



# Wellhead Protection Area Desktop Study

## Wolf Farm Soccer Fields

E. Springville Rd and York Road (PA SR 74)  
South Middleton Township, PA



**Triad Project No.: 03-23-0318**

**Prepared for:**  
KEYSTONE FC  
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**April 29, 2023**



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**SITE SUMMARY**

Site Name:	Wolf Farm Soccer Fields
Latitude:	40°10'28.45"N (near center of site)
Longitude:	77° 7'47.98"W (near center of site)
Nearest Cross Street:	E. Spring Road and York Road (PA SR 74)
Municipality:	South Middleton Township
State:	Pennsylvania
Site Area:	49.09 acres
Proposed Improvements:	3 Turf/6 Grass Soccer Fields, Parking, Irrigation well, & Stormwater management
Estimated Water Usage:	1,663,200 to 1,995,840 gallons per year btw Apr./Oct.
Well Head Protection Zone:	Zone 3, Municipal Well No. 2 is located southwest approximately 9,400 feet from the site
Soils:	HaA, HaB, HcB, HcC, HuA, Pe
Site Geology:	Zullinger Formation
Site Topography:	Flat to gently rolling hills with majority of the site draining towards the south. Approximately 16% of the northern portion of the site drains to the north.
Surface Water:	None. Nearest surface water is Boiling Springs to the south.
Watersheds:	Middle Yellow Breeches Creek and Hogestown Run
Site Visit:	4/29/2023
Current Site Conditions:	Fallow agricultural fields/moderate to high vegetation
Closed Depressions:	23 within the site boundary
Open Sinkholes:	Two
Outcrops of bedrock:	Present
Surface Drainage into Ground:	None observed
"Ghost Lakes" after Rainfall	None observed
Fracture Traces:	6 mapped within the boundary of the site
Limonite Excavations/Quarries	None identified

## 1.0 INTRODUCTION

Triad Engineering, Inc. (Triad) was retained by Keystone FC to conduct a Wellhead Protection Area Desktop Study for the property located to the south of York Road (PA SR 74), west of South Ridge Road, north of Linsey Road, and west of East Springville Road, near Carlisle, Pennsylvania. The site comprises of approximately 49.09 acres. The site is located within South Middleton Township Wellhead Protection Area (WHPA) Zone No. 3. Municipal Well No. 2 is located approximately 9,400 feet (1.78 miles) or more to the southwest of the site. This Wellhead Protection Area Desktop Study has been completed in general accordance with the South Middleton Township Municipal Ordinance No. 2016-06, entitled Wellhead Protection Districts and South Middleton Township Municipal Order No. 01 of 2001 – updated April 15, 2019, entitled Subdivision & Land Development Ordinance (SALDO), Article 11 entitled Wellhead Protection Design Requirements.

These ordinances require a Pennsylvania licensed Professional Geologist to conduct the following prior to any land development within a Wellhead Protection Area (WHPA) Zones 2 and/or 3: a site visit, review aerial photographs, soils, geologic and other available related data including the Wellhead Protection Study as the data relates to the subject property, and to prepare a map of the site showing closed depressions, open sinkholes, surface drainage into ground, “ghost lakes” after rainfall, lineaments, faults, fracture traces, limonite excavations, and quarries.

## 2.0 SITE DESCRIPTION

The site is situated immediately to the southeast of the intersection of East Springville Road and York Road (PA SR 74) in South Middleton Township, Pennsylvania. A location/topography plan is attached to this report as **Figure 1**. The site consists of approximately 49.09 acres and at the time of this evaluation, the site is comprised of agricultural fields and forest. According to the Carlisle, PA, 7.5-Minute Topographic Quadrangle Map, the elevation of the site is between approximately 550-560 feet. The topography of the site generally slopes towards the south with approximately 16 percent of the site sloping towards the north.

The site is located at the northern edge of the WHPA, Zone 3 for municipal Well 2 which is located approximately 9,400 feet (1.78 miles) to the southwest. The WHPA is depicted on **Figure 2**. Municipal Well 2 is in Spring Meadows Park Boiling Springs which consists of approximately 91.16 acres with baseball fields, football fields, soccer fields, and additional park features.

Keystone FC is proposing to improve the site by constructing three synthetic turf fields, six grass fields, associated parking/facilities, and associated stormwater management features. A minimum of one irrigation well is proposed to provide watering as necessary for the grass fields. Based on water usage at similar size parks, it is estimated that approximately 1,663,200 to 1,995,840 gallons per year (gpy) of water will be needed for irrigation. The field irrigation needs will be directly related to precipitation and is typically needed between the months of April and October. This equates to approximately 237,600 to 285,120 gallons per month during the typical seven months of needed irrigation. The proposed site features are generally depicted in **Figure 3**.

### 2.1 Soils

According to the United States Department of Agriculture, Natural Resources Conservation Service, Web Soil Survey (WSS), the site is underlain by eight soil types. The Web Soil Survey Map is included in **Appendix A**. The site is underlain by the following soil types, in order by the percent of coverage:

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
HaA	Hagerstown silt loam, 0 to 3 percent slopes	13.4	27.9%
HaB	Hagerstown silt loam, 3 to 8 percent slopes	12.5	26.0%
HcB	Hagerstown silt loam, rocky, 3 to 8 percent slopes	0.9	1.9%
HcC	Hagerstown silt loam, rocky, 8 to 15 percent slopes	3.6	7.5%
HuA	Huntington silt loam, 0 to 5 percent slopes	17.5	36.4%
Pe	Penlaw silt loam	0.1	0.3%
<b>Totals for Area of Interest</b>		<b>48.1</b>	<b>100.0%</b>

### 2.2 Geology/Hydrogeology

According to the Pennsylvania GEOlogic Data Exploration website (PaGEODE), the site is underlain by one geological formation with the contact of another formation along the southern site boundary, the Zullinger Formation underlays the site, and the Elbrook Formation contacts the Zullinger Formation at the southern site boundary. It is noted that the municipal well, located near Spring Meadows Park Boiling Springs, approximately 9,400 feet (1.78 miles) southwest of the site, is underlain by the Elbrook formation. The site geology is depicted on **Figure 4** and on the *Plate 1. Bedrock Geologic Map Showing Hydrology of the Northern Part of the Cumberland Valley, Cumberland County, Pennsylvania*; 1981 is included as **Appendix B**.

The Zullinger formation, according to PaGEODE, “consists of well-bedded, interbanded medium-gray limestone and dolomite, interlaminated limestone and dolomite, stromatolitic limestone, and local thin quartz-sand beds. The beds are thin to thick bedded. It is probably 2,500 feet thick”.

According to PaGEODE, the Elbrook Formation is described as “consists of light-gray to yellowish-gray, finely laminated siliceous limestone having interbeds of dolomite, calcareous shale, and silty limestone. It is cherty and well bedded. The beds are mostly thick, but flaggy and massive beds also occur. It is about 3,000 feet thick”.

Open-File Report 8902 *Sinkholes and Karst-Related Features of Cumberland County, Pennsylvania*, included as **Appendix C**, was reviewed to evaluate the presence of karst activity in the site vicinity. The Report identifies karst features such as sinkholes, closed depressions, caverns, past mines, and underground openings on the topographic mapping quadrangle. The Map indicates numerous closed depressions within the site boundary.

According to the United States Geological Survey (USGS) 7.5-minute series topographic map of the Carlisle quadrangle, the site consists of gently rolling terrain, predominantly draining towards the south of the site. Groundwater flow direction is expected to flow to the south from the site, flowing downgradient, perpendicular to the topographic contours. Approximately 16 percent of the site does drain to the north and groundwater in this portion of the site most likely follows the topography to the north.

According to the EPA WATERS Geoviewer, the site is located within the Middle Yellow Breeches watershed to the south and the Hogestown Run watershed to the north, and the closest downgradient surface water is Boiling Springs, which is located approximately 8,350 feet southeast from the subject property boundary.

According to the map of *Bedrock Geologic Map Showing the Hydrology of the Northern Part of the Cumberland Valley, Cumberland County, Pennsylvania* by Albert E. Becher and Samuel I. Root, dated 1981, the Zullinger formation has a median specific capacity of 1.5 gallon per minute (gpm) per foot and calculated median sustained yield of 82 gpm. Distribution of yielding zones with depth varies little to 450 feet, the maximum depth for which data are available. The Elbrook formation has a median specific capacity of 3.8 gpm per foot and calculated median sustained yield of 218 gpm. An existing production well has a sustained yield of 2,000 gpm. Yielding zones decrease significantly below the depth of 150 feet.

### 3.0 FRACTURE TRACE ANALYSIS

A fracture trace analysis is utilized to identify surficial expressions of fracture concentration in the underlying bedrock. Groundwater wells that intercept these zones of fractures, or areas of conduit flow, generally provide higher yields. A fracture trace analysis relies primarily on the use of aerial photographs to delineate the presence of these subsurface fractures, paying particular attention to the specific locations where these fractures in the bedrock intersect. Google Earth is also used to help delineate the presence of subsurface features.

On the aerial photographs, the fracture traces are located by identifying natural linear features consisting of, but not necessarily limited to, tonal variation in soils and vegetation, alignment of vegetative patterns, straight stream segments, wind and water gaps, alignment of sinkholes and closed depressions, and gullies and tributary valleys oblique to local and/or regional topographic slope.

This fracture trace analysis utilized Google Earth Imagery (4/1994, 3/1995, 4/1999, 4/2003, 2/2004, 9/2005, 10/2006, 3/2007, 10/2008, 9/2010, 8/2012, 9/2013, 4/2016 and 3/2020) and stereo pair aerial photographs from 4/1938, 3/1968 and 2003 which were obtained from the United States Geological Survey (USGS) EarthExplorer website ([explorer.usgs.gov](http://explorer.usgs.gov)) and Pennsylvania Imagery Navigator ([maps.psiee.psu.edu](http://maps.psiee.psu.edu)). Based on the aerial photographs reviewed as part of this analysis, most of the site has remained undeveloped.

The fracture trace analysis performed for the site identified 12 fracture traces in the site vicinity and approximately six fracture trace intersections within the property boundary as depicted on the Fracture Trace Analysis and Karst Feature plan included as **Figure 5**.

### 4.0 SITE VISIT

The site visit was conducted on April 29, 2023, by Mr. Nicholas Wolfe, PG (PG004859). The site visit consisted of walking around the site to observe site features and document karst features observed. It is important to note that karst features may exist within inaccessible areas or concealed by vegetation and weren't documented during this site visit. The weather during the site visit was cloudy, with rain and temperatures at approximately 55 degrees Fahrenheit. Mapped karst features are depicted in **Figure 5**.

#### Observations:

**General:** The site consisted of fallow agricultural fields and woodlands with moderate to heavy vegetation.

**Closed Depressions:** Approximately 23 closed depressions were mapped, and field observed. No other closed depressions were observed.

**Open Sinkholes:** Two open sinkholes were observed.

**Surface Drainage into Ground:** No direct drainage was observed.

**“Ghost Lakes” after Rainfall:** None were observed.

**Lineaments, Faults and Fracture Traces:** Mapped fracture traces were verified.

**Limonite Excavations and Quarries:** None were observed.

## 5.0 DESIGN AND CONSTRUCTION RECOMMENDATIONS

### 5.1 Wellhead Protection Design

Municipal Ordinance No. 01 of 2001 – updated April 15, 2019, entitled Subdivision & Land Development Ordinance (SALDO), Article 11 entitled Wellhead Protection Design Requirements, Sections 1108 a.(8), (9), and (10) state:

- “Buildings, structures, impervious surfaces, utilities and swimming pools shall not be located within fifty feet (50') of any features identified in Section 1108(a).(3.) unless detailed geotechnical work shows that there will be no negative impact on groundwater recharge or quality”.
- “Salt or de-icing storage areas, gasoline or other chemical storage areas and blasting shall not be located within one hundred feet (100') of any features identified in Section 1108 a.(3) unless detailed geotechnical work shows that there will be no negative impact on groundwater recharge or quality”.
- “Storm water facilities, including, but not limited to, detention basins, shall not be located within twenty-five feet (25') of any features identified in Section 1108 a (3.) unless special precautions are taken to protect groundwater recharge and quality, including the installation of lines, impermeable beds and concrete pipe utilizing O-ring joints”.

Based on this assessment, it is Triad’s opinion that there will be no negative impact on groundwater recharge or quality if buildings, structures, impervious surfaces, utilities, salt or de-icing storage area, petroleum products or other chemical storage areas are built to, comply with, and maintained to any, and all, codes and regulations at the local, state, and/or federal level that pertain to each individual subject listed above.

Regarding blasting, a detailed grading plan has not been prepared at this time; however, based on the existing site topography we anticipate any required blasting would be at an absolute minimal. It is Triad’s opinion that any necessary blasting will not have a negative impact on groundwater recharge or quality.

With respect to stormwater facilities, including, but not limited to, detention basins, it is Triad’s opinion that there will be no negative impact on groundwater recharge or quality if storm water

facilities are built within 25 feet of any features identified in Section 1108 a.(3), or built anywhere on site, if any sinkholes identified in section 1108 a.(3) are remediated. We recommend that Triad be retained to provide on-site consulting and oversight services during remediation. A geotechnical engineer or geologist should be present full time during all remediation work to aid in directing the remediation contractor and to document all remediation activities.

**Based on Figure 5 and Appendix C, there are concerns regarding closed depressions and sinkholes. The site is relatively flat and observed closed depressions were scattered across the site. The identified closed depressions are based on historical mapping and field verification; however, no level was used to verify the closed depressions to confirm that no outlet existed, only visual observations were utilized.** Based on the abundance of closed depressions and sinkholes across the site, any proposed storm water retention facilities with respect to Municipal Ordinance No. 01 of 2001 – updated April 15, 2019 entitled Subdivision & Land Development Ordinance (SALDO), Article 11 entitled Wellhead Protection Design Requirements, Sections 1108 a.(12) which states that “Storm water shall not be directed into a sinkhole or closed depression”, Triad recommends all closed depressions and sinkholes within these areas be remediated via the methods described below. Any alternative methods proposed should be approved by a geotechnical engineer and/or geologist. The intent as stated in Municipal Ordinance No. 01 of 2001 – updated April 15, 2019 entitled Subdivision & Land Development Ordinance (SALDO), Article 11 entitled Wellhead Protection Design Requirements, Sections 1106, “is to minimize impervious surfaces and reduce storm water runoff; to provide storm water management practices that maintain groundwater recharge; and, protect and enhance surface and groundwater quality from the impacts of development on storm water quality utilizing Best Management Practices.” It is understood that the site has very low loading ratios and that storm water management runoff will be dispersed across the site to avoid specific concentrations.

Regarding the proposed use of an irrigation well that will need to produce approximately 1,663,200 to 1,995,840 gpy mainly during the period from the month of April through October. It is Triad’s opinion that this well will have a negligible impact on groundwater recharge or quality. The South Middleton Township Municipal Ordinance No. 2016-06, entitled Wellhead Protection Districts requires grouting and a sanitary seal for all at or below-grade well openings in Zones 2 and 3. The ordinance does not prohibit the use of wells; however, withdrawal of 100,000 gallons per day for any single use is prohibited. The proposed irrigation well will use less than 10,000 gallons per day during peak watering. It is recommended that a Triad geologist be retained to oversee the drilling and testing of the irrigation well.

## 5.2 Sinkhole Remediation

Repair of sinkholes should involve cleaning of the loose soil, soft rock, and miscellaneous debris to the throat of the sinkhole. The excavation should extend away from the center of the sinkhole, as necessary, to remove all loose soils. The throat of the sinkhole or solution channel should then be cleaned out such that the solution cavity and surrounding rock is exposed. A large excavator and possible hand excavations will likely be required to achieve this desired goal. Due to the differential weathering of the underlying bedrock and limited information regarding the subsurface strata, predicting the horizontal and vertical limits of the excavation is impossible. The contractor should be prepared to extend the vertical excavation a minimum of 20 feet and be prepared to excavate to greater depths if required. The contractor should also be prepared to hoe-ram large boulders and rock ledges. Upon completion of the excavation operations, the throat of the sinkhole and the surrounding excavation should be filled with either a concrete plug, reverse graded filter and/or a combination of the two. The final determination will be based on the depth to the throat and overall subsurface conditions encountered. However, it is generally recommended that concrete plug be utilized within building and pavement areas and a reverse graded filter be utilized within storm water management ponds.

For a concrete plug, we recommend that the throat of the sinkhole or channels and the surrounding bedrock be filled with lean-mix concrete (min.  $f'_c=1,500$  psi). The initial mix should be stiff enough such that a plug can be developed in the throat of the feature. In lieu of this initial measure, competent large boulder(s), sized greater than or approximately equal to  $B/2$ , where "B" is the width of the throat, should be placed in the bottom, and concrete or grout can then be placed around the rock to form a massive plug. A diagram depicting a typical concrete plug bonded to rock section is included as **Figure 6**.

Construction of a reverse graded filter should involve placement of larger stone or boulders within the throat of the sinkhole. The diameter of the large stone or boulders should be at least one-half the diameter of the throat of the sinkhole. If the immediate throat cannot be fully exposed or if a significantly large throat is encountered, large boulders combined with lean-mix concrete may be required in the bottom of the excavation to serve as a very large conglomerate of resistant material. After placement of the larger stone/boulders and possible lean-mix concrete, the filter should consist of sequentially smaller graded stone, such as variable-sized rip rap followed by surge stone. The reverse graded filter should also be surrounded with a non-woven geotextile fabric. A diagram depicting a typical reverse graded filter section is included as **Figure 7**.

Upon completion of the concrete plug or filter placement, the remainder of the excavated area should be backfilled with low permeability clayey soil compacted to not less than 98 percent of

the maximum dry density based on the Standard Proctor moisture-density test (ASTM D 698). Fill materials should be placed in loose lifts not more than 6 inches for light compaction equipment and 10 inches for material compacted by heavy compaction equipment. Moisture contents of the fill materials should be adjusted, as necessary, to achieve the required compaction. Compaction testing should be performed on each lift of material placed.

We recommend that Triad be retained to provide on-site consulting and oversight services during remediation. A geotechnical engineer or geologist should be present full time during all remediation work to aid in directing the remediation contractor and to document all remediation activities.

### **5.3 Construction in Karst Considerations**

Triad recommends the following procedures be used during construction activities (clearing and grubbing, trenching, blasting, boring or drilling) to limit potential impacts to karst features and related water resources.

1. Construction activities (clearing and grubbing, trenching, blasting, boring or drilling) be conducted in a manner that minimizes alteration of existing grade and hydrology of karst features:
  - In linear excavations adjacent to karst features, spoils be stockpiled and managed up-slope of the excavation, and runoff controlled according to the project specifications.
  - Surface water control measures, including, but not limited to, diversion (direct water flow into trench or off right-of-way areas past the area of concern), detention or collection and transportation, be utilized to prevent construction influenced surface water from free flowing into karst features.
  - Karst features will not be utilized for the disposal of water.
  - Excavations should be backfilled as soon as practically feasible to limit ponding of water and concentrated areas of surface water infiltration.
  
2. Blasting be conducted in a manner that will not compromise the structural integrity or alter the karst hydrology of known or inferred subsurface karst structures. If rock is required to be hammered or blasted, the following parameters should be adhered to:
  - The excavation be carefully inspected for voids or other openings, or signs of enhanced secondary porosity.
  - Blasting be conducted by a qualified blasting contractor, in accordance with the contractor's written and approved blasting plan.

- If a track drill is used to prepare the hole(s) for the explosive charge(s) and the boring encounters an open or clay-filled void, cave, or other signs of enhanced secondary porosity, Triad should be notified immediately to evaluate the encountered feature prior to any blasting.
3. The following general guidelines should be incorporated for construction practices in karst terrain:
- To reduce the risk of groundwater contamination, equipment should not be parked or left idling for extended periods of time (more than 12 hours), refueled, or serviced within 100 feet of any karst feature.
  - Equipment refueling should not be performed within flagged or marked buffer areas of streambeds, sinkholes, fissures, or areas draining into these or other karst features, except by hand-carried cans (5-gallon maximum capacity) when necessary.
  - Equipment servicing and maintenance areas should be sited outside of flagged or marked buffer areas of streambeds, sinkholes, fissures, or areas draining into these or other karst features.
  - Prevent runoff resulting from construction equipment washing operations to directly enter any karst feature by locating these operations outside of the buffer area.
  - Hazardous materials, chemicals, fuels, lubricating oils, and petroleum products should not be stored within 100 feet of any karst feature.
  - All equipment should be checked by a construction inspector daily for leaks prior to beginning work in karst areas. If any leaks are observed, or damaged or defective equipment is discovered, drip pans and other containment will be deployed immediately, and the equipment removed or repaired as soon as practical.
4. The intent of Erosion Sediment Control (ESC) and related Best Management Practices (BMPs) is to confine project-related disturbance to the LOD, protect sensitive karst features, and minimize erosion and enhance revegetation in those areas.
5. Discharge of hydrostatic testing water in karst areas will be avoided if practicable. If circumstances require hydrostatic testing water to be discharged in karst areas, we recommend a discharge location be selected in consideration of the following guidelines:
- Do not discharge hydrostatic testing water directly into flagged or marked buffer areas of karst features or channels or surface features that flow towards karst feature(s).

- Where possible, discharge hydrostatic test water down-gradient of karst features unless on-the-ground circumstances (e.g., manmade structures, terrain, and other sensitive resources) prevent such discharge.
  - i. If those circumstances occur, discharge water into uplands greater than 500 feet from flagged or marked buffer areas of karst features unless on-the ground circumstances (e.g., manmade structures, terrain, other sensitive resources) prevent such discharge.
  - ii. If “i” above is not practicable, discharge water as far from flagged or marked karst features as practical and utilize additional sediment and water flow control devices to minimize effects.
- Control the rate and volume of discharge to prevent land erosion, sediment mobilization and ponding of water.

## 6.0 SUMMARY AND CONCLUSIONS

Triad was retained by Keystone FC to conduct a Wellhead Protection Area Desktop Study for the property Wolf Farm Soccer Fields site. Triad performed a desktop review and site reconnaissance at the site. Several fracture traces and karst features were identified.

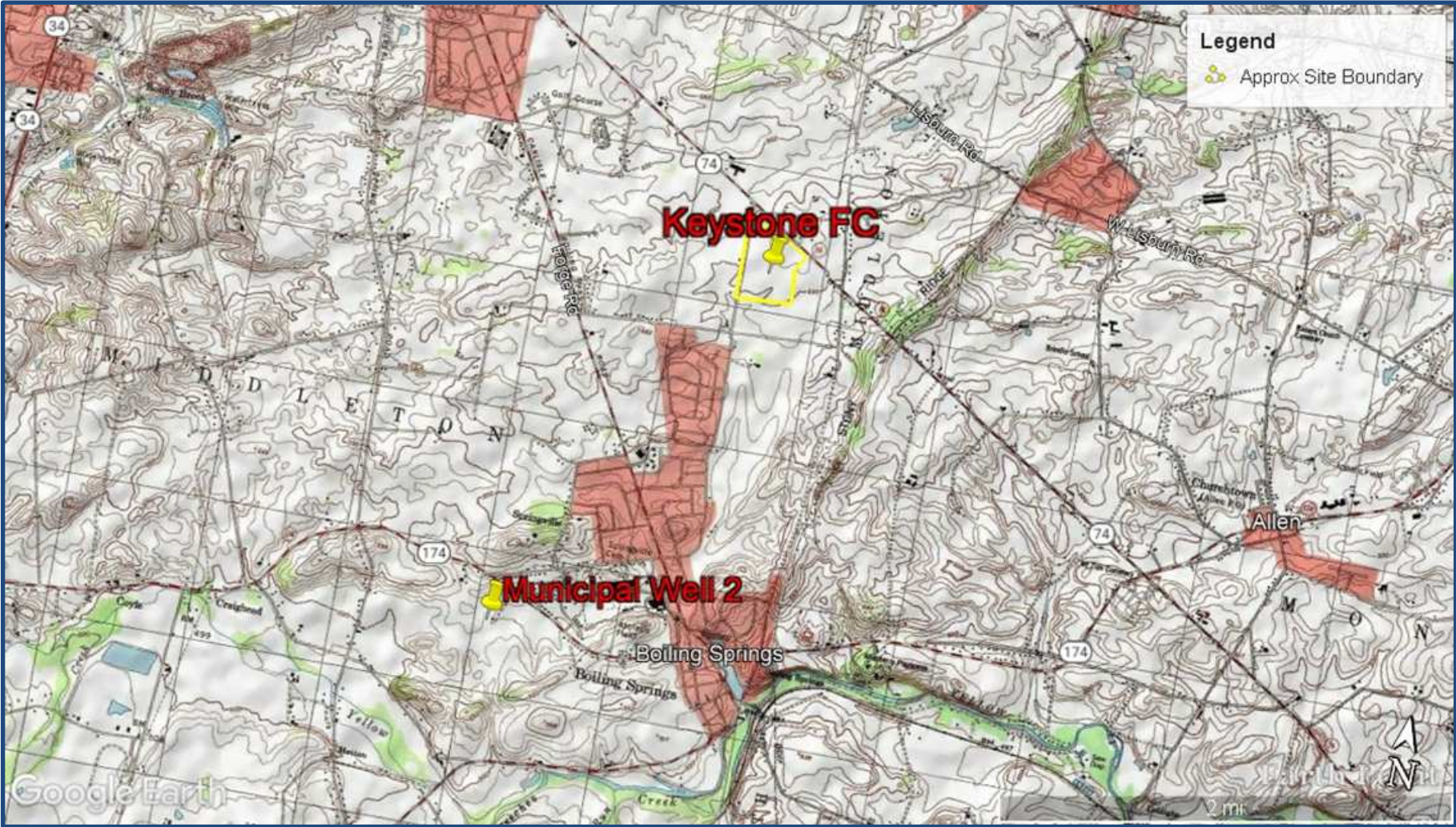
**Based Triad’s findings from the services performed, it is Triad’s opinion that there will be no negative impact on groundwater recharge or quality if a well, buildings, structures, impervious surfaces, utilities, salt or de-icing storage area, petroleum products or other chemical storage areas are built to, comply with, and maintained to any and all codes and regulations at the local, state, and/or federal level that pertain to each individual subject listed above. Regarding blasting, it is Triad’s opinion that blasting will not have a negative impact on groundwater recharge or quality. With respect to storm water facilities, including, but not limited to, detention basins, it is Triad’s opinion that there will be no negative impact on groundwater recharge or quality if storm water facilities are built within 25 feet of any features identified in Section 1108 a.(3), or built anywhere on site, if any closed depressions and sinkholes identified in section 1108 a.(3) are remediated. Recommendations for sinkhole remediation are provided in this report. We recommend that Triad be retained to provide on-site consulting and oversight services during remediation. A geotechnical engineer or geologist should be present full time during all remediation work to aid in directing the remediation contractor and to document all remediation activities.**

# Figures

# FIGURE 1 SITE LOCATION/TOPOGRAPHY PLAN

WOLF FARM SOCCER FIELDS  
SOUTH MIDDLETON TOWNSHIP, PENNSYLVANIA

Triad Project Number: 03-23-0318



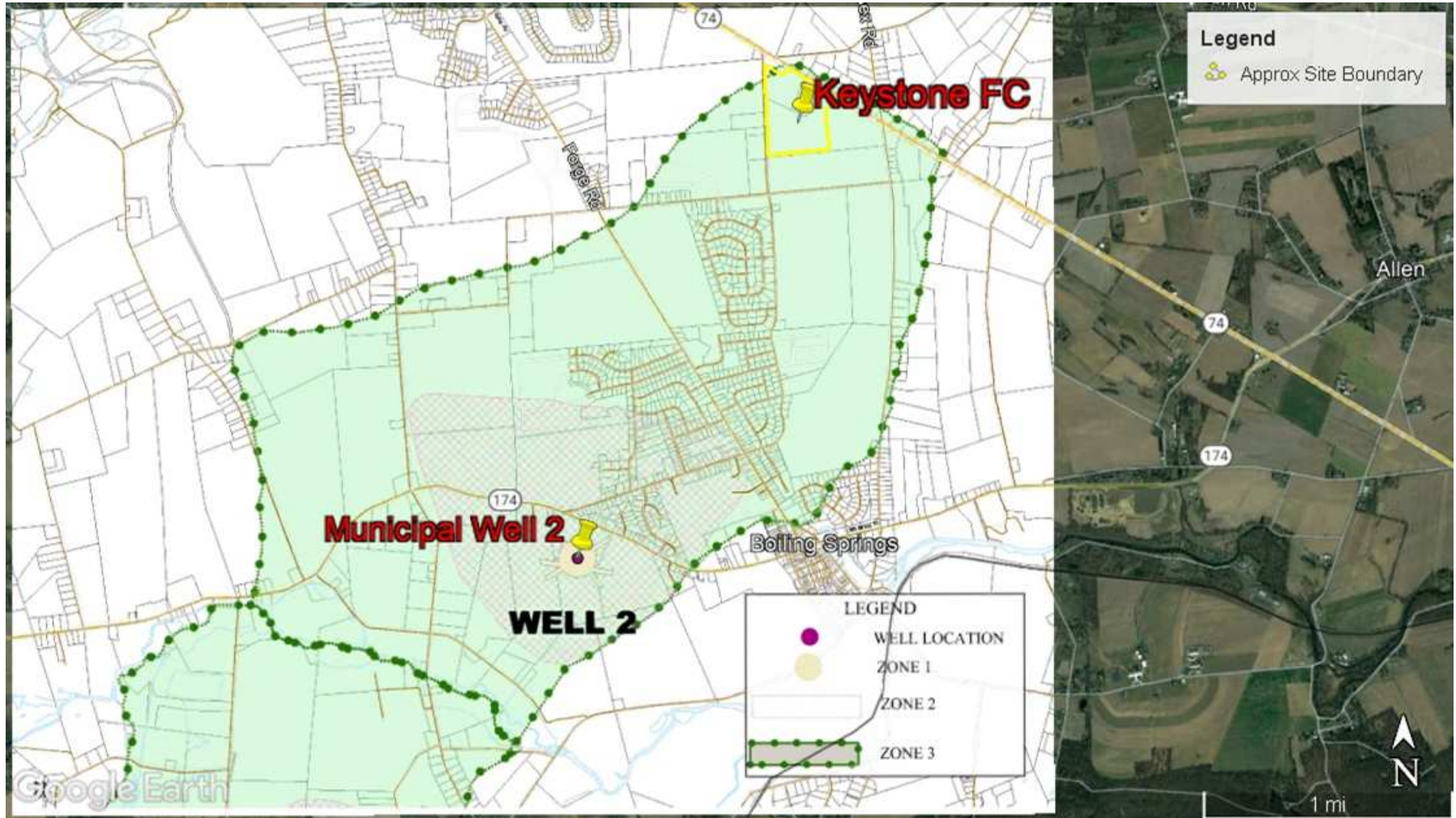
Source:  
GoogleEarth, Earth Point Topo Map



# FIGURE 2 WELLHEAD PROTECTION AREA MAP – WELL 2

WOLF FARM SOCCER FIELDS  
SOUTH MIDDLETON TOWNSHIP, PENNSYLVANIA

Triad Project Number: 03-23-0318



Source:  
South Middleton Township Municipal Ordinance No. 2016-06, entitled Wellhead Protection Districts  
Google Earth



# FIGURE 3 PROPOSED SITE IMPROVEMENTS

WOLF FARM SOCCER FIELDS  
SOUTH MIDDLETON TOWNSHIP, PENNSYLVANIA

Triad Project Number: 03-23-0318



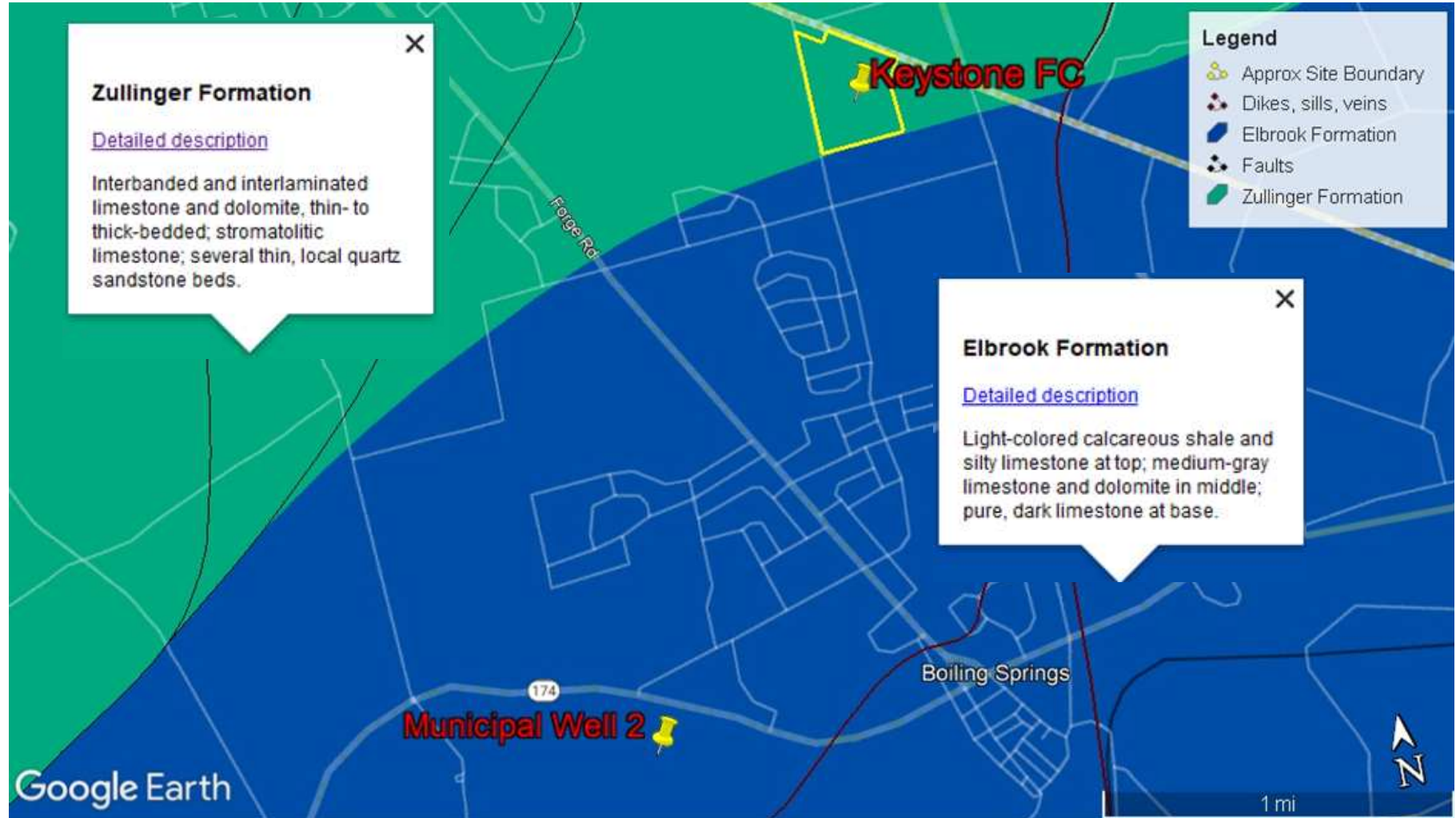
Source:  
Frederick, Seibert, & Associates, Inc. Site & Landscape Plan (C-101),  
GoogleEarth



# FIGURE 4 SITE GEOLOGICAL MAP

WOLF FARM SOCCER FIELDS  
SOUTH MIDDLETON TOWNSHIP, PENNSYLVANIA

Triad Project Number: 03-23-0318



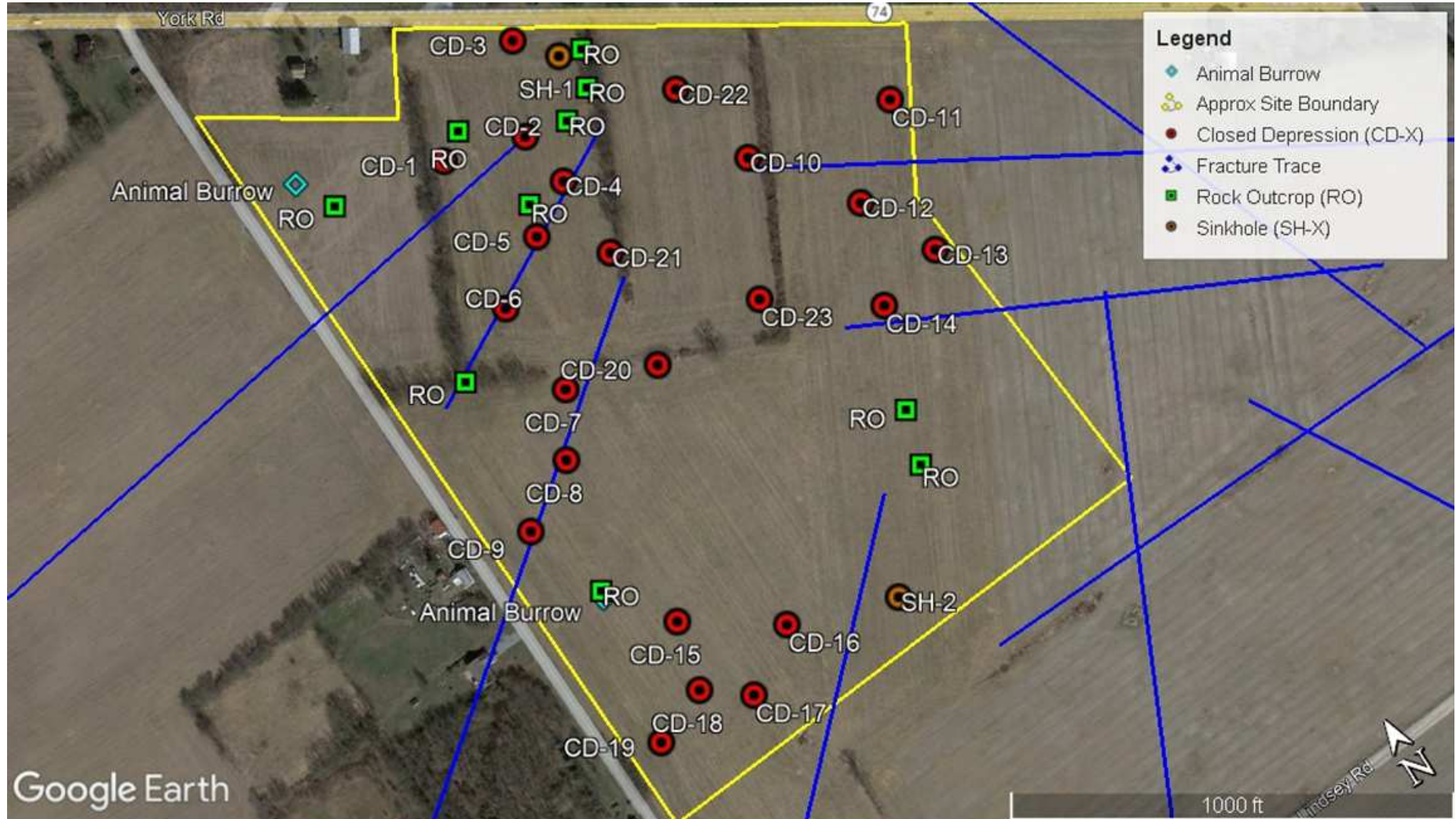
Source:  
GoogleEarth

# FIGURE 5

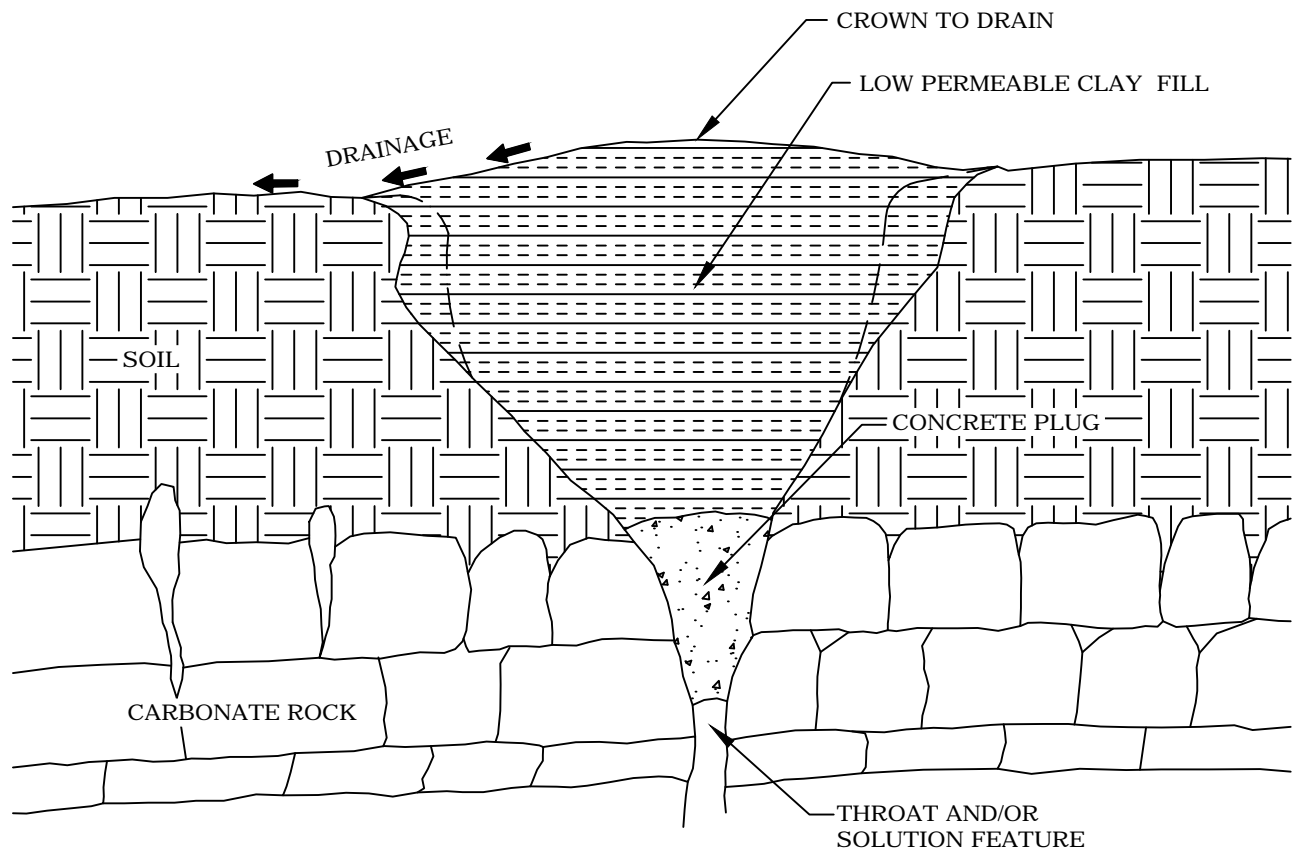
## FRACTURE TRACE ANALYSIS AND KARST FEATURES PLAN

WOLF FARM SOCCER FIELDS  
SOUTH MIDDLETON TOWNSHIP, PENNSYLVANIA

Triad Project Number: 03-23-0318



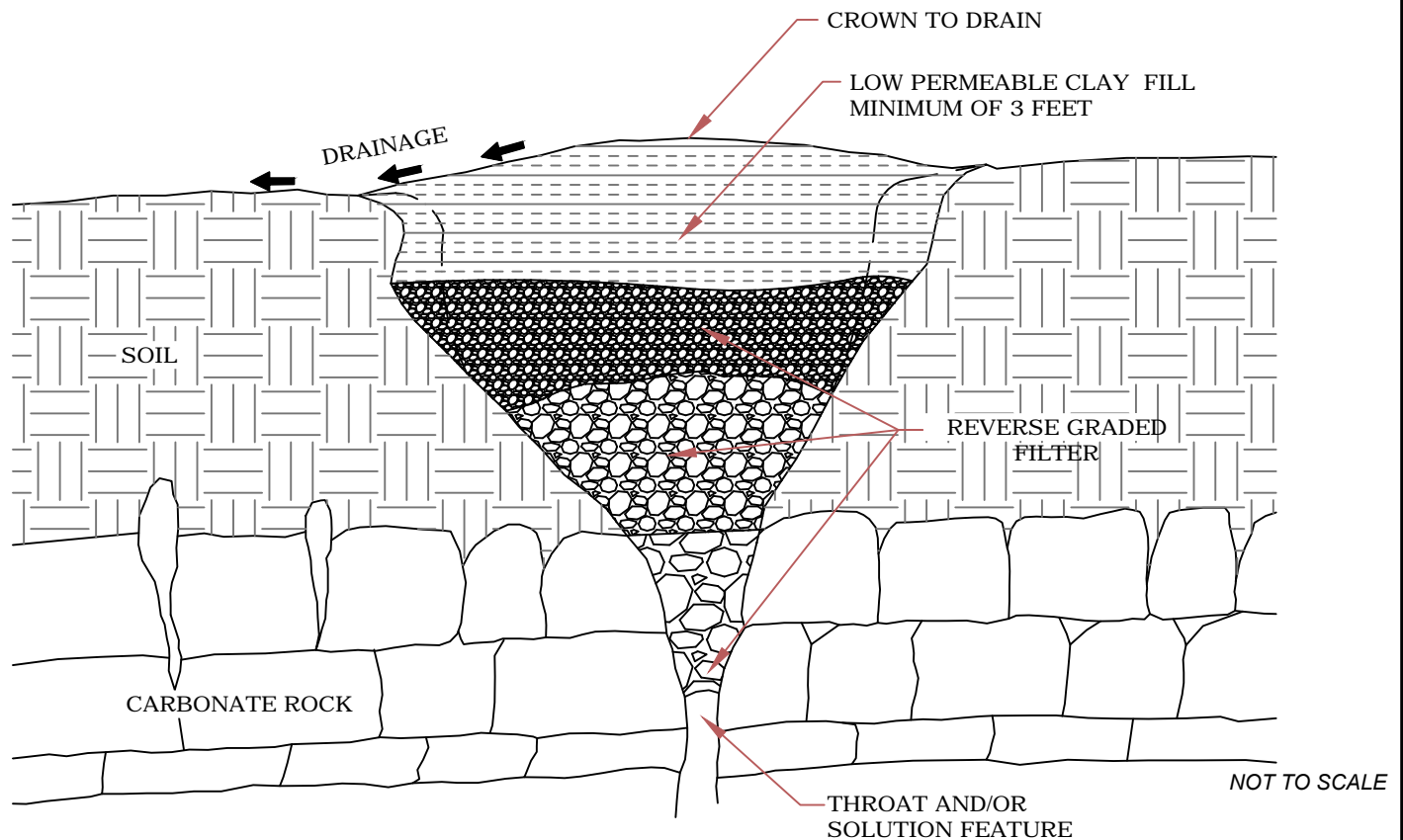
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#### **SINKHOLE REMEDIATION NOTES**

1. IN GENERAL A RISK OF SINKHOLE DEVELOPMENT WITHIN THE SWM FACILITY AND SITE CAN BE ANTICIPATED DUE TO THE KARST GEOLOGY IN THE AREA.
2. REPAIR OF EXISTING SINKHOLES SHOULD INVOLVE CLEANING OF THE LOOSE SOIL, SOFT ROCK AND ANY DEBRIS TO THE THROAT OF THE SINKHOLE. THE EXCAVATIONS SHOULD EXTEND AWAY FROM THE CENTER OF THE SINKHOLE, AS NECESSARY, TO REMOVE ALL LOOSE SOIL AND EXPOSE ANY ADDITIONAL THROATS.
3. THE THROATS OF THE SINKHOLE OR SOLUTION CHANNELS SHOULD THEN BE CLEANED OUT SUCH THAT THE SOLUTION CAVITY AND AS MUCH SURROUNDING ROCK AS POSSIBLE IS EXPOSED. A LARGE TRACKHOE AND POSSIBLE HAND EXCAVATIONS WILL LIKELY BE REQUIRED TO ACHIEVE THIS DESIRED GOAL. TRIAD SHOULD HAVE A REPRESENTATIVE ON SITE TO OBSERVE THE EXCAVATION AND APPROVE.
4. DUE TO THE DIFFERENTIAL WEATHERING OF THE UNDERLYING BEDROCK AND LIMITED INFORMATION REGARDING THE SUBSURFACE STRATA, PREDICTING THE HORIZONTAL AND VERTICAL LIMITS OF THE EXCAVATION IS IMPOSSIBLE.
5. UPON COMPLETION OF THE EXCAVATION OPERATIONS, WE RECOMMEND THAT THE THROAT OF THE SINKHOLE OR CHANNELS AND THE SURROUNDING BEDROCK BE FILLED WITH LEAN MIX CONCRETE. THE INITIAL MIX SHOULD BE STIFF ENOUGH SUCH THAT A PLUG CAN BE DEVELOPED IN THE THROAT OF THE FEATURE.
6. IN LIEU OF THIS INITIAL MEASURE, COMPETENT LARGE BOULDER(S) SIZED GREATER THAN OR APPROXIMATELY EQUAL TO  $B/2$  WHERE "B" IS THE WIDTH OF THE THROAT, SHOULD BE PLACED IN THE BOTTOM, AND CONCRETE OR GROUT CAN THEN BE PLACED AROUND THE ROCK TO FORM A MASSIVE PLUG.
7. UPON COMPLETION OF THE PLUG AND A MINIMUM OF 24 HOURS, THE REMAINDER OF THE EXCAVATED AREA (MINIMUM OF 4 FEET IN DEPTH) SHOULD BE BACKFILLED WITH A LOW PERMEABILITY CLAYEY SOIL COMPACTED TO NOT LESS THAN 95 PERCENT OF THE MAXIMUM DRY DENSITY BASED ON THE STANDARD PROCTOR MOISTURE-DENSITY TEST (ASTM D 698)

NOT TO SCALE



#### **SINKHOLE REMEDIATION NOTES**

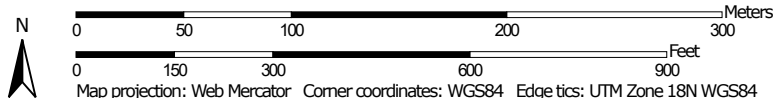
1. IN GENERAL A RISK OF SINKHOLE DEVELOPMENT WITHIN THE SWM FACILITIES AND SITE CAN BE ANTICIPATED DUE TO THE KARST GEOLOGY IN THE AREA.
2. REPAIR OF EXISTING SINKHOLES SHOULD INVOLVE CLEANING OF THE LOOSE SOIL, SOFT ROCK AND ANY DEBRIS TO THE THROAT OF THE SINKHOLE. THE EXCAVATIONS SHOULD EXTEND AWAY FROM THE CENTER OF THE SINKHOLE, AS NECESSARY, TO REMOVE ALL LOOSE SOIL AND EXPOSE ANY ADDITIONAL THROATS.
3. THE THROATS OF THE SINKHOLE OR SOLUTION CHANNELS SHOULD THEN BE CLEANED OUT SUCH THAT THE SOLUTION CAVITY AND AS MUCH SURROUNDING ROCK AS POSSIBLE IS EXPOSED. A LARGE TRACKHOE AND POSSIBLE HAND EXCAVATIONS WILL LIKELY BE REQUIRED TO ACHIEVE THIS DESIRED GOAL. TRIAD SHOULD HAVE A REPRESENTATIVE ON SITE TO OBSERVE THE EXCAVATION AND APPROVE.
4. DUE TO THE DIFFERENTIAL WEATHERING OF THE UNDERLYING BEDROCK AND THE NATURE OF KARST GEOLOGY, PREDICTING THE HORIZONTAL AND VERTICAL LIMITS OF THE EXCAVATION IS IMPOSSIBLE.
5. UPON COMPLETION OF THE EXCAVATION OPERATIONS, THE THROAT OF THE SINKHOLE AND THE SURROUNDING BEDROCK SHOULD BE FILLED WITH A REVERSE GRADED FILTER. THE FILTER SHOULD INVOLVE PLACEMENT OF LARGER STONE OR BOULDERS WITHIN THE THROAT OF THE SINKHOLE.
6. THE DIAMETER OF THE LARGE STONE OR BOULDERS SHOULD BE AT LEAST ONE-HALF THE DIAMETER OF THE THROAT OF THE SINKHOLE. IF THE IMMEDIATE THROAT CAN NOT BE FULLY EXPOSED OR IF A SIGNIFICANTLY LARGE THROAT IS ENCOUNTERED, LARGE BOULDERS COMBINED WITH POSSIBLE LEAN CONCRETE MAY BE REQUIRED IN THE BOTTOM OF THE EXCAVATION TO SERVE AS A VERY LARGE CONGLOMERATE OF RESISTANT MATERIAL.
7. AFTER PLACEMENT OF THE LARGER STONE OR BOULDERS, THE FILTER SHOULD CONSIST OF SEQUENTIALLY SMALLER GRADED STONE SUCH AS VARIABLE SIZED RIP RAP FOLLOWED BY SURGE STONE. THE REVERSE GRADED FILTER SHOULD BE COVERED WITH A NON-WOVEN GEOTEXTILE FABRIC. THE REMAINDER OF THE EXCAVATED AREA (MINIMUM OF 3 FEET) SHOULD BE BACKFILLED WITH LOW PERMEABILITY ON-SITE CLAYEY SOIL COMPACTED TO NOT LESS THAN 95 PERCENT OF THE MAXIMUM DRY DENSITY BASED ON THE STANDARD PROCTOR MOISTURE-DENSITY TEST (ASTM D 698). TRIAD SHOULD BE ON SITE DURING THE REMEDIATION WORK TO MONITOR THE EXCAVATION AND PERFORM COMPACTION TESTING ON THE CLAY BACKFILL.

# Appendix A

Soil Map—Cumberland County, Pennsylvania




Map Scale: 1:3,510 if printed on A portrait (8.5" x 11") sheet.





## MAP LEGEND

### Area of Interest (AOI)

 Area of Interest (AOI)

### Soils

 Soil Map Unit Polygons

 Soil Map Unit Lines

 Soil Map Unit Points

### Special Point Features



Blowout



Borrow Pit



Clay Spot



Closed Depression



Gravel Pit



Gravelly Spot



Landfill



Lava Flow



Marsh or swamp



Mine or Quarry



Miscellaneous Water



Perennial Water



Rock Outcrop



Saline Spot



Sandy Spot



Severely Eroded Spot



Sinkhole



Slide or Slip



Sodic Spot



Spoil Area



Stony Spot



Very Stony Spot



Wet Spot



Other



Special Line Features

### Water Features



Streams and Canals

### Transportation



Rails



Interstate Highways



US Routes



Major Roads



Local Roads

### Background



Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

**Warning:** Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service

Web Soil Survey URL:

Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cumberland County, Pennsylvania

Survey Area Data: Version 17, Sep 6, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 6, 2020—Nov 7, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
HaA	Hagerstown silt loam, 0 to 3 percent slopes	13.4	27.9%
HaB	Hagerstown silt loam, 3 to 8 percent slopes	12.5	26.0%
HcB	Hagerstown silt loam, rocky, 3 to 8 percent slopes	0.9	1.9%
HcC	Hagerstown silt loam, rocky, 8 to 15 percent slopes	3.6	7.5%
HuA	Huntington silt loam, 0 to 5 percent slopes	17.5	36.4%
Pe	Penlaw silt loam	0.1	0.3%
<b>Totals for Area of Interest</b>		<b>48.1</b>	<b>100.0%</b>

**Appe di B**



**Appe di c**

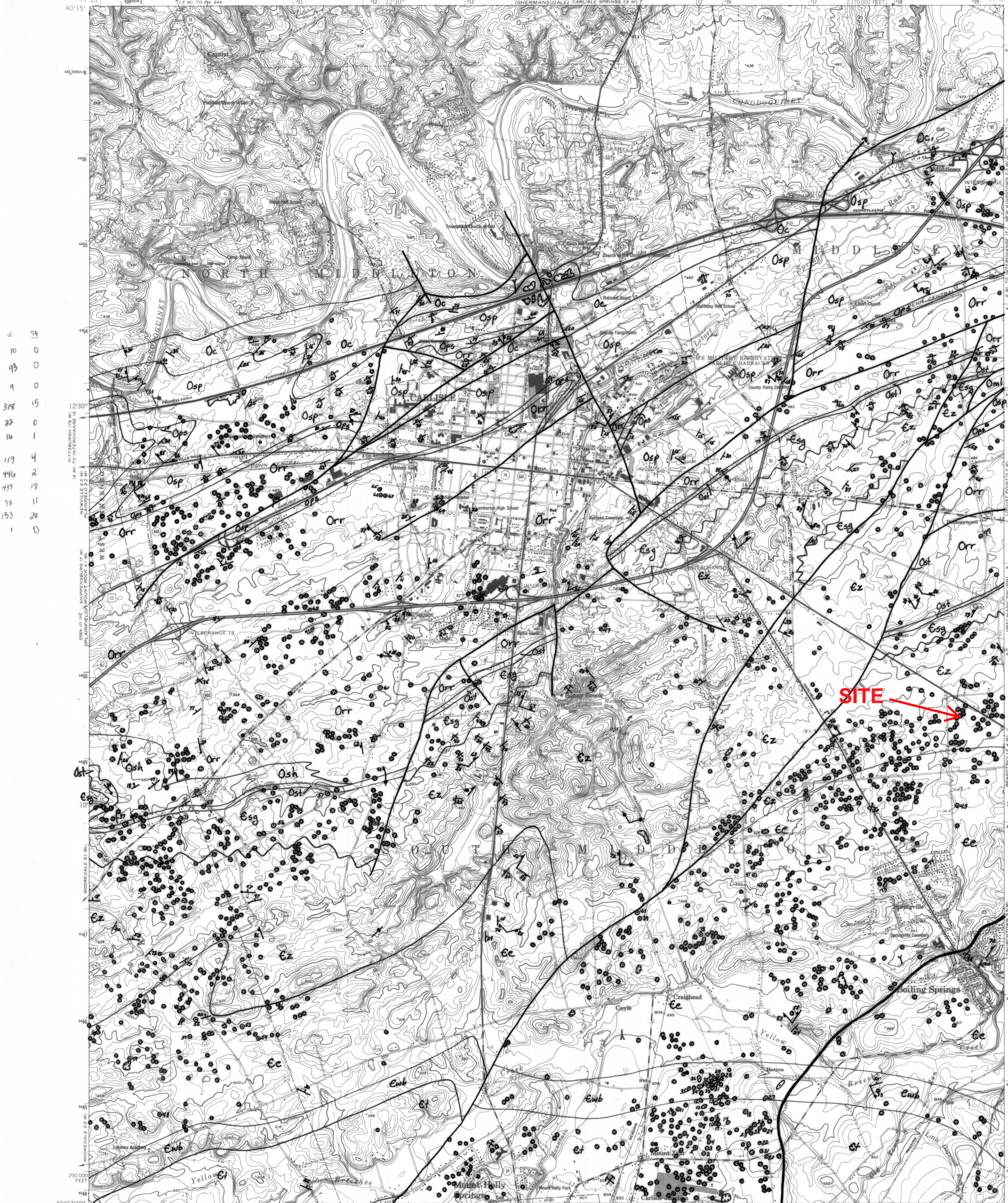
# SINKHOLES AND KARST-RELATED FEATURES OF CUMBERLAND COUNTY, PENNSYLVANIA

by W.E. Kochanov  
1989

OPEN FILE REPORT: 8902

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

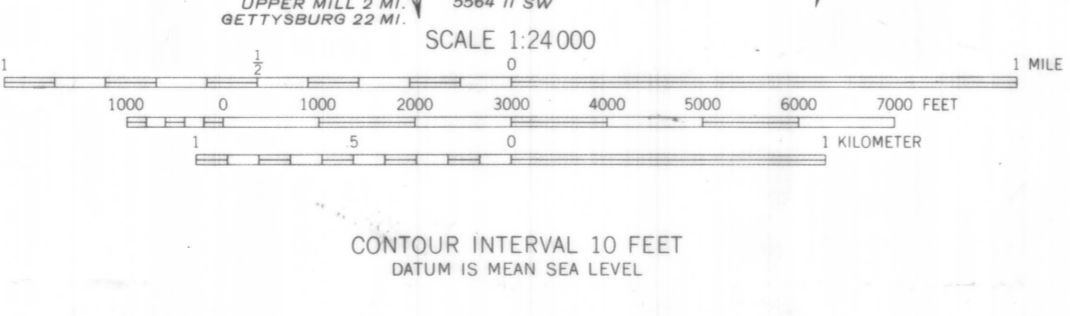
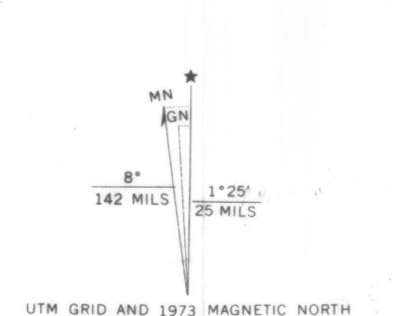
0686  
CARLISLE QUADRANGLE  
PENNSYLVANIA—CUMBERLAND CO.  
7.5 MINUTE SERIES (TOPOGRAPHIC)  
NW/4 CARLISLE 15' QUADRANGLE



SYSTEM	SERIES	FORMATION
CARBONIFEROUS	MIDDLE	Hartinsburg Formation, Limestone Osl
		Chamberburg Formation Oc
		St. Paul Group Osp
		Pinesburg Formation Opa
		Onelawna Formation Ool
		Keokuk Run Formation Orr
		Spier Formation Ose
		Stonshenge Formation Oa
		Stoufferstown Formation Ost
		Shadygrove Formation Osg
CARBONIFEROUS	LOWER	Zullinger Formation Ozl
		Hibrook Formation Oa
		Waynesboro Formation Owb
CARBONIFEROUS	LOWER	Townston Formation Otc

SYMBOLS	
	individual sinkhole
	or sinkhole group
	closed depressions
	surface mine, iron
	surface mine limestone/dolomite
	surface mine type unknown
	cave entrance
	bedding orientation strike and dip
	approximate strike and dip
	overturned, bed strike and dip
	joint orientation strike and dip
	joint orientation strike and 90° dip
	fault contact
	formation contact

Mapped by the Army Map Service  
Published for civil use by the Geological Survey  
Control by USGS, USC&GS, USCE, and USFS  
Topography from aerial photographs by photogrammetric methods  
Aerial photographs taken 1951. Field check 1952  
Polyconic projection. 1927 North American datum  
10,000-foot grid based on Pennsylvania coordinate system, south zone  
1000-meter Universal Transverse Mercator grid ticks,  
zone 18, shown in blue  
Red tint indicates area in which only landmark buildings are shown  
Revisions shown in purple compiled by the Geological Survey in  
cooperation with State of Pennsylvania agencies from aerial  
photographs taken 1968 and 1973. This information not field checked  
Purple tint indicates extension of urban areas



ROAD CLASSIFICATION  
Heavy-duty ——— Light-duty ———  
Medium-duty ——— Unimproved dirt ———  
○ Interstate Route □ U.S. Route ○ State Route

0686  
CARLISLE, PA.  
NW/4 CARLISLE 15' QUADRANGLE  
N4007.5—W7707.5/7.5  
1952  
PHOTOREVISED 1968 AND 1973  
AMS 5564 II NW—SERIES V831

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS  
FOR SALE BY U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092  
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

**The work presented here has not been reviewed for formal publication.**

**Bureau of Topographic and Geologic Survey  
P.O. Box 8453, Harrisburg, PA 17105-8453**

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1988