

World History (Cold War to Present) Preserved in the Sediment Record at an Industrial Facility

Sediment Management Working Group Sponsor Forum

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Emma Applegate
Nathan Stevens, PG
Jeffrey Hale, PG

Site Setting & Characteristics

- Active oil refinery adjacent to industrialized estuary since early 1900s
- Tidally influenced creek traversing site
 - Multiple discharge points along waterbody
 - Flow primarily non-contact cooling water
- Man-made drainage ditch to creek
 - Relatively stagnant water within ditch
 - Flow primarily stormwater and / or backflow from adjacent ditch (non-contact cooling water)
- Confluence with estuary

- Enhance CSM with temporal framework applied to sediment profile
- Evaluate depositional characteristics
 - Net scour or deposition
 - Sediment deposition rate
- Decipher historical context preserved in sediment record:
 - Natural deposition & scour
 - Modern anthropogenic chemicals
 - Radioisotope deposition
 - Anthropogenic artifacts





- Borings sampled for radiometric analytes
 - Pb-210
 - Cs-137
 - Be-7
- Radiometric results evaluated with constant flux, constant sedimentation model
- Some luck – historical artifacts found in a boring!
- Stratification of anthropogenic chemical markers
- Comparative bathymetry

- Sample section size
- Sample section frequency
- Potentially disturbed locations
- Samples were run wet due to presence of petroleum; running in a wet state impacts the measurement of the concentrations; method not corrected for dry weight
- Presence of water, attenuates the alpha particles resulting in estimated concentrations

- Assumes a uniform deposition rate
 - Does not account for scour or changes in deposition rate
- Assumes uniform lithology
 - Grain size affects radioisotope uptake and distribution
- Limited data resolution can hinder analysis or misalign dates
 - Affected by number of samples analyzed and length of samples

Lead-210

- “Supported” Pb-210 is produced via decay of naturally occurring Radium-226 (^{226}Ra)
 - Time independent
- Young sediments contain “unsupported” Pb-210
 - Produced from atmospheric Radon-222 (^{222}Rn)
 - Pb-210 is not replaced as it decays
- Half life = 22.3 years

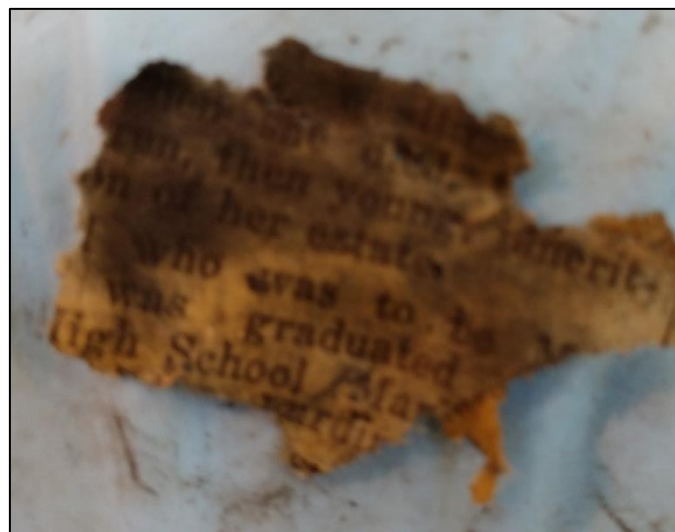
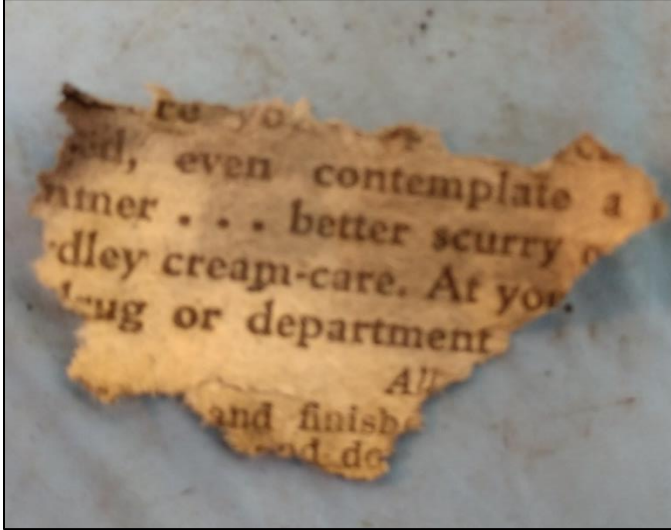
Cesium-137

- Commonly produced in nuclear reactors or atomic bombs
- Large amounts of Cs-137 in atmosphere following World War II
- Absence of Cs-137 is associated with 1954
 - Was not present in measurable quantities prior to this
- Peak concentration is associated with 1963
- Half life = 30.2 years

Beryllium-7

- Cosmogenic radioisotope
- Produced through interactions of cosmic rays with upper atmosphere
- Removed from atmosphere through precipitation
- Half life = 53.3 days

Historical Artifact Find!

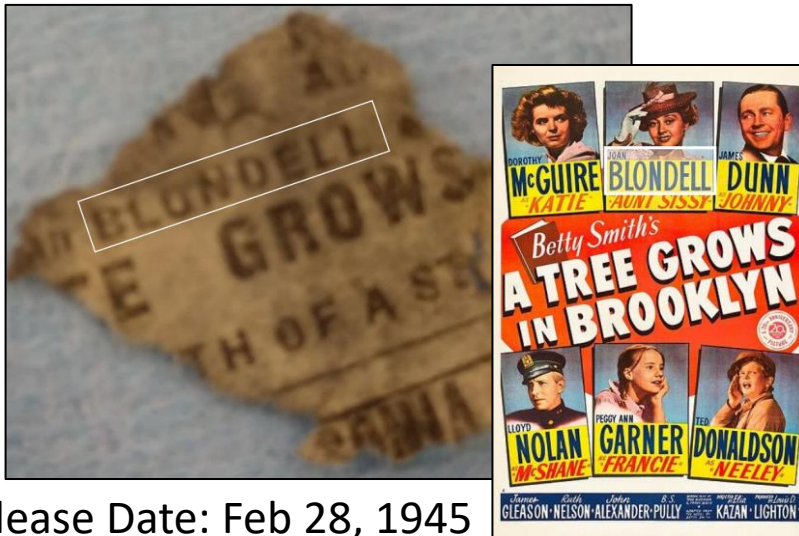


Historical Artifact Find!

1945 Movie Advertisements



Release Date: Sept 14, 1945

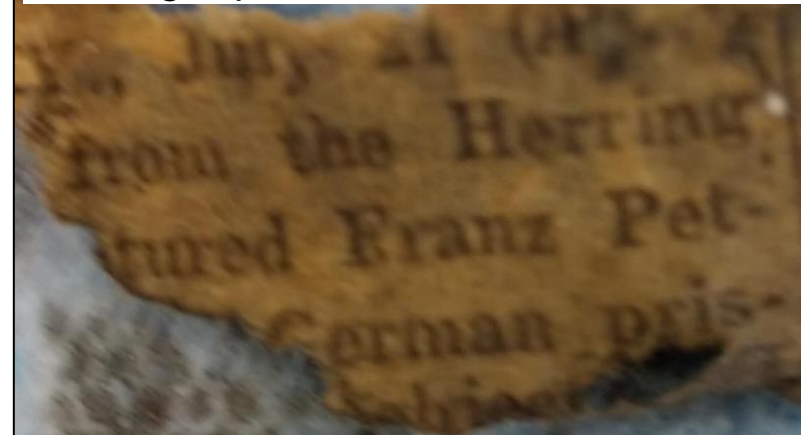


Release Date: Feb 28, 1945



Seven heavy bomber groups and fighter groups –
February, 1945 Dresden bombing

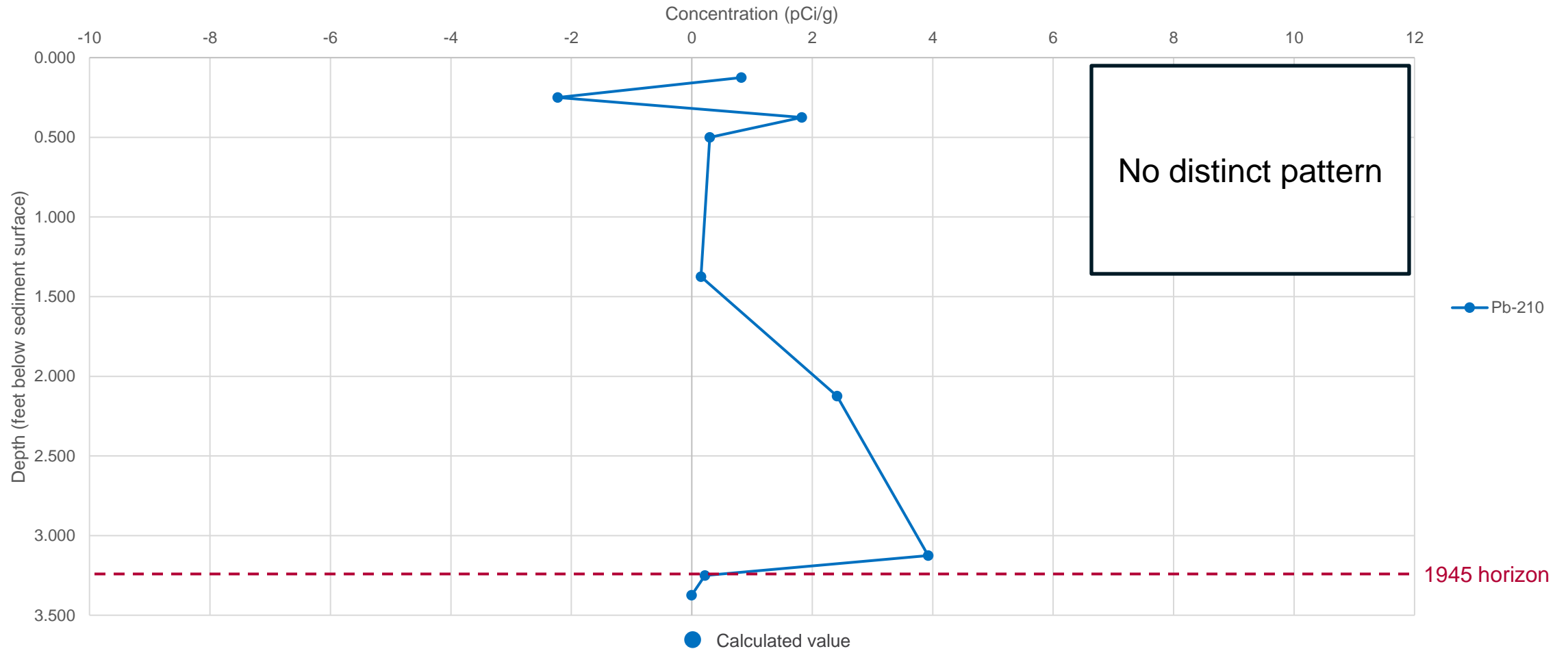
From the Herring...captured Franz Pet-
... German pris-oner – Operation
Herring, April 19-23, 1945

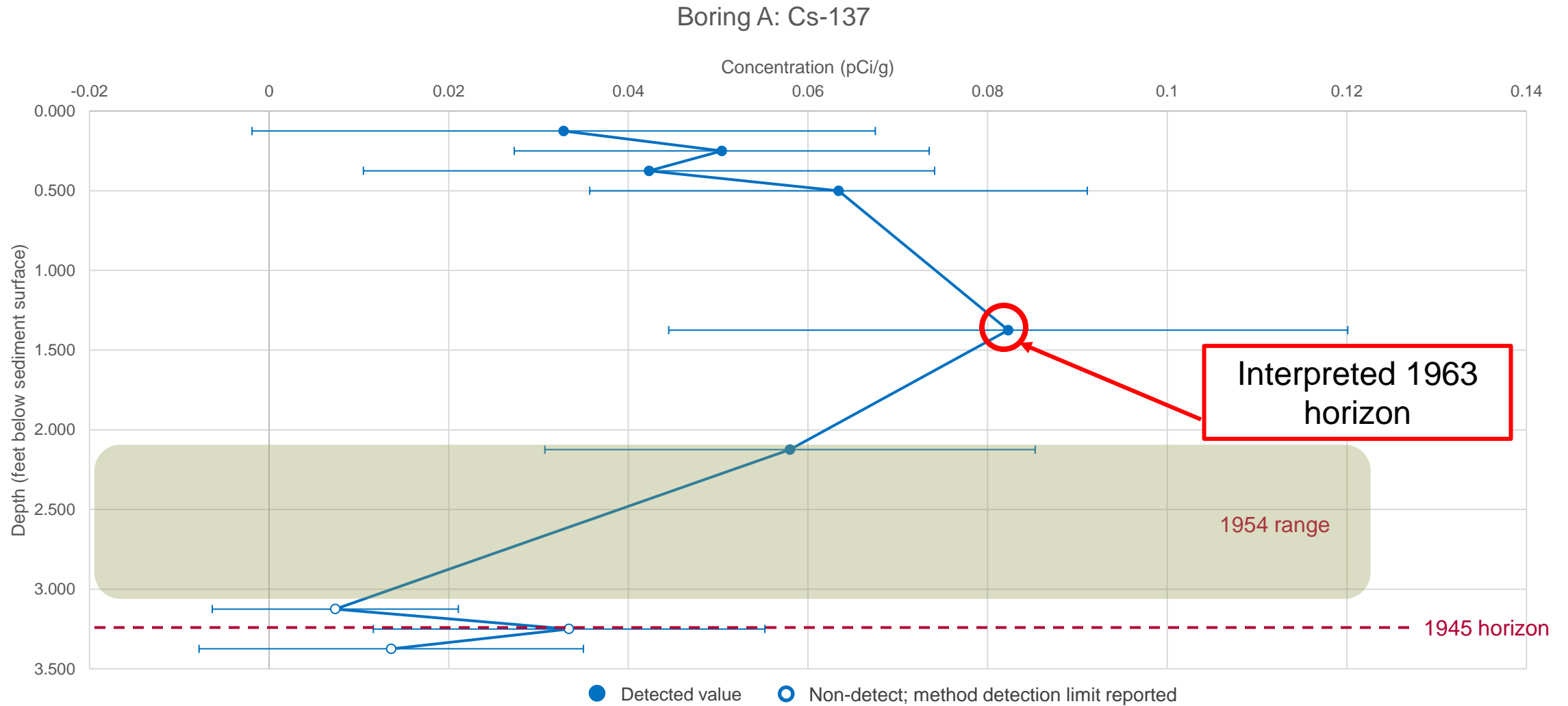


World War II
news articles

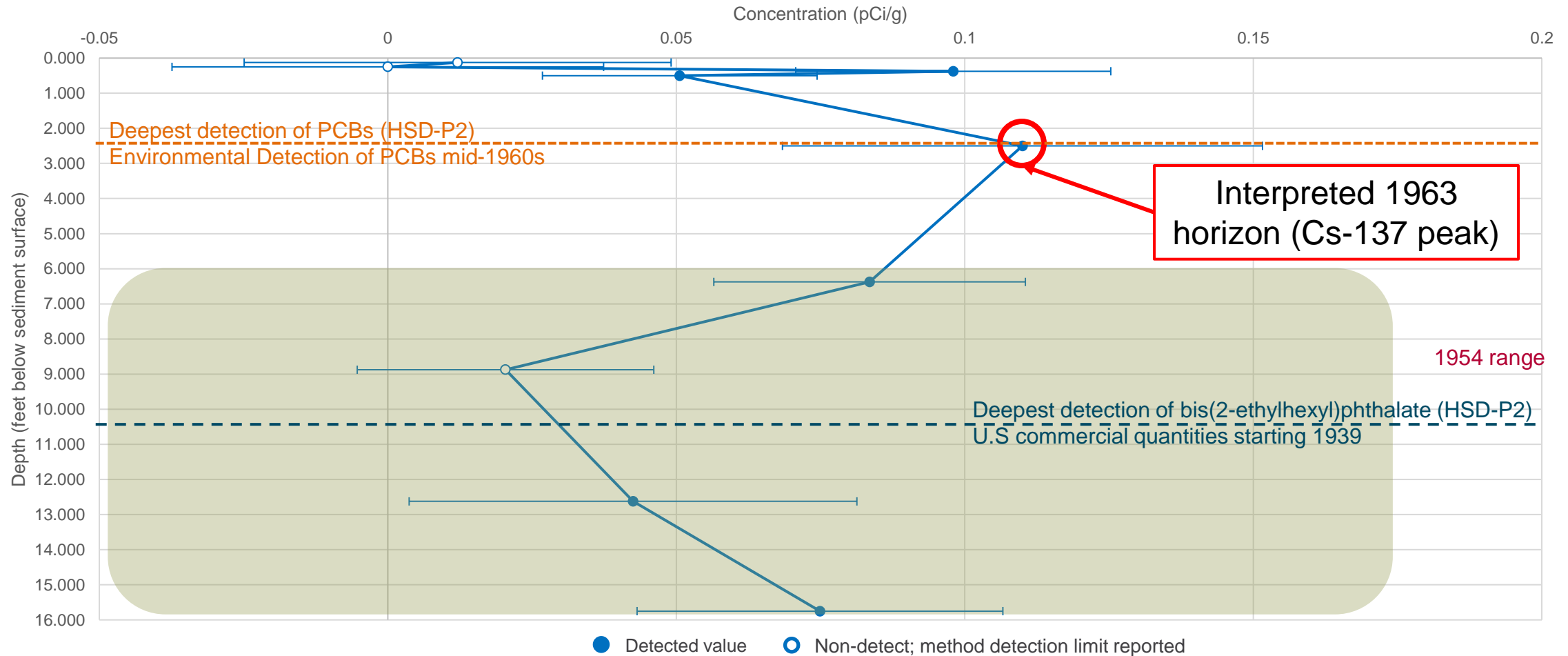
Boring A: Pb-210 (Unsupported)

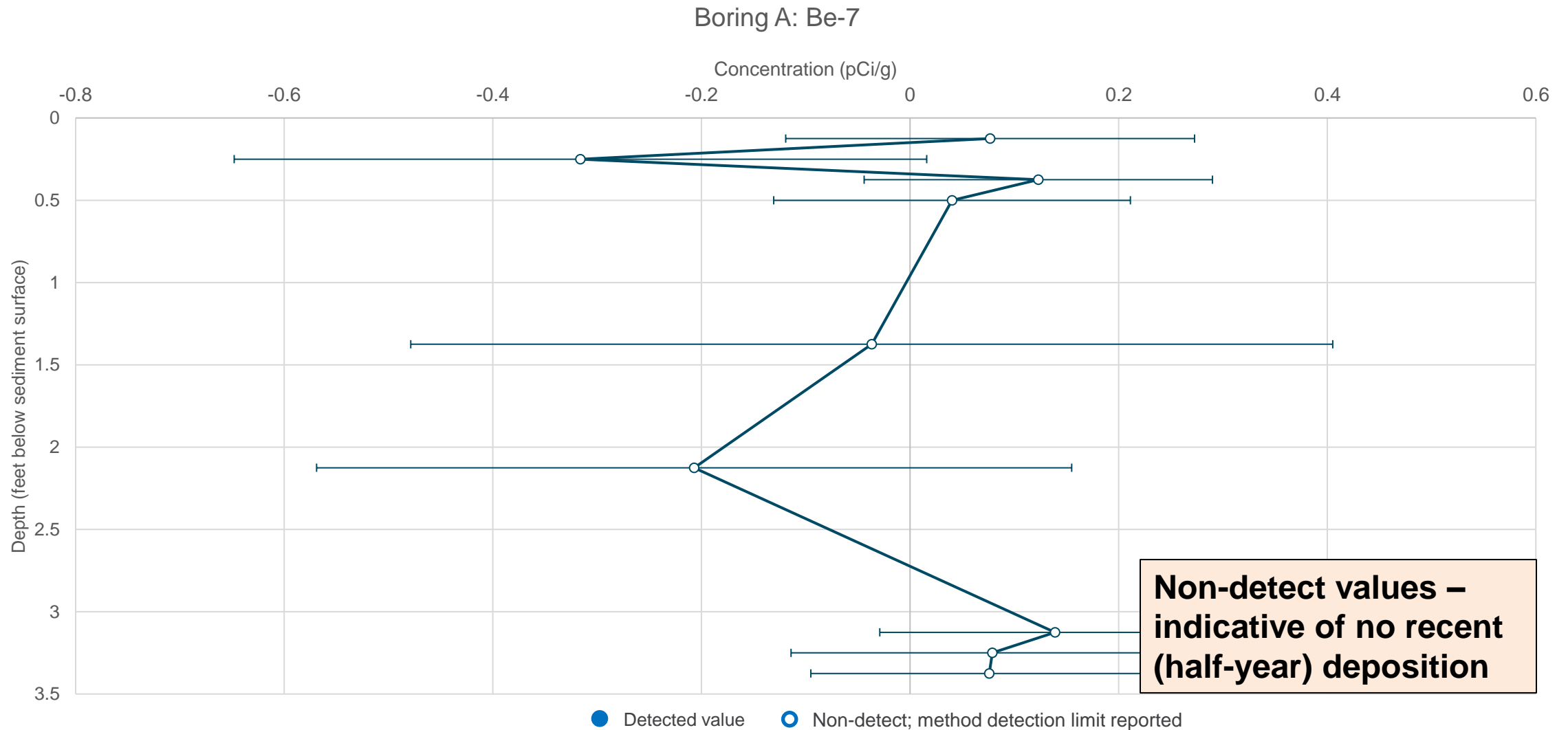
Boring A: Unsupported Pb-210

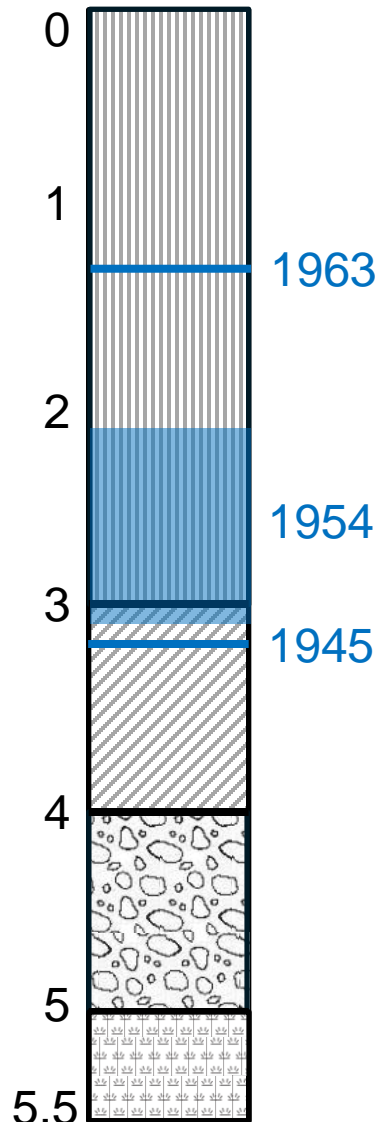




SED-O3: Cs-137







- Assuming a constant sedimentation rate:
 - Using 1945 – 1963 slope: deposition* is ~0.104 ft/yr
 - Using 1945 – 2023 slope: deposition is ~0.042 ft/yr
 - Using 1954 – 2023 slope: deposition ranges from ~0.031 to ~0.045 ft/yr
 - Using 1954 – 1963 slope: deposition ranges from ~0.083 to ~0.194 ft/yr
 - Using 1963 – 2023 slope (1963 peak method): deposition is ~0.023 ft/yr

*minimum estimated deposition rate

Most realistic scenarios

- Comparing Cs-137 concentrations in sediment to long-term atmospheric deposition, depositional environment strength can be evaluated
- Results indicate that deposition and / or scour are occurring at low magnitudes (if occurring at all)

$$\sum_i^n (C_{cs} \times l \times \rho_b)_i$$

Where:

C_{cs} = Cs-137 concentration (pCi/g)

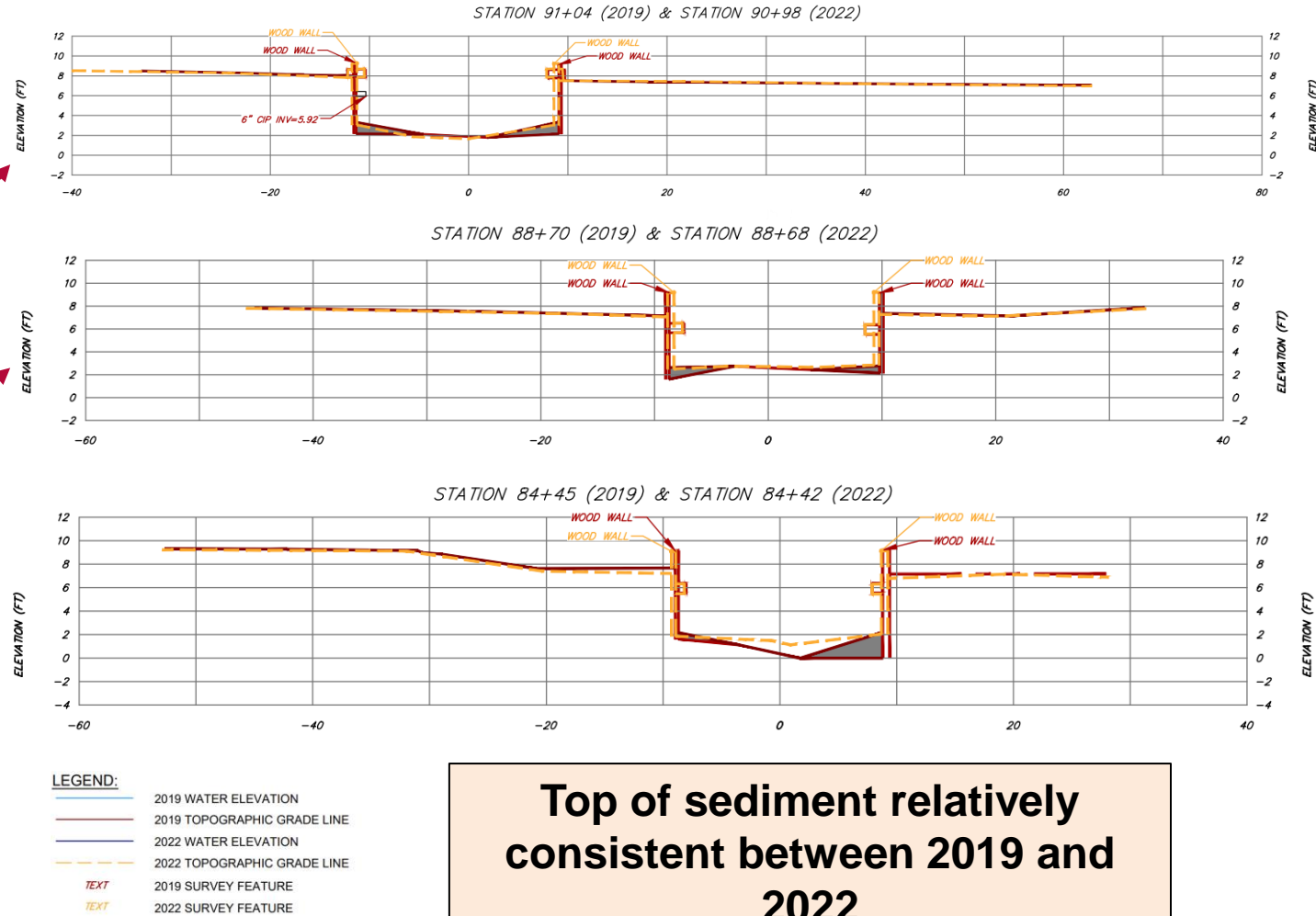
l = length of core segment (cm)

ρ_b = dry bulk density (g/cm³)

Comparative Bathymetry

Investigation
Area – Ditch

Boring A



- Congruent time horizons identified within sediment:
 - Mid 1960s (deepest detection of PCBs)
 - 1963 (Cs-137 peak)
 - 1954 range (Cs-137 detect to non-detect)
 - 1945 (newspaper fragments; non-detect Cs-137)
 - Post 1939 (Deepest detection of bis[2-ethylhexyl]phthalate)
- Cs-137 evaluation indicates weak depositional strength in drainage ditch
 - Supported by comparative bathymetry
- Cs-137 evaluation indicated strong depositional strength near estuary
 - Supported by sediment profile imaging
- Depositional rate estimable
- Results provide temporal framework and historical context to CSM

Thank You!

Emma Applegate eapplegate@kleinfelder.com

Nathan Stevens, PG nstevens@kleinfelder.com

Jeffrey Hale, PG jehale@kleinfelder.com

