Suspended sediment production in a tributary to Woodman Brook

Sediment from T-Creek entering Woodman Brook (Photo by Dick Lord: 2010)

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Undergraduate Thesis

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Introduction:

High levels of suspended sediment is one of the most common problems leading to impaired water quality in rivers and streams (Berry et al., 2003). High levels of suspended sediment pose water quality problems that range from reduction of aesthetic quality to degradation of aquatic habitats. Sediment production is a natural process and contributes to turbidity in surface water systems. Turbidity is a measure of water clarity, or how much suspended sediment in water decreases the passage of sunlight (EPA, 2012). Suspended sediment particles can range from 0.0004 mm to about 1 mm and can alter the color of water. Increased turbidity has the potential to raise the temperature of water because sediment absorbs more heat than water (EPA, 2012); increased water temperatures will in turn decrease the amount of dissolved oxygen (DO) in the water. Decreased amounts of sunlight reaching the bed of a stream will decrease the amount of photosynthesis, which will also decrease DO concentrations. On top of reduced DO, suspended sediment can clog fish gills and reduce river roughness. Reduction of river roughness degrades habitat for macro invertebrates and smothers fish eggs (Berry et al., 2003). Suspended sediment concentrations greater than 0.1 g/L can have harmful ecological effects, and the potential to degrade economically important water ways (Berry et al., 2003).

Sources of suspended sediment include soil erosion, waste discharge, urban runoff, and eroding stream banks (EPA, 2012). In many situations, suspended sediment results from non-point sources, which can make remediation a difficult task. For example, agricultural practices can cause sediment erosion from large plots of land, which will be washed into a river system and increase turbidity. It can be even more difficult to identify and control sources of suspended sediment from natural processes. Main sources of sediment from natural processes include soil erosion from upland areas as a result of overland flow, head cutting and knick-point migration in low order stream systems, and remobilization of sediment through a number of processes including flood plain inundation, channel migration, and avulsion (Hupp et al., 1997).

Erosion along the banks of streams can occur from multiple processes. Advective forces from stream currents will cut banks and mobilize sediment. The particle size that a river can entrain is related to its velocity to the sixth power (Hickin, N.D.). A small increase in velocity results in the ability of a river to entrain larger sediment grains. Groundwater can also have the force necessary to erode sediment into a stream, especially at the groundwater-stream interface (Midgley et al., 2013).

Seepage occurs when water emerges from the ground into a stream. A similar, but different process, known as hyporheic flow, occurs when stream water infiltrates the bank for a period of time before re-emerging into the stream (Dingman, 2008). Hyporheic flow and seepage are different processes because of the length of time the water remains underground and therefore how chemically similar it is to current surface water. Hyporheic flow has subsurface residence times of minutes to days. Groundwater can be stored below the ground for days to years as it slowly moves down the hydraulic gradient. Groundwater can recharge streams and generate base flow conditions during dry periods. When groundwater has high head gradients following large rain or snow melt events, it has the potential to be a powerful geomorphic tool (Bierman and Montgomery, 2014).

Groundwater springs and seeps are locations where groundwater emerges at the surface of the earth under pressure from up gradient forcing. A spring is a single location where water emerges, where as a seep can occur over a larger area (Todd and Mays, 2005). There are multiple types of groundwater springs that result from a regions lithology and stratigraphy. Lithology is the mineral composition, grain size distribution, and grain shape characteristics of unconsolidated material and will affect hydraulic conductivity and resistance to groundwater flow (Dingman, 2008). Stratigraphy is the geometric characteristics and age relations among different geologic formations. The geologic make-up of an area will strongly influence the locations groundwater hydrology. Under certain geologic conditions, sediment transport during groundwater recharge can be a significant source of instream suspended sediment and cause damage to aquatic ecosystems (Midgley et al., 2013).

Site Description:

This study focused on a groundwater spring that occurs along a 1st order stream that is a tributary to Woodman Brook in Durham, New Hampshire (figure 1). For the purpose of this study, the unnamed tributary of interest will be referred to as T-Creek. T-Creek is an appropriate name because it is located on Thompson Farm and the stream intermittently becomes highly turbid. Woodman Brook is a tributary to the Lamprey River (figure 1-B). T-Creek enters Woodman Brook approximately 700 meters upstream of where Woodman Brook enters the Lamprey River. Downstream of where T-Creek enters, Woodman Brook is impounded by a culvert under Bennett Road. Water that passes through the culvert then enters the Lamprey River approximately half of a mile downstream of Packers Falls.

The groundwater spring is located approximately 80 meters upstream of where T-Creek enters Woodman Brook (figure 1-C). The location of the spring is in a small wooded 25-foot-deep valley that is surrounded by grassy fields (figure 1-C). T-Creek drains Thompson Farm pastures. Approximately 25 m upstream of the spring, T-Creek runs through a culvert under a farm dirt road. A second spring between the culvert and the study spring significantly contributes to baseflow in T-Creek. During dry conditions, no water flows through the culvert, and instead the upstream spring is the beginning of surface flow in T-Creek. No suspended sediment has been observed from this second upstream spring.

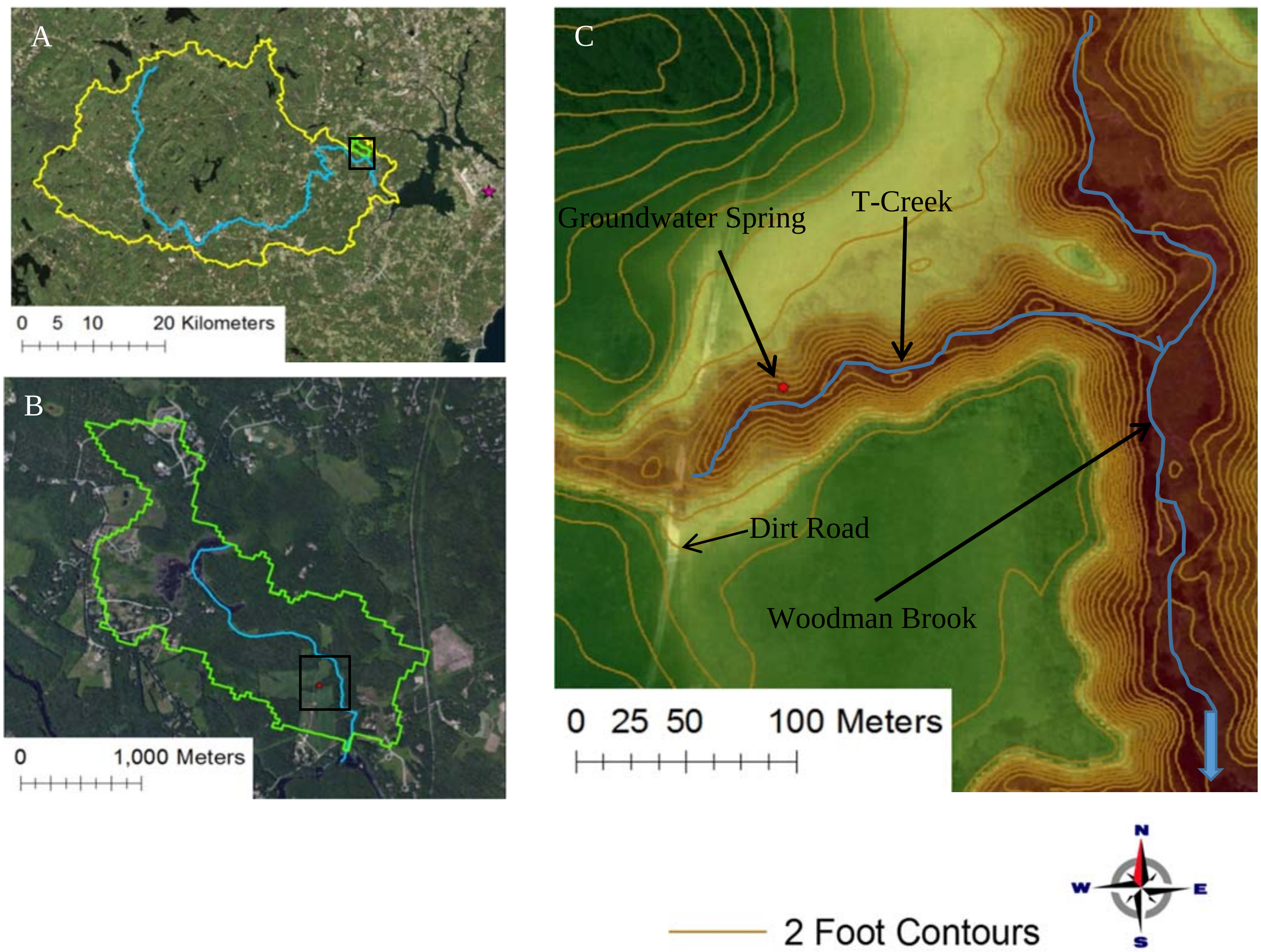


Figure 1: A) Lamprey River watershed in southeastern New Hampshire, B) Woodman Brook watershed in Durham, C) T-Creek. Black boxes in figure 1-A and 1-B represent the approximate

area of the succeeding image. The color in figure 1-C represents changes in elevation (red is low elevation and green is high elevation). Aerial imagery, hydrography, 2-foot contours, and lidar retrieved from NH Granit (http://www.granit.unh.edu/data/downloadfreedata/downloaddata.html).

There is some anthropogenic disturbance in the small valley where T-Creek sits. There is a tire wall which may be a remnant of a former obstacle course, plus concrete blocks and boulders that suggest buildings may have once been located near the valley. This area was actively used for farming in the late 1800s before being acquired by the Thompson family in 1920 (UNH COLSA). The Thompson property became a popular estate and hosted tourists and travelers in the early and mid-1900s (Dick Lord, personal communication). In 1972, the last remaining member of the family, Ina Thompson, donated Thompson Farm to the University of New Hampshire (UNH COLSA). The 205 acre Thompson Farm is now used for conservation timber harvesting, tapping maple trees, and a multitude of recreational activities. Northwest of the property, seeps and springs are known to occur.

The Problem:

Since 2008, the groundwater spring on T-Creek, during high flow in the spring time, has created high levels of suspended sediment in T-Creek (Dick Lord, personal communication). The spring flows year round, but has previously been observed to only have high suspended sediment levels from about April to June. Anecdotal observations suggest that over the past 5 years the problem has been getting worse. The years 2010 and 2014 were observed to have the largest sediment loads since the problem was noticed in 2008 (Dick Lord, personal communication). During 2010 and 2014, the suspended sediment load in T-Creek was transported to Woodman Brook and eventually flowed through the culvert into the Lamprey River (figure 2). It is uncertain how long the T-Creek groundwater spring has been producing sediment, and what processes lead to this source of suspended sediment, but there is concern over its potential to degrade downstream water quality. The New Hampshire Department of Environmental Services was informed of the suspended sediment and investigated the problem in 2010. They decided not to take any action because they concluded that the phenomenon is naturally occurring (Dick Lord, personal communication).

Figure 2: A) Groundwater spring discharging turbid water into T-Creek (2015). The white pipes are 2” PVC bore holes. B) Suspended sediment from T-Creek entering Woodman Brook (Dick Lord 2010). C) Suspended sediment from Woodman Brook entering the Lamprey River (Dick Lord 2010).

This study attempted to determine the source of the groundwater and sediment produced by the T-Creek groundwater spring by monitoring groundwater levels near the spring, and examining sediment samples from the site. The main objective of this project was to examine relationships between groundwater characteristics, geology, and suspended sediment discharge from the spring during fall 2014 and spring 2015.

Methods:

Geological Assessment: To characterize the local surficial geology and obtain bore holes for groundwater monitoring, suction coring was used to obtain in-situ sediment samples from varying depths on the bank uphill of the spring (figure 3). Suction coring was performed using two different methods. For the first method, a handheld post driver was used to hammer 2 inch PVC pipe into the ground (figure 3-A). The pipe was then sealed with a rubber stopper and manually removed, and the sediment sample was manually extruded from the pipe. For the second method, an Arts Machine Shop Inc. (AMS) sludge sampler, which is a metal cylinder with an internal plexiglass sleeve, was pounded into the ground using an attachable hammer (figure 3-B). The hammer was then replaced with a T-handle, which was used to pull the cylinder out. The cylinder had a rubber gasket on the top that created a seal when removing the device. Once the cylinder was removed from the ground, the internal sleeve was removed to obtain the sediment sample. It was challenging to remove undisturbed sediment samples using both methods. Suction coring was performed at multiple locations on the bank adjacent to the T-Creek groundwater spring on numerous occasions between 9/17/2014 and 4/9/2015.

Suspended sediment samples were obtained following evaporation of water samples collected from water exiting the groundwater spring on 6/14/2014 and 6/2/2015. For the second sample, the dried sediment mass was divided by the volume of water collected to estimate the suspended sediment concentration.

Stratigraphic observations were obtained from core samples. In addition, smear slides were created from suspended sediment exiting the groundwater spring on 6/14/14 and bank sediment from a sediment sample extracted on 9/9/14 from a bore hole near the groundwater spring. The smear slide of suspended sediment was a water sample collected by Anne Lightbody in May of 2014. The water sample was dried over time by evaporation. Smear slides were also made from sediment samples extracted on 9/9/2015 from a bore hole near the groundwater spring at a depth of 18 inches (figure 4-A).

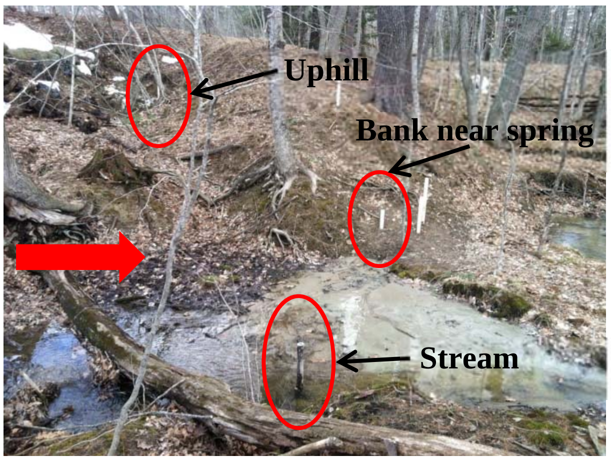
A) B)

Figure 3: Taking core samples using A) post driver and 2 inch PVC and B) AMS sludge sampler

Water Table Elevations: Two bore holes were made deep enough to extend below the water table. PVC well casings were inserted into the bore holes; these casings were capped on the bottom, were vented above the ground surface, and were screened across the water table. One bore hole was located near the spring on the bank. A second bore hole was located uphill of the spring at a horizontal distance of about 40 feet (figure 4-A); no clay was found excavating this hole. In addition, a third well casing was installed in T-Creek just upstream of the groundwater spring discharge (figure 4-B); this casing was screened below the water surface and vented above the water level. Pressure transducers (Solinst Levellogger Junior 3001) that record total pressure were installed into each PVC casing. Atmospheric pressure, from Pease Air force Base (National Oceanic and Atmospheric Administration National Climactic Data Center. NOAA NCDC), was subtracted from total pressure to obtain the height of water above each logger. Water table and stream levels were recorded for periods between 3/24/2015 to 6/17/2015. To compare observations at different locations, a horizontal datum was created at the level of the stream bed (figure 5). The tops of well casings were surveyed using an optical auto level (Sokkia C4), and a datum was created by using surveying measurements of top of casing and the length of string for each pressure transducer. The horizontal datum allows for water elevations to be presented relative to a common horizontal surface.

Meteorological data (precipitation and air temperature) were obtained from a station on Thompson Farm through NOAA NCDC (http://www.ncdc.noaa.gov/data-access/land-based-station-data). The data were recorded hourly at a location approximately 100 meters from the groundwater spring location. Snow depth data were acquired from Tristan Amaral, who collected daily snow depth measurements at Thompson Farm in close proximity to the NCDC station. The measurements were consistently taken as a height above ground.

A)



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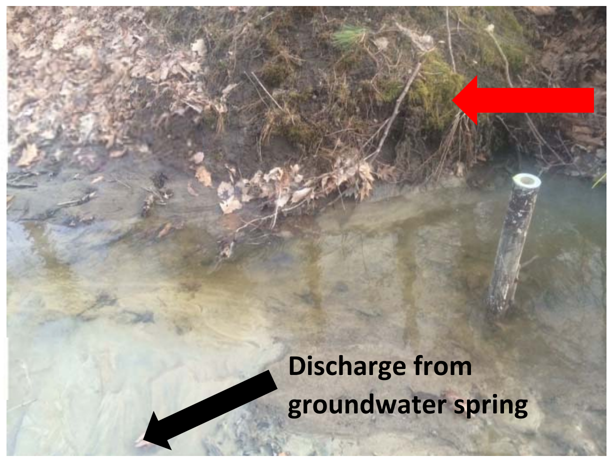

Figure 4: A) Photograph showing the three well casings containing pressure transducers. B) Photograph showing pressure transducer in T-Creek. Red arrows represent stream flow direction.

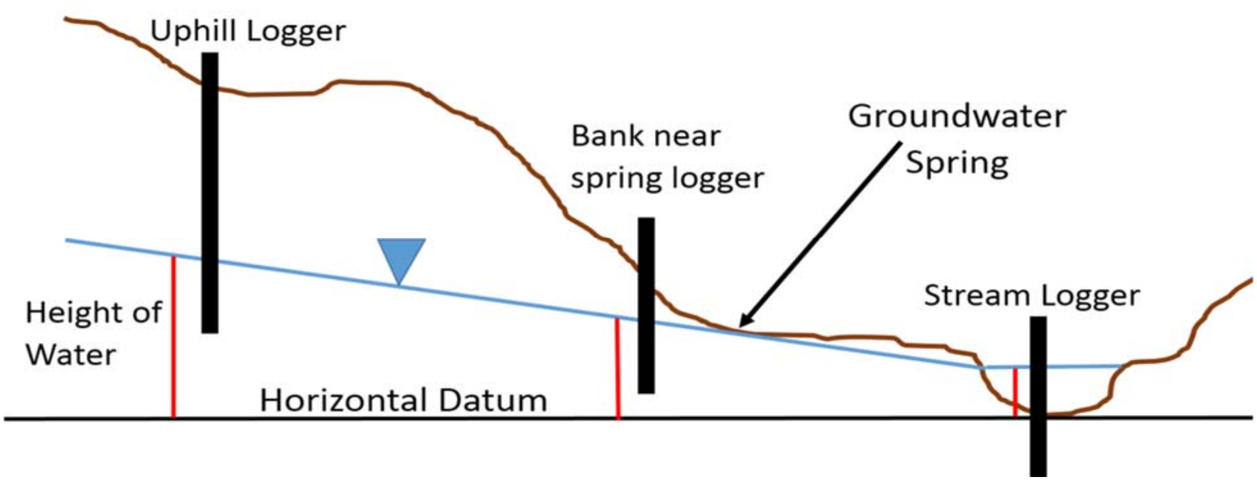

Figure 5: Diagram showing cross-section through bank with logging pressure transducer casings (not to scale).

Stream Chemistry:

The pressure transducers also recorded water temperature. In addition, a HydroLab DS 5 logging sonde was deployed in T-Creek downstream of the spring to record turbidity and conductivity (figure 6). T-Creek was about 10 inches deep where the instrument was deployed and the probes were between 2 and 8 inches above the stream bed. The HydroLab was deployed between 4/9/2015 and 5/21/2015, although the optical turbidity sensor rapidly fouled and only provided data immediately following cleaning. Visual observations of turbidity were obtained from photographs taken during site visits. Photographed turbidity levels were rated as high, medium, or low, then given a numeric value by comparison with simultaneous turbidity measurements recorded by the HydroLab on 4/14/2015. On 4/9/2015, conductivity was also measured using a hand-held Corning CD-55 throughout the stream reach and in groundwater springs. A simple macroinvertebrate sample was also taken on 3/24/2015. The focus of the survey was looking at differences between macroinvertebrate populations upstream and downstream of the groundwater spring that produces sediment. Multiple hand samples of both sediment and large debris were examined upstream and downstream of the spring. Discharge estimations were taken on 4/18/2015. Locations with discharge estimations were in T-Creek near the groundwater spring, in T-Creek just before entering Woodman Brook, and in Woodman Brook before T-Creek enters. Discharge was estimated using the velocity area method. The contribution of streamflow in Woodman Brook from T-Creek was estimated using the discharge estimates, and the contribution to streamflow in T-Creek from the groundwater spring was estimated using dilution gauging from conductivity measurements.

Figure 6: Hydrolab DS-5 in T-Creek. Instrument had protective housing when un-supervised (not shown).

Results:

Suspended sediment production from the T-Creek groundwater spring was relatively low in 2015. Even so, high levels of turbidity, which turned T-Creek opaque milky white and which reached Woodman Brook, were observed on 4/2, 4/7, and 6/2. During 2015, unlike in 2010 and 2014, the sediment quantity was insufficient to elevate turbidity once mixed across Woodman

Brook, and no turbidity was observed downstream entering the Lamprey. On 4/16, during relatively low suspended sediment production, the Hydrolab in T-Creek downstream of the groundwater seep recorded a turbidity of 80 NTU. On 6/2, during relatively high (though not peak) turbidity production, there was approximately 55 g/L of suspended sediment in the water exiting the spring, which is well above a level that can cause ecological impairment to fish and aquatic insects (Berry et al. 2003).

Observations from 3/24/2015, when levels of suspended sediment from the spring were relatively low, showed that there were benthic macro-invertebrates present in T-Creek upstream of the location of the groundwater spring, but not below the spring. Species found in T-Creek above the groundwater spring were scuds and caddisflies, which are considered moderately tolerant to pollution. The stream bed above the spring is coarser and has exposed small rocks, which may provide a better habitat for benthic macro-invertebrates. Downstream of the spring, the stream bed is silted in with fine sediment likely contributed from the groundwater spring. The lack of macro-invertebrates downstream suggests that the groundwater spring may be degrading the quality of stream habitat, even when it is not actively contributing turbidity to the stream.

Temperatures in T-Creek were similar to groundwater temperatures during baseflow in mid-March 2015 (figure 7), but decreased as snow melted in late March (figure 9). Groundwater temperature next to the spring increased relatively smoothly from mid-March through mid-April, unlike the water temperature in T-Creek, which exhibited both seasonal and daily fluctuations that more closely resembled air temperatures (figure 7). The large difference between groundwater and stream water temperature suggests that the water flowing from the spring is groundwater as opposed to hyporheic flow.

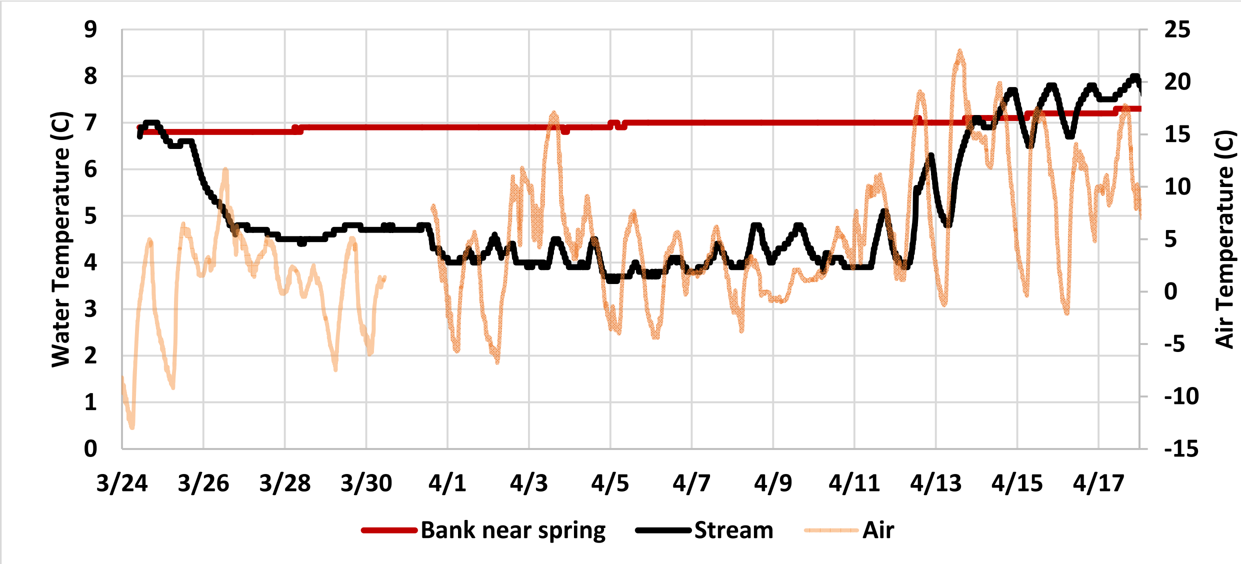

Figure 7: Air temperature, water temperature in T-Creek, and groundwater temperature in the bank near the spring.

The conductivity of water discharged from both groundwater springs was higher than conductivity in T-Creek, and increased the streams conductivity (figure 8), again suggesting that the water from the springs was from a different source than stream water. Stream conductivity increased downstream of these conductivity sources, indicating that the springs contributed a substantial fraction of water in the creek (figure 8).

Conductivity measurements recorded by the HydroLab decreased following rain events (figure 9-A), consistent with surface water from precipitation events diluting the conductivity in T-Creek. Conversely, conductivity increased during base flow, which was consistent with increased groundwater contribution to stream flow.

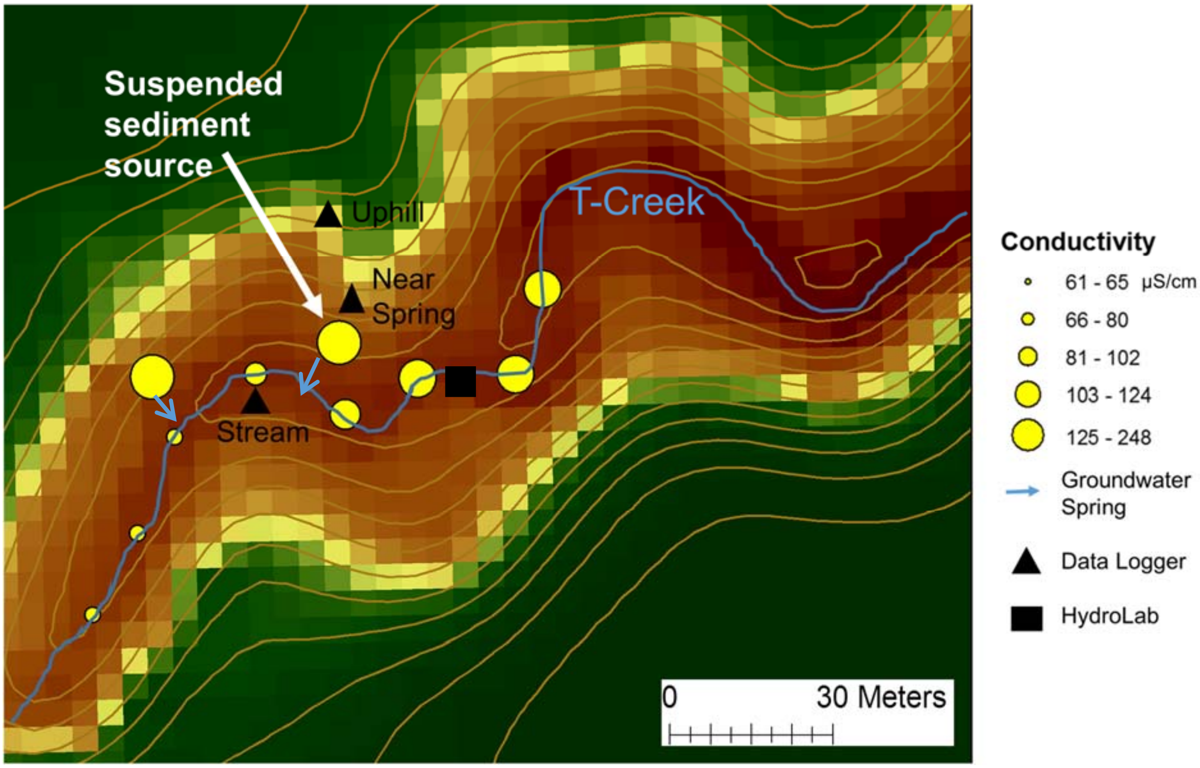

Figure 8: Conductivity measurements along T-Creek on 4/9/2015. Locations of pressure transducers (data loggers) and the HydroLab are also shown.

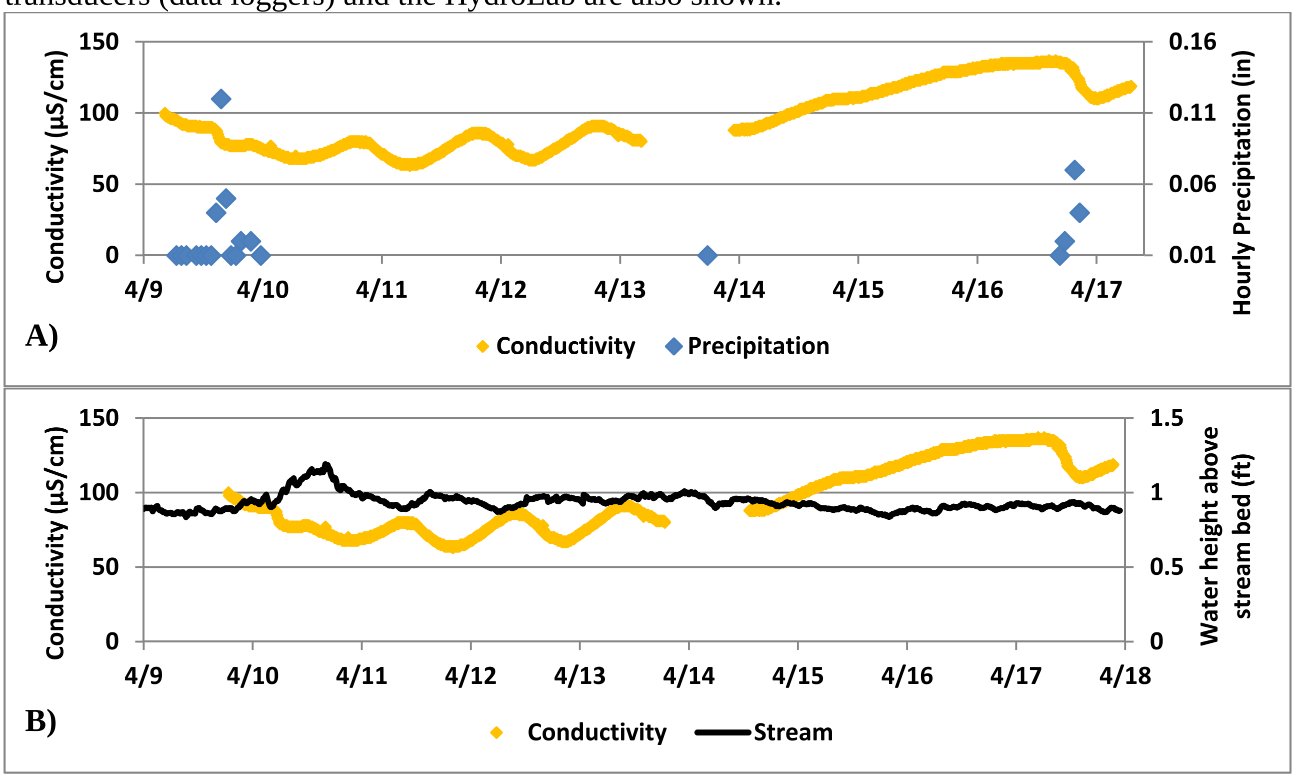

Figure 9: Conductivity recorded by the HydroLab and A) hourly precipitation, B) water height in T-Creek. Missing hourly precipitation data indicate no rain fell during that hour.

Dilution gauging shows that the groundwater spring contributed roughly 18 percent of streamflow to T-Creek on 4/9/2015 and 1 percent on 4/18/2015. Also, the contribution from T-Creek to Woodman Brook was estimated was 9 percent on 4/18/2015.

Location:	**Discharge (cubic feet per second):**
T-Creek: below groundwater spring	2.0
T-Creek: just before entering Woodman Brook	2.7
Woodman Brook: above T-Creek confluence	9.1

Table 1: Discharge estimations from 4/18/2015

Comparisons between water table elevations in the different well casings offered incite to hydrologic responses during spring of 2015. Water table elevation and stream stage both increased following snow melt and precipitation events (figures 10-12). Following snow melt on 3/31 and 4/2, groundwater levels in the bank near the spring and stream water level both increased within 1-2 days. Following a wintry-mix precipitation event on 4/8-4/9, the level of groundwater in the bank near the spring did not increase as much as T-Creek did. A few times between 3/24 and 4/15 the water level in T-Creek was equal to or greater than the water level in the bank near the spring (figure 10). Because the groundwater and stream temperatures remained distinct (figure 7), it is likely that the spring stopped flowing but did not reverse during these times. The rain events on 4/22 and 5/31-6/1 resulted in a large response in the groundwater elevation uphill of the spring as well as the stream; during both, there was a much smaller response in the bank near the spring (figure 11). In general, there was more variability in groundwater elevations uphill of the spring compared to in the bank near the spring (figure 12), suggesting that the spring may be hydrologically disconnected from the local surficial aquifer. Increased water table elevation uphill of the spring, from precipitation events, resulted in an increased hydraulic gradient towards the stream. The hydraulic gradient between the uphill bore hole to the stream varied between 1.5 and 3.2 ft/ft, and the hydraulic gradient between the near-bank bore hole and the stream varied between 0.75 and 1.5 ft/ft.

The first observation of suspended sediment discharge in 2015 was on 3/23, when there was still over a foot of snow on the ground. The highest levels of turbidity were observed during early April and early June. High turbidity was observed on 4/2 and 4/7 approximately 1 day after large amounts of snow melt (figure 13). The high levels of suspended sediment on 4/2 and 4/7 both correspond to elevated stream level and elevated water table measurements in the bank near the spring (figure 10). Another period of high turbidity was observed on 6/2, following a high intensity rain event on 5/31 to 6/1 (figure 11). The water table elevation in the bank near the spring only gradually increased during the suspended sediment event on 6/2, while the water level uphill of the spring and in the stream increased suddenly (figure 11). This is a different result than the events on 3/31 and 4/4, suggesting that groundwater responds differently to snow melt than to summer rain events.

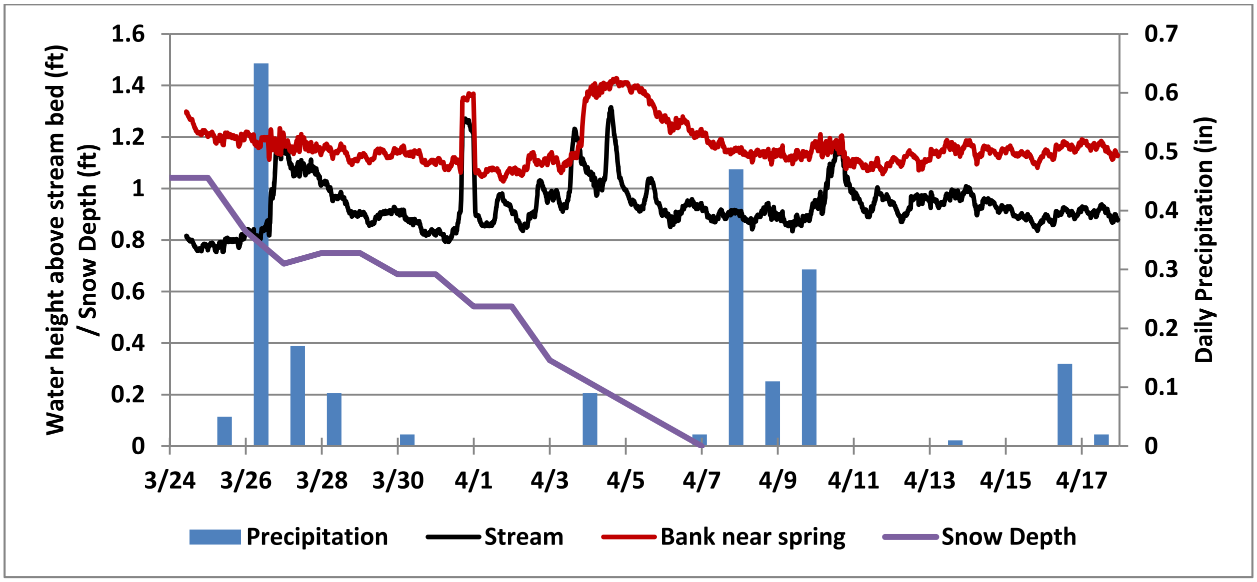

Figure 10: Time series of water elevation, precipitation, and snow depth.

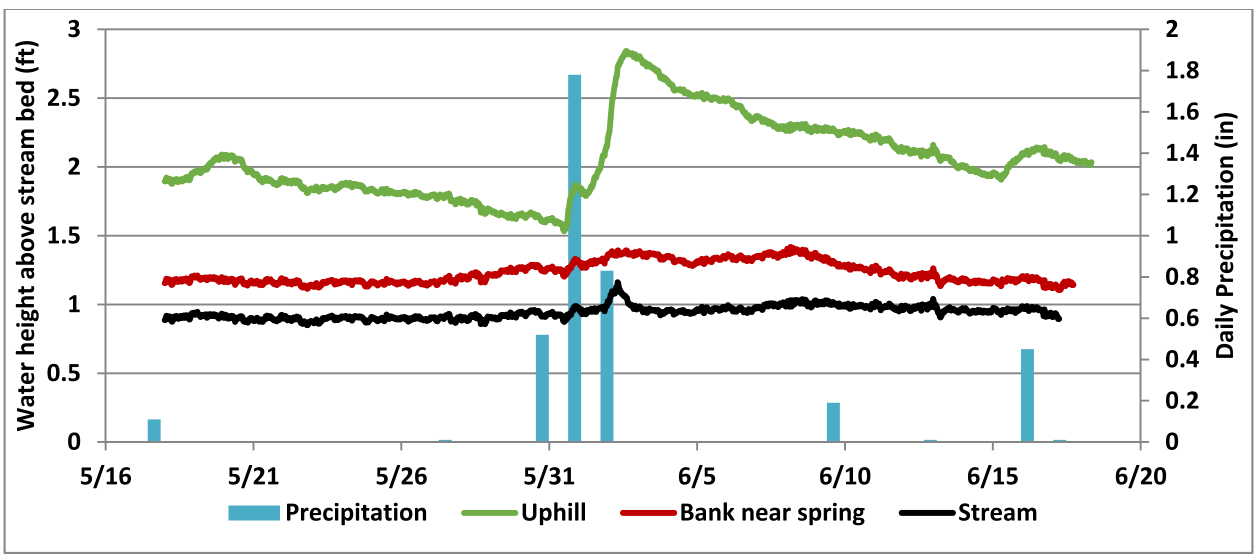

Figure 11: Time series of water elevation and precipitation.

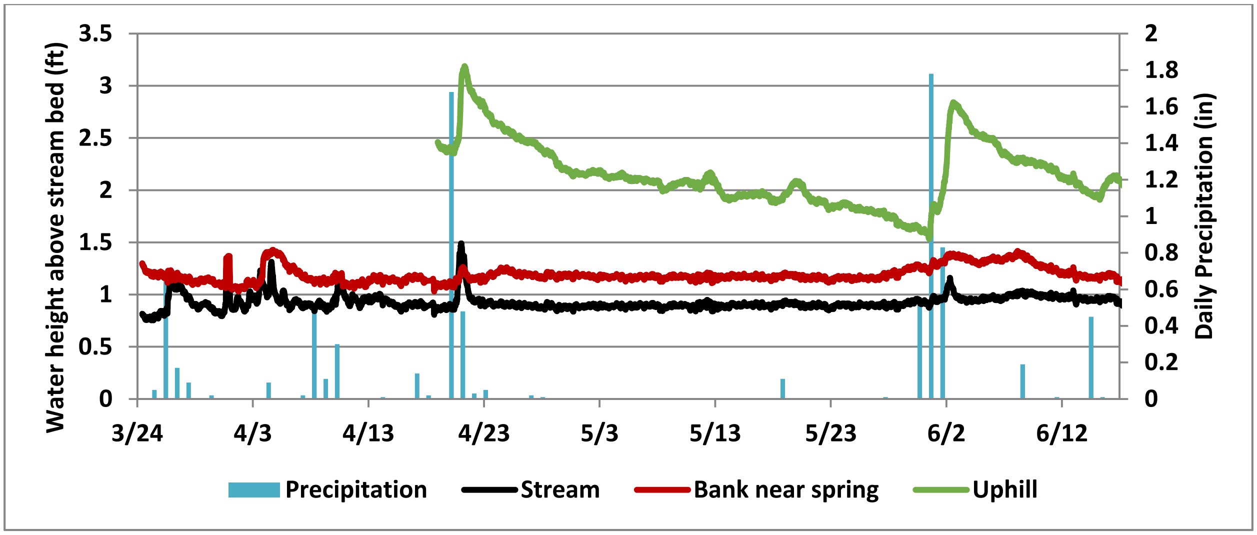

Figure 12: Full record of water table elevations and precipitation.

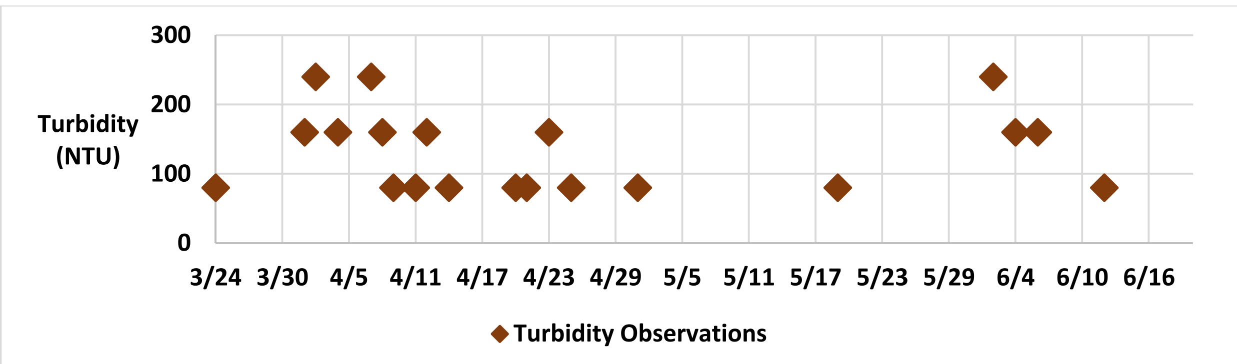

Figure 13: Turbidity flowing from the T-Creek groundwater spring as determined from visual observations. NTU values are obtained based on comparison to HydroLab measurements on 4/14. Missing data indicate no site visit on that day.

The stratigraphy of the bank near the spring consisted of two visually different materials. There was a whitish grey silt/clay material that was encountered in multiple bore holes at approximately the elevation of the stream bed. Above the silt/clay was dry tightly packed brown sandy clay. The same materials were encountered in the bank uphill of the spring, but the silt/clay was encountered at an approximate depth of 1 foot above the stream bed.

Bank near spring bore hole:	Material:	Uphill of spring bore hole:	Material:
0-7 inches	Tightly packed brown sandy clay	0-8 inches	Loosely packed brown sandy clay
7-14 inches	Hollow cavern	8-42 inches	Tightly packed brown sandy clay
14-30 inches	Whitish grey silty clay	42-56 inches	Whitish grey silty clay

Table 2: Description of material from two bore holes near groundwater. Depths are relative to ground surface.

When taking a core sample in the bank near the groundwater spring during September 2014, a hollow cavern was found below the ground surface. The cavern started at a depth of 7 inches and was 7 inches in height extending down to 14 inches below the ground level, which was the approximate location of the water table. The cavern was located at the interface between the brown sandy clay above and the whitish grey silt/clay below, and its horizontal extent is unknown. Immediately following the disturbance of core acquisition, the spring began to discharge suspended sediment.

Suspended sediment from water exiting the groundwater spring was, on average, larger grained than samples taken from bore holes near the spring. Smear slides were made from three sediment samples, but only two were adequate for examination under a microscope in plane and cross-polarized light (figure 14). Iron coated a majority of mineral grains within the smear slides, hindering identification. Minerals that were identified included feldspars, quartz, biotite, and amphibole. These types of minerals were found in both bank material and samples of suspended sediment discharged by the spring. The source of the sediment that is mobilized and discharged by the spring could not be definitively identified.

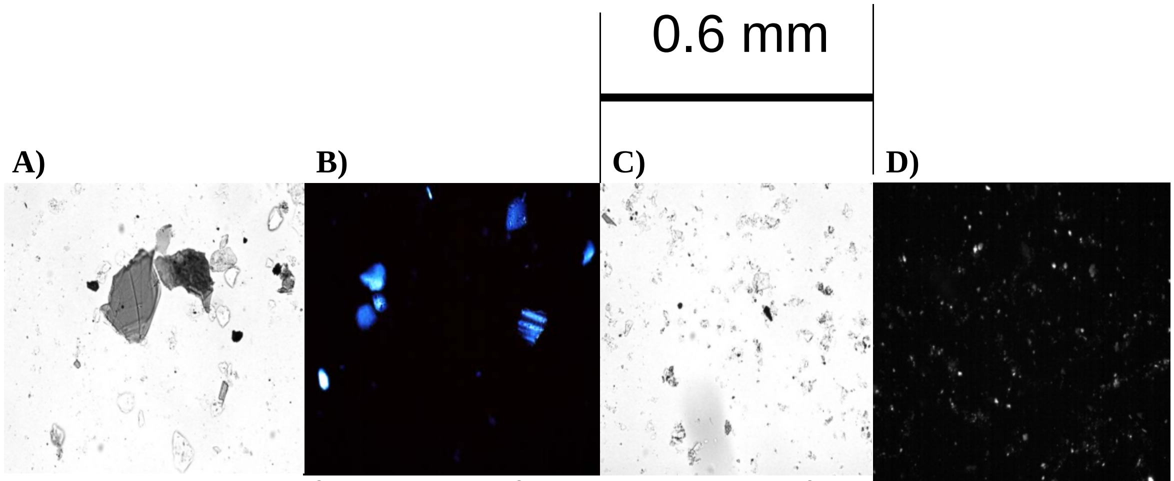

Figure 14: Photomicrograph of smear slides of evaporated sediment from spring in A) plane-polarized light and B) cross-polarized light, and sediment from bank near spring at a depth of 1.5 feet in C) plane-polarized light and D) cross-polarized light. Scale bar for all images is 0.6 mm.

Discussion:

The goal of this project was to determine the source of water and suspended sediment discharged from the groundwater spring on T-Creek. Multiple difficulties were encountered. Suction coring using both the post driver and the AMS sludge sampler was troublesome and more time consuming than expected. The layer of wet clay that was encountered in the valley was difficult to remove below the surface. When using the PVC pipe, it was hard to get a seal on the top of the pipe. If a seal was obtained, the pipe would frequently get stuck in the ground and could not be removed, necessitating painstaking removal of sediment in small segments. Recovered sediment samples were compacted, which resulted in samples that may not have represented the true stratigraphy of the bore hole.

Problems were also encountered when deploying the HydroLab. Calibrating the instrument for turbidity proved to be troublesome. In addition, there were multiple occurrences when the instrument recorded zero values or quickly varying high numbers suggesting fouling of the optical sensors when deployed in situ. Ultimately, most turbidity results were derived from visual observations.

Despite the methodological problems that were encountered, more was learned about the processes that result in sediment production from the groundwater spring on T-Creek. During 2015, sediment production was found to be highly episodic, with high turbidity levels observed only a few times, all immediately after snowmelt or precipitation events. High suspended sediment concentrations were observed following increases in the near-bank and uphill water table, and during periods of relatively high head gradient directed from the bank into the stream.

In the past, the majority of suspended sediment production has occurred in May (Dick Lord, personal communication). During 2015, very little precipitation fell during the month of May, resulting in record-setting low flows in the Lamprey River at United States Geological Survey gage 01073500 at Packers Falls and a very low water table (figure 12). Perhaps as a result, very little suspended sediment was produced by the spring during May 2015. In 2010 and 2014, there was more rain in the month of May then in 2015 (figure 15), and higher levels of suspended sediment were also observed. Water input from snowmelt or precipitation may be necessary to mobilize suspended sediment from the groundwater spring.

The groundwater spring was found to be at the interface between a larger-grain-sized, more permeable brown sandy clay and a smaller-grain-sized, less permeable whitish silty clay. Groundwater springs often emerge from the ground where a less permeable layer comes in contact with the ground surface and are called contact springs (Todd and Mays, 2005).

There are two generalized mechanisms that might be responsible for the groundwater spring and sediment mobilization. One possibility is that water infiltrates the ground uphill from the spring and travels vertically underground down to the shallow impermeable clay layer, then travels horizontally on top of this surface. Observations during spring 2015 are less consistent with this mechanism. First, the source of the spring would be a surficial aquifer, which would be expected to dry out during drought conditions. However, the spring was observed to continue flowing at approximately the same discharge throughout a period of hydrologic drought in May 2015. Second, the uphill and near-bank measurement locations would be in the same aquifer, and the water table would be expected to rise and fall similarly at both. However, the water table records at these two locations were poorly correlated, with the near-bank location not responding very much to precipitation events. Third, the source layer of sediment would have to be located above the clay, yet the layer of sediment found above the clay had a different composition than the sediment mobilized from the spring.

Another possibility is that the source of the spring is a confined aquifer below the clay layer. Water could have been forced under pressure through the clay layer along a zone of weakness, such as the pathway of a decayed root, resulting in a groundwater spring. Water exiting the groundwater spring could then have carved a cavern just above the clay layer. Observations are more consistent with this mechanism. First, a confined aquifer could continue flowing even during periods of surface drought, and the spring continued to flow at approximately the same discharge during May 2015. Second, the hydraulic head and temperature in a deeper aquifer would both be relatively steady, which is consistent with observations from the near-bank measurement location. Third, the source of mobilized sediment would likely be within or under the clay layer, which would explain why the sediment observed exiting the spring was observed to be different than the bank material Finally, other artesian springs are located higher in the T-Creek watershed (Julian Smith, personal communication), as well as several miles to the south between the Piscassic and Lamprey Rivers in Epping (Birch 1989).

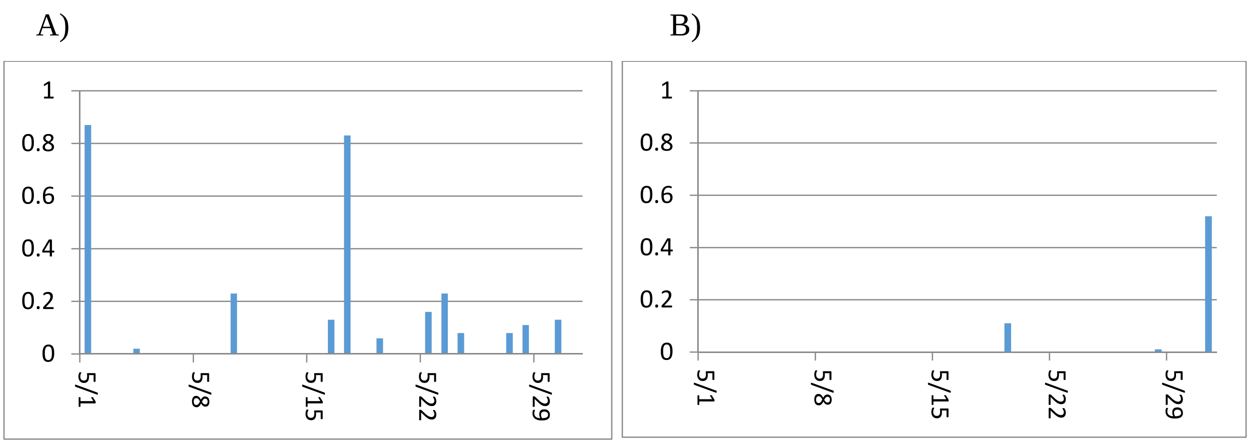

Figure 15: Daily precipitation (inches) for the month of May in A) 2014, and B) 2015

Even though suspended sediment from the T-Creek spring did not reach the Lamprey River this year, the problem should still be monitored into the future. Surface turbidity should be monitored, particularly following large rain events, to gain a better understanding of the influence of snow melt and precipitation on sediment production from the T-Creek spring. Comparison between the dry 2015 spring and a wet future spring could shed light on the mechanisms that control sediment production. Consistent observation each year could help determine whether the problem is getting worse over time. Because suspended sediment transport is episodic, future monitoring campaigns should include frequent springtime measurements in order to determine the total amount of sediment transported, the duration of turbidity loading, peak sediment concentrations, and the impact on in-stream fauna.

The acquisition of a deep core sample would aid in characterizing the structure of the local aquifer. The technique used here to obtain core samples only allowed for cores at depths up to 4 feet, yet it is possible that sediment is being mobilized from deeper elevations. A deep bore hole would allow the characterization of a greater fraction of the local stratigraphy, which may reveal the source of the sediment produced by the spring, as well as enable comparison with regional deposits of glacial-marine sediments (Birch 1989). In addition, a deep bore hole would allow observation of hydraulic head within a hypothesized local confined aquifer, which may be hydrologically connected to the water emerging from the spring.

This research project increased our understanding of the hydrogeologic processes behind suspended sediment production by the T-Creek groundwater spring. However, more work is necessary to fully understand the mechanisms that mobilize water and sediment from the spring and therefore possible avenues of control or abatement.

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