Using ESRI's ArcScene to Visualize the Geospatial Relationship Between AMD Seeps, a Coal Refuse Disposal Area, and Underground Mining Operations

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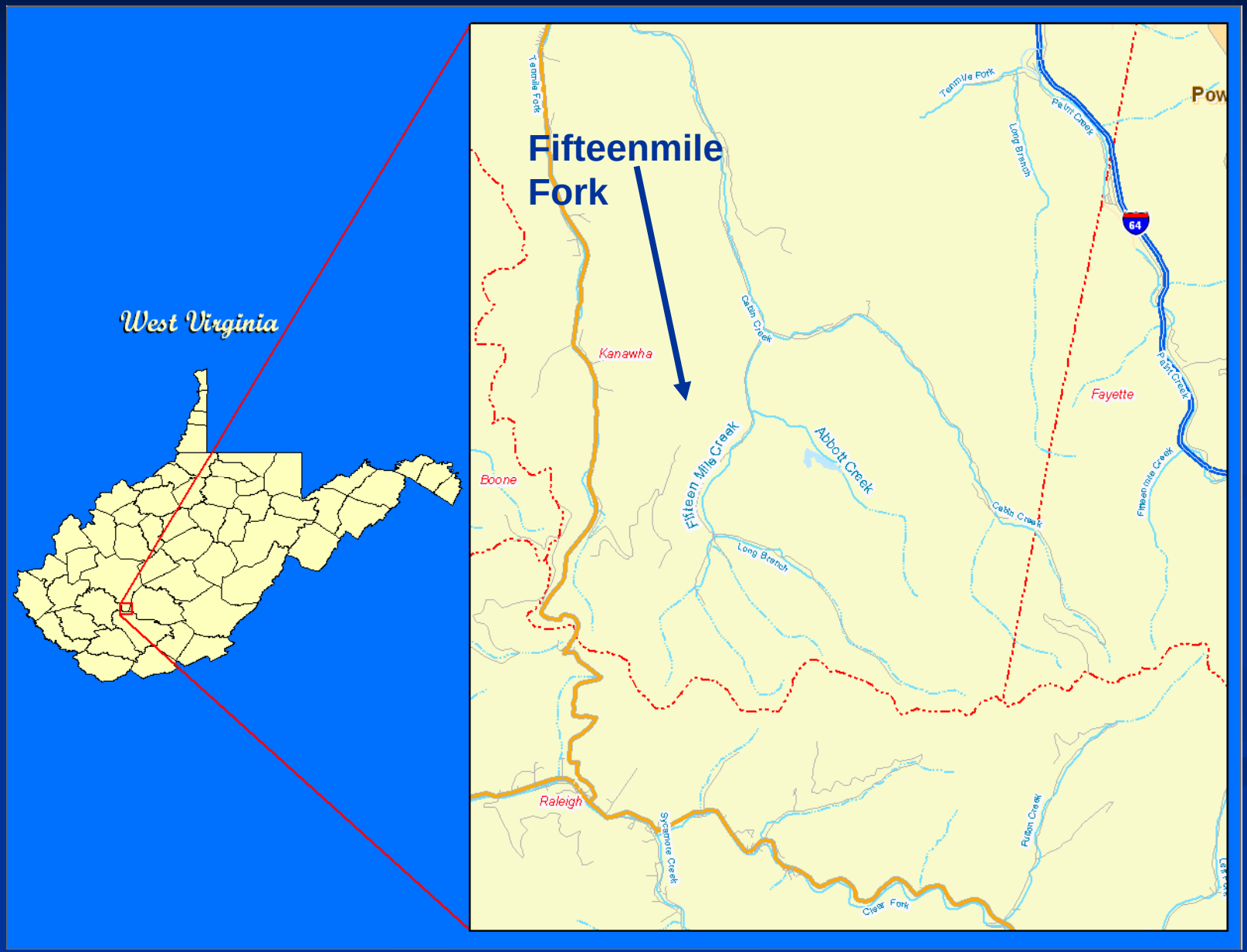
GIS Visualization Tools

Application: Permitting and Hydro Assessments

- ArcMap and ArcScene Were Used to Visualize
- Geospatial Relationships Between
  - Thickness of Refuse Materials in Fill
  - Surrounding Underground Mines in 3 Seams
  - Occurrence and Distribution of AMD Seeps
  - Receiving stream, Fifteenmile Fork/Cabin Ck.
- Example: 3-D Model of Fifteenmile AMD Seeps

Location Map of the Study Area



AMD Seep Zone

AMD seep chemistry

- **Runoff chemistry**
  - **pH 3.2 s.u.**
  - **Fe-d 240 mg/L**
  - **Mn-d 13.2 mg/L**
  - **Al-d 22.1 mg/L**

Historical perspective

- The use of Abbott Hollow as a refuse disposal area started approximately 60 years ago
- Before the effective date of the Surface Mining Control and Reclamation Act (SMCRA), Fifteenmile Fork watershed had extensive mining with refuse placement
- Placement and/or maintenance of acid-toxic prone refuse materials
- There is no historical analytical data available (pre-1980)

  - No dates of seeps and impacts first occurred

    + Pre- and/or post-SMCRA refuse placement
- Extensive multi-seam underground and surface mining, and refused fill placement makes it difficult to visualize

  - The geospatial distribution of the AMD seeps with respect to the underground mining activities

Advantages of ArcScene

- Three different sources of information are available in the study area:

  - Occurrence and distribution of the AMD seeps

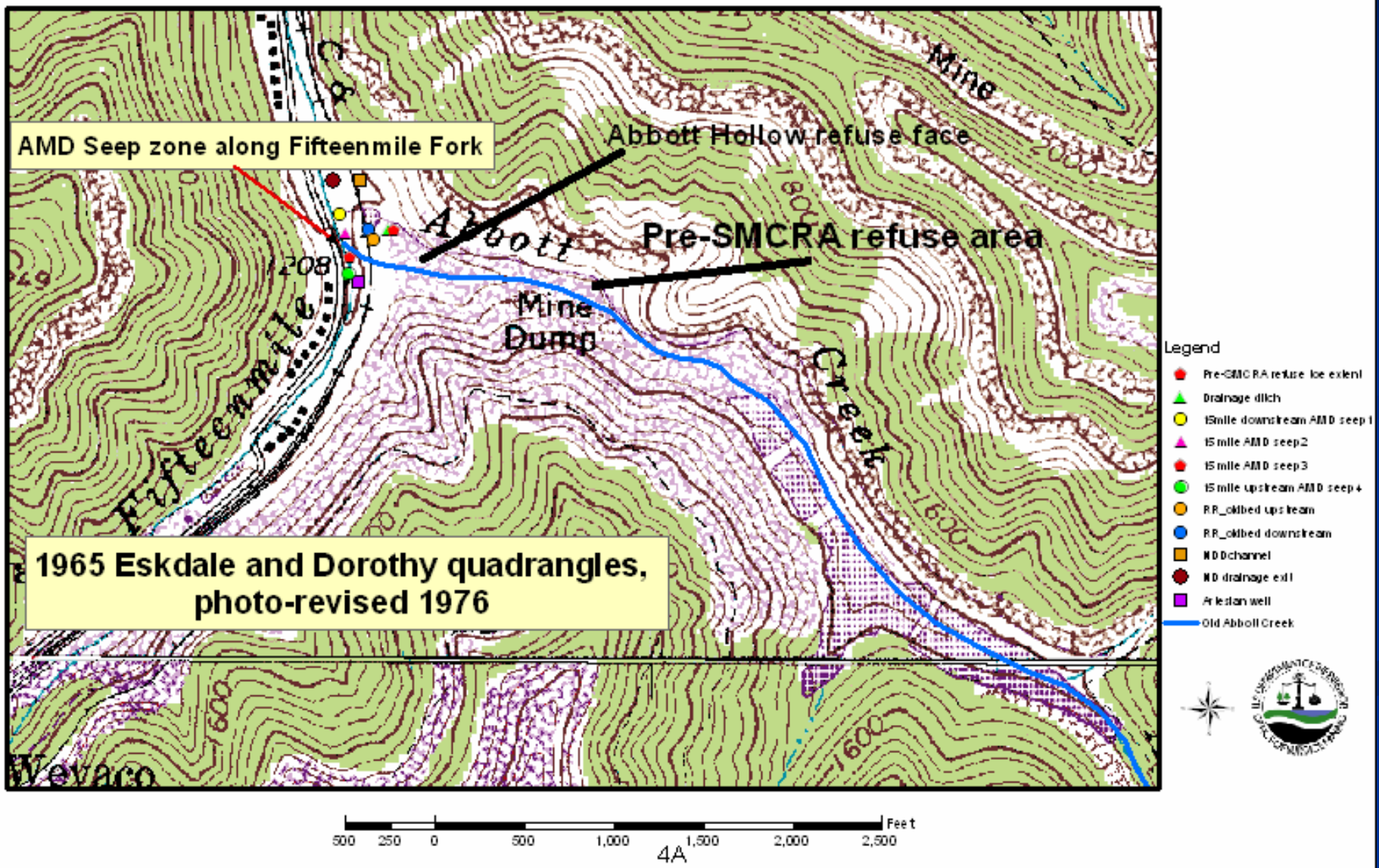
  - Location of the Abbott Hollow Refuse facility

  - Location of the pre-SMCRA underground and auger mines in No. 2 Gas, Powellton, and Eagle

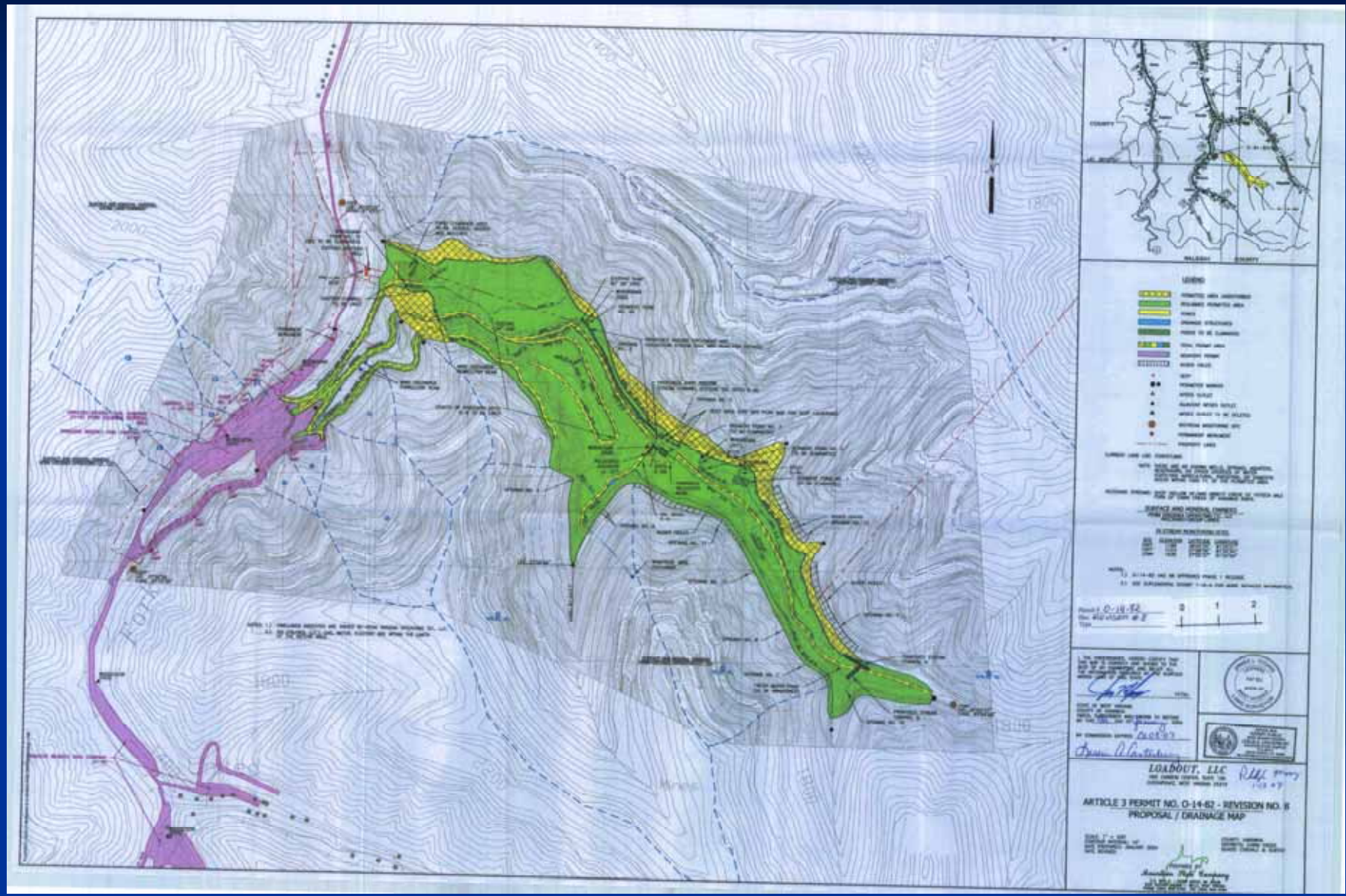
- ArcScene utilizes these types of information to help visualize the 3-D relationships between underground mines, the refuse fill, and the seeps

AMD Seeps at Abbott Hollow

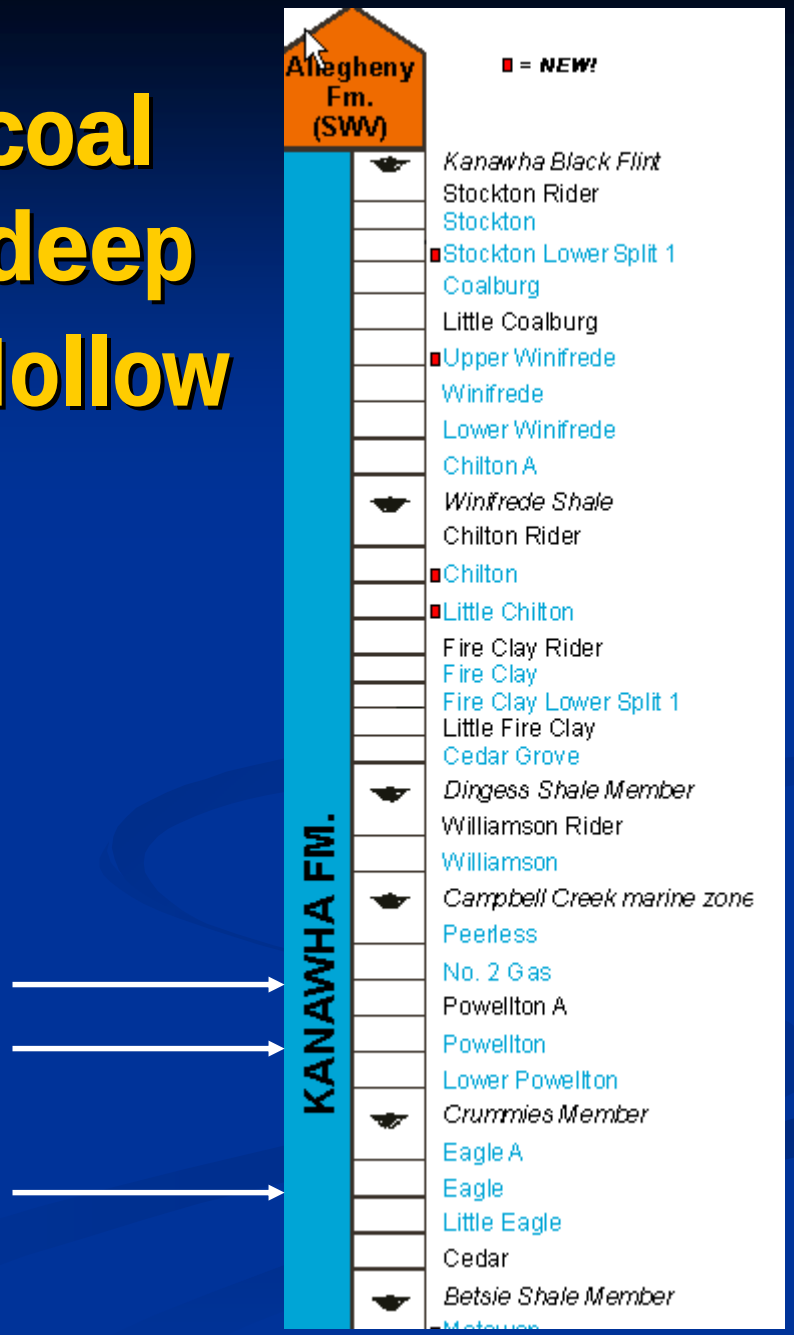
Figure 1-Loadout, LLC-Abbott Hollow refuse area, O-14-82 permit boundary



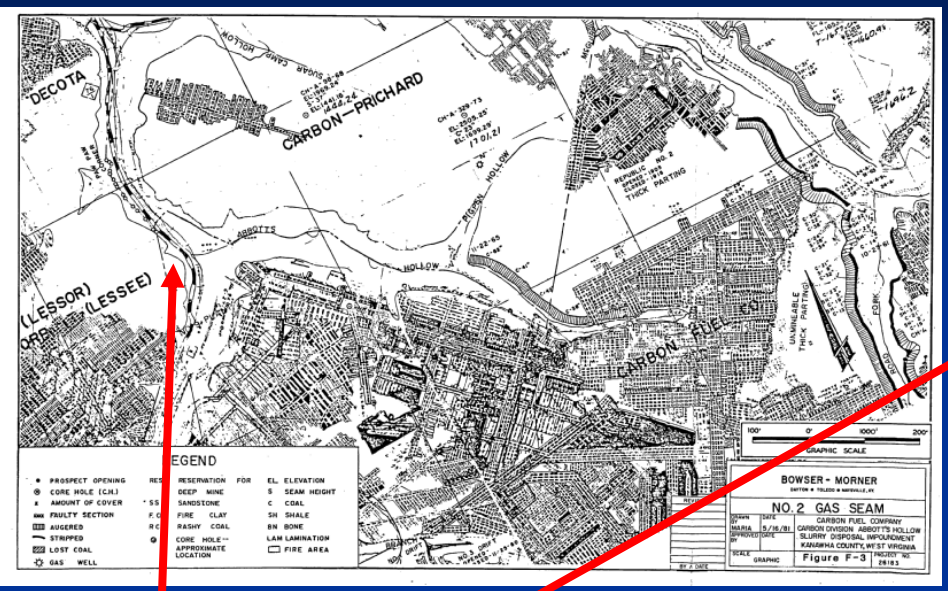
Abbott Hollow Refuse Permit Boundary

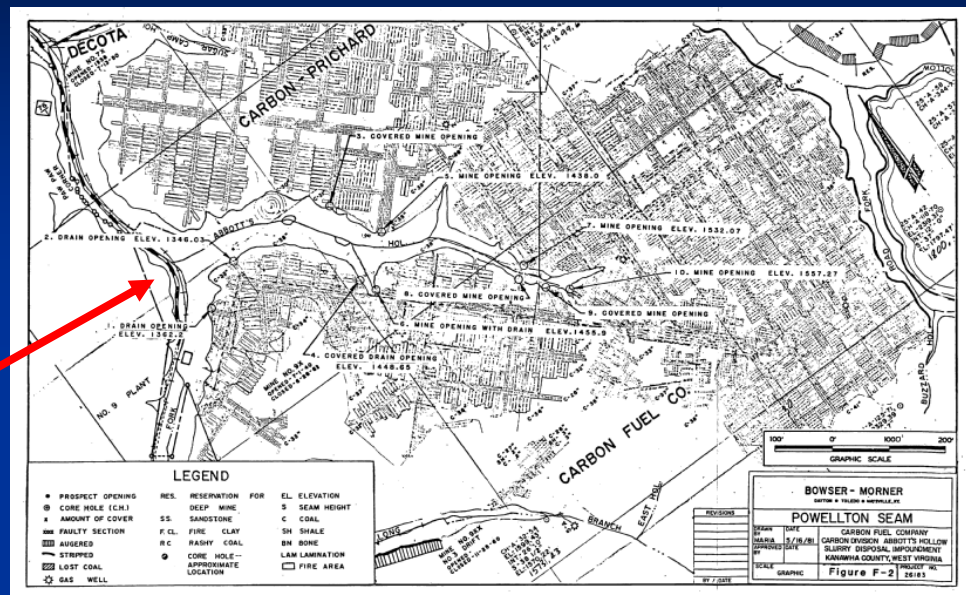


Stratigraphy of coal seams that were deep mined at Abbott Hollow



Underground mining in Abbott Hollow

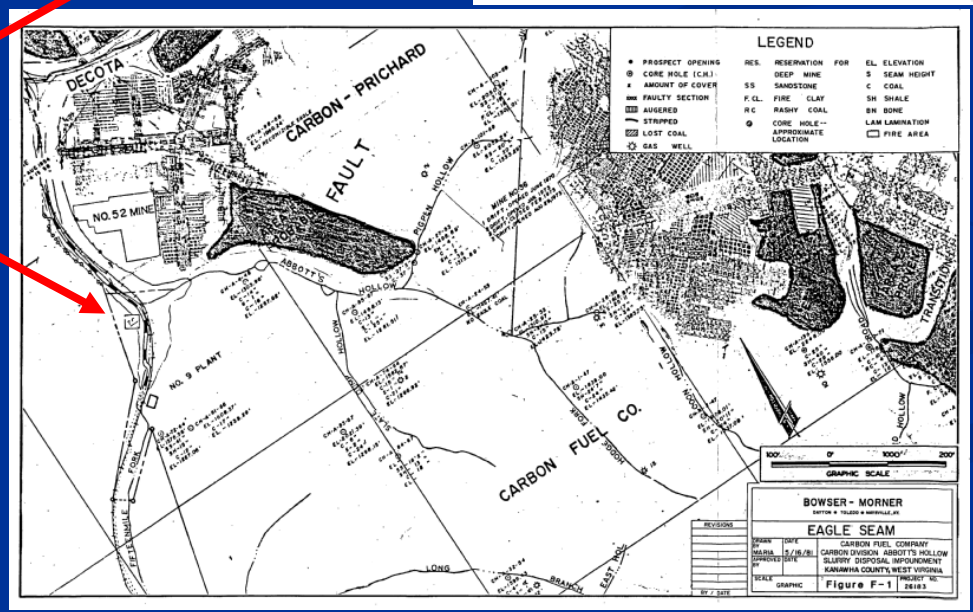




No. 2 Gas seam

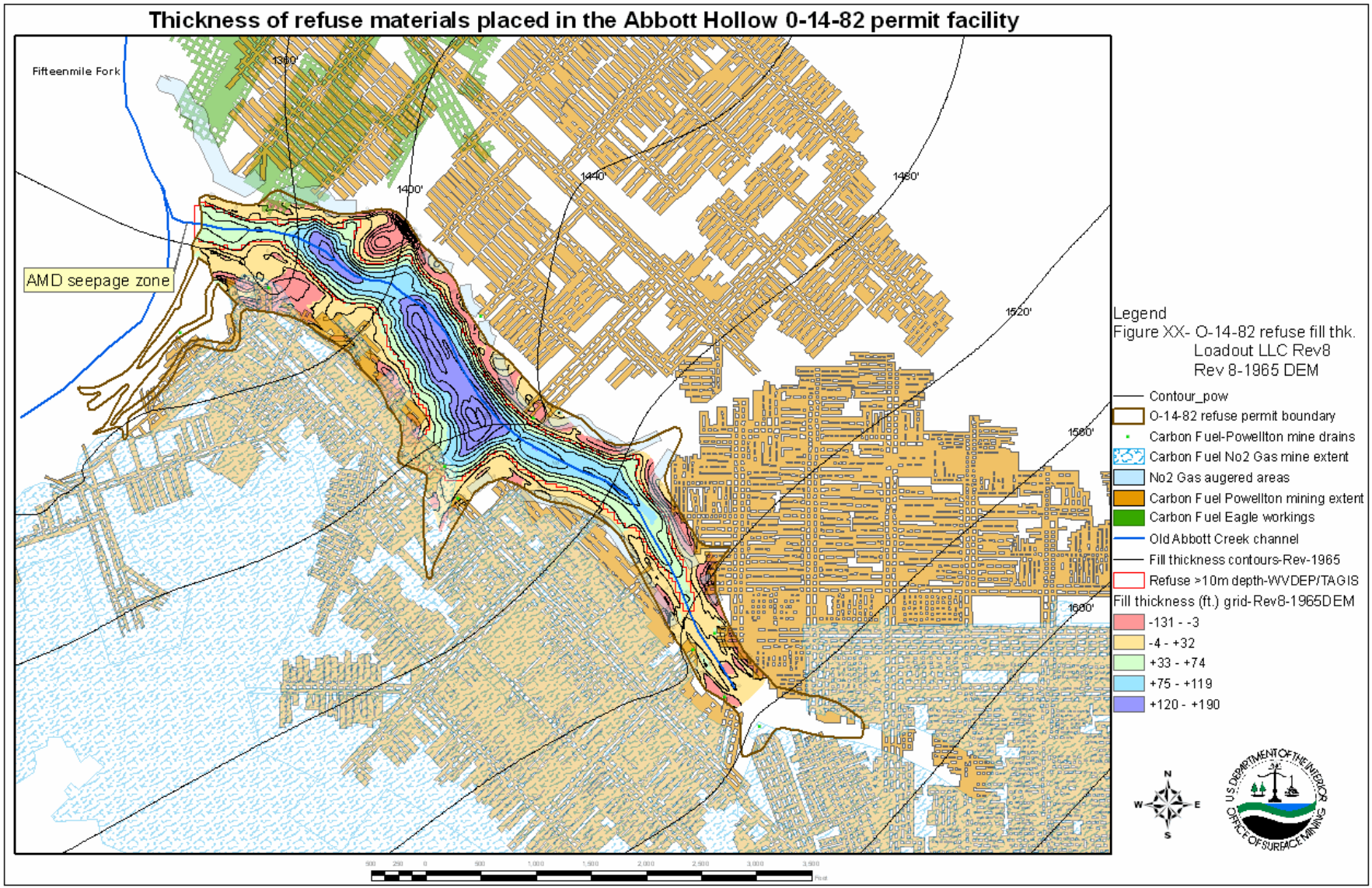
Powellton seam

AMD Seeps



Eagle seam

Refuse Fill and Underground Mines



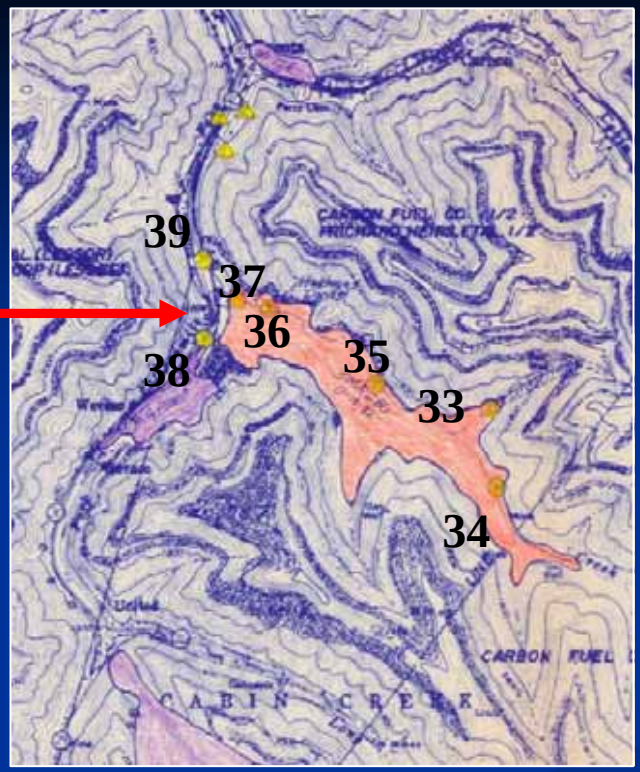
Ambient Water Quality

- A pattern of elevated metals occurs downstream of the Abbott Hollow refuse area, stains and coats the Fifteenmile Fork streambed
- Iron, manganese, and pH levels exceed in-stream water quality limits downstream of the refuse site

  -Metals and acidity levels are compliance levels upstream of Abbott Hollow
- Pattern results in discharge that cause significant loadings of acidity and metals
- Seeps result in adverse impacts to the receiving stream, Fifteenmile Fork

Abbott Hollow and Fifteenmile Fork historical water quality

AMD Seeps



ID	Location	Date	pH su	Fe-t mg/L	Fe-d mg/L	Mn-t mg/L	Cond. umhos/cm
33	Pig Pen trib. of 15_Mile Fork	10/22/80	7.30	0.46	0.08	0.36	1100
34	Abbott refuse area	10/22/80	7.5	0.19	0.08	0.01	1040
35	Abbott refuse area	10/22/80	6.8	0.70	0.07	0.50	1040
36	Abbott refuse area	10/22/80	3.90	182	1.86	12.32	3040
37	Abbott refuse area	10/22/80	3.80	176	90.5	11.36	2380
38	Upstream Seeps Abbott Hollow	10/22/80	3.50	142.4	93.5	11.12	2180
39	Downstream Fifteenmile Fk.	10/22/80	3.50	112.4	102.0	10.64	2280

Water chemistry

Upstream of Abbott refuse

Sample date at NPDES ussf	Average Fe-t mg/L	Sample date at NPDES ussf	Average Fe-t mg/L	Sample date at NPDES ussf	Average Fe-t mg/L	Sample date at NPDES ussf	Average Fe-t mg/L
1/31/1996	0.345	9/30/2000	0.765	1/31/2001	0.35	1/31/2002	0.75
2/28/1996	0.11	10/31/2000	0.685	2/28/2001	0.32	2/28/2002	0.72
3/31/1996	0.2	11/30/2000	0.49	3/31/2001	0.655	3/31/2002	0.36
4/30/1996	0.265	12/31/2000	0.54	4/30/2001	0.27	4/30/2002	0.48
5/31/1996	0.14			5/31/2001	0.305	5/31/2002	0.39
6/30/1996	0.1			6/30/2001	0.370	6/30/2002	0.505
7/31/1996	0.1			7/31/2001	2.870	7/31/2002	0.35
8/31/1996	0.1			8/31/2001	2.460	8/31/2002	0.48
9/30/1996	0.5			9/30/2001	1.090	9/30/2002	0.485
10/31/1996	0.1			10/31/2001	0.695	10/31/2002	0.35
11/30/1996	0.07			11/30/2001	0.64	11/30/2002	0.275
12/31/1996	.09			12/31/2001	0.93	12/31/2002	0.185

Sample date at NPDES ussf	Average Fe-t mg/L	Sample date at NPDES ussf	Average Fe-t mg/L	Sample date at NPDES ussf	Average Fe-t mg/L	Sample date at NPDES ussf	Average Fe-t mg/L
1/31/2003	0.23	1/31/2004	0.22	1/31/2005	0.45	1/31/2006	0.26
2/28/2003		2/29/2004	0.20	2/28/2005	0.28	2/28/2006	0.21
3/31/2003	0.235	3/31/2004	0.245	3/31/2005	0.235	3/31/2006	0.19
4/30/2003	0.24	4/30/2004	0.23	4/30/2005	0.205	4/30/2006	0.14
5/31/2003	0.18	5/31/2004	0.295	5/31/2005	0.165		
6/30/2003	0.15	6/30/2004	0.28	6/30/2005	0.17		
7/31/2003	0.28	7/31/2004	0.230	7/31/2005	0.415		
8/31/2003	0.29	8/31/2004	0.275	8/31/2005	0.345		
9/30/2003	0.195	9/30/2004	0.24	9/30/2005	0.48		
10/31/2003	0.195	10/31/2004	0.255	10/31/2005	0.25		
11/30/2003	0.26	11/30/2004	0.22	11/30/2005	0.44		
12/31/2003	0.17	12/31/2004	0.295	12/31/2005	0.24		

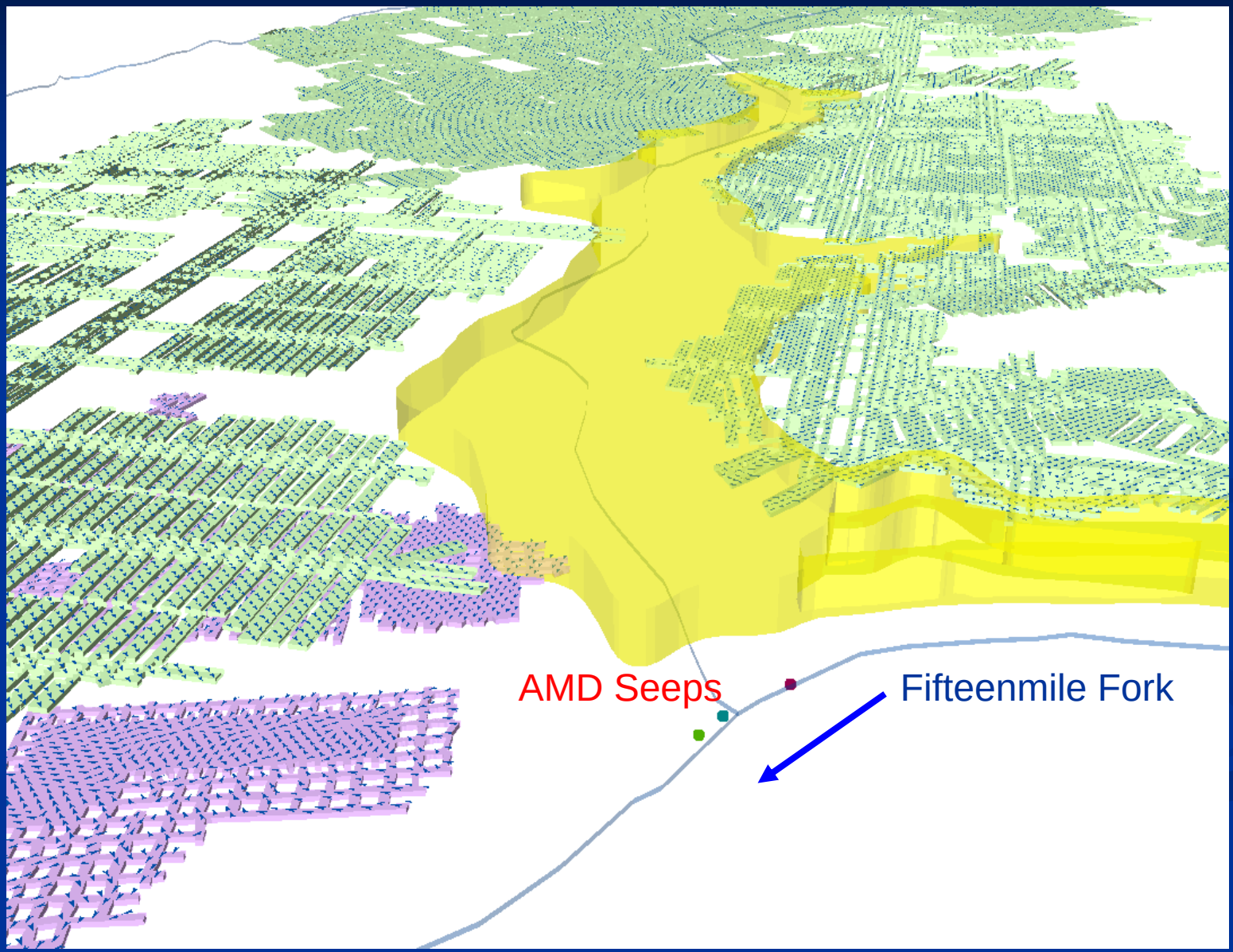
Water chemistry

Downstream of Abbott refuse

Sample date at NPDES dssf	Average Fe-t mg/L	Sample date at NPDES dssf	Average Fe-t mg/L	Sample date at NPDES dssf	Average Fe-t mg/L	Sample date at NPDES dssf	Average Fe-t mg/L
1/31/1996	10.000	1/31/2000	10.85	1/31/2001	22.80	1/31/2002	29.70
3/31/1996	9.800	2/29/2000	6.22	2/28/2001	13.50	2/28/2002	23
4/30/1996	7.130	3/31/2000	10.27	3/31/2001	11.63	3/31/2002	9.20
		4/30/2000	4.47	4/30/2001	10.14	4/30/2002	5.56
		5/31/2000	7.25	5/31/2001	11.50	5/31/2002	7.15
		6/30/2000	7.23	6/30/2001	8.40	6/30/2002	22.4
		7/31/2000	6.21	7/31/2001	8.62	7/31/2002	21.7
		9/30/2000	18.80	8/31/2001	7.32	8/31/2002	34.8
		10/31/2000	20.90	9/30/2001	26.65	9/30/2002	40.3
		11/30/2000	31.35	10/31/2001	36.10	10/31/2002	25.55
		12/31/2000	28.85	11/30/2001	41.50	11/30/2002	9.08
				12/31/2001	33.10	12/31/2002	7.675

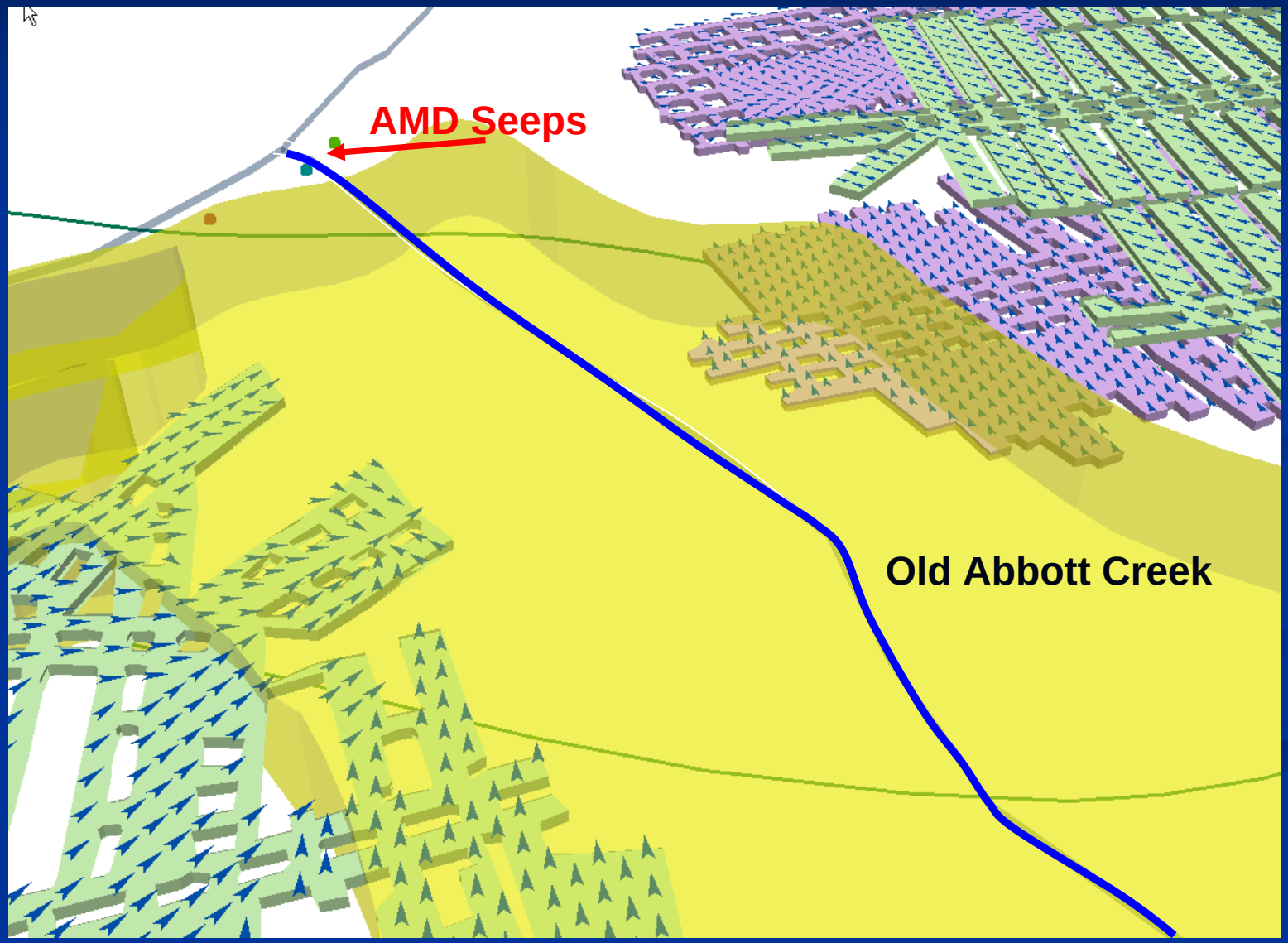
Sample date at NPDES dssf	Average Fe-t mg/L	Sample date at NPDES dssf	Average Fe-t mg/L	Sample date at NPDES dssf	Average Fe-t mg/L	Sample date at NPDES dssf	Average Fe-t mg/L
4/30/2003	11.37	1/31/2004	5.88	1/31/2005	10.6	1/31/2006	12.1
5/31/2003	9.85	2/29/2004	12.25	2/28/2005	7.255	2/28/2006	5.6
6/30/2003	8.05	3/31/2004	9.30	3/31/2005	9.49	3/31/2006	11.6
7/31/2003	18.90	4/30/2004	9.92	4/30/2005	8.41	4/30/2006	3.08
8/31/2003	18.80	5/31/2004	18.45	5/31/2005	19.2		
9/30/2003	20.55	6/30/2004	10.40	6/30/2005	29.9		
10/31/2003	20.55	7/31/2004	20	7/31/2005	8.9		
11/30/2003	5.21	8/31/2004	27.20	8/31/2005	14.6		
12/31/2003	5.45	9/30/2004	8.79	9/30/2005	33.9		
		10/31/2004	10.2	10/31/2005	28.7		
		11/30/2004	10.5	11/30/2005	26.7		
		12/31/2004	11.6	12/31/2005	24.2		

Abbott Hollow Refuse Area

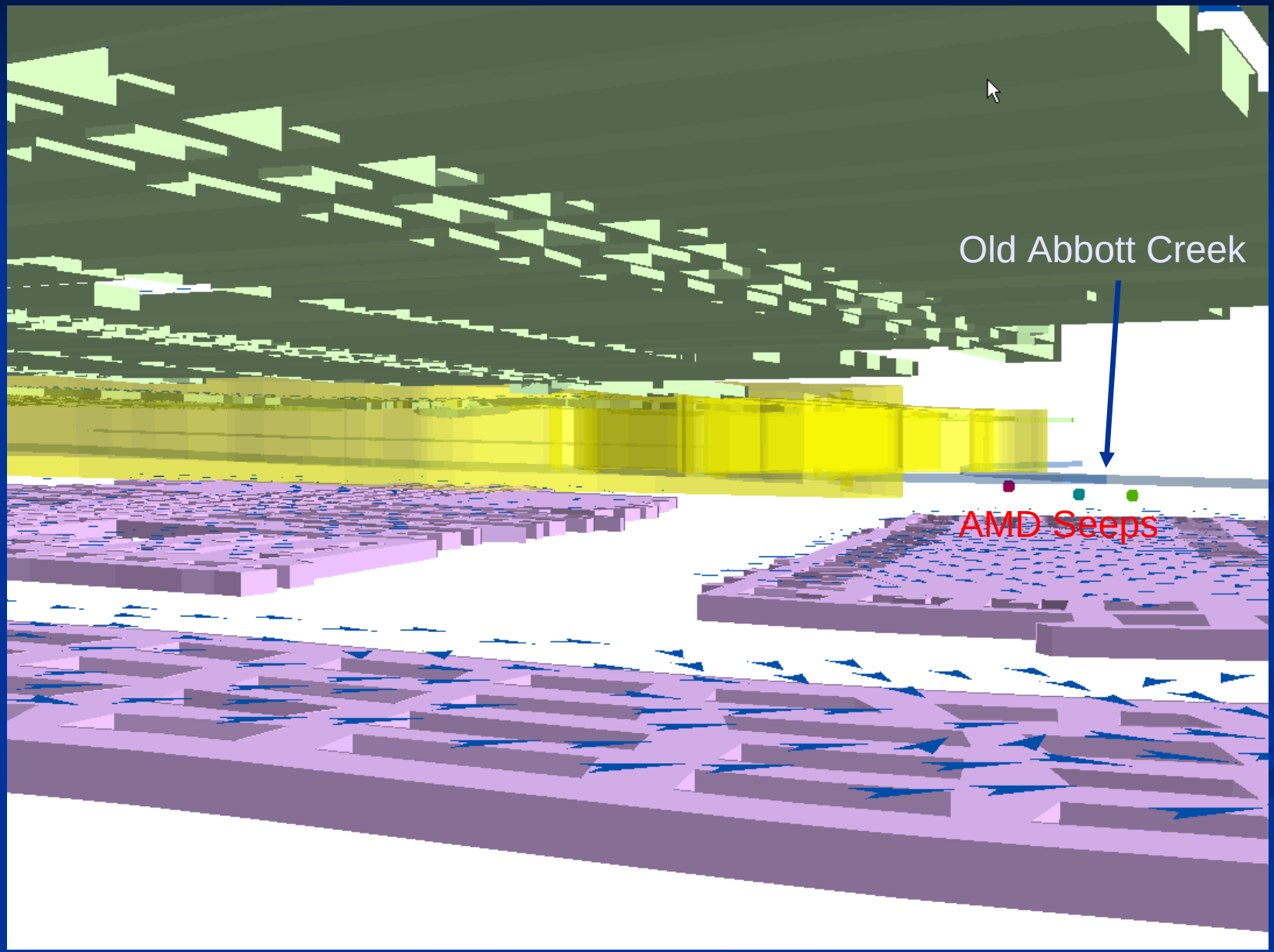


Abbott Hollow fill

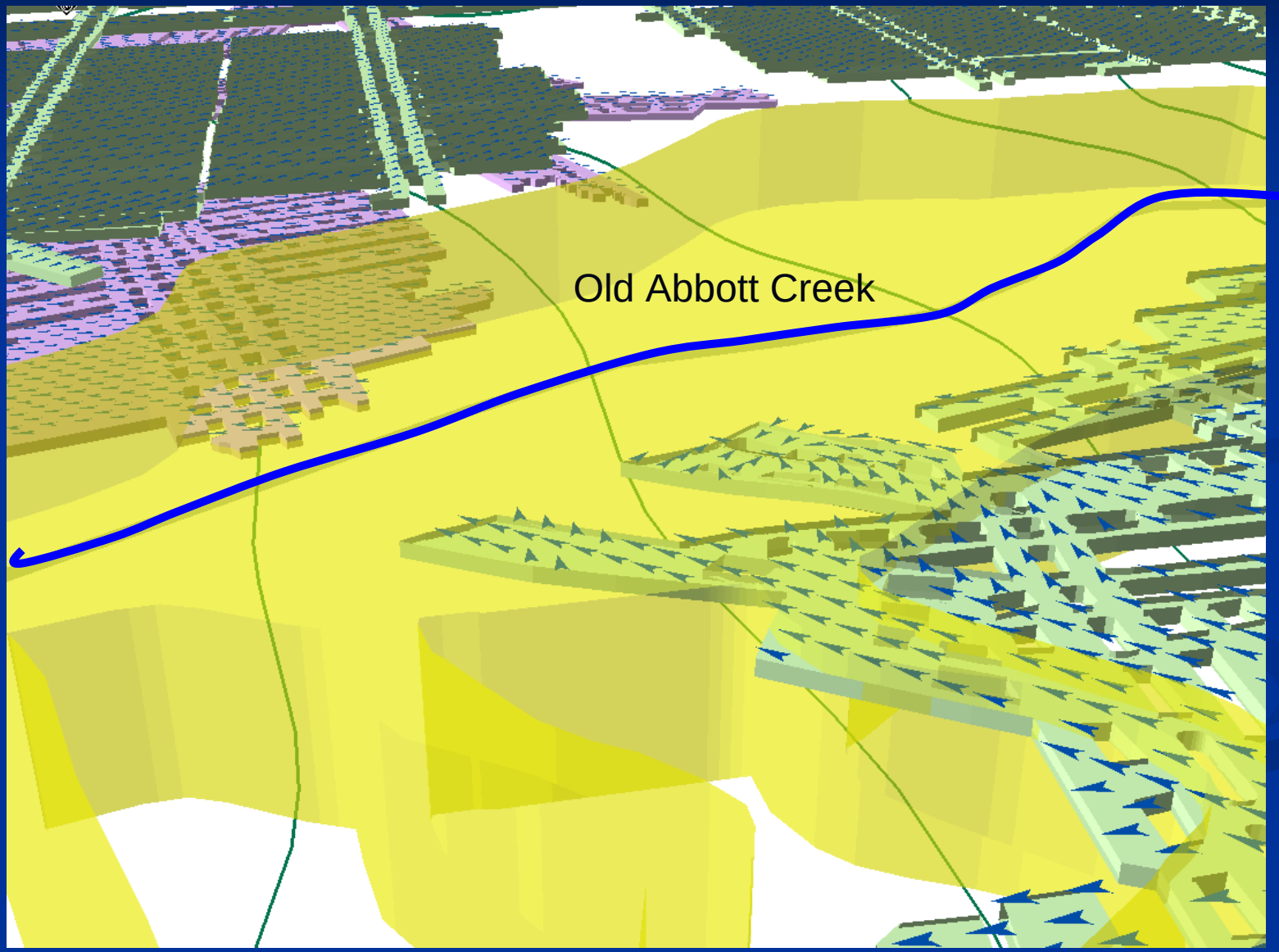
Powellton and Eagle mines proximity to fill



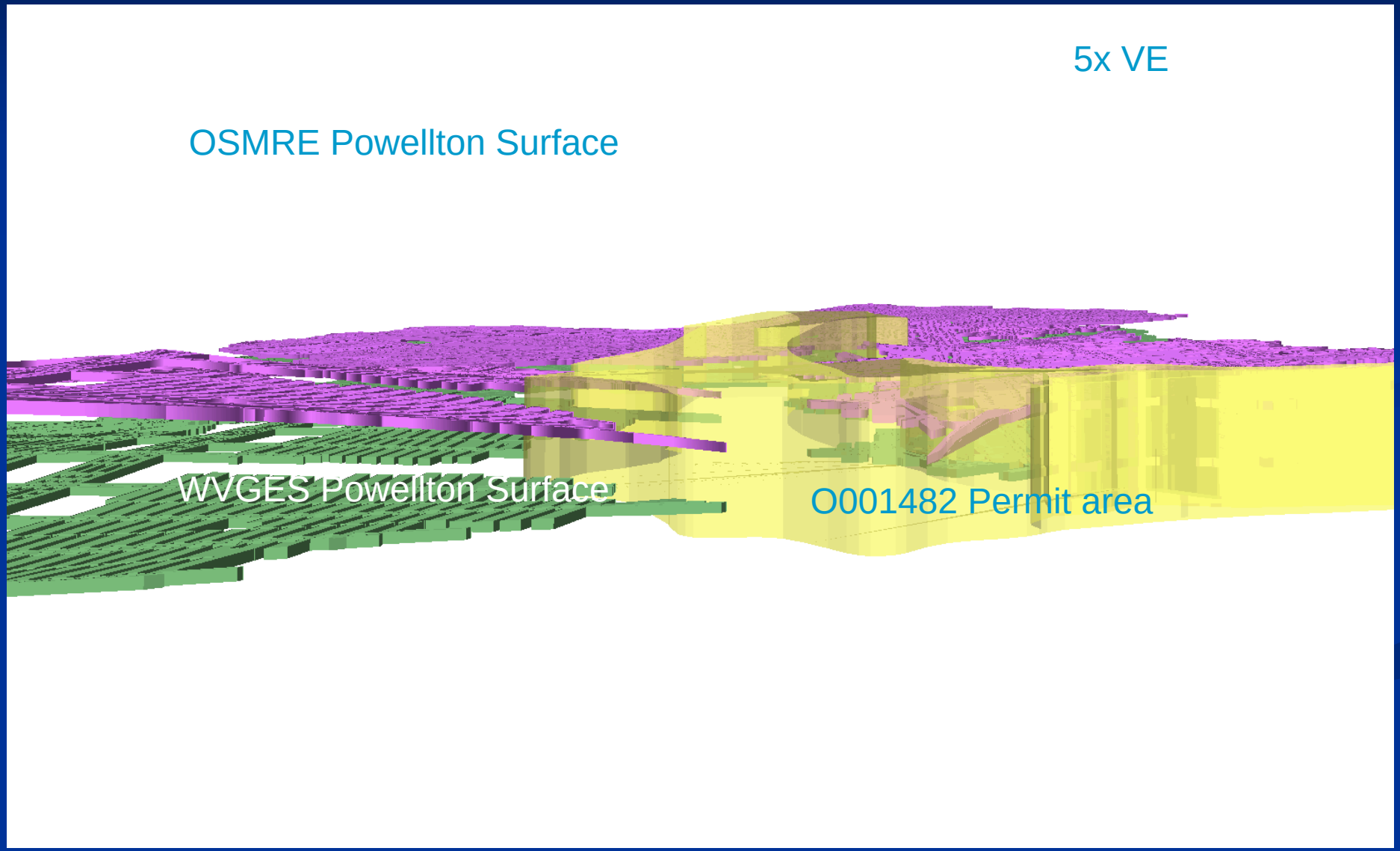
Eagle mining below Abbott fill



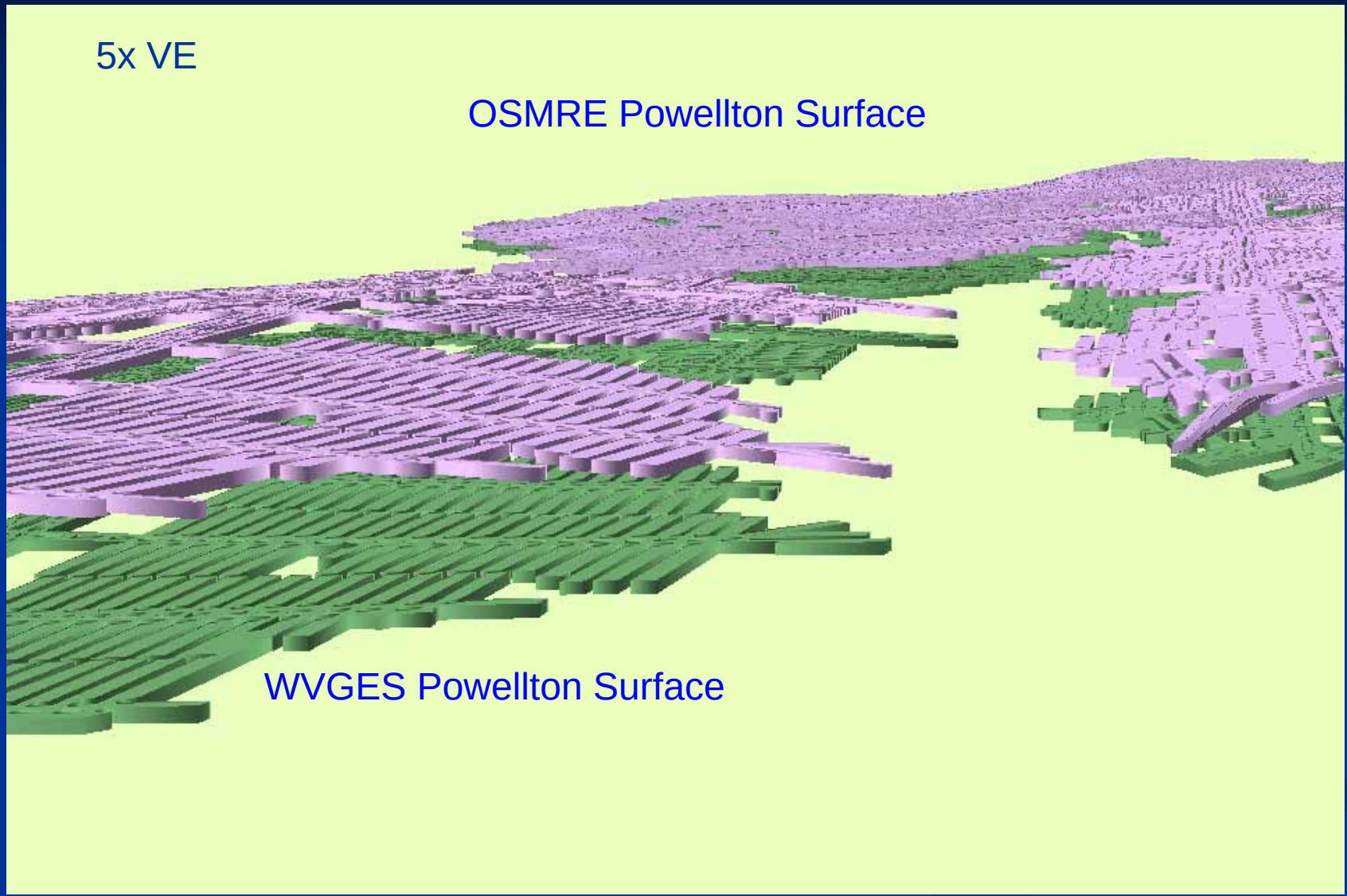
Flow arrows indicate direction of mine water to old Abbott Creek



Powellton seam: Local Variation OSMRE vs. WVGES

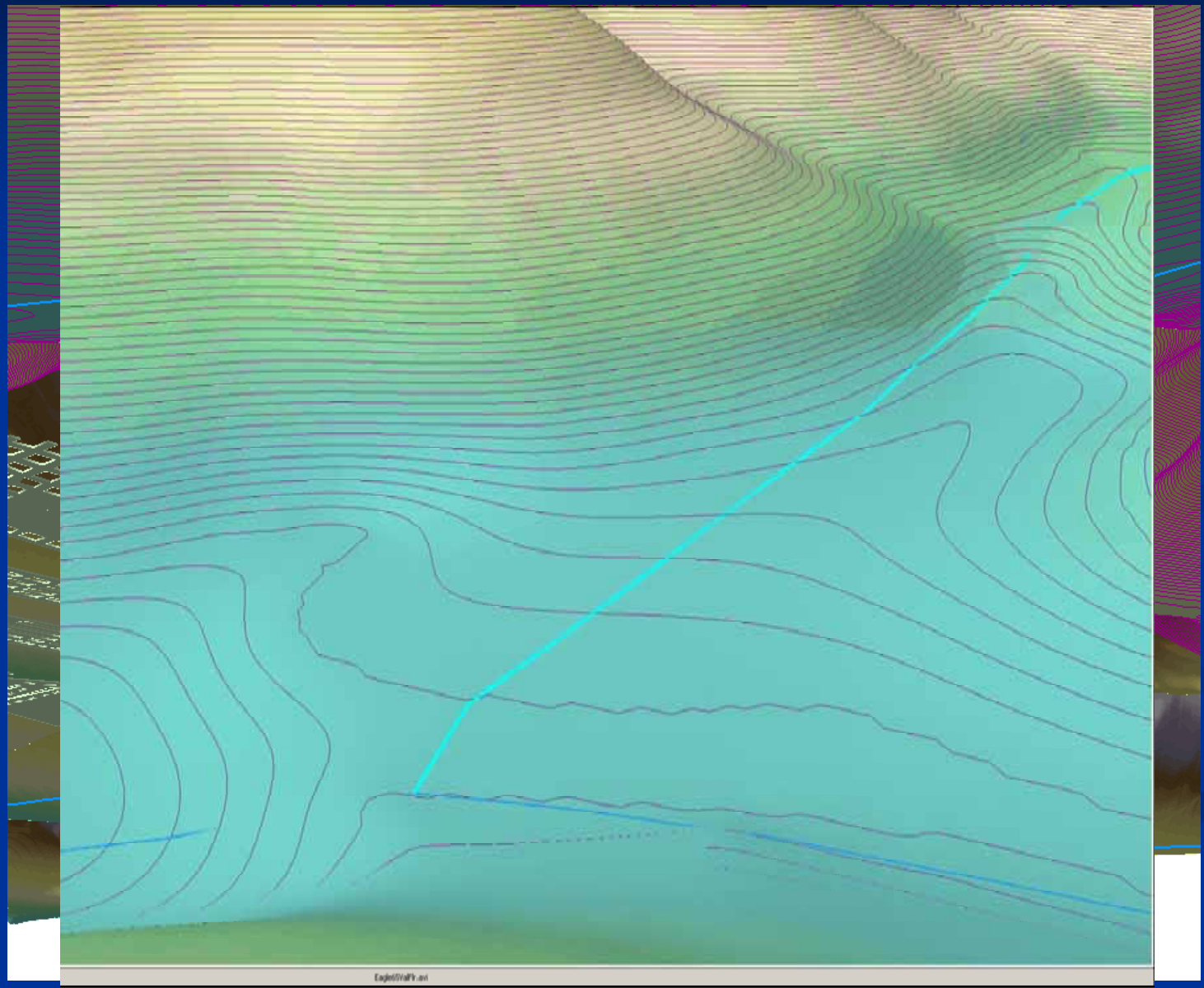


Powellton seam local Variation: OSMRE vs. WVGES



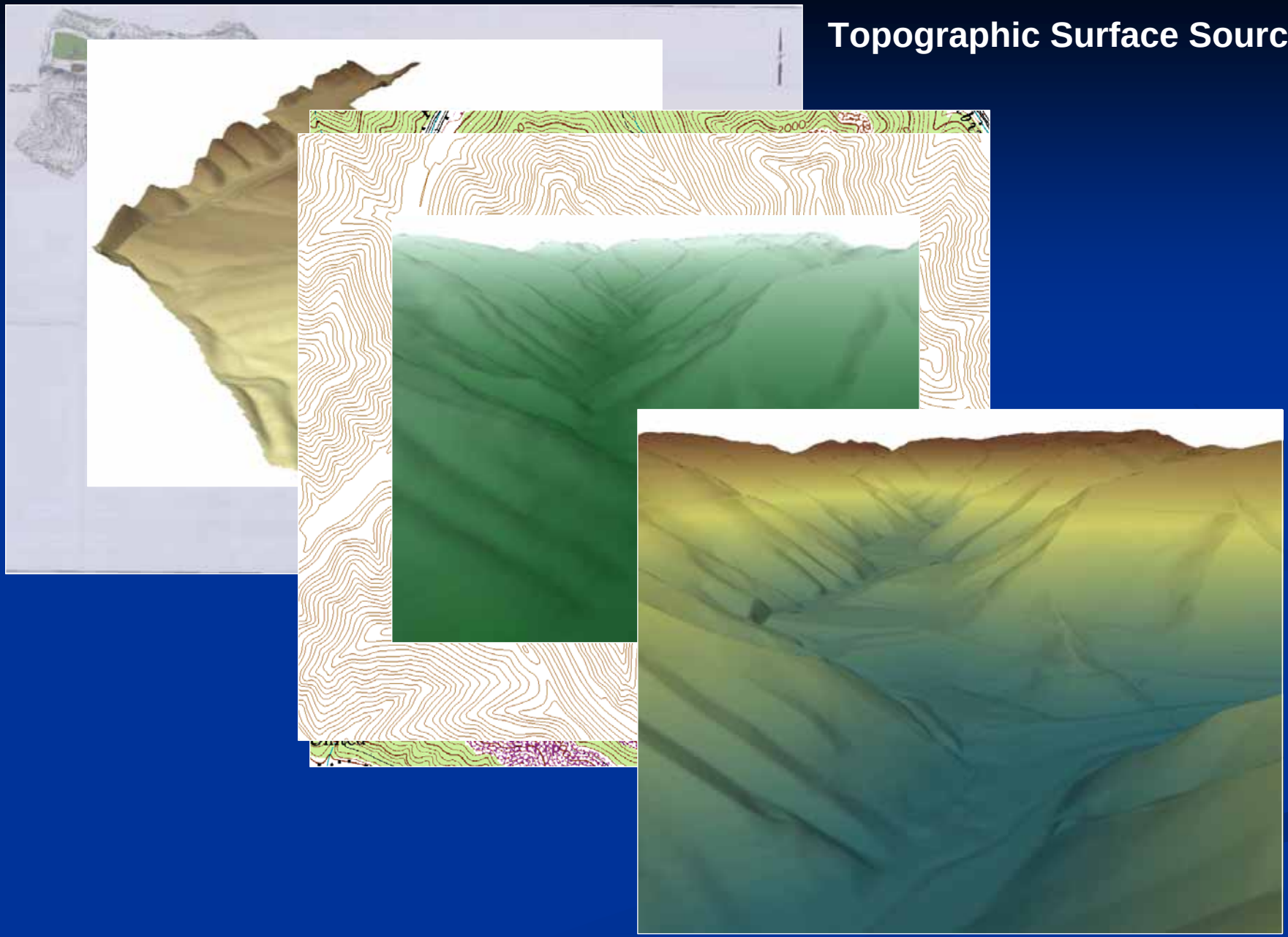
Proximity of Eagle Mine to 1965 Valley Floor

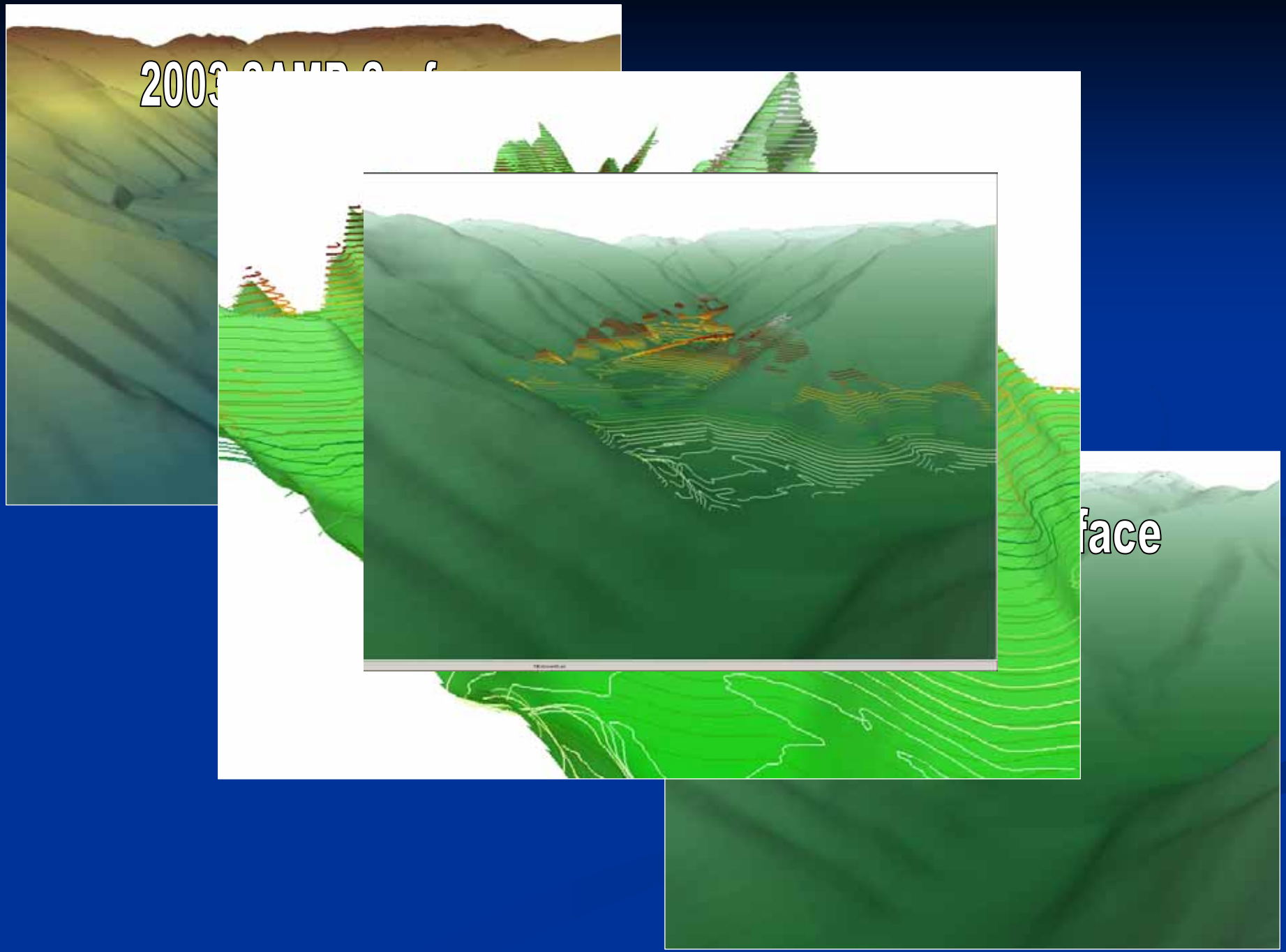
(view under eagle looking up toward valley floor)



Site Characterization

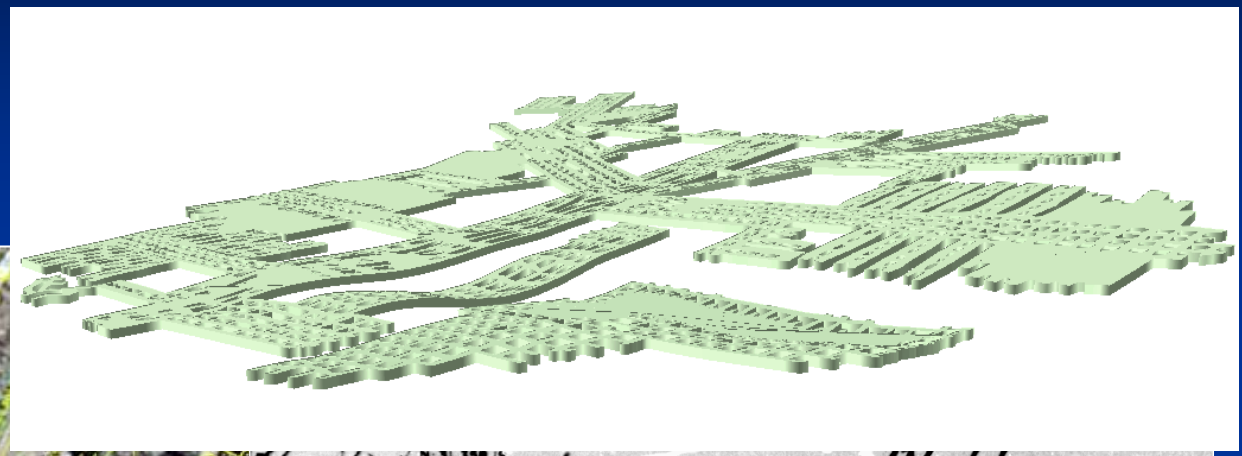
Topographic Surface Sources

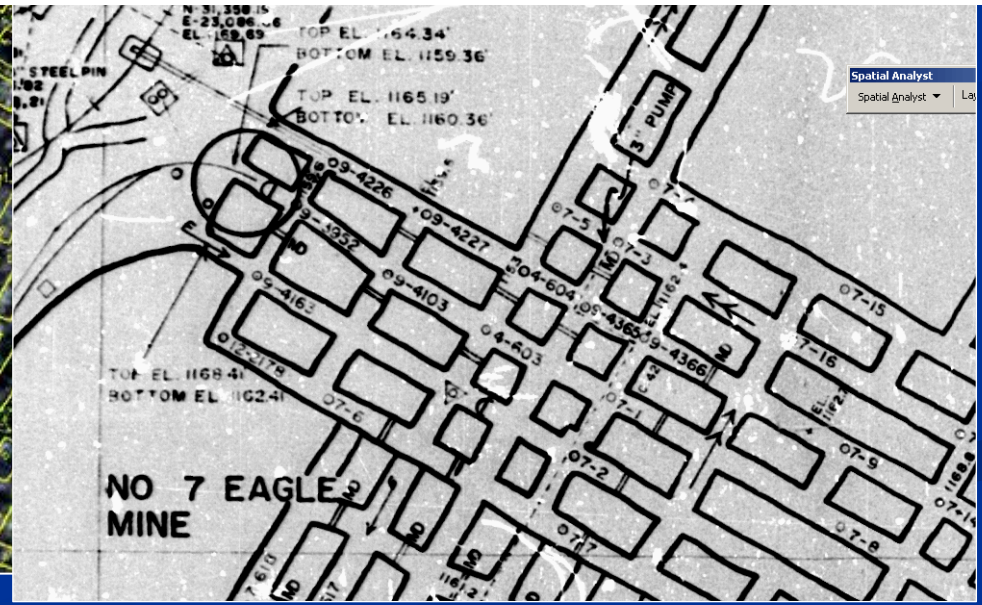




Coal Surface Generation

Georeferencing and Elevation Extraction





Summary

- The use of ESRI's ArcScene 3D visualization modeling application allows a 3D perspective

  - Relationship between underground mining, the refuse area, and the AMD seeps.


Video Clip

- Local geologic structure depicted by ArcScene is believed to control the flowpaths and contribution of inflows from underground mining into the refuse pile


Video Clip

- Refuse pile has geochemical character to produce the AMD Seeps that emanate from the refuse toe

The End