

Natural Gas from Shale: *Landscape Impacts and Remediation*



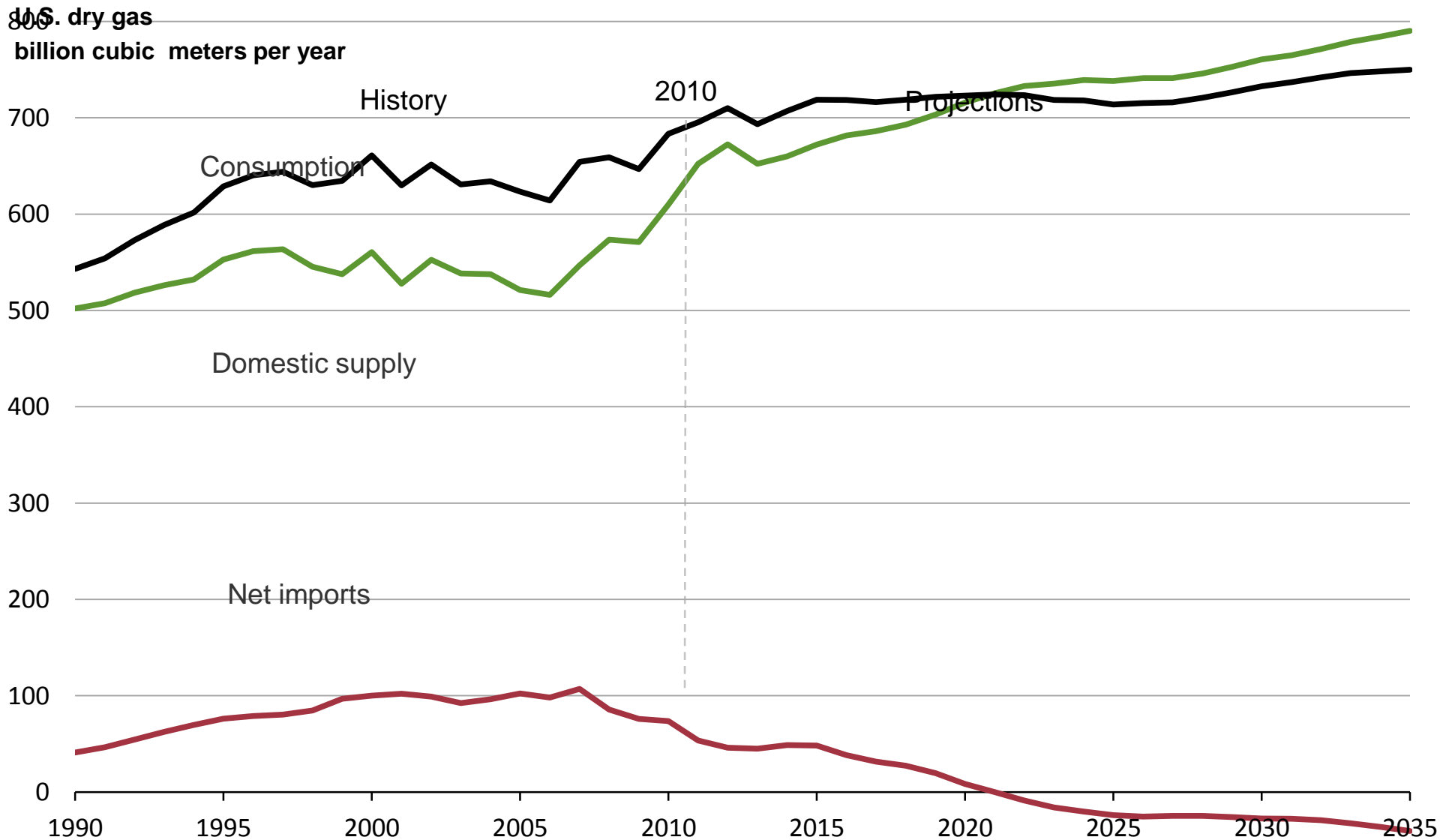


Marcellus Center for Outreach and Research (MCOR)

- Conduct research related to shale development in PA, the U.S., and globally
- Coordinate throughout Penn State University system
- Collaborative approach with other institutions, government agencies, NGOs, etc
- Research related to downhole technologies and above ground impacts--best management practices (BMPs)
- Science-based outreach sessions to various stakeholders and the public

Energy Security: U.S. Self-sufficient in Natural Gas

Oil and
Natural Gas

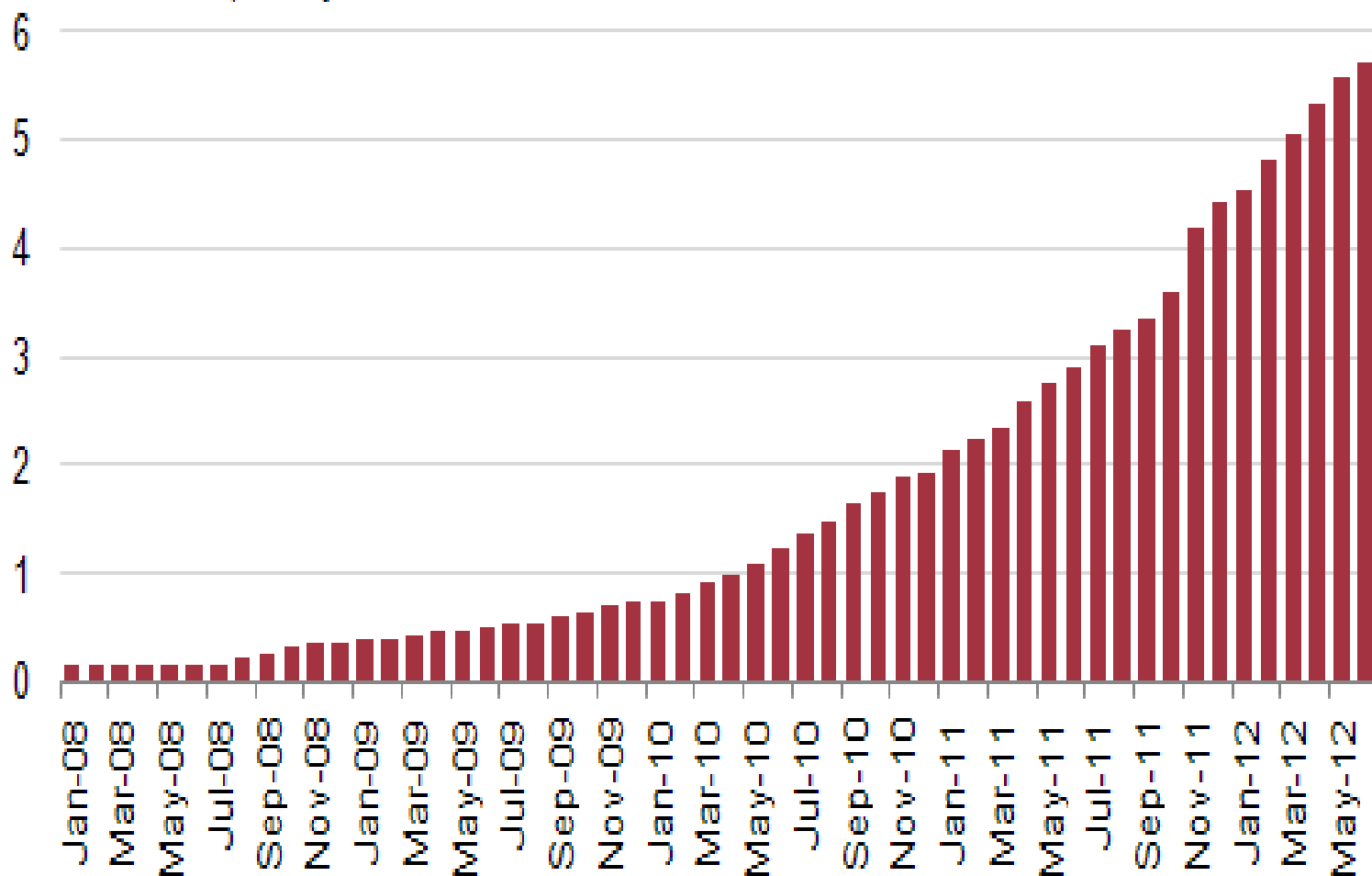


• Source: DOE, EIA, Annual Energy Outlook 2012 Early Release

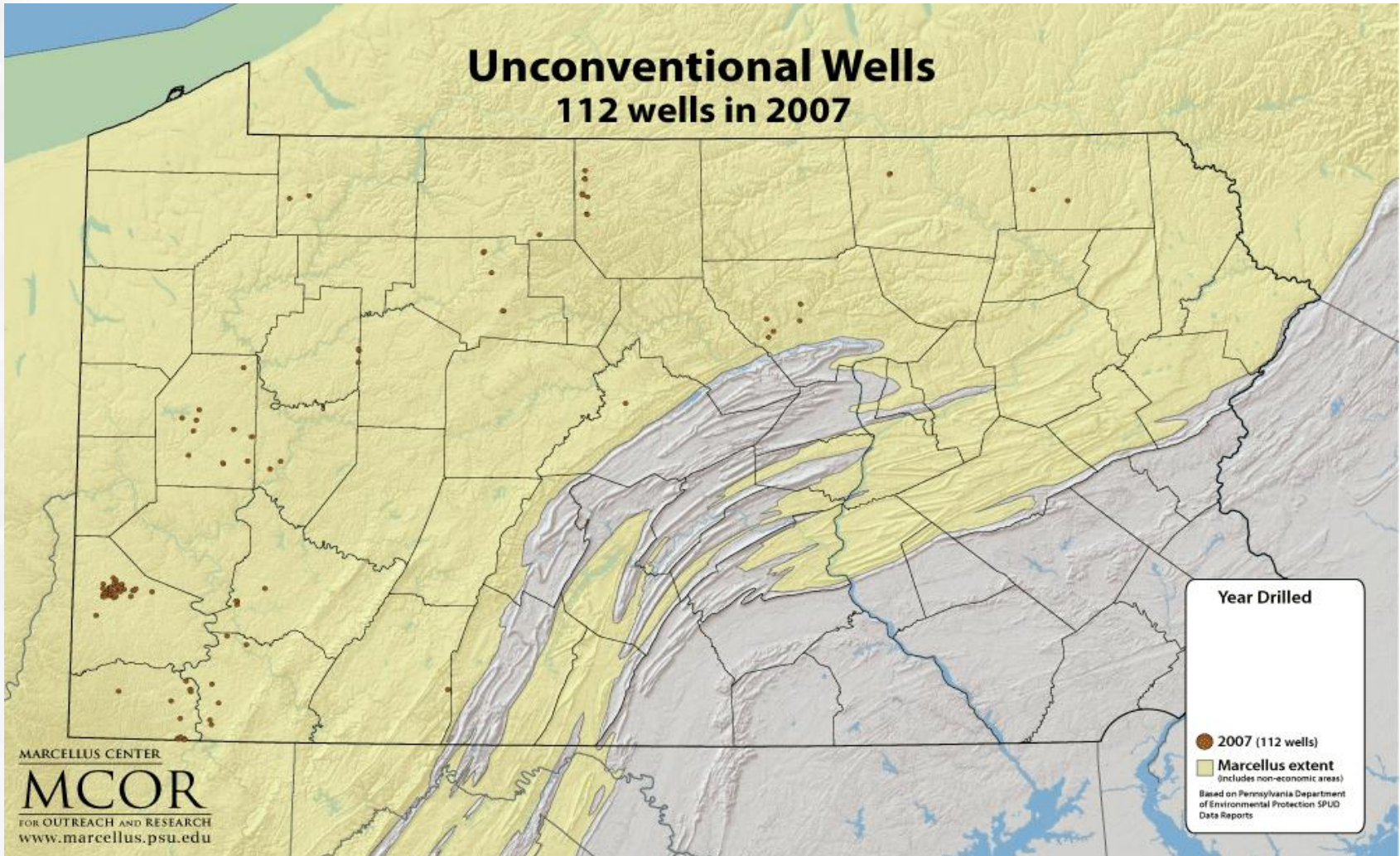
Estimated average monthly dry natural gas production in Pennsylvania, January 2008 - June 2012



billion cubic feet per day



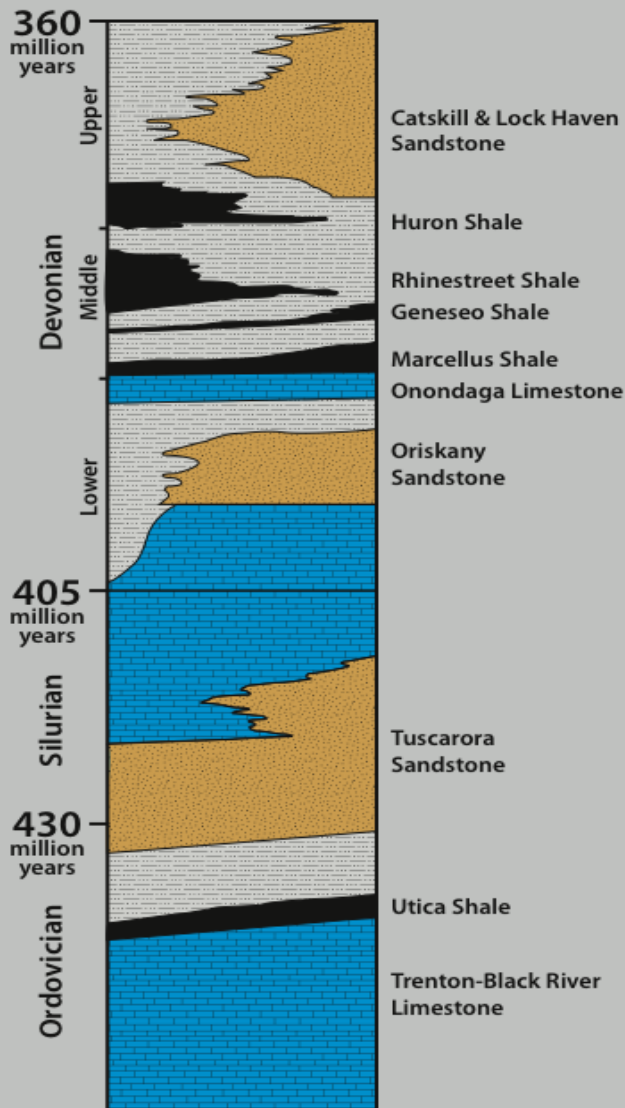
Marcellus Wells Drilled (12/1/12)



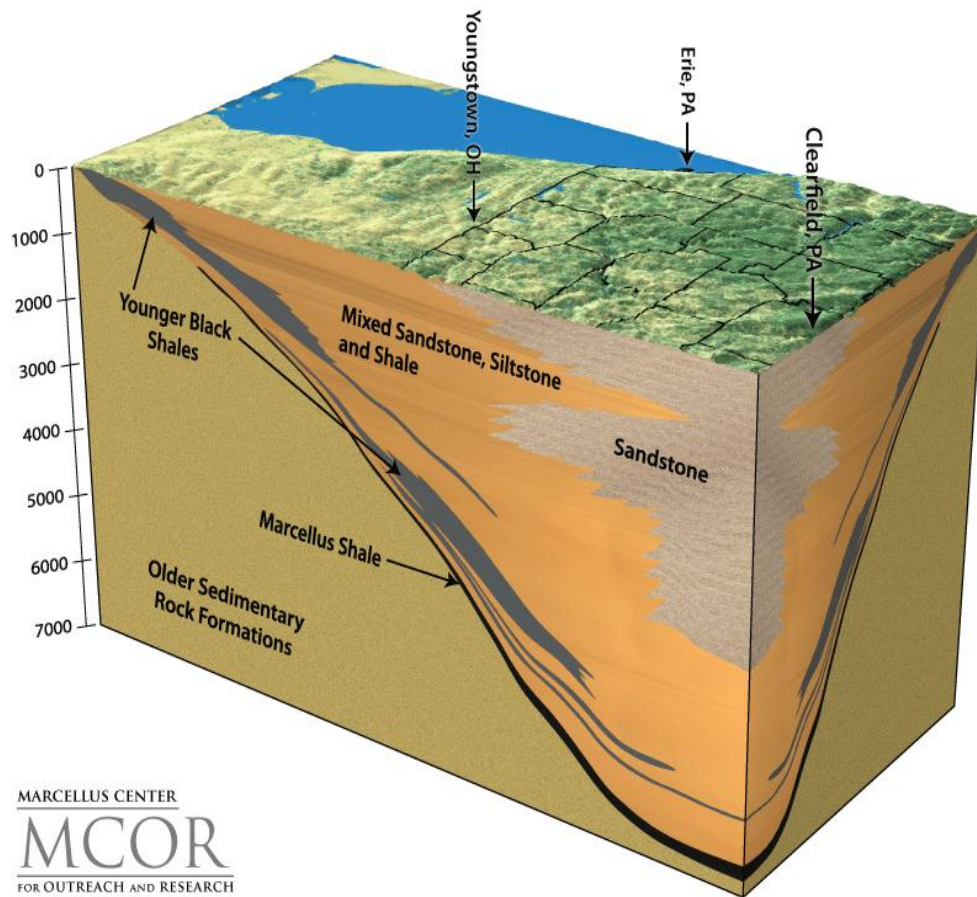


Other Shale Targets

Key Gas-Producing Formations in Pennsylvania



Generalized Geologic Cross Section Showing Marcellus Shale in Western Pennsylvania

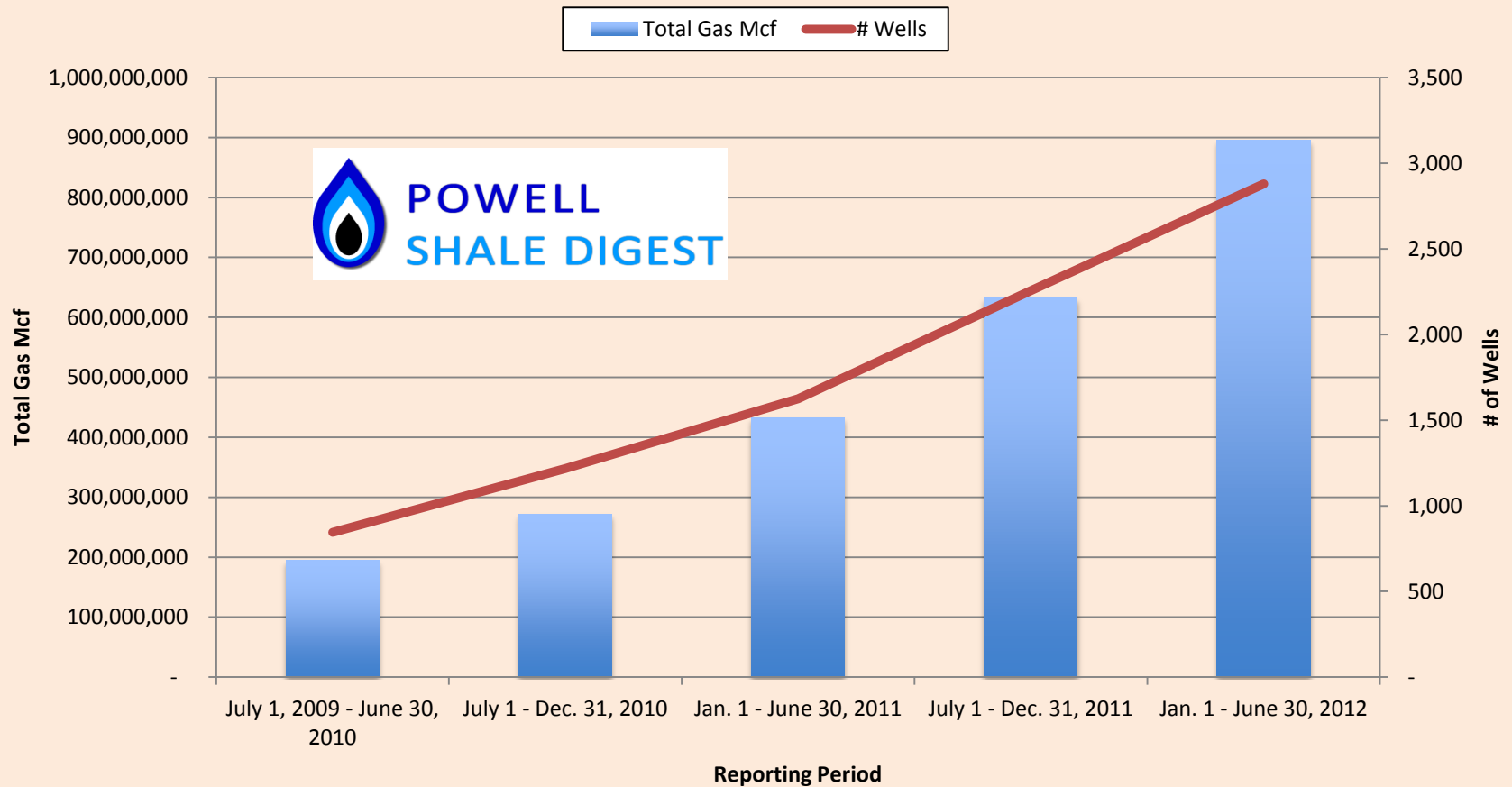


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Growth Of Shale Gas Dev'l

Pennsylvania Unconventional Growth in Total Gas Mcf & # Wells by Reporting Period July 1, 2009 - June 30, 2012



Source: Pennsylvania Department of Environmental Protection

Powell Shale Digest, Sep. 24, 2012



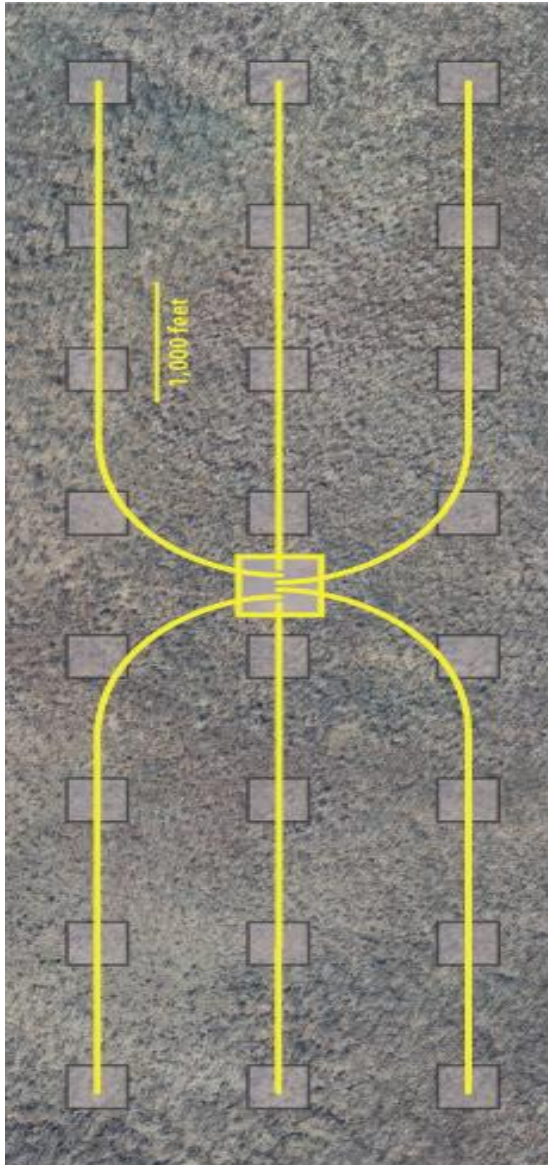
Evolving Shale Policy Issues

- Economics of development
- Constraints in transmission pipeline capacity
- Marcellus wells on pipeline
- Pennsylvania's Legislative Act 13
- Regulatory updates PA vs. NY or OH
- Water sourcing and regulation
- Waste fluid management
- Global implications and impact locally

Common NGS Well Sites



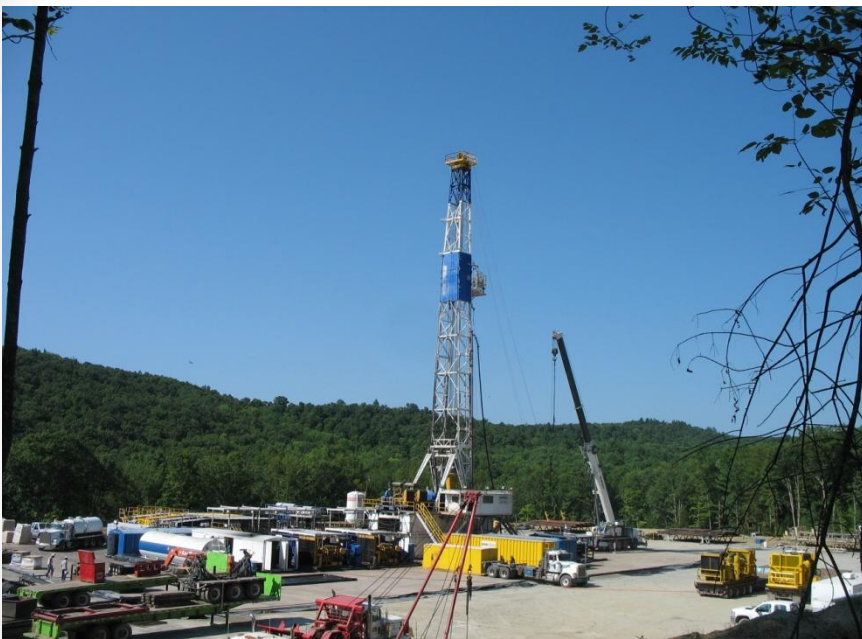
Horizontal Drilling Patterns



- Smaller overall footprint
 - 2% land disturbance vs. vertical ~19%
 - One drilling pad
 - Fewer roads, pipeline connections
- Drilling Unit
 - 1-2 square mile



Drilling Process Overview





Groundwater/Pad Protections





Hydraulic Fracturing Process and Impacts



Typical Marcellus Well Pad



- Completed well pads 1-2 hectares
- Remainder replanted/restored
- Access road and pipeline connection
- Production equipment onsite
- Typically quiet



Noise Abatement Techniques



Proximity to Agriculture





Land Use Changes



- Pipeline
 - 50K miles for gathering lines
- Agricultural use
 - Multi-generational use
- “Industrialization”
- Holistic land planning
- State Forest
 - Wild lands
 - Wildlife habitat
 - Timber resource
 - Certification
- Terminal use of property
- Aesthetics
 - Impact to tourism
- Traffic
 - Mitigation??

Protection of Agricultural Soils

- Separation of soil horizons and similar restoration
- Establishment of productive cover crops or vegetation
- Prevention of invasive species
- Payment for crop loss – multi-year



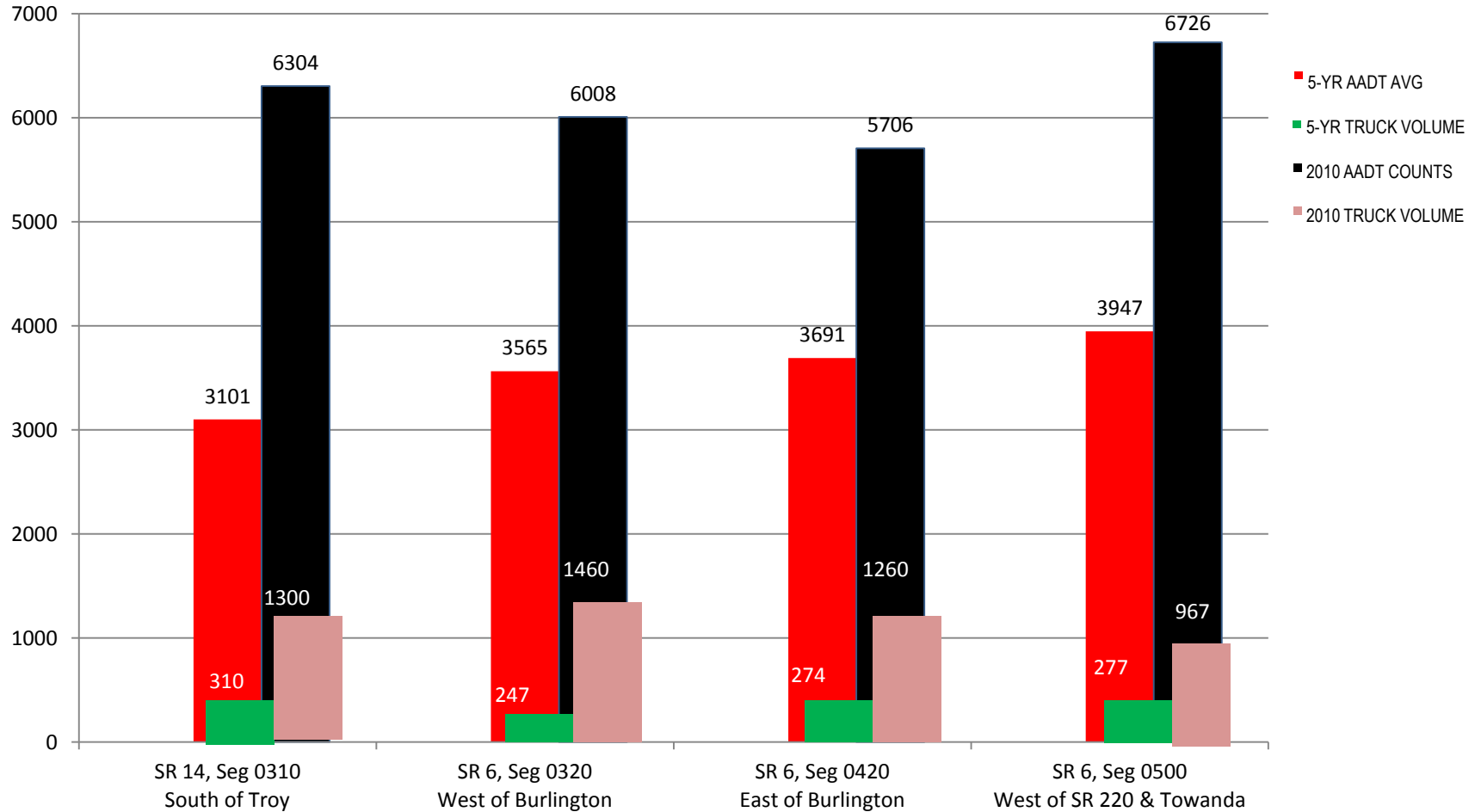
Site Renovation





Traffic Increases

Bradford County Traffic 5-Year Average vs. 2010 Counts



“AADT” is Average Annual Daily Traffic Source: PennDOT



Roads



- \$500M+ in road repairs since 2008 in Marcellus
- \$90M+ in one region of PA in one year
- 1000+ truck trips/well
- Piping vs. trucks
- Truck corridors
- Spill prevention
- Vehicle inspection



Pictures: Chesapeake Energy

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Larger/Permanent Investment






New Water Infrastructure





www.marcellus.psu.edu
www.msetc.org
www.naturalgas.psu.edu



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