Using integrative passive sampling devices to obtain more meaningful and cost effective data on metal-associated impacts from stormwater runoff

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DGT2017
Gold Coast, Australia
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Stormwater Monitoring Challenges

- Grab (and composite) stormwater samples may not be representative of biological impacts to receiving environment
- Total recoverable metal concentrations not biologically meaningful
- Difficulties with composite autosamplers
  - Reliability
  - Costly/labor intensive
- Diffusive Gradients in thin Film (DGT)
  - Time-averaging
  - Relatively inexpensive
  - No major equipment set up
  - Lower likelihood for sample contamination
- US Navy NESDI Program
  - Demonstration and validation of advanced technologies

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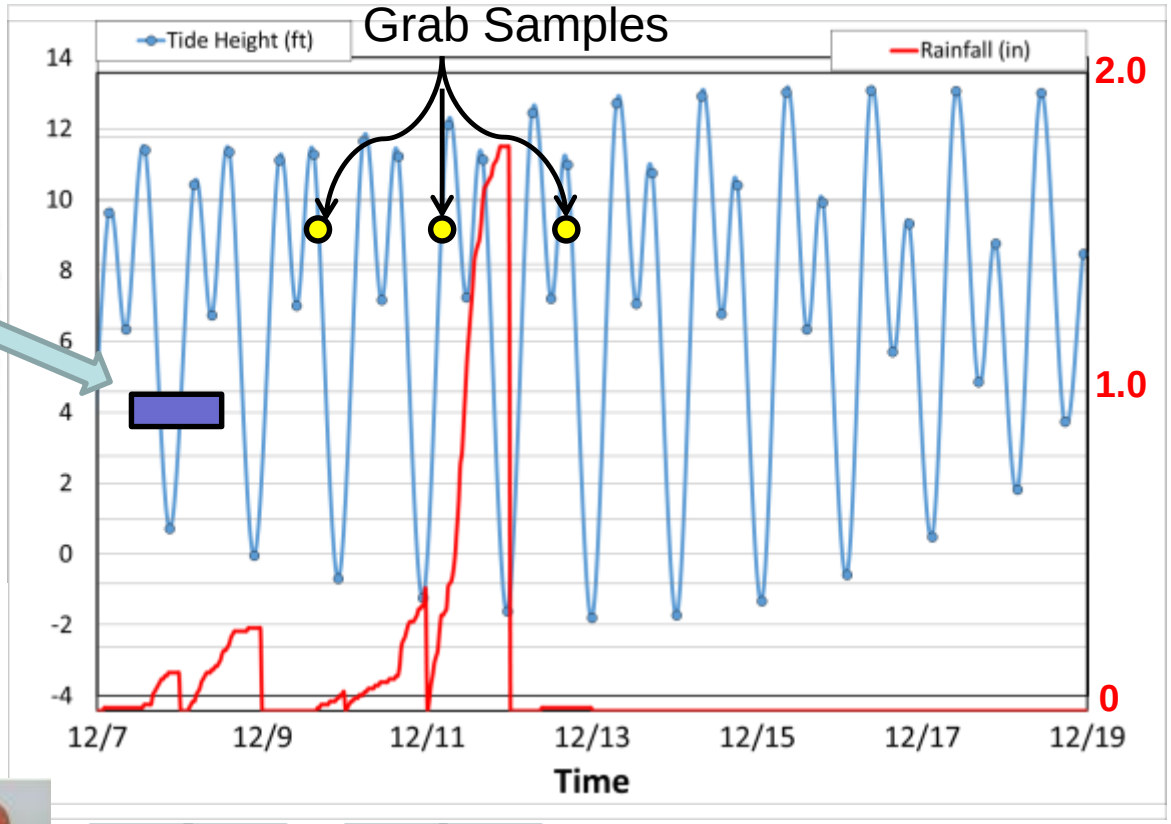
Objectives

1. Integrate passive sampling (e.g. DGT) into existing stormwater monitoring programs to improve data collection, evaluation of stormwater impacts, and management effectiveness
2. Validate the use of passive sampling devices to capture pulse inputs from stormwater runoff and better identify sources
3. Optimize stormwater sampling designs to obtain better information with lower costs
4. Gain regulatory and public acceptance of technical approach

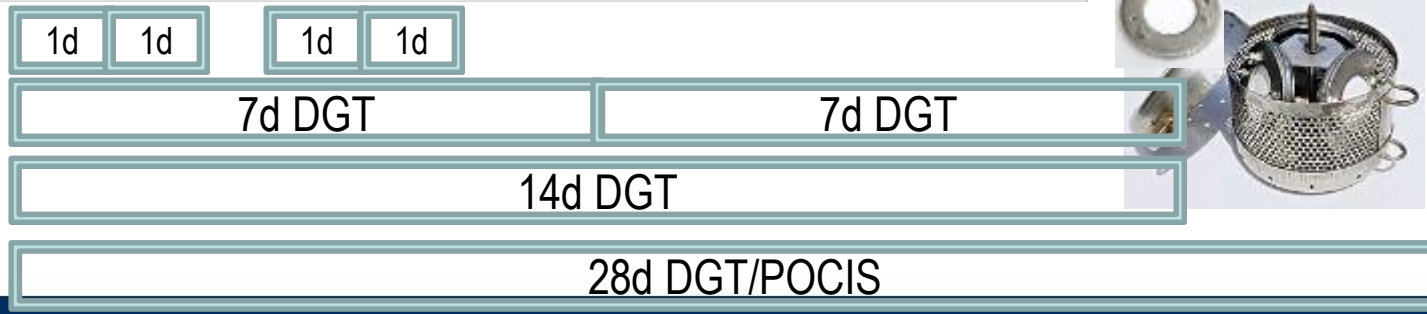
Why Passive Sampling?
Need to sample the pulse (more representative)

Autosampler Composite Sample



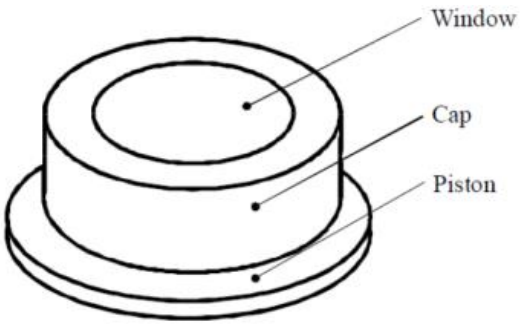
Passive Samplers Diffusive Gradient in Thin-films (**DGT**) for Metals

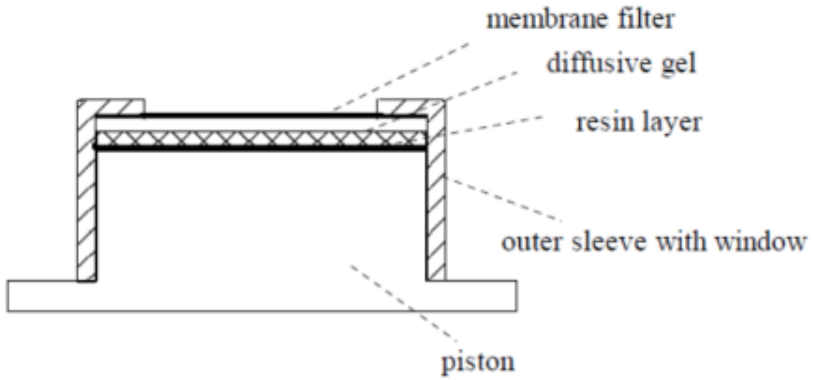
Polar Organic Chemical Integrative Sampler (**POCIS**)



Methods

- Samplers from DGT® Research (C-LSNM)
- Chelex 100 binding layer (0.40 mm)
- 0.78 mm APA diffusive gel
- Polyethersulphone membrane (0.14 mm)
- Window size 3.14 cm^2
- Digestions of binding layer with nitric acid
- Analysis by ICP/MS
- Exposures from 1.5 hours to 30 days
- Freshwater and Saltwater





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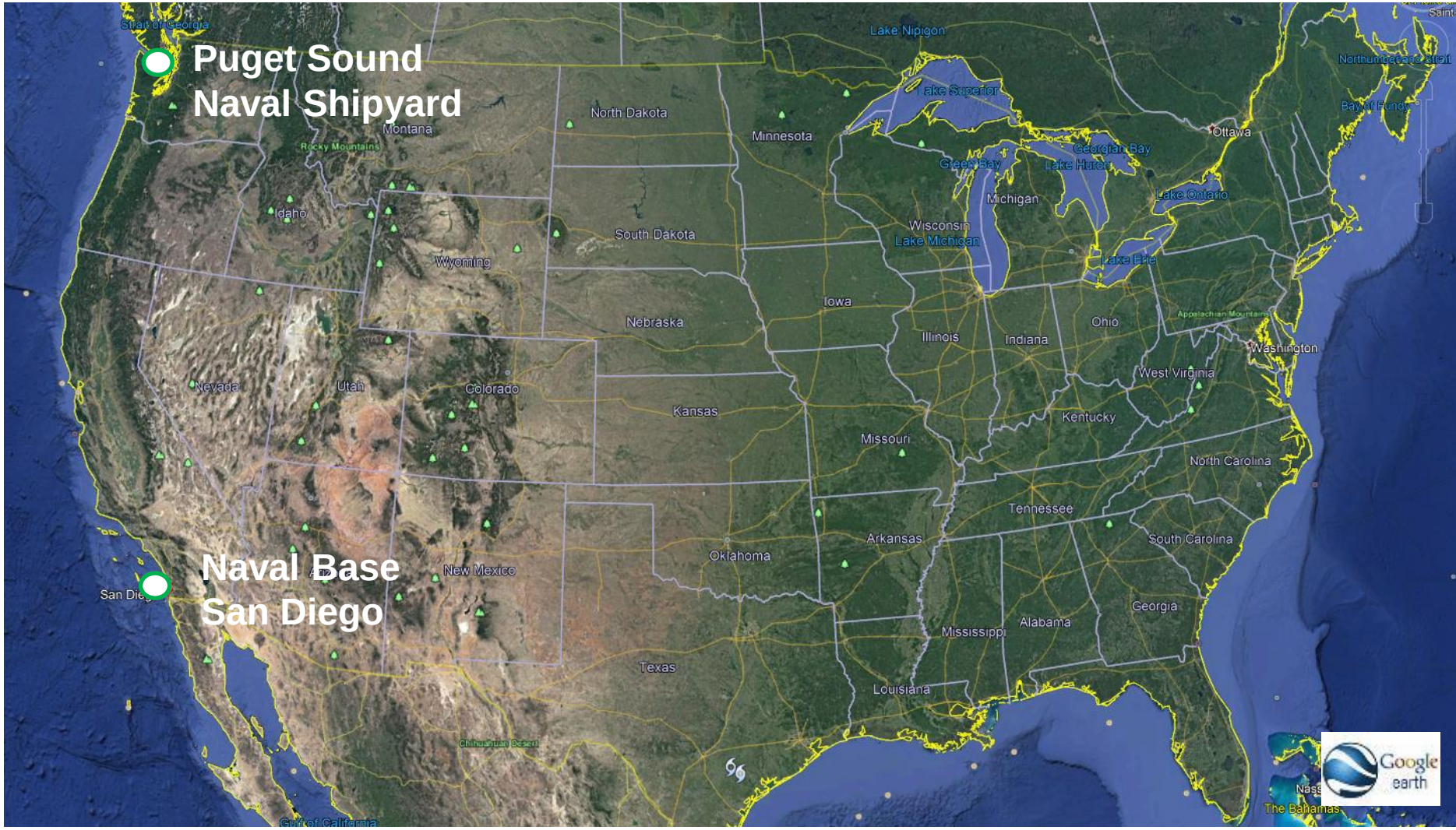
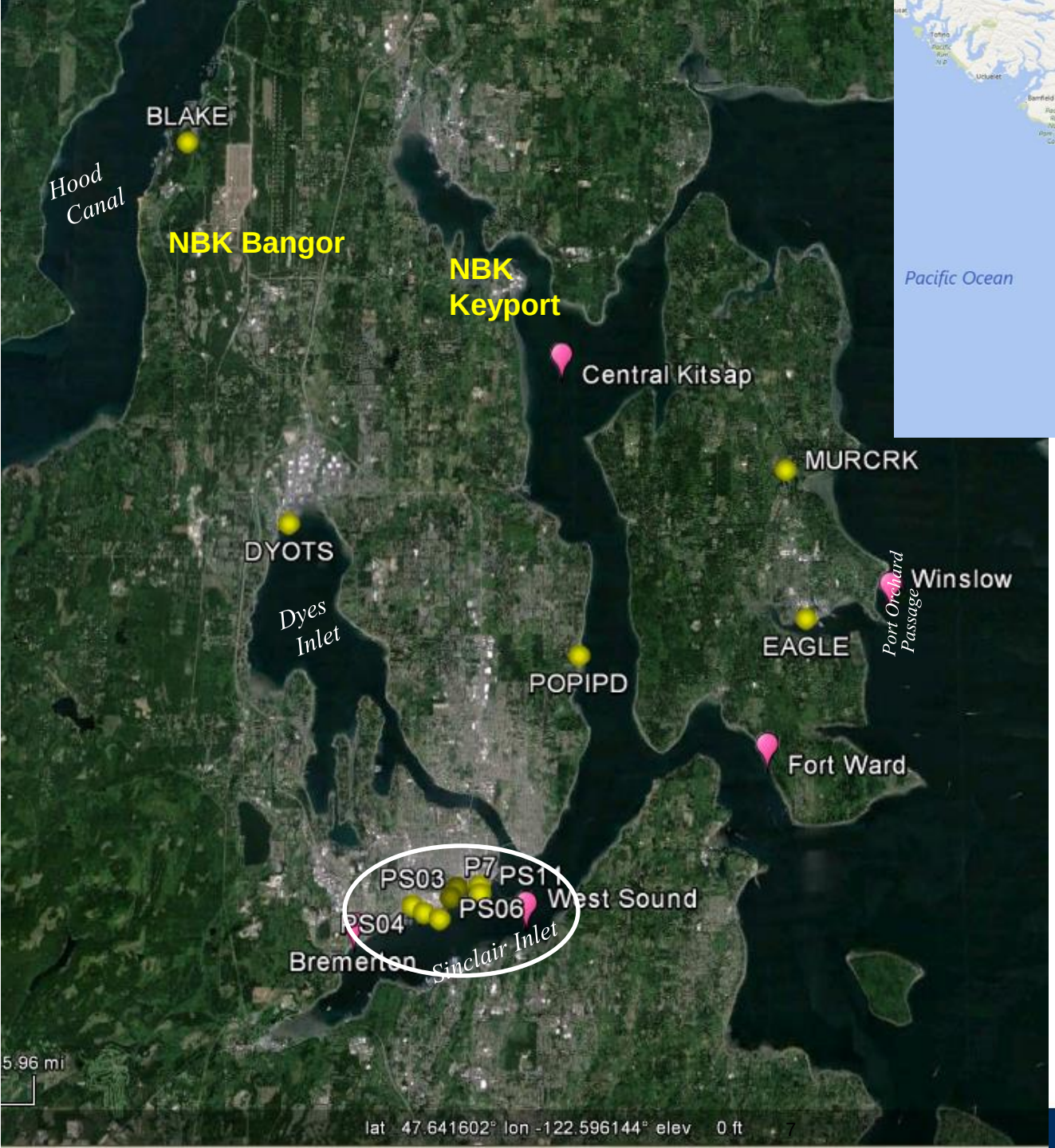
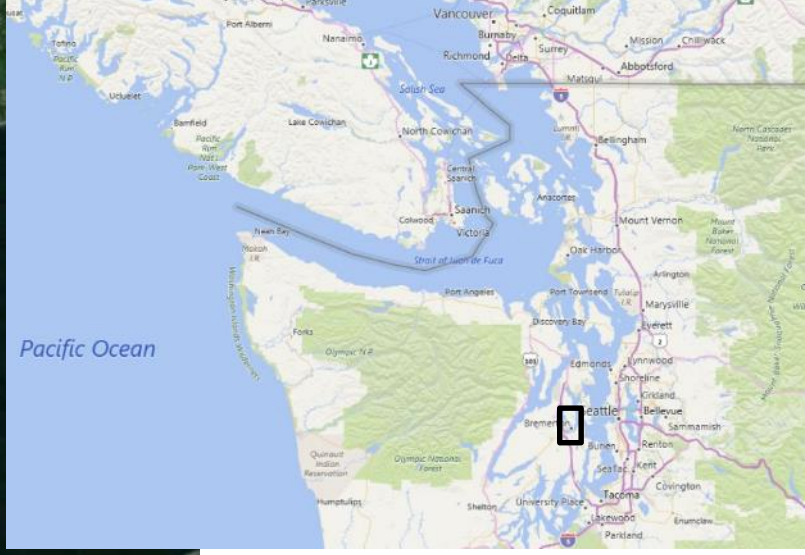
Test Sites







Puget Sound Ambient Monitoring

- Station Location
- WWTP Outfall

Polar Organic Chemical Integrative Sampler (POCIS)

Sampling Locations (POCIS + DGT)
Within PSNS&IMF and NBK-Bremerton

Diffusive Gradient in Thin film (DGT) Metals

Samplers will be tied to floating dock/barges (as shown) so that they are submerged about 1-2 ft below surface. One POCIS and one DGT sampler will be deployed at each location. Samplers should remain submerged at all times.

PS11
Bresting Barge at NW end of Pier 7

PS08
Diver's Barge near DD5

PS09
Bresting barge along YRBM31

PS16
Bresting barge at SW end of Pier 7

PS04
Barge at SW end of Pier C

PS03
Small boat dock W of Pier D

PS06
Floating Dock on N side of Pier 9

Sinclair Inlet

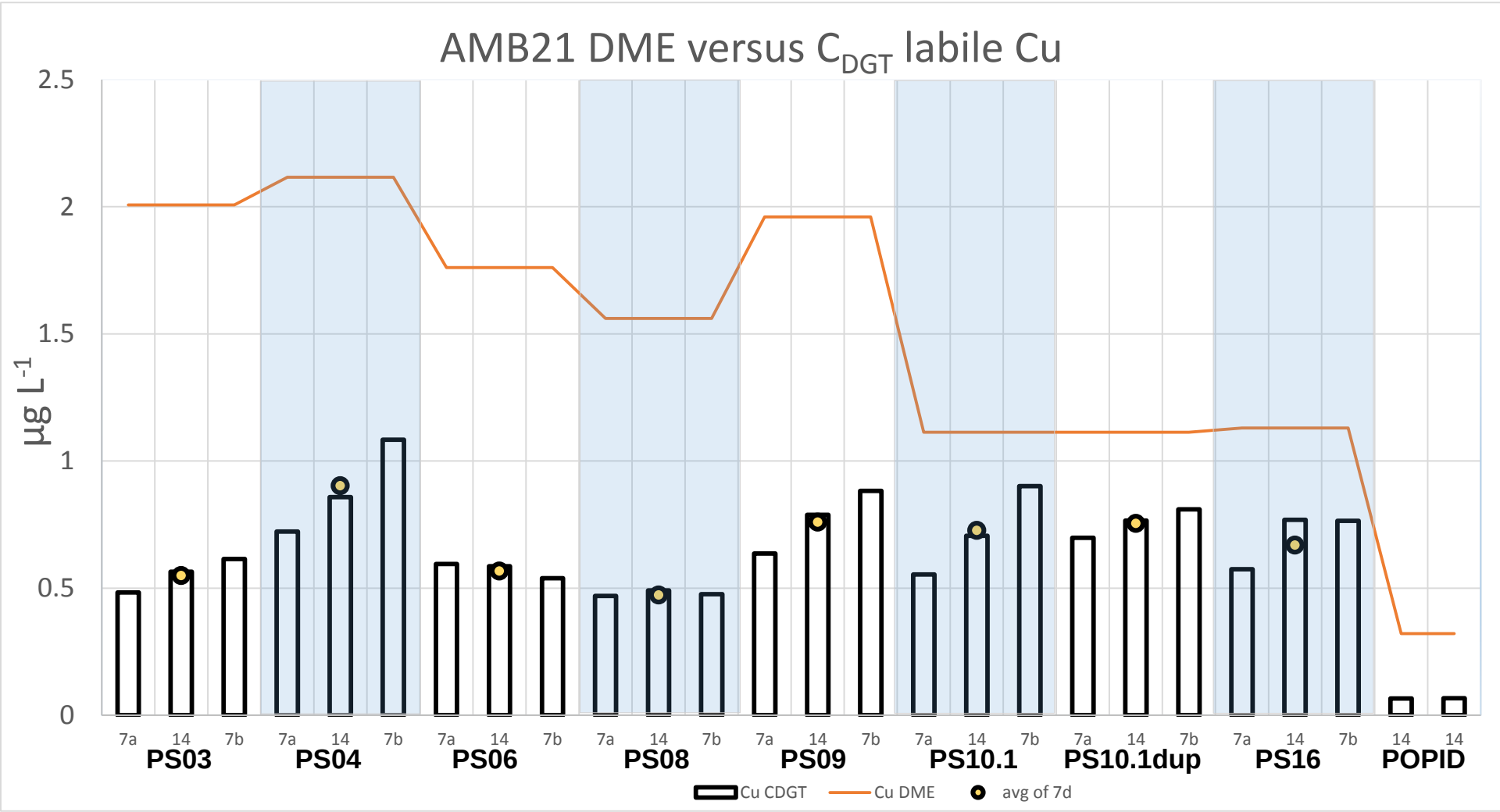
Figure 1-7
Location of NPDES Stormwater and Discharge Outfalls

CLEAN

Ambient Monitoring in Sinclair Inlet March 2016

- DGTs incorporated into ongoing ambient nearshore and marine monitoring
- Two 7-day DGTs overlapping with one 14-day DGT
  - Enclosed in plastic basket
  - Rocks used to weight basket to 1 m depth

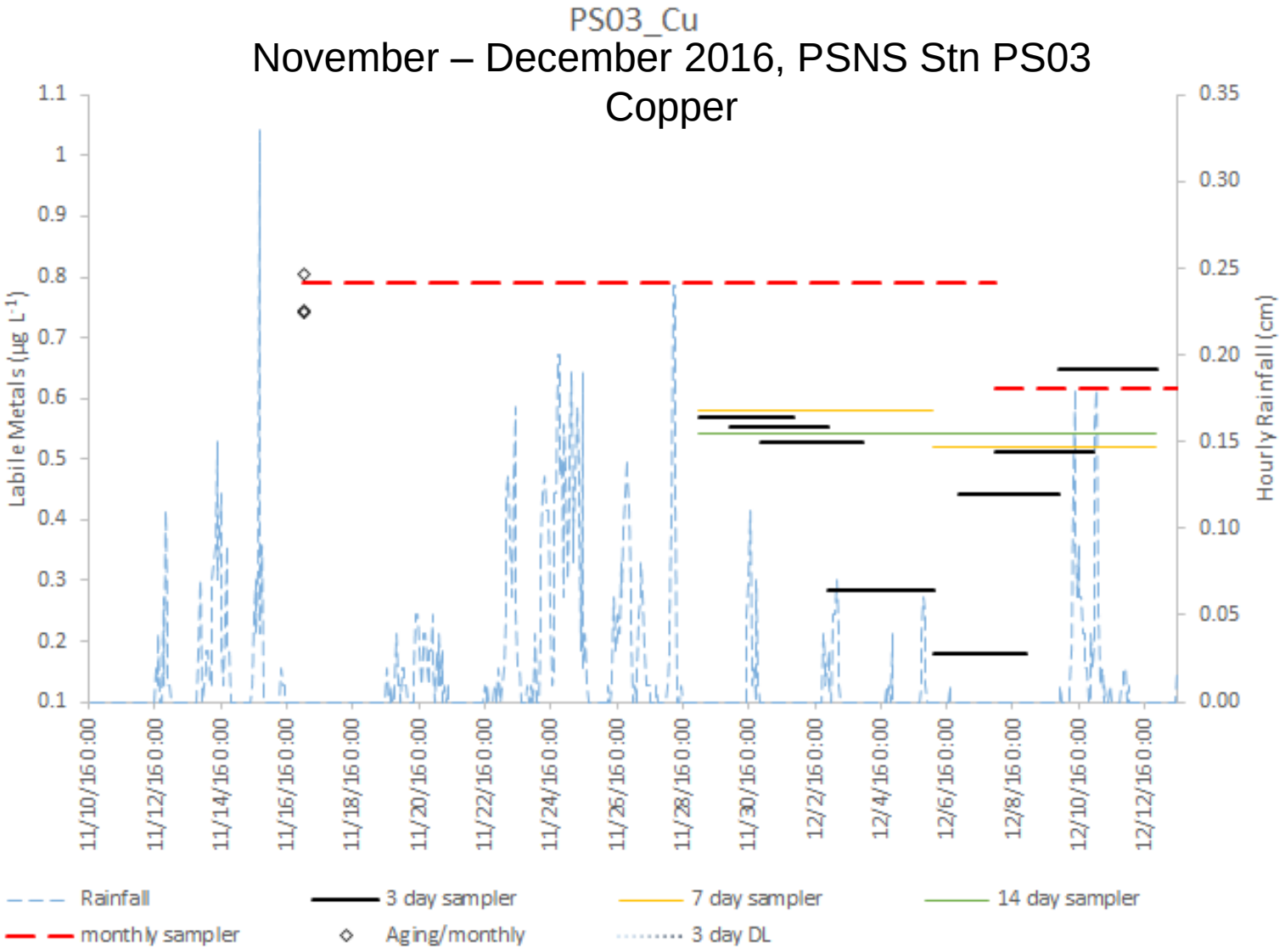
Ambient Monitoring in Sinclair Inlet – Copper March 2016



Ambient Monitoring in Sinclair Inlet November – December 2016

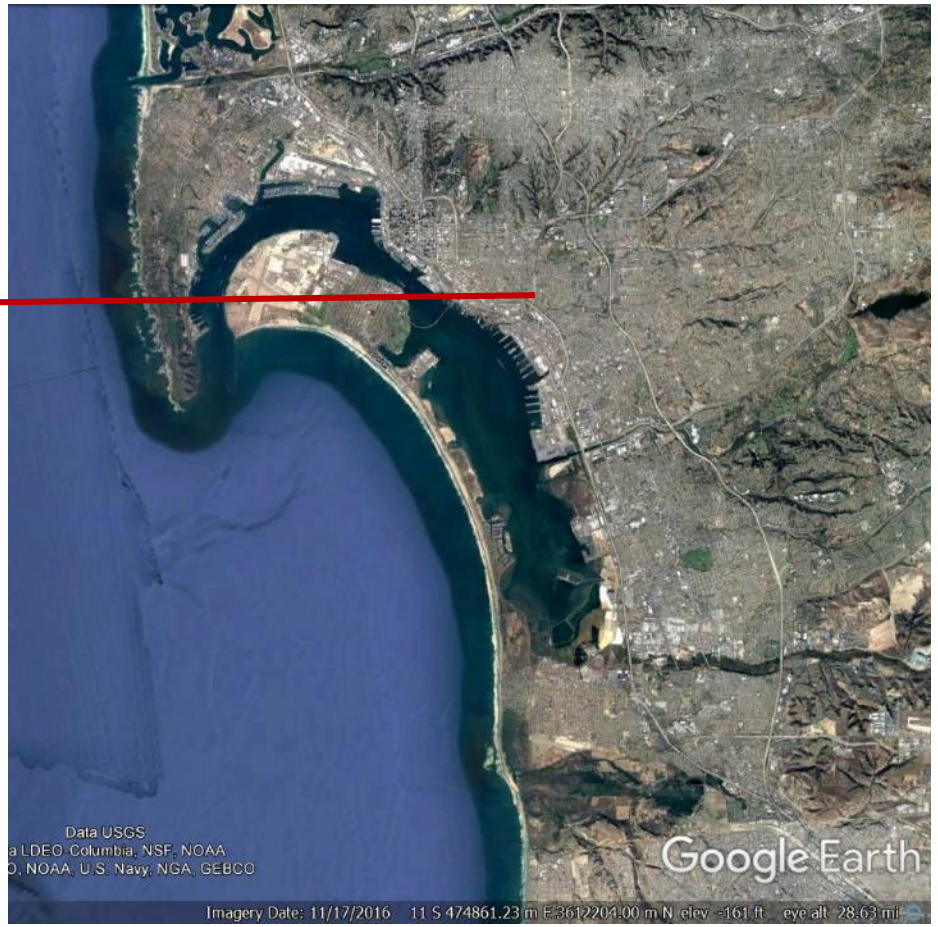
- Two 7-day DGTs overlapping with one 14-day DGT
- 3-d DGTs deployed 4 times per week for two weeks
- 1-month DGTs (coinciding with 1-month POCIS deloyments)
- Same deployment methods and stations

Ambient Monitoring in Sinclair Inlet – December 2016



Stormwater Monitoring at End of Pipe

Naval Base San Diego



Stormwater Monitoring at End of Pipe

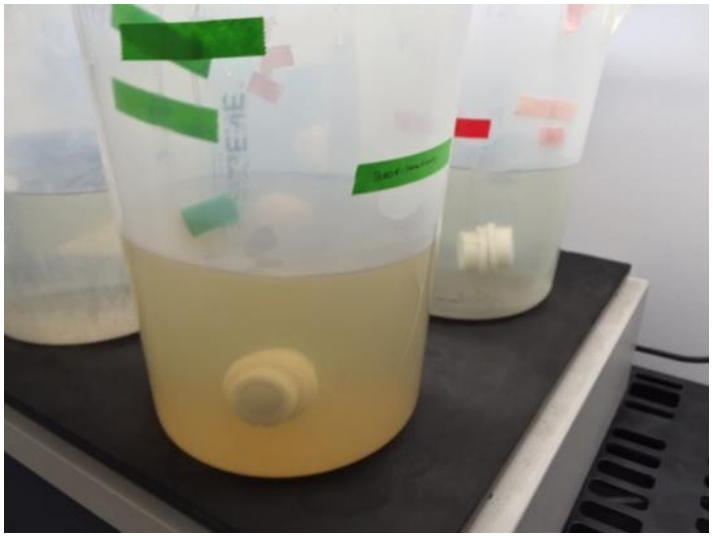
Monitoring with DGTs for Best Management Practice (BMP) effectiveness

- Permeable paver and biofiltration BMPs
- DGT deployment coordinated with autosampling at site
- ***Are DGTs able to provide useful data over short pulsed events?***

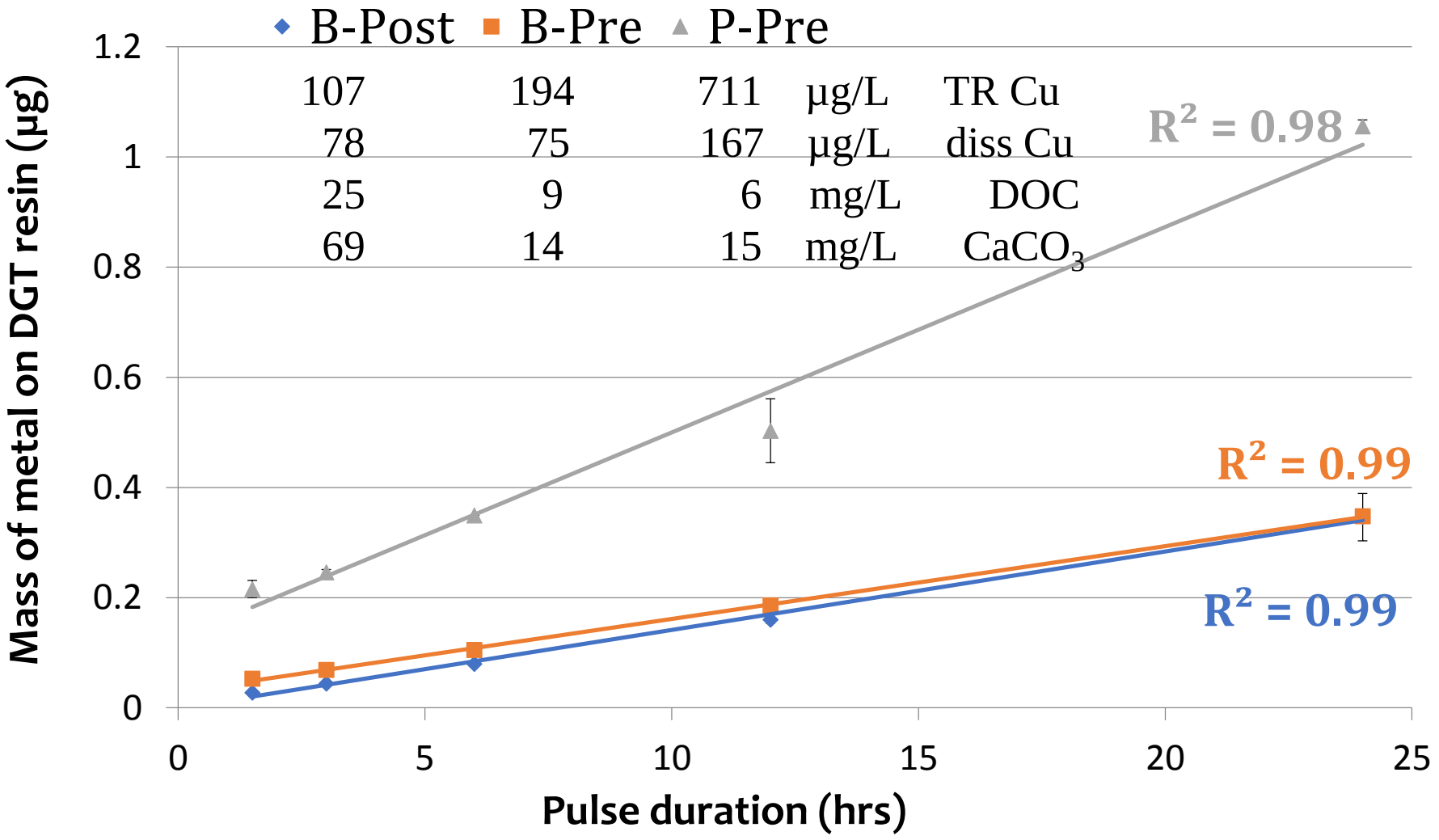
Storm Event	DGT Evaluation	Storm size (in.)	Flow duration (h)
Nov 26, 2016	Lab only	0.32	21.2
Dec 16, 2016	Lab only	0.89	13.7
Jan 18, 2017	Lab + Field	0.90	9.9
Feb 17, 2017	Lab + Field	1.22	10.0

Laboratory Evaluation of Short Exposure Times

- Stormwater samples collected from 24 hr composite
- Samples suspended in solution for multiple time points:
  - 1.5, 3, 6, 12, and 24 hours
  - Duplicates
  - Moderate mixing (67 RPM)

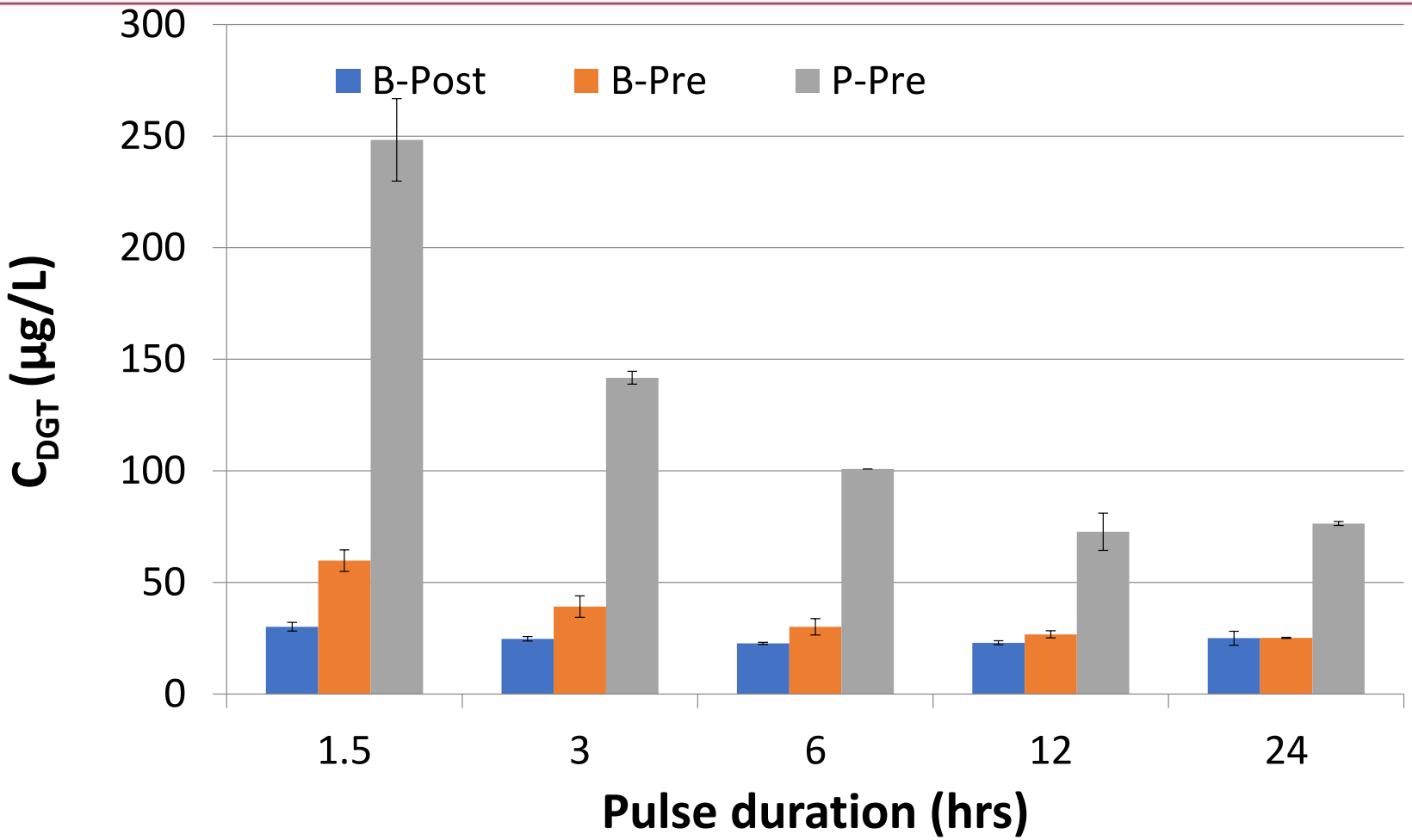


Laboratory Evaluation of Short Exposure Times Copper



Laboratory Evaluation of Short Exposure Times

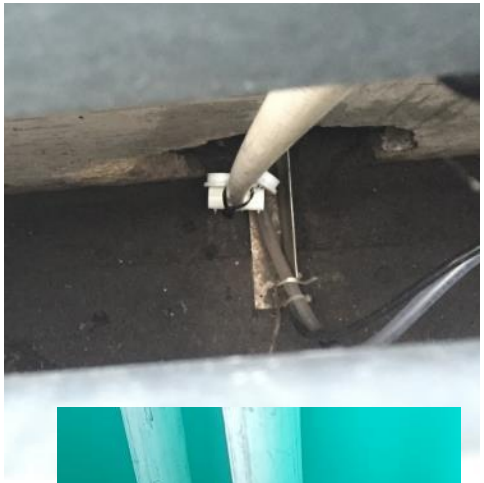
Copper – exposure period is same as pulse duration



- Relatively low ionic strength of stormwater and/or insufficient washing of APA gel can result in erratic uptake (Warnken et al. 2005; Davison and Zhang 2012)

Field Deployment in Stormwater Conveyance Systems

- DGTs placed just above vault floor in triplicate
- Plastic coated HOBO level logger to monitor water depth
- Samplers deployed for whole storm, or used in time series to monitor labile metals over course of storm



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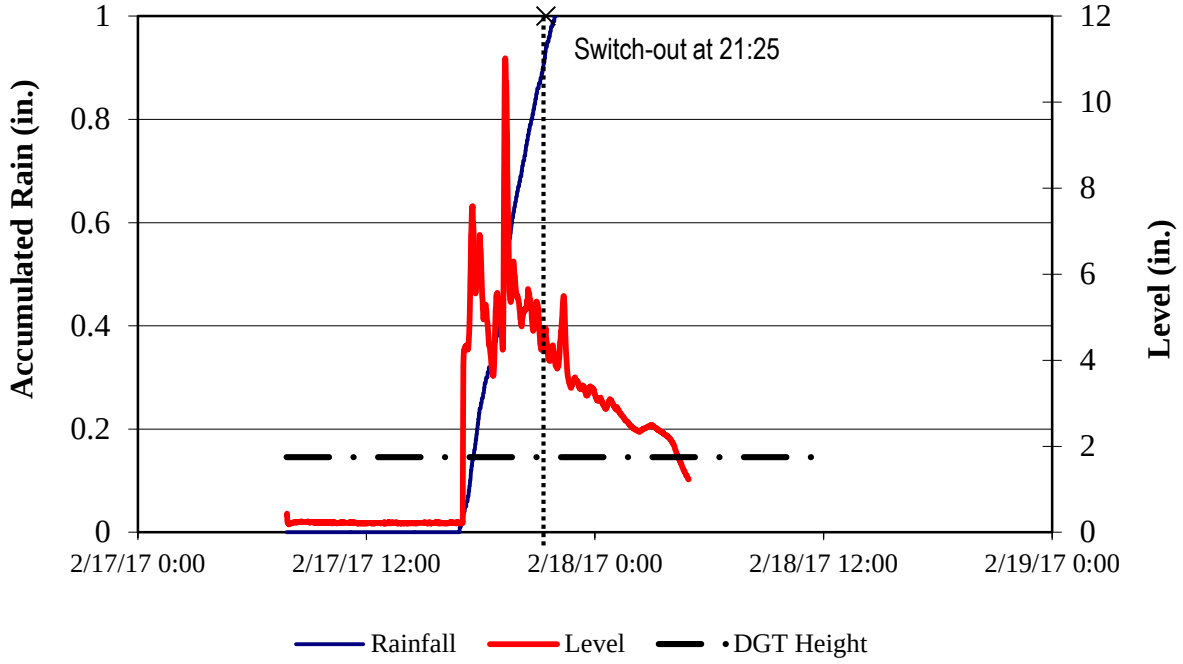
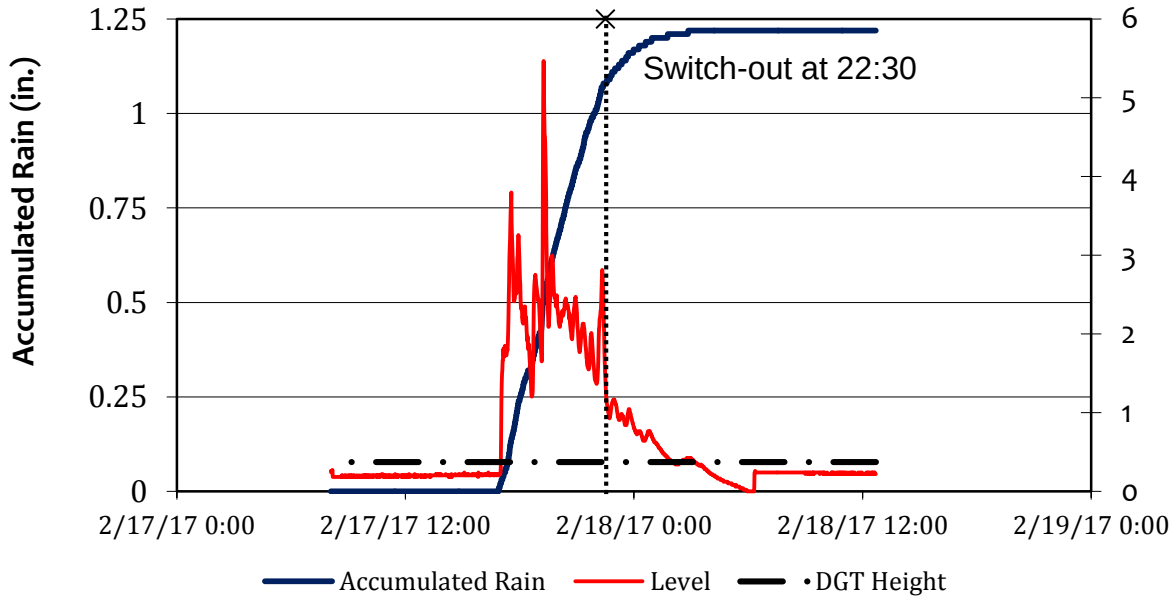
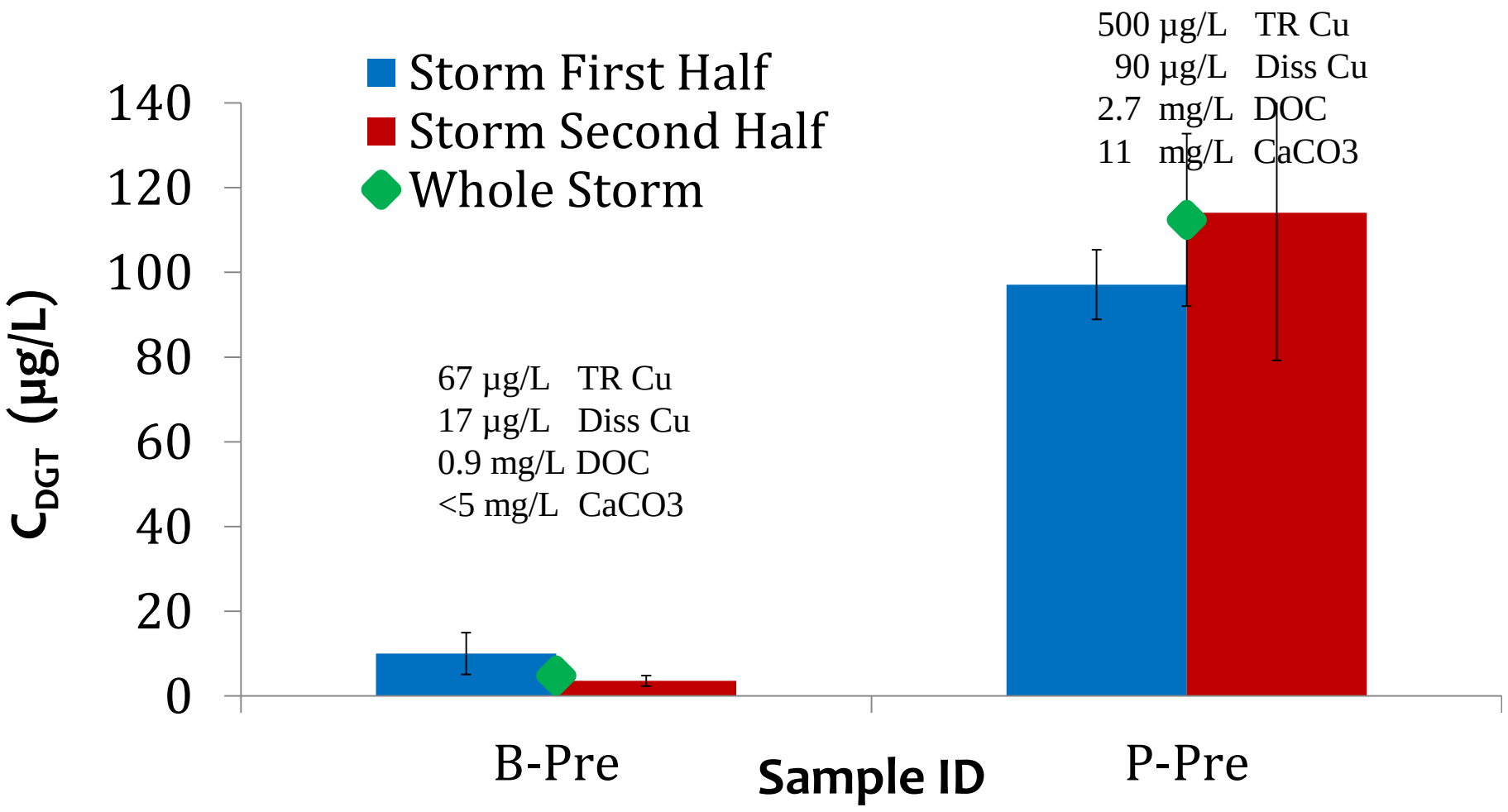
NBSD Biofiltration Reference: Feb. 17, 2017



NBSD Pavers Reference: Feb. 17, 2017



Field Deployment in Stormwater Conveyance Systems - Copper



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Conclusions and Future Directions

- Highly sensitive, reproducible results that support trace level changes in metal availability over time in a marine estuary
- End of pipe sampling promising, but needs additional work to address possible issues associated with…
  - Low ionic strength samples
  - Potential impacts associated with dynamic systems (pulsed exposures, little time for equilibration of metal)
  - Comparison with dissolved or total recoverable concentrations inappropriate.
- Regulatory acceptance
  - Provide supplemental data to reduce costly traditional monitoring
  - Connect C_{DGT} to predictors of toxicity (e.g. BLM)
  - Develop DOC (saltwater) or DOC and hardness (freshwater) relationships for C_{DGT}

Acknowledgements

- U.S. Navy's Environmental Sustainability Development to Integration (NESDI) Program
  - Project #523, "Integrated Diagnostic Stormwater Monitoring with Passive Sampling"
  - https://epl.navfac.navy.mil/NESDI/Access/ProjectFactSheet.aspx?ProjID=523
- Puget Sound Naval Shipyard (Project ENVironmental InvestVESTment; ENVVEST)
- POC: Gunther Rosen (rosen@spawar.navy.mil)