January 17, 2021

Springfield Township Board of Supervisors
2230 Township Road
Quakertown, PA 18951

Re: Preliminary Groundwater Review
Hydrogeologic Consulting Services
H&K's Proposed Quarries – Springfield Township

Dear Board Members:

In accordance with your request, RMS Environmental LLC (RMS) is providing this letter report reviewing the submission of H&K Group, Inc.'s Preliminary Conditional Use Application (Application) dated March 13, 2020. The Application was submitted for a G-7 Quarry Use Permit for new non-coal mining operations. Our review focused on the Preliminary Groundwater Model Report prepared by VF Britton and the Wetland/Watercourse Boundary Verification letter provided by Valley Environmental Services, Inc.

The sections below provide background information on the geology and hydrogeology of the project area, a review of the preliminary groundwater model report by VF Britton and our conclusions.

Background

General

The planned quarry area includes four parcels, owned by Liberty Home Development Corporation, LTD, which encompass approximately 196 acres (see **Figure 1**). H&K, the Tenant, entered into an Agreement with the landowner, the Landlord, on December 21, 2018 regarding the lease of said properties to conduct non-coal surface mining. As outlined in the Agreement mining activities will be initiated in the South Extraction Area and extend for a period of twenty years from the date of the Agreement before mining activities can commence in the North Extraction Area.

The proposed G-7 Quarry Use will involve two separate excavation areas identified as North Extraction Area and South Extraction Area. These areas have been defined based upon the environmental resources, i.e., wetlands, streams, etc., and the dimensional setback requirements mandated by both the Township Zoning Ordinance and 25 Pa Code Chapter 77: Noncoal Mining. Access to the proposed use will be via Springfield Street opposite the existing entrance to Coopersburg Materials, an asphalt batch plant.

Improvements related to the quarry use will be limited to the access road, weigh scale, scale house, storage building, and the processing equipment and stockpile areas related to each excavation area. As mining progresses in the North Excavation Area, reclamation of the South Extraction Area will advance toward completion as outlined later in this narrative.

Geology

The geology underlying Springfield Township is shown on **Figures 1** to **3** (Lyttle and Epstein, 1987). The geology of the Springfield area is comprised of three formations: Jurassic Diabase to the northwest and interfingered Triassic Lockatong Formation and Triassic Brunswick Group. According to the geologic map prepared by these authors, the local wells are drilled into the Jurassic Diabase.

The Jurassic diabase outcrops along the northwest portion of the study area. The intrusions are thought to have occurred in early Jurassic times. Near the contact with the diabase, the Brunswick Group sedimentary rocks have been metamorphosed to dark, hard, hornfels through the intense temperature of the diabase intrusion. The metamorphism of the sedimentary rocks makes the shales and siltstones more susceptible to fracturing.

Diabase rocks are more resistant to weathering than the sedimentary rocks in the area, hence the topography and hilly terrain in the study area. Diabase of early Jurassic age, which occurs as extensive sheets, is considered a York Haven-type diabase based on com-position (Smith, 1973). The diabase is a dark-gray to black, fine- to coarse-grained, crystalline rock composed largely of calcic plagioclase and augite. Near the chilled margins, the diabase is very fine- to fine-grained. Diabase intruded under high temperature and low pressure into rocks of pre-Jurassic age. The diabase has been exposed by weathering of the softer intruded rocks.

The Brunswick Group comprises soft red shales and siltstones and, to a lesser extent, fine-grained sandstones, and gray argillites. Most of the Brunswick Group formations were deposited under fluvial conditions. The Lockatong Formation consists of laminated to thick-bedded, gray and black siltstone and shale. Lockatong sediments were deposited in a large, shallow alkaline lake (Sloto and Schreffler, 1994). The strike of the strata in the Newark Super Group is northeast-southwest with a dip of around 10° to the northwest. Folding in the Lockatong Formation and Brunswick Group are not prevalent, and the shales have not developed cleavage.

The bedrock contains numerous near-vertical fractures or joints. Fractures can be developed along bedding planes or occur inclined at steep angles. The degree of fracture development and their orientation are variable between the interbedded layers due to differences in physical properties, including grain size and hardness. Harder, more competent rocks generally show more fracturing than pliable units. Enhancement of fracturing along bedding planes occurs in the Lockatong Formation and Brunswick Group. Fractures can occur over widely spaced areas, or within concentrated, narrow zones. Zones of fracturing can be aligned with or at angle to joint development. Three sets of fractures can be recognized in the Lockatong Formation and Brunswick Group. The main set trend northeast to southwest and is sub-parallel to the strike of the bedding. The second set is parallel to the dip and the third set is vertical or sub-vertical.

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Hydrogeology

Diabase sheets form prominent hills that cap underlying sedimentary rock. Twelve percent of the study area is underlain by diabase. Diabase is massive and weathers to large, spheroidal boulders. Diabase boulders weather to a buff-colored, granular sand. The sand, in turn, breaks down into a sticky, red, montmorillonite-type swelling clay. The land is unsuitable for agriculture and is largely wooded.

Diabase has no primary porosity, and the depth of fracturing rarely exceeds 100 to 150 ft. Therefore, all ground water flow is through fractures, and nearly all groundwater storage is in the upper weathered zone. Where the weathered zone is absent, little groundwater storage is available.

Water-bearing and groundwater flow characteristics of diabase are similar to that of crystalline rocks, but diabase is not as fractured and does not have the thick weathered zone frequently associated with crystalline rocks. The reasons for this are (1) diabase is younger than the crystalline rocks and has not been subjected to the intense folding and faulting that produced the fracturing of the crystalline rocks; (2) diabase sheets are more resistant to weathering and stand topographically higher than the more easily eroded adjacent rocks, thus undergoing less weathering by circulating ground water; and (3) surface runoff is greater from diabase ridges than the surrounding rocks, probably because of the day-rich soil, and there is less chance for recharge.

Many wells drilled into diabase penetrate underlying hydrogeologic units, and these wells may derive some or all of their water from the underlying units. The potentiometric surface map of McManus and Rowland (1993) shows the potentiometric surface in the Coffman Hill diabase sheet (labeled as the upper aquifer system) and in the underlying sedimentary rocks (labeled as the lower aquifer system).

Shallow wells completed in diabase derive water only from diabase. Deeper wells, which yield little or no water from diabase, penetrate the underlying sedimentary rocks. Away from the edge of the diabase sheets, little or no hydraulic connection exists between the diabase and the underlying sedimentary rocks.

The yield of a well drilled into a bedrock aquifer is initially dependent on the number, size, and degree of hydraulic interconnection of the water-bearing zones encountered. The higher the degree of fracturing encountered during the drilling of the wells, the higher their yield (and the amount of recharge received). High yield wells in this hydrogeologic unit also coincide with areas of increased subsurface fracturing. The resulting hydraulic head in a deep well is the composite of the heads of the water-bearing zones penetrated (Sloto and Schreffler, 1994). Because of the vertical zone-dependence of these Jurassic Diabase rocks, differences of depths drilled of adjacent wells can lead to differing water levels within the wells.

Based on the yield of the wells present therein, the Jurassic Diabase within the Springfield region is characterized by below-average (for this hydrogeologic unit) porosity and permeability. This general observation notwithstanding, even within these regions, however, there is great variability in the porosity and permeability of the bedrock, based, again, on evaluation of well yields.

When a well begins operation some groundwater mining occurs since water must be pumped from storage in the aquifer in order to create the necessary hydraulic gradients that allow water to flow toward the well. Over the long-term, the yield of a well is determined by the hydraulic characteristics of the aquifer and the amount of recharge, usually in the form of precipitation, received by the area interconnected with and contributing flow to the well.

When a well is pumped, the water level in the pumped well and nearby area is lowered. The difference between the pre-pumping or static water level and the pumping water level is called drawdown. In ideal aquifers, the area affected by the pumping (capture zone) resembles an inverted cone which projects on the surface of the ground as a circle with the center coinciding with the pumped well. In anisotropic aquifers, such as within the study area, the area of impact develops preferentially along the direction of higher permeability and its projection on the surface of the ground exhibits an elliptical shape. In these aquifers, the area of impact cannot extend indefinitely and is limited to the network of fractures interconnected with the pumped well and their lateral extent. In addition to knowledge and experience, defining the areal extent and degree of impact of a fractured bedrock well requires the design of an extensive and meaningful monitoring well network and the collection of detailed water level data. Experience shows that the degree of impact on water levels in monitored wells is independent of the distance from the pumping well. Experience also shows that the following observations are true:

1. Monitored wells that intersect fractures directly connected to the fractures intersected by the pumping well will respond to pumping within a short time and will exhibit the largest amount of drawdown.

2. Wells that intersect secondary fractures interconnected with the primary ones will show a delayed response to pumping and the amount of drawdown will be small.

3. Wells that do not fall into the previous two categories will not show any impact.

Review of Preliminary Groundwater Model Report – VF Britton

The purpose of the preliminary groundwater model prepared by VF Britton (Britton) is to provide a preliminary numeric representation of the hydrogeologic conditions existing as the site and the surrounding area based on the existing conceptual site model. Britton determined that the current ground elevation in the site area is 600 feet above mean sea level (ft-msl). The proposed quarry pits will be mined to a bench elevation of 400 ft-msl. Quarry operations will begin in the southern quarry. Data used in the preliminary model was collected from two on-site boreholes in the planned northern pit, two residential wells and six well location data points provided by the Pennsylvania Groundwater Information System (PAGWIS).

No data was collected from the planned Southern pit area. The data used to prepare the preliminary model was limited and not site related. The sections below provide our understanding and observations regarding model input parameters and parameter evaluation, including:

- Boundary conditions,
- Surface water,
- Model grid,
- Model layers and geologic characteristics,
- Hydraulic conductivity assignment,
- Recharge,
- Drawdown,
- Numerical flow calibration, and
- Sensitivity Analysis

Boundary Conditions

Boundary conditions represent locations in the model where water flows into or out of the model region due to external factors such as wells, lakes, rivers, groundwater divides, geology, etc. "Britton states, "It should be noted that the Northern Pit area is located very close to the northern boundary of the regional groundwater divide (watershed boundary) and; therefore, the model domain was expanded in a northern direction into the neighboring watershed to prevent the potential for the Northern Pit dewatering simulation from interacting with the model boundary."

No discussion is given how this variation impacts the dewatering simulation. The regional groundwater divide indicates groundwater will not easily travel from one side to the other, therefore, expanding the model in the northern direction may limit the effects that the dewatering simulation would have on groundwater to the east, west and south of the site. Even though the model was expanded further to the north, the groundwater divide acts as a natural groundwater boundary, therefore; some boundary condition should be identified in the model at this location.

Surface Water

Conductance values used to simulate surface water bodies are within accepted ranges. It is important to note that, although a wetland delineation was performed by Valley Environmental Services, Inc., limited information was provided regarding the impacts of quarry activities on local wetlands and surface waters.

The proposed quarry model does not take into account the effects that could be caused to the wetlands. Moreover, in Valley Environmental Services, Inc.'s (VES) correspondence to H&K dated February 13, 2020, Mr. Mease states "Based upon a combination of biologic, geomorphologic, and hydrologic traits observed it is VES's professional opinion that Wetlands A, B, F, G, J, I, and H, as identified on the plan entitled "Wetlands & Waters Delineation Map" (sheet number 1 of 3, dated February 12, 2020, prepared by the H&K Group's Engineering & Environmental Services Division) are primarily fed via perennial sources of hydrology like *groundwater (springs) and baseflow*." Dewatering the proposed quarry could have negative effects to the Perennial Wetlands A, G, H, I and J surrounding the Northern Pit and Perennial Wetlands B and F.

Quarry operations routinely create fluctuations in volume of water that can change the form and function of a wetland (Zedler and Kercher 2005). Also, changes in water quality from quarry operations can have a negative impact on the biodiversity and local species that live in impacted wetlands. Therefore, an Ecological Monitoring Plan should be developed to evaluate the impacts on the wetlands and surrounding area. The Plan should include:

- Collection of baseline wetland data for at least a year,
- Perform vegetation inventories and semi-annual monitoring,
- Rain event monitoring, and
- Determination of groundwater inputs and discharge and if discharged water pumped from the quarry will create excessive overland flow towards the wetlands.

Model Grid

Model grid was set at 100 by 100 feet for general domain of model. A finer spaced grid in the area of the quarry should be implemented in the final groundwater model (50 by 50 feet). The finer grid spacing will allow for a more accurate solution of water levels and flows in the vicinity of the planned quarry pits.

Model Layers and Geologic Characteristics

Britton makes note that based on publication data of Sloto and Schreffler (1994), and RMS agrees, that the upper 100 feet of consolidated rock have the highest permeability when compared to underlying rocks. The diabase has very limited water-bearing capacity below 50 to 100 feet. RMS agrees with this and is thus concerned that the H&K plan to dewater up to 200 feet below the surface, meaning below the Diabase's largest water bearing zone (Sloto and Schreffler, 1994) could cause wells proximal to the site to lose a large portion of their water supply.

Hydraulic Conductivity Assignment

Hydraulic conductivity values used by Britton fall in line with published values, site specific values should be determined during the next phase of field work.

Recharge

Historically, RMS has used 25% as the average recharge rate for the Lockatong and Brunswick Formations, which is in line with values used by Britton. Using 5% recharge for Diabase is reasonable, but this value should be field tested at the site.

Drawdown

In the Northern Pit two boreholes, HK-2 & HK-3, were drilled with observed groundwater elevations of 606 ft-msl and 593 ft-msl, respectively. In Figure 11 of the Preliminary Groundwater Report, Britton shows a drawdown contour of between 40 and 50 feet on the edges of the bench level of 400 ft-msl, when in actuality the proposed drawdown in the Northern Pit will be greater than 200 feet. There is an underestimate regarding the drawdown inside the Northern Pit boundaries, though the entire Pit will not be down to 400 ft-msl there is not a steep enough drawdown gradient to get from the pre-pumping groundwater elevation to the 400 ft-msl bench level.

In the Southern Pit no boreholes were drilled therefore there is no information indicating the actual groundwater elevation. In Figure 12 of the Preliminary Groundwater Report, Britton shows a drawdown contour of between 40 and 50 feet on the edges of the bench level of 400 ft-msl, when in actuality the proposed drawdown in the Southern Pit will be greater than 200 feet. There is an underestimate regarding the drawdown inside the Southern Pit boundaries, though the entire Pit will not be down to 400 ft-msl there is not a steep enough drawdown gradient to get from the pre-pumping groundwater elevation to the 400 ft-msl bench level.

Numerical Flow Calibration

A small number of control points were used to determine the accuracy of the computed groundwater elevation. This is not unexpected for a Preliminary Groundwater Model.

Sensitivity Analysis

Based on the Sensitivity Analysis conducted on this model the two most important characteristics were Hydraulic Conductivity in the top layer (0 to 100 feet) of the Diabase and recharge in the Diabase. If and when a Final Groundwater Model is conducted for the proposed quarry it is imperative that field tests are performed to confirm that the values Britton used aren't just reasonable, but accurate.

The model should also be run for the pumping of both quarries at the same time to determine the impact of this scenario on the surrounding area. The report states that reclamation activities will occur in the southern pit while quarry operations will commence in the northern pit. Dewatering activities may be needed in the southern pit during reclamation activities. Therefore, pumping of both pits simultaneously may occur and should be evaluated.

Findings

RMS's review of the Ground Water Models implemented by Britton has found the numeric flow model construction to be based on sound science. RMS has made the following observations regarding the simulation of drawdown in the Northern and Southern Pits:

- Monitor groundwater levels in the southern pit area prior to final model development,
- Evaluate boundary conditions near the northern pit to determine if the natural groundwater boundary effects flow in this area during dewatering activities,
- Develop an Ecological Monitoring Plan to monitor the effect on wetlands and surface waters during pumping conditions,
- Refine the model grid in the area of the pits to allow more accurate solution of water levels and flows in the vicinity of the quarry pits,
- Run the model for simultaneous pumping of both quarries in the event this scenario is necessary, and
- Collect real time data, to the extent practicable, for use in the final groundwater model.

Should the Township have any questions or need any additional information, please do not hesitate to contact us at 215.364.1661 or mmercuri@rmsenvironmental.com.

Sincerely,
RMS Environmental LLC

Matthew Mercuri, PG
Managing Partner

cc: Robert Wynn, Township Engineer
Jason Wager, Township Manager/Zoning Officer

References

Anderson, Mary P., and William W. Woessner, 2002. *Applied Groundwater Modeling: Simulation of Flow and Advective Transport*. Acad. Press.

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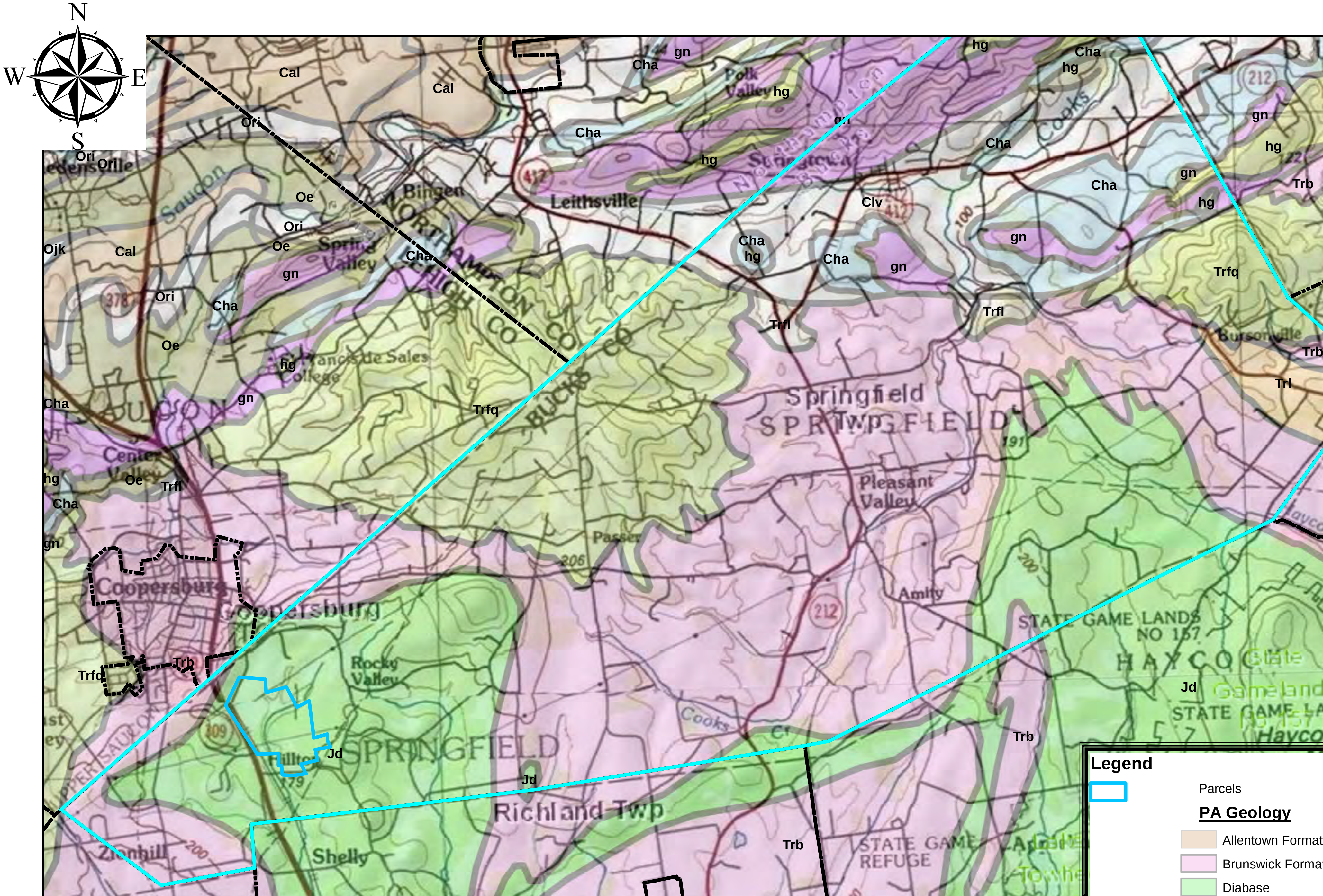
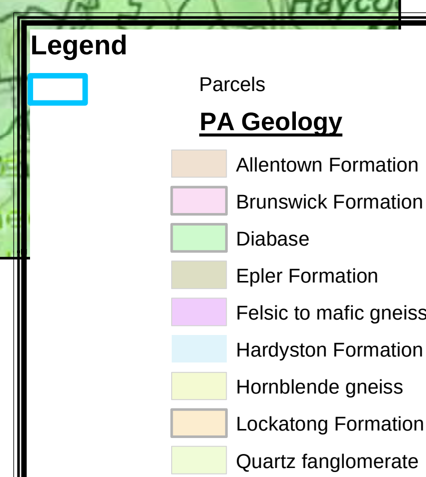
McManus, B.C., and Rowland, C.J., 1993, *Altitude and configuration of the potentiometric surfaces of the upper and lower aquifer systems in Bridgeton, Nockamixon, and Tinicum Townships, Bucks County, Pennsylvania, April 1991 through April 1992*: U.S. Geological Survey Water-Resources Investigations Report 92-4194, scale 1:24,000.

Sloto, Ronald A. and Curtis L. Schreffler, 1994. *Hydrogeology and Ground Water Quality of Northern Bucks County, Pennsylvania*. U.S.G.S. Water Resources Investigation 94-4109.





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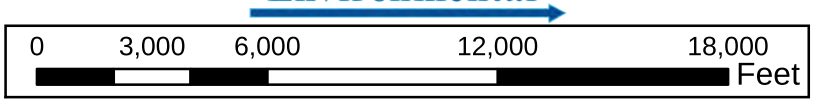
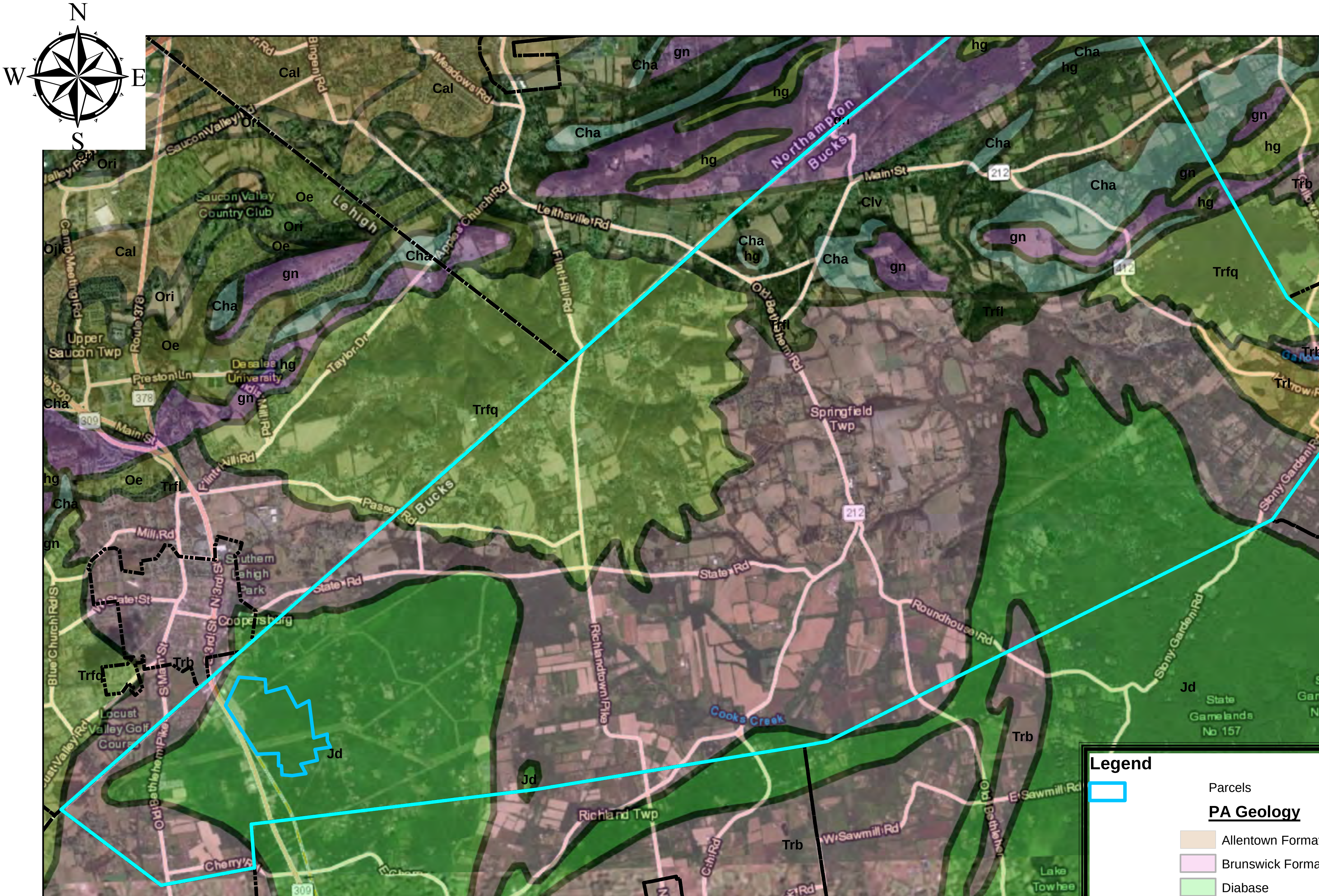
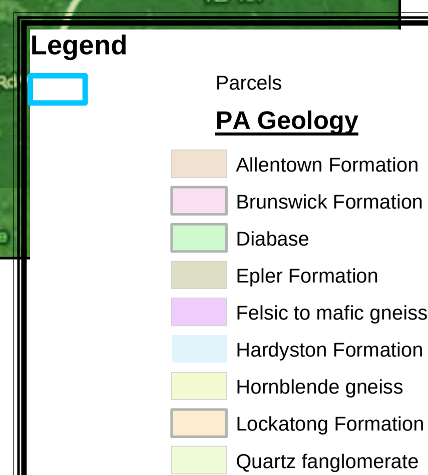


Figure 1
Geology and Topographic Map
Springfield Township
(Lyttle and Epstein, 1987)





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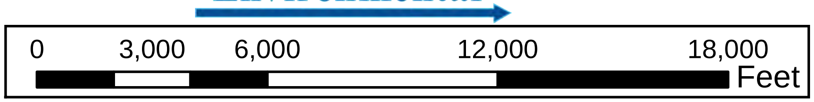

Figure 2
Geology and Aerial of Springfield Township (Lyttle and Epstein, 1987)

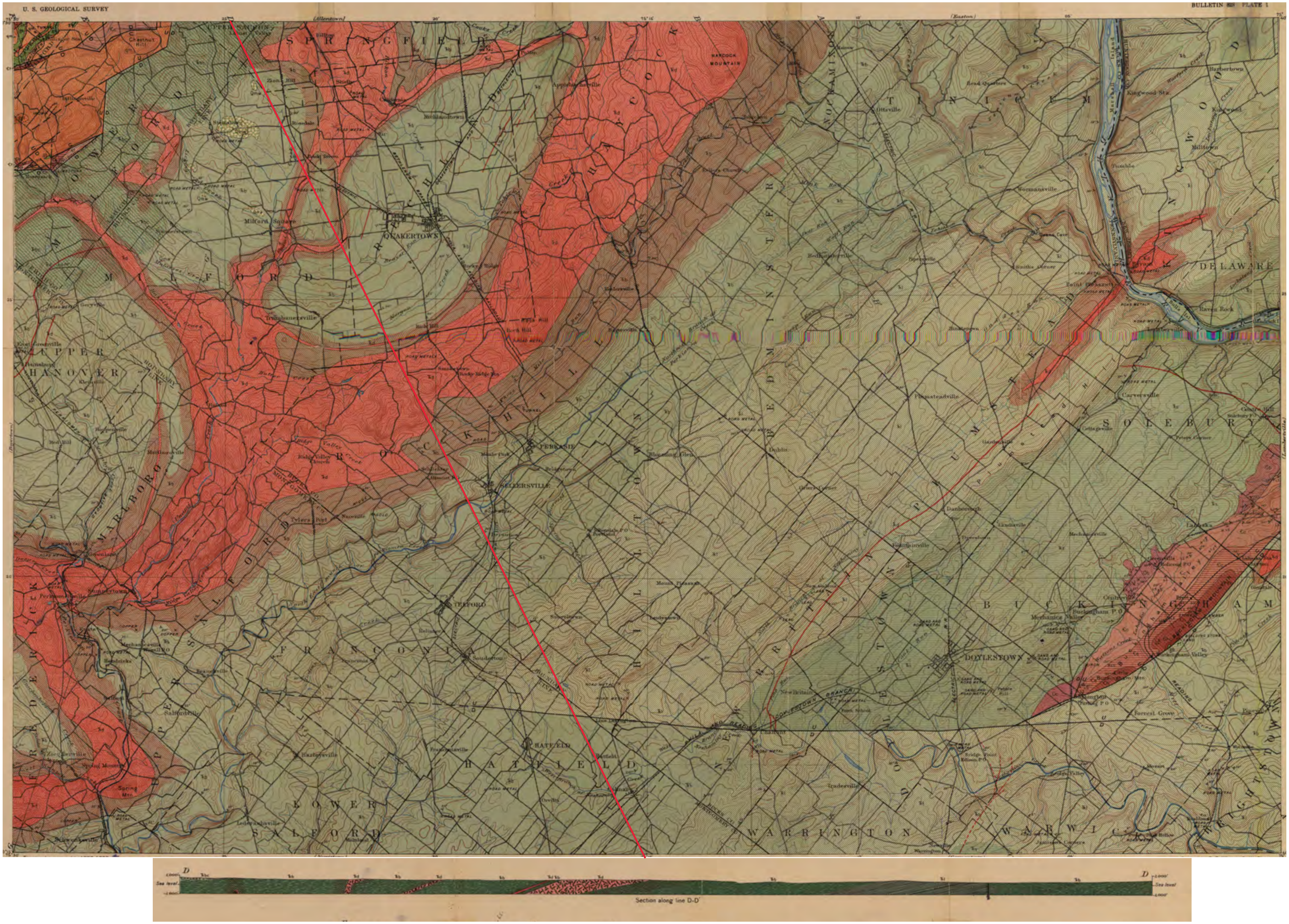

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Figure 3
Geologic Cross-Section
Springfield Township
(Lyttle and Epstein, 1987)