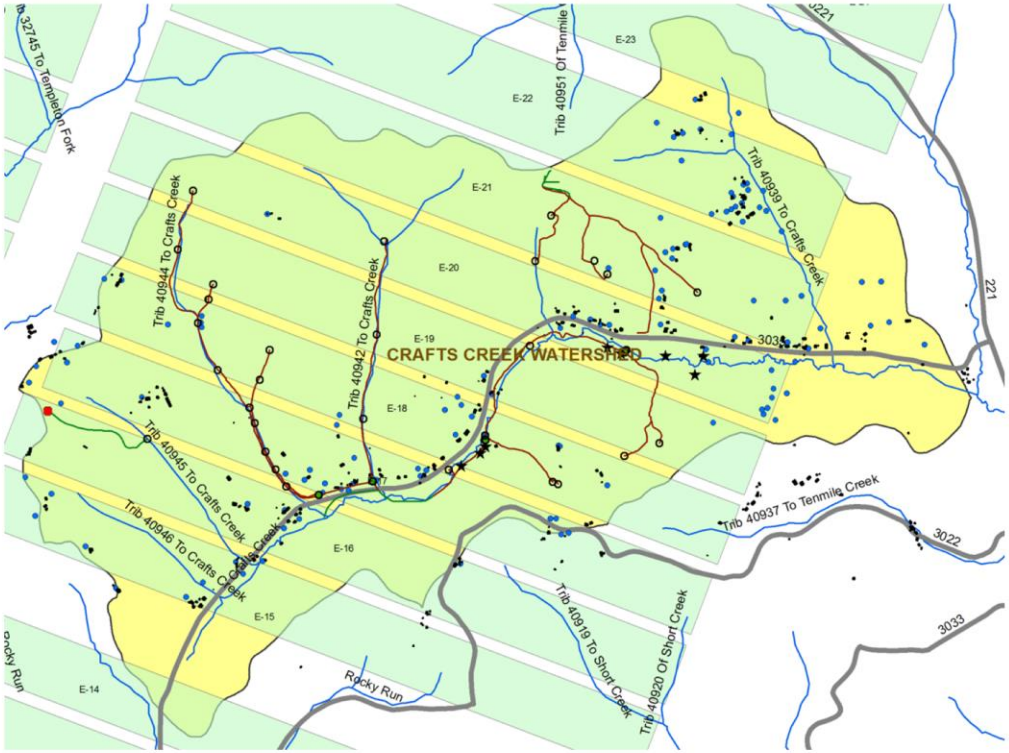
# The Effects of Subsidence Resulting from Underground Bituminous Coal Mining, 2008-2013

**Bituminous Mine Subsidence and Land Conservation Act**
**Act 54 Amendments**
**4th Five-Year Report**





Stephen J. Tonsor
Alison N. Hale
Anthony Iannacchione
Daniel J. Bain
Michael Keener
Erin Pfeil-McCullough
Keith Garmire


Pennsylvania Department of Environmental Protection

# ACT 54

## Bituminous Mine Subsidence and Land Conservation Act

**SECTION 18.1 OF ACT 54** REQUIRES THAT THE DEP:

- Compile information related to surface impacts of underground bituminous coal mining

- Report findings every 5 years to
  - the Governor
  - General Assembly
  - Citizens Advisory Council

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# ACT 54 TEAM

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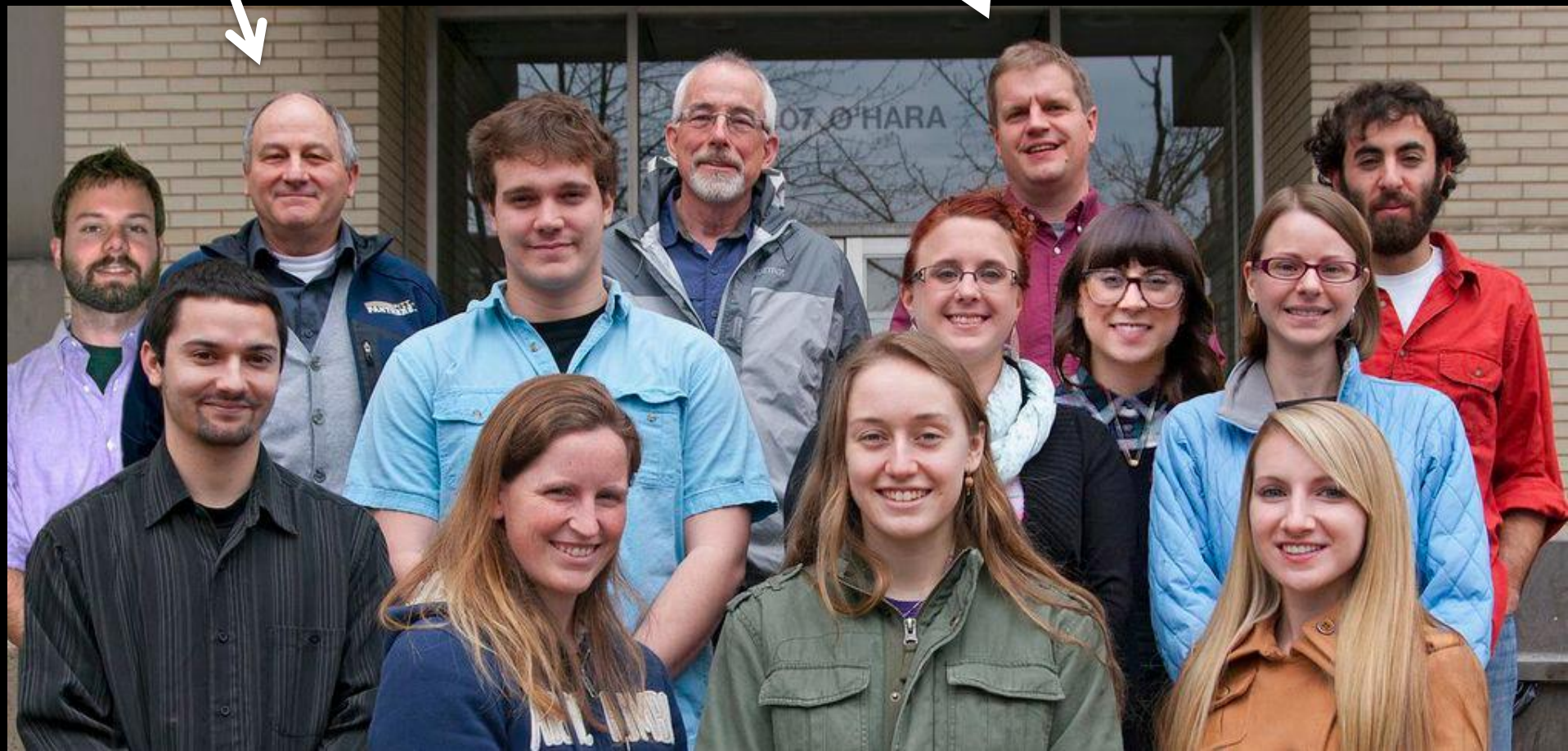

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Environmental Engineering

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Geology and Planetary Science

Dr. Stephen Tonsor
Biological Sciences

Dr. Alison Hale
Biological Sciences

# Acknowledgements


- **PADEP**
  - Greg Shuler, Geologist
  - Tom Callaghan, Director of the Bureau of Mining Programs
  - California District Mining Office

- **Mine companies**
  - Consol Energy, Inc.
  - Alpha Natural Resources
  - Mepco Intermediate Holdings
  - Rosebud Mining Co.

- **Various organizations**
  - Dr. Timothy Pearce, Carnegie Museum of Natural History
  - Chris Tracey, Western Pennsylvania Conservancy
  - Jared Pritts, Army Corps of Engineers

# Most definitive Act 54 report to date

- Greater data coverage
- Greater experience in the Act 54/DEP context

# The Effects of Subsidence Resulting from Underground Bituminous Coal Mining, 2008-2013

**Bituminous Mine Subsidence and Land Conservation Act**
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Under contract with the PADEP,
the University was tasked with providing:

- Detailed analysis of underground mining effects on surface features

- Data-based recommendations on the process for obtaining and managing information related to these effects.

**Bituminous Mine Subsidence and Land Conservation Act**
**Act 54 Amendments**
**4th Five-Year Report**

## CENTRAL VALUES AND GOALS of ACT 54 team:

- Coal is a treasured natural inheritance from Pennsylvania's ancient ecosystem.

**Bituminous Mine Subsidence and Land Conservation Act**
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- Impartiality is a core value

**Bituminous Mine Subsidence and Land Conservation Act**
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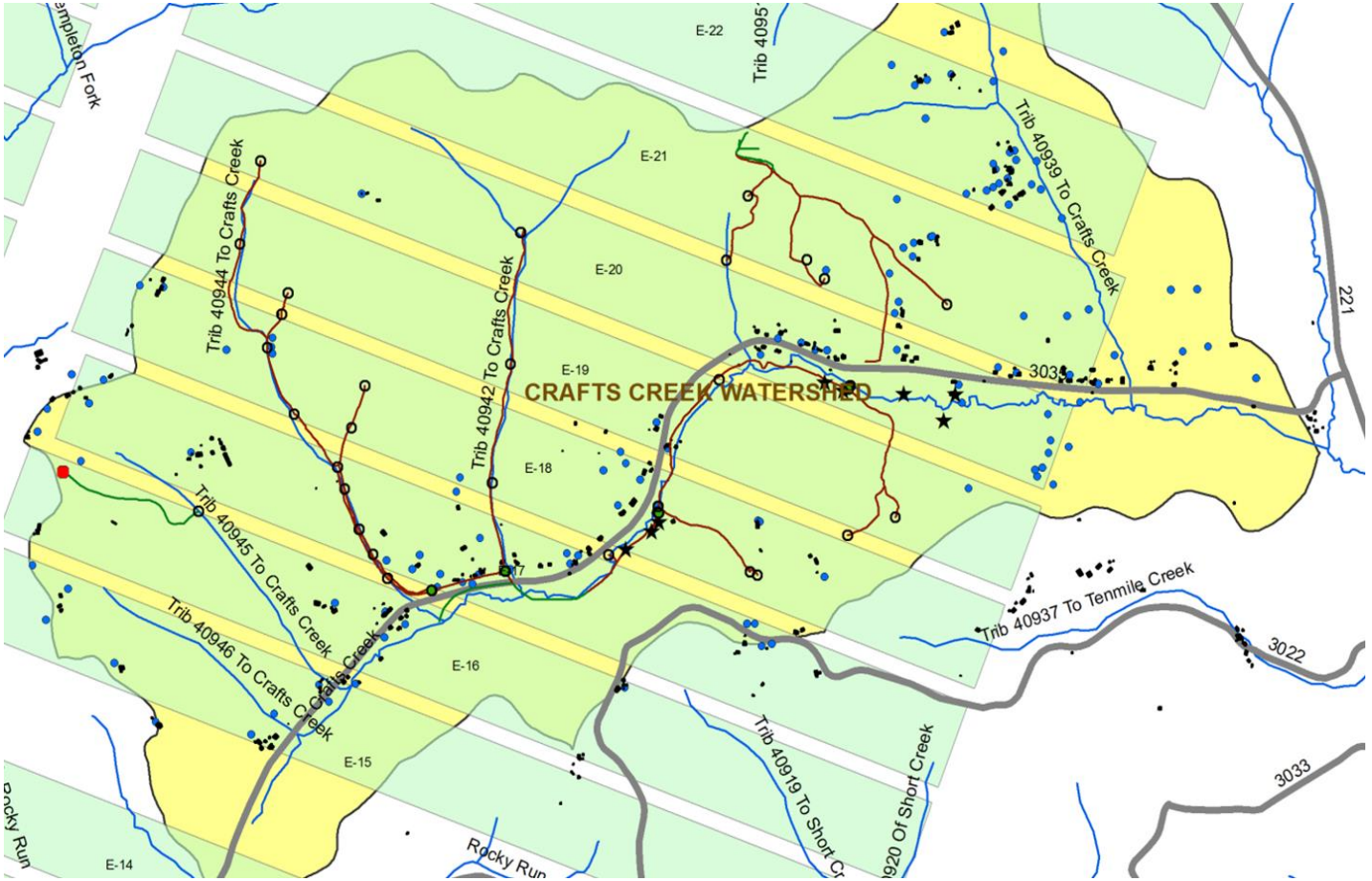
**4th Five-Year Report**

## CENTRAL VALUES AND GOALS of ACT 54 team:

- Coal is a treasured natural inheritance from Pennsylvania's ancient ecosystem.
- The goal is wise use of the Commonwealth's coal.
- Impartiality is a core value
- We provide the best unbiased information possible

# ANALYZING IMPACTS IS MAINLY A SPATIAL PROBLEM

The University developed a Geographic Information System: **ACT54GIS**



# ACT54GIS
# BASE DATA FROM PA SPATIAL DATA ACCESS (PASDA):

- **Roads:**
  - Local roads created by PennDOT
  - State roads created by PennDOT
- **Hydrologic features:**
  - Networked streams of Pennsylvania from the Environmental Resources Research Institute (ERRI) at PSU
  - Small watersheds from the USGS Water Resources Division's major watersheds dataset by ERRI at PSU
- **Political boundaries:**
  - Statewide county boundaries created by PennDOT
- **Elevation:**
  - PAMAP Program LAS: 3.2 ft resolution LiDAR Digital Elevation Models (DEMs)

PASDA, http://www.pasda.psu.edu/

# ACT54GIS
# MINING DATA:

## 6-month mining maps

- Submitted to PADEP, depicting:
  - Mining activity during the prior 6 months
  - Prediction of mining activity in the following 6 months
  - Surface features, including
    - Properties
    - Structures
    - Water supplies and utilities
    - Streams, wetlands
- 525 6-month mining maps were used in constructing the ACT54GIS.

**ACT54GIS**
**SURFACE FEATURES TRACKED BY PADEP:**

**BITUMINOUS UNDERGROUND**
**MINING INFORMATION SYSTEM – BUMIS**

- Intended to track impacts on surface features

- Features included:
  - Structures
  - Utilities – power, water, gas, roads
  - Wells & springs
  - Streams

## PROBLEMS ENCOUNTERED WITH BUMIS

- Spatial coordinates rarely provided in BUMIS.
- Features intended to have an associated unique identification number
  - 40% of features lacked this number
  - PADEP corrected 250 errors
  - After error corrections, 30% still lacked ID numbers.
  - Often one number applies to multiple features
- Data entry errors are common
- Data is often incomplete
- There has been no QA/QC process

- **BUMIS cannot be relied upon to be the authoritative source of information on undermined surface features.**

**ACT54GIS**
**LAYERS CONSTRUCTED BY THE UNIVERSITY**

- Mining Extents
- Surface Features
- Overburden
- Buffers
- Stream Observations
- Stream Bio-monitoring Stations
- Topography
- Wetlands

## MINING ACTIVITY August 2008 – August 2013:

- 31,234 acres undermined
- 18% less area than in the 3rd reporting period
- 46 mines in operation
  - 7 longwall
  - 34 room-and-pillar
  - 5 pillar recovery

**EFFECTS ON STRUCTURES August 2008 – August 2013:**

- 389 structure effects reported.
- 330 (85%) were resolved during the reporting period
  - average time to resolution 169 days.
- 238 (61%) deemed to be due to undermining.
- 157 (66%) were resolved by agreement.
- Tracking structure effects was often difficult due to frequent lack of unique structure identifiers in BUMIS.

**EFFECTS ON WELLS, SPRINGS & PONDS 2008 – 2013:**

- 855 reported effects
  Evenly split between longwall and room & pillar mines.

- 201 (24%) unresolved at end of reporting period

- Average resolution time for remainder = 220 days.

- Where operator was deemed to be responsible:
  - time to resolution = 415 days.
  - 70% were resolved by agreement.
  - If settled by agreement, no way to determine if water supply permanently impacted.

- Difficulties with BUMIS compromised ability to collect and interpret data.

**EFFECTS ON HYDROLOGY 2008 – 2013:**

- > 750 water quantity and quality sampling points
- 31,000 sampling events
- Reported flow monitoring is insufficient to meet permitting requirements or report on hydrologic effects.
- Relatively minor changes in sampling protocols and frequencies can result in greatly improved analysis of effects.

**EFFECTS ON STREAMS 2008 – 2013:**

- 96 miles of streams undermined
- 51 miles undermined by longwall mining
- 39 miles of streams undermined by longwall mining experienced flow loss, pooling or both somewhere along channel
- Maximum dry season flow loss: ~1,000 to 10,000 ft.
- Maximum wet season flow loss: ~100 to 1,000 ft
- Insufficient data was available to determine the lengths of subsidence-induced pooling.

# EFFECTS ON STREAMS 2008 – 2013: FLOW LOSS

- Macroinvertebrate assemblages used as a metric of a stream's health, using PADEP's Total Biological Score (TBS).
- Two mayfly families, Ephemerellidae and Heptageniidae, are often lost from streams post-mining.
- Community composition shifts significantly post-mining.

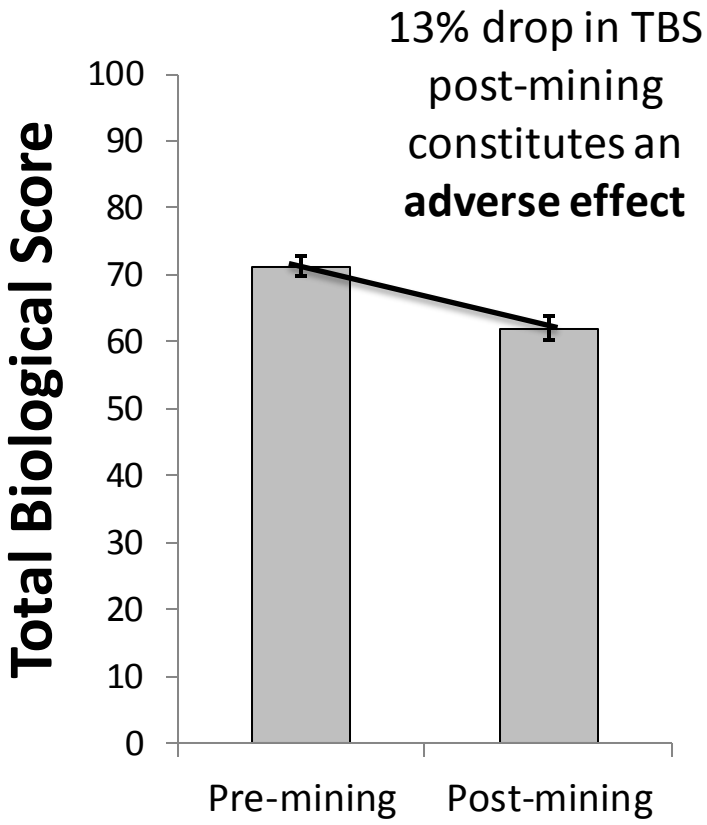



Figure VII-7

**On average, macroinvertebrates appear to be adversely affected by flow loss following longwall mining.**

# EFFECTS ON STREAMS 2008 – 2013: FLOW LOSS

- Stream conductivity and pH increase significantly in stream impacted by flow loss after longwall mining.

| Table VII-10 | **Pre-mining** | **Post-mining** |
|---|---|---|
| **Conductivity*** | 169 +/- 9 | 330 +/- 12 |
| **pH*** | 7.30 +/- 0.04 | 7.88 +/- 0.07 |

US EPA conductivity benchmark
for aquatic life: **300 µS**

**Stream chemistry is adversely affected by flow loss impacts following longwall mining and does not appear to recover within the time frame of study.**

US EPA. 2011. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=220171#Download

# EFFECTS ON STREAMS 2008 – 2013: POOLING

- Subsidence-induced pooling reduces TBS on average.
- 28 stream segments received gate cut mitigation, following which TBS, on average, returned to pre-mining levels.

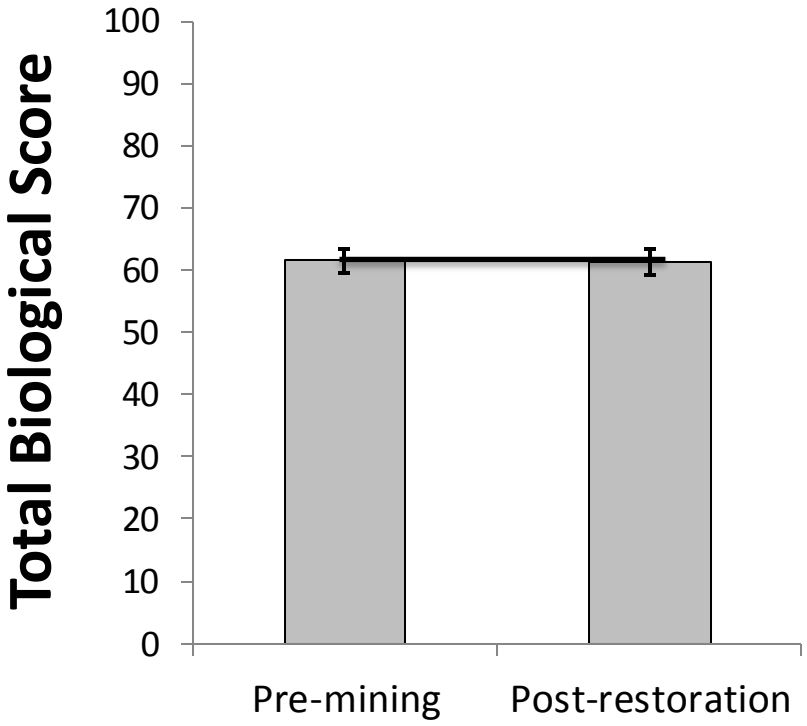



Figure VII-19


Figure VII-11

## EFFECTS ON STREAMS 2008 – 2013: UNRESOLVABLE EFFECTS FROM 3RD ASSESSMENT

- 8 stream impacts were deemed unresolvable by PADEP.
- Mitigation techniques did not restore stream flow to pre-mining conditions.
- These unrecoverable streams were characterized by:
  - Shallow depth to mining
  - Impacts at depths less than 400 ft.

**Some streams, especially with shallow mining depths, do not recover from subsidence-driven loss of flow.**

**EFFECTS ON WETLANDS 2008 – 2013:**

- Assessment process still developing
  - Many active mines' permits pre-date TGD 563-2000-655
  - For these, data from permit revisions was used.

- 33-41% of wetland acreage is lost after subsidence

- Losses are offset by subsidence-driven origin of new wetlands.

- Lost wetlands are a mix of palustrine emergent, scrub/shrub, and forest types.

- New wetlands are mostly palustrine emergent.

**Although there is no net loss of wetlands, longwall mining changes the character of the wetlands.**

## RECOMMENDED CHANGES IN PADEP PRACTICES:

- Standardization of data acquisition and submission to PADEP
  - Changes in timing and frequency of data acquisition
  - Establishment of standards for submitted data.
    - All submission should be electronic on standardized forms with standardized contents and metadata.
    - PADEP data entry & management
      - Written protocols for entry and QA/QC
    - This would facilitate:
      - rapid and efficient compilation of the Act54 report
      - more uniform and efficient regulatory process.

## RECOMMENDED CHANGES IN PADEP PRACTICES:

- Identification and tracking of impacts through modernization of data management system.
    - Link BUMIS to a GIS system.
    - Develop a single standardized data base for stream impacts.
    - Establish rigorous standards for impact on & recovery of stream flow.
    - Improve and standardize reporting on wetlands effects.

# Language from Master Agreement on recommendations to be made by University

- **Task: 10.0 Recommendations / Conclusions**

- 10.1–The University will submit an evaluation of the compiled data with conclusions concerning the effectiveness of PADEP's implementation of Act 54, and policies.

- 10.2–The University will provide recommendations based on the analysis of the data to the on how to improve the implementation of Act 54s.