United States Environmental Protection Agency

Technical Roundtables on EPA's Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources

WASTEWATER TREATMENT AND WASTE DISPOSAL

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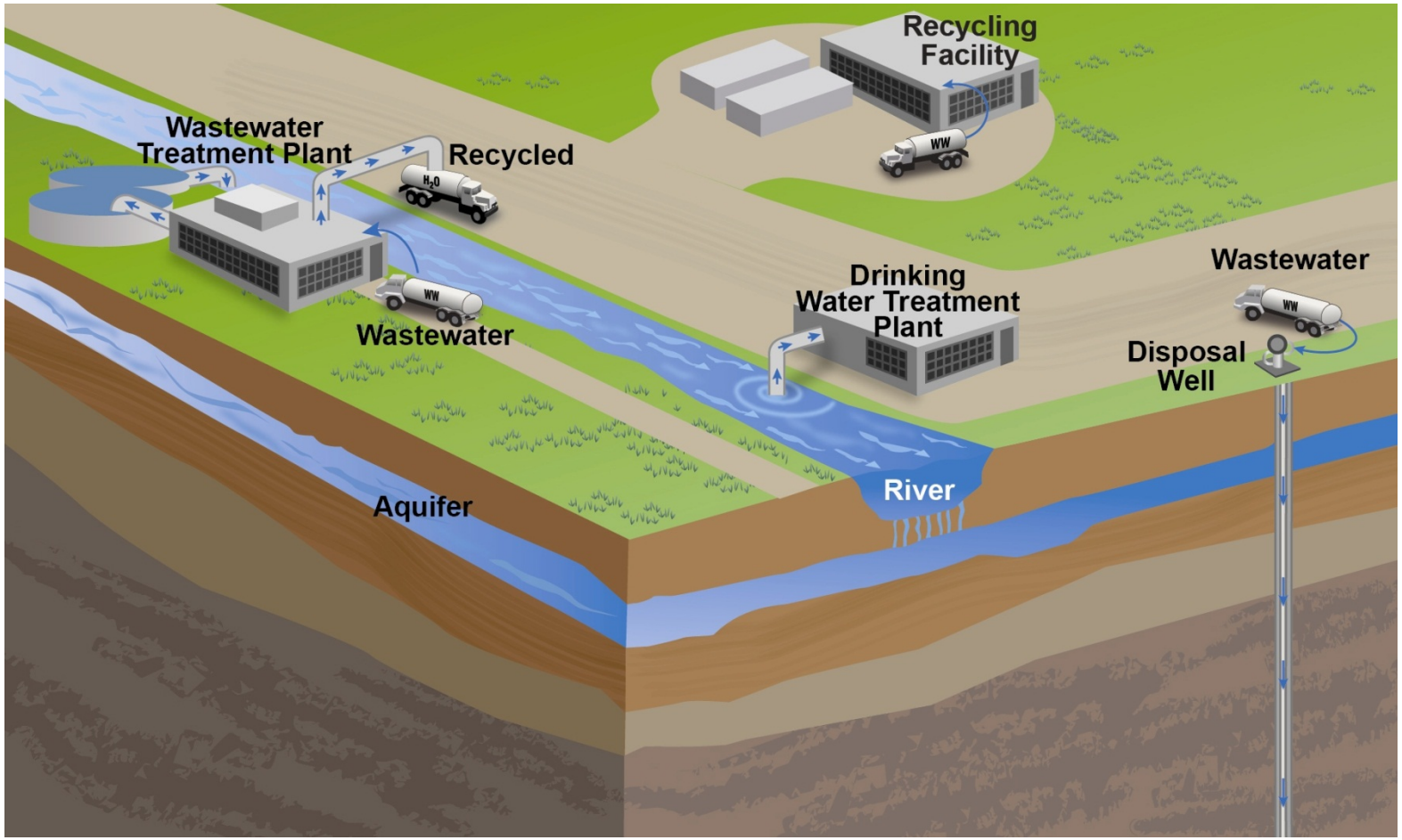
Wastewater Treatment and Waste Disposal



What are the possible impacts of inadequate treatment of hydraulic fracturing wastewaters on drinking water resources?

Wastewater Treatment and Waste Disposal Research Projects

Secondary Research Questions	Applicable Research Projects
1. What are the common treatment and disposal methods for hydraulic fracturing wastewaters, and where are these methods practiced?	Literature Review Well File Review FracFocus Analysis
2. How effective are conventional publicly owned treatment works (POTWs) and commercial treatment systems in removing organic and inorganic contaminants of concern in hydraulic fracturing wastewaters?	Literature Review Wastewater Treatability Studies
3. What are the potential impacts from surface water disposal of treated hydraulic fracturing wastewater on drinking water treatment facilities?	Literature Review Surface Water Modeling Source Apportionment Studies Br-DBP Precursor Studies

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Reviews

Analysis of Existing Data: Literature Review

Data Sources:

- Existing papers and reports, focusing on peer-reviewed literature.

Anticipated Data:

- Information on wastewater treatment and disposal from hydraulic fracturing operations.

Research Progress:

- Identifying, reviewing, and evaluating existing literature following procedures in the study plan.

Next Steps:

- Continue to review and assess literature related to wastewater treatment and disposal according to research questions in the study plan.

Analysis of Existing Data: Well File Review

Data Sources:

- Well-specific records provided by nine oil and gas operators.
- Many records classified as confidential business information.

Anticipated Data:

- Hydraulic fracturing wastewater treatment and disposal practices for 333 wells hydraulically fractured in 2009 and 2010.

Research Progress:

- Extraction of available data from the well files is underway.

Next Steps:

- Continue extracting data from well files.
- Work with oil and gas operators to clarify information provided.
- Analyze data to address research questions.

Analysis of Existing Data: FracFocus

Data Sources:

- National Registry for chemicals used in hydraulic fracturing.

Anticipated Data:

- Information on recycling practices and water types by volume and geographic location.

Research Progress:

- Data were extracted, checked for quality issues, and organized in a database for analysis.
- Perform analyses to address research questions.

Next Steps:

- Analyze water usage.
- Summarize data by water source or type.

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Laboratory and Field Studies

Wastewater Treatability Studies

OBJECTIVES:

This project focuses on the efficacy of treatment processes at publicly owned treatment works (POTWs) and commercial wastewater treatment facilities (CWTs), since discharge of treated wastewater to surface waters provides an opportunity for chemicals found in the effluent to be transported to downstream drinking water intakes. This project will also explore treatment processes for reusing hydraulic fracturing wastewater.

APPROACH:

- Fate and transport of selected contaminants in wastewater treatment/reuse processes.
  - Analyze the fate and transport of selected hydraulic fracturing-related contaminants in wastewater treatment and water reuse processes.
  - Monitor impacts on wastewater treatment efficiency.

RESEARCH PROGRESS:

Initial studies on establishing thresholds of total dissolved solids (TDS) tolerance in chemostat bioreactors are in progress.

Wastewater Treatability Studies

NEXT STEPS:

- Once the basic salt thresholds have been established, selected chemicals will be added to the salt stock solutions.
- Salt concentrations will be kept below the thresholds where effects on the biological processes were observed. Potentially biodegradable pollutants (e.g., organics) will be measured, and EPA will attempt to identify breakdown products.
- Constituents that are not biodegradable (e.g., elements, anions) will be tracked through the system by analyzing system effluent using the appropriate EPA methods and by analyzing residuals from the primary clarifier and the bioreactors.
- Studies on fate of selected contaminants in commercial treatment systems using coagulation/flocculation/filtration and/or evaporation.

Wastewater Treatability Studies Residuals

OBJECTIVE:

Characterize the concentrations and chemical speciation of selected contaminants in treatment residuals (filter press solids, precipitates, salts from evaporation processes).

APPROACH:

- Examine the concentrations and chemical speciation of elemental contaminants in treatment residuals.
- Assess oxidation state and chemical speciation of selected contaminants.

RESEARCH PROGRESS:

- Comparisons on existing SW846 Methods (e.g., Methods 3050B, 3051A, 3052) for analyte recovery.
- Optimization of SW846 6010C (ICP-AES) to handle high salt samples.
- Development of sample handling procedures.

NEXT STEPS:

- Solid residuals characterization using X-ray Fluorescence, X-ray Absorption Spectroscopy, Scanning and Transmission Electron Microscopy, X-ray Diffraction, and bulk digestion methods.
- Examine the viability of semi-volatile organic analyses using pressurized solvent extraction (SW846 Method 3545A).

Surface Water Modeling

OBJECTIVE:

Use established surface water transport models and theory to identify generic conditions that may lead to elevated concentrations of bromide and radium chemicals at public water supply intakes. Data from two wastewater treatment facilities in Pennsylvania that have discharged treated hydraulic fracturing wastewater to rivers are being used to approximate realistic discharges.

APPROACH:

- Collect model inputs
  - Wastewater treatment facility effluent data from the National Pollutant Discharge Elimination System (NPDES) monitoring reported to states.
  - United States Geological Survey (USGS) stream water quality and flow rate data.
- Use three modeling approaches to determine potential downstream impacts.

  1) Steady-state mass balance model – Estimated impacts from steady discharges to receiving waters for low, medium, and high flow and discharge conditions.

  2) Empirical model/hybrid empirical-numerical model – Estimate impacts with time-variable chemical concentrations and discharge volumes in a procedure that combines data from the empirical analysis with numerical simulation.
    - Monte Carlo simulation is being used to estimate the uncertainties in the outputs for each of these approaches.

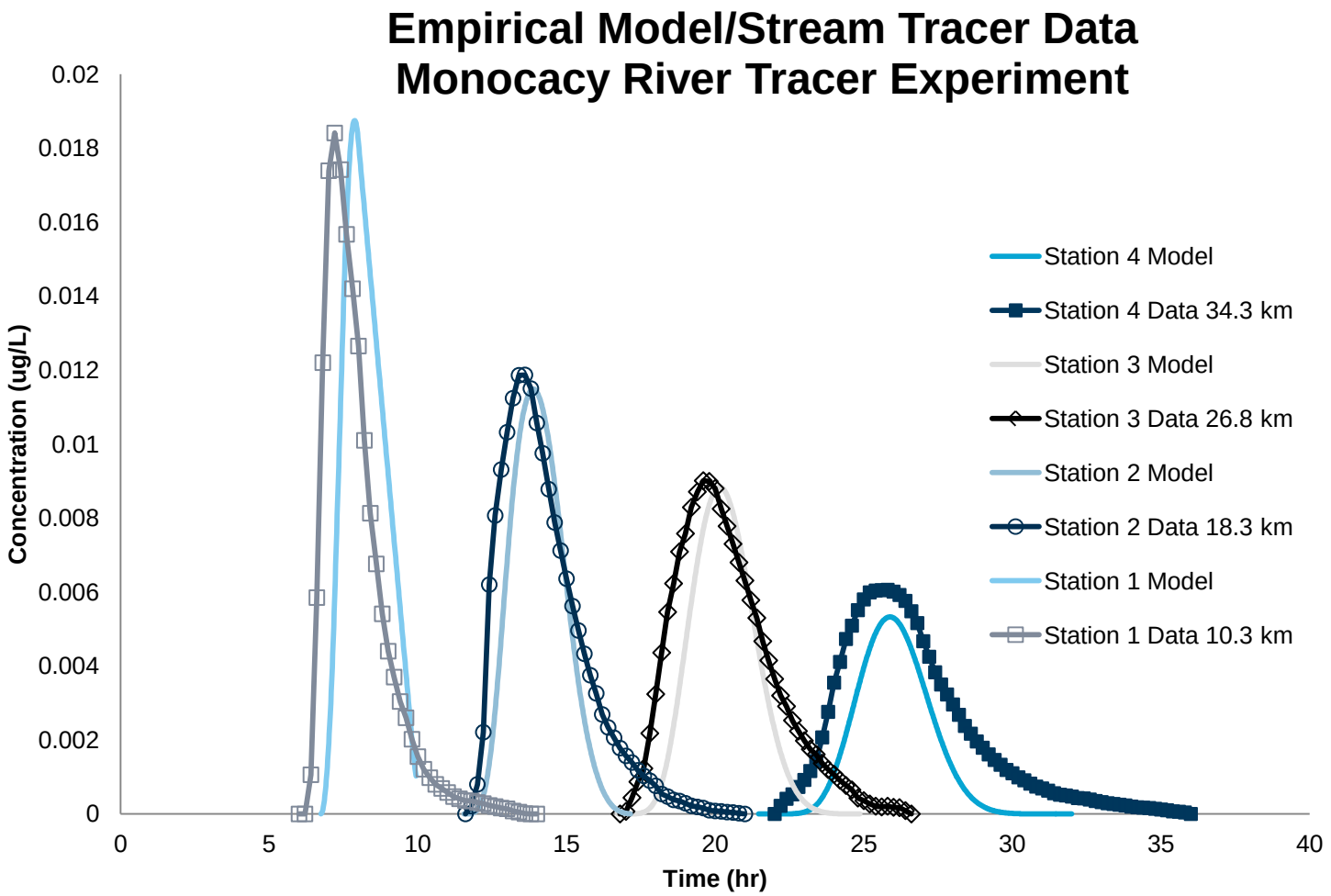
  3) Numerical model – Confirm results of empirical and hybrid models using comparisons to USGS tracer data and the EPA Water Quality Simulation Package (WASP).

Surface Water Modeling

APPROACH (continued):

- Confirm accuracy of models using tracer data from previous studies and model development efforts.
  - Perform empirical simulations with Monte Carlo Simulation.
    - Account for the variability in model inputs, such as discharge concentration and volume, stream flow rate, distance to drinking water intake.
  - Perform numerical simulations using a hybrid approach.
    - Dispersion coefficients estimated from tracer experiments.
    - Travel time and dispersion coefficients estimated from empirical equations.
    - Dispersion coefficients estimated from methods published in the recent literature.
    - Parameters calibrated to tracer data.
- Run models with different discharge scenarios and stream flow scenarios based on data collected.

Surface Water Modeling



Surface Water Modeling

Research Progress:

- Input Data Collection
  - Collected data from wastewater treatment facilities in western Pennsylvania (NPDES permits).
  - Compiled USGS flow data for segments of the river that flow downstream to drinking water intakes.
- Model Development
  - Confirmed accuracy of the hybrid empirical-numerical model by comparing it to a tracer experiment that was used in developing the original empirical formulas.
  - Currently comparing hybrid model results to additional tracer experiments to cover the range of flow conditions.
  - Applied the EPA WASP model to simulate the same tracer experiments.

Next Steps:

- Perform additional calibration of the WASP model.
- Develop description of the models and apply the models to the tracer experiments.
- Perform treatment plant simulations.

Source Apportionment Studies

OBJECTIVES:

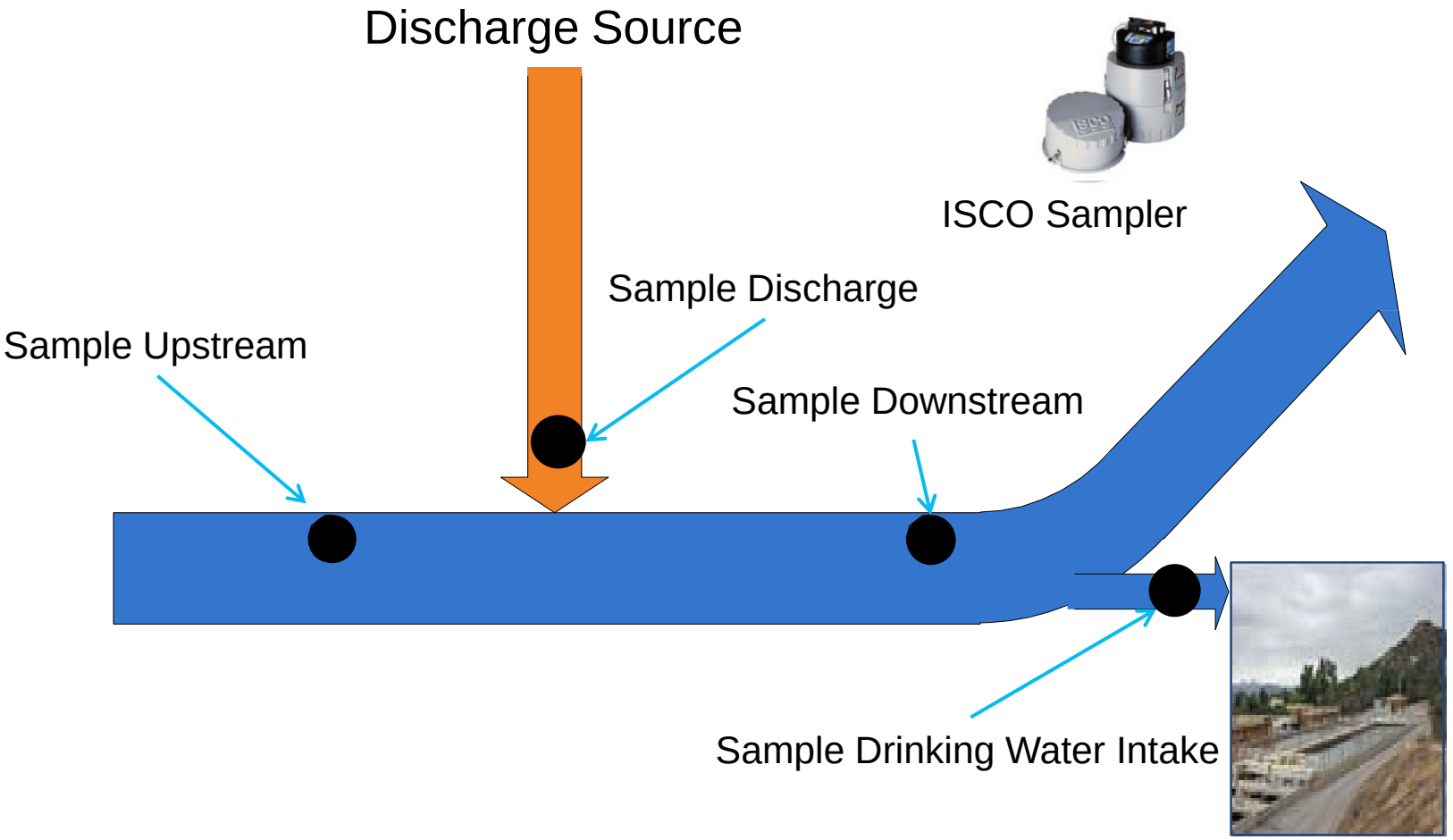
- Establish an approach whereby surface water samples may be evaluated to determine the extent to which hydraulic fracturing wastewaters (treated or untreated) may be present.
- Distinguish whether any elevated bromide and chloride in those samples may be due to hydraulic fracturing or other activities.
- Quantify the inorganic chemical composition of discharges in two Pennsylvania river systems from CWTs that accept and treat flowback and produced water, wastewater from coal-fired power plants, acid mine drainage, storm water runoff of roadway deicing material, and other industrial sources.
- Investigate the impacts of the discharges by simultaneously collecting multiple upstream and downstream samples to evaluate transport and dispersion of inorganic species.
- Estimate the impact of these discharges on downstream bromide and chloride levels at drinking water treatment system intakes using mathematical models.

Source Apportionment Studies

APPROACH:

- Sample Analyses
  - Collecting water samples at five locations on two river systems that have an existing CWT currently accepting hydraulic fracturing wastewater.
  - Computer models will be used to compare data from the river systems.
  - Analyze samples for a suite of elements and ions.
  - Conduct strontium 87/86 ratio analyses.
- Source Apportionment Modeling
  - Use peer-reviewed receptor models to identify and quantify different contaminant source types.
  - Analyze major ions and inorganic trace elements.
  - Receptor models – Unmix, Positive Matrix Factorization, Chemical Mass Balance.

Source Apportionment Studies



Source Apportionment Studies

RESEARCH PROGRESS:

- EPA collected samples during spring (175 samples), summer (184), and fall (183) of 2012.
- Four effluent source types were collected.
- Compared discharge concentrations of chloride, bromide, sulfate, and sodium and conductivity from the two monitored CWTs.

NEXT STEPS:

EPA continues to analyze field and source samples to obtain the necessary data for source apportionment modeling. The data will be used as input to the receptor models described above to identify and quantify the sources of chloride and bromide at drinking water treatment system intakes.

Disinfection Byproduct (DBP) Precursor Studies – Br Analysis

OBJECTIVE:

Optimize existing EPA methods for the analysis of bromide and bromate in high salt matrices.

APPROACH:

- Establish sample dilution rate recommendations.
- Minimize interference to instrumental analysis from elevated TDS matrices using EPA Method 300.1 (Rev. 1).
- Investigate potential interference from selected anions on bromide/bromate analysis by comparing instrument responses to solutions with added anions.
- Calculate the method detection limits (MDLs) and lowest concentration minimum reporting levels (LCMRLs).

RESEARCH PROGRESS:

- MDLs/LCMRLs established using EPA Method 300.1.
- Identification of interfering anions.
- Sample dilution rate recommendations established.

NEXT STEPS:

- Spike recovery studies will be performed.
- When these results are complete, the optimized method will be validated by outside laboratories.

DBP Precursor Studies – Br DBP Formation

OBJECTIVE:

This project will ultimately provide drinking water treatment systems with information on the potential for DBP formation in surface waters receiving discharges from wastewater treatment facilities, along with possible mitigation strategies.

APPROACH:

- Analyze and characterize hydraulic fracturing wastewater for halides.
- Selected analytes include chloride, bromide, and iodide.
- Evaluate the effects of high TDS on chlorination, chloramination, and ozonation of surface water receiving discharges of treated hydraulic fracturing wastewater.
- Analyze samples for disinfection byproducts, including trihalomethanes (THMs), haloacetic acids (HAAs), and N-nitrosamines; elemental composition; anion concentration; TDS; and total organic carbon.
- Three treatments will be applied to the wastewater samples (deionized H_2O, deionized H_2O + humic acid, and surface water).

DBP Precursor Studies – Br DBP Formation

RESEARCH PROGRESS:

- Influent and effluent samples obtained from two CWTs that accept hydraulic fracturing wastewater for treatment.

NEXT STEPS:

- THM formation comparisons among hydraulic fracturing wastewater samples and less complex matrices.
- EPA anticipates obtaining data for the formation of HAAs and nitrosamines, though THMs are the priority at this time.
- THM formation study results are expected to be completed by April 2013.

Questions for Discussion

- Are there other sources of data and/or samples that could be obtained for further study?
- What are the most important future research topics regarding wastewater management and water reuse?