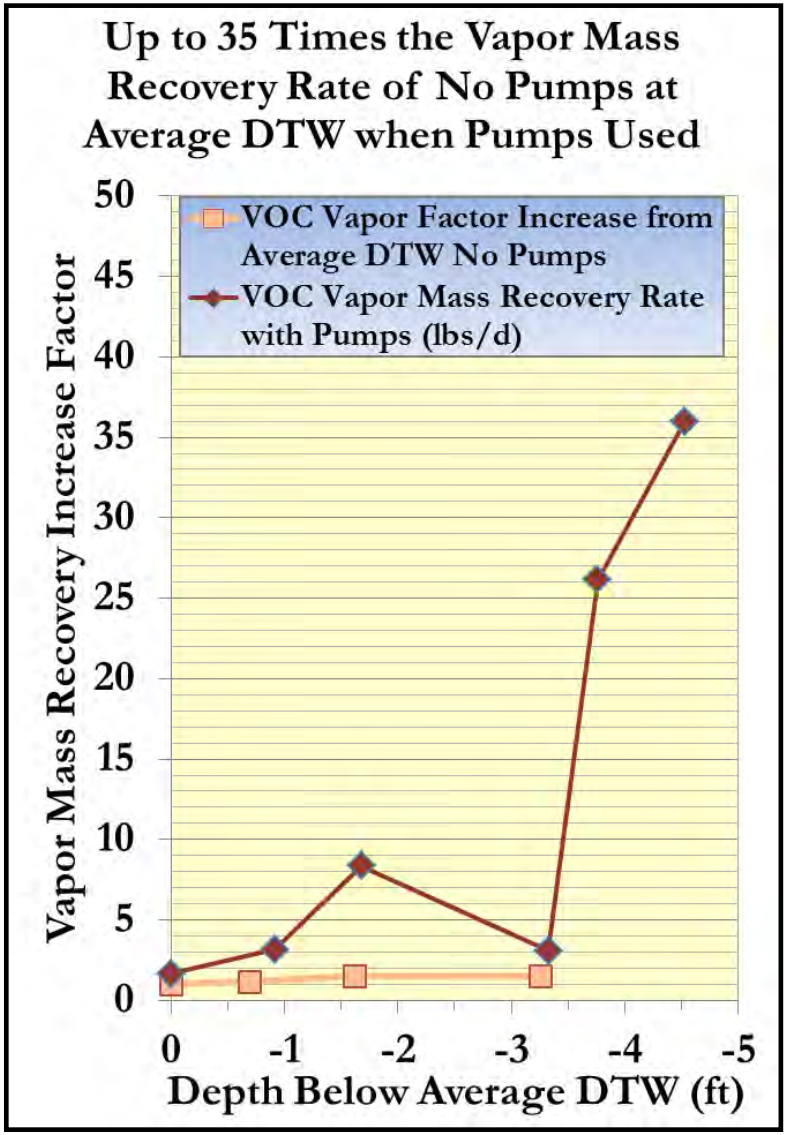
Dual-Phase Review: Significantly More Vapor Mass Recovery Achieved After Pumps were Added at a Bulk Plant Remediation with Submerged Product





MS Site

Critical Dual-Phase Remedy Vulnerability: Deep Mass Below Remedy's Reach

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Dual-Phase (32 Evaluations)		65%	13%		71%

Estimated 20% of all MS sites and 40% of O&M Costs

Multiple Causes: Natural water levels only seasonally low limits duration of deeper mass remediation even with pumps

Suggested Solution: Perform ADA drought analysis to determine optimal operation periods

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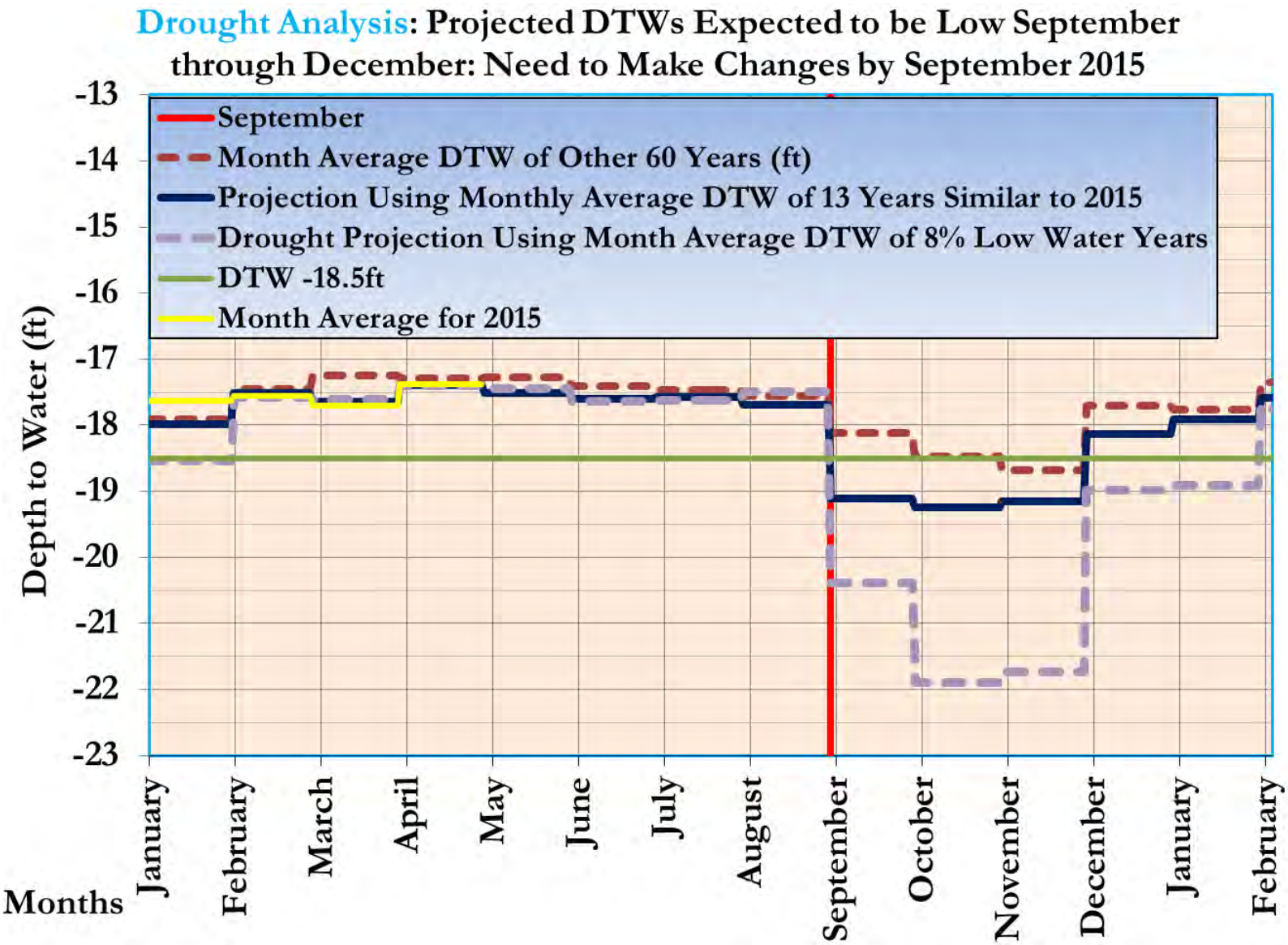
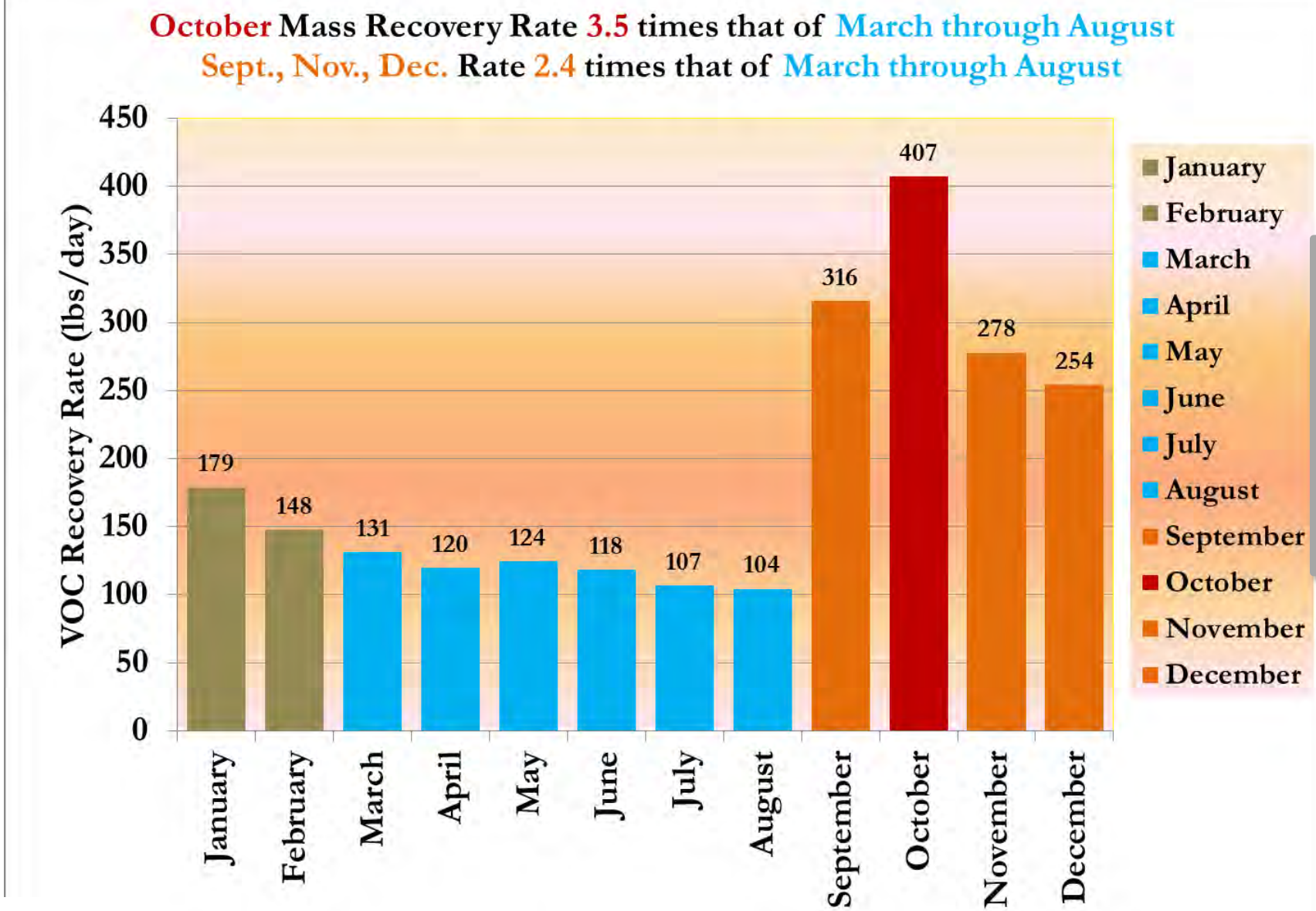
Drought Analysis: Based on 13 Years Most Similar to 2015 in February through April Water Levels are Projected to be Slightly Lower this Fall



AI 70617
Winnsboro, LA

Drought Analysis: Activate System with New Wells by September 2015 and Operate through December then Shut Off



AI 70617
Winnsboro, LA

Monitoring Program Design Flaw: Dedicated Deeper Screened Wells Below Typical Water Level Not Installed to Monitor Deep Mass

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Missed Source Mass		Vertically			Waste (action without mass reduction)
		Deep (below remedy's reach)	Shallow (above remedy's reach)		
Dual-Phase (32 Evaluations)		65%	13%		71%

Estimated 20% of all MS sites and 40% of O&M Costs

Cause: Monitoring Wells only installed across the water table and not with screen only below typical water levels

Suggested Solution: Include two Monitoring Wells screened below water table in between recovery wells with deepest PID readings

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Advanced Data Analysis Evaluates an Ozone Remedy

- February 2011, a PulseOx® In-situ Chemical Oxidation Ozone Sparging Technology (Ozone system) began operating
- Six months to a one year later, product was observed at MW-2
- After four years of operations, benzene was monitored at 3 ppm in groundwater at MW-2 in 2014,
- and TPH-G, which was monitored in the first two samples collected at MW-2 at 150 and 170 ppm, still reported concentrations of 150 ppm in June 2014

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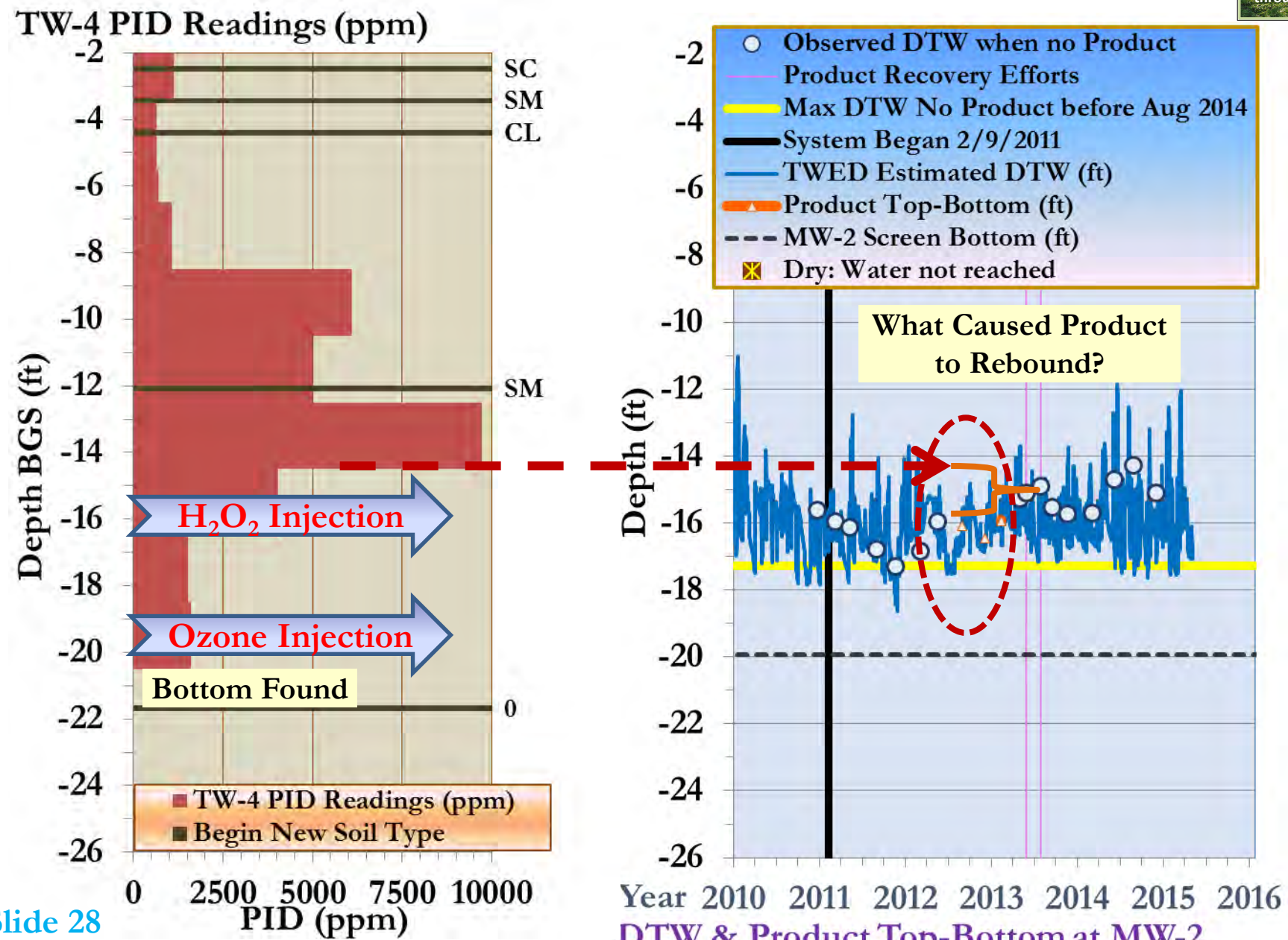
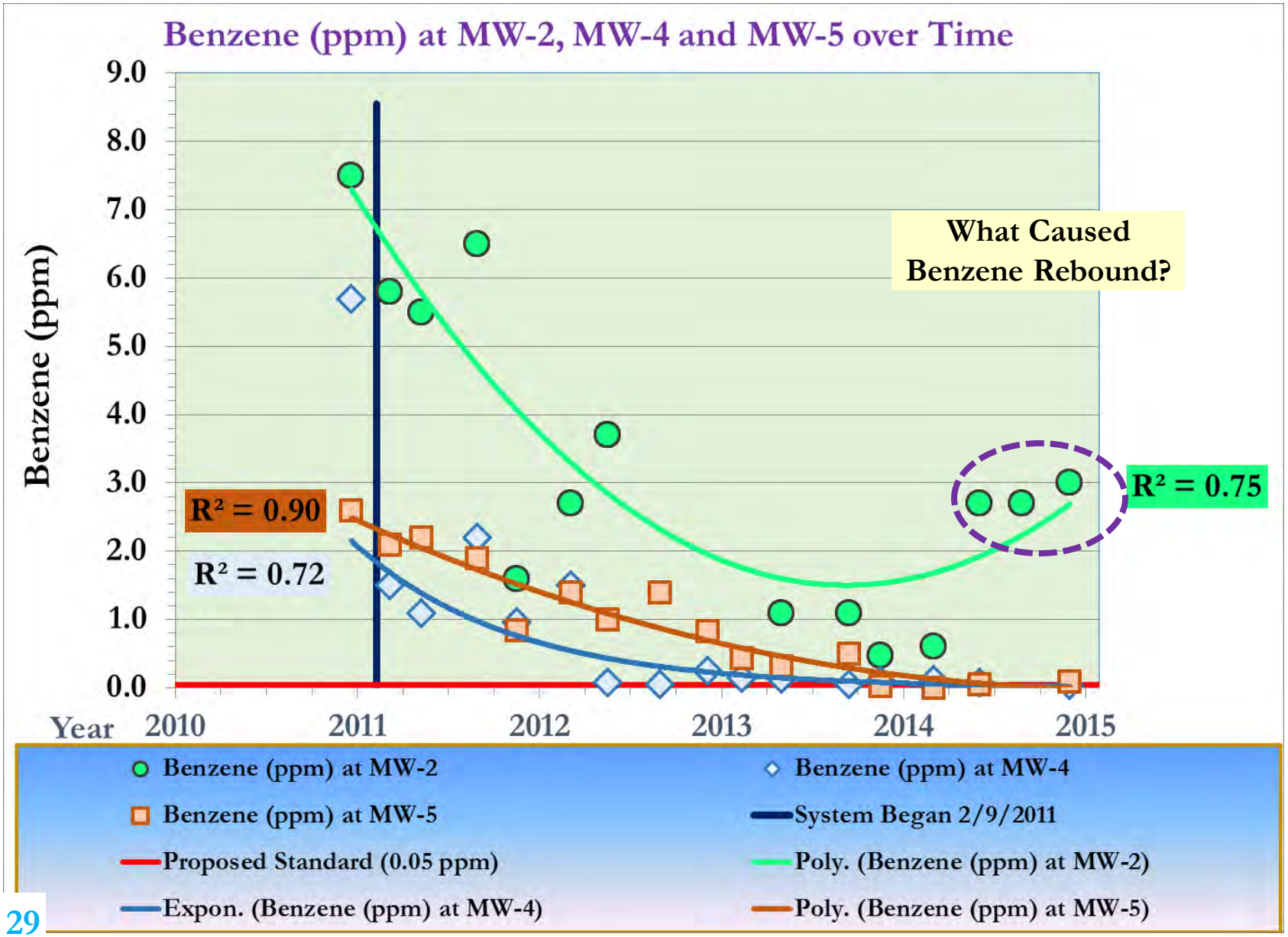
Product Occurrence Analysis (POA): Shallow Mass Suspected of Draining During Dry Period to Yield Thin Product Layer at MW-2



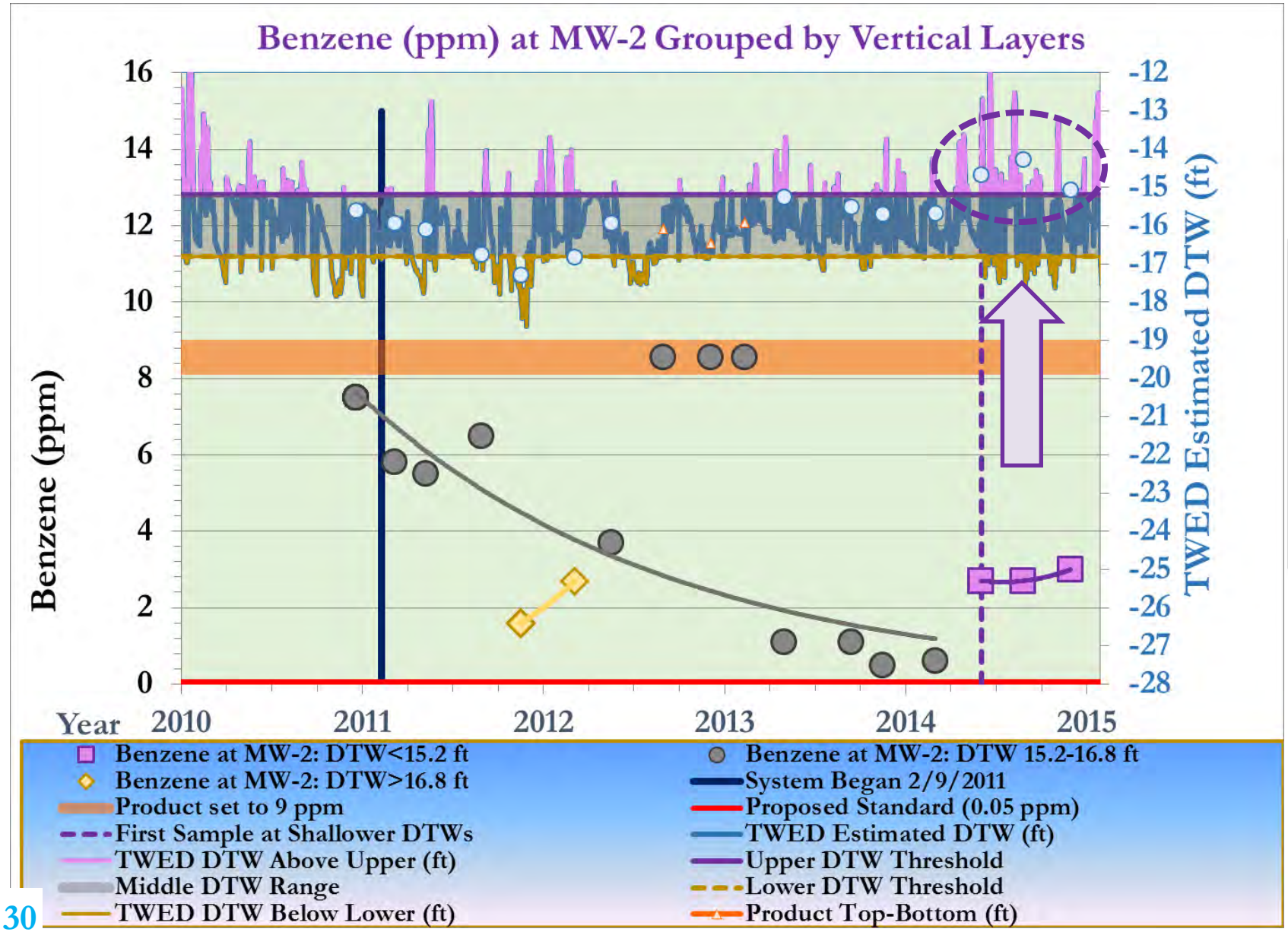
West Monroe, LA

System Efficiency Evaluation (SEE): Clear Declining Trends for Benzene Give the False Impression that All Remedial Goals will be Met



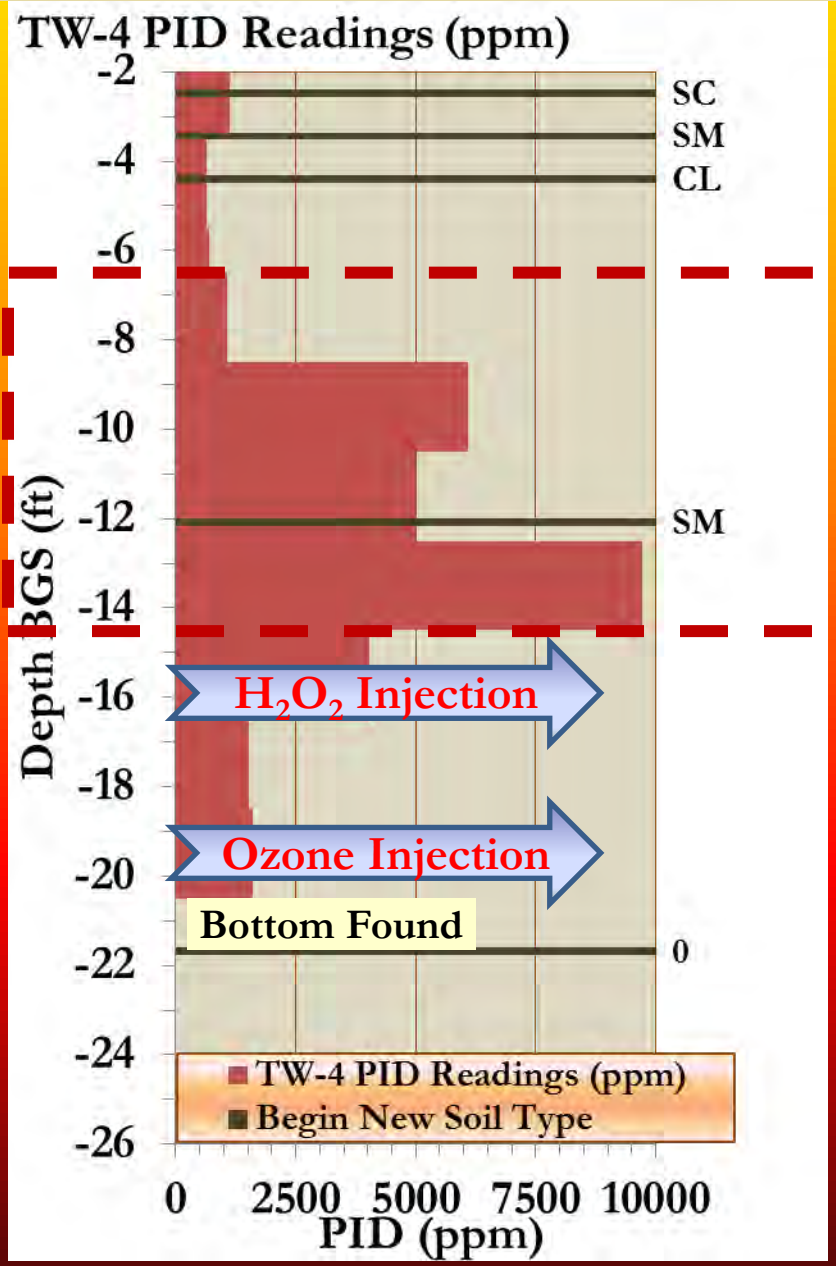
West Monroe, LA

SOURCE TRACKER: Rebound of Benzene at MW-2 Occurred at Shallower DTWs; Thus, Confirming Missed Shallow Mass

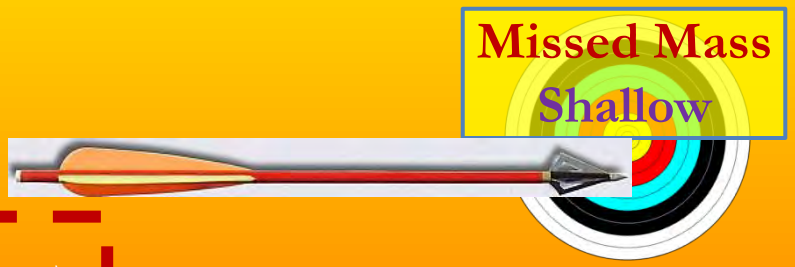


West Monroe, LA

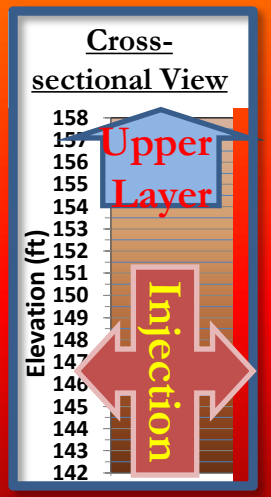
Critical Injection Technology (including ozone) Vulnerability: Mass Above Water Table During Time of Injection



Critical Vulnerability



100% of Injection Technology problem sites



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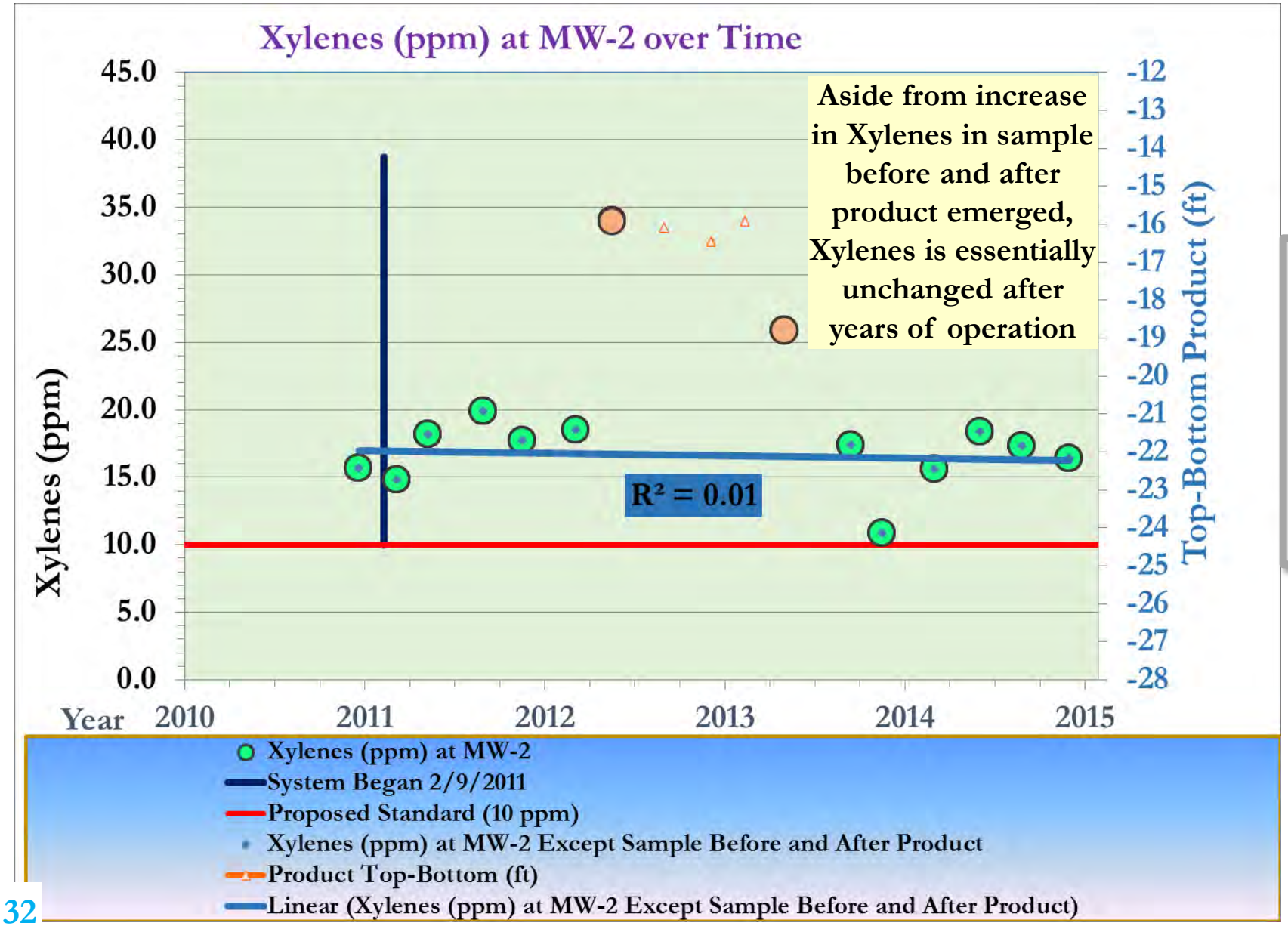
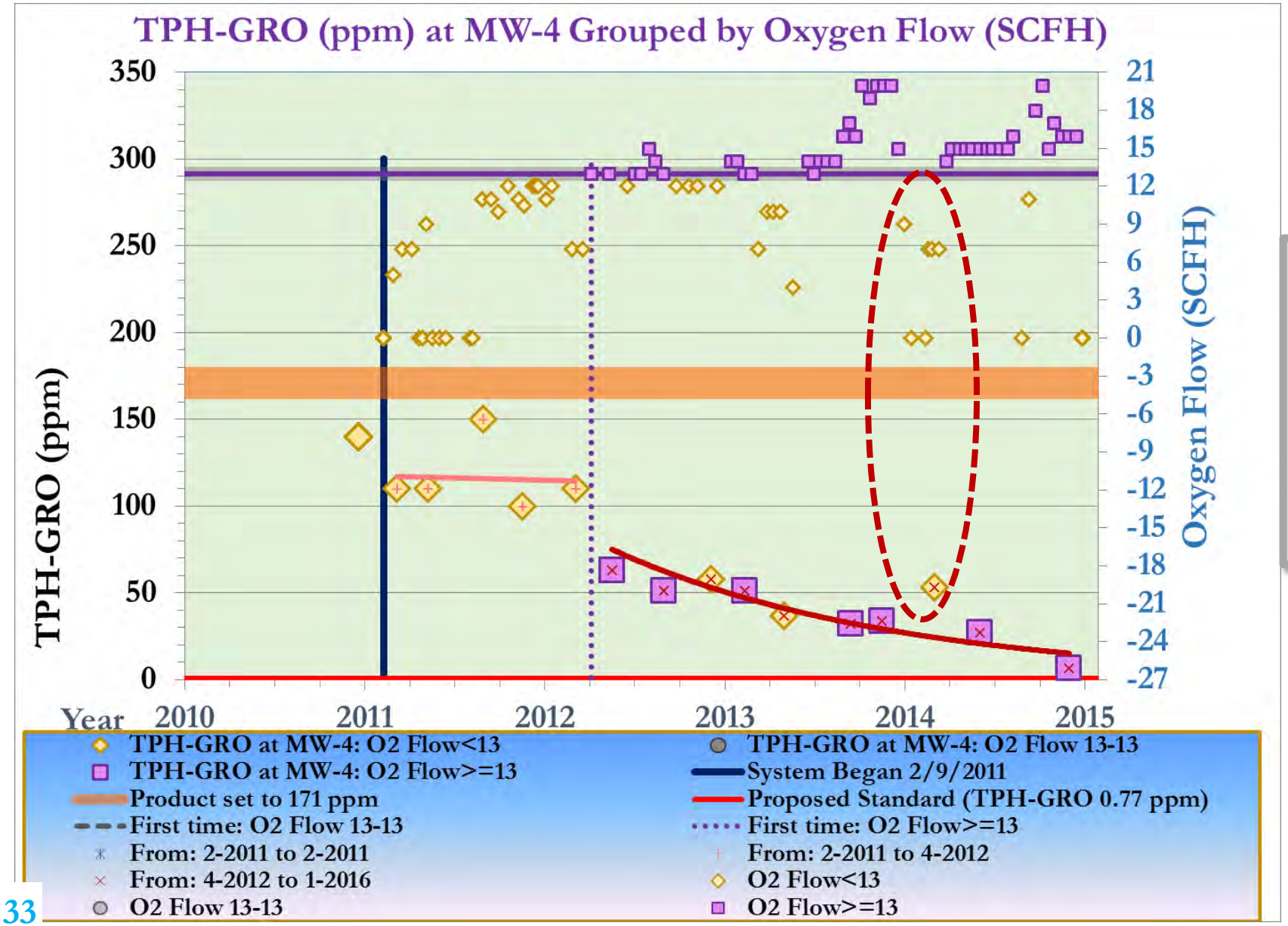
SEE: Ozone Remedy Failed to Cause Any Reduction in Xylenes at MW-2; Therefore, its Effectiveness is Chemical Dependent



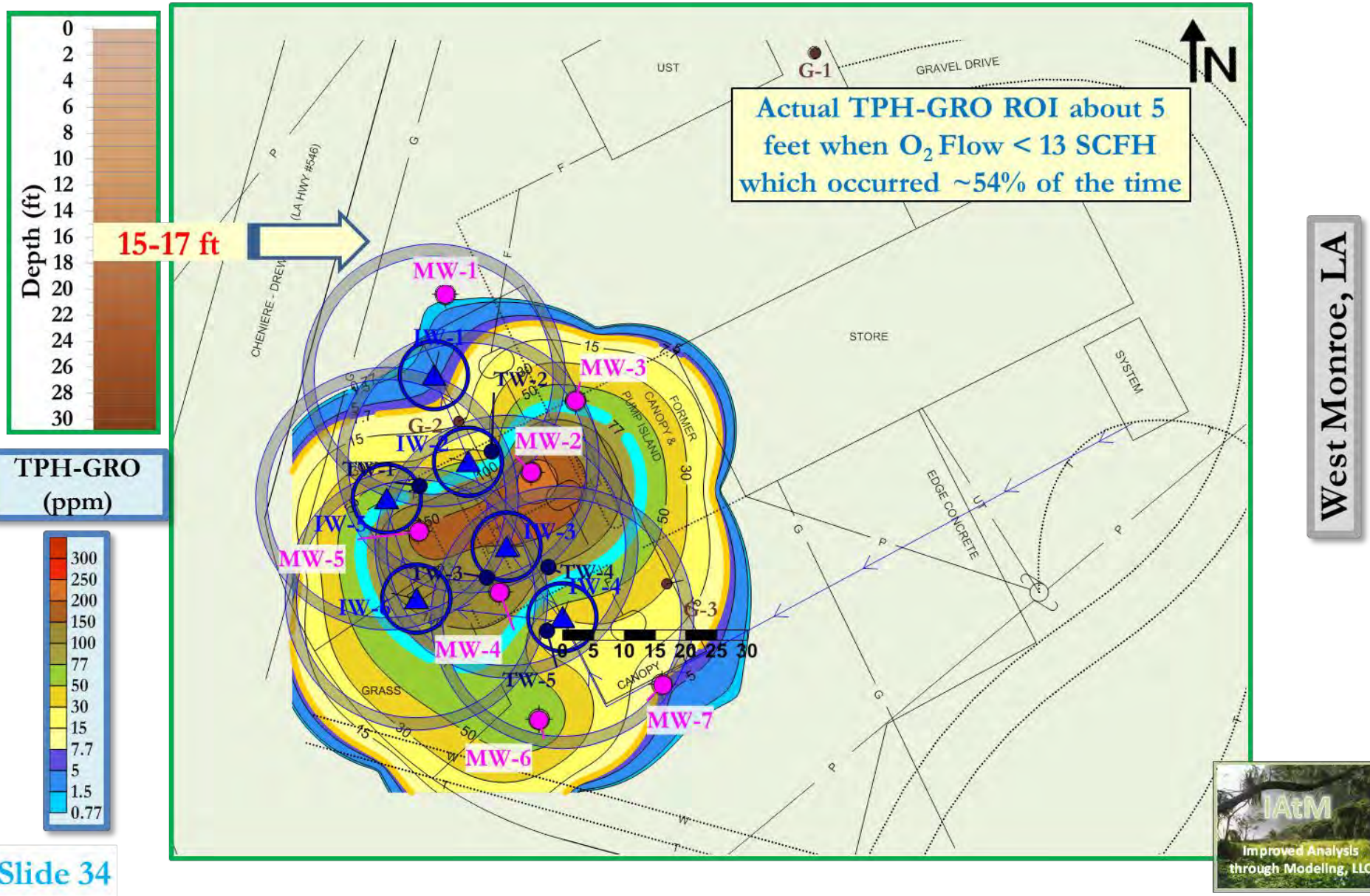
West Monroe, LA

SEE: Radius of Influence (Effective Mass Reduction) (ROI) for TPH-GRO Did not Reach MW-4 (Closest Well) Until O_2 Flow >= 13 SCFH

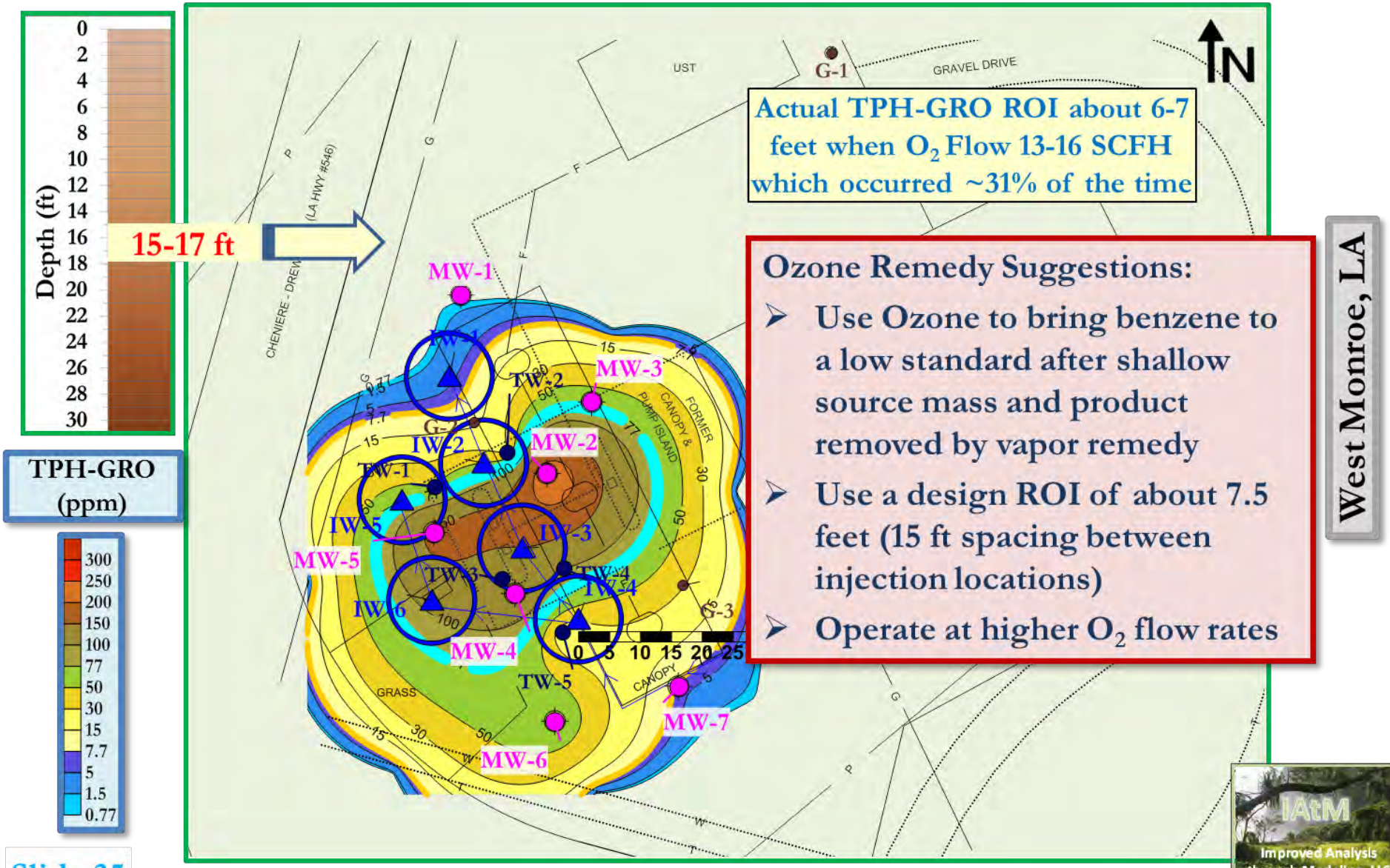


West Monroe, LA

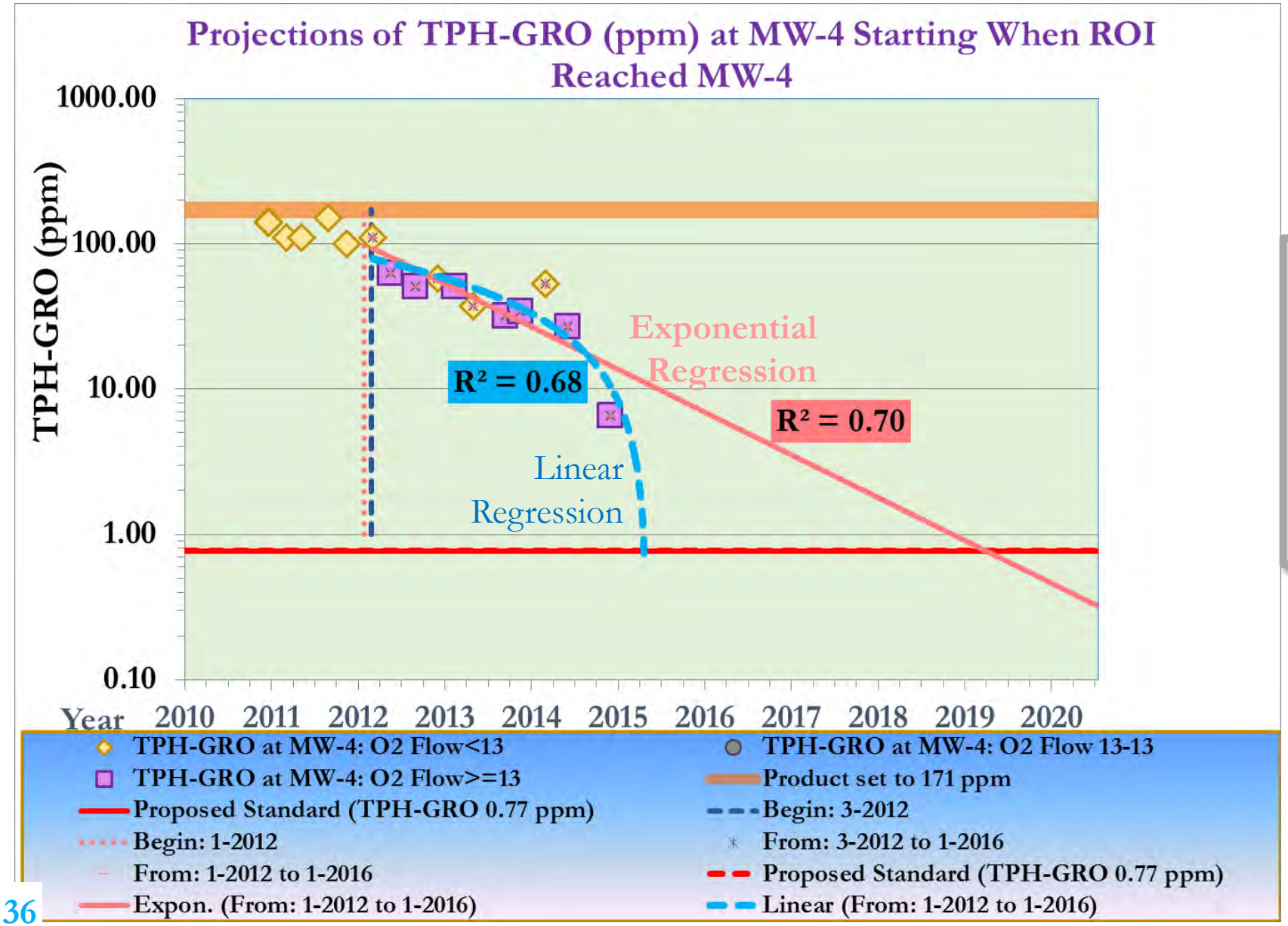
SEE: ROI for TPH-GRO Very Small and Much Less than Suggested by Ozone Vendor Case Study when Oxygen Flow less than 13 SCFH



SEE: ROI for TPH-GRO Reaches MW-4 when Oxygen Flow between 13 to 16 SCFH; However, Large Gap Near MW-5 Slows Reduction Relative to MW-4



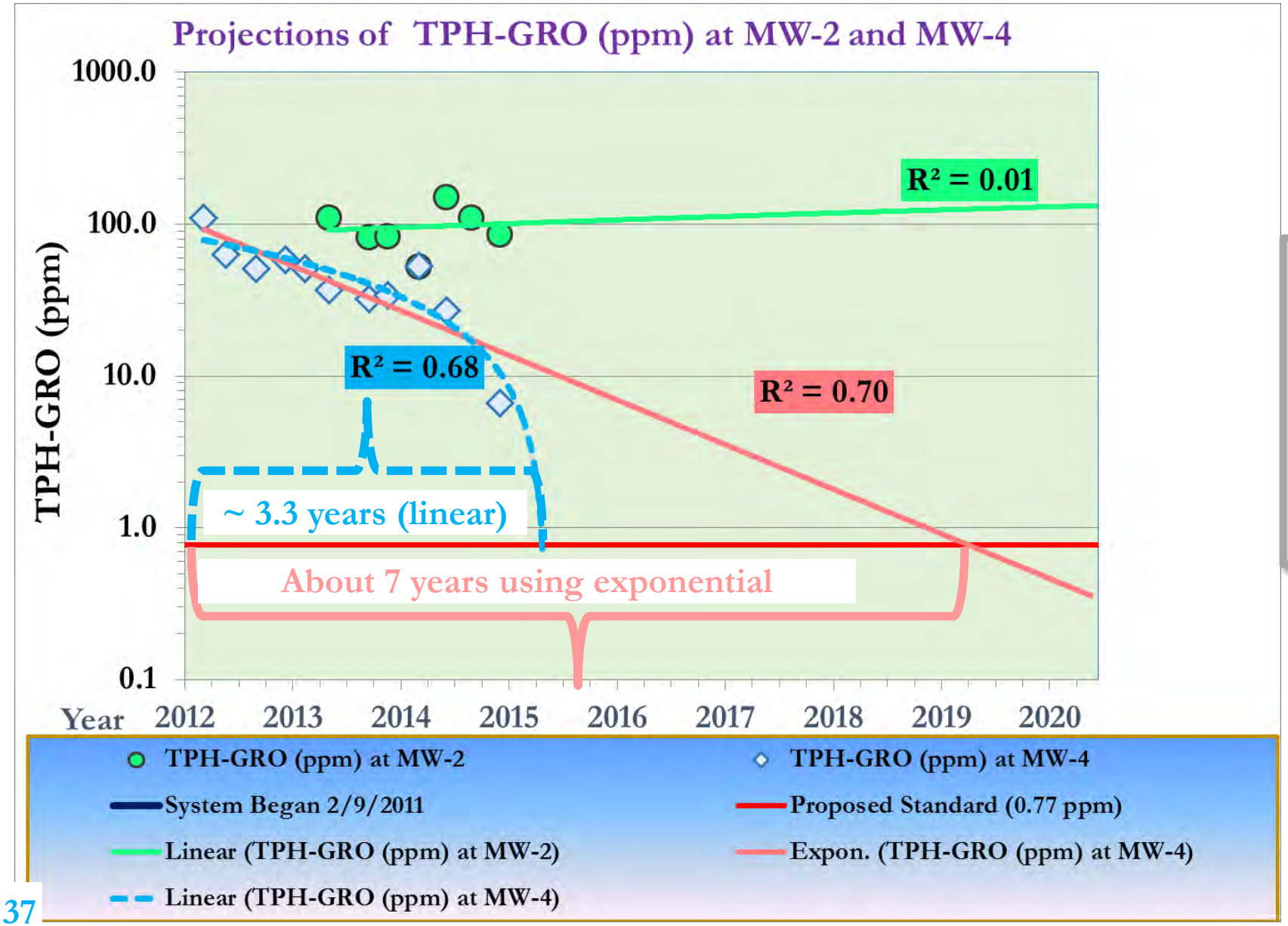
Time to Standard: Estimating Time Needed to Reduce TPH-GRO at MW-4 When O_2 Flow High Enough to Reach Well



Note: Log scale

West Monroe, LA

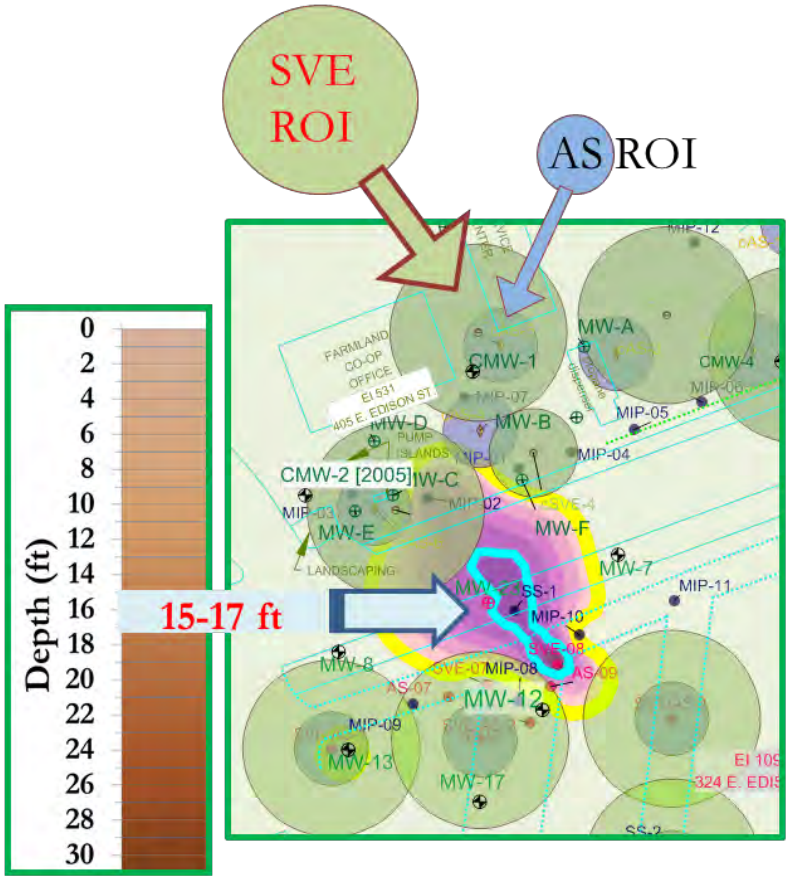
Time to Standard: If New Ozone Locations and Vapor Recovery Added: 3.3-7 Years of Operation Still Required at MW-2 to Reach Goal

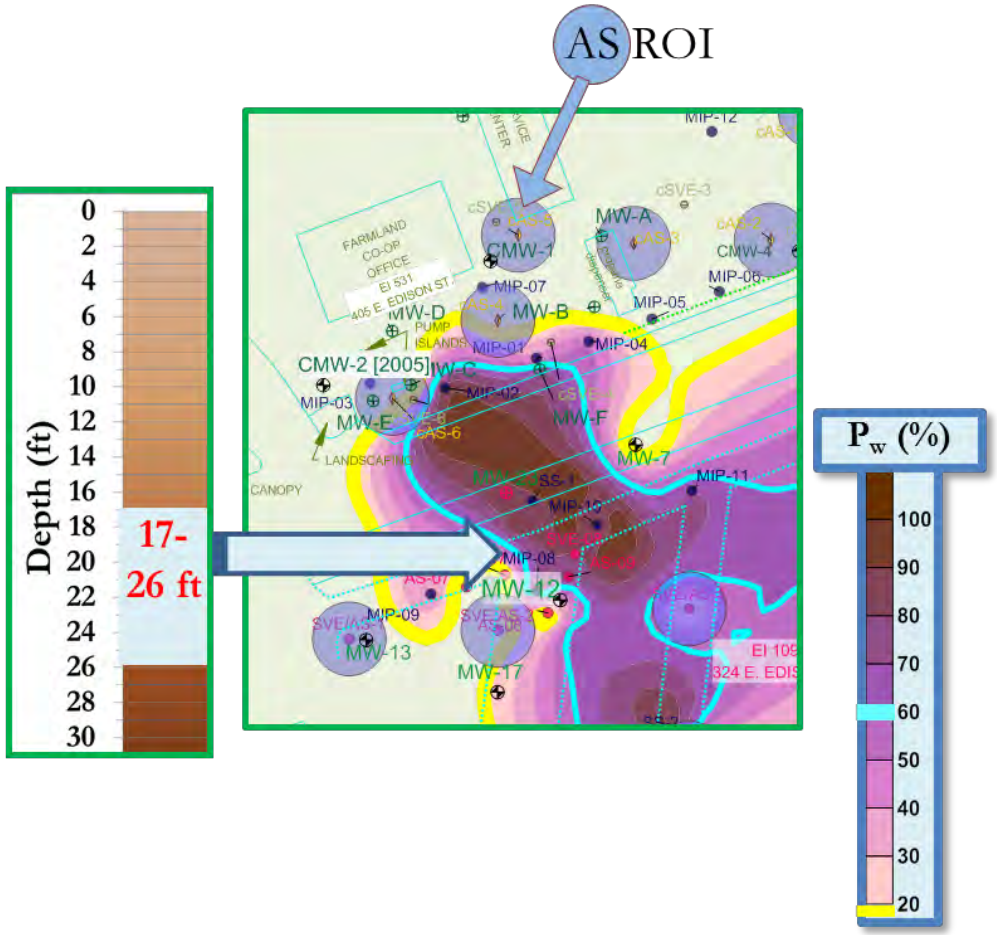


Note: Log scale

West Monroe, LA

SVE/AS: 8 of the Last 8 (100%) SVE/AS Systems Evaluated Failed Because Designs Did Not Realize AS ROI Considerably Smaller than SVE ROI

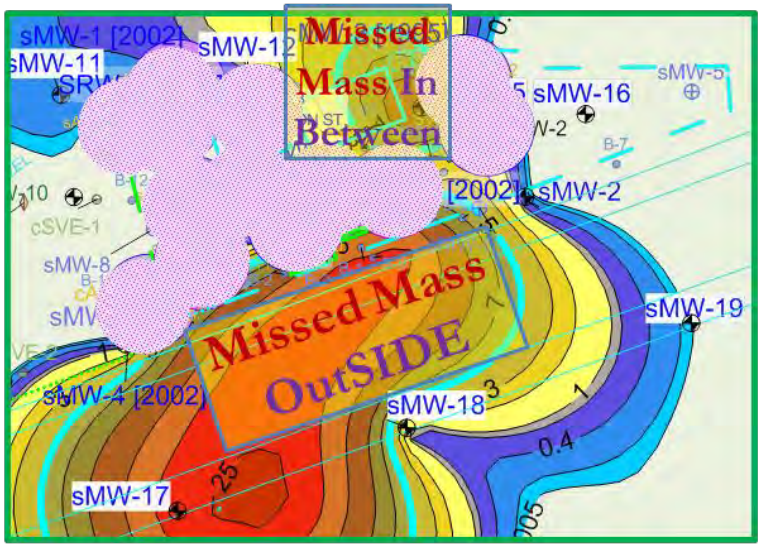




Brush, CO

SVE/AS Systems: Observations from Evaluation of Problem Sites

1. SVE/AS frequently overestimate AS ROI causing mass to be missed In Between and OutSIDE



89% of SVE/AS problem sites

Busch, CO

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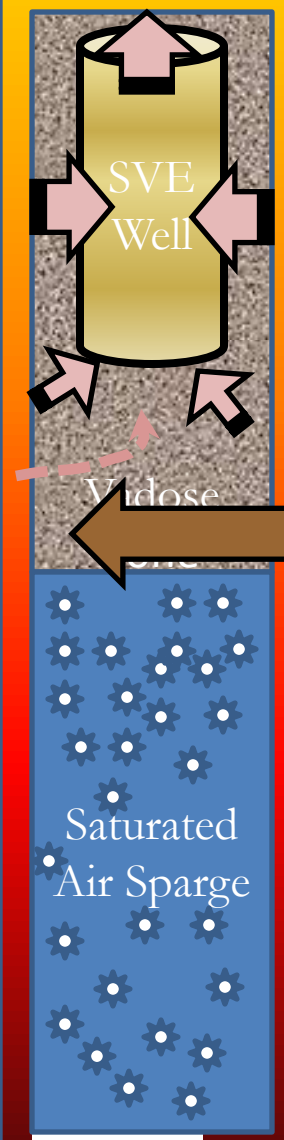
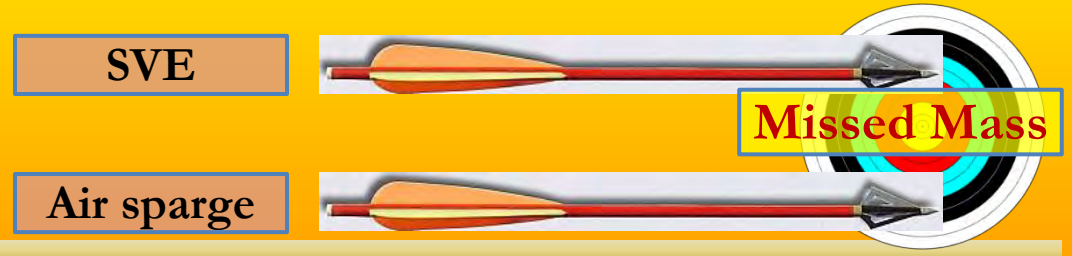
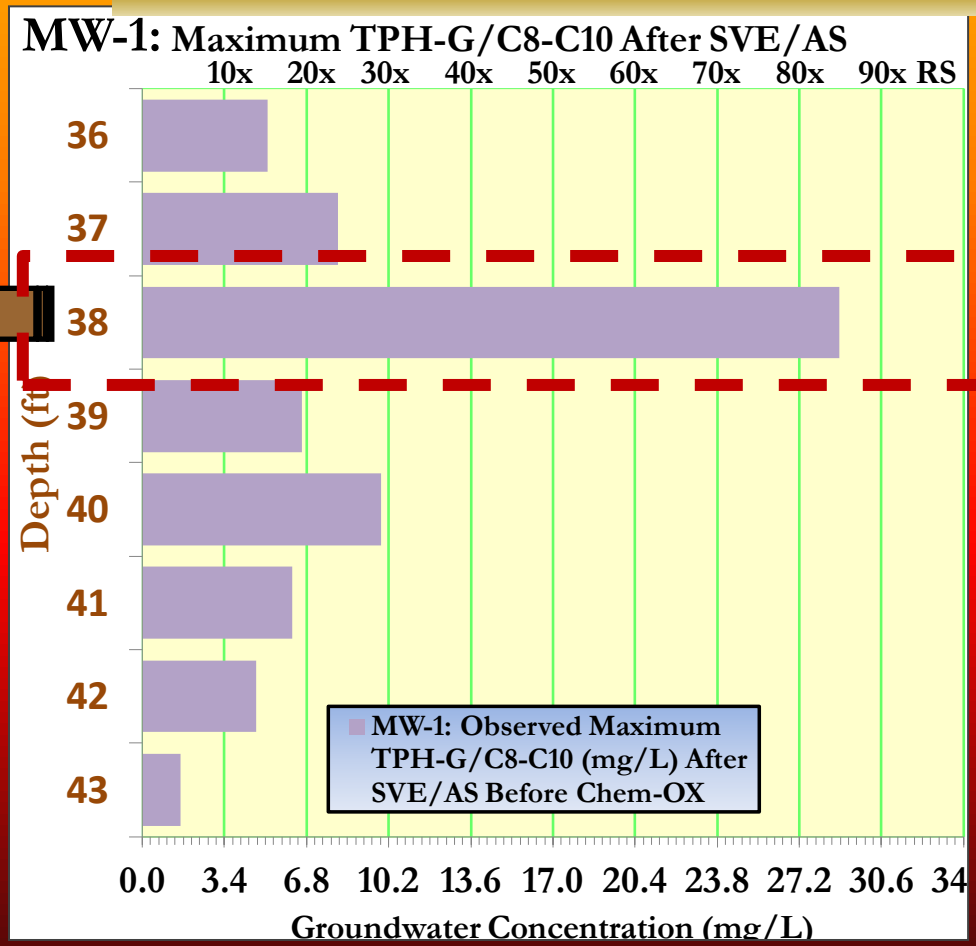
Critical SVE/AS Technology Vulnerability: Mass Below SVE Well and Above Water Table During Time of Injection





SOURCE TRACKER: Concentrations by Depth



56% of SVE/AS problem sites

Critical Vulnerability

Bastrop, LA

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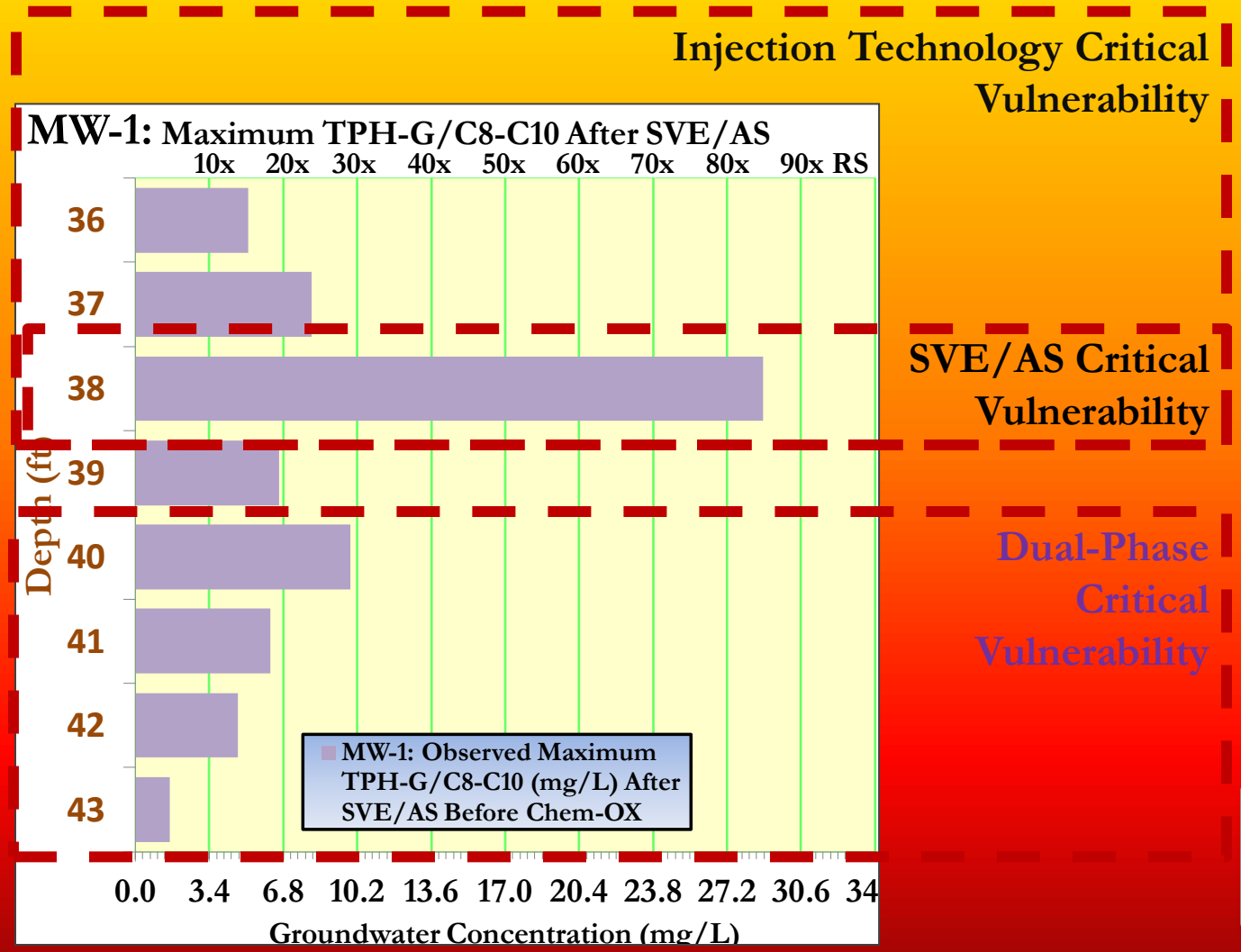
Critical Dual-Phase (miss deep mass) and Injection or Air Sparging (miss shallow mass) Vulnerabilities are vertically opposite

Advanced Data Analysis (ADA) has Eyes to See Root Causes for Failure to Cleanup in Nine States

Missed Source Mass	Vertically Deep (below remedy's reach)	Vertically Shallow (above remedy's reach)	Waste (action without mass reduction)
Dual-Phase (32 Evaluations)	65%	13%	71%
Injection (ISCO, Ozone, Other) (10 Evaluations)	10%	100%	80%
SVE/AS (9 Evaluations)	22%	56%	44%

Suggested Solution: Couple dual-phase with air sparging or injection technology during high water season

Dual-Phase Critical Vulnerability Has Limited Overlap with Different Technologies: Solution: Combine Remedies



Bastrop, LA

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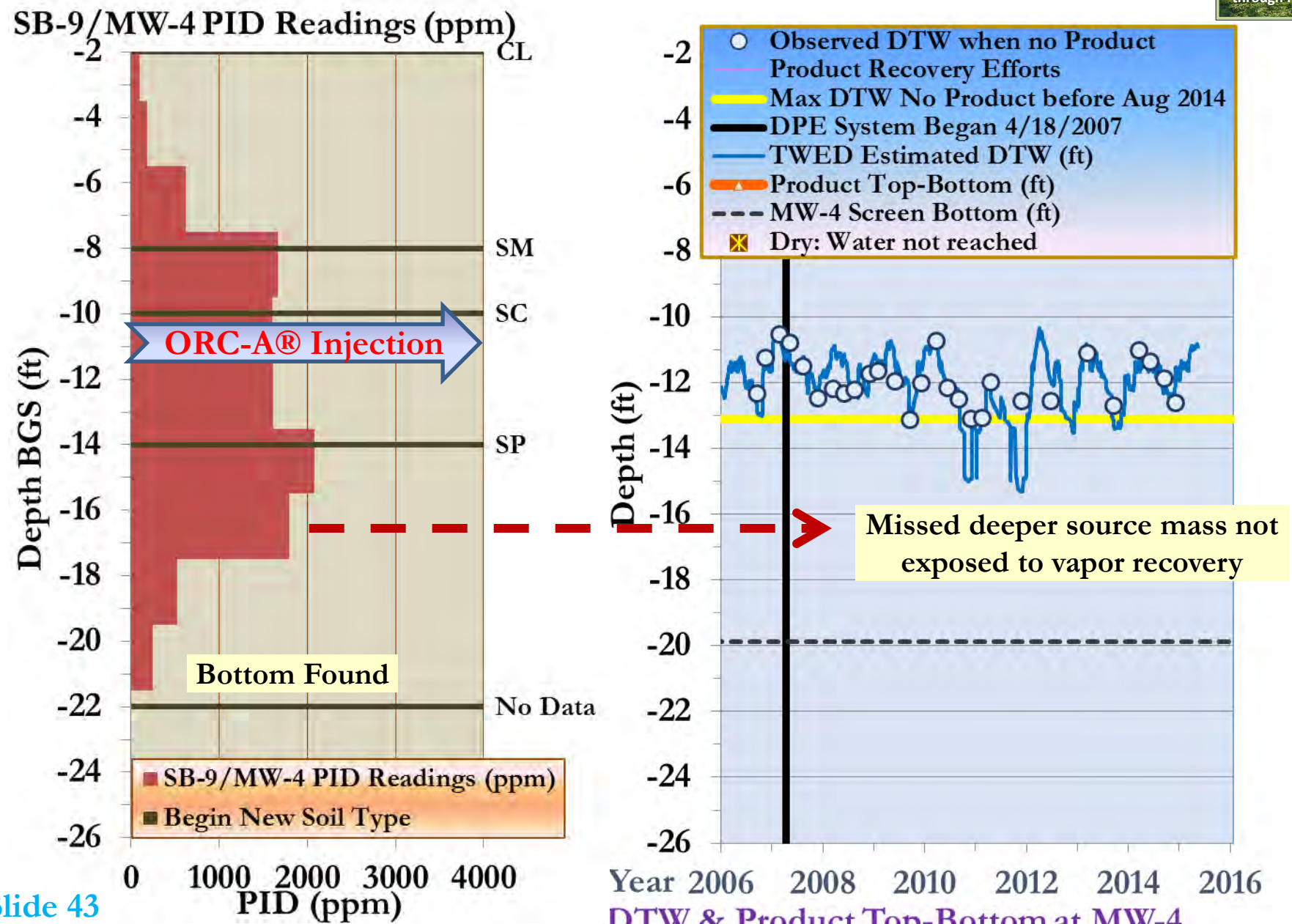
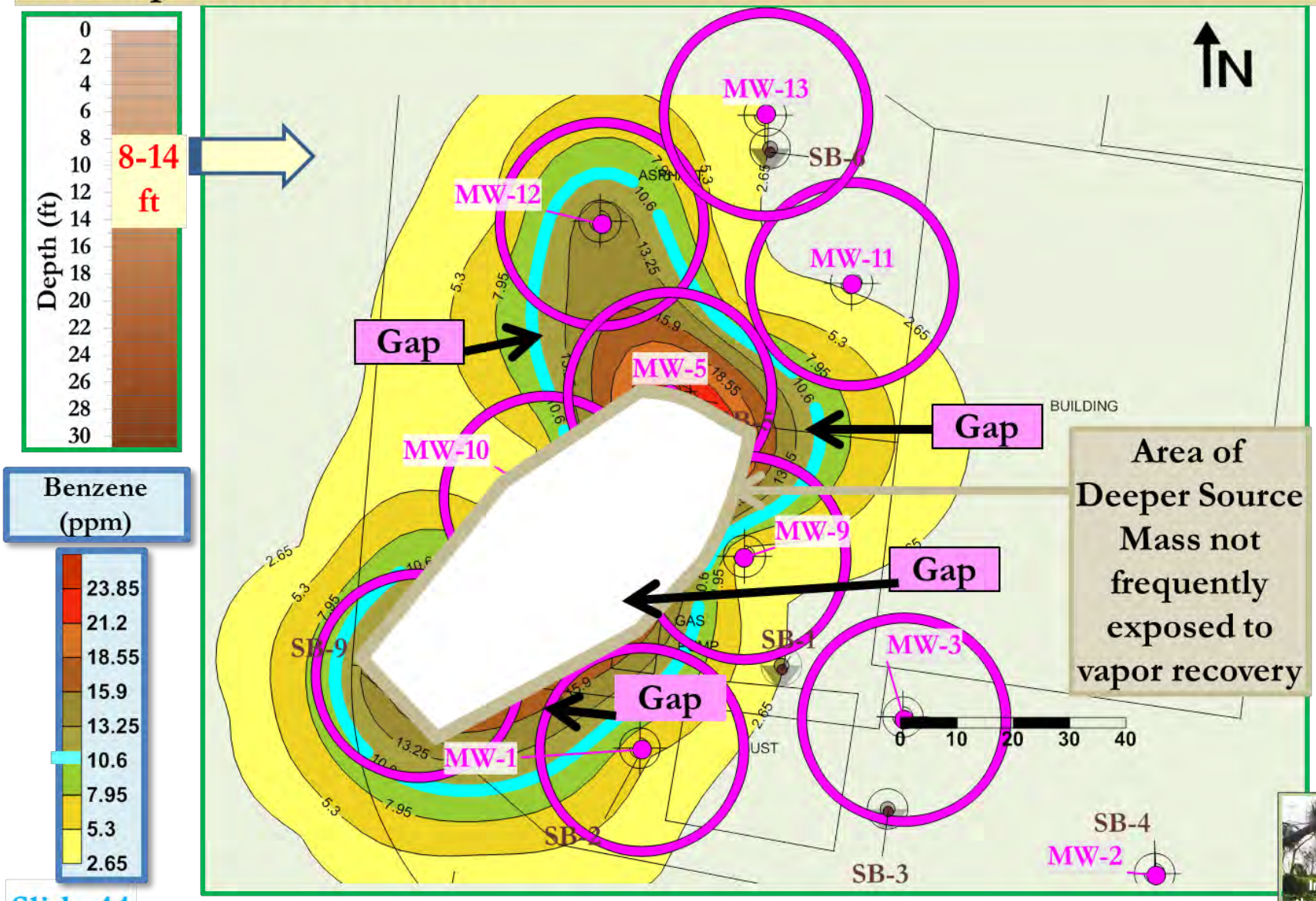
SOURCE BOTTOM: Missed Deeper Source Mass at MW-4 Prior to ORC-A® Injections



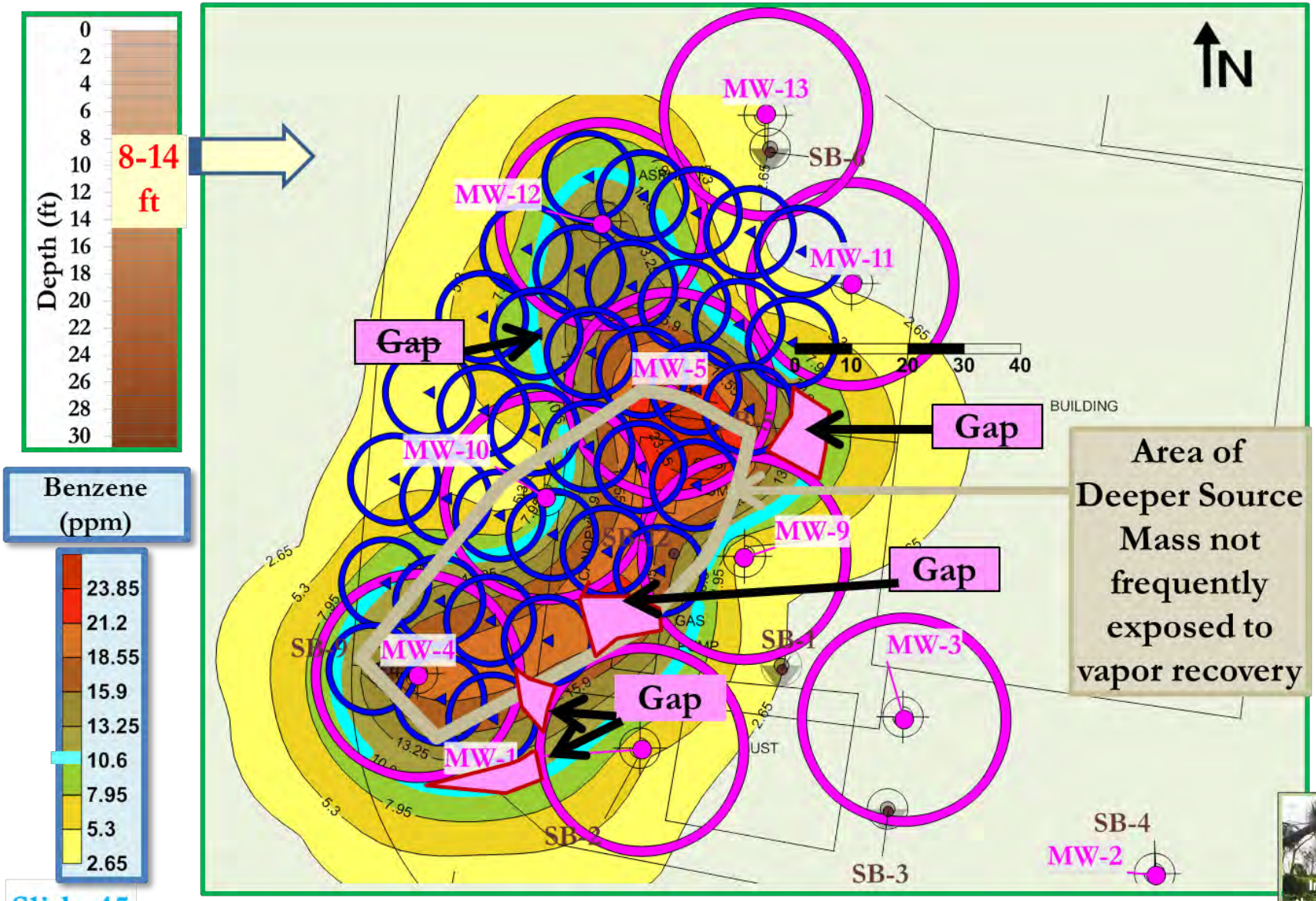
West Monroe, LA

System Efficiency Evaluation (SEE): Gaps in Effective Vapor Mass Reduction Exist in Areas where Benzene Maximum is estimated at more than 40 times the Cleanup Goal Based on ROI



Woodworth, LA

SEE: The ORC-A® Injections did not Completely Eliminate the Identified Gaps; Thus, Leaving Pockets of Minimally Reduced Source Mass

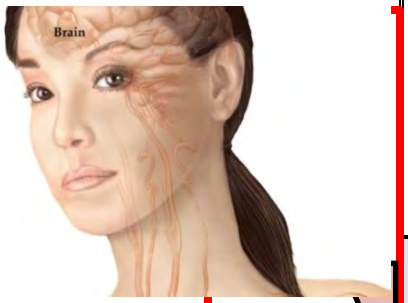


Woodworth, LA

The Complication of Multiple Releases Can Influence Site Conceptual Model and All Remedies

Advanced Data Analysis (ADA) has Eyes to See Root Causes for Failure to Cleanup in Nine States

Missed Source Mass	Spatially		Vertically		Waste (action without mass reduction)
	In Between recovery/ injection wells	OutSIDE treatment area	Deep (below remedy's reach)	Shallow (above remedy's reach)	
Dual-Phase (32 Evaluations)	74%	68%	65%	13%	71%
Injection (ISCO, Ozone, Other) (10 Evaluations)	50%	90%	10%	100%	80%
SVE/AS (9 Evaluations)	89%	89%	22%	56%	44%



Estimated 16% of all MS sites and 32% of O&M Costs

Cause: Multiple releases not included in estimated source extents used for remedial design

Suggested Solution: Use ADA's Source Release Assessment if Multiple Releases are suspected

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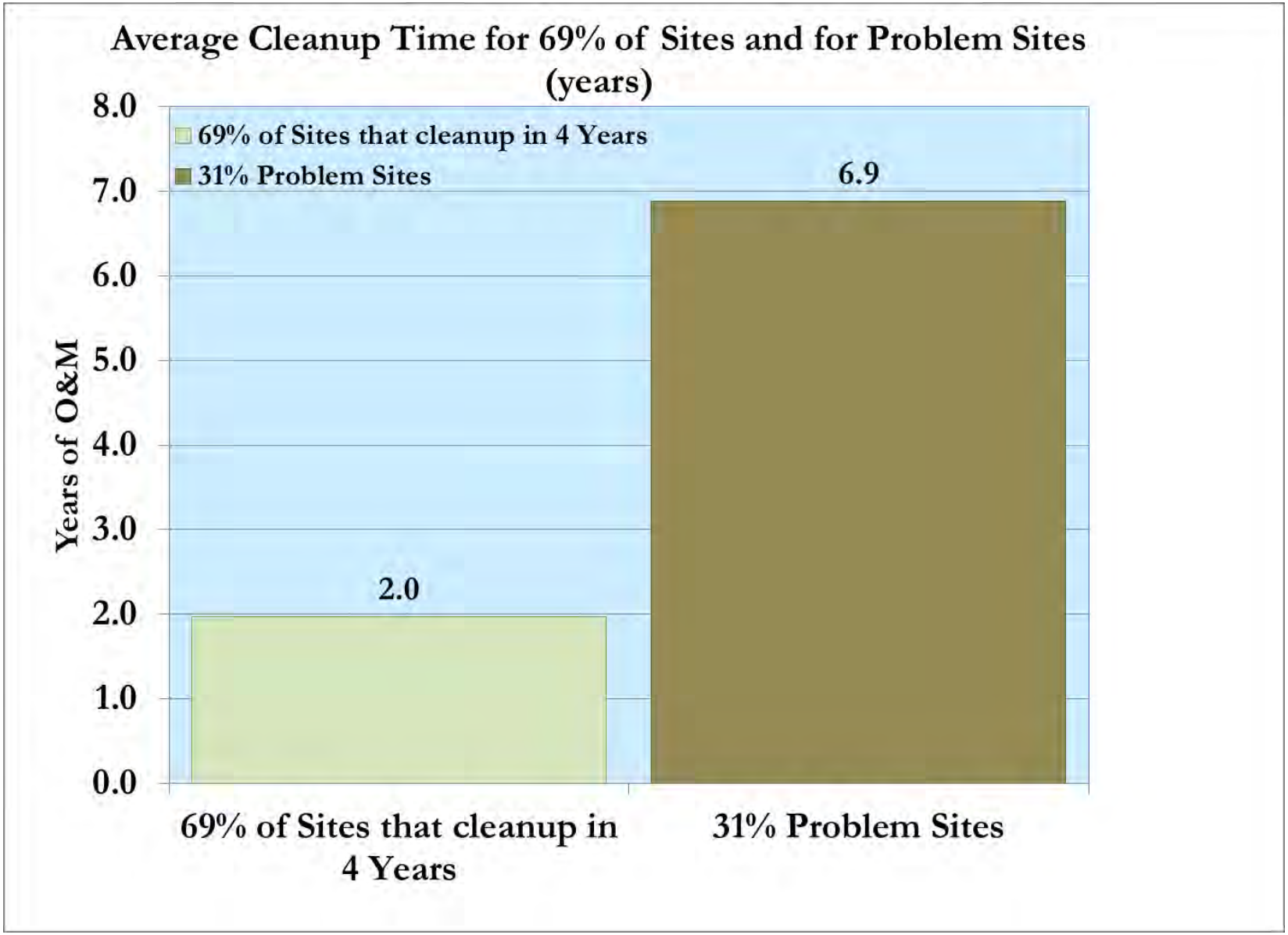
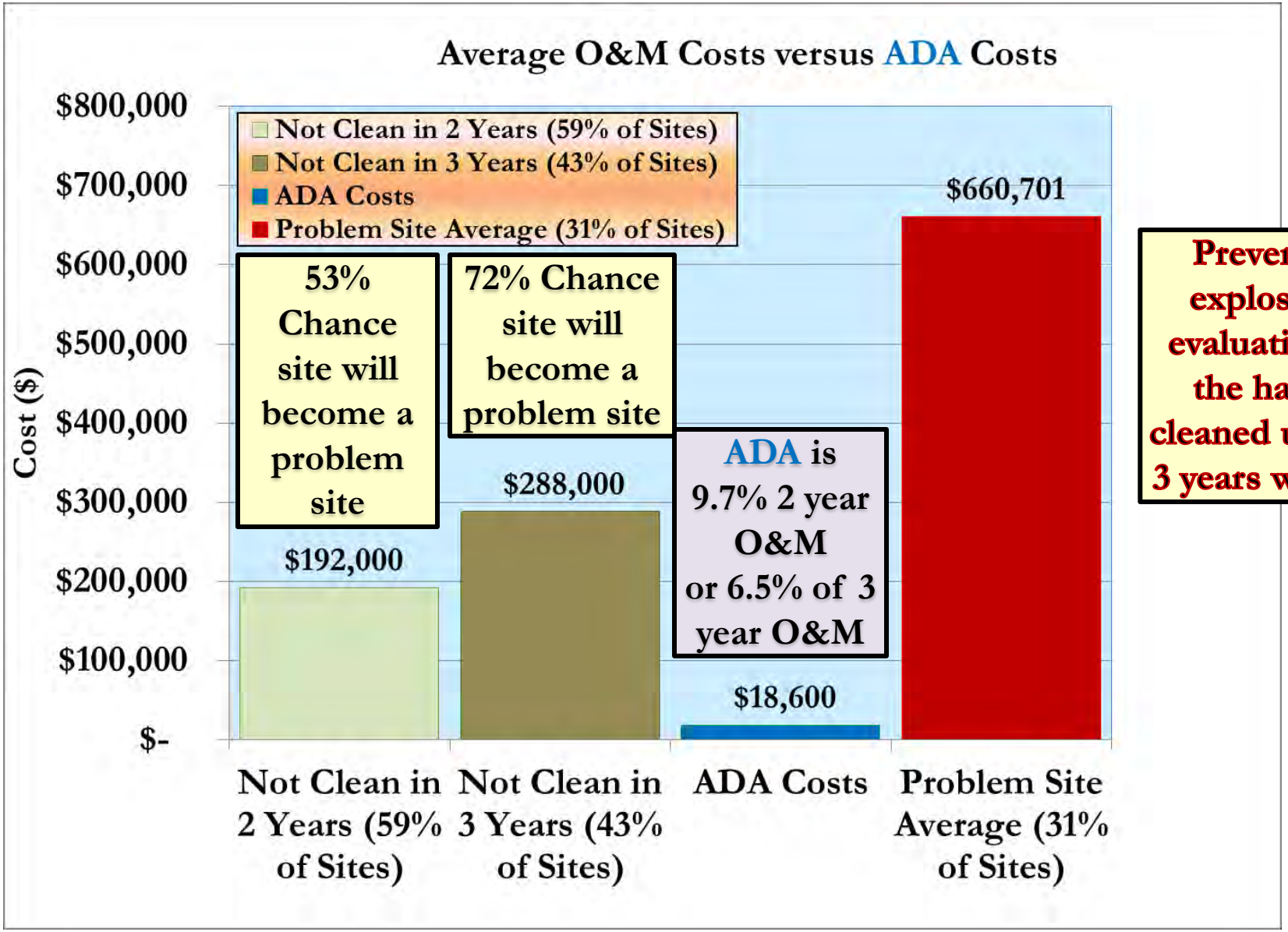
Significantly Longer Average Cleanup Times for Sites that Do not Cleanup in 4 Years



Significantly Greater Costs for Sites that Do not Cleanup in 4 Years;
Solution: Apply ADA to Sites with exceedances after 2 to 3 years



Prevent cost explosion by evaluating sites the have not cleaned up in 2 to 3 years with ADA

Assumes an average monthly O&M of $8,000