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MEMORANDUM

VIA EMAIL

To: Maya van Rossum, Delaware Riverkeeper

From: Mary Paist-Goldman, P.E.

Subject: Report on potential stream impacts from
Sheep Hole Road bridge replacement
Tinicum Township, Bucks County, Pennsylvania
Princeton Hydro Project No. 1020.017

Date: July 7, 2016

Pursuant to your request, Princeton Hydro has completed a site assessment of the Headquarters Road Bridge at Sheep Hole Road. Our review included:

- Determination of Effects Report (DOE) prepared by PennDOT dated November 2015.
- A memorandum by A.D. Marble and Company dated June 20, 2016.
- A Comment Response Document prepared by PennDOT and dated June 23, 2016
- Photos taken by pH staff on January 17, 2016
- Site walk and photos taken by pH staff on June 29, 2016.

Based on the reviewed documents, it appears that PennDOT is recommending Alternative 6 as described in the DOE for final design of the Sheep Hole Road bridge. In summary, Alternative 6 includes the following elements:

- Alternative 6 requires 0.014 acres of ROW acquisitions but this does not appear to include acquisitions necessary for the new alignment to meet existing grade on the western side.
- There is a proposed 0.042 acres of Temporary Construction Easement in the Ridge Valley Rural Historic District.
- Alternative 6 will result in an increase in 468 square feet in impervious area, an increase of 33%.
- Based on the Alternative 3 (which includes maintaining the existing substructure and rehabilitating it; DOE Figure 7) and Alternative 6 ("Two-Lane Bridge Replacement;

DOE Figure 10) cross sections, the proposed bridge replacement will result in an increase of 0.73 feet in water surface elevation in the 25-year event.

- If Alternative 6 is anticipated to increase the 25-year water surface elevation by 0.73 feet over Alternative 3, it is likely that the 100-year water surface elevation will also be impacted. (It is noteworthy that the DOE mentions that Alternative 2 would increase the 100-year floodplain elevation, but no such discussion was included for the other alternatives.)

Below are anticipated environmental impacts resulting from the various alternatives proposed for implementation of the bridge replacement described in the DOE:

- The proposed increase in impervious area will result in an increase in the rate and volume of runoff entering the stream in the vicinity of the bridge. This could lead to increased erosion in and around the bridge within the stream. Since the footprint of disturbance is increasing, the disturbed lands during construction will result in compaction in areas not designated as impervious. This will result in further increases in the volume and rate of runoff.
- The increase in impervious surfaces will also, during periods of higher temperatures, increase the temperature of the runoff entering the creek, which is detrimental to sensitive fish and other aquatic organisms.
- In discussion of Alternative 2, the DOE report references a change in water surface elevation for the 25-year event, however, the hydraulic modeling was not provided and no additional storm events were noted. The existing conditions plan does not indicate the water surface elevation anywhere so it is difficult to ascertain how the proposed water surface elevation was determined. The increase in water surface elevation is of concern as the geometry in the channel is changing, which can indicate changes in velocity and shear stress in the vicinity of the bridge. These changes can indicate increases in erosion and scour potential.
- The existing bridge opening (between abutments, minus piers) for the existing bridge (neglecting the temporary erosion protection) is 63 feet. The proposed bridge opening for Alternative 6 is 73 feet. The existing configuration has two piers while Alternative 6 reduces it to one pier. PennDOT is claiming that the removal of one pier reduces the scour at that pier, thus improving downstream water quality. It is true that scour at that former pier location will be reduced, but what they have failed to acknowledge is the potential increase in scour just upstream of the bridge as a result of the larger opening. The large sand/gravel bars that currently exist upstream of the bridge are likely present because of the existing bridge configuration. If the bridge opening is expanded, there is potential that the upstream sediment will mobilize until a new stable equilibrium is reached. Because of this potential to mobilize upstream sediment, the proposed bridge alignment may increase scour in the creek from existing conditions. Since no hydraulic modeling for the existing and proposed alternatives has been provided, insufficient information and justification has been provided regarding scour potential in and around the bridge. The proposed west abutment and road raises the existing road elevation approximately 2.5 feet but the full extent of that fill (including intrusions into

neighboring properties and into the floodplain) are not included. Fill in the overbank of the creek can result in changes to water depths during flood events as well as velocities. These impacts can be detrimental depending on the magnitude of the changes. This is another example of the myopic approach focused only on the impact at the bridge rather than overall impacts to the stream and watershed area. The potential impacts should be detailed to ensure compliance with the existing PennDOT antidegradation policy.

- The pasture to the west of Tinicum Creek appears to be within the FEMA 100-year flood zone A. Extension/raising of the western approach road as proposed by PennDOT may result in fill within the floodplain. Fill in floodplain areas reduces the overall available conveyance area and can impact the overall flood flow patterns in the system. These changes can increase velocities and create erosion in overbank areas in and around the fill.
- The Tinicum Creek is an EV waterway warranting level 4 Post Construction Stormwater Management (PCSM). Level 4 PCSM includes:
    - reducing post-construction runoff peak rate to pre-construction runoff peak rate for the 1-yr through 100-yr storm events,
    - reducing runoff volume for 2-yr 24-hr storm events and smaller, and water quality analyses for TSS and TP.

  The Determination of Effects Report does not address these requirements.
- The existing cross section shown in Figure 3 does not accurately portray the existing ground line in the stream and also does not include the current scour protection that is in place.
- The following assertion from the Determination of Effects Report for Alternative 6 is not demonstrated by PennDOT's analysis:

  > "The permanent condition is a benefit to the hydraulics of Tinicum Creek, as the reduction of potential scour would improve water quality by reducing the deposition of sediment in this Exceptional Value stream. This alternative would also improve the free-flowing nature of the creek through the removal of two piers and the repositioning of the western abutment outside of the stream channel."

  While the change from two piers to one pier reduces the scour potential at the location of the removed pier, the extent to which the scour changes with the proposed design was not provided. And in fact, given the anticipated shifting of the west abutment into the existing banks, there is a significant potential for increased scour in and around the west abutment.

- The close proximity of the downstream pasture and fenceline to the stream makes the proposed alignment of primary concern. Given the potential for sediment mobilization both in the form of bed and bank materials resulting from the change in bridge configuration, a comprehensive geomorphic study should be undertaken to best quantify the sediment losses and stream impacts caused by the proposed bridge realignment in Alternative 6. This is primarily due to the shifting of the west abutment.

The Determination of Effects Report notes that over time, the stream has started to shift its alignment towards the west abutment, destabilizing the upstream banks.

- In its current configuration, the western cell of the bridge (between the abutment and the pier) contains the stream thalweg (the thalweg is a line drawn to join the lowest points along the entire length of a stream bed or valley in its downward slope, defining its deepest channel.) and majority of the flow. The west abutment serves to redirect the thalweg back towards the center of the channel. This redirection keeps the thalweg in the middle of the channel and keeps the stream energy off of the banks and no erosion of the banks in this area is currently evident.
- Moving the abutment 15 feet to the west may have immediate, temporary reductions to scour of the abutment itself, however, it will result in an overall shift in the stream thalweg to the west and into the downstream bank. This will ultimately result in an increase in scour in the vicinity of the bridge and the abutment itself. Potential loss of the banks could extend for 500 feet downstream of the bridge and be as wide as 30 feet depending on the amount of trees that are compromised and lost as a result of increased pressure on the banks.
- The proposed approach lacks consideration of the antidegradation policies in effect to protect EV streams like the Tinicum Creek.
- Among the many deficiencies, the PennDOT analyses fail to give due consideration to shifts in stream alignment at this location and the potential detrimental impacts resulting from the shift that will result from the proposed Alternative 6. These changes should be assessed from a hydrologic and hydraulic analysis as well as consideration of changes to the potential Bank Erosion Hazard Index in the stream.
- The shift in stream thalweg has the potential to endanger the integrity of the existing tree line, fence, and pasture downstream of the bridge. There are alternative practices beneficial to stream health and water quality that could provide more protection to the downstream section and encourage flow to remain in the current center of the channel.
- Although from a 1-D hydraulic modeling perspective, the bridge opening itself does not have an impact on downstream scour, the realignment of the bridge opening 15 feet to the west shifts the trajectory of the flow from the middle of the channel directly into the existing bank. The bank on river right is currently a narrow stand of mature trees in very close proximity to an agricultural fence line and active pasture; shifting the flow towards that bank will very likely destabilize it, resulting in the loss of existing trees and herbaceous vegetation, the fence, and part of the private pasture. Figure 10 does not address this potential loss from erosion of private property and established vegetation. This sediment would mobilize downstream, potentially causing issues for aquatic organisms, changing flow patterns, and raising concerns about water quality.
- In response to PennDOT's statement that the bridge scour will be addressed using riprap, we offer the following:
    - Riprap installation is the standard practice in and around bridges to address scour, however, there are other alternatives that could be utilized that take into consideration the natural function of the stream and also provide scour benefits.

Use of rock and large woody debris can be employed to provide both habitat for fish species and aquatic organisms while still ensuring scour protection.

- In addition, while all streams shift their positions over time, it is unnecessary to realign the bridge opening to "catch" the moving stream. Standard natural channel design measures could be installed upstream of the bridge to direct flow into the center of the stream channel and take the pressure off of the river right bank. There are various configurations of vanes made with stones or logs that span all or part of the channel that, when appropriately designed and installed could safely redirect flows into the existing channel without compromising the current bridge configuration or the downstream property owner.

- Per PADEP's Chapter 105, Subchapter C. Culverts and Bridges, the following must be addressed for all bridges and culverts.
- Per §105.161 the following are the design criteria for determining hydraulic capacity

"(a) Bridges and culverts shall be designed and constructed in accordance with the following criteria:

(1) The structure shall pass flood flows without loss of stability.
(2) The structure may not create or constitute a hazard to life or property, or both.
(3) The structure may not materially alter the natural regimen of the stream.
(4) The structure may not so increase velocity or direct flow in a manner which results in erosion of stream beds and banks.
(5) The structure may not significantly increase water surface elevations.
(6) The structure shall be consistent with local flood plain management programs.

Alternative 6 as described elsewhere in this report has the potential to impact the stability downstream of the bridge as well as direct flow in a manner which would result in erosion of the streambank.

- *(b) In determining flood flows and frequencies for purposes of this subchapter, hydrologic analysis shall be by methods generally accepted in the engineering profession.*

  Insufficient information has been provided to determine if this condition can be complied with.
- Per §105.165 Bridge Abutments

  (a) Bridge abutments shall be set well into the banks in such manner as to assure minimal increase in flood elevations

  (b) Bridge abutments shall be aligned with the flow of the stream. The Department may require, the construction of wing walls at the upstream side of the bridge to assist in directing flood flows through the bridge opening.

  The proposed bridge abutment on river right has not been aligned with the current flow of the stream and will result in potential downstream erosion as previously discussed. Given the sensitive nature of the historic district and potential destabilization of the existing agricultural use, the incorporation of natural channel design measures should

be considered and redirection of the stream away from the banks instead of encouraging the stream to flow towards the downstream banks should be encouraged.