SHAMOKIN CREEK WATERSHED

Acid Mine Drainage Treatment for Beneficial Reuse & Environmental Restoration

Prepared by

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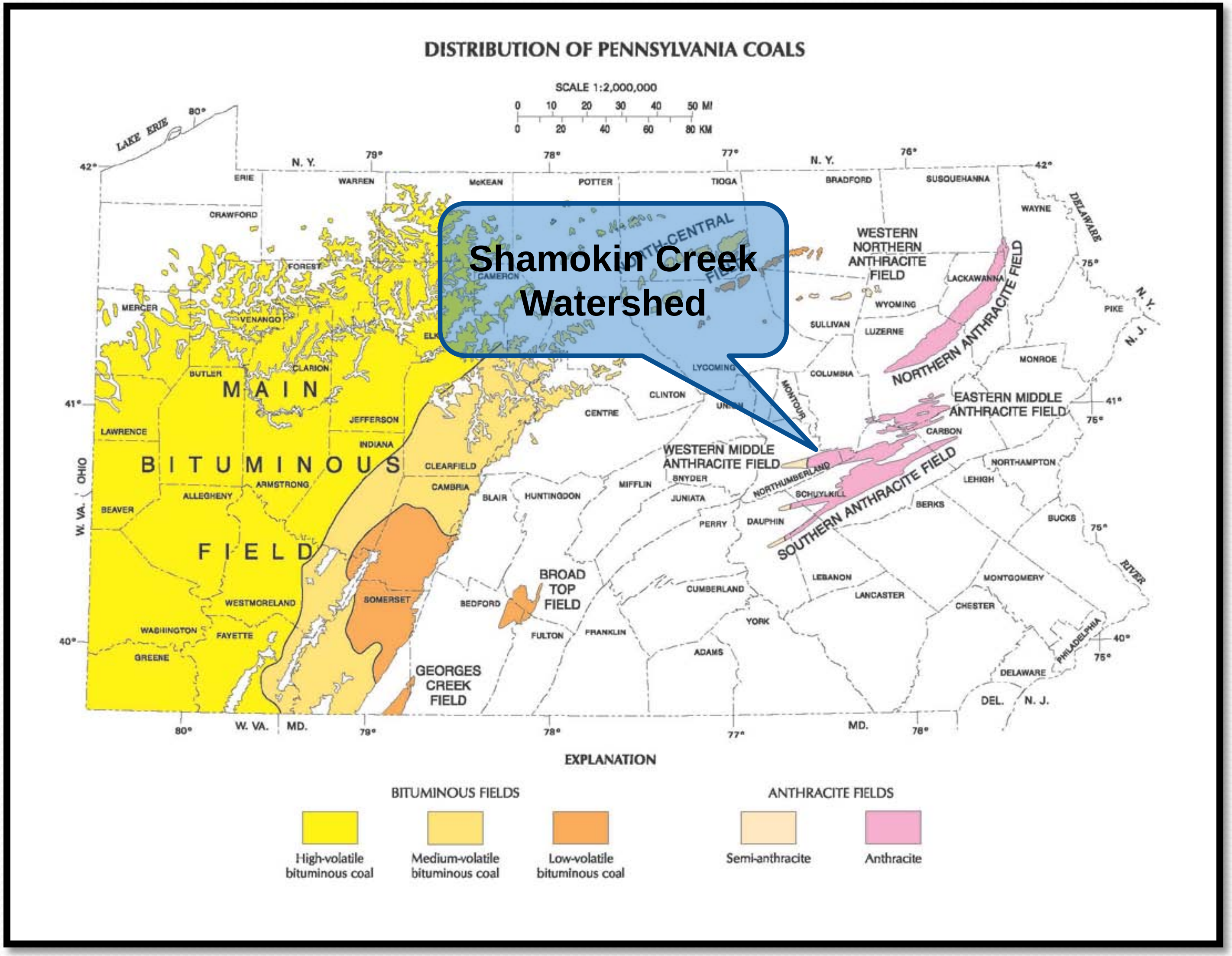
Coal Regions of Pennsylvania



Coal Mining History of the Region

- 1790 - Discovery of Anthracite Coal in Quaker Run
- 1830's – Major Mining Started
  - *Invention of Steam Engine*
  - *Expansion of Railroads*
  - *Mechanical Breaker*
- 1830 to 1900 - Development of Major Collieries
  - *Scott Colliery near Kulpmont*
  - *Excelsior Colliery near Excelsior*
  - *Corbin Colliery near Ranshaw*
  - *Hickory Ridge Colliery near Marion Heights*
- Peaked during WWII – 100 million tons/year
- Post WWII anthracite mining declining
  - *Great Depression*
  - *Petroleum & Natural Gas Discoveries*
  - *Western PA Bituminous Coal for Steel*
- Slight Increase in WWII
- Post-WWII Mining was limited
  - *Less deep mining*
  - *Greater surface mining*
- **1960 - All coal mining had ceased in Watershed**

1836 - 1st Major Coal Mine Cameron Colliery

Acid Mine Drainage
Sources In The Watershed


Strip Mines Outflows


Boreholes to drain mines


Culm Pile Drainage

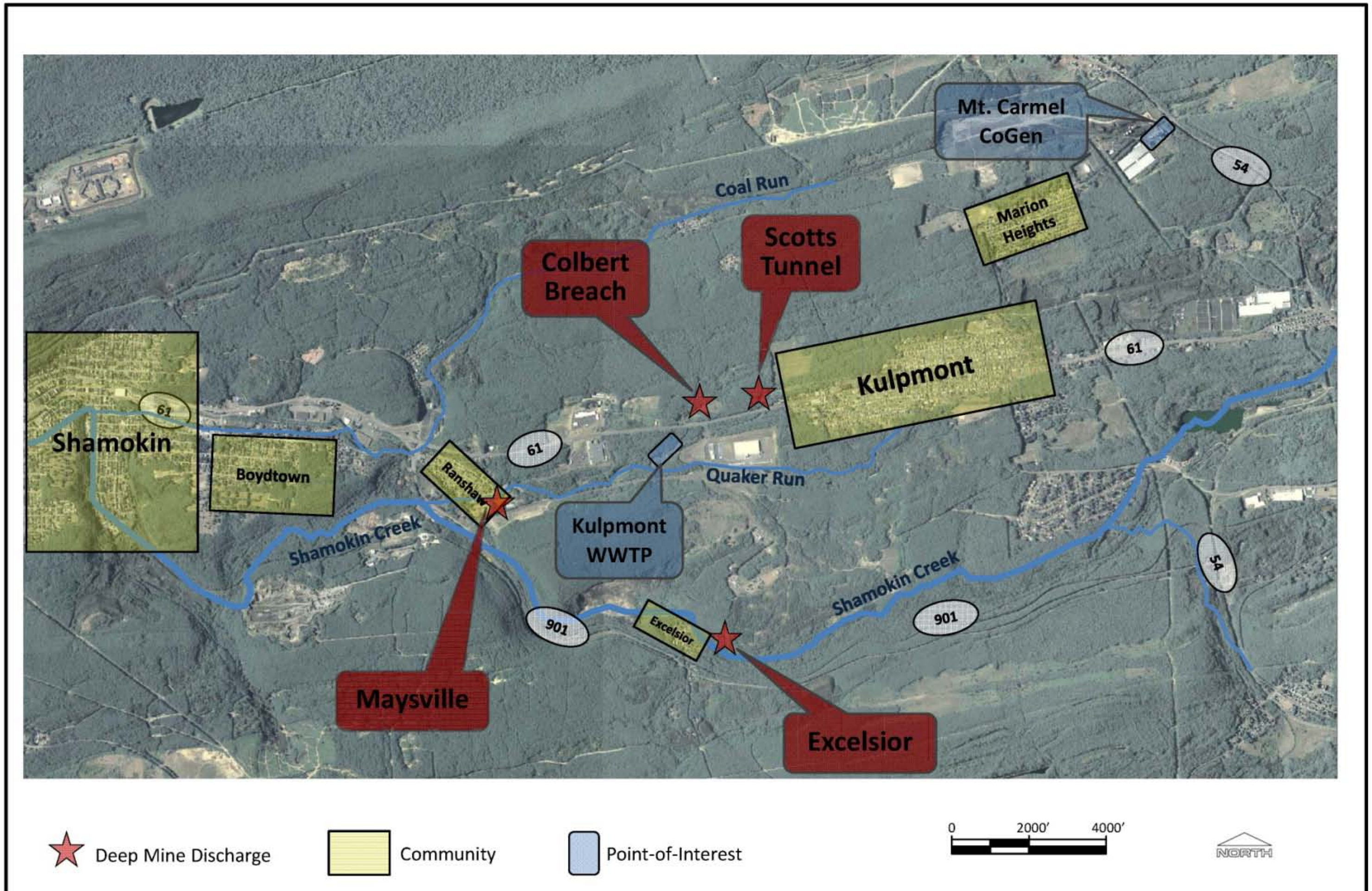

Air Shaft Outflow


Deep, Mine Outflows

Purpose of the Feasibility Study

- Focus on High Flow Discharges Previously Considered Untreatable Due to High Costs and/or Land Area.
- Evaluate New & Innovative Treatment Approaches Developed in the Last Decade.
  - lower capital costs
  - lower long term operating costs
- Consider the Beneficial Reuse of the Treated Water and Byproduct (iron oxide solids) from the treatment.
  - generate revenues to pay for the treatment
  - enhance economic conditions in local communities

Feasibility Study Area
AMD Treatment & Water Reuse



Shamokin Creek Feasibility Study Project Area.

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Acid Mine Drainage
Sources In The Study Area

Acid Mine Drainage
Sources In The Watershed

Approximately 60 Discharges from Deep Mines, Surface Mines, & Culm Piles Throughout the Watershed (Cravotta & Kirby 2004)

Top Ten Discharge

Rank	Location ID	Local Name	Flow MGD	Iron		% Watershed Load
				mg/L	lbs/day	
1	*SR19*	*Scott Mine Tunnel*	*12.4*	*30.6*	*2349*	*22.7*
2	*SR12*	*Excelsior Strip Pit Overflow*	*9.1*	*30.4*	*1742*	*20.3*
3	SR53	Cameron Mine Air Shaft	3.2	58.4	1152	13.2
4	SR49	Henry Clay Stirling Mine	8.5	26.1	1030	12.9
5	SR23	Big Mtn Mine #1	2.3	29.7	330	5.9
6	SR15	Corbin Drift	1.0	44.9	415	5.7
7	SR51A	Cameron Mine Drift	1.5	49.1	464	4.6
8	*SR21*	*Maysville Mine Borehole*	*2.5*	*23.4*	*307*	*3.9*
9	SR5B	Mid. Valley Mine Tunnel	3.2	9.9	207	3.7
10	*SR20*	*Colbert Mine Breach*	*1.1*	*30.9*	*292*	*2.2*
Top 10 Total			**48.4**		**8289**	**95.1%**
Yellow Total			**25.1**		**4690**	**53.8%**

Treated AMD Beneficial Reuse

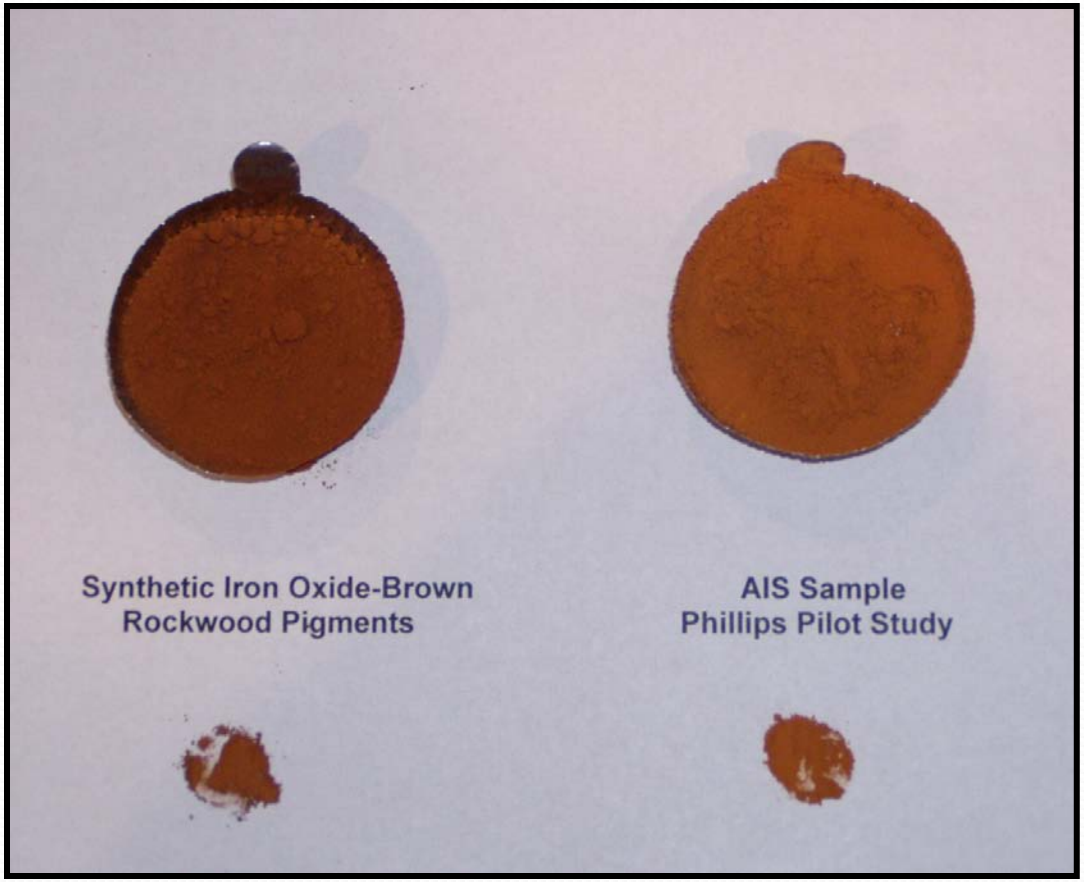
- **Industrial Reuse**
  - Evaporative Cooling at Power Plants
  - Make-up Water in Natural Gas Well Hydro-fracturing
  - Low Temperature Geothermal (Open or Closed-Loop) for heating and cooling
- **Recreational Reuse**
  - Trout Culture for Stream Stocking
- **Water Supply Augmentation**
  - Low Flow Augmentation for the Susquehanna River

AMD Byproduct (Solids) Handling

- **Disposal Options**
  - **Deep Mine Injection** – liquid sludge injected through a borehole into the deep mine.
  - **Mine Pit Disposal** – dewatered sludge is disposed in nearby open pits and strip cuts of active surface mines.
  - **Lagoon Burial** – accumulated sludge in dry lagoons is buried with overburden and top soil.
  - **Land Application** – dewatered sludge is blended with mine waste at active deep mines or with topsoils as part of surface reclamation.
  - **Landfilling** – dewatered sludge is transported and disposed in landfills.
- **Reuse Options – Depend on Characteristics/Treatment Process**
  - **Metallurgical** – used in steel production and the powdered metal industry.
  - **Corrosion Inhibitor in Concrete** – an additive to inhibit reinforcing bar chloride corrosion in concrete.
  - **Environmental** – various uses in pollution abatement including phosphorous removal and trace metal sorption in wastewater treatment.
  - **Pigments/Colors** – use as a pigment in various materials including masonry, concrete and paints.
  - **Agricultural Soil Amendment** – soil amendment to bind in the soil and prevent runoff of phosphorous.

High Value Beneficial Solids Reuse

Low-Grade Quality Iron Oxide Pigment @ $ 250 per ton



Approximate Production in Feasibility Study Area = 1,600 tons (dry weight)

Treatment for Feasibility Study AMD

- **Passive Treatment Options**
  - Anoxic Limestone Drain – 200,000 Tons & $8.5 million
  - Aerobic Ponds – 60 acres & $5.0 million
  - *Capital Costs & Size – Not Feasible*
- **Current Active Treatment Options**
  - Conventional Lime Treatment
  - High Density Sludge (HDS) Lime Treatment
- **Innovative Active Treatment Options**
  - Activated Iron Solids (AIS) Treatment
  - Value Extraction Process (VEP) Process

Comparison of Select Active Treatment
Conventional Lime, HDS Lime, & AIS Treatment

Capital Costs
- **Conventional Lime** – $4.1 million
- HDS Lime - $5.2 million
- AIS Treatment- $4.7 million

Operating Costs
- Conventional Lime – $980,000 per year
- HDS Lime - $670,000 per year
- **AIS Treatment -** $430,000 per year

Effluent Quality
- All produce similar effluent quality for iron
- Conventional & HDS Lime have a higher effluent pH (8.5/7.0)
- **AIS Treatment** has slightly lower hardness

Sludge Characteristics
- Conventional Lime produce low density high volume sludge
- Conventional & HDS Lime produce calcium contaminated sludge
- **HDS Lime & AIS Treatment** produce high density low volume sludge
- **AIS Treatment** produces high iron (>95%) and low calcium (<5%) sludge

SELECTION – AIS Treatment selected due to lower operating costs & sludge characteristic consistent with identified beneficial reuse. Estimated Operating Cost = $0.11/1,000 gallons

Advanced Treatment Approach

- **Facility Size**
  - 1 MGD Facility
  - Expandable Components (in 1 MGD increments)
- **Treatment Approach**
  - Ozonation for residual metal oxidization.
  - Ultra-filtration for removal of particulate solids.
- **Effluent Water Quality Meets Beneficial Reuses Including**
  - Cooling Water and Supply for Boiler Water (using R/O)
  - Low Temperature Geothermal
  - Most Industrial Water Applications – **Hydrofracking Water Source**
  - Potable Water except for Sulfate
- **Facility Costs**
  - Capital Costs - $1.9 Million
  - Operating Costs - $150,000 per year
  - Estimated Treatment Costs - $0.35 per 1,000 gallons

Feasibility Study
Facility Locations & Layout

Collection & Treatment System(s)

Advanced Treatment System(s)

Cooling Water Distribution & Storage

Geothermal District(s)

Scotts Tunnel & Colbert Breach

Collection Systems & Pipelines

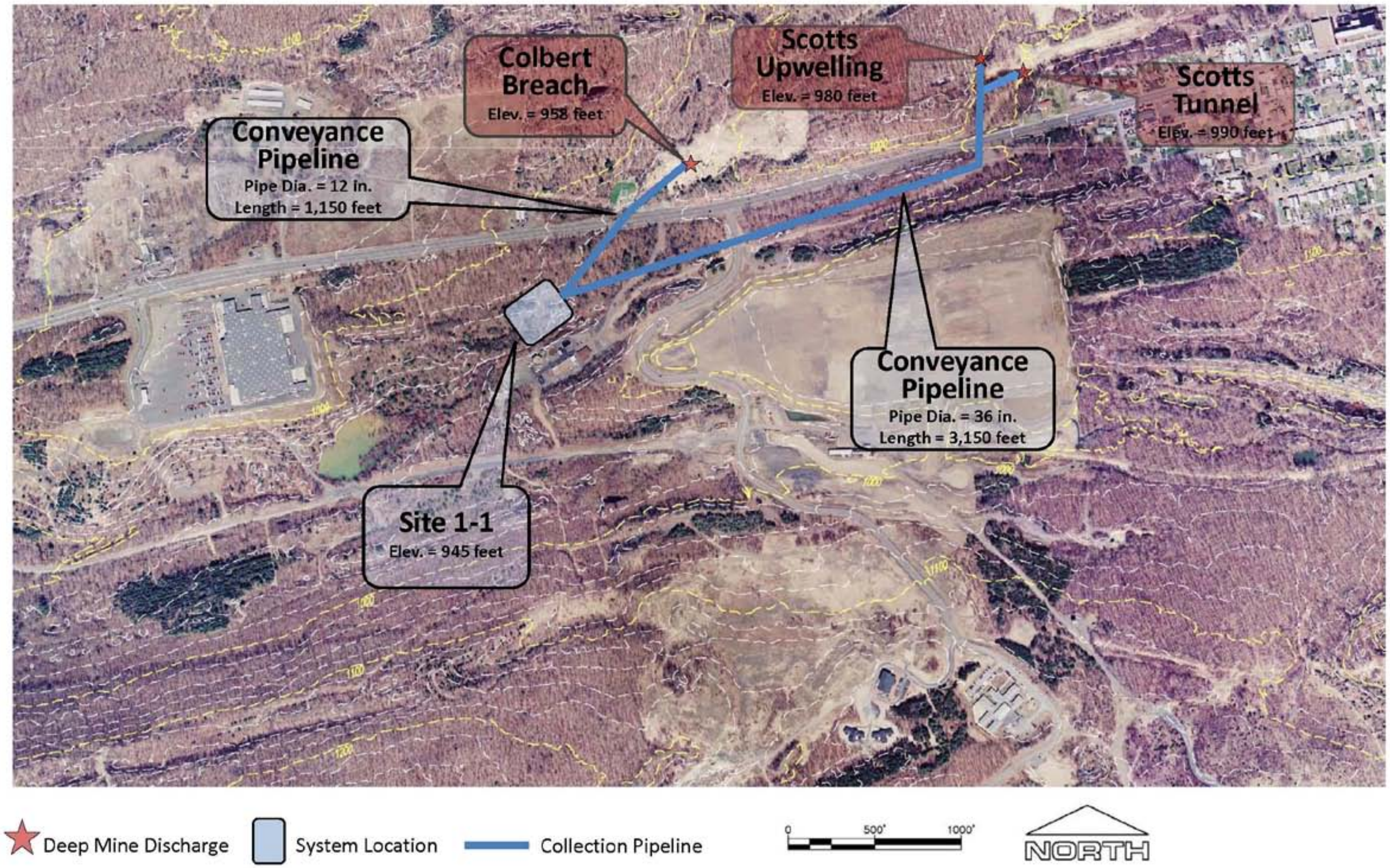


Figure 7-2. Scotts Tunnel & Colbert Breach Treatment System Locations and Collection Pipelines in the Shamokin Creek Feasibility Study Project Area.

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Scotts Tunnel & Colbert Breach
AMD & Advanced Treatment Facilities

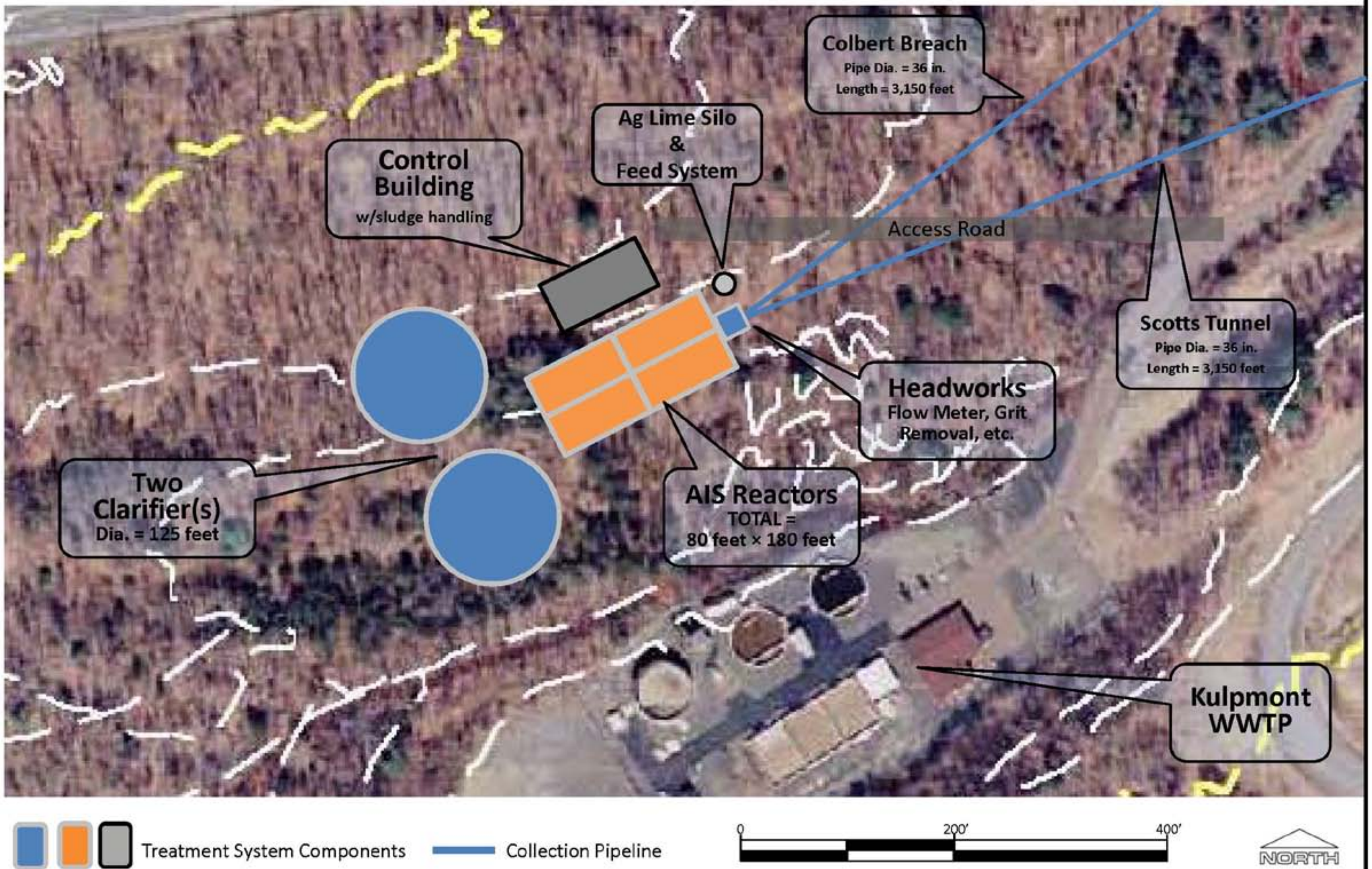

Figure 7-3. Scotts Tunnel & Colbert Breach Treatment System Conceptual Layout in the Shamokin Creek Feasibility Study Project Area.

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Scotts Tunnel & Colbert Breach
Cooling Water Pumping, Pipeline & Storage

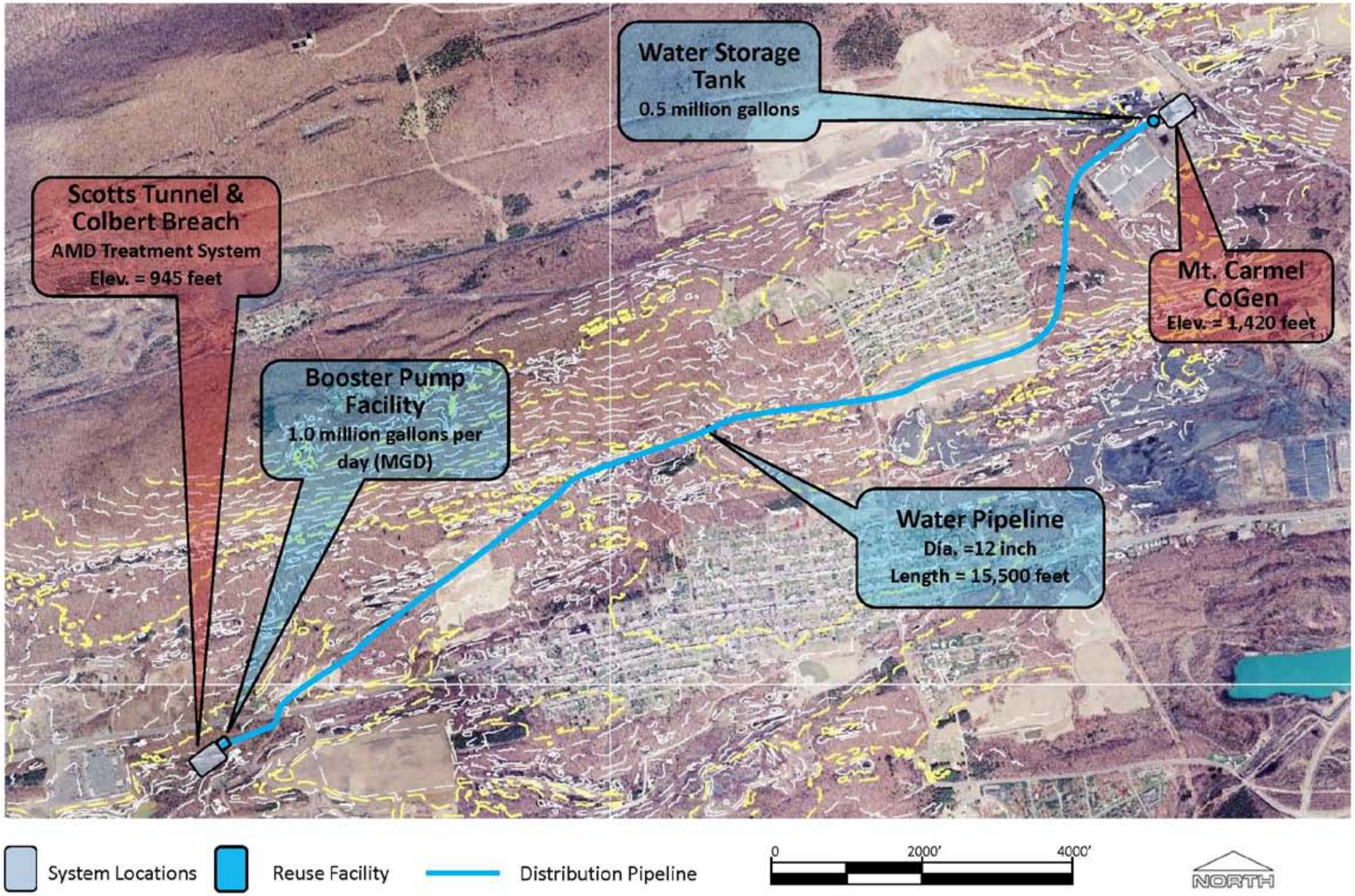

Figure 7-6. Beneficial Water Reuse: Conceptual Layout for Pumping, Distribution and Storage for Evaporative Cooling at the Mt. Carmel Cogen.

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Scotts Tunnel & Colbert Breach
Geothermal Cooling Water District(s)

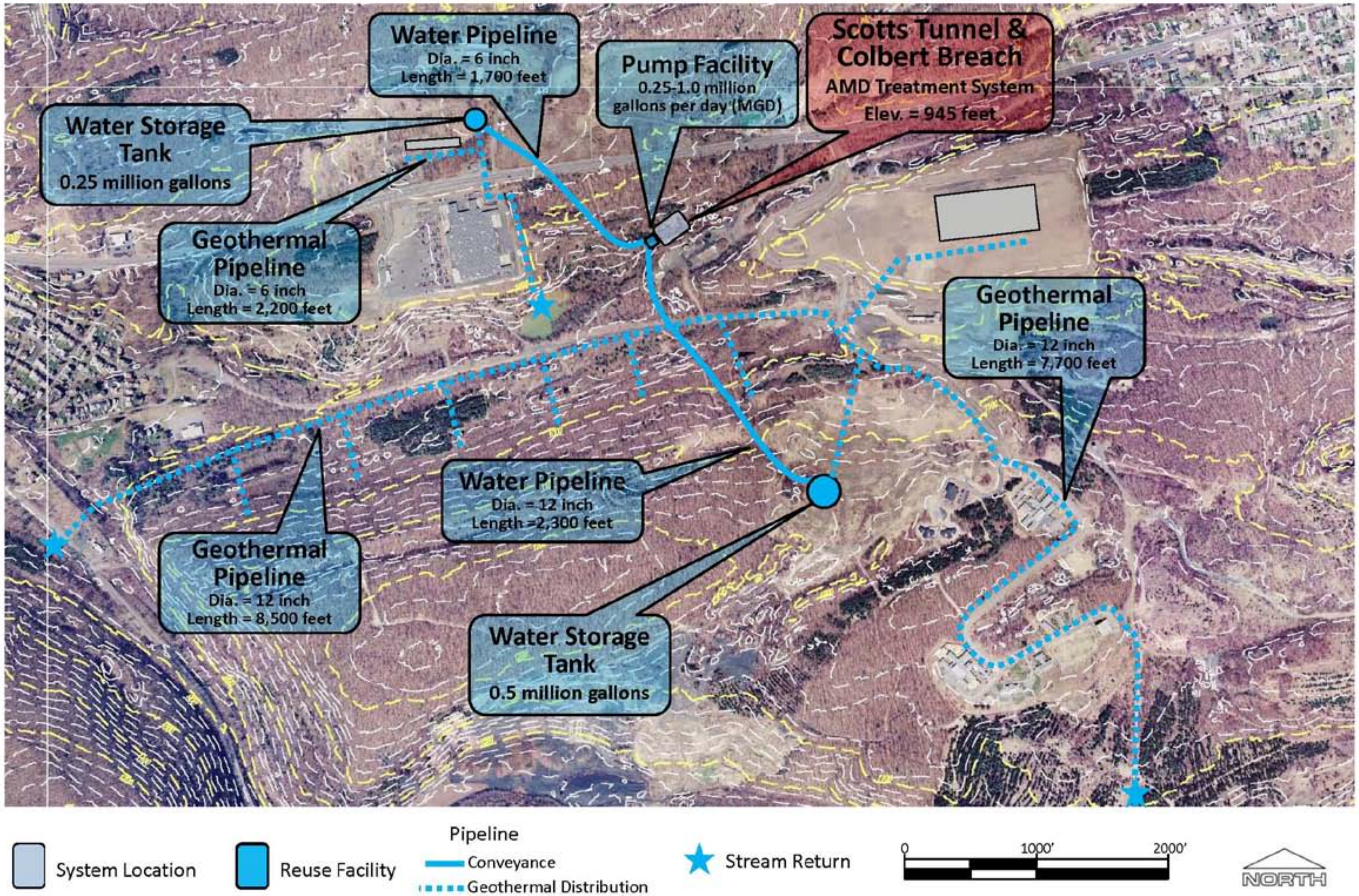

Figure 7-9. Conceptual Layout of the Scotts Tunnel & Colbert Breach Open Loop Geothermal District(s) in the Shamokin Creek Feasibility Study Project Area (Walmart Retail Center, SEEDCO Industrial Park & Northwest Academy).

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Feasibility Study
Financial Evaluation

Estimated Overall Project Capital Costs

Item	Description	Size	Quantity	Total
Scotts Tunnel & Colbert Breach AMD				
1	Collection & Conveyance	36 in./12 in.	2	$640,000
2	AIS Treatment System	13.5 MGD	1	$6,170,000
3	Advanced Treatment System	1-5 MGD	1	$2,990,000
4	Cooling Water Distribution	0.75 MGD	1	$1,700,000
5	Open Loop Geothermal System	1.0-2.0 MGD	1	$2,420,000
6	Beneficial Solids Reuse	2.3 tons/day	1	$960,000
Project Sub-Total				**$14,880,000**
Excelsior & Maysville AMD				
1	Collection & Conveyance	36 in./12 in.	2	$1,850,000
2	AIS Treatment System	11.9 MGD	1	$5,780,000
3	Advanced Treatment System	1 MGD	1	$1,940,000
4	Open Loop Geothermal System	1.0	1	$1,160,000
5	Beneficial Solids Reuse	1.9 tons/day	1	$960,000
Project Sub-Total				**$9,890,000**
Total Feasibility Study Capital Cost				**$24,770,000**

Estimated Overall Project Operating Costs

Item	Description	Daily	Annual
Scotts Tunnel & Colbert Breach AMD Project			
1	Collection & Conveyance	NA	NA
2	AIS Treatment System	$1,340	$489,000
3	Advanced Treatment System (3 MGD)	$540	$197,500
4	Cooling Water Distribution	$230	$85,000
5	Open Loop Geothermal System	$120	$45,000
6	Beneficial Solids Reuse	$180	$65,300
Project Sub-Total		**$2,410**	**$882,000**
Excelsior & Maysville AMD Project			
1	Collection & Conveyance	NA	NA
2	AIS Treatment System	$1,205	$440,000
3	Advanced Treatment System (1 MGD)	$285	$104,000
4	Open Loop Geothermal System	$85	$31,000
5	Beneficial Solids Reuse	$180	$65,300
Project Sub-Total		**$1,755**	**$640,000**
Total Feasibility Study Operating Cost		**$4,165**	**$1,522,000**

Comparison of Market Value Vs. Beneficial Reuse Water Cost

Summary of Aqua PA Consumptive Charges for Industrial Water		
Volume Use Gallons Per Month	**Volume Use Gallons Per Day**	**Charge $/1,000 gallons**
Less than 10,000	Less than 333	$7.615
10,000 to 33,300	333 to 1,110	$6.690
33,300 to 333,300	1,100 to 11,110	$5.550
333,300 to 3,333,300	11,110 to 111,110	$5.081
3,333,300 to 10,000,000	111,110 to 333,333	$4.590
Greater than 10,000,000	Greater than 333,333	$3.670

Summary of Predicted Cost To Produce Beneficial Reuse Water *Cost includes 100% AMD Flow Treated by AIS*					
Capital Investment	**Grant Funding**	**Beneficial Reuse Flow Cost of Water ($/1000 gals)**			
		1.0 MGD	**2.0 MGD**	**3.0 MGD**	**5.0 MGD**
$0	100%	4.35 (3.40)	***2.25 (1.95)***	***1.55 (1.20)***	***0.97 (0.78)***
$6 million	25%	5.55 (4.55)	2.85 (2.35)	***1.95 (1.60)***	***1.20 (1.00)***
$12 million	50%	6.75 (5.80)	3.45 (2.95)	***2.35 (2.00)***	***1.45 (1.25)***
$24 million	0%	9.15 (8.20)	4.65 (4.15)	3.15 (2.80)	***1.95 (1.75)***

Value in () represents costs with beneficial reuse of solids at $225 per ton

Financial Evaluation Summary

- The projects in the Feasibility Study requires a substantial capital investment and annual operating cost.
- Analysis indicates it is possible treat all the AMD flow in the Study Area and produce a limited volume of beneficial reuse water at below the market-value of potable water.
- The analysis also indicates public funding will be required to produce a market-value water.
  - Public funding required is 25 to 100% of Capital Costs.
  - Funding depends on volume of Beneficial Reuse Water Demand.
- Based on a comprehensive analysis, The Scotts Tunnel & Colbert Breach Project should be pursued.
  - Current Cooling Water Demand (~ 1 MGD)
  - Potential Geothermal Use at Existing Facilities (1-2 MGD)
  - Potential Increased Geothermal and Industrial Water Demand (2-5 MGD)

Conclusions

The Feasibility Study Indicates:

1. **Long Term Sustainable Treatment of the AMD in the Study Area using Active Treatment in Combination with Beneficial Water (and Solids) Reuse is Possible.**

2. **Project Success would have Substantial Implications Improving Local Social, Economic, & Environmental Conditions.**

Where Do We Go From Here?

1. Public Participation & Involvement
2. Develop Project Public & Private Partners
   a. Project Management
   b. Treatment System Operation
   c. Project Funding & Development
3. Market the Project to Local, State & Federal Agencies & Private Companies
4. Obtain Funding For Design, Construction & Operation of the Project
5. ?????