An Approach to Evaluate Whether There Has Been Sufficient Active Treatment to Justify a Transition to MNA

John T. Wilson (john@scissortailenv.com) and Barbara Wilson
(Scissortail Environmental Solutions, LLC, Ada, OK, USA

Mark L. Ferrey
(Minnesota Pollution Control Agency, St. Paul, MN, USA)

David L. Freedman and Olivia Dunn
(Clemson University, Clemson, SC, USA)

Dave Adamson and Charles Newell
(GSI Environmental, Houston, TX, USA)

Two Paths to MNA

MNA as a Remedy

Clean it ALL up.

MNA as Risk Management

Keep it on your side of the fence

MNA for Risk Management

Identify a point-of-compliance down gradient of the plume and locate sentry wells.

Construct a model to describe the plume.

Use the model to forecast the future extent of contaminants downgradient of the source area.

If forecasted concentrations at the point-of-compliance are acceptable, implement MNA as risk management.

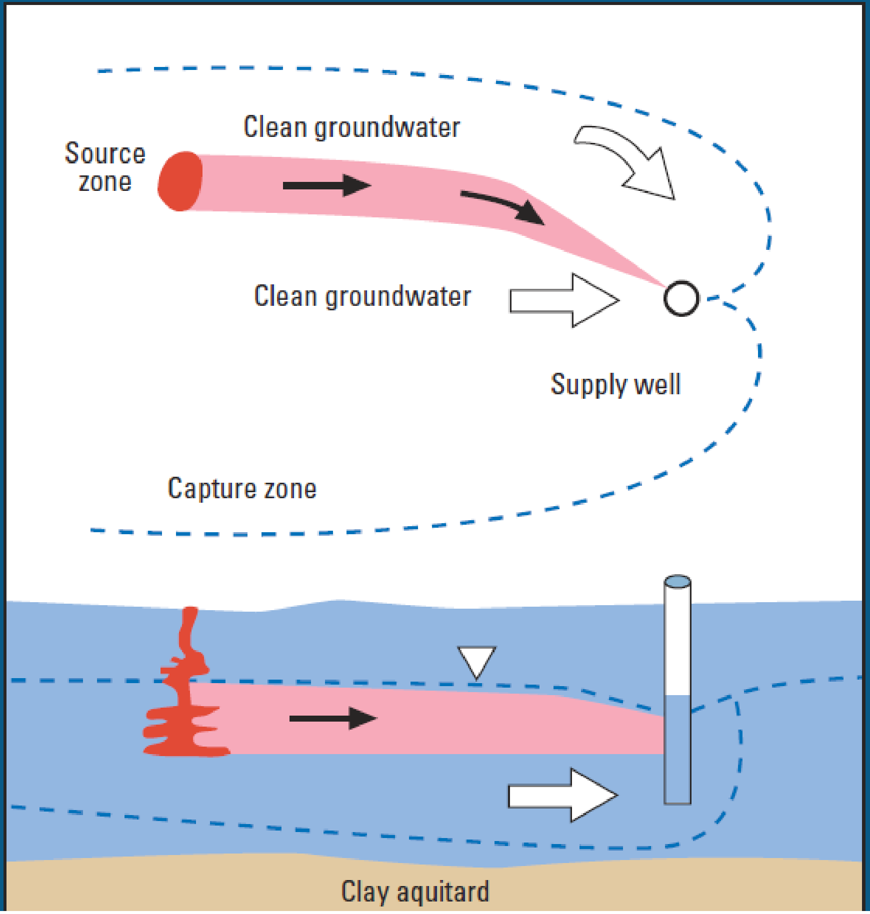
Monitor contaminants in the monitoring wells as long as contamination is present in the plume.

Plume Capture in a Pumped Well

FIGURE 1

Plume capture by a supply well

A dissolved plume of contaminants can be hydraulically captured by a downgradient supply well. The contaminant release shown is migrating within a uniform sand aquifer (no fill) overlying a clay aquitard. Clean water on all sides of the plume is also extracted, diluting the concentration of dissolved contaminants in the water pumped from the well.



M. D. Einarson and D. Mackay.

Predicting Impacts of Ground Water Contamination.

Environmental Science & Technology, Vol. 35, No. 3, pages 66A – 73A, 2001.

The Challenge to Recognize When it is Acceptable to Stop Pumping an Extraction Well

The capture zone of an extraction well is usually larger than the contaminated flow path in the aquifer.

The contaminated groundwater is blended with clean groundwater in the extraction well.

The groundwater produced by the extraction well may meet standards, but that does not mean all the groundwater in the capture zone meets standards.

The Answer?

Don’t use data from the extraction well to evaluate whether there has been sufficient treatment.

Use data from the monitoring wells in the capture zone of the extraction well.

The Approach

Analyze data from the site before pumping and extract a rate constant for natural attenuation in concentrations with distance along the flow path.

Use

(1) the concentration of contaminant in the monitoring well,

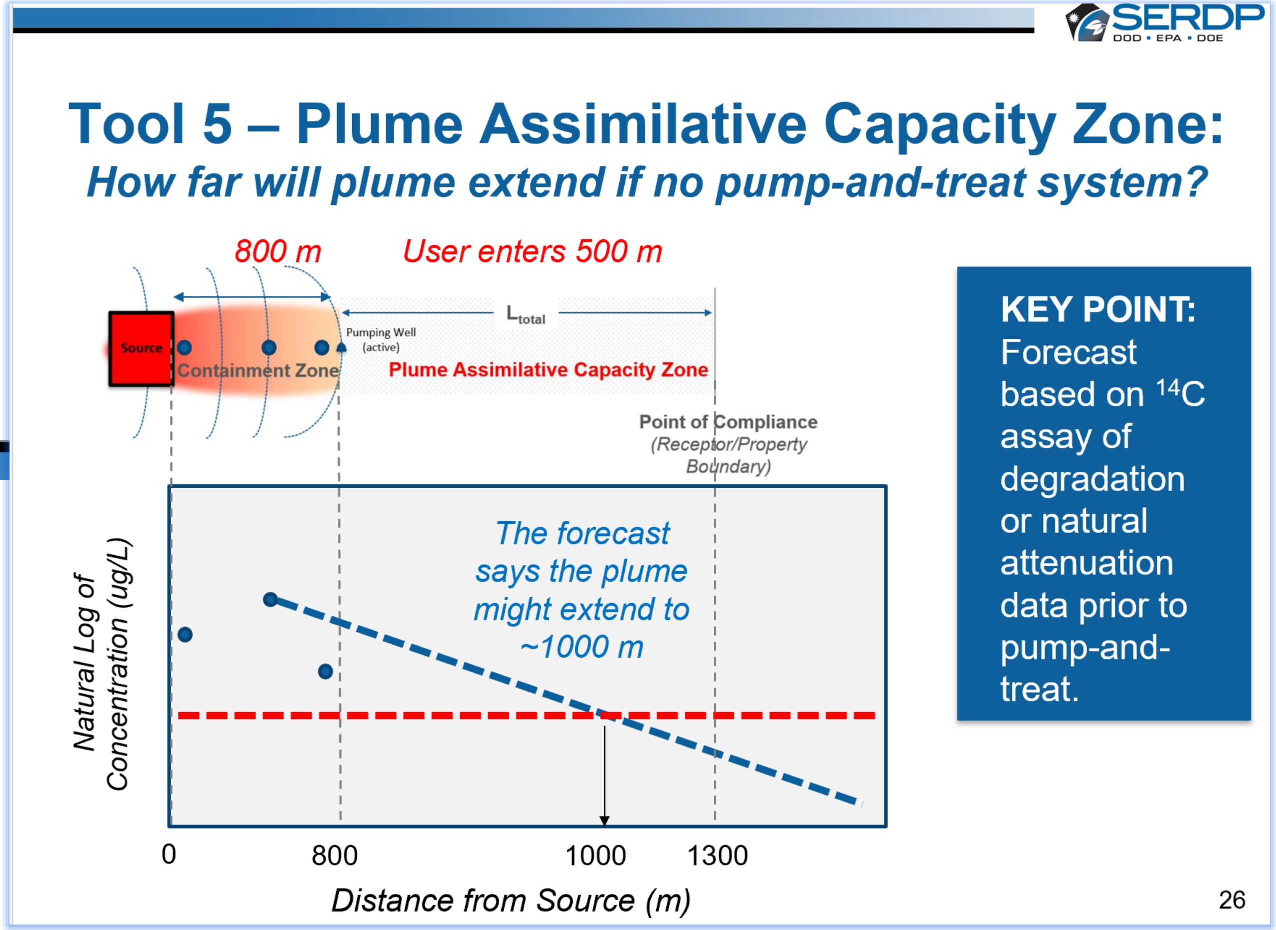
(2) the distance from the monitoring well to the point of compliance,

(3) the rate constant for natural attenuation

to determine if the concentration of contaminants in groundwater in the monitoring wells will exceed standards when it reaches the point of compliance.

Transitioning from Active Remedies to Monitored Natural Attenuation

ER20-1429
David Adamson
GSI Environmental Inc.



Tool 5. Can I meet my cleanup goal at a downgradient point of compliance after the transition from active treatment?

What Does this Tool Do?

This tool uses site monitoring data to evaluate if concentration-based cleanup goals will be exceeded at a downgradient point of compliance (e.g., site boundary) after transitioning from active treatment (e.g., pump-and-treat) to passive treatment (e.g., MNA). It includes several different options to estimate a site-specific attenuation rate constant, and then uses this rate constant to project the concentration vs. distance from the contaminant source. The predicted concentration at the downgradient point of compliance is then compared to the concentration goal.

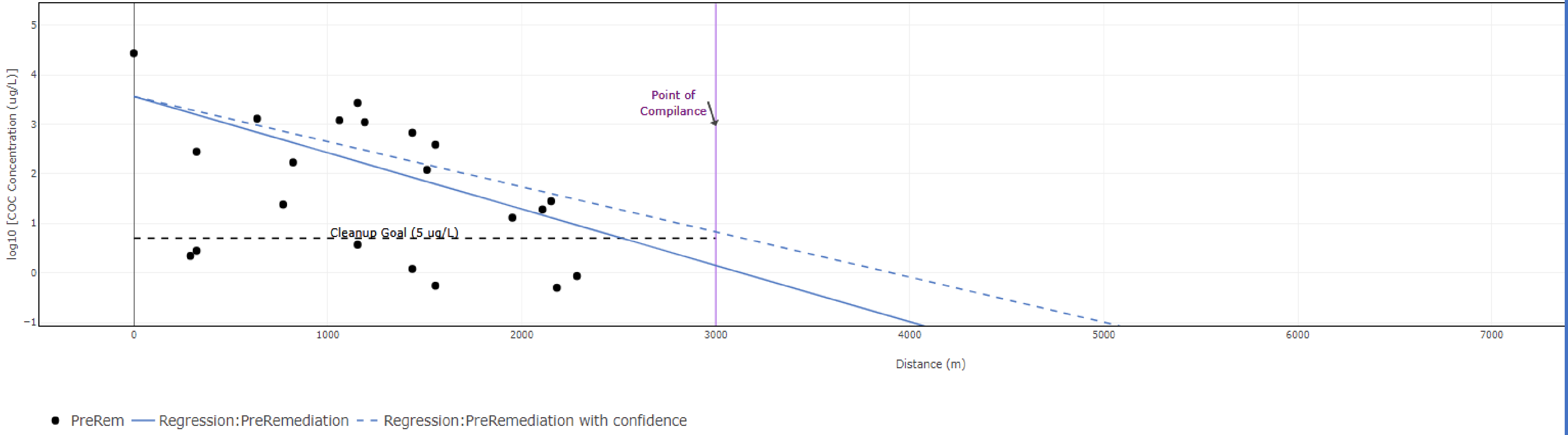
How Does it Work?

1. Use “Site-Specific Information” tab to enter relevant monitoring locations and concentration data.
2. Select “Use Pre-Remediation Rate Constant” tab if concentration data are available for the monitoring period prior to the start of active treatment. This will project the concentration vs. distance during the Post-Remediation period using the rate constant that applied before active treatment.
3. Select “Use Lab-Based Rate Constant” tab if a biodegradation rate constant is available from a lab-based microcosm, 14C assay, or biomarker data. This rate constant will be used to project the concentration vs. distance during the Post-Remediation period.
4. Select “Use Post-Remediation Rate Constant” tab if concentration data are available for the period after active treatment has stopped. This will project the concentration vs. distance during the Post-Remediation period using the recent rate constant assuming steady state conditions have been restored.

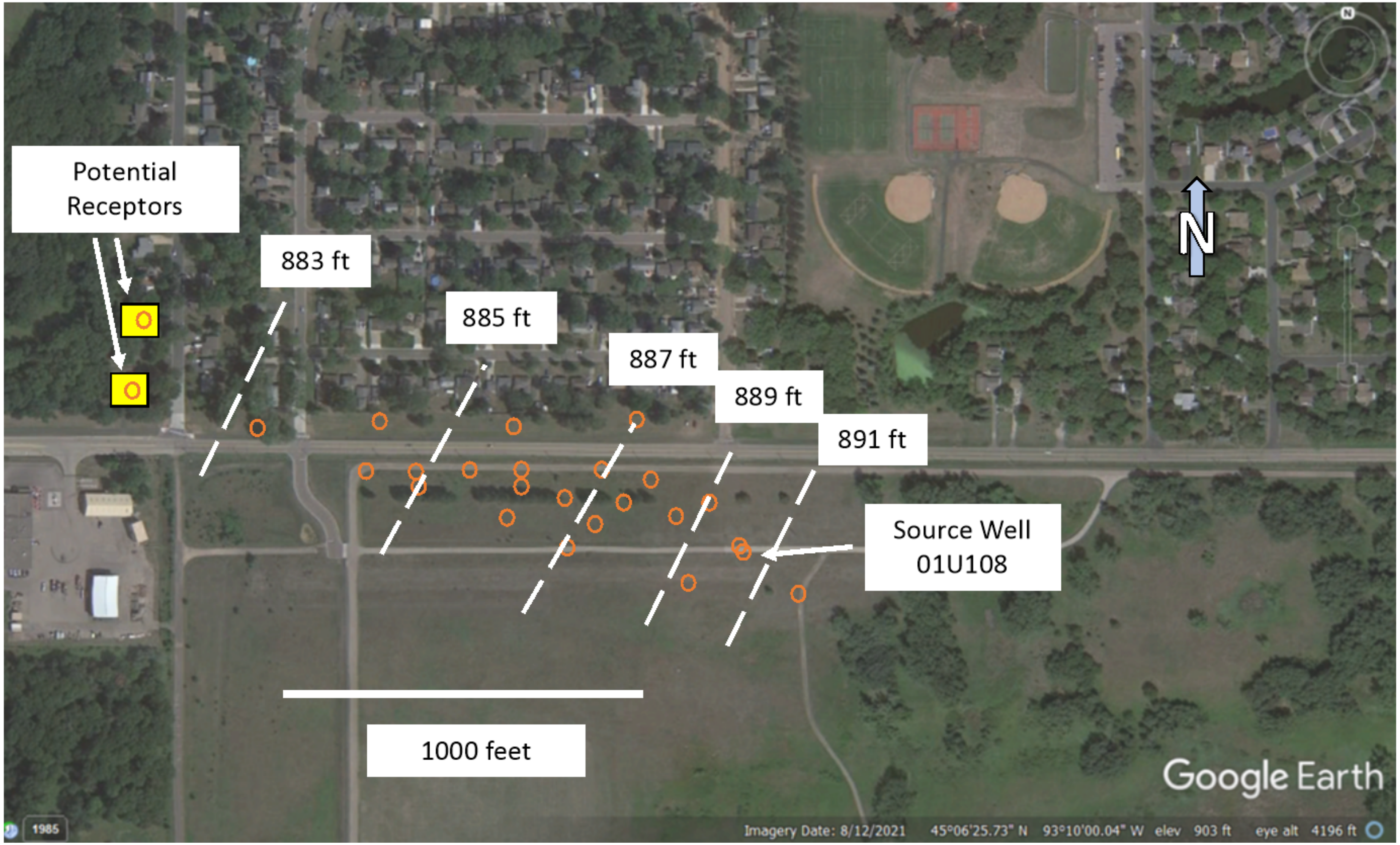
Results

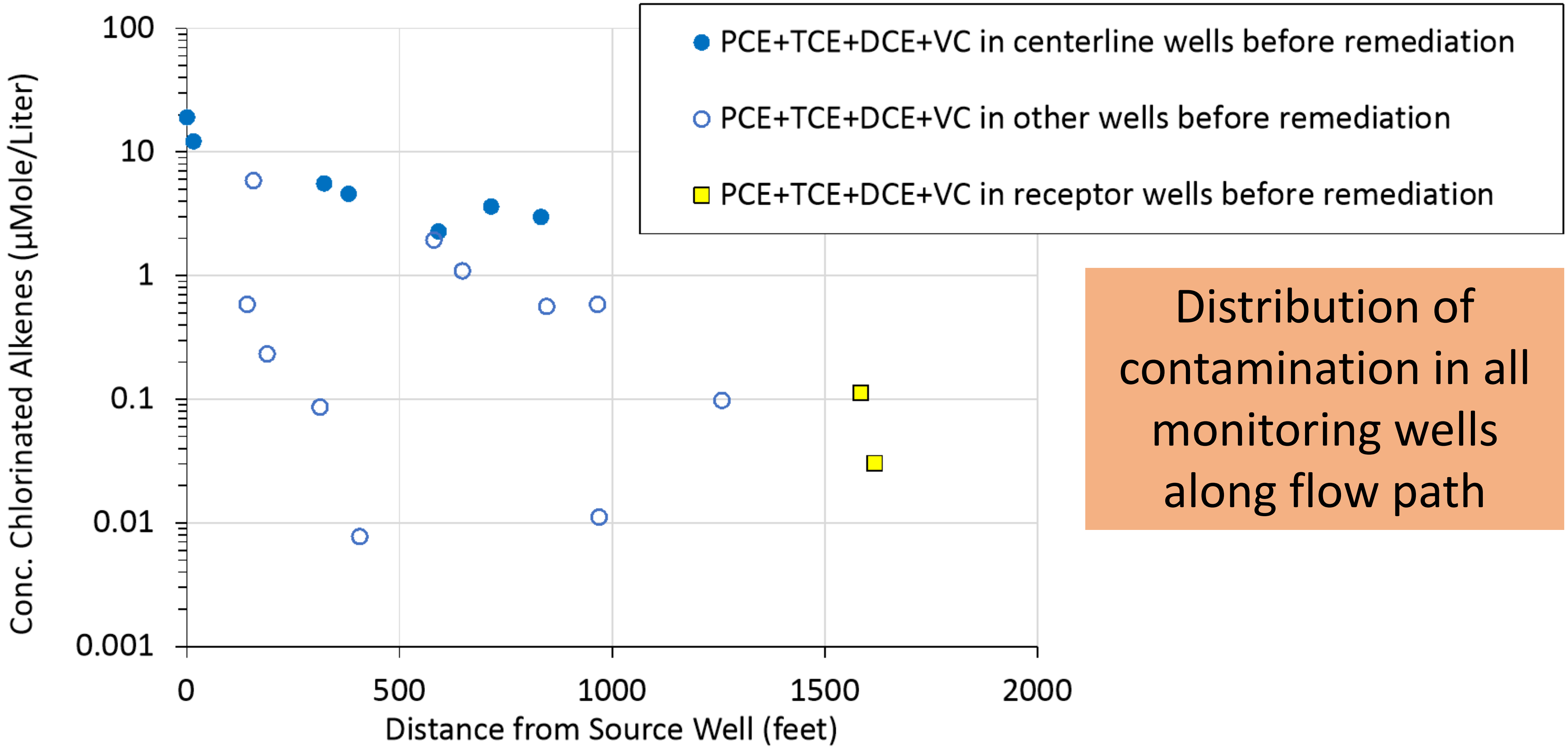
1. Pre-Remediation Period (actual)

Mean Concentration of COC in Selected Wells Over Distance

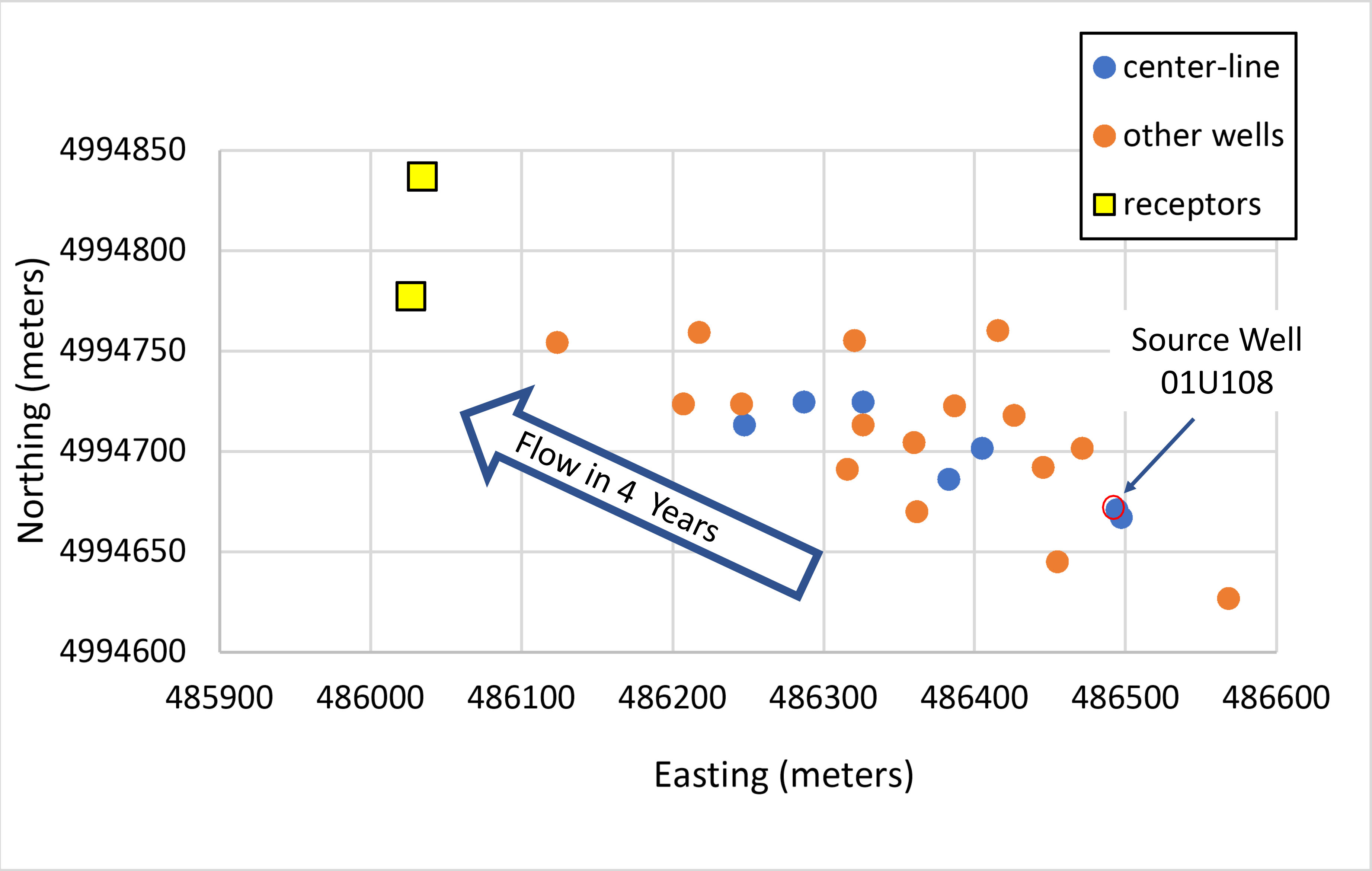


Case Study at Site A of the Former Twin Cities Army Ammunition Plant, near St Paul, MN





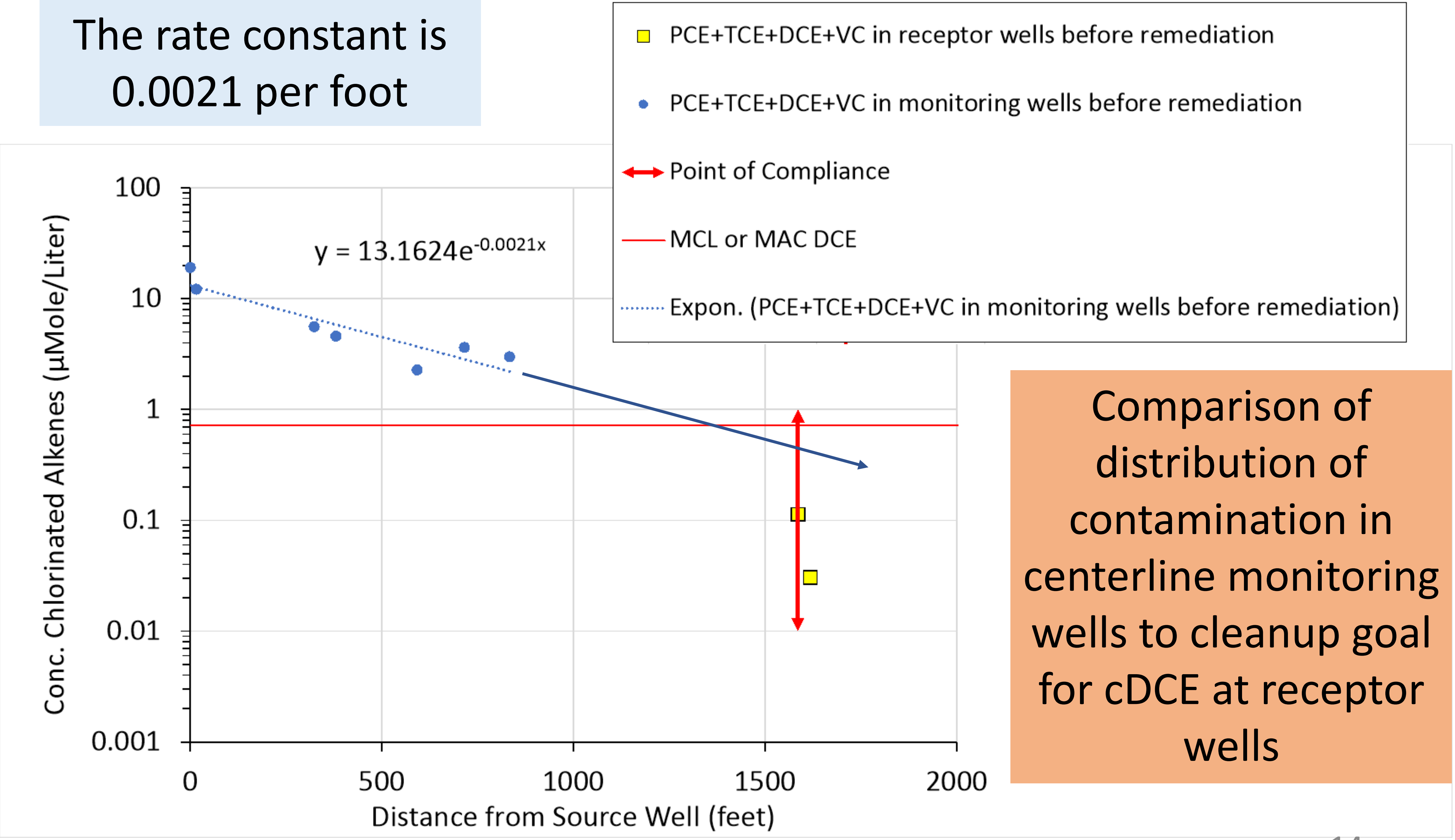
Distribution of contamination in all monitoring wells along flow path


center-line
other wells
receptors
4994850
4994800
4994750
4994700
4994650
4994600
Northing (meters)
485900
486000
486100
486200
486300
486400
486500
486600
Easting (meters)
Flow in 4 Years
Source Well
01U108

Distribution of contaminants in centerline wells before active remedy

Distance from Source	Date Sampled	PCE	TCE	*c*DCE + *t*DCE	1,1-DCE	VC
feet		µg/L	µg/L	µg/L	µg/L	µg/L
0	4/11/1988	900	550	800	<1	<1.9
16	9/13/1988	620	380	540	<1	<1.9
323	8/3/1994	0.59	3.8	110	<1	<1.9
380	8/3/1994	<1	7.9	190	<1	<1.9
592	6/9/1994	<1	1.5	220	<1	<1.9
715	6/9/1994	<1	2.4	290	<1	<1.9
833	9/7/1993	<1	0.58	110	<1	<1.9
Cleanup Goal		7	30	70	6	2

The rate constant is 0.0021 per foot



Comparison of distribution of contamination in centerline monitoring wells to cleanup goal for cDCE at receptor wells

Table 3.4 in He et al. (2009) lists a rate constant for removal of cDCE in sediment from Site A at TCAAP of 0.73 per year. Correcting for removal of 0.21 per year in the container control, this corresponds to a rate constant for degradation of 0.52 per year.

The seepage velocity at Site A is 210 feet per year. This corresponds to a rate constant of 0.0025 per foot of travel along the flow path.

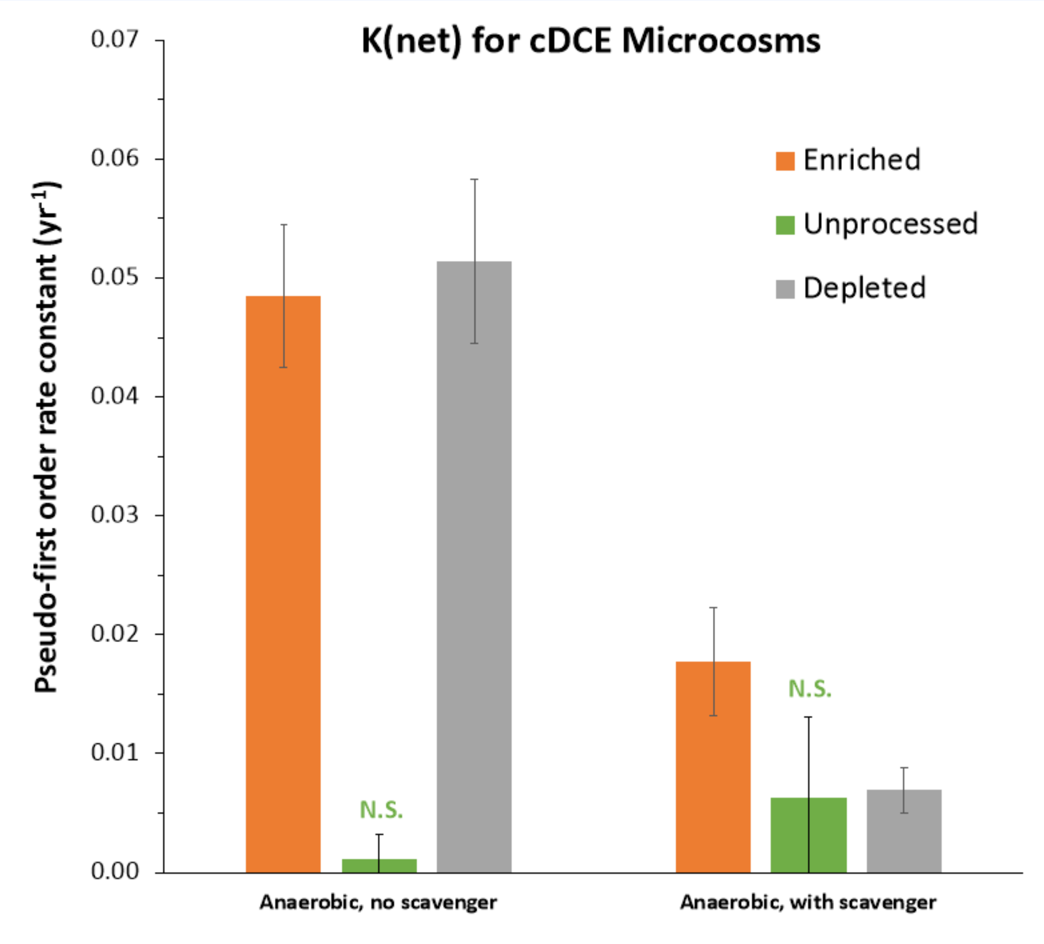
The rate constant for abiotic degradation can explain the field scale rate of natural attenuation of 0.0021 per foot.

He et al. 2009. Identification and Characterization Methods for Reactive Minerals Responsible for Natural Attenuation of Chlorinated Organic Compounds in Groundwater. EPA/ 600/R-09/113.

Development of Protocols to Quantify Abiotic Transformation Rates and Mechanisms for Chlorinated Ethenes in Water Supply Aquifers
ER20-1368

David L. Freedman
Clemson University

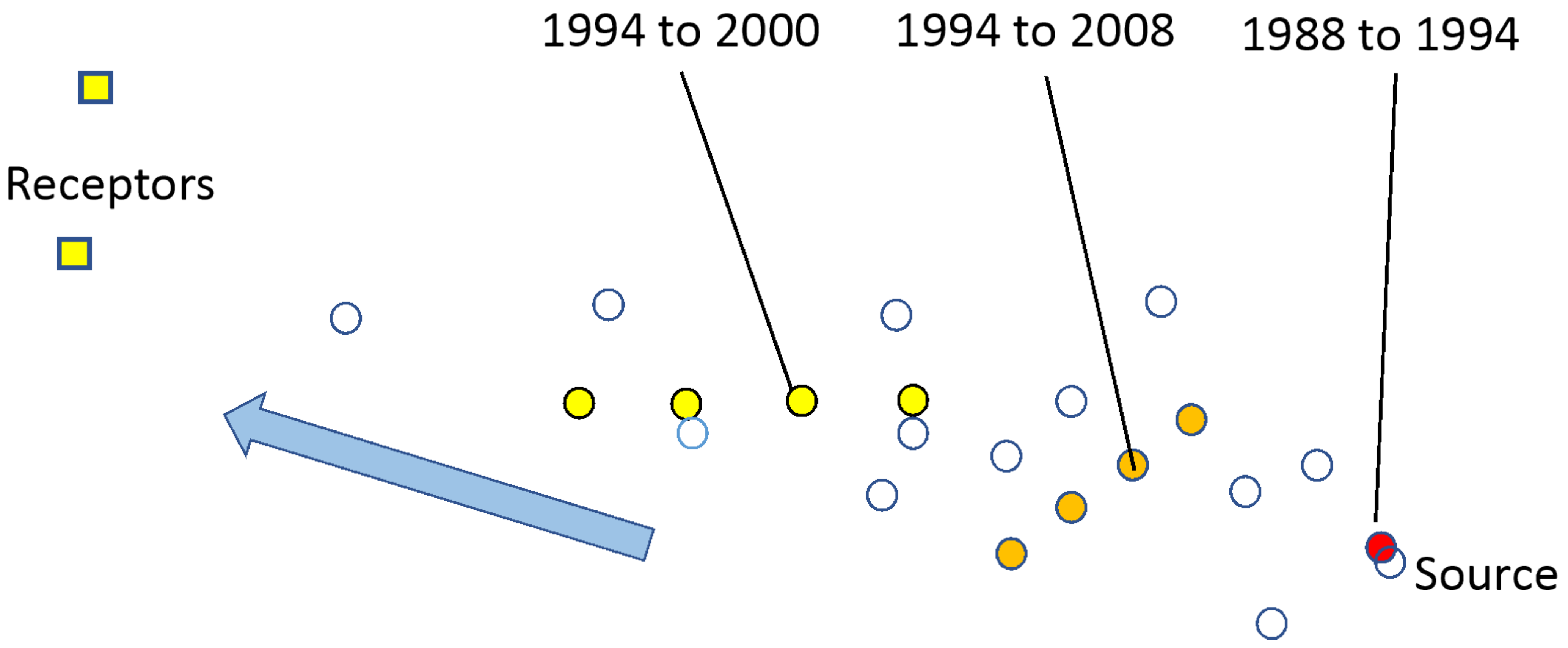
SERDP
DOD ▪ EPA ▪ DOE



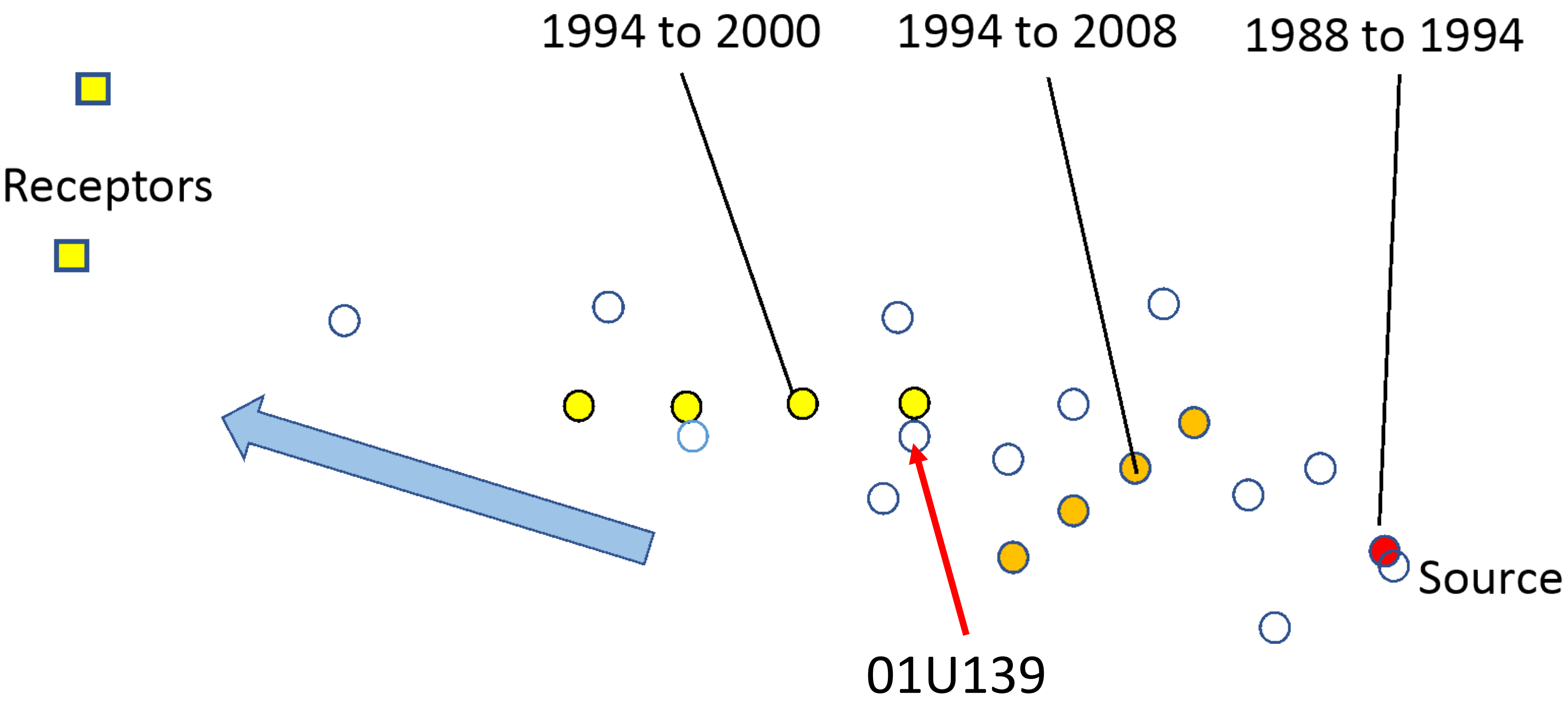
Olivia Dunn in David Freedman's lab at Clemson did a ^{14}C assay to extract a rate constant for abiotic degradation of cDCE.

In one treatment of her microcosm system under anoxic conditions, the rate constant for degradation of cDCE is 0.054 ± 0.014 per year at 95% confidence. Her microcosm system has 0.9 mL of water per 1.0 gm of sediment. Natural aquifer material is near 0.13 mL/gm. Correcting to a natural water content, the expected rate constant in the aquifer is 0.39 ±0.10 per year at 95% confidence. She included a control without sediment to account for production of degradation products from radiolysis of the cDCE. The rate constant in the control was 0.0055 ± 0.0024 per year. Correcting for radiolysis, the rate constant for degradation of cDCE under anaerobic conditions was 0.38 per year. This is in reasonable agreement with the rate constant from the conventional microcosm (0.52 per year).

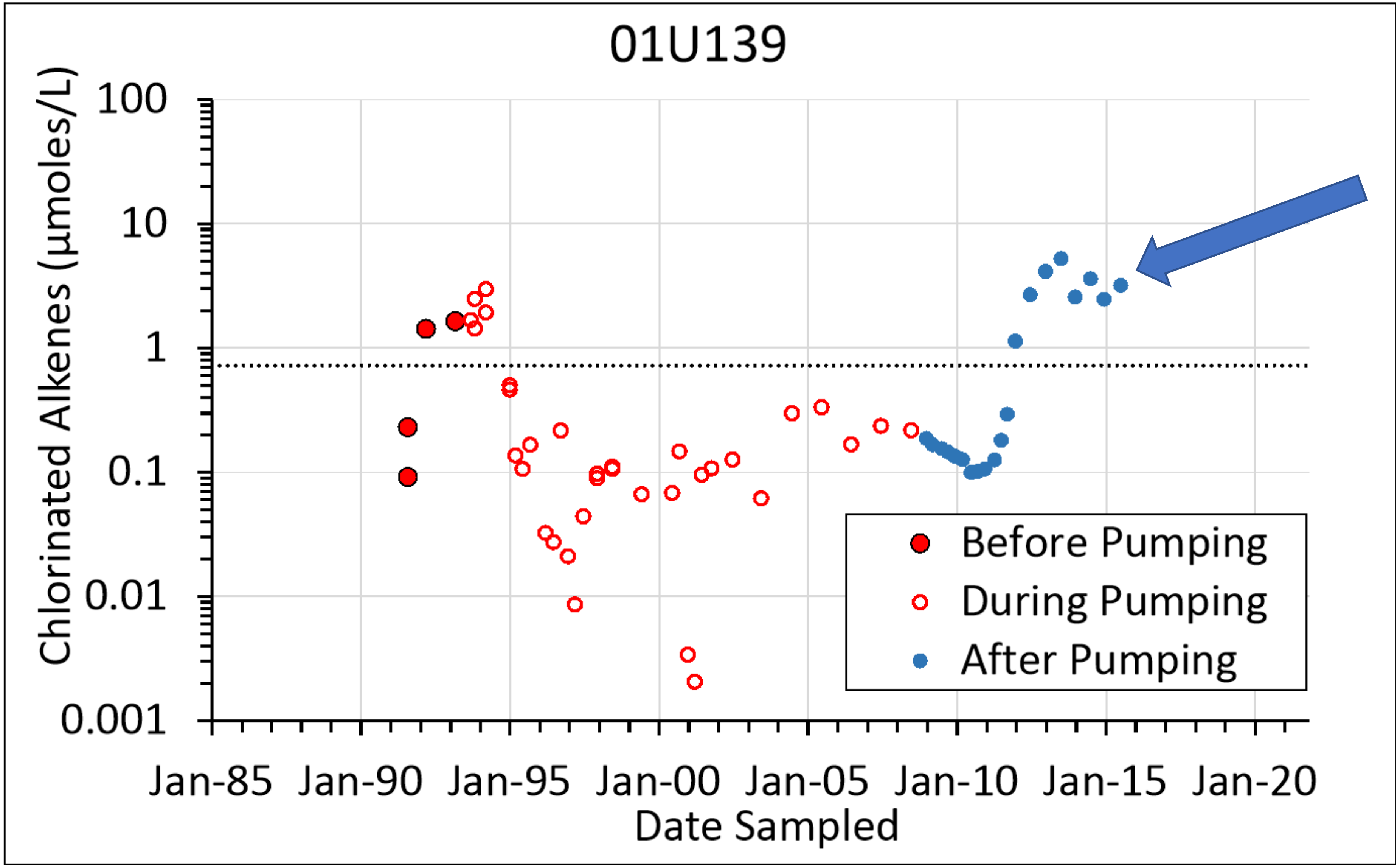
Period of operation of extraction wells



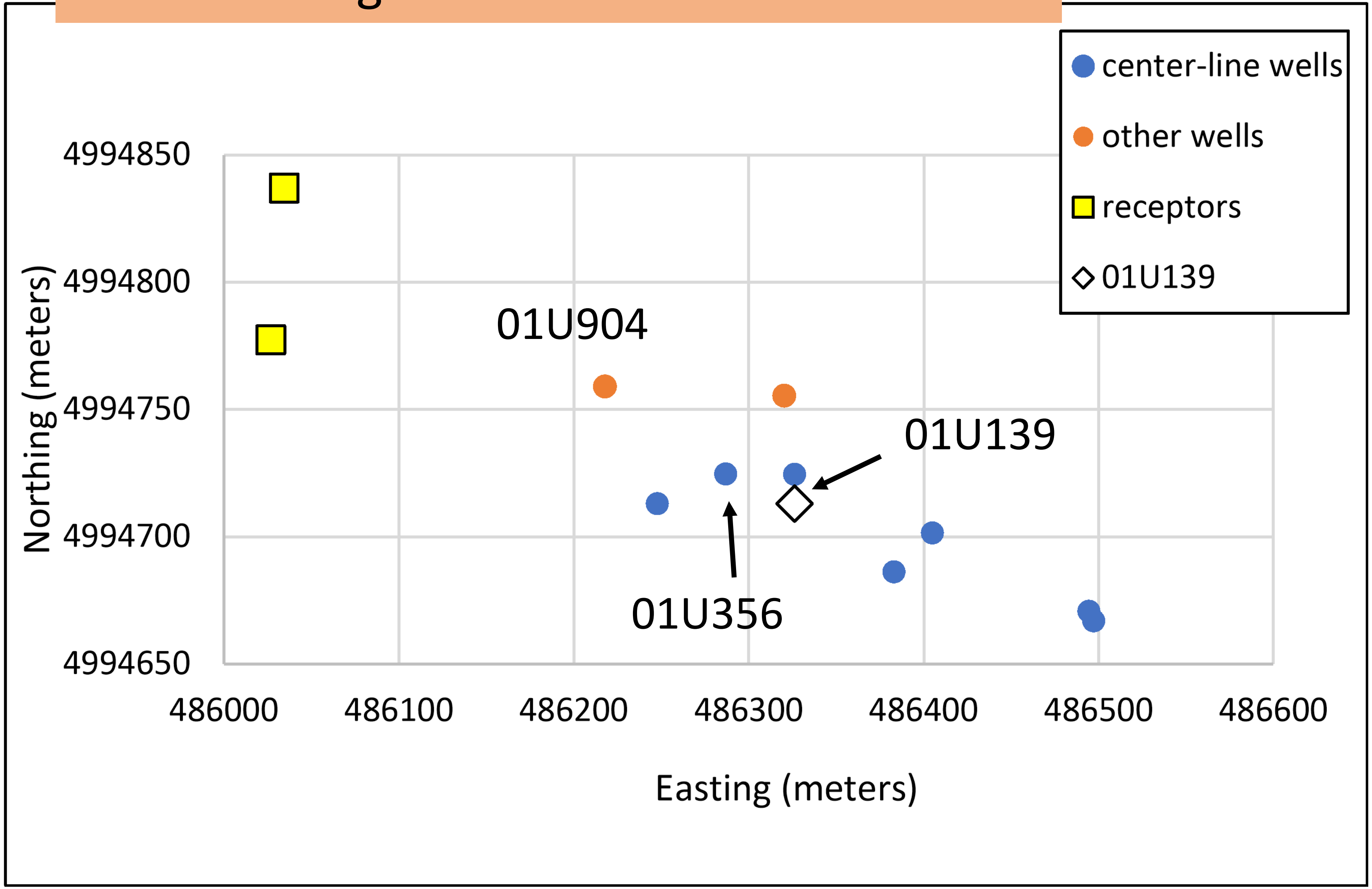
01U139 was the most contaminated well of the wells sampled in June 2015 at time the site was proposed for transition to MNA



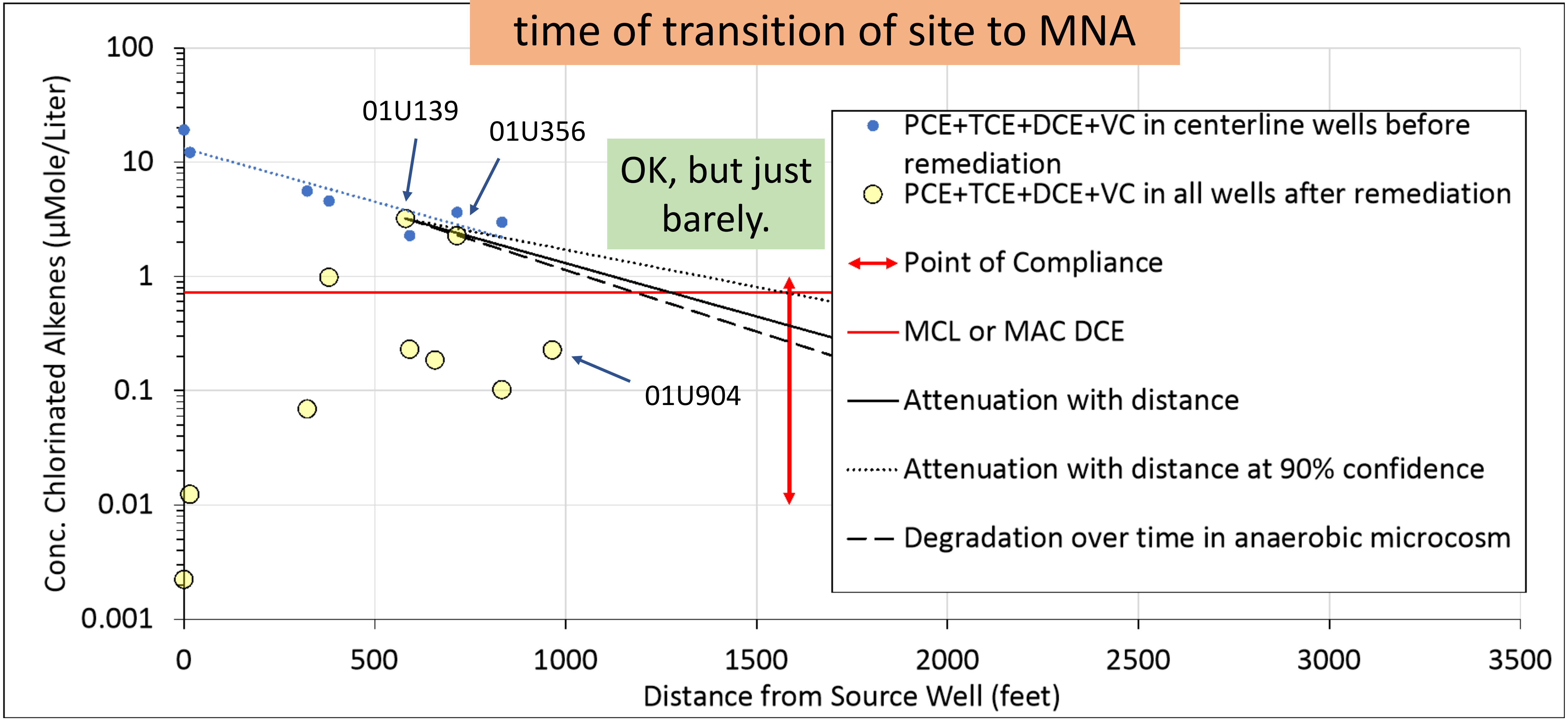
Concentrations in well 01U139 in 2015, when proposed to transition site to MNA.



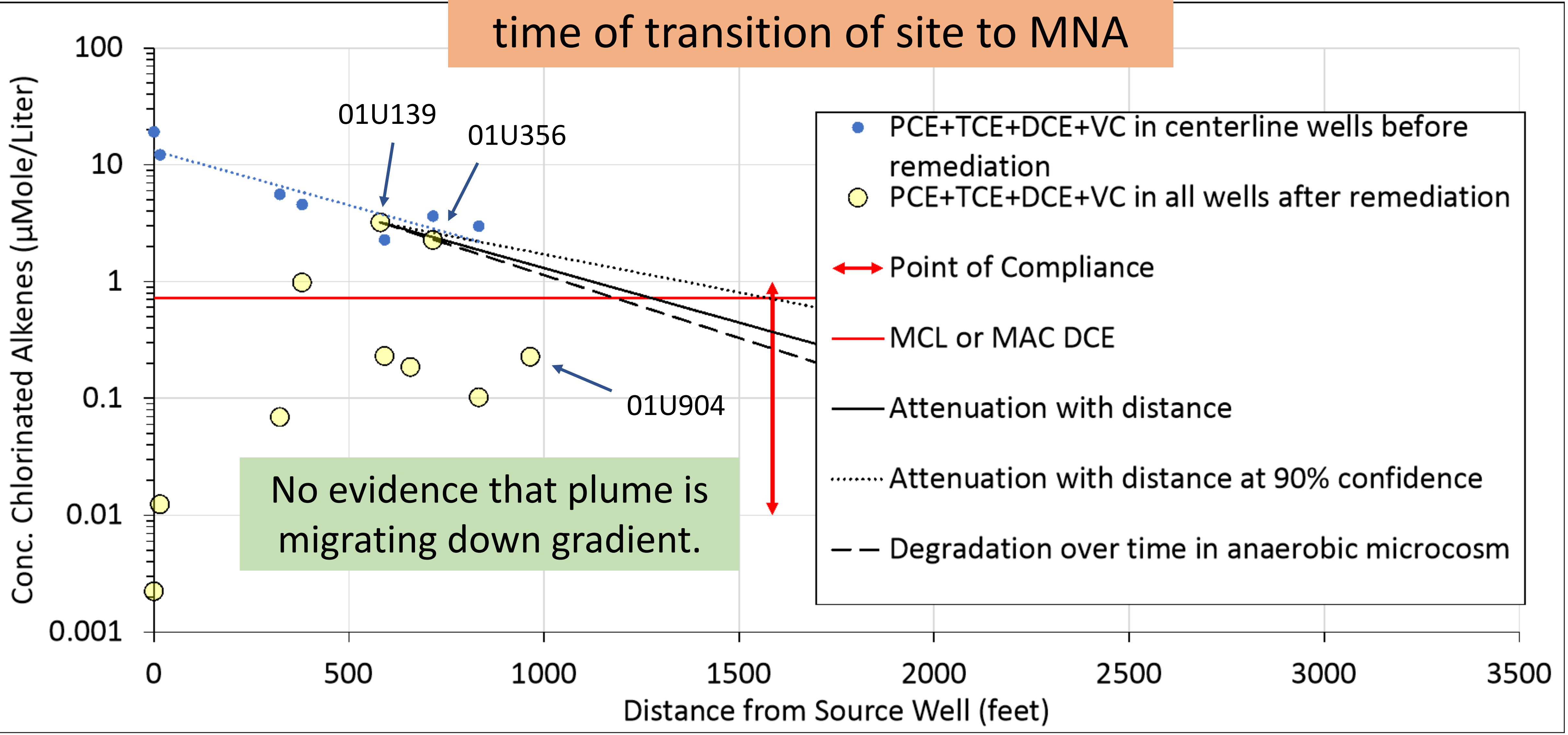
Wells 01U356 and 01U904 were directly down gradient of well 01U139



Risk to receptors in June 2015 at time of transition of site to MNA

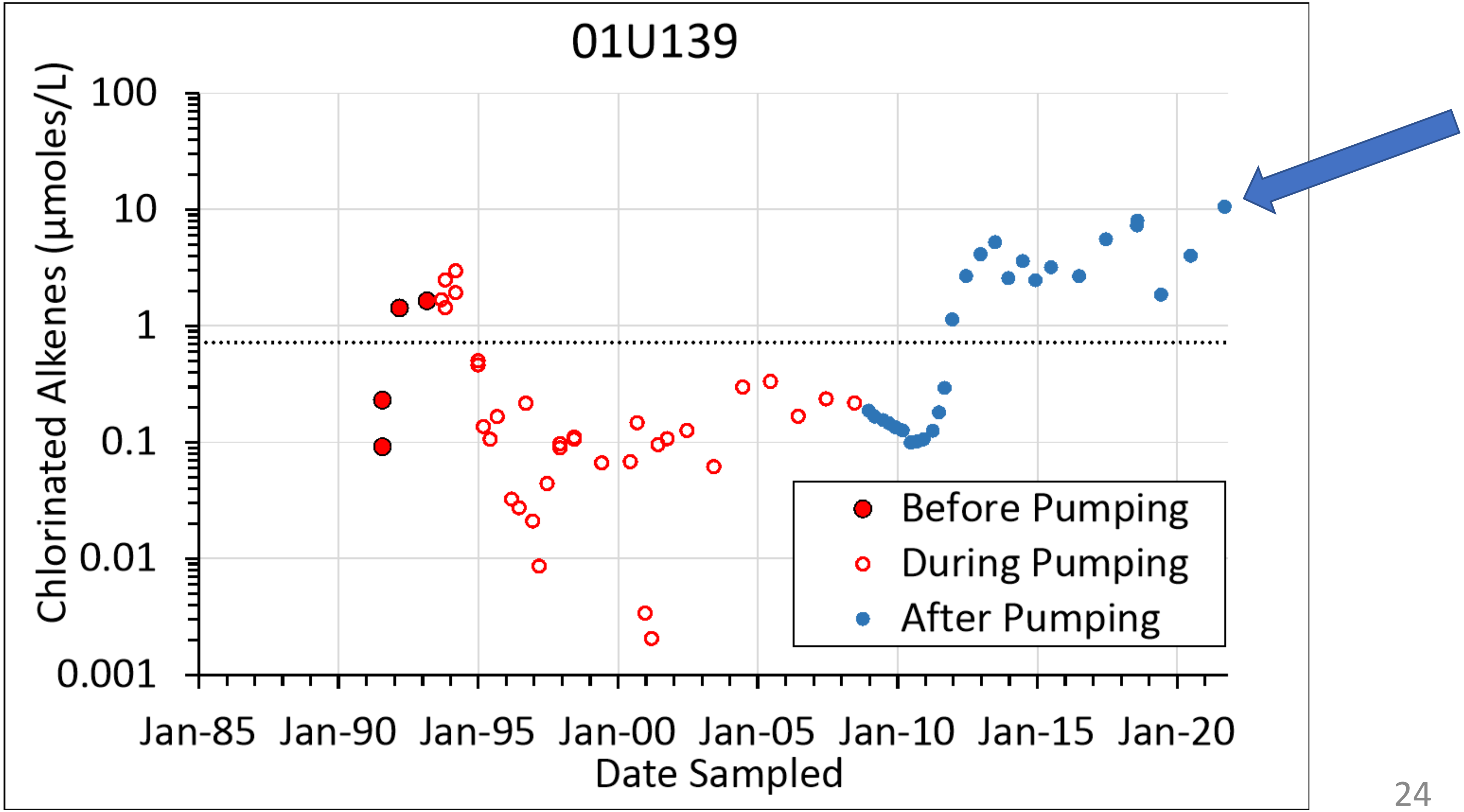


Risk to receptors in June 2015 at time of transition of site to MNA

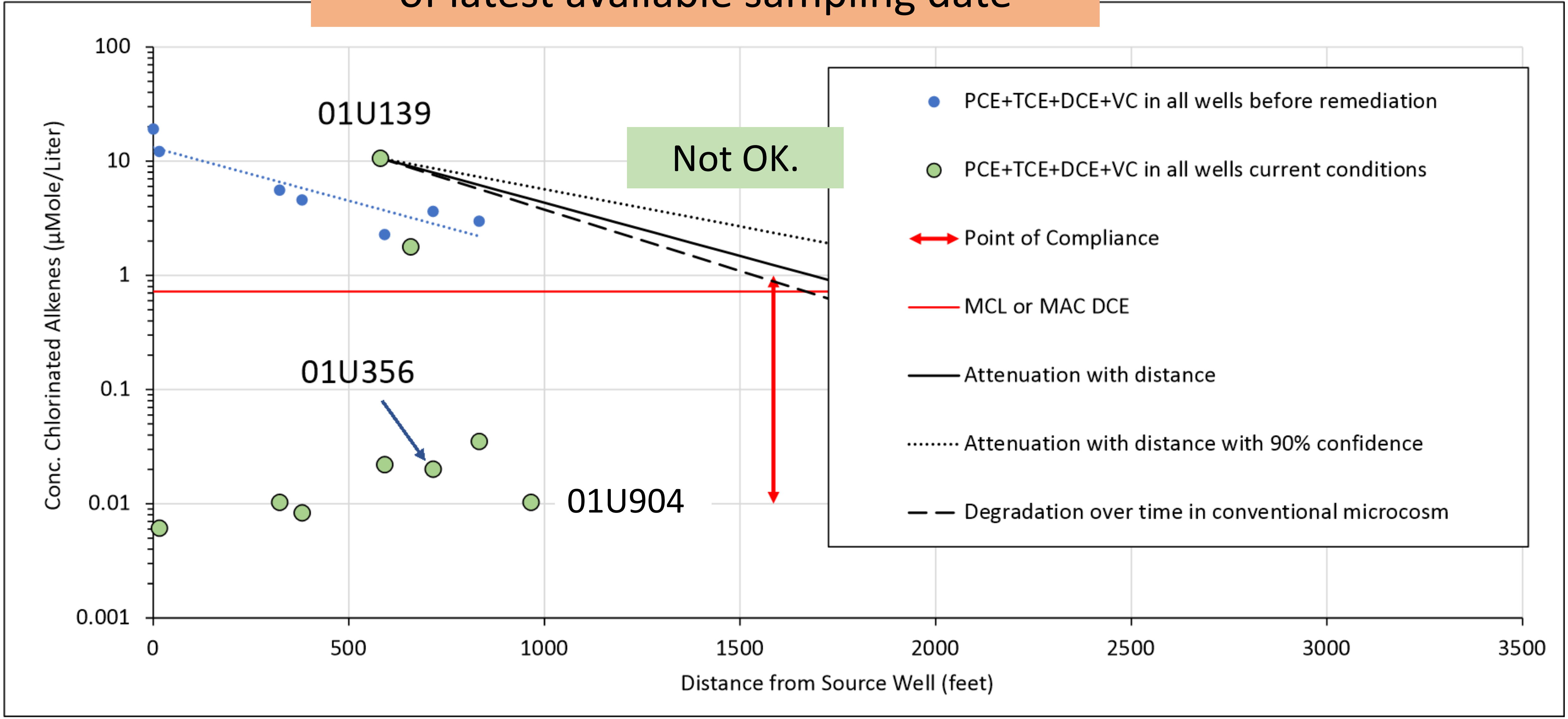


No evidence that plume is migrating down gradient.

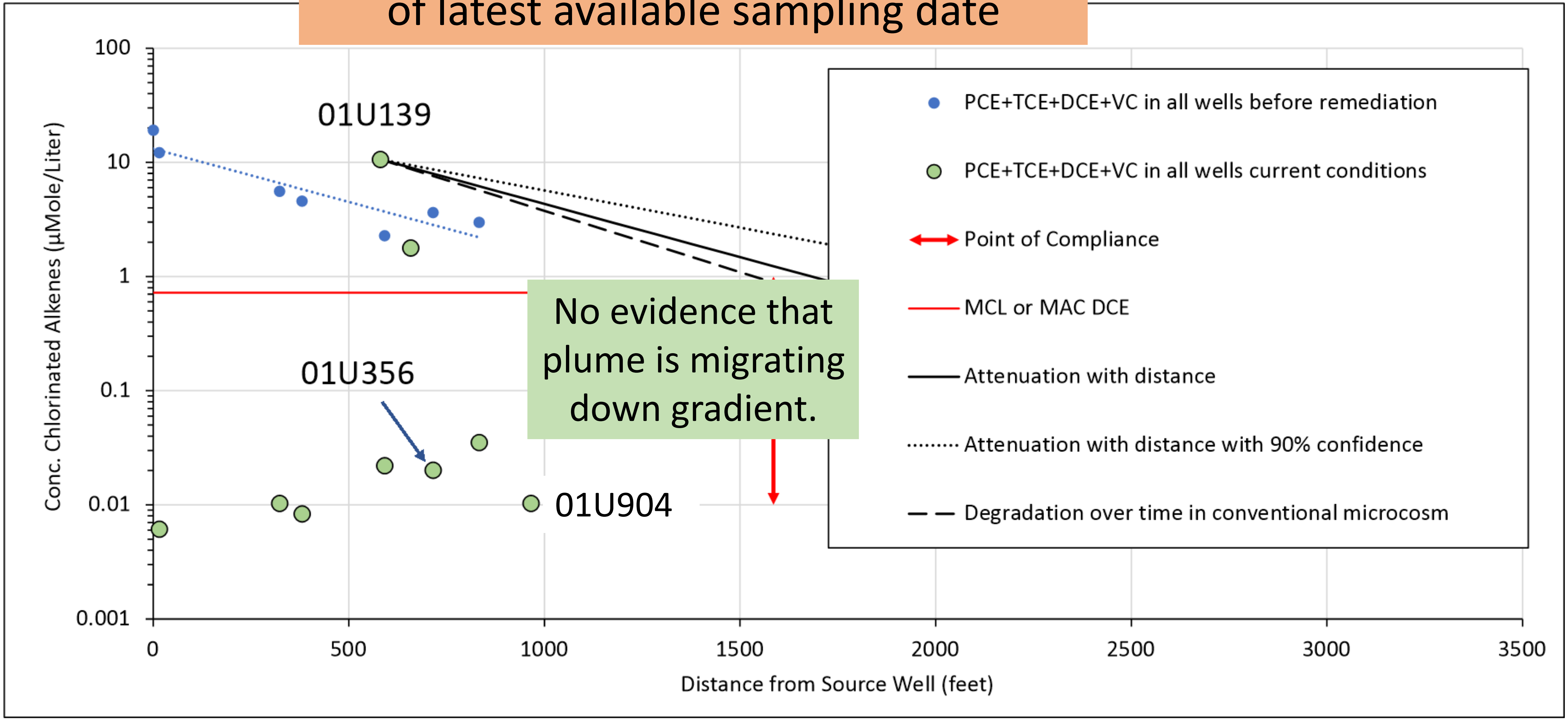
Concentrations in well 01U139 at latest available sample date (2021)



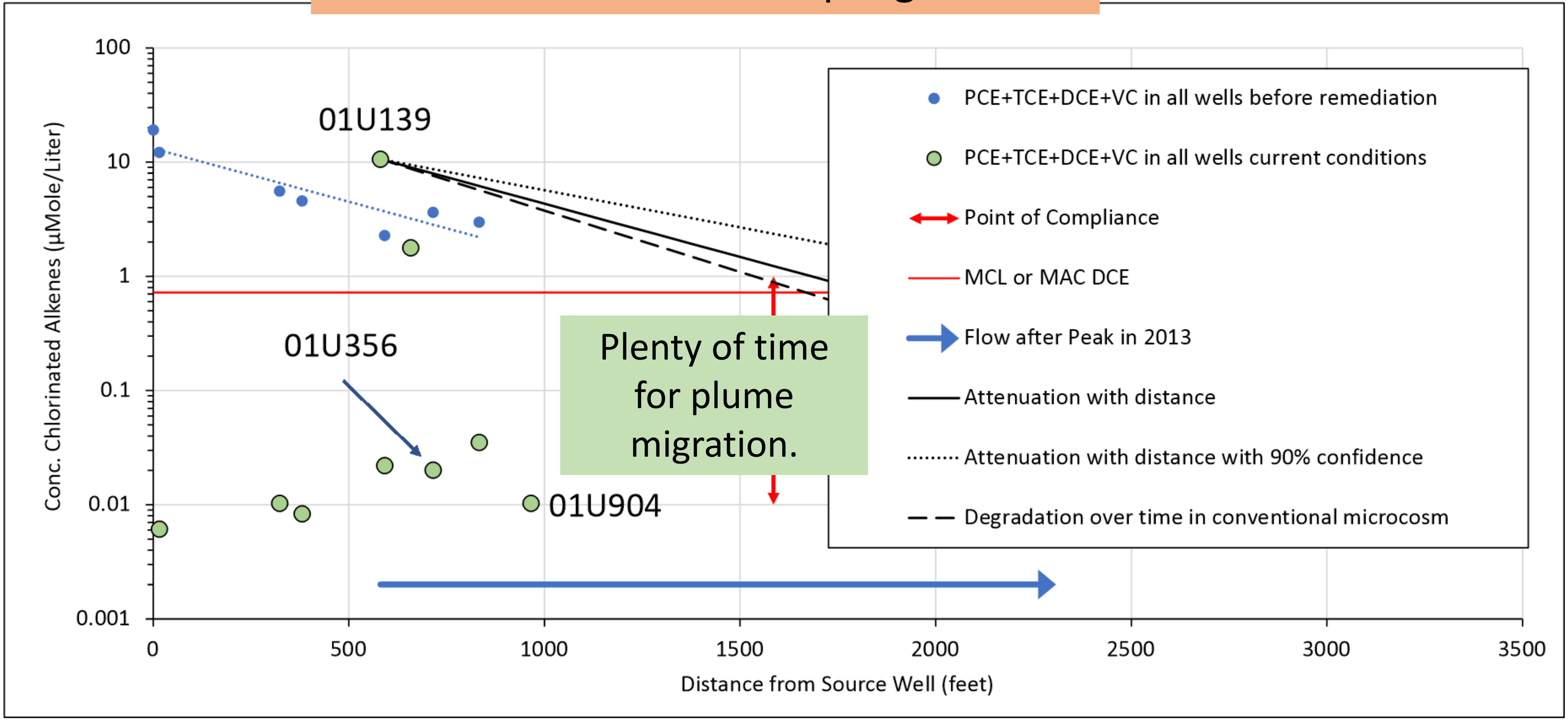
Risk to receptors in June 2021 at time of latest available sampling date



Risk to receptors in June 2021 at time of latest available sampling date



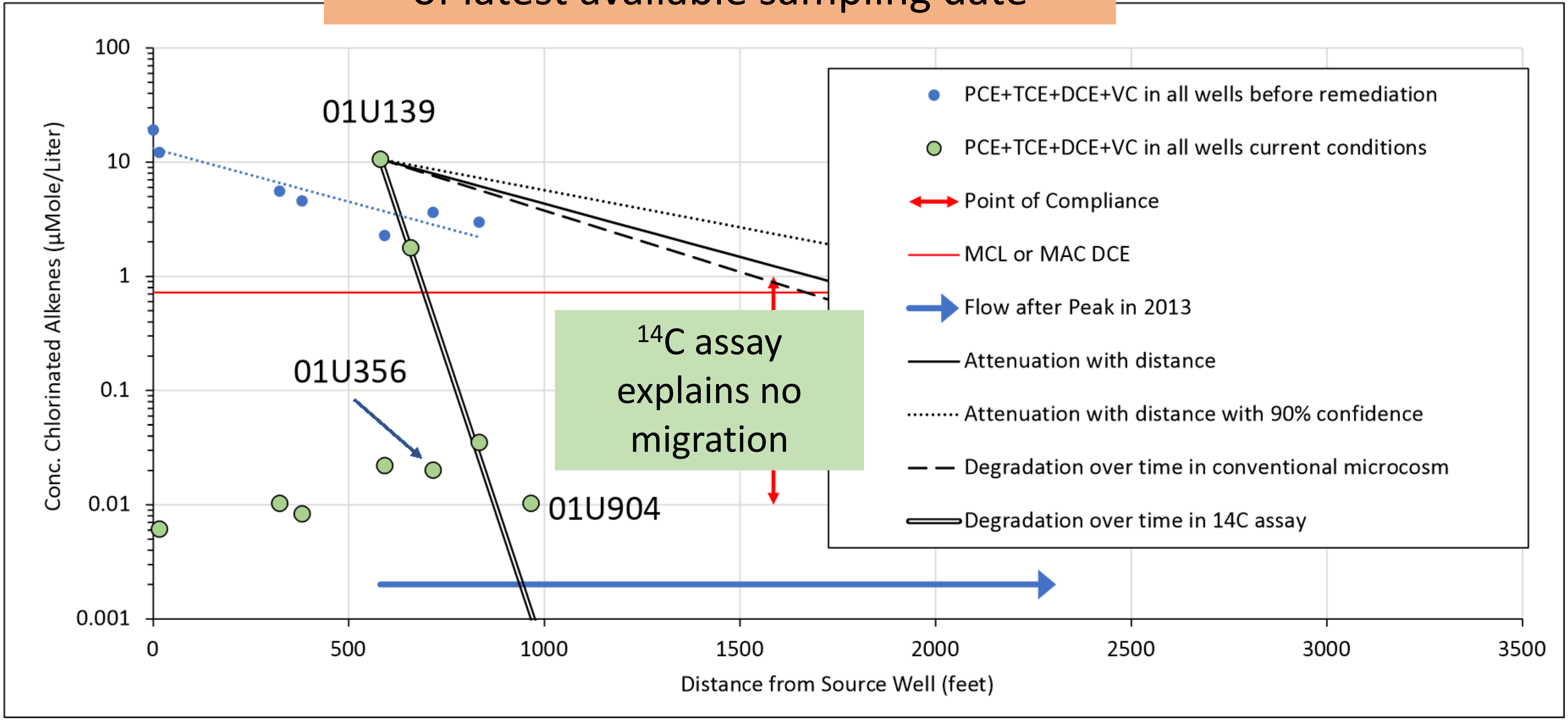
Risk to receptors in June 2021 at time of latest available sampling date



Since the conventional microcosm studies were done, the groundwater at the site has transitioned from anoxic to aerobic.

In the Clemson studies in another treatment under aerobic conditions, the rate constant for degradation of cDCE is 0.73 ± 0.14 per year at 95% confidence. Correcting to a natural water content, the expected rate constant in the sediment is 5.1 ± 1.0 per year at 95% confidence. She included a control without sediment to account for radiolysis of the cDCE. The rate constant in the control was 0.0077 ± 0.0031 per year. Correcting for radiolysis, the rate constant for degradation of cDCE under aerobic conditions was 5 per year, which would be equivalent to a rate constant with distance of 0.023 per foot of travel.

Risk to receptors in June 2021 at time of latest available sampling date



The approach provided a simple comparison to evaluate whether concentrations of contaminants in monitoring wells at the time of transition to MNA would be acceptable or not acceptable when the groundwater in the monitoring well reached the point of compliance.

The attenuation with distance along the flow path in the aquifer could be plausibly explained by rates of abiotic degradation extracted from conventional microcosm studies and ^{14}C degradation assays.