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

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Anthony Iannacchione
Daniel J. Bain
Michael Keener
Erin Pfeil-McCullough
Keith Garmire

Research was conducted by the University of Pittsburgh for the Pennsylvania Department of Environmental Protection
Dear Mr. Shuler,

This letter accompanies the University’s 4th Act 54 assessment period report entitled “The Effects of Subsidence Resulting from Underground Bituminous Coal Mining, 2008 to 2013”. This report is the culmination of work by 24 researchers at the University of Pittsburgh over a two-year period. We believe it to be the most comprehensive Act 54 assessment to date.

Thank you for the opportunity to work with you in providing this information to the citizens of the Commonwealth of Pennsylvania.

Sincerely,

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Justin Coughlin, Undergraduate Researcher
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ACRONYMS AND ABBREVIATIONS

Units of measurement

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>%</td>
<td>percent</td>
</tr>
<tr>
<td>cfs</td>
<td>cubic feet per second</td>
</tr>
<tr>
<td>ft</td>
<td>feet</td>
</tr>
<tr>
<td>ft³</td>
<td>cubic feet</td>
</tr>
<tr>
<td>GB</td>
<td>gigabytes</td>
</tr>
<tr>
<td>gpm</td>
<td>gallons per minute</td>
</tr>
<tr>
<td>in</td>
<td>inches</td>
</tr>
<tr>
<td>lbs</td>
<td>pounds</td>
</tr>
<tr>
<td>m</td>
<td>meters</td>
</tr>
<tr>
<td>MA</td>
<td>million years ago</td>
</tr>
<tr>
<td>mi</td>
<td>miles</td>
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</tbody>
</table>

General

- Act 54: 1994 amendments to BMSLCA
- Act54GIS: University of Pittsburgh’s Act 54 geographic information system
- ArcGIS: geographic information systems software produced by ESRI
- AutoCAD: design software produced by Autodesk
- BMSLCA: Bituminous Mine Subsidence and Land Conservation Act
- BUMIS: Bituminous Underground Mining Information System
- CAD: computer-aided design
- CDMO: California District Mining Office
- DEM: digital elevation model
- EIA: United States Energy Information Administration
- EHB: Environmental Hearing Board
- EPA: United States Environmental Protection Agency
- ERRI: Environmental Resources Research Institute
- GIS: geographic information system
- GPS: global positioning system
- MrSID: multi-resolution seamless image database
- MSI: Mine Subsidence Insurance
- NHD: National Hydrography Dataset
- NLCD: National Land Cover Database
- PADEP: Pennsylvania Department of Environmental Protection
- PAGWIS: Pennsylvania Groundwater Information System
- PASDA: Pennsylvania Spatial Data Access
- PennDOT: Pennsylvania Department of Transportation
- PSU: Penn State University
- RMSE: root mean squared error
- RPZ: rebuttable presumption zone
- SE: standard error
- SMCRA: Surface Mining Control and Reclamation Act of 1977
- SSA: Surface Subsidence Agent
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>TIF</td>
<td>tagged-image format</td>
</tr>
<tr>
<td>USGS</td>
<td>United State Geological Survey</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator coordinate system</td>
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**Hydrology**

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<tbody>
<tr>
<td>HMR</td>
<td>Hydrologic Monitoring Report</td>
</tr>
<tr>
<td>NWIS</td>
<td>National Water Information System</td>
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**Streams**

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<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>EPT</td>
<td>Ephemeroptera, Plecoptera, and Trichoptera taxa</td>
</tr>
<tr>
<td>FRAGSTATS</td>
<td>spatial pattern analysis software by the University of Massachusetts</td>
</tr>
<tr>
<td>MBII</td>
<td>Macroinvertebrate Biotic Integrity Index</td>
</tr>
<tr>
<td>NMDS</td>
<td>Non-metric multi-dimensional scaling</td>
</tr>
<tr>
<td>PLS regression</td>
<td>Partial least squares regression</td>
</tr>
<tr>
<td>SAS</td>
<td>Statistical Analysis System software produced by SAS Institute</td>
</tr>
<tr>
<td>TBS</td>
<td>Total Biological Score</td>
</tr>
<tr>
<td>UNT</td>
<td>unnamed tributary</td>
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<tr>
<td>WRDS</td>
<td>Water Resources Data System</td>
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**Wetlands**

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<tbody>
<tr>
<td>NWI</td>
<td>National Wetlands Inventory</td>
</tr>
<tr>
<td>PEM</td>
<td>Palustrine emergent wetlands</td>
</tr>
<tr>
<td>PEM1</td>
<td>Palustrine emergent wetlands that are dominated by vegetation that remains standing until the following growing season</td>
</tr>
<tr>
<td>PEM1B</td>
<td>Palustrine emergent wetlands that are dominated by vegetation that remains standing until the following growing season and that are characterized by a saturated water regime</td>
</tr>
<tr>
<td>PFO</td>
<td>Palustrine forested wetlands</td>
</tr>
<tr>
<td>PFO1</td>
<td>Palustrine forested wetlands that are dominated by broad-leaved deciduous vegetation</td>
</tr>
<tr>
<td>POW</td>
<td>Palustrine open water wetland</td>
</tr>
<tr>
<td>PSS</td>
<td>Palustrine scrub/shrub wetlands</td>
</tr>
<tr>
<td>PUBHh</td>
<td>Palustrine unconsolidated bottom wetlands that are permanently flooded due to a dike or impoundment</td>
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