

# Quantification of Oxygenated Polycyclic Aromatic Hydrocarbons in the Vicinity of the Former Gasworks at Bay Shore, New York

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# Presentation Outline

Describe contamination area and remediation processes to date

Outline oxygenated PAHs and PAHs in modified lab methods

Show results of oxy-PAH sampling

Discuss the potential implications and need for continued monitoring

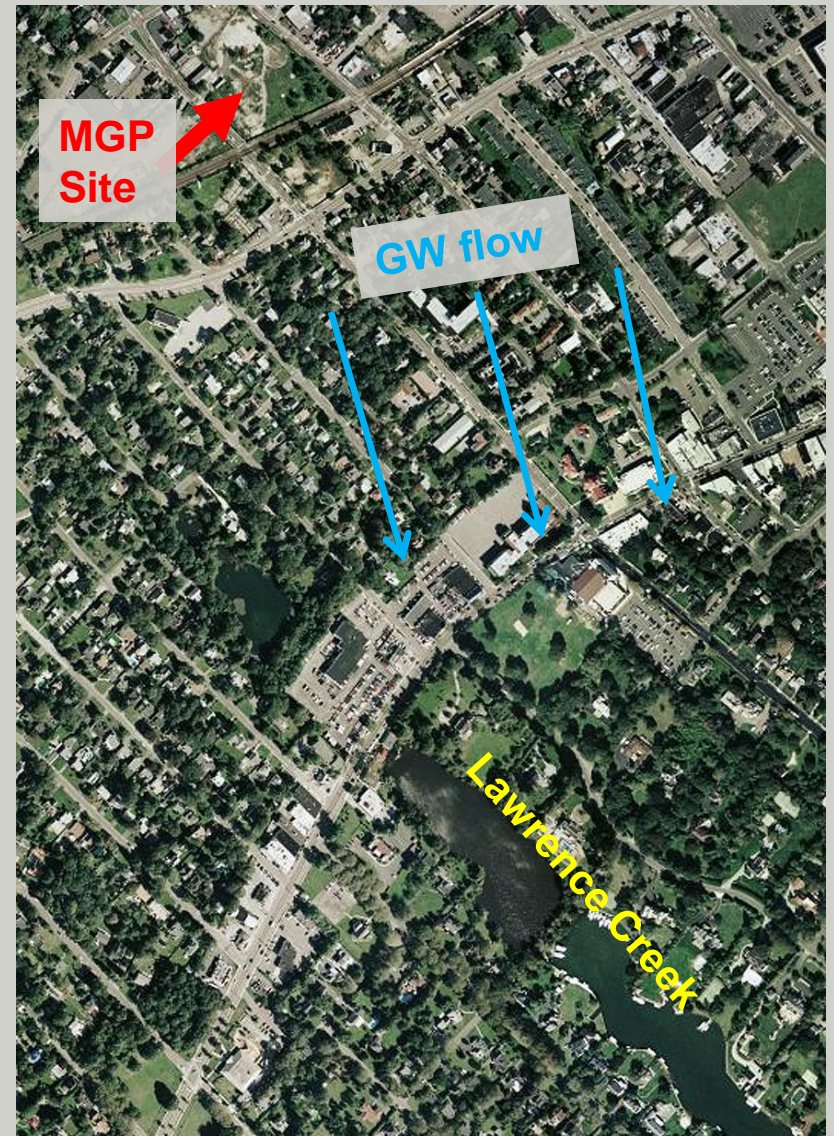
# Bay Shore, NY

South shore of Long Island

Glacial material: sand  
underlain by clay at 80 ft. BLS

Groundwater flow: Horizontal  
movement under ~ 120 private  
properties @ about 1 ft./day

Groundwater-fed stream also  
affected (Lawrence Creek);  
feeds into Great South Bay



# History

Operated 1889 to 1973

NY issues “area of concern” (AOC) designation in 1999; site becomes part of state voluntary MGP cleanup program, not listed as superfund site

Contaminant plume affects the Upper Glacial Aquifer extending down more than 40 feet in some areas



# Remediation

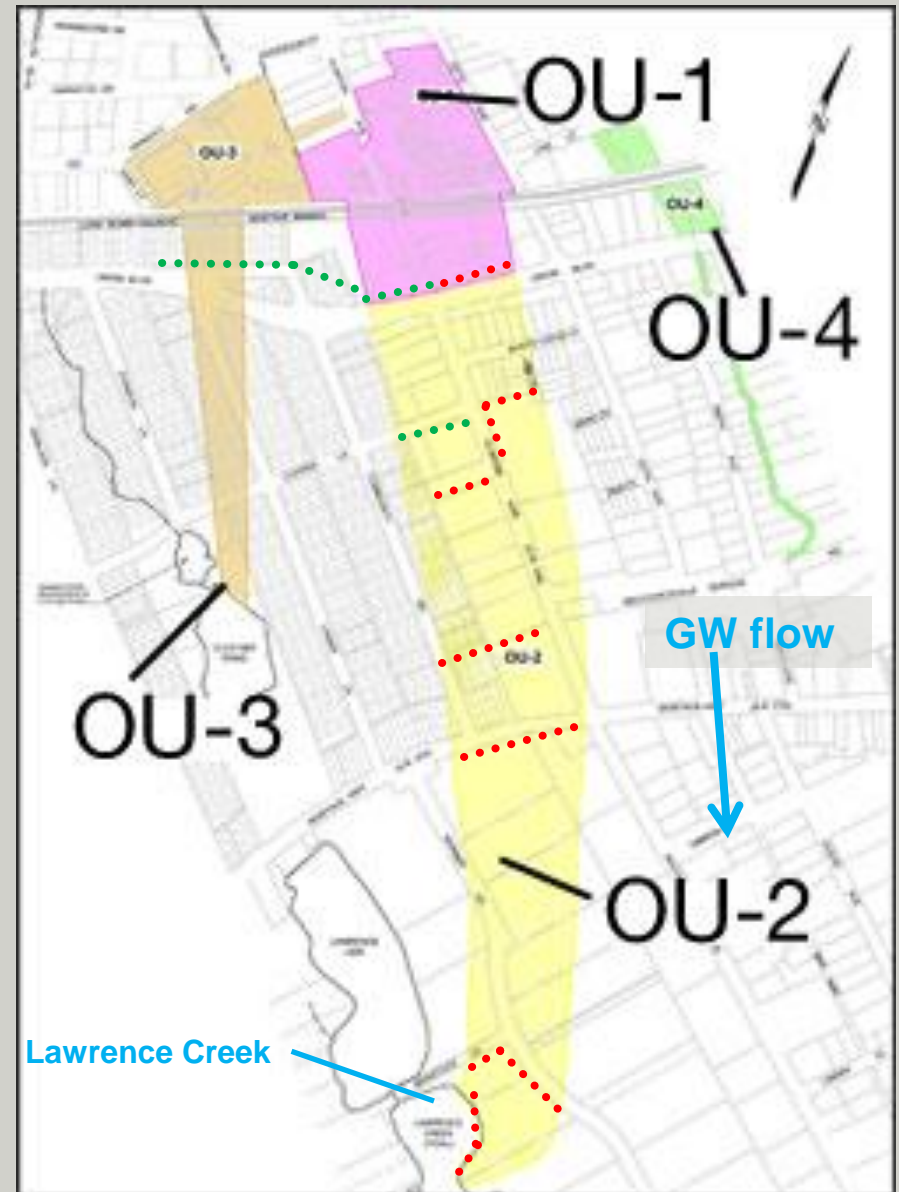
Operable Units (OU) depict plume boundaries

OU1: 100,000 tons of soil removed to date, pilot site for multiple In-Situ Chemical Oxidation (ISCO) tests beneath excavated areas

OU2: Oxygen-gas Injection (OGI) lines in service since 2005 in the lower portions of the plume, near Lawrence Creek. Additional oxygen injection lines completed 2008-2009

OU3: Original OGI site

OU4: Surfactant-ISCO comprehensive study; no OGI to date



# Oxygenated Polycyclic Aromatic Hydrocarbons (oxy-PAHs)

Can be emitted from the same sources as PAHs

May be formed through both chemical (e.g. Fenton reagents) and biological (e.g. microbial) oxidation of PAHs in the environment

Oxidation enhances mobility due to increased polarity

Lundstedt et.al. compiled a list of oxy-PAHs and their toxicological effects on certain organisms that show some are more toxic than the parent PAH<sup>1</sup>

# Oxy-PAHs and former Gasworks

Study of the soils from Husarviken gasworks (Sweden)<sup>1,2</sup> has shown that oxy-PAHs form and may accumulate as a result of the following oxidative treatments:

- Pilot-scale bioslurry reactor

- Lab-scale Fenton/Ethanol treatment

Mutagenic studies of *Salmonella* strains show oxidation products (including but not limited to oxy-PAHs) in bioslurry soils more toxic than PAH due to increased bioavailability<sup>2</sup>

In cooperation with the Suffolk County Department of Health Services, USGS has developed a method to monitor oxy-PAHs in groundwater at the Bay Shore former gasworks that may be associated with oxidative processes

# oxy-PAHs analyzed

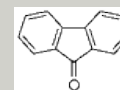
## Compound

## CAS number

## Structure

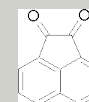
9-Fluorenone

486-25-9



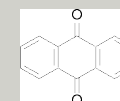
Acenaphthenequinone

82-86-0



9,10-Anthraquinone

84-65-1



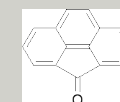
Phenathrene-1,4-dione

569-15-3



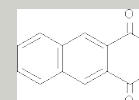
4H-Cyclopenta[def]phenanthren-4-one

5737-13-3



1,4-Anthraquinone

635-12-1



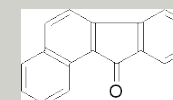
9,10-Phenanthrenequinone

84-11-7



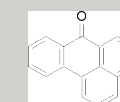
Benzofluorenone

479-79-8



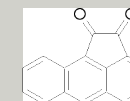
Benzanthrone

82-05-3



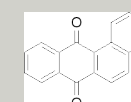
Aceanthracenequinone

6373-11-1



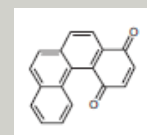
7,12-Benz[a]anthracenquinone

2498-66-0



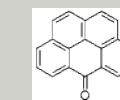
Benzo[c]phenanthrene-[1,4]quinone

109699-80-1



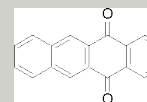
Benzo[cd]pyrenone

3074-00-8

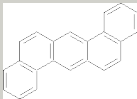
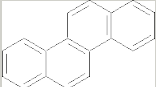
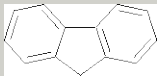


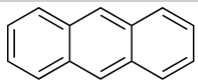
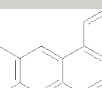
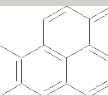
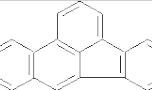

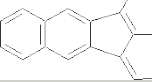
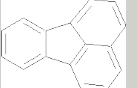
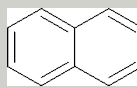
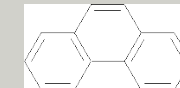





5,12-Naphthacenequinone

1090-13-7



# PAHs analyzed

Compound	CAS number	Detection Limit (µg/L)	Structure	
Dibenz[a,h]anthracene	53-70-3	0.42		
Chrysene	218-01-9	0.32		
Fluorene	86-73-7	0.34		
Acenaphthene	83-32-9	0.28		
Acenaphthylene	208-96-8	0.3		
Anthracene	120-12-7	0.38		
Benz[a]anthracene	56-55-3	0.26		
Benzo[a]pyrene	50-32-8	0.32		
Benzo[b]fluoranthene	205-99-2	0.3		
Benzo[ghi]perylene	191-24-2	0.38		
Benzo[k]fluoranthene	207-08-9	0.3		
Fluoranthene	206-44-0	0.3		
Indeno[1,2,3-cd]pyrene	193-39-5	0.38		
Naphthalene	91-20-3	0.22		
Phenanthrene	85-01-8	0.32		
Pyrene	129-00-0	0.36		

# Sample Preparation and Analysis

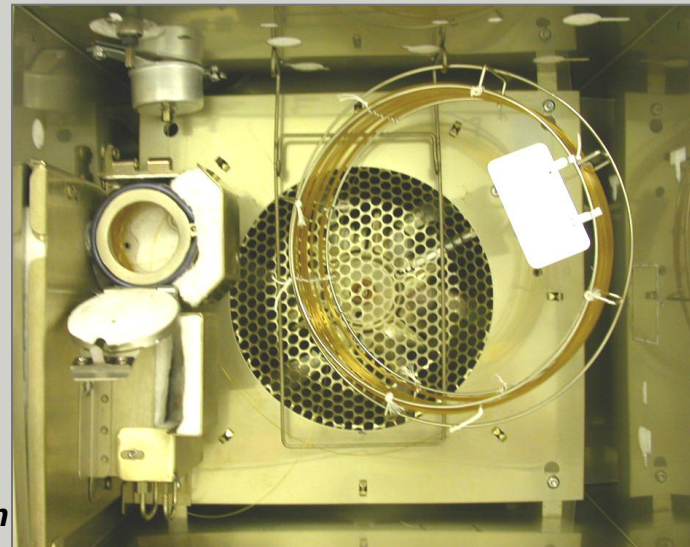
Sodium chloride added to sample and continuous liquid-liquid extraction is performed

Compounds separated using Gas Chromatography (GC) techniques

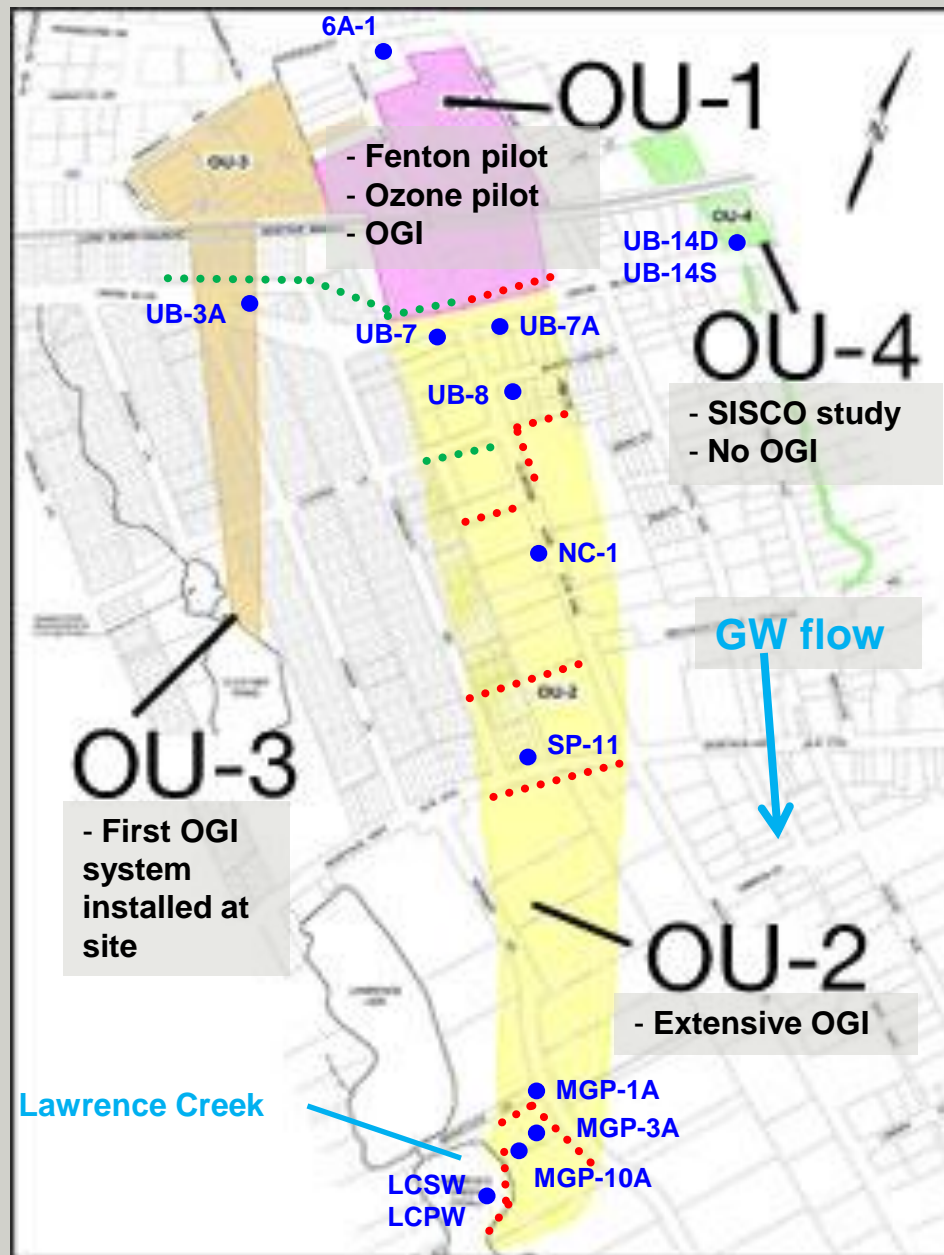
Characterized using Mass Spectrometry (MS) under Selected Ion Monitoring to obtain lower detection limits



*Gas Chromatograph – Mass Spectrometer*



# Sample Locations

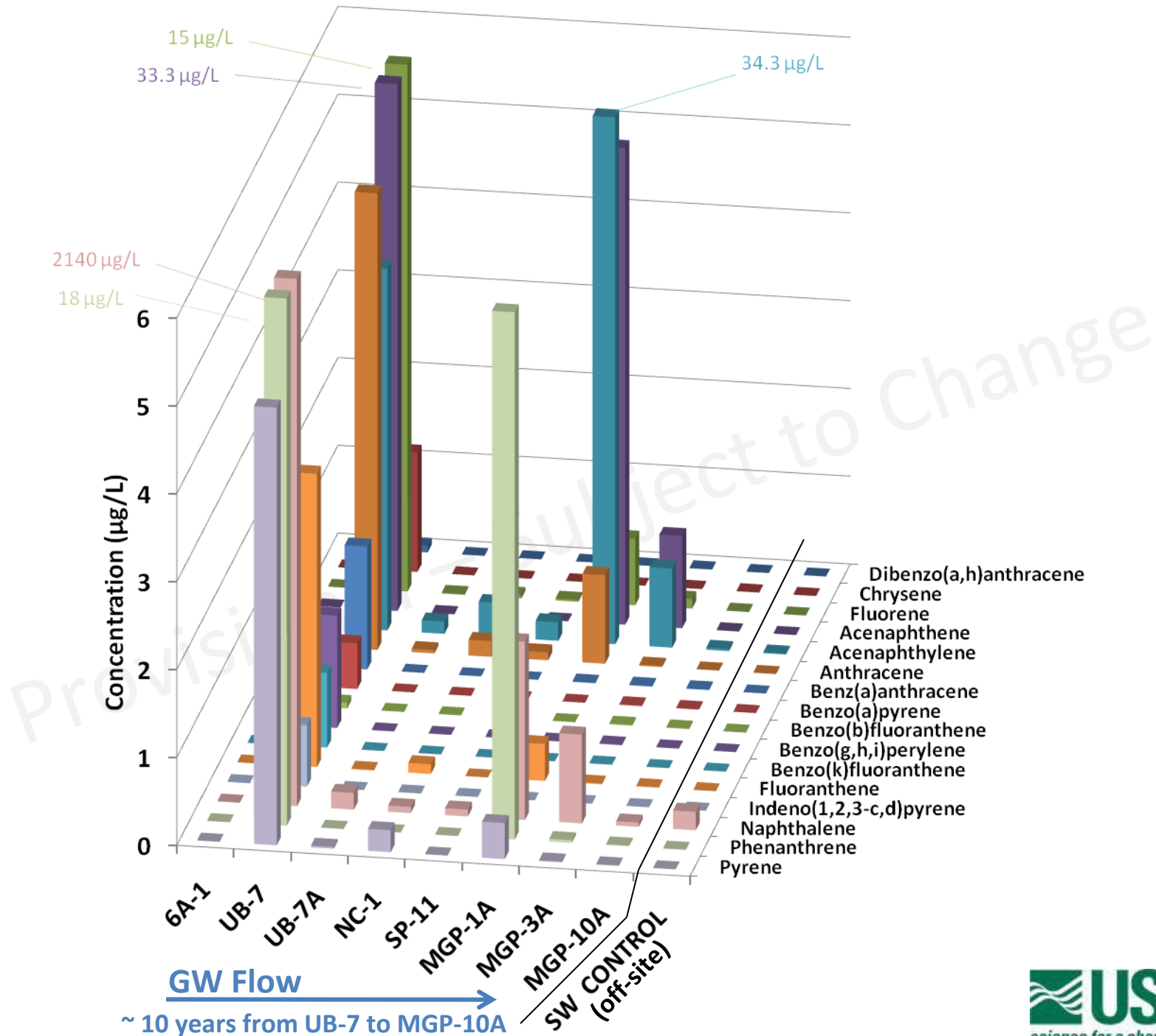


..... Oxygen-gas  
Injection  
(OGI) line

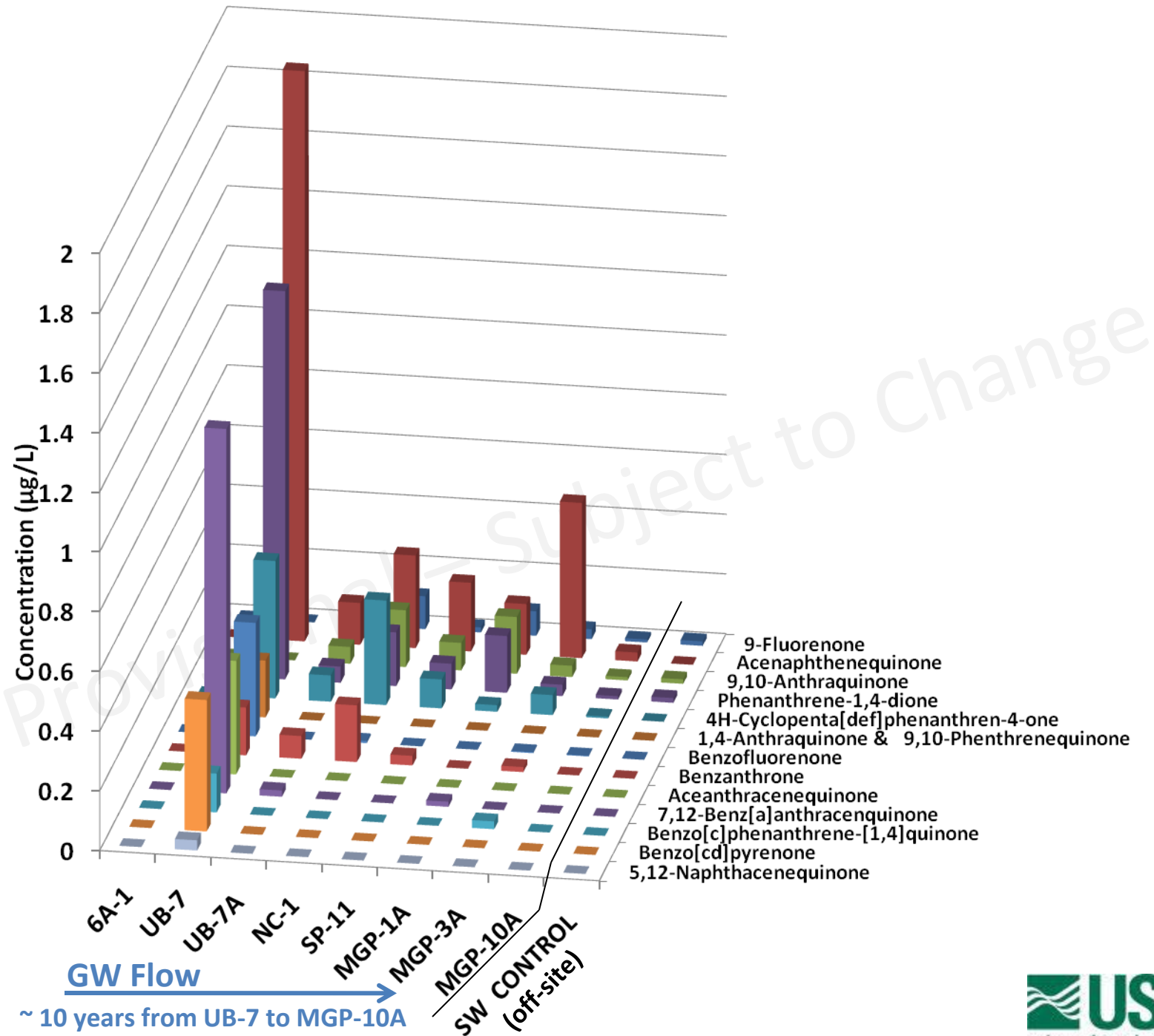
..... Recently  
activated  
OGI

• Sample Location

PAHs



oxy-PAHs

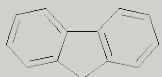


6A-1,  
up-gradient  
CONTROL,  
no detects

# PAH / oxy-PAHs Pairs

## PAH

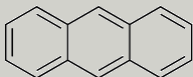
Fluorene



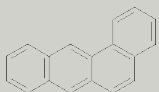
Acenaphthene & Acenaphthylene



Anthracene



Benz[a]anthracene

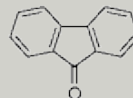


Phenanthrene

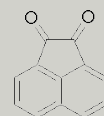


## oxy-PAH

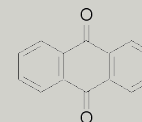
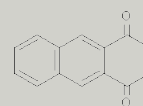
9-Fluorenone



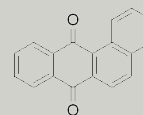
Acenaphthenequinone



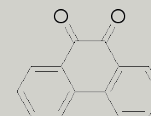
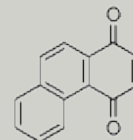
1,4-Anthraquinone & 9,10-Anthraquinone



7,12-Benz[a]anthracenquinone



Phenanthrene-1,4-dione & 9,10-Phenanthrenequinone

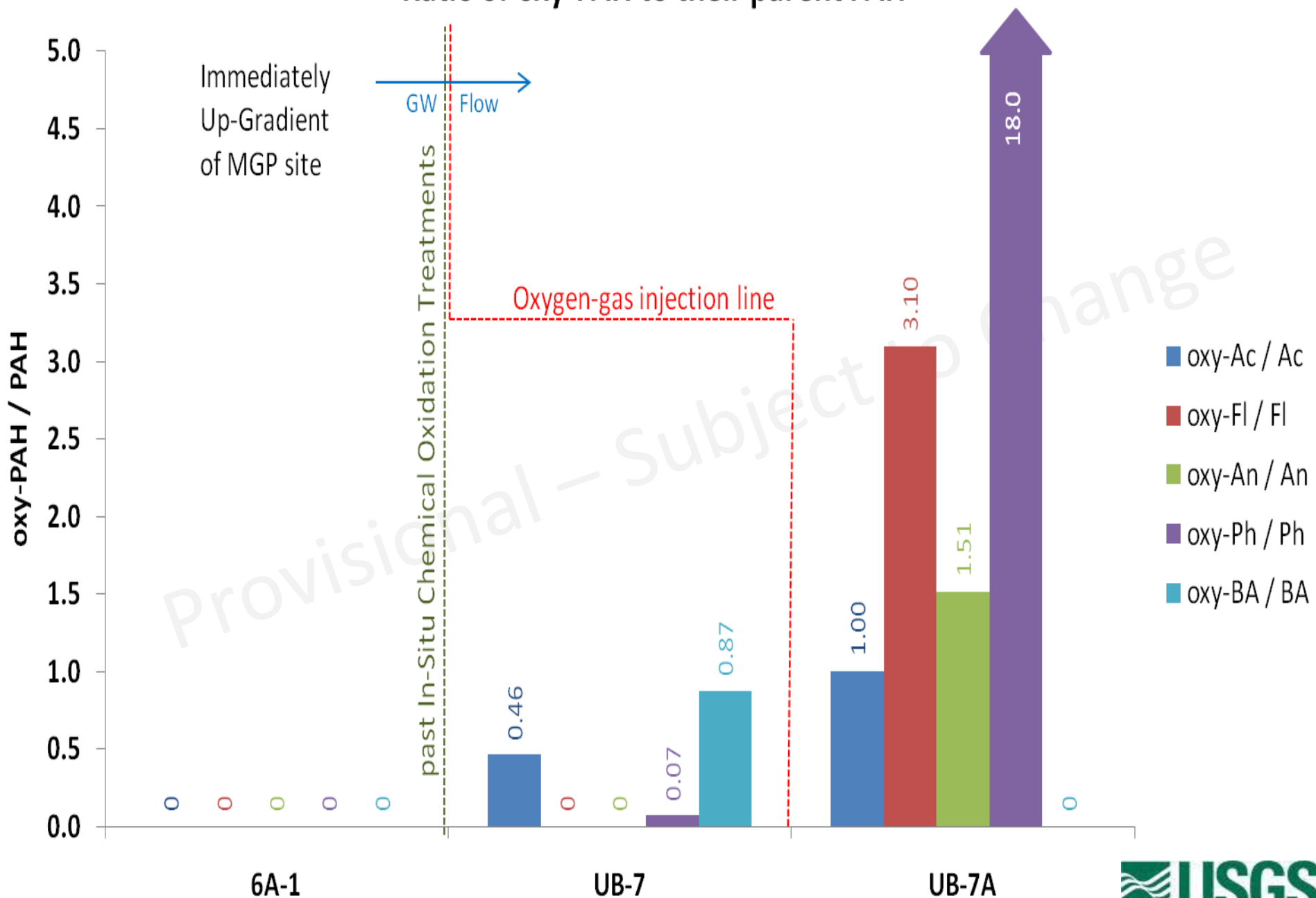


Biological or

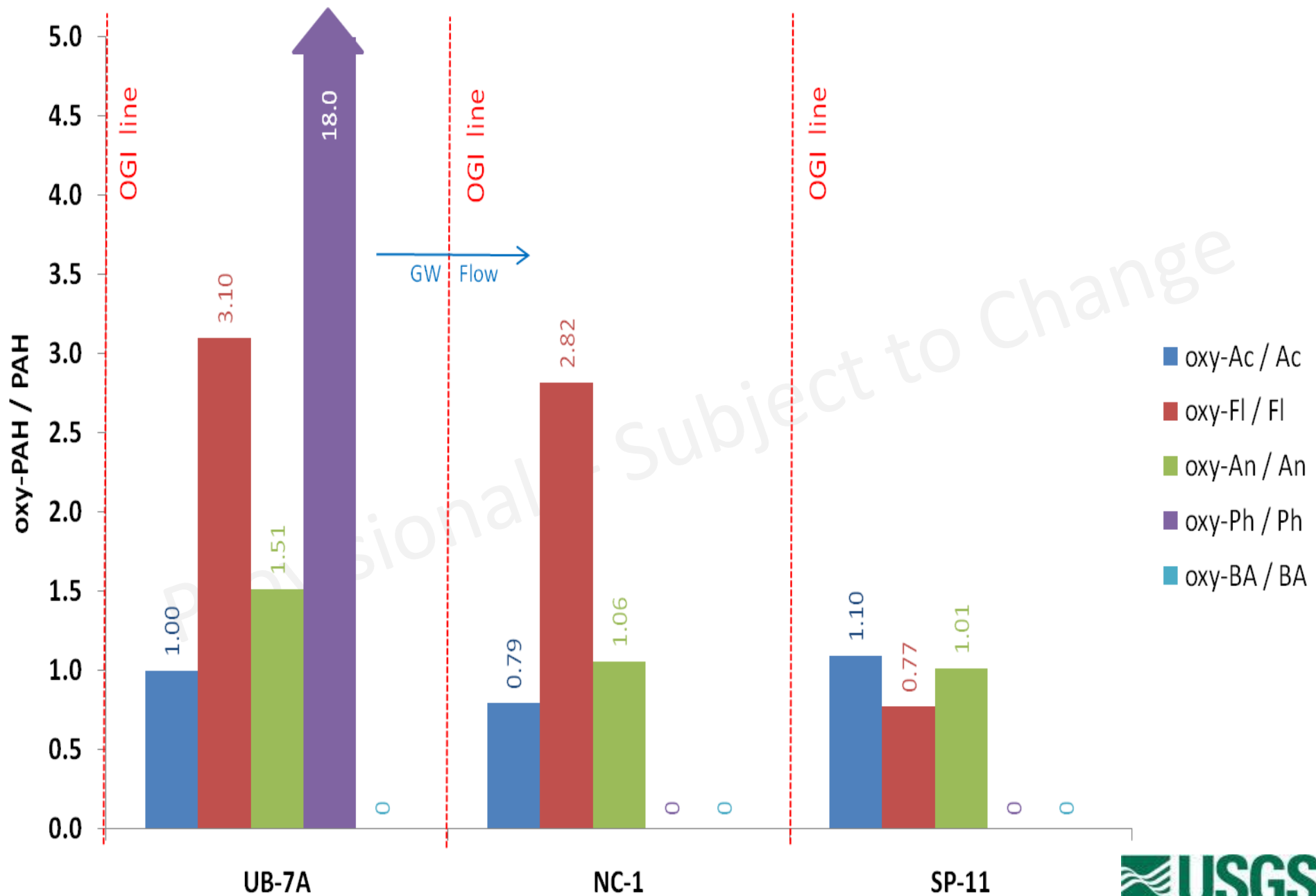


Chemical  
Oxidation

# Ratio of oxy-PAH to their parent PAH

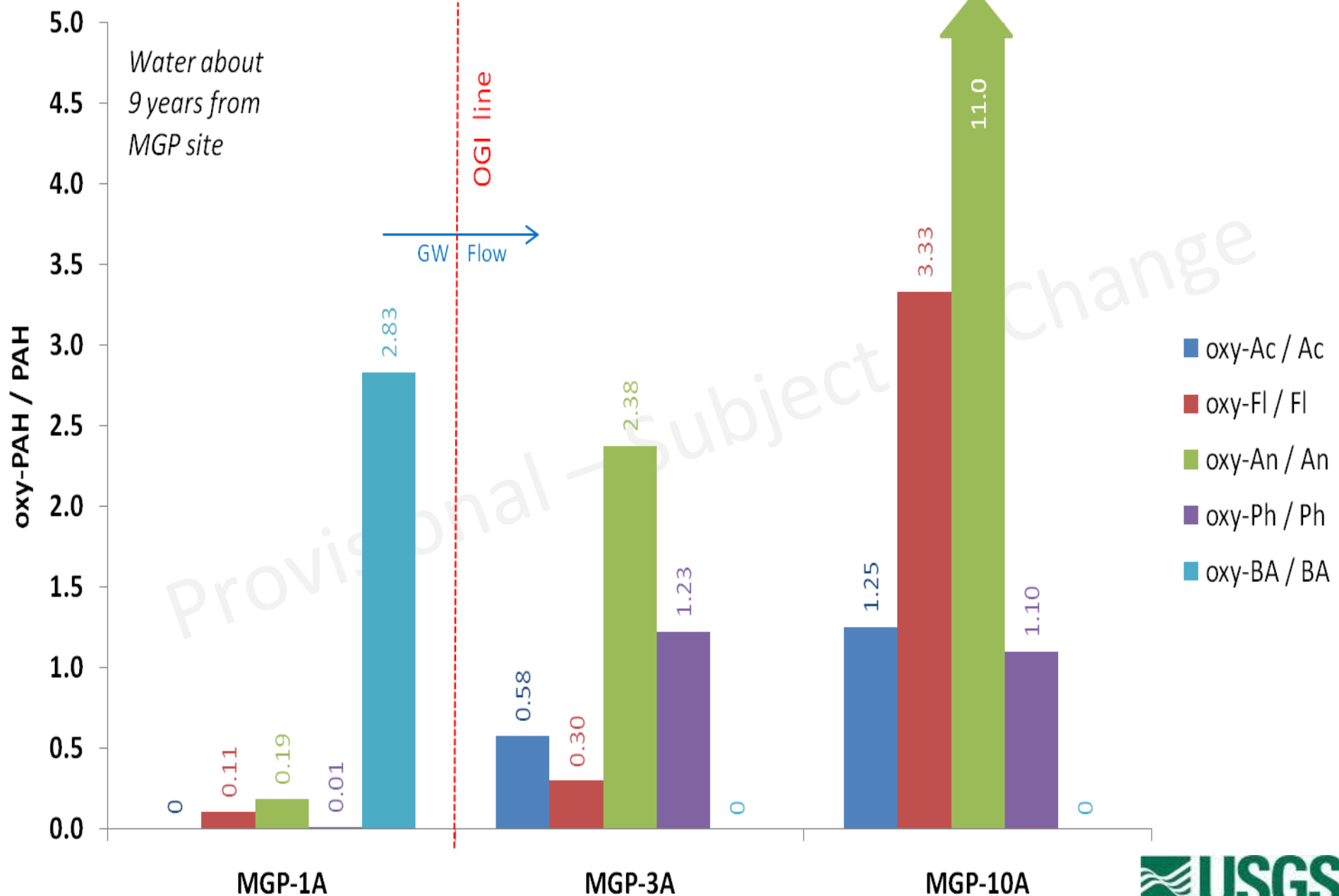


# Ratio of oxy-PAH to their parent PAH



## Ratio of oxy-PAH to their parent PAH

Water about  
9 years from  
MGP site



# Conclusions

Significant amounts of PAHs and other organic compounds are present in some samples analyzed

Trace amounts of oxy-PAHs are present in most samples

Although concentrations are low, some oxy-PAH ratios compared to parent-PAHs are higher post-OGI system

This study demonstrated a method for the identification and quantification of some oxy-PAHs in ground water, though future work will likely expand this compound list based on the initial findings

Continuous (bi-annually) sampling is needed to monitor select wells and establish trends as remediation projects progress to lend more insight into the fate of PAHs in ground water undergoing oxidative treatment

# References

Bay Shore site: <http://bayshoreworksmgp.com>

Toxicity:

[http://proceedings.instep.ws/2006\\_04\\_02\\_MGP2006/content/pdf/04\\_Neuhauser\\_65.pdf](http://proceedings.instep.ws/2006_04_02_MGP2006/content/pdf/04_Neuhauser_65.pdf)

<sup>1</sup> Lundstedt S, White PA, Lemieux CL, Lynes KD, Lambert IB, et al. (2007) **Sources, Fate, and Toxic Hazards of Oxygenated Polycyclic Aromatic Hydrocarbons (PAHs) at PAH-contaminated Sites.** AMBIO: A Journal of the Human Environment: Vol. 36, No. 6 pp. 475–485

<sup>2</sup> Lemieux CL, Lynes KD, White PA, Lundstedt S, Oberg L, Lambert IB (2009) **Mutagenicity of an Aged Gasworks Soil During Bioslurry Treatment.** Environ Molec Mut, 50: 404-412

- **OFR 93-125**

Fishman, M.J., ed., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93-125, 217 p.

**Method ID:** O-3116-87

# Thank-you

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