

# EVALUATION OF HYDROPHYTIC PLANT SPECIES IN CONSTRUCTED WETLANDS ON RECLAIMED AML SITES IN THE ANTHRACITE REGION OF PENNSYLVANIA<sup>1</sup>

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**Abstract:** The Pennsylvania Department of Environmental Protection (DEP), Bureau of Abandoned Mine Reclamation (BAMR), Wilkes-Barre District Office has made a concerted effort to construct new wetlands whenever possible on its reclaimed sites. Over the past thirteen years, BAMR has created over 140 acres of wetlands in the anthracite region for stormwater control, mine drainage treatment, mitigation for existing wetlands, or as requested by the property owners. Wetland plant species were hydroseeded in these constructed wetlands. Since 1994, BAMR personnel have planted rootstock and seed in a number of the newly constructed wetlands as part of Earth Day activities. The wetlands were monitored on a yearly basis to determine the types of hydrophytic vegetation that thrived, as well as the percent coverage of that vegetation. Hydrology, soils, and wildlife presence on these sites were also recorded.

## INTRODUCTION

The study of the effectiveness of constructed wetlands on abandoned mine sites began in 1994 as part of a program evaluation of BAMR by the then Pennsylvania Department of Environmental Resources (DER). In that year, ten recently constructed sites (1991 to 1994) were chosen to be evaluated on size, vegetative coverage, hydrology, water quality, soils, and presence of wildlife. The U.S. Army Corps of Engineers (Army COE) and/or DER also permitted these sites. A data collection form was developed to meet the needs of this evaluation as well as the monitoring requirements of the regulatory agencies.

The year 1994 also saw the beginning of an annual planting of rootstock and seed by BAMR personnel in the constructed wetlands. This began as a requirement by the Army COE to plant starter plots of *T. latifolia* (cattail), *S. fluviatilis* (river bulrush) and *S. eurycarpum* (giant burreed) as mitigation on the Tuscarora and Tuscarora East sites. These species provide food and

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cover for aquatic wildlife. The success of these plantings led to experimentation with other species on future constructed sites. Usually 200 to 400 rhizomes or rootstock were planted on each site. Attrition due to waterfowl was a small problem on some of the sites. Existing muck, if available, from the strip pits was stockpiled and incorporated into the new wetlands. This muck provided a seed base for wetland vegetation adapted to the climate of the site. Different mixtures of material suitable for planting rootstock were tried. This included on-site topsoil mixed with hay, straw and/or wood chips. The results from these experiments are documented later in this report. Twenty-eight (28) sites constructed from 1994 up to the present time were studied and recorded.

It was then decided to study the early wetlands on reclaimed sites built circa 1985 to 1990 in order to evaluate the volunteer growth of wetland vegetation. Twenty-three (23) of these early sites were studied, making a total of fifty-one (51) wetlands documented in this paper.

## **METHODS**

Extensive field observations were conducted to gather all the essential data necessary to perform the evaluation. This included photographic documentation of the site to match the location of the plant species shown on the plans. These photos would later become useful to visually measure the year by year growth or decline of those species. Detailed identification of the plant species observed were recorded, as well as the depth of saturation of the soil in those areas. Also identified were the source of hydrology, the percent of open water, the depth of water and water quality. Wildlife observations were also recorded.

## **DATA INTERPRETATION**

The 51 wetlands studied varied in size from 0.1 acres to 25.0 acres. Twenty-three (23) of the sites were pre-1994 (before rootstock planting). Table 1 lists the types of vegetation found on these early sites which were, in some cases, seeded with reed canary grass, or just volunteer growth. The total area of wetlands is 52.1 acres, of which 17.0 acres (33%) are open water. Species such as *E. ambigens* (spike rush), *J. effusus* (common rush), and *T. latifolia* (cattail) were the most predominate, comprising 20.2 acres (39%) of the total areal coverage. Other miscellaneous species, such as grasses, comprised 9.1 acres (18%) of the wetlands. Two of these sites (**Wanamie D&H RR I** and **Wanamie D&H RR II**) will be studied in detail later in this report.

The remainder of wetlands studied (28 sites) were constructed in 1994 or later. These wetlands were seeded during construction with a wetland mixture, usually reed canary grass or rice cut grass. Rootstock plantings were conducted after the water level in the wetlands stabilized, usually the next planting season. The total area of these wetlands is 87.2 acres, with 60.4 acres (69%) being open water. Planted species include *T. latifolia*, comprising 7.6 acres (9%) of the total areal coverage; *S. fluvatilis* (river bulrush) 0.9 acres (1%); *S. eurycarpum* (giant burreed) 0.1 acres (<1%); and *S. latifolia* (arrowhead) 0.1 acres (<1%). Seeded species include *P.*

*arundinacea* (reed canarygrass) 1.1 acres (1%); and *L. oryzoides* (rice-cut grass) 5.2 acres (6%). As in the earlier wetlands, other miscellaneous volunteer species, comprised a large portion (6.0 acres, (7%)) of the areal coverage. Table 2 lists the types of vegetation on these sites. Eight of these sites were studied more in detail and are described in the next section.

These sites are: **Tuscarora East, Tuscarora II, Mary D South, Sandy Run South, Tomhicken East, Colliery Road I, Upper Lehigh, and North Eynon.**

## **CASE STUDIES**

Ten sites in various locations throughout the anthracite region were chosen to investigate the success/failure of vegetative cover in the constructed wetlands. These wetlands range in age from newly constructed to eight years old. Table 3 depicts the hydrophytic vegetation acreage totals measured in these sites.

### **1. Wanamie D&H RR I**

This reclaimed site is located in the borough of Wanamie, Luzerne County, Pennsylvania near the city of Wilkes-Barre. Reclamation of the 45-acre site was completed in 1991 and resulted in the creation of a wetland measuring 0.63 acres. Hydrology to this wetland is all surface runoff. Water depth is 1 to 2 feet. Dominant species include *P. arundinacea* and *T. latifolia*. *P. arundinacea* was seeded in August of 1991. Open water makes up 6% of the total wetland area. Vegetation has increased from 0.13 acres in 1995 to 0.59 acres at present. Dragonflies, grasshoppers and deer tracks were observed in and around the wetland.

### **2. Wanamie D&H RR II**

This 26-acre reclaimed site is also located in the borough of Wanamie next to the above-mentioned site. Reclamation was completed in 1992 and resulted in the creation of two wetlands measuring 1.29 acres. Hydrology to this wetland is also surface runoff and water depth ranges between 1 to 2 feet. Dominant species include *P. arundinacea* and *T. latifolia*. As in Wanamie D&H RR I, *P. arundinacea* was hydroseeded in June of 1992. Open water makes up 16% of the wetland. Vegetation has increased from 0.17 acres in 1995 to a high of 1.62 acres (1998) to 1.08 acres at present. Dragonflies, grasshoppers, waterbugs, frogs, and minnows have been observed in the wetland.

### **3. Tuscarora East Site 'A' and 'B'**

This reclaimed site is located in Schuylkill County, Pennsylvania, near the borough of Tamaqua. Reclamation of the 53 acres was completed in 1993 and included two wetlands measuring 3.07 acres (Wetland 'A') and 4.99 acres (Wetland 'B'). This site was the first wetland

planted by BAMR personnel. A portion of the site was previously used as a landfill for the borough of Tamaqua, resulting in iron and other pollutants seeping into Wetland 'B'. The wetlands created measured 8.06 acres and have increased in size between 1995-1997, after which the growth leveled off. Wetland 'A' is spring-fed and contains water most of the time ranging in depth from 1-4 ft. Open water makes up 75% of the wetland area. Dominant species include *S. eurycarpum* and *T. latifolia*, both planted. Vegetation has increased from 0.31 acres in 1995 to 0.76 acres at present. Wetland 'B' is located west of Wetland 'A' and is fed from surface runoff and an outlet from Wetland 'A'. Water levels can vary in this wetland from 0 to 4 feet. This area often dries out during drought periods, but then recharges after a storm event. Open water is normally 64% of the wetland. *T. latifolia*, and *P. arundinacea*, both planted species, are dominant. *J. effusus* and *S. cypernius* (wool-grass) are also thriving. Vegetation has increased from 0.10 acres in 1995 to a high of 1.99 acres (1997) to 1.78 acres at present. This wetland also acts to purify the leachate from the closed landfill, and discharges clean water into the headwaters of the Schuylkill River. Wildlife observed at the site includes wood ducks, mallard ducks, wild turkey, and white-tailed deer.

#### **4. Mary D South**

This 11 acre reclaimed site is located in Schuylkill County, Pennsylvania in Walker Township. Reclamation was completed in 1993. It treats acid mine water from numerous seeps at the base of the former highwall. *T. latifolia* and *J. effusus* are the predominant species, and are believed to be brought from the transplanted muck from the former wetland at the base of the highwall. The 2.04 acre wetland is predominately vegetation, with some open water (9%) meandering its way through the wetland to an unnamed tributary of the Schuylkill River. Water depth is less than 1 ft. *T. latifolia*, *J. effusus*, *S. cypernius*, and *E. ambigens* are predominant volunteer species. *P. arundinacea* was seeded and covers 0.19 acres. Water samples were taken from various points in the wetland, which resulted in an increase in pH and reduction of metals as the water flows through the wetland. Wildlife observed at the site includes mallard ducks, Canadian geese, tadpoles and white-tailed deer.

#### **5. Sandy Run South**

This 56-acre site was completed in 1994. Reclamation of this site, located in Luzerne County, created two wetlands measuring 1.71 acres (Upper) and 0.59 acres (Lower). The Upper wetland is fed by surface runoff from a small drainage area. Open water makes up 52% of the total wetland area, with an average water depth of 0.75 feet. *T. latifolia*, *S. eurycarpum* and *S. latifolia*, all planted species, were dominant. The Lower wetland is shallow (0.25 feet) and has less open water (30%). It is also fed by surface runoff. *T. latifolia* and *Carex* sp. were dominant. Tadpoles, killdeer, and red-winged blackbirds were observed at the site.

## **6. Tuscarora II Site 'A' and 'B'**

This reclaimed site is located in Schuylkill County, Pennsylvania across Route 209 from the Tuscarora East site. The 76-acre site, constructed in late 1994, created two wetlands measuring 1.58 acres (Wetland 'A') and 7.75 acres (Wetland 'B'). Wetland 'A' is fed by surface runoff from a small drainage area. Because of that small watershed, open water makes up 9% of the total wetland area, with an average water depth of 0.5 feet. However, vegetation is present, with *T. latifolia* and *S. cypernius* (both planted) dominating. Total vegetative area has increased from 0.57 acres in 1995 to 1.44 acres at present. The larger Wetland 'B', located west of Wetland 'A', has a greater watershed with open water being 43% of the wetland and depths from 1 to 2 feet. *T. latifolia* and *S. fluvatilis* (both planted) and *P. arundinacea* (seeded) are dominant. Vegetation has fluctuated between 4.01 and 4.45 acres. Wildlife observed at the site includes wood ducks, mallard ducks, wild turkey and white-tailed deer.

## **7. Colliery Road I**

This site is located in an urban area of Dickson City borough in Lackawanna County, near the city of Scranton. Commercial and residential development has completely surrounded the 37 acres of reclaimed mineland, constructed in 1995. Two wetlands totaling 2.60 acres have been constructed to handle stormwater runoff from this site and upstream runoff from a shopping mall. Because of the large area needed to control that stormwater, and the shaly composition of the soil, the lower wetland remains dry most of the year. However, vegetation has recently increased in this wetland, after declining due to a drought in 1997. The dominant species are *P. pensylvanicum* (Pennsylvania smartweed, seeded) and *T. latifolia* (planted). The smaller upper wetland does hold water (0.5 to 1.5 feet) because of ditches conveying stormwater runoff to the wetland and siltation brought on from previous construction above the site. Vegetation is predominantly *T. latifolia* (planted) and *L. oryzoides* (seeded). Vegetation has increased from 1.98 acres in 1996 to 2.45 acres at present. Wildlife observed at the site includes mallard ducks and white-tailed deer.

## **8. Tomhicken East**

This 45 acre reclaimed site is located west of the city of Hazleton near Black Creek. The wetland, constructed in 1995, measures 0.83 acres. Due to the depth of this wetland (greater than 3 ft.), open water constitutes 67% of it and vegetation is limited to the perimeter. *P. arundinacea* (seeded) is the dominant species, with *J. effusus*, *S. eurycarpum*, (planted) and *T. latifolia* (planted) less dominant. Hydrology to the wetland is from surface runoff and an intermittent stream. Vegetation has increased from 0.12 acres in 1995 to 0.32 acres at present. Wildlife observed at the site includes wood ducks, mallard ducks, wild turkey and white-tailed deer.

## **9. Upper Lehigh**

This 75-acre site was the 1997 AML National Award Winner for the best reclamation site in the country. Three wetlands (Wetlands 'A', 'B', and 'C') were created to control stormwater runoff to the site. Wetlands 'A' and 'C' are fed by streams and are controlled at a constant water elevation. Water depth (2 to 3 feet) is greater than in Wetland 'B'. Between those two wetlands is Wetland 'B', which is only seasonally inundated. Wetland 'A' is located at the west end of the project and is vegetated with *T. latifolia*, *L. oryzoides* (seeded) and *P. pensylvanicum* around the perimeter and on the island. Total wetland area is 4.80 acres, with open water constituting 65% of it. Wetland 'B' measures 6.35 acres and is heavily vegetated with *T. latifolia*, *L. oryzoides*, and *E. ambigens*. Open water is 5% of the total area. Water depth is 0 to 1.5 feet. Wetland 'C' measures 7.75 acres and is mostly open water (85%), with an average depth of 3 ft.. The wetland outlets through multiple culverts under a highway to Pond Creek. Vegetation, mainly *L. oryzoides*, and *E. ambigens*, is concentrated on the island, the delta area of an incoming stream, and along parts of the shoreline. It is. These wetlands provide habitat for mallard ducks, Canada geese, and killdeer. Deer tracks were observed near the wetlands also.

## **10. North Eynon**

This site, completed in 1998, is one of the largest reclaimed sites in the anthracite region, measuring 243 acres. Three wetlands (Wetlands 'A', 'B' and 'C') were created to control stormwater runoff from two drainage areas upstream of the reclamation site. Because of past mining, the original watercourse on the eastern end (Tinklepaugh Creek) has been obliterated from the area and downstream of the site. On the western end, Wildcat Creek is still intact and receives runoff from the outlet of Wetland 'C'. This area is also enclosed by residential and commercial development. The Archibald Pothole State Park is a property owner and requested that a flat area in the reclamation site be constructed for future sports fields. BAMR design engineers granted that request and adjusted the grades so that an area would be reserved for recreation along with a drainage ditch to handle stormwater runoff. Wetland 'A' measures 3.70 acres and is 94% open water. Depth of the wetland is 1 to 2 feet. Dominant vegetation is *T. latifolia* and *L. oryzoides*. Wetland 'B' measures 10.96 acres and is 87% open water. Water depth is 1 to 3 feet. Vegetation, mainly *T. latifolia*, *S. latifolia*, and *E. ambigens*, is concentrated at the southern end where it adjoins a small existing wetland created during the past surface mining. Wetland 'C' measures 0.93 acres and is 78 % open water. Water depth is 1 to 1.5 feet. It is vegetated with *T. latifolia* and *S. fluvatilis*. This is a new wetland and requires additional evaluation/study. Wildlife observed at the site includes ducks, killdeer and red-winged blackbirds.

## **CONCLUSIONS**

After the data was analyzed, it was found that hydrology plays a very important part in the success of a wetland. The size of a created wetland should be proportional to its watershed to ensure a stable water level. Wetlands that leaked or had insufficient hydrology did not support

the species that BAMR had planted. Water depth was also important. Wetlands that were too deep did not support the introduced species. Water depths up to 1.5 feet were more conducive to the establishment of vegetation than greater depths.

The following conclusions/observations may be drawn from a comparison of the pre- and post-1994 constructed wetlands:

- Wetlands created after 1994 indicated a more diverse species of vegetation than the earlier wetlands.
- Volunteer species, such as *E. ambigens* (spike rush), (common rush), and (woolgrass) are found in pre- and post-1994 wetlands, but in lesser amounts in the newer wetlands.
- *T. latifolia* (broad-leafed cattail) will grow almost anywhere.
- In most cases, wetland vegetative cover has increased since 1994.
- Seeded and planted species conducive to wildlife are showing promise in the newer wetlands.

In closing, five years of observation have demonstrated that planting and seeding hydrophytic plant species on reclaimed mine sites is working well in the Anthracite region of Pennsylvania. Because wetlands are dynamic, it will take many more years of study to ascertain the success of these created wetlands. The Bureau of Abandoned Mine Reclamation, Wilkes-Barre District Office, will continue to monitor and experiment with innovative ideas to improve the functions and values of future constructed wetlands.





Table 1

## Hydrophytic Vegetation in Pre-1994 Constructed Wetlands

Project Title	Total Area	Cattail	Spike Rush	Common Rush	Reed Canary Grass	Common Reed	White Birch	Woolgrass	Sedge	Other	Open Water
Plains Township	1.00	0	0	0	0	0	0	0	0	0	1.00
Pearl Street	0.25	0	0	0	0	0	0	0	0	0	0.25
Beaver Meadows	4.60	0	0	0	0	0	0	3.50	0.30	0	0.80
Maple Hill	0.20	0	0	0	0	0	0	0	0	0.10	0.10
Greenfield Road	0.30	0.09	0.20	0	0	0	0	0	0	0	0.01
Korn Krest	1.22	0.09	0.41	0.41	0.09	0	0	0	0	0	0.22
Loomis Colliery	5.20	0	1.20	1.20	0.17	0.20	0.20	0	0	0	2.23
Powderly Creek Backfilling	0.85	0	0.21	0.30	0	0	0	0	0.02	0	0.32
Powderly Creek Stream	0.10	0	0	0	0.07	0	0	0	0	0	0.03
Locust Gap II	1.99	0.17	0.78	0.25	0	0.41	0	0	0	0	0.38
Eynon - Jermyn	0.07	0.02	0.01	0.01	0	0	0	0.02	0	0.01	0.00
Wanamie D&H RR I	0.63	0.28	0.01	0.10	0.08	0	0	0	0	0.12	0.04
Reevesdale	0.23	0	0	0	0.06	0	0	0	0	0.15	0.02
Delano II	1.70	0	0.02	0.03	0.26	0.02	0	0.02	0.02	0.03	1.30
Delano I	0.82	0	0	0	0	0	0	0	0	0	0.82
Morea West	0.72	0	0	0	0	0	0	0	0	0	0.72
Wanamie D&H RR II (A)	0.65	0.27	0.06	0.04	0.07	0	0	0	0	0	0.21
(B)	0.64	0.04	0.12	0.16	0.20	0	0	0	0.06	0.06	0.00
Wadesville I	1.23	0.07	0.04	0.05	0.05	0	0	0	0	0	1.02
White Oak Run	0.83	0	0.07	0.02	0.02	0	0.03	0	0	0	0.69
Kelayres	25.00	3.50	7.30	2.30	0	0	0	0	0	6.90	5.00
Wadesville II	3.90	0.30	0.02	0.06	0	0.04	0	0	0	1.77	1.71
Heckscherville II	0.10	0	0	0	0	0	0	0	0	0	0.10
<b>Totals in Acres</b>	<b>52.11</b>	<b>4.83</b>	<b>10.45</b>	<b>4.93</b>	<b>1.07</b>	<b>0.67</b>	<b>0.23</b>	<b>3.54</b>	<b>0.34</b>	<b>9.08</b>	<b>16.97</b>







Table 2 **Hydrophytic Vegetation in Post-1994 Constructed Wetlands**

Project Title	Total Area	Cattail	River Bulrush	Wild Rice	Giant Burreed	Spike Rush	Common Rush	Reed Canary Grass	Common Reed	Wool grass	Rice Cutgrass	Sedge	Arrow head	Other	Open Water
<b>Tuscarora E. (A)</b>	3.07	0.31	0.11	0	0	0.12	0.02	0.13	0	0.06	0	0.09	0	0	2.23
<b>(B)</b>	4.99	0.64	0	0	0.11	0	0.80	0.42	0	0	0	0	0	0	3.02
<b>Mary D South</b>	2.04	0.93	0	0	0	0.12	0	0.19	0	0.18	0	0.05	0	0.38	0.19
<b>Steins West</b>	1.14	0.01	0	0	0	0.15	0.05	0	0	0	0	0.08	0	0	0.85
<b>Sandy Run South</b>	2.30	0.84	0	0	0.02	0.07	0	0	0	0	0	0.11	0.02	0	1.24
<b>Tuscarora II (A)</b>	1.58	0.95	0	0	0	0.08	0.06	0.03	0	0	0	0.08	0	0.24	0.14
<b>(B)</b>	7.75	2.14	0.63	0	0	0.27	0	0.36	0	0	0	0	0	1.05	3.30
<b>Lansford N.E.</b>	0.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10
<b>Colliery Road</b>	2.60	0.28	0.08	0.05	0	0.33	0.35	0	0	0	0.55	0	0.02	0.79	0.15
<b>Branchdale East</b>	5.52	0	0	0	0	0.15	0.05	0	0	0	0	0.06	0	0	5.26
<b>Tomhicken East</b>	0.83	0.06	0.01	0.03	0	0.07	0	0	0	0	0	0.02	0	0	0.64
<b>Atlas North</b>	1.61	0.14	0	0	0	0.37	0.15	0	0.27	0	0	0	0	0.30	0.38
<b>Sterry Creek S.</b>	1.16	0	0	0	0	0.05	0	0	0	0	0	0	0	0	1.11
<b>Upper Lehigh (A)</b>	4.40	0.28	0	0	0	0	0	0	0	0	0.91	0	0	0.21	3.00
<b>(B)</b>	6.50	0.43	0	0	0	0.86	0.21	0	0	0	2.80	0	0.02	0	2.20
<b>(C)</b>	8.00	0	0	0.02	0	0.15	0	0	0	0	0.80	0	0	0.03	7.00
<b>Pine Creek</b>	0.39	0	0	0	0	0	0	0	0	0	0	0	0	0.26	0.13
<b>Sugar Notch</b>	0.05	0	0	0	0	0.01	0.01	0	0	0	0	0	0	0	0.03
<b>Tomhicken</b>	2.67	0	0	0	0	0	0	0	0	0	0	0	0	0	2.67
<b>Curry Hill</b>	0.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0.20
<b>North Eynon (A)</b>	3.70	0.15	.02	0	0	0	0	0	0	0	0.04	0	0	0	3.49
<b>(B)</b>	10.96	0.20	0	0	0	0.18	0	0	0	0	0	0	0.05	0.71	9.82
<b>(C)</b>	0.93	0.04	0.02	0	0	0	0	0	0	0	0	0	0	0.14	0.73
<b>McCauley Mtn. *</b>	2.20	0	0	0	0	0	0	0	0	0	0	0	0	0	2.20
<b>Colliery Road II *</b>	0.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0.86
<b>Pardeesville *</b>	1.50	0	0	0	0	0	0	0	0	0	0	0	0	0	1.50
<b>John Percival CC*</b>	1.65	0	0	0	0	0	0	0	0	0	0	0	0	0	1.65
<b>Blue Coal Corp. *</b>	8.50	0	0	0	0	0	0	0	0	0	0	0	0	0	8.50
<b>Totals in Acres</b>	<b>87.20</b>	<b>7.57</b>	<b>0.87</b>	<b>0.10</b>	<b>0.13</b>	<b>2.89</b>	<b>1.79</b>	<b>1.13</b>	<b>0.27</b>	<b>0.24</b>	<b>5.15</b>	<b>0.52</b>	<b>0.11</b>	<b>6.01</b>	<b>60.42</b>

\* New wetland, no vegetative growth as of July, 1999.

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Table 3

**WETLAND VEGETATION 1994-1999**

SITE	Acres (Percent Vegetative Cover)				
	1995	1996	1997	1998	1999
Wanamie D&H RR I	0.13 (39)	Not sampled	Not sampled	0.46 (62)	0.59 (94)
Wanamie D&H RR II	0.17 (52)	Not sampled	Not sampled	1.62 (72)	1.08 (84)
Tuscarora East A	0.31 (10)	1.16 (37)	1.17 (37)	0.64 (20)	0.76 (25)
Tuscarora East B	0.10 (02)	1.93 (39)	1.99 (40)	1.78 (36)	1.78 (36)
Mary D South	0.72 (40)	1.80 (100)	1.80 (100)	1.76 (98)	1.85 (91)
Sandy Run S.	-	-	-	-	1.16(48)
Tuscarora II A	0.57 (35)	1.24 (76)	0.98 (60)	1.06 (65)	1.44 (91)
Tuscarora II B	4.01 (52)	4.71 (61)	4.16 (54)	4.01 (52)	4.45 (57)
Colliery Road I	-	1.98 (61)	1.04 (32)	2.86 (88)	2.45 (95)
Tomhicken	-	0.12 (12)	0.32 (32)	0.47 (46)	0.32 (33)
Upper Lehigh A	-	-	1.40 (32)	Not sampled	1.68 (35)
Upper Lehigh B	-	-	4.30 (66)	Not sampled	6.03 (95)
Upper Lehigh C	-	-	1.00 (13)	Not sampled	1.16 (15)
North Eynon A	-	-	-	-	0.21 (06)
North Eynon B	-	-	-	-	1.48 (13)
North Eynon C	-	-	-	-	0.20 (22)

