SECTION V: Effects of Mining on Water Supplies

V.A – Overview

The University was tasked with assessing water supplies impacted by underground bituminous mining during the 4th Act 54 assessment period. This section includes an inventory of water supplies undermined during the 4th assessment period and evaluates the 855 reported water supply effects from this period. In addition, the University reports on 211 unresolved effects from the 3rd assessment period and provides a brief summary of their current status. Information on water supply reported effects from the 3rd assessment period are discussed by Witkowski (2011). Topics covered in this section include analysis of:

- Actions by the mine operators and PADEP,
- Determinations of liability by the PADEP,
- Development of permanent replacement water supplies, and
- Length of time required to resolve reported effects.

Lastly, the University used statistical analyses and modeling to aid in assessing a water supply's susceptibility to impacts from underground mining.

V.B – Reported Effects

The topic of reported effects was discussed in Section IV.B and should be referred prior to reviewing Section V (see a portion of this discussion below):

> *… 'A reported effect occurs when a feature is thought to be impacted by subsidence. Mine operators, residents, or agents of PADEP request a feature be considered for repair or compensation. A reported effect can be found to be 'company liable' or it may be classified as 'not due to underground mining'. …*

Here too, when analyzing the reported effects database extracted from BUMIS, the water supply 'feature type' associated with the reported effect database was not always adequately classified.

The BUMIS database contains significant occurrences where water supplies were classified as land reported effects and vice-versa. The same problem was true of BUMIS structure data analyzed in Section IV. In addition, unresolved water supply reported effects were, for the most part, not given an interim status. The number of water supply reported effects has significantly increased since the 3rd assessment period.

V.C – Data Sources

Information regarding water supplies comes mostly from the PADEP's BUMIS database and company submitted six-month mining maps. Additional information is collected from hydrologic monitoring reports and interviews with field agents.

V.C.1 – Water Supplies Tracked by PADEP

The Act 54 legislation defines a water supply as:

> *"any existing source of water used for domestic, commercial, industrial or recreational purposes or for agricultural uses, including use or consumption of water to maintain the health and productivity of animals used or to be used in agricultural production and the watering of lands on a periodic or permanent basis by a constructed or manufactured system in place on the effective date of this act to provide irrigation for agricultural production of plants and crops at levels of productivity or yield historically experienced by such plants or crops within a particular geographic area, or which serves any public building or any noncommercial structure customarily used by the public, including, but not limited to, churches, schools and hospitals."*

Water supplies must have one of the specified uses in the Act 54 legislation, as stated by the property owner in the pre-mining survey, to be considered in the inventory provided by BUMIS and the six-month mining maps.

V.C.2 – University's Process for Tracking Water Supplies

To comply with the standards discussed above, the University developed a process to compile and categorize information about water supplies in the Act54GIS database.

First, the University calculated a Rebuttable Presumption Zone (RPZ) and used this buffer as a basic criterion for inventorying undermined water supplies (see Section II.C.4). Within the RPZ, any adverse effects on a water supply are initially presumed to be caused by undermining. The mining operator can rebut that assumption by providing evidence to the contrary (see Section V.D below). The RPZ was created by projecting a 35-degree line (from vertical) from the edge of mining to the surface (PADEP, 2008). All structures that fell outside the RPZ were eliminated with one exception. If a water supply was outside the RPZ but associated with a 'reported effect' within or prior to the 4th assessment period, it was retained.

Next, basic information about each water supply was collected and entered into the Act54GIS database. This information consisted of:

- Property owner (name)
- Property ID (number)
- Property number (typically the tax ID)
- County
- Feature ID
- Feature number (number)
- Feature type
- Feature use (Residential, Recreational, Agricultural, Community/Institution, Public, Commercial, Industrial, and Unknown)

Following construction of the water supply inventory, the University's Act54GIS database was linked to BUMIS to obtain additional information on water supplies with reported effects (see Sections IV-B and V-B). By linking the two databases, the University determined which water supplies in the inventory had reported effects. For those with a reported effect, the following characteristics were recorded:

- Reported effects ID (number)
- Occurrence of additional reported effects (number)
- Claim ID (structure assessment number)
- Cause (mining or other)
- Description of the reported effect
- Occurrence date
- Intermediate resolution date
- Final resolution date
- Resolution status

Using these data, reported effects were tracked by mine type, date of occurrence/resolution, type of effect, type of resolution, and actions taken by the DEP and mine operators.

Lastly, ArcGIS tools were utilized to measure the overburden depth (ft), distance to mining (ft), and topographic location (i.e. hilltop, hillside, valley bottom) for all water supplies with reported effects. Analyses were then performed to determine trends associated with water supply impacts and underground coal mining.

V.D – PADEP Determination of Liability

In accordance with ACT 54, mining companies are required to restore or replace water supplies that are contaminated, diminished, or interrupted by their underground mining operations. The Act also requires the mine operator to notify PADEP of any claim made by a landowner or water user. The PADEP tracks the claims from origin to settlement. A mining company and a property owner may settle a claim with a private agreement. Once an agreement has been made between the company and the property owner, the PADEP has no legal authority to intercede and tracking is ended.

The PADEP is responsible for determining liability associated with reported effects. As mentioned above, if a water supply falls within the RPZ the mining company is assumed liable for the impact. The company may rebut the claim if there is data available that shows no relation to mining. If the water supply is located outside of the RPZ, the PADEP is responsible for determining the reason for the impact. Factors used in determination of liability include type of mining, proximity to mining, overburden, seasonality of the claim, pre-mining water supply data, and observed effects on neighboring water supplies. If the PADEP determines that the mining company is responsible for the water supply impact and the property owner is without water, the company must provide the property owner with a temporary water supply until a permanent replacement of pre-mining quality and quantity is in place or an agreement between the water supply owner and the mining company is established. A temporary supply is generally in the form of a storage tank, called a water buffalo, placed on the property in question. The water buffalo is periodically filled with trucked water that is sufficient for the owner's needs. The University was unable to determine the number of temporary water supplies placed during the 4th assessment period because of the many mine operator – property owner agreements established

during this period. Permanent water supply replacement actions include, but are not limited to, repairing wells or springs, drilling new wells or springs, or connecting to a public water supply.

In BUMIS, water supply reported effects are noted as either *water loss* or *water contamination.* Seven hundred and twenty-one (84%) of the water supply reported effects were categorized as water loss and 134 (16%) as contamination. Water loss can signify either a reduction of water quantity or a complete loss of the supply while water contamination indicates a reduction in water quality. A reported effect can also have the classification of *not an actual problem;* this describes a reported effect that upon investigation by the mining company or PADEP was determined not to have been impacted by mining. *Not an actual problem* can also be assigned to a reported effect if a mining company provides a temporary water supply as a precaution but no problem developed post-mining.

V.E – Summary Information about Water Supplies Undermined During the 4th Assessment Period

During this assessment period, there were 855 reported effects to wells, springs, and ponds; the effects are tabulated in Table V-1 by mining type. The total number of reported effects included effects from mines that were active during the assessment period as well as effects from mines that ceased operation prior to the 21 August 2008 assessment period start date. Longwall and room-and-pillar mines show the most reported effects while pillar recovery mines show the least. Mines not in operation during this period comprised 6% of the total reported effects. Mines of all types are included in this section.

Table V-1. Number of reported 'water loss/water contamination' effects by mining type.

Mining Type	**Reported Effects**
Room-and-Pillar	384
Pillar Recovery	24
Longwall	393
Mines not in operation during 4th assessment (Non-active)	54
TOTAL	855

When an effect has been resolved, it is given a final resolution status. The final resolution indicates that there is no further impact to the water supply, or the case is closed due to an agreement regardless of whether the water supply is restored. Final resolutions are divided into three categories: 1) *Company Not Liable*, 2) *Company Liable*, and 3) *Unresolved* (see Appendix B). The *Company Not Liable* classification consists of effects that are *Withdrawn, Not An Actual Problem, Not Due To Underground Mining,* etc. The largest category within the *Company Not Liable* class is *Not Due To Underground Mining.* Most of the water supplies in this category have been found to be too distant from mining activity to be the result of mining. The *Company Liable* classification contains *Agreements, Permanent Supplies, Recovered/Repaired, and Resolved* categories. The majority of this class is comprised of agreements between the landowner and the mining company. This class differs greatly from the *Company Not Liable* class when comparing resolution times. *Company Not Liable* resolutions generally are resolved within a few months while a small number of *Company Liable* effects can take years to reach

resolution. Table V-2 lists the 29 categories used by the PADEP to classify the resolutions of water supply reported effects and average days required for resolution.

Table V-2. Determination of liability based on final resolution status as of 20 August 2013.

Final Resolution		**Number**	**Average Time to Resolution (Days)**
Class	**Category**		
Company Not Liable (Unaffected/No Liability)	Claim not filed W/in 2 years	1	536
	Damage Not Covered By BMSLCA	1	0
	No Actual Problem	12	26
	No Current Use	5	82
	No Liability	8	7
	Not Due To Underground Mining	224	99
	Owner Failed to Respond to DEP	1	965
	Water Supply Not Covered By BMSLCA	8	5
	Withdrawn	26	66
Company Liable (Assigned/Assumed Liable)	Agreement (Pre Mining)	25	29
	Agreement (Unspecified)	197	355
	Closed/Info Appended to Another Case	1	133
	Company Purchased Property	37	122
	Compensated	0	-
	Landowner Negotiations	1	724
	Perm Water Supply (Public) & O&M Bond	2	1189
	Perm WS (Well/Spring) & O&M Bond	9	764
	Permanent Supply (Public)	3	733
	Permanent Supply (Public) & Agreement	10	298
	Permanent Supply (Unspecified)&Agreement	2	572
	Permanent Supply (Well/Spring)	5	476
	Permanent Supply (Well/Spring)&Agreement	23	730
	Repaired	15	107
	Resolved	11	49
	Stream Recovered	1	183
	Vented - Resolved	0	-
	Water Supply Recovered	29	173
		657 (Total)	220 (Avg.)

A total of 201 water supply reported effects were unresolved at the end of the 4th assessment period. Unresolved effects are given an interim status to indicate the processes occurring in assessing the liability of the effect. However, only three of the unresolved reported effects were given an interim status in BUMIS. The status of the remaining unresolved reported effects could not be determined from the BUMIS database.

Figure V-1 illustrates a status summary of the total water supply reported effects during the 4th assessment period. The *Company Liable* class is further broken into 4 subclasses of *Agreement, Permanent Supply, Recovered/Repaired, and Resolved*. *Agreements* represent 70% of the total company liable effects, *Permanent Supplies* represent 15%, *Recovered/Repaired* 12%, and *Resolved* 3%.

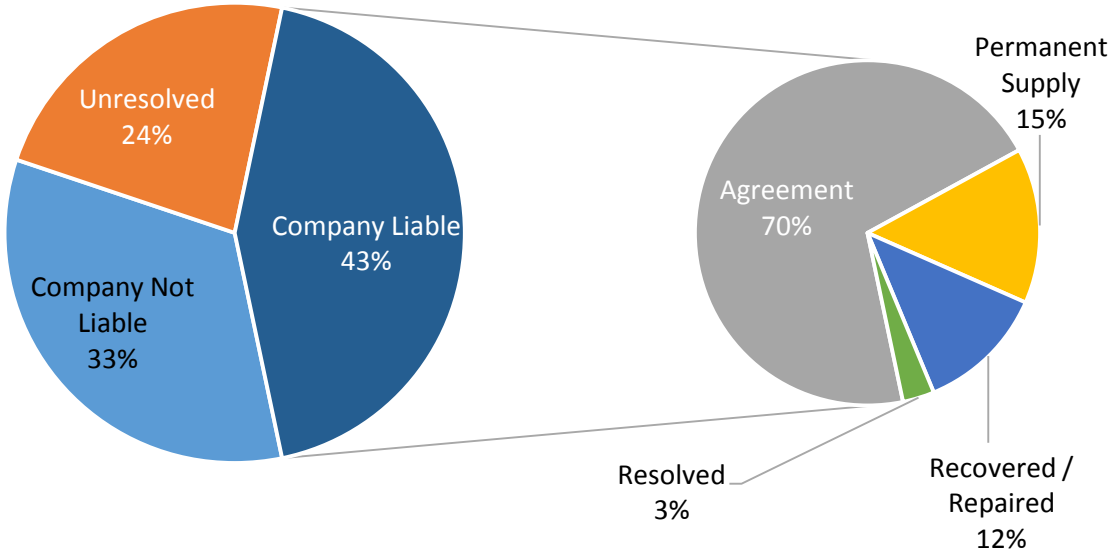

Figure V-1. Final resolution status of the water supply reported effects (n=855) classification as of 20 August 2013. The Company Liable Classification has been separated into four categories: Agreement, Permanent Supply, Recovered / Repaired, and Resolved.

The times to resolution for the 654 resolved effects are shown in Figure V-2 classified by mining type. The time to resolution was calculated by subtracting the resolution date from the date the effect is reported. The plot shows that 25% of total reported effects are resolved within 13 days. A majority of these rapidly resolved effects consisted of agreements that are resolved on the same day as the reported onset of the effect. In fact, more than 25% of all reported longwall effects are resolved on the day of their first reported occurrence. Half of the total reported effects are resolved within about two months, while 75% are resolved within a year. The time to resolution for the remaining 25% of effects is between one and four and one-half years. Many of the effects with prolonged times to resolution are associated with *Permanent Supplies* for which the average times to resolution can exceed two years (Figure V-3). Reported effects that are considered *no liability* or *resolved* had the shortest time to resolution (Figure V-3).

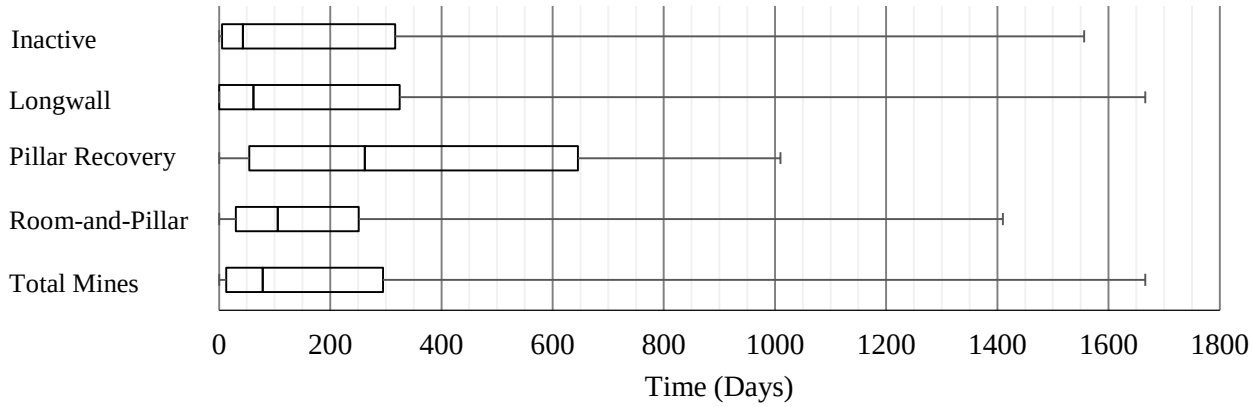

Figure V-2. Box and whisker plot of the time to resolution of the 65 resolved water supply effects sorted by mining type, as of 20 August 2013.

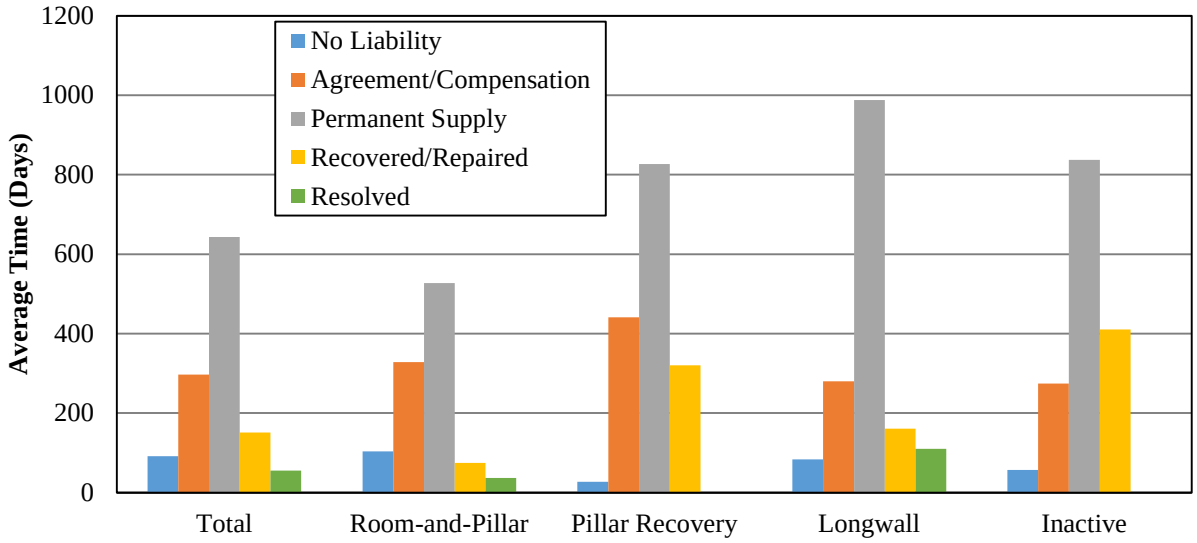

Figure V-3. The average number of days required to resolve the reported effects (n=657) classified by mining type and categorized based on the resolution status as of 20 August 2013.

Figure V-4 represents the total number of reported water supply effects for each mine type by two categories of impact: *water loss* and *water contamination.* Water losses represent the majority of water supply effects, covering 84% of the total. The remaining 16% are categorized as *water contamination* effects. Room-and-pillar mines show the greatest percentage of water contamination effects at 25% while pillar recovery mines show the fewest at 9%.

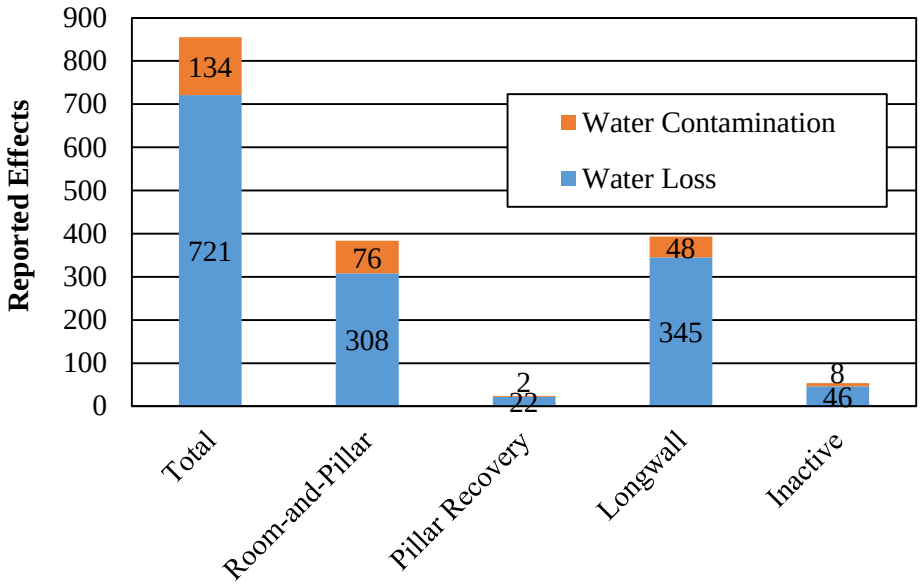

Figure V-4. Total water supply reported effects (n=855) classified by type of impact and organized by mining type as of 20 August 2013.

Reported effects can also be classified by the water supply's use and type. Water supply use can be categorized as *Agricultural, Commercial, Public,* or *Residential*. Figure V-5 quantifies the reported water supply effects by use. Here, as in structure reported effects (see Section IV), the use of water supplies was not being adequately reported in BUMIS.

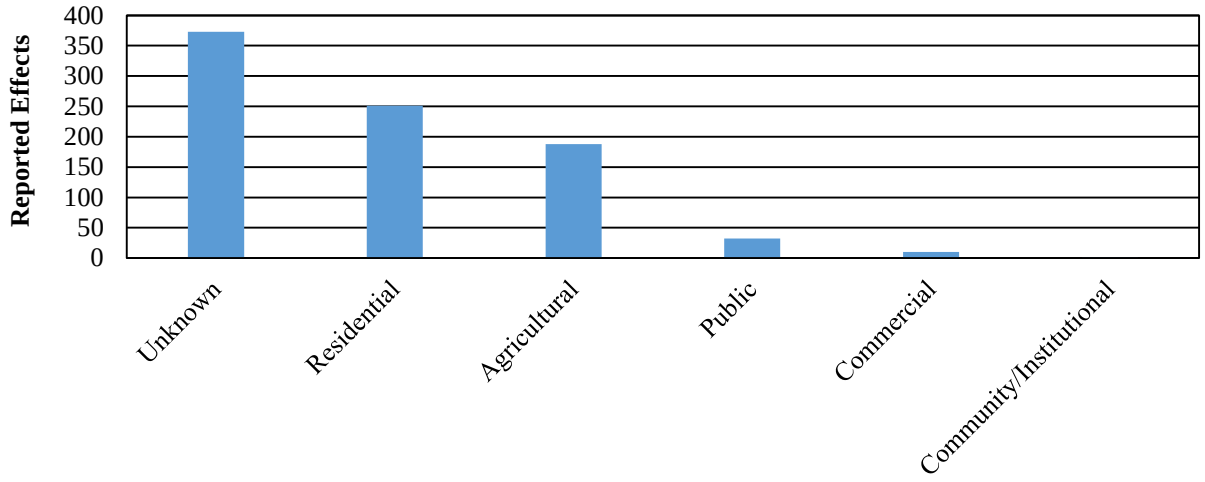

Figure V-5. Total water supply reported effects (n=855) as of 20 August 2013 classified by feature use.

Figure V-6 quantifies the water supply reported effects by type. Water supply types are placed in one of nine categories. The 'land' feature type seem to be a 'catch-all' classification and contains some effects that should be classified as land reported effects, not water supply reported effects.

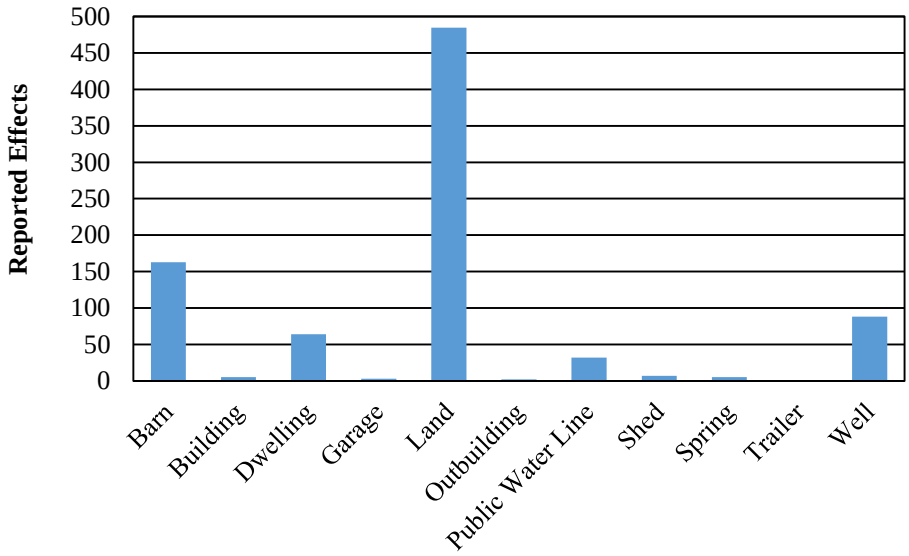

Figure V-6. Total water supply reported effects (n=855) as of 20 August 2013 classified by feature type.

The University analyzed the Company Liable water supply effects to determine the relationship between proximity to mining and determination of company liability. The University calculated the angle from vertical necessary to draw a line from the nearest edge of the mining extent to the reported effect. Figure V-7 illustrates the distribution of the water supply impacts as a function of

this angle. 60% of the impacts are within a 10º angle of the edge of mining. About 77% of the water supply impacts are within the RPZ angle used for initial determination of company liability. The remaining 23% outside the RPZ angle are determined to be company liable after further investigation of the reported effect. Of the total 654 resolved reported effects, 57%, or 371, were found to be Company Liable.

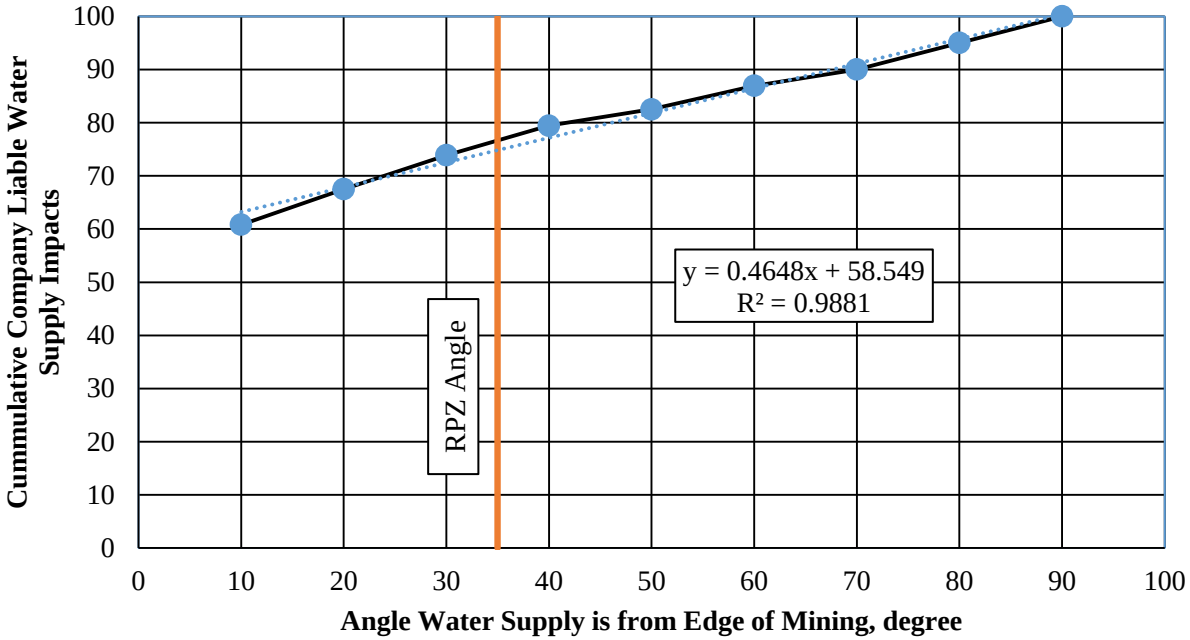

Figure V-7. Distribution of the company liable water supply effects and the angle the water supply is from mining.

V.F – Comparison to Previous Act 54 Reports

Since the creation of Act 54, three reports have been submitted to the Commonwealth regarding the effects of underground bituminous coal mining on surface features. Figure V-8 illustrates a comparison of the total acres mined and total reported water supply effects across these reports and the current Act 54 assessment. Despite an 18% drop in number of acres mined, the number of water supply reported effects has increased by approximately 25% (855 from 683). The increase in reported water supply effects may be attributable to the encroachment of underground mining into more heavily populated areas where the density of water supplies to mining acres is greater than in more rural areas. Another potential cause may be a growing public awareness of Act 54 and its codification of the rights of citizens to redress by the mining company of any adverse effects on water supplies. Lastly, some of the increase could be due to the classification of land reported effects as water supply reported effects.

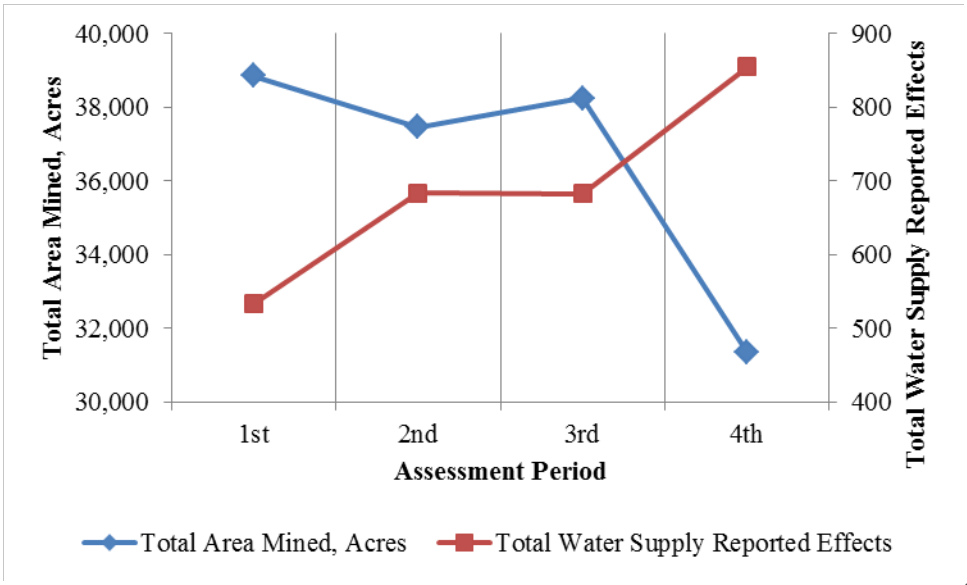

Figure V-8. Comparison of mined acres and total water supply reported effects from the 4th Act 54 assessment with data from previous assessments.

V.G – Characteristics of Company Liable Water Supply Effects

The University was able to accurately locate 367 unique company liable water supply effects, several with multiple effects, and performed rudimentary analysis. Overburden of company liable water supply effects are easily grouped on either side of the 500-ft value (Figure V-9). Room-and-pillar effects clustered between 100 and 500-ft of overburden, while longwall effects clustered between 500 and 900-ft. Three contributing factors for the trends in Figure V-9 are:

- room-and-pillar mines are shallower than longwall mines (averaging 381-ft compared to 783-ft)
- longwall mines undermined more surface lands than room-and-pillar mines (54.3% of the total verses 39.4%), and
- extraction ratios (Re) for room and pillar mines are significantly lower than for longwall mines (RP ranged from Re = 0.4 to 0.7; L ranged from Re = 0.4 to 1.0, see Section III).

The interplay of these three factors in the occurrence of company liable water supply effects is not well understood.

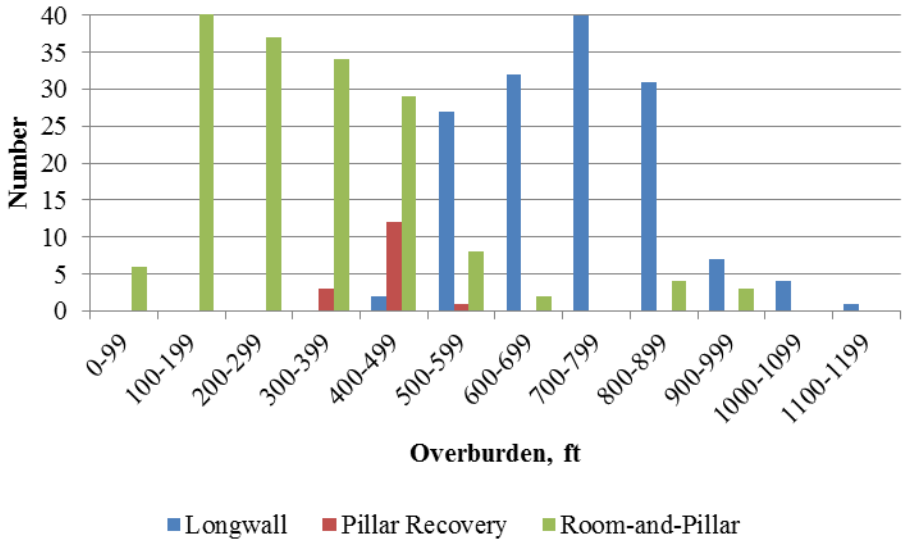

Figure V-9. Overburden distribution of company liable water supply effects. Note that equal numbers of company liable water supply effects between longwall and room-and-pillar mines.

Two hundred and eighty-three company liable water supply effects, some with multiple problems, were located within the tops of the hills, along the hillside slopes, or within the valley bottoms (Figure V-10). The topographic position, i.e. hilltop, hillside, or valley bottom, can be a significant factor in determining the likelihood of company liable water supply effects. Wells are often drilled along the hillside or within the valley bottom as hilltop wells require considerable drilling depth to reach typical groundwater aquifers. Springs are often found on hillsides, especially near the valley bottoms and represent the discharge points for perched aquifers. It is therefore expected to see the distribution of company liable water supply effects as shown in Figure V-10, where effects within hillsides dominate. Few hilltop water supplies are expected, so limited effects are likely. Conversely, water supplies within the valley bottom are least likely to be affected since this area received water from the surrounding hillsides and hilltops as well as the associated streams and wetlands. The data suggests that hillsides water supplies need special attention when planning for subsidence events.

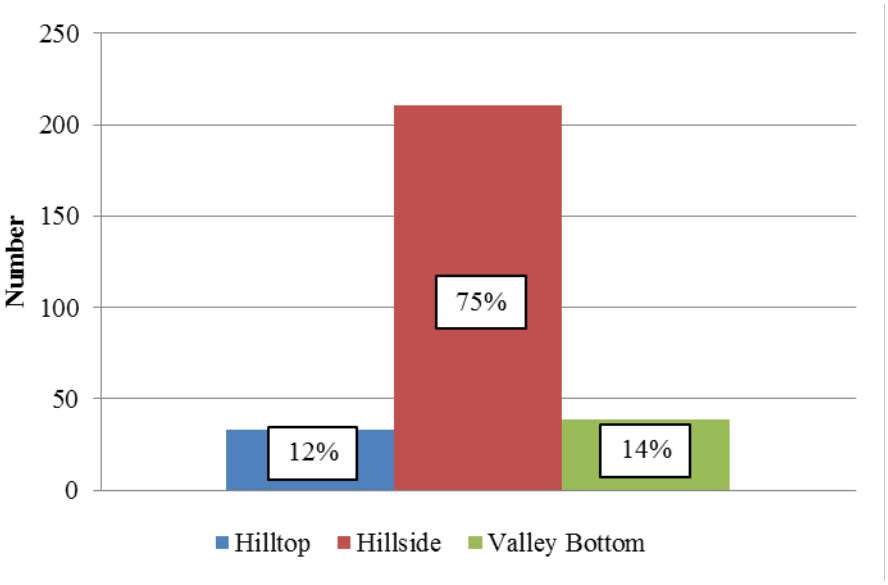

Figure V-10. Company liable water supply effects categorized by their topographic location.

The influence of mining on company liable water supply effects was examined by placing the data into one of four categories: 1) above the 'full extraction' panel [longwall or pillar recovery panels], 2) above the room-and-pillar developments, 3) inside the RPZ buffer but outside the mine, and 4) outside the RPZ buffer (Figure V-11). Three hundred and sixty-three water supplies were accurately located and their positions measured with respect to mining during the 4th assessment period. Seventy (19%) company liable water supply effects occur above the longwall panels. However, 186 (51%) company liable water supply effects lie outside the RPZ buffer. Many of these effects were found to be undermined in early assessment periods or they occurred during the 3rd assessment period but didn't reach a resolution until the 4th assessment period. These data suggest that a company liable water supply can occur when a mine is in a Non-active status and outside the RPZ. This is especially true of room-and-pillar mines.

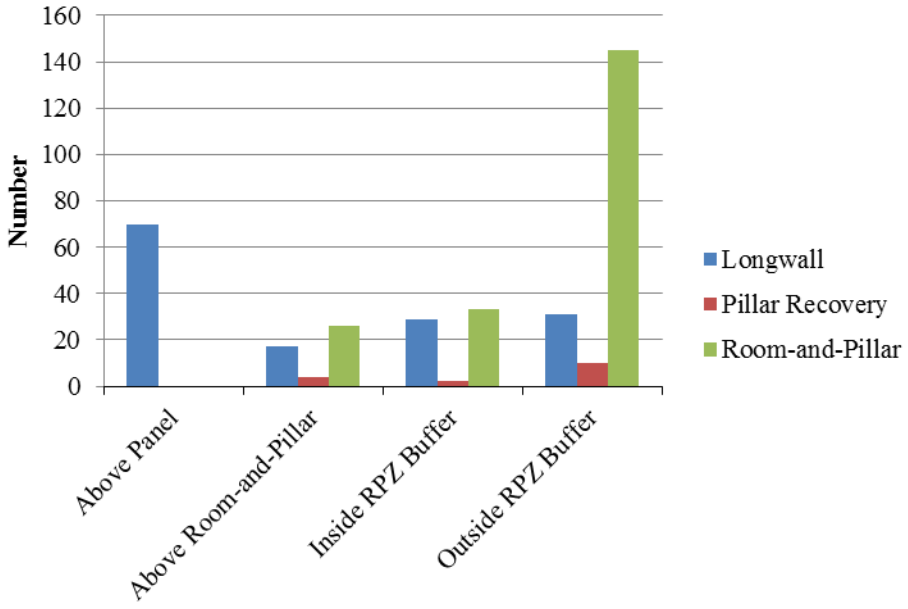

Figure V-11. Location of the company liable water supply effects with respect to the position of key mining zones extracted during the 4th assessment period.

V.H – Summary

Eight hundred and fifty-five water supply reported effects occurred during the 4th assessment period. Three hundred and ninety-three were from the seven longwall mines, 384 from room-and-pillar mines, 24 from pillar recovery mines, and 54 from non-active mines. An additional, 211 water supply reported effects were carryovers, classified as unresolved, from the 3rd assessment period. Of the 654 resolved cases, the average time to reach a final resolution was 220 days with 50% being resolved in the first two months and the final 25% taking between one and 4.5 years.

Three hundred and seventy-one water supply reported effects were found to be company liable, or 43% of the total. Four company liable water supply effects categories were identified: *Agreements* (70% to total company liable water supply effects); *Permanent Supply* (15%); *Recovered/Repaired* (12%), and *Resolved* (3%). The type of agreement was significant in the length of time to a resolution with *Agreements* having the least days and the *Resolved* taking the most days.

Water losses represent the majority of water supply effects, with 84% of the total. Water contamination represents the remaining 16% of the total. Room-and-pillar mines show the greatest percentage of water contamination effects at 25% while pillar recovery mines show the fewest at 9%.

The University was unable to locate all features on six-month mining maps with a corresponding BUMIS report. The feature ‘types’ and ‘uses’ were often not classified within BUMIS in a

manner consistent with information collected during the 3rd assessment period making comparisons difficult. In addition, unresolved water supply reported effects were, for the most part, not given an interim status.

References

Witkowski, M.N. (2011) "The Effects of Longwall Coal Mining on the Hydrogeology of Southwestern Pennsylvania," 30th International Conference on Ground Control in Mining, Morgantown, WV, July 26-28, 2011.