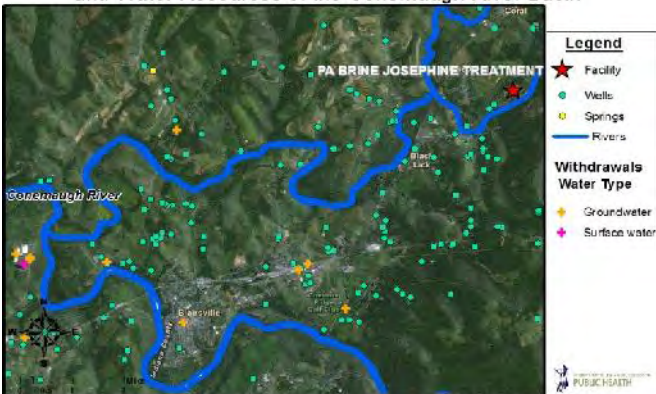


Hart Resources PA Brine Josephine Treatment Facility and Water Resources of the Conemaugh River Basin



Data released from the PA DEP or the University of Pittsburgh Graduate School of Public Health. © 2011 University of Pittsburgh.

Contaminant Characterization of Effluent from Pennsylvania Brine Treatment Inc., Josephine Facility:

Implications for Disposal of Oil and Gas Flowback Fluids from Brine Treatment Plants

EPA Hydraulic Fracturing Study Technical Workshop 3,
 Fate and Transport
 March 28-29, 2011, EPA Potomac Yards Conference
 Facility

Conrad D. Volz, DrPH, MPH, Kyle Ferrar, MPH, Drew Michanowicz, MPH, CPH, Charles Christen, DrPH, MEd, Shannon Kearney, MPH, CPH, Matt Kelso, BS and Samantha Malone, MPH, CPH
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 Center for Healthy Environments and Communities



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<http://www.chec.pitt.edu>
cdv5@pitt.edu

<http://www.fractracker.org>

Facilities Accepting Natural Gas Solid Wastes and Waste Water Conemaugh River Basin



Legend

- ★ Facility
- Rivers



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Data obtained from the PADEP at:
https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/DataExports/ExportWasteData.aspx?PERIOD_ID=2010-2

Pennsylvania Brine Treatment, Josephine Facility Offloading



[Picture taken by Kyle Ferrar, December 1, 2010, at location (40.826°N, 79.172°W)]

Concentrations of Selected Important Contaminants from Marcellus Shale Flowback Water

Total Dissolved Solids (TDS): 161,636 mg/L*

Barium: 2,950 mg/L*

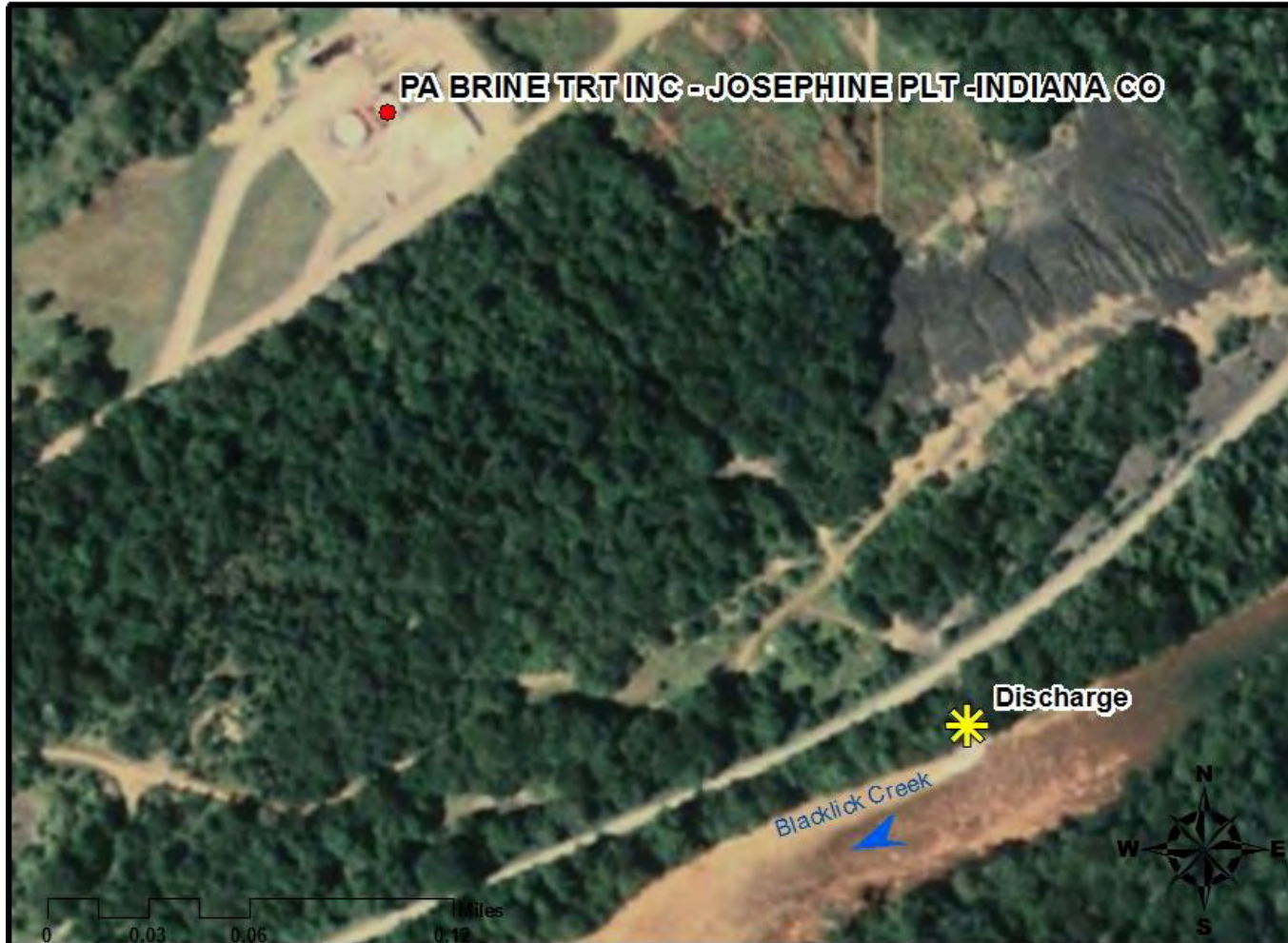
Strontium: 3,280 mg/L*

Chloride: 95,400 mg/L*

* From Blauch, MF et al, 2009, Marcellus Shale Post-Frac Flowback Water-Where is all the Salt Coming From, SPE 125740.



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Legend

- Facility

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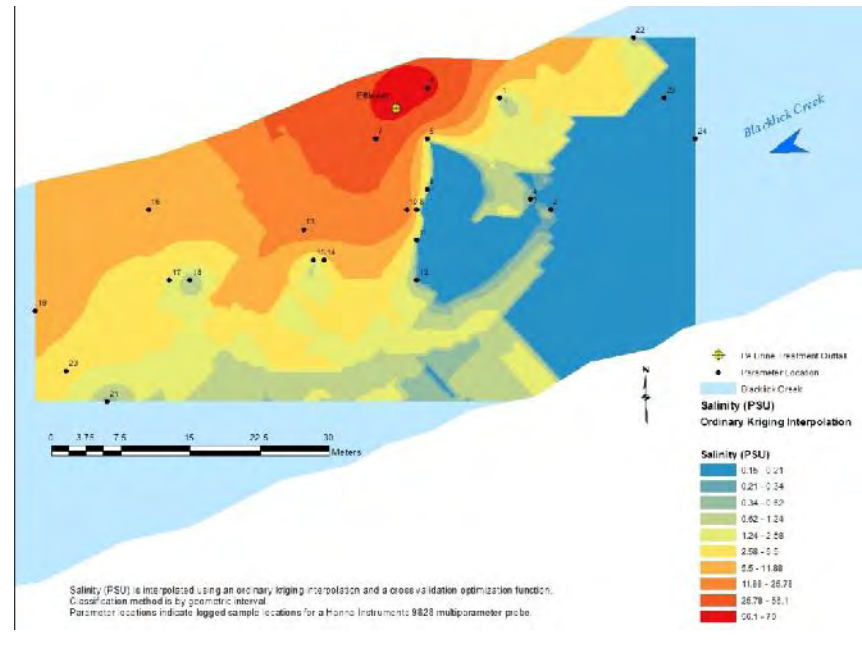
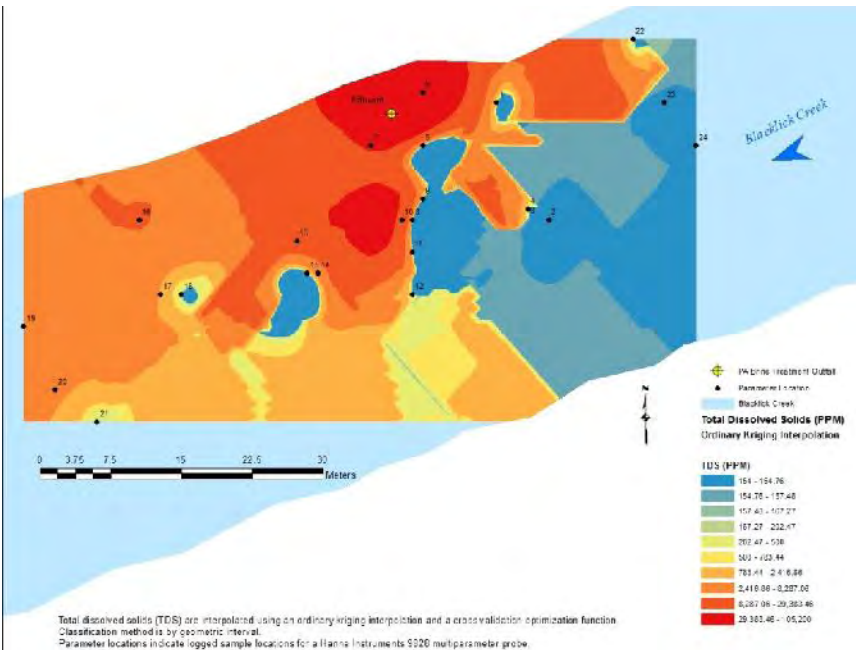
Volz, et al., 2011

<http://www.fractracker.org>



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PBT-Josephine Facility Outfall on Blacklick Creek and Kriging Interpolation of Instream TDS and Salinity



Contaminants of environmental public health importance that were detected in all samples taken over the 24 hour period

Contaminants over MCL's, MRL's, consumption of fish criteria and/or aquatic CMC CCC concentrations;

- barium (Ba) [mean, 27.3 ppm; maximum, 37.0 ppm]
- bromides (Br) [mean, 1068.8 ppm; maximum, 1100.0 ppm]
- strontium (Sr) [mean, 2983.1 ppm, maximum 3120.0 ppm]
- benzene [mean 0.012 ppm; maximum 0.013 ppm]
- 2 butoxyethanol (2-BE) [mean 59ppm; maximum 66 ppm]

Detected Contaminants

- ethylbenzene (mean, 0.002 ppm)
- toluene (mean, 0.025 ppm)
- xylenes (mean, 0.028 ppm)



Contaminant concentrations of ecological and secondary drinking water importance include:

- chlorides (Cl) [mean 117,625 ppm, maximum 125,000 ppm]
- magnesium (Mg) [mean 1247.5 ppm; maximum 1300.0 ppm]
- manganese (Mn) [mean 0.08 mg/L; maximum 0.15]
- total dissolved solids (TDS) [mean 186,625 ppm; maximum 190,000 ppm]
- sulfate (SO₄) [mean 560 ppm; maximum 585 ppm], and pH [mean 9.58 units; maximum 10 units].



Barium in PBT-Josephine Facility Effluent

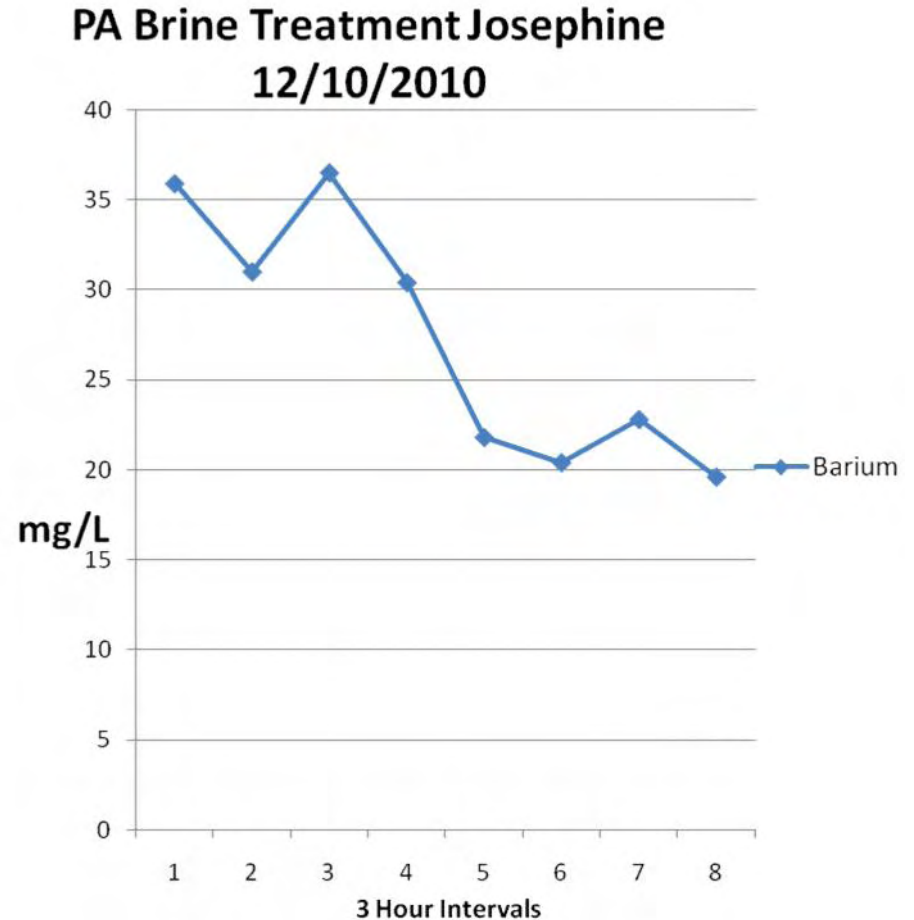
[Ba Mean] = 27.30 mg/L; σ = 6.96 [Min.] = 20 mg/L; [Max.] = 37 mg/L; MDL; 0.002 mg/L

- [Mean Ba] \approx 14 x (MCL) of Ba in drinking water of 2 ppm.

- The Ba ATSDR MRL's oral intermediate/chronic exposure are .2 mg/kg/day. Derived MRLs for barium in drinking are 6.89, 5.77, and 3.04 (mg/L/day) for adult men, adult women, and children, respectively (renal). [Mean Ba] is 3.96, 4.73, and 8.98 X the derived drinking water MRL's for intermediate and chronic exposures for adult men, women, and children, respectively.

- The Ba consumption concentration of "water and organism" and "organism alone" is 1 ppm. The [Ba Mean] is over 27 times these criteria.

- EPA Ba CMC of 21 ppm exceeded; EPA CCC Ba is 4.1 ppm, 6.66X [Mean Ba].



Volz, C.D. et al., 2011 <http://www.fractracker.org>



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Strontium in PBI-Josephine Facility Effluent

[Mean Sr]= 2981 mg/L; σ = 82.71

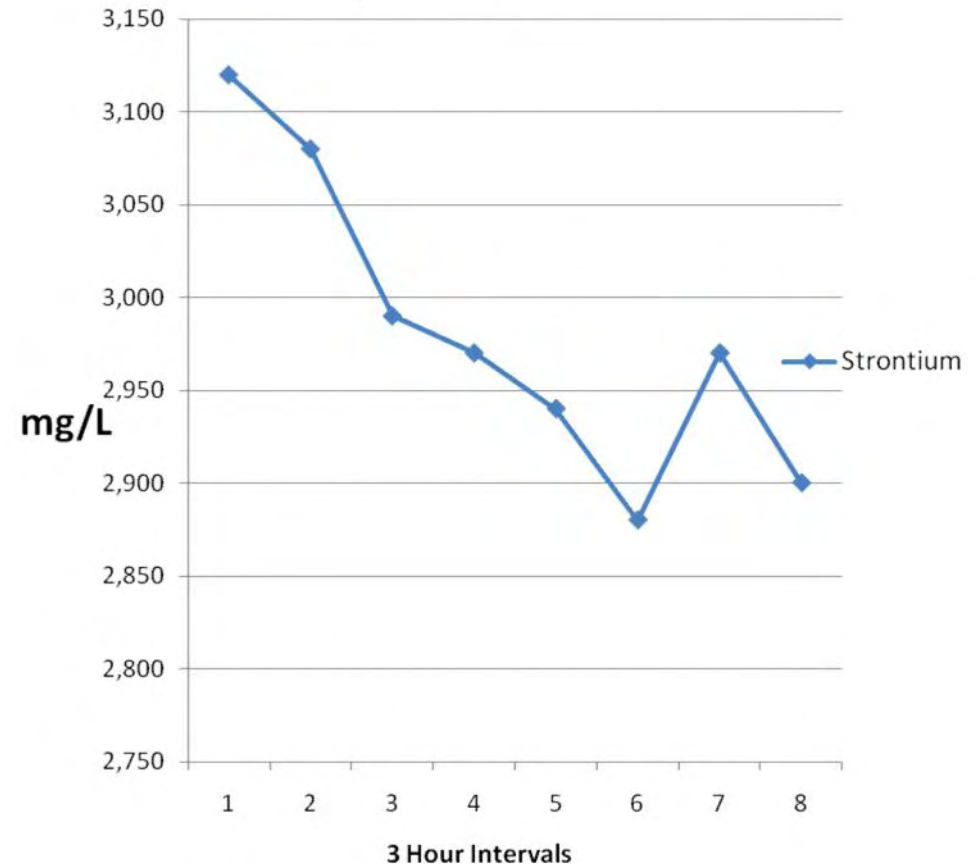
[Min.] = 2,880 mg/L; [Max.] = 3,120 mg/L; MDL; 0.03 mg/L

- Sr ATSDR MRL for oral route, intermediate exposure is 2 mg/kg of body mass/day (musculoskeletal endpoints). The derived Sr MRL's adult men, and women, and children are 68.87 mg/L/day, 57.67 mg/L/day, and 30.45 mg/L/day, respectively.

- [Mean Sr] is 43.29, 51.68 and 97.90 X the derived drinking water MRL's for intermediate exposures for adult men, women, and children, respectively.

- The [Mean Sr] is 29,811 and 5,962 times the 100 ppb and 500 ppb notification levels required by its PA DEP NPDES permit.

PA Brine Treatment Josephine
12/10/2010



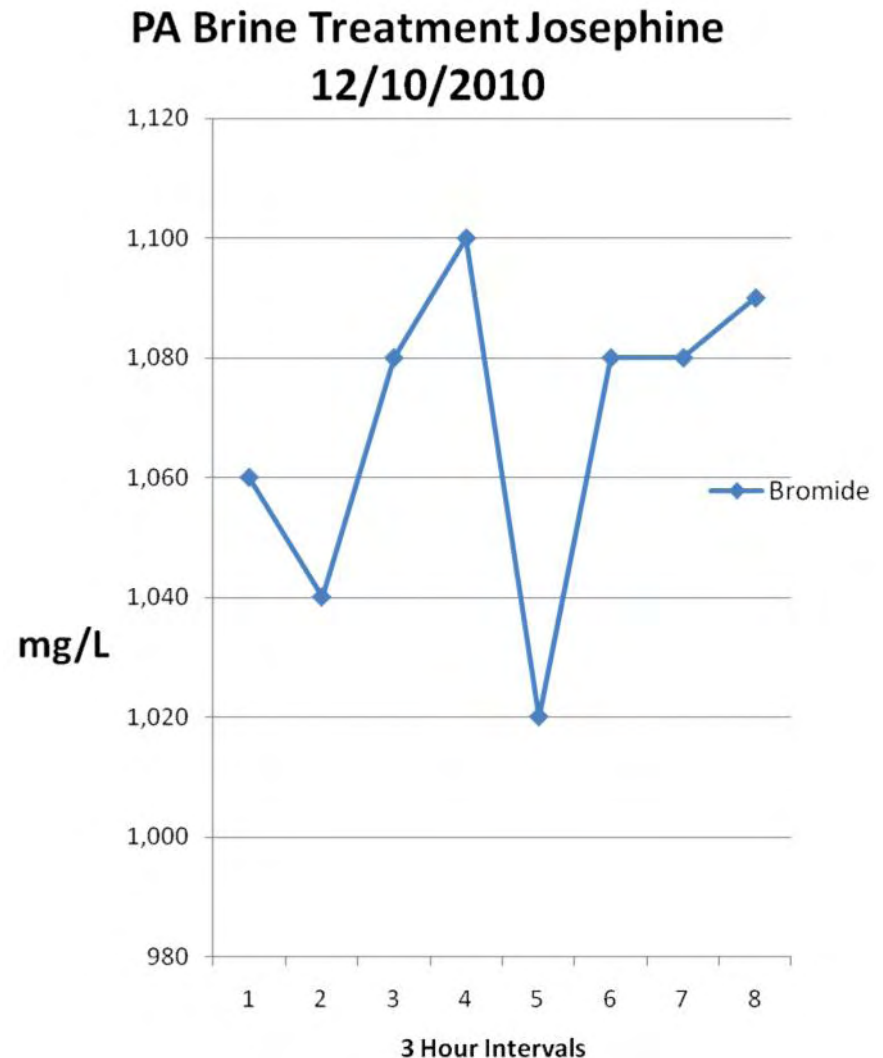
Bromide in PBT-Josephine Facility Effluent

[Mean] = 1068.75 mg/L; σ = 26.96 [Min.] = 1020 mg/L; [Max.] = 1100 mg/L; MDL; 0.016 mg/L

- Bromide can be involved in reactions between chlorine and naturally occurring organic matter in drinking-water, forming brominated and mixed chloro-bromo byproducts, such as trihalomethanes or halogenated acetic acids.
- There is general agreement that background bromide levels in fresh-water sources be kept at about 0.1 ppm (Bonacquisti, 2006).
- [Mean Br], which is 1,068,800 ppb; is 10,688X the 100 ppb level at which authorities become concerned.
- Reports from PSWA and other SW PA authorities indicate upward trends of THM's.

Volz, C.D. et al., 2011

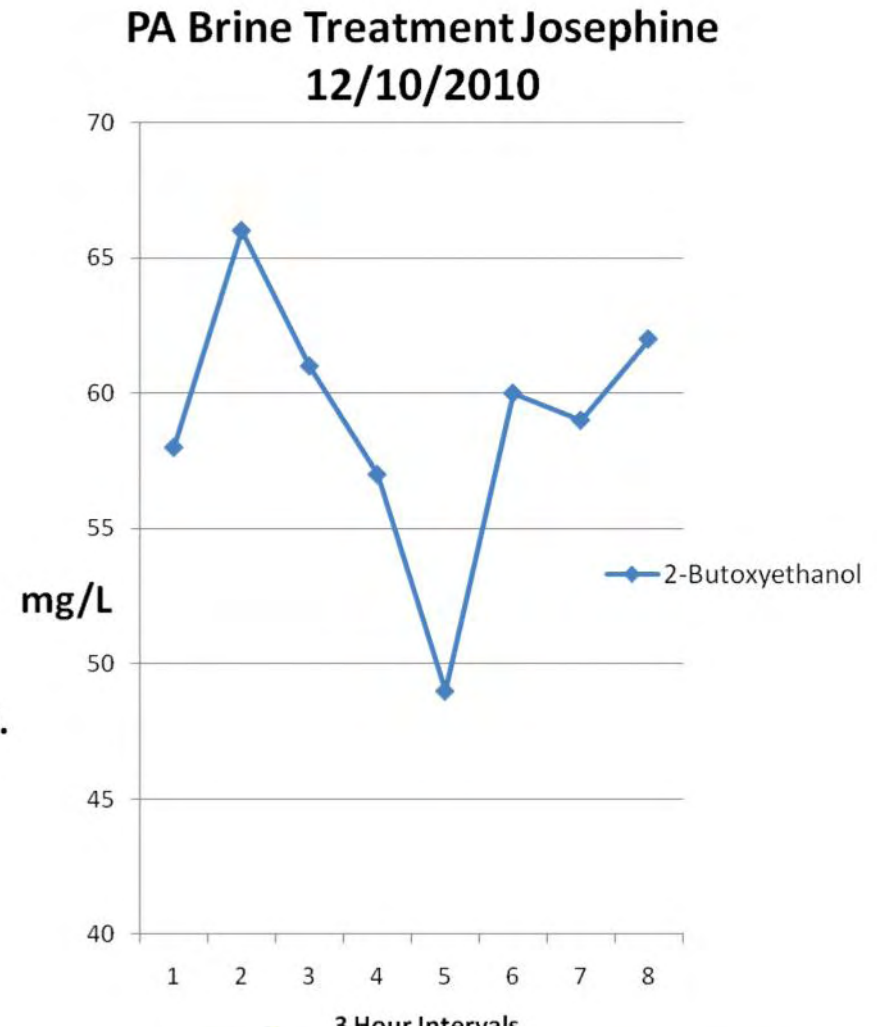
<http://www.fractracker.org>



2-butoxyethanol in PBT-Josephine Effluent

[Mean 2-BE] = 59.0 mg/L; σ = 4.9; [Min.] = 49 mg/L; [Max.] = 66 mg/L; MDL; 0.63 mg/L

- 2-BE, glycol ether, anti-foaming and anti-corrosion agent in slickwater formulations.
- ATSDR MRL for oral route, acute exposures is 0.4 mg/kg/day (hematological effects), [UF= 90]; MRL for oral route, intermediate exposure is 0.07 mg/kg/day (hepatic) [UF= 1000].
- The derived water MRL's acute exposure for adult men, adult women, and children are 13.77, 11.53, and 6.09 (mg/L/day), respectively.
- The derived MRL's for 2-BE in drinking water for intermediate exposure for adult men, adult women, and children are 2.41, 2.02 , and 1.07 (mg/L/day), respectively.
- [Mean 2-BE] is 4.28, 5.12, and 9.69 X and 24.48, 29.21, and 55.14 X the derived acute and intermediate MRL's, respectively, for adult males and females, and children, respectively.



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Volz, C.D. et al., 2011

Chloride in PBT-Josephine Facility Effluent

[Mean Cl] = 117,625 mg/L; $\sigma = 3,815$;

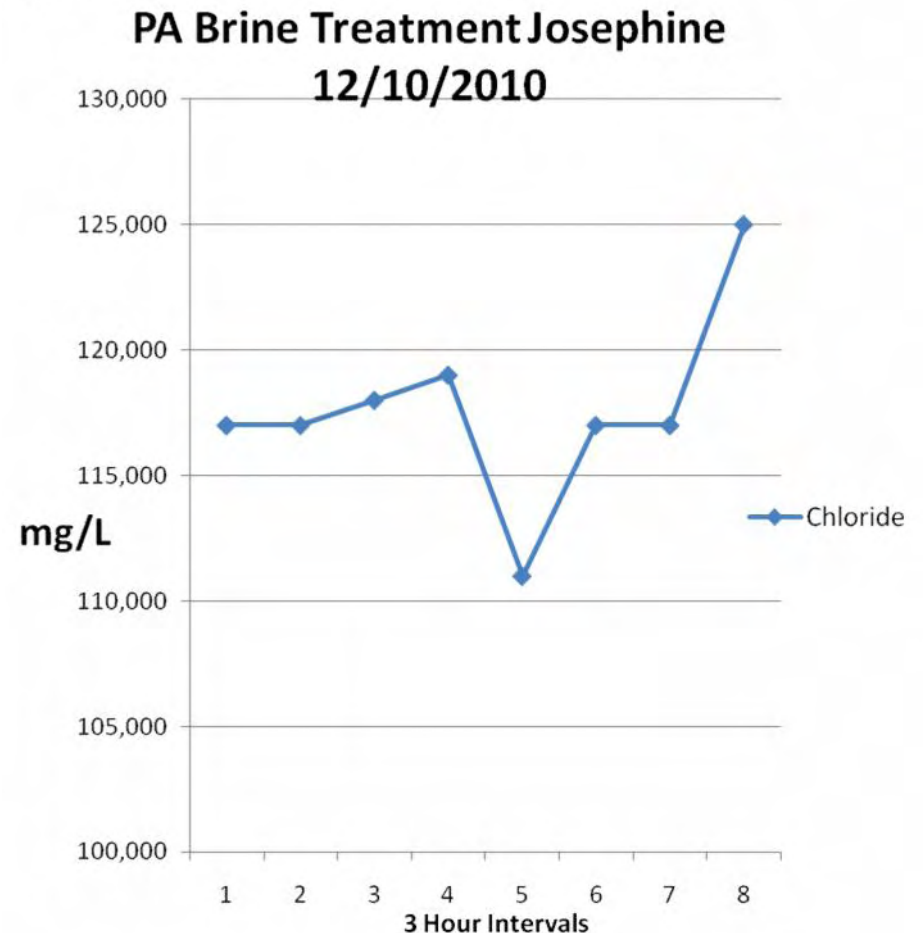
[Min.] = 111,000 mg/L; [Max.] =

125,000 mg/L; MDL; 1.5 mg/L

- [Mean Cl] is 470.5 times the SMCL for chlorides in drinking water of 250 mg/L.

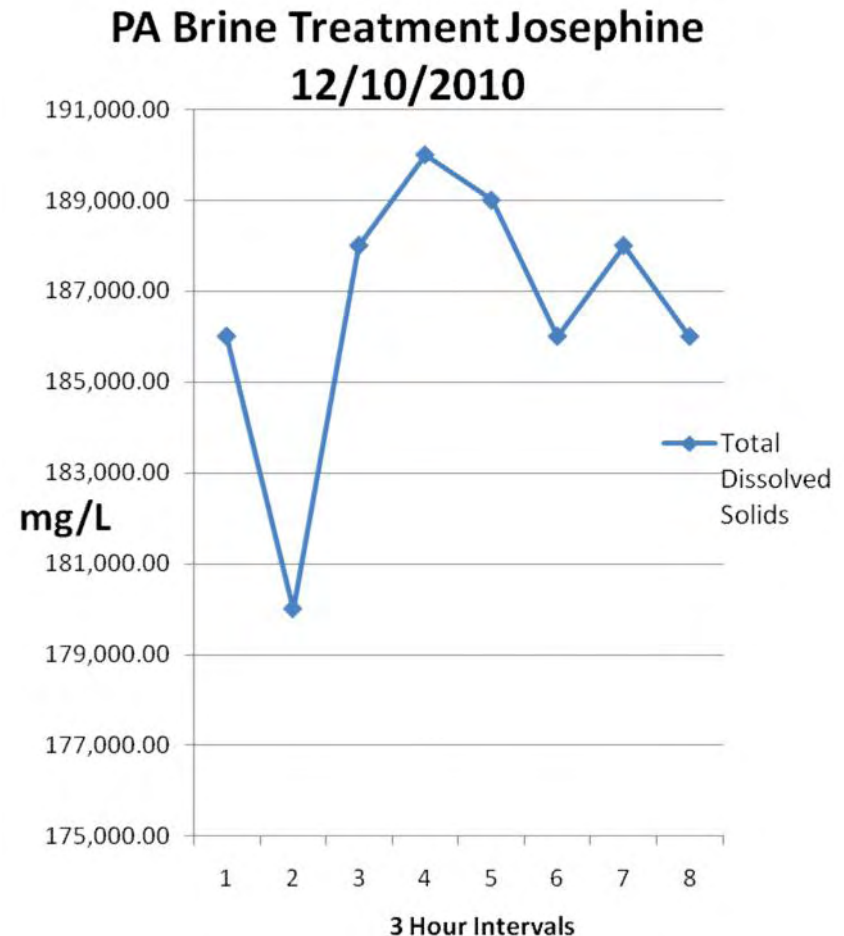
- To protect aquatic communities, the EPA CMC for chlorides in surface water is 860 mg/L, and the EPA CCC for chlorides in surface water is 230 mg/L.

- The [Mean Cl] was 138 times the CMC and 511 times the CCC.



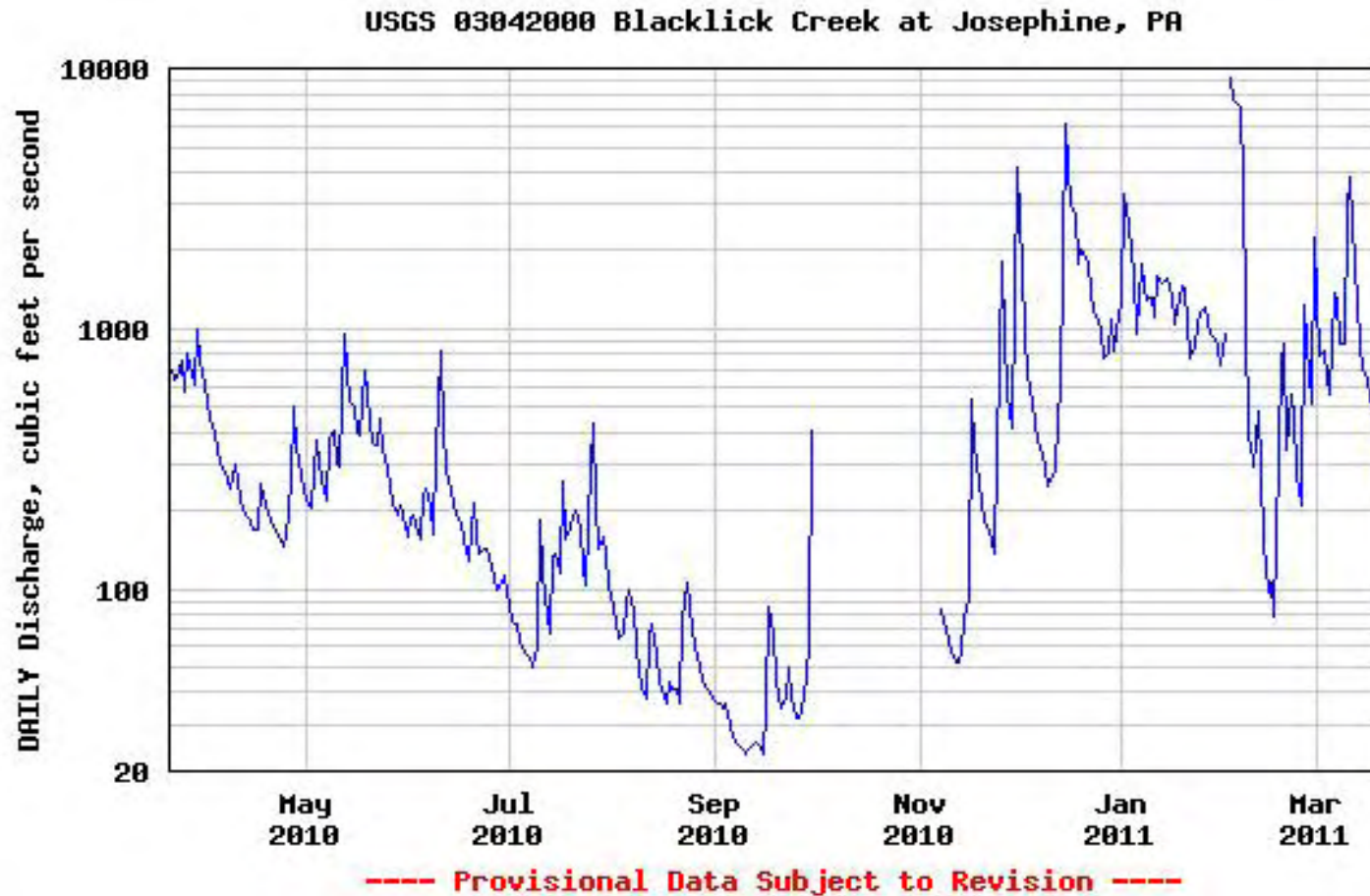
Total Dissolved Solids (TDS) in PBT-Josephine Facility Effluent

- EPA SMCL for TDS in drinking water is 500 mg/L; the mean concentration of TDS in effluent water is 373 times the SMCL.
- It should be noted that new or expanded discharges of TDS in Pennsylvania are limited to discharging only 500 mg/L of TDS as a monthly average.
- The DEP permit allows the PBT-Josephine plant to discharge unlimited levels of chloride and TDS into Blacklick Creek, and only requires monitoring and reporting of these discharges.



<http://www.fractracker.org>





- TDS and CI levels from Kriged Interpolation indicate potential for Golden Algae bloom in Blacklick Creek
- Stream flow during September 2010 reached a low of 25 cfs.

Hart Resources PA Brine Josephine Treatment Facility and Water Resources of the Conemaugh River Basin

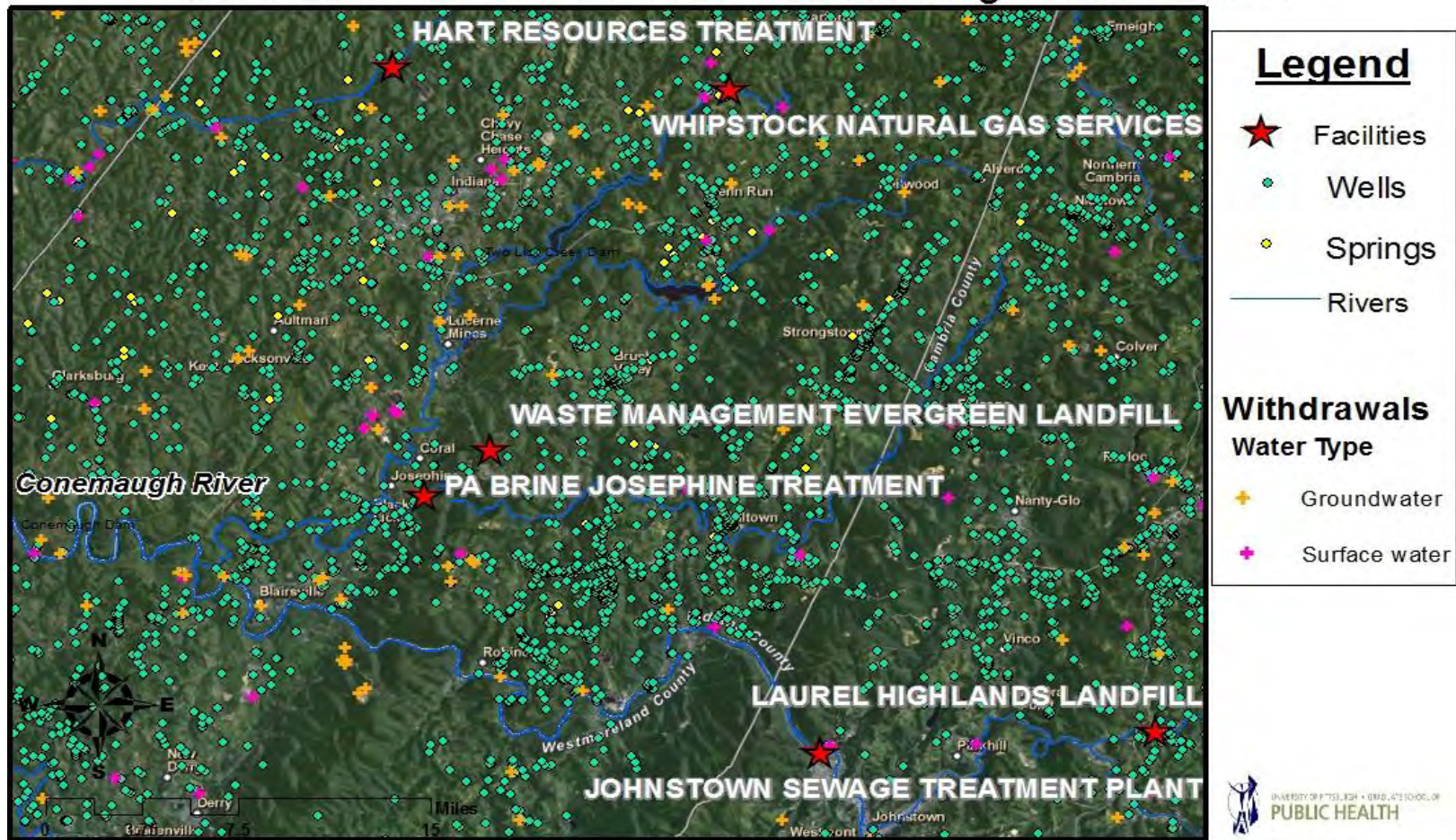


Data obtained from the PADEP at:
https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/DataExports/ExportWasteData.aspx?PERIOD_ID=2010-2,
www.PASDA.PSU.EDU

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Facilities Accepting Natural Gas Solid Wastes and Waste Water and Water Resources of the Conemaugh River Basin

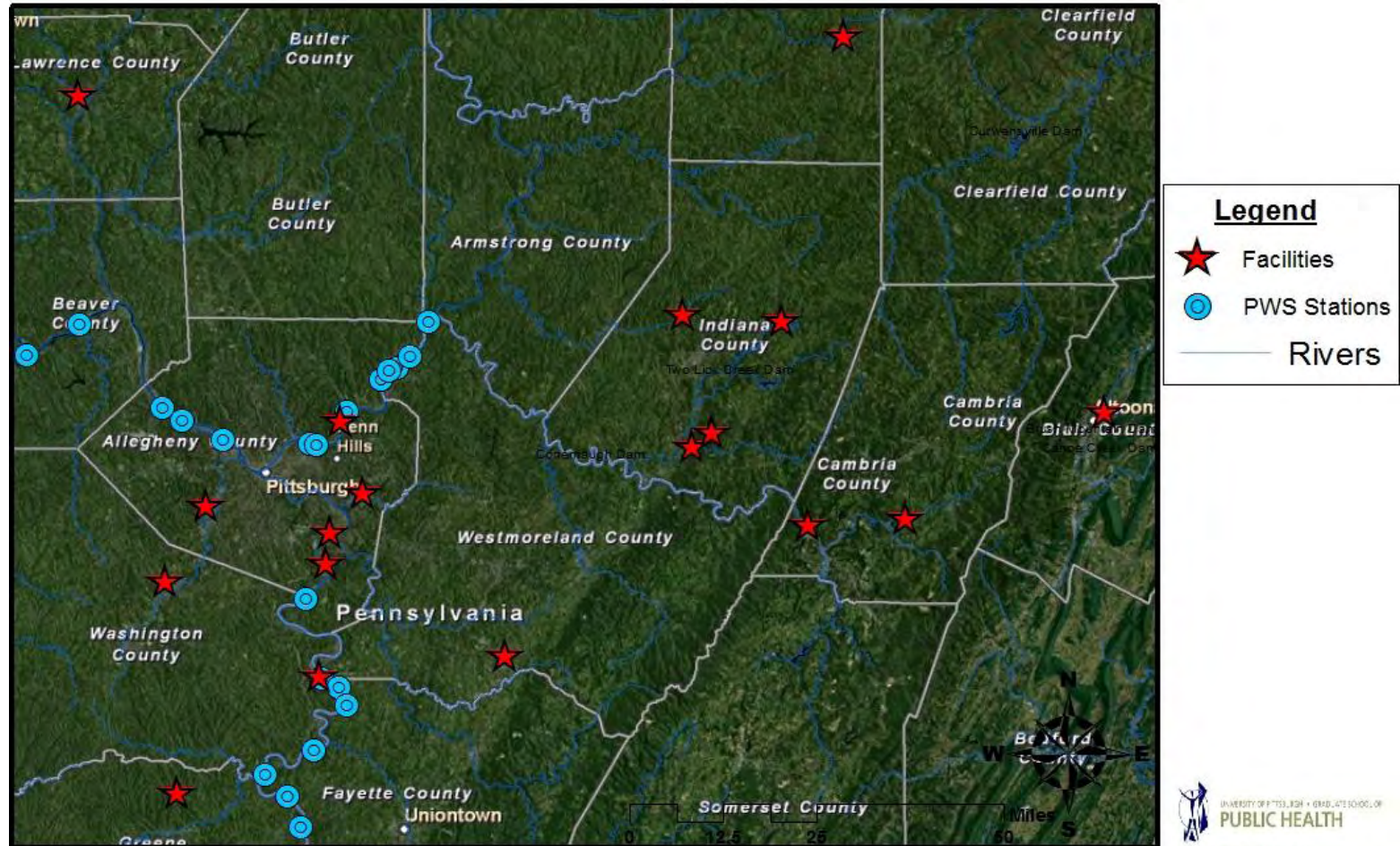


Data obtained from the PADEP at https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/DataExports/ExportWasteData.aspx?PERIOD_ID=2010-2

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Facilities Accepting Natural Gas Solid Wastes and Wastewater and Public Water Supply Withdrawal Stations

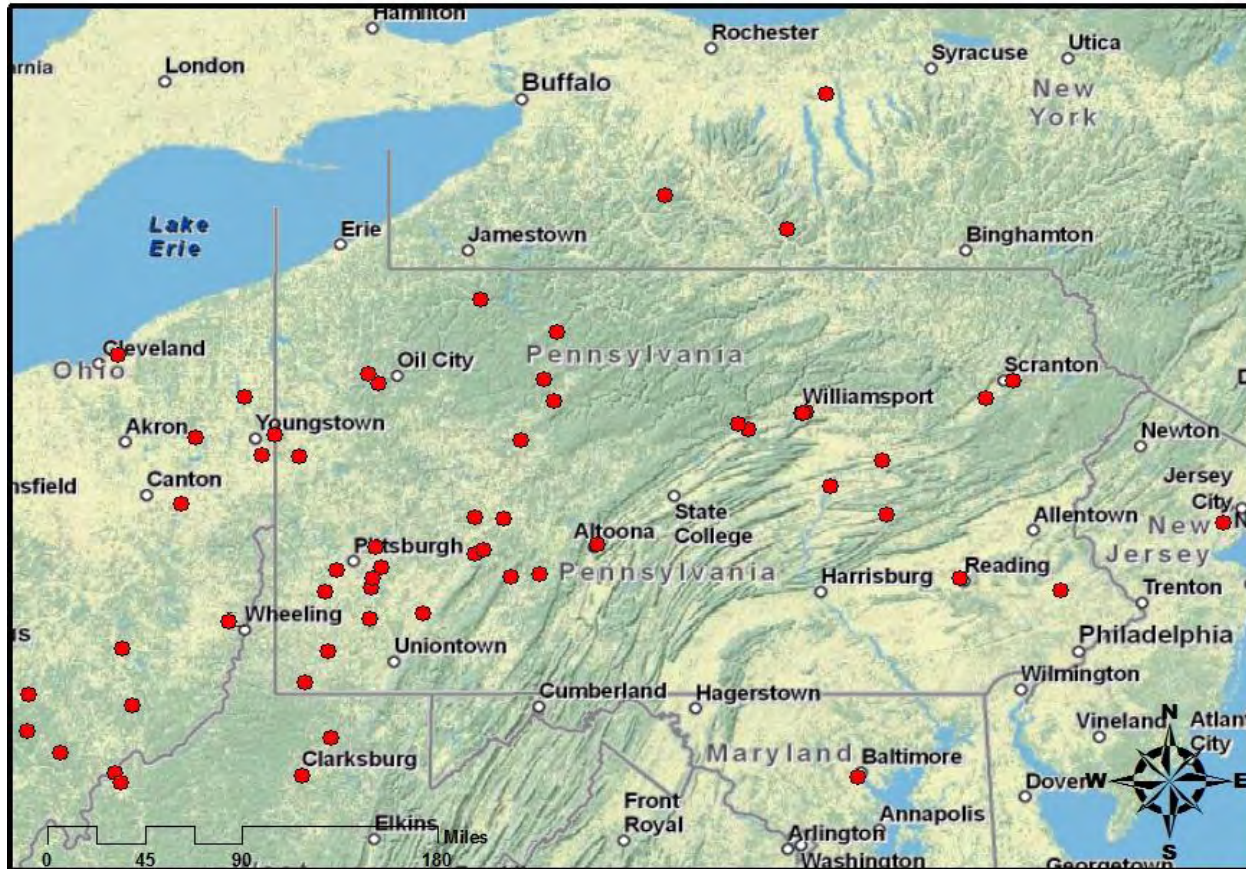


Data obtained from the PADEP at:
[https://www.paolandgasreporting.state.pa.us/publicreports/Modules/DataExports/ExportWasteData.aspx?PERIOD_ID=2010-2,](https://www.paolandgasreporting.state.pa.us/publicreports/Modules/DataExports/ExportWasteData.aspx?PERIOD_ID=2010-2)
www.PASDA.PSU.EDU

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Facilities Accepting Natural Gas Wastewater MD, NY, NJ, OH, WV & PA



Legend

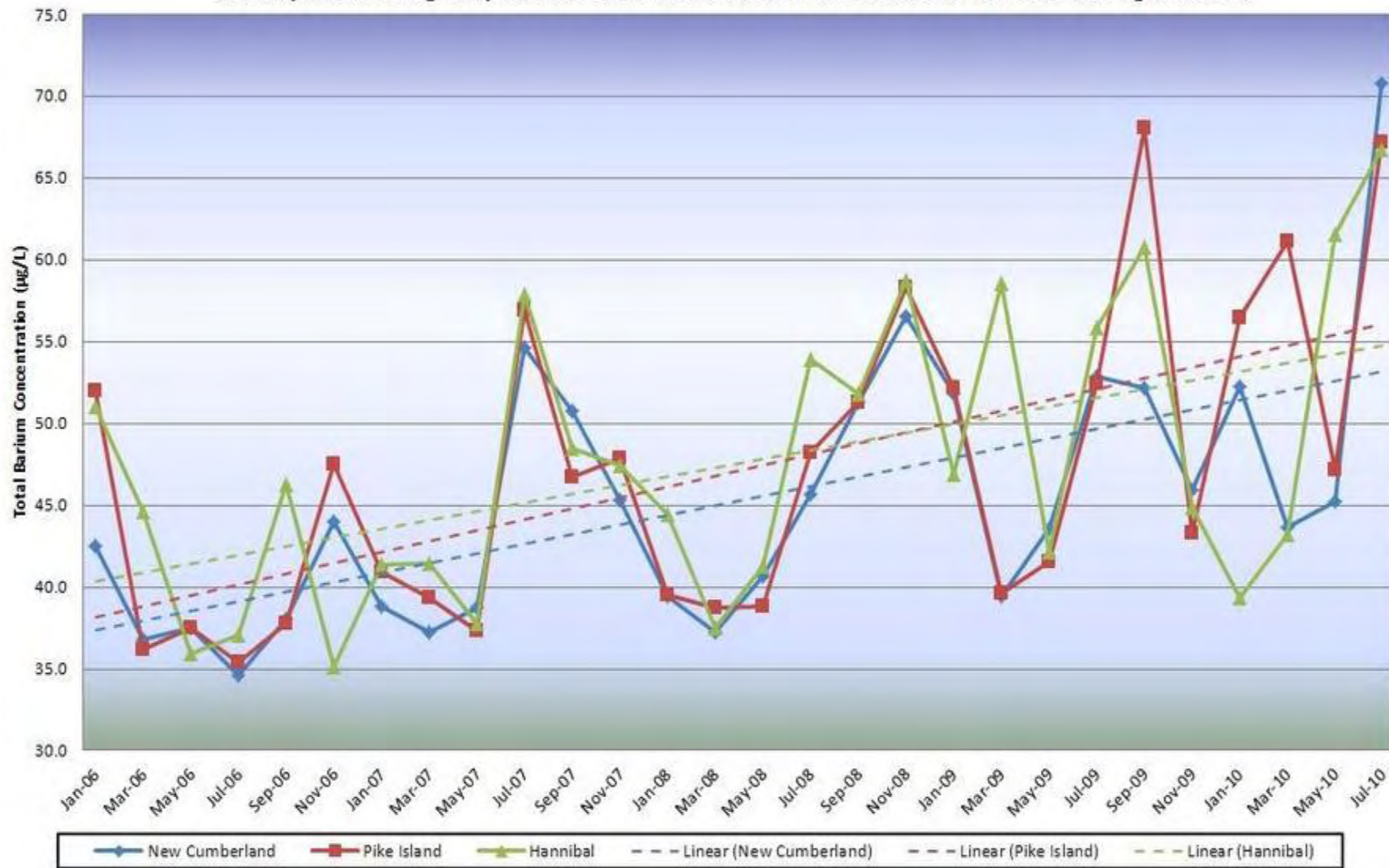
- Facilities

Data obtained from the PADEP at:
https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/DataExports/ExportWasteData.aspx?PERIOD_ID=2010-2

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ORSANCO Ohio River Total Barium Concentration ($\mu\text{g/L}$) with Trend Lines
 January 2006 through July 2010 at New Cumberland, Pike Island, and Hannibal Testing Locations



Volz, C.D. et al., 2011



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Environmental Public Health Recommendations

- Operations at this plant should be halted until all contaminants of human and aquatic health concern in accepted oil and gas fluids are known and it can be determined that the treatment processes used at the plant effectively remove these contaminants from the fluids being treated.
- The PA DEP should reevaluate the permit given to this operator as it clearly allows for chlorides and total dissolved solids to be discharged at levels exceeding aquatic health criteria.
- All approaches to the effluent discharge area and a reasonable distance downstream (at least 100 meters) from streamside and landside should be posted with warning signs. These signs should discourage any use of and/or contact with stream water.
- An advisory to all anglers should be issued stating that fish taken from this stream, both up and down stream may be contaminated in order to discourage fish take and consumption.

Environmental Public Health Recommendations

- Studies to determine the levels of all potential Marcellus Shale flowback fluid contaminants in downstream water, sediments and pore water should be undertaken immediately.
- Residential and other private well water users downstream of the effluent outfall of the PBT-Josephine Facility should be advised that there may be contaminants in their well water and discouraged from using it for drinking, cooking or bathing until such water is tested for continuous safe use.
- Municipal water authorities downstream of this outfall should be notified of the contaminants found in effluent from the PBT- Josephine Facility, of other possible contaminants in Marcellus Shale flowback fluids and oil and gas wastewater, and that there are other treatment facilities and POTW's in the Blacklick, Conemaugh, and Kiskikiminetas drainages that accept and discharge oil and gas waste fluids into surface water.

Environmental Public Health Recommendations

- All municipal water authorities at reasonable distances downstream of “brine treatment” and POTW’s accepting Marcellus Shale flowback fluids and other oil and gas wastewater in the region extending eastward across Ohio, Pennsylvania and West Virginia and New York should be notified of these results.
- The PA DEP and other state and federal regulatory authorities should immediately review all surface water discharge permits granted to brine treatment facilities and POTW’s that accept Marcellus Shale flowback fluids and oil and gas wastewater, to ensure that 2-BE concentrations being discharged are below all applicable standards, guidelines and criteria. This review should be informed by results of this report but should be extended to all known contaminants in flowback and other oil and gas wastewater.