Inter-Fluve, Inc.
Technical Memorandum

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DATE:	March 16, 2012
REGARDING:	Tasks 2 and 7: Suncook River Existing Data Collection and Fluvial Geomorphic Analysis

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Introduction

The avulsion that occurred on the Suncook River in 2006 caused incision and bank erosion as well as downstream deposition. As the Suncook River continues to adjust to the new planform, infrastructure in two locations has been identified by the NH Department of Environmental Services (NH DES) as being at risk of damage or failure: the Rt 4 bridge over the Suncook River and the Black Hall Rd crossing over Leighton Brook, both in Epsom, NH. Inter-Fluve was contracted to design and permit measures to stabilize the Suncook River and Leighton Brook in an effort to protect these two road crossings.

Fluvial geomorphology is the foundational study driving the Suncook River design project. Inter-Fluve geomorphologists completed a geomorphic assessment of the study area, topographic surveys, grain-size distributions of the channel bed and sub-armor layer, hydrologic and hydraulic analyses, meander limit analysis, and analyzed existing studies and relevant data. This technical memo summarizes the collected existing data in the context of this project, provides a citation list of the existing data, and describes the methods and results of the various geomorphic analyses completed.

Geologic Setting

Bedrock Geology

Though large portions of New Hampshire are made up of Devonian granitic bedrock, the Suncook River in our study area flows through the lower part of the Rangeley Formation: gray, thinly laminated Lower Silurian meta-argillite rock (Srl - code on the map in Figure 1) (Bennett et al., 2006). East of Black Hall Rd in the headwaters of Leighton Brook, the bedrock is part of the undivided Littleton Formation, composed of Lower Devonian metasedimentary rock including gray metapelite, metawacke, and subordinate metavolcanics (Dl). South of this lies the upper part of the Rangeley Formation, a rusty-weathering Lower Silurian pelitic schist (Sru). More than 2 miles to the west, the bedrock is primarily Late Devonian Concord Granite (Dc1m), which is also found further south and scattered throughout areas to the north.

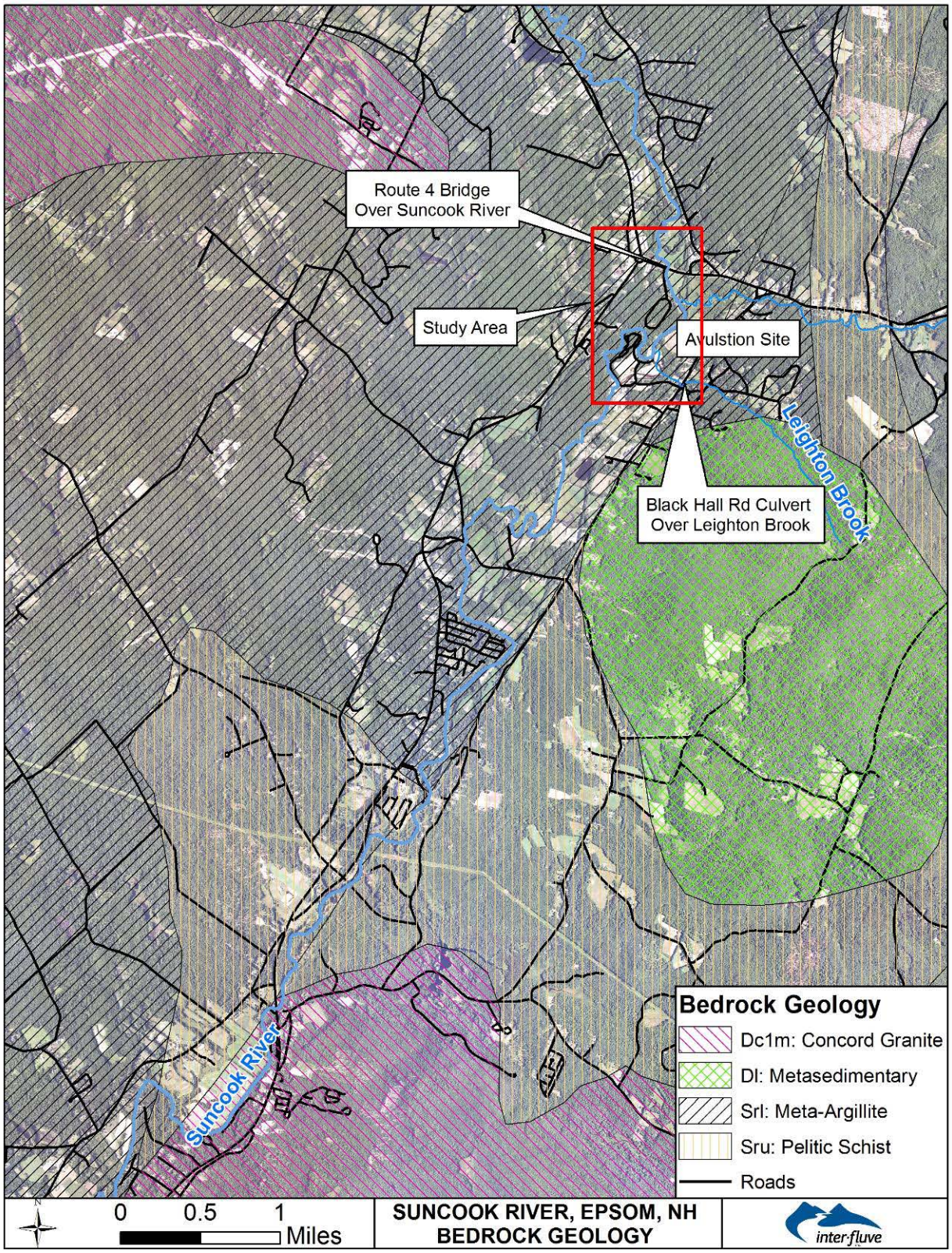


Figure 1: Bedrock geology around the study area.

Within the study area, this bedrock is generally far below the ground surface. Borings completed during bridge construction for Rt 4 over the overflow channel of the Suncook River showed bedrock 55-80 ft below the ground surface (VHB, 1996). Recent soil borings on either side of the Suncook River downstream of the Rt 4 bridge in the vicinity of proposed grade control structures revealed bedrock at 35-40 ft below the surface (Appendix A). Exposed bedrock was found on Bear Island, southwest of the avulsion site, and along the primary and secondary Suncook River channels that were abandoned following the avulsion (Figure 2).

Figure 2: Exposed bedrock in the abandoned side channel of the Suncook River downstream from Huckins Mills Dam. (Photo: Inter-Fluve)

Glacial History/Surficial Geology/Soils

All of New Hampshire was covered in continental glacial ice during the Pleistocene epoch, and evidence of the latest glaciation (Wisconsin glaciation) from 18,000-20,000 years ago is apparent throughout the state (Van Diver, 1987). Much of the region around the Suncook River is dominated by glacial till, while the Suncook River valley itself is dominated by glacial lake and river sediments as well as modern alluvium (Figure 3). Glacial Lake Merrimack or Lake Hooksett sediments were observed in a few locations where the Suncook River had eroded down several feet following the avulsion (Figure 4). These lake deposits consist of layers of very fine-grained silts and clays. Above this glacial lake material, the relatively flat valley bottom adjacent

to the Suncook River is dominated by fine sandy/silty loam soils (Appendix B). To the east of the Suncook River downstream of the Rt 4 bridge, the soils are made up of Pootatuck very fine sandy loam while the west side is made up of Saco mucky silt loam. The same arrangement of soils is found at the avulsion site and areas just upstream. Downstream of the snowmobile bridge on Leighton Brook, the soils are Saco mucky silt loam, but upstream they are Windsor loamy fine sand. In summary, fine sandy/silty soils dominate the Suncook River alluvial valley, which was confirmed by the soil borings (Appendix A).

Hydrology

The Basis of Design Memo that accompanied the recently submitted 30% Designs provides a detailed description of the hydrology of the Suncook River and the hydraulic modeling completed (Inter-Fluve, 2012). In summary, our study area includes the Suncook River and two primary tributaries, the Little Suncook River and Leighton Brook. The USGS completed a HEC-RAS hydraulic model for the Suncook River and calculated the discharge for various flood recurrence intervals. We supplemented this with an assessment of the USGS StreamStats program hydraulic results for the Little Suncook River and Leighton Brook (Table 1).

Table 1: Water discharge at various recurrence intervals for the Suncook River and tributaries using data from the USGS Flood Study (Flynn, 2009) and the USGS StreamStats program.

Stream and Location	Source of Data	Flows (cfs) at Given Recurrence Interval (yrs)								
		1.8	2	5	10	25	50	100	500	April 2007
Suncook River at Rt 4	USGS, 2009	2145	2,320	3,700	4,870	6,690	8,330	10,200	15,900	11,000
Little Suncook River at mouth	USGS, 2009	459	534	851	1,121	1,539	1,914	2,351	3,661	2,538
Little Suncook River at mouth	USGS StreamStats	650	713	1,100	1,420	1,820	2,150	2,530	3,440	2,700
Leighton Brook at mouth	USGS StreamStats	35	38.9	66.8	91.2	126	154	189	276	200

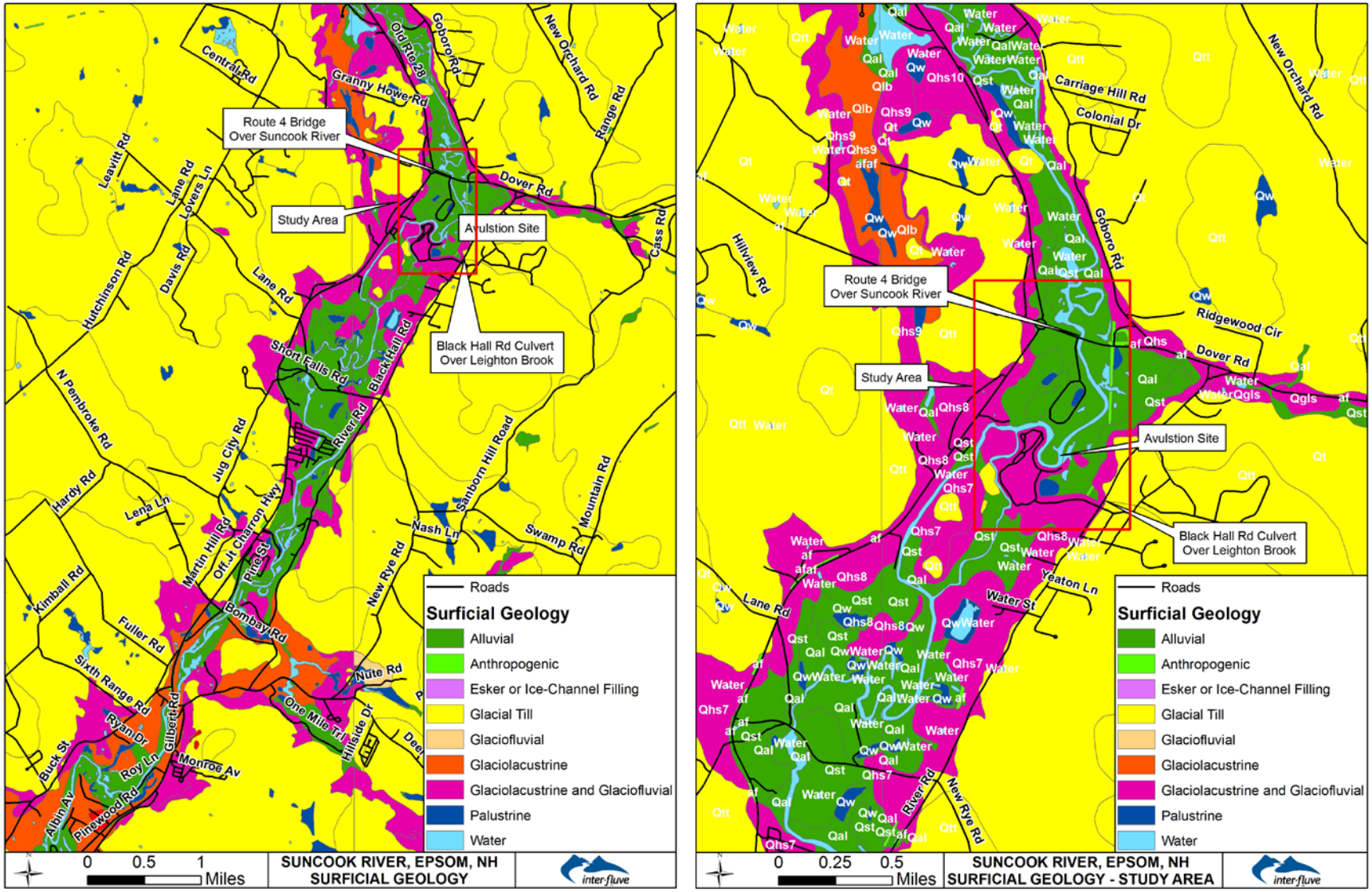


Figure 3: Surficial geology of the Suncook River and surroundings. The image on the right is focused on the study area and provides the surficial geology codes for reference.

Figure 4: Exposed glacial lake sediments in the form of fine-grained layered silt and clay. (Photo: Inter-Fluve)

Geomorphology

Channel Planform and Geometry

The Suncook River is a wide, meandering river in the vicinity of the study area. Prior to the avulsion, the Huckins Mills Dams created an impoundment that extended from Bear Island to reaches upstream of the Rt 4 bridge. The Suncook River is a dynamic river that has adjusted its course over time. Oxbow bends, or abandoned meander bends, were observed throughout the area, with obvious examples immediately upstream of the Rt 4 bridge (Figure 5). As described above, the bank material is fine-grained, lending to relatively easy bank erosion and channel migration.

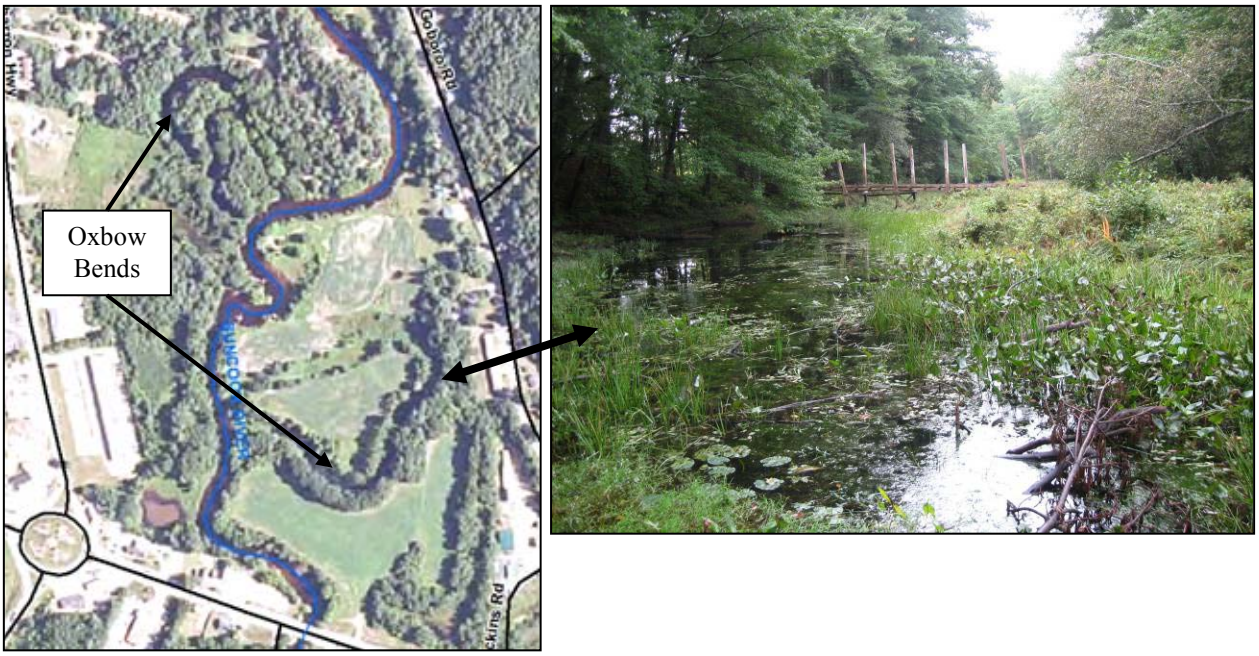


Figure 5: (Left) Suncook River north of the Rt 4 bridge with oxbow bends on either side. (Right) Oxbow bend to the east of the Suncook River.

After the avulsion occurred, the dams no longer impounded water and the channel in the former impoundment was reactivated leading to bed and bank erosion. The new Suncook River channel through the former sand pit was substantially shorter than its previous channel, increasing the channel slope in this area. This resulted in vertical channel instability that has been moving upstream since. Areas downstream have been in a very active period of channel change since the avulsion as large amounts of sediment were initially transported downstream. Sediment continues to move downstream as the channel continues to adjust through the sand pit area and elsewhere. Deposition that has occurred further downstream has resulted in flooding concerns (VHB, 2008).

Since the avulsion, the Suncook River channel geometry has adjusted as well. Upstream of the avulsion, the channel has deepened and widened to varying degrees up to the Rt 4 bridge (see cross section comparisons in the Task 4 Technical Memo regarding the completed surveys). Upstream of the avulsion, the channel is primarily an entrenched channel with deep pools and fast riffles, but few depositional point bars or other depositional bars. Downstream of the avulsion, the channel is migrating and changing course rapidly, but is primarily a wide channel with depositional point bars and corresponding deeper pools on the outside bends. Mid-channel depositional bars are also frequent and large wood structures are creating complexity as well.

Bank and Bed Substrate

As discussed above, the channel banks consist of fine and very fine sand, silt, and loam (Figure 6). Underlying this material, layers of very fine silt and clay were identified near the water surface. Coarser sand and gravel was found in one location on the left bank (looking downstream) where the existing channel intersected a historic channel location at the meander bend downstream of the confluence with the Little Suncook River.

Figure 6: The Suncook River is bounded by tall sandy banks and hillslopes in many locations, including (left) between the Rt 4 bridge and the Little Suncook River and (right) immediately upstream of the avulsion site.

The channel bed of the Suncook River in the study area consists of riffles dominated by glacial lag deposits and deep pools dominated by sand (see the Task 3 Site Assessment Technical Memo for a complete description of the surface and subsurface grain size analyses completed to date). The glacial lag deposits consist of very large boulders, cobbles, and occasionally consolidated till with protruding boulders (Figure 7). These lag deposits do not appear to extend extensively beyond the channel banks, as revealed in the soil boring exploration. They are currently maintaining the channel gradient, but erosion on the edges of these lag deposits presents the possibility that the deposits could be outflanked resulting in increased bank erosion as well as excessive bed incision. This increased bed incision could lead to further instability upstream and potential risk to infrastructure.

Figure 7: Glacial lag deposits on the bed of the Suncook River (clockwise from upper left) 400, 900, and 3000 ft downstream from the Rt 4 bridge.

Meander Migration Analysis/Channel Change Patterns

The Suncook River will continue to evolve downstream of the avulsion site leading to concern about the continued instability along Leighton Brook. As the Suncook River migrates further towards Leighton Brook, the elevation at the confluence decreases leading to increased channel slope along Leighton Brook and the propagation of another knickpoint migrating upstream towards infrastructure. If the Suncook River migrates away from the Leighton Brook confluence, the slope will decrease, erosion and incision will reduce, and deposition near the mouth will increase. We evaluated the recent meander migration patterns for the meander bend of the Suncook River at the mouth of Leighton Brook to estimate the direction and magnitude of future changes that might impact the stabilization designs and restoration for Leighton Brook.

In the existing 30% design plans, we have recommended that rock be buried under the bed of Leighton Brook between 30 and 90 ft upstream of its confluence with the Suncook River. This, combined with rock grade control structures here and upstream on Leighton Brook, would

provide stability if the Suncook River continues to migrate towards Leighton Brook. If the Suncook does migrate, the buried rock would be exposed, fall to the new channel bed elevation, and create a gradual, stable riffle rather than a steep sandy knickpoint that could migrate. The location of this buried rock was partially based on a meander migration analysis that estimated the potential direction and extent of Suncook River migration through 2015.

The meander migration study we completed was based on the National Cooperative Highway Research Program methods (Lagasse et al., 2004). We obtained orthorectified air photos for the years 2007, 2009, and 2010. We also used survey data that we collected along the tops and toes of channel banks in 2011 to provide another year of data. We used the top of bank to identify and delineate the channel boundaries. Because of air photo resolution and vegetation cover, the top of bank cannot be precisely identified in all air photos, but the best approximations were made using standard GIS analytical techniques.

Once the air photos and survey data were compiled in GIS, the channel in each year of data was delineated based on the top of bank features (Figure 8). Circles were then drawn so that the outer edge of the circle matched the outer edge of the delineated top of bank along the meander bend. The centroid of each of these circles was marked and the radius of curvature measured. We then measured the angle and distance of centroid movement between each successive year to estimate the directional trend of the meander bend. These measurements allowed us to estimate the amount of movement per month between years of data.

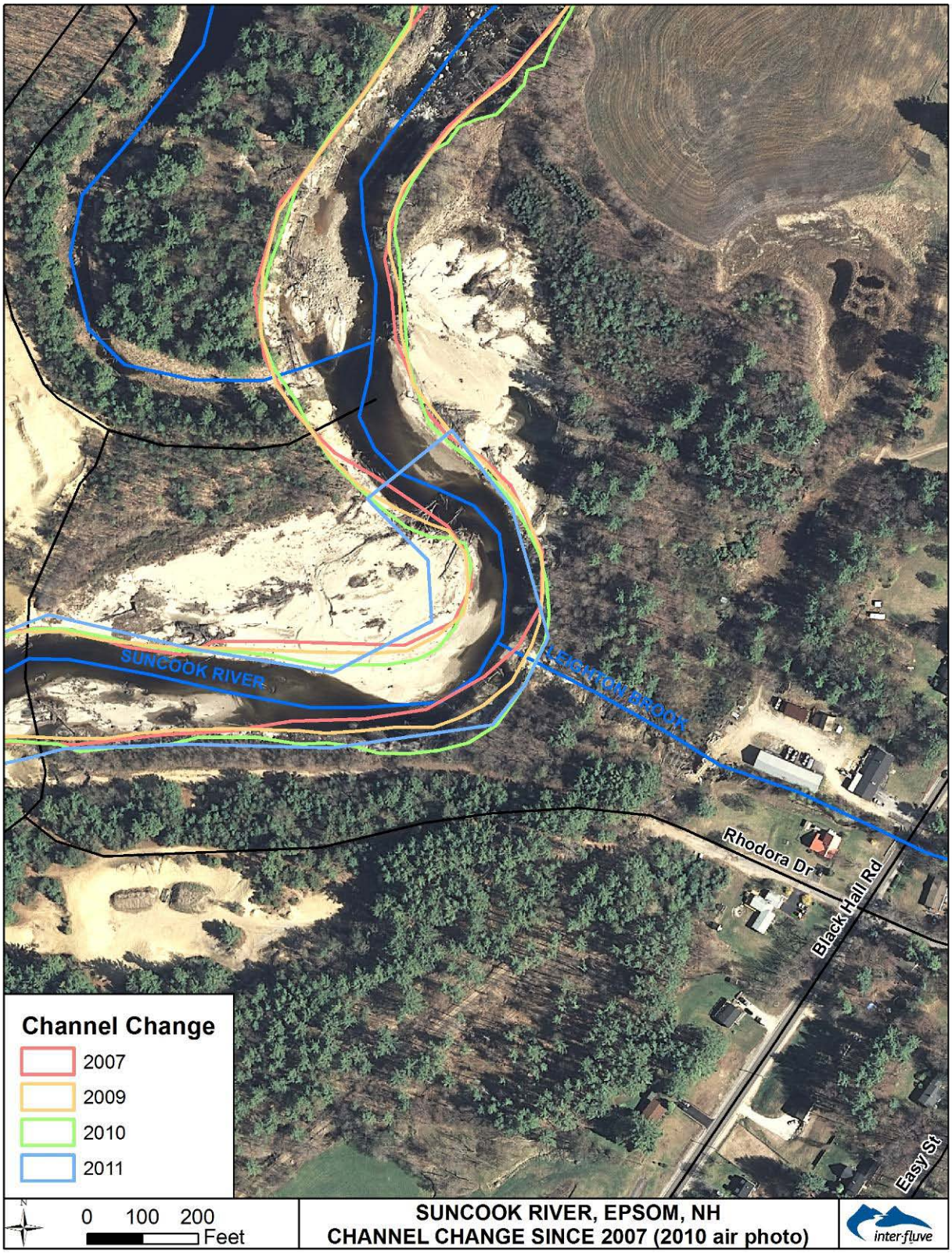


Figure 8: Suncook River channel boundaries delineated based on the top of bank in different air photos and survey data at the confluence with Leighton Brook.

We used this information to estimate the meander migration in the future. Since the movement between 2010 and 2011 was minor and in a different direction than previous years and to what was expected (west/northwest, rather than south/southwest), we used the more conservative direction and rate of movement (2.2 ft/month) that was measured between 2009 and 2010 to project movement in the future (equations 7.3 and 7.4, Lagasse et al., 2004):

$$R_{CX} = R_{C2010} + \left[\left(\frac{R_{C2010} - R_{C2009}}{M_B}\right)(M_C)\right] \qquad \textit{Equation 1}$$

R_{CX} = Predicted radius of curvature in Year X (ft)

R_{C2010} = Radius of curvature in 2010

R_{C2009} = Radius of curvature in 2009

M_B = Number of months in Period B: between data in 2009 and 2010

M_C = Number of months in Period C: between data in 2010 and Year X

$$\theta_X = \left[\left(\frac{\theta_B - \theta_A}{M_B}\right)(M_C)\right] + \theta_B \qquad \textit{Equation 2}$$

θ_X = Predicted angle of outer bank migration for Period Year X (between 2010 and future Year X)

θ_A = Angle of outer bank migration in Period A: between 2007 and 2009

θ_B = Angle of outer bank migration in Period B: between 2009 and 2010

M_B = Number of months in Period B: between data in 2009 and 2010

M_C = Number of months in Period C: between data in 2010 and Year X

The projections of meander bend migration indicate that the meander bend at the mouth of Leighton Brook is likely to continue to migrate in a south/southwesterly direction, but that because of the increasing radius of curvature, this could increase erosion another 15 ft upstream into Leighton Brook in 2012. By 2015, the projections suggest that this particular meander bend will have moved far enough to the south/southwest, that the Leighton Brook confluence will be moving west, thus lengthening the channel, reducing the channel slope, and reducing instability (Table 2, Figure 9).

Table 2: Meander migration measurements for past, present, and future channel location of the meander bend at the mouth of Leighton Brook.

Year	Time Since Previous Data (month)	Radius of Curvature (ft)	Distance Centroid Moved (ft)	Dist Moved Per Month (ft)	Angle of Movement (degrees)
2007		236			
2009	27	254	32.9	1.2	199
2010	15	272	33.7	2.2	207
2011	12	286	12.2	1	307
2012	24*	301	52.8	2.2	219
2015	60*	344	132	2.2	237

* Future data was based on the more conservative data from 2010, rather than 2011. '2012' is 2 years after the 2010 data, and '2015' is 5 years after.

This meander migration analysis in no way should be misunderstood to mean the meander limit or meander belt width of the Suncook River. The Suncook River has the potential to meander hundreds of feet over many years and has done that throughout its history as is indicated by its many oxbow bends and meander scars. VHB estimated the meander belt width to be approximately 1040 ft (VHB, 2008). The VT DEC River Management Program suggests that the total belt width of a meandering river is six times the channel width, and more specifically, three times the channel width on either side of the meander centerline (VT ANR, 2004). This measurement is based on the formula developed by Williams (1986) who collected data on over 100 rivers around the world:

$$B = 3.7W^{1.12} \qquad \textit{Equation 3}$$

- B = belt width
- W = channel width.

To estimate the belt width for the Suncook River, we measured the channel width along 14 cross sections between the Rt 4 bridge and 2.7 miles upstream using the USGS HEC-RAS cross section data (Table 3). We used this data because this reach of the Suncook River has not been substantially impacted by the avulsion, has experienced channel migration in the past as evidenced by multiple oxbow bends, has a similar planform and valley width, and flows through similar bedrock and surficial geology (Holocene alluvial) as well as similar soil groups (primarily Pootatuck very fine sandy loam and Saco mucky silt loam).

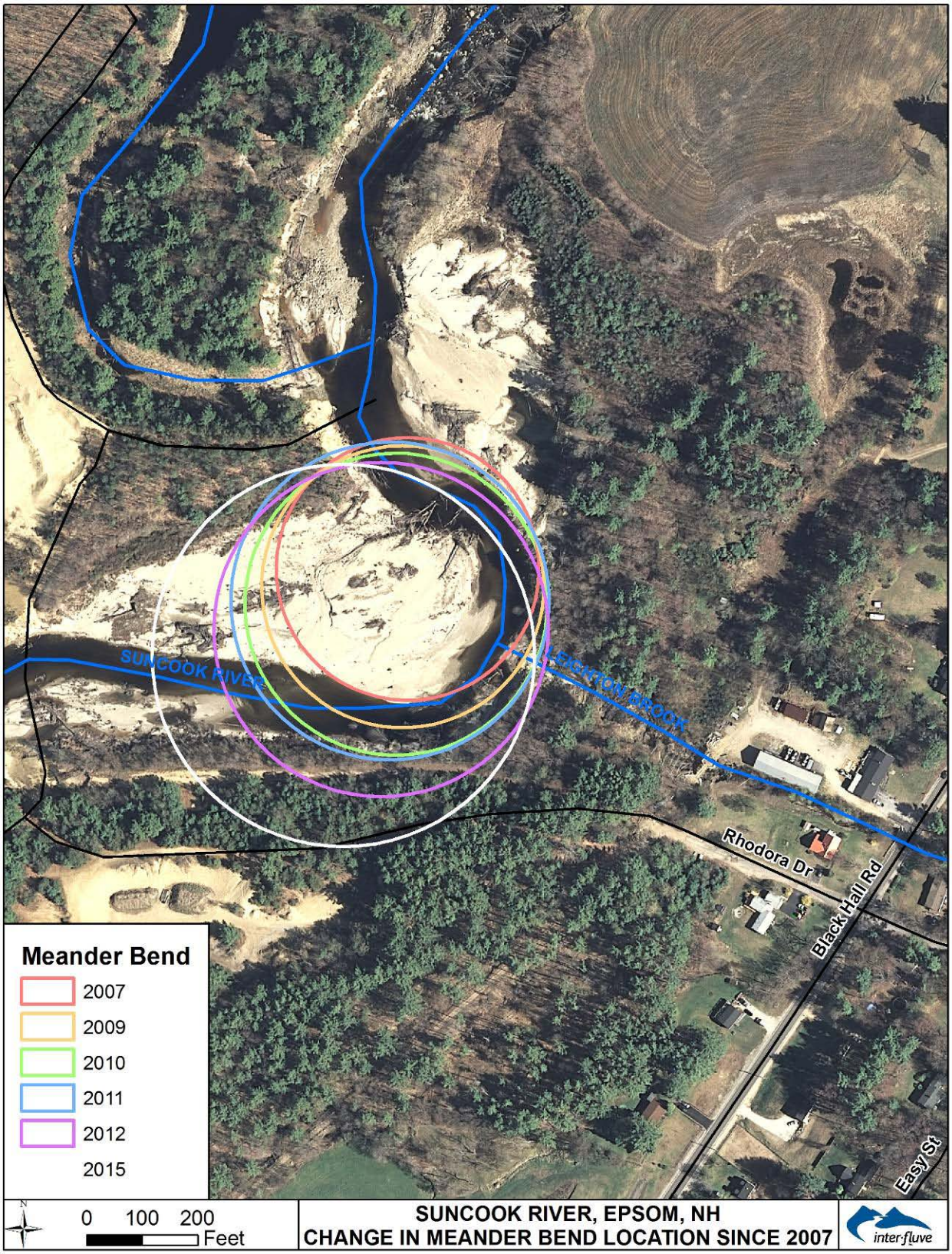


Figure 9: Circles drawn to match the delineated outer top of bank for each year of data.

The average width of the channel along the 14 measured cross sections is 106 ft and is not substantially different if the high and low values are removed (105 ft). Approximately 1 mile upstream of the Rt 4 bridge, the channel cross section becomes noticeably narrower in upstream reaches. The average channel width for cross sections upstream of this point is 125 ft, whereas the average channel width for cross sections downstream is 81 ft. Using these channel width measurements, the Suncook River belt width ranges from 507 ft to 826 ft using the Williams (1986) equation and 485 to 750 ft using the approximated '6 times the channel width' method from the VT geomorphic protocols (Table 4). For the purposes of this study, we use the more conservative values obtained using the Williams (1986) method.

Table 3: Suncook River channel widths at cross sections upstream from the Rt 4 bridge.

USGS HEC-RAS Cross Section	Channel Width (ft)
DJ	164
DK	107
DL	103
DM	138
DN	114
DO	120
DP	109
DQ	145
DR	90
DS	79
DT	100
DU	56
DV	93
DW	67

Table 4: Average channel widths and belt widths for the Suncook River.

	Channel Width (ft)	Belt Width (ft) (Williams, 1986)	Belt Width (ft) (VT ANC, 2004)
Average	106	687	636
Average excluding the high and low values	105	682	633
Average From Cross Sections DJ to DQ	125	826	750
Average From Cross Sections DR to DW	81	507	485

To identify the location of the Suncook River belt width, we delineated the meander center line by drawing a line through the cross over points in the river (VT ANR, 2004). We then created a 'buffer' in GIS on either side of this line to correspond to the various belt width calculations, ranging from 510 to 830 ft, or 255 to 415 ft on either side of meander center line (Figure 10). Upstream of the Rt 4 bridge, this belt width generally corresponds to the width of the Holocene alluvium and encompasses most of the former channel locations (oxbows, etc.). It should be noted, however, that in a few locations upstream of the Rt 4 bridge, former channel locations are outside of this belt width, suggesting that the channel can, and likely will in its geologic time scale, migrate throughout the width of the Holocene alluvial valley.

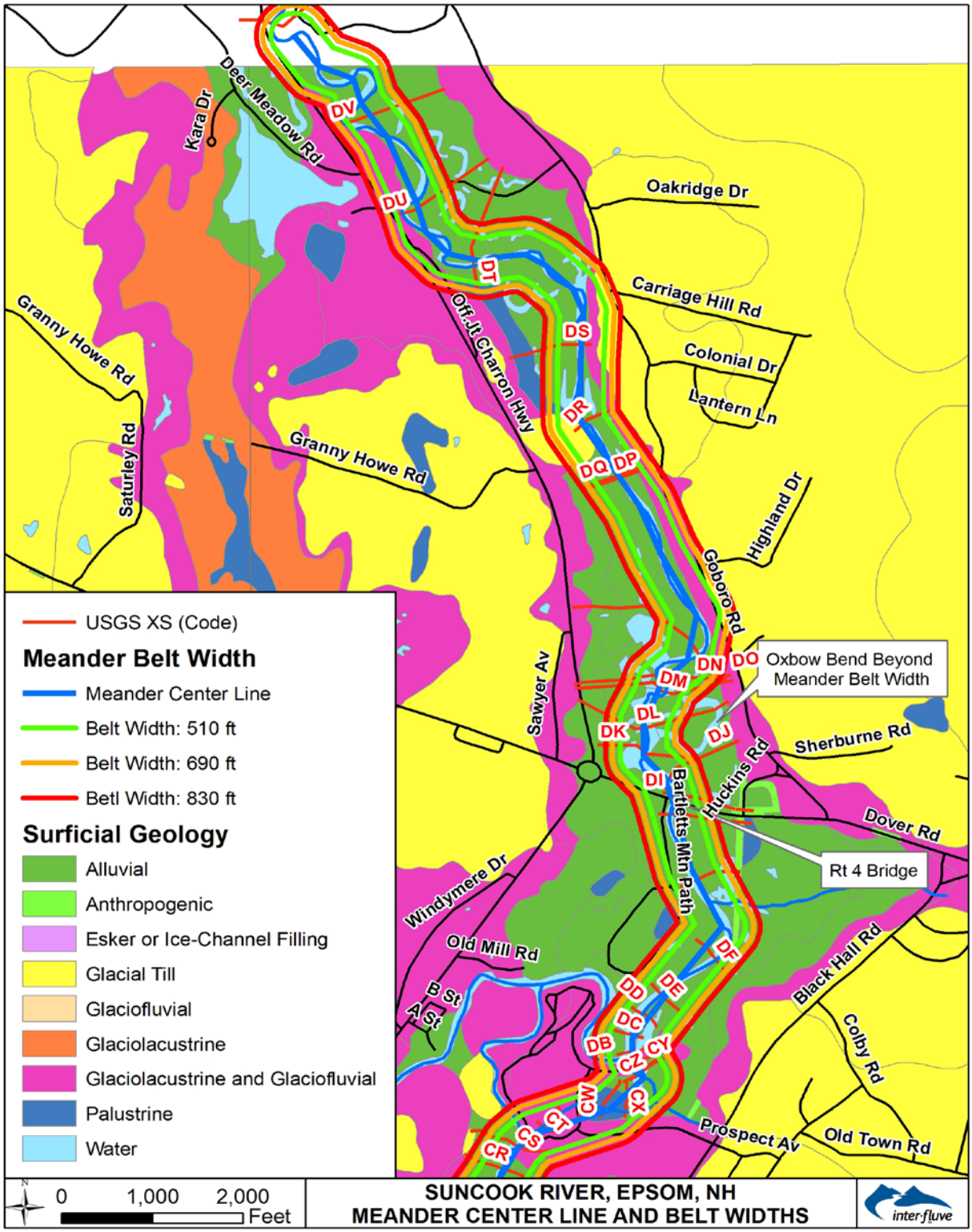


Figure 10: Meander center line and belt widths for the Suncook River based on channel width calculations from the USGS HEC-RAS cross sections.

The meander bend at the current mouth of Leighton Brook has already exceeded the 510-ft belt width and is currently at the extent of the 690-ft belt width. To reach the 830-ft belt width, the Suncook River would need to migrate another 75 ft upstream along Leighton Brook (Figure 11). As mentioned above, the Suncook River has the potential to migrate beyond these belt widths within the Holocene alluvium. The high terrace banks along the outside of this meander bend, however, may slow the migration of the channel at this location.

Implications for Design

The meander migration analysis and the channel belt width analysis both suggest that additional migration of the meander bend at the mouth of Leighton Brook is possible and likely. The belt width analysis suggests that the channel has the potential to continue migrating eastward up Leighton Brook for another approximately 75 ft (and further if the belt width derived by VHB or the extent of the Holocene alluvium is used). The meander migration analysis suggests that the migration trend of the existing meander bend is in a south, southwesterly direction. Because of the size of the meander bend, the results suggest that the Suncook River could erode another approximately 15 ft up Leighton Brook through 2012, but that by 2015 the meander bend could be moving southward and westward, leading to a lengthening of Leighton Brook and decreasing of the channel slope and erosion potential of Leighton Brook. However, the potential exists that because of continued channel movement and migration, a different meander bend from upstream could migrate downstream and further impact Leighton Brook to the full extent of the meander belt width.

We have included a buried rock buttress in the 30% designs that will protect the mouth of Leighton Brook against upstream-migrating knickpoints to the limit of the meander migration analysis (15 ft upstream of the existing mouth). With the results of the channel belt width analysis, we may consider moving this buried rock upstream some distance in the event that the Suncook River continues to migrate to its belt width limit.

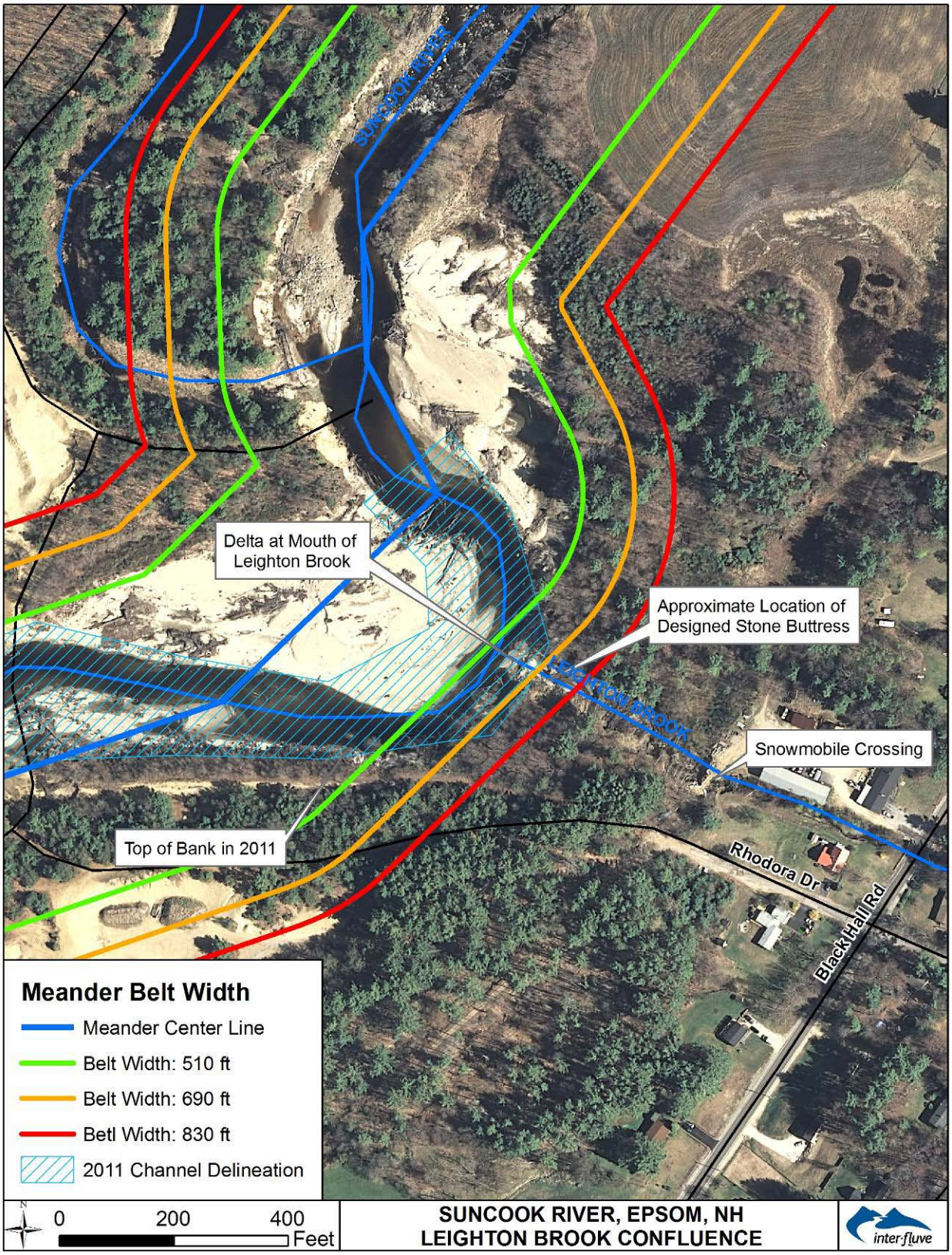


Figure 11: Meander belt width at the confluence with Leighton Brook.

Suncook River Annotated Bibliography

Bridge/Culvert Information

Clifford, G., 2009. Epsom Black Hall Road Box Culvert Replacement Details for Leighton Brook: for Amended Permit #2008-01939.

Drawings and details of the culvert that was replaced in 2009. Provided by the Town of Epsom.

NH State Highway Department, 1924. Plan and Profile of Proposed Federal Aid Project No 210-C Central Rd: Designs for Rt 4 Bridge Construction. Town of Epsom, NH

Design drawings and details for the construction of the Rt 4 bridge in 1924. Shows location of some 'ledge' under the bridge as well as location of old piers.

NH Department of Public Works and Highways, 1970. Plans of Proposed Federal Aid Primary Project F012-2(9): Central Road Over Suncook River (Routes US 4, US 202, NH 9). Town of Epsom, NH.

Design drawings and details for updates made to the Rt 4 bridge in 1970.

VHB, 1996. NH Department of Transportation General Plan and Elevation for US Route 4 Over Suncook River, Bridge No 086/127, State Project 11141. Town of Epsom, NH.

Design drawings and details for updates made to the Rt 4 bridge in 1996.

VHB, 1996. NH Department of Transportation General Plan and Elevation for US Route 4 Over Suncook River Overflow, Bridge No 088/126, State Project 11141. Town of Epsom, NH.

Design drawings and details for updates made to the Rt 4 bridge over the overflow channel in 1996. Shows boring information for the piles that were dug.

Fluvial Geomorphology/Restoration Alternatives

FEMA, 2010. Flood Insurance Study, Merrimack County, New Hampshire, Volumes 1 and 2. FIS #: 33013CV001A.

Lagasse, P.F., Spitz, W.J., Zevenbergen, L.W., and Zachmann, D.W., 2004. Handbook for Predicting Stream Meander Migration. National Cooperative Highway Research Program Report 533, Transportation Research Board of the National Academies, Washington, D.C.

Describes the various methods for calculating meander migration patterns. Also discusses the methods for predicting changes in the future.

Perignon, M.C., 2007. Mechanisms governing avulsions in transient landscapes: Analysis of the May 2006, Suncook River avulsion in Epsom, New Hampshire, B.S thesis, 68 pp., Massachusetts Institute of Technology, Cambridge, Massachusetts.

The objective of the thesis was to understand what controls avulsions in transient landscapes and to determine if the mechanisms which control avulsions in net-depositional environments are also responsible for the avulsion that occurred in the Suncook River. Additionally, the magnitude and importance of the May 2006 flood in the hydrologic history of the Suncook River was assessed.

Vanasse Hangen Brustlin, Inc., 2008. Geomorphology-based Restoration Alternatives, Suncook River, Epsom, New Hampshire, Final Technical Report for the Town of Epsom, New Hampshire and The NH Department of Environmental Services, 82 pp., May 28, 2008.

The goal of this study was to provide sufficient information to interested stakeholders to allow an informed decision as to what course of action should be followed to prevent further impacts to private property, ecological resources, and water quality following the avulsion that occurred on the Suncook River.

VT ANR, 2004. Stream Geomorphic Assessment Protocol Handbook.

Williams, G.P., 1986. River Meanders and Channel Size. Journal of Hydrology 88:147-164.

Wittkop, C., 2008. Suncook River Long-Term Observations. Summary observations report submitted as Appendix D in the VHB Alternatives Analysis.

Describes the changes that took place on the Suncook River following the avulsion and puts them in a geomorphic and geologic context.

Geology

Lyons and others, 1997. Bedrock Geologic Map of New Hampshire. U.S. Geological Survey, Reston, VA.

Bennett, D. S, , Wittkop, C.A., and Dicken, C.L., 2006 , Bedrock Geologic Map of New Hampshire - A Digital Representation of the Lyons and others 1997 map and ancillary files: U.S. Geological Survey Data Series 215, scale 1:250,000, CD-ROM.

Hydrology/Hydraulics

Flynn, R.H., 2010, Flood Study of the Suncook River in Epsom, Pembroke, and Allenstown, New Hampshire, 2009: U.S. Geological Survey Scientific Investigation Report 2010-5127, 64p. (Also available at http://pubs.usgs.gov/sir/2010/5127.)

This report presents water-surface elevations and profiles using HEC-RAS analysis. Steady-state water-surface profiles were developed for the Suncook River from its confluence with the Merrimack River in the Village of Suncook (in Allenstown and Pembroke, NH) to the upstream corporate limit of the town of Epsom, NH (approximately 15.9 river miles). The analyses in this study reflect flooding potentials that are based on existing conditions in the communities of Epsom, Pembroke, and Allenstown.

Flynn, R.H., 2010. HEC-RAS Hydraulic Model for Suncook River.

Stekl, P.J, and S.M. Flanagan, 1997. Geohydrology and Water Quality of Stratified Drift Aquifers in the Upper Merrimack River Basin, South-Central New Hampshire, report to US Geological Survey, Water-Resources Investigations Report 95-4123, 142pp., 1997.

This report presents the results of a study by the U.S. Geological Survey to describe the geohydrology and background water quality of stratified-drift aquifers in the Upper Merrimack River Basin in south-central New Hampshire. The report describes the geohydrologic characteristics of the stratified-drift aquifers in the Upper Merrimack River Basin, provides estimates of water availability in selected aquifers on the basis of an analytical technique, and describes the ambient ground-water quality in stratified-drift aquifers.

URS Group, Inc., 2008. Independent Evaluation of Recent Flooding in New Hampshire, report to Federal Emergency Management Agency Department of Homeland Security, Contract No. HSFEHQ-06-D-0162, 129 pp., July 2008.

The report elucidates the cause of flooding, whether it was aggravated by anthropomorphic causes, and what can be done in the future to mitigate impacts. The study recommendations are intended to help reduce local flooding. More importantly, the recommendations will help New Hampshire and its citizens plan for future flood events and reduce future flood losses through sound floodplain management and effective emergency response during flood events.

Sediment Transport

Flynn, R.H., 2011, Analysis of the transport of sediment by the Suncook River in Epsom, Pembroke, and Allenstown, New Hampshire, after the May 2006 flood: U.S. Geological Survey Scientific Investigations Report 2011–5088, 73 p. (Also available at http://pubs.usgs.gov/sir/2011/5088.)

This study characterizes the sediment transport in the Suncook River. HEC–RAS model was used to simulate flow and the transport of non-cohesive sediments. In addition, analyses in this study reflect flooding potentials for selected recurrence intervals that are based on the Suncook River streamgage flow data and on streambed elevations predicted by HEC–RAS.

Flynn, R.H., 2011. HEC-RAS Sediment Transport Model for the Suncook River, Epsom, NH.

Soils

NRCS. Hydric Soils - Merrimack and Belknap Counties, New Hampshire. Web Soil Survey, National Cooperative Soil Survey.

NRCS. Soil Map - Merrimack and Belknap Counties, New Hampshire. Web Soil Survey, National Cooperative Soil Survey.

Water Quality

Daley, Michelle L., 2006. Initial Water Quality Results for the Suncook River after Avulsion on May 15, 2006. NH Water Resources Center, Department of Natural Resources, University of New Hampshire, June 20, 2006.

Researchers from the Department of Natural Resources at the University of New Hampshire collected samples from 10 sites for water quality analysis. The samples were collected over a two day period to characterize water quality in four areas 1) the upstream/un-impacted reach 2) the new reach 3) the dewatering reach (West Branch and Mason Brook tributary) and 4) the downstream reach. Results of this analysis are described in the report.

Air Photos

USACOE, 2006. Aerial Photos taken of Epsom and Suncook Rivers immediately after the avulsion occurred.

Maps and GIS Data

USGS:

- topographic maps: 1921, 1957, 1995
- Air photos
- Bedrock Geology

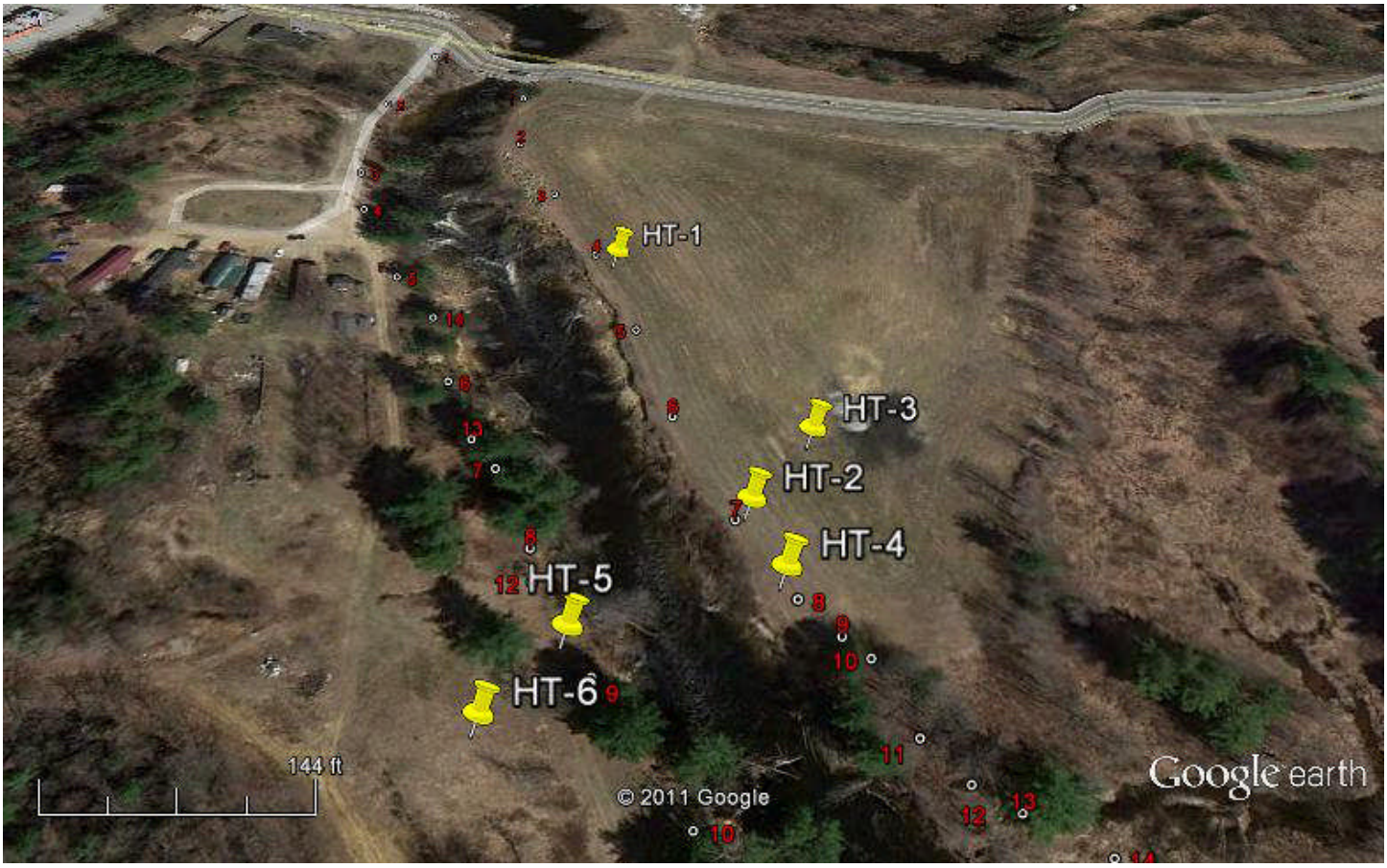
GRANIT:

- air photos (2003, 2009 NAIP)
- Roads
- Rivers

NHGS shapefiles/air photos

- Air photos
- Contours
- Geodetic controls
- GeoLogs
- Geophysical lines
- Glacial geology
- Surficial geology
- Cross section pins from VHB study

Appendix A: Soil borings completed by Hydroterra Environmental Services adjacent to the Suncook River in the vicinity of the proposed grade control structures downstream of the Rt 4 bridge. The first page is a map of boring locations.



Google earth

feet 300
meters 100

HYDROTERRA Environmental Services	**PROJECT:** Suncook River - Geophysical Project		**BORING NO.** **HT-1**
272 1/2 Dover Point Rd., Dover, NH	**LOCATION:**		**SHEET** 1 of 2
CONTRACTOR New Hampshire Boring			**FILE NO.**
DRILLING METHOD Wash and Drive	**Northing**	**Easting** / **Boring Elev. (ft)**	**Location**
GEOLOGIST Jack McKenna	264614.6'	1066928.4' / 334.4' NAVD 88	
DATE 12/15/2011	NH State 84 (ft)	NH State 84 (ft) / Ground Surface	

DEPTH (feet bgs)	Elev (feet)	SAMPLE NO.	BLOWS / 6"	SAMPLE INTERVAL (feet bgs)	PID-VOC Headspace (ppm)	STRATA DESCRIPTION	STRATA CHANGE	Notes
	334.40'	S-1	5/5/9/10	0 – 2.0'	NA	0 - 1.0' Dark Brown, Silty SAND, some roots	*TOPSOIL* ELEV 333.40'	
		S-2	7/7/9/11	2.0' – 4.0'				
		S-3	3/9/10/10	4.0' – 6.0'		1.0' - 6.0' Lt.brown/tan, loose, fine to med SAND,	*GLACIAL OUTWASH*	
	329.4	S-4	9/10/10/11	6.0' – 8.0'				
		S-5	11/9/8/10	8.0' – 10.0'		6.0' - 9.0' Reddish brown/gray, fine SAND, some Silt, trace Clay		
	324.4	S-6	11/10/10/8	10.0' – 12.0'		9.0' - 14.0' Brown, med to coarse SAND, dry		
		S-7	8/9/9/9	12.0' – 14.0'				
	319.4	S-8	10/15/22/20	14.0' – 16.0'		14.0' - 16.0' Brown, coarse SAND, moist		
		S-9	11/12/20/18	16.0' – 18.0'		16.0' - 20.0' Gray, fine Sandy SILT, wet	ELEV 318.4' *FLUVIAL*	
						Roller Bit to 20.0' - Set Casing to 12.0 ft below grade		
	314.4							

HYDROTERRA Environmental Services	**PROJECT:** Suncook River - Geophysical Project				**BORING NO.** **HT-1**
272 1/2 Dover Point Rd., Dover, NH	**LOCATION:**				**SHEET** 2 of 2
CONTRACTOR New Hampshire Boring					**FILE NO.**
DRILLING METHOD Wash and Drive	**Northing**	**Easting**	**Boring Elev. (ft)**		**Location**
GEOLOGIST Jack McKenna	264614.6'	1066928.4'	334.4' NAVD 88		
DATE 12/15/2011	NH State 84 (ft)	NH State 84 (ft)	Ground Surface		

DEPTH (feet bgs)	Elev (feet)	SAMPLE NO.	BLOWS / 6"	SAMPLE INTERVAL (feet bgs)	PID-VOC Headspace (ppm)	STRATA DESCRIPTION	STRATA CHANGE	Notes
	314.40'	S-10	10/18/12/13	20 – 22.0'	NA			
21								
22						20.0' - 25.0' Gray, fine Silty SAND, wet		
23								
24								
25	309.4	S-11	10/11/10/11	25.0' – 27.0'		25.0' - 27.0' Same as above, trace clay		
26							*FLUVIAL*	
27								
28								
29								
30	304.4	S-12	10/18/19/17	30.0' – 32.0'		30.0' - 32.0' Gray, fine Silty SAND, trace clay		
31								
32								
33								
34								
35	299.4	S-13	11/12/32/40	35.0' – 37.0'		35.0' - 36.5' Same as above		
36							ELEV 297.9'	
37								
38		S-14	28/48/60-4"			36.5' - 40.0' Gray, dense Silty SAND, rock frags	*TILL*	
39								
40	294.4					*END OF BORING @ 40.0' bgs*		

HYDROTERRA Environmental Services	**PROJECT:** Suncook River - Geophysical Project	**BORING NO.**	**HT-2**
272 1/2 Dover Point Rd., Dover, NH	**LOCATION:**	**SHEET**	1 of 2
CONTRACTOR New Hampshire Boring		**FILE NO.**	
DRILLING METHOD Wash and Drive	**Northing** / **Easting** / **Boring Elev. (ft)**	**Location**	
GEOLOGIST Jack McKenna	264274.8' / 1067045.2' / 331.8' NAVD 88		
DATE 12/15/2011	NH State 84 (ft) / NH State 84 (ft) / Ground Surface		

DEPTH (feet bgs)	Elev (feet)	SAMPLE NO.	BLOWS / 6"	SAMPLE INTERVAL (feet bgs)	PID-VOC Headspace (ppm)	STRATA DESCRIPTION	STRATA CHANGE	Notes
	331.80'	S-1	6/7/6/7	0 – 2.0'	NA	0 - 1.0' Dark Brown, Silty SAND, some roots	*TOPSOIL*	
		S-2	6/7/9/7	2.0' – 4.0'				
		S-3	8/8/7/9	4.0' – 6.0'		1.0' - 6.0' Brown, loose, fine to med SAND, dry	*GLACIAL*	
5	326.8							
		S-4	7/7/9/8	6.0' – 8.0'				
8						6.0' - 10.0' Brown/gray, fine SAND, some Silt, trace Clay		
		S-5	9/9/8/9	8.0' – 10.0'				
10	321.8							
		S-6	7/7/9/10	10.0' – 12.0'		10.0' - 12.0' Brown/gray, fine - med Silty SAND, some wood / peat		
		S-7	6/5/8/9	12.0' – 14.0'		12.0' - 16.0' Gray, laminated fine Silty SAND, interlayered silt and sand layers		
15	316.8							
		S-8	10/11/14/16	14.0' – 16.0'				
		S-9	16/17/19/20	16.0' – 18.0'		16.0' - 20.0' Tan, med to coarse, SAND, wet		
						Roller Bit to 20.0' - Set Casing to 12.0 ft below grade		
20	311.8							

HYDROTERRA Environmental Services 272 1/2 Dover Point Rd., Dover, NH	PROJECT: Suncook River - Geophysical Project				BORING NO. HT-2
	LOCATION:				SHEET 2 of 2
CONTRACTOR New Hampshire Boring					FILE NO.
DRILLING METHOD Wash and Drive	Northing	Easting		Boring Elev. (ft)	Location
GEOLOGIST Jack McKenna	264274.8'	1067045.2'		331.8' NAVD 88	
DATE 12/15/2011	NH State 84 (ft)	NH State 84 (ft)		Ground Surface	

DEPTH (feet bgs)	Elev (feet)	SAMPLE NO.	BLOWS / 6"	SAMPLE INTERVAL (feet bgs)	PID-VOC Headspace (ppm)	STRATA DESCRIPTION	STRATA CHANGE	Notes
	311.80'	S-10	10/9/8/10	20 – 22.0'	NA	20.0' - 22.0' Grey Sandy SILT, trace clay	ELEV 311.8' *FLUVIAL*	
21								
22								
23								
24								
25	306.8	S-11	10/9/8/10	25.0'	NA	25.0' - 27.0' Gray, laminated fine Sandy SILT, interlayered silt and sand layers		
26								
27								
28								
29								
30	301.8	S-12	14/16/19/20	30.0' – 32.0'		30.0' - 32.0' Same as above		
31								
32								
33								
34						34.0' - 38.0' Gray, dense Silty SAND, rock frags	ELEV 297.8'	
35	296.8	S-13	49/50/59/60					
36							*TILL*	
37								
38								
39						*END OF BORING @ 38.0' bgs*		
40	291.8							

HYDROTERRA Environmental Services	**PROJECT:** Suncook River - Geophysical Project		**BORING NO.** **HT-3**
272 1/2 Dover Point Rd., Dover, NH	**LOCATION:**		**SHEET** 1 of 1
CONTRACTOR New Hampshire Boring			**FILE NO.**
DRILLING METHOD Wash and Drive	**Northing**	**Easting** / **Boring Elev. (ft)**	**Location**
GEOLOGIST Jack McKenna	264347.9'	1067093.8 / 330.7' NAVD 88	
DATE 12/15/2011	NH State 84 (ft)	NH State 84 (ft) / Ground Surface	

DEPTH (feet bgs)	Elev (feet)	SAMPLE NO.	BLOWS / 6"	SAMPLE INTERVAL (feet bgs)	PID-VOC Headspace (ppm)	STRATA DESCRIPTION	STRATA CHANGE	Notes
	330.70'	S-1	5/8/9/14	0 – 2.0'	NA	0 - 1.0' Dark Brown, Silty SAND, some roots	*TOPSOIL*	
1							ELEV 329.70'	
2		S-2	17/19/15/16	2.0' – 4.0'				
3								
4		S-3	17/23/17/23	4.0' – 6.0'		1.0' - 6.0' Brown, loose, fine to med SAND, dry with red staining coarse grained zones	*GLACIAL*	
5	325.7							
6		S-4	23/22/23/27	6.0' – 8.0'		6.0' - 10.0' Brown/gray, fine Silty SAND, trace Clay		
7								
8		S-5	19/17/16/14	8.0' – 10.0'		Small interlayered silt and sand layers		
9								
10	320.7	S-6	13/16/15/15	10.0' – 12.0'		10.0' - 12.0' Brown/gray, fine - med Silty SAND,		
11								
12		S-7	8/12/14/15	12.0' – 14.0'		12.0' - 13.0' Same as above		
13							ELEV 317.7	
14		S-8	9/11/10/11	14.0' – 16.0'				
15	315.7							
16		S-9	7/7/7/10	16.0' – 18.0'		13.0' - 20.0' Gray, fine Sandy SILT, some clay	*FLUVIAL*	
17								
18		S-9	10/7/9/12	18.0' – 20.0'				
19								
20	310.7					***END OF BORING @ 20.0' bgs***		

HYDROTERRA Environmental Services	**PROJECT:** Suncook River - Geophysical Project		**BORING NO.** **HT-4**
272 1/2 Dover Point Rd., Dover, NH	**LOCATION:**		**SHEET** 1 of 1
CONTRACTOR New Hampshire Boring			**FILE NO.**
DRILLING METHOD Wash and Drive	**Northing**	**Easting**	**Boring Elev. (ft)**	**Location**
GEOLOGIST Jack McKenna	264208.1'	1067063.2	331.5' NAVD 88	
DATE 12/15/2011	NH State 84 (ft)	NH State 84 (ft)	Ground Surface	

DEPTH (feet bgs)	Elev (feet)	SAMPLE NO.	BLOWS / 6"	SAMPLE INTERVAL (feet bgs)	PID-VOC Headspace (ppm)	STRATA DESCRIPTION	STRATA CHANGE	Notes
	331.50'	S-1	3/7/8/7	0	NA	0 - 1.0' Dark Brown, Silty SAND, some roots	*TOPSOIL*	
1							ELEV 330.5'	
2				2.0'				
3								
4						1.0' - 6.0' Brown, loose, fine to med SAND, dry with red staining coarse grained zones	*GLACIAL OUTWASH*	
5	326.5			5.0'				
		S-2	8/10/12/9					
6								
						6.0' - 10.0' Gray, fine - med SAND, trace silt		
7				7.0'				
8								
9								
10	321.5			10.0'				
		S-3	15/14/16/15			10.0' - 12.0' Gray, fine - med, SAND		
11								
12				12.0'				
13								
14							ELEV 317.5	
15	316.5			15.0'				
		S-4	5/4/6/4					
16							*FLUVIAL*	
						14.0' - 20.0' Gray, fine Sandy SILT, some clay		
17				17.0'				
18								
		S-5	7/6/9/8					
19								
						END OF BORING @ 20.0' bgs		
20	311.5			20.0'				

HYDROTERRA Environmental Services	**PROJECT:** Suncook River - Geophysical Project		**BORING NO.** **HT-5**
272 1/2 Dover Point Rd., Dover, NH	**LOCATION:**		**SHEET** 1 of 2
CONTRACTOR New Hampshire Boring			**FILE NO.**
DRILLING METHOD Wash and Drive	**Northing**	**Easting** / **Boring Elev. (ft)**	**Location**
GEOLOGIST Jack McKenna	264159.0'	1066921.2 / 335.4' NAVD 88	
DATE 12/15/2011	NH State 84 (ft)	NH State 84 (ft) / Ground Surface	

DEPTH (feet bgs)	Elev (feet)	SAMPLE NO.	BLOWS / 6"	SAMPLE INTERVAL (feet bgs)	PID-VOC Headspace (ppm)	STRATA DESCRIPTION	STRATA CHANGE	Notes
	335.4'	S-1	5/6/7/6	0 – 2.0'	NA	0 - 0.5' Dark Brown, Silty SAND, some roots 0.5' - 2.0' Brown, loose, fine to med SAND, dry	*TOPSOIL* ELEV 334.9'	
1								
2								
3								
4							*GLACIAL OUTWASH*	
5	330.4'	S-2	7/7/7/9	5.0' – 7.0'		5.0' - 7.0' Gray, fine to med SAND, dry		
6								
7								
8								
9						Encounter gravel/boulders @ 8.5' bgs		
10	325.4	S-3	23/25/25/54	10.0' – 12.0'		10.0' - 12.0' Gray, gravelly SAND		
11								
12								
13								
14							ELEV 321.4'	
15	320.4	S-4	42/54/34/25	15.0' – 17.0'		15.0' - 17.0' Gray, fine Silty SAND, some clay, rx	*TILL*	
16								
17								
18								
19								
20	315.4			20.0'				

HYDROTERRA Environmental Services	**PROJECT:** Suncook River - Geophysical Project				**BORING NO.** **HT-5**
272 1/2 Dover Point Rd., Dover, NH	**LOCATION:**				**SHEET** 2 of 2
CONTRACTOR New Hampshire Boring					**FILE NO.**
DRILLING METHOD Wash and Drive	**Northing**	**Easting**		**Boring Elev. (ft)**	**Location**
GEOLOGIST Jack McKenna	264159.0'	1066921.2		335.4' NAVD 88	
DATE 12/15/2011	NH State 84 (ft)	NH State 84 (ft)		Ground Surface	

DEPTH (feet bgs)	Elev (feet)	SAMPLE NO.	BLOWS / 6"	SAMPLE INTERVAL (feet bgs)	PID-VOC Headspace (ppm)	STRATA DESCRIPTION	STRATA CHANGE	Notes
	315.4'	S-5	46/43/40/60-3"	20	NA		*TILL*	
21						**20.0' - 21.0' Gray, fine Silty SAND, some clay, rx frags**		
						21.0' - 22.0' Gray, med, SAND	ELEV 314.4'	
22				22.0'				
23								
24								
25	310.4'			25.0'			*FLUVIAL*	
		S-6	38/45/46/55			**25.0' - 27.0' Gray, fine Silty SAND**		
26								
27				27.0'				
28								
29								
30	305.4			30.0'				
		S-7	23/25/25/54			**30.0' - 32.0' Gray, fine Sandy SILT**		
31								
32				32.0'				
						END OF BORING @ 32.0' bgs		
33								
34								
35								
36								
37								
38								
39								
40								

HYDROTERRA Environmental Services	**PROJECT:** Suncook River - Geophysical Project				**BORING NO.** **HT-6**
272 1/2 Dover Point Rd., Dover, NH	**LOCATION:**				**SHEET** 1 of 2
CONTRACTOR New Hampshire Boring					**FILE NO.**
DRILLING METHOD Wash and Drive	**Northing**	**Easting**		**Boring Elev. (ft)**	**Location**
GEOLOGIST Jack McKenna	264085.9'	1066877.1		332.8' NAVD 88	
DATE 12/15/2011	NH State 84 (ft)	NH State 84 (ft)		Ground Surface	

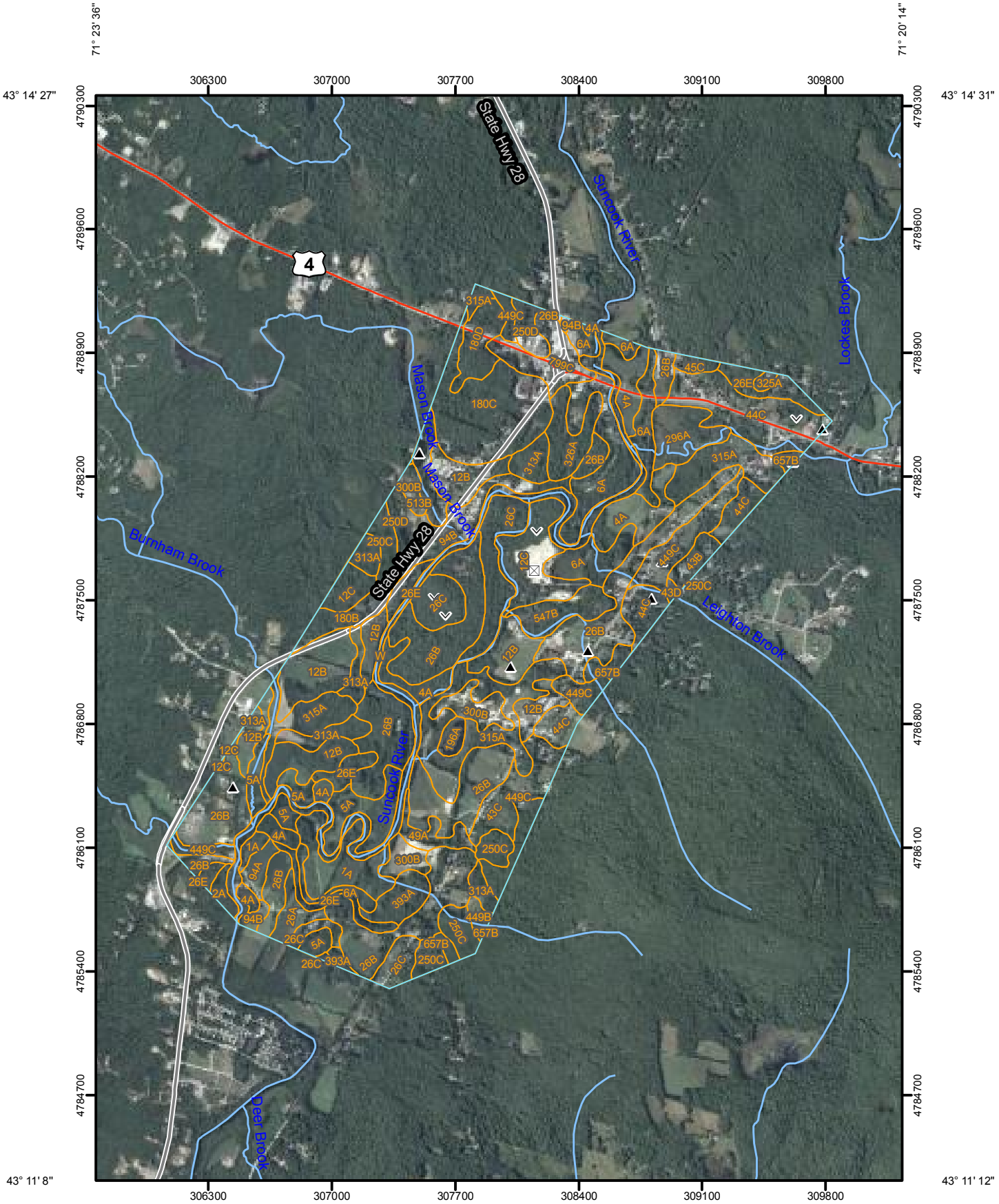
DEPTH (feet bgs)	Elev (feet)	SAMPLE NO.	BLOWS / 6"	SAMPLE INTERVAL (feet bgs)	PID-VOC Headspace (ppm)	STRATA DESCRIPTION	STRATA CHANGE	Notes
	332.8'	S-1	2/2/6/5	0	NA	0 - 0.5' Dark Brown, Silty SAND, some roots	*TOPSOIL* ELEV 332.3'	
1						0.5' - 2.0' Brown, loose, fine to med SAND, dry		
2				2.0'				
3								
4								
5	327.8'			5.0'				
		S-2	7/9/11/13			5.0' - 7.0' Gray, fine Silty SAND, dry		
6								
7				7.0'				
8							*GLACIAL OUTWASH*	
9								
10	322.8			10.0'				
		S-3	14/22/18/21			10.0' - 12.0' Gray, fine to med SAND		
11								
12				12.0'		Coarse grained zones @ 11.5'		
13								
14								
15	317.8			15.0'				
		S-4	12/13/15/13			15.0' - 17.0' Gray, fine to med, SAND		
16								
17				17.0'				
18								
19								
20	312.8			20.0'				

HYDROTERRA Environmental Services	**PROJECT:** Suncook River - Geophysical Project				**BORING NO.** **HT-6**
272 1/2 Dover Point Rd., Dover, NH	**LOCATION:**				**SHEET** 2 of 2
CONTRACTOR New Hampshire Boring					**FILE NO.**
DRILLING METHOD Wash and Drive	**Northing**	**Easting**	**Boring Elev. (ft)**		**Location**
GEOLOGIST Jack McKenna	264085.9'	1066877.1	332.8' NAVD 88		
DATE 12/15/2011	NH State 84 (ft)	NH State 84 (ft)	Ground Surface		

DEPTH (feet bgs)	Elev (feet)	SAMPLE NO.	BLOWS / 6"	SAMPLE INTERVAL (feet bgs)	PID-VOC Headspace (ppm)	STRATA DESCRIPTION	STRATA CHANGE	Notes
	312.8'	S-5	10/11/10/12	20	NA	**20.0' - 22.0' Gray, fine to med, SAND**	***GLACIAL OUTWASH***	
21								
22				22.0'				
23								
24							ELEV **308.8'**	
25	**307.8'**			25.0'			***FLUVIAL***	
		S-6	15/13/12/15			**25.0' - 27.0' Gray, fine, Sandy SILT**		
26								
27				27.0'				
						END OF BORING @ 27.0' bgs		
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								

Appendix B: Soil classification and description obtained from the USDA NRCS.

Soil Map—Merrimack and Belknap Counties, New Hampshire
(Suncook River Avulsion Study Area)



Map Scale: 1:29,300 if printed on A size (8.5" x 11") sheet.

N

Meters: 0 250 500 1,000 1,500

Feet: 0 1,000 2,000 4,000 6,000

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Gully

Short Steep Slope

Other

Political Features

Cities

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

MAP INFORMATION

Map Scale: 1:29,300 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 19N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Merrimack and Belknap Counties, New Hampshire
Survey Area Data: Version 17, Oct 27, 2009

Date(s) aerial images were photographed: 8/28/2003; 9/10/2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Merrimack and Belknap Counties, New Hampshire (NH609)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
1A	Occum very fine sandy loam, 0 to 3 percent slopes, frequently flooded	38.0	2.2%
2A	Suncook loamy fine sand, 0 to 3 percent slopes, occasionally flooded	5.4	0.3%
4A	Pootatuck very fine sandy loam, 0 to 3 percent slopes, occasionally flooded	66.8	3.9%
5A	Rippowam very fine sandy loam, 0 to 3 percent slopes, frequently flooded	49.3	2.9%
6A	Saco mucky silt loam, 0 to 2 percent slopes, frequently flooded	98.5	5.8%
12B	Hinckley gravelly fine sandy loam, 3 to 8 percent slopes	126.1	7.4%
12C	Hinckley gravelly fine sandy loam, 8 to 15 percent slopes	52.4	3.1%
26A	Windsor loamy fine sand, 0 to 3 percent slopes	11.5	0.7%
26B	Windsor loamy fine sand, 3 to 8 percent slopes	297.7	17.5%
26C	Windsor loamy fine sand, 8 to 15 percent slopes	69.6	4.1%
26E	Windsor loamy fine sand, 15 to 60 percent slopes	43.3	2.5%
43B	Canton very fine sandy loam, 3 to 8 percent slopes, very stony	9.9	0.6%
43C	Canton very fine sandy loam, 8 to 15 percent slopes, very stony	30.6	1.8%
43D	Canton very fine sandy loam, 15 to 25 percent slopes, very stony	1.7	0.1%
44C	Montauk fine sandy loam, 8 to 15 percent slopes	91.0	5.3%
45C	Montauk fine sandy loam, 8 to 15 percent slopes, very stony	5.0	0.3%
49A	Whitman very fine sandy loam, 0 to 3 percent slopes, very stony	12.3	0.7%
94A	Agawam-Ninigret fine sandy loams, 0 to 3 percent slopes	8.3	0.5%
94B	Agawam-Ninigret fine sandy loams, 3 to 8 percent slopes	34.3	2.0%
180B	Windsor-Hollis complex, 3 to 8 percent slopes	16.9	1.0%
180C	Windsor-Hollis complex, 8 to 15 percent slopes	75.5	4.4%
180D	Windsor-Hollis complex, 15 to 35 percent slopes	21.2	1.2%
196A	Meadowsedge peat, 0 to 1 percent slopes, ponded	6.3	0.4%
250C	Chatfield-Hollis-Montauk complex, 8 to 15 percent slopes, very stony	37.3	2.2%
250D	Chatfield-Hollis-Montauk complex, 15 to 35 percent slopes, very stony	22.5	1.3%
296A	Catden mucky peat, 0 to 1 percent slopes	25.8	1.5%

Merrimack and Belknap Counties, New Hampshire (NH609)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
300B	Udipsamments, 0 to 6 percent slopes	32.2	1.9%
313A	Deerfield fine sandy loam, 0 to 5 percent slopes	45.6	2.7%
315A	Mashpee sand 0 to 5 percent slopes	113.1	6.6%
325A	Scarboro mucky fine sandy loam, 0 to 1 percent slopes, very stony	2.4	0.1%
326A	Scarboro mucky fine sandy loam, 0 to 1 percent slopes	23.3	1.4%
393A	Timakwa mucky peat, 0 to 1 percent slopes	19.2	1.1%
449B	Scituate fine sandy loam, 3 to 8 percent slopes, very stony	4.3	0.3%
449C	Scituate fine sandy loam, 8 to 15 percent slopes, very stony	59.5	3.5%
513B	Ninigret fine sandy loam, 0 to 5 percent slopes	13.9	0.8%
547B	Walpole sandy loam, 3 to 8 percent slopes, very stony	21.5	1.3%
657B	Ridgebury very gravelly fine sandy loam, 3 to 8 percent slopes, very stony	13.4	0.8%
799C	Urban land-Canton complex, 0 to 15 percent slopes	28.6	1.7%
W	Water	67.1	3.9%
Totals for Area of Interest		**1,701.2**	**100.0%**