Marcellus Shale Committee's Response to *PADEP's Permitting Strategy for High TDS Wastewater Discharges*

PADEP Water Resources Advisory Committee Meeting

November 10, 2009

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Agenda

- Marcellus Shale Committee's Mission
- Wastewater Volumes & Contaminants Generated from Marcellus Shale Wells
- PADEP Permitting Strategy
- Treatment/Disposal Options & Impacts
- Conclusions

Marcellus Shale Committee's Mission

- **Responsible Development of Natural Gas in the Marcellus Shale**

- **Enhancement of PA's Economy by Providing a Clean Burning Energy Source**

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Disclaimer

The estimates on the following slides of:

- produced water flowback requiring treatment,
- produced water contaminant loadings, and
- impacts of treated residual produced water on PA rivers

are based on drilling projections in the Penn State study and current operating information.

The estimates are preliminary and may not be applicable in all situations.

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Well Drilling Produced Water (including Flowback Water) Generated

- Penn State Study (August 5, 2009)
  - 2010 Estimates – 1000 Marcellus Wells Drilled
  - 2020 Estimates – 2800 Marcellus Wells Drilled

- Produced Water (including Flowback Water) Generated during Well Completion – Approximately 0.5 to 1.0 million gallons

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Residual Produced Water Needing Treatment

- More than 50% of Operators Reuse at least a Portion of Produced Water

- Recent Recycling/Reuse Methods Have Reduced Treatment/Disposal Needs by an Estimated 80% Based on Current Operating Information

- Residual Produced Water Needing Treatment
  - 2010 Estimate – 0.55 million gal/day (mgd)
  - 2020 Estimate – 1.5 mgd

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Produced Water Contaminants

- **Average Contaminant Concentrations (ppm)**

TDS –	90,000
Sulfates –	20
Chlorides –	60,000

- **Contaminant Loadings (lbs/day)**

	2010	2020
TDS –	0.4 million	1.1 million
Sulfates –	91	225
Chlorides –	0.3 million	0.8 million

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Impacts of Treated Residual Produced Water on PA Rivers

- Estimated Effluent from 12 Treatment Plants Discharged into PA Rivers (Metals and TSS Removal but Only Minimal TDS and Chlorides Removal)

- Average Increases in Contaminant Concentrations in Rivers (ppm) *

	2010	2020
TDS –	13.8	38.6
Sulfates –	0.0	0.0
Chlorides –	9.4	26.3

* Based on Q7-10 Flow in Monongahela River at Masontown (Average Flow is over 6 Times Q7-10 Flow)

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PADEP Permitting Strategy for High TDS Wastewater Discharges

- **Proposed Effluent Standards (end-of-pipe)**

TDS –	**500 mg/L**
Sulfates –	**250 mg/L**
Chlorides –	**250 mg/L**

- **To Take Effect on January 1, 2011**

PADEP Permitting Strategy for High TDS Wastewater Discharges

- **High Produced Water Estimates are a Major Factor in DEP's Proposing New Limits**

  2009 – 9 mgd
  2010 – 16 mgd
  2011 – 19 mgd
  SRBC – 20 mgd (during same time frame)

- **Estimated Residual Produced Water Needing Treatment Based on Recycling Methods**

  2010 – 0.55 mgd

PADEP Permitting Strategy for High TDS Wastewater Discharges

- Another Factor PADEP Noted in Proposing New Standards
  - Limited Assimilative Capacity in PA Rivers
  - Example Cited - High TDS & Sulfate Conc. in the Monongahela River in Fall 2008

- MSC Report on Mon River Concluded
  - Gas Well Operations Had Minimal Impact
  - Main Source of Problem – Sulfates from Mine Drainage Mostly from WV
  - Historically Low Flowrates Resulted in Low/No Assimilative Capacity for TDS

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PADEP Permitting Strategy for High TDS Wastewater Discharges

- PADEP Noted that NPDES Procedures Must Take into Account
  - Water Quality-Based Effluent Limits
  - Plan to Allocate Assimilative Capacity of the Watershed (lbs/day)

- However, the Proposed Effluent Standards
  - Are Based on USEPA Secondary Drinking Water Standards
  - Have been Adopted by DEP as WQS
  - Assimilative Capacity Not Considered
  - Take a “One Standard Fits All” Approach

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Residual Produced Water Treatment and Disposal Options

- Conventional/Pre-treatment – Metals and Suspended Solids (TSS) Removal
- Mechanical Evaporation – TDS Removal
- Crystallization – TDS Brine Concentrator
- Deep Well Injection

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Conventional/Pre-treatment

- Uses Chemical Precipitation Process to Remove TSS and Heavy Metals (including NORM); Minimal TDS and No Chlorides Removal
- Reductions in TDS and Chlorides Concentrations Principally Achieved by Assimilative Capacity and Dilution in Receiving Stream
- Precipitated Solids Are Landfilled
- Has Been Used in PA for Many Years for Treating Produced Water from Shallow Wells

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Mechanical Evaporation

- Uses High Temperature and Pressure to Remove Water Vapor from Wastewater
- Recovered Distillate (55 to 60%) Is Very High Quality and Can Be Used
- Concentrated TDS Brine Stream (40 to 45%) can Be Converted to Salt Cake or Disposed of via Deep Well Injection
- Complex Operation Requires Pre-treatment Step and Is Expensive to Own, Operate and Maintain

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Crystallization

- Converts Concentrated TDS Brine Stream from Evaporator to Salt Cake
- Salt Cake Has To Be Landfilled or Converted to Salable Salt for Possible Use (Market for Salable Salt Is Uncertain)
- Landfilling Large Quantities of Salt Cake May Pose Long-term Risk to Aquifers (No Existing Landfills Permitted in PA)
- As with Mechanical Evaporation Crystallization Is Expensive to Own, Operate and Maintain

Deep Well Injection

- Traditionally Not Used Much in PA for Produced Water Disposal but Growing Interest by Marcellus Gas Producers
- Converting Abandoned Gas Wells to Injection Wells Is Being Evaluated
- Both USEPA and PADEP Are Supporting Injection Well Permit Applications
- Cost-effective and Environmentally Responsible Method for Residual Produced Water Disposal

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Cost and Power Demand Comparisons

	$/gal	Kwh/1000 gal
Metals/TSS Removal	0.04 to 0.08	1 to 3
TDS Removal (Incl. Pre-treatment, Evaporation & Crystallization)	0.12 to 0.25	100 to 250
Injection Well Disposal	0.02 to 0.08	0.5 to 1.0

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Conclusions

- Estimated Produced Water Volumes Cited in PADEP Permitting Strategy Are Significantly Higher than Those Based on Well Data in Penn State Study

- Recycling Methods Have The Potential to Reduce Residual Produced Water Volumes Needing Treatment by as Much as or More than 80%

- PADEP Permitting Strategy Does Not Take Into Account Assimilative Capacities Available to Accommodate Greatly Reduced Produced Water Volumes

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Conclusions

- TDS Removal Processes
  - Have Very High Capital/O&M Costs
  - Require Very High Electric Power Demand (Carbon Footprint)
  - Generate Residual Wastes (Salt Cake) that, if not Otherwise Used, Represent a Disposal Problem
- In Summary, Discharging Treated Produced Water into PA Rivers
  - Would Not Significantly Impact PA Rivers at Current Reduced Volumes
  - Can Be Achieved without Using TDS Removal Processes

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