MEMORANDUM

To: Coopers Mills Dam Committee

From: Mike Burke, PE

Date: 1/18/16

Re: Evaluation of effect of Coopers Mills Dam on Long Pond water level

The purpose of this memorandum is to summarize analysis completed to evaluate the influence of Coopers Mills Dam (CMD) on pond levels in Long Pond, and the potential for an adverse effect on Long Pond associated with the proposed removal of CMD. The analysis included field observation and hydraulic modeling to evaluate the potential surface water and subsurface connectivity between CMD and Long Pond. The primary conclusions of the study are summarized below, followed by the details of the evaluation.

Conclusions

Based on the study detailed below it can be definitively stated that the Coopers Mills Dam exerts no hydraulic or hydrologic influence on levels observed in Long Pond. Important facts and conclusions of this report include:

- The outlet structure of Long Pond is 16.3 feet higher than the spillway height of CMD;
- The elevation of Long Pond is controlled by a relic concrete water control structure at its outlet that is no longer maintained. This concrete structure is two feet higher than the underlying geology;
- The field data, analysis and resulting graph below clearly demonstrate that river flow out of Long Pond will be identical for either existing or proposed dam removal conditions for at least 1300 feet of the stream below Long Pond, and that the surface flow in this area is solely influenced by the slope and capacity of the river channel;
- Due to the elevation difference and the surface and subsurface geology between Long Pond and CMD there is no subsurface connectivity between CMD and Long Pond;
- Inter-Fluve is available to meet with Long Pond residents and/or review the results of this work with any interested parties.

Site Characteristics

The Sheepscot River flows though the 523-acre Long Pond before descending through a bedrock-, boulder-, and cobble-lined reach of stream to reach the CMD impoundment (Figure 1). Long Pond occupies an elongated glacially-formed depression, with its outlet in a shallow alcove (referred to as 'The Basin') that is approximately 2.5 miles downstream of the deepest central portion of the pond. To reach the basin, the river travels through an approximately 1.2-mile long outlet channel that is substantially narrower than the central portion of the pond where several private residences and camps line the shore. Water depths near the outlet appear to be approximately 10 feet less than in the deeper central portion.

Outflow from Long Pond is controlled by a shallow relic concrete water control structure that is no longer maintained (Figure 2). The structure is founded on bedrock, and includes provisions for stop logs that were presumably historically installed to seasonally adjust the pond level to enhance the pond levels that historically were controlled by the geology that underlies the pond. At the time of the site visit (September 2015), there were no stop logs deployed in the water control structure. During normal conditions, all of the water exiting the pond flows over the spillway of the concrete structure which is approximately 2 feet higher in elevation than the underlying natural outlet. During short duration periods of flooding, it is possible that some flow goes around the structure but the concrete outlet structure clearly controls water levels in the pond. Any leakage beneath the structure would be controlled by the geology which underlies the structure.

The outlet structure is located 0.5 miles upstream of the spillway of CMD and 0.3 miles upstream of the upper end of the CMD impoundment. Based on a ground survey conducted by the U. S. Fish and Wildlife Service (USFWS; May 5, 2004), the spillway of the Long Pond outlet structure is 16.3 feet higher in elevation than the spillway of CMD, while the natural outlet of the pond is approximately 14.2 feet higher.

Surface Water Connectivity

To evaluate the potential for surface water connectivity, we extended an existing hydraulic model that simulates flow through the CMD impoundment, structure and vicinity to include the Long Pond outlet and the reach of stream that flows between the two water bodies. The hydraulic model had previously been developed by Kleinschmidt Associates to support the CMD Alternatives Analysis Study (Kleinschmidt Associates 2006) using the U. S. Army Corps of Engineers river modeling software HEC-RAS (USACE 2010). HEC-RAS is an industry standard one-dimensional hydraulic modeling software designed to analyze the flow of water through rivers, streams, lakes and other water bodies, and includes features for simulating flow through hydraulic structures of many configurations including dams, bridges and diversions.

We extended the model by adding 10 cross sections to represent the reach of stream from the upper end of the CMD impoundment up to and including the Long Pond outlet (Figure 3). The additional cross sections represent the bathymetry of the river and the surrounding topography, and were based on a combination of the USFWS ground survey and available high-resolution LiDAR (**Li**ght **D**etection and **R**anging) topography data that was collected in 2012 by the Maine Geological Survey.

We used the extended river model to simulate a range of river flows to assess the influence, if any, of CMD on the flow exiting Long Pond. The simulated river flows included typical (median) river flows for each calendar month, and flood flows ranging from the 2-year return period flood to the 100-year return period flood. The simulations included cases representing the existing conditions and the proposed dam removal condition.

Selected results from the model for dry (7Q10[1]), average flood (2-year return period flood), and rare flood (100-year return period flood) conditions are shown in Figure 4. In the figure, the red traces represent the surface of the water along the river for the existing conditions, the blue traces represent the surface of the water along the river for the proposed condition with the dam removed, and the dashed black lines represent the stream bed at the bottom of the river.

Under the existing condition (red traces), the influence of the dam can be seen in the level water surface that extends approximately 1150 feet upstream of the dam for the dry condition (7Q10) and 1375 feet for flood conditions (2-year and 100-year floods). The depth of flow over the dam ranges from 0.03 feet for dry conditions and 7.3 feet for the 100-year return period flood. Upstream of these respective locations, the surface of the water along the river closely parallels the average bottom of the river channel. From these results, it can be concluded that the influence of CMD on the surface flow of the river extends between 1150 and 1375 feet upstream of the dam over the range of flow that can be expected, and that the surface flow for the 1400 feet of river immediately downstream of the Long Pond outlet is solely controlled by the slope and capacity of the river channel itself.

For the proposed dam removal condition (blue traces), the surface of the water along the river closely parallels the average bottom of the river channel for the entire length of stream between CMD and the Long Pond outlet for the dry and average flood (2-year return period flood) conditions. For the rare flood (100-year return period flood) condition, the bridge downstream of the dam influences the flow in the river for approximately 500 feet upstream of the bridge (380 feet upstream of the current dam location) as indicated by the relatively flat surface of the water along this length. From this point upstream to the Long Pond outlet, the surface of the water along the river also closely parallels the average bottom of the river channel for the rare flood condition.

When comparing the river flow for the existing conditions (red traces) and proposed condition with the dam removed (blue traces), it can clearly be seen that the surface of the water along the river for both cases converges a minimum of 1300 feet downstream of the Long Pond outlet over a range in flow from dry to rare floods. Based on this, it can be concluded that river flow out of Long Pond will be identical for either existing or proposed dam removal conditions for at least 1300 of the stream

[1] The lowest stream flow for seven consecutive days that would be expected to occur once in ten years.

and that the surface flow in this area is solely influenced by the slope and capacity of the river channel. Therefore, it can likewise be concluded that removal of CMD will have no effect on the surface flow out of Long Pond, including flow velocity, depth, width or any other characteristic.

Subsurface Water Connectivity

Surface water connectivity as evaluated and described above is the primary means of potential influence of Coopers Mills dam on Long Pond. A secondary means of potential influence is through subsurface pathways, which was evaluated and is discussed below.

The surficial geology of the area between Long Pond and CMD is mapped as glacial till (silt, sand and gravel-sized rock debris with surface boulders deposited by glacial ice) and glaciomarine deposits including Presumpscot formation (primarily silts and clays deposited on the late glacial ocean floor), combined with extensive shallow bedrock exposures (Figure 5). Bedrock exposures, weathered bedrock and large glacial erratics are commonly observed along the river between the Long Pond outlet and CMD.

Predominantly silts and clays, the glaciomarine deposits have relatively low permeability. In conjunction with local bedrock exposures and the consolidated till, the subsurface geology therefore results in negligible far field subsurface water movement leading to the conditions that naturally formed and sustained Long Pond. Furthermore, since the level pool and rare flood elevations of the Coopers Mills impoundment are both substantially lower than (greater than 16 feet and 8.5 feet, respectively) and distant from (0.3 miles) the spillway at the Long Pond outlet structure, it is not possible for CMD to exert a subsurface hydraulic control on the pond. This is because the above set of factors would require the impoundment to exert an uphill subsurface hydraulic influence at substantial distance through geology that prevents far field subsurface flow, which is not physically possible. Therefore, it can be clearly concluded that the CMD exerts no subsurface hydraulic influence on pond levels in Long Pond, and that the proposed removal of CMD will not adversely affect levels in the pond via this potential pathway.

References

Kleinschmidt Associates 2006. Coopers Mills Dam Alternatives Analysis.

US Army Corps of Engineers (USACE) 2010. HEC-RAS River Analysis System, Version 4.1. User's Manual.

Weddle, T. 2010. Surficial geology of the Weeks Mills quadrangle, Maine. Maine Geological Survey, Open-File Map 10-1.

Figures

Figure 1. Aerial overview.

Figure 2. Long Pond outlet structure.

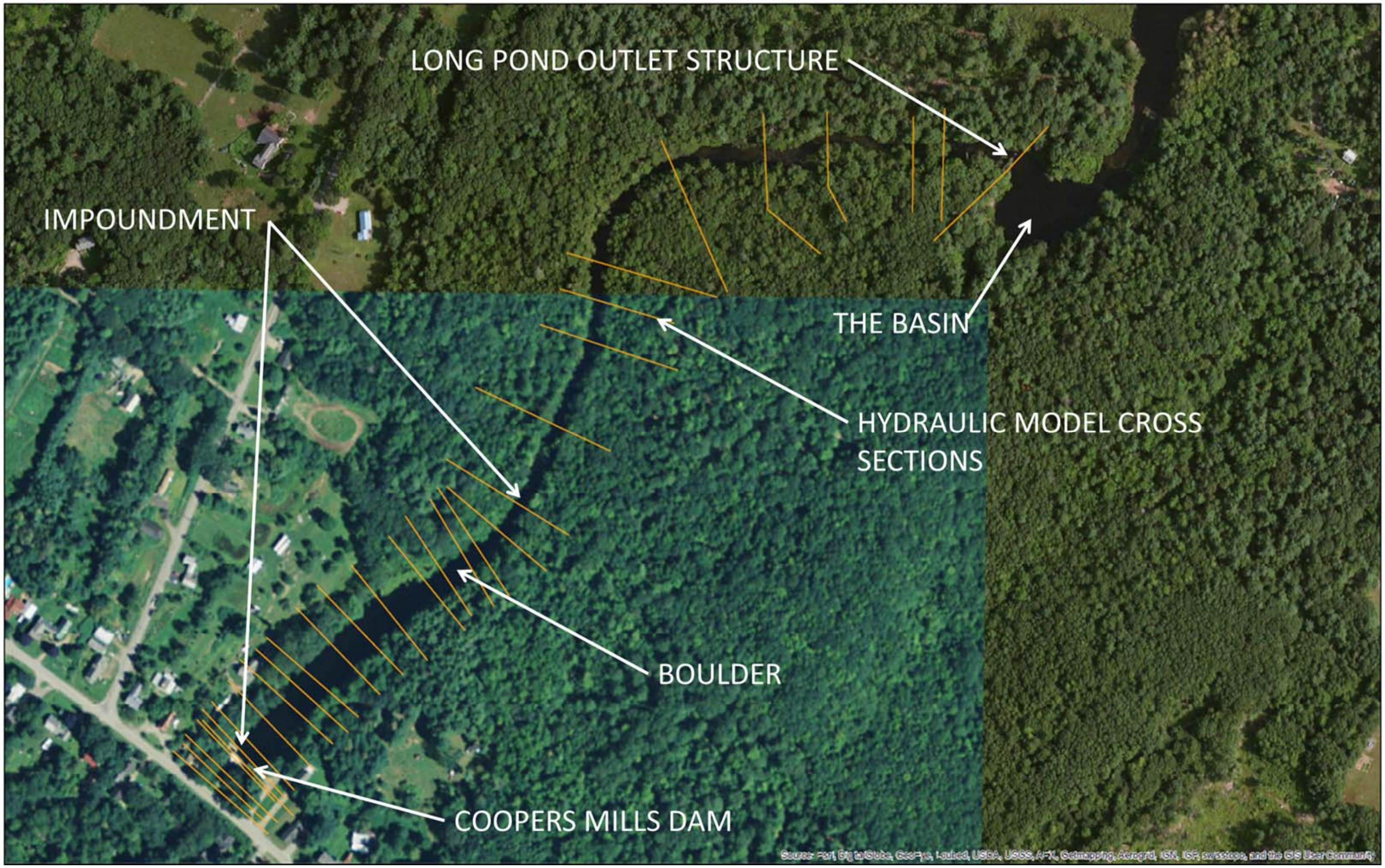

Figure 3. Overview of hydraulic model layout with key features identified. The boulder that is labeled in the figure as a reference point is a prominent large boulder located toward the upper end of the Coopers Mills Dam impoundment that is easily observed on site. The location of the boulder is also shown on Figure 4 to allow cross reference between the two figures.

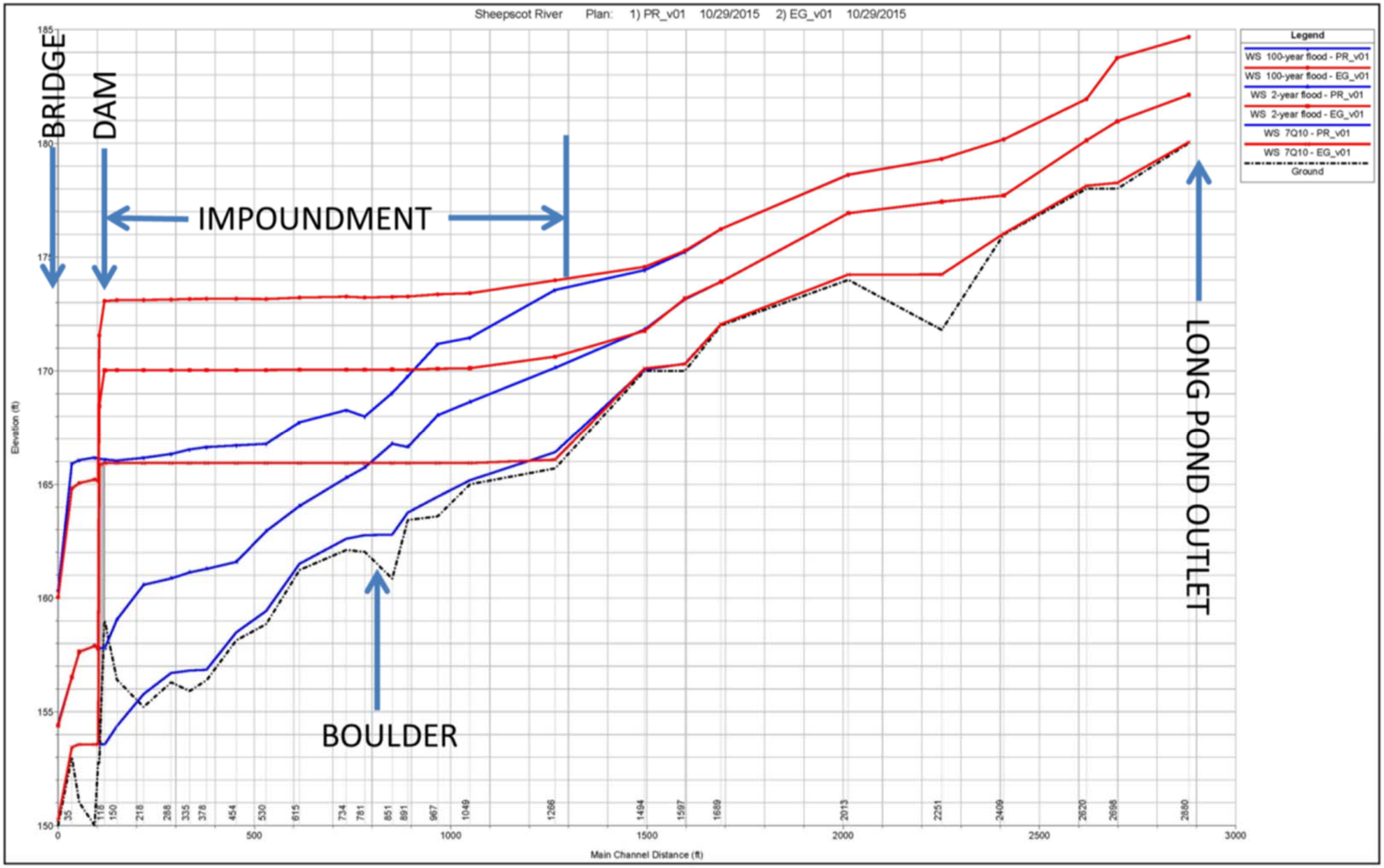

Figure 4. Plot of hydraulic model results. X-axis is distance upstream from the Main Street bridge, Y-axis is elevation. Simulated river water surface for existing conditions is represented by the red traces. Simulated water surface for proposed conditions with dam removed is represented by the blue traces. The river bed is represented by the dashed black line. The boulder that is labeled in the figure as a reference point is a prominent large boulder located toward the upper end of the Coopers Mills Dam impoundment that is easily observed on site. The location of the boulder is also shown on Figure 3 to allow cross reference between the two figures.

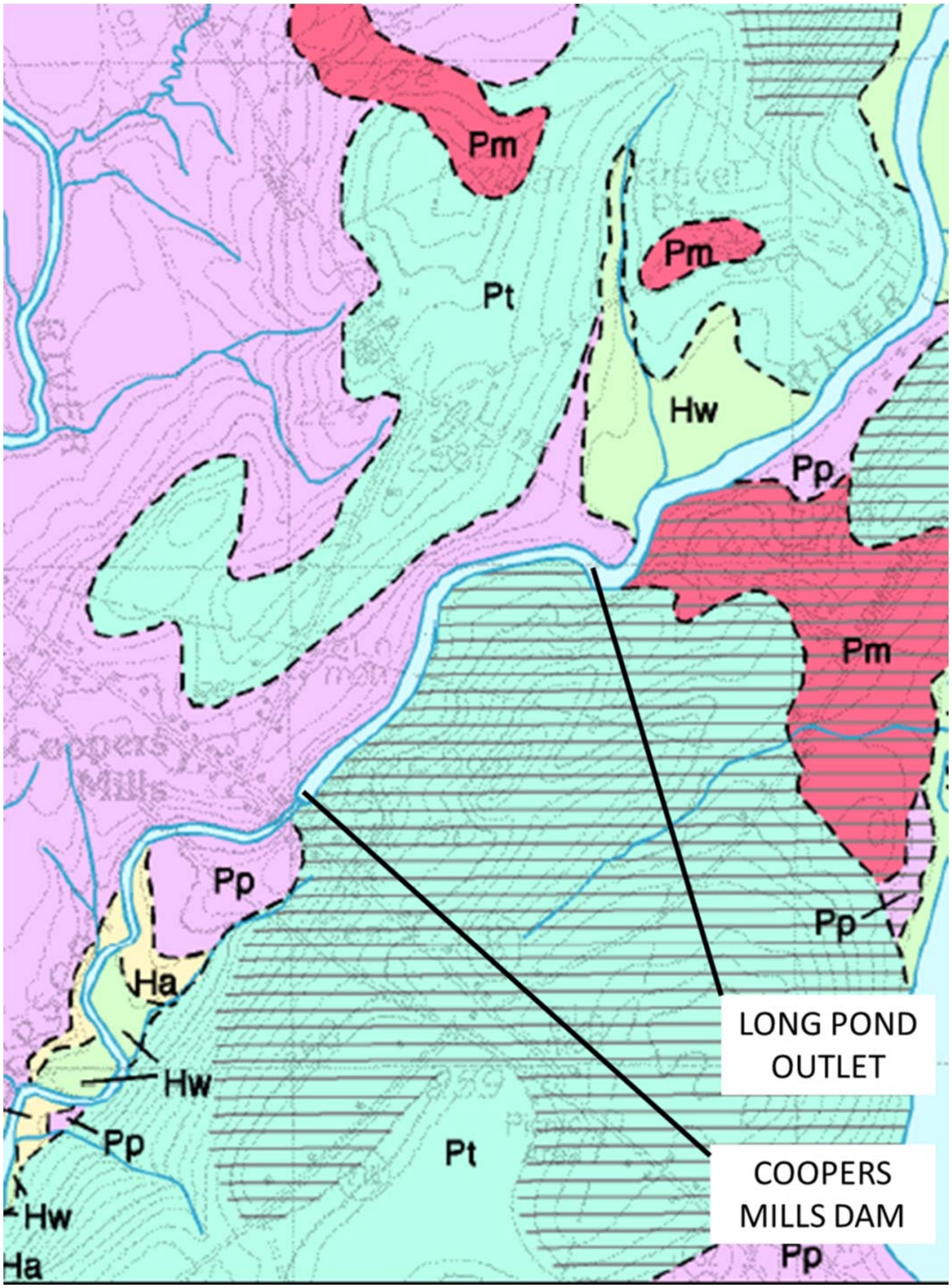

Figure 5. Excerpt from Weeks Mills surficial geology quadrangle map (Weddle 2010). Map unit Pp (pink) indicates Presumpscot formation, Pm (dark pink) indicates Pleistocene glaciomarine deposits, Pt (cyan) indicates till, and Hw (light green) indicates wetland deposits. The horizontal lines indicate areas of shallow bedrock outcrops. The light blue polygon along the river indicates water.