



LEBANON CONSERVATION COMMISSION
FEBRUARY 12, 2026 - 6:30 PM
COUNCIL CHAMBERS, CITY HALL OR
REMOTE VIA VIRTUAL PLATFORM
LEBANONNH.GOV/LIVE

1. Call to Order

- A. To participate in this meeting, please [join live via Microsoft Teams](#) or call 929-229-5356 (access code: 511 550 476#). If you have trouble accessing this meeting, please [email Mark Goodwin](#)

2. Approval of Minutes

- A. January 8, 2026

3. Open to the Public

4. Permit Review

- A. **City of Lebanon, Hanover Street Ext., unnamed stream** - Review and Comment on NHDES Wetland Major Impact Application for the replacement of a 60" Reinforced Concrete Pipe/Corrugated Metal Pipe with a 12' wide by 4' high open bottom box culvert. The project is located on an unnamed perennial stream. **CC2026-01 - DES #2026-00115**

5. Study Items

- A. Review of the Mascoma Lake Watershed Based Management Plan

6. Committee Reports

- A. Biodiversity Group (Invasives)
- B. Stewardship
- Ranger
 - Trail Coordinator
 - Monitors and Stewards
- C. Wild about Lebanon
- D. Amphibian Crossings
- E. LUCT/Current Use
- F. Other Subcommittees

7. Other Business

- A. FYIs
- B. Follow Up
- C. Workshops and Educational Opportunities

8. Future Agenda Items

9. Adjournment

The order of agenda items is subject to change.

Meetings are open for in-person and remote attendance. Members of the public who wish to attend remotely may do so by going to LebanonNH.gov/Live where you will find instructions on how to enter the meeting. Members of the public will be able to participate and ask questions through the City's virtual platform or by phone. Please note: Should technical difficulties occur during the meeting that disrupt virtual or phone connection(s), the meeting will continue without remote access capabilities.

Any person with a disability who wishes to attend this public meeting and needs additional accommodation, please contact the ADA coordinator at City Hall by calling 603-448-4220 at least 72 hours in advance so that the City can make any necessary arrangements.

DRAFT

LEBANON CONSERVATION COMMISSION
MEETING MINUTES
CITY COUNCIL CHAMBERS, CITY HALL
Remote Via Microsoft Teams
LebanonNH.gov/Live
January 8, 2026
6:30 PM

MEMBERS PRESENT: Sarah Riley (Chair), Bruce James (Vice Chair), Erling Heistad, Barbara Hirai, Chris Johnson, Donald Lacey, Ernst Oidtman

MEMBERS ABSENT: Susan Almy (Alt.)

STAFF PRESENT: Mark Goodwin (GIS Coordinator)

1. CALL TO ORDER:

A. Chair Riley called the meeting to order at 6:31 PM.

B. Nomination of Officers:

Conservation Commission **Chair and Vice Chair for 2026**

Mr. Erling Heistad MOVED to nominate Sarah Riley to continue as the Chair of the Conservation Commission through December 31, 2026.

Seconded by Ms. Barbara Hirai

**The MOTION was approved (6-0), 1 abstention (Riley)*

Mr. Donald Lacey MOVED to nominate Bruce James to continue as the Vice Chair of the Conservation Commission through December 31, 2026.

Seconded by Mr. Ernst Oidtman

**The MOTION was approved (6-0), 1 abstention (James)*

2. APPROVAL OF MINUTES:

A. December 11, 2025

Vice Chair Bruce James MOVED to approve the minutes as amended

Seconded by Mr. Erling Heistad

**The MOTION was approved (7-0)*

Pg. 4, Lines 17&18, include in Motion wording

Pg. 4, Lines 22-25, number 3 sections of land

Pg. 4, Line 27, remove "and power lines"

Pg. 6, Lines 13&14, remove "the transition from fossil Fuels to electric vehicles". Add the word deleterious before the word "impact"

Pg. 7, Change to Mr. Heistad for Motion and Seconded by Chair Riley

1
2
3 **3. OPEN TO THE PUBLIC:**
4

5 **4. PERMIT REVIEW:**

6 A. None
7

8 **5. STUDY ITEMS:**
9

10 A. Kleen Laundry River Restoration Project Discussion – Jon Livadas (30 minutes)
11

12 Mr. Jon Livadas started by thanking the Conservation Commission for their support of the ARM funding.
13 While they applied for approximately \$450,000, they were awarded substantially less, in an amount of
14 approximately \$250,000; they are waiting until the next meeting to see how they can “realize” that
15 money. Much of that money will be spent along the riverbank at their property, and unfortunately, they
16 will not be able to work on the nearby island. They will however be able to restore the riverbank, as well
17 as remove a 10-foot mound of bricks along with many of the invasive species there.
18

19 They are also working with DES to apply for low interest loans, to start to remediate the office building
20 and demolish that and get it off site, along with the building materials which contain PCBs . They also
21 want to start working their way into the hillside where there is contamination from offsite and onsite.
22

23 He inquired if there are any other funds, grants, etc. as he continues to search for help with the horizontal
24 site work and mostly remediation; he is open to working with anyone locally or nationally, that can help
25 provide funds to assist in cleaning up this site.
26

27 Chair Riley said they were really excited about this project as presented in their October meeting by Chris
28 Spalding, and she is glad to hear that they are interested and actively looking for other sources of funds.
29 She referenced a draft of Watershed Management Plan for Mascoma Lake, and there is a list of
30 organizations that provide relevant grant opportunities for this kind of project. She mentioned 2, the
31 Northeast Forest and River Fund (grants from \$50K to \$200K) for projects that restore and sustain
32 healthy forests and rivers through habitat restoration, stream connectivity, etc. (perhaps the island part of
33 this project would apply), and also the Five Star Urban Waters Restoration Grants program, which is a
34 National Fish and Wildlife Federation program and could apply to erosion due to unstable streambanks or
35 degraded shorelines caused by development. She will forward Mr. Livadas the Draft Management Plan so
36 that he can see the full list of resources. The Conservation Commission also mentioned several other
37 potential grant organizations in their October meeting, while reviewing this project.
38

39 She said that this is such a good project and could spread and reiterated that Con Com has funds to help
40 with the conservation component and if the island is kept in the project, this is in the Conservation
41 Commission’s wheelhouse. Mr. Livadas said that Con Com might have access to grants that his
42 organization does not have.
43

44 He said that it is imperative that this island restoration work be completed in conjunction with the
45 building project and that they cannot work their way back. Once they build the building and are in the
46 riverbank, it’s never going to make a lot of sense again to drive excavators into the river again, because
47 they would be disturbing all the work that they previously completed/spent money on.
48

49 He remains open to any ConCom ideas, and he will research the information Chair Riley is sending to
50 him regarding other possible grants.
51

1 Mr. Goodwin asked if the ARM fund award allows for them to scale this project (e.g. this is what we had
2 planned to do, you gave us X funds so we will decrease the effort to match what you have provided.). Mr.
3 Livadas said that they will discuss this in their next meeting. He thinks there was some assumption by the
4 ARM grant providers that Mr. Livadas' company, a for-profit, would use their funds for the land/island
5 restoration work, which they cannot do, since all these funds are over and above what his firm had
6 budgeted for this project. They are trying to find the right balance with this extremely expensive project,
7 and it is exceedingly hard to fundraise for, given the current economic environment nationally. They plan
8 to apply again next year for future funds, though they also let the grantors know that this cleanup for the
9 island has a limited window of time when they will be excavating, and that timeframe will be the time to
10 complete the island cleanup.

11
12 Mr. Livadas repeated his thanks to the Conservation Commission; he plans to meet with ConCom again
13 and continue to keep them updated.

14
15 B. Status Update & Review – 2026 Con Com Goals (60 minutes)

16
17 Mr. Goodwin began by saying that they need to reassess and think of what their big interests are for the
18 Conservation Commission for 2026. He shared a **DRAFT** outline of Goals for 2026 document (also in the
19 Agenda Packet) on the room screen.

20 Chair Riley encouraged all attendees to speak freely. For the remainder of today's meeting, the following
21 were discussed, with a focus on bullets/narrative in **green print**.

22
23 **Property Stewardship**

- 24 • **Forest Management Plans: review existing plans and access status of recommended action items;**
25 **evaluate the need for additional management plans where none exist, and for non-forest lands,**
26 **meadow lands (e.g. LeBron Meadows) (MP5.4b.2)**
- 27 • **Review trail maintenance infrastructure needs, e.g. footbridges, etc. (MP5.4b.2)**
- 28 • **Continued distribution & posting of signage/kiosks/map resources and include updating and/or**
29 **refreshing existing Kiosks maps (MP 5.4b.2)**
- 30 • **Invasive species management ***
- 31 • **Continue to explore access opportunities to conservation properties, including:**
32 **-Goodwin Conservation Property bridge across Great Brook**
33 **-Alana Cole ADA opportunities**
34 **-Other ADA opportunities**
35 **-Talk with the Upper Valley Trails Alliance to follow up about grant monies and get a free site**
36 **visit; possible locations -Rail Trail to DPW Switchback Trail and/or connecting Pat Welch Park**
37 **to the Northern Rail Trail.**
- 38 • **Check if Hanover is hiring a Ranger and if so, possibly partner up with them**
- 39 • **Post opportunities for Stewards on all kiosks**

40
41 The current Ranger for Lebanon has applied to graduate school so in all likelihood will not be able to
42 continue his role here. The position is still funded. Mr. Johnson posed that they could possibly find a
43 Dartmouth student especially since the pace is flexible and he will work with the Outdoor Programs
44 Office. It was noted by Mr. Heistad that this role will require some oversight.

45
46 Chair Riley shared that the Tree Advisory Board recently learned that they need to plant approximately
47 200 trees and complete a street inventory of all trees in Lebanon/West Lebanon. They might hire a
48 contractor and this board will also be looking for volunteers, along with input on ideal spots for these
49 trees.

1 Preference is for mostly native trees and trees that are known to do well in urban environments but no
2 maples or ash. Chair Riley has a list of preferred trees such as honey locust, Kentucky coffee tree,
3 hackberry, sycamore, some oaks, etc.

4
5 There was discussion about people signing up to help with property stewardship, but not all Con Com
6 members are seeing the information on who has signed up. Also, Vice Chair James cited an example of
7 having worked with 4-5 stewards who signed up and completed an orientation to a trail section with him,
8 but then never have any of them have followed through, even though they showed great enthusiasm and
9 energy. Disseminating the list(s) of people who have signed up along with a more stringent follow up
10 could prove worthwhile for this important stewardship program. Chair James has taken on this
11 responsibility of walking these areas almost daily and has completed and submitted Wikiloc Table Maps
12 to Mr. Goodwin.

13
14 Mr. Lacey suggested they talk with people that they see regularly on these trails and that could be an
15 obvious opportunity of potential stewards of specific areas. Mr. Goodwin said that they need to spread a
16 wider net for finding volunteer stewards.

17
18 Mr. Goodwin said that ConCom has already budgeted \$10,120 for the 2026 ConCom fund, for the care of
19 land, kiosks, etc., etc. Many cities the size of Lebanon and larger, have a person dedicated to open space
20 planning. Mr. Goodwin wears many hats for the City of Lebanon, including his role as GIS Coordinator,
21 overseeing 2,000 acres, among other things, and is happy to do so, but he also acknowledged that
22 someone with more time could be beneficial to Lebanon, to focus on ConCom 2026 goals and expand
23 their capacity. The question was posed should ConCom expand the usage of their LOST FUNDS to help
24 with some of this work? Mr. Goodwin said the eyes and the ears that ConCom members already provide
25 is invaluable. Mr. Johnson offered to help Mr. Goodwin with some of the deep development (for the
26 maps/trails, adding Farnham Hill, Baker's Crossing, etc.).

27
28 *Mr. Goodwin, as staff liaison, said that there are 2 citizens willing to get herbicide education (Lynn
29 Fisher and Eric no last name provided) and he showed the expenses involved (sans the equipment and
30 chemicals, etc.) to get the licenses to apply these chemicals. The total is \$312 to cover filing applications,
31 registrations for exams, core manual, NH specific manual, Category B study materials but potentially a
32 total of \$1,000 to cover Commercial not for hire pesticide license,

33
34 ConCom agreed to allocate \$1,000 from the LOST FUND for the training and outfitting of the two
35 volunteers. Mr. Goodwin said they will come back to this to decide the details of projects, when/where
36 the work is to be done, etc., etc.

37
38 Mr. Goodwin said he will also check to see the costs involved to get some "trail counters" to see how
39 many people are walking these trails (e.g. Lakeside Trail) . This will also inform ConCom where best
40 spend their efforts on maintenance.

41
42 Mr. Heistad said that ConCom has the resources to do what he/others need to do to accomplish their
43 goals, in addition to what they are already doing to assist with invasive species, conserve lands, and
44 reporting their feedback to Mr. Goodwin/ConCom – being the boots on the ground as they walk these
45 trails.

46
47 It was noted there can be other work done, that is not listed above.

48 49 **Education/Outreach**

- 50
51
 - Explore Water Resource Education & Protection Initiatives

- 1 -Participation in the 2025 Mascoma Watershed Planning Study (the lakes watershed)
- 2 • Continued support for Wild About Lebanon (MP 5.6a.5) (SP5.7.1)
- 3 -Explore having theme-based outings with a naturalist, ecologist, botanist, etc. Partner with
- 4 other organizations/municipalities
- 5 • Host Amphibian Crossing Program (SP5.9.4) (Mr. Johnson will update these maps prior to their
- 6 February meeting).
- 7 • Host biennial Mascoma River clean up (every 2 years)- June or July 2026 (SP5.8.3)
- 8 • Participation with the Upper Valley Forest Health Work Group
- 9 • Increased awareness and encouragement for land protection (MP 5.6a.4)
- 10 -Note: updated CoL ConCom Program Web Page
- 11 -Chair Riley said there is ample opportunity for outreach to the community and information
- 12 sharing in the weekly City of Lebanon communication
- 13

14 Mr. Donald Lacey inquired if they have Wild About Lebanon scheduled for this upcoming year. They do
15 not and Chair Riley said that she would love to; based on lower attendance from their most recent ones,
16 she wondered if they need to infuse these with more “spice” and perhaps have some experts in to talk
17 about a specific topic. She encouraged members to brainstorm for ideas for this. They can use “Nature
18 Groupie” for advertising their events and efforts.

19
20 Mr. Chris Johnson volunteered to lead photography events and there was much enthusiasm about this as it
21 should prove to be a draw to Wild About Lebanon. He suggested they also partner with the Upper Valley
22 Photo Society. Mr. Lacey suggested AVA Gallery; these groups are connected. The goal will be to take in
23 nature in a more artistic way and look at conservation areas with an eye towards aesthetics.

24
25 Mr. Heistad commented on having a Wild About Lebanon event at the Rutter Land; they can decide who
26 best to lead this.

27
28 Chair Riley will be the point person and Con Com members can email her so that she can help organize
29 events.

30
31 Ms. Hirai said she would like for them to have a walk(s) with a focus on birds and bird walks and Mr.
32 Johnson has some ideas about who can lead these. – Martin Brook and the newly conserved Rutter lands
33 are 2 possibilities.

34
35 Mr. Goodwin had several ideas for consideration including reaching out to include other neighboring
36 conservation commissions such as Hanover and Hartford, the local Audubon Society, etc. as well as other
37 organizations and people (for example UVLT) to see what they might already have planned and consider
38 joint efforts to co-sponsor events.

39
40 He added that there is some funding available to draw speakers (e.g. wetland specialist)

41
42 Chair Riley said that she has reached out to Jay Cairelli, Director of Public Works, about the solar
43 powered digital signs (mobile) and the plan is to have them stationed at either end of Old Pine Tree
44 Cemetery Road, because there are lots of amphibians crossing at that road. She hopes they are functioning
45 and can be deployed to put these to use. It was also agreed that publicizing these crossings can help
46 increase public awareness and an opportunity to see these in real time.

47
48 Mr. Johnson committed to updating the amphibian crossing maps, using their most recent data,
49 prior to their February meeting.

Chair Riley said they might have a spring vernal pool event or meeting; historically vernal pool has been a big draw for the public.

She also said that the Hanover Conservation Commission is working on creating a gathering for some other Upper Valley Conservation Commissions, possibly as early as late Winter or early Spring 2026.

Land Conservation

- Expand the conservation land portfolio within the City of Lebanon (MP 5.4a.1),(SP 5.6.2) areas of interest: Starr Hill area, Mouth of the Mascoma, Bakers Crossing
- Work with the Upper Valley Land Trust regarding permanently protecting Baker's Crossing (SP 5.6.2)
- Review and modify as needed existing regulations related to OS protection (e.g. ridgeline, aquifer, steep slopes, etc.) (MP 5.2b.2 & MP 5.5a.4) Steep slopes (SP 5.9.1)
- Assess the feasibility mitigation projects as part of the Wetland Permit process
- Implement recommendations from the Northern Lebanon Study (SP 5.9.3)
- Implement recommendations from the wildlife corridor plans (SP 5.9.3)
- Examine the applicability of a vernal pool overlay district (SP 5.9.2)
- Conduct review of existing steep slope regulations (SP 5.9.1)

Miscellaneous

- Explore LOST Fund Investment Opportunities ***
- Continue to pursue participation in the NH F&G doe harvest program (SP 5.6.3)
- Innovative stormwater regulation existing in the Site Plan regulations to be migrated to the subdivision regulations as appropriate (SP 5.8.2)
- Continue to be involved in the inclusion of green infrastructure to the max extent possible for the pending Exit 18 project **ConCom request to add to the SP
- Incorporate aquatic passage and wildlife friendly designs into culvert replacement projects city-wide in line with NH Stream Crossing Initiative. (MP 5.2.22) **ConCom request to add to the SP
- Work with DPW to reduce road salt use near sensitive habitat areas. **ConCom request to add to the SP

****This account has in excess of \$1M, and it was agreed that it would be prudent to look at this account monthly, and to have statements sent to ConCom's Chair automatically. Someone will need to request this process to be automated.*

6. COMMITTEE REPORTS:

A. Biodiversity Group (Invasives)

B. Stewardship

-Ranger

-Trail Coordinator

-Monitors and Stewards

C. Wild about Lebanon

D. Amphibian Crossings

E. LUCT/Current Use

F. *Other Subcommittees – “Class 6 roads” Committee – get an update from this Committee- Ms. Riley said she would love to see this become a part of their public trail network, this important part of Lebanon history.*

7. OTHER BUSINESS:

A. FYIs

B. Follow Up

C. Workshops and Educational Opportunities

8. FUTURE AGENDA ITEMS:

9. ADJOURNMENT:

The meeting ended at 9:01PM.

Respectfully submitted,

Cinda Mersel

Recording Secretary



STANDARD DREDGE AND FILL WETLANDS PERMIT APPLICATION

Water Division / Land Resources Management /
Wetlands Bureau



[Check the status of your application](#)

RSA/Rule: RSA 482-A/Env-Wt 100-900

Applicant name: City of Lebanon		Town name: Lebanon	
Administrative Use Only	Administrative Use Only	Administrative Use Only	File No.: Check No.: Amount: Initials:

A person may request a waiver of the requirements in administrative rules Env-Wt 100-900 to accommodate situations where strict adherence to the requirements would not be in the best interest of the public or the environment but is still in compliance with RSA 482-A. A person may also request a waiver of the standards for existing dwellings over water pursuant to RSA 482-A:26, III(b). For more information, please consult the [Waiver Request Form](#).

SECTION 1 - REQUIRED PLANNING FOR ALL PROJECTS (Env-Wt 306.05; RSA 482-A:3, I(d)(2))

Please use the [Land Resources Management Permit Planning Tool \(LRMPPT\)](#), the [DataCheck Tool](#), the [Stream Crossing Initiative Data Viewer](#) or other sources to assist in identifying key features such as [Priority Resource Areas \(PRAs\)](#), [protected species or habitats](#), coastal areas, designated rivers or designated prime wetlands.

Has the required planning been completed?	☒ Yes ☐ No
Does the property contain a PRA? If yes, provide the following information:	☐ Yes ☒ No
Does the project qualify for an Impact Classification Adjustment (such as a New Hampshire Fish and Game Department (NHFG) agreement for a classification downgrade) or a Project-Type Exception (such as a Maintenance or Statutory Permit-by-Notification (SPN) project)? See Env-Wt 407.02 and Env-Wt 407.04.	☐ Yes ☒ No
Protected species or habitat?	☐ Yes ☒ No
If yes, species or habitat name(s):	☐ Yes ☒ No
DataCheck project ID number: NHB25-1833	☐ Yes ☒ No
Bog?	☐ Yes ☒ No
Floodplain wetland contiguous to a tier 3 or higher watercourse?	☒ Yes ☐ No
Designated prime wetland or duly-established 100-foot buffer?	☐ Yes ☒ No
Sand dune, tidal wetland, tidal water or undeveloped tidal buffer zone?	☐ Yes ☒ No
Is the property within a designated river corridor? If yes, provide the following information:	☐ Yes ☒ No
Name of Local River Management Advisory Committee (LAC):	☐ Yes ☒ No
A copy of the application was sent to the LAC on (mm/dd/yyyy):	☐ Yes ☒ No
For dredging projects, is the subject property contaminated?	☐ Yes ☒ No
If yes, list contaminant:	☐ Yes ☒ No
Is there potential to impact impaired waters, Class A waters or Outstanding Resource Waters?	☐ Yes ☒ No
For stream crossing projects, provide watershed size (see LRMPPT or Stream Stats): 774.4 Acres	

lrmppt@des.nh.gov or (603) 271-2147

29 Hazen Drive, PO Box 95, Concord, NH 03302-0095

des.nh.gov

SECTION 2 - PROJECT DESCRIPTION (Env-Wt 311.04(i))

Provide a description of the project and the purpose of the project, the need for the proposed impacts to jurisdictional areas, an outline of the scope of work to be performed, and whether impacts are temporary or permanent.

The project includes replacement of a 60" Reinforced Concrete Pipe/Corrugated Metal Pipe with a 12' wide by 4' high open bottom box culvert. The project is located on an unnamed perennial stream. The existing pipe and headwalls are severely deteriorated and in need of replacement. The proposed replacement will greatly enhance the continuity of the stream by increasing the opening size, providing an improved stream alignment, and creating a natural stream bottom.

SECTION 3 - PROJECT LOCATION

Separate wetland permit applications must be submitted for each municipality within which wetland impacts occur.

Address: Hanover Street Extension

Town or city: Lebanon

Tax map/block/lot/unit: n/a

U.S. Geological Survey (USGS) topo map waterbody name:

☐ n/a

unnamed stream

(Optional) Latitude / longitude in decimal degrees (to five decimal places):

SECTION 4 - APPLICANT (DESIRED PERMIT HOLDER) INFORMATION (Env-Wt 311.04(a))

If the applicant is a trust or a company, then complete with the trust or company information.

Name: City of Lebanon, Attn: Brian Vincent, P.E.

Mailing address: 193 Dartmouth College Highway

Town or city: Lebanon

State: NH

ZIP: 03766

Email address: brian.vincent@lebanonnh.gov

Phone: 603-448-3112

Electronic communication: By initialing here, I hereby authorize NHDES to communicate all matters relative to this application electronically: BV

SECTION 5 - AUTHORIZED AGENT INFORMATION (Env-Wt 311.04(c)) ☐ N/A

Last name, first name, middle initial: Vignale, Michael, S.

Company name: KV Partners, LLC

Mailing address: P.O. Box 432

Town or city: New Boston

State: NH

ZIP: 03070

Email address: mvignale@kvpllc.com

Phone: 603-731-1562

Electronic communication: By initialing here, I hereby authorize NHDES to communicate all matters relative to this application electronically: MSV

SECTION 6 - PROPERTY OWNER INFORMATION (IF DIFFERENT THAN APPLICANT) (Env-Wt 311.04(b))			
<i>If the owner is a trust or a company, then complete with the trust or company information.</i> ☐ Same as applicant			
Name:			
Mailing address:			
Town or city:		State:	ZIP:
Email address:		Phone:	
Electronic communication: By initialing here, I hereby authorize NHDES to communicate all matters relative to this application electronically:			
SECTION 7 - RESOURCE-SPECIFIC CRITERIA ESTABLISHED IN Env-Wt 400, Env-Wt 500, Env-Wt 600, Env-Wt 700, OR Env-Wt 900 HAVE BEEN MET (Env-Wt 313.01(a)(3))			
Describe how the resource-specific criteria have been met for each chapter listed above (please attach information about stream crossings, coastal resources, prime wetlands, or non-tidal wetlands and surface waters):			
Wt 400 - A Certified Wetland Scientist delineated and classified the wetlands. Wt 500 - Not applicable to this project. Wt 600 - No prime wetlands on this project. Wt 900 - Stream crossings were designed as required.			
SECTION 8 - AVOIDANCE AND MINIMIZATION			
Impacts within wetland jurisdiction must be avoided to the maximum extent practicable (Env-Wt 313.03(a)).* Any project with unavoidable jurisdictional impacts must then be minimized as described in the Wetlands Best Management Practice Techniques For Avoidance and Minimization and the Wetlands Permitting: Avoidance, Minimization and Mitigation fact sheet. For minor or major projects, a functional assessment of all wetlands on the project site is required (Env-Wt 311.03(b)(10)). * Please refer to the application checklist to ensure you have attached all documents related to avoidance and minimization, as well as functional assessment (where applicable). Use the Avoidance and Minimization Checklist, the Avoidance and Minimization Narrative, or your own avoidance and minimization narrative. <i>*See Env-Wt 311.03(b)(6) and Env-Wt 311.03(b)(10) for shoreline structure exemptions.</i>			
SECTION 9 - MITIGATION REQUIREMENT (Env-Wt 311.02)			
<i>If unavoidable jurisdictional impacts require mitigation, a mitigation pre-application meeting must occur at least 30 days but not more than 90 days prior to submitting this Standard Dredge and Fill Permit Application.</i>			
Mitigation pre-application meeting date (mm-dd-yyyy):		☒ N/A - Mitigation is not required.	
SECTION 10 - THE PROJECT MEETS COMPENSATORY MITIGATION REQUIREMENTS (ENV-WT 313.01(A)(1)C)			
<i>Confirm that you have submitted a compensatory mitigation proposal that meets the requirements of Env-Wt 800 for all permanent unavoidable impacts that will remain after avoidance and minimization techniques have been exercised to the maximum extent practicable</i>			
☐ I confirm submittal.		☒ N/A – Compensatory mitigation is not required)	

SECTION 11 - IMPACT AREA (Env-Wt 311.04(g))

For each jurisdictional area that will be or has been impacted, provide square feet (SF) and, if applicable, linear feet (LF) of impact, and note whether the impact is After-The-Fact (ATF; meaning work was started or completed without a permit).

For intermittent and ephemeral streams, LF of impact are measured along the thread of the channel. Please note, installation of a stream crossing in an ephemeral stream may be undertaken without a permit per rule Env-Wt 309.02(d); however, other dredge or fill impacts should be included below.

For perennial streams/ivers, LF of impact are calculated by summing the lengths of disturbances to the channel and banks.

Permanent (PERM) impacts are impacts that will remain after the project is complete (e.g., changes in grade or surface materials). Temporary (TEMP) impacts are impacts not intended to remain (and will be restored to pre-construction conditions) after the project is completed.

JURISDICTIONAL AREA		PERM. SF	PERM. LF	PERM. ATF	TEMP. SF	TEMP. LF	TEMP. ATF
Wetlands	Forested wetland	1200		☐	270		☐
	Scrub-shrub wetland			☐			☐
	Emergent wetland			☐			☐
	Wet meadow			☐			☐
	Vernal pool			☐			☐
	Designated prime wetland			☐			☐
	Duly-established 100-foot prime wetland buffer			☐			☐
Surface Water	Intermittent / ephemeral stream			☐			☐
	Perennial stream or river	727	85	☐	103	6	☐
	Lake / pond			☐			☐
	Docking - lake / pond			☐			☐
	Docking - river			☐			☐
Banks	Bank - intermittent stream			☐			☐
	Bank - perennial stream / river	119	170	☐	30	18	☐
	Bank / shoreline - lake / pond			☐			☐
Tidal	Tidal waters			☐			☐
	Tidal marsh			☐			☐
	Sand dune			☐			☐
	Undeveloped tidal buffer zone (TBZ)			☐			☐
	Previously-developed TBZ			☐			☐
	Docking - tidal water			☐			☐
TOTAL		2046	255		403	24	

SECTION 12 - APPLICATION FEE (RSA 482-A:3, I)			
☐ Minimum impact: Flat fee of \$600.			
☐ Non-enforcement related, publicly funded and supervised restoration projects, regardless of impact classification: flat fee of \$600 (refer to RSA 482-A:3, 1(c) for restrictions).			
☐ Minor or major impact fee: Calculate using the table below:			
Permanent and temporary (non-docking):	2449	SF	× \$0.60 = \$ 1469.4
Seasonal docking structure:	2449	SF	× \$3.00 = \$ 1469.4
Permanent docking structure:	2449	SF	× \$6.00 = \$ 1469.4
Projects proposing shoreline structures (including docks): add \$600.			\$ 1469.4
Total			\$ 1469.4
The application fee for minor or major impact is the above calculated total or \$600, whichever is greater.			\$ 1469.4
SECTION 13 - PROJECT CLASSIFICATION (Env-Wt 306.05) Indicate the project classification.			
☐ Minimum impact project		☐ Minor project	☒ Major project
SECTION 14 - REQUIRED CERTIFICATIONS (Env-Wt 311.11) Initial each box below to certify.			
Initials:	To the best of the signer's knowledge and belief, all required notifications have been provided.		
Initials:	The information submitted on or with the application is true, complete and not misleading to the best of the signer's knowledge and belief.		
Initials:	The signer understands that: • The submission of false, incomplete, or misleading information constitutes grounds for NHDES to: 1. Deny the application. 2. Revoke any approval that is granted based on the information. 3. If the signer is a certified wetland scientist, licensed surveyor, or professional engineer licensed to practice in New Hampshire, refer the matter to the office of professional licensure and certification established by RSA 310.		
Initials:	If the applicant is not the owner of the property, each property owner's signature shall constitute certification by the signer that he or she is aware of the application being filed and does not object to the filing.		
SECTION 15 - REQUIRED SIGNATURES (Env-Wt 311.04(d); Env-Wt 311.11)			
Signature (owner):		Print name legibly:	Date:
Signature (applicant, if different from owner):		Print name legibly:	Date:
Signature (agent, if applicable):		Print name legibly:	Date:
SECTION 16 - TOWN / CITY CLERK SIGNATURE (Env-Wt 311.04(f))			
As required by RSA 482-A:3, I(a)(1), I hereby certify that the applicant has filed four application forms, four detailed plans, and four USGS location maps with the town or city indicated below.			
Town or city clerk signature:		Print name legibly:	
Town or city:		Date:	

DIRECTIONS FOR TOWN/CITY CLERK:

Per RSA 482-A:3, I(a)(1)

1. IMMEDIATELY sign the original application form and four copies in the signature space provided above.
2. Return the signed original application form and attachments to the applicant so that the applicant may submit the application form and attachments to NHDES by mail or hand delivery.
3. IMMEDIATELY distribute a copy of the application with one complete set of attachments to each of the following bodies: the municipal conservation commission, the local governing body (board of selectmen or town/city council), and the planning board.
4. Retain one copy of the application form and one complete set of attachments and make them reasonably accessible for public review.

DIRECTIONS FOR APPLICANT:

Submit the original permit application form bearing the signature of the town/city clerk, additional materials, and the application fee to NHDES by mail or hand delivery at the address at the bottom of this page. If not filing electronically, make check or money order payable to "Treasurer – State of NH."

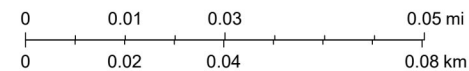
Map by NH DES OneStop Data Mapper



11/25/2025, 4:58:21 PM

- City/Town
- Parcels
- Flood Plain Wetlands Adjacent to Tier 3 Streams
- Designated Rivers Quartermile Buffer

1:1,400



Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, (c) OpenStreetMap contributors, and the GIS User Community, NHDRA, Axiomatic, Inc.



**US Army Corps
of Engineers**®
New England District

**New Hampshire General Permits (GPs)
Appendix B - Corps Secondary Impacts Checklist
(for inland wetland/waterway fill projects in New Hampshire)**

1. Attach any explanations to this checklist. Lack of information could delay a Corps permit determination.
2. All references to “work” include all work associated with the project construction and operation. Work includes filling, clearing, flooding, draining, excavation, dozing, stumping, etc.
3. See GC 5, regarding single and complete projects.
4. Contact the Corps at (978) 318-8832 with any questions.

1. Impaired Waters	Yes	No
1.1 Will any work occur within 1 mile upstream in the watershed of an impaired water? See http://des.nh.gov/organization/divisions/water/wmb/section401/impaired_waters.htm to determine if there is an impaired water in the vicinity of your work area.*		X
2. Wetlands	Yes	No
2.1 Are there are streams, brooks, rivers, ponds, or lakes within 200 feet of any proposed work?	X	
2.2 Are there proposed impacts to SAS, special wetlands. Applicants may obtain information from the NH Department of Resources and Economic Development Natural Heritage Bureau (NHB) DataCheck Tool for information about resources located on the property at https://www2.des.state.nh.us/nhb_datacheck/ . The book Natural Community Systems of New Hampshire also contains specific information about the natural communities found in NH.		X
2.3 If wetland crossings are proposed, are they adequately designed to maintain hydrology, sediment transport & wildlife passage?	X	
2.4 Would the project remove part or all of a riparian buffer? (Riparian buffers are lands adjacent to streams where vegetation is strongly influenced by the presence of water. They are often thin lines of vegetation containing native grasses, flowers, shrubs and/or trees that line the stream banks. They are also called vegetated buffer zones.)		X
2.5 The overall project site is more than 40 acres?		X
2.6 What is the area of the previously filled wetlands?	0 SF	
2.7 What is the area of the proposed fill in wetlands?	2449 SF	
2.8 What is the % of previously and proposed fill in wetlands to the overall project site?	0%	
3. Wildlife	Yes	No
3.1 Has the NHB & USFWS determined that there are known occurrences of rare species, exemplary natural communities, Federal and State threatened and endangered species and habitat, in the vicinity of the proposed project? (All projects require an NHB ID number & a USFWS IPAC determination.) NHB DataCheck Tool: https://www2.des.state.nh.us/nhb_datacheck/ USFWS IPAC website: https://ecos.fws.gov/ipac/location/index		X

3.2 Would work occur in any area identified as either “Highest Ranked Habitat in N.H.” or “Highest Ranked Habitat in Ecological Region”? (These areas are colored magenta and green, respectively, on NH Fish and Game’s map, “2010 Highest Ranked Wildlife Habitat by Ecological Condition.”) Map information can be found at: • PDF: www.wildlife.state.nh.us/Wildlife/Wildlife_Plan/highest_ranking_habitat.htm . • Data Mapper: www.granit.unh.edu . • GIS: www.granit.unh.edu/data/downloadfreedata/category/databycategory.html .		X
3.3 Would the project impact more than 20 acres of an undeveloped land block (upland, wetland/waterway) on the entire project site and/or on an adjoining property(s)?		X
3.4 Does the project propose more than a 10-lot residential subdivision, or a commercial or industrial development?		X
3.5 Are stream crossings designed in accordance with the GC 21?	X	
4. Flooding/Floodplain Values	Yes	No
4.1 Is the proposed project within the 100-year floodplain of an adjacent river or stream?		X
4.2 If 4.1 is yes, will compensatory flood storage be provided if the project results in a loss of flood storage?		X
5. Historic/Archaeological Resources		
For a minimum, minor or major impact project - a copy of the Request for Project Review (RPR) Form (www.nh.gov/nhdhr/review) with your DES file number shall be sent to the NH Division of Historical Resources as required on Page 11 GC 8(d) of the GP document**	X	

*Although this checklist utilizes state information, its submittal to the Corps is a Federal requirement.

** If your project is not within Federal jurisdiction, coordination with NH DHR is not required under Federal law.



United States Department of the Interior

FISH AND WILDLIFE SERVICE
New England Ecological Services Field Office
70 Commercial Street, Suite 300
Concord, NH 3301-5094
Phone: (603) 223-2541 Fax: (603) 223-0104



In Reply Refer To:
Project Code: 2026-0020506
Project Name: Hanover Street Culvert Replacement

11/26/2025 16:24:05 UTC

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

Updated 4/12/2023 - Please review this letter each time you request an Official Species List, we will continue to update it with additional information and links to websites may change.

About Official Species Lists

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Federal and non-Federal project proponents have responsibilities under the Act to consider effects on listed species.

The enclosed species list identifies threatened, endangered, proposed, and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested by returning to an existing project's page in IPaC.

Endangered Species Act Project Review

Please visit the “**New England Field Office Endangered Species Project Review and Consultation**” website for step-by-step instructions on how to consider effects on listed

species and prepare and submit a project review package if necessary:

<https://www.fws.gov/office/new-england-ecological-services/endangered-species-project-review>

NOTE Please do not use the **Consultation Package Builder** tool in IPaC except in specific situations following coordination with our office. Please follow the project review guidance on our website instead and reference your **Project Code** in all correspondence.

Northern Long-eared Bat - (Updated 4/12/2023) The Service published a final rule to reclassify the northern long-eared bat (NLEB) as endangered on November 30, 2022. The final rule went into effect on March 31, 2023. You may utilize the **Northern Long-eared Bat Rangewide Determination Key** available in IPaC. More information about this Determination Key and the Interim Consultation Framework are available on the northern long-eared bat species page:

<https://www.fws.gov/species/northern-long-eared-bat-myotis-septentrionalis>

For projects that previously utilized the 4(d) Determination Key, the change in the species' status may trigger the need to re-initiate consultation for any actions that are not completed and for which the Federal action agency retains discretion once the new listing determination becomes effective. If your project was not completed by March 31, 2023, and may result in incidental take of NLEB, please reach out to our office at newengland@fws.gov to see if reinitiation is necessary.

Additional Info About Section 7 of the Act

Under section 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to determine whether projects may affect threatened and endangered species and/or designated critical habitat. If a Federal agency, or its non-Federal representative, determines that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Federal agency also may need to consider proposed species and proposed critical habitat in the consultation. 50 CFR 402.14(c)(1) specifies the information required for consultation under the Act regardless of the format of the evaluation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

<https://www.fws.gov/service/section-7-consultations>

In addition to consultation requirements under Section 7(a)(2) of the ESA, please note that under sections 7(a)(1) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species. Please contact NEFO if you would like more information.

Candidate species that appear on the enclosed species list have no current protections under the ESA. The species' occurrence on an official species list does not convey a requirement to

consider impacts to this species as you would a proposed, threatened, or endangered species. The ESA does not provide for interagency consultations on candidate species under section 7, however, the Service recommends that all project proponents incorporate measures into projects to benefit candidate species and their habitats wherever possible.

Migratory Birds

In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts see:

<https://www.fws.gov/program/migratory-bird-permit>

<https://www.fws.gov/library/collections/bald-and-golden-eagle-management>

Please feel free to contact us at **newengland@fws.gov** with your **Project Code** in the subject line if you need more information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat.

Attachment(s): Official Species List

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

New England Ecological Services Field Office
70 Commercial Street, Suite 300
Concord, NH 3301-5094
(603) 223-2541

PROJECT SUMMARY

Project Code: 2026-0020506
Project Name: Hanover Street Culvert Replacement
Project Type: Culvert Repair/Replacement/Maintenance
Project Description: The project includes replacement of a 60" Reinforced Concrete Pipe/Corrugated Metal Pipe with a 12' wide by 4' high open bottom box culvert. The project is located on an unnamed perennial stream. T

Project Location:

The approximate location of the project can be viewed in Google Maps: <https://www.google.com/maps/@43.65133765,-72.25310417392652,14z>



Counties: Grafton County, New Hampshire

ENDANGERED SPECIES ACT SPECIES

There is a total of 2 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries¹, as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

-
1. [NOAA Fisheries](#), also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
Tricolored Bat <i>Perimyotis subflavus</i> No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/10515	Proposed Endangered

INSECTS

NAME	STATUS
Monarch Butterfly <i>Danaus plexippus</i> There is proposed critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/9743	Proposed Threatened

CRITICAL HABITATS

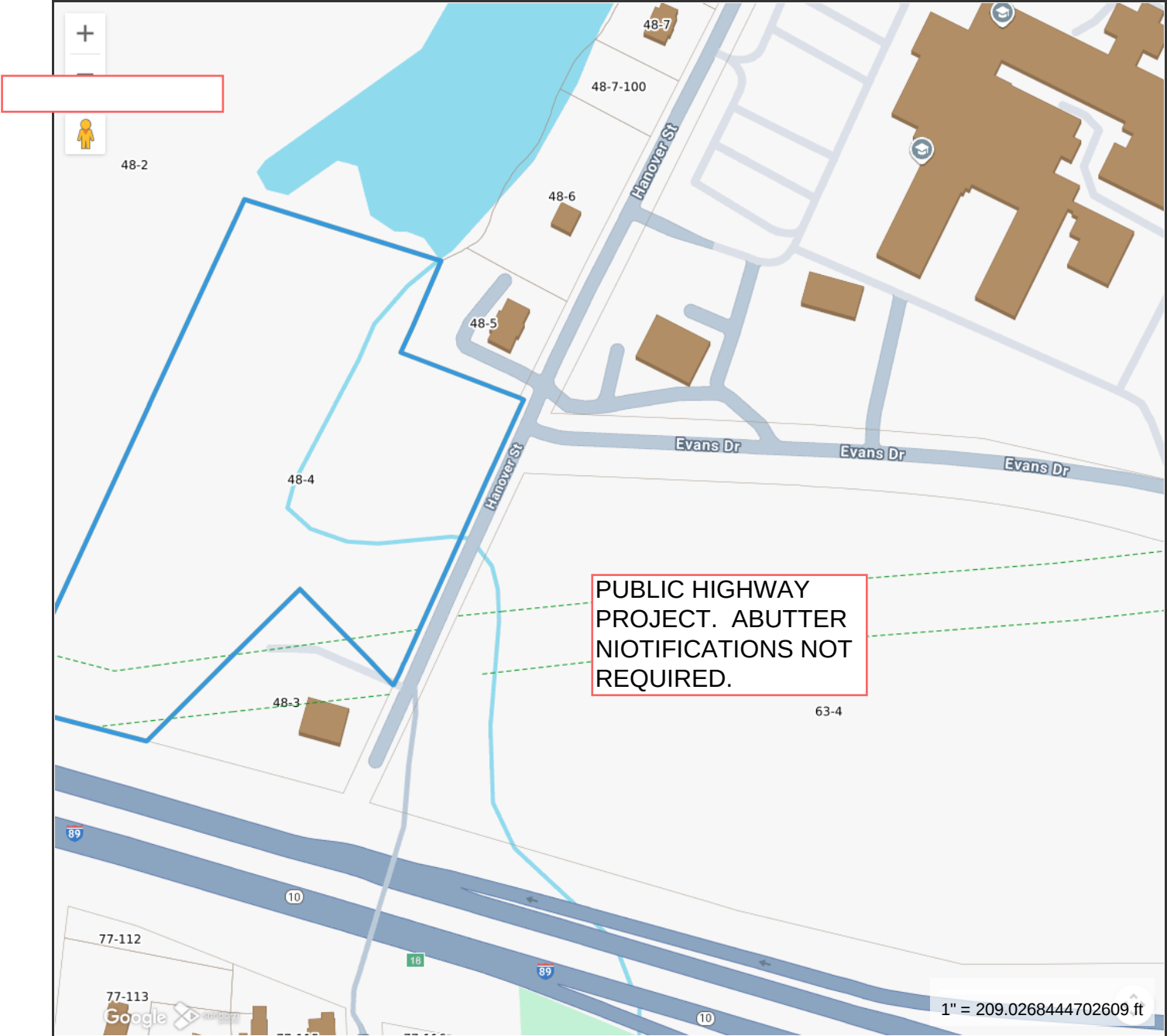
THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

IPAC USER CONTACT INFORMATION

Agency: Lebanon city
Name: Michael Vignale
Address: P.O. Box 432
City: New Boston
State: NH
Zip: 03070
Email: mvignale@kvpllc.com
Phone: 6037311562

Hanover Street Culvert Replacement



Property Information

Property ID 48-4
Location 174 HANOVER ST EXT
Owner MARCHESE RICHARD TTEE



MAP FOR REFERENCE ONLY
NOT A LEGAL DOCUMENT

City of Lebanon, NH makes no claims and no warranties, expressed or implied, concerning the validity or accuracy of the GIS data presented on this map.

Geometry updated 09/29/2025
Data updated 11/18/2018

Print map scale is approximate.
Critical layout or measurement activities should not be done using this resource.

Hanover Street Culvert Replacement - Lebanon, NH

Photos taken September 2025



Photo 1 – Looking east, downstream towards culvert inlet



Photo 2 – Looking west, upstream near culvert inlet

Hanover Street Culvert Replacement - Lebanon, NH

Photos taken September 2025



Photo 3 – Looking west, upstream at culvert outfall



Photo 4 – Looking southwest, downstream near culvert outlet

Hanover Street Culvert Replacement - Lebanon, NH

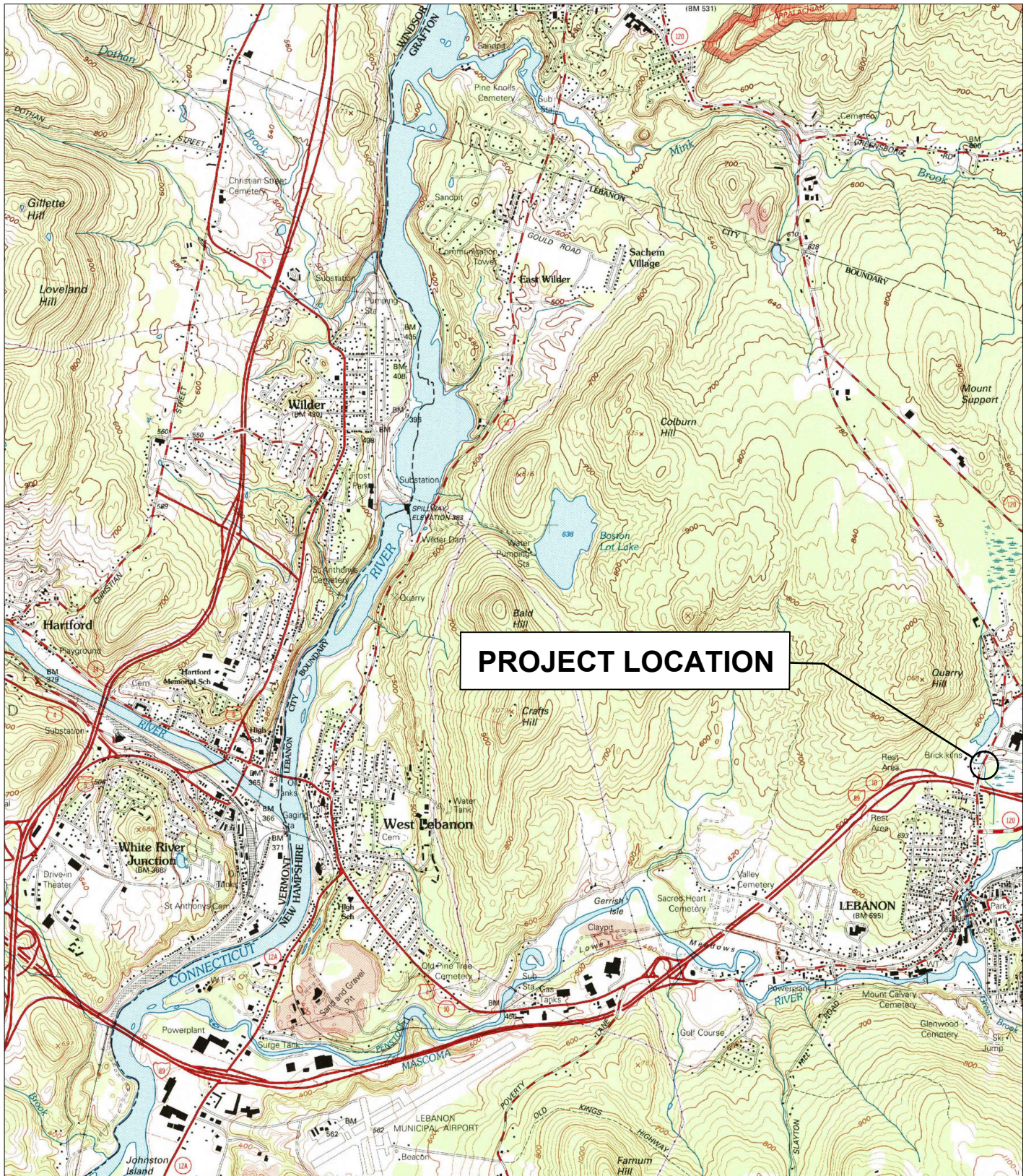
Photos taken September 2025



Photo 5 – Looking north on Hanover Street from culvert location



Photo 6 – Looking north on Hanover Street from culvert location



HANOVER STREET CULVERT - USGS MAP
LEBANON, NH

NOT TO SCALE

HANOVER STREET CULVERT – LEBANON, NH

PROJECT DESCRIPTION

Description of Previous Land Use

The area where culvert construction is proposed is located within the existing Town right of way or easements where there are currently a 60” corrugated metal/reinforced concrete pipe and paved roadway. The proposed culvert will be relocated to the south to improve the stream alignment. All work proposed is within the Town right-of-way or easements to be obtained. There have been many previous ground disturbances in the area by road construction and other private property improvements.

Project Description

- The proposed improvements include replacement of the existing 60” culvert with a 12’ span precast open bottom rigid frame structure.

Known Archeological Resources within the Project Area

There are no known archeological resources within the project area.

Work Sequence

- Notify permitting agencies that construction is going to begin and conduct a preconstruction meeting.
- Cut and clear all trees within the disturbance area unless otherwise directed by the engineer. All vegetation cleared will be removed from the site by the contractor.
- Construct temporary and permanent erosion control devices including silt fences sedimentation ponds, dewatering facilities, ponds, and any other devices specified.
- Set up dewatering and bypass pumping systems and complete existing pipe and headwall removal.
- Excavate for bridge and headwall foundations, dewater excavation as required, place foundations, construct superstructure and headwalls and backfill.
- Stabilize the site in accordance with the erosion control requirements as indicated on the plans including loaming and seeding all slopes except those directly adjacent to the roadway where gravels will be placed.
- Grade and compact the gravel and crushed gravel base courses and pave the binder course.
- Complete permanent seeding and landscaping.
- Complete final paving.

- Clean the site, drainage structures, pipes, swales, ponds, level spreaders and silt fences, of any accumulated sediment.
- After the site is fully stabilized, remove all temporary erosion control devices and restore disturbed areas as required.
- Notify permitting agencies that construction has been completed.

Coordination with Conservation Commission

- Coordination with the Conservation Commission has not been completed yet.

New Hampshire Natural Heritage Bureau

NHB DataCheck Results Letter

To: Michael S. Vignale
P.O. Box 432
New Boston, NH 03070

From: NH Natural Heritage Bureau

Date: 5/21/2025 (This letter is valid through 5/21/2026)

Re: Review by NH Natural Heritage Bureau of request dated 5/21/2025

Permit Type: Standard Dredge & Fill - Major

NHB ID: NHB25-1533

Applicant: Michael S. Vignale

Location: Lebanon
Tax Map: n/a, Tax Lot: n/a
Address: 193 Dartmouth College Highway

Proj. Description: Project includes replacement of a 72" corrugated metal pipe with an open bottom concrete box structure

The NH Natural Heritage database has been checked for records of rare species and exemplary natural communities near the area mapped below. The species considered include those listed as Threatened or Endangered by either the state of New Hampshire or the federal government. We currently have no recorded occurrences for sensitive species near this project area.

A negative result (no record in our database) does not mean that a sensitive species is not present. Our data can only tell you of known occurrences, based on information gathered by qualified biologists and reported to our office. However, many areas have never been surveyed, or have only been surveyed for certain species. An on-site survey would provide better information on what species and communities are indeed present.

Based on the information submitted, no further consultation with the NH Fish and Game Department pursuant to Fis 1004 is required.



AVOIDANCE AND MINIMIZATION CHECKLIST

Water Division/Land Resources Management Wetlands Bureau

[Check the Status of your Application](#)



RSA/Rule: RSA 482-A/ Env-Wt 311.07(c)

This checklist can be used in lieu of the written narrative required by Env-Wt 311.07(a) to demonstrate compliance with requirements for Avoidance and Minimization (A/M), pursuant to RSA 482-A:1 and Env-Wt 311.07(c).

For the construction or modification of non-tidal shoreline structures over areas of surface waters without wetland vegetation, complete only Sections 1, 2, and 4 (or the applicable sections in [Attachment A: Minor and Major Projects \(NHDES-W-06-013\)](#)).

The following definitions and abbreviations apply to this worksheet:

- “A/M BMPs” stands for [Wetlands Best Management Practice Techniques for Avoidance and Minimization](#) dated 2019, published by the New England Interstate Water Pollution Control Commission (Env-Wt 102.18).
- “Practicable” means available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes (Env-Wt 103.62).

SECTION 1 - CONTACT/LOCATION INFORMATION

APPLICANT LAST NAME, FIRST NAME, M.I.: **City of Lebanon, NH**

PROJECT STREET ADDRESS: **Hanover Street**

PROJECT TOWN: **Lebanon**

TAX MAP/LOT NUMBER: **n/a**

SECTION 2 - PRIMARY PURPOSE OF THE PROJECT

Env-Wt 311.07(b)(1)	Indicate whether the primary purpose of the project is to construct a water-access structure or requires access through wetlands to reach a buildable lot or the buildable portion thereof.	☐ Yes ☒ No
---------------------	---	---

If you answered “no” to this question, describe the purpose of the “non-access” project type you have proposed:

Culvert replacment on a Town Road

irm@des.nh.gov or (603) 271-2147

NHDES Wetlands Bureau, 29 Hazen Drive, PO Box 95, Concord, NH 03302-0095

www.des.nh.gov

SECTION 3 - A/M PROJECT DESIGN TECHNIQUES

Check the appropriate boxes below in order to demonstrate that these items have been considered in the planning of the project. Use N/A (not applicable) for each technique that is not applicable to your project.

Env-Wt 311.07(b)(2)	For any project that proposes new permanent impacts of more than one acre or that proposes new permanent impacts to a Priority Resource Area (PRA), or both, whether any other properties reasonably available to the applicant, whether already owned or controlled by the applicant or not, could be used to achieve the project's purpose without altering the functions and values of any jurisdictional area, in particular wetlands, streams, and PRAs.	☐ Check ☒ N/A
Env-Wt 311.07(b)(3)	Whether alternative designs or techniques, such as different layouts, construction sequencing, or alternative technologies could be used to avoid impacts to jurisdictional areas or their functions and values.	☐ Check ☒ N/A
Env-Wt 311.07(b)(4) Env-Wt 311.10(c)(1) Env-Wt 311.10(c)(2)	The results of the functional assessment required by Env-Wt 311.03(b)(10) were used to select the location and design for the proposed project that has the least impact to wetland functions.	☐ Check ☒ N/A
Env-Wt 311.07(b)(4) Env-Wt 311.10(c)(3)	Where impacts to wetland functions are unavoidable, the proposed impacts are limited to the wetlands with the least valuable functions on the site while avoiding and minimizing impacts to the wetlands with the highest and most valuable functions.	☒ Check ☐ N/A
Env-Wt 313.01(c)(1) Env-Wt 313.01(c)(2) Env-Wt 313.03(b)(1)	No practicable alternative would reduce adverse impact on the area and environments under the department's jurisdiction and the project will not cause random or unnecessary destruction of wetlands.	☒ Check ☐ N/A
Env-Wt 313.01(c)(3)	The project would not cause or contribute to the significant degradation of waters of the state or the loss of any PRAs.	☒ Check ☐ N/A
Env-Wt 313.03(b)(3) Env-Wt 904.07(c)(8)	The project maintains hydrologic connectivity between adjacent wetlands or stream systems.	☒ Check ☐ N/A
Env-Wt 311.10 A/M BMPs	Buildings and/or access are positioned away from high function wetlands or surface waters to avoid impact.	☐ Check ☒ N/A
Env-Wt 311.10 A/M BMPs	The project clusters structures to avoid wetland impacts.	☐ Check ☒ N/A
Env-Wt 311.10 A/M BMPs	The placement of roads and utility corridors avoids wetlands and their associated streams.	☐ Check ☒ N/A
A/M BMPs	The width of access roads or driveways is reduced to avoid and minimize impacts. Pullouts are incorporated in the design as needed.	☐ Check ☒ N/A
A/M BMPs	The project proposes bridges or spans instead of roads/driveways/trails with culverts.	☒ Check ☐ N/A

irm@des.nh.gov or (603) 271-2147

NHDES Wetlands Bureau, 29 Hazen Drive, PO Box 95, Concord, NH 03302-0095

www.des.nh.gov

A/M BMPs	The project is designed to minimize the number and size of crossings, and crossings cross wetlands and/or streams at the narrowest point.	☐ Check ☒ N/A
Env-Wt 500 Env-Wt 600 Env-Wt 900	Wetland and stream crossings include features that accommodate aquatic organism and wildlife passage.	☒ Check ☐ N/A
Env-Wt 900	Stream crossings are sized to address hydraulic capacity and geomorphic compatibility.	☒ Check ☐ N/A
A/M BMPs	Disturbed areas are used for crossings wherever practicable, including existing roadways, paths, or trails upgraded with new culverts or bridges.	☒ Check ☐ N/A
SECTION 4 - NON-TIDAL SHORELINE STRUCTURES		
Env-Wt 313.03(c)(1)	The non-tidal shoreline structure has been designed to use the minimum construction surface area over surfaces waters necessary to meet the stated purpose of the structure.	☐ Check ☒ N/A
Env-Wt 313.03(c)(2)	The type of construction proposed for the non-tidal shoreline structure is the least intrusive upon the public trust that will ensure safe navigation and docking on the frontage.	☐ Check ☒ N/A
Env-Wt 313.03(c)(3)	The non-tidal shoreline structure has been designed to avoid and minimize impacts on the ability of abutting owners to use and enjoy their properties.	☐ Check ☒ N/A
Env-Wt 313.03(c)(4)	The non-tidal shoreline structure has been designed to avoid and minimize impacts to the public's right to navigation, passage, and use of the resource for commerce and recreation.	☐ Check ☒ N/A
Env-Wt 313.03(c)(5)	The non-tidal shoreline structure has been designed, located, and configured to avoid impacts to water quality, aquatic vegetation, and wildlife and finfish habitat.	☐ Check ☒ N/A
Env-Wt 313.03(c)(6)	The non-tidal shoreline structure has been designed to avoid and minimize the removal of vegetation, the number of access points through wetlands or over the bank, and activities that may have an adverse effect on shoreline stability.	☐ Check ☒ N/A



STANDARD DREDGE AND FILL WETLANDS PERMIT APPLICATION ATTACHMENT A: MINOR AND MAJOR PROJECTS



Water Division/Land Resources Management
Wetlands Bureau

[Check the Status of your Application](#)

RSA/ Rule: RSA 482-A/ Env-Wt 311.10; Env-Wt 313.01(a)(1); Env-Wt 313.03

APPLICANT'S NAME: City of Lebanon

TOWN NAME: Lebanon

Attachment A is required for *all minor and major projects*, and must be completed *in addition* to the [Avoidance and Minimization Narrative](#) or [Checklist](#) that is required by Env-Wt 307.11.

For projects involving construction or modification of non-tidal shoreline structures over areas of surface waters having an absence of wetland vegetation, only Sections I.X through I.XV are required to be completed.

PART I: AVOIDANCE AND MINIMIZATION

In accordance with Env-Wt 313.03(a), the Department shall not approve any alteration of any jurisdictional area unless the applicant demonstrates that the potential impacts to jurisdictional areas have been avoided to the maximum extent practicable and that any unavoidable impacts have been minimized, as described in the [Wetlands Best Management Practice Techniques For Avoidance and Minimization](#).

SECTION I.I - ALTERNATIVES (Env-Wt 313.03(b)(1))

Describe how there is no practicable alternative that would have a less adverse impact on the area and environments under the Department's jurisdiction.

THE PROJECT INCLUDES REPLACEMENT OF A 60" REINFORCED CONCRETE PIPE/CORRUGATED METAL PIPE WITH A 12' WIDE BY 4' HIGH OPEN BOTTOM BOX CULVERT. THE PROJECT IS LOCATED ON AN UNNAMED PERENNIAL STREAM. THE EXISTING PIPE AND HEADWALLS ARE SEVERELY DETERIORATED AND IN NEED OF REPLACEMENT. THE PROPOSED REPLACEMENT WILL GREATLY ENHANCE THE CONTINUITY OF THE STREAM BY INCREASING THE OPENING SIZE, PROVIDING AN IMPROVED STREAM ALIGNMENT, AND CREATING A NATURAL STREAM BOTTOM.

SECTION I.II - MARSHES (Env-Wt 313.03(b)(2))

Describe how the project avoids and minimizes impacts to tidal marshes and non-tidal marshes where documented to provide sources of nutrients for finfish, crustacean, shellfish, and wildlife of significant value.

NOT APPLICABLE

SECTION I.III - HYDROLOGIC CONNECTION (Env-Wt 313.03(b)(3))

Describe how the project maintains hydrologic connections between adjacent wetland or stream systems.

HYDROLOGIC CONNECTIVITY IS ENHANCED BY REPLACING 60" CULVERT WITH A LARGER SPAN STRUCTURE.

SECTION I.IV - JURISDICTIONAL IMPACTS (Env-Wt 313.03(b)(4))

Describe how the project avoids and minimizes impacts to wetlands and other areas of jurisdiction under RSA 482-A, especially those in which there are exemplary natural communities, vernal pools, protected species and habitat, documented fisheries, and habitat and reproduction areas for species of concern, or any combination thereof.

THE NEW OPEN BOTTOM BOX CULVERT WILL BE INSTALLED IN THE ABOUT SAME LOCATION AS THE EXISTING CULVERT EXCEPT WILL BE RELOCATED SOUTHWARD TO IMPROVE STREAM ALIGNMENT. WORK IS PROPOSED UPSTREAM AND DOWNSTREAM TO MATCH THE NEW CULVERT BACK TO THE EXISTNG STREAM.

SECTION I.V - PUBLIC COMMERCE, NAVIGATION, OR RECREATION (Env-Wt 313.03(b)(5))

Describe how the project avoids and minimizes impacts that eliminate, depreciate or obstruct public commerce, navigation, or recreation.

THE STREAM IS NOT NAVIGABLE. REPLACEMENT OF THE CULVERT WILL ENSURE ACCESS TO A PUBLIC ROAD THEREBY ENHANCING PUBLIC COMMERCE AND SAFETY.

SECTION I.VI - FLOODPLAIN WETLANDS (Env-Wt 313.03(b)(6))

Describe how the project avoids and minimizes impacts to floodplain wetlands that provide flood storage.

THE CULVERT IS WITHIN A DESIGNATED FLOOD PLAIN AREA. Any fill will be fully compensated by the installation of a larger open structure and removal of soils in that newly created opening.

SECTION I.VII - RIVERINE FORESTED WETLAND SYSTEMS AND SCRUB-SHRUB – MARSH COMPLEXES (Env-Wt 313.03(b)(7))

Describe how the project avoids and minimizes impacts to natural riverine forested wetland systems and scrub-shrub – marsh complexes of high ecological integrity.

THE NEW OPEN BOTTOM BOX CULVERT WILL BE INSTALLED IN THE ABOUT SAME LOCATION AS THE EXISTING CULVERT EXCEPT WILL BE RELOCATED SOUTHWARD TO IMPROVE STREAM ALIGNMENT. WORK IS PROPOSED UPSTREAM AND DOWNSTREAM TO MATCH THE NEW CULVERT BACK TO THE EXISTING STREAM.

SECTION I.VIII - DRINKING WATER SUPPLY AND GROUNDWATER AQUIFER LEVELS (Env-Wt 313.03(b)(8))

Describe how the project avoids and minimizes impacts to wetlands that would be detrimental to adjacent drinking water supply and groundwater aquifer levels.

NO IMPACTS TO ANY PUBLIC OR PRIVATE DRINKING WATER SUPPLIES ARE EXPECTED

SECTION I.IX - STREAM CHANNELS (Env-Wt 313.03(b)(9))

Describe how the project avoids and minimizes adverse impacts to stream channels and the ability of such channels to handle runoff of waters.

THE BRIDGE WAS DESIGNED IN ACCORDANCE WITH THE STREAM CROSSING RULES (SEE ATTACHED WORKSHEET) EXCEPT WHERE A WAIVER IS REQUESTED.

SECTION I.X - SHORELINE STRUCTURES - CONSTRUCTION SURFACE AREA (Env-Wt 313.03(c)(1))

Describe how the project has been designed to use the minimum construction surface area over surface waters necessary to meet the stated purpose of the structures.

NO ADDITIONAL IMPERVOIUS AREA IS PROPOSED

SECTION I.XI - SHORELINE STRUCTURES - LEAST INTRUSIVE UPON PUBLIC TRUST (Env-Wt 313.03(c)(2))

Describe how the type of construction proposed is the least intrusive upon the public trust that will ensure safe docking on the frontage.

NOT APPLICABLE

SECTION I.XII - SHORELINE STRUCTURES – ABUTTING PROPERTIES (Env-Wt 313.03(c)(3))

Describe how the structures have been designed to avoid and minimize impacts on ability of abutting owners to use and enjoy their properties.

NOT APPLICABLE

SECTION I.XIII - SHORELINE STRUCTURES – COMMERCE AND RECREATION (Env-Wt 313.03(c)(4))

Describe how the structures have been designed to avoid and minimize impacts to the public's right to navigation, passage, and use of the resource for commerce and recreation.

NOT APPLICABLE

SECTION I.XIV - SHORELINE STRUCTURES – WATER QUALITY, AQUATIC VEGETATION, WILDLIFE AND FINFISH HABITAT (Env-Wt 313.03(c)(5))

Describe how the structures have been designed, located, and configured to avoid impacts to water quality, aquatic vegetation, and wildlife and finfish habitat.

THE CULVERT WAS DESIGNED IN ACCORDANCE WITH THE STREAM CROSSING RULES (SEE ATTACHED WORKSHEET).

SECTION I.XV - SHORELINE STRUCTURES – VEGETATION REMOVAL, ACCESS POINTS, AND SHORELINE STABILITY (Env-Wt 313.03(c)(6))

Describe how the structures have been designed to avoid and minimize the removal of vegetation, the number of access points through wetlands or over the bank, and activities that may have an adverse effect on shoreline stability.

NOT APPLICABLE.

PART II: FUNCTIONAL ASSESSMENT**REQUIREMENTS**

Ensure that project meets the requirements of Env-Wt 311.10 regarding functional assessment (Env-Wt 311.04(j); Env-Wt 311.10).

FUNCTIONAL ASSESSMENT METHOD USED:

A Waiver Request was submitted related to this requirement (attached)

NAME OF CERTIFIED WETLAND SCIENTIST (FOR NON-TIDAL PROJECTS) OR QUALIFIED COASTAL PROFESSIONAL (FOR TIDAL PROJECTS) WHO COMPLETED THE ASSESSMENT:

DATE OF ASSESSMENT:

Check this box to confirm that the application includes a NARRATIVE ON FUNCTIONAL ASSESSMENT:

☐

For minor or major projects requiring a standard permit without mitigation, the applicant shall submit a wetland evaluation report that includes completed checklists and information demonstrating the RELATIVE FUNCTIONS AND VALUES OF EACH WETLAND EVALUATED. Check this box to confirm that the application includes this information, if applicable:

☐

Note: The Wetlands Functional Assessment worksheet can be used to compile the information needed to meet functional assessment requirements.



WETLANDS RULE WAIVER OR DWELLING OVER WATER WAIVER REQUEST FORM

WATER DIVISION/LAND RESOURCES MANAGEMENT WETLANDS BUREAU



RSA/Rule: RSA 482-A/ Env-Wt 204

Administrative Use Only	Administrative Use Only	Administrative Use Only	File No.:
			Check No.:
			Amount:
			Initials:

A person may request a waiver to requirements in Rules Env-Wt 100-900 to accommodate situations where strict adherence to the requirements would not be in the best interests of the public or the environment. A person may also request a waiver of standard for existing dwellings over water pursuant to RSA 482-A:26, III (b).

SECTION 1 - PROJECT LOCATION INFORMATION (Env-Wt 204.03(c))			
ADDRESS: Hanover Street	TOWN/CITY: Lebanon	STATE: NH	ZIP CODE: 03766
TAX MAP/LOT NUMBER: n/a			
SECTION 2 - WAIVER REQUESTOR INFORMATION (Env-Wt 204.03(a))			
LAST NAME, FIRST NAME, M.I.: City of Lebanon, Attn: Brian Vincent, P.E.			
MAILING ADDRESS: 193 Dartmouth College Highway			
TOWN/CITY: Lebanon		STATE: NH	ZIP CODE: 03766
EMAIL ADDRESS (if available): brian.vincent@lebanonnh.gov or if not FAX NUMBER:		DAYTIME TELEPHONE NUMBER: 603-448-3112	
SECTION 3 - APPLICANT INFORMATION (Env-Wt 204.03(b))			
If request is being made on behalf of someone else, include the following information regarding the person being represented. If requestor is the applicant, check the following box and proceed to Section 4.			
☒ Requestor is the applicant.			
LAST NAME, FIRST NAME, M.I.:			
MAILING ADDRESS:			
TOWN/CITY:		STATE:	ZIP CODE:
EMAIL ADDRESS (if available): or if not FAX NUMBER:		DAYTIME PHONE NUMBER:	

irm@des.nh.gov or (603) 271-2147

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SECTION 4 - WAIVER INFORMATION**SECTION 4A - WAIVER TO RULE Env-Wt 100-900**

☐ N/A - If you are not requesting a rule waiver, check this box and proceed to Section 4b

Provide the number of the specific section of each rule for which a waiver is sought (Env-Wt 204.03(d)):
Env-Wt **311.10**

Provide a complete explanation of why a waiver is being requested, including an explanation of the operational and economic consequences of complying with the requirement and, if the requested waiver would extend the duration of a permit, the reason(s) why the permit holder was not able to complete the project within the specified time (Env-Wt 204.03(f)(1)):

Env-Wt 311.10 states that the applicant shall submit a wetland evaluation report that includes completed checklists and information demonstrating the relative functions and values of each wetland evaluated. This is a small culvert replacement in about the same footprint as the existing culvert (same roadway embankment area) and any changes in wetland functions is highly unlikely. Accordingly, the functional assessment will not yield additional information in consideration of this permit.

If applicable, provide a complete explanation of the alternative that is proposed to be substituted for the requirement in Env-Wt, including written documentation or data, or both, to support the alternative (Env-Wt 204.03(g)):

Not applicable

SECTION 4B – DWELLING OVER WATERS WAIVER UNDER RSA 482-A:26, III(b).

☒ N/A - If you are not requesting a standard waiver, check this box and proceed to Section 5)

Identify the specific standard to which a waiver is being requested (Env-Wt 204.03(e)):
RSA 482-A:

Provide a complete explanation of why a waiver is being requested, including a complete explanation of how the statutory criteria of RSA 482-A:26, III(b) will be met (Env-Wt 204.03(f)(2)):

SECTION 5 - ADDITIONAL WAIVER INFORMATION (Env-Wt 204.03(h); Env-Wt 204.03(i))
 (applicable to Waivers of Rules *and* Standards under RSA 482-A:26, III(b))

Indicate whether the waiver is needed for a limited duration and, if so, an estimate of when the waiver will no longer be needed (Env-Wt 204.03(h)):

Not applicable

Provide a complete explanation of why the applicant believes that having the waiver granted will meet the criteria in Env-Wt 204.05 or 204.06, as applicable (Env-Wt 204.03(i)):

The waiver will not extend the duration of the permit (Env-Wt 204.5) or result in avoidable impacts to natural resources or abutting properties (Env-Wt 204.06) because granting the waiver will not change the proposed construction.

SECTION 6 - REQUIRED CERTIFICATIONS (Env-Wt 204.04)

Initial each box and sign below to certify:

Initials: [REDACTED]	The information provided is true, complete, and not misleading to the knowledge and belief of the signer.
Initials: [REDACTED]	The signer understands that: - Any waiver granted based on false, incomplete, or misleading information shall be subject to revocation; and - He or she is subject to the penalties for falsification in official matters, currently established in RSA 641.

SECTION 7 - REQUESTOR SIGNATURE (Env-Wt 204.04)

SIGNATURE (APPLICANT): *	PRINT NAME LEGIBLY:	DATE:
[REDACTED]	[REDACTED]	[REDACTED]
SIGNATURE (REQUESTOR):	PRINT NAME LEGIBLY:	DATE:
[REDACTED]	[REDACTED]	[REDACTED]

*In lieu of an applicant signature, you may include a separate signed and dated authorization for the requestor to act on the person's behalf in connection with the request.

irm@des.nh.gov or (603) 271-2147

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WETLANDS PERMIT APPLICATION STREAM CROSSING WORKSHEET

Water Division/Land Resources Management
Wetlands Bureau



RSA/Rule RSA 482-A/ Env-Wt-900

This worksheet can be used to accompany Wetlands Permit Applications when proposing stream crossings.

SECTION 1 - TIER CLASSIFICATIONS

Determine the contributing watershed size at [USGS StreamStats](#).

Note: Plans for tier 2 and 3 crossings shall be designed and stamped by a professional engineer who is licensed under RSA 310-A to practice in New Hampshire.

Size of contributing watershed at the crossing location: **774** acres

- ☐ **Tier 1:** A tier 1 stream crossing is a crossing located on a watercourse where the contributing watershed size is less than or equal to 200 acres.
- ☐ **Tier 2:** A tier 2 stream crossing is a crossing located on a watercourse where the contributing watershed size is greater than 200 acres and less than 640 acres.
- ☒ **Tier 3:** A tier 3 stream crossing is a crossing that meets **any** of the following criteria:
- ☒ On a watercourse where the contributing watershed is more than 640 acres.
 - ☐ Within a [designated river corridor](#) unless:
 - a. The crossing would be a tier 1 stream based on contributing watershed size, or
 - b. The structure does not create a direct surface water connection to the designated river as depicted on the national hydrography dataset as found on GRANIT.
 - ☒ Within a [100-year floodplain](#) (see Section 2 below).
 - ☐ In a jurisdictional area having any protected species or habitat ([NHB DataCheck](#)).
 - ☐ In a prime wetland or within a duly-established 100-foot buffer, unless a waiver has been granted pursuant to RSA 482-A:11, IV(b) and Env-Wt 706. Review the [Wetlands Permit Planning Tool \(WPPT\)](#) for town prime wetland and prime wetland buffer maps to determine if your project is within these areas.
- ☐ **Tier 4:** A tier 4 stream crossing is a crossing located on a tidal watercourse.

SECTION 2 - 100-YEAR FLOODPLAIN

Use the [FEMA Map Service Center](#) to determine if the crossing is located within a 100-year floodplain. Please answer the questions below:

- ☐ **No:** The proposed stream crossing *is not* within the FEMA 100-year floodplain.
- ☒ **Yes:** The proposed project *is* within the FEMA 100-year floodplain. Zone = **AE**
Elevation of the 100-year floodplain at the inlet: **578** feet (FEMA El. or Modeled El.)

SECTION 3 - CALCULATING PEAK DISCHARGE

Existing 100-year peak discharge (Q) calculated in cubic feet per second (CFS): 111 CFS	Calculation method: StreamStats
Estimated bankfull discharge at the crossing location: 30 CFS	Calculation method: HydroCAD

lrn@des.nh.gov or (603) 271-2147

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➡ **Note: If tier 1, then skip to Section 10** ⬅

SECTION 4 - PREDICTED CHANNEL GEOMETRY BASED ON REGIONAL HYDRAULIC CURVES

For **tier 2, tier 3 and tier 4** crossings only.

Bankfull Width: feet Mean Bankfull Depth: feet

Bankfull Cross Sectional Area: square feet (SF)

SECTION 5 - CROSS SECTIONAL CHANNEL GEOMETRY: MEASUREMENTS OF THE EXISTING STREAM WITHIN A REFERENCE REACH

For **tier 2, tier 3 and tier 4** crossings only.

Describe the reference reach location:

Reference reach watershed size: acres

Parameter	Cross Section 1 Describe bed form riffle (e.g. pool, riffle, glide)	Cross Section 2 Describe bed form (e.g. pool, riffle, glide)	Cross Section 3 Describe bed form (e.g. pool, riffle, glide)	Range
Bankfull Width	10 feet	feet	feet	10 feet
Bankfull Cross Sectional Area	12 SF	SF	SF	12 SF
Mean Bankfull Depth	1.5 feet	feet	feet	1.5 feet
Width to Depth Ratio	6.7			6.7
Max Bankfull Depth	2 feet	feet	feet	2 feet
Flood Prone Width	50 feet	feet	feet	50 feet
Entrenchment Ratio	5.0			5

Use **Figure 1** below to determine the measurements of the Reference Reach Attributes

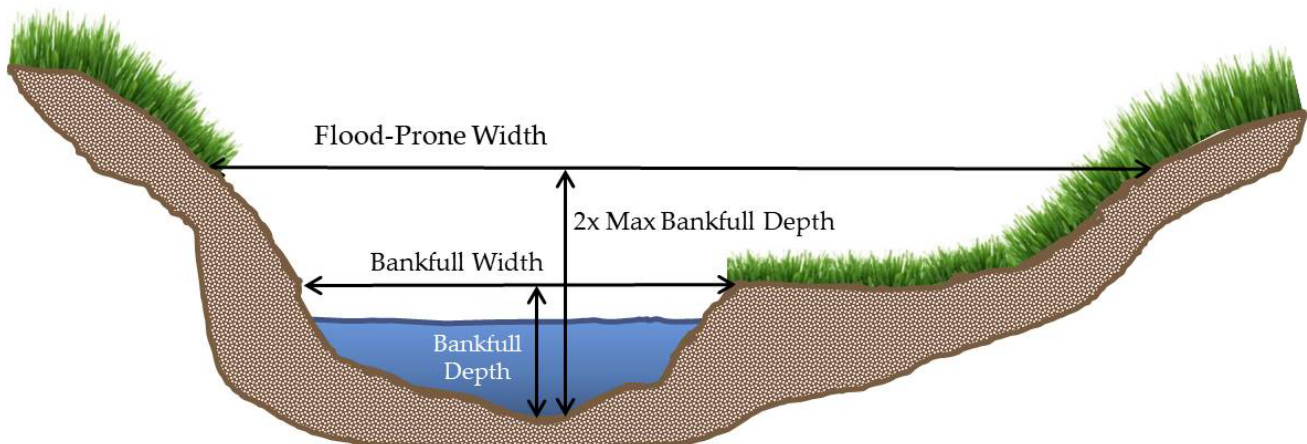


Figure 1: Determining the Reference Reach Attributes.

SECTION 6 - LONGITUDINAL PARAMETERS OF THE REFERENCE REACH AND CROSSING LOCATION

For **tier 2, tier 3 and tier 4** crossings only.

Average Channel Slope of the Reference Reach: %

Average Channel Slope at the Crossing Location: %

SECTION 7 - PLAN VIEW GEOMETRY

Note: Sinuosity is measured a distance of at least 20 times bankfull width, or 2 meander belt widths.

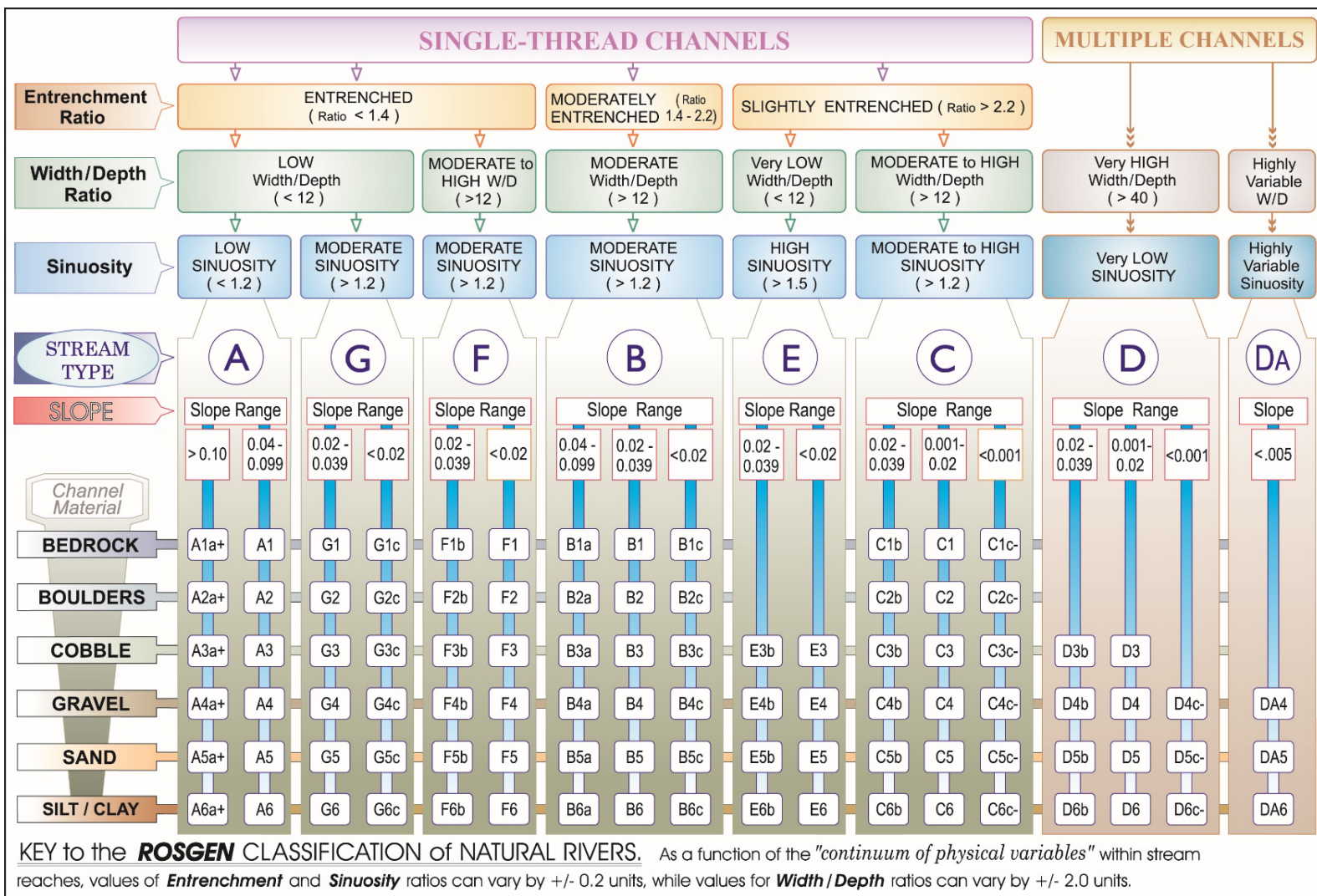
For **tier 2, tier 3 and tier 4** crossings only.

Sinuosity of the Reference Reach:

Sinuosity of the Crossing Location:

SECTION 8 - SUBSTRATE CLASSIFICATION BASED ON FIELD OBSERVATIONS*For tier 2, tier 3 and tier 4 crossings only.*

% of reach that is bedrock:	%
% of reach that is boulder:	%
% of reach that is cobble:	100 %
% of reach that is gravel:	%
% of reach that is sand:	%
% of reach that is silt:	%

SECTION 9 - STREAM TYPE OF REFERENCE REACH*For tier 2, tier 3 and tier 4 crossings only.*Stream Type of Reference Reach: **B3a**Refer to Rosgen Classification Chart (**Figure 2**) below:**Figure 2:** Reference from Applied River Morphology, Rosgen, 1996.lrn@des.nh.gov or (603) 271-2147

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SECTION 10 - CROSSING STRUCTURE METRICS

Existing Conditions	Existing Structure Type: ☐ Bridge span ☐ Pipe arch ☐ Open-bottom culvert ☒ Closed-bottom culvert ☐ Closed-bottom culvert with stream simulation ☐ Other:				
	Existing Crossing Span: <i>(perpendicular to flow)</i> 5 feet		Culvert Diameter: 5 feet Inlet Elevation: El. 574.5 feet		
	Existing Crossing Length: <i>(parallel to flow)</i> 74 feet		Outlet Elevation: El. 574.7 feet Culvert Slope: .004		
Proposed Conditions	Proposed Structure Type:	Tier 1	Tier 2	Tier 3	Alternative Design
	Bridge Span	☐	☐	☒	☐
	Pipe Arch	☐	☐		☐
	Closed-bottom Culvert	☐	☐		☐
	Open-bottom Culvert	☐	☐	☐	☐
	Closed-bottom Culvert with stream simulation	☐	☐	☐	☐
	Proposed Structure Span: 12 feet <i>(perpendicular to flow)</i>		Culvert Diameter: 6 feet Inlet Elevation: El. 574.80 feet		
	Proposed Structure Length: 90 feet <i>(parallel to flow)</i>		Outlet Elevation: El. 574.20 feet Culvert Slope: 0.0067		
Proposed Entrenchment Ratio:* 1.20 <i>For Tier 2, Tier 3 and Tier 4 Crossings Only. To accommodate the entrenchment ratio, floodplain drainage structures may be utilized.</i>					

* Note: Proposed Entrenchment Ratio must meet the minimum ratio for each stream type listed in **Figure 3**, otherwise the applicant must address the Alternative Design criteria listed in Env-Wt 904.10.

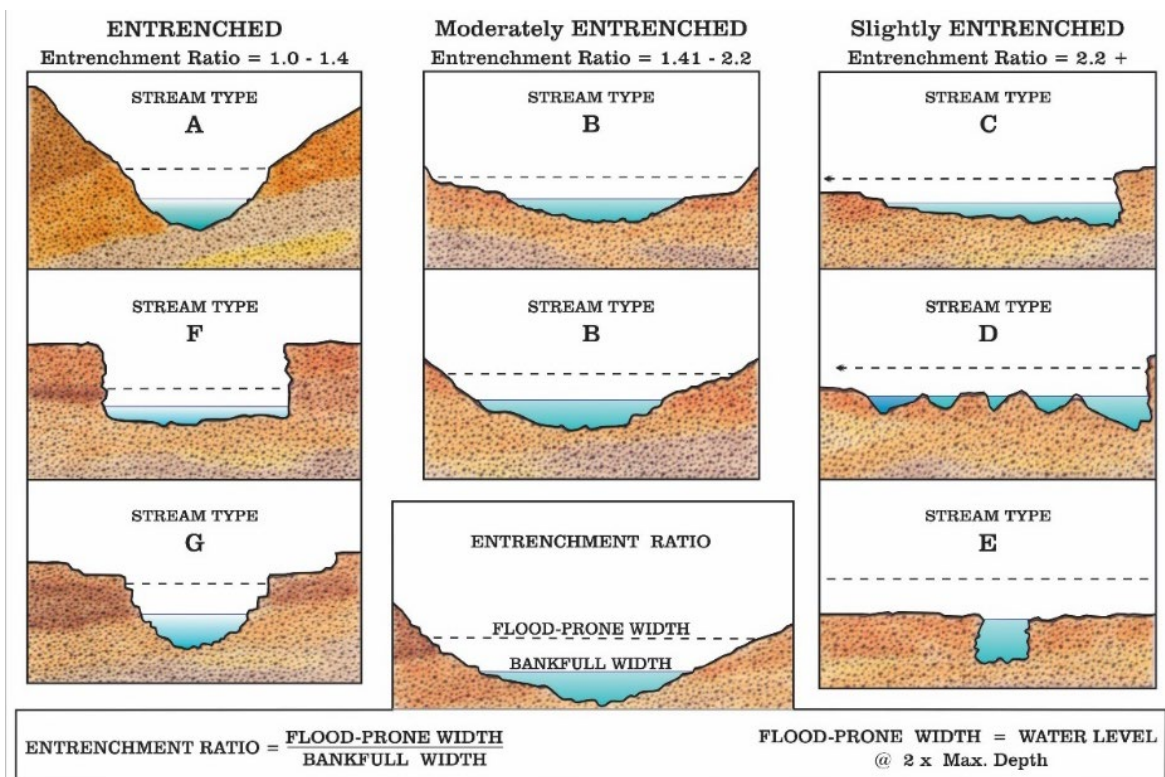


Figure 3: Reference from Applied River Morphology, Rosgen, 1996.

SECTION 11 - CROSSING STRUCTURE HYDRAULICS		
	Existing	Proposed
100 year flood stage elevation at inlet:	580.99	577.54
Flow velocity at outlet in feet per second (FPS):	6.08	5.40
Calculated 100 year peak discharge (Q) for the <i>proposed</i> structure in CFS:		111
Calculated 50 year peak discharge (Q) for the <i>proposed</i> structure in CFS:		92

SECTION 12 - CROSSING STRUCTURE OPENNESS RATIO
For tier 2, tier 3 and tier 4 crossings only.

Crossing Structure Openness Ratio* = 7.50
 * Openness box culvert = (height x width)/length
 Openness round culvert = (3.14 x radius²)/length

SECTION 13 - GENERAL DESIGN CONSIDERATIONS
 Env-Wt 904.01 requires all stream crossings to be designed and constructed according to the following requirements. Check each box if the project meets these general design considerations.

All stream crossings shall be designed and constructed so as to:

- ☒ Not be a barrier to sediment transport.
- ☒ Prevent the restriction of high flows and maintain existing low flows.
- ☒ Not obstruct or otherwise substantially disrupt the movement of aquatic life indigenous to the waterbody beyond the actual duration of construction.
- ☒ Not cause an increase in the frequency of flooding or overtopping of banks.
- ☒ Maintain or enhance geomorphic compatibility by:
 - a. Minimizing the potential for inlet obstruction by sediment, wood, or debris, and
 - b. Preserving the natural alignment of the stream channel.
- ☒ Preserve watercourse connectivity where it currently exists.
- ☒ Restore watercourse connectivity where:
 - a. Connectivity previously was disrupted as a result of human activity(ies), and
 - b. Restoration of connectivity will benefit aquatic life upstream or downstream of the crossing, or both.
- ☒ Not cause erosion, aggradation, or scouring upstream or downstream of the crossing.
- ☒ Not cause water quality degradation.

SECTION 14 - TIER-SPECIFIC DESIGN CRITERIA
 Stream crossings must be designed in accordance with the tier specific design criteria listed in Part Env-Wt 904.

☐ The proposed project meets the tier specific design criteria listed in Part Env-Wt 904 and each requirement has been addressed in the plans and as part of the wetland application.

SECTION 15 - ALTERNATIVE DESIGN

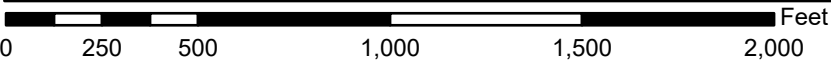
NOTE: If the proposed crossing does not meet all of the general design considerations, the tier specific design criteria, or the minimum entrenchment ratio for each given stream type listed in **Figure 3**, then an alternative design plan and associated requirements must be addressed pursuant to Env-Wt 904.10.

☒ I have submitted an alternative design and addressed each requirement listed in Env-Wt 904.10.

National Flood Hazard Layer FIRMette



72°15'31"W 43°39'16"N



1:6,000

Basemap Imagery Source: USGS National Map 2023

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) Zone A, V, A99
		With BFE or Depth Zone AE, AO, AH, VE, AR
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
		Future Conditions 1% Annual Chance Flood Hazard Zone X
		Area with Reduced Flood Risk due to Levee. See Notes. Zone X
		Area with Flood Risk due to Levee Zone D
OTHER AREAS		NO SCREEN Area of Minimal Flood Hazard Zone X
		Effective LOMRs
		Area of Undetermined Flood Hazard Zone D
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on **11/26/2025 at 7:00 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Memorandum

Project: Hanover Street Culvert Replacement - Lebanon

Subject: Alternative Design Report

From: Michael Vignale, P.E., KV Partners, LLC

Date: November 26, 2025

An alternative design is hereby requested by the City of Lebanon for the culvert on Hanover Street based on the following analysis:

Financial Comparison

- Required Structure based on Stream Crossing Worksheet (steel/concrete bridge with a 50' span) - \$1,200,000 - \$2,000,000
- Proposed Structure - \$400,000

Physical Limitations of the Site

There are no physical limitations to the site that would restrict a larger span structure from being installed other than the additional wetland impacts during construction. The alternative design is being requested since this is a replacement project and larger structures are cost prohibitive and proposed structure has adequate hydraulic capacity.

Hydraulic Analysis (see attached)

The existing 60" culvert is adequate to pass the 100-year design storm without overtopping the roadway but is in extremely poor condition. The City has no history of damage to the roadway from flooding at this location but does experience frequent sink holes due to the severe deterioration of the culvert. The proposed 12' span bridge will pass all storms up to the 100-year storm without any surcharge on the culvert headwall or overtopping the roadway.

General Design Considerations

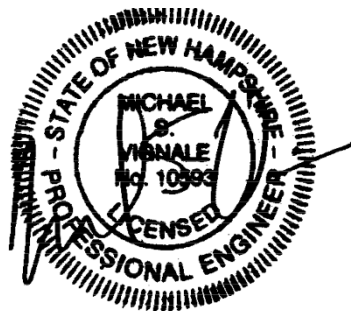
- The proposed structure will be less of a barrier to sediment transport than the existing 60" culvert since it is proposed to be a larger span open bottom box culvert with natural stream bed materials placed in the stream bed within the culvert.

- The proposed 12' span bridge will pass all storms up to the 100-year storm without any surcharge on the culvert headwall or overtopping the roadway.
- The movement of aquatic organisms indigenous to the waterbody will be greatly enhanced by the installation of the open bottom box culvert and creation of a natural streambed.
- The geomorphic compatibility will be greatly enhanced by increasing the span but will not provide the entrenchment ratio indicated in the Stream Crossing Rules. An Alternative Design is being requested for only this element of the design.
- Inlet obstruction by sediment, wood, or debris will be less likely with the larger span.
- The culvert is being relocated to the south which improves the alignment of the stream channel.
- The watercourse connectivity will be enhanced by the larger span, open bottom culvert.
- The culvert replacement will reduce erosion, aggradation, and scouring and not cause increased water quality degradation by providing a larger opening thereby reducing outlet velocities and scour potential.
- The proposed culvert will reduce stream flow velocities slightly (6.08 FPS to 5.40 FPS) compared to the existing culvert thereby reducing scour potential. Also, the relocation of the culvert to improve stream alignment and increased opening size will reduce scour potential significantly. Rip rap (covered with streambed materials) is only required within the work area to re-establish the natural streambed following construction of the new culvert and to match the wider culvert opening to the existing channel.

KV Partners LLC



Michael S. Vignale, P.E.
Principal Engineer



Hanover Street Culvert Replacement – Hydraulic Analysis

Project Description

The proposed improvements include replacement of the existing 60" diameter pipe culvert with an open bottom concrete rigid frame culvert that is 12' wide and 4' high.

The project is needed to increase hydraulic capacity and replace a deteriorating culvert prior to collapse. The new box culvert will be constructed to the south of the existing culvert to improve stream alignment. The stream bed upstream, downstream and under the box culvert will be reconstructed with riprap and rounded stones/gravel under natural riverbed materials to the maximum extent possible. Areas outside the streambed will be stabilized with rip-rap top dressed with rounded stones and gravels to minimize any voids in the surface. The culvert was designed for the 100-year design storm.

Methodology

Overall flow rates at this location were determined by StreamStats NH (copy of the analysis is attached).

Hydraulic computations assumed the area was not inundated by the flood zone and the downstream area allowed for a free discharge. The roadway was analyzed as a weir for any potential roadway overtopping condition.

ENV-Wt 904.09(c) Discussion

1. The City of Lebanon informed KV Partners that there has been no history of flooding at this location or any history of damages to the roadway. Their interest in replacing this culvert is to replace a severely deteriorated pipe culvert.
2. (a) Replacement of a 60" corrugated metal pipe with a 12' x 4' open bottom box culvert clearly meets all the requirements of this section.
(b) Hydraulic capacity will be increased by 85%
(c) Aquatic organism passage will be maintained and enhanced by the significantly larger culvert.
(d) The culvert enhances the connectivity by creating a simulated natural streambed with an open bottom box culvert.
(e) Potential flooding of the banks will be reduced by installing the much larger culvert

Conclusions

The proposed 12' x 4' open bottom box culvert will pass all storms up to the 100-year storm without any surcharge on the culvert headwall or overtopping the roadway.

The proposed improvements increase culvert capacity by 85% (60 CFS to 111 CFS)

ATTACHMENTS

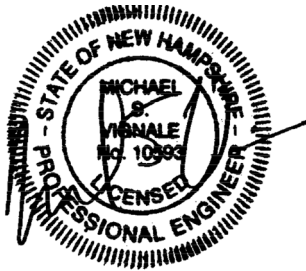
- StreamStats Report
- Existing Condition Calculations
- Proposed Condition Calculations

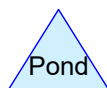
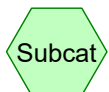
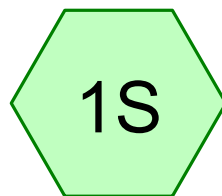
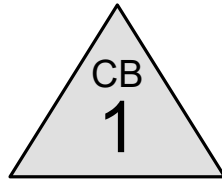
KV Partners LLC



Michael S. Vignale, P.E.

Principal Engineer





Routing Diagram for Hanover Street Ext Culvert EXISTING
Prepared by Michael Vignale, P.E., Printed 11/26/2025
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Hanover Street Ext Culvert EXISTING

Prepared by Michael Vignale, P.E.

Printed 11/26/2025

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Page 2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
500.000	36	Woods, Fair, HSG A (1S)
274.000	60	Woods, Fair, HSG B (1S)
774.000	44	TOTAL AREA

Hanover Street Ext Culvert EXISTING

Type II 24-hr 100-year Rainfall=6.48"

Prepared by Michael Vignale, P.E.

Printed 11/26/2025

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S:

Runoff Area=774.000 ac 0.00% Impervious Runoff Depth>0.67"
Tc=200.0 min CN=44 Runoff=110.80 cfs 42.914 af

Pond 1:

Peak Elev=580.99' Inflow=110.80 cfs 42.914 af
Outflow=110.80 cfs 42.914 af

Total Runoff Area = 774.000 ac Runoff Volume = 42.914 af Average Runoff Depth = 0.67"
100.00% Pervious = 774.000 ac 0.00% Impervious = 0.000 ac

Hanover Street Ext Culvert EXISTING

Prepared by Michael Vignale, P.E.

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Type II 24-hr 100-year Rainfall=6.48"

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Summary for Subcatchment 1S:

Runoff = 110.80 cfs @ 14.91 hrs, Volume= 42.914 af, Depth> 0.67"

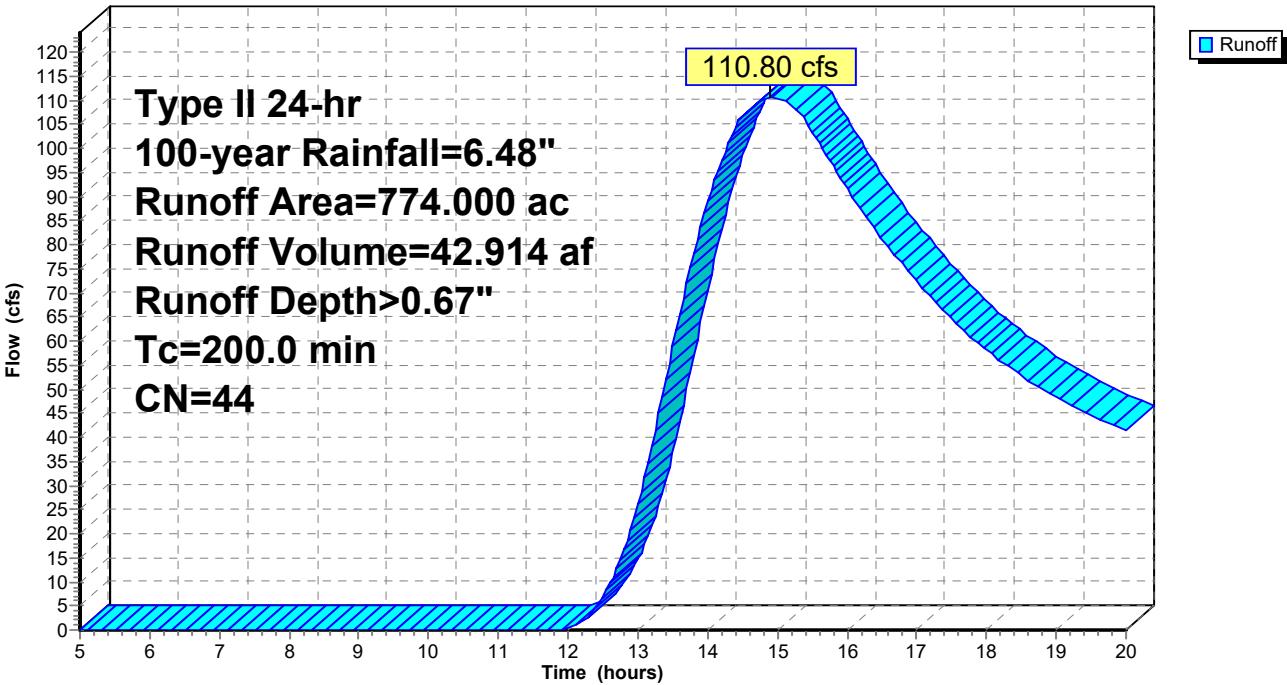
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=6.48"

Area (ac)	CN	Description
274.000	60	Woods, Fair, HSG B
500.000	36	Woods, Fair, HSG A
774.000	44	Weighted Average
774.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
200.0					Direct Entry,

Subcatchment 1S:

Hydrograph



Hanover Street Ext Culvert EXISTING

Prepared by Michael Vignale, P.E.

HydroCAD® 10.00-26 s/n 03841 © 2020 HydroCAD Software Solutions LLC

Type II 24-hr 100-year Rainfall=6.48"

Printed 11/26/2025

Page 5

Summary for Pond 1:

Inflow Area = 774.000 ac, 0.00% Impervious, Inflow Depth > 0.67" for 100-year event
Inflow = 110.80 cfs @ 14.91 hrs, Volume= 42.914 af
Outflow = 110.80 cfs @ 14.91 hrs, Volume= 42.914 af, Atten= 0%, Lag= 0.0 min
Primary = 110.80 cfs @ 14.91 hrs, Volume= 42.914 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Peak Elev= 580.99' @ 14.91 hrs

Flood Elev= 590.00'

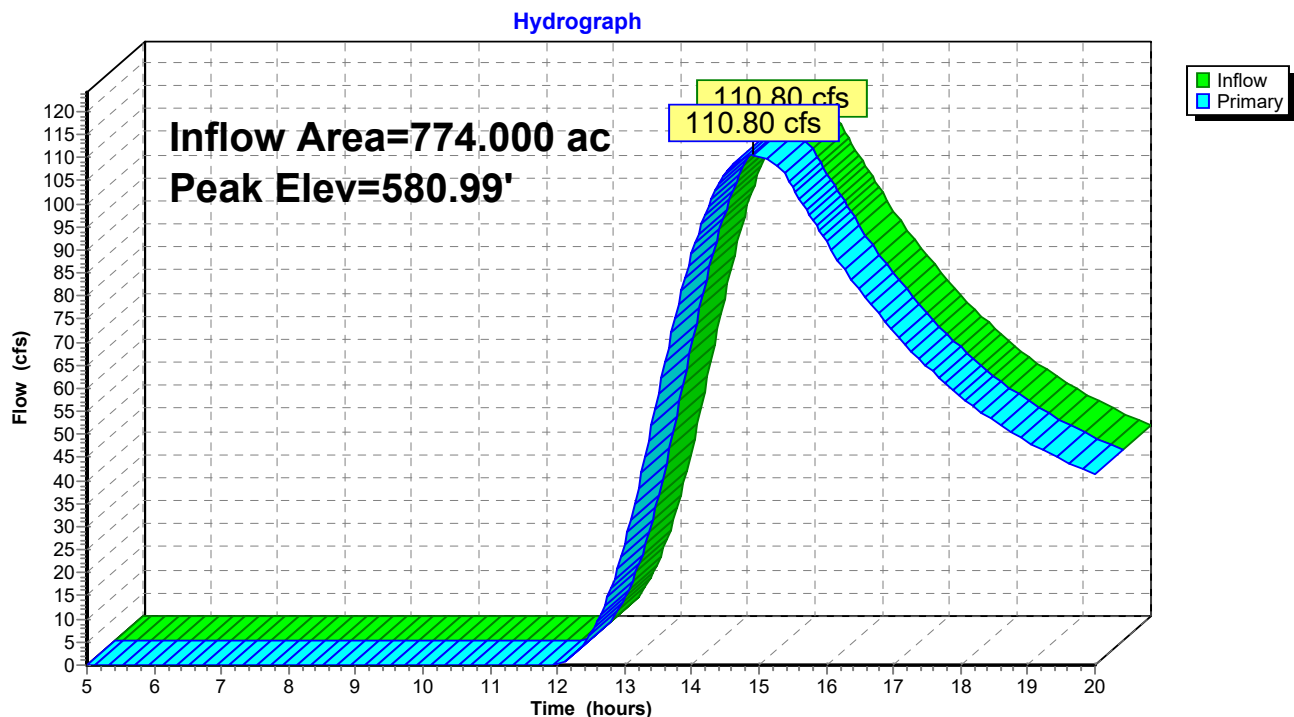
Device	Routing	Invert	Outlet Devices
#1	Primary	575.37'	60.0" Round Culvert w/ 8.0" inside fill L= 74.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 574.50' / 574.70' S= -0.0027 ' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 18.08 sf
#2	Primary	587.00'	100.0' long x 30.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

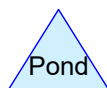
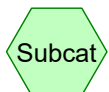
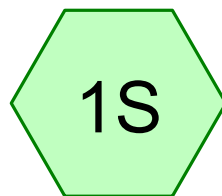
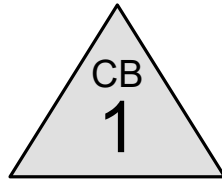
Primary OutFlow Max=109.96 cfs @ 14.91 hrs HW=580.99' (Free Discharge)

1=Culvert (Barrel Controls 109.96 cfs @ 6.08 fps)

2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 1:





Routing Diagram for Hanover Street Ext Culvert PROPOSED
Prepared by Michael Vignale, P.E., Printed 11/26/2025
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Hanover Street Ext Culvert PROPOSED

Prepared by Michael Vignale, P.E.

Printed 11/26/2025

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Page 2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
500.000	36	Woods, Fair, HSG A (1S)
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774.000	44	TOTAL AREA

Hanover Street Ext Culvert PROPOSED

Type II 24-hr 100-year Rainfall=6.48"

Prepared by Michael Vignale, P.E.

Printed 11/26/2025

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Page 3

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S:

Runoff Area=774.000 ac 0.00% Impervious Runoff Depth>0.67"
Tc=200.0 min CN=44 Runoff=110.80 cfs 42.914 af

Pond 1:

Peak Elev=577.54' Inflow=110.80 cfs 42.914 af
Outflow=110.80 cfs 42.914 af

Total Runoff Area = 774.000 ac Runoff Volume = 42.914 af Average Runoff Depth = 0.67"
100.00% Pervious = 774.000 ac 0.00% Impervious = 0.000 ac

Hanover Street Ext Culvert PROPOSED

Prepared by Michael Vignale, P.E.

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Type II 24-hr 100-year Rainfall=6.48"

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Page 4

Summary for Subcatchment 1S:

Runoff = 110.80 cfs @ 14.91 hrs, Volume= 42.914 af, Depth> 0.67"

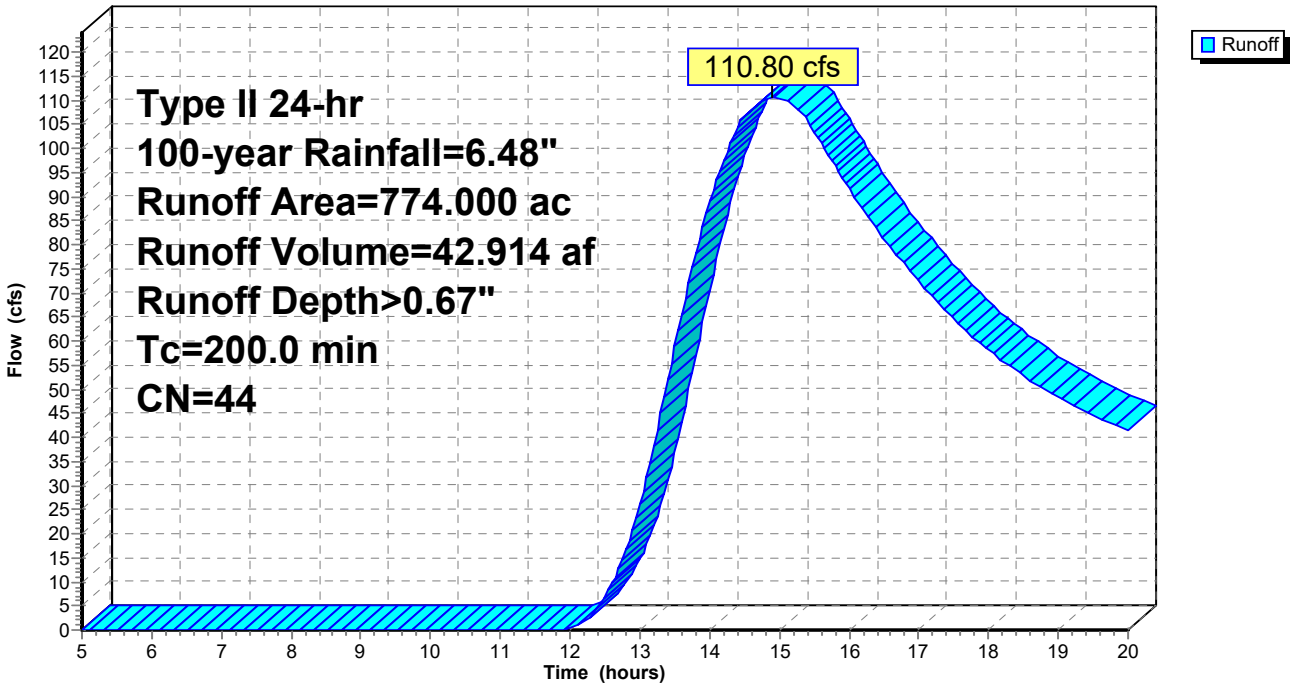
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=6.48"

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500.000	36	Woods, Fair, HSG A
774.000	44	Weighted Average
774.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
200.0					Direct Entry,

Subcatchment 1S:

Hydrograph



Hanover Street Ext Culvert PROPOSED

Prepared by Michael Vignale, P.E.

HydroCAD® 10.00-26 s/n 03841 © 2020 HydroCAD Software Solutions LLC

Type II 24-hr 100-year Rainfall=6.48"

Printed 11/26/2025

Page 5

Summary for Pond 1:

Inflow Area = 774.000 ac, 0.00% Impervious, Inflow Depth > 0.67" for 100-year event
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Primary = 110.80 cfs @ 14.91 hrs, Volume= 42.914 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Peak Elev= 577.54' @ 14.91 hrs

Flood Elev= 590.00'

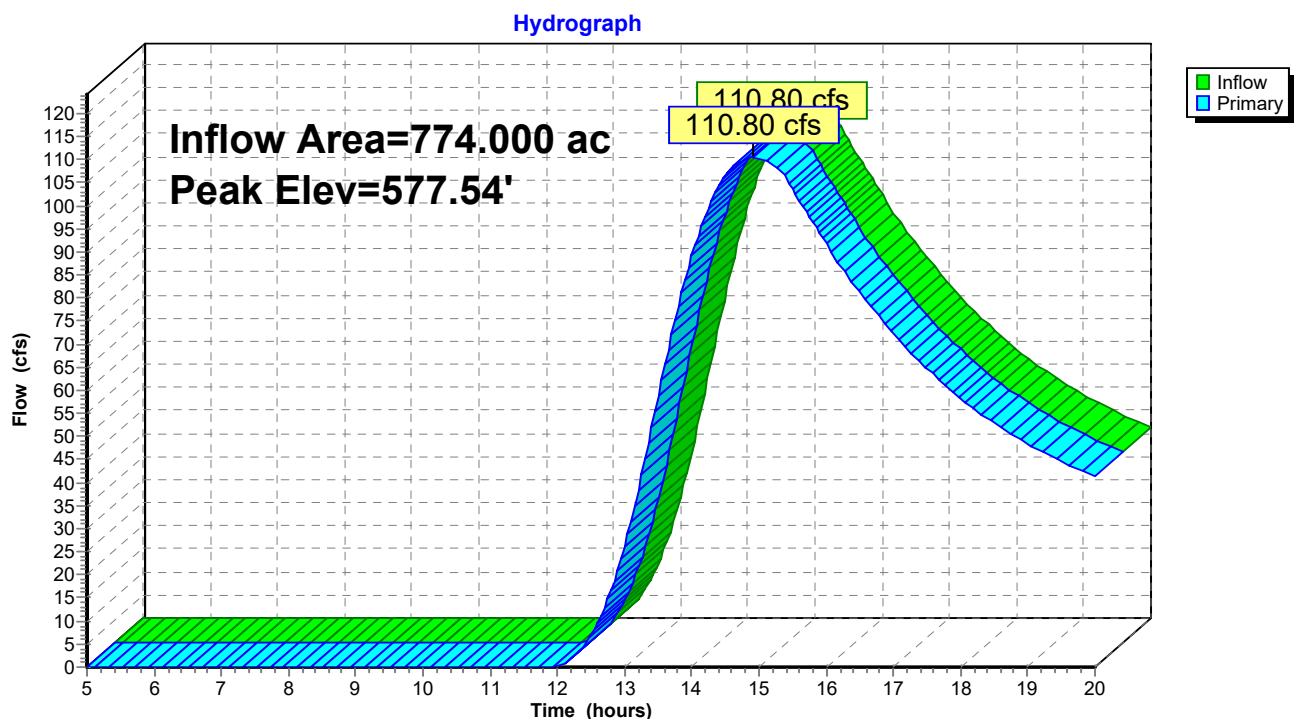
Device	Routing	Invert	Outlet Devices
#1	Primary	574.80'	120.0" W x 48.0" H Box Culvert L= 90.0' Box, 30-75° wingwalls, square crown, Ke= 0.400 Inlet / Outlet Invert= 574.80' / 574.20' S= 0.0067 ' S= 0.0067 ' Cc= 0.900 n= 0.030 Stream, clean & straight, Flow Area= 40.00 sf
#2	Primary	587.00'	100.0' long x 30.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=110.78 cfs @ 14.91 hrs HW=577.54' (Free Discharge)

1=Culvert (Barrel Controls 110.78 cfs @ 5.40 fps)

2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 1:



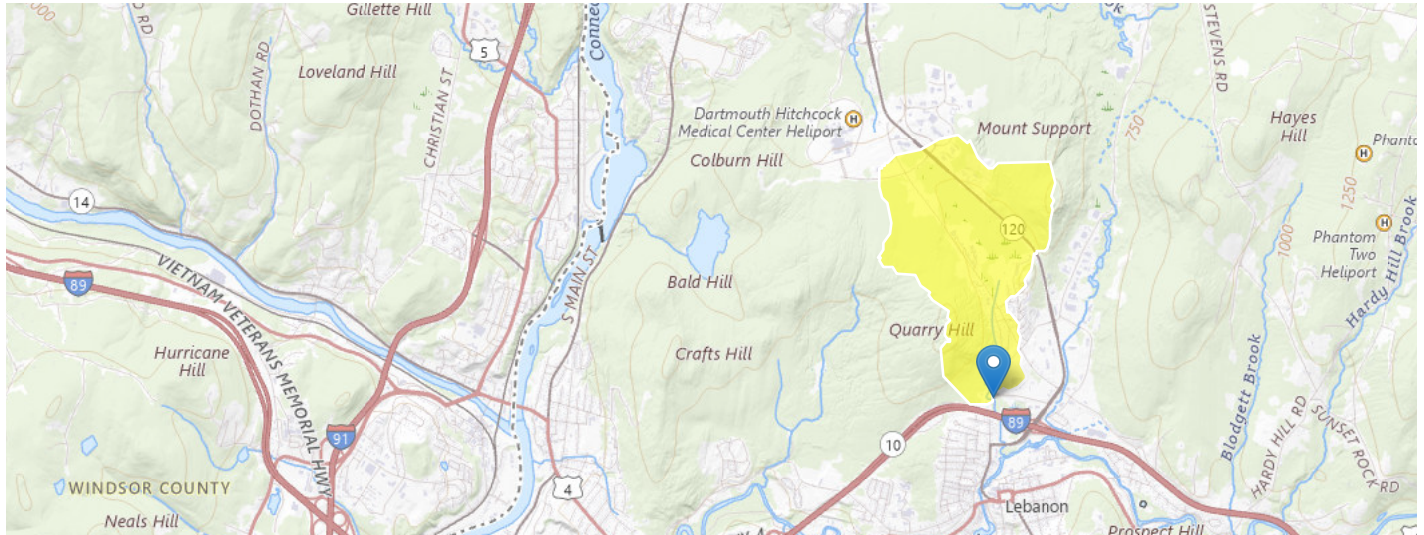
StreamStats Report

Region ID: NH

Workspace ID: NH20250514185938740000

Clicked Point (Latitude, Longitude): 43.65146, -72.25307

Time: 2025-05-14 15:00:18 -0400



[+ Collapse All](#)

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
APRAVPRE	Mean April Precipitation	3.093	inches
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	134	feet per mi
DRNAREA	Area that drains to a point on a stream	1.21	square miles
WETLAND	Percentage of Wetlands	10.7109	percent

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Peak Flow Statewide SIR2008 5206]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
APRAVPRE	Mean April Precipitation	3.093	inches	2.79	6.23
CSL10_85	Stream Slope 10 and 85 Method	134	feet per mi	5.43	543
DRNAREA	Drainage Area	1.21	square miles	0.7	1290
WETLAND	Percent Wetlands	10.7109	percent	0	21.8

Peak-Flow Statistics Flow Report [Peak Flow Statewide SIR2008 5206]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error, PC: Percent Correct, RMSE: Root Mean Squared Error, PseudoR^2: Pseudo R Squared (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp	Equiv. Yrs.
50-percent AEP flood	25.3	ft^3/s	15.3	41.9	30.1	3.2
20-percent AEP flood	41.8	ft^3/s	24.8	70.3	31.1	4.7

Statistic	Value	Unit	PIL	PIU	ASEp	Equiv. Yrs.
10-percent AEP flood	55.7	ft ³ /s	32.4	95.8	32.3	6.2
4-percent AEP flood	75.2	ft ³ /s	42.1	134	34.3	8
2-percent AEP flood	91.5	ft ³ /s	49.6	169	36.4	9
1-percent AEP flood	111	ft ³ /s	58.1	212	38.6	9.8
0.2-percent AEP flood	159	ft ³ /s	76.3	331	44.1	11

Peak-Flow Statistics Citations

Olson, S.A.,2009, Estimation of flood discharges at selected recurrence intervals for streams in New Hampshire: U.S.Geological Survey Scientific Investigations Report 2008-5206, 57 p. (<http://pubs.usgs.gov/sir/2008/5206/>)

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Application Version: 4.28.1

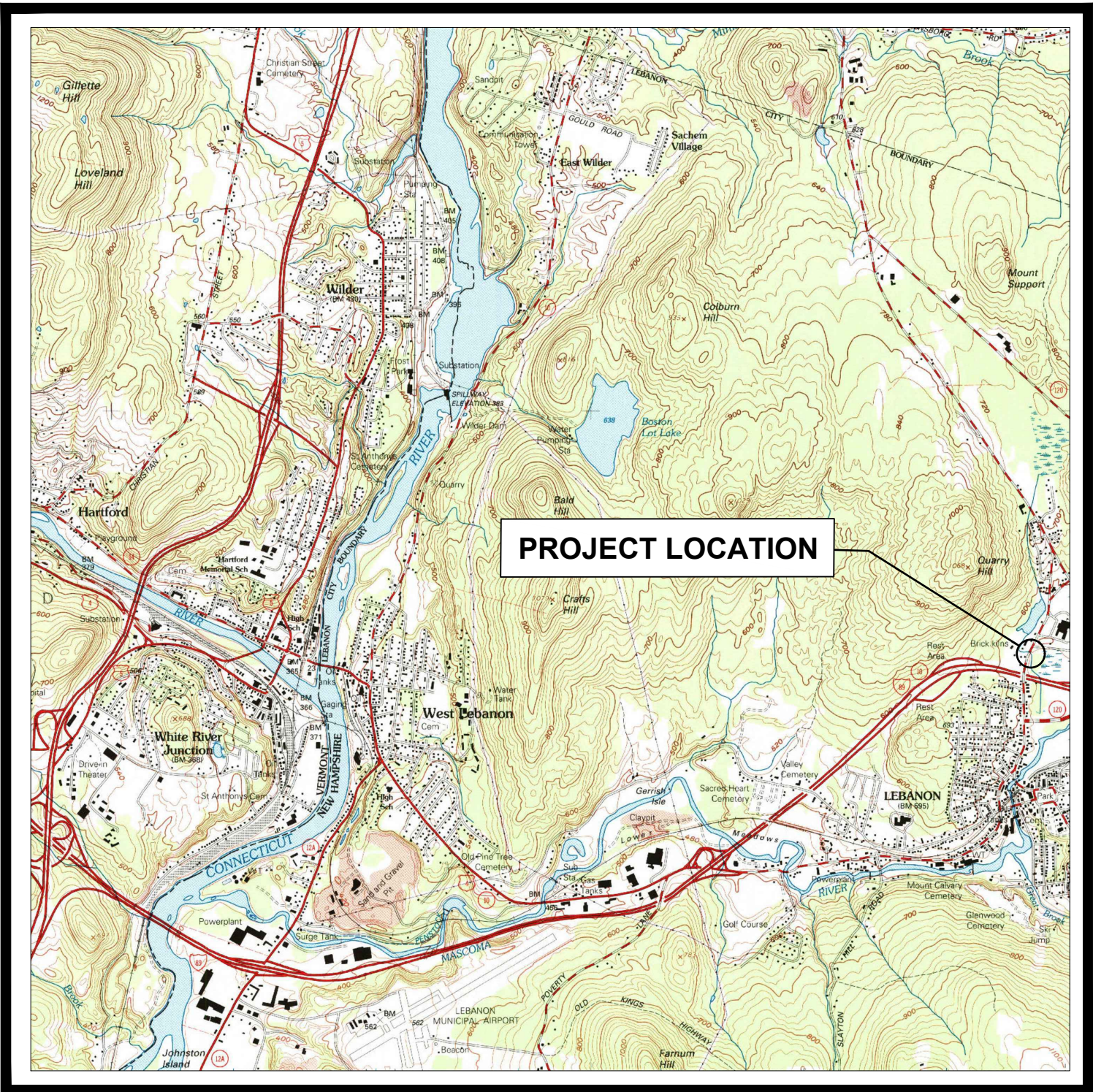
StreamStats Services Version: 1.2.22

NSS Services Version: 2.2.1

CITY OF LEBANON, NEW HAMPSHIRE
GRAFTON COUNTY
CULVERT REPLACEMENT PROJECT
(HANOVER STREET)

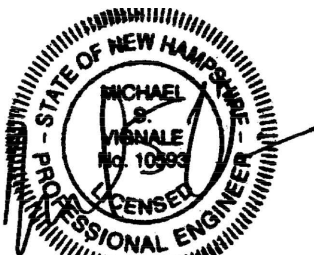
INDEX

<u>SHEET</u> <u>NO.</u>	<u>DESCRIPTION</u>
1	COVER SHEET
2	GENERAL NOTES AND LEGEND
3	EXISTING CONDITIONS PLAN
4	CONSTRUCTION PLAN
5 - 6	CONSTRUCTION DETAILS 1 - 2



Locus Map
Not to Scale

OCTOBER 2025



10-30-25

KVP*Partners* **LLC**

P.O. Box 432
New Boston, NH 03070
(603) 731-1562

GENERAL NOTES

1. THE CONTRACTOR SHALL VERIFY ALL RELEVANT ANGLES, LENGTHS, ELEVATIONS, AND INVERTS PRIOR TO CONSTRUCTION.
2. THE LOCATION OF EXISTING UTILITIES AND SUBSURFACE STRUCTURES AS SHOWN ON THE DRAWINGS ARE APPROXIMATE ONLY. THE CONTRACTOR SHALL NOTIFY THE ENGINEER AND APPROPRIATE UTILITY AUTHORITY OF ANY DISCREPANCY WITH THE DRAWINGS. NEITHER THE ENGINEER NOR THE OWNER WARRANTS OR GUARANTEES THE CONDITIONS SHOWN ON THE DRAWINGS.
3. THE CONTRACTOR SHALL VERIFY THE LOCATION OF ALL SUBSURFACE STRUCTURES AND UTILITIES THROUGH THE APPROPRIATE AGENCY. THE CONTRACTOR SHALL VERIFY THE LOCATION OF ALL EXISTING UTILITIES PRIOR TO ANY EXCAVATION. THE CONTRACTOR SHALL CALL THE DIG-SAFE CENTER (1-888-344-7233) AT LEAST 72 BUSINESS HOURS PRIOR TO ANY EXCAVATION.
4. THE CONTRACTOR SHALL COORDINATE ALL CONSTRUCTION ACTIVITIES WITH THE VARIOUS AFFECTED UTILITY AUTHORITIES TO PREVENT UNNECESSARY DELAY OF WORK OR INTERRUPTION OF SERVICES.
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTING AND SUPPORTING ALL UTILITIES DURING CONSTRUCTION AND FOR COORDINATING SUCH ACTIVITY WITH THE APPROPRIATE UTILITY AUTHORITIES. ANY UTILITY DESTROYED OR DAMAGED BY THE CONTRACTOR SHALL BE IMMEDIATELY REPAIRED OR REPLACED AS DIRECTED BY THE UTILITY AUTHORITY AT NO ADDITIONAL COST TO THE OWNER.
6. THE CONTRACTOR SHALL MAINTAIN TRAFFIC IN A SAFE MANNER AT ALL TIMES DURING CONSTRUCTION AND IN ACCORDANCE WITH THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD) AND AS REQUIRED BY THE TOWN POLICE DEPARTMENT OR THE ENGINEER. IT IS UNDERSTOOD THAT NO ROADWAYS WILL BE CLOSED AND NO DETOURS WILL BE PERMITTED TO ACCOMMODATE CONSTRUCTION AND THE CONTRACTOR SHALL PLAN THE CONSTRUCTION ACTIVITIES ACCORDINGLY.
7. THE CONTRACTOR SHALL INSTALL AND MAINTAIN ACCESS TO ALL ABUTTING PROPERTIES WITHIN THE PROJECT AREA AT ALL TIMES, UNLESS OTHERWISE APPROVED BY THE OWNER.
8. THE CONTRACTOR SHALL CONFINE ALL OPERATIONS AND ACTIVITIES FOR CONSTRUCTION PURPOSES TO THE TOWN'S RIGHT-OF-WAY, OR IN STAGING/STOCKPILE AREAS APPROVED BY THE TOWN. THE CONTRACTOR SHALL LOCATE STAGING AREAS THROUGH AGREEMENTS WITH AFFECTED PROPERTY OWNERS, OR PROVIDE ALTERNATE MEANS TO STORE MATERIAL AT THE WORK AREA AS REQUIRED.
9. DURING NON-WORKING HOURS, THE CONTRACTOR SHALL SECURE ALL EQUIPMENT AND MATERIALS WITHIN THE LIMITS OF WORK.
10. THE CONTRACTOR SHALL TAKE PHOTOGRAPHS OR A VIDEO OF THE ENTIRE PROJECT THAT PRIOR TO THE BEGINNING OF ANY WORK AT NO COST TO THE TOWN. THE PHOTOGRAPHS OR VIDEO SHALL FULLY DOCUMENT EXISTING CONDITIONS IN AND NEAR THE PROJECT AREA AND BE ARCHIVED IN THE TOWN OFFICES AND REMAIN THE PROPERTY OF THE TOWN. DIGITAL IMAGES ARE ACCEPTABLE IF IN A FORMAT THAT CAN BE VIEWED BY THE TOWN.
11. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ANY DAMAGE TO EXISTING PAVEMENT, ROADWAYS, SIGNS, CURBS, SIDEWALKS, DRIVEWAYS, MAILBOXES, FENCES, PLANTINGS OR OTHER PHYSICAL FEATURES CAUSED BY THE CONTRACTOR'S ACTIVITIES AND SHALL REPAIR THEM AT NO ADDITIONAL COST TO THE OWNER. ALL AREAS BEYOND THE LIMITS OF CONSTRUCTION WHICH ARE DISTURBED BY THE CONTRACTOR SHALL BE RESTORED TO THEIR ORIGINAL CONDITION AT NO ADDITIONAL COST TO THE OWNER.
12. THE CONTRACTOR SHALL TAKE PRECAUTIONS DURING CONSTRUCTION TO MINIMIZE THE AMOUNT OF DEBRIS THAT COLLECTS IN CATCH BASINS, CULVERTS AND MANHOLES. THE CONTRACTOR SHALL CLEAN ALL CATCH BASINS, CULVERTS AND MANHOLES AFFECTED BY CONSTRUCTION IN ORDER TO MAINTAIN AN OPERATING SYSTEM.
13. ALL EXISTING CURB, SIGNS, DRAINAGE STRUCTURES, UTILITIES AND ANY OTHER MATERIALS WITHIN THE RIGHT OF WAY THAT ARE REMOVED BY THE CONTRACTOR MAY BE INSPECTED BY THE OWNER. THE OWNER RESERVES THE RIGHT TO RETAIN OWNERSHIP AND MAY DIRECT THE CONTRACTOR TO SALVAGE AND STOCKPILE ANY SUCH EXISTING MATERIALS AT NO ADDITIONAL COST TO THE OWNER. ANY EXISTING MATERIALS THE OWNER CHOOSES NOT TO SALVAGE AND STOCKPILE SHALL BE REMOVED AND DISPOSED OF BY THE CONTRACTOR AT NO ADDITIONAL COST TO THE OWNER.
14. ALL WORK SHALL BE DONE IN ACCORDANCE WITH ALL APPLICABLE LOCAL, STATE AND FEDERAL CODES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL REQUIRED PERMITS FROM APPLICABLE GOVERNMENTAL AGENCIES, INCLUDING THE OWNER, PRIOR TO THE START OF ANY CONSTRUCTION.
15. THE CONTRACTOR IS REQUIRED TO PROVIDE ADEQUATE SHORING FOR THE SOIL CONDITIONS AND DEPTHS ENCOUNTERED DURING CONSTRUCTION.
16. IN THE EVENT THE CONTRACTOR ENCOUNTERS EXISTING MATERIAL REASONABLY BELIEVED TO BE HAZARDOUS WHICH HAS NOT BEEN RENDERED HARMLESS, THE CONTRACTOR SHALL IMMEDIATELY STOP WORK IN THE AFFECTED AREA AND REPORT THE CONDITION TO THE OWNER AND ENGINEER. WORK IN THE AFFECTED AREA SHALL NOT RESUME UNTIL WRITTEN VERIFICATION BY THE OWNER THAT THE MATERIAL HAS BEEN REMOVED OR OTHERWISE BEEN RENDERED HARMLESS.
17. THE CONTRACTOR AND ALL SUBCONSULTANTS SHALL FAMILIARIZE THEMSELVES WITH THE CONTRACT DOCUMENTS. ALL DRAWINGS OF ANY PARTICULAR TRADE SHALL BE USED IN CONJUNCTION WITH DRAWINGS OF ALL OTHER TRADES TO COORDINATE THE CONSTRUCTION. ANY DISCREPANCIES SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER BEFORE PROCEEDING WITH THE AFFECTED WORK. ANY PROPOSED CHANGES, VARIATIONS, OR SUBSTITUTIONS MUST BE REVIEWED AND ACCEPTED BY THE ENGINEER PRIOR TO IMPLEMENTATION.
18. ALL PROPOSED WORK WILL BE COMPLETED IN ACCORDANCE WITH NHDOT STANDARD SPECIFICATIONS AND DETAILS (LATEST VERSION AND ALL AMENDMENTS) UNLESS OTHERWISE NOTED ON THESE PLANS OR SPECIFIED IN THE CONTRACT DOCUMENTS.
19. IMPLEMENT THE FOLLOWING MEASURES AS A MINIMUM PRIOR TO THE WINTER SUSPENSION OF WORK:
 - a. MAINTAIN TRAFFIC ON NEW PAVEMENT WITH APPROPRIATE PAVEMENT MARKINGS FOR THE WINTER.
 - b. PAVE ALL DRIVES THAT HAVE HAD PAVEMENT REMOVED DURING CONSTRUCTION.
 - c. STABILIZE AND/OR VEGETATE ALL DISTURBED SLOPES.
 - d. REMOVE TEMPORARY TRAFFIC CONTROL BARRIERS THAT HINDER WINTER MAINTENANCE.
 - e. PRIOR TO WINTER MAINTENANCE SEASON (BEGINNING NOVEMBER 1), ARRANGE A REVIEW OF THIS PROJECT WITH THE TOWN TO ENSURE THE ROADWAY IS ACCEPTABLE FOR WINTER MAINTENANCE.

ABBREVIATIONS

R&S	REMOVE AND STOCKPILE
R&D	REMOVE AND DISPOSE
R&R	REMOVE AND RESET
SDWK.	SIDEWALK
PVMT.	PAVEMENT
PROP.	PROPOSED
STA.	ROADWAY CENTERLINE STATION
CB	CATCH BASIN
MH	MANHOLE
RCP	REINFORCED CONCRETE PIPE
CMP	CORRUGATED METAL PIPE
HDPE	HIGH DENSITY POLYETHELENE PIPE
TYP.	TYPICAL
APPROX.	APPROXIMATE
INV.	PIPE INVERT
EXIST.	EXISTING
MIN.	MINIMUM
CONC.	CONCRETE
BIT.	BITUMINOUS
WCR	WHEELCHAIR RAMP

PAVEMENT NOTES

PROPOSED PAVEMENT STRUCTURE WILL CONSIST OF THE FOLLOWING:

ROADWAYS

- 1 1/2" BIT. CONC. SURFACE COURSE
- 2 1/2" BIT. CONC. BINDER COURSE
- 6" CRUSHED GRAVEL BASE COURSE
- 12" GRAVEL BASE COURSE

DRIVEWAYS

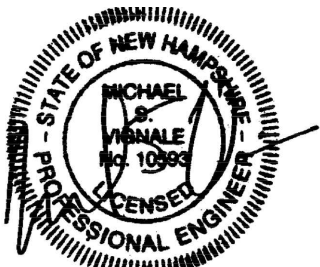
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- 6" CRUSHED GRAVEL BASE COURSE

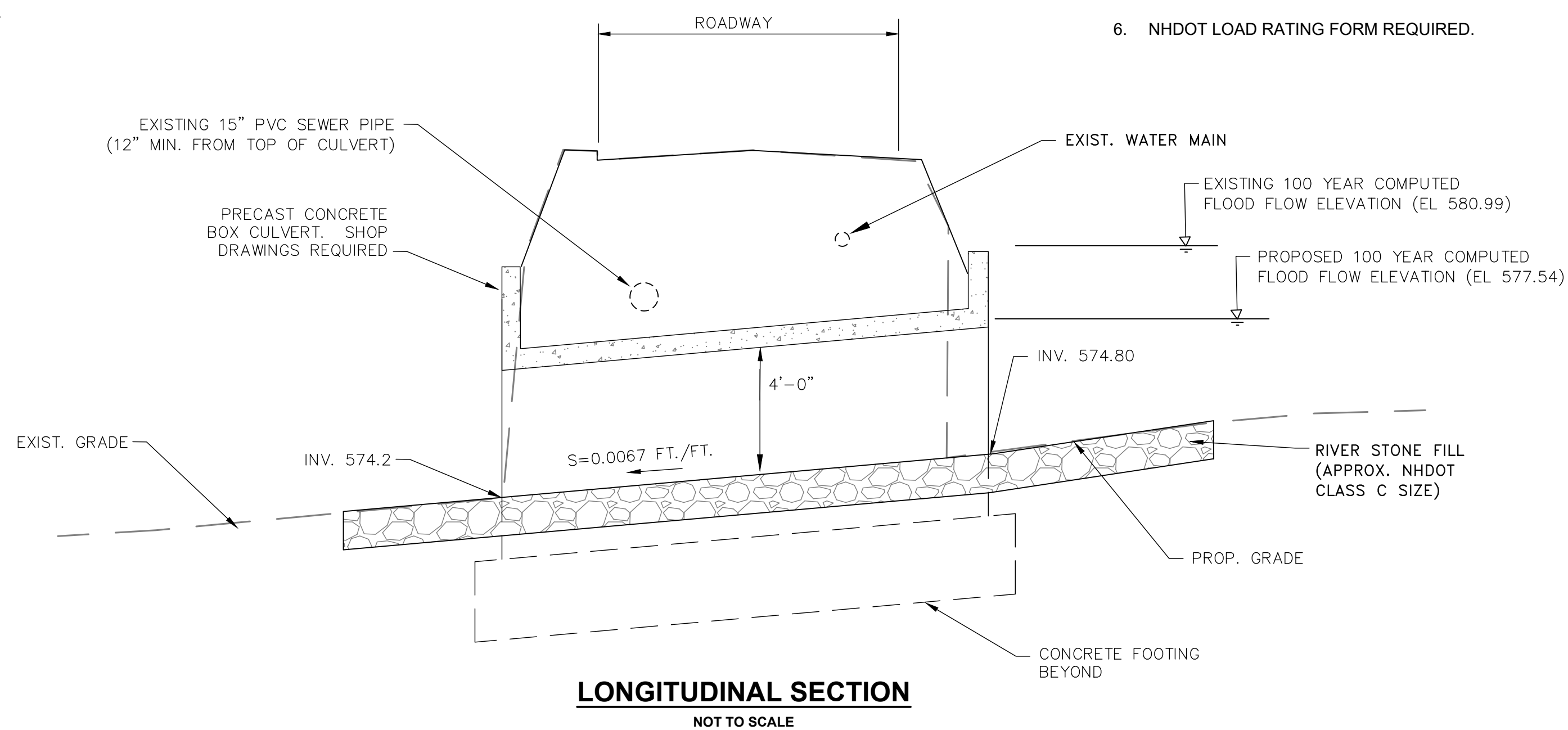
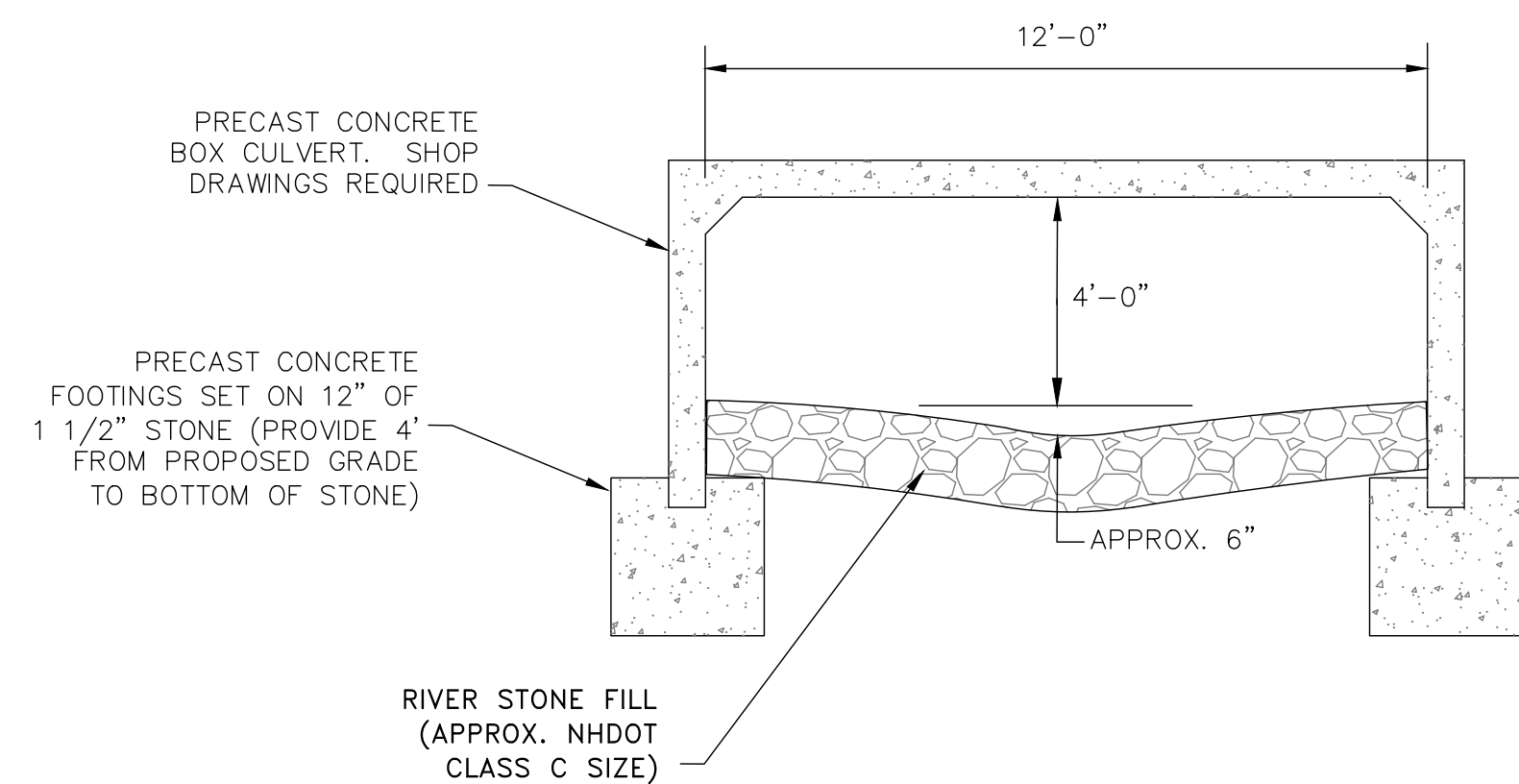
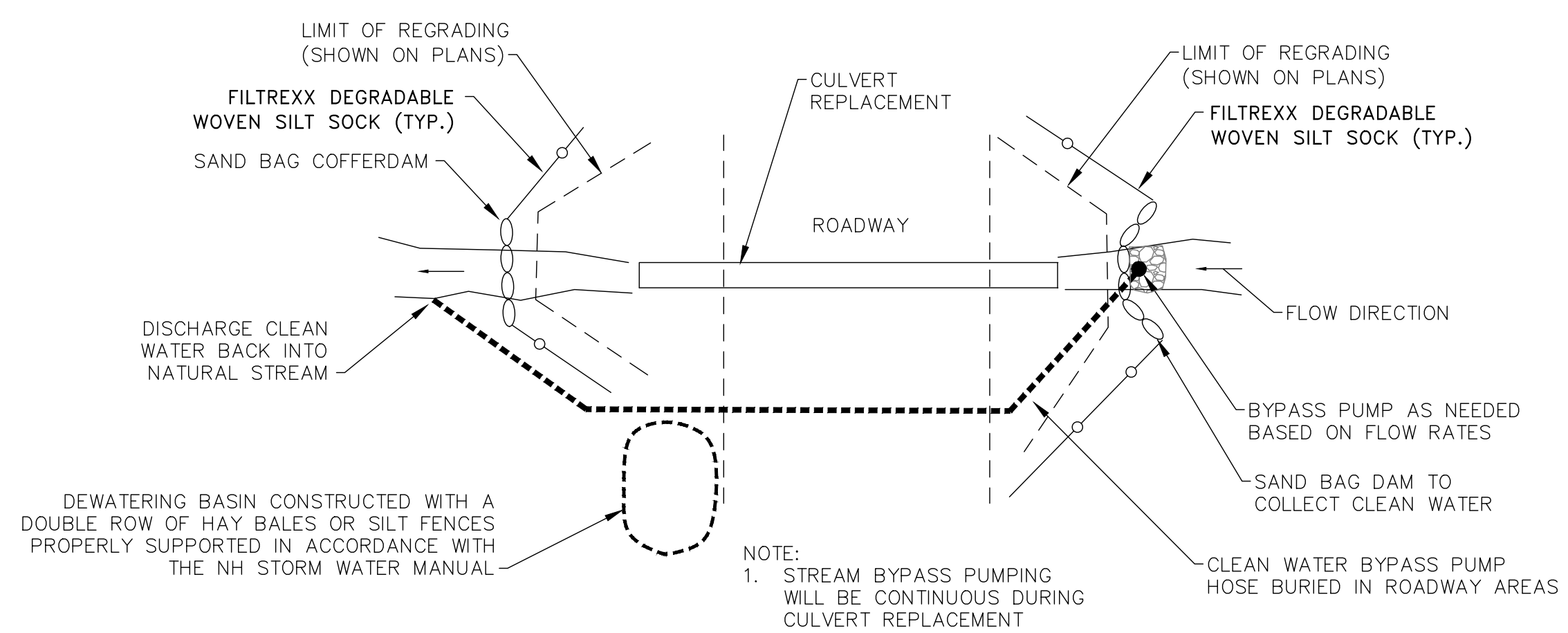
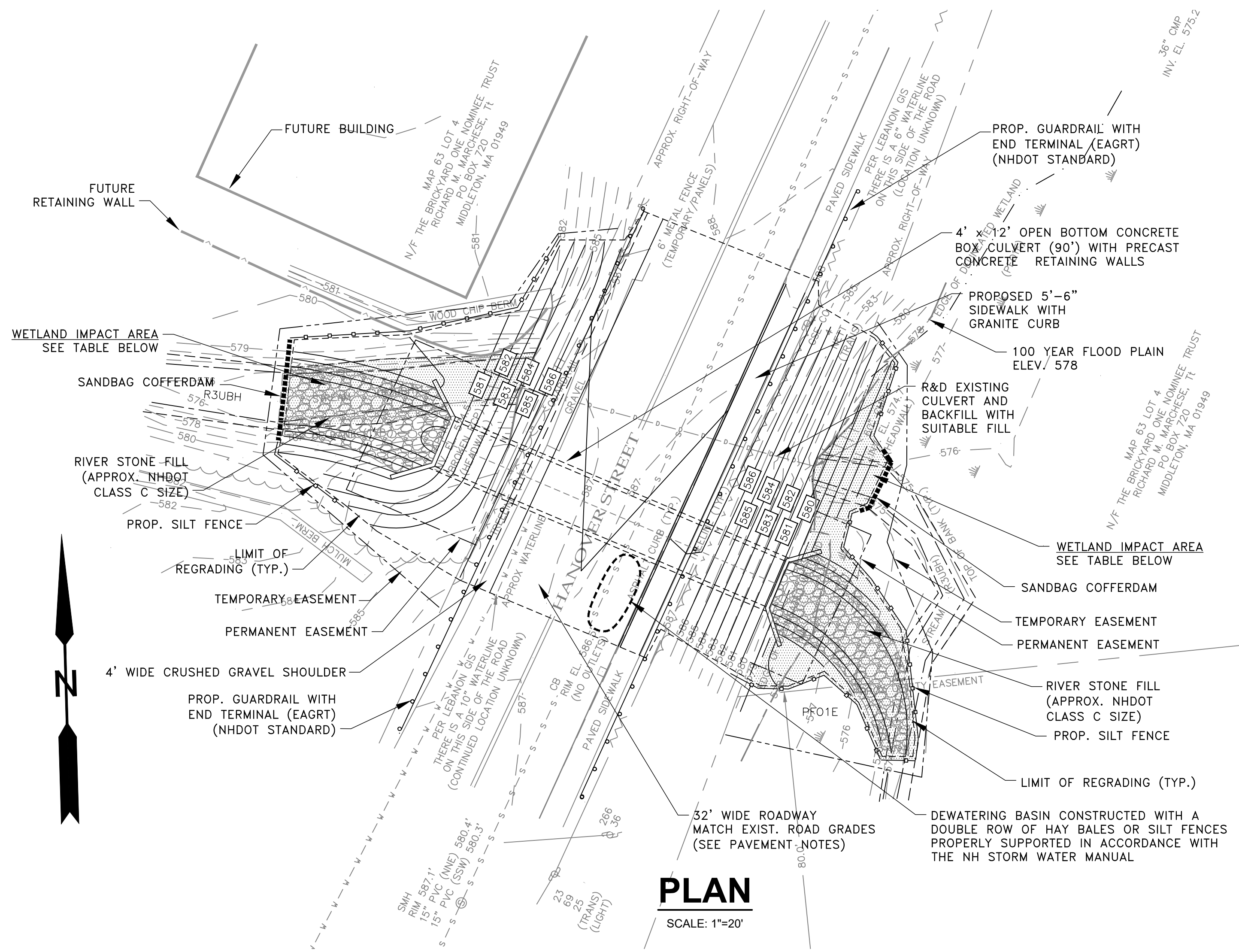
BIT. CONC. SIDEWALKS

- 2.5" BIT. CONC. SURFACE COURSE (PLACED IN TWO COURSES)
- 6" CRUSHED GRAVEL BASE COURSE

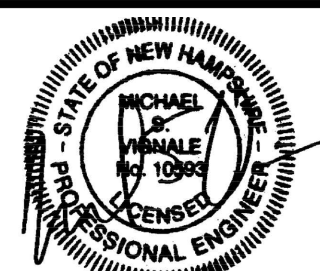
CEM. CONC. SIDEWALKS (CURB RAMPS)

- 4" CEM. CONC. SURFACE
- 6" CRUSHED GRAVEL BASE COURSE

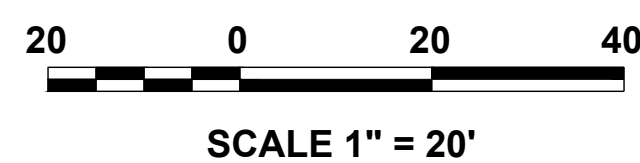
REVISIONS				 10-30-25	KVPartners LLC P.O. Box 432 New Boston, NH 03070 (603) 731-1652	NOT TO SCALE	HANOVER STREET CULVERT REPLACEMENT PROJECT LEBANON, NEW HAMPSHIRE		SHEET NO. 2
NUMBER	DATE	BY	DESCRIPTION						OCTOBER 2025
							GENERAL NOTES AND LEGEND		



Cowardin Classification	Permanent Impacts (SF)	Permanent Impacts (LF)	Temporary Impacts (SF)	Temporary Impacts (LF)
PFO1E	1200	N/A	270	N/A
R3UBH (bed)	727	85	103	6
R3UBH (banks)	119	170	30	18

[illegible]**KVPartners LLC**

P.O. Box 432
New Boston, NH 03070
(603) 731-1562



HANOVER STREET CULVERT REPLACEMENT PROJECT

CONSTRUCTION PLAN

SHEET NO.

4

OCTOBER 2025

SEQUENCE OF CONSTRUCTION

- CUT AND CLEAR ALL TREES WITHIN THE DISTURBANCE AREA UNLESS OTHERWISE DIRECTED BY THE ENGINEER. ALL VEGETATION CLEARED WILL BE REMOVED FROM THE SITE BY THE CONTRACTOR.
- CONSTRUCT TEMPORARY AND PERMANENT EROSION CONTROL DEVICES INCLUDING SILT FENCES, SEDIMENTATION PONDS, DEWATERING FACILITIES, PONDS AND ANY OTHER DEVICES SPECIFIED.
- COMPLETE GRUBBING OPERATIONS. REMOVE ALL PEAT, MUCK, ORGANIC MATERIALS FROM THE ROADWAY FOUNDATION AREA. ALL STUMPS, DEBRIS AND TOPSOIL, ORGANIC MATERIALS, PEAT MUCK, ETC. AND WILL BE DISPOSED OF OFF SITE BY THE CONTRACTOR.
- NATIVE MATERIAL REMOVED FROM THE STREAMBED SHOULD BE STOCKPILED SEPARATELY AND REUSED TO EMULATE A NATURAL CHANNEL BOTTOM AND ANY NEW MATERIALS USED MUST BE AS SIMILAR TO THE NATURAL STREAM SUBSTRATE AS PRACTICABLE. MATERIALS USED TO EMULATE A NATURAL CHANNEL BOTTOM MUST BE WELL-GRADED AND WASHED-IN, SO AS TO PREVENT DISRUPTED CONNECTIVITY DURING PERIODS OF LOW FLOW.
- EXCAVATE FOR CULVERT, DEWATER EXCAVATION AS REQUIRED, PLACE HEADWALLS, CULVERT AND BACKFILL.
- INSTALL RIP-RAP, TOP DRESSING STONE AND GRAVEL, STOCKPILED STREAMBED MATERIALS AND SHAPE A STREAMBED TO REPLICATE THE NATURAL STREAMBED UPSTREAM AND DOWNSTREAM OF THE WORK AREA.
- STABILIZE THE SITE IN ACCORDANCE WITH THE EROSION CONTROL REQUIREMENTS AS INDICATED ON THE PLANS INCLUDING LOAMING AND SEEDING ALL SLOPES EXCEPT THOSE DIRECTLY ADJACENT TO THE ROADWAY WHERE GRAVELS WILL BE PLACED.
- GRADE AND COMPACT THE GRAVEL AND CRUSHED GRAVEL BASE COURSES.
- COMPLETE PERMANENT SEEDING AND LANDSCAPING.
- CLEAN THE SITE, DRAINAGE STRUCTURES, PIPES, SWALES, PONDS, LEVEL SPREADERS AND SILT FENCES, OF ANY ACCUMULATED SEDIMENT.
- AFTER THE SITE IS FULLY STABILIZED, REMOVE ALL TEMPORARY EROSION CONTROL DEVICES AND RESTORE DISTURBED AREAS AS REQUIRED.
- NOTIFY PERMITTING AGENCIES THAT CONSTRUCTION HAS BEEN COMPLETED.

SEEDING SPECIFICATIONS

MIXTURE	POUNDS PER ACRE	POUNDS PER 1000 SF
TALL FESCUE	20	0.46
CREeping RED FESCUE	20	0.45
BIRDSFOOT TREFOIL	8	0.20
TOTAL	48	1.10

- SEEDBED PREPARATION
 - SURFACE AND SEEPAGE WATER SHOULD BE DRAINED OR DIVERTED FROM THE SITE TO PREVENT DROWNING OR WINTER KILLING THE PLANTS.
 - STONES LARGER THAN 4" SHOULD BE REMOVED AS THEY INTERFERE WITH SEEDING AND FUTURE MAINTENANCE OF THE AREA. WHERE FEASIBLE THE SOIL SHOULD BE TILLED TO A DEPTH OF 4" PRIOR TO PREPARE THE SEEDBED AND MIX FERTILIZER AND LIME INTO THE SOIL. THE SEEDBED SHOULD BE LEFT IN A REASONABLY SMOOTH AND FIRM CONDITION. THE LAST TILLAGE OPERATION SHOULD BE COMPLETED ACROSS THE SLOPE.
- ESTABLISHING A STAND
 - LIME AND FERTILIZER SHOULD BE APPLIED PRIOR TO OR AT THE TIME OF SEEDING AND INCORPORATED INTO THE SOIL. KINDS AND AMOUNTS OF LIME AND FERTILIZER SHOULD BE BASED ON SOILS TESTING. WHEN SOILS TEST ARE NOT AVAILABLE THE FOLLOWING RATES SHALL APPLY:
 - AGRICULTURAL LIMESTONE: 2 TONS PER ACRE OR 0.09 LBS. PER SQ. FT.
 - NITROGEN (N): 50 POUNDS PER ACRE OR 1.1 POUND PER 1000 SQ. FT.
 - PHOSPHATE (P205): 100 POUNDS PER ACRE OR 2.2 POUNDS PER 1000 SQ. FT.
 - POTASH (K20): 100 POUNDS PER ACRE OR 2.2 POUNDS PER 1000 SQ. FT.(NOTE: THIS IS THE EQUIVALENT OF 500 POUNDS PER ACRE OF 10-20-20 OF FERTILIZER OR 1000 POUNDS OF 5-10-10 OF FERTILIZER PER ACRE)
 - SEED SHOULD BE SPREAD UNIFORMLY BY THE METHOD MOST APPROPRIATE FOR THE SITE. METHODS INCLUDE BROADCASTING, DRILLING AND HYDROSEEDING. WHERE BROADCASTING IS USED, COVER SEED WITH 0.25 INCHES OF SOIL OR LESS BY CULTIPACKING OR RAKING.
 - REFER TO TABLE 7-35 OF "STORMWATER MANAGEMENT AND SEDIMENTATION CONTROL HANDBOOK FOR URBAN AND DEVELOPING AREAS IN NEW HAMPSHIRE" FOR APPROPRIATE SEED MIXTURES AND TABLE 7-36 FOR RATES OF SEEDING. ALL LEGUMES (CROWNVELCH, BIRDSFOOT TREFOIL, AND FLATPEA) MUST BE INOCULATED WITH THEIR SPECIFIC INOCULANT.
 - WHEN SEEDED AREAS ARE MULCHED, PLANTINGS MAY BE MADE FROM EARLY SPRING TO EARLY OCTOBER. WHEN SEEDED AREAS ARE NOT MULCHED, PLANTINGS SHOULD BE MADE FROM EARLY SPRING TO MAY 20 OR FROM AUGUST 10 TO SEPTEMBER 1.
- MULCH
 - HAY, STRAW, OR OTHER MULCH, WHEN NEEDED, SHOULD BE APPLIED IMMEDIATELY AFTER SEEDING.
 - MULCH WILL BE HELD IN PLACE USING TECHNIQUES FROM THE "BEST MANAGEMENT PRACTICE FOR MULCHING" AS SHOWN IN "STORMWATER MANAGEMENT AND SEDIMENTATION CONTROL HANDBOOK FOR URBAN AND DEVELOPING AREAS IN NEW HAMPSHIRE".
- MAINTENANCE TO ESTABLISH A STAND
 - PLANTED AREAS SHOULD BE PROTECTED FROM DAMAGE BY FIRE, GRAZING, TRAFFIC, AND DENSE WEED GROWTH.
 - FERTILIZATION NEEDS SHOULD BE DETERMINED BY ON SITE INSPECTIONS. SUPPLEMENTAL FERTILIZER IS USUALLY THE KEY TO FULLY COMPLETE THE ESTABLISHMENT OF ANY STAND BECAUSE MOST PERENNIALS TAKE 2 TO 3 YEARS TO BECOME ESTABLISHED.
 - IN WATERWAYS CHANNELS, OR SWALES WHERE UNIFORM FLOW CONDITIONS ARE ANTICIPATED, OCCASIONAL MOWING MAY BE NECESSARY TO CONTROL THE GROWTH OF WOODY VEGETATION.

EROSION CONTROL NOTES

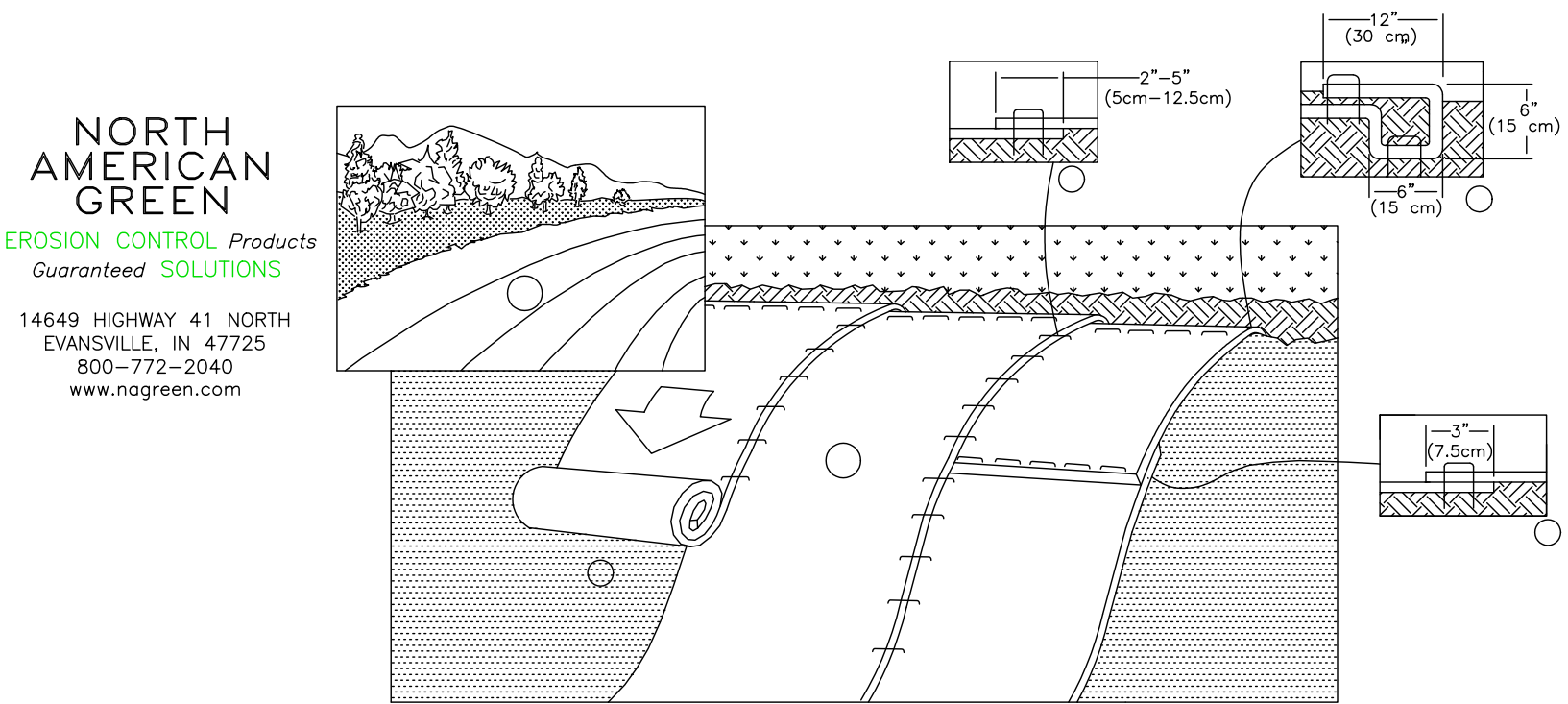
- THE SMALLEST PRACTICAL AREA SHALL BE DISTURBED DURING CONSTRUCTION AT ANY ONE TIME AND IN NO CASE SHALL THE AREA OF DISTURBANCE EXCEED FIVE ACRES.
- DISTURBED AREAS SHALL NOT REMAIN EXPOSED FOR LONGER THAN 60 DAYS. ALL DISTURBED AREAS SHALL BE PERMANENTLY STABILIZED WITHIN 72 HOURS OF FINAL GRADING.
- TEMPORARY SEEDING SHALL BE APPLIED TO ALL DISTURBED AREAS (TO BE VEGETATED) IN ACCORDANCE WITH THE REQUIRMENTS OF PAGE 7-247 THROUGH 7-249 OF THE "STORMWATER MANAGEMENT AND SEDIMENTATION CONTROL HANDBOOK FOR URBAN AND DEVELOPING AREAS IN NEW HAMPSHIRE".
- INSTALLATION OF SILT FENCES AND/OR HAY BALE SEDIMENTATION BARRIERS SHALL BE COMPLETED PRIOR TO THE START OF ANY CONSTRUCTION IN ACCORDANCE WITH THE DETAILS HEREIN, WITH THE MANUFACTURER'S RECOMMENDATIONS AND IN ACCORDANCE WITH NHDES PERMIT REQUIREMENTS.
- ALL DITCHES, PONDS AND DRAINAGE INFRASTRUCTURE SHALL BE STABILIZED PRIOR TO DIRECTING FLOW TO THEM.
- ALL SLOPES IN STEEPER THAN 2:1 SHALL HAVE EROSION CONTROL MATTING PLACED UNLESS OTHERWISE PERMITTED BY THE ENGINEER. SLOPES THAT ARE 2:1 OR FLATTER SHALL HAVE EROSION CONTROL MATTING PLACED AS DIRECTED BY THE ENGINEER AND AS REQUIRED TO STABILIZE THE SLOPE.
- STONE CHECK DAMS SHALL BE INSTALLED AT 50 FOOT INTERVALS OR AS SHOWN ON THE DETAIL ALONG THE CENTERLINE OF THE PROPOSED DRAINAGE DITCHES, OR AS DIRECTED BY THE ENGINEER, UNTIL PERMANENT SURFACE TREATMENTS ARE INSTALLED AND FULLY STABILIZED.
- SEDIMENTATION BARRIERS SHALL BE KEPT CLEAN OF ACCUMULATED SEDIMENTS DURING CONSTRUCTION AS REQUIRED TO PROTECT ALL RESOURCE AREAS.
- EROSION CONTROL MEASURES SHALL BE INSPECTED ON A WEEKLY BASIS AND AFTER EVERY STORM EVENT IN EXCESS OF 0.5". EROSION CONTROL MEASURES SHALL BE MAINTAINED FOR THE DURATION OF THE CONSTRUCTION OR UNTIL ALL DISTURBED AREAS ARE FULLY STABILIZED WITH APPROPRIATE SURFACE TREATMENTS (GRASSES, STONE, PAVEMENT, ETC.).
- EXISTING VEGETATION SHALL REMAIN UNDISTURBED WHEREVER POSSIBLE AND ANY DISTURBED AREAS SHALL BE STABILIZED AS SOON AS POSSIBLE FOLLOWING REGRADING.
- UNLESS OTHERWISE NOTED, ALL DISTURBED AREAS SHALL HAVE A MINIMUM OF 4" OF LOAM, BE PROPERLY FERTILIZED AND SEEDED IN ACCORDANCE WITH THE NOTES HEREIN AND THE SPECIFICATIONS.
- ALL EROSION CONTROL MEASURES SHALL BE CLEANED OF ANY ACCUMULATED DEBRIS AND REMOVED UPON STABILIZATION OF ALL DISTURBED AREAS.
- AN AREA SHALL BE CONSIDERED STABLE IF ONE OF THE FOLLOWING HAS OCCURRED:
 - BASE COURSE GRAVELS HAVE BEEN INSTALLED IN AREAS TO BE PAVED;
 - A MINIMUM OF 85% VEGETATED GROWTH HAS BEEN ESTABLISHED;
 - A MINIMUM OF 3" OF NON-EROSIVE MATERIAL SUCH AS STONE OR RIPRAP HAS BEEN INSTALLED; OR
 - EROSION CONTROL BLANKETS HAVE BEEN PROPERLY INSTALLED.

WINTER CONSTRUCTION NOTES

- ALL PROPOSED VEGETATED AREAS WHICH DO NOT EXHIBIT A MINIMUM OF 85% VEGETATIVE GROWTH BY OCTOBER 15TH, OR WHICH ARE DISTURBED AFTER OCTOBER 15TH, SHALL BE STABILIZED BY SEEDING AND INSTALLING EROSION CONTROL BLANKETS ON SLOPES GREATER THAN 3:1, AND SEEDING AND PLACING 3 TO 4 TONS OF MULCH PER ACRE, SECURED WITH ANCHORED NETTING, ELSEWHERE. THE INSTALLATION OF EROSION CONTROL BLANKETS OR MULCH AND NETTING SHALL NOT OCCUR OVER ACCUMULATED SNOW OR ON FROZEN GROUND AND SHALL BE COMPLETED IN ADVANCE OF THAW OR SPRING MELT EVENTS;
- ALL DITCHES OR SWALES WHICH DO NOT EXHIBIT A MINIMUM OF 85% VEGETATIVE GROWTH BY OCTOBER 15TH, OR WHICH ARE DISTURBED AFTER OCTOBER 15TH, SHALL BE STABILIZED TEMPORARILY WITH STONE OR EROSION CONTROL BLANKETS APPROPRIATE FOR THE DESIGN FLOW CONDITIONS; AND
- AFTER NOVEMBER 15TH, INCOMPLETE ROAD OR PARKING SURFACES, WHERE WORK HAS STOPPED FOR THE WINTER SEASON, SHALL BE PROTECTED WITH A MINIMUM OF 3 INCHES OF CRUSHED GRAVEL PER NHDOT ITEM 304.3.

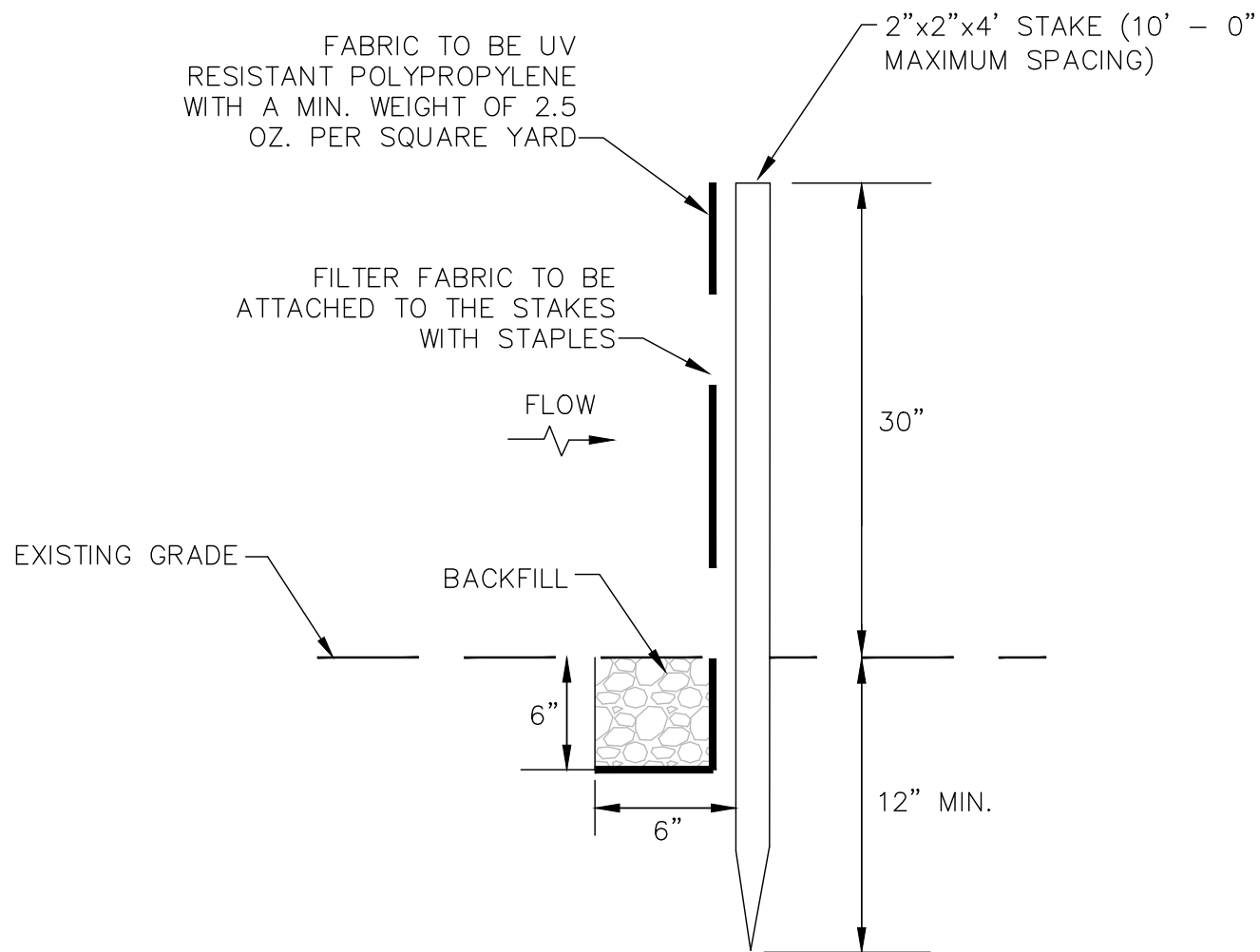
MAINTENANCE

- ALL TEMPORARY EROSION CONTROL MEASURES SHOULD BE INSPECTED AFTER EACH RAINFALL EVENT AND AT LEAST WEEKLY. ANY NECESSARY REPAIRS SHALL BE MADE IMMEDIATELY. ACCUMULATED SEDIMENTS SHALL BE REMOVED FROM ALL EROSION CONTROL DEVICES WHEN SEDIMENTS HAVE REACHED A LEVEL OF ONE HALF THE HEIGHT OF THE EROSION CONTROL MEASURE.
- ALL PERMANENT WATER QUANTITY/QUALITY AND EROSION CONTROL MEASURES (OUTLET PROTECTION, DETENTION PONDS, LEVEL SPREADERS AND VEGETATED SWALES) SHALL BE INSPECTED ANNUALLY AND AFTER EVERY MAJOR STORM EVENT. ANY REPAIRS REQUIRED TO KEEP THE MEASURE FUNCTIONING AS INTENDED SHALL BE COMPLETED IMMEDIATELY.



- PREPARE SOIL BEFORE INSTALLING ROLLED EROSION CONTROL PRODUCTS (RECP's), INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED.
NOTE: WHEN USING CELL-O-SEED DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
- BEGIN AT THE TOP OF THE SLOPE BY ANCHORING THE RECP's IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30cm) OF RECP's EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE RECP's WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" 30 CM PORTION OF RECP's BACK OVER SEED AND COMPACTED SOIL. SECURE RECP's OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) APART ACROSS THE WIDTH OF THE RECP's.
- ROLL THE RECP's (A.) DOWN OR (B.) HORIZONTALLY ACROSS THE SLOPE. RECP's WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL RECP's MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEM", STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
- THE EDGES OF PARALLEL RECP's MUST BE STAPLED WITH APPROXIMATELY 2" - 5" (5 CM - 12.5 CM) OVERLAP DEPENDING ON RECP's TYPE.
- CONSECUTIVE RECP's SPICED DOWN THE SLOPE MUST BE PLACED END OVER END (SHINGLE STYLE) WITH AN APPROXIMATE 3" (7.5 CM) OVERLAP. STAPLE THROUGH OVERLAPPED AREA, APPROXIMATELY 12" (30 CM) APART ACROSS ENTIRE RECP's WIDTH.
NOTE:
*IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY SECURE THE RECP's.

SLOPE INSTALLATION

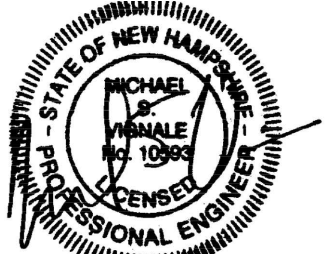


NOTES:

- INSTALL SILT FENCES AT THE LOCATIONS SHOWN ON THE PLANS AND AS DIRECTED BY THE ENGINEER.

SEDIMENTATION BARRIER DETAIL

NOT TO SCALE

REVISIONS				 10-30-25	KVPartners LLC P.O. Box 432 New Boston, NH 03070 (603) 731-1562	NOT TO SCALE	HANOVER STREET CULVERT REPLACEMENT PROJECT LEBANON, NEW HAMPSHIRE		SHEET NO. 5
NUMBER	DATE	BY	DESCRIPTION				CONSTRUCTION DETAILS		OCTOBER 2025



- ## PAVEMENT NOTES

PROPOSED PAVEMENT STRUCTURE WILL CONSIST OF THE FOLLOWING

ROADWAYS

- 1 1/2" BIT. CONC. SURFACE COURSE
2 1/2" BIT. CONC. BINDER COURSE
6" CRUSHED GRAVEL BASE COURSE
12" GRAVEL BASE COURSE

DRIVEWAYS

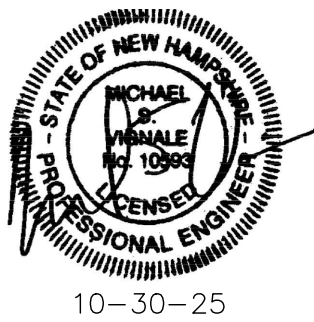
- 1" BIT. CONC. SURFACE COURSE
2" BIT. CONC. BINDER COURSE
6" CRUSHED GRAVEL BASE COURSE

BIT. CONC. SIDEWALKS

- 2.5" BIT. CONC. SURFACE COURSE (PLACED IN TWO COURSES)
6" CRUSHED GRAVEL BASE COURSE

CEM CONC. SIDEWALKS (CURB RAMPS)

- 4" CEM. CONC. SURFACE
6" CRUSHED GRAVEL BASE COURSE

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New Boston, NH 03070
(603) 731-1562

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HANOVER STREET CULVERT REPLACEMENT PROJECT

LEBANON, NEW HAMPSHIRE

CONSTRUCTION DETAILS

HEET NO.

6

OCTOBER 2025

MASCOMA LAKE

WATERSHED-BASED MANAGEMENT PLAN

PREPARED BY FB ENVIRONMENTAL ASSOCIATES

in partnership with the City of Lebanon and Vanasse Hangen Brustlin (VHB)

January 2025 | **DRAFT**



MASCOMA LAKE

WATERSHED-BASED MANAGEMENT PLAN

January 2025 | **DRAFT**

Prepared by **FB ENVIRONMENTAL ASSOCIATES**
in partnership with the City of Lebanon and VHB



CONTACT

Robert Buras, Water Treatment Superintendent
City of Lebanon
51 N Park Street
Lebanon, NH 03766

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Nonpoint Source Management Program Quality Assurance Program Plan*

Cover Photo: © Mascoma Lake Association

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STEERING COMMITTEE

Robert Buras, Water Treatment Superintendent, City of Lebanon
Rick Brown, Assistant Director of Public Works, City of Lebanon
Sarah Riley, Conservation Committee, City of Lebanon
Mark Goodwin, GIS Coordinator, City of Lebanon
Shirley Green, Conservation Commission Chair, Crystal Lake Association, Town of Enfield
Ed Morris, Town Manager, Town of Enfield
Christina Hall, Deputy Director of Engineering and Utilities, Town of Hanover
Dylan McDermott, Water Treatment Superintendent, Town of Hanover
Robert Barr, President, Mascoma Lake Association
James Martel, Mascoma Lake Association, Member
Dan Regan, Crystal Lake Association, Member
James Jukosky, Town of Canaan, Member
Meghan Butts, Executive Director, Upper Valley Lake Sunapee Regional Planning Commission

TECHNICAL CONSULTANT STAFF

Forrest Bell, CEO/Owner, FB Environmental Associates
Laura Diemer, CLM, Senior Project Manager, Lake Services Lead, FB Environmental Associates
Grace Little, Project Manager, FB Environmental Associates
Christine Bunyon, Project Manager/GIS Specialist, FB Environmental Associates
Evan Ma, Project Scientist II, FB Environmental Associates
Amelia Wallis, Project Scientist I, FB Environmental Associates
Garrison Beck, Water Resource Team Lead, VHB
Ben Miller, Project Engineer, VHB

For questions, comments, or additional information related to the Mascoma Lake Watershed-Based Management Plan, please contact the City of Lebanon.

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LIST OF ABBREVIATIONS

ACRONYM	DEFINITION
AC	Assimilative Capacity
AIPC	Aquatic Invasive Plant Control, Prevention and Research Grants
ACEP	Agricultural Conservation Easement Program
ALI	Aquatic Life Integrity
ARM	Aquatic Resource Mitigation Fund
BCCD	Belknap County Conservation District
BMP	Best Management Practice
CAGR	Compound Annual Growth Rate
CCCD	Carroll County Conservation District
CHL-A	Chlorophyll-a
CNMP	Comprehensive Nutrient Management Plan
CSP	Conservation Stewardship Program
CUM	Cubic Meters
CWA	Clean Water Act
CWP	Center for Watershed Protection
CWSRF	Clean Water State Revolving Fund
DO	Dissolved Oxygen
DPW	Department of Public Works
EMD	Environmental Monitoring Database
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESRI	Environmental Systems Research Institute
FBE	FB Environmental Associates
FT	Feet
HA	Hectare
HAB	Harmful Algal Bloom
ILFP	In-Lieu Fee Program
KG	Kilogram
LCHIP	Land and Community Heritage Investment Program
LID	Low Impact Development
LLMP	Lakes Lay Monitoring Program
LLRM	Lake Loading Response Model
LRCT	Lakes Region Conservation Trust
LRPC	Lakes Region Planning Commission
LWCF	Land and Water Conservation Fund
MLA	Mascoma Lake Association
M	Meter
NAIP	National Agriculture Imagery Program
NAWCA	North American Wetlands Conservation Act
NERFG	New England Forest and River Grant
NCEI	National Centers for Environmental Information
NFWF	National Fish and Wildlife Foundation
NH GRANIT	New Hampshire Geographically Referenced Analysis and Information Transfer System

ACRONYM	DEFINITION
NHACC	New Hampshire Association of Conservation Commissions
NHD	National Hydrography Dataset
NHDES	New Hampshire Department of Environmental Services
NHFG	New Hampshire Fish and Game Department
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source Pollution
NRCS	Natural Resources Conservation Service
NRI	Natural Resources Inventory
NWI	National Wetlands Inventory
PCR	Primary Contact Recreation
PCS	Potential Contamination Source
PFAS	Per- and polyfluoroalkyl substances
ppb, ppm	parts per billion, parts per million
RCCP	Regional Conservation Partnership Program
RCRA	Resource Conservation and Recovery Act
ROW	Right-of-Way
SCC	State Conservation Committee
SCCD	Strafford County Conservation District
SDT	Secchi Disk Transparency
TP	Total Phosphorus
UNH	University of New Hampshire
USLE	Universal Soil Loss Equation
WBMP	Watershed-Based Management Plan
YR	Year

DEFINITIONS

Adaptive management approach recognizes that the entire watershed cannot be restored with a single restoration action or within a short time frame. The approach provides an iterative process to evaluate restoration successes and challenges to inform the next set of restoration actions.

Anoxia is a condition of low dissolved oxygen.

Assimilative Capacity is a lake's capacity to receive and process nutrients (phosphorus) without impairing water quality or harming aquatic life.

Best Management Practices (BMPs) are conservation practices designed to minimize discharge of NPS pollution from developed land to lakes and streams. Management plans should include both non-structural (non-engineered) and structural (engineered) BMPs for existing and new development to ensure long-term restoration success.

Build-out analysis combines projected population estimates, current zoning restrictions, and a host of additional development constraints (conservation lands, steep slope and wetland regulations, existing buildings, soils with low development suitability, and unbuildable parcels) to determine the extent of buildable areas in the watershed.

Chlorophyll-a (Chl-a) is a measurement of the green pigment found in all plants, including microscopic plants such as algae. Measured in parts per billion or ppb, it is used as an estimate of algal biomass; the higher the Chl-a value, the higher the number of algae in the lake.

Clean Water Act (CWA) requires states to establish water quality standards and conduct assessments to ensure that surface waters are clean enough to support human and ecological needs.

Cyanobacteria are photosynthetic bacteria that can grow prolifically as blooms when enough nutrients are available. Some cyanobacteria can fix nitrogen and/or produce microcystin, which is highly toxic to humans and other life forms.

Dissolved Oxygen (DO) is a measure of the amount of oxygen dissolved in water. Low oxygen can directly kill or stress organisms and stimulate release of phosphorus from bottom sediments.

Epilimnion is the top layer of lake water directly affected by seasonal air temperature and wind. This layer is well-oxygenated by wind and wave action.

Eutrophication is the process by which lakes become more productive over time (oligotrophic to mesotrophic to eutrophic). Lakes naturally become more productive or "age" over thousands of years. In recent geologic time, however, humans have enhanced the rate of enrichment and lake productivity, speeding up this natural process to tens or hundreds of years.

Fall turnover is the process of complete lake mixing when cooling surface waters become denser and sink, especially during high winds, forcing warmer, less-dense water to the surface. This process is critical for the natural exchange of oxygen and nutrients between surface and bottom layers in the lake.

Flushing rate (also called retention time) is the amount of time water spends in a waterbody. It is calculated by dividing the flow in or out by the volume of the waterbody.

Full build-out refers to the time and circumstances in which, based on a set of restrictions (e.g., environmental constraints and current zoning), no more building growth can occur, or the point at which lots have been subdivided to the minimum size allowed.

Hypolimnion is the bottom-most layer of the lake that experiences periods of low oxygen during stratification and is devoid of sunlight for photosynthesis.

Impervious surfaces or cover refer to any surface that will not allow water to soak into the ground. Examples include paved roads, driveways, parking lots, and roofs.

Internal Phosphorus Loading is the process whereby phosphorus bound to lake bottom sediments is released back into the water column during periods of anoxia. The phosphorus can be used as fuel for plant and algae growth, creating a positive feedback to eutrophication.

Low Impact Development (LID) is an alternative approach to conventional site planning, design, and development that reduces the impacts of stormwater by working with natural hydrology and minimizing land disturbance by treating stormwater close to the source, and preserving natural drainage systems and open space, among other techniques.

Nonpoint Source (NPS) Pollution comes from diffuse sources throughout a watershed, such as stormwater runoff, seepage from septic systems, and gravel road erosion. One of the major constituents of NPS pollution is sediment, which contains a mixture of nutrients (like phosphorus) and inorganic and organic material that stimulate plant and algae growth.

Non-structural BMPs, which do not require extensive engineering or construction efforts, can help reduce stormwater runoff and associated pollutants through operational actions, such as land use planning strategies, municipal maintenance practices, and targeted education and training.

Oligotrophic lakes are less productive or have fewer nutrients (i.e., low levels of phosphorus and chlorophyll-a), deep Secchi Disk Transparency readings (8.0 m or greater), and high dissolved oxygen levels throughout the water column. In contrast, **eutrophic** lakes have more nutrients and are therefore more productive and exhibit algal blooms more frequently than oligotrophic lakes. **Mesotrophic** lakes fall in-between with an intermediate level of productivity.

pH is the standard measure of the acidity or alkalinity of a solution on a scale of 0 (acidic) to 14 (basic).

Riparian refers to wildlife habitat found along the banks of a lake, river, or stream. Not only are these areas ecologically diverse, but they are also critical to protecting water quality by preventing erosion and filtering polluted stormwater runoff.

Secchi Disk Transparency (SDT) is a vertical measure of the transparency of water (ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Transparency is an indirect measure of algal productivity and is measured in meters (m).

Structural BMPs, or engineered Best Management Practices, are often at the forefront of most watershed restoration projects and help reduce stormwater runoff and associated pollutants.

Thermal stratification is the process whereby warming surface temperatures in summer create a temperature and density differential that separates the water column into distinct, non-mixable layers.

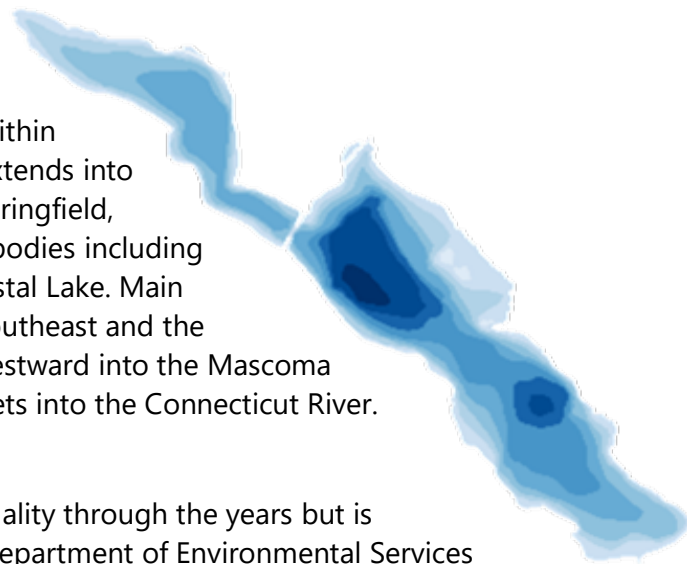
Thermocline or **metalimnion** is the markedly cooler, dynamic middle layer of rapidly changing water temperature. The top of this layer is distinguished by at least a degree Celsius drop per meter of depth.

Total Phosphorus (TP) is one of the major nutrients needed for plant growth. It is generally present in small amounts (measured in parts per billion (ppb)) and limits plant growth in lakes. In general, as the amount of TP increases, the number of algae also increases.

Trophic State is the degree of eutrophication of a lake and is designated as oligotrophic, mesotrophic, or eutrophic.

EXECUTIVE SUMMARY

With a 98,232-acre watershed, Mascoma Lake is a 1,148-acre lake in western New Hampshire, located within the Upper Valley region. Mascoma Lake resides within the towns of Enfield and Lebanon, while its watershed extends into Canaan, Hanover, Orange, Dorchester, Lyme, Grafton, Springfield, and Grantham. Mascoma Lake is fed by upstream waterbodies including Goose Pond, Canaan Street Lake, Grafton Pond, and Crystal Lake. Main tributaries to the lake include the Knox River from the southeast and the Mascoma River from the north. Mascoma Lake drains westward into the Mascoma River, which flows through the City of Lebanon and outlets into the Connecticut River.



The Problem

Mascoma Lake has experienced relatively good water quality through the years but is currently assessed as impaired on the New Hampshire Department of Environmental Services (NHDES) 2024 Section 303(d) list of impaired surface waters. It is impaired for aquatic life integrity (ALI) due to low dissolved oxygen (DO) and low pH, as well as for primary contact recreation (PCR) due to elevated cyanobacterial hepatotoxic microcystins. All impairments are classified as Category 5-M, indicating that a Total Maximum Daily Load (TMDL) is required. A TMDL calculates the maximum amount of pollutant a waterbody can receive while still meeting water quality standards. This requirement, mandated by the Clean Water Act, ensures states identify and address waterbodies that fail to meet these standards.

Historic NHDES Lake Trophic Survey Reports (1976, 1985, 2000) classify Mascoma Lake as mesotrophic, with moderate levels of aquatic plant growth, algal growth, nutrients, and clarity. However, the most recent report (2008) re-classified the lake as oligotrophic, a classification characterized by low phytoplankton abundance and few aquatic plants. This change was due to increased summer bottom dissolved oxygen levels. While dissolved oxygen levels were improved in the most recent trophic survey report, the lake's impairment status, in addition to frequent cyanobacteria blooms, has raised concern about the lake.

In 2024, NHDES a warning for Mascoma Lake lasting eight days and one watch. In the previous year, the lake received two warnings (each lasting seven days) and three watches. The blooms contained a diverse mix of potentially toxic types (taxa) including *Dolichospermum*, *Woronichinia*, and *Microcystis*. These cyanobacteria blooms largely occur despite low nutrient levels in the water and highlight that anthropogenic inputs to Mascoma Lake, such as impacts from stormwater runoff or shoreline erosion from increased wave action, can affect the health of the lake, especially as climate change increases the frequency of large precipitation events and extends the ice-free period on lakes.

Other waterbodies in the Mascoma Lake watershed can impact the water quality of Mascoma Lake because they contribute water, and therefore nutrients, to the lake. Crystal Lake generally has good water quality and has been classified as oligotrophic for all three trophic surveys (1978, 1987, and 2005) and is not listed on the NHDES 303(d) list. However, three cyanobacteria warnings (for a total of 20 days) and three watches were issued in 2023, which may indicate changes to the water quality in recent years. Both Goose Pond and Canaan Street Lake are listed on the NHDES 303(d) list as impaired with a TMDL required (5-M) for pH and cyanobacteria hepatotoxic microcystins. Clark Pond is similarly impaired for pH, and Reservoir Pond is impaired for chlorophyll-*a* and total phosphorus. The most recent reported

blooms in Canaan Street Lake and Goose Pond were in 2010 and 2022, and no other waterbodies in the watershed have had reported cyanobacteria blooms.

Cyanobacteria blooms are typically spurred by a combination of warming waters and excessive nutrients, in particular phosphorus, in surface waters. Sources of phosphorus in the watershed impacting the lake's water quality include stormwater runoff from developed areas largely from impervious cover, shoreline erosion, erosion from construction activities or other disturbed ground particularly along roads, excessive fertilizer application, failed or improperly functioning septic systems, leaky sewer lines, unmitigated agricultural activities, and pet, livestock, and wildlife waste. The model results revealed changes in phosphorus loading and in-lake phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Mascoma Lake is threatened by current development activities in the watershed and will degrade further with continued development in the future, especially when compounded by the effects of ongoing climate change. In the Mascoma Lake watershed, the watershed load is the largest source of phosphorus, and runoff from residential/commercial development contributes approximately 73% of the watershed phosphorus load.

Various studies have been conducted in the watershed. In 2012, the Mascoma River Local Advisory Committee (Mascoma LAC) developed a corridor management plan as a resource to protect the Mascoma River and its watershed by outlining actions and goals for municipalities and community partners. For Canaan Street Lake, a Watershed Protection Plan was developed in 2006, which evaluated current and historical water quality, identified contamination sources, and provided management recommendations to protect the future of the Town's drinking water supply.

The Goal

The goal of the Mascoma Lake Watershed-Based Management Plan (WBMP) is to improve the water quality of Mascoma Lake such that it continues to meet the state water quality standards for ALI and PCR and substantially reduces the likelihood of harmful cyanobacteria blooms. This goal will be achieved by accomplishing the following objectives over the next 10 years and beyond:

Objective 1: Reduce phosphorus loading from existing development by 4% (86 kg/yr) to Mascoma Lake to decrease average in-lake summer total phosphorus concentration to 8.7 ppb.

Objective 2: Mitigate (prevent or offset) phosphorus loading from future development by 745 kg/yr to Mascoma Lake to maintain the average summer in-lake total phosphorus concentration over the next 10 years (2035).

It is important to note that, while the focus of the objectives for this plan is on phosphorus, the treatment of stormwater and sediment erosion will result in the reduction of many other kinds of pollutants that may impact water quality. These pollutants include other nutrients (e.g., nitrogen), petroleum products, bacteria, road salt/sand, excessive organic material (such as raking/blowing leaves and grass cuttings into surface waters. or erosion from boat wakes), and heavy metals (cadmium, nickel, zinc, etc.).

Measures of success for achieving the goal and objectives should be based on a reduction in phosphorus loading from the major tributaries to Mascoma Lake and/or from shorefront BMPs and septic system upgrades, as well as a reduction in the frequency and severity of cyanobacteria blooms in the lake. While any amount of phosphorus load reduction to the lake will be helpful for controlling cyanobacteria blooms, it is important to understand that the dominant cyanobacteria taxa in the lake can uptake phosphorus from phosphorus-rich sediments and store phosphorus for later use under more optimal growth conditions. Thus, the management implications for minimizing the risk of cyanobacteria blooms are not straightforward and depends on a number of factors out of our direct control. The physiological

characteristics of these cyanobacteria taxa also mean that the typical application of the state's water quality standards for lakes in the form of assimilative capacity analysis are less relevant for Mascoma Lake.

The Solution

As part of the development of the Mascoma Lake WBMP, a build-out analysis, land-use model, water quality and assimilative capacity analysis, septic system database development, shoreline desktop evaluation, and watershed survey were conducted to identify and quantify the sources of phosphorus and other pollutants to the lake. Results from these analyses were used to determine recommended management strategies for the identified pollutant sources in the watershed. An Action Plan (Section 5) was developed in collaboration with the Steering Committee comprised of key watershed stakeholders (see Acknowledgements). The following actions were recommended to meet the established water quality goal and objectives for Mascoma Lake:

WATERSHED STRUCTURAL BMPS: Sources of phosphorus from existing watershed development should be addressed through installation of stormwater controls, stabilization techniques, buffer plantings, etc. for the following: stormwater infrastructure, the high priority sites (and the medium and low priority sites as opportunities arise) identified during the watershed survey, the high and medium impact shoreline properties (and low priority properties as opportunities arise) identified during the shoreline survey, and any new or redevelopment projects in the watershed with high potential for soil erosion.

MONITORING: A long-term water quality monitoring plan is critical to evaluate the effectiveness of implementation efforts over time. MLA, in concert with the NHDES Volunteer Lake Assessment Program (VLAP), along with the University of New Hampshire (UNH) Lakes Lay Monitoring Program (LLMP) and volunteers for other waterbodies in the watershed, should continue the annual monitoring program and consider incorporating additional monitoring recommendations laid out in this plan.

EDUCATION AND OUTREACH: MLA, and other key watershed stakeholders, should continue all aspects of their education and outreach strategies and consider developing new ones or improving existing ones to reach more watershed residents. Examples include providing educational materials to existing and new property owners, as well as renters, by distributing them at various locations and through a variety of means, such as websites, newsletters, social media, community events, or community gathering locations. Educational campaigns should include raising awareness of water quality concerns, septic system maintenance, fertilizer and pesticide use, pet waste disposal, waterfowl feeding, invasive aquatic species, boat pollution, shoreline buffer improvements, gravel road maintenance, and stormwater runoff controls.

OTHER ACTIONS: Additional strategies for reducing phosphorus loading to the lake include: revising local ordinances such as setting low impact development (LID) requirements on new development, including setting limits on impervious cover; identifying and replacing malfunctioning septic systems; inspecting and remediating leaky sewer lines; using best practices for road maintenance and other activities including municipal operations such as infrastructure cleaning; conserving large or connective habitat corridor parcels; and improving agricultural practices. Future development should also be considered as a pollutant source and potential threat to water quality. Mascoma Lake is at risk for greater water quality degradation because of new development in the watershed unless climate change resiliency and LID strategies are incorporated into existing zoning standards.

The recommendations of this plan will be carried out by a diverse stakeholder group in the form of a dedicated committee, including representatives from MLA, municipalities (e.g., select boards, planning boards), conservation commissions, state and federal agencies or organizations, nonprofits, land trusts,

schools and community groups, local business leaders, and landowners. The cost of successfully implementing the plan is estimated at \$1.7-1.8 million over the next 10 or more years in addition to the dedication and commitment of volunteer time and support to manage plan implementation. However, many costs are still unknown or were roughly estimated and should be updated as information becomes available. This financial investment can be accomplished through a variety of funding mechanisms via both state and federal grants, as well as commitments from municipalities or donations from private residents. Of significant note, this plan meets the nine planning elements required by the EPA, and Mascoma Lake is now eligible for federal watershed assistance grants.

Important Notes

The success of this plan is dependent on the continued effort of a dedicated committee that meets regularly to coordinate resources for implementation, review progress, and make any necessary adjustments to the plan to maintain relevance of action items and interim milestones. A reduction in nutrient loading is no easy task, and because there are many diffuse sources of phosphorus reaching surface waters in the watershed, it will require an integrated and adaptive approach across many different parts of the watershed community to be successful. The recommendations in this plan are idealized and, in some cases, may be difficult to achieve given the physical and political realities of the community dealing with old infrastructure, lack of access to key lakefront areas, and limited funding and volunteer or staff capacity. The water quality goal and objectives are set to meet a desired future water quality condition, which may or may not be accomplished within the 10-year lifespan of this plan.

Finally, we all have a common responsibility to protect our lakes for future generations to enjoy. Private landowners arguably hold the most power in making a significant impact on restoring and maintaining excellent water quality in our lakes; however, engaging private landowners as a single stakeholder group can be difficult and outreach efforts often have limited reach, especially to those individuals who may require the most education and awareness of important water quality protection actions. MLA and other relevant stakeholders will continue to engage the public as much as possible so that private individuals can help review and implement the recommendations of this plan and protect the water quality of Mascoma Lake long into the future.

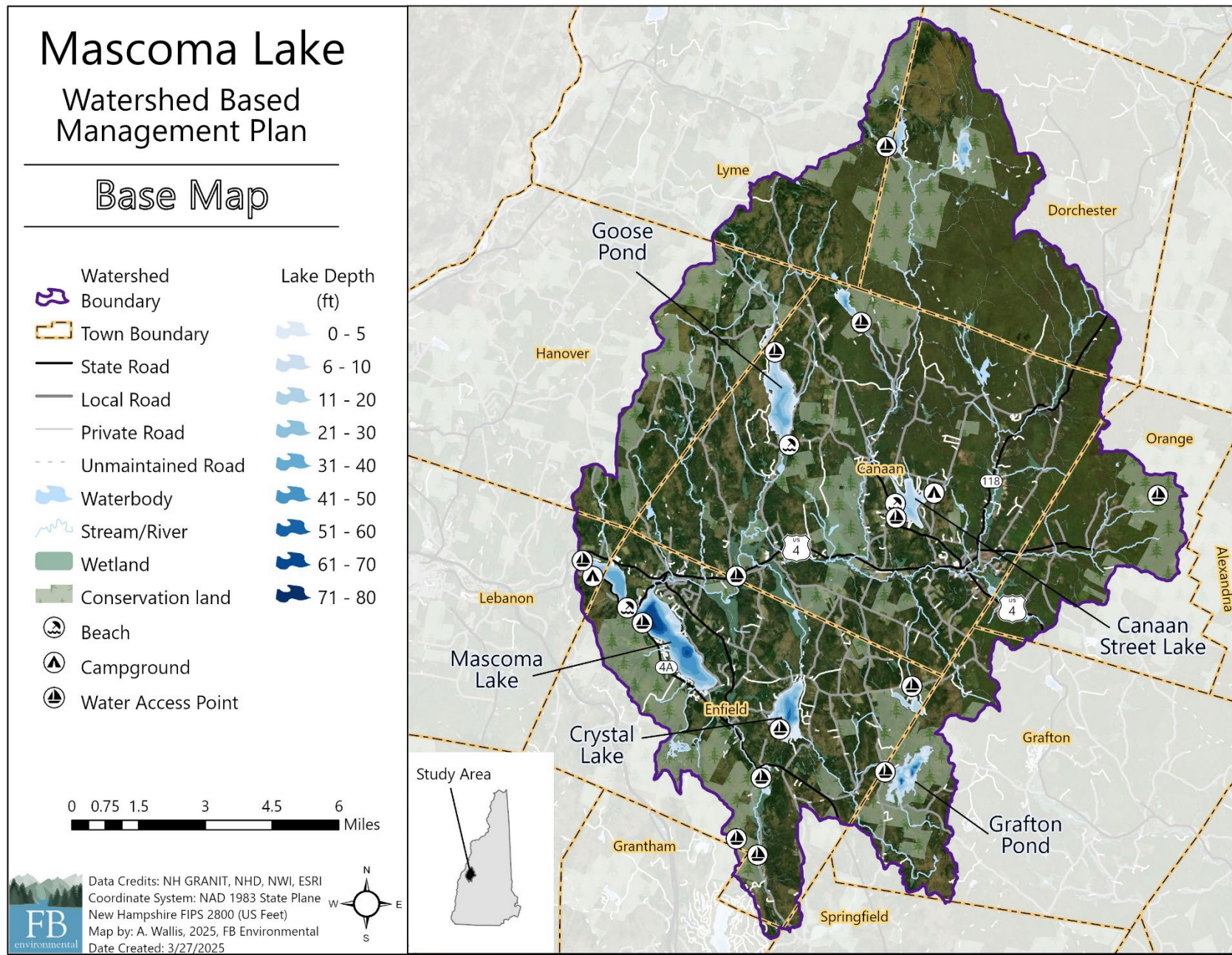


Figure 1. Mascoma Lake watershed.

1 INTRODUCTION

1.1 WATERBODY DESCRIPTION AND LOCATION

Mascoma Lake is a 1,148-acre (471-hectare) lake with a watershed spanning 98,232 acres (39,753 hectares) across the towns of Canaan (36%), Enfield (21%), Dorchester (15%), Hanover (9%), Orange (7%), Lyme (6%), Grafton (5%), Lebanon (1%), Grantham (0.1%) and Springfield (0.01%). Mascoma Lake is fed by upstream waterbodies including Goose Pond (625 acres), Grafton Pond (319 acres), Canaan Street Lake (291 acres), Crystal Lake (401 acres), Reservoir Pond (159 acres), Cummins Pond (135 acres), Clark Pond (104 acres), Lary Pond (64 acres), George Pond (49 acres), and a number of additional small waterbodies. There are many streams that run through the watershed, including but not limited to Lovejoy Brook, Goose Pond Brook, Marshall Brook, Clark Pond Brook, Hoyt Brook, Indian River, Orange Brook, Haines Brook, Moose Brook, Bicknell Brook, Little Brook, and Crystal Lake Brook. The two main tributaries are the Mascoma River that drains a large portion of the northern watershed and the Knox River that enters from the east. The lake outlets to the west in the Mascoma River, which eventually joins the Connecticut River.

Precipitation and air temperature data for the surrounding region of Mascoma Lake, were collected from Oak Ridge National Laboratory's Daymet service from 1994-2023 (Figure 2). Annual air temperature (from average monthly data) generally ranges from 7 °F to 71 °F, with an average of 44.3°F (Daymet). The area experiences moderate to high rainfall and snowfall, averaging 49.0 inches of precipitation annually.

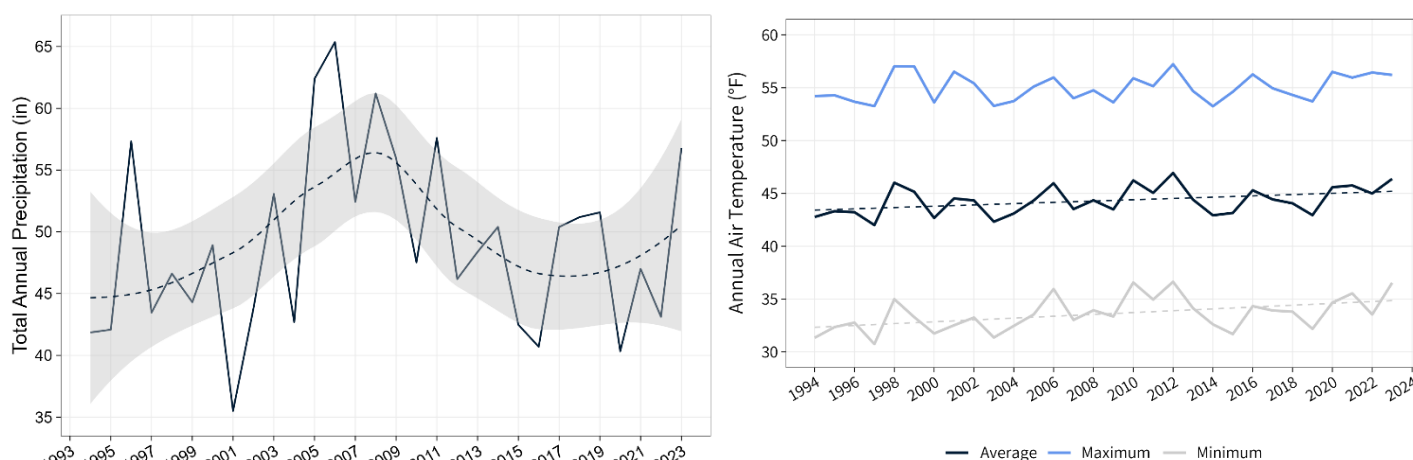


Figure 2. Total annual precipitation (top) and annual max, average, and min of monthly air temperature (bottom) from 1994 - 2023 for the region. Data collected from Daymet. The dashed line and grey shaded area for precipitation represents the Locally Estimated Scatterplot Smoothing (LOESS) regression and 95% confidence intervals, respectively. The dashed lines for air temperature indicate a statistically significant trend ($p < 0.05$) for minimum and average annual air temperatures.

The highest elevation in the watershed is located at Smarts Mountain (around 3,220 feet above sea level), that is in Lyme and Dorchester in the northernmost portion of the watershed. Cardigan Mountain is the second tallest point (around 3,150 feet above sea level) and is west of Orange. Mascoma Lake and the adjacent shoreline are approximately 750 feet above sea level. These elevation measurements were derived from digital elevation models provided by NH GRANIT and topographic basemaps from Esri.

The Mascoma Lake watershed is situated within a temperate zone of converging weather patterns from the hot, wet southern regions and the cold, dry northern regions of the continent, which result in various natural phenomena such as heavy snowfalls, severe thunder and lightning storms, and occasional hurricanes.

The watershed is characterized primarily by mixed forest that includes both conifers (e.g., white pine and eastern hemlock) and deciduous (e.g., beech, red oak, and maple) tree species. Fauna that use these forested resources include land mammals (moose, deer, black bear, coyote, bobcats, fisher, fox, raccoon, weasel, porcupine, muskrat, mink, chipmunks, squirrels, snowshoe hares, and bats), water mammals (muskrat, otter, and beaver), land and water reptiles and amphibians (turtles, snakes, frogs, and salamanders), various insects, birds (herons, loons, geese, multiple species of ducks, wild turkeys, ruffed grouse, cormorants, bald eagles, and song birds), and fish.

1.2 WATERSHED PROTECTION GROUPS

A citizen-led group, the [Mascoma Lake Association](#) (MLA) has members from Lebanon, Enfield, and Canaan, and is authorized by state law to advise on the river's management and protection. Members are appointed for three-year terms by the NH Department of Environmental Services and work to promote appreciation and responsible stewardship of the Mascoma River.



The [Mascoma River Local Advisory Committee](#) (Mascoma River LAC), composed of residents of Lebanon, Enfield, and Canaan, is authorized by state law to advise on the management and protection of the Mascoma River. Mascoma River LAC members are local citizens interested in the river – they are nominated by their Town and appointed to a three-year term by the Commissioner for NH Department of Environmental Services. Mascoma River LAC promotes recognition and appreciation of the Mascoma River and works for the wise stewardship of its resources.



The [Connecticut River Conservancy](#) (CRC) works to restore and protect the Connecticut River watershed through advocacy, restoration, and community engagement. Their efforts include dam removal, invasive species management, water quality monitoring, and improving habitat resilience. Through partnerships across four states, CRC promotes science-based solutions for healthy, life-filled rivers from source to sea.

The [Canaan Lake Association](#) protects the health of Canaan Street Lake for both the environment and future generations. It promotes watershed education, community engagement, and partnerships to support water quality, recreation, and conservation efforts.

Led by an elected board, the [Goose Pond Lake Association](#) (GPLA) holds a passion for the pond and works to protect its environment. Initiatives include the Weed Watcher Program to monitor invasive plants, a water quality program that tests key indicators, and biannual roadside clean-ups.

Across 45 towns in Vermont and New Hampshire, the [Upper Valley Land Trust](#) (UVLT) works to permanently protect the region's farms, forests, wildlife habitats, and scenic landscapes. By partnering with local conservation groups, UVLT provides expertise and technical assistance to landowners and stewards permanent conservation agreements. The trust also prioritizes ensuring public access to natural areas.



Established in 1963, the [Upper Valley Lake Sunapee Regional Planning Commission](#) (UVLSRPC) is one New Hampshire's nine Regional Planning Commissions, and serves 27 municipalities to provide planning assistance in the Upper Valley Lake Sunapee Region. They collaborated with the Mascoma River Local Advisory Committee to develop the Mascoma River Corridor Management Plan in 2012.



The [Grafton County Conservation District](#) (GCCD) is one of 10 county conservation districts in New Hampshire that operate as resource management agencies and a subdivision of local governments. The Grafton County Conservation District supports sustainable land management by providing technical assistance, conservation programs, and educational outreach to landowners. Partnering with the USDA NRCS and other agencies, it helps address local environmental concerns through workshops, farm demonstrations, and resource planning. All of the towns within the Mascoma Lake watershed are part of GCCD (except for Grantham and Springfield which comprises 0.2% of the watershed and are part of the Sullivan County Conservation District).



The [New Hampshire Association of Conservation Commissions](#) (NHACC) works to provide educational assistance to conservation commissions throughout New Hampshire (217 in total). As a non-profit organization, the NHACC's mission is to instill responsible use of the available natural resources by promoting conservation and serving as the communication link between conservation commissions, while providing technical support on the logistics of conservation commission meetings and document language. Conservation commissions in the Mascoma Lake watershed include those of Hanover, Enfield, Lyme, Dorchester, Grantham, Canaan, Lebanon, and Springfield.



The [New Hampshire Department of Environmental Services](#) (NHDES) works with local organizations to improve water quality in New Hampshire at the watershed level. NHDES works with communities to identify water resource goals and to develop and implement watershed plans. This work is achieved by providing financial and technical assistance to local watershed management organizations and by investigating actual and potential water contamination problems, among other activities.



1.3 PURPOSE AND SCOPE

The purpose and overarching goal of the Mascoma Lake Watershed-Based Management Plan (WBMP) is to guide implementation efforts over the next 10 years (2026-2035) to improve the water quality of Mascoma Lake such that it continues to meet state water quality standards for Aquatic Life Integrity (ALI) and Primary Contact Recreation (PCR) and substantially reduces the likelihood of harmful cyanobacteria blooms in the lake. Efforts to protect Mascoma Lake will also help protect downstream waterbodies including the Mascoma and Connecticut Rivers.

As part of the development of this plan, a **build-out analysis**, land-use model, water quality and **assimilative capacity** analysis, and shoreline and watershed surveys were conducted to better understand the sources of phosphorus and other pollutants to the lake (Sections 2 and 3). Results from these analyses were used to establish the water quality goal and objectives (Section 2.4), determine recommended management strategies for the identified pollutant sources (Section 4), and estimate pollutant load reductions and costs needed for remediation (Sections 5 and 6). Recommended management strategies involve using a combination of **structural and non-structural Best Management Practices** (BMPs), as well as an **adaptive management approach** that allows for regular updates to the plan (Section 4). An Action Plan (Section 5) with associated timeframes, responsible parties, and estimated costs was developed in collaboration with the Steering Committee (Section 1.4). This plan meets the nine elements required by the United States Environmental Protection Agency (EPA) and therefore communities become eligible for federal watershed assistance grants (Section 1.5).

1.4 COMMUNITY INVOLVEMENT AND PLANNING

The plan was developed through the collaborative efforts of numerous meetings, public presentations, and conference calls between FB Environmental Associates (FBE), NHDES, representatives from the towns of Lebanon, Canaan, and Enfield, lake associations, business owners, and private landowners (see Acknowledgments).

1.4.1 Plan Development Meetings

Several meetings were held over the duration of the plan development.

November 13, 2024: Kick-off virtual meeting with NHDES and the public to introduce the watershed planning process.

April 15, 2025: Steering Committee met to review and discuss engagement and education memo.

May 5, 2025: Steering Committee met to discuss potential BMP sites around the Mascoma watershed

June 24, 2025: Steering Committee met to discuss the BMP sites identified for the Mascoma watershed.

September 19, 2025: Steering Committee met to discuss BMP site selection for designs.

October 28, 2025: Steering Committee met to review the water quality analysis and modeling results and set the water quality goal.

TBD: Steering Committee met to review the draft WBMP.

1.4.2 Final Public Presentation

A final virtual public presentation was held on December 18, 2024 to summarize the analyses and recommendations detailed in the plan. The presentation was attended by about 30 people. An opportunity for public feedback on the plan was offered. Several written comments were received and incorporated into the final plan.

1.5 INCORPORATING EPA'S NINE ELEMENTS

EPA guidance lists nine components that are required within a WBMP to restore waters impaired or likely to be impaired by nonpoint source (NPS) pollution. These guidelines highlight important steps in restoring and protecting water quality for any waterbody affected by human activities. The nine required elements found within this plan are as follows:

- A. IDENTIFY CAUSES AND SOURCES:** Sections 2 and 3 highlight known sources of NPS pollution to Mascoma Lake and describe the results of the watershed survey and other assessments conducted in the watershed. These sources of pollutants must be controlled to achieve load reductions estimated in this plan, as discussed in item (B) below.
- B. ESTIMATE PHOSPHORUS LOAD REDUCTIONS EXPECTED FROM MANAGEMENT MEASURES:** Sections 2 and 5 describe the calculation of pollutant load to Mascoma Lake and the amount of reduction needed to meet the water quality goal, respectively.
- C. DESCRIPTION OF MANAGEMENT MEASURES:** Sections 4 and 5 identify ways to achieve the estimated phosphorus load reduction and reach water quality targets. The Action Plan focuses on several major topic areas that address NPS pollution. Management options in the Action Plan focus on non-structural BMPs integral to the implementation of structural BMPs.
- D. ESTIMATE OF TECHNICAL AND FINANCIAL ASSISTANCE:** Sections 5 and 6 include a description of the associated costs, sources of funding, and primary authorities responsible for implementation. Sources of funding need to be diverse and should include local, state, and federal granting agencies, local groups, private donations, and landowner contributions for implementation of the Action Plan.

- E. EDUCATION & OUTREACH:** Section 4 describes how the educational component of the plan is already being or will be implemented to enhance public understanding of the project.
- F. SCHEDULE FOR ADDRESSING PHOSPHORUS REDUCTIONS:** Section 5 provides a list of action items and recommendations to reduce the phosphorus load to Mascoma Lake. Each item has a set schedule that defines when the action should begin and/or end or run through (if an ongoing activity). The schedule should be adjusted by the committee on an annual basis (see Section 4 on Adaptive Management).
- G. DESCRIPTION OF INTERIM MEASURABLE MILESTONES:** Section 6 outlines indicators along with milestones of implementation success that should be tracked annually.
- H. SET OF CRITERIA:** Sections 2 and 6 can be used to determine whether loading reductions are being achieved over time, substantial progress is being made towards water quality objectives, and if not, criteria for determining whether this plan needs to be revised.
- I. MONITORING COMPONENT:** Section 6 describes the long-term water quality monitoring strategy for Mascoma Lake, the results of which can be used to evaluate the effectiveness of implementation efforts over time as measured against the criteria in (H) above. The success of this plan cannot be evaluated without ongoing monitoring and assessment and careful tracking of load reductions following successful BMP implementation projects.

2 ASSESSMENT OF WATER QUALITY

This section provides an overview of the past, current, and future state of water quality based on the water quality assessment and watershed modeling, which identified pollutants of concern and informed the established water quality goal and objectives for Mascoma Lake.

2.1 WATER QUALITY SUMMARY

2.1.1 Water Quality Standards & Impairment Status

2.1.1.1 Designated Uses & Water Quality Criteria

The **Clean Water Act** (CWA) requires states to determine designated uses for all surface waters within the state's jurisdiction. Designated uses are the desirable activities and services that surface waters should be able to support and include uses for ALI, fish consumption, shellfish consumption, drinking water supply, primary contact recreation (swimming), secondary contact recreation (boating and fishing), and wildlife. Surface waters can have multiple designated uses. **PCR and ALI are the two major uses for lakes – ALI being the focus of this plan.** In New Hampshire, all surface waters are also legislatively classified as Class A or Class B, most of which are Class B (Env-Wq 1700). **Mascoma Lake is classified as Class B waters in the State of New Hampshire.** Additionally, from 1974 to 2010, NHDES conducted surveys of lakes to determine **trophic state** (**oligotrophic**, **mesotrophic**, or **eutrophic**). The trophic surveys evaluated physical lake features, as well as chemical and biological indicators. **For Mascoma Lake, the trophic state was determined to be mesotrophic for 1976, 1985, and 2000 surveys, then the 2008 Lake Trophic Survey classified the lake as oligotrophic** (NHDES, 1976, 1985, 2000, 2008). In-lake water quality was consistent with the standards for oligotrophic lakes across the 1979-2000 timeframe, and it is now assessed as oligotrophic.

Water quality criteria are then developed to protect designated uses, serving as a “yardstick” for identifying water quality exceedances and for determining the effectiveness of state regulatory pollution control and prevention programs. Depending on the designated use and type of waterbody, water quality criteria can become more or less strict if the waterbody is classified as either Class A or B or as oligotrophic, mesotrophic, or eutrophic. To determine if a waterbody is meeting its designated uses, water quality criteria for various parameters (e.g., **chlorophyll-a**, **total phosphorus**, **dissolved oxygen**, **pH**) are applied to the water quality data. If a waterbody meets or is better than the water quality criteria, the designated use is supported. The waterbody is considered impaired for the designated use if it does not meet water quality criteria. Water quality criteria for each classification and designated use in New Hampshire can be found in RSA 485 A:8, IV and in the state's surface water quality regulations.

2.1.1.2 Antidegradation Provisions

The Antidegradation Provision (Env-Wq 1708) in New Hampshire's water quality regulations serves to protect or improve the quality of the state's waters. The provision outlines limitations on increases for future pollutant loading. Certain development projects (e.g., projects that require an Alteration of Terrain Permit or 401 Water Quality Certification) may be subject to an Antidegradation Review to ensure compliance with the state's water quality regulations. The Antidegradation Provision is often invoked during the permit review process for projects adjacent to waters that are designated impaired, high quality, or outstanding resource waters. While NHDES has not formally designated high-quality waters, unimpaired waters are treated as high quality with respect to issuance of water quality certificates. Antidegradation requires that a permitted activity cannot use more than 20% of the remaining assimilative capacity of a high-quality water. This is on a parameter-by-

parameter basis. For impaired waters, antidegradation requires that permitted activities discharge no additional loading of the impaired parameter.

2.1.1.3 Waterbody Impairment Status

The Mascoma Lake watershed contains Mascoma Lake and at least 15 upstream lakes and ponds with monitored assessment units, including Crystal Lake, Canaan Street Lake, Goose Pond, Spectacle Pond, and Reservoir Pond. Mascoma Lake is currently assessed as oligotrophic, but the main lake assessment unit is formally listed as impaired for Aquatic Life Integrity on the New Hampshire 303(d) List of Impaired Waters due to excessively low pH, low dissolved oxygen saturation, and the presence of the non-native aquatic plant Eurasian milfoil (*Myriophyllum spicatum*). Several associated beach assessment units are listed as impaired for Primary Contact Recreation due to the presence of cyanobacteria hepatotoxic microcystins. All Mascoma Lake assessment units are also listed as impaired for fish consumption because of the statewide mercury TMDL. According to NHDES assessments developed from the 2024 305(b)/303(d) listing process and recent VLAP data, Mascoma Lake is currently classified as oligotrophic, but is borderline oligotrophic/mesotrophic, with stable long-term trends in total phosphorus, chlorophyll-a, and Secchi depth and recurring deep-water anoxia that increases the risk of internal phosphorus loading. Other assessment factors are generally rated as meeting or likely meeting water quality standards based on available data. However, cyanobacteria blooms have emerged as a serious and increasing concern for Mascoma Lake and upstream Crystal Lake, as reflected in the growing number of cyanobacteria bloom warnings and alerts summarized in the cyanobacteria bloom history for the watershed.

Table 1. NHDES assessment units covering lakes/ponds in the Mascoma Lake watershed and their associated water quality rating as reported on the NHDES 2020/2022 Watershed Report Cards.

Assessment Unit Name	AUID	Area (acres)	Water Quality
NHLAK801060105-04-01	Mascoma Lake	1154.776	Poor
NHLAK801060105-04-02	Mascoma Lake - Shakoma Beach	0.533	Poor
NHLAK801060105-04-03	Mascoma Lake - Crescent Beach	1.28	Likely Bad
NHLAK801060105-04-04	Mascoma Lake - Dartmouth College Beach	0.18	Poor
NHLAK801060105-04-05	Mascoma Lake - Lakeview Condominium Association Beach	0.702	Likely Bad
NHLAK801060105-01	Cole Pond	16.533	Poor
NHLAK801060105-02	Enfield Reservoir	21.073	No Data
NHLAK801060105-05	Smith Pond	62.651	No Data
NHLAK801060105-06	Bear Pond	12.912	No Data
NHLAK801060103-01	Goose Pond	622.979	Poor
NHLAK801060103-02	Little Goose Pond	18.288	Poor
NHLAK801060104-01	Crystal Lake	399.709	Likely Bad
NHLAK801060104-02	Grafton Pond	318.127	Poor
NHLAK801060104-03	Unnamed Pond	6.897	No Data
NHLAK801060101-01-01	Canaan Street Lake	290.116	Poor
NHLAK801060101-01-02	Canaan Street Lake - Town Beach	0.436	Poor
NHLAK801060101-01-04	Canaan St Lake - Crescent Campsites	0.223	No Data
NHLAK801060101-02	Clark Pond	103.881	Poor
NHLAK801060101-03	Cummins Pond	134.484	Poor
NHLAK801060101-04	Modgetts Pond	9.896	No Data
NHLAK801060101-05	Reservoir Pond	158.329	Poor

Assessment Unit Name	AUID	Area (acres)	Water Quality
NHLAK801060101-06	Little Clark Pond	10.492	No Data
NHLAK801060102-01	Lary Pond	64.188	No Data
NHLAK801060102-02	Mirror Pond	21.536	No Data
NHLAK801060102-03	Spectacle Pond	94.993	Likely Bad

2.1.2 Water Quality Data Collection

Mascoma Lake has been monitored through multiple long-term state and volunteer programs. The lake was included in the 1976, 1985, 2000, and 2008 NHDES Lake Trophic Surveys and has been periodically sampled through the NHDES Volunteer Lake Assessment Program (VLAP).

Water quality data used in this plan were obtained from the NHDES Environmental Monitoring Database. There were 10 water quality monitoring stations identified within Mascoma Lake and an additional station in Crystal Lake. Figure 3 and Figure 4 provide an overview of available water quality data for a subset of stations. Key sites summarized in this plan include:

- **MASENF1D (Mascoma Lake Eastern Deep Spot):** Epilimnetic composite and discrete-depth samples have been collected since 1991, with routine sampling 2×/yr in 1991–1992 and 3×/yr from 1993–2024. Parameters analyzed include total phosphorus, chlorophyll-a, apparent color, chloride, specific conductivity, pH, alkalinity, turbidity, and Secchi disk transparency. Phytoplankton net-tow samples were taken infrequently (2017, 2019, 2022). Temperature and dissolved oxygen profiles have been collected annually since 1991 and up to three times per year since 2007, totaling 72 profiles in the NHDES database. Recent decade data include 25 profiles, with 16 meeting Class B timing requirements and showing no epilimnetic DO violations.
- **MASENF2D (Mascoma Lake Western Deep Spot):** Epilimnetic composite samples and variable-depth grab samples were collected between 2017 and 2022 for total phosphorus, chlorophyll-a, color, total nitrogen, alkalinity, turbidity, chloride, specific conductivity, and pH. YSI EXO2 profiles were collected in 2017 and 2018 for temperature, dissolved oxygen, specific conductivity, pH, oxidation-reduction potential, turbidity, chlorophyll-a fluorescence, phycocyanin fluorescence, and total dissolved solids.
- **CRYENFD/1 (Crystal Lake Deep Spot):** Volunteers collected weekly Secchi transparency readings and seasonal (1–3×/yr) epilimnetic composite samples for total phosphorus, chlorophyll-a, apparent color, and alkalinity. UNH CFB collected variable-depth total phosphorus samples throughout the water column (1–15 m) and select-depth samples (1, 7, 15 m) for chlorophyll-a, alkalinity, pH, turbidity, and specific conductivity. Only three recent temperature/DO profiles exist for this station.

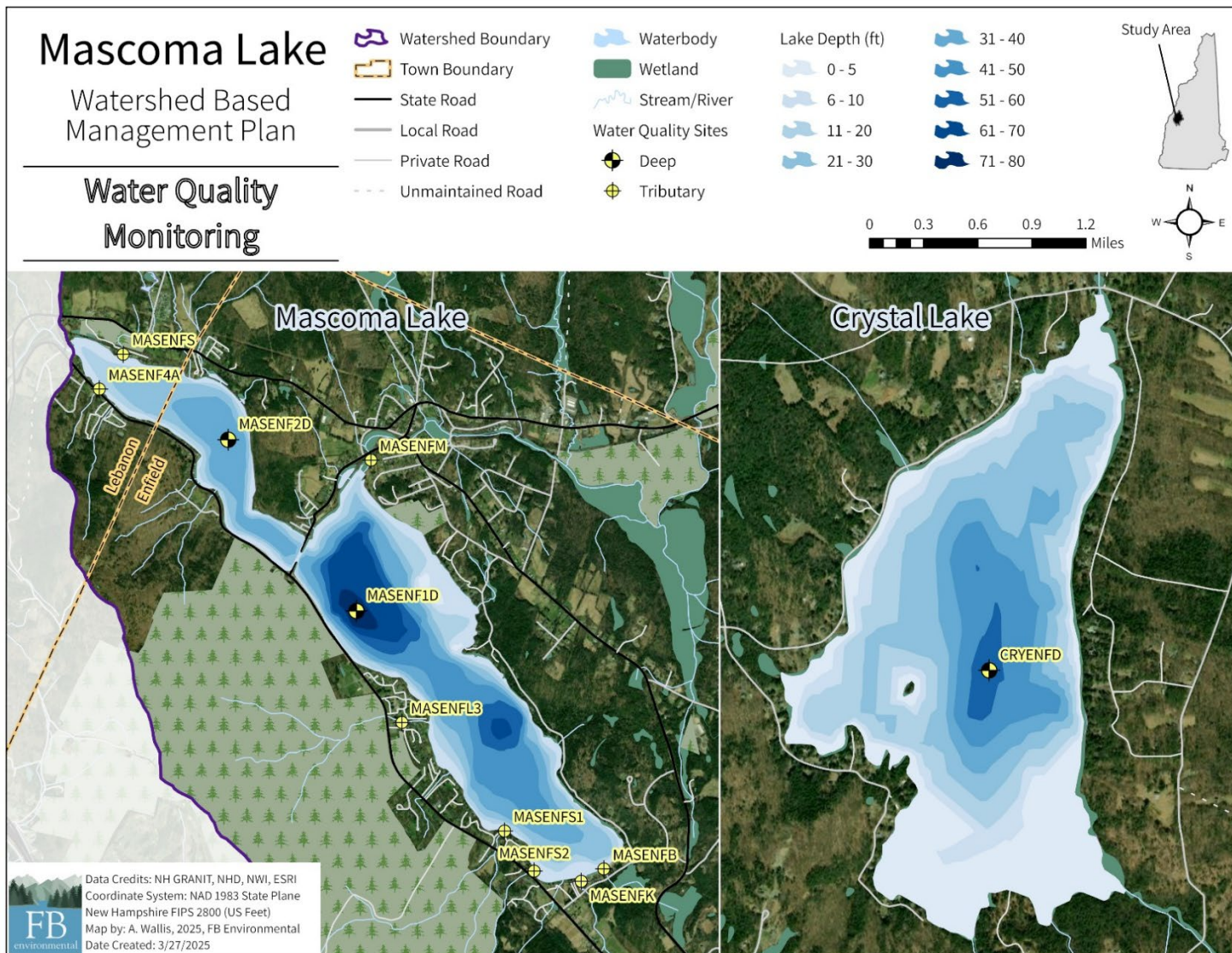


Figure 3. Water quality monitoring sites in Mascoma Lake and Crystal Lake. Sites on other waterbodies are not included. Refer to Table 2 for site descriptions.

Table 2. Site ID and description. Refer to Figure 3 for locations of all sites.

Site ID	Site Description	Waterbody	Site Type
MASENF2D	MASCOMA LAKE-STATION 2 DEEP SPOT	Mascoma Lake	Lake/Pond
MASENF1D	MASCOMA LAKE-STATION 1 DEEP SPOT	Mascoma Lake	Lake/Pond
MASENFK	MASCOMA LAKE-KNOX RIVER INLET	Mascoma Lake	River/Stream
MASENFL3	MASCOMA LAKE-LASALETTE #3	Mascoma Lake	River/Stream
MASENFM	MASCOMA LAKE-MASCOMA RIVER INLET	Mascoma Lake	River/Stream
MASENFRT4A	MASCOMA LAKE-RT 4A BRIDGE	Mascoma Lake	River/Stream
MASENFS	MASCOMA LAKE-SUCKER BROOK	Mascoma Lake	River/Stream
MASENFS1	MASCOMA LAKE-SHAKER BROOK	Mascoma Lake	River/Stream
MASENFS2	MASCOMA LAKE-SMITH POND BROOK	Mascoma Lake	River/Stream
MASENFB	MASCOMA LAKE-BROWNS BROOK	Mascoma Lake	River/Stream
CRYENFD	CRYSTAL LAKE-DEEP SPOT	Crystal Lake	Lake/Pond

2.1.3 Trophic State Indicator Parameters

Total phosphorus, chlorophyll-a, and Secchi disk transparency are trophic state indicators, or indicators of biological productivity in lake ecosystems. The combination of these parameters helps determine the extent and effect of eutrophication in lakes and helps signal changes in lake water quality over time. For example, changes in Secchi disk transparency may be due to a change in the amount and composition of algae communities (typically because of greater total phosphorus availability) or the amount of dissolved or particulate materials in a lake. Such changes are often the result of human disturbance or other impacts to the lake's watershed. Generally, higher total phosphorus concentrations in the hypolimnion compared to the epilimnion suggest that some amount of internal loading is occurring, because the internal phosphorus load originates from the bottom sediment-water interface.

In Mascoma Lake, higher total phosphorus concentrations were most often measured in the hypolimnion compared to the epilimnion, indicating that some amount of internal phosphorus loading is likely occurring (Figure 4). Comparison between recent (2015-2024) and historical (1991-2014) total phosphorus concentrations at the eastern deep spot [MASENF1D] shows minimal differences between historical and current phosphorus concentrations. Total phosphorus concentrations at the western, shallower deep spot [MASENF2D] were more variable for all depth zones and reached a maximum of 66 ppb in the hypolimnion, which suggests that internal loading may be occurring even in shallower areas of the lake (with a maximum depth of 10 meters). The eastern and western portions of the lake are bisected by Main Street in Enfield and are connected by a shallow area (~3 meters) that is freely flowing under a bridge. Differences in water chemistry between the two basins may in part be related to the morphometric and morphological differences between the two areas. No recent data exist for the western deep spot [MASENF2D], with samples last collected in 2011. Additional sampling could reveal changes in internal loading since the last sampling events.

For the available time period, 1985-2024, no statistically significant trends were found for median epilimnetic total phosphorus, chlorophyll-a, or Secchi disk transparency at either deep spot of Mascoma Lake [MASENF1D, MASENF2D] nor the deep spot of Crystal Lake [CRYENFD] (Figure 5). The 2023 VLAP Individual Lake Report for Mascoma Lake also found stable trends for total phosphorus, chlorophyll-a, and Secchi disk transparency, though higher concentrations of total phosphorus were observed in 2023.

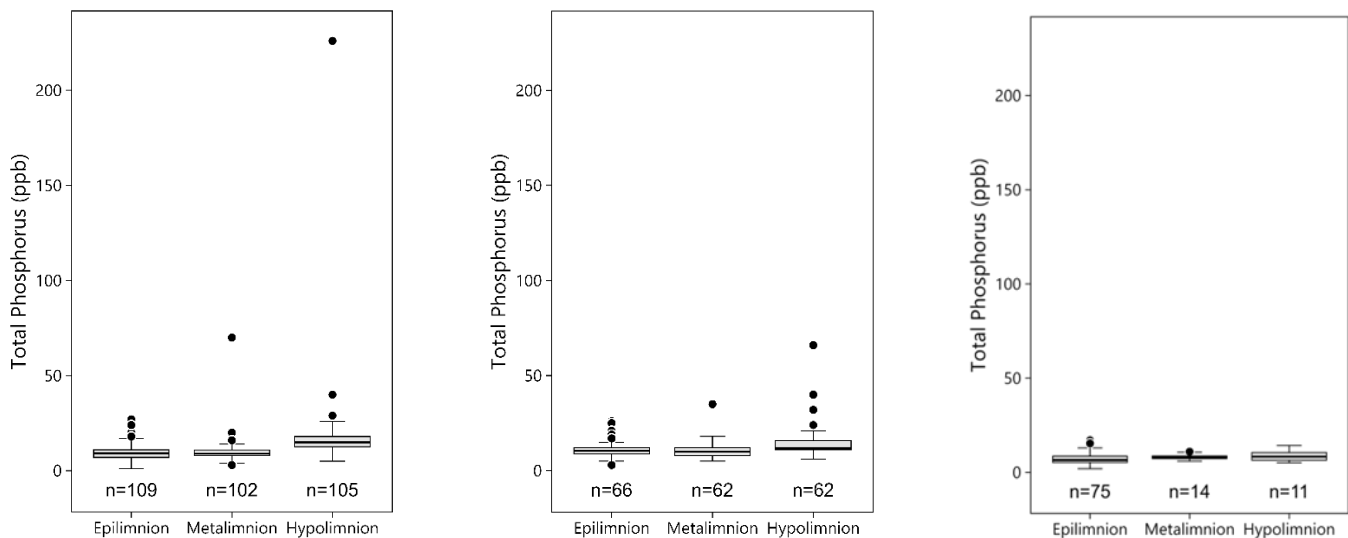


Figure 4 Boxplots showing median total phosphorus concentration in the epilimnion, metalimnion, and hypolimnion of the eastern deep spot of Mascoma Lake [MASENF1D] from 1985-2024 (*left*), the western deep spot of Mascoma Lake [MASENF2D] from 1985-2011 (*middle*), and the deep spot of Crystal Lake [CRYENFD/1 Deep] from 1987-2024 (*right*).

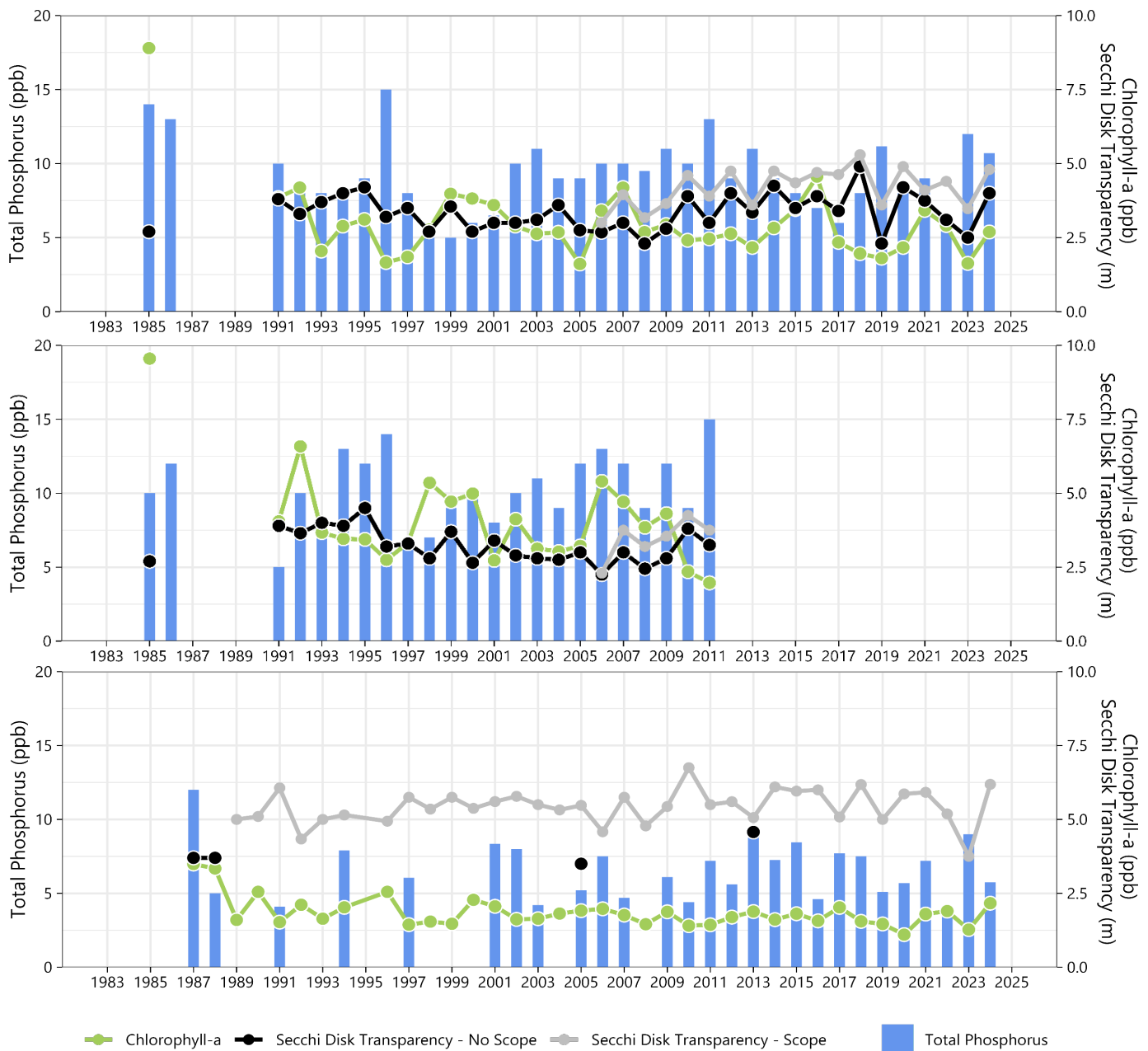


Figure 5. Median epilimnion grab/composite total phosphorus, median composite epilimnion chlorophyll-a, and median water clarity (Secchi Disk depth for scope and no scope methods) measured at the Mascoma Lake eastern deep spot [MASENF1D] (*Top*), Mascoma Lake western deep spot [MASENF2D] (*Middle*), and Crystal Lake deep spot [CRYENFD/1 Deep] (*Bottom*). Sample depths for total phosphorus were 0-5 meters for Mascoma Lake sites and 0-6.5 meters for Crystal Lake sites. Sample depths for chlorophyll-a were 0-9 meters [MASENF1D], 0-5 meters [MASENF2D], and 0-6.5 meters [CRYENFD/1 Deep]. No statistically significant trends were detected for any sites using the *rkt* package in R Studio.

2.1.4 Dissolved Oxygen & Water Temperature

A common occurrence in New Hampshire's lakes is the depletion of dissolved oxygen in the deepest part of lakes throughout the summer months. This occurs when thermal stratification prevents warmer (less dense), oxygenated surface waters from mixing with cooler (denser), oxygen-depleted bottom waters in the lake. Chemical and biological processes occurring in bottom waters deplete the available oxygen throughout the summer, and because these waters are colder and denser, the oxygen cannot be replenished through mixing with surface waters. Dissolved oxygen levels below 5 ppm (and water temperature above 24 °C) can stress and reduce habitat for cold-water fish and other sensitive aquatic organisms. In addition, anoxia (low dissolved oxygen) at the lake bottom can result in the release of sediment-bound phosphorus (otherwise known as internal phosphorus loading), which can become a readily available nutrient source for algae and cyanobacteria. While thermal stratification and depletion of oxygen in bottom waters are a natural phenomenon in dimictic lakes such as Mascoma Lake, it is important to track these parameters to make sure the extent and duration of low oxygen does not change drastically because of human disturbance in the watershed resulting in excess phosphorus loading.

Mascoma Lake is a dimictic lake, undergoing two cycles of stratification and mixing annually. Stratification takes place during summer, as surface waters warm, forming a thermal barrier due to differences in water densities. Additionally, winter months see stratification when the lake freezes over, with colder surface waters sitting atop warmer bottom waters. Dimictic lakes undergo both "fall turnover" and "spring turnover," characterized by the loss of these temperature gradients, enabling water mixing.

Figure 6 shows temperature and dissolved oxygen profiles for both deep spot stations on Mascoma Lake [MASENF1D, MASENF2D] averaged across sampling dates during thermal stratification largely in summer (between spring and fall turnover). For the true deep spot [MASENF1D], data are available for 1991-2024. The change in temperature, seen most dramatically between 5 and 10 m, indicates thermal stratification in the water column. The average dissolved oxygen of <2 ppm at 21-23 m depth indicates the possibility of internal loading under anoxic conditions. Dissolved oxygen <5 ppm may reduce fish habitat in Mascoma Lake; this was measured typically around 15 meters and as shallow as 6 meters. Historic recordings of temperature and dissolved oxygen profiles included multiple water column profiles per sampling season which provide insight into seasonal changes in the lake. Additional profiles in the early autumn months (September and October) can provide additional insight into the possible internal loading in Mascoma Lake.

Dissolved oxygen patterns differ slightly from the western deep spot [MASENF2D], which is in a smaller portion of the lake that is west of Main Street in Enfield. The two sides of the lake are bisected by the street and are connected by a shallow area (~3 meters) that flows freely under a bridge. The western deep spot [MASENF2D] typically experiences oxygen <5 ppm beginning at 7 meters and oxygen <2 ppm as shallow as 8 meters, according to profiles taken between 1991 and 2011 (Figure 6). No recent profiles exist for this sample station. Shallower anoxia (low oxygen) at the western deep spot may be influenced by sinking and decomposing detritus at the sediment-water interface that depletes oxygen levels.

Crystal Lake [CRYENFD/1 Deep] has similar temperature and dissolved oxygen dynamics to Mascoma Lake, with the change in temperature most evident between 4 and 9 meters. The dissolved oxygen profiles show a metalimnetic maximum, which is an area of elevated dissolved oxygen in the metalimnion, which suggests photosynthetic activity by algae. Dissolved oxygen is also depleted in the hypolimnion of Crystal Lake, regularly reaching below 5 ppm (threshold for Aquatic Life Integrity) and occasionally below 2 ppm (increased risk of internal loading).

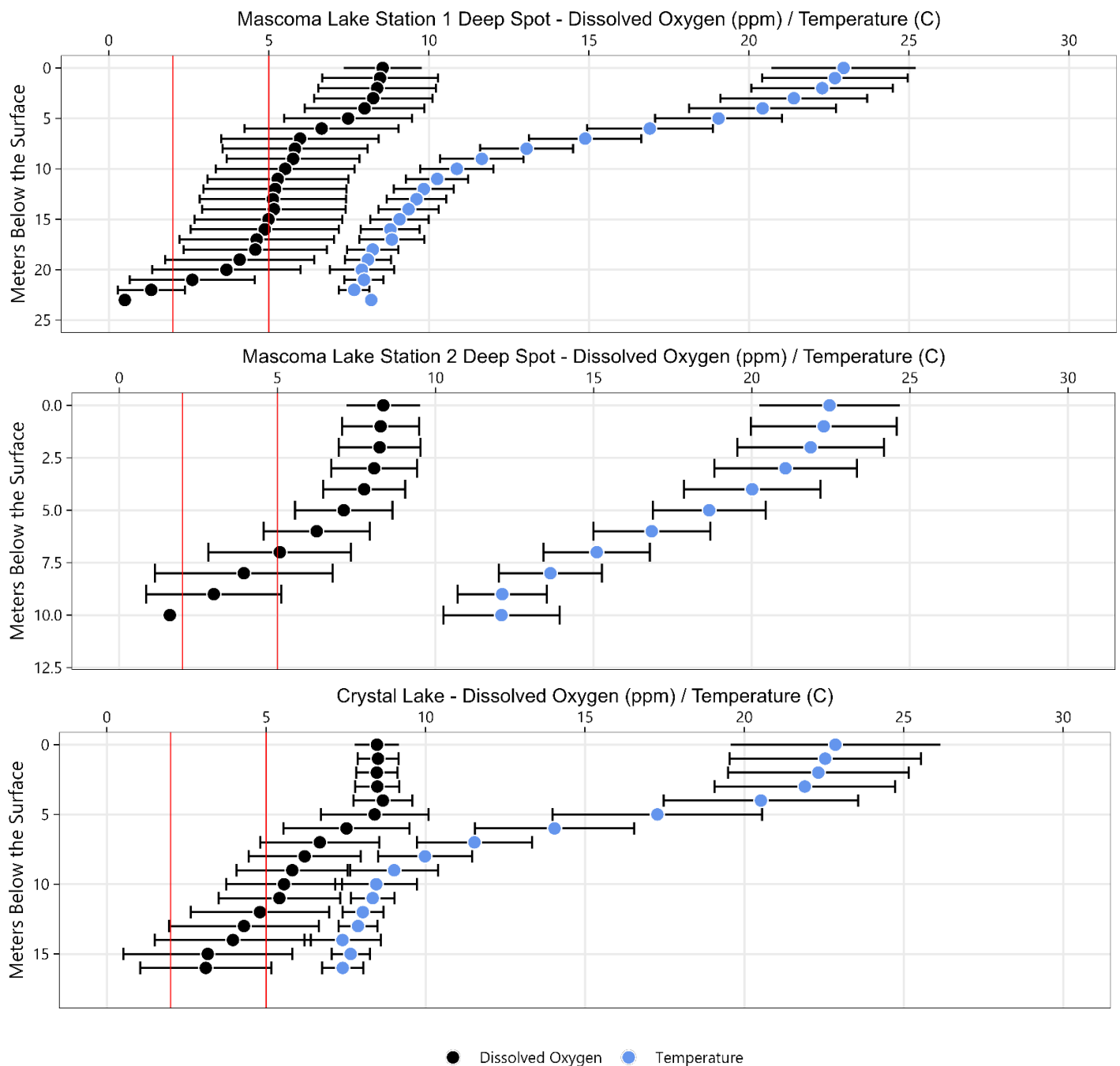


Figure 6. (Top) Dissolved oxygen (black) and water temperature (blue) profiles for the eastern deep spot of Mascoma Lake [MASNF1D]. Data represent profiles collected from 1991 to 2024 (n=72). (Middle) Dissolved oxygen (black) and water temperature (blue) profiles for the western deep spot of Mascoma Lake [MASNF2D]. Data represent profiles collected from 1991 to 2011 (n=35). (Bottom) Dissolved oxygen (black) and water temperature (blue) profiles for the deep spot of Crystal Lake [CRYENFD/1 Deep]. Data represent profiles collected between 1987 to 2024 (n=12). Dots represent average values across sampling dates for each respective depth, and bars represent standard deviation for all figures. Red lines at 5 ppm and 2 ppm represent thresholds for Aquatic Life Integrity and internal phosphorus loading risk, respectively, due to low dissolved oxygen.

2.1.5 Phytoplankton (Cyanobacteria) and Zooplankton

2.1.5.1 Phytoplankton/Zooplankton Surveys

The 2023 VLAP Individual Lake Report for Mascoma Lake shows phytoplankton population (relative percent cell count per taxa) for 2013, 2015, 2017, 2019, and 2022. These data suggest that Mascoma Lake is typically dominated by diatoms and golden-brown algal groups. In 2013, approximately 70% of the phytoplankton population was comprised of cyanobacteria. Phytoplankton samples collected on 6/20/2017, 6/11/2019, and 6/21/2022 show that species such as *Dinobryon* (golden-brown), *Asterionella* (diatom), *Tabellaria* (diatom), and *Rhizosolenia* (diatom) are common. Cyanobacteria in these samples were dominated by *Anabaena/Dolichospermum*, which are the most common species found in Mascoma Lake's blooms. Dominant phytoplankton species noted in NHDES Lake Trophic Survey Reports from 1976, 1985, 2000, and 2008 are similar to those from more recent VLAP phytoplankton samples (Table 3) and include *Coelosphaerium* (cyanobacteria) and *Ceratium* (dinoflagellate). *Coelosphaerium* is a type of cyanobacteria but seldom produces blooms in New Hampshire. *Ceratium* is a motile, mixotrophic algae, meaning it both consumes other algae and produces its own energy through photosynthesis.

The dominant zooplankton species in the 1976, 1985, 2000, and 2008 surveys were *Nauplius* larvae (copepod), *Kellicottia* (rotifer), *Cyclopoid* (copepod), *Polyarthra* (rotifer), *Keratella* (rotifer), and *Daphnia* (cladoceran). Copepods are small crustaceans that eat phytoplankton and provide an important food source to fish. Rotifers are small zooplankton whose population can respond quickly to environmental changes. *Daphnia* are among the most efficient grazers of phytoplankton but were only shown to be a dominant zooplankter (17%) on 7/10/2008. A diverse balance of phytoplankton and zooplankton is typically an indicator of a healthy lake ecosystem.

Table 3. Plankton results for Mascoma Lake from the 1976, 1985, 2000, and 2008 Lake Trophic Survey Reports.

Date	Phytoplankton Species (% Total)	Total Phytoplankton Count (cells/mL)	Zooplankton Species (% Total)	Total Zooplankton Count (cells/L)
2/4/1976	Very sparse, none	No Data	<i>Cyclopoid</i> copepod (60%)	No Data
7/19/1976	<i>Tabellaria</i> (90%)	No Data	<i>Nauplius</i> larva (30%) <i>Polyarthra</i> (25%)	151
8/20/1985	<i>Anabaena</i> (90%)	No Data	<i>Kellicottia</i> (30%) <i>Polyarthra</i> (15%)	150
2/12/1986	<i>Asterionella</i> (75%)	No Data	Sparse, none	17
8/28/2000	<i>Tabellaria</i> (50%) <i>Rhizosolenia</i> (25%) <i>Asterionella</i> (20%)	No Data	<i>Kellicottia</i> (22%) <i>Nauplius</i> larva (22%) <i>Polyarthra</i> (15%)	119
2/15/2001	<i>Tabellaria</i> (50%) <i>Asterionella</i> (30%) <i>Coelosphaerium</i> (10%)	No Data	<i>Nauplius</i> larva (38%) <i>Kellicottia</i> (29%) <i>Cyclopoid</i> copepod (19%)	21
7/10/2008	<i>Dinobryon</i> (40%) <i>Ceratium</i> (20%) <i>Anabaena</i> (15%)	No Data	<i>Nauplius</i> larva (31%) <i>Polyarthra</i> (17%) <i>Daphnia</i> (17%)	150
3/4/2009	<i>Coelosphaerium</i> (45%) <i>Tabellaria</i> (20%) <i>Asterionella</i> (20%)	No Data	<i>Keratella</i> (31%) <i>Nauplius</i> larva (15%) <i>Cyclopoid</i> copepod (15%)	13

2.1.5.2 Cyanobacteria Bloom History

Nutrients such as phosphorus and nitrogen, as well as algae and cyanobacteria, naturally occur in the environment, including lakes and tributaries and their contributing watersheds, and are essential to lake health. Under natural conditions, algae and cyanobacteria concentrations are regulated by limited nutrient inputs and lake mixing processes that keep them from growing too rapidly. However, human-related disturbances, such as erosion, overapplied fertilizers, polluted stormwater runoff, excessive domesticated animal waste, and inadequately treated wastewater, can dramatically increase the amount of nutrients entering lakes and their tributaries. Excess nutrient loading to human-disturbed lake systems, in combination with a warming climate, has fueled the increasing prevalence of Harmful Algal Blooms (HABs) defined as the rapid growth of algae and cyanobacteria in lakes across the United States.

Cyanobacteria are small photosynthesizing, sometimes nitrogen-fixing, single-celled bacteria that grow in colonies in freshwater systems. Cyanobacteria blooms can (but not always) produce microcystins and other toxins that pose a serious health risk to humans, pets, livestock, and wildlife, such as neurological, liver, kidney, and reproductive organ damage, gastrointestinal pain or illness, vomiting, eye, ear, and skin irritation, mouth blistering, tumor growth, seizures, or death. Blooms can form dense mats or surface scum that can occur within the water column or along the shoreline. Dried scum along the shoreline can harbor high concentrations of microcystins that can re-enter a waterbody months later. There are several different species of cyanobacteria, such as:

Dolichospermum (formerly *Anabaena*): typically observed as filaments, associated with microcystins, anatoxins, saxitoxins, and cylindrospermopsin, documented in Mascoma Lake in 2009, 2022, 2023, and 2024.

Microcystis: typically observed as variations of small-celled colonies, associated with microcystins and anatoxins, documented in 2013 and 2023.

Woronichinia: typically forms dense colonies, associated with microcystins were documented in 2023.

Cyanobacteria are becoming more prevalent in low-nutrient lake systems likely due to climate change warming effects (e.g., warmer water temperatures, prolonged thermal stratification, increased stability, reduced mixing, and lower flushing rates at critical low-flow periods that allow for longer residence times) that allow cyanobacteria to thrive and outcompete other phytoplankton species (Przytulska, Bartosiewicz, & Vincent, 2017; Paerl, 2018; Favot, et al., 2019). Many cyanobacteria can regulate their buoyancy and travel vertically in the water column to maximize their capture of both sunlight and sediment phosphorus (even during stratification and/or under anoxic conditions) for growth. In addition, some cyanobacteria can also fix atmospheric nitrogen, if enough light, phosphorus, iron, and molybdenum are available for the energy-taxing process. Some taxa are also able to store excess nitrogen and phosphorus intracellularly for later use under more favorable conditions. Because of these traits and as climate warming increases the prevalence and dominance of cyanobacteria, cyanobacteria are one of the major factors driving positive feedbacks with lake eutrophication and may be both accelerating eutrophication in low-nutrient lakes and preventing complete recovery of lakes from eutrophic states (Dolman, et al., 2012; Cottingham, Ewing, Greer, Carey, & Weathers, 2015). A better understanding of cyanobacteria's role in nutrient feedbacks will be needed for more effective lake restoration strategies.

Mascoma Lake has had seven officially reported NHDES cyanobacteria bloom warnings, the first of which was issued in 2009 (Table 4). It has also had six cyanobacteria alerts, which were documented via photograph but not officially enumerated. All bloom warnings lasted eight days or less, suggesting that Mascoma Lake does not experience long-lasting, whole-lake blooms. However, bloom frequency appears to have increased in recent years, with 2020, 2021, 2022, and 2024 having one bloom warning/alert each, and 2023 having a total of five warnings/alerts. Most blooms have been reported to be dominated by *Dolichospermum* with cell counts

between 100,800 and 1,279,400 cells/mL. One *Microcystis* bloom was observed in August 2013, which lasted 4 days and had a cell count of 1,300,000 cells/mL. A bloom recorded in August 2023 was comprised of a diverse mix of *Woronichinia*, *Dolichospermum*, and *Microcystis*. *Dolichospermum* (formerly *Anabaena*) can outcompete other phytoplankton with its ability to fix atmospheric nitrogen. All three cyanobacteria can regulate their buoyancy throughout the water column to avoid harsh light conditions on the surface and access nutrients from deeper thermal layers. These taxa all have the potential to produce toxins. Mascoma Lake experienced one cyanobacteria bloom in 2024 which lasted eight days that consisted of *Dolichospermum* and had a cell count of 176,800 cells/mL.

Crystal Lake's blooms were similarly short and primarily composed of *Dolichospermum* and *Microcystis*. *Aphanizomenon* are a taxon observed in Crystal Lake that were not observed in Mascoma Lake; these cyanobacteria appear like grass clippings in the water and are able to fix nitrogen. The 9/6/2023 bloom on Crystal Lake had the highest cell count observed (2,950,000 cells/mL), and the 10/9/2023 bloom had the same diversity of cyanobacteria found in Mascoma Lake (Table 4).

Table 4. Bloom warnings for Mascoma Lake and Crystal Lake as reported by NHDES. Alerts not shown.

Lake	Warning Date	Duration (Days)	Dominant Taxa	Total Cell Concentration (cells/mL)
Mascoma Lake	June 17, 2009	7	<i>Dolichospermum (Anabaena)</i>	> 70,000 or > 50%
	August 15, 2009	3	<i>Dolichospermum (Anabaena)</i>	1,259,600
	August 30, 2013	4	<i>Microcystis</i>	1,300,000
	June 3, 2022	7	<i>Dolichospermum</i>	1,279,400
	July 14, 2023	7	<i>Dolichospermum</i>	100,800
	August 4, 2023	7	<i>Woronichinia, Dolichospermum, Microcystis</i>	641,600
	June 19, 2024	8	<i>Dolichospermum</i>	176,800
Crystal Lake	August 9, 2023	7	<i>Dolichospermum, Aphanizomenon</i>	291,500
	September 6, 2023	7	<i>Dolichospermum, Microcystis</i>	2,950,000
	October 9, 2023	6	<i>Dolichospermum, Microcystis, Woronichinia</i>	596,800

It is impossible to fully eradicate cyanobacteria in Mascoma Lake as they are naturally occurring bacteria that have been on the planet for millennia and are resilient to environmental changes; some species of cyanobacteria can become dormant in sediment and then can jump-start cell reproduction once conditions are favorable (warm water temperatures and plenty of sunlight and nutrients). Given the long-term trend of increasing air and water temperatures due to climate change and increased phosphorus loading from development in the watershed, the likelihood of blooms will continue and possibly accelerate, though year-to-year variability in weather may determine the availability of phosphorus and/or the presence of other oxygen compounds such as nitrates and thus determine the timing, extent, and severity of blooms in any given year. Despite this, conditions favorable for blooms can be substantially minimized by reducing nutrient-rich runoff

from the landscape during warm, sunny spells. Water level and flow also help to either flush out blooms or limit upstream nutrient sources to stymie growth.

2.1.6 Fish

Fish are an important natural resource for sustainable ecosystem food webs and provide recreational opportunities. Mascoma Lake is an oligotrophic lake that supports populations of warm and cold water species including but not limited to lake trout, rainbow trout, landlocked Atlantic salmon, smallmouth bass, largemouth bass, chain pickerel (Eastern), black crappie, white and yellow perch, and pumpkinseed (common sunfish).

2.1.7 Invasive Species

The introduction of non-indigenous invasive aquatic plant and animal species to New Hampshire's waterbodies has been on the rise. These invasive aquatic plants are responsible for habitat disruption, loss of native plant and animal communities, reduced property values, impaired fishing and degraded recreational experiences, and high removal costs. Once established, invasive species are difficult and costly to remove. NHDES indicates in its Lake Information Mapper that variable leaf milfoil has been present in Mascoma Lake. In particular, the MLA has an active volunteer scuba diving group that removes and manages Eurasian watermilfoil in Mascoma Lake. The Mascoma Lake Association, Goose Pond Lake Association, Canaan Street Lake Association, Crystal Lake Association and Friends of Grafton Pond are involved in the NHDES Weed Watchers program for early detection and NH Lakes Association's Lake Host program for prevention. Volunteers affiliated with the Volunteer River Assessment Program monitor the Mascoma River for invasive species on an informal basis.

2.1.8 Assimilative Capacity

The assimilative capacity of a waterbody describes the amount of pollutants that can be added to a waterbody without causing a violation of the water quality criteria based on lake trophic designation. Mascoma Lake is a borderline oligotrophic/mesotrophic waterbody; however, the lake is currently assessed as oligotrophic. The previous mesotrophic designation (in 1976, 1985, and 2000) was largely attributed to a degradation in dissolved oxygen in the bottom waters which had improved by 2008. For enhanced protection of water quality, the oligotrophic designation was selected for running the assimilative capacity analysis for Mascoma Lake (and other upstream waterbodies for which data were summarized). For oligotrophic waterbodies, the water quality criteria are set at 8.0 ppb for total phosphorus and 3.3 ppb for chlorophyll-a, above which the waterbody is considered impaired. NHDES requires that 10% of the difference between the best possible water quality and the water quality standard be kept in reserve; therefore, total phosphorus and chlorophyll-a must be at or below 7.2 ppb and 3.0 ppb, respectively, to achieve Tier 2 High Quality Water status. Support determinations are based on the nutrient stressor (phosphorus) and response indicator (chlorophyll-a), with chlorophyll-a dictating the assessment if both chlorophyll-a and total phosphorus data are available and the assessments differ.

Results of the assimilative capacity analysis show that Mascoma Lake is achieving Tier 2 (High Water Quality) status for the oligotrophic class designation, based on low chlorophyll-a levels (Table 7). However, the existing median total phosphorus concentrations exceed the oligotrophic threshold, suggesting that factors other than total phosphorus (e.g., light) may also be responsible in part for controlling algal growth. Elevated total phosphorus levels indicate that reductions in the total phosphorus load are likely needed to maintain the chlorophyll-a concentration below the 3.0 ppb threshold and reduce the frequency of cyanobacteria blooms.

Table 5. Aquatic life integrity (ALI) nutrient criteria ranges by trophic class in New Hampshire. TP = total phosphorus. Chl-a = chlorophyll-a, a surrogate measure for algae.

Trophic State	TP (ppb)	Chl-a (ppb)
Oligotrophic	< 8.0	< 3.3
Mesotrophic	> 8.0 - 12.0	> 3.3 - 5.0
Eutrophic	> 12.0 - 28.0	> 5.0 - 11.0

Table 6. Decision matrix for aquatic life integrity (ALI) assessment in New Hampshire. TP = total phosphorus. Chl-a = chlorophyll-a, a surrogate measure for algae concentration.

Nutrient Assessments	TP Threshold Exceeded	TP Threshold NOT Exceeded	Insufficient Info for TP
Chl-a Threshold Exceeded	Impaired	Impaired	Impaired
Chl-a Threshold NOT Exceeded	Potential Non-support	Fully Supporting	Fully Supporting
Insufficient Info for Chl-a	Insufficient Info	Insufficient Info	Insufficient Info

Table 7. Assimilative capacity (AC) analysis results for the Mascoma Lake deep spot [MASENF1D] and other waterbodies throughout the watershed with sufficient data.

Site	Parameter	AC Threshold (ppb)	Existing Median WQ (ppb)*	Remaining AC (ppb)	Results
MASCOMA LAKE – STATION 1 DEEP SPOT [MASENF1D]	Total Phosphorus	7.2	9.0	-1.8	Tier 2 (High Water Quality)
	Chlorophyll-a	3.0	2.6	0.4	
CRYSTAL LAKE-DEEP SPOT [CRYENFD/1 Deep]	Total Phosphorus	7.2	6.4	0.8	Tier 2 (High Water Quality)
	Chlorophyll-a	3.0	1.7	1.3	
CANAAN STREET LAKE-DEEP SPOT [CANCAND]	Total Phosphorus	7.2	6.3	0.9	Tier 2 (High Water Quality)
	Chlorophyll-a	3.0	1.8	1.2	
GOOSE POND-DEEP SPOT [GOOCAND]	Total Phosphorus	7.2	7.0	0.2	Tier 1 (Within Reserve)
	Chlorophyll-a	3.0	3.0	0.0	
SPECTACLE POND-VLAP DEEP SPOT [SPEENFD2]	Total Phosphorus	7.2	8.8	-1.6	Tier 1 (Within Reserve)
	Chlorophyll-a	3.0	3.2	-0.2	
RESERVOIR POND-DEEP SPOT [RESDORD]	Total Phosphorus	7.2	5.7	1.5	Impaired
	Chlorophyll-a	3.0	5.0	-2.0	

* Existing water quality data truncated to May 24-Sept 15 in the previous 10 years (2015-2024) for composite, epilimnion, or upper samples (in order of priority on a given day). Data were summarized by day, then month, then year using median statist

2.2 WATERSHED MODELING

2.2.1 Lake Loading Response Model (LLRM)

Environmental modeling is the process of using mathematics to represent the natural world. Models are created to explain how a natural system works, to study cause and effect, or to make predictions under various scenarios. Environmental models range from very simple equations that can be solved with pen and paper, to highly complex computer software requiring teams of people to operate. Lake models, such as the Lake Loading Response Model (LLRM), can make predictions about phosphorus concentrations, chlorophyll-a concentrations, and water clarity under different pollutant loading scenarios. These types of models play a key role in the watershed planning process. EPA guidelines for watershed plans require that pollutant loads to a waterbody be estimated.

The LLRM is an Excel-based model that uses environmental data to develop a water and phosphorus loading budget for lakes and their tributaries (AECOM, 2009). Water and phosphorus loads (in the form of mass and concentration) are traced from various sources in the watershed through tributary basins and into the lake. The model incorporates data about watershed and sub-watershed boundaries, land cover, point sources (if applicable), septic systems, waterfowl, rainfall, volume and surface area, and internal phosphorus loading. These data are combined with coefficients, attenuation factors, and equations from scientific literature on lakes, rivers, and nutrient cycles to generate annual average predictions of total phosphorus, chlorophyll-a, Secchi disk transparency, and algal bloom probability. The model can be used to identify current and future pollutant sources, estimate pollutant limits and water quality goals, and guide watershed improvement projects. A complete detailing of the methodology employed for the Mascoma Lake LLRM is provided in the *Mascoma Lake Loading Response Model Report* (FBE, 2025a).

2.2.1.1 Lake Morphology & Flow Characteristics

The morphology (shape) and bathymetry (depth) of lakes and ponds are considered reliable predictors of water clarity and lake ecology. Large, deep lakes are typically clearer than small, shallow lakes as the differences in lake area, number and volume of upstream lakes, and **flushing rate** affect lake function and health.

The surface area of Mascoma Lake is 1,164 acres with a maximum depth of 69 feet (21 meters) and volume of 39,706,676 m³ (Appendix A, Map A- 1). The **areal water load** is 21 ft/yr (6.4 m/yr), and the flushing rate is 2.3 times per year. The flushing rate of 2.3 means that the entire volume of Mascoma Lake is replaced 2.3 times per year.

2.2.1.2 Land Cover

Characterizing land cover within a watershed on a spatial scale can highlight potential sources of NPS pollution that would otherwise go unnoticed in a field survey of the watershed. For instance, a watershed with large areas of developed land (i.e., impervious cover) and minimal forestland will likely be more at risk for NPS pollution than a watershed with well-managed development and large tracts of undisturbed forest, particularly along headwater streams. Land cover is also the essential element in determining how much phosphorus is contributing to a surface water via stormwater runoff and baseflow.

Current land cover in the Mascoma Lake watershed was determined by FBE using a combination of wetlands from the National Wetlands Inventory (NWI), waterbodies from the National Hydrography Dataset (NHD), roads from the New Hampshire Department of Transportation (NHDOT), and building footprints from the publicly available Microsoft building footprints layer. All data were acquired from New Hampshire's data clearinghouse, NH GRANIT. FBE edited the land cover file to add residential and commercial development, logging, excavation and other land uses using ESRI World Imagery and Google Earth satellite imagery. For

more details on methodology, see the *Mascoma Lake Loading Response Model Report* (FBE, 2025a). Refer also to Appendix A, Map A- 2.

The FBE created watershed land cover for the Mascoma Lake watershed found that development accounts for 5% (1,670 hectares) of the watershed, while forested and natural areas account for 83% (29,816 hectares). Wetlands and open water represent 10% (3,434 hectares) of the watershed, not including the surface areas of Mascoma Lake and Crystal Lake. Agriculture represents 2% (931 hectares). Land cover for the Crystal Lake watershed found that development accounts for 5% of the watershed, while forested and natural areas accounted for 84% of the watershed. Like the Mascoma Lake Watershed, wetlands and open water accounted for 10% of the watershed, but for the Crystal Lake watershed agriculture only accounted for 1% of the watershed land cover.

Figure 7 shows a breakdown of land cover by major category for the entire watershed (not including waterbody areas), as well as total phosphorus load by major land cover category (refer to 2.2.1.2 or FBE, 2025a). Developed areas cover 5% of the entire watershed and contribute 48% of the entire total phosphorus watershed load to Mascoma Lake. Developed areas in the Crystal Lake Watershed cover 5% of the direct watershed and contribute 50% of the direct total phosphorus watershed load. Development and associated impervious surfaces are concentrated along the shoreline of Mascoma Lake and downtown Enfield and represent a significant impact to water quality by contributing contaminated runoff with minimal treatment directly to Mascoma Lake.

Developed areas within the Mascoma Lake watershed are characterized by **impervious surfaces**, including areas with asphalt, concrete, compact gravel, and rooftops that force rain and snow that would otherwise soak into the ground to run off as stormwater. Stormwater runoff carries pollutants to waterbodies that may be harmful to aquatic life, including sediments, nutrients, pathogens, pesticides, hydrocarbons, and metals. There are documented correlations between the percentage of effective impervious cover in a drainage area and the water quality of the receiving waterbody, with higher percent impervious cover, often greater than 10% as per the NHDES "1065 Rule", causing degradation of water quality and aquatic habitat. While an impervious cover analysis was not completed for this plan, impervious cover in the direct watershed to Mascoma Lake is less than 10% since developed land cover (at 5%) reflects all human-impacted areas in addition to impervious surfaces and includes such non-impervious areas as lawns.

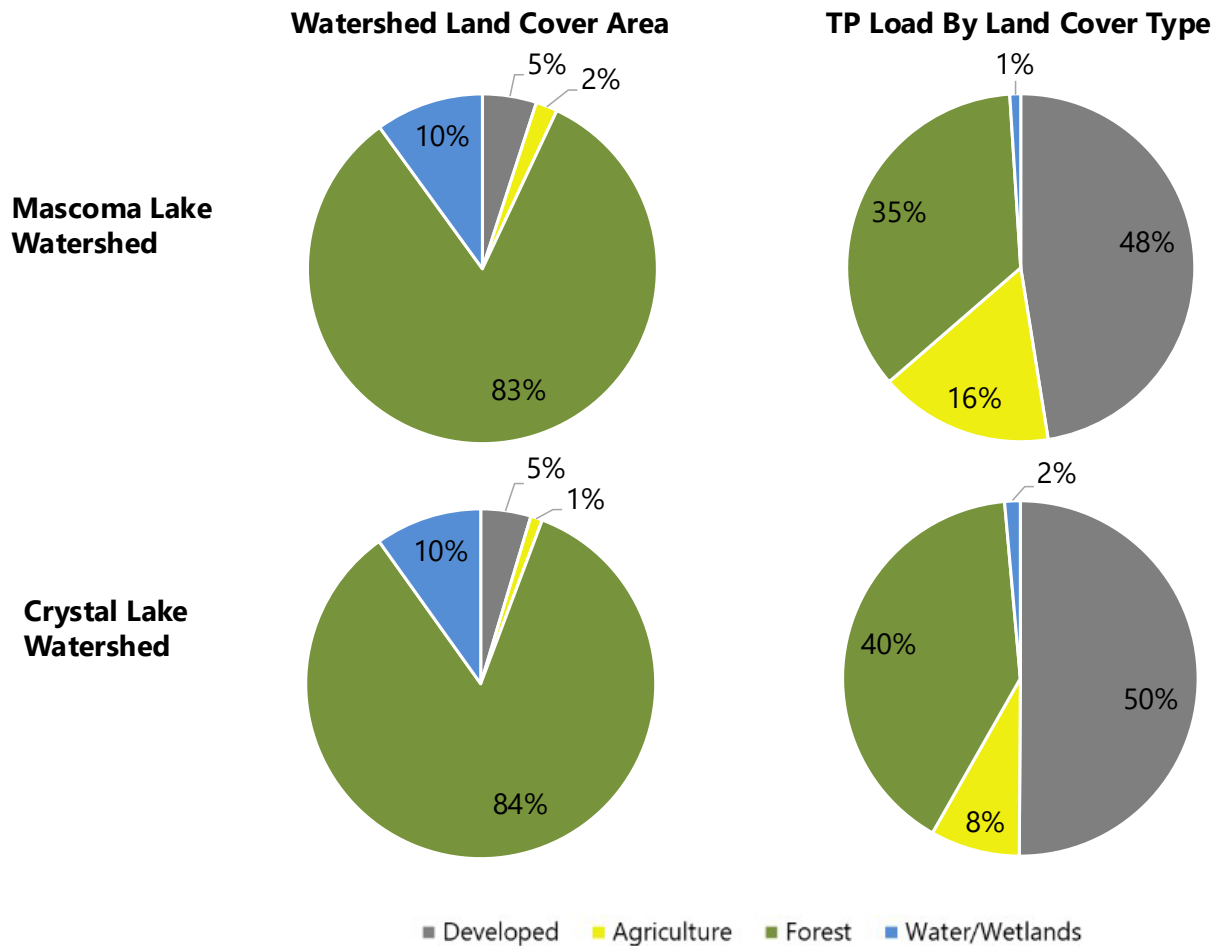


Figure 7. Watershed land cover area by major category (agriculture, developed, forest, and water/wetlands) and total phosphorus (TP) watershed load by major land cover type for the Mascoma Lake and Crystal Lake watersheds. The water/wetlands category does not include the lake area of Mascoma Lake or Crystal Lake.

2.2.1.3 Internal Phosphorus Loading

Phosphorus that enters the lake and settles to the bottom can be re-released from sediment under anoxic conditions, providing a nutrient source for algae, cyanobacteria, and plants. Internal phosphorus loading can also result from wind-driven wave action or physical disturbance of the sediment (boat props, aquatic macrophyte management activities). Internal loading estimates were derived from dissolved oxygen and temperature profiles taken at the deep spots of each waterbody (to determine average annual duration and depth of anoxia defined as <2 ppm dissolved oxygen) and epilimnion/hypolimnion total phosphorus data taken at the deep spots of each waterbody (to determine the average difference between surface and bottom phosphorus concentrations). These estimates, along with anoxic volume and surface area, helped determine the rate of release and mass of the annual internal phosphorus load. The internal load estimate in any given year is highly variable and warrants further investigation.

2.2.1.4 LLRM Results

Overall, model predictions for Crystal Lake and Mascoma Lake were in good agreement with observed data for total phosphorus (4% and 2%, respectively), moderate agreement for Secchi disk transparency (6% and 12%, respectively) and poor agreement for chlorophyll-a (15% and 37%, respectively). It is important to note that the LLRM does not explicitly account for all the biogeochemical processes occurring within a waterbody that

contribute to overall water quality and is less accurate at predicting chlorophyll-a and Secchi disk transparency. For example, chlorophyll-a is estimated strictly from nutrient loading, but other factors strongly affect algae growth, including transport of phosphorus from the sediment-water interface to the water column by cyanobacteria, low light from suspended sediment, grazing by zooplankton, presence of heterotrophic algae, and flushing effects from high flows. There was insufficient data available to evaluate the influence of these other factors on observed chlorophyll-a concentrations and Secchi disk transparency readings. The model predicts zero cyanobacteria bloom days for Crystal Lake and one cyanobacteria bloom day for Mascoma Lake. Although both lakes have received bloom warnings for multiple days in recent summers, these blooms were generally shoreline accumulations and not representative of epilimnion water column cell densities that the model predicts.

Watershed runoff combined with baseflow (94%) was the largest phosphorus loading contribution across all sources to Mascoma Lake, which is the final receiving waterbody in the watershed (Figure 8). The watershed load (94%) to Mascoma Lake includes the total phosphorus load from Crystal Lake (7%) (Figure 8). Atmospheric deposition (2%), internal loading (1%), waterfowl (1%), and septic systems (2%) were relatively minor sources to Mascoma Lake but may be seasonally important during low flow summer conditions. For Crystal Lake, the model predicted 73% of the total phosphorus load originates from watershed sources, with septic systems (9%), internal loading (9%), atmospheric deposition (6%), and waterfowl (3%) making up the remaining phosphorus load.

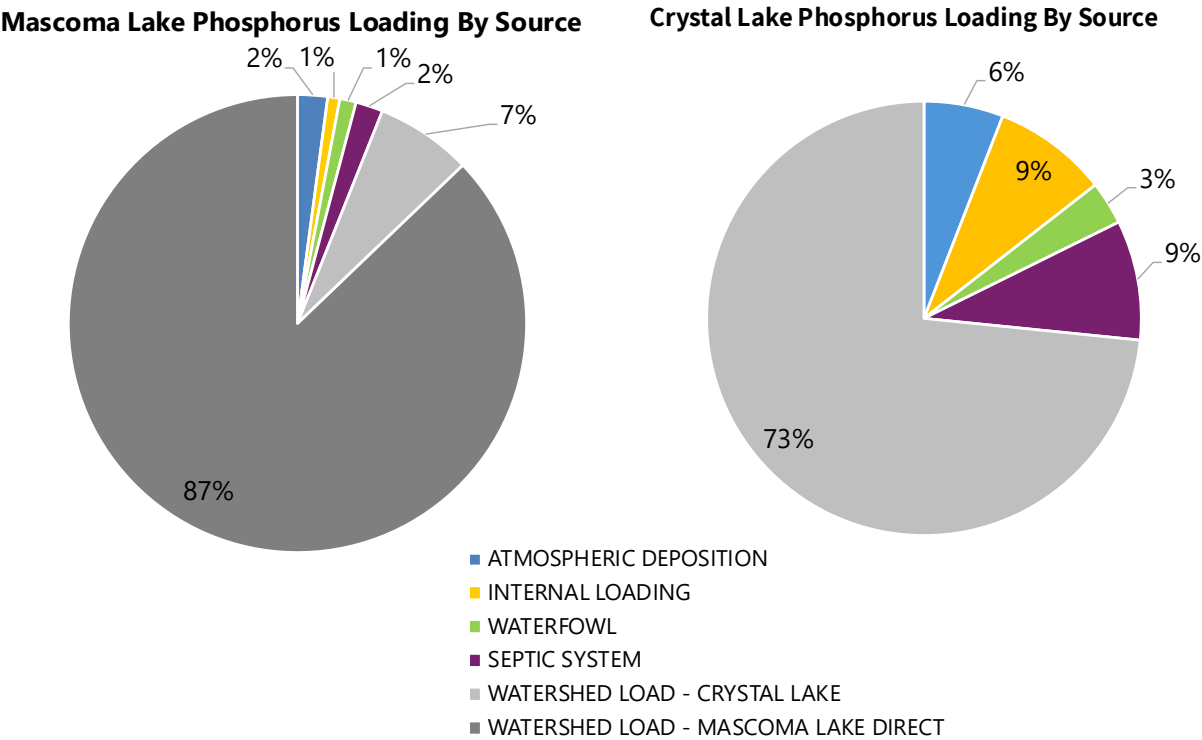


Figure 8. Summary of total phosphorus loading by major source for Mascoma Lake and Crystal Lake. Refer to Table 9 for a breakdown.

Development in the watershed is most concentrated along primary roadways through Enfield and Canaan and is particularly dense in the Canaan and Enfield town centers. Development is also dense around the shoreline where septic systems or holding tanks are located within a short distance of the water, leaving little horizontal (and sometimes vertical) space for proper filtration of wastewater effluent. Improper maintenance or siting of

these systems can cause failures, which leach untreated, nutrient-rich wastewater effluent to the lake. Much of the southwestern shoreline of Mascoma Lake is sewered as well as Main Street in Enfield. The entirety of the Crystal Lake shoreline is serviced by septic systems. Sewer can also represent a potential vulnerability if the sewer systems are old or damaged and leaking wastewater into groundwater near waterbodies. Note that the septic system load estimate is only for those systems directly along the shoreline of Mascoma and Crystal Lakes and potentially short-circuiting minimally treated effluent to the lakes. The load from septic systems throughout the rest of the watershed is inherent to the coefficients used to generate the watershed load.

Normalizing for the size of a sub-watershed (i.e., accounting for its annual discharge and direct drainage area) better highlights sub-watersheds with elevated pollutant exports relative to their drainage area. Sub-watersheds with moderate to high phosphorus export rates (>0.2 kg/ha/yr) generally correspond to more developed areas, particularly dense urban development along Mascoma Lake's shoreline. Drainage areas directly adjacent to waterbodies have a direct hydrologic connection to the lake and are often targeted for development, increasing the potential for phosphorus export. Other high-loading areas with extensive developed land include sub-watersheds near the U.S. Route 4 corridor, encompassing downtown Enfield and Canaan, as well as development near Canaan Street Lake and Canaan Center.

Development in eastern Canaan and along New Hampshire Route 118 occurs within the largely undeveloped Lower Indian River sub-watershed, resulting in lower total phosphorus loads compared to other Route 4 and urban corridor sub-watersheds. Similarly, the Goose Pond sub-watershed shows relatively low loading despite shoreline development, due to extensive forest cover in its northern portion. Smaller sub-watersheds on Mascoma Lake's western shore, including the Lower and Upper Shaker Village and Smith Pond sub-watersheds, have lower phosphorus loading since a large portion of their land is conserved under the Lower Shaker WMA and the Smith Pond Shaker Forest. The areas with the lowest relative phosphorus load are concentrated in the northernmost part of the watershed, which is largely forested with low levels of development.

Once the model is calibrated for current in-lake phosphorus concentration, it can be used to manipulate land cover and other factor loadings to estimate pre-development loading scenarios (e.g., what in-lake phosphorus concentration was prior to human development or the best possible water quality for the lakes). Pre-development loading estimation showed that total phosphorus loading to Mascoma Lake (including the Crystal Lake model as an input source) increased by approximately 174% from 893 kg/yr prior to European settlement to 2,444 kg/yr under current conditions (Table 8). These additional phosphorus sources are coming from development in the watershed (especially from the direct shoreline of Mascoma, Crystal, and Canaan Street Lakes, as well as U.S. Route 4 and downtown areas of Enfield and Canaan), septic systems, atmospheric dust, and internal loading (Table 9). Water quality prior to settlement was predicted to be excellent with extremely low phosphorus and chlorophyll-a concentrations and high water clarity (Table 8).

The model can also manipulate land cover and other factors to estimate future loading scenarios (e.g., what in-lake phosphorus concentration might be at full build-out under current zoning or the worst possible water quality for the Lake). Refer to the 2025 Mascoma Lake Watershed Buildout Report (FBE, 2025) for details on methodology. Note: the future LLRM scenario did not assume a 10% increase in precipitation over the next century (NOAA Technical Report NESDIS 142-1, 2013), which would have resulted in a lower predicted in-lake phosphorus concentration; this is because the model does not consider the rate and distribution of the projected increase in precipitation. Climate change models predict more intense and less frequent rain events that may exacerbate erosion of phosphorus-laden sediment to surface waters and therefore could increase in-lake phosphorus concentration (despite dilution and flushing impacts that the model assumes).

Future loading estimation showed that total phosphorus loading to Mascoma Lake (including the Crystal Lake model as an input source) may increase by approximately 276% from 2,444 kg/yr to 9,194 kg/yr at full build-out (2166) under current zoning (Table 9). Additional phosphorus will be generated from more development in

the watershed (especially in undeveloped headwater areas), greater atmospheric dust, more septic systems, and enhanced internal loading (Table 8, Table 9). The Mascoma Lake model predicted higher (worse) phosphorus (28.0 µg/L), higher (worse) chlorophyll-a (11.4 µg/L) with 246 bloom days, and lower (worse) water clarity (1.8 m) compared to current conditions for Mascoma Lake (Table 8). Predicted future water quality was similarly poor for Crystal Lake.

Table 8. In-lake water quality predictions for Crystal Lake and Mascoma Lake. TP = total phosphorus. Chl-a = chlorophyll-a. SDT = Secchi disk transparency. Bloom Days represent average annual probability of chlorophyll-a exceeding 8 µg/L.

Lake	Model Scenario	Median TP (µg/L)	Predicted Median TP (µg/L)	Mean Chl-a (µg/L)	Predicted Mean Chl-a (µg/L)	Mean SDT (m)	Predicted Mean SDT (m)	Bloom Days
Crystal Lake	Pre-Development	--	2.7	--	0.4	--	10.9	0
	Current (2024)	6.8*	7.1	1.7	2.0	5.5	5.1	0
	Future (2166)	--	20.9	--	7.9	--	2.2	145
Mascoma Lake	Pre-Development	--	2.7	--	0.4	--	10.7	0
	Current (2024)	7.5*	7.4	3.1	2.1	4.4	5.0	1
	Future (2166)	--	28.0	--	11.4	--	1.8	246

**Represents an estimate of average annual total phosphorus concentration; this is different from the existing median total phosphorus concentration from summer epilimnion data used for the assimilative capacity analysis.*

Table 9. Total phosphorus (TP) and water loading summary by model and source for Crystal Lake and Mascoma Lake. Italicized sources sum to the watershed load.

CRYSTAL LAKE

Development State	Measurement	Atmospheric	Internal	Waterfowl	Septic System	Watershed Load	Total Load To Lake
Pre-Development	TP (KG/YR)	11.6	0.0	10.0	0.0	94.4	116.0
	%	10	0	9	0	81	100
	WATER (CU.M/YR)	2,041,112	0	0	0	22,285,796	24,326,908
Current (2024)	TP (KG/YR)	18.3	26.5	10.0	27.6	227.1	309.5
	%	6	9	3	9	73	100
	WATER (CU.M/YR)	2,041,112	0	0	22,784	22,243,307	24,307,202
Future (2033)	TP (KG/YR)	41.6	77.7	10.0	27.6	751.9	908.7
	%	5	9	1	3	83	100
	WATER (CU.M/YR)	2,041,112	0	0	22,784	22,039,078	24,102,973

MASCOMA LAKE

Development State	Measurement	Atmospheric	Internal	Waterfowl	Septic System	Watershed Load	<i>Direct Land Use Load</i>	<i>Load from Crystal Lake</i>	Total Load To Lake
Pre-Development	TP (KG/YR)	33.0	0.0	28.3	0.0	832.0	769.8	62.2	893.2
	%	4	0	3	0	93	86	7	100
	WATER (CU.M/YR)	5,594,647	0	0	0	247,185,611	223,713,574	23,472,038	252,780,259
Current (2024)	TP (KG/YR)	51.8	20.8	28.3	47.0	2,295.9	2,129.9	166.0	2,443.7
	%	2	1	1	2	94	87	7	100
	WATER (CU.M/YR)	5,594,647	0	0	37,341	246,845,405	223,393,073	23,452,332	252,477,394
Future (2033)	TP (KG/YR)	117.7	76.9	28.3	56.4	8,915.1	8,429.2	486.0	9,194.4
	%	1	<1	<1	<1	97	91	5	100
	WATER (CU.M/YR)	5,594,647	0	0	49,094	244,288,606	221,040,503	23,248,103	249,932,348

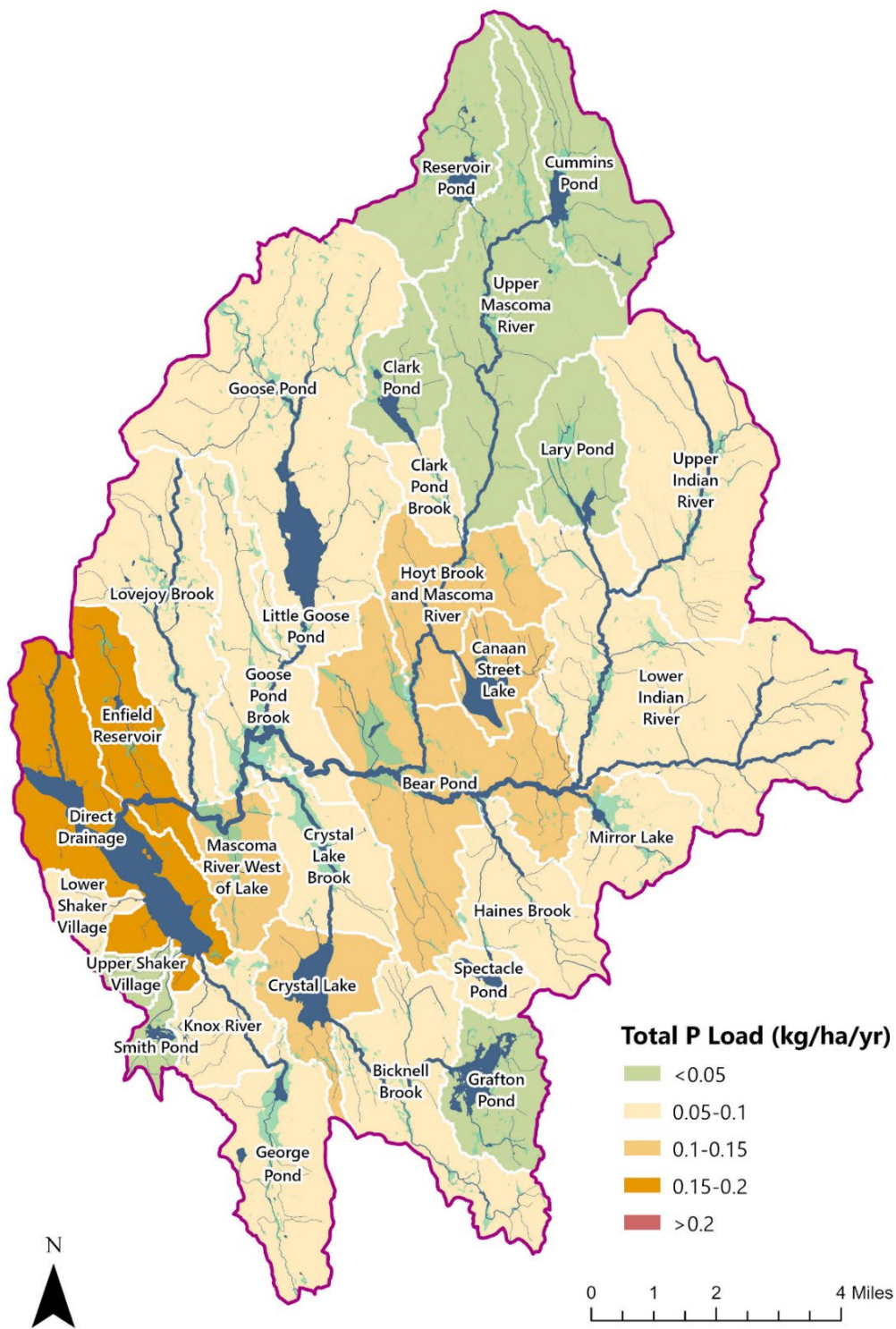


Figure 9. Map of current total phosphorus load per unit area (kg/ha/yr) for each sub-watershed in the Mascoma watershed. Sub-watersheds with higher phosphorus load per unit area are located along the highly developed shoreline of Mascoma Lake and along U.S. Route 4 which included downtown Enfield and Canaan. The upper portion of the watershed which is largely undeveloped has the lowest phosphorus loading values. The phosphorus load per unit area were calculated using the total baseflow phosphorus and runoff phosphorus for each sub-watershed directly and does not incorporate routing patterns or attenuation factors.

2.2.2 Build-out Analysis

A full build-out analysis was completed for the Mascoma Lake watershed for the municipalities of Lyme, Dorchester, Hanover, Lebanon, Enfield, Grantham, Springfield, Grafton, Orange, and Canaan (FBE, 2024b). A build-out analysis identifies areas with development potential and projects future development based on a set of conditions (e.g., zoning regulations, environmental constraints) and assumptions (e.g., population growth rate). A build-out analysis shows what land is available for development, how much development can occur, and at what densities. "Full Build-out" is a theoretical condition representing the moment in time when all available land suitable for residential, commercial, and industrial uses has been developed to the maximum capacity permitted by local ordinances and zoning standards. Local ordinances and zoning standards are subject to change, and the analysis requires simplifying assumptions; therefore, the results of the build-out analysis should be viewed as planning-level estimates only for potential future outcomes from development trends.



FULL BUILD-OUT is a theoretical condition representing the moment in time when all available land suitable for residential, commercial, and industrial uses has been developed to the maximum capacity permitted by current local ordinances and current zoning standards.

To determine where development may occur within the study area, the build-out analysis first subtracts land unavailable for development due to physical constraints, including environmental restrictions (e.g., wetlands, conserved lands, hydric soils), zoning restrictions (e.g., shoreland zoning, street right-of-ways (ROWs), and building setbacks), and practical design considerations (e.g., lot layout inefficiencies) (Appendix A, Map A- 3). Existing buildings also reduce the capacity for new development.

The build-out analysis showed that 44% (43,918 acres) of the study area is buildable under current zoning regulations (Appendix A, Map A- 4). The Town of Canaan, excluding the Historic District, has the most buildable area available with 23,979 acres available (Table 10). FBE identified 9,358 existing buildings in the watershed, with build-out projections adding 33,633 more, for a total of 42,991 at full build-out. (Appendix A, Map A- 5).

Three iterations of the TimeScope Analysis were run using compound annual growth rates CAGRs for 10-, 20-, and 50-year from 2010-2020 (0.45%), 2000-2020 (1.22%), and 1970-2020 (1.09%), respectively, to project the rate of new development into the future (Table 11). Full build-out is projected to occur in 2365 at the 10-year CAGR, 2151 at the 20-year CAGR, and 2166 for the 50-year CAGR (Figure 10).

Note that the growth rates used in the TimeScope Analysis are based on town-wide census statistics but have been applied here to only the portions of the municipalities within the watershed. If areas closer to town centers within each municipality develop faster than lands within the watershed (as applicable), watershed full build-out conditions may occur sooner or later. Projecting population growth or development using census data comes with inherent limitations. For instance, building rates may not align with population growth due to factors such as differences between commercial and residential development or changes in household size. Many projected buildings would also require new road construction, which could slow the rate of development. As such, the TimeScope Analysis might overestimate or underestimate the time needed for the study area to reach full build-out. Population growth and development are influenced by a range of social and economic factors, including policies adopted by federal, state, and local levels. The relationships among the various factors may be complex and therefore difficult to model accurately.

Table 10. Amount of buildable land and projected buildings by each town's zone in the entire Mascoma Lake watershed, including towns of Canaan, Dorchester, Enfield, Grafton, Grantham, Hanover, Lebanon, Lyme, Orange, and Springfield, NH.

Town	Zone	Total Area (Acres)	Buildable Area (Acres)	Percent Buildable Area	No. Existing Buildings	No. Projected Buildings	Total No. Buildings	Percent Increase
Canaan	Historic District	270	122	45%	85	40	125	47%
	Rest of Town	33,668	23,979	71%	1,776	26,447	28,223	1489%
Dorchester	Rural	14,246	4,567	32%	45	1,463 (2,926)	1,508	3251%
Enfield	Conservation (C)	654	85	13%	7	10	17	143%
	Community Business (CB) - on-lot water and sewer	189	142	75%	20	92	112	460%
	Community Business (CB) - municipal water and sewer	125	61	49%	110	65	175	59%
	Residential (R1) - on-lot water and sewer	7,809	1,546	20%	3455	899	4,354	26%
	Residential (R1) - with municipal water and sewer	1,224	93	8%	2528	197	2,725	8%
	Rural Residential (R3)	3,733	1,731	46%	430	350	780	81%
	Rural Residential-Agricultural (R5)	8,787	3,578	41%	296	416	712	141%
	US Route 4 (RT4) - Buildings directly along Rt 4	190	143	75%	55	228	283	415%
	Commercial/Industrial	78	62	80%	0	22	22	N/A
Grafton	Town of Grafton	7,513	2,685	36%	78	2,641 (5,282)	2,719	3386%
Grantham	Conservation District (CD)	44	0	0%	0	0	0	0%
	Rural Residential I (RR1)	68	29	42%	17	22 (44)	39	129%
Hanover	Forestry & Recreation (F)	7,435	2,104	28%	39	65	104	167%
	Goose Pond (GP)	47	10	20%	38	17	55	45%
	Rural Residence (RR)	740	207	28%	6	44 (88)	50	733%

<i>Town</i>	Zone	Total Area (Acres)	Buildable Area (Acres)	Percent Buildable Area	No. Existing Buildings	No. Projected Buildings	Total No. Buildings	Percent Increase
<i>Lebanon</i>	Rural Land 1 (RL1)	473	51	11%	110	31 (62)	141	28%
	Rural Land 2 (RL2)	264	91	34%	71	53 (106)	124	75%
	Rural Land 3 (RL3)	60	33	55%	0	3 (6)	3	N/A
<i>Lyme</i>	Mountain and Forest District	4,459	494	11%	0	6 (12)	6	N/A
	East Lyme District	1,266	325	26%	20	17 (34)	37	85%
	Rural District	55	33	60%	0	7 (14)	7	N/A
<i>Orange</i>	Rural Residential	6,873	1,681	24%	168	475 (950)	643	283%
<i>Springfield</i>	Rural Residential	71	66	93%	4	23 (46)	27	575%
	Forest Conservation	2	2	63%	0	0	0	0%
<i>All</i>	Total	100,343	43,918	44%	9,358	33,633	42,991	359%

*Parcels on municipal sewer were modeled to have two dwelling units per acre. Numbers in parentheses and italicized represent number of buildings if each parcel built an ADU on their lot.

Table 11. Compound annual growth rates for the municipalities in the Mascoma Lake watershed, used for the TimeScope Analysis. Data from U.S. Census Bureau.

Town	50 yr. Avg. 1970-2020	30 yr. Avg. 1990-2020	20 yr. Avg. 2000-2020
Canaan	1.37%	0.74%	0.67%
Dorchester	1.77%	-0.48%	-0.20%
Enfield	1.30%	0.38%	-0.17%
Grafton	2.68%	1.36%	0.99%
Grantham	4.56%	3.40%	2.28%
Hanover	0.67%	0.85%	0.45%
Lebanon	0.77%	0.53%	0.64%
Lyme	0.91%	0.51%	0.19%
Orange	2.00%	0.52%	-0.38%
Springfield	2.84%	1.57%	1.44%
Combined	1.09%	1.23%	1.22%

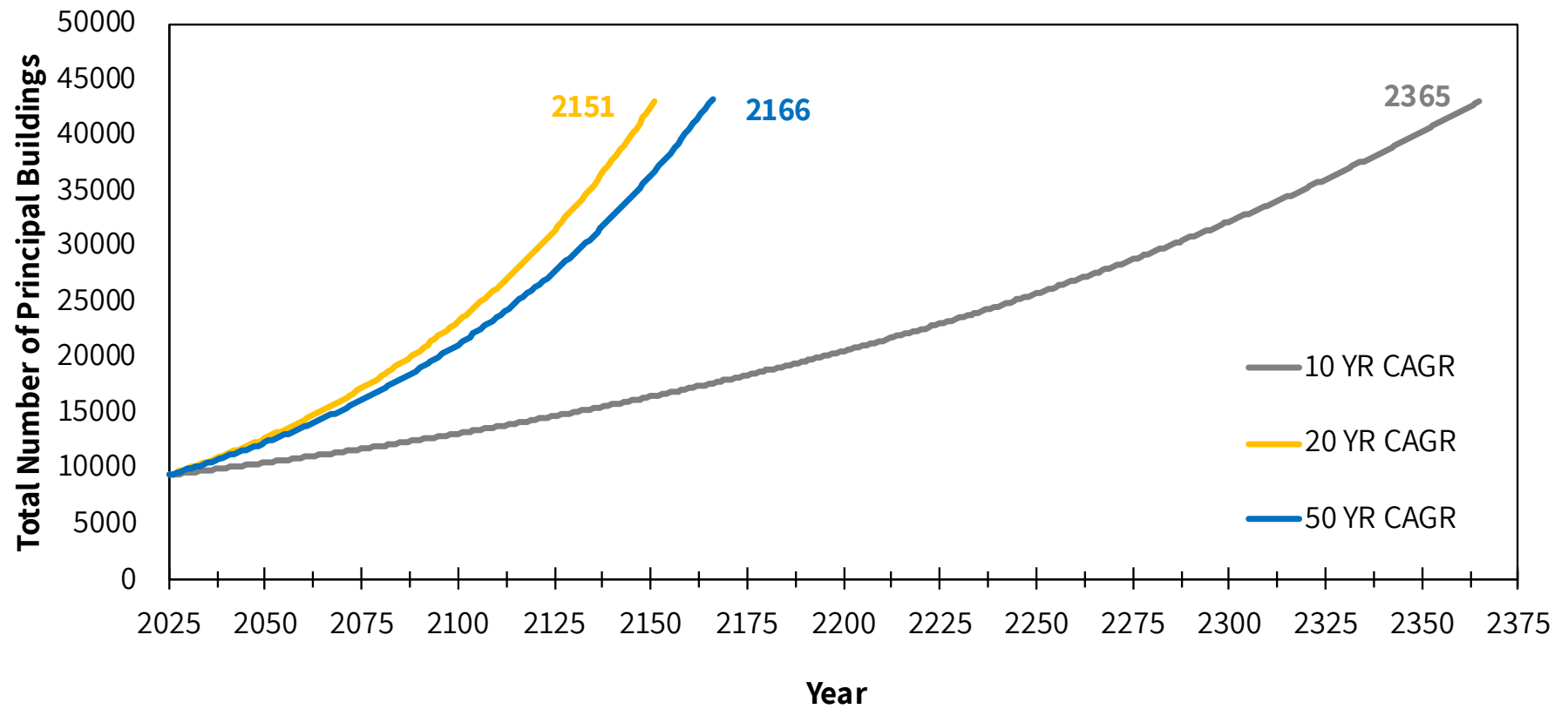


Figure 10. Full build-out projections of the Mascoma Lake watershed (based on compound annual growth rates).

2.3 WATER QUALITY GOAL & OBJECTIVES

The model results revealed changes in total phosphorus loading and in-lake total phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Mascoma Lake is threatened by current development activities in the watershed and will degrade further with continued development in the future. These results can be used to make informed management decisions and set an appropriate water quality goal for Mascoma Lake.

Although Mascoma Lake is classified as oligotrophic, recent monitoring shows conditions that challenge this status, with the 2023 VLAP Report documenting elevated total phosphorus and chlorophyll-a levels during heavy rainfall events and long-term assessments identifying impairments for low pH, low dissolved oxygen, Eurasian milfoil, and microcystin. Historical trophic surveys reveal recurring summer anoxia in the hypolimnion, indicating internal phosphorus loading that can fuel cyanobacteria despite low surface nutrient concentrations, particularly under increasing climate-driven stress. Water quality is further influenced by upstream lakes, ponds, and tributaries, including Crystal Lake, which experienced cyanobacteria blooms in 2023 despite oligotrophic conditions, suggesting limited reserve capacity for Mascoma Lake to assimilate additional nutrients under “business as usual” conditions. Consequently, reducing watershed phosphorus inputs and strengthening long-term management actions are essential to protect Mascoma Lake’s water quality and limit future cyanobacteria bloom risk.

The goal of the Mascoma Lake WMP is to improve the water quality of Mascoma Lake such that it meets the state water quality standards for the protection of Aquatic Life Integrity (ALI) and Primary Contact Recreation (PCR) and substantially reduces the likelihood of harmful cyanobacteria blooms. This goal will be achieved by accomplishing the following objectives. More detailed action items to achieve these objectives will be provided in the Action Plan of the WMP.

Objective 1: Reduce phosphorus loading from existing development by 4% (86 kg/yr) to Mascoma Lake to reduce average in-lake summer total phosphorus concentration to 8.7 ppb.

Objective 2: Mitigate (prevent or offset) phosphorus loading from future development by 745 kg/yr to Mascoma Lake to maintain the average summer in-lake total phosphorus concentration over the next 10 years (2035).

Measures of success for achieving these objectives should focus on demonstrating measurable reductions in phosphorus loading to Mascoma Lake from major tributaries, shoreline properties, stormwater sources, and septic systems, as well as clear evidence that management actions are reducing cyanobacteria risk. Success would be indicated by documented decreases in annual phosphorus loads from priority sub-watersheds, increased implementation of BMPs and septic upgrades contributing to the targeted 4% reduction from existing development and the mitigation of 745 kg/yr from future development, and reductions in the frequency, duration, and severity of cyanobacteria blooms. Because internal phosphorus loading and climate variability can mask short-term changes in in-lake concentrations, stabilization or gradual improvement of average summer total phosphorus levels should be considered a long-term indicator rather than an immediate measure of progress. Over time, sustained reductions in watershed phosphorus inputs remain the most reliable means to protect Mascoma Lake’s water quality and limit future cyanobacteria bloom risk.

Reality Check for Meeting Objectives 1 and 2: The watershed survey conducted by VHB identified 5 sites impacting the lake. Remediating these sites could prevent up to 1.5 kg/yr of phosphorus from entering Mascoma Lake. Treating vulnerable shoreline sites (scoring ≥ 5) could reduce the phosphorus load to Mascoma Lake by 30.4 kg/yr as identified from the shoreline vulnerability analysis. Upgrading the 222 known shorefront septic systems along Mascoma Lake (139) and Crystal Lake (83) that are older than 25

years, is estimated to reduce the phosphorus load to Mascoma Lake by 22.2 kg/yr. Mitigating the impacts of unpaved roads less than 50 feet from a surface water throughout the watershed could prevent about 30.6 kg/yr of phosphorus load to Mascoma Lake. Stabilizing the banks around culverts assessed as vulnerable by NHDES in the watershed (n=4) could prevent about 1.4 kg/yr in phosphorus load to Mascoma Lake (all loads calculated using the PLET model). **In sum, treating all existing pollutant sources identified as coming from the external watershed load could reduce the phosphorus load to Mascoma Lake by approximately 86 kg/yr, which meets 100% of Objective 1 for Mascoma Lake.**

Objective 2 can be met through zoning and ordinance revisions that implement low impact development strategies, encourage cluster development with open space protection, as well as conservation of key parcels of forested and/or open land, and/or targeted outreach and education.

The interim goals for each objective allow flexibility in reassessing water quality objectives following more data collection and expected increases in phosphorus loading from new development in the watershed over the next 10 or more years (Table 12). Understanding predicted water quality following watershed improvements compared to likely water quality following no action will help guide adaptive changes to interim goals (e.g., goals are on track or goals are falling short). If the goals are not being met because of limited funding or other implementation resource constraints, rather than because phosphorus loading from new development is outpacing reductions from improvements to existing development, the conditions for adjusting interim goals are very different. For each interim goal year, stakeholders should update the water quality data and model and assess why goals are or are not being met. Stakeholders will then decide how to adjust the next interim goals to better reflect water quality conditions and practical limitations to implementation.

Table 12. Summary of water quality objectives for Mascoma Lake. Interim goals/benchmarks are cumulative. TP refers to total phosphorus.

Interim Goals / Benchmarks	2028	2030	2035
Objective 1 Reduce phosphorus loading from existing development to Mascoma Lake by 86 kg/yr to improve average in-lake summer or annual total phosphorus concentration to 8.7 ppb.	Achieve 1% (21.5 kg/yr) reduction in TP loading to Mascoma Lake.	Achieve 2% (43 kg/yr) reduction in TP loading to Mascoma Lake; re-evaluate water quality and track progress.	Achieve 4% (86 kg/yr) reduction in TP loading to Mascoma Lake; re-evaluate water quality and track progress.
Objective 2 Mitigate (prevent or offset) phosphorus loading from future development by 475 kg/yr to Mascoma Lake to maintain average summer in-lake total phosphorus concentration in the next 10 years (2035).	Prevent or offset 118.8 kg/yr in TP loading from new development to Mascoma Lake.	Prevent or offset 237.5 kg/yr in TP loading from new development to Mascoma Lake; re-evaluate water quality and track progress.	Prevent or offset 475 kg/yr in TP loading from new development to Mascoma Lake; re-evaluate water quality and track progress.

3 POLLUTANT SOURCE IDENTIFICATION

This section describes sources of excess phosphorus to Mascoma Lake. Sources of phosphorus to lakes include stormwater runoff, shoreline erosion, construction activities, illicit connections, failed or improperly functioning septic systems, leaky sewer lines, boat discharges, fabric softeners and detergents in greywater, fertilizers, pet, livestock, and wildlife waste. These external sources of phosphorus to lakes can then circulate within lakes and settle on lake bottoms, contributing to internal phosphorus loads over time. Additional phosphorus sources can enter the lake from atmospheric deposition but are not addressed here because of limited local management options. Wildlife is mentioned as a potential source but largely for nuisance waterfowl such as geese or ducks that may be congregating in large groups because of human-related actions such as feeding or having easy shoreline access (i.e., lawns). Climate change is also not a direct source but can exacerbate the impact of the other phosphorus sources identified in this section and should be considered when striving to achieve the water quality objectives.

3.1 WATERSHED DEVELOPMENT

NPS pollution comes from many diffuse sources on the landscape and is more difficult to identify and control than point source pollution. NPS pollution can result from contaminants transported by overland runoff (e.g., agricultural runoff or runoff from suburban and rural areas), groundwater flow, or direct deposition of pollutants to receiving waters. Examples of NPS pollution that can contribute nutrients to surface waters via runoff, groundwater, and direct deposition include erosion from disturbed ground or along roads, stormwater runoff from developed areas, malfunctioning septic systems, leaky sewer lines, boat discharges, excessive fertilizer application, pet waste, unmitigated agricultural activities, flooding, potential contamination sources, and wildlife waste.

3.1.1 Historical Development

Before the first settlers arrived in Enfield in 1761, Indigenous communities of the Abenaki language, including the Penacook, Winnepesaukee, Pigwacket, Sokoki, Cowasuck, and Ossipee bands, lived and traveled along Mascoma Lake and the surrounding area (Enfield Heritage Commission, n.d.). The region's waterways linked the Connecticut River with the Atlantic coast and southern villages which were corridors of travel and trade. Local Indigenous settlements were semi-permanent, seasonal, and clustered along flat areas of the shoreline. Material traces of Indigenous presence, such as stone flakes, pottery fragments, axes, and stone jugs, have been found along the flat, beachy shoreline of Mascoma Lake near the Knox and Mascoma River inlets, as well as at the shores of Canaan Street Lake and near the Goose Pond outlet (Enfield Heritage Commission, n.d., Wallace, 1910). During this period, the land was cultivated for crops such as corn, beans, squash, sunflowers, Jerusalem artichokes, ground cherries, and tobacco. However, epidemics in 1615 and 1620 devastated Indigenous populations, a loss further compounded by conflicts with colonists and the Iroquois League (Enfield Heritage Commission, n.d.). These factors, along with migration north, further reduced the Indigenous presence in the region.

Early colonial settlers established villages along the Mascoma River in the mid-18th century, with Lebanon, Enfield, and Canaan all chartered in 1761 (UVLSRPC, 2010). In 1793, the Shakers established a community along the western shores of Mascoma Lake, constructing over 100 buildings and cultivating more than 3,000 acres of farmland (Enfield Shaker Museum, 2023). The Shakers relied on agriculture for subsistence while also trading regionally trading their seeds, produce, flour, woven goods, and flannels (Enfield Shaker Museum, 2023). The first cottage on Mascoma Lake was built in 1883 on the eastern shoreline at Point Comfort, quickly followed by

several other cottages and a cookhouse (Enfield Heritage Commission, n.d.; MLA, 2024). Located across from the Shaker Village, they primarily relied on boats for communication, particularly trade (Enfield Heritage Commission, n.d.). In the surrounding towns, communities began to utilize the rivers and waterways for water-powered industries, beginning with sawmills and gristmills in the 1760s and later expanding to wool carding mills, textile mills, and tanneries (Child, 1709-1886; Mascoma River Local Advisory Committee, 2012). Enfield alone had over twenty mills, driving the development of churches, hotels, shops, and the development of a bustling downtown in North Enfield. The Town of Canaan became known as "Factory Village" for its production of lumber, leather, and grain (Town of Canaan, 2025).

The completion of the Northern Railroad in 1847 (spanning 143 miles from Boston to White River Junction, VT) and the construction of the Fourth New Hampshire Turnpike in 1804 transformed the region (Enfield Heritage Commission, n.d.; The Mascoma River Greenway, n.d.). By linking the towns to broader trade networks, the railroad and turnpike boosted local industries and population growth in Enfield and Canaan (Town of Canaan, 2025; UVLSRPC, 2010). In 1849, the Shaker Bridge was built across a narrow segment of the lake, connecting the Shaker Village to the railroad and expanding their trade network for selling seeds, herbs, and other goods (UVLSRPC, 2010). Though reconstructed, the bridge remains in place today and serves as a popular route for travel across the lake. With the success of the mills, the attraction of the lake, the easy access by train, and the development of hotels, taverns, and other amenities, Enfield and Mascoma Lake became a popular tourist destination by 1900 (Sanborn & Carr, 2006).

During the peak of industrial activity, mills and factories used the Mascoma River both for energy and as a dumping ground for untreated waste, including textile dyes and chemical byproducts (UVLSRPC, 2010). The Baltic Mill in Enfield alone discharged 740,000 gallons of untreated textile waste and 5,000 gallons of raw sewage daily, resulting in discolored water and visible contamination, such as oily residues and gas bubbles along the riverbanks (Enfield Heritage Commission, n.d.). Additionally, the Mascoma River watershed received 30,000 gallons per day of raw sewage from the town of Enfield, around 1967, waste from Mascoma Lake houses went straight into the lake. After years of severe pollution, sanitation issues, and algal blooms, the New Hampshire Water Supply and Pollution Control Commission ordered the towns of Enfield and Lebanon to cease polluting these waterways. This led to the construction of a combined sewage treatment plant, and in 1988, the development of a sewer system in Enfield which pumps waste to Lebanon for treatment (Enfield Heritage Commission, n.d.). The Clean Water Act of 1972 also played a pivotal role in establishing water quality standards and reducing industrial pollution, both regionally and nationwide (UVLSRPC, 2010). These efforts, in addition to the closure of the mills in the 1960s and 1970s, marked a stark improvement in the water quality (UVLSRPC, 2010).

By 1923, a decline of Shaker membership led to the closure of their community in Enfield, and the land was purchased by the Missionaries of Our Lady of La Salette (Enfield Shaker Museum, 2023). Today, the area is owned by the Enfield Shaker Museum, which was established in 1986 and operates as an educational center for Shaker history. Approximately 1,100 acres of this land is now under permanent conservation and managed by N.H. Fish and Game (Enfield Heritage Commission, n.d.). Like its historical appeal for natural beauty and recreational opportunities, Mascoma Lake remains a popular destination today, as its shoreline becomes increasingly developed with summer cottages and year-round homes.



(Left) A photo of Shaker Bridge taken from the vicinity of the 4th New Hampshire Turnpike, just south of the bridge. Circa 1889. Credit: Enfield Shaker Museum. (Middle left) View of a Shaker agricultural field on the shore of Mascoma Lake. The people in the photo include both Shakers and non-Shakers. Circa 1881. Credit: Enfield Shaker Museum. (Middle right). Hiram Baker at the Shaker sawmill. Circa 1903. Credit: Enfield Shaker Museum. (Right) Postcard of the Enfield Depot Street train station looking west towards Mount Cardigan. Circa 1906-1915. Credit: Enfield Shaker Museum.

3.1.2 Watershed Survey

A desktop and field-based watershed survey of the Mascoma Lake direct watershed was completed by technical staff from VHB. The objective of the watershed survey was to identify and characterize sites contributing to NPS pollution and/or providing opportunities to mitigate NPS pollution in the watershed. Additional desktop analysis was performed by FBE staff for surrounding roads and stormwater infrastructure.

VHB identified five areas that could be improved to reduce phosphorus loading to the lake. For each location, VHB staff created detailed plans with recommendations for BMPs and highlighted existing infrastructure. Information collected included a description of site conditions, GPS coordinates, identification of NPS issues such as erosion, runoff flow paths, and slope constraints, measurements of affected areas, the receiving waterbody, and whether runoff discharged directly or indirectly. VHB also outlined preliminary recommendations for mitigating identified NPS problems based on topography and site layout. VHB then developed plan recommendations for those locations. Implementing BMPs at the five priority sites could remove an estimated 1.5 kg/yr of phosphorus. The primary issues identified across the reviewed plans were uncontrolled stormwater flow causing erosion and inadequate or failing infiltration/retention features. Appendix B summarizes the recommendations, load reduction estimates, and estimated costs for each site.

As part of FBE's desktop watershed survey, culverts and road segments located near surface areas were evaluated to identify vulnerable problem sites within the Mascoma Lake watershed (Figure 16). Using the New Hampshire Stream Crossing Initiative Data Viewer, a GIS-based screening tool, FBE identified four culverts adjacent to Mascoma Lake that may be vulnerable based on storm capacity and structural condition. These culverts are generally undersized and overtop during moderate to large storm events, with several exhibiting sediment blockage, inlet and outlet scour, reduced hydraulic capacity, and limited aquatic passage despite some being in fair to good structural condition.

FBE also conducted a desktop analysis of roads located near waterbodies, as roads near surface waters can contribute elevated nutrients, contaminants, and sediment due to impervious surfaces, reduced soil filtration, and increased erosion potential. Runoff from road surfaces and roadside ditches, particularly along unpaved or poorly maintained sections, can rapidly transport sediment and pollutants into adjacent waterways, especially where culverts are undersized or drainage is inadequate. Within the Mascoma Lake watershed, approximately 16 miles of roadway lie within 50 feet of a waterbody, of which 46% are paved and 54% are unpaved. Most of these near-shore roads are in the towns of Canaan (41%) and Enfield (37%).

To address the identified vulnerabilities at culverts and along near-shore road segments, a range of BMPs may be appropriate depending on site conditions, drainage area, and roadway use. For culverts, BMPs include upsizing or replacing undersized crossings to improve hydraulic capacity and reduce overtopping during storm events, stabilizing inlet and outlet areas to address scour and sediment mobilization. Stabilizing the banks around culverts assessed as vulnerable by NHDES in the watershed (n=4) could prevent about 1.4 kg/yr of phosphorus load to Mascoma Lake (calculated using the PLET model). For road segments located close to surface waters, BMPs may include improved ditch stabilization, installation of check dams or level spreaders, paving roads, regrading or armoring concentrated flow paths, and conversion of eroding roadside ditches to vegetated swales. Mitigating the impacts of unpaved roads less than 50 feet from a surface water throughout the watershed could prevent about 30.6 kg/yr of phosphorus load to Mascoma Lake.

Site C-1: Huse Park Subsurface

Location: 43.6441, -72.1438

Impact: High

Observations: Stormwater from the paved parking areas continues to concentrate along existing flow paths that direct runoff toward the open field and ultimately to the downgradient drainage feature. The current layout does not provide much treatment or dispersion before runoff infiltrates or leaves the site. Flow lines from multiple areas converge near the proposed BMP location, creating erosion issues during large storm events. Watershed delineation for Huse Park identified 37,870 square feet of impervious surface. This large impervious region highlights the need for a centralized treatment system that can reliably manage the water that comes through this region.

Recommendations: Install a subsurface infiltration BMP, as shown in Figure 11, sized to treat the required water quality volume. The system was designed based on the delineated watershed and pollutant load reduction calculations, and would include two catch basins tied into the subsurface infiltration chambers. Grading should ensure that contributing drainage areas flow consistently toward the BMP without creating new points of concentrated flow. Incorporating the catch basins will reduce sediment loading and extend the life of the subsurface system.



Figure 11. Site C-1 Huse Park Subsurface site plans. Refer to Appendix C for enlarged images.

Site C-2: Huse Park Infiltration

Location: 43.6441, -72.1438

Impact: High

Observations: Runoff from the southeast corner of the parking lot and adjacent gravel areas currently drains downslope without defined pretreatment. The delineated drainage area includes 2,231 square feet of impervious surface contributing directly to this location. The proposed infiltration trench would intercept a large amount of the flow from the region. The surrounding ground shows signs of erosion and compaction that could deliver sediment to the trench and reduce its long-term infiltration capacity.

Recommendations: Implement the proposed infiltration trench as shown in Figure 12, sized using the pollutant load reduction calculations and watershed delineation. The trench would outlet to an existing catch basin and requires regrading and repaving of the southeast corner of the parking lot. The BMP footprint has been located to avoid conflict with the existing sanitary sewer line. Proposed BMPs include adding pretreatment to reduce sediment loading, stabilize disturbed soils around the trench, and establishing a defined, stabilized overflow path connected to the existing catch basin. These combined measures will enhance stormwater treatment performance and extend the trench's functional lifespan.



Figure 12. Site C-2 Huse Park Infiltration Trench site plans by VHB. Refer to Appendix C for enlarged images.

Site C-3: Bank Bio-filtration

Location: 43.6434, -72.1433

Impact: Moderate

Observations: Stormwater from the adjacent driveway and upper slope currently concentrates as it moves downslope toward the bank, where steep grades and limited vegetation make the area vulnerable to erosion. Flow disperses across the wooded slope without treatment, increasing the potential for sediment and nutrient delivery to the lake. Watershed delineation for the Mascoma Bank area identified 23,671 square feet of impervious surface. The proposed biofiltration basin is well positioned to intercept runoff however, the steep terrain and existing informal flow paths may continue to convey water around the system unless intentionally directed to the BMP.

Recommendations: Implement the proposed biofiltration basin as shown in Figure 13. The BMP would receive flow from the existing outlet along the berm through a proposed inlet ditch. The selected basin footprint avoids impacts to the existing sanitary sewer line to the west and is in a relatively flat area between the Bank and the Mascoma River. Establish clearly defined routes to ensure runoff enters the BMP for treatment. Stabilize disturbed soils and steep bank areas to reduce sediment transport and improve long-term stability. Incorporate an overflow outlet to safely convey high flows downslope without causing erosion. These improvements will enhance the BMP's ability to capture, filter, and slow runoff before it reaches the lake.



Figure 13. Site C-3 Bank Bio-infiltration site plans by VHB. Refer to Appendix C for enlarged images.

Location: 43.6429, -72.1443

Observations: Runoff from the Enfield Public Library parking lot currently drains toward the wooded slope without treatment. The steep terrain below the parking area increases the risk of erosion and the potential for direct discharge to downslope resources. Watershed delineation for this site identified 20,856 square feet of impervious surface contributing to this drainage area. The proposed subsurface BMP is located to capture the majority of the parking lot runoff.

URL: <http://dx.doi.org/10.1016/j.sbspro.2012.09.004>



FB Environmental Associates

Site C-5: Beach

Location: 43.6311, -72.1578

Impact: Moderate

Observations: The beach area exhibits clear signs of erosion, including steep unvegetated slopes, exposed soils, and concentrated runoff pathways that deliver sediment directly to Mascoma Lake. Stormwater from the adjacent roadway and upper slopes flows across the beach without treatment, particularly during spring runoff when snowbanks redirect flow downslope. These conditions accelerate shoreline degradation and reduce water quality in the nearshore area. Parameters such as gully width, length, depth, soil type, and unit weight indicate that ongoing erosion has contributed to phosphorus loading, estimated at 0.41 pounds per year assuming a ten year erosion period.

Recommendations: Construct the proposed retaining wall and associated regrading shown in Figure 15 to substantially reduce the slope and stabilize the eroding beach area. The wall will allow a break in slope and create a more stable terrace that limits soil movement. Regrade the beach to soften slope angles and reduce runoff velocities. Install the proposed swale near the sidewalk edge to capture stormwater from the roadway and upper slopes, reducing untreated flow that contributes to shoreline erosion. Stabilize soils above and behind the retaining wall with native vegetation to enhance long-term erosion resistance. Establish a defined drainage path to safely convey runoff during large storms or spring melt events. Collectively, these measures will reduce sediment and phosphorus loading to Mascoma Lake and provide long-term stabilization of the beach area.



Figure 15. Site C-5 at the beach on Mascoma Lake site plans by VHB. Refer to Appendix C for enlarged images.

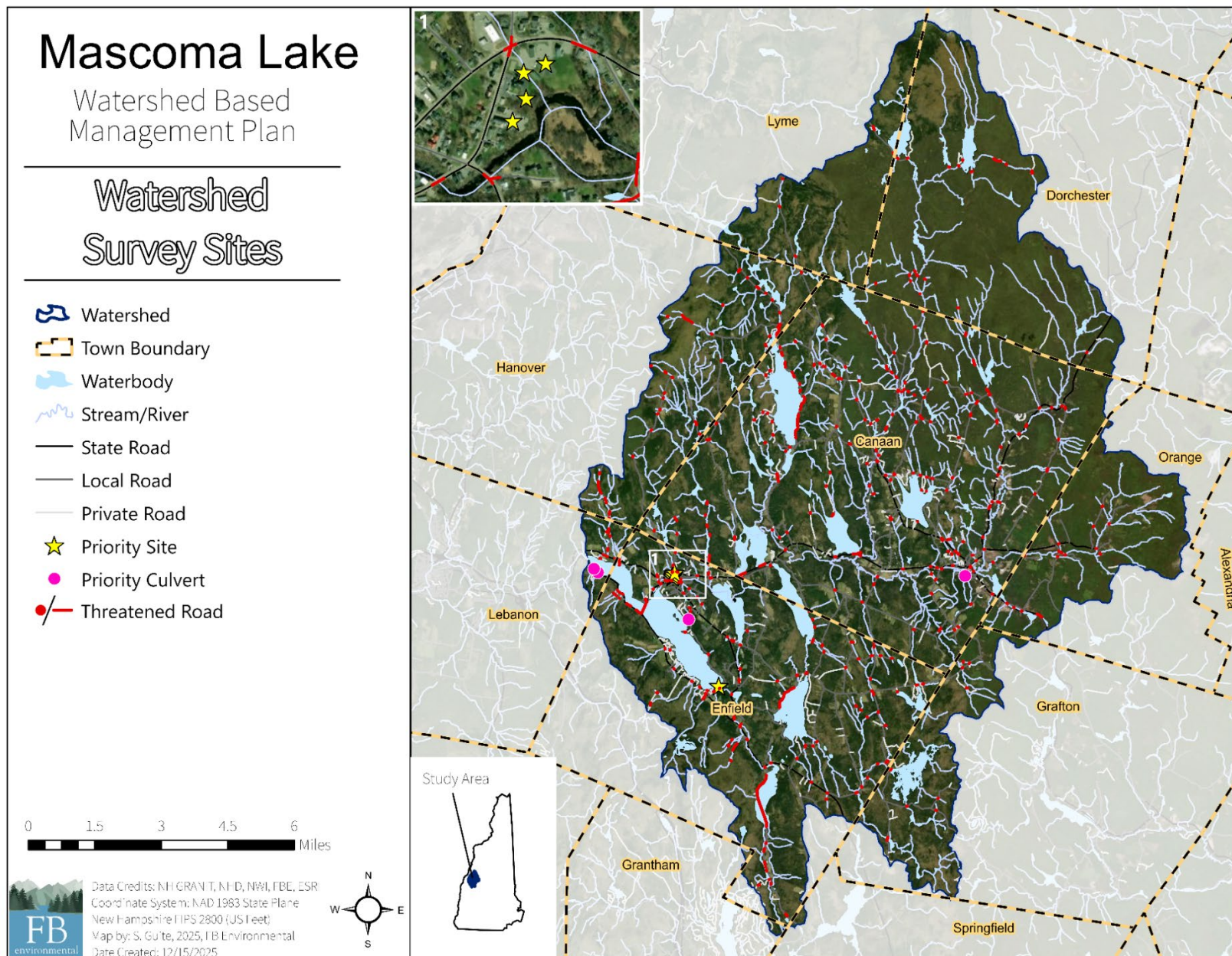


Figure 16. Location of identified nonpoint source sites in the Mascoma Lake direct watershed.

3.1.3 Shoreline Evaluation

FBE technical staff conducted a desktop shoreline evaluation of Mascoma Lake. The shoreline evaluation uses a simple scoring method to highlight shoreline properties around the lake that exhibit significant erosion. This method of shoreline evaluation is a technique used to assess the overall condition of properties within the shoreland zone and prioritize properties for technical assistance or outreach. To evaluate the relative likelihood a parcel may be negatively affecting water quality, FBE conducted a spatial overlay analysis of multiple attributes in ArcGIS Pro. First, the New Hampshire parcel data layer was clipped to the state Shoreland Zone (all land within 250 feet of the shoreline). The total likelihood score for each parcel's Shoreland Zone was calculated based on three factors: slope of the land, density of development within the Shoreland Zone, and building distance to the shoreline. These three metrics are summed together as the Shoreline Vulnerability Score.

1. The slope of the land was calculated using the US Geological Survey Elevation 1/3 arc-second Digital Elevation Model (DEM) downloaded from the National Map Data Download Application. Using the "add surface information tool", the mean slope was calculated for each parcel based on the DEM raster. Likelihood scores for the average percent slope of each parcel were given as follows: slope 0-5% = score 0; slope 5-10% = score 1; slope 10-15% = score 2; slope 15-20% = score 3; slope greater than 20% = score 4. The average slope per parcel within the Mascoma Shoreline fell between 0.25% and 18.65%.
2. To determine the relative density of development within the Shoreland Zone, the "kernel tool" was run using a building point file developed by FBE to identify high density areas. To calculate the density risk for each parcel, the "add surface information tool" was run with the kernel density layer as the input file. The likelihood scores for urban density (houses per acre) were as follows: <0.2 = score 0; 0.2-1 = score 1; 1-2 = score 2; >2 = score 3. This gives a higher score to parcels clustered in a more developed area, as higher levels of impervious surface and human activity contribute more pollution entering the lake.
3. To calculate the building distance to the shoreline, the following risk scores were assigned:
no building = score 0; >150ft = score 1; 75ft-150ft = score 2; <75ft = score 3.

A total of 512 parcels were evaluated along the shoreline of Mascoma Lake in Enfield and Lebanon, NH. Most of the parcels have a relatively low slope grade, though 156 parcels are moderately sloped and 30 parcels are more severely sloped. However, it is important to note that the slope values used in this analysis represent parcel-wide averages. As a result, steep, erosion-prone areas may be ranked lower if the parcel's topography is highly variable or if the parcel is particularly large. House distances to the lake were well distributed among 75 ft, 150 ft, and >250 ft from the shoreline, though more houses are located closer to the water. Most parcels received a moderate housing density score of 1, with 147 parcels scoring 2 and 24 scoring 3, reflecting areas of concentrated shoreline development.

The average shoreline vulnerability score for the Mascoma Lake shoreline is 3.1 (Table 13). A disturbance score of **5 or above** indicates shoreline conditions may be detrimental to lake water quality, and should be the target of outreach, education, and mitigation efforts. One hundred parcels received a total risk score of 5 or higher, indicating they may be more susceptible to erosion or contribute greater amounts of runoff from more densely developed areas or homes built closer to the shoreline. These parcels (scoring 5 or higher) are contributing approximately 30.4 kg per year of phosphorus to Mascoma Lake. This estimate is based on the EPA Region 5 bank stabilization model using silt loam soils, a 3-foot bank height, and a moderate lateral recession rate of 0.1 feet per year to represent all sites. Scores between 3 and 4 may also indicate at-risk parcels, though these are less of a priority than the higher scoring parcels (Appendix A; Map A- 11).

Table 13. Average scores for each evaluated condition criterion and the average Total Shoreline Vulnerability Score for the Shoreland Zone of Mascoma Lake. Note: the numbers in parentheses are the range of possible scores for that variable.

Evaluated Condition	Average Score	Average Shoreline Vulnerability Score (0-10)
Slope (0-4)	0.43	3.1
House Distance to Shore (0-3)	1.3	
House Density (0-3)	1.3	

Scores can be used to prioritize areas of the shoreline for remediation. Recommendations largely include improving shoreline vegetated buffers. Encouraging landowners to plant and/or maintain vegetated buffers as a BMP along their shoreline, particularly in areas of bare soil, will help mitigate erosion and reduce sediment and nutrient loading to the lake.

3.1.4 Soil & Shoreline Erosion

Erosion can occur when ground is disturbed by digging, construction, plowing, foot or vehicle traffic, or wildlife. Rain and associated runoff are the primary pathways by which eroded soil reaches lakes and streams. Once in surface waters, nutrients are released from the soil particles into the water column, causing excess nutrient loading to surface waters or cultural eutrophication. Since development demand near lakes is high, construction activities in lake watersheds can be a large source of nutrients. Unpaved roads and trails used by motorized vehicles near lakes and streams are especially vulnerable to erosion. Stream bank erosion can also have a rapid and severe effect on lake water quality and can be triggered or worsened by upstream impervious surfaces like buildings, parking lots, and roads which send large amounts of high velocity runoff to surface waters. Maintaining natural vegetative buffers around lakes and streams and employing strict erosion and sedimentation controls for construction can minimize these effects.

3.1.4.1 Surficial Geology

The composition of soils in the area reflects the dynamic geological processes that have shaped the landscape of New Hampshire over millions of years. Some 300 to 400 million years ago, much of the northeastern United States was covered by a shallow sea; layers of mineral deposition compressed to form sedimentary layers of shale, sandstone, and limestone (Goldthwait, 1951). Over time, the Earth’s crust then folded under high heat and pressure to change the sedimentary rocks into metamorphic rocks (quartzite, schist, and gneiss parent material). This metamorphic parent material has since been modified by bursts of molten material intrusions to form igneous rock, including granite for which New Hampshire is famous (Goldthwait, 1951). Erosion has further modified and shaped this parent material over the last 200 million years.

The current landscape formed approximately 12,000 years ago at the end of the Great Ice Age, as the mile-thick glacier over half of North America melted and retreated, scouring bedrock and depositing glacial till to create the deeply scoured basin of the region’s lakes. The retreating ice also eroded mountains and left behind remnants of drumlins and eskers from ancient stream deposits. The glacier deposited a layer of glacial till more than three feet deep. Glacial till is composed of unsorted material, with particle sizes ranging from loose and sandy to compact and silty to gravelly. This material laid the foundation for vegetation and streams as the depression basins throughout the region began to fill with water (Goldthwait, 1951).

Mascoma Lake is located within the Connecticut Valley, which was shaped most recently by the Wisconsin Glaciation. As the climate warmed and glaciers retreated, ice sheets blocked north-draining rivers and Glacial Lake Hitchcock was formed. This large glacial lake persisted for several thousand years, from approximately 16,000–15,000 years ago to around 12,000–11,000 years ago. Upon this lake formation and the continued

glacial melt, sediments were deposited, including boulders, gravel, sand, silt, and clay, leaving behind extensive deposits throughout the valley. This glacial legacy is evident not only in the region's soil but also in the presence of aquifers.

There are several aquifers in the watershed (7%, 6,701 acres of the watershed), as shown by the NH GRANIT statewide aquifer transmissivity data layer. This includes aquifers underneath Mascoma Lake, and within the watershed underneath the Mascoma River. Most of these aquifers have a maximum transmissivity between 2,000 and 4,000 ft²/day, while a couple have a maximum transmissivity of 4,000 ft²/day or higher.

By receiving groundwater from these aquifers, any contamination that enters these aquifers will move quickly due to the high transmissivity of the material and enter Mascoma Lake and other surface waters. Therefore, protection of the aquifer is vital to the protection of surface waters.

3.1.4.2 Soils and Erosion Hazard

The soils in the Mascoma Lake watershed (Appendix A, Map A- 6) are a direct result of geologic processes. Of the 78 different soil series present within the Mascoma Lake watershed (excluding soils beneath waterbodies), the most prevalent soil group in the watershed is the Tunbridge-Lyman-Rock outcrop complex (17,731 acres, 10.2%), followed by Marlow fine sandy loam (9,295 acres, 5.4%), Marlow-Tunbridge association (8,539 acres, 4.9%), Becket fine sandy loam (8,025 acres, 4.6%) and Monadnock-Hermon association (8,002 acres, 4.6%). These five soils are well-drained, with the Monadnock Hermon Association and Tunbridge Lyman Rock Outcrop Complex also classified as excessively drained. The presence of rock outcrops in the Tunbridge Rock Outcrop Complex may further influence its drainage characteristics. The remaining 70.3% of the watershed (soils under waterbodies) is a combination of 73 additional soil series ranging from 4.3% to 0.005% of the watershed.

Soil erosion hazard is dependent on a combination of factors, including land contours, climate conditions, soil texture, soil composition, permeability, and soil structure (O'Geen et al., 2006). Soil erosion hazard should be a primary factor in determining the rate and placement of development within a watershed. Soils with negligible soil erosion hazard are primarily low-lying wetland areas near abutting streams. The soil erosion hazard for the Mascoma Lake watershed was determined from the associated slope and soil erosion factor K_w ¹ used in the Universal Soil Loss Equation (USLE). The USLE predicts the rate of soil loss by sheet or rill erosion in units of tons per acre per year. A rating of "slight" specifies erosion is unlikely to occur under standard conditions. A rating of "moderate" specifies some erosion is likely and erosion-control measures may be required. A rating of "severe" specifies erosion is very likely and erosion-control measures and revegetation efforts are crucial. A rating of "very severe" specifies significant erosion is likely and control measures may be costly. Excluding soils under waterbodies, "very severe" and "severe" erosion hazard areas account for 8% (7,544 acres) and 15% (14,707 acres) of the Mascoma Lake watershed, respectively, and are most concentrated along the western watershed boundary and west of Mascoma Lake (Appendix A, Map A- 7). Moderate erosion hazard areas account for 53% (51,707 acres) of the watershed land area. Slight erosion hazard areas account for 20% (19,745 acres), and 5% (4,528 acres) are not rated. Development should be restricted in areas with severe erosion hazards due to their inherent tendency to erode at a greater rate than what is considered tolerable soil loss. Since a highly erodible soil can have greater negative impact on water quality, more effort and investment are required to maintain its stability and function within the landscape, particularly from BMPs that protect steep slopes from development and/or prevent stormwater runoff from reaching water resources. Other areas prone to erosion include steeply sloped areas and areas with roadways within 50 feet of the waterbody (Appendix A; Map A- 8).

¹ K_w = the whole soil k factor. This factor includes both fine-earth soil fraction and large rock fragments.

3.1.4.3 Shoreline Erosion

Water level fluctuations in lakes and ponds can occur on long- and short-term timescales due to naturally changing environmental conditions or as a response to human activity. The effect of lake level fluctuation on physical and environmental conditions depends on several factors including the degree of change in water level, the rate of change, seasonality, and the size and depth of the waterbody (Leira & Cantonati, 2008; Zohary & Ostrovsky, 2011). Changes in lake level can impact flora and fauna mainly by altering available habitat, impacting nesting locations, and altering available food sources. In addition to impacts on biological communities, lakes can experience physical impacts on water quality from changes in lake level. Frequent lake level fluctuations can impact the shoreline, leading to erosion and increased sedimentation in near-shore habitats, which can inhibit light penetration and alter water clarity. Exposed shoreline sediment that is inundated at high water levels can release phosphorus, leading to alterations in nutrient accumulation and algae populations. High and low water levels can have detrimental effects on water systems, so finding a balance in managing water level at appropriate times throughout the year is critical to maintaining a healthy waterbody for both recreational enjoyment and aquatic life use. Management strategies become even more challenging when considering the impact of increased wake boating and extreme weather events (droughts and storms) on water level.

3.1.5 Wastewater

3.1.5.1 Septic Systems

Untreated discharges of sewage (domestic wastewater) are prohibited regardless of source. An example of an NPS discharge of untreated wastewater is from insufficient or malfunctioning subsurface sewage treatment and disposal systems, commonly referred to as septic systems, which may also include holding tanks and cesspools. When properly designed, installed, operated, and maintained, septic systems can reduce phosphorus concentrations in sewage within a zone close to the system depending on the development and maintenance of an effective biomat, the adsorption capacity of the underlying native soils, and the proximity to a restrictive layer or groundwater. Age, overloading, or poor maintenance can result in system failure and the release of nutrients and other pollutants into surface waters. Nutrients from underperforming septic systems can enter surface waters through surface overflow or breakout, stormwater runoff, or groundwater. Cesspools are buried concrete structures that allow solid sludge to sink to the bottom and surface scum to rise to the top and eventually leak out into surrounding soils through holes at the top of the structure. Holding tanks are completely enclosed structures that must be pumped regularly to prevent effluent back-up into the home.

FBE completed an initial review of available data on septic systems within 250 feet of the Mascoma Lake shoreline in 2025. The objective of this data survey was to determine the number of septic systems along the shoreline of Mascoma Lake and the proportion of older septic systems. FBE queried the NHDES OneStop online database for subsurface permits and reviewed Lebanon and Enfield tax parcel records. There were 224 shoreline properties with buildings identified (within 250 feet of the shoreline). One hundred thirty-nine of the 224 properties (62%) had septic systems older than 25 years.

FBE estimated the pollutant loading from shoreline septic systems using default literature values for daily water usage, phosphorus concentration output per person, and system phosphorus attenuation factors. The number of people using shoreline septic systems was determined by reviewing individual tax records per parcel. Properties with mailing addresses outside of Wolfeboro and Alton, depending on parcel location, were assumed to be seasonal. As detailed in the *Mascoma Lake Loading Response Model Report* (FBE, 2025a), shoreline septic systems contribute 47.0 kg/yr of total phosphorus loading to Mascoma Lake, comprising 2% of the total phosphorus load from all sources to the lake. Septic systems, cesspools, or holding tanks are located

within a short distance to the water, leaving little horizontal (and sometimes vertical) space for proper filtration of wastewater effluent. Improper maintenance or siting of these systems can cause failures, which leach untreated, nutrient-rich wastewater effluent directly to the lake. This effluent contains not only nutrients and bacteria but also microplastics, pharmaceuticals, and other pollutants harmful to public health.

In an effort to regulate septic systems on shoreline properties within the Mascoma Lake watershed, the Town of Enfield has drafted a septic ordinance which was unanimously approved by the selectboard on November 18, 2024, and is scheduled to go into effect on January 1, 2025. The ordinance applies to all private subsurface sanitary disposal systems located wholly or partially within Enfield's Protected Shoreland (EPS), defined as the 250-foot buffer around George Pond, Spectacle Pond, Crystal Lake, and Lake Mascoma. As defined by this ordinance, all systems shall be inspected by a NH Licensed Septic Evaluation and pumped a minimum of once every three years, with the possibility of an exemption to up to six years. Changes in the use or size of structures require approval from NHDES for the use applied for, and a new system must be installed to meet these standards as approved by NHDES. Sale of property requires a copy of the septic system evaluation reported to the town within 30 days of the purchase. Details and exceptions to the ordinance can be found [here](#) in the adopted ordinance.

3.1.5.2 Sewer Systems

The City of Lebanon maintains sewer along the northern portion of Route 4A in the watershed, which includes both gravity and force sewer mains. The Town of Enfield also has sewer lines in parts of 4A, including Lower Shaker Village and areas just south of it. A large portion of downtown Enfield is sewered with forced lines, and in total, the Town of Enfield services a total of 610 connections, which pipe the wastewater to the Lebanon Wastewater Treatment Facility. None of the properties surrounding Crystal Lake are sewered.

A significant limitation of the phosphorus loading model is the assumption that sewered shoreline areas do not contribute additional phosphorus through groundwater to Mascoma Lake, when it is likely that some portion of the sewer system is leaking nutrient-rich effluent into surrounding soils.

3.1.5.3 Boat Discharges

Boats can discharge nutrients in sewage from installed toilets and greywater (such as drainage from sinks, showers, and laundry). Dumping even small amounts of raw sewage into surface waters can significantly affect local ecosystems, causing algal blooms and degraded water quality.

3.1.6 Fertilizers

When lawn and garden fertilizers are applied in excessive amounts, in the wrong season, or just before heavy precipitation, they can be transported by rain or snowmelt runoff to lakes and other surface waters where they can promote cultural eutrophication and impair the recreational and aquatic life uses of the waterbody. Many states and local communities are beginning to set restrictions on the use of fertilizers by prohibiting their use altogether or requiring soil tests to demonstrate a need for any phosphate application to lawns.

Municipal properties, which are often used for recreation, can be fertilized. In the City of Lebanon, soils on town properties are sampled and analyzed each fall to determine the following year's fertilizer treatment plan. The recommended fertilizer is spread in the spring and again in the fall, with aeration and seeding in the spring. The town uses SeaBlend Organic fertilizer, which in 2024, the ratio of applied fertilizer was 12-0-12 (Nitrogen – Phosphorus – Potassium). Grass clippings and leaves are left in place until the volume of leaf litter is too substantial, at which time it is vacuumed and either disposed of on-site in passive areas or taken to organic waste at the City landfill.

3.1.7 Pets

In residential areas, fecal matter from pets can be a significant contributor of nutrients to surface waters. Each dog is estimated to produce 200 grams of feces per day, which contain concentrated amounts of phosphorus (CWP, 1999). If pet feces are not properly disposed of, these nutrients can be washed off the land and transported to surface waters by stormwater runoff. Pet feces can also enter by direct deposition of fecal matter from pets standing or swimming in surface waters.

3.1.8 Agriculture

Agriculture in the Mascoma Lake watershed includes cropland and grazing areas. Agricultural activities, including dairy farming, raising livestock and poultry, growing crops, and keeping horses and other animals for pleasure or profit, involve managing nutrients.

Agricultural activities and facilities with the potential to contribute to nutrient impairment include:

- Plowing and earth moving;
- Fertilizer and manure storage and application;
- Livestock grazing;
- Animal feeding operations and barnyards;
- Paddock and exercise areas for horses and other animals; and
- Leachate from haylage/silage storage bunkers.

Diffuse runoff of farm animal waste from land surfaces (whether from manure stockpiles or cropland where manure is spread), as well as direct deposition of fecal matter from farm animals standing or swimming in surface waters, are significant sources of agricultural nutrient pollution in surface waters. Farm activities like plowing, livestock grazing, vegetation clearing, and vehicle traffic can also result in soil erosion which can contribute to nutrient pollution.

Excessive or ill-timed application of fertilizer or poor storage which allows nutrients to wash away with precipitation not only endangers lakes and other waters, but it also means those nutrients are not reaching the intended crop. The key to nutrient application is to apply the right amount of nutrients at the right time. When appropriately applied to soil, synthetic fertilizers or animal manure can fertilize crops and restore nutrients to the land. When improperly managed, pollutants in manure can enter surface waters through several pathways, including surface runoff and erosion, direct discharges to surface water, spills and other dry-weather discharges, and leaching into soil and groundwater.

3.1.9 Flooding

Areas of concern for flooding include hilly areas, areas with large amounts of impervious cover, and areas located within a floodplain. Zoning ordinances within the watershed regulate development in flood hazard areas, which may include restrictions on development, requirements for flood-resistant construction practices, and proper water and sewer systems design to mitigate flood risks.

The water level in Mascoma Lake and other lakes in the watershed is managed by dams, which in the fall, are drawn down to mitigate the risk of ice damage and spring flooding. The dams help mitigate shoreline flooding and ensure a reliable drinking water supply for the City of Lebanon through the Mascoma River. Though the probability of dam failure is low in the watershed, the possible failure of multiple dams could have adverse effects on water quality, infrastructure, and/or public safety.

Thirty-four active dams within the watershed are registered with NHDES. Of these dams, three (3) are classified as significant hazards, including the Canaan Sewage Lagoon Dam, the Crystal Lake Dam, and the Harris Brook Reservoir Dam. Additionally, two (2) are classified as high hazard: the George Pond Dam and the Goose Pond Dam. In fall 2023, the New Hampshire Department of Environmental Services' Dam Bureau began repairing the Goose Pond dam. Leakage was first detected in 2012, and the dam posed a significant threat to downstream communities and ecosystems. Officials warned that a failure could cause catastrophic flooding, sending water across Route 4 into Enfield, inundating Mascoma Lake, and surging into the Mascoma River. Projections indicate the floodwaters could reach Lebanon, endangering infrastructure and potentially resulted in loss of life. The project is expected to be completed by May 2025.

3.1.10 Future Development

Understanding population growth, and ultimately development patterns, provides critical insight into watershed management, particularly as it pertains to lake water quality. According to the U.S. Census Bureau, Canaan, Dorchester, Enfield, Grafton, Grantham, Hanover, Lebanon, Lyme, Orange, and Springfield have experienced moderate population growth over the last 50 years, increasing from a total of 24,889 people in 1970 to 42,820 people in 2020 (see Section 2.2.2). The Mascoma Lake watershed area has long been treasured as a recreational haven for both summer vacationers and year-round residents. The lake and surrounding region offer fishing, hiking, boating, sailing, canoeing, kayaking, and swimming in the summer, and ice fishing, cross-country skiing, snowshoeing, and snowmobiling in the winter. The desirability of the Upper Valley area as a recreational destination will likely stimulate continued population growth in the future. Growth figures and estimates suggest that towns should continue to consider the effects of current municipal land-use regulations, particularly impervious cover limits, on local water resources. As the region's watersheds are developed, erosion from disturbed areas and runoff from impervious surfaces increase the potential for water quality decline.

3.2 POTENTIAL CONTAMINATION SOURCES

Point source (PS) pollution can be traced back to a specific source such as a discharge pipe from an industrial facility, municipal treatment plant, permitted stormwater outfall, or a regulated animal feeding operation, making this type of pollution relatively easy to identify. Section 402 of the CWA requires all such discharges to be regulated under the National Pollutant Discharge Elimination System (NPDES) program to control the type and quantity of pollutants discharged. NPDES is the national program for regulating point sources through issuance of permit limitations specifying monitoring, reporting, and other requirements under Sections 307, 318, 402, and 405 of the CWA.

NHDES operates and maintains the OneStop database and data mapper, which house data on Potential Contamination Sources (PCS) within the State of New Hampshire. Identifying the types and locations of PCS within the watershed may help identify sources of pollution and areas to target for restoration efforts. On November 21, 2024, FBE downloaded datasets for above and underground storage tanks, solid waste facilities, hazardous waste generators, local potential contamination sources, automobile salvage yards, and remediation sites in the Mascoma Lake watershed. Four (4) aboveground storage tanks, 69 underground storage tanks, five (5) solid waste facilities, 37 hazardous waste generators, 24 local potential contamination sources, three (3) automobile salvage yards, and 99 remediation sites were identified in the study area (Appendix A, Map A- 9).

3.2.1 Above and Underground Storage Tanks

Above and underground storage tanks include permitted containers with oil and hazardous substances such as motor fuels, heating oils, lubricating oils, and other petroleum and petroleum-contaminated liquids. There are four (4) aboveground storage tanks within the Mascoma Lake watershed, two (2) in Enfield and two (2) in

Canaan. There are 69 underground storage tanks within the Mascoma Lake watershed. Clusters of these tanks are primarily located in downtown Enfield, Canaan, and Canaan Center. Route 4 has some commercial businesses as it connects Enfield and Canaan, along which a couple of underground storage tanks are located. Route 118 and Route 4A have a few tanks as well. Ownership of these tanks ranges from commercial industries, gas stations, hospitals, marinas, schools, local government, residential properties to farms and utilities.

3.2.2 Solid Waste Facilities

There are five solid waste facilities within the Mascoma Lake watershed. Two (2) of these are no longer in operation. The three (3) active solid waste facilities include Hammond Grinding & Recycling in Orange; the Enfield Transfer Station and Recycling Center; and the Canaan Transfer Station.

3.2.3 Hazardous Waste Sites

Hazardous waste generating facilities are identified through the EPA's Resource Conservation and Recovery Act (RCRA) and require federal or state regulation. Only seven of the 37 hazardous waste generating facilities within the Mascoma Lake watershed are listed as active; the remaining facilities are classified as either inactive (21) or declassified (9).

3.2.4 Local Potential Contamination Sources

Local potential contamination sources are sites that may represent a hazard to drinking water quality supplies due to the use, handling, or storage of hazardous substances. There may be overlap between local potential contamination sources and other PCS identified in this section. Of the 24 potential contamination sources within the Mascoma Lake watershed, most are concentrated around Enfield and West Canaan, primarily along Route 4.

3.2.5 NPDES Outfalls

There are no NPDES outfalls within the Mascoma Lake watershed.

3.2.6 Automobile Salvage Yards

There are three automobile salvage yards within the Mascoma Lake watershed--one in Enfield, Canaan, and Orange--all of which are active.

3.2.7 Remediation Sites

The 99 remediation sites present within the Mascoma Lake watershed include leaking storage facilities that contain fuel or oil; actual or potential discharges of hazardous materials; hazardous waste projects; non-hazardous and non-sanitary holding tanks; initial spill response sites; lined wastewater lagoons; non-domestic wastewater; historical dump sites; on-premise use facilities containing fuel oil; rapid infiltration basins; septic lagoons; subsurface wastewater disposal systems; solid waste transfer stations; oil spills or releases; underground injection control; or submerged vehicles.

3.3 INTERNAL PHOSPHORUS LOAD

Phosphorus that enters the lake and settles to the bottom can be re-released from sediment under anoxic conditions, providing a nutrient source for algae, cyanobacteria, and plants, otherwise known as internal phosphorus loading. The watershed modeling in Section 2.2 identified internal phosphorus loading as a minor portion of the total phosphorus load for Mascoma Lake, estimated at 20.8 kg-P/yr (1%). However, additional

monitoring may be conducted to refine the internal loading estimate, which was based on a limited amount of data. The City of Lebanon funded the collection and analysis of sediment cores from Mascoma Lake during development of this plan, the results of which helped to refine the internal phosphorus load and determine applicability of any in-lake treatment options.

3.3.1 Sediment Analysis

FBE collected sediment cores from 14 sites on 8/19/2025 around Mascoma Lake representing a gradient of water depths (Figure 17). Using a gravity corer, the top 10 cm of sediment was collected from each site, deposited in a labeled bag, double-bagged, and placed in a cooler on ice for transport. FBE shipped samples overnight to the University of Wisconsin-Stout Center for Limnological Research and Rehabilitation Laboratory for analysis of moisture content, wet and dry bulk density, loss on ignition (LOI) or organic content, total phosphorus, and biologically labile phosphorus by sequential lab extractions (Psenner and Puckso, 1988)².

3.3.1.1 Sediment Characterization

Sediment cores collected from Mascoma Lake were characterized as largely loose (or watery), brown, smooth silt with occasional redoximorphic features evident and noticeable color gradations from reddish at the top to gray at the bottom. Organic content was generally uniform throughout the lake sediment samples, ranging between 7% - 16% (Figure 18, Table 14). Redoximorphic features provide visual evidence of oxygen fluctuations in the sediment, with reddish-orange, oxidized (oxygen-rich) areas and greyish-black, reduced (oxygen-poor) areas. Certain cores (namely ML-12 and ML-6, which represent the deep spots of the two respective basins) had an odor indicative of sulfur reduction at the lake bottom, which suggests that the reducing conditions required for phosphorus release were present at the time of sampling. Refer to photos.

² Phosphorus fractions analyzed included loosely bound phosphorus, iron bound phosphorus, labile organic phosphorus, and aluminum bound phosphorus and respectively represent the increasing degree in which phosphorus is bound in the sediment. Loosely bound phosphorus is the most readily available fraction for uptake by biota. Iron bound phosphorus is phosphorus bound to iron which can be released under low oxygen conditions. Labile organic phosphorus is phosphorus bound to organic matter that is slowly released during microbial decomposition and is generally less available than loosely and iron bound phosphorus fractions but can still be a significant contributor to the internal phosphorus load. Aluminum bound phosphorus is phosphorus bound to aluminum which is generally considered permanently retained within sediments except under high pH conditions. The remaining fraction of phosphorus is considered "refractory," including calcium bound phosphorus, and is permanently retained within sediments.

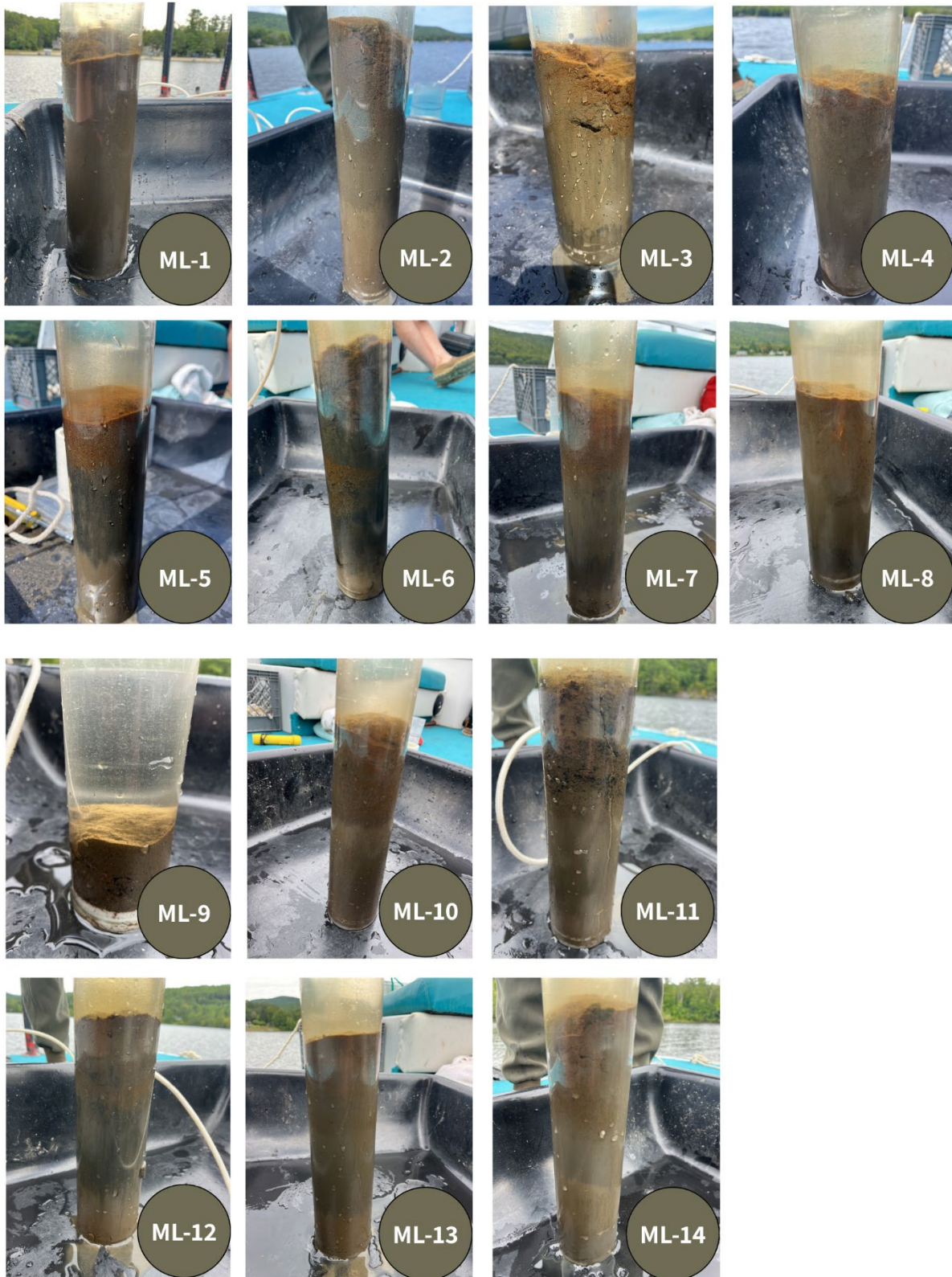


Figure 17. Photos of sediment cores collected from all sites. Refer to Figure 19 for locations.

Partially decomposed plant material was only found in one sediment core (ML-14, 4.7m); other sites were generally too deep for aquatic vegetation to grow. Organic content in the cores was low and relatively constant across depths (7 – 16%) (Figure 18). The percentage of solids in the cores was also consistent across sites, without any geographic or depth-related patterns. Though the two sites (ML-9, ML-10) with the highest percent solids content were located near outflows with influence from road wash-out and settling. These sediment cores also had relatively high wet bulk density across sites, meaning there was a relatively high mass of sediment in the space it takes up (sediment is dense). The sediment cores were all characterized by smooth, silty soil, sometimes with black speckles indicating the presence of organic matter. Only one core had grit (indicative of sand and gravel), which was ML-11, in the northwestern basin of the lake. Notably, two sediment cores had higher clay content at the bottom of the 10-centimeter core (ML-4, ML-6), both of which are in deep holes where sediment from the watershed and organic matter can “focus.”

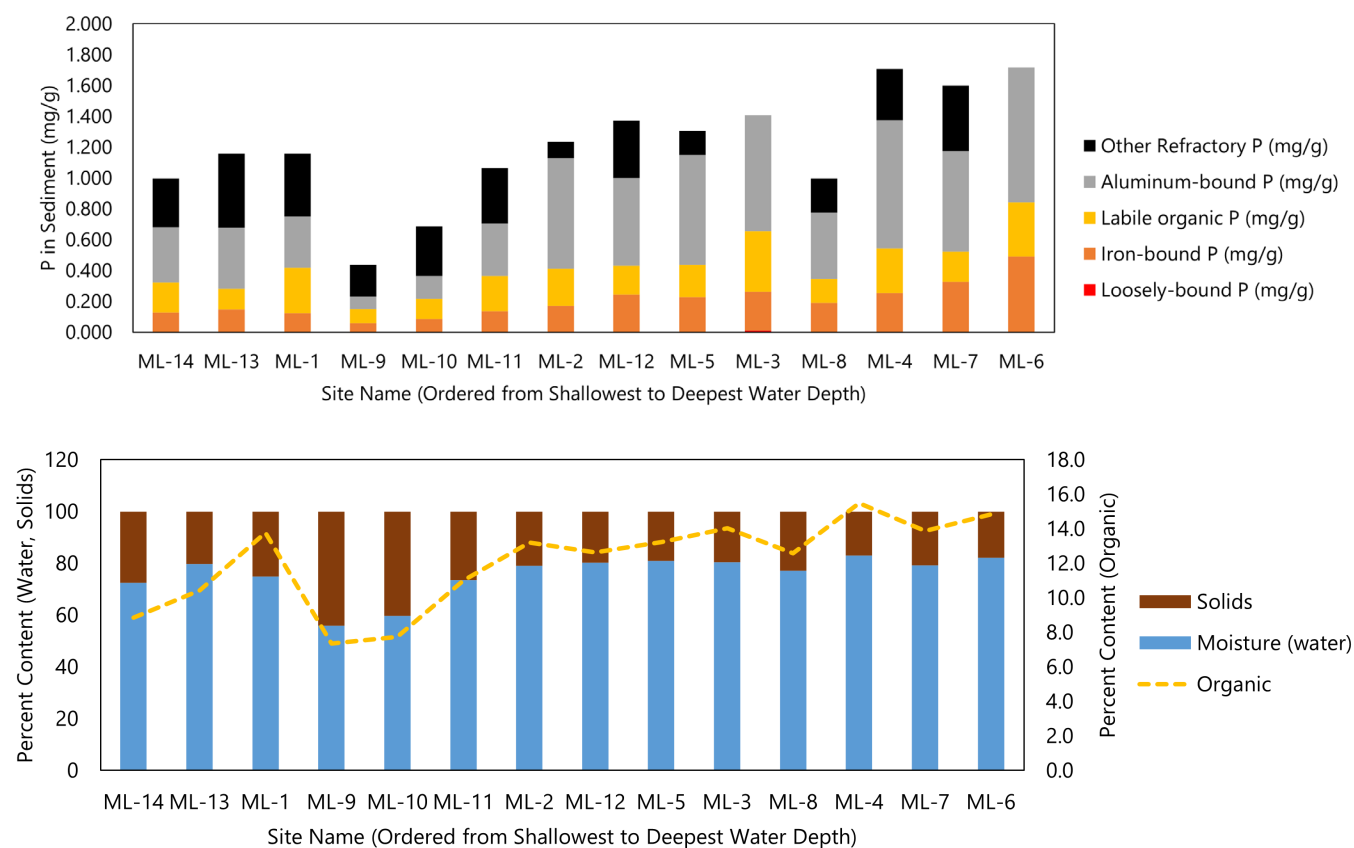


Figure 18. [TOP] Phosphorus (P) fractions and [BOTTOM] water, solids, and organic matter content (percent, %) in sediment cores (representing top 10 cm) at various water depths across Mascoma Lake. Refer to Table 14 for data and Figure 19 for locations. Sites are ordered from deepest to shallowest water depth.

3.3.1.2 Mobile Phosphorus Mass Available

Mobile phosphorus in sediments is the sum of loosely bound, iron bound, and labile organic phosphorus, with loosely bound and iron bound being the most readily available fractions under anoxic conditions (10-30% of which is typically released per year) and labile organic phosphorus being available following decay over longer time periods (5-10% of which is typically released per year). In general, deeper sites in Mascoma Lake tended to

have higher total phosphorus concentrations, with the exception of shallower sites located in the northwestern basin of the lake (ML-14, ML-13) and one nearshore site on the southeastern tip of the lake (ML-1) (Figure 18., Table 14). The amount of mobile phosphorus (both the iron bound and labile organic fractions of phosphorus) also generally increased with depth. The iron-bound phosphorus and the slow-decaying labile organic phosphorus comprised relatively equal portions of the mobile phosphorus in sediment across sites. Iron-bound phosphorus was generally within the expected range, between 0.056 – 0.487 mg/g. For reference, iron bound phosphorus can range from 0.1 - >1 mg/g in deep lakes (like Mascoma Lake) where phosphorus can “focus” in the deepest part of the lake. Mascoma Lake has three deep holes (in depth order, ML-12, ML-4, and ML-6), all of which have the highest sediment total phosphorus concentrations in their respective basins.

Dissolved oxygen/temperature profiles collected for the northwestern basin and main lake of Mascoma Lake (near sediment sites ML-12 and ML-6, respectively) show stark differences between areas of the lake that are hydrologically separated by a major road. Profiles for the northwestern basin (site MASENF2D) were collected from 1991-2011 and show anoxia extending as shallow as 7 meters. Anoxia establishes in bottom waters (around 9 meters) beginning in June and peaks in August. Because this basin is shallower and appears to be slightly disconnected from the main lake, the water column appears to have a slightly different mixing regime, and the water column begins to destabilize in September; more data are needed in shoulder months to confirm. In the main lake (site MASENF1D), anoxia is observed to begin in July, extend as shallow as 10 meters, and peak in September (closer to lake turnover).

The average concentration of loosely bound and iron bound phosphorus in sediment in regularly anoxic areas of the lake (>7 meters for the northwestern basin and >10 meters for the main lake) is 0.177 mg/g and 0.288 mg/g, respectively (Table 14). The average concentration of all three mobile fractions in sediment is 0.360 mg/g and 0.557 mg/g in the regularly anoxic zones for the northwestern basin and main lake, respectively. Loosely bound and iron bound phosphorus typically drive internal phosphorus loading in lakes, but labile organic phosphorus can also play a significant role. These mobile phosphorus concentrations in sediment are similar to those of other lakes in the region that experience significant internal phosphorus loading (especially the iron-bound phosphorus concentration).

3.3.1.3 Internal Phosphorus Loading Estimate

The partial net estimate of the internal phosphorus load to Mascoma Lake was estimated at 20.8 kg/yr representing about 1% of the total phosphorus load to the lake, according to the modeling performed for this WMP (see section 2.2). The internal phosphorus load estimate was highly variable and warrants continued monitoring to refine the estimate. Details on recommended monitoring are provided in section 6.4.

As an alternate check on the internal phosphorus loading estimate from the LLRM, we can use the sediment data paired with dissolved oxygen data and literature-based empirical formulas or assumptions to estimate the net and gross internal phosphorus load to Mascoma Lake.

Using the loosely bound and iron bound phosphorus fractions to derive the release rate (RR in mg/m²/d) multiplied by the anoxic factor (AF in d/yr) or anoxic area (AA in d/yr) and total lake surface area (m²) according to Nürnberg (1988), we estimate a gross internal phosphorus load of **273 kg/yr** (net = 216 kg/yr).

These results are an order of magnitude higher than the partial net estimate derived as part of the LLRM. There are a couple explanations for this discrepancy.

First, the water quality-derived partial net estimate may be too low given some limitations with sampling methods:

- (1) **Mascoma Lake is a deep (70 ft+, 21m+), stratified lake.** This means that thermocline erosion, and eventually fall turnover when the entire water column mixes, occurs a bit later in the fall, which extends the duration of thermal stratification and thus the exposure of bottom sediments to anoxic conditions that can release phosphorus into the water column. Consequently, peak internal loading likely occurs in September-October, which has not typically been sampled in the past. Additionally, VLAP protocols collecting discrete grab samples for phosphorus analysis at three mid-layer depths misses the full variation in phosphorus concentrations throughout the water column. Mid-layer depth in the hypolimnion is around 12-18 m, which is 6-10 m above the lake bottom and represents an area with potentially the highest concentrations of phosphorus coming from sediment release.
- (2) **Discrete profiles taken only at the deep spots may miss spatial variations in anoxia that impact internal loading.** Anoxia can differ throughout the lake based on the morphology/morphometry of different coves, bays, or basins (as is seen with the northwestern basin of Mascoma Lake). The northwestern basin has not been sampled since 2011, representing a data gap. Other shallower areas may have slightly more/less anoxia at depth which can worsen/lessen the risk of internal loading.

Second, the sediment-derived gross estimate may be too high given some natural controls on the net release of phosphorus from sediment in Mascoma Lake. The sediment-derived gross estimate is a modeled potential (not actual) release of phosphorus from sediment. Mascoma Lake sediments have a relatively high wet bulk density, which generates a high mass of potentially releasable phosphorus. There are many mechanisms that control phosphorus release and thus the effective internal phosphorus load to the lake. These mechanisms include groundwater inflows, rapid precipitation of released phosphorus with iron, aluminum, clay, or organic particles, low upward flux of phosphorus out of sediments due to higher bulk density, or high nitrate or manganese in bottom waters or sediments that are more readily used electron receptors than iron.

Regardless, internal load estimations ranging from 21 – 273 kg-P/yr are plausible for the system. Because Mascoma Lake has a high total phosphorus load from a large watershed (2,444 kg-P/yr), having a larger range for an internal load estimate does not impact the model calibration. The predicted in-lake total phosphorus concentration is still within 5% of observed data using the higher internal load estimate from the sediment data. With this full range in mind, the internal load may comprise between 1% to 10% of the total phosphorus load to Mascoma Lake, which is below the critical 20% threshold where in-lake treatment measures such as alum treatments are considered.

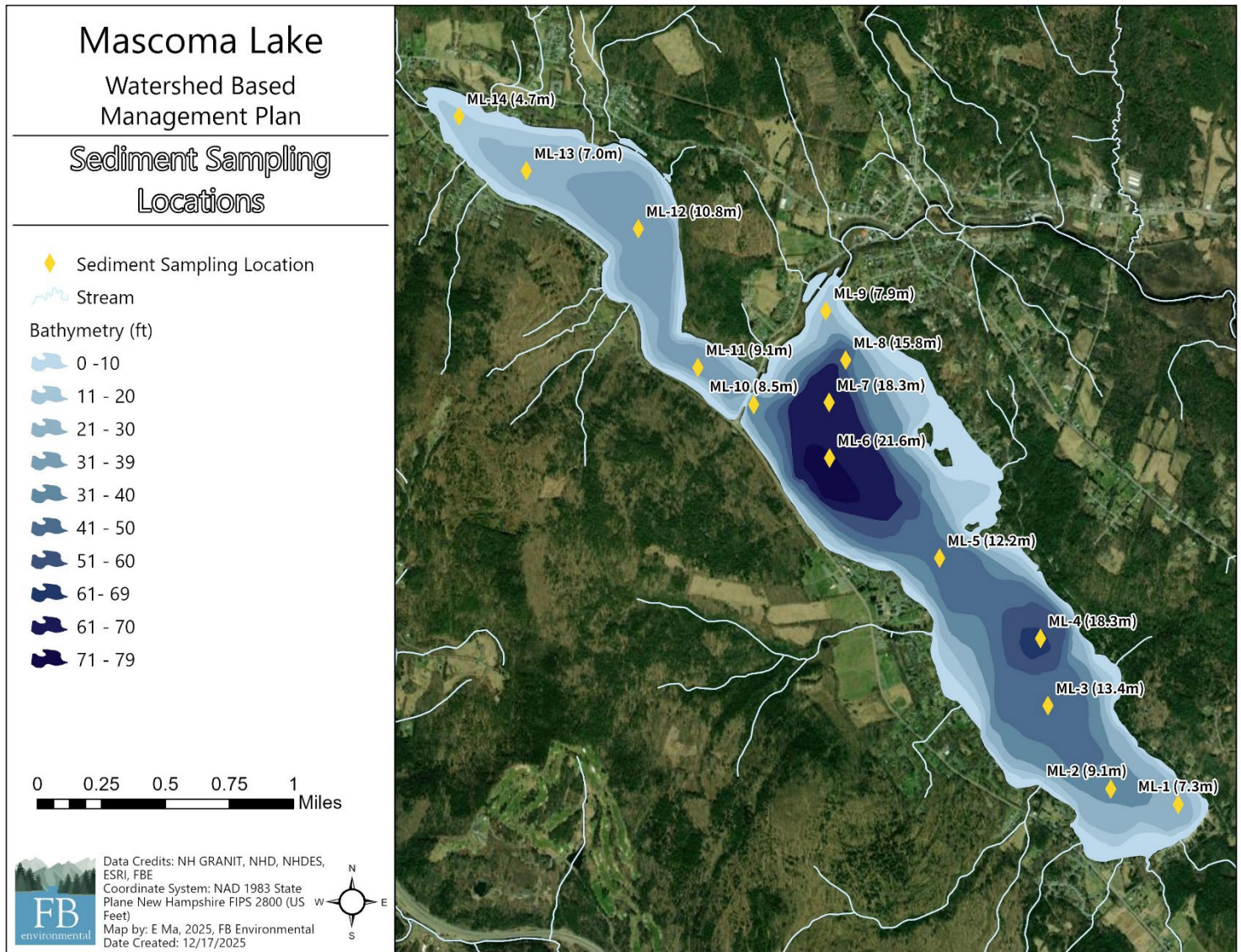


Figure 19. Sediment core sample locations around Mascoma Lake.

Table 14. Sediment sample results for Mascoma Lake ordered from shallowest to deepest water depth. Gray highlighted rows are part of the northwestern basin of Mascoma Lake. Samples were analyzed by the University of Wisconsin-Stout Center for Limnological Research and Rehabilitation. P=Phosphorus. LOI = Loss on Ignition (organic content). The reporting limit for loosely-bound P is 0.010 mg/g, so values below the limit are approximate.

Date	Station ID	Water Depth	Water Depth	Core Length	Moisture content	Solids Content	LOI	Wet bulk density	Dry bulk density	Loosely bound P	Iron bound P	Labile organic P	Aluminum bound P	Other Refractory P	Total P
	Units	ft	m	cm	%	%	%	g/cm ³	g/cm ³	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g
8/19/2025	ML-14	15.3	4.7	10.0	72.5	27.5	8.9	1.182	0.330	0.004	0.125	0.193	0.359	0.316	0.997
8/19/2025	ML-13	23	7.0	10.0	79.7	20.3	10.4	1.126	0.231	0.004	0.145	0.133	0.396	0.479	1.157
8/19/2025	ML-1	24	7.3	10.0	74.9	25.1	13.8	1.153	0.295	0.004	0.121	0.293	0.333	0.406	1.157
8/19/2025	ML-9	26	7.9	4.0	55.9	44.1	7.3	1.336	0.604	0.004	0.056	0.090	0.082	0.206	0.438
8/19/2025	ML-10	28	8.5	10.0	59.7	40.3	7.7	1.296	0.534	0.004	0.081	0.132	0.148	0.321	0.686
8/19/2025	ML-11	30	9.1	10.0	73.5	26.5	11.0	1.169	0.315	0.004	0.134	0.227	0.340	0.360	1.065
8/19/2025	ML-2	30	9.1	10.0	79.1	20.9	13.2	1.126	0.240	0.004	0.168	0.240	0.716	0.109	1.237
8/19/2025	ML-12	35.3	10.8	10.0	80.2	19.8	12.6	1.119	0.225	0.004	0.240	0.188	0.569	0.372	1.373
8/19/2025	ML-5	40	12.2	10.0	80.9	19.1	13.2	1.113	0.215	0.004	0.225	0.207	0.714	0.155	1.305
8/19/2025	ML-3	44	13.4	10.0	80.4	19.6	14.0	1.115	0.222	0.010	0.253	0.391	0.753	0.000	1.373
8/19/2025	ML-8	52	15.8	10.0	77.1	22.9	12.6	1.141	0.266	0.004	0.187	0.154	0.429	0.223	0.997
8/19/2025	ML-4	60	18.3	10.0	83.0	17.0	15.5	1.097	0.190	0.004	0.252	0.289	0.830	0.333	1.708
8/19/2025	ML-7	60	18.3	10.0	79.3	20.7	13.9	1.123	0.237	0.004	0.324	0.194	0.652	0.426	1.600
8/19/2025	ML-6	71	21.6	10.0	82.1	17.9	14.8	1.103	0.200	0.004	0.487	0.350	0.877	0.000	1.656

3.4 WILDLIFE

Fecal matter from wildlife such as geese, gulls, other birds, and beaver may be a significant source of nutrients in some watersheds. This is particularly true when human activities, including the direct and indirect feeding of wildlife and habitat modification, result in the congregation of wildlife (CWP, 1999). Congregations of geese, gulls, and ducks are of concern because they often deposit their fecal matter next to or directly into surface waters. Examples include large mowed fields adjacent to lakes and streams where geese and other waterfowl gather, as well as the underside of bridges with pipes or joists directly over the water that attract large numbers of pigeons or other birds. Studies show that geese inhabiting **riparian** areas increase soil nitrogen availability (Choi et al., 2020) and gulls along shorelines increase phosphorus concentration in beach sand pore water that then enters surface waters through groundwater transport and wave action (Staley et al. 2018). When submerged in water, the droppings from geese and gulls quickly release nitrogen and phosphorus into the water column, contributing to eutrophication in freshwater ecosystems (Mariash et al., 2019). On a global scale, fluxes of nitrogen and phosphorus from seabird populations have been estimated at 591 Gg N per year and 99 Gg P per year, respectively (with the highest values derived from arctic and southern shorelines) (Otero et al., 2018). Additionally, other studies show greater concentrations of nitrogen, ammonia, and dissolved organic carbon downstream of beaver impoundments when compared to similar streams with no beaver activity in New England (Bledzki et al., 2010). The model estimated that waterfowl are likely contributing 28.3 kg/yr (1%) of the total phosphorus load to Mascoma Lake and 10 kg/yr (3%) of the total phosphorus load to Crystal Lake.

3.5 CLIMATE CHANGE

Climate change will have important implications for water quality that should be considered and incorporated into WBMPs. In the last century, New England has already experienced significant changes in stream flow and air temperature. Out of 28 rural stream flow stations throughout New England, 25 showed increased flows over the record likely due to the increased frequency of extreme precipitation events and higher total annual precipitation in the region. In 79 years of recorded flooding in the Oyster River in Durham, NH, three of the four highest floods occurred in the past 10 years (Ballesterio et al., 2017). The average annual air temperature in New England has risen by 1°C to 2.3 °C since 1895 with greater increases in winter air temperature (IPCC, 2013). Lake ice-out dates occur earlier as warmer winter air temperature melts the snowpack and lake ice; earlier ice-out allows a longer growing season and increases the duration of anoxia in bottom waters. Increasing storm frequencies will flush more nutrients to surface waters for algae to feed on and flourish under warmer air temperatures.

These trends will likely continue to impact both water quality and quantity. Climate change models predict a 10% to 40% increase in stormwater runoff by 2050, particularly in winter and spring and an increase in both flood and drought periods as seasonal precipitation patterns shift. Adding to this stress is population growth and corresponding development in New Hampshire. The build-out analysis for the watershed showed that about 43,918 acres is still developable and up to 33,633 new buildings could be added to the watershed at full build-out based on current zoning standards. Mascoma Lake is at serious risk of water quality degradation because of new development in the watershed unless climate change resiliency and **low impact development** (LID) strategies are incorporated to existing zoning standards.

4 MANAGEMENT STRATEGIES

The following section details management strategies for achieving the water quality goal and objectives using a combination of structural and non-structural restoration techniques, as well as outreach and education and an adaptive management approach. A key component of these strategies is the idea that existing and future development can be remediated or conducted in a manner that sustains environmental values. All stakeholder groups have the capacity to be responsible watershed stewards, including citizens, businesses, the government, and others. Specific action items are provided in the Action Plan (Section 5).

4.1 STRUCTURAL NONPOINT SOURCE (NPS) RESTORATION

Structural NPS restoration techniques are engineered infrastructure designed to intercept stormwater runoff, often allowing it to soak into the ground, be taken up by plants, harvested for reuse, or released slowly over time to minimize flooding and downstream erosion. These BMPs often incorporate some mechanism for pollutant removal, such as sediment settling basins, oil separators, filtration, or microbial breakdown. They can also consist of removing or disconnecting impervious surfaces, which in turn reduces the volume of polluted runoff generated, minimizing adverse impacts to receiving waters.

4.1.1 Watershed & Shoreline BMPs

Five (5) NPS sites identified during the 2025 watershed survey and 512 high/medium/low impact rated shoreline properties from the 2025 desktop shoreline survey were documented to have some impact on water quality through the delivery of phosphorus-laden sediment (refer to Section 3.1.2-3.1.3). Other significant external phosphorus sources include aging septic systems, roads, and culverts (n=4). As such, structural BMPs to reduce the external watershed phosphorus load are a necessary and important component for the protection of water quality in the watershed.

The following series of BMP implementation action items are recommended for achieving Objective 1:

- Address the five highlighted priority sites identified during the 2025 watershed survey. The sites were ranked based on phosphorus load reduction and waterbody proximity. The full prioritization matrix with recommended improvements is provided in Appendix B.
- Provide technical assistance to the 100 high-risk shoreline properties identified during the 2025 desktop shoreline survey. Workshops and tours of demonstration sites can help encourage landowners to utilize BMPs on their own property. Conduct regular shoreline surveys to continue prioritizing properties for technical follow-up.
- Mitigate erosion and runoff from unpaved roads located within 50 feet of surface waters throughout the watershed by implementing BMPs such as improved ditching, cross-culverts, turnouts, crown restoration, and surface stabilization.
- Upgrade or replace aging shorefront septic systems (222 identified as older than 25 years) along Mascoma Lake and Crystal Lake, particularly systems older than 25 years, through inspection, repair, replacement, or conversion to advanced treatment systems where appropriate.
- Stabilize vulnerable culverts and associated streambanks identified by NHDES (n=4) using erosion control, bank stabilization, and flow-dissipation measures to reduce sediment and nutrient transport.

For the proper installation of structural BMPs in the watershed, landowners should work with experienced professionals on sites that require a high level of technical knowledge (engineering). Whenever possible,

pollutant load reductions should be estimated for each BMP installed. More specific and additional recommendations are included in Section 5. For helpful tips on implementing BMPs, see Additional Resources.

4.1.2 In-Lake Treatment Options

Several in-lake management alternatives with varying levels of effectiveness, longevity, cost, risk, and effort exist to address cyanobacteria blooms. Management alternatives typically focus on controlling factors that influence cyanobacteria growth and abundance: namely, light and nutrients. Management techniques such as dyes, surface covers, and selective plantings seek to establish light limitation, while methods such as nutrient input reduction, circulation, hypolimnetic or sediment oxygenation, dilution and flushing, drawdown, dredging, phosphorus inactivation, selective plantings, and selective withdrawal are used to reduce nutrient availability, directly or indirectly. Other techniques aim to target cyanobacteria through food-web manipulation or disrupting cellular processes (e.g., stocking herbivorous fish, removing bottom-feeding fish, algaecides, sonication).

For evaluating applicability to Mascoma Lake, strong preference should be given to techniques that reduce phosphorus loading as the primary source of nutrition supporting cyanobacteria growth. While many in-lake treatment options aim to address the internal phosphorus load, the internal phosphorus load was estimated to comprise only 1% to 10% of the total phosphorus load to Mascoma Lake (though this estimate may be refined with additional sampling). Given the relatively low contribution of internal phosphorus load in Mascoma Lake, many in-lake treatment options are not applicable and warranted no further consideration. For example, phosphorus inactivation using chemicals such as aluminum sulfate are commonly used for lakes in which internal phosphorus loading comprises >20% of the total phosphorus load; this type of treatment is expensive (especially for a relatively small internal phosphorus load) and can have less longevity in highly flushed systems such as Mascoma Lake. The relatively low internal phosphorus load also precludes other options such as dredging and hypolimnion or sediment oxygenation/aeration. Recommended management techniques with the greatest applicability for Mascoma Lake relate to external phosphorus load reduction through nonpoint source controls and pollutant trapping; no in-lake treatments are recommended due to the relatively low internal phosphorus load in Mascoma Lake:

- **Reduction of external phosphorus load** through nonpoint source controls and pollutant trapping is key for sustainable restoration of Mascoma Lake. The watershed survey (section 3.1.2) identified several nonpoint source pollution sites to remediate with structural BMPs, as well as several non-structural BMPs to reduce future sources of phosphorus from the watershed. External phosphorus load reduction efforts should continue to reduce existing sources and minimize new sources of phosphorus from the watershed.

4.2 NON-STRUCTURAL NONPOINT SOURCE (NPS) RESTORATION

Non-structural NPS restoration techniques refer to a broad range of behavioral practices, activities, and operational measures that contribute to pollutant prevention and reduction. The following section highlights important restoration techniques for several key areas, including pollutant reduction best practices, zoning and ordinance updates, land conservation, septic system regulation, sanitary sewer system inspections, boats and marinas, fertilizer use prohibition, pet waste management, agricultural practices, in-lake treatment options, and nuisance wildlife controls.

4.2.1 Pollutant Reduction Best Practices

Pollutant reduction best practices include recommendations and strategies for improving road management and municipal operations to protect water quality. Following standard best practices for road maintenance and drainage management protects both infrastructure and water quality through the reduction of sediment and

other pollutant transport. Refer to the *New Hampshire Stormwater Manual* (NHDES, 2008a) for standard road design and maintenance best practices.

Even though none of the watershed towns are required to comply with the six minimum control measures under the New Hampshire Small MS4 General Permit, each town could consider instituting the permit's key measures, such as street sweeping, catch basin cleaning, and road/ditch maintenance, if not already in place. The MS4 permit also covers illicit discharge detection and elimination plans (and ordinance inclusion), source control and pollution/spill prevention protocols, and education/outreach and training for residents, municipal staff, and stormwater operators, all of which are aimed at minimizing polluted runoff to surface waters.

The City of Lebanon inspects and cleans stormwater outfalls and culverts at least once a year, as well as prior to forecasted heavy storms. A culvert inventory is currently being created. When culverts are installed, they are upsized in anticipation of higher capacities for future large storm events. Streets are swept following winter operations and periodically throughout the summer and fall months. If temperatures allow, DPW treats the roadways with magnesium brine to help with the reduction of salt use throughout snowstorms. Salt is also treated with magnesium brine in the spinner during application to activate salt and reduce the quantity required. All trucks are equipped with calibrated application rates of up to 250 pounds per lane-mile and can be adjusted as the supervisor sees fit to conserve the amount of salt when needed. Salt is stored in a contained and covered salt shed within the DPW property. Lebanon maintains approximately 5 miles of dirt roads, which are graded every spring and fall. DPW efforts along gravel roads have focused on ditching roads throughout the summer months, inspecting and replacing failed culverts as needed, and following up on outfall areas prior to and following storms. Leaves, grass clippings, and organic debris are vacuumed and contained in vacuum trailers and hauled to the solid waste facility for composting.

4.2.2 Zoning and Ordinance Updates

Regulations through municipal zoning and ordinances such as LID strategies that prevent polluted runoff from impervious surfaces associated with new and re-development projects in the watershed are equally important as implementing structural BMPs on existing development. In fact, local land use planning and zoning ordinances can be among the most critical components of watershed protection. FBE completed a preliminary ordinance review of natural resource protections for the towns of Hanover, Lebanon, Enfield, and Canaan (Table 15). These municipalities have incorporated several important regulations into their local ordinances, including wetlands protections, floodplain regulations, setback requirements, and stormwater controls, though the level of detail, consistency, and enforcement mechanisms vary between towns. A more robust review of these ordinances is encouraged to develop more specific recommendations for improving regulations related to natural resource protection and water quality. The towns should also consider the staffing capacity and administrative support necessary to effectively enforce both existing and proposed ordinances.

Local land use planning and zoning ordinances should also consider incorporating climate change resiliency strategies to protect water quality and improve infrastructure in response to projected changes in temperature, precipitation, water levels, wind loads, storm surges, soil moisture, and groundwater levels (Ballesterio et al., 2017). There are nine strategies that can aid in minimizing the adverse effects associated with climate change and include the following (McCormick and Dorworth, 2019), several of which are partially addressed within the current ordinances of Hanover, Lebanon, Enfield, and Canaan but could be further strengthened and expanded. More details on ordinance recommendations and suggestions can be found in Table 16.

- **Installing Green Infrastructure and Nature-Based Solutions:** Planning for greener infrastructure requires that we think about creating a network of interconnected natural areas and open spaces

needed for groundwater recharge, pollution mitigation, reduced runoff and erosion, and improved air quality. Examples of green infrastructure include forest, wetlands, natural areas, riparian (banks of a water course) buffers, and floodplains; all of which already exist to various extents in the watershed and have minimized the damage created by intense storms. As future development occurs, these natural barriers must be maintained or even increased to reduce runoff of pollutants into freshwaters. See also Section 4.2.3: Land Conservation.

- **Using LID Strategies:** Use of LID strategies requires replacing traditional approaches to stormwater management using curbs, pipes, storm drains, gutters, and retention ponds with innovative approaches such as bioretention, vegetated swales, and permeable paving.
- **Minimizing Impervious Surfaces:** Impervious surfaces such as roads, buildings, and parking lots should be minimized by creating new ordinances and building construction design requirements which reduce the imperviousness of new development. Property owners can increase the permeability for their lots by incorporating permeable driveways and walkways.
- **Encouraging Riparian Buffers and Maintaining Floodplains:** Municipal ordinances should forbid construction in floodplains, and in some instances, floodplains should be expanded to increase the land area to accommodate larger rainfall events. Riparian (vegetated) buffers and filter strips along waterways should be preserved and/or created to slow runoff and filter pollutants.
- **Protecting and Re-establishing Wetlands:** Wetlands are increasingly important for preservation because wetlands hold water, recharge groundwater, and mitigate water pollution.
- **Encouraging Tree Planting:** Trees help manage stormwater by reducing runoff and mitigating erosion along surface waters. Trees also provide critical shading and cooling to streams and land surfaces.
- **Promoting Landscaping Using Native Vegetation:** Landowners should promote the use of native vegetation in landscaping, and landscapers should become familiar with techniques which minimize runoff and the discharge of nutrients into waterbodies (Chase-Rowell et al., 2012).
- **Slowing Down the Flow of Stormwater:** To slow and infiltrate stormwater runoff, roadside ditches can be armored or vegetated and equipped with turnouts, settling basins, check dams, or infiltration catch basins. Rain gardens can retain stormwater, while water bars can divert water into vegetated areas for infiltration. Water running off roofs can be channeled into infiltration fields and drainage trenches.
- **Coordinating Infrastructure, Housing, and Transportation Planning:** Coordinate planning for infrastructure, housing, and transportation to minimize impacts on natural resources. Critical resources including groundwater must be conserved and remain free of pollutants especially as future droughts may deplete groundwater supplies.

Table 15. Ordinance review summary of regulatory and non-regulatory tools for natural resource protection in Enfield, Canaan, and Lebanon which comprises the majority of the Mascoma Lake watershed and the entire lake shoreline.

REGULATORY TOOLS

Strategy	Lebanon	Enfield	Canaan
Zoning districts addressing environmental protection.	Overlay districts (e.g., Wetlands Conservation, Riverbank Protection) set additional restrictions to safeguard ecological areas. These include limited development, conservation buffers, and performance standards for activities like vegetation clearing and grading.	The Conservation District is specifically established to maintain natural resources and regulate activities to prevent environmental degradation. It includes limitations on structures, density, and activities to ensure resource protection.	Not by zoning district; subdivision process has some elements.
Shoreland zoning.	Structures must be set back at least 50 feet from designated shorelines. Clear-cutting and land disturbance are restricted to maintain riparian buffers. Only low-impact uses are permitted.	Structures must be set back at least 50 feet from seasonal high-water lines of rivers, lakes, and wetlands. For Prime Wetlands, the setback is 100 feet.	The Comprehensive Shoreland Protection Act (CSPA) governs activities within 250 feet of protected shorelands.
Waterfront parcels.	Waterfront subdivisions require natural buffer zones and stormwater management measures to reduce runoff. The subdivision review process assesses environmental impacts before approval.	The ordinance includes specific setback and density requirements that regulate land use near waterbodies to minimize environmental impacts.	Waterfront lots must meet shoreland setback and frontage requirements. New subdivisions must address water quality impacts through nutrient loading analyses and stormwater controls to minimize run-off into adjacent waterbodies.

Strategy	Lebanon	Enfield	Canaan
Cluster development and/or open space provisions for subdivisions.	Cluster subdivisions must dedicate at least 25% of the site to open space. This open space should be contiguous, accessible, and used for conservation, recreation, or natural habitat protection.	Cluster development is permitted in multiple districts to preserve open space. It is encouraged under Section 405 to consolidate development into smaller areas while retaining open lands.	Developers are encouraged to include open spaces in subdivisions. Open space areas must be designated for recreation or conservation and integrated into subdivision designs.
Protection of wetlands.	A 100-foot no-build buffer is enforced around wetlands of significant ecological value. Wetland crossings and alterations are subject to strict permitting and mitigation requirements.	Wetlands are designated as sensitive areas with mandatory setbacks and activity restrictions to prevent degradation.	Wetland delineation is required as part of subdivision plans. Developments must include stormwater measures to avoid direct discharge into wetlands and maintain buffer zones.
Protection of groundwater.	Activities that risk contamination, such as fuel storage or heavy chemical use, are prohibited in designated groundwater protection zones. Development must not reduce groundwater recharge capacity.	No structures are allowed within 400 feet of wellheads associated with the town's drinking water supply.	Stormwater regulations mandate minimizing impervious surfaces to support groundwater recharge. Subdivisions must ensure drinking water safety by maintaining wellhead protection zones (75-foot radius).
Protection of steep slopes.	Construction on slopes over 25% is generally prohibited. Erosion control plans and vegetative stabilization are required for any permitted activity in such areas.	Development on steep slopes is regulated to mitigate erosion and maintain stability.	Stormwater regulations mandate minimizing impervious surfaces to support groundwater recharge. Subdivisions must ensure drinking water safety by maintaining wellhead protection zones (75-foot radius).

Strategy	Lebanon	Enfield	Canaan
Septic pump-out ordinance or regulation of septic and sewer systems.	Septic systems must be inspected regularly and are prohibited within 125 feet of sensitive water resources. Sewer systems must adhere to setback and design standards to prevent leakage.	Sewage and gray water disposal must comply with state laws, especially for temporary accommodations like RVs.	In areas not currently served by public sewer systems, it shall be the responsibility of the subdivider or their agent to provide the necessary state approvals for the construction of an individual sewage disposal system. For new lots with on-site septic, the number of dwelling units per lot shall not exceed 1 unit per 150 feet of shoreland frontage, and for any lot that does not have direct frontage, one unit per 150 feet of lot width as measured parallel to the shoreland frontage that lies between the lot and the reference line.
Nutrient loading analysis required for fresh waterbodies.	Developments near fresh waterbodies must conduct nutrient analyses to evaluate potential impacts. Mitigation strategies, such as vegetative buffers or advanced septic technologies, may be required.	While specific nutrient analysis is not mentioned, setbacks and land-use regulations aim to reduce nutrient runoff into waterbodies.	Subdivisions impacting waterbodies are required to demonstrate compliance with water quality standards, including phosphorus and sediment reduction targets.
Low impact development requirements and standards.	LID practices like bioretention, permeable pavements, and green roofs are required to manage stormwater naturally. New developments are assessed for compliance with LID requirements.	LID approaches are encouraged for stormwater management in parking lots and other areas to reduce runoff.	Regulations promote practices such as: Preserving natural vegetation. Using vegetative swales and buffers for stormwater treatment. Controlling post-development runoff to match pre-development conditions.

Strategy	Lebanon	Enfield	Canaan
Environmental Ordinances (e.g. green building codes, green infrastructure, tree preservation, limits on impervious surface cover)	These include tree preservation rules, maximum impervious cover limits, and incentives for using renewable energy technologies or green building practices.	Limits on impervious surface coverage and landscaping requirements are specified, particularly in the Route 4 District.	Ordinances address: Green infrastructure. Preservation of trees and other natural features. Limiting impervious surface coverage in subdivisions.
Fertilizer and/or pesticide ordinances.	Application near sensitive areas is heavily restricted. Fertilizers must be phosphorus-free unless soil tests demonstrate a need. Licensed professionals must apply pesticides under strict guidelines.	No specific ordinances are highlighted, but environmental protections in sensitive areas imply regulation of such substances.	Rules limit the use of fertilizers and pesticides near waterbodies to reduce runoff and protect water quality.
Implement and enforce a Stormwater Management Plan.	Developers must submit detailed stormwater management plans. Requirements include capturing and treating runoff, minimizing peak flow rates, and integrating green infrastructure.	Landscaping and LID requirements incorporate stormwater management strategies to handle runoff sustainably.	Developers must include plans that: Control peak runoff during storms. Use techniques like detention basins and infiltration systems. Prohibit snow plowing or storage within 25 feet of wetlands.

CONSERVATION FUNDING STRATEGIES

Strategy	Lebanon	Enfield	Canaan
Development transfer overlay district.	Not mentioned.	Not mentioned.	Not mentioned.

Strategy	Lebanon	Enfield	Canaan
Conservation impact fees.	The City authorizes the assessment of impact fees on new developments under Section 213 of the Zoning Ordinance to finance public capital facilities, including conservation-related initiatives.	Conservation impact fees are outlined in Article IX of the Zoning Ordinance. These fees are charged to developers to offset the cost of public infrastructure or services necessitated by new development. The fees are calculated based on specific methodologies and are administered to support conservation and community growth without overburdening existing residents.	The Master Plan encourages the exploration of impact fees to offset municipal costs due to new development. These fees are proposed to reduce the financial burden on town infrastructure while supporting conservation goals.
Wetland mitigation funds.	Lebanon has a Wetlands Conservation District designed to protect wetlands, including high-value areas. This district mandates buffers and prioritizes on-site or nearby mitigation when wetland impacts are unavoidable.	Not mentioned.	Not mentioned.
Fee in lieu of land dedication.	Not mentioned.	Not mentioned.	Not mentioned.
Stormwater utility district.	Not mentioned.	Not mentioned.	Not mentioned.
Open space or non-lapsing conservation fund.	Not mentioned.	The Master Plan emphasizes the importance of conserving open spaces to maintain the town's rural character, ecological health, and recreation opportunities. Approximately one-third of Enfield's land area is protected as public open space or private conservation land. These efforts ensure long-term preservation and are supported by ongoing conservation funding mechanisms.	The Master Plan emphasizes preserving open spaces as part of the town's rural character and promoting cluster development to maintain large undeveloped areas. However, there's no direct mention of a dedicated fund.

Strategy	Lebanon	Enfield	Canaan
Has a Land Use Change Tax per RSA 79-A:25.	The Master Plan mentions that approximately 18,000 acres of open space in Lebanon are in current use under New Hampshire's Current Use Taxation Program, which aligns with RSA 79-A.	Not mentioned.	Not mentioned.
Participate or collaborate with a local watershed association.	Lebanon collaborates with watershed groups such as the Mascoma River Local Advisory Committee and Connecticut River Joint Commission for water resource management.	The Master Plan prioritizes protecting water resources, wildlife habitats, and forests. It identifies strategies to preserve ecological integrity through both regulatory and non-regulatory methods. Environmental protection is a guiding principle in Enfield's vision, which includes sustainable development and conservation of key natural areas.	The Master Plan discusses protecting shorelines and surface waters through collaboration with conservation organizations. Though watershed associations are not directly named, these efforts align with watershed conservation practices.
Participate or collaborate with a local land trust.	The City works with local organizations for conservation purposes, including preserving lands for ecological and recreational uses. The Master Plan highlights partnerships for land conservation initiatives.	Not mentioned.	Not mentioned.

NON-REGULATORY TOOLS

Strategy	Lebanon	Enfield	Canaan
Open space plan.	Lebanon's 2021 Open Space Plan is a foundational element of its conservation strategy, emphasizing the protection of open spaces, working lands, and natural areas to maintain rural character and ecological health. Approximately 70% of Lebanon's land is undeveloped, and the city dedicates 100% of Land Use Change Tax revenues to a conservation fund.	Not mentioned.	While there is no specific Open Space Plan mentioned, the Master Plan promotes open space conservation through cluster development and preserving undeveloped land for wildlife corridors and recreation.
Master Plan addresses natural resources and environmental protection.	The Master Plan highlights the importance of protecting natural resources such as wetlands, forests, and waterbodies. Key protections include the Wetlands Conservation District and the Riverbank Protection District. These measures align with efforts to balance growth while preserving biodiversity and ecological integrity.	The Master Plan focuses on protecting water resources, wildlife, and forests through both regulatory and non-regulatory strategies.	The Master Plan outlines strategies for protecting natural resources, including enforcing setbacks, limiting development in sensitive areas (e.g., wetlands, steep slopes), and conserving wildlife habitats. Specific measures include protecting Canaan Street Lake and aquifers as critical drinking water resources.

Strategy	Lebanon	Enfield	Canaan
A town-wide natural resources inventory.	Lebanon completed the "Natural Lebanon" natural resource inventory (NRI) in 2010. The NRI documents critical resources, including wetlands, farmland, and wildlife corridors, providing a data-driven foundation for conservation planning and decision-making.	Enfield's Conservation Commission developed a comprehensive Natural Resources Inventory (NRI) in 2005, documenting critical ecological features such as wetlands, wildlife corridors, and forests. This inventory is periodically updated and serves as a foundational tool for land use planning, zoning decisions, and environmental conservation.	The Master Plan refers to the use of natural resource inventories to guide land-use decisions and prioritize critical areas for protection. This inventory helps identify and map important ecological and hydrological features.
Smart Growth Plan.	The City integrates Smart Growth principles into its planning, focusing on compact, mixed-use development near existing urban centers, reducing rural sprawl, and conserving farmland and natural areas.	Principles of smart growth, such as concentrating development in village centers, are integrated into the Master Plan, but not under this specific name.	The Master Plan incorporates smart growth principles by encouraging clustered development near village centers while preserving rural and undeveloped areas. These strategies are aimed at reducing sprawl and protecting natural resources.
Stormwater system mapping	The Master Plan identifies challenges with stormwater infrastructure, including combined sewer overflows and EPA mandated upgrades. Lebanon has removed all CSOs as of 2024.	Not mentioned.	Not mentioned.

Strategy	Lebanon	Enfield	Canaan
Consistent Public Outreach and Engagement / Public education programs	The City emphasizes community engagement, including educational initiatives on water conservation, invasive species management, and climate change mitigation. Public input and collaboration are highlighted as essential for effective planning and environmental stewardship.	Public outreach is a central theme in Enfield's Master Plan. The planning process included community surveys, focus groups, and visioning workshops to gather input from residents. Educational initiatives aim to raise awareness about conservation, sustainable development, and the town's environmental priorities.	The Master Plan highlights public involvement in the planning process, including surveys, forums, and workshops. It emphasizes ongoing community engagement to ensure conservation and land-use policies reflect public priorities.
Incentive-based programs for voluntary low impact development implementation.	None identified.	None identified.	None identified.
Incentive-based programs for stormwater reduction efforts.	The City promotes stormwater reduction through infrastructure improvements and planning requirements. Incentives may include design flexibility for developments that incorporate effective stormwater management.	None identified.	None identified.

Strategy	Lebanon	Enfield	Canaan
Conservation Commission	Lebanon has a Conservation Commission actively involved in land protection, natural resource management, and providing guidance on development impacts.	The Conservation Commission is a formal body responsible for overseeing the protection of natural resources in Enfield. Its duties include managing the NRI, advising on development projects, and collaborating with stakeholders to enhance conservation efforts. This body plays a vital role in implementing the town's environmental goals.	The Conservation Commission is active in guiding conservation efforts, conducting natural resource inventories, and advising on development impacts. The commission's role is critical in implementing the town's environmental protection goals.
Incentivize and/or encourage property owners to implement low impact development stormwater practices.	None identified.	None identified.	None identified.
Encourage property owners to put land into farmland/tree growth programs.	The City recognizes the importance of maintaining agricultural and forested lands. Incentives include the current use taxation program (RSA 79-A), which encourages landowners to preserve open space and working lands.	Not mentioned.	Not mentioned.

Table 16. Summary table of town recommendations for natural resource protection based off the Ordinance Review for the towns of Lebanon, Enfield, and Canaan.

REGULATORY TOOLS

Strategy	Lebanon Recommendations	Enfield Recommendations	Canaan Recommendations
Zoning districts addressing environmental protection.	Expand overlay districts to include smaller tributaries and headwater areas. Increase buffer widths for higher-risk zones.	Expand Conservation Districts to include buffer zones around all significant waterbodies and wetlands, and incorporate mandatory riparian buffers to reduce runoff and protect aquatic habitats.	Create environmental overlay districts to protect wetlands, steep slopes, aquifer recharge areas, and the Canaan Street Lake watershed since protections currently occur only through the subdivision process.
Shoreland zoning.	Enforce a wider setback (e.g., 75-100 feet) and restrict impervious surfaces within the shoreland zone.	Increase the setback requirement from waterbodies to 75 feet for general areas and 150 feet for Prime Wetlands. Introduce vegetative buffer requirements for additional erosion and nutrient runoff control.	Adopt local shoreland standards that reinforce or exceed CSPA by requiring stormwater treatment, larger natural buffers, and riparian vegetation restoration for redevelopment.
Waterfront parcels.	Require mandatory stormwater treatment systems and larger open-space requirements near waterbodies.	Implement stricter lot size and frontage requirements for waterfront subdivisions, and mandate open space preservation along shorelines to maintain water quality and ecosystem integrity.	Require enhanced stormwater controls, vegetated buffers, and limits on expansion of impervious surfaces on waterfront lots to reduce direct runoff into Canaan Street Lake and other waterbodies.
Cluster development and/or open space provisions for subdivisions.	Incorporate native vegetation restoration in open spaces and mandate green infrastructure for stormwater management.	Require a higher percentage of preserved open space for cluster developments near waterbodies and encourage integration of natural filtration features like rain gardens and wetlands.	Strengthen cluster development standards by requiring a minimum percentage of preserved open space and ensuring that conserved areas include riparian zones, wetlands, or steep slopes.

Strategy	Lebanon Recommendations	Enfield Recommendations	Canaan Recommendations
Protection of wetlands.	Strengthen protections with a no-disturb buffer and require compensatory wetland restoration for permitted impacts.	Increase setbacks from wetlands for all development and establish a no-disturbance buffer zone around all wetlands to better protect against habitat loss and water quality degradation.	Adopt a stand-alone wetland protection ordinance establishing setbacks, buffer widths, and performance standards, rather than relying on subdivision review alone.
Protection of groundwater.	Introduce stricter controls on industrial activities in groundwater recharge areas and encourage rainwater harvesting.	Expand protections for wellhead areas by enforcing stricter land-use controls within a larger radius and requiring regular monitoring of potential contamination sources.	Expand drinking water protection by establishing a mapped groundwater protection overlay with restricted land uses, increased setbacks, and stormwater infiltration requirements.
Protection of steep slopes.	Prohibit clear-cutting on steep slopes and require tiered erosion and sediment control measures during construction.	Prohibit development on steep slopes near waterbodies to prevent sedimentation and implement mandatory erosion control measures during construction.	Create a steep slope development ordinance that restricts clearing, grading, and new road cuts on slopes greater than 15 to 25 percent to prevent erosion and sedimentation to surface waters.
Septic pump-out ordinance or regulation of septic and sewer systems.	Identify and map areas where advanced septic treatment technologies are necessary to protect water quality and require them there.	Identify and map sensitive soils for septic systems. Mandate regular pump-outs and inspections within sensitive soil areas. Require that septic systems adequately prevent phosphorus pollution to lakes and streams, generally through adequate setback distances, vertical separation distances, avoiding highly porous soils, and ensuring adequate effluent flow paths through unsaturated soils.	Adopt a mandatory 3 to 5 year pump-out requirement for properties within the Canaan Street Lake watershed and require proof of system condition during property transfers.

Strategy	Lebanon Recommendations	Enfield Recommendations	Canaan Recommendations
Nutrient loading analysis required for fresh waterbodies.	Require detailed nutrient management plans for agricultural and residential areas near waterbodies.	Implement a requirement for nutrient loading assessments in site plans for developments near waterbodies. Develop a nutrient reduction plan for high-impact areas.	Require nutrient loading analyses for all subdivisions and large redevelopments within lake watersheds and tie approvals to demonstrated phosphorus load reductions.
Low impact development requirements and standards.	Provide incentives for developers to exceed LID requirements and require ongoing maintenance plans for LID features.	Make LID strategies mandatory in all developments, including rain gardens, permeable pavements, and green roofs, to reduce runoff and improve water infiltration.	Adopt LID design standards requiring infiltration, limits on effective impervious area, vegetated buffers, and use of practices like rain gardens and swales in all new development.
Environmental Ordinances (e.g. green building codes, green infrastructure, tree preservation, limits on impervious surface cover)	Incorporate stronger tree-preservation policies and increase restrictions on impervious surface limits near critical water resources.	Lower maximum impervious surface limits in all districts and require onsite stormwater infiltration features for developments exceeding certain thresholds.	Create an environmental protection ordinance that sets maximum allowable impervious cover for lake watershed parcels and protects mature trees and natural vegetation during site development.
Fertilizer and/or pesticide ordinances.	Prohibit fertilizer application within 25 feet of waterbodies and provide community education programs on reducing chemical usage.	Restrict fertilizer and pesticide application near waterbodies and promote the use of organic or low-impact alternatives. Educate landowners on safe application practices.	Adopt a fertilizer and pesticide use ordinance for lake watershed parcels that restricts phosphorus fertilizers and requires setbacks from shorelines and wetlands.

Strategy	Lebanon Recommendations	Enfield Recommendations	Canaan Recommendations
Implement and enforce a Stormwater Management Plan.	Mandate post-construction monitoring of stormwater systems to ensure they function as designed, reducing pollutants.	Develop a comprehensive stormwater management plan that includes regular maintenance of stormwater infrastructure, monitoring of runoff impacts, and incentives for retrofitting outdated systems.	Develop a town-wide stormwater management plan that includes erosion control standards, post-construction monitoring, and regular inspection requirements.

CONSERVATION FUNDING STRATEGIES

Strategy	Lebanon Recommendations	Enfield Recommendations	Canaan Recommendations
Development transfer overlay district.	Establish a transfer of development rights overlay district that shifts development pressure away from high priority water resources, wetlands, and steep slopes toward designated growth areas with existing infrastructure.	Implement development transfer overlay districts to direct growth away from sensitive lake and waterbody areas, concentrating development in less environmentally critical zones.	Establish overlay districts to redirect development away from sensitive lake and waterbody areas. Use transferred development rights to preserve riparian zones and critical watershed lands.
Conservation impact fees.	Expand conservation impact fees to explicitly support watershed protection projects, including stormwater retrofits, riparian buffer restoration, and land acquisition in high loading subwatersheds.	Increase conservation impact fees to fund watershed protection programs, buffer zones around lakes, and public education on waterbody conservation.	Increase conservation impact fees and earmark them for projects protecting lakes and water quality, such as wetland restoration, stormwater infrastructure, and public education campaigns.

Strategy	Lebanon Recommendations	Enfield Recommendations	Canaan Recommendations
Wetland mitigation funds.	Create a dedicated wetland mitigation fund to support off site wetland restoration and enhancement projects when on site mitigation is not feasible, with priority given to projects that improve water quality and flood resilience.	Establish dedicated wetland mitigation funds to restore degraded wetlands that act as natural filters for lakes and waterbodies.	Create a wetland mitigation fund to finance restoration and protection of wetlands adjacent to lakes. Require developers to contribute to the fund for any permitted wetland disturbances.
Fee in lieu of land dedication.	Adopt a fee in lieu of land dedication option for subdivisions, with revenues directed to the open space conservation fund for land acquisition or restoration projects that protect surface waters and groundwater recharge areas.	Introduce a fee system where developers contribute to conservation funds instead of dedicating land, ensuring stable funding for lake protection initiatives.	Implement a fee-in-lieu program where developers can contribute to conservation funds instead of dedicating land. Use these funds to acquire high-priority lands for lake and watershed protection.
Stormwater utility district.	Develop a stormwater utility district with an impervious area based fee structure and credit program for property owners who reduce runoff through green infrastructure or LID practices.	Create stormwater utility districts to manage runoff and implement infrastructure that reduces pollutants entering lakes and waterbodies.	Establish a stormwater utility district to fund infrastructure improvements that reduce polluted runoff into lakes. Include stormwater fee incentives for property owners implementing best management practices.
Open space or non-lapsing conservation fund.	Formalize and expand the non lapsing conservation fund to prioritize riparian corridors, wetlands, floodplains, and lake shoreline parcels that provide direct water quality benefits.	Allocate more resources to the open space fund to preserve land surrounding lakes and waterbodies, ensuring natural filtration systems remain intact.	Strengthen and expand the open space fund to focus on acquiring and conserving riparian buffers, lakefront properties, and areas critical to water filtration and wildlife habitats.

Strategy	Lebanon Recommendations	Enfield Recommendations	Canaan Recommendations
Has a Land Use Change Tax per RSA 79-A:25.	Keep doing that!	Use land use change tax revenues to fund conservation easements and riparian buffer restoration around lakes and streams.	Allocate revenues from land use change taxes specifically to projects that protect water quality, such as riparian restoration and erosion control measures.
Participate or collaborate with a local watershed association.	Strengthen collaboration with MLA	Strengthen collaboration with MLA	Strengthen collaboration with MLA
Participate or collaborate with a local land trust.	Work with local and regional land trusts to prioritize conservation easements along streams, lake shorelines, and headwater areas that contribute to nutrient and sediment loading.	Collaborate with local land trusts to protect critical lakefront properties through conservation easements or acquisitions.	Collaborate with land trusts to secure conservation easements or acquire critical lakefront properties to prevent development and protect water quality.
Open space plan.	Increase emphasis on riparian buffer preservation in open space priorities. Collaborate with land trusts to acquire conservation easements specifically protecting waterbodies.	Develop a detailed open space plan focusing on preserving riparian buffers, wetlands, and forests near lakes to enhance water quality and habitat.	Develop a comprehensive Open Space Plan that prioritizes the conservation of riparian areas, wetlands, and lake watersheds. Include strategies for maintaining public access while preserving ecological integrity.

NON-REGULATORY TOOLS

Strategy	Lebanon Recommendations	Enfield Recommendations	Canaan Recommendations
Master Plan addresses natural resources and environmental protection.	Expand buffer zone requirements for wetlands and watercourses. Implement stricter regulations on developments near sensitive habitats.	Include clear policies and action items in the Master Plan to regulate development, enforce buffer zones, and fund lake conservation projects.	Update the Master Plan to include explicit goals and action plans for reducing nutrient runoff, preventing erosion, and maintaining healthy riparian zones around lakes.

Strategy	Lebanon Recommendations	Enfield Recommendations	Canaan Recommendations
A town-wide natural resources inventory.	Update the inventory regularly to reflect changes in land use and climate impacts. Incorporate interactive GIS tools for better stakeholder access and decision-making.	Expand the Natural Resources Inventory to map and prioritize vulnerable lake ecosystems and their contributing watersheds.	Regularly update the natural resources inventory to include detailed data on lake watersheds, water quality trends, and critical habitat areas. Use this data to guide land-use decisions.
Smart Growth Plan.	Incentivize developments with minimal impervious surfaces. Promote green infrastructure in urban areas to improve water infiltration.	Adopt smart growth strategies that limit impervious surfaces near lakes, protect green spaces, and encourage compact, sustainable development.	Adopt a Smart Growth Plan that limits sprawl around lakes, directs growth to areas with existing infrastructure, and protects sensitive shorelands through zoning and conservation easements.
Stormwater system mapping	Maintain detailed mapping of tributaries and stormwater pipes and outfalls. Post a success story regarding CSO removal with a link from the City's homepage.	Conduct comprehensive stormwater system mapping to identify and mitigate sources of runoff pollution affecting lakes and waterbodies.	Conduct a comprehensive stormwater system mapping project to identify and address sources of runoff pollution entering lakes. Use this information to prioritize infrastructure upgrades.
Consistent Public Outreach and Engagement / Public education programs	Develop specific campaigns on the importance of water conservation and best practices for stormwater management. Increase visibility of educational programs through community events and schools.	Enhance public education programs to promote responsible land use practices, such as reducing fertilizer use and maintaining septic systems near lakes.	Launch public education programs focused on preventing lake pollution, such as proper septic system maintenance, limiting fertilizer use, and adopting green infrastructure on private properties.
Incentive-based programs for voluntary low impact development implementation.	Provide tax rebates or grants for properties adopting LID technologies such as rain gardens or bioswales. Mandate LID implementation for large developments.	Offer tax breaks or grants to developers who incorporate green infrastructure and low-impact designs that reduce lake pollution.	Create incentives like tax reductions or grants for developers and homeowners who use low-impact development practices, such as rain gardens, permeable pavements, and vegetative buffers.

Strategy	Lebanon Recommendations	Enfield Recommendations	Canaan Recommendations
Incentive-based programs for stormwater reduction efforts.	Establish a stormwater utility fee with credits for reducing runoff. Fund retrofitting projects to install sustainable drainage systems.	Provide financial incentives for property owners to install rain gardens, permeable pavements, or other stormwater management system.	Offer financial incentives to encourage stormwater reduction efforts, such as subsidies for installing rain barrels or implementing infiltration systems that prevent runoff into lakes.
Conservation Commission	Expand the commission's role in monitoring water quality and coordinating with state programs. Provide additional funding to support water-focused initiatives.	Empower the Conservation Commission to enforce stricter regulations and provide guidance for lakefront property management.	Empower the Conservation Commission to enforce stricter development regulations near lakes, provide guidance to property owners, and oversee watershed conservation projects.
Incentivize and/or encourage property owners to implement low impact development stormwater practices.	Offer financial incentives like tax rebates or grants to property owners adopting LID measures such as permeable pavement or rain gardens.	Create a recognition program for property owners who adopt stormwaterbest practices, such as installing rain barrels or planting native vegetation.	Develop recognition programs or grants to encourage property owners to adopt low-impact practices, such as naturalized landscaping, bioswales, and other stormwater management solutions.
Encourage property owners to put land into farmland/tree growth programs.	Promote agroforestry practices that conserve water and soil. Offer incentives for landowners to establish tree cover along waterways to prevent erosion.	Promote programs that convert lake-adjacent lands into protected forests or managed farmland to minimize runoff and stabilize shorelines.	Promote state programs that encourage landowners to preserve tree growth or farmland, focusing on lands that contribute to healthy watersheds and prevent runoff into lakes.

4.2.3 Land Conservation

Land conservation is essential to the health of a region, particularly for the protection of water resources, enhancement of recreation opportunities, vitality of local economies, and preservation of wildlife habitat. Land conservation is one of many tools for protecting water quality for future generations. For Mascoma Lake, 20% (19,317 acres) of the watershed's land area (excluding Mascoma Lake or Crystal Lake) has been classified as conservation land (refer to Appendix A, Map A- 10). Major conserved areas with over 1,000 acres of conserved land in the watershed include: the Mascoma Conservation Easement (CE), Cardigan Mountain State Forest, Henry Laramy Wildlife Management Area (WMA), and Lower Shaker WMA. Many of the conservation areas border parts of lakes, ponds, streams, or riverways in the watershed.

Local groups should continue to pursue opportunities for land conservation in the Mascoma Lake watershed based on the highest valued habitat identified by the New Hampshire Fish & Game (NHFG). NHFG ranks habitat based on its value to the state, biological region (areas with similar climate, geology, and other factors that influence biology), and supporting landscape context. These habitat rankings are published in the State's 2015 Wildlife Action Plan (with updated statistics and data layers released in January 2020), which serves as a blueprint for prioritizing conservation actions to protect Species of Greatest Conservation Need in New Hampshire. The Mascoma Lake watershed is part of the Sunapee Uplands and White Mountain Foothills ecoregional subsection of the biological region (NHFG, 2015). Approximately 26,528 acres (27%) of the Mascoma Lake watershed are considered Highest Ranked Habitat in New Hampshire (including the waterbody of Mascoma Lake). Many of the conserved areas overlap with the Highest Ranked Habitat in New Hampshire and the Highest Ranked Habitat in the Biological Region. A map of priority habitats for conservation based on the NH Wildlife Action Plan can be found in Appendix A, Map A- 10.

4.2.4 Septic System Regulation

When properly designed, installed, operated, and maintained, septic systems can treat residential wastewater and reduce the impact of excess pollutants in ground and surface waters. It is important to note, however, that traditional septic systems are designed for pathogen removal from wastewater and not specifically for other pollutants such as nutrients. The phosphorus in wastewater is "removed" only by binding with soil particles or being recycled through plant growth and is not removed entirely from the watershed system. Nutrient removal can only be achieved through more expensive, alternative septic systems. Proper design, installation, operation, maintenance, and replacement considerations include the following:

- Proper design includes adequate evaluation of soil conditions, seasonal high groundwater levels, and impermeable materials, and proximity of sensitive resources (e.g., drinking water wells, surface waters, wetlands, etc.);

- Proper siting and installation mean that the system is installed in conformance with the approved design and siting requirements (e.g., setbacks from waterways);

- Proper operation includes how the property owner uses the system. While most systems excel at treating normal domestic sewage, disposing of some materials, such as toxic chemicals, paints, personal hygiene products, and oils and grease in large volumes, garbage, can adversely affect the function and design life of the system, resulting in treatment failure and potential health threats; proper operation also includes how the property owner protects the system; allowing

vegetation with extensive roots to grow above the system will clog the system; driving large vehicles over the system may crush or compact piping or leaching structures;

Proper maintenance means having the septic tank pumped at regular intervals to eliminate accumulations of solids and grease in the tank; it may also mean regular cleaning of effluent filters, if installed. The frequency of septic pumping depends on the use and total volume entering the system. A typical 3-bedroom, 1,000 gallon tank should be pumped every three to four years;

Proper replacement of failed systems may include programs or regulations to encourage upgrades of conventional systems (or cesspools and holding tanks) to more innovative alternative technologies.

Management strategies for reducing water quality impacts from septic systems (as well as cesspools and holding tanks) start with education and outreach to property owners so that they are better informed and able to properly operate and maintain their systems. Other management strategies include setting local regulations to enforce proper maintenance and inspection of septic systems and establishing funding mechanisms to support replacement of failing systems (with priority for cesspools and holding tanks).

4.2.5 Sanitary Sewer System Inspections

Because a portion of the watershed also relies on or includes infrastructure for a municipal sewer system, it is important for municipalities with sewer to develop a program (if not already in place) to inspect and evaluate their sanitary sewer system and reduce identified leaks and overflows, especially in areas near waterbodies.

4.2.6 Boats & Marinas

NHDES provides an interactive map of boat pump-out locations, including both public and private boat pump-outs, dump stations for portable toilets, and mobile pump-out vessels. There are no active pump-out facilities in Mascoma Lake, though best practices at public boat launches should be installed by the town and followed by boat owners.

Target outreach to marina owners, boat dealers, and their consumers regarding state and EPA requirements; and

Ensure boat launches provide clean and safe onshore restrooms and install runoff management practices;

- Provide an appropriate location for boat washing that minimizes runoff to surface waters;
- Consider alternatives to asphalt for parking lots and vessel storage areas such as permeable pavement;
- Install infiltration trenches at the leading edge of a boat ramp to catch pollutants in an oil absorbent barrier or crushed stone before discharge;
- Install vegetated buffers between surface waters and upland areas; and
- Protect storm drains with filters or oil-grit separators. Stencil words (such as "Drains to the Lake") on storm drains to alert customers and visitors that storm drains lead directly to waterbodies without treatment. Contact the appropriate municipal public works department before stenciling any drain.

4.2.7 Fertilizer Use Prohibition

Management strategies for reducing water quality impacts from residential, commercial, and municipal fertilizer application start with education and outreach to property owners. New Hampshire law prohibits the use of fertilizers within 25 feet of a surface water. Outside of 25 feet, property owners can have their soil tested before considering application of fertilizers to their lawns and gardens to determine whether nutrients are needed and if so in what quantity or ratio. A soil test kit can be obtained through the UNH Cooperative Extension. Many New England communities are starting to adopt local regulations prohibiting the use of both fertilizers and pesticides, most especially near critical waterbodies. The watershed towns could consider a similar prohibition, at the very least within a watershed zoning overlay for major lakes and ponds. In 2024, HB1293 was passed by the legislature to prohibit the sale of fertilizer with a phosphate content level greater than 0.67 percent.

4.2.8 Pet Waste Management

Pet waste collection as a pollutant source control involves a combination of educational outreach and enforcement to encourage residents to clean up after their pets. Public education programs for pet waste management are often incorporated into a larger message of reducing pollutants to improve water quality. Signs, posters, brochures, and newsletters describing the proper techniques to dispose of pet waste can be used to educate the public and create a cause-and-effect link between pet waste and water quality (EPA, 2005). Adopting simple habits, such as carrying a plastic bag on walks and properly disposing of pet waste in dumpsters or other refuse containers, can make a difference. It is recommended that pet owners do not put dog and cat feces in a compost pile because it may contain parasites, bacteria, pathogens, and viruses that are harmful to humans and may or may not be destroyed by composting. "Pooper-scooper" ordinances are often used to regulate pet waste disposal. These ordinances generally require the removal of pet waste from public areas, other people's properties, and occasionally from personal property, before leaving the area. Fines are typically the enforcement method used to encourage compliance with these ordinances.

4.2.9 Agricultural Practices

Manure and fertilizer management and planning are the primary tools for controlling nutrient runoff from agricultural areas. Direct outreach and education should be conducted for small hobby farms and any larger-scale operations in the watershed. NRCS is a great resource for such outreach and education to farmers. Larger-scale agricultural operations can work with the NRCS to complete a Comprehensive Nutrient Management Plan (CNMP). These plans address soil erosion and water quality concerns associated with agricultural operations through setting proper nutrient budgets, identifying the types and amount of nutrients necessary for crop production (by conducting soil tests and determining proper calibration of nutrient application equipment), and ensuring the proper storage and handling of manure. Manure should be stored or applied to fields properly to limit runoff of solids containing high concentrations of nutrients. Manure and fertilizer management involve managing the source, rate, form, timing, and placement of nutrients. Writing a plan is an ongoing process because it is a working document that changes over time.

4.2.10 Nuisance Wildlife Controls

Human development has altered the natural habitat of many wildlife species, restricting wildlife access to surface waters in some areas and promoting access in others. Minimizing the impact of wildlife on water quality generally requires either reducing the concentration of wildlife in an area or reducing their proximity to a waterbody. In areas where wildlife is observed to be a large source of nutrient contamination, such as large and regular congregations of waterfowl, a program of repelling wildlife from surface waters (also called harassment programs) may be implemented. These programs often involve the use of scarecrows, kites, a daily human presence, or habitat modification to reduce attractiveness of an at-risk area. Providing closed trash cans near waterbodies, as well as discouraging wildlife from entering surface waters by installing fences, pruning trees, or making other changes to landscaping, can reduce impacts on water quality. Public education and outreach that prohibit waterfowl or other wildlife feeding is an important step in reducing the impact of nuisance wildlife on the lake.

4.3 OUTREACH & EDUCATION

Awareness through education and outreach is a critical tool for protecting and restoring water quality. Most people want to be responsible watershed stewards and not cause harm to water quality, but many are unaware of best practices to reduce or eliminate contaminants from entering surface waters. The MLA and the City of Lebanon are the primary local entities responsible for education and outreach campaigns in the watershed and for supporting the development and implementation of the plan. MLA should continue all aspects of its education and outreach strategies and consider developing new ones or improving existing ones to reach more watershed residents. Refer to Section 5: Action Plan. Examples include providing educational materials to existing and new property owners, as well as renters, by distributing them at various locations and through a variety of means, such as websites, newsletters, social media, community events, or community gathering locations. Additionally, MLA should continue to engage with local stakeholders such as conservation commissions, land trusts, municipalities, businesses, and landowners. Educational campaigns should include raising awareness of water quality, septic system maintenance, fertilizer and pesticide use, pet waste disposal, waterfowl feeding, invasive aquatic species, boat pollution, shoreline buffer improvements, gravel road maintenance, and stormwater runoff controls.

4.4 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach, to be employed by a dedicated committee, is highly recommended for protecting Mascoma Lake. Adaptive management enables stakeholders to conduct restoration actions in an iterative manner. Through this management process, restoration actions are taken based on the best available information. Assessment of the outcomes following restoration action, through continued watershed and water quality monitoring, allows stakeholders to evaluate the effectiveness of one set of restoration actions and either adopt or modify them before implementing effective measures in the next round of restoration actions. This process enables efficient utilization of available resources through the combination of BMP performance testing and watershed monitoring activities. Adaptive management features the establishment of an ongoing program that provides adequate funding, stakeholder guidance, and efficient coordination of restoration actions. Implementation of this approach ensures that restoration actions are implemented and that surface waters are monitored to document restoration over an extended time. The adaptive management components for implementation efforts should include:

- **Maintaining an Organizational Structure for Implementation.** Communication and a centralized organizational structure are imperative to successfully implementing the actions outlined in this plan. A diverse group of stakeholders should be assembled to coordinate watershed management actions. This group can include representatives from state and federal agencies or organizations, municipalities, local businesses, non-profits, and other interested groups or private landowners. Refer to Section 6.1 Plan oversight.
- **Establishing a Funding Mechanism.** A long-term funding mechanism should be established to provide financial resources for management actions. In addition to initial implementation costs, consideration should also be given to the type and extent of technical assistance needed to inspect and maintain structural BMPs. Funding is a key element of sustaining the management process, and once it is established, the plan can be fully vetted and restoration actions can move forward. A combination of grant funding, private donations, and municipal funding should be used to ensure implementation of the plan. Refer to Section 6.3 for a list of potential funding sources.
- **Determining Management Actions.** This plan provides a unified watershed management strategy with prioritized recommendations for restoration using a variety of methods. The proposed actions in this plan should be used as a starting point for grant proposals. Once a funding mechanism is established, designs for priority restoration actions on a project-area basis can be completed and their implementation scheduled. Refer to Section 5: Action Plan.
- **Continuing and Expanding the Community Participation Process.** Plan development has included active involvement of a diversity of watershed stakeholders. Plan implementation will require continued and ongoing participation of stakeholders, as well as additional outreach efforts to expand the circle of participation. Long-term community support and engagement is vital to successfully implement this plan. Continued public awareness and outreach campaigns will aid in securing this engagement. Refer to Section 4.3: Outreach & Education.
- **Continuing the Long-Term Monitoring Program.** A water quality monitoring program is necessary to track the health of surface waters in the watershed. Information from the monitoring program will provide feedback on the effectiveness of management practices. Refer to Section 6.4: Monitoring Plan.
- **Establishing Measurable Milestones.** A restoration schedule that includes milestones for measuring restoration actions and monitoring activities in the watershed is critical to the success of the plan. In addition to monitoring, several environmental, social, and programmatic indicators have been identified to measure plan progress. Refer to Section 6.5: Indicators to Measure Progress and Section 2.3: Water Quality Goal for interim milestones.

5 ACTION PLAN

5.1 ACTION PLAN

The Action Plan (Table 17) outlines responsible parties, approximate costs, an implementation schedule, and potential funding sources for each recommendation within the following major categories: (1) Watershed & Shoreline BMPs; (2) Road and Driveway Management; (3) Municipal Operations; (4) Municipal Land Use Planning & Zoning; (5) Land Conservation; (6) Septic System Management; and (7) Education and Outreach. Cost estimates for each recommendation will need to be adjusted based on further research and site design considerations. The plan is designed to be implemented from 2026-2035 and is flexible to allow for new priorities throughout the 10-year implementation period as additional data are acquired.

Table 17. Action plan for the Mascoma Lake watershed.

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
1	Municipal Land Use Planning & Zoning	Present WMP recommendations to Select Boards, City Council, and Planning Boards in Lebanon, Canaan, and Enfield. Discuss the connection between municipal land use planning and water quality in the Mascoma Watershed.	City of Lebanon (Conservation Commission), Town of Canaan, Town of Enfield, Mascoma Lake Association	\$1K 2027	Grants (319), CWSRF
2	Municipal Land Use Planning & Zoning	Meet with municipal staff to review recommendations to improve or develop ordinances addressing setbacks, buffers, lot coverage, low impact development, and open space.	City of Lebanon (Planning Dept., Conservation Commission), Town of Canaan, Town of Enfield, Mascoma Lake Association	\$10K 2027	Town funds, Grants (319), CWSRF
3	Municipal Land Use Planning & Zoning	Enhance performance standards for unpaved roads less than 50 feet from a surface water throughout the watershed to prevent erosion and protect lake water quality. This would achieve 36% (30.6 kg/yr P of 86 kg/yr P) of Objective 1.	City of Lebanon, Town of Canaan, Town of Enfield	N/A 2027	Town funds

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
4	Municipal Land Use Planning & Zoning	Stabilize banks around culverts assessed as vulnerable by NHDES (4 culverts) achieves 1.6% (1.4 kg/yr P of 86 kg/yr P) of Objective 1.	Town of Enfield	N/A 2027	Town funds
5	Watershed and Shoreline BMPs	Complete design and construction of mitigation measures of the top 2 highest-ranked watershed survey sites. Achieves 1.2% (1.04 kg/yr P of 86 kg/yr P) of Objective 1.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield, private landowners and associations	\$751K 2027-29	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Town funds, private landowners
6	Watershed and Shoreline BMPs	Treat vulnerable shoreline sites (scoring ≥ 5) to reduce phosphorus load, target 50% of this group achieves 17.5% (15.2 kg/yr P of 86 kg/yr P) of Objective 1.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield	N/A 2027-28	Private landowners
7	Watershed and Shoreline BMPs	Complete a field shoreline survey. Use results to target technical assistance for high-impact sites. Cost assumes consultant support for survey and data analysis.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield	\$7K 2027,2030	Town funds, Grants (Moose Plate), CWSRF
8	Education and Outreach	Create accessible (ADA-compliant) homeowner packets and digital materials tailored to shorefront owners, upstream residents near tributaries, recreational users, and short-term renters. Include: septic care, fertilizer-free landscaping/native plants, dirt-road erosion tips, invasive species prevention, and cyanobacteria/ALS risk awareness with safe-use guidance. Mail to shoreline owners in April; push digital versions via town/MLA site, social media, and QR codes at kiosks/launches	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield	\$20-\$60K 2027-37	Town funds, Grants (319), CWSRF

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
9	Education and Outreach	Post predictable, scheduled updates (content calendar) on WMP progress, lake conditions, bloom advisories, LakeSmart, and events. Use a 'Did You Know?' series; ensure alt text, captions, screen-reader compatibility. Track engagement and adjust topics accordingly.	Mascoma Lake Association	N/A 2027-37	Grants
10	Education and Outreach	Coordinate MLA, Conservation Commissions, NH LAKES, MWCC, UVLT, and Mascoma River LAC/Greenway to co-host workshops and co-publish materials. Leverage UVLSRPC to host resources and expand reach. Include youth/schools and the sailing team for hands-on stewardship	Lebanon, Canaan, Enfield Conservation Commissions, Mascoma Lake Association	TBD 2027-37	Town funds
11	Septic System Management	Distribute educational materials to property owners about septic system function and maintenance. There are 222 known shorefront septic systems that are older than 25 years. If these are updated based on awareness and education, it could reduce phosphorus load to the lake which achieves 26% (22.2 kg/yr P of 86 kg/yr P) of Objective 1.	Towns of Lebanon, Canaan, Enfield, Mascoma Lake Association	\$3K 2026,2030 ,2035	Town funds, Grants (319), CWSRF
12	Watershed and Shoreline BMPs	Treat vulnerable shoreline sites (scoring ≥ 5) to reduce phosphorus load, target the remaining 50% of this group achieves 17.5% (15.2 kg/yr P of 86 kg/yr P) of Objective 1.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield	N/A 2029-31	Private landowners
13	Septic System Management	Look into whether any septic pumping companies would give a quantity discount or a discount to members to incentivize septic system pumping.	Towns of Lebanon, Canaan, Enfield	N/A 2027-2028	CWSRF

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
14	Municipal Land Use Planning & Zoning	Incorporate WMP recommendations into municipal Master Plans (Lebanon, Canaan, Enfield) and encourage regular review of the WMP action plan. Adopt/strengthen zoning ordinance provisions and enforcement mechanisms: 1. to promote conservation subdivisions to allow development but also set aside land for conservation. 2. to establish a lake protection overlay zoning ordinance that prohibits erosion from sites in sensitive areas (e.g., lake shorefront, along lake tributaries, steep slopes); and 3. to promote low impact development practices and reduce impervious areas; 4. to require stormwater regulations that align with MS4 Permit requirements; 5. to promote or require vegetative buffers around lake shore and tributary streams; 6. to require shorefront "tear down and replace" home construction to be no more non-conforming than existing structures; 7. to require shorefront seasonal to year-round conversions of homes to demonstrate no additional negative impacts to lake water quality;	Towns of Lebanon, Canaan, Enfield	N/A 2027-28	Town funds
15	Municipal Land Use Planning & Zoning	Increase municipal staff capacity through code enforcement/building inspectors to ensure compliance with stormwater and shoreland regulations.	Towns of Lebanon, Canaan, Enfield	TBD 2028-36	Town funds

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
16	Septic System Management	Institute a minimum pump-out/inspection ordinance for shorefront septic systems (e.g., every 3–5 years). Pump-out cost (~\$250) remains responsibility of owners. Enfield has a new ordinance that considers shorefront septic systems (2025). Their action item should focus on implementing and enforcing the rule.	Towns of Lebanon, Canaan, Enfield	N/A 2028-31	Town funds
17	Septic System Management	Expand septic system regulations to require inspections at time of property sale (inspection within past 3 years on file; upgrades required if failing). Lebanon and Canaan should consider adoption of this requirement, while Enfield has already implemented stronger septic ordinances (pump-outs every 3 years, inspections every 6 years, with evaluation required at property transfer).	Towns of Lebanon, Enfield	N/A 2028-31	Town funds
18	Watershed and Shoreline BMPs	Complete design and construction of mitigation measures at the next three highest-ranked survey sites. Achieves 0.5% (0.46 kg/yr P of 86 kg/yr P) of Objective 1.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield, private landowners/associations	\$847K 2030-35	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Town funds, private landowners
19	Watershed and Shoreline BMPs	Promote LakeSmart evaluations and certifications through NH Lakes to educate shoreline owners on lake-friendly practices (shoreline buffers, mowing height, avoiding lawns). Coordinate with NHDES Soak Up the Rain NH for workshops. Cost assumes coordination/materials for ~10 workshops.	Mascoma Lake Association, NH Lakes, NHDES Soak Up the Rain NH, Towns of Lebanon, Canaan, Enfield	\$5K 2027-36	NH Lakes, NHDES, Grants (319, Moose Plate), CWSRF

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
20	Education and Outreach	Provide checklists for homeowners to vet landscapers (no P-fertilizer near water, buffer protection, native plants). Distribute to shoreline HOAs, rental hosts (Airbnb/Vrbo), and lakefront businesses	Mascoma Lake Association	N/A 2027-35	
21	Watershed and Shoreline BMPs	Work with NRCS to implement soil conservation practices such as stormwater control, manure storage, cover crops, no-till methods, timing of manure applications, and other agricultural BMPs which reduce erosion and nutrient pollution to surface waters from agricultural activities.	NRCS, Farm owners (Lebanon, Canaan, Enfield)	TBD 2026-35	Grants, NRCS
22	Land Conservation	Inspect wetlands for Prime Wetland Designations and survey for vernal pools within the watershed. Provide support to Lebanon, Canaan, Enfield Conservation Commissions.	Towns of Lebanon, Canaan, Enfield, Mascoma Lake Association, local land trusts	TBD 2028-30	Town funds
23	Road and Driveway Management	Review practices for road and drainage maintenance currently used by public and private entities/groups and determine areas for improvement. Enfield recently (2025) completed 50-60 manhole repairs and pipe lining.	Towns of Lebanon, Canaan, Enfield, Mascoma Lake Association	\$3K 2027	CWSRF, Town funds, Grants (Moose Plate, NFWF 5-Star)
24	Education and Outreach	Educate contractors and municipal staff about erosion and sediment control practices required in permits. Ensure municipalities have adequate resources to enforce conditions.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield	\$6K 2027-36	Town funds, Grants (319), CWSRF
25	Road and Driveway Management	Work with Lebanon, Canaan, and Enfield Public Works to reduce salt usage on roads in sensitive watershed areas. Identify reduced-salt areas and promote low-salt strategies. Focus on town roads like Shaker Blvd and gravel roads (dust suppression with $MgCl_2$). For Route 4A/Main St, recommend coordination with NHDOT.	Towns of Lebanon, Canaan, Enfield	N/A 2027-30	Town funds

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
26	Municipal Operations	Review and update winter operations procedures to be consistent with Green SnowPro best management practices for winter road, parking lot, and sidewalk maintenance.	Towns of Lebanon, Canaan, Enfield (Public Works/Highway)	N/A 2027-30	Town funds
27	Road and Driveway Management	Participate in Green SnowPro training. Aim for certification once rules are adopted statewide. Program educates and certifies winter maintenance professionals in salt reduction practices that protect water quality while ensuring safety.	Towns of Lebanon, Canaan, Enfield (Public Works/Highway)	Est. \$150-\$250/pers on 2028-32	Town funds
28	Road and Driveway Management	Develop or update written protocols for municipal road maintenance. Incorporate water quality considerations into roadway evaluations and action plans.	Towns of Lebanon, Canaan, Enfield, Mascoma Lake Association	\$20K 2028-30	CWSRF, Town funds, Grants (Moose Plate, NFWF 5-Star)
29	Road and Driveway Management	Hold informational workshops on proper road/driveway maintenance and winter practices. Provide homeowner education on salt/sand use for driveways/walkways. Cost assumes up to 5 workshops.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield, private landowners	\$5-10K 2028, 2031	CWSRF, Town funds, Grants (Moose Plate, NFWF 5-Star), private landowners
30	Education and Outreach	Encourage private property and road owners to hire Green SnowPro certified commercial salt applicators.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield	N/A 2028-35	Grants, Town funds
31	Road and Driveway Management	Continue training contractors and municipal staff on best practices for road maintenance. Host at least one workshop; consider joint workshops across Lebanon, Canaan, and Enfield for cost savings.	Towns of Lebanon, Canaan, Enfield, Mascoma Lake Association	\$15K 2028-29	CWSRF, Town funds, Grants (Moose Plate, NFWF 5-Star)

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
32	Road and Driveway Management	Establish inspection and maintenance agreements for private unpaved roads. Cost does not include implementation of road upgrades by landowners. Assumes municipalities can support added oversight.	Towns of Lebanon, Canaan, Enfield, private landowners	N/A 2030-36	Town funds, private landowners
33	Municipal Operations	Review and optimize MS4 compliance for towns (Lebanon is MS4 regulated, Canaan and Enfield may not be). Include infrastructure mapping, erosion/sediment controls, illicit discharge programs, and good housekeeping practices (e.g., catch basin cleaning).	Towns of Lebanon, Canaan, Enfield (Public Works/Highway)	TBD 2030-36	Town funds
34	Municipal Operations	Develop best practice design standards for stormwater control measures, including deep sump catch basins.	Towns of Lebanon, Canaan, Enfield (Public Works/Highway)	N/A 2030-36	Town funds
35	Septic System Management	Evaluate locations of older and/or noncompliant septic systems (including cesspools or holding tanks) to identify clusters where conversion to community septic systems might be desirable.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield	TBD 2030-32	CWSRF, Town funds
36	Land Conservation	Update the existing Natural Resource Inventories (NRIs) for Lebanon and Enfield, and complete a new NRI for Canaan.	Towns of Lebanon, Canaan, Enfield (Conservation Commissions), Mascoma Lake Association	\$25K 2029-31	Town funds, Grants (NFWF NEFRG), CWSRF

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
37	Land Conservation	Create a priority list of watershed areas that need protection once the NRI has been completed.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield Conservation Commissions, local land trusts (UVLT, etc.)	\$10-15K 2031-35	Grants (NFWF NEFRG, NAWCA), CWSRF, Town funds
38	Land Conservation	Maximize conservation of intact forests and ecologically important properties through education, zoning, and private/public conservation programs.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield, UVLT, private landowners	TBD 2031-35	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP, NFWF NEFRG), Town funds, private landowners
39	Land Conservation	Enhance community education regarding private land conservation easements. Host workshops educating landowners on the benefits.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield Conservation Commissions, UVLT	TBD 2031-35	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP, NFWF NEFRG), Town funds, private landowners

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
40	Land Conservation	Identify potential conservation buyers and property owners interested in easements within the watershed. Use available funding mechanisms, such as the Regional Conservation Partnership Program (RCCP) and the Land and Community Heritage Investment Program (LCHIP), to provide conservation assistance to landowners.	Mascoma Lake Association, Towns of Lebanon, Canaan, Enfield, UVLT	N/A 2031-35	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP)
41	Education and Outreach	Offer workshops for landowners with ten acres or more for NRCS assistance with land conservation. Cost assumes up to two workshops.	Mascoma Lake Association	\$5K 2030-34	Grants (RCCP, ACEP, CSP, EQIP)
42	Septic System Management	Develop and maintain a town-wide septic system inventory database to facilitate enforcement of septic ordinances. Lebanon and Canaan should initiate new databases, while Enfield is already developing one (using NHDES records and town data through the Assessing and Health Offices).	Towns of Lebanon, Canaan	\$5K 2031-35	Town funds, CWSRF
43	Septic System Management	Conduct a septic system risk assessment to identify areas in town which may be more susceptible to septic system malfunction due to high groundwaters, soil filtering capacity, risk of flooding, age of infrastructure.	Towns of Lebanon, Canaan, Enfield	\$15-20K 2031-35	Town funds
44	Education and Outreach	Add bloom signage and QR codes at launches/parks; train volunteers and summer ramp inspectors to communicate cyanobacteria precautions, clean-drain-dry, and pet safety	Mascoma Lake Association	\$10K 2027-36	Grants (NHDES AIPC)
45	Education and Outreach	Collaborate with NH Lakes on legislative or advocacy issues such as boat speed limits.	Mascoma Lake Association, NH Lakes	N/A 2027-36	Grants

Priority Level	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
46	Road and Driveway Management	Enhance the existing municipal street sweeping and catch basin maintenance program to further reduce salt and sediment entering local waterways. Lebanon has their own street sweepers and complete sweeping once a year. Enfield does not have street sweepers, NHDOT completes sweeping every other year. Consider increasing sweeping frequency on municipal paved roads, particularly during dry-weather periods between winter storms, when road salt and sand can be more easily collected.	Towns of Lebanon, Canaan, Enfield, private landowners	TBD 2032-36	Town funds
47	Education and Outreach	Partner with the Mascoma River Greenway and Friends of the Northern Rail Trail to promote watershed-friendly recreation (bike/pedestrian trails, signage about stormwater impacts, invasive species, cyanobacteria).	Mascoma Lake Association, Mascoma River Greenway, local conservation commissions.	\$10-20K 2027-30	Recreational Trails Program (RTP), Moose Plate, private donations.

5.2 POLLUTANT LOAD REDUCTIONS

To meet the water quality goal, Objective 1 set a target phosphorus load reduction of 86 kg/yr to achieve an average in-lake summer total phosphorus concentration 8.7 ppb, which meets state water quality standards for oligotrophic waterbodies and is anticipated to reduce the likelihood of cyanobacteria blooms in Mascoma Lake. The following opportunities for phosphorus load reductions to achieve Objective 1 were identified in the watershed based on field and desktop analyses:

The watershed survey conducted by VHB identified five sites impacting the lake. Remediating these sites could prevent up to 1.5 kg/yr of phosphorus from entering Mascoma Lake.

Treating vulnerable shoreline sites (scoring ≥ 5) could reduce the phosphorus load to Mascoma Lake by 30.4 kg/yr³ as identified through the shoreline vulnerability analysis.

Upgrading the 222 known shorefront septic systems along Mascoma Lake (139) and Crystal Lake (83) that are older than 25 years is estimated to reduce the phosphorus load to Mascoma Lake by 22.2 kg/yr.

Mitigating the impacts of unpaved roads less than 50 feet from surface water throughout the watershed could prevent about 30.6 kg/yr⁴ of phosphorus from entering to Mascoma Lake.

Stabilizing the banks around culverts assessed as vulnerable by NHDES in the watershed (n=4) could prevent about 1.4 kg/yr⁵ of phosphorus from entering Mascoma Lake.

Addressing these field-identified phosphorus load reduction opportunities associated with the external watershed load (i.e., watershed and shoreline sites and septic systems) could reduce the phosphorus load to Mascoma Lake by 86 kg/yr, meeting 100% of the needed reductions to achieve Objective 1 (Table 18).

Objective 2 (preventing or offsetting additional phosphorus loading from anticipated new development) can be met through ordinance revisions that implement LID strategies, limit impervious cover, and encourage cluster development with open space protection and/or through conservation of key parcels of forested and/or open land.

It is important to note that, while the focus of the objectives for this plan is on phosphorus, the treatment of stormwater and sediment erosion will result in the reduction of many other kinds of pollutants that may impact water quality. These pollutants would likely include other nutrients (e.g., nitrogen), petroleum products, bacteria, road salt/sand, excessive organic material (raking/blowing leaves and grass cuttings or erosion from boat wakes), and heavy metals (cadmium, nickel, zinc, etc.). Without a monitoring program in place to measure these other pollutants, it will be difficult to track the success of efforts that reduce these other pollutants. However, there are various spreadsheet models available that can estimate reductions in these pollutants depending on the types of BMPs installed. These reductions can be tracked to help assess long-term response.

³ Calculated from Region 5 Tool as bank stabilization. Fields selected include sandy loam, length of 100 ft, height of 3ft, and moderate lateral recession rate of 0.1ft/yr.

⁴ Calculated using the Region 5 Tool as gully stabilization. Fields selected include sandy loam, top width 1ft, bottom width 0.5ft, depth 0.25ft, length = 50% of total length (45,643 ft), 5 years, 0.8 efficiency factor. Field verification of all the unpaved roads less than 50 ft from a surface water is needed to validate this load reduction value.

⁵ Calculated using the Region 5 Tool as bank stabilization. Fields selected include sandy loam, two banks, each with a length of 10 ft, height 5 ft, Lateral recession rate 0.1 ft/yr, and an efficiency factor of 0.8. Field verification of the four vulnerable culverts is needed to validate this load reduction value.

Table 18. Breakdown of phosphorus load sources and modeled water quality for current and target conditions that meet the water quality goal (Objective 1) for Mascoma Lake and that reflect all field identified reduction opportunities in the watershed. Reduction percentages are based on the current condition value for each parameter.

Parameter	Unit	Current Condition	Target Condition	Reduction	% change
Total P Load (All Sources) ³	kg/yr	2,444	2,358	-86	-4%
(A) Background P Load ¹	kg/yr	912	912	0	0%
(B) Disturbed (Human) P Load ²	kg/yr	1,532	1,446	-86	-6%
(C) Developed Land Use P Load	kg/yr	1,464	1,400	-64	-4%
(D) Septic System P Load	kg/yr	47	25	22	-47%
(E) Internal P Load	kg/yr	21	21	0	0%
In-Lake TP*	ppb	9.0	8.7	-0.3	-4%
In-Lake Chl-a*	ppb	2.6	2.5	-0.1	-5%
In-Lake SDT*	meters	4.4	4.4	0	0%
In-Lake Bloom Probability*	days	1	0	-1	-100%

¹ Sum of forested/water/natural land use load, waterfowl load, and atmospheric load

² Sum of developed land use load, shorefront septic system load, and internal load ($B = C+D+E$)

³ Total P Load (All Sources) = A + B

* Water quality parameters were sourced from the model

6 PLAN IMPLEMENTATION & EVALUATION

The following section details the oversight and estimated costs (with funding strategy) needed to implement the action items recommended in the Action Plan (Section 5), as well as the monitoring plan and indicators to measure progress of plan implementation over time.

6.1 PLAN OVERSIGHT

The recommendations of this plan will be carried out by a diverse stakeholder group in the form of a dedicated committee, including representatives from MLA, municipalities (e.g., select boards, planning boards), conservation commissions, state and federal agencies or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and landowners. The committee will need to meet regularly and work collaboratively to coordinate resources across stakeholder groups to fund and implement the management actions. The Action Plan (Section 5) will need to be updated periodically (typically every 2, 5, and 10 years) to ensure progress and to incorporate any changes in watershed activities. Measurable milestones (e.g., number of BMP sites, volunteers, funding received, etc.) should be tracked by the committee.

The Action Plan (Section 5) identifies the stakeholder groups responsible for each action item. Generally, the following responsibilities are noted for each key stakeholder:

- MLA will conduct water quality monitoring, facilitate outreach activities and watershed stewardship, and raise funds for stewardship work.
- Municipalities will be responsible for establishing a dedicated committee and will work to address NPS problems identified in the watershed, including conducting regular best practices maintenance on roads, adopting ordinances for water quality protection, and addressing other recommended actions specified in the Action Plan. Other stakeholder groups can work with each municipality to provide support in reviewing and tailoring the recommendations to fit the specific needs of each community.
- Conservation Commissions will work with municipal staff and boards to facilitate the implementation of the recommended actions specified in the Action Plan.
- NHDES can provide technical assistance, permit approval, and the opportunity for financial assistance through the 319 Watershed Assistance Grant Program and other funding programs.
- Private landowners will seek opportunities for increased awareness of water quality protection issues and initiatives and conduct activities in a manner that minimizes pollutant impacts to surface waters.

The success of this plan is dependent on the continued effort of volunteers and a strong and diverse committee that meets regularly to coordinate resources for implementation, review progress, and make any necessary adjustments to the plan to maintain relevant action items and interim milestones. A reduction in nutrient loading is no easy task, and because there are many diffuse sources of phosphorus reaching the rivers, lakes, and ponds from existing development, roads, septic systems, and other land uses in the watershed, it will require an integrated and adaptive approach across many different parts of the watershed community to be successful.

6.2 ESTIMATED COSTS

The strategy for reducing pollutant loading to Mascoma Lake to meet the water quality goal and objectives set in Section 2.3 will be dependent on available funding and labor resources but will include approaches that address sources of phosphorus loading, as well as water quality monitoring and education and outreach. Additional significant but difficult to quantify strategies for reducing phosphorus loading to the lake include revising local ordinances such as setting LID requirements on new construction, identifying and replacing malfunctioning septic systems, performing proper road maintenance, and improving agricultural practices (refer to Section 5: Action Plan for more details). With a dedicated stakeholder group in place and with the help of grant or local funding, it is possible to achieve the target phosphorus reductions and meet the established water quality goal for Mascoma Lake in the next 10 years. **The cost of successfully implementing the plan is estimated to be at least \$1.7 - \$1.8 million over the next 10 or more years** (Table 19). However, many costs are still unknown or were preliminary estimated and should be updated as information becomes available. In addition, costs to private landowners (e.g., septic system upgrades, private road maintenance, etc.) are not fully reflected in the estimate.

Table 19. Estimated pollutant reduction (TP) in kg/year and estimated total and annual 10-year costs for implementation of the Action Plan to meet the water quality goal and objectives for Mascoma Lake. The light gray shaded planning actions are necessary to achieve the water quality goal. Other planning actions are important but difficult to quantify for TP reduction and costs, the latter of which were roughly estimated here as general placeholders.

Planning Action	TP Reduction (kg/yr)	Estimated Total Cost	Estimated Annual Cost
Watershed & Shoreline BMPs	31.9	\$1.6M	\$160,000
Road Management	30.6	\$43,000-\$48,000	\$4,300 - \$4,800
Municipal Operations	1.4 (culvert stabilization)	TBD	TBD
Municipal Land Use Planning & Zoning	TBD	\$11,000	\$1,000
Land Conservation		\$35,000 - \$40,000	\$3,500 - \$4,000
Septic System Management	22.2	\$23,000 - \$28,000	\$2,300 - \$2,800
Agricultural Practices	TBD	TBD	TBD
Education & Outreach	TBD	\$51,000 - \$101,000	\$5,100 - \$10,100
Monitoring	NA	\$50,000 - \$200,000	\$5,000 - \$2,000
Total	86.1	\$1.8M - \$2M	\$181K - \$202K

* Estimated increase in phosphorus load from new development in the next 10 years.

6.3 FUNDING STRATEGY

It is important that the committee develop a strategy to collect the funds necessary to implement the recommendations listed in the Action Plan (Section 5). Funding to cover ordinance revisions and third-party review could be supported by municipalities through tax collection (as approved by majority vote by town residents). Monitoring and assessment funding could come from a variety of sources, including state and federal grants, municipalities, or donations. Funding to improve septic systems, roads, and shoreland zone buffers would likely come from private landowners. As the plan evolves into the future, the establishment of a funding subcommittee will be a key part in how funds are raised, tracked, and spent to implement and support the plan. Listed below are state and federal funding sources that could assist the committee with future water quality and watershed work on Mascoma Lake. Links to each funding source are embedded in the title.

Funding Options:

- [EPA/NHDES 319 Grants \(Watershed Assistance Grants\)](#) – This NPS grant is designed to support local initiatives to restore impaired waters (priorities identified in the NPS Management Program Plan, updated 2024) and protect high quality waters. 319 grants are available for the implementation of watershed-based plans and typically fund \$50,000 to \$150,000 projects over the course of two years.
- [NH State Conservation Committee \(SCC\) Grant Program \(Moose Plate Grants\)](#) – County Conservation Districts, municipalities (including commissions engaged in conservation programs), and qualified nonprofit organizations are eligible to apply for the SCC grant program. Projects must qualify in one of the following categories: Water Quality and Quantity; Wildlife Habitat; Soil Conservation and Flooding; Best Management Practices; Conservation Planning; and Land Conservation. The total SCC grant request per application cannot exceed \$40,000.
- [Land and Community Heritage Investment Program \(LCHIP\)](#) – This grant provides matching funds to help municipalities and nonprofits protect the state's natural, historical, and cultural resources.
- [Aquatic Resource Mitigation Fund \(ARM\)](#) – This grant provides funds for projects that protect, restore, or enhance wetlands and streams to compensate for impacted aquatic resources. The fund is managed by the NHDES Wetlands Bureau that oversees the state In-Lieu Fee Program (ILFP) compensatory mitigation program. A permittee can make a payment to NHDES to mitigate or offset losses to natural resources because of a project's impact to the environment.
- [New England Forest and River Grant \(NEFRG\)](#) – This grant awards \$50,000 to \$200,000 to projects that restore and sustain healthy forests and rivers through habitat restoration, fish barrier removal, and stream connectivity such as culvert upgrades.
- [Aquatic Invasive Plant Control, Prevention and Research Grants \(NHDES AIPC\)](#) – Funds are available each year for projects that prevent new infestations of exotic plants, including outreach, education, Lake Host Programs, and other activities.
- [Clean Water State Revolving Fund \(NHDES CWSRF\)](#) – This fund provides low-interest loans to communities, nonprofits, and other local government entities to improve and replace wastewater collection systems with the goal of protecting public health and improving water quality. A portion of the CWSRF program is used to fund NPS pollution prevention, watershed protection and restoration, and estuary management projects that help improve and protect water quality in NH.
- [Regional Conservation Partnership Program \(RCPP\)](#) – This NRCS grant provides conservation assistance to producers and landowners for projects carried out on agricultural land or non-industrial private forest land to achieve conservation benefits and address natural resource challenges. Eligible activities include land management restoration practices, entity-held easements, and public works/watershed conservation activities.

- [Agricultural Conservation Easement Program \(ACEP\)](#) - This NRCS grant protects the agricultural viability and related conservation values of eligible land by limiting nonagricultural uses which negatively affect agricultural uses and conservation values, protect grazing uses and related conservation values by restoring or conserving eligible grazing land, and protecting, restoring, and enhancing wetlands on eligible land. Eligible applicants include private landowners of agricultural land, cropland, rangeland, grassland, pastureland, and non-industrial private forestland.
- [Conservation Stewardship Program \(CSP\)](#) - This NRCS grant helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resource concerns. Eligible lands include private agricultural lands, non-industrial private forestland, farmstead, and associated agricultural lands, and public land that is under control of the applicant.
- [Environmental Quality Incentives Program \(EQIP\)](#) - This NRCS grant provides financial and technical assistance to agricultural producers and non-industrial forest managers to address natural resource concerns and deliver environmental benefits. Eligible applicants include agricultural producers, owners of non-industrial private forestland, water management entities, etc.
- [National Fish and Wildlife Federation \(NFWF\) Five Star and Urban Waters Restoration Grants \(NFWF 5-Star\)](#) - Grants seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. Eligible projects include wetland, riparian, in-stream and/or coastal habitat restoration; design and construction of green infrastructure BMPs; water quality monitoring/assessment; outreach and education.
- [North American Wetlands Conservation Act \(NAWCA\) Grants](#) - The U.S. Standard Grants Program is a competitive, matching grants program that supports public-private partnerships carrying out projects in the United States that further the goals of the North American Wetlands Conservation Act (NAWCA). These projects involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats for the benefit of all wetlands-associated migratory birds.
- [National Park Service - Land and Water Conservation Fund Grant Program \(LWCF\)](#) - Eligible projects include acquisition of parkland or conservation land; creation of new parks; renovations to existing parks; and development of trails. Municipalities must have an up-to-date Open Space and Recreation Plan. Trails constructed using grant funds must be ADA-compliant.

6.4 MONITORING PLAN

A long-term water quality monitoring plan is critical for evaluating the effectiveness of implementation efforts over time. Building on the historic data summarized in this report, the following monitoring efforts are recommended to be conducted by MLA as feasible.

- Continue to monitor the two deep spots on Mascoma Lake, including the deep spots (MASENF2D and MASENF1D) for all parameters included in the UNH LLMP protocol. This includes sampling three to five times per summer (June-September or October) for at least total phosphorus (epilimnion, metalimnion, and hypolimnion), chlorophyll-a (composite or epilimnion), Secchi disk transparency, and dissolved oxygen-temperature profiles to the lake bottom.
 - Ensure that dissolved oxygen-temperature profiles are collected concurrently with sampling of lake deep spot stations and consider collecting profiles at a higher frequency (e.g., every two weeks from May-October).
 - Consider adding total nitrogen and nitrogen species (total dissolved nitrogen, nitrate-nitrite, and ammonium) to routine lake sampling.
- Continue to monitor the lake for cyanobacteria blooms and alert NHDES immediately. Coordinate with NHDES to collect samples for analysis.

- Monitor total phosphorus and flow (as well as specific conductance, chloride, temperature, and/or turbidity, if able) at major tributary inflows to Mascoma Lake, at least two to five times per year each summer, specifically targeting wet and dry weather conditions.
- Consider collecting monthly samples for the speciation and enumeration of phytoplankton and zooplankton in the water column.

6.5 INDICATORS TO MEASURE PROGRESS

The following environmental, programmatic, and social indicators and associated numeric targets (milestones) will help to quantitatively measure the progress of this plan in meeting the established goal and objectives for the Mascoma Lake watershed (Table 20). These benchmarks represent short-term (2026), mid-term (2029), and long-term (2034) targets derived directly from actions identified in the Action Plan (Section 5). Setting milestones allows for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant to ongoing activities. The committee should review the milestones for each indicator on an ongoing basis to determine if progress is being made, and then determine if the plan needs to be revised if the targets are not being met.

Environmental Indicators are a direct measure of environmental conditions. They are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions. They assume that recommendations outlined in the Action Plan (Section 5) will be implemented accordingly and will result in an improvement in water quality. Programmatic indicators are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality improvements are being met, these programmatic measurements list actions intended to meet the water quality goal. Social Indicators measure changes in social or cultural practices and behavior that lead to implementation of management measures and improved water quality.

Table 20. Environmental, programmatic, and social indicators for the Mascoma Lake Watershed-Based Management Plan. ** indicators particularly relevant to assessing progress toward achieving the water quality goal and objectives. Milestones are cumulative starting at year 1.

ENVIRONMENTAL INDICATORS

Indicator	2027	2032	2037
Achieve an average summer deep spot epilimnion total phosphorus concentration of 8.7 ppb at the deep spot station in Mascoma Lake (included but likely not a meaningful measure of success in this case)	<8.9 ppb	<8.8 ppb	<8.7 ppb
Eliminate the occurrence of cyanobacteria or algal blooms in Mascoma Lake (milestones based on observed data from 2024)**	6 days/yr	3 days/yr	0 days/yr
Achieve an average summer water clarity of 9 m or deeper at the deep spot stations in Mascoma Lake	6 m+	7.5 m+	9.5 m+
Prevent and/or control the introduction and/or proliferation of invasive aquatic species all waterbodies	Invasives Controlled	Invasives Controlled	Invasives Controlled

PROGRAMMATIC INDICATORS

Indicator	2027	2032	2037
Amount of funding secured from municipal/private work, fundraisers, donations, and grants	\$270,000	\$900,000	\$1,800,000
Number of NPS sites remediated (5 identified) **	1	3	5
Percentage of shorefront properties with LakeSmart certification **	25%	50%	75%
Number of watershed/shoreline properties receiving technical assistance visits	25	50	100
Number of workshops and trainings for stormwater improvements to residential properties (e.g., NHDES Soak Up the Rain NH program)	1	2	5
Number of updated or new ordinances that target water quality protection	1	2	3
Number of new municipal staff for inspections and enforcement of regulations	1	1	2
Number of voluntary or required septic system inspections (seasonal conversion and property transfer)	5	10	25
Number of septic system upgrades **	10	25	50
Number of informational workshops and/or trainings for landowners, municipal staff, and/or developers/landscapers on	2	5	10

Indicator	2027	2032	2037
local ordinances, watershed goals, and/or best practices for road management and winter maintenance			
Number of parcels with new conservation easements or number of parcels put into permanent conservation	1	2	5
Number of copies of watershed-based educational materials distributed or articles published	200	500	1,000
Number of new best practices for road management and winter maintenance implemented on public and private roads by the municipalities	2	5	10
Number of municipalities fully implementing key aspects of the MS4 program	1	2	3
Number of meetings and/or presentations to municipal staff and/or boards related to the WBMP	4	12	30
Number of CNMPs completed or NRCS technical assistance provided for farms in the watershed	1	2	3

SOCIAL INDICATORS

Indicators	2027	2032	2037
Number of new association members	20	50	75
Number of volunteers participating in educational campaigns	5	10	25
Number of people participating in informational meetings, workshops, trainings, BMP demonstrations, or group septic system pumping	25	50	100
Number of watershed residents installing conservation practices on their property and/or participating in LakeSmart	25	50	100
Number of municipal DPW staff receiving Green SnowPro training	1	3	5
Number of groups or individuals contributing funds for plan implementation	25	50	100
Number of newly trained water quality and invasive species monitors	2	4	6
Percentage of residents making voluntary upgrades or maintenance to their septic systems (with or without free technical assistance), particularly those identified as needing upgrades or maintenance	10%	25%	50%
Number of farmers working with NRCS, CCCD, SCCD, or BCCD	1	2	3
Number of daily visitors to the MLA website	10	25	50

ADDITIONAL RESOURCES

[Buffers for wetlands and surface waters: a guidebook for New Hampshire municipalities.](#) Chase, et al. 1997. NH Audubon Society.

[Conserving your land: options for NH landowners.](#) Lind, B. 2005. Center for Land Conservation Assistance / Society for the Protection of N.H. Forests.

[Environmental Fact Sheet: Erosion Control for Construction within the Protected Shoreland.](#) New Hampshire Department of Environmental Services, SP-1, 2020.

[Gravel road maintenance manual: a guide for landowners on camp and other gravel roads.](#) Maine Department of Environmental Protection, Bureau of Land and Water Quality. April 2010.

[Gravel roads: maintenance and design manual.](#) U.S. Department of Transportation, Federal Highway Program. November 2000. South Dakota Local Transportation Assistance Program (SD LTAP).

[Innovative land use techniques handbook.](#) New Hampshire Department of Environmental Services. 2008.

[Landscaping at the water's edge: an ecological approach.](#) University of New Hampshire, Cooperative Extension. 2007.

[New Hampshire Homeowner's Guide to Stormwater Management: Do-It-Yourself Stormwater Solutions for Your Home.](#) New Hampshire Department of Environmental Services, Soak Up the Rain NH. Revised November 2019.

[Protecting water resources and managing stormwater.](#) University of New Hampshire, Cooperative Extension & Stormwater Center. March 2010.

[Stormwater Manual, Volumes 1-3.](#) New Hampshire Department of Environmental Services. 2008.

[University of New Hampshire Stormwater Center 2009 Biannual Report.](#) University of New Hampshire, Stormwater Center. 2009.

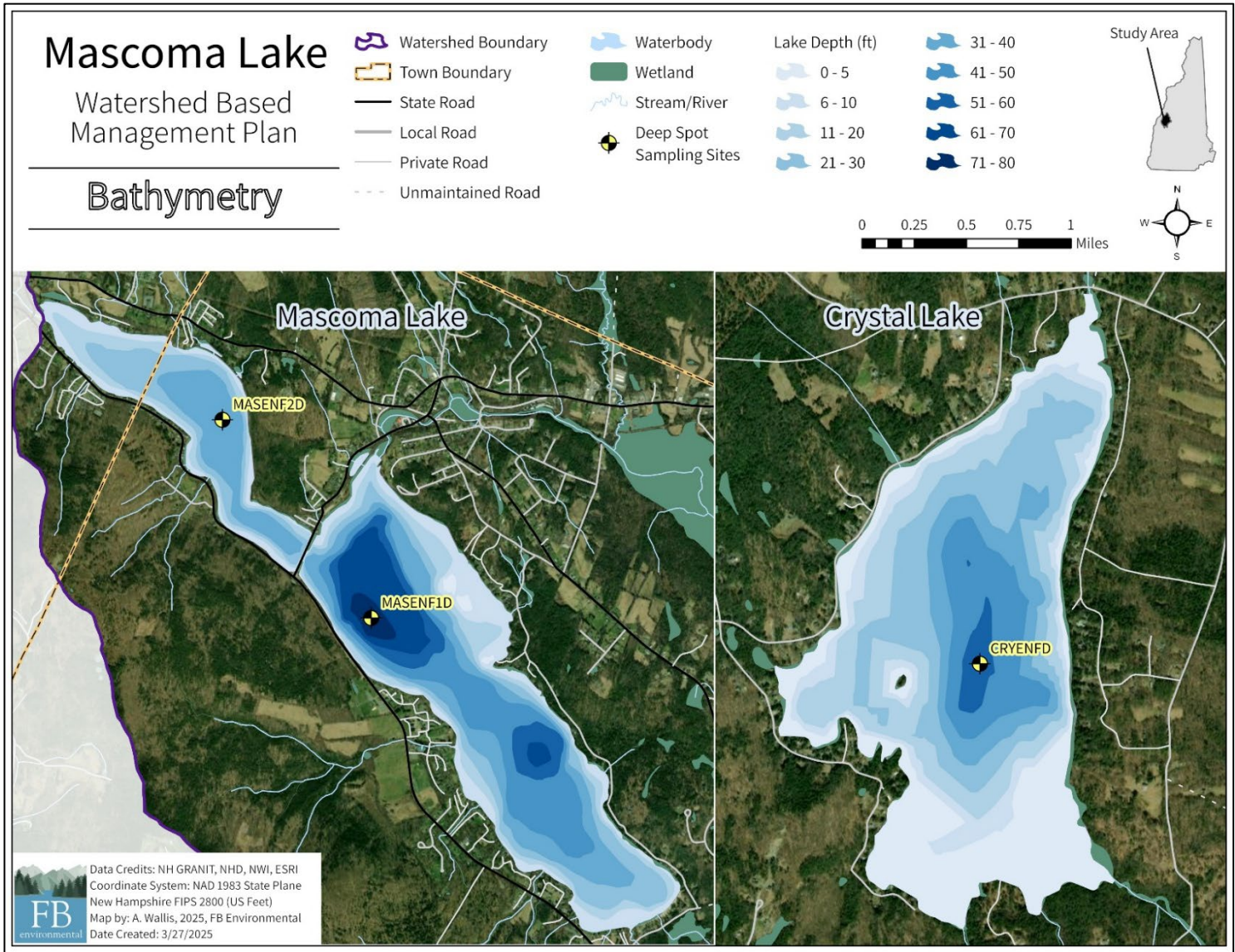
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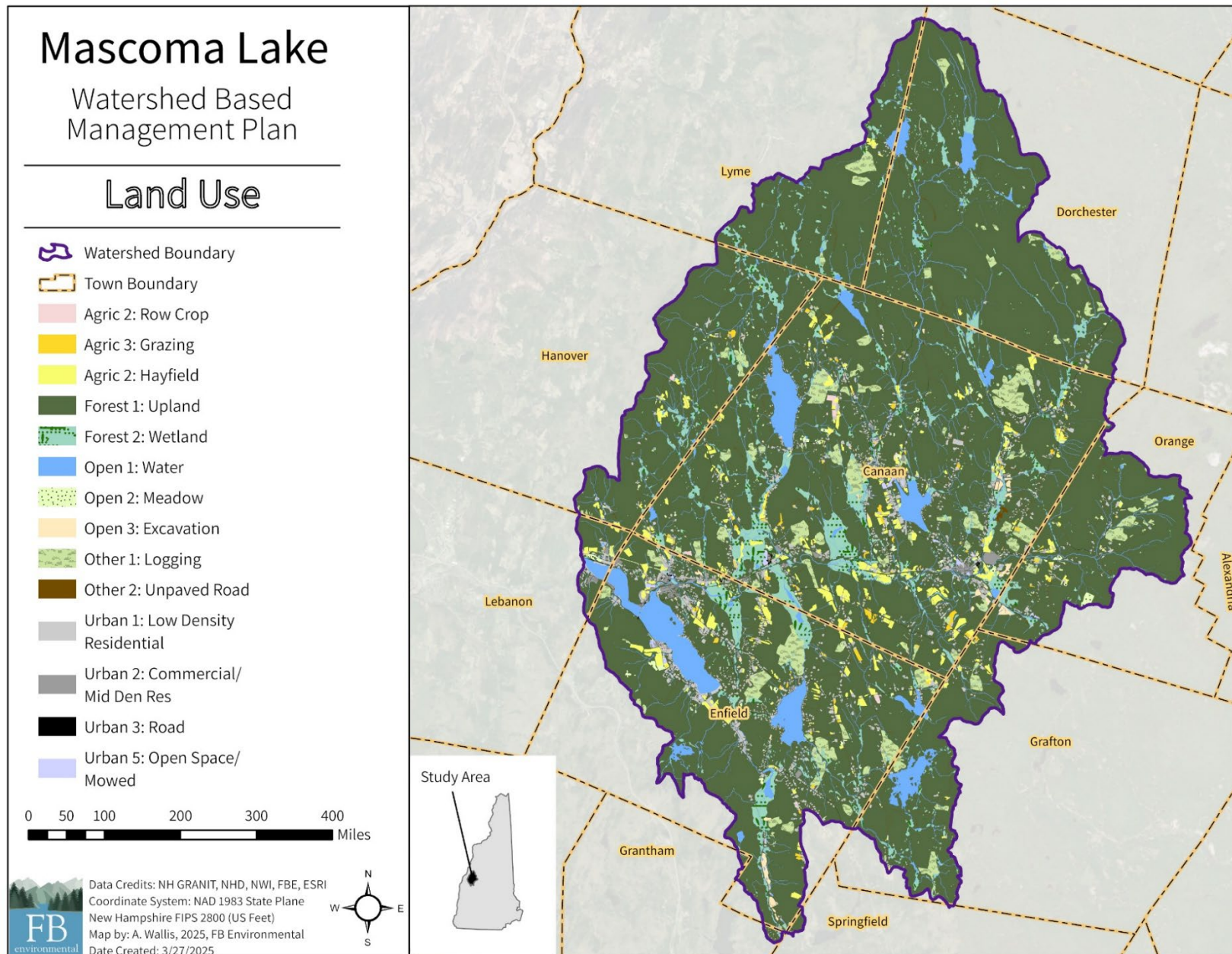
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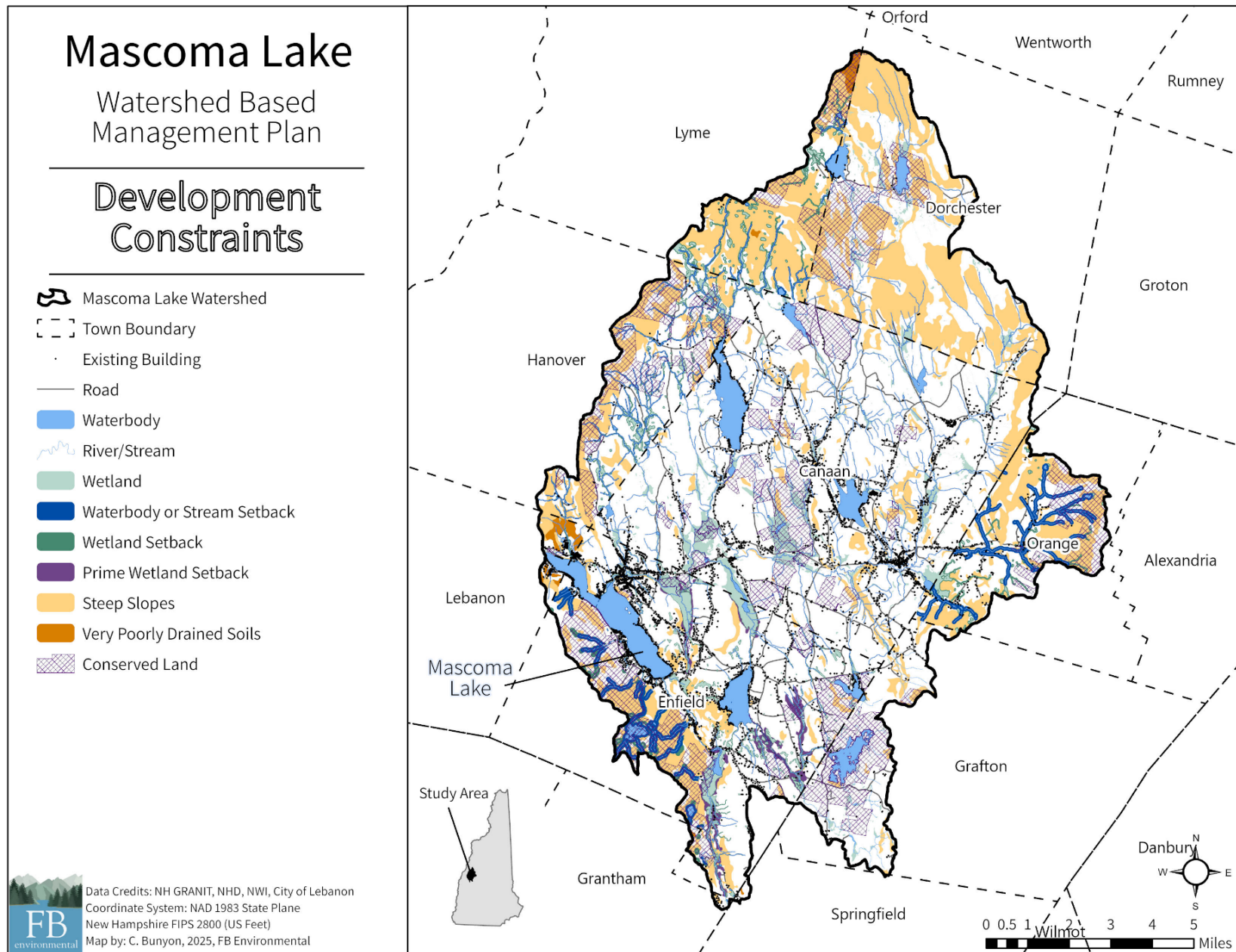
APPENDIX A: SUPPORTING MAPS



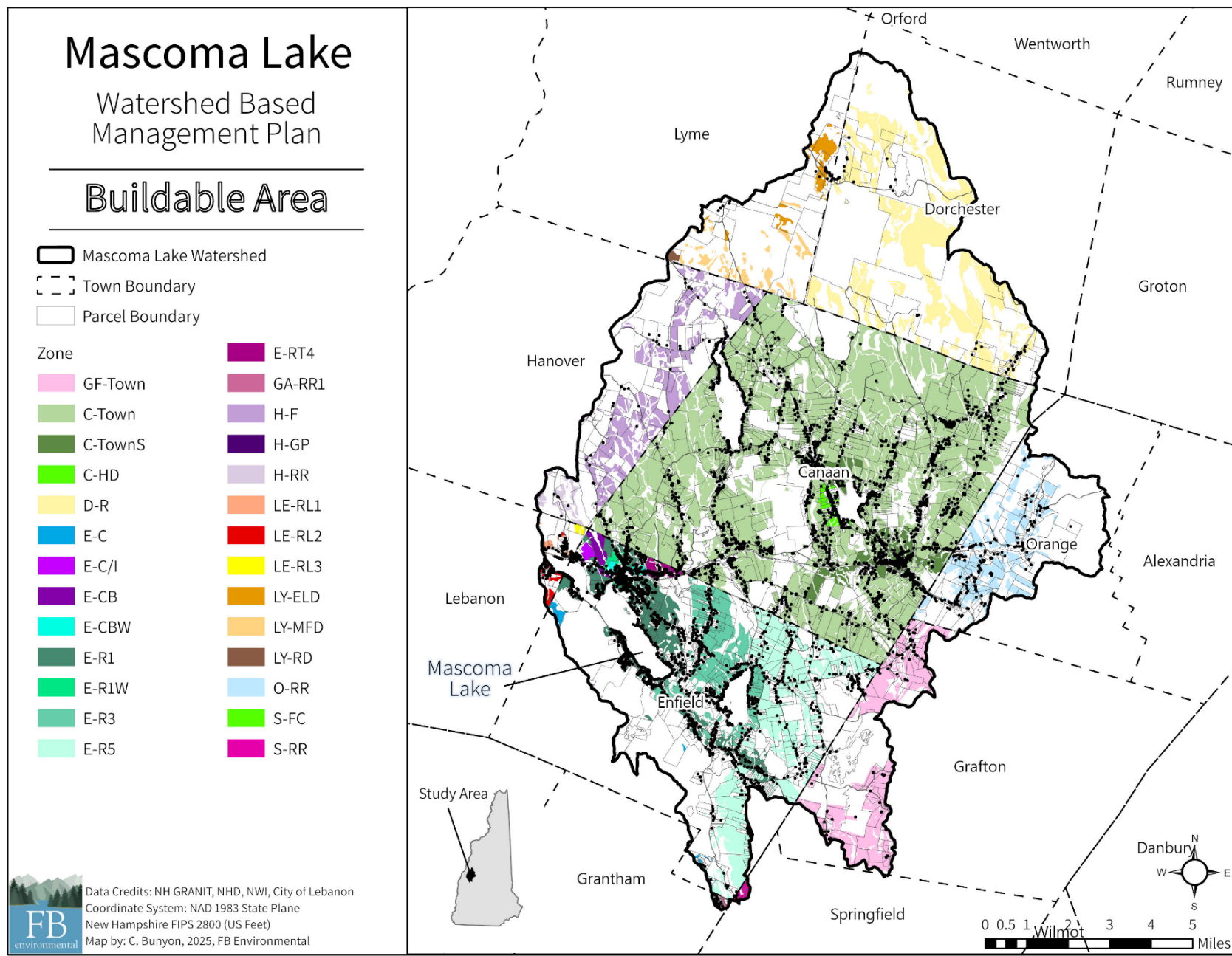
Map A-1. Bathymetry as 10-foot depth contours for Mascoma Lake and 5-foot depth contours in Crystal Lake.



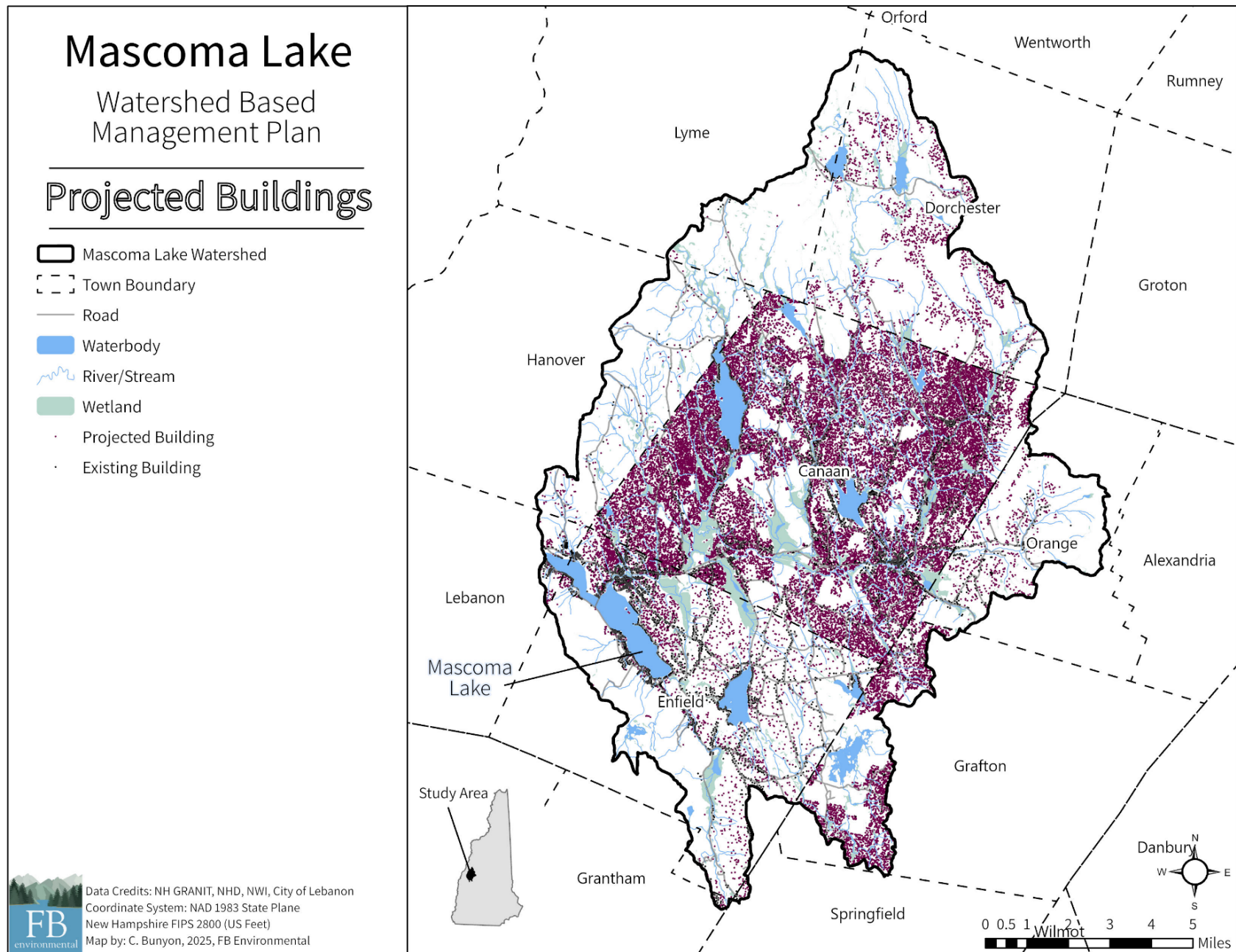
Map A-2. Land cover for the Mascoma Lake watershed.



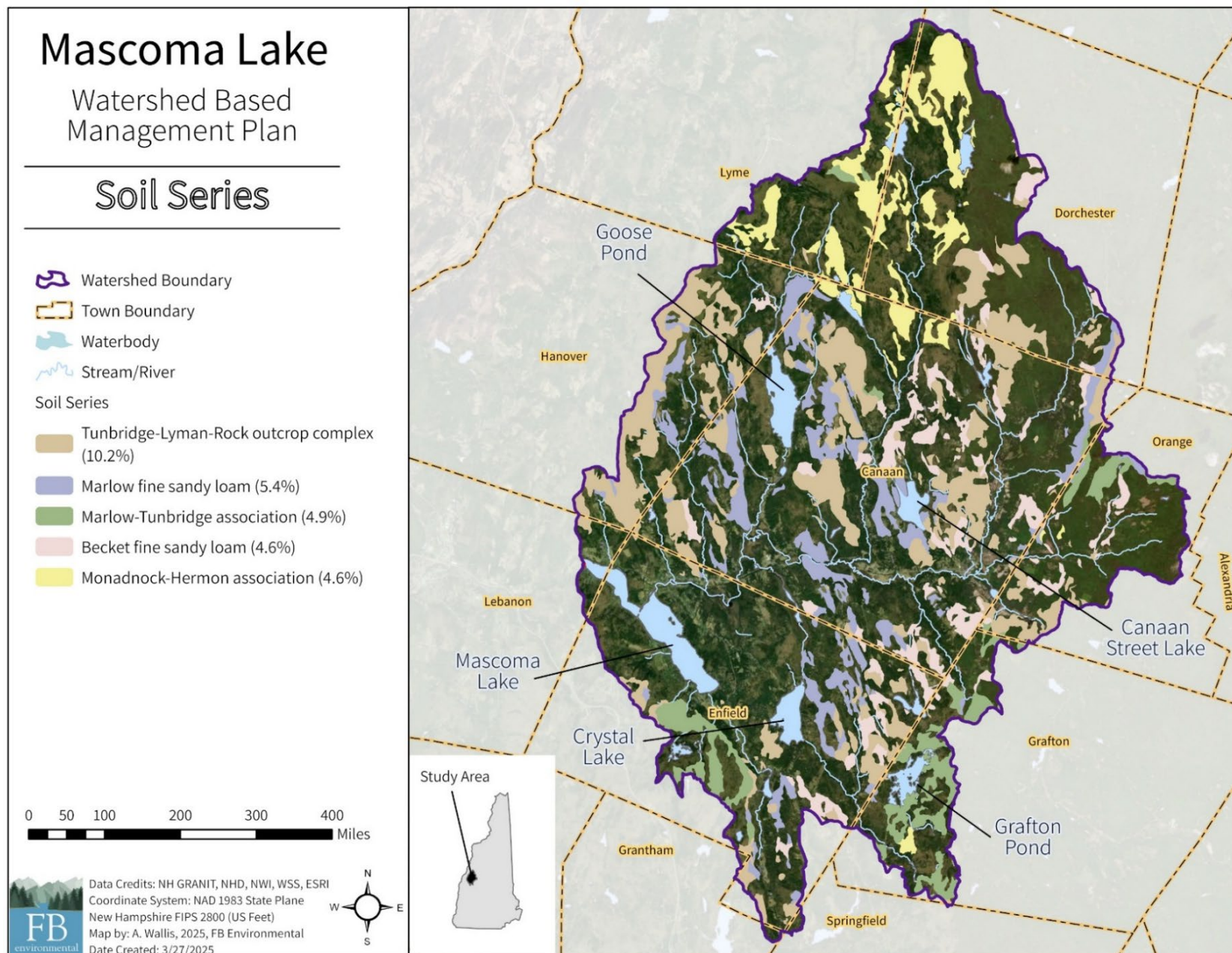
Map A- 3. Development constraints in the Mascoma Lake watershed.



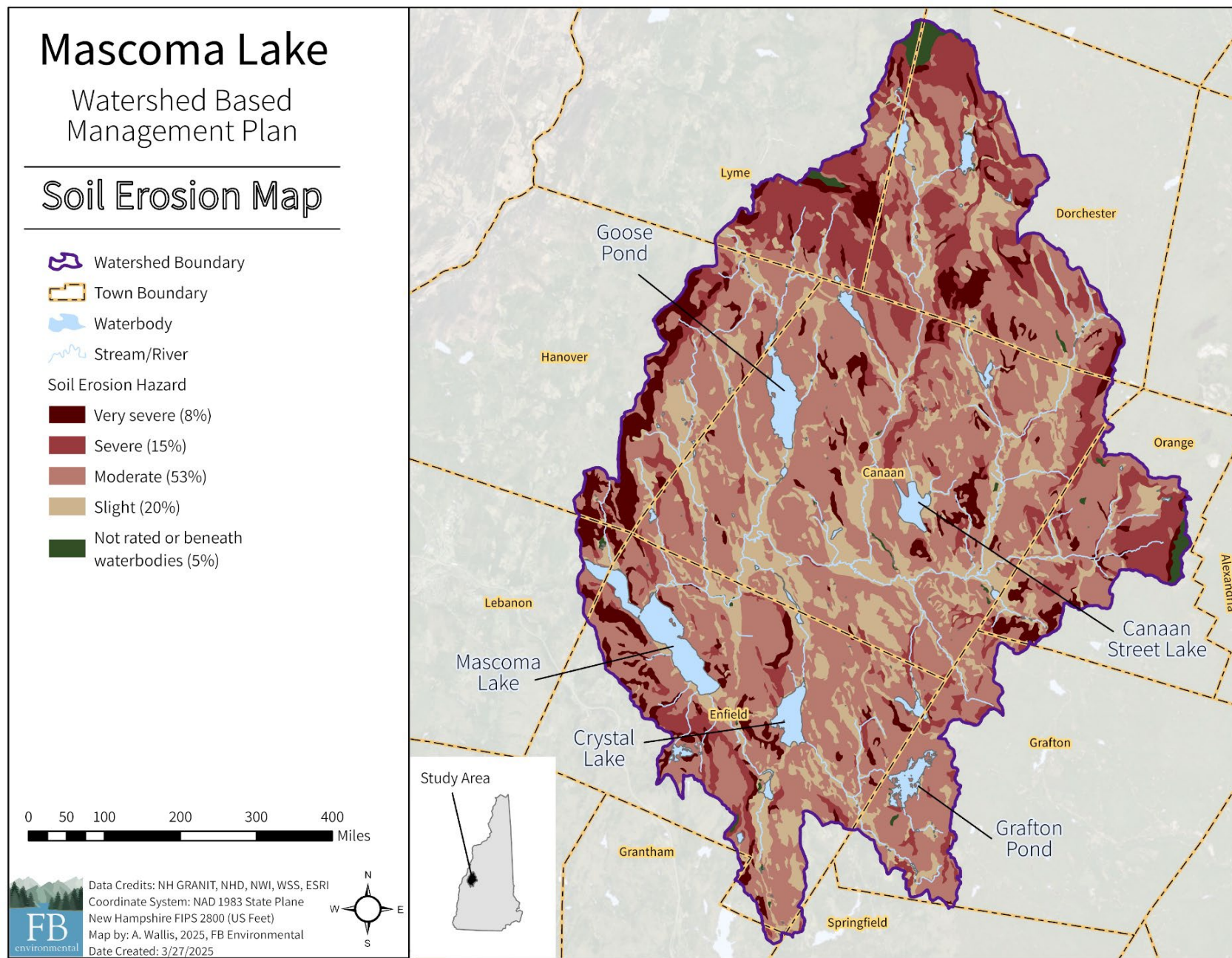
Map A-4. Buildable area by municipal zone in the Mascoma Lake watershed.



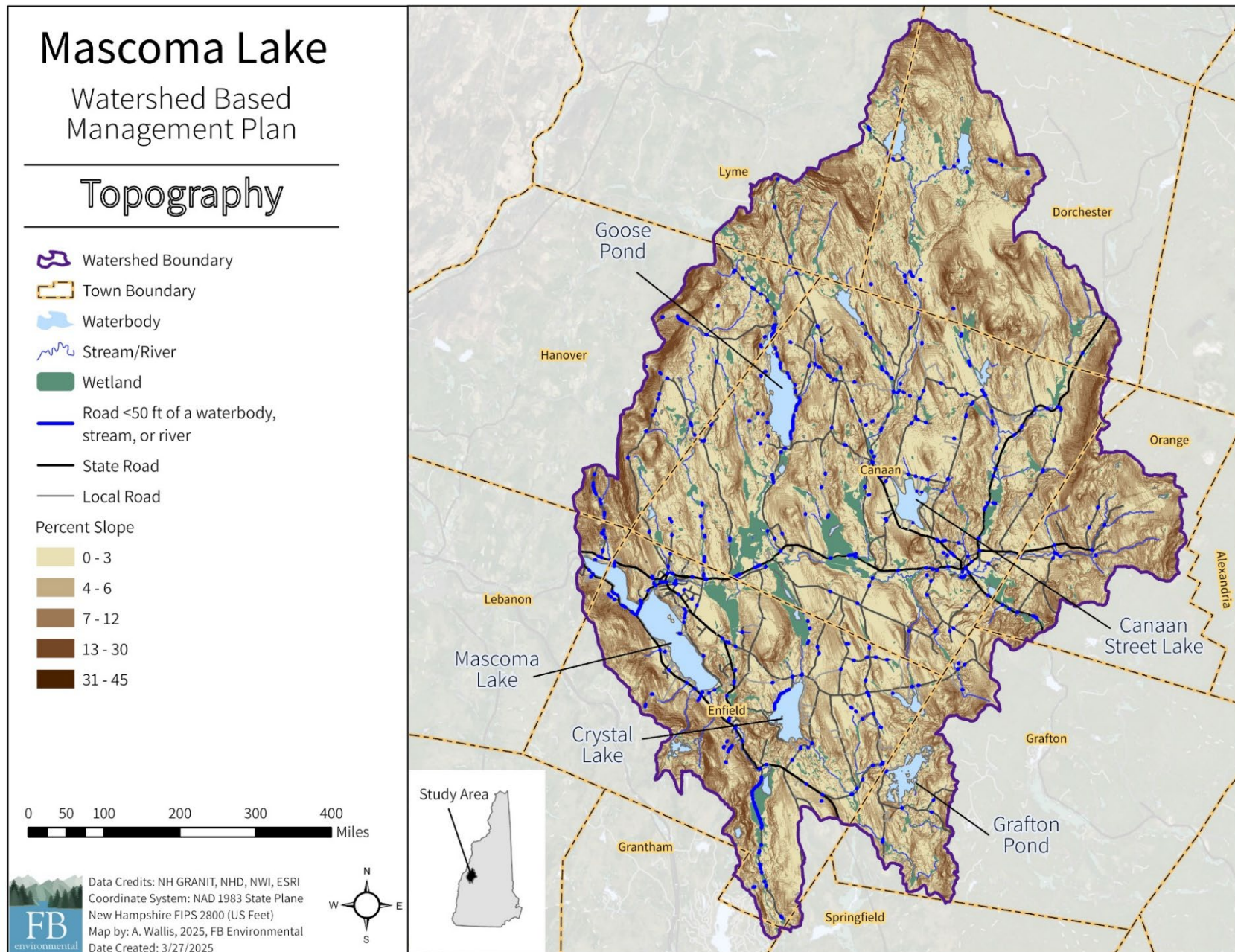
Map A-5. Projected buildings in the Mascoma Lake watershed.



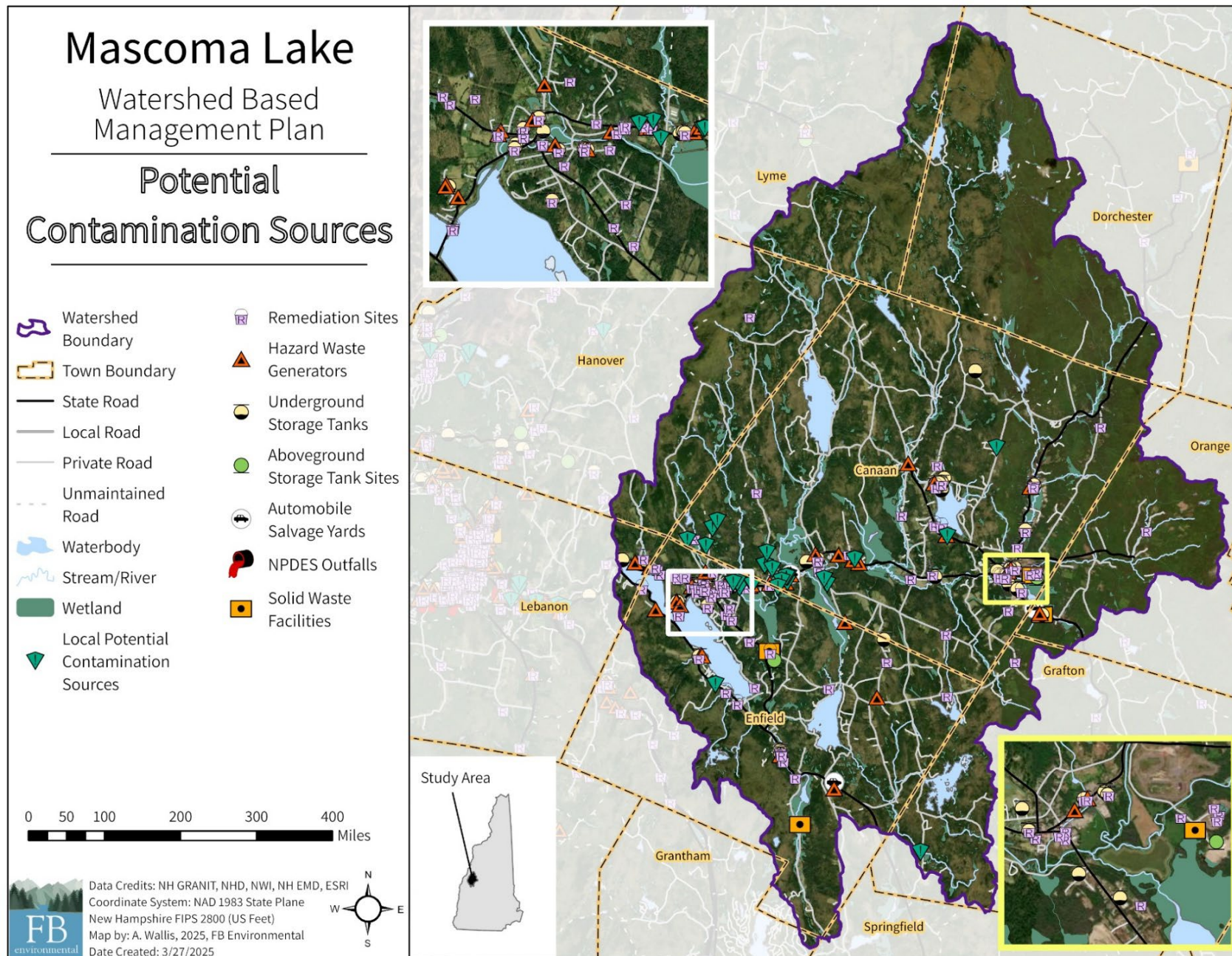
Map A-6. Soil series in the Mascoma Lake watershed.



Map A-7. Soil Erosion Hazard in the Mascoma Lake watershed.



Map A-8. Topography of the Mascoma Lake watershed.



Map A-9. Potential sources of contamination in the Mascoma Lake watershed.

Mascoma Lake

Watershed Based Management Plan

Habitat

-  Watershed Boundary
-  Town Boundary
-  Conservation Land
-  Coldwater Fishery
-  Warm/Cool Fishery
-  Coldwater Classification
-  Warm/Cool Classification

Identified Species

-  Eastern Brook Trout

Habitat Classification

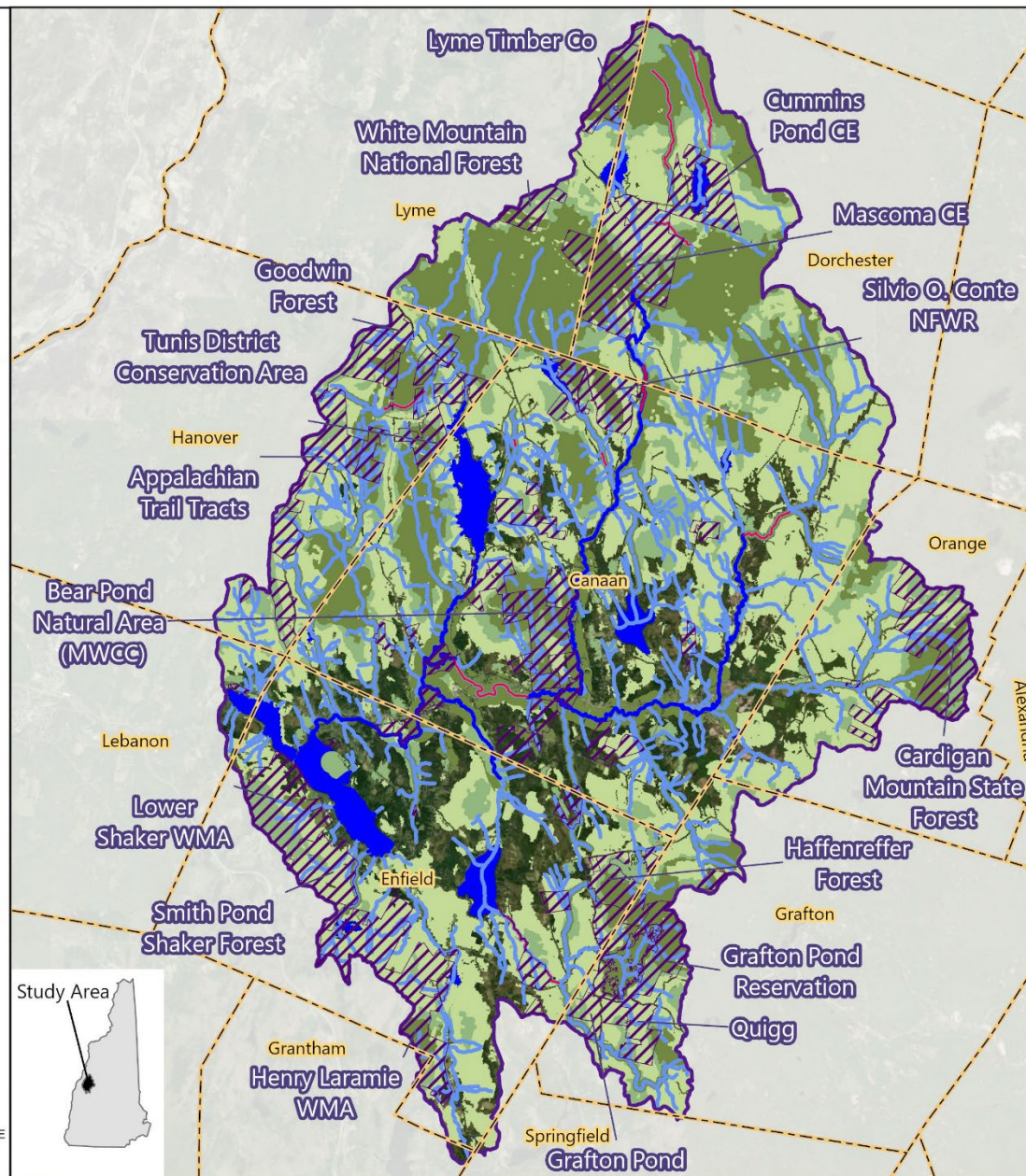
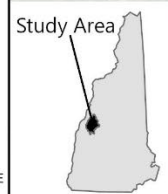
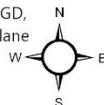
-  Highest Ranked Habitat in New Hampshire
-  Highest Ranked Habitat in Biological Region
-  Supporting Landscapes

Conserved lands smaller than 300 acres are not labeled at this scale.

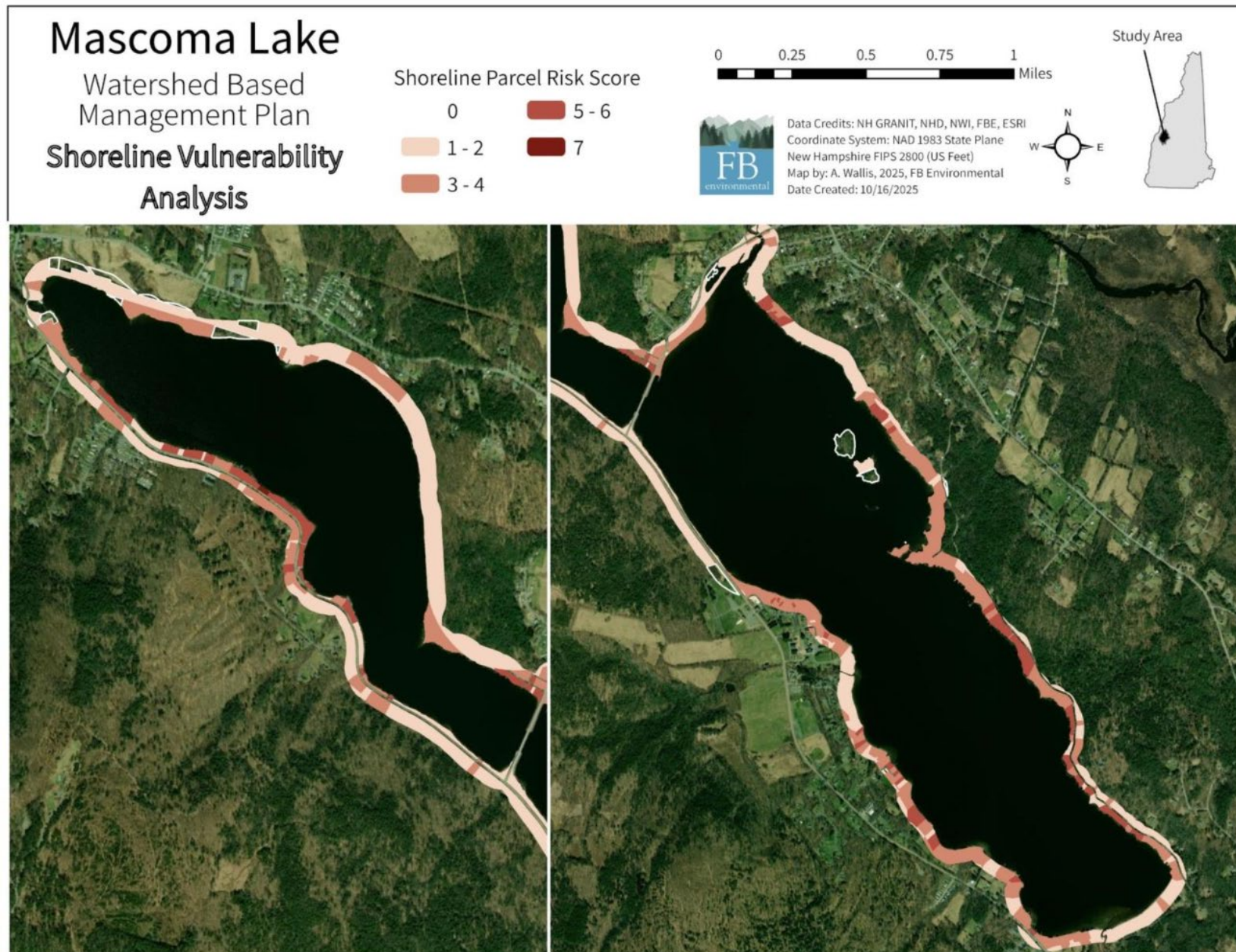
0 0.75 1.5 3 4.5 6 Miles



Data Credits: NH GRANIT, NHD, NWI, NH FGD,
ESRI Coordinate System: NAD 1983 State Plane
New Hampshire FIPS 2800 (US Feet)
Map by: A. Wallis, 2025, FB Environmental
Date Created: 3/27/2025



Map A-10. Conservation land and High value habitat according to the 2020 New Hampshire Wildlife Action Plan within the Mascoma Lake watershed.



Map A-11. Map of the total parcel Shoreline Vulnerability Score for the shoreline zone (land within 250 feet of the shoreline) for Mascoma Lake.

APPENDIX B: BMP MATRIX

Table B-1. Site ID, location description, town, primary recommended actions, estimated pollutant load reductions, and estimated implementation costs for the five sites identified in the direct Mascoma Lake watershed. Pollutant load reductions and cost estimates are preliminary and are for planning purposes only. Cost estimates are intended for planning only; there may be additional costs associated with engineering design and construction, and thus actual construction costs could be highly variable.

BMP	Sheet Reference	Impervious Area draining to BMP (sq ft)	Runoff Depth (in)	Impervious P Load to BMP (kg/yr)	P Removal Efficiency (%)	P Load Removed (kg/yr)	EPA Water Quality Curve	Cost
Huse Park Subsurface	C-1	37,870	1	0.68	98%	0.68	Infiltration Trench	314,000
Huse Park Infiltration	C-2	2,231	0.9	0.045	100%	0.045	Infiltration Trench	60,000
Bank Bio-filtration	C-3	23,671	1	0.545	52%	0.227	Bio-filtration	295,000
Library Subsurface	C-4	20,856	1	0.41	98%	0.363	Infiltration Trench	203,000
Beach	C-5	N/A	N/A	N/A	N/A	0.186	N/A	229,000
Total						1.501		\$1,101,000

APPENDIX C: BMP SITE PLANS



Site C-1 Huse Park Subsurface site plans.

