Ohio River Valley Water Sanitation Commission

February 8, 2012

Water requirements for Marcellus Shale

- Fracing a typical horizontal well requires 3-5 million gallons
- Pump Rates from 70 – 100 bpm
- Is that a lot of water?
  - 5 million gallons is 1.8 inches of water over an area of 100 acres, the approximate drainage area of a well
  - PA receives about 40 inches of rainfall per year
  - If the productive area of the Marcellus takes 50 years to drill, annual water use over the productive area would be 0.04 inches of water per year or 1/10th of 1% of annual rainfall

Water requirements for Marcellus Shale

Water use per million btu of energy:

•Deep shale natural gas	0.60-5.80 gallons
•Marcellus Shale gas – avg	1 gallon
•Nuclear (uranium ready to use in a power plant)	8-14 gallons
•Conventional oil	8-20 gallons
•Synfuel-coal gasification	11-26 gallons
•Coal (delivered power plant)	13-32 gallons
•Oil shale	22-56 gallons
•Tar sands/oil sands	27-68 gallons
•Fuel ethanol from corn	2,510-29,100 gallons (irrigation)
•Biodiesel from soy	14,000-75,000 gallons (irrigation)

Shale gas production uses less water than any other significant energy source

Source: U.S. Dept. of Energy

Source Requirements

- Reliability/Seasonality
- Quality/Compatibility
- Location/Proximity

Sources – Municipal

Sources – Alternative

TABLE 1 – WATER QUALITY AND QUANTITY

Parameter	Value
Mine Pool #1	1.9 billion gallons
Mine Pool #2	1.8 billion gallons
Average Discharge Flow	935 gpm
Average pH	6.0
Average Alkalinity	112 mg/l
Average Acidity	52 mg/l
Average Total Iron	100.5 mg/l
Average Total Manganese	1.1 mg/l
Average Total Aluminum	0.6 mg/l
Average Sulfates	762 mg/l

Parameter	Min	Max	Average	Units
Flow	80	45,553	1,638	gpm
pH	2.8	8.6	5	
TSS	2	656	29	ppm
TDS	144	3,486	1,120	ppm
Chlorides	1	348	31	ppm
Sulfate	5	2,800	416	ppm
Hardness	74	1,559	435	ppm
Iron (total)	0	238	19	ppm
Magnesium (total)	2	525	47	ppm

PA DEP – Orphaned Mine Discharge Project

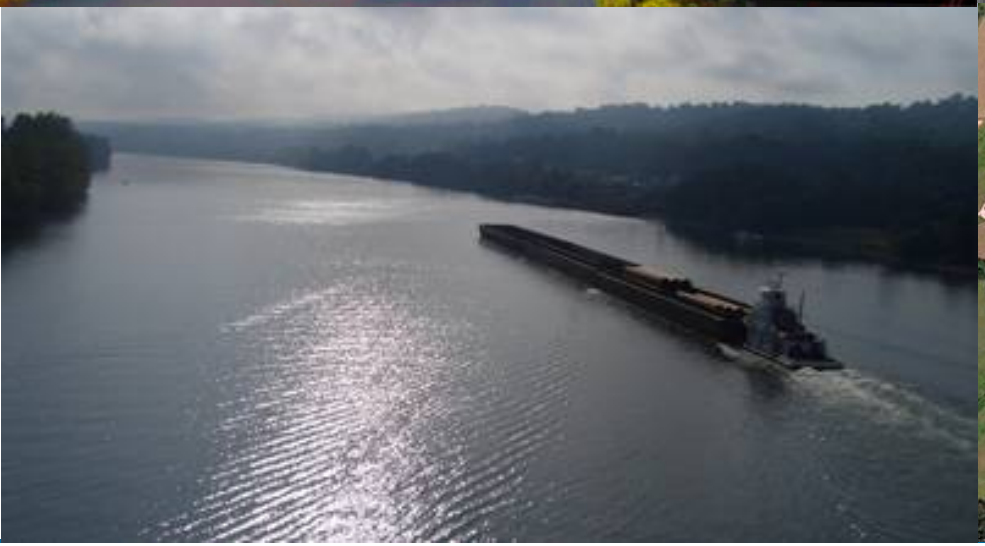
Sources – Alternative

Parameter	Value	Units
pH	5.0-9.0	
TSS	30	ppm
5-Day BOD	30	mg/l

EPA Secondary Treatment Standard

FYI, Reuse BOD = 49 to 7,175 mg/l

Sources – Surface Water



Sources – Surface Water

on: CR4

	Charters Run/Charters Creek
	WWF
	Yes
	0.20

Method:
Follow Susquehanna River Basin Commission (SRBC) Policy No. 2003-01.

Footnotes:
(1) From USGS Stream Stats Data-Collection Station Report.
(2) From USGS Low-Flow Statistics for Pennsylvania Streams.
(3) From USGS Stream Stats Ungaged Report.

Step #1: Determine SRBC Passby Fl

Withdrawal Location
CR4: Extraction point associated with Paxton #3H (1.4 miles).

Step #2: Determine Q7-10 Flow Rate

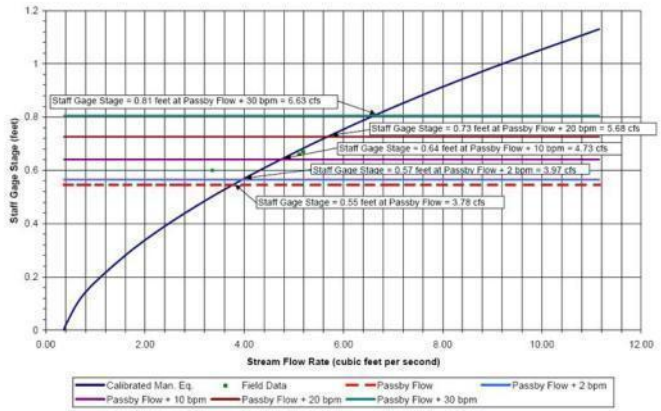
Withdrawal Location
CR4: Near existing Water Withdrawal Location on Charters Run

Step #3: Determine the Probability t

Flow Dur		
Probability of Exceedance		
P1		
P5		
P10		
P20		
P25		
P30		
P40		
P50		
P60		
P70		
P75		
P80		
P90		
P95	45	2.59
P99	29	1.67

FIGURE 4

Stage-Discharge Curve for Upstream Cross Section on Chartiers Run
Range Resources, Washington County, PA



available over 80 percent of the time.

Step #4: Determine the Months of the Year when the Total Required Flow will be Available

Monthly Data				
Month	Station Mean Flow[1] (cfs)	Weighted Mean Flow[2] (cfs)	Total Required Flow (cfs)	Is There Sufficient Flow?
January	334	19.26	3.97	Yes
February	441	25.41	3.97	Yes
March	587	33.83	3.97	Yes
April	458	26.39	3.97	Yes
May	327	18.84	3.97	Yes
June	211	12.16	3.97	Yes
July	151	8.70	3.97	Yes
August	145	8.36	3.97	Yes
September	99.4	5.73	3.97	Not Always
October	94.1	5.42	3.97	Not Always
November	130	7.49	3.97	Not Always
December	226	13.02	3.97	Yes

CONCLUSION:

On average, there should be sufficient flow in Chartiers Run at CR4 through out the year to allow a withdrawal rate of 0.19 cfs and maintain a SRBC passby flow of 3.78 cfs. However, there may be specific days during September through November when the flow rate goes below the required flow rate and a withdrawal could not be taken from the stream. A rule-of-thumb (2 X Weighted Mean Flow > Total Required Flow Rate) was used to determine the months when flow rates may be too low for withdrawal. An in-stream flow measurement will be required on a daily basis to confirm the stream flow rate and the availability of water for withdrawal.

4/24/2009 1 2.3.3 - CR4 Calculation

Water supply sources

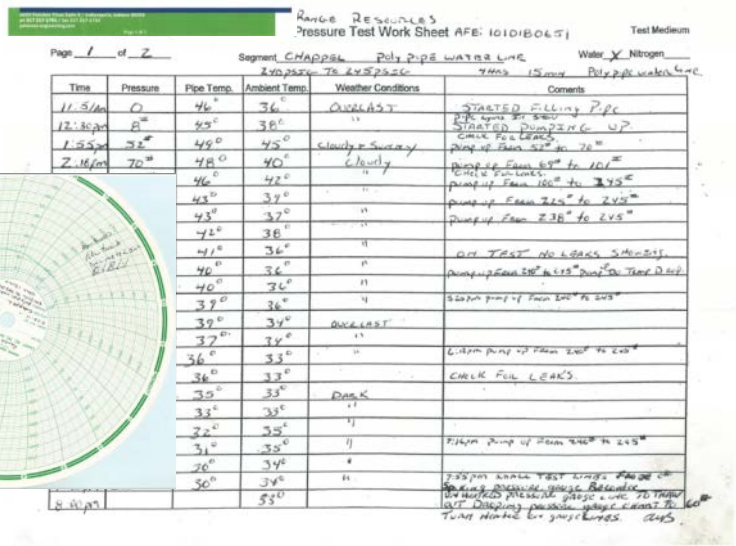
- Larger streams, rivers, and reservoirs
  - Water can be safely withdrawn at reasonable rates all year with exceptions for very driest periods
  - DEP has adopted SRBC method for analyzing water withdrawal and must approve all water management plans
  - Protection of downstream uses
  - Cumulative impact considerations
- Reuse is now a significant water source
  - 29.5% of Range's total water usage in 2011 was from reuse

Water Transfer

- Minimize Trucking
  - Source water, 800 - 900 trucks per well
  - Flowback, ~180 trucks per well
  - Proximity is key
- Pumping and Pipelines
  - Temporary
    - Integrity
    - Distance
  - Permanent network
    - Link large sources to storage locations
  - Noise Mitigation

Water Transfer

- 3rd Party Engineer Develops Test
  - Pipe rating
  - Component ratings
  - Layout
  - Weather conditions
- Separate Testing Firm Executes
- Approximately 8 hours
- Any failure results in re-test
- Scheduled 3-7 days prior to Frac
- Procedure/test for each job



Treatment, Reuse, and Disposal

- 10-30% of frac water flows back to surface after frac; balance is bound in micro fractures in shale
- Water flowed back after frac contains salts and other naturally occurring dissolved minerals present in ancient sea water
- Water is gathered and removed from site by either truck or pipeline
- Management methods during 2011:
  - Recycle
  - Injection wells
  - Advanced treatment facilities

Recycling - Challenging Convention

- April 2009
  - Started accumulating recycle water
    - DEP Chapter 78 Dam Permitted Impoundment
- August 2009
  - Competed first recycled water frac

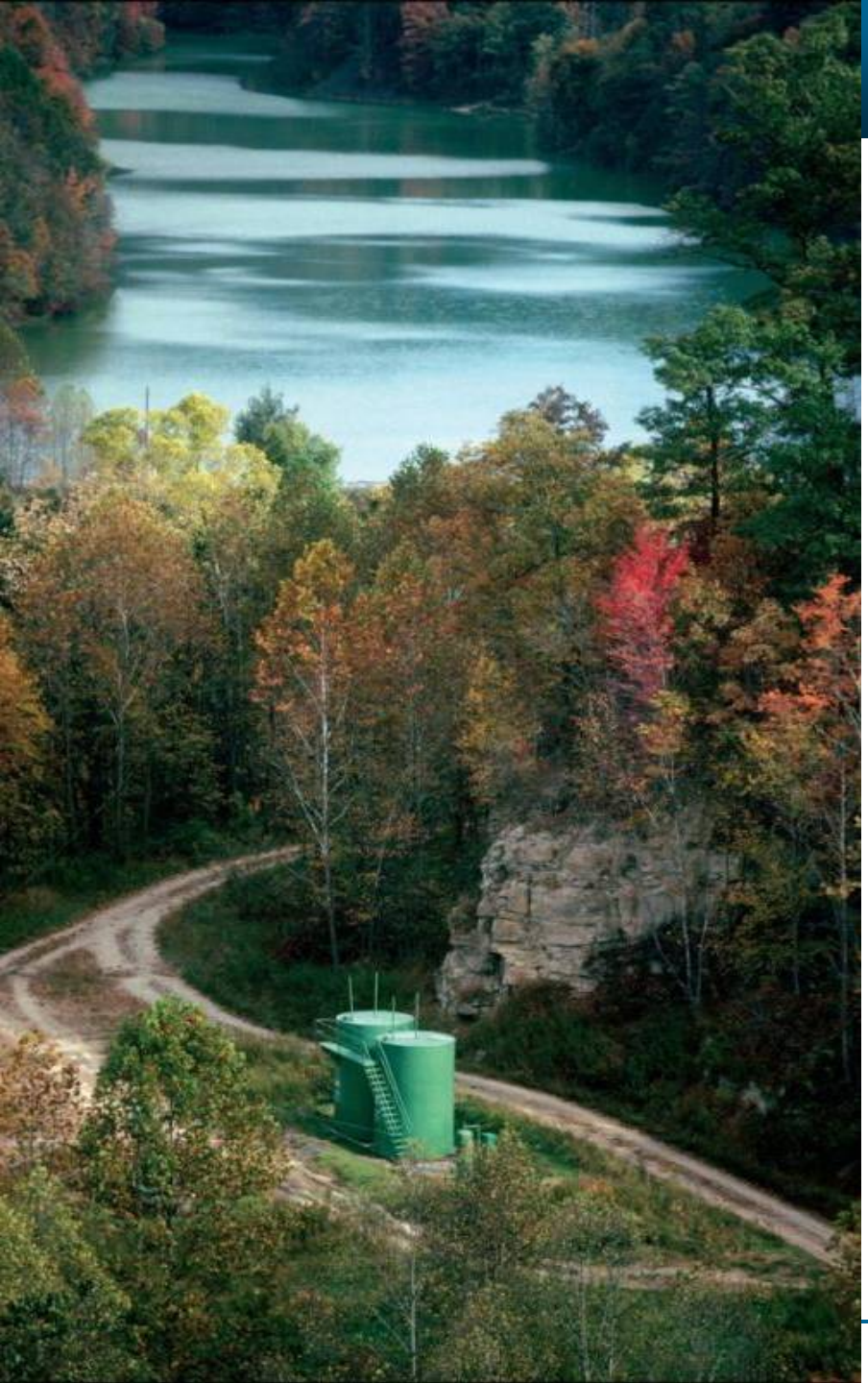
Rapidly Evolving Technology

- Recycling technology did not develop in other shale gas plays due to abundant opportunities for disposal by injection into deep rock formations
- Recycling in the Marcellus play has been driven by lack of other disposal options and regulatory framework
- Estimated that 75% of all Marcellus flowback water is currently being recycled
- Technology will continue to improve rapidly

Range Recycling 2011

- **Entire Marcellus Operations (North and South)**
  - **Flowback**
    - **Recycle 92.4%**
    - **Thermal/evaporative treatment 7.4%**
  - **Production Brine**
    - **Recycle 73.4%**
    - **Disposal Wells 17.5%**
    - **Thermal/evaporative treatment 9.1%**
  - **Drilling Fluids**
    - **Recycle 76.6%**
    - **Thermal/evaporative treatment 22.5%**
  - **Overall Recycle Rate 81.4%**

    (7.6% to disposal wells, 10.7% to advanced treatment)



Thank You

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MyRangeResources.com

MarcellusCoalition.org

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