Middle States Geographer, 2016, 49: 33-42

WISSAHICKON CREEK DRAINAGE BASIN ORIGIN AS DETERMINED BY TOPOGRAPHIC MAP INTERPRETATION

Eric Clausen
100 West Ave D-17
Jenkintown, PA 19046

ABSTRACT: Topographic map interpretation methods are used to determine the Wissahickon Creek drainage basin origin. Wissahickon Creek flows for approximately 23 miles in a south direction to join the Schuylkill River in northwest Philadelphia. Wind gaps, through valleys, and saddles notched into drainage divides surrounding the Wissahickon drainage basin combined with orientations of valleys leading to and from those divide crossings document how the Wissahickon Creek valley and adjacent south oriented valleys eroded headward across multiple flood formed southwest oriented channels. Massive southwest oriented flood flow initially moved across the region on a topographic surface as high or higher than the highest regional elevations seen today. Headward erosion of south oriented valleys into this surface captured the floodwaters and lowered base level, which enabled the southwest oriented flow to significantly lower elevations in the Piedmont Province Gettysburg-Newark Section and Chester Valley. Headward erosion of the south oriented Wissahickon valley beheaded and in some cases reversed southwest oriented flow channels that had been supplying water to the southeast oriented Schuylkill River. Rapid erosion of the Wissahickon drainage basin ended when headward erosion of the southeast and south oriented Neshaminy Creek valley beheaded southwest oriented flow routes to the Wissahickon valley.

Keywords: *Chester Valley, Delaware-Schuylkill River drainage divide, Neshaminy Creek, Pennypack Creek, Tookany (Tacony) Creek*

INTRODUCTION

Why Study the Wissahickon Creek Drainage Basin Origin?

Wissahickon Creek originates as a southwest oriented stream at an elevation of about 420 feet on Triassic sedimentary rock in the Gettysburg-Newark Lowland Section of the Piedmont Province (as defined by Potter, 1999) and flows for approximately 2 miles before turning to flow short distances in south and east directions and then 20 miles in a south direction across geological structures to enter Philadelphia (PA) where it has eroded a deep gorge across the Upper Piedmont Section of the Piedmont Province. Once in Philadelphia Wissahickon Creek joins the southeast oriented Schuylkill River. Gasioroski (1997) describes the wooded valley in northwest Philadelphia as being "considered by many to be one of the most beautiful urban parks in the world." Geologic, geographic, cultural, and other park features are well described in Gasioroski's *Middle States Geographer* paper and other publications (e.g. Goodwin, 1964, and Contosta and Franklin, 2010). While these publications describe park features they do not address how the Wissahickon Creek drainage basin originated. The Delaware-Schuylkill River drainage divide bounds the Wissahickon drainage basin east side and understanding how the Wissahickon drainage basin originated may help in understanding how the larger Delaware and Schuylkill River drainage basins originated.

Figure 1 shows the Wissahickon Creek location in relation to Philadelphia and to the surrounding drainage routes. Northeast oriented Neshaminy Creek tributaries bracket southwest oriented Wissahickon headwaters and west of the Wissahickon headwaters and of northeast oriented Neshaminy Creek tributaries located north of the Wissahickon headwaters are southwest oriented streams, which flow to south oriented Perkiomen Creek (west of Figure 1) with water eventually reaching the Schuylkill River. The southeast oriented Delaware River segment and southeast oriented Schuylkill River along with south oriented Perkiomen Creek (west of Figure 1), Wissahickon Creek, Tookany (Tacony) Creek, Pennypack Creek, Neshaminy Creek, and other streams too small to be seen in Figure 1 form a series of relatively closely spaced south or southeast oriented drainage routes located in valleys cut across the regional northeast to southwest oriented geologic structures, while Neshaminy Creek tributaries including east oriented Little Neshaminy Creek and tributaries to other south oriented drainage routes also flow in valleys that cut across regional geologic structures. Detailed topographic maps showing drainage divides surrounding the Wissahickon

Creek drainage basin are interpreted here in an effort to determine how and why this drainage system consisting of valleys cut across the regional geologic structures originated.

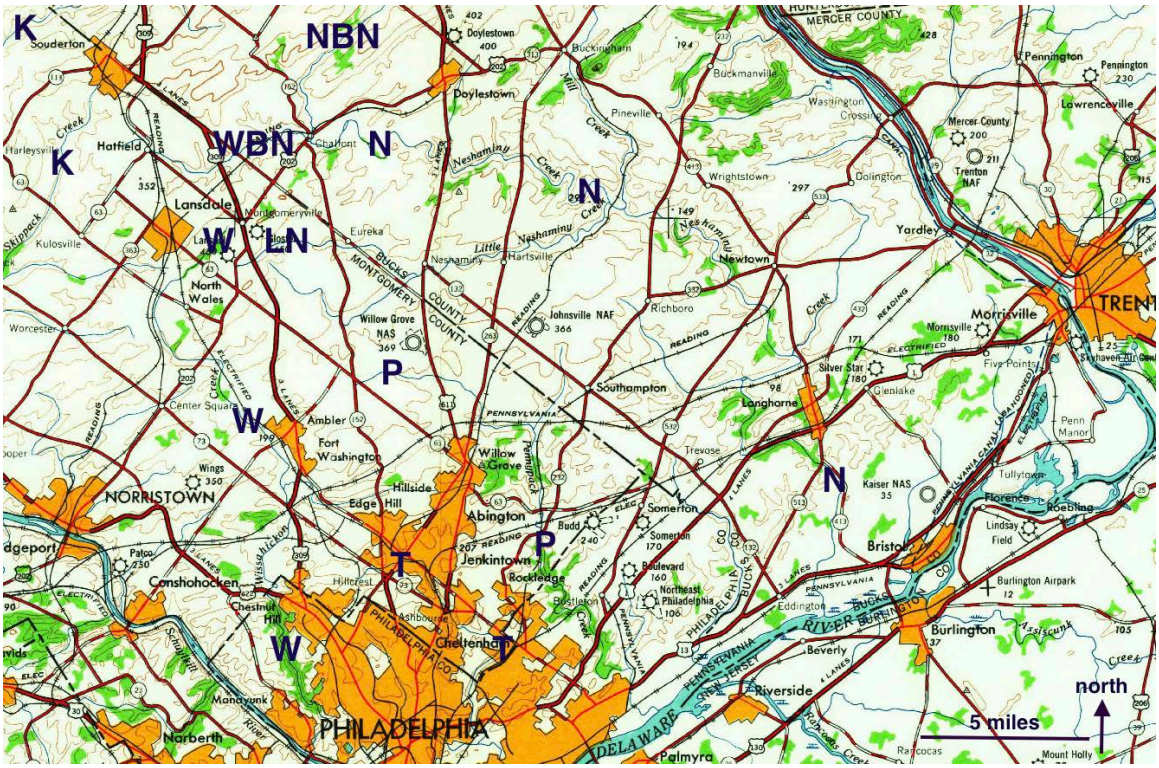

Figure 1. Section of 1964 USGS 1:250,000-scale Newark (NJ) topographic map with 100-foot contour interval showing the Wissahickon Creek location. The letters "W" identify Wissahickon Creek, "T" Tookany (Tacony-Frankford) Creek, "P" Pennypack Creek, and "N" Neshaminy Creek, all flowing to the Delaware River and the letters "K" identify tributaries to south oriented Perkiomen Creek (west of Figure 1) flowing to the Schuylkill River. The letters "NBN" identify the North Branch Neshaminy Creek, "WBN" West Branch Neshaminy Creek, and "LN" Little Neshaminy Creek.

Previous Research Related to the Wissahickon Creek Drainage Basin Origin

Wissahickon Creek has been included in erosion rate studies involving various Pennsylvania and southeast Pennsylvania streams (e.g. Chirico, P.G. and Epstein, J.B, 2000: Evans, Sheeder, and Lehning, 2003: and Cianfrani, Hession, and Rizzo, 2006) and there are studies of erosion rates in nearby Pennsylvania Piedmont river valleys (e.g. Reusser, L. Bierman, P., Pavich, M., Larsen, J., and Finkel, R., 2006), however the only recent literature found asking the types of questions being asked in this paper was written by the author of this paper (Clausen, 2016). Questions asked in this paper include: what type of drainage system crossed the Wissahickon drainage basin area before the Wissahickon Creek drainage basin existed, why does the south oriented Wissahickon Creek valley cut across geologic structures including some higher in elevation than the Wissahickon Creek headwaters, why do the Wissahickon Creek headwaters first flow in a southwest direction and then turn in an east direction before turning in a south direction, and how and why was the Wissahickon Creek drainage basin eroded?

While seldom asked today questions addressed in this paper were commonly asked during the early 1900s, usually without satisfactory results. Wissahickon Creek is mentioned in the United States Geological Survey (USGS) *Philadelphia folio* (Bascom, F., Clark, W.B., Darton, N.H., Knapp, G.N., Kuemmel, H.B., Miller, B.L., and Salisbury, R.D., 1909, p. 3) in which its watershed is described as "646 square miles in area and… underlain partly by Triassic shales and partly by crystalline rocks." The Wissahickon Creek upper courses are "in an open shallow valley" while for its final 6 miles "the stream has cut a rocky channel which lies about 200 feet below the general level of the country." While not specifically mentioning Wissahickon Creek Bascom et al (p. 18) state, "larger streams maintain courses which are independent of the lithologic character and structure of the underlying rock. An explanation of this fact is found in the presence of the

cover of Cretaceous, Tertiary, or Quaternary materials which, existing at the time of the development of the drainage, masked the pre-Paleozoic and Paleozoic formations beneath it. The drainage, superimposed upon this cover, became too well established in courses… and independent of the concealed rock floor to alter these courses when subsequently the rock floor was uncovered." Elsewhere on the same page Bascom et al note the Cretaceous, Tertiary, or Quaternary cover is missing from the Piedmont region. The lack of any Cretaceous, Tertiary, or Quaternary cover in the Piedmont region and from regions further inland led to a still unresolved debate regarding the origins of major Piedmont and Appalachian drainage routes summarized by Thornbury (1965) and Morisawa (1989). Strahler (1945) considered the problem unproductive and pointed researchers in different directions. This paper attempts to solve what has been a long dormant regional geomorphology problem.

METHOD

Drainage divides as seen on detailed topographic maps provide information about drainage systems that existed prior to present day drainage system formation. This information is obtained from through valleys, wind gaps, and saddles notched into the drainage divides and from the orientations of valleys leading to and from these divide crossings. Divide crossings are best seen on detailed topographic maps available where a small contour interval is important. For that reason 1:24,000 scale topographic maps with 10 or 20-foot contour intervals from the United States Geological Survey (USGS) Historical Map Collection website and the Pennsylvania Department of Natural Resources (DCNR) Interactive Map Resources website for the Wissahickon Creek drainage basin and adjacent areas were used. All research described in this paper was initially done using newer 1:24,000-scale USGA topographic maps, however three figures in this paper use older and somewhat less detailed 1:62,500 scale USGS topographic maps (with 20 foot contour intervals) to show larger regions and also to show landforms and drainage routes before more recent urban development. Maps used in the original hypothesis tests all had 10 or 20-foot contour intervals and for that reason all elevations given in this paper are in feet.

Drainage divides between closely spaced streams cutting across geologic structures, such as in the Wissahickon Creek region, were most likely created when headward erosion of deeper valleys captured flow from earlier drainage routes and in the process reversed flow on downstream ends of beheaded flow channels. In the case of drainage divides surrounding the Wissahickon Creek drainage basin the drainage divide crossings are today drained in two different directions with one direction being towards Wissahickon Creek and the other direction being towards an adjacent stream. The two opposing valleys, which originate at or near each drainage divide crossing were interpreted as relics of a drainage channel that once crossed the present day divide and that had eroded a valley now only seen at the drainage divide crossing. Orientations of the two opposing valleys were interpreted to be orientations of earlier drainage channels.

Questions asked at each drainage divide crossing were "in what direction did the original channel flow, what evidence demonstrates the original flow channel was captured, and which of the two opposing valleys was reversed and how did the reversed flow valley obtain enough water to be eroded?" The number and orientations of the divide crossings were also noted and the questions were asked "how did these previous drainage channels fit into a recognizable drainage pattern and why were a series of deeper south oriented valleys able to erode headward across the earlier drainage channels?" Results of the topographic map interpretation of divide crossings on both sides of the south oriented Wissahickon Creek drainage basin are next described with a Wissahickon drainage basin origin presented in the conclusion.

WISSAHICKON DRAINAGE BASIN MAP INTERPRETATION RESULTS

Wissahickon Creek-Schuylkill River Drainage Divide

Figure 2 illustrates a section of the 1943 USGS 1:62,500-scale Norristown (PA) topographic map with a 20-foot contour interval and shows the Wissahickon-Schuylkill drainage divide segment south of West Point. Southwest oriented Wissahickon Creek headwaters seen in Figure 1 turn in a south-southeast direction between North Wales and West Point to flow through a water gap and then turns in an east direction before turning in a south direction. The water gap cuts across a southwest to northeast oriented high ridge with elevations exceeding 460 feet visible on both sides of Wissahickon Creek (remember Wissahickon Creek

originates at an elevation of about 420 feet). The ridge is offset by a fault at the water gap location providing a zone of easier to erode bedrock that determined the water gap location. The ridge elevation is comparable to the West Branch Neshaminy-Wissahickon Creek headwaters divide elevation and to elevations surrounding the downstream Wissahickon gorge seen in subsequent figures.

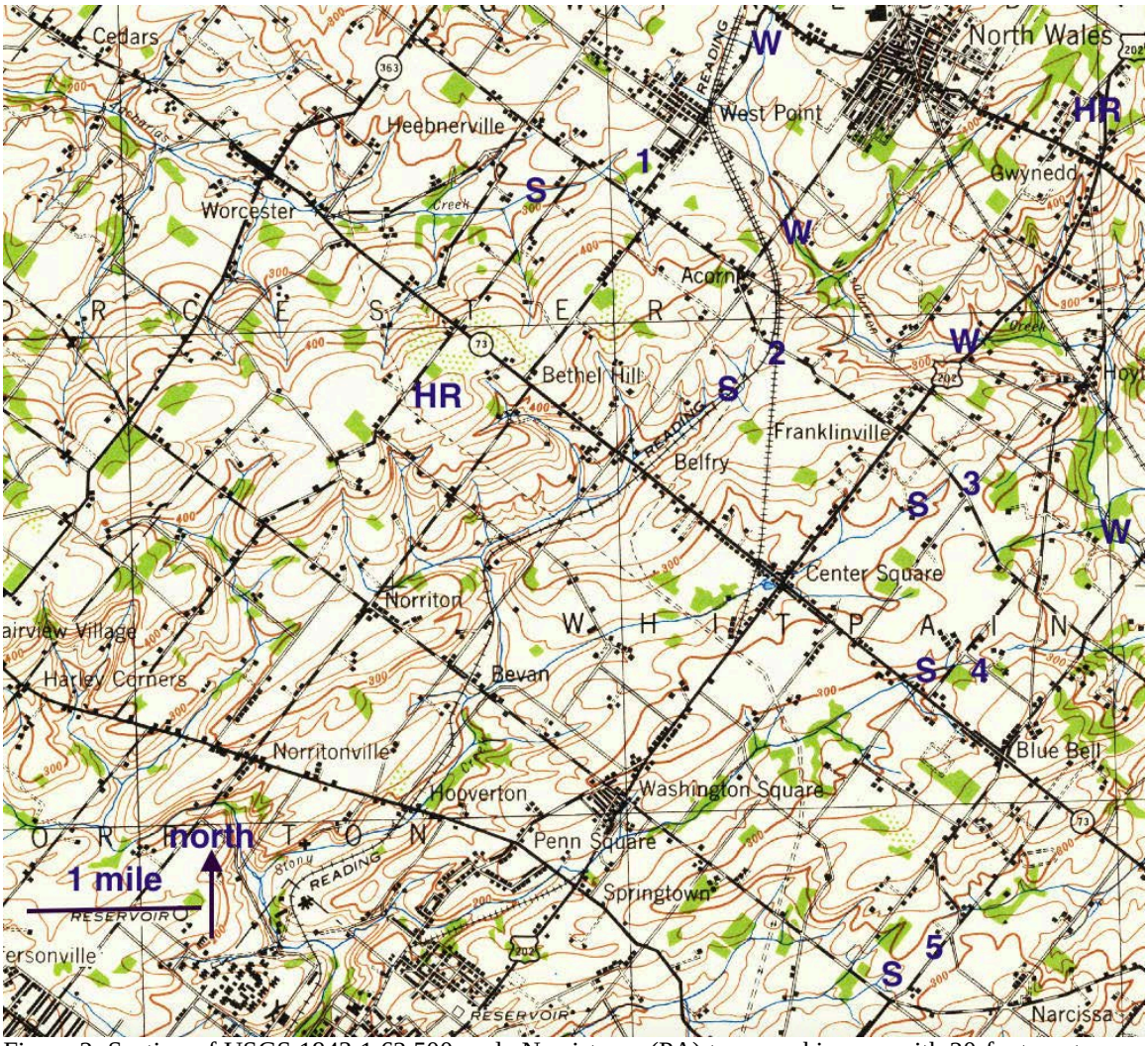

Figure 2: Section of USGS 1943 1:62,500-scale Norristown (PA) topographic map with 20-foot contour interval showing a Wissahickon-Schuylkill drainage divide segment south of West Point. The letter "W" identifies Wissahickon Creek. The letter "S" identifies headwaters of streams flowing to the Schuylkill River. Numbers identify divide crossings discussed in the text. The letters "HR" identify the 460-foot plus high ridge referred to in the text.

A Wissahickon Creek U-turn seen in Figure 1, but only partially seen in Figure 2, can be explained if prior to Wissahickon Creek valley headward erosion southwest oriented water flowed on a topographic surface at least as high as the 460-foot high ridge and was first captured by headward erosion of the southwest oriented Stony Creek valley (valley used by Reading Railroad in Figure 2), which eroded headward from the Schuylkill River valley. Headward erosion of the deeper south oriented Wissahickon valley next captured southwest oriented flow to Stony Creek (see the southwest oriented tributary where east oriented Wissahickon Creek turns in a south direction) and beheaded and reversed flow on what had been a west oriented channel leading to the southwest oriented Stony Creek valley. The reversed flow then captured southwest oriented Stony Creek headwaters flowing on the northeast side of the offset ridge, which probably also included flow in the southwest oriented Wissahickon headwaters valley.

Five divide crossings linking the Wissahickon Creek valley with headwaters of southwest oriented Schuylkill River tributaries are seen in Figure 3. These divide crossings are numbered and were eroded by channels moving water in a southwest direction across the present day Wissahickon-Schuylkill drainage divide. Divide crossing “1” has an elevation of between 320 and 340 feet, divide crossing “2” an elevation of between 320 and 340 feet, divide crossing “3” an elevation of between 300 and 320 feet, divide crossing “4” an elevation of between 320 and 340 feet, and divide crossing “5” an elevation of between 280 and 300 feet. The similarities of elevations on these five divide crossings suggest southwest oriented water was flowing in all of the channels at the time headward erosion of deeper Wissahickon Creek valley beheaded all five flow channels in sequence from south to north. Elevation of ridges between divide crossing “1” and “2” exceed 460 feet, between divide crossing “2” and “3” exceed 360 feet, between divide crossing “3” and “4” exceed 340 feet, and between divide crossing “4” and “5” exceed 380 feet and south of divide crossing “2” are all much lower than elevations surrounding the downstream Wissahickon gorge.

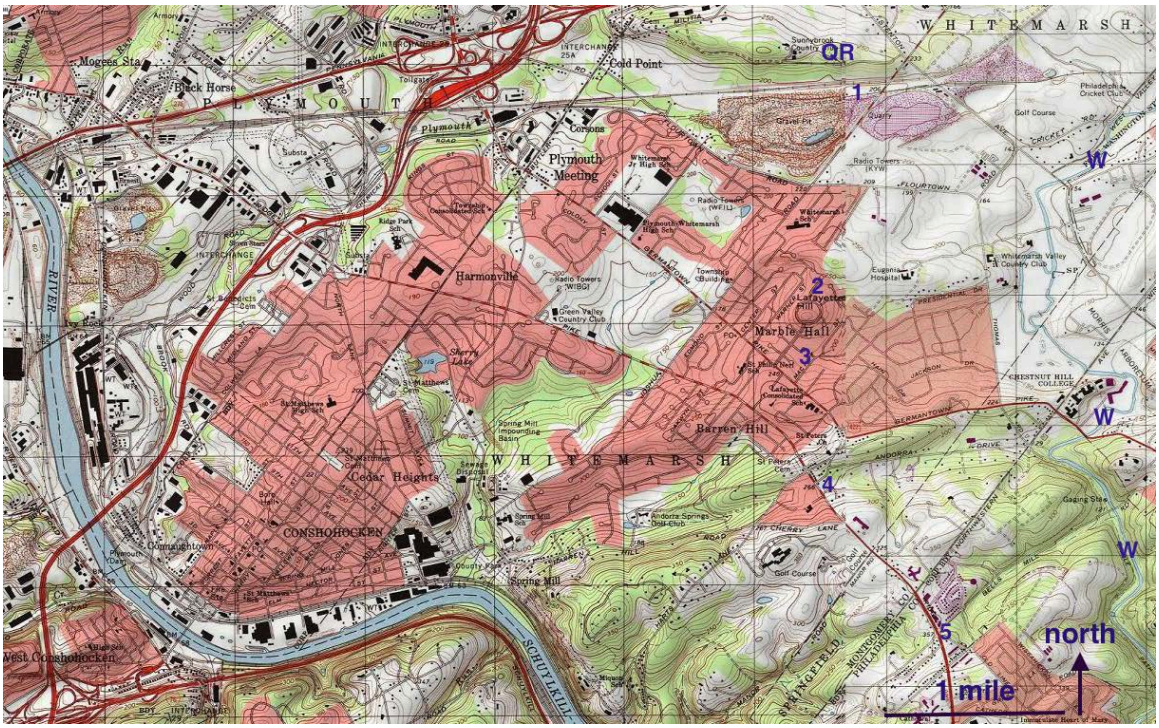

Figure 3: Composite of 1992 Norristown and 1998 Germantown USGS topographic maps (with 10-foot contour interval) taken from Pennsylvania DCNR Interactive Map Resources website showing where the Wissahickon-Schuylkill drainage divide crosses the Chester Valley and rises in elevation as it enters the higher elevation Piedmont Upland Section to the south. The letters “W” identify Wissahickon Creek and “QR” a quartzite ridge on the Chester north margin. The Chester Valley is located between the quartzite ridge and higher elevations to the south. Numbers identify divide crossings mentioned in the text.

Figure 3 uses a composite of two 1:24,000-scale USGS topographic maps to illustrate where the Wissahickon-Schuylkill drainage divide crosses the carbonate-floored Chester Valley and continues south into the Upper Piedmont Section, which is underlain by much more erosion resistant rock. The letter “W” identifies Wissahickon Creek and numbers identify the most obvious divide crossings. Between the marked quartzite ridge in Figure 3 and the southeast corner of Figure 2 there is another pronounced divide crossing (unseen in figures here) with a floor elevation of less than 250 feet. In Figure 3 the elevation of divide crossings “1” and “3” is between 200 and 210 feet, divide crossing 2 is between 230 and 240 feet, divide crossing “4” is between 260 and 270 feet, and divide crossing “5” is between 340 and 350 feet. Wissahickon-Schuylkill drainage divide elevations rise to more than 420 feet just south for Figure 3 before decreasing (Figure 4). Wissahikon-Schuylkill drainage divide elevations seen between the 460-foot plus high ridge observed in Figure 2 and the Piedmont Upland Section seen in Figures 3 and 4 suggest the intervening lower

region was deeply eroded by immense quantities of southwest oriented water moving to the deeper Schuylkill River valley. Headward erosion of southwest oriented tributary valleys from the southeast oriented Schuylkill River valley concentrated the flow in deeper channels that were beheaded when Wissahickon Creek valley headward erosion captured the southwest oriented flow.

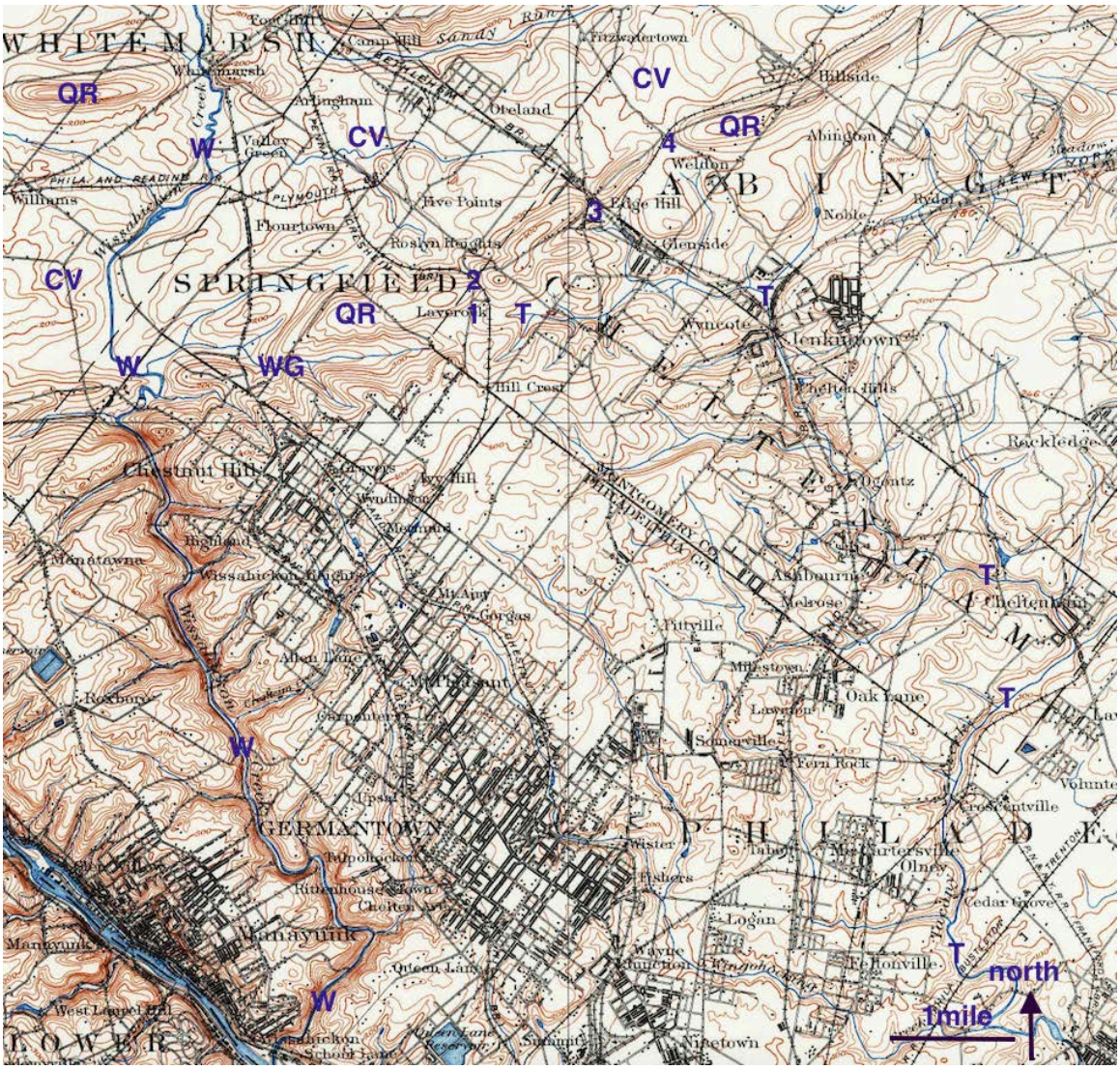

Figure 4: Section of USGS 1894 USGS Germantown (PA) 1:62:500-scale topographic map with a 20-foot contour interval showing the Wissahickon Creek gorge, a Wissahickon-Schuylkill drainage divide segment at its southern end, and a Delaware-Schuylkill River drainage divide segment. The letters "W" identify Wissahickon Creek, "T" Tookany (Tacony) Creek, "CV" the carbonate-floored Chester Valley, "QR" quartzite ridges bounding the Chester Valley, and "WG" a water gap eroded by a Wissahickon Creek tributary. Numbers near and along the southern quartzite ridge identify wind gaps discussed in the text.

Figure 4 illustrates the Wissahickon gorge and the south end of the Wissahickon-Schuylkill drainage divide. Wissahickon Creek enters its deep gorge just north of Chestnut Hill while the Schuylkill River flows across the figure southwest corner in a separate gorge. Note how elevations on both sides of the Wissahickon Creek gorge in the Chestnut Hill area exceed 420 feet. The Schuylkill and Wissahickon gorges are eroded into the erosion resistant Wissahickon Formation metamorphic rock (largely schist and gneiss) that underlies the higher elevation Piedmont Upland Section seen south of the Chester Valley. Shallow divide crossings between the two gorges link northeast oriented Wissahickon Creek tributaries with southwest oriented Schuylkill River tributaries, but the best evidence for southwest oriented flow across the Wissahickon-

Schuylkill drainage divide is found in the orientations of the Schuylkill River and Wissahickon Creek tributaries. Note how tributaries to both gorges from the east are oriented in southwest directions while many tributaries from the west are oriented in northeast directions. Also note how Wissahickon Creek turns in a southwest direction to join southeast oriented Schuylkill River as a barbed tributary. These valley orientations suggest immense volumes of southwest oriented water flowed across the region as the gorges were being eroded with the Schuylkill River gorge being eroded first. Water to erode northeast oriented tributary valleys came from yet to be beheaded southwest oriented flow still moving on the high level surface north and west of the actively eroding gorge valley heads.

Delaware River-Schuylkill River Drainage Divide

Figure 4 also illustrates a segment of the southern end of the Delaware-Schuylkill River drainage divide, which more specifically is the drainage divide between Tookany (or Tacony) and Wissahickon Creeks. Tookany (or Tacony) Creek flows to the southwest oriented Delaware River (as seen in Figure 1) while Wissahickon Creek as seen in Figure 4 flows to the southeast oriented Schuylkill River. Some shallow divide crossings can be seen at the heads the southwest oriented Wissahickon Creek gorge tributaries, but the most obvious divide crossings are the four numbered wind gaps near and across the Edge Hill quartzite ridge located along the Chester Valley southeast margin.

Wind gap number 1 (floor elevation 350-360 feet) is located between headwaters of a west oriented Wissahickon Creek tributary and the east oriented Tookany (Tacony) Creek headwaters. The west oriented Wissahickon tributary flows through a water gap (marked by the letters “WG”) cut across the Edge Hill quartzite ridge while Tookany (Tacony) Creek near Jenkintown turns abruptly in a south direction at an obvious elbow of capture. Clausen (2016) suggests prior to headward erosion of the deep south oriented Tookany (Tacony) Creek valley all regional elevations were high enough that diverging and converging flow channels crossed the present day Edge Hill quartzite ridge (highest elevations exceed 420 feet today). Wind gaps numbered 2 (350-360 feet) and 3 (320-330 feet) were initiated by water moving into the Chester Valley area while wind gap 4 (320-330 feet) and an unseen wind gap east of Figure 4 were initiated by water moving from the Chester Valley area to the southeast side of today’s ridge and drainage divide.

A major west oriented flow channel south of the Edge Hill quartzite ridge crossed the present day Tookany (Tacony) Creek drainage basin and eroded wind gap number “1” and the water gap labeled “WG” as it moved water to what at that time was an actively eroding Wissahickon Creek valley. Headward erosion of the south oriented Tookany (Tacony) Creek valley captured the west oriented flow moving in this channel and flow on the east end of the beheaded channel reversed direction to create the east oriented Tookany (Tacony) Creek headwaters. Water to erode the east oriented headwaters valley spilled from the still higher in elevation Chester Valley area to the north, which at that time had only begun to be actively eroded by southwest oriented flow moving to the actively eroding and deep Wissahickon Creek valley head (which at that time was eroding headward across what is now the Chester Valley). Spillage from the Chester Valley area into the actively eroding Tookany (Tacony) Creek drainage basin reversed flow through wind gaps “2” and “3” and captured water moving through wind gap “4” and the wind gap east of Figure 4 (360-370 feet) until headward erosion of west oriented Wissahickon Creek tributary valleys north of the ridge lowered the present day Chester Valley floor so as to create the present day notched Edge Hill ridge as the drainage divide between Wissahickon Creek drainage to the north and Tookany (Tacony) Creek drainage to the south, which also is a Delaware-Schuylkill River drainage divide segment.

Figure 5 illustrates a segment of the Delaware-Schuylkill River drainage divide (which is also the Delaware River-Wissahickon Creek) drainage divide north of the Chester Valley. The Lower Paleozoic carbonate-floored Chester Valley eastern end is labeled “CV” and in this region is located between two Cambrian age quartzite ridges (labeled “QR”). The region north of the northern quartzite ridge is underlain by Triassic age sedimentary rock. Northeast oriented Little Neshaminy Creek tributaries (labeled “LN”) and northeast and east oriented Pennypack Creek tributaries (labeled “P”) drain the east side of the drainage divide to the southwest oriented Delaware River (as seen in Figure 1) and the Delaware-Schuylkill River drainage divide can be traced across the figure between the southwest oriented Wissahickon Creek tributaries and the northeast and east oriented Little Neshaminy Creek and Pennypack Creek tributaries.

Numbers on Figure 5 identify six divide crossings and unlike divide crossings seen in figure 2 elevations of the figure 5 divide crossings are different. Divide crossing “1” has an elevation of between 420 and 440 feet, divide crossing “2” of between 360 and 380 feet, divide crossing “3” of between 300 and 320 feet, divide crossing “4” of between 340 and 360 feet, divide crossing “5” of between 360 and 380 feet, and divide crossing “6” of between 280 and 300 feet. All Delaware-Schuylkill drainage divide elevations seen in

figure 5 are lower than the ridge exceeding 460 feet through which the Wissahickon Creek water gap seen in figure 2 has been cut and also lower than the highest elevations on either side of the Wissahickon gorge. The differing divide crossing elevations suggest that initially southwest oriented water flowed on a regional surface at least 420 feet high and headward erosion of the deep south oriented Wissahickon Creek valley lowered base level, which in turn enabled southwest oriented flow to erode deeper channels (now southwest oriented Wissahickon Creek tributary valleys) headward in a northeast direction. Delaware-Schuylkill River drainage divide elevations seen in figure 5 also suggest the numbered divide crossings are simply deeper channels eroded into the floor of a what was once broad southwest oriented broad valley (more than 15 miles wide) that southwest oriented flood flow eroded across what is today the Delaware River-Schuylkill River drainage divide.

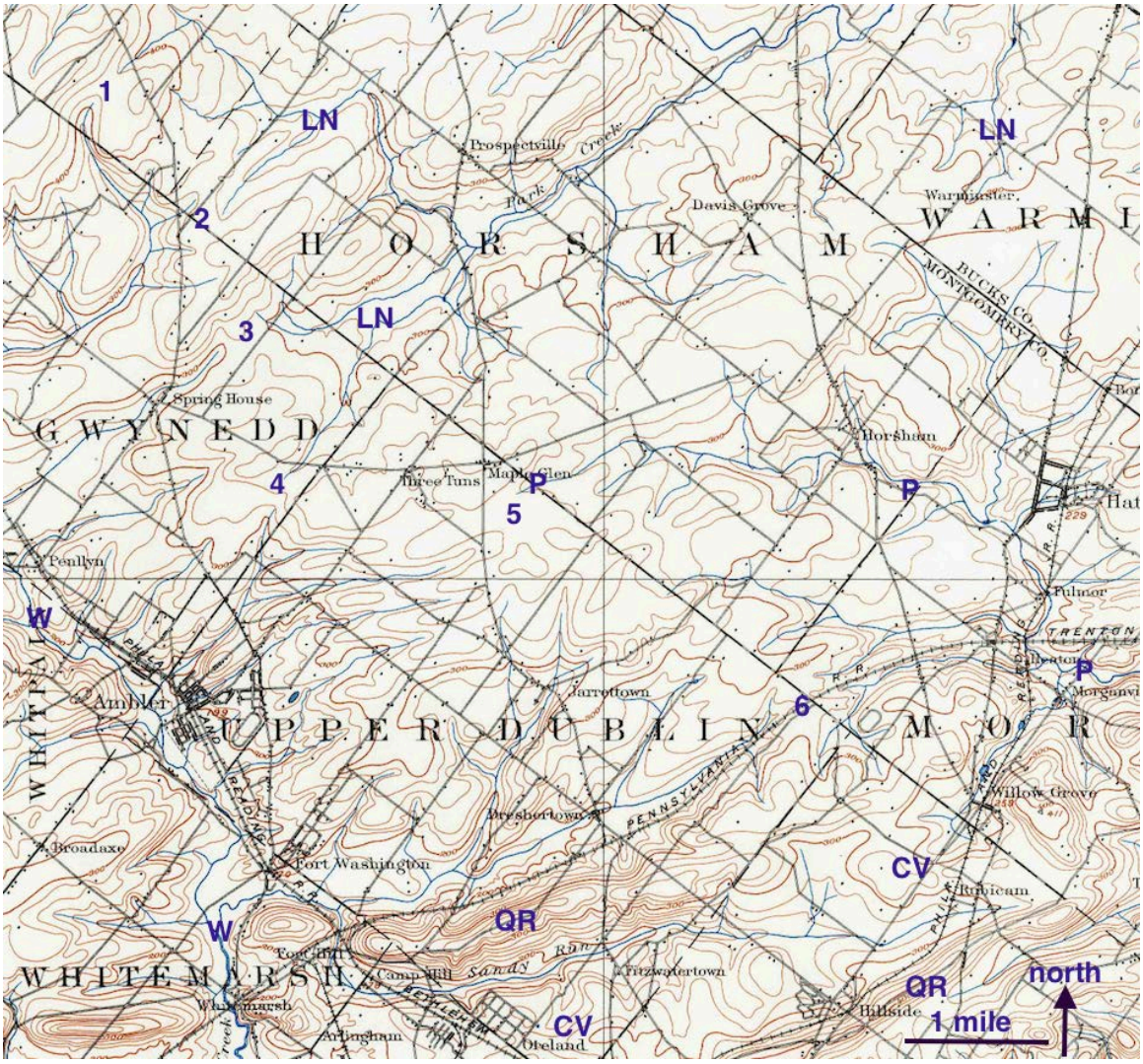

Figure 5: Section of USGS 1894 USGS Germantown (PA) 1:62:500-scale topographic map with a 20-foot contour interval showing the Delaware-Schuylkill River drainage divide segment north of figure 4 and east of figure 2. The letters "W" identify Wissahickon Creek, "P" Pennypack Creek, and "LN" Little Neshaminy Creek tributaries. Numbers identify six Delaware-Schuylkill River divide crossings. The letters "CV" identify the Chester Valley and "QR" quartzite ridges bounding the Chester Valley.

CONCLUSIONS

Drainage divides surrounding the Wissahickon Creek drainage basin document a Wissahickon Creek-Schuylkill River drainage divide low region between the 460-foot high ridge seen in figure 2 and the Piedmont Upland Section to the south that is crossed by ten or more deeper divide crossings. The low region was eroded by massive amounts of water moving to what must have been a much deeper southeast oriented Schuylkill River valley prior to headward erosion of the south oriented Wissahickon Creek valley. The deeper divide crossings are today at heads of southwest oriented Schuylkill River tributaries and are relics of southwest oriented valleys eroded headward as the southwest oriented flow became concentrated in channels that were being carved along zones of more easily to erode bedrock materials. Headward erosion of the deeper south-oriented Wissahickon Creek valley captured the southwest oriented flow and beheaded the southwest oriented flow channels to create what is today the Wissahickon Creek-Schuylkill River drainage divide. Capture of the southwest oriented flow provided the immense water volumes needed for the Wissahickon Creek valley to erode northward. Orientations of tributaries to the Wissahickon Creek and Schuylkill River gorges (south of the Chester Valley) suggest the gorges were eroded by massive southwest oriented flow moving across the present day Piedmont Upland Section prior to deep erosion of the Chester Valley and Triassic age sedimentary bedrock regions to the north

The southernmost segment of the Delaware River-Wissahickon Creek drainage divide was created when headward erosion of the deep south-oriented Tookany (Tacony) Creek valley beheaded and reversed flow to what was at that time the newly eroded Wissahickon Creek valley and a second segment was created when in the Chester Valley headward erosion of deep west and southwest oriented tributary valleys eroded headward from the actively eroding Wissahickon Creek valley to capture water spilling over the Edge Hill quartzite ridge into the newly eroded Tookany (Tacony) Creek valley. A third Delaware-Wissahickon drainage divide segment was created when north of the Chester Valley headward erosion of the deep south oriented Pennypack Creek valley beheaded and reversed southwest flow moving to the newly eroded Wissahickon Creek valley. Headward erosion of the east oriented Little Neshaminy Creek valley from the southeast and south oriented Neshaminy Creek valley next beheaded southwest oriented flow to the newly eroded Wissahickon Creek valley to create a fourth Delaware-Wissahickon drainage divide segment. The northernmost Delaware River-Wissahickon Creek drainage divide segment was created when headward erosion of the deep east, southeast, and south oriented Neshaminy Creek valley beheaded and reversed southwest oriented flow to the Wissahickon Creek headwaters valley to create what is today a northeast oriented West Branch Neshaminy Creek segment seen in figure 1 and to end all flood flow to what at that time was the newly created Wissahickon Creek drainage basin.

Topographic map evidence cannot determine the floodwater source other than to say the water came from the northeast. Similar studies of drainage divides surrounding other drainage basins can be used to follow the floodwaters headward toward the water source and downstream to determine whether the floodwaters once crossed drainage divides south and west of the Schuylkill River valley. The Delaware-Schuylkill River drainage divide north and west of the Wissahickon Creek drainage basin also needs to be studied to determine whether or not floodwaters once crossed it. Map evidence of the type illustrated here cannot determine when during geologic history floodwaters crossed the region and eroded the Wissahickon Creek drainage basin. Immense quantities of water were required to erode the Wissahickon Creek and adjacent creek drainage basins. The only known geologic events capable of producing such volumes of water would be associated with rapid melting of a large continental ice sheet, although further work is required to properly investigate such a hypothesis.

REFERENCES

Bascom, F., Clark, W.B., Darton, N.H., Knapp, G.N., Kuemmel, H.B., Miller, B.L., and Salisbury, R.D., 1909, *Philadelphia folio, Norristown, Germantown, Chester, and Philadelphia, Pennsylvania-New Jersey-Delaware*: p.18. United States Geological Survey Folios of the Geologic Atlas: 162.

Chirico, P.G., and Epstein, J.B., 2000, Geographic information system analysis of topographic change in Philadelphia, Pennsylvania, during the last century: United States Geological Survey Open File Report 00-224: 13 p.

Cianfrani, C.M., Hession, W.C., and Rizzo, D.M., 2006, Watershed imperviousness impacts on stream channel condition in southeast Pennsylvania: *Journal of the American Water Resources Association*, 42(4), 941-956.

Clausen, E., 2016, Using topographic map interpretation methods to determine Tookany (Tacony) Creek erosion history upstream from Philadelphia, Pennsylvania, USA: *Journal of Geography and Geology* 8(4) 30-45.

Contosta, D. and Franklin, C., 2010, *Metropolitan Paradise: the struggle for nature in the city*: Saint Joseph's University Press. Philadelphia PA.

Evans, B.M., Sheeder, S.A., and Lehning, 2003, A spatial technique for estimating streambank erosion based on watershed characteristics: *Journal of Spatial Hydrology*, 3(1), 1-13.

Gasiorowski, C., 1997, Philadelphia's Wissahickon valley: its geology and geography: *Middle States Geographer*, 30: 42-49.

Goodwin, B.K., 1964, *Guidebook to the geology of the Philadelphia area*: Bulletin G41: Pennsylvania Geological Survey, fourth series, Harrisburg, PA.

Morisawa, M, (1989), The rivers and valleys of Pennsylvania, revisited: In Gardner, T. W. and Sevon, W. D. (Eds.) Appalachian Geomorphology: *Geomorphology* (2) 1-22.

Pennsylvania Department of Conservation and Natural Resources (DCNR) Interactive Map Resources website: http://www.dcnr.state.pa.us/learn/interactivemapresources/index.htm (*Accessed 2/17/2017).*
Potter, N., 1999, Physiography and Southeast of Blue Mountain: in *The Geology of Pennsylvania*: Pennsylvania Geological Survey and Pittsburgh Geological Society, pp. 342-351.Harrisburg and Pittsburgh, PA.

Reusser, L., Bierman, P., Pavich, M., Larsen, J., and Finkel, R., An episode of rapid bedrock channel incision during the last glacial cycle, measured with ^{10}Be: *American Journal of Science*, 306(2) 69-102.

Strahler, A. N. (1945). Hypotheses of stream development in the folded Appalachians: *Geological Society of America Bulletin* 56(1) 45-88.

Thornbury, W. D. (1965) *Regional Geomorphology of the United States*: John Wiley and Sons, New York. 610 pp.

United States Geological Survey Historical Map Collection website: https://ngmdb.usgs.gov/maps/TopoView/ (*Accessed 2/17/2017).*