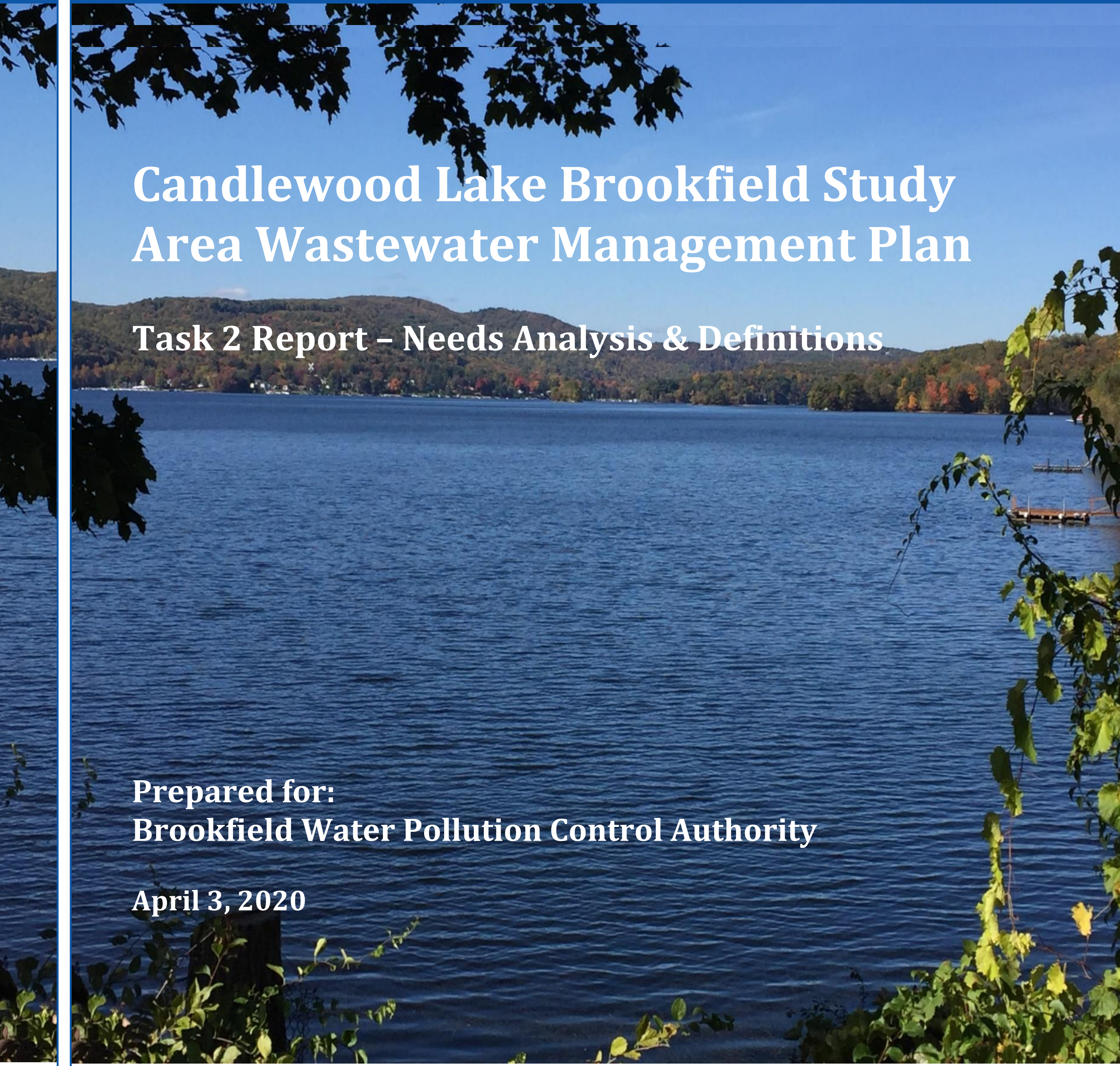

Candlewood Lake Brookfield Study Area Wastewater Management Plan

Task 2 Report – Needs Analysis & Definitions

Prepared for:
Brookfield Water Pollution Control Authority

April 3, 2020

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1 INTRODUCTION & EXECUTIVE SUMARY

This Report presents the Task 2 Wastewater Management Needs Analysis and Definitions of the septic systems in the Brookfield Candlewood Lake Drainage Area and adjacent Areas of Concern. The purpose of the Wastewater Management Needs Report is to objectively define the wastewater improvement needs as accurately as possible based upon the cause of the Need – which enables the most precise, objective and transparent determination of the appropriate solution(s) and optimization of solution options cost-effectiveness.

In this Report, a property by property Wastewater Management Needs Definition is provided by determining needs in the categories of:

a. **Performance Need** – defined as septic systems not providing sufficient nitrogen, phosphorus and other constituents removal and thereby causing groundwater and/or surface water contamination such that the water bodies are not meeting their water quality standards and are therefore impaired. The primary areas of concern are septic impacts on:

   i. Quality of Candlewood Lake;
   ii. Groundwater aquifer, which is the water supply for the study area.

b. **Functional Need Due to Bacterial / Public Health Considerations** – defined as septic systems that are malfunctioning (such as flooded drainfield or breakout, inadequately draining waste fixtures, foul odors, excessive septic pumping, etc.) or have insufficient depth (minimum of 2 feet required) from drainfield bottom to seasonal high groundwater are classified as having a Functional Need. Malfunctioning systems are considered a public health threat.

c. **Insufficient Space** - lots having inadequate space for a CT Department of Health (DoH) code compliant wastewater system in the future when the current system fails. Properties with insufficient space require an off-site solution or DoH variances.

The methodologies used for determining the Needs in the various Categories are described in the following Sections that present the data and basis for addressing each Need type. Solution options are addressed in the Task 3 Report.

As described in this Report, the following Needs Definition conclusions have been determined by the Task 2 efforts.

1. **Impact on Quality of Candlewood Lake** – Wastewater represents a major source of nitrogen (N) and a significant but non-dominant source of phosphorus (P) to Candlewood Lake. Inputs of each are likely to be maximal in the littoral zone of the lake and likely promote the growths of milfoil and green algae mats in that area. The high ratio of N to P in groundwater inputs does not favor cyanobacteria, which are more likely to grow over deeper water where internal loading of P from sediment can be elevated and is likely to have a low ratio of N to P. However, the N and P recycled from the sediment ultimately came from the watershed, including the wastewater inputs, over many years, so management of watershed sources remains a valid approach to improving lake conditions. Consequently, it is likely that the internal load from sediments will have to be addressed separately, but in answer to the central question of the influence of wastewater on lake

water quality, wastewater is a major source of N and a minor source of P and its removal would be a benefit to the lake.

Reducing wastewater phosphorus and nitrogen contributions to the Lake will have a positive impact on milfoil control.

2. **Impact on Groundwater Drinking Water Aquifer** - Wastewater nitrate and PFOA/PFOS discharges to the Peninsula water supply have resulted in unhealthy nitrate and PFOA/PFOS concentrations. This wastewater impact on drinking is a serious public health issue. Solution options include:

   - Remove wastewater discharges to Peninsula drinking water aquifer;
   - Treat the water supply to remove nitrates and PFOA/PFOS;
   - Provide a new water supply source.

3. **Functional Need** – Approximately 25% of developed properties have reported a septic system problem.

4. **Insufficient Space** – Between 20% to 32%of developed properties have insufficient space to accommodate a CT Department of Health (DoH) code compliant septic system with the vast majority of those challenging sites on the Peninsula. For these properties, off-site solutions (i.e. sewers) will be required or code variances.

The following is recommended.

Based upon the numerous factors that point to the need for a community wide wastewater solution, it is recommended that a Peninsula and Non-Peninsula High Density area community-wide sewer system be implemented.

- The sewer system type and treatment/discharge option should be determined based technical and economic/financial optimization analysis to be performed in a subsequent project Report.

- Associated with a Peninsula (approximately 1,000 properties) community-wide wastewater system, Candlewood Lake studies should be performed to document improvements associated with the wastewater improvements.

- The degree to which wastewater improvements need to be implemented for the 400 +/- developed properties in the remaining Brookfield Candlewood Lake drainage area should be evaluated as part of the Peninsula wastewater improvement project.

2 PERFORMANCE NEEDS

Performance Needs are assessed by determining the Study Area septic system impacts on the water quality of Candlewood Lake and on area deep groundwater, which is the water supply for much of the study area. The methodologies used for these determinations are presented below.

2.1 SEPTIC SYSTEM INFLUENCE ON CANDLEWOOD LAKE & GROUNDWATER DRINKING WATER AQUIFER

STUDY METHODOLOGY

A. Background

The methodology used to determine septic system impacts on the quality of Candlewood Lake and groundwater water supply aquifer consisted of the following techniques that collectively enabled a scientific determination of septic wastewater purification prior to it reaching Candlewood Lake and the deep groundwater water supply aquifer. Then a quantitative estimate of septic impacts on Lake water quality will be performed by updating the Task 1 Report Table 4-6.

For Candlewood Lake quality impacts, phosphorus is the primary concern as it is considered to be the controlling nutrient for Lake's quality. Nitrate nitrogen, which for practical purposes all wastewater nitrogen forms get converted to, is a primary concern for protection of drinking water sources due to the public health limit of 10 parts per million (ppm), which is equivalent to milligrams per liter (mg/L). However it is noted that the US EPA issued an advisory in 2015 https://www.epa.gov/sites/production/files/documents/nandpfactsheet.pdf that phosphorus and nitrogen should both be considered to protect lake water quality. Other constituents of concerned are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) which can cause adverse health effects and are sometimes referred to as forever chemicals as from a practical perspective, they do not degrade. As of January 2020, the CT drinking water standards for the total of PFOA + PFOS is 70 parts per trillion (ppt). Figure 2-1, from US EPA (https://federalleadership.chesapeakebay.net/130627_ches_bay_tech_assist_manual.pdf), illustrates how septic water travels to groundwater and then to surface water.

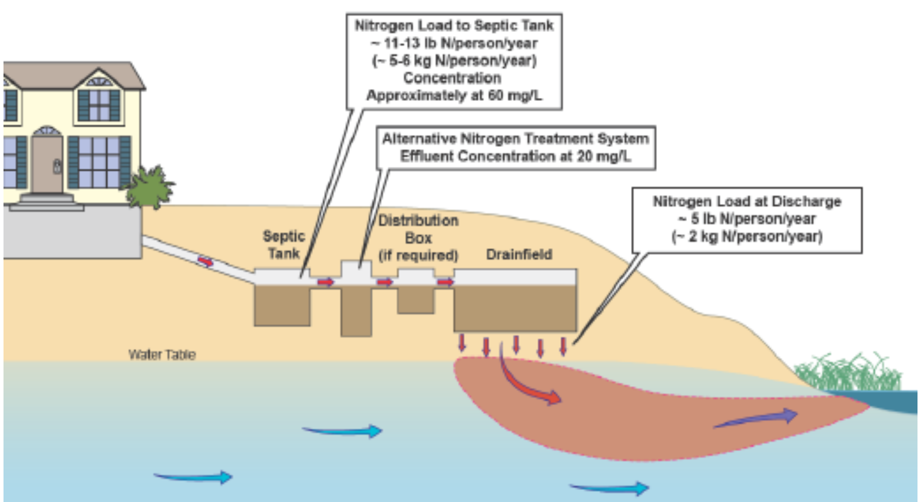


Figure 2-1 Septic Effluent Travel to Groundwater

In analyzing water quality, the following constituents are used as septic system tracers as they are typically absent or in low concentrations in waters not affected by septic systems.

Boron - a constituent used in laundry detergents
Chloride – common residential wastewater constituent, although road deicing salts can be a major contributor
Artificial sweeteners, in particular Acesulfame (ACE)
Electric conductivity – measure of ions as there will more ions in wastewater than groundwater
pH – typically, wastewater that passes through a drainfield will have a lower pH due to nitrification with its alkalinity consumption and pH Lowering
PFOA/PFOS - perfluorooctanoic acid (PFOA) and/or perfluorooctane sulfonate (PFOS)

For reference,

Phosphorus - Soluble Reactive Phosphorus (SRP) is the phosphorus form most readily available for algae. While phosphorus (P) chemistry is extremely complex, for simplicity Total phosphorus = SRP + organic P

Nitrogen - Total Nitrogen (TN) = Organic Nitrogen + Ammonia-N (NH_3) + Nitrite-N (NO_2) + Nitrate-N (NO_3)
Total Kjeldahl Nitrogen (TKN) = Organic Nitrogen + Ammonia-N

B. Sites Selection for Testing

To assess septic system impacts on the quality of Candlewood Lake and the groundwater drinking water aquifer, the following sites were selected as representative of the study area on which data would be collected to determined septic impacts, see the Site Testing Locations Map Figure 2-2:

- 76 South Lake Shore Drive
- 4 Longview Drive
- 74 North Lake Shore Drive

B.1 Drinking Water Aquifer

Additionally , drinking water from two (2) properties on the Peninsula (hereinafter defined as that area served by the Candlewood Shores Tax District (CSTD), Arrowhead Point Homeowners Association – see Figure 2-3) were sampled for the range of water quality constituents to ascertain whether septic systems are influencing the deep groundwater water supply aquifer. The two properties were:

- ✓ Residential property, 9 Arrowhead Road
- ✓ CSTD Office 55 Longview Drive

To enable a comparison, drinking water was also analyzed at 21 Main Drive, Brookfield, CT, which is a location outside of the Study Area and in the Aquarion of Western Brookfield District, that was understood not to be influenced by septic systems.

Drinking water supply wells are located within the districts as shown on Figure 2-3.

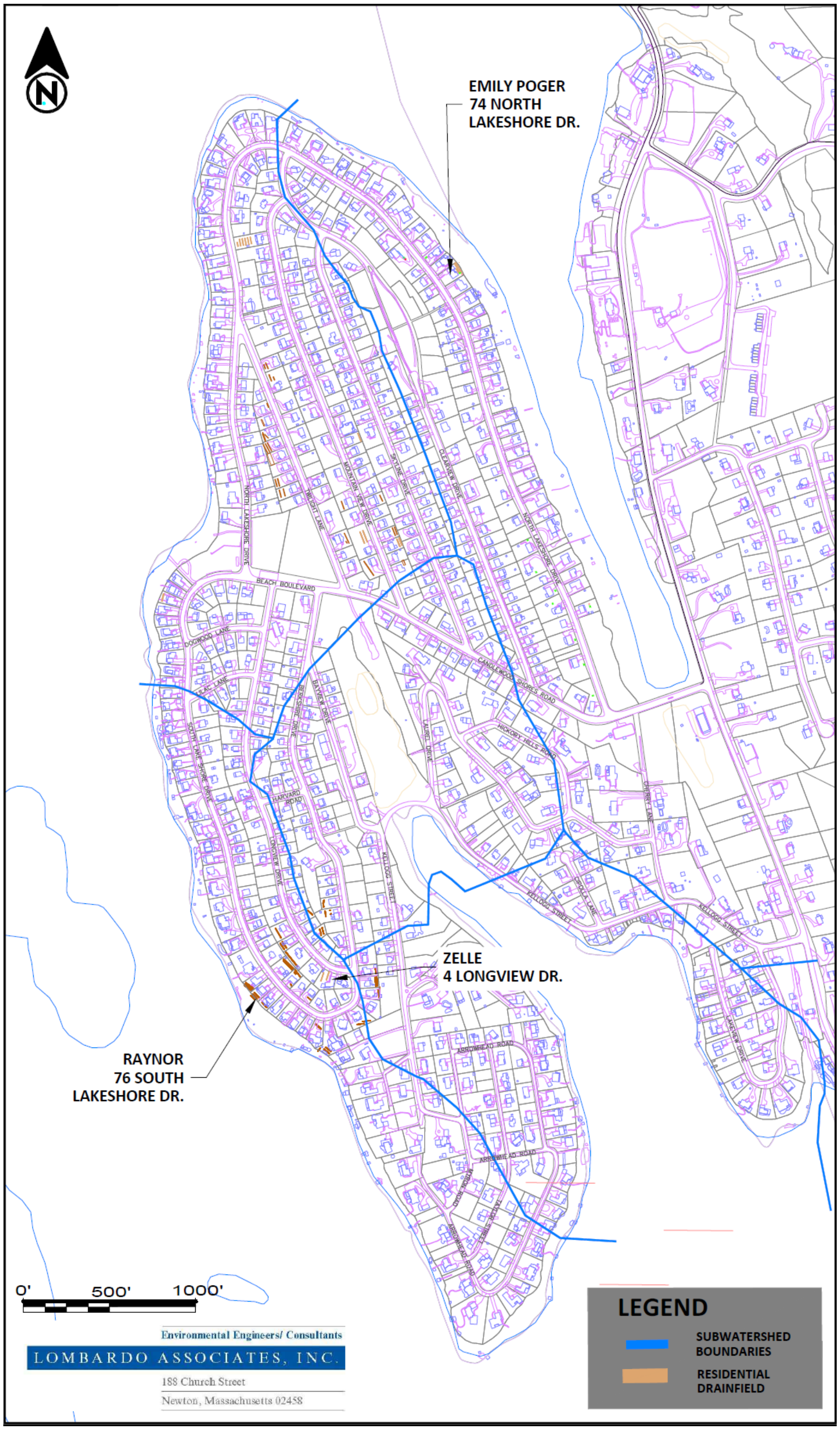


Figure 2-2 Site Testing Locations Map

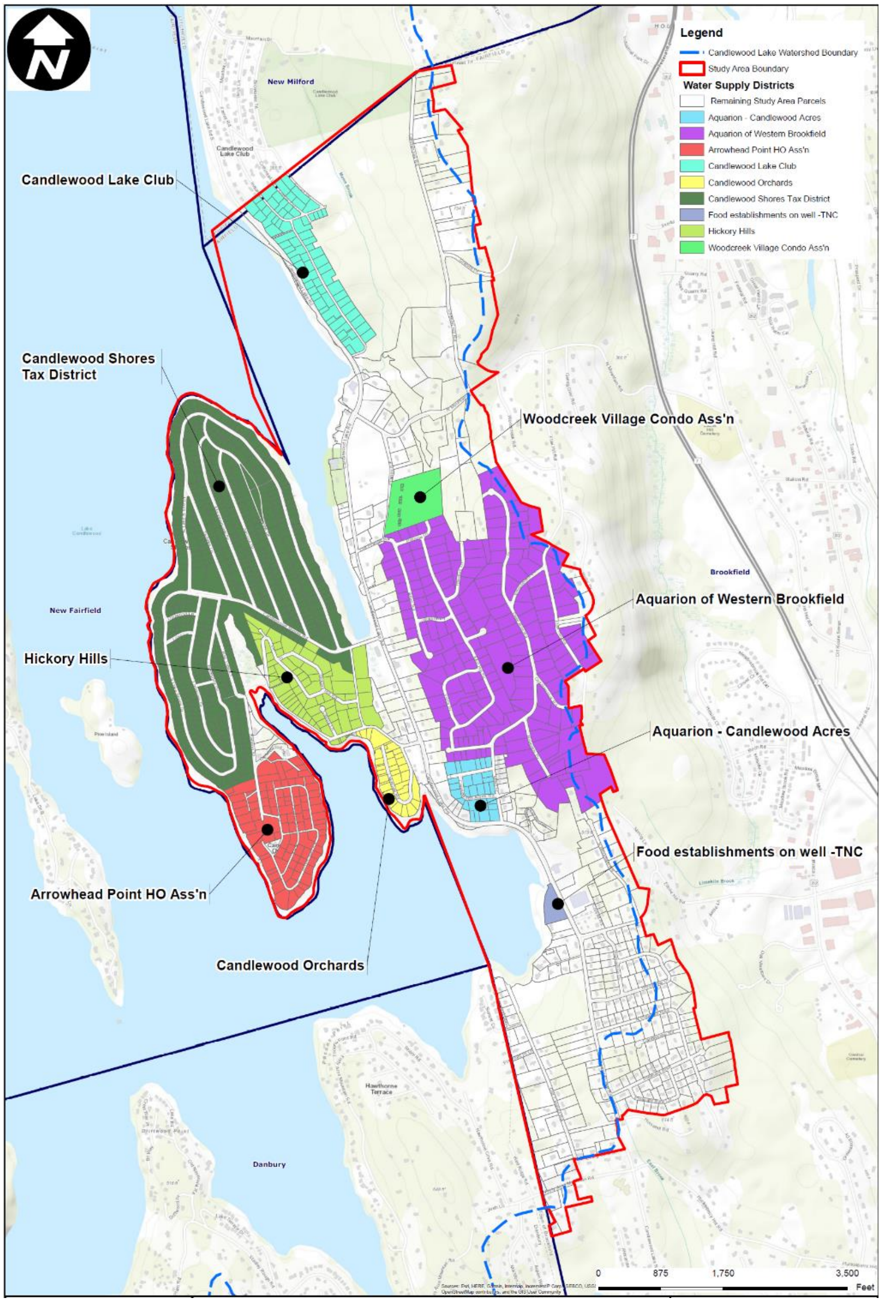


Figure 2-3 Study Area Water Supply Districts

B.2 Candlewood Lake Water Quality - Septic Tracers Sampling

Candlewood Lake water samples were collected near shore behind the property at 76 South Lake Shore Drive and analyzed for septic tracers of Boron and ACE.

B.3 Septic Wastewater Purification

To assess wastewater purification in septic systems and in the subsurface from the drainfield through the unsaturated soil and in groundwater prior to entering Candlewood Lake, the three residential properties listed above were selected for detailed testing of:

- Septic Tank effluent
- Drainfield soils to determine phosphorus removal within drainfield soils
- Groundwater quality immediately down gradient of the drainfields
- Groundwater quality slightly upgradient of the shoreline just prior to entering Candlewood Lake

Also, to assess septic purification from upland septic sources, groundwater quality was sampled across a cross section of a large area owned by FirstLight – located between the properties along 74 – 84 South Lake Shore Drive and Candlewood Lake. Soil samples from different elevations in the drainfield were analyzed for desorbable and acid extractable phosphorus and were examined with an electron microprobe to determine the degree to which septic wastewater phosphorus precipitates in the soils and thereby is removed.

The residential properties were selected in the following manner:

a. The quarterly water use records provided by CSTD were analyzed to identify properties that appeared to be full time residences – using the metric that average water use needed to be >> 100 gallons per day throughout the year.
b. Candidates were then sorted by those properties for which septic system record drawings existed.
c. Letters requesting expressions of interest in being test sites and willingness to sign an Access Agreement were sent to the remaining candidate property owners.
d. For properties expressing interest in being test sites, telephone interviews were performed and potentially viable candidate sites identified.
e. Site visits were then made to the potentially viable candidate sites (8 sites) to assess site conditions, in particular access and likely depth to groundwater.
f. The following residential sites were selected and property owners Access Agreements obtained, after which the sampling program was implemented.

    i. 76 South Lake Shore Drive (SLSD)
    ii. 4 Longview Drive (LV)
    iii. 74 North Lake Shore Drive (NLSD)

Figures 2-4 through 2-6 are site plans of the three sites with septic system and soils/groundwater sampling locations indicated, respectively. Figures 2-7 and 2-8 illustrate section views of sampling locations for the 76 South Lake Shore Drive and 74 North Lake Shore Drive sites. As groundwater was not located (due to its excessive depth), no groundwater sampling was performed at 4 Longview Drive.

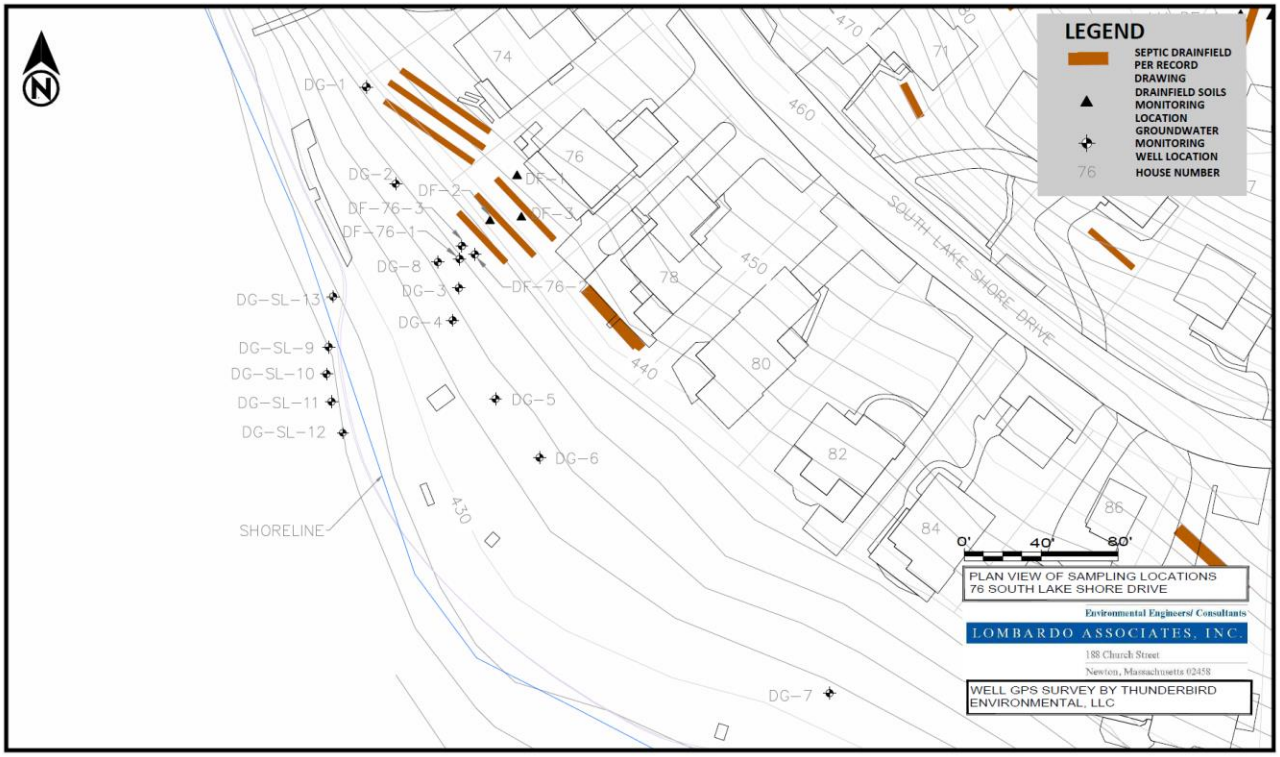


Figure 2-4 Site Plan – 76 South Lake Shore Drive

Figure 2-5 Site Plan – 4 Longview

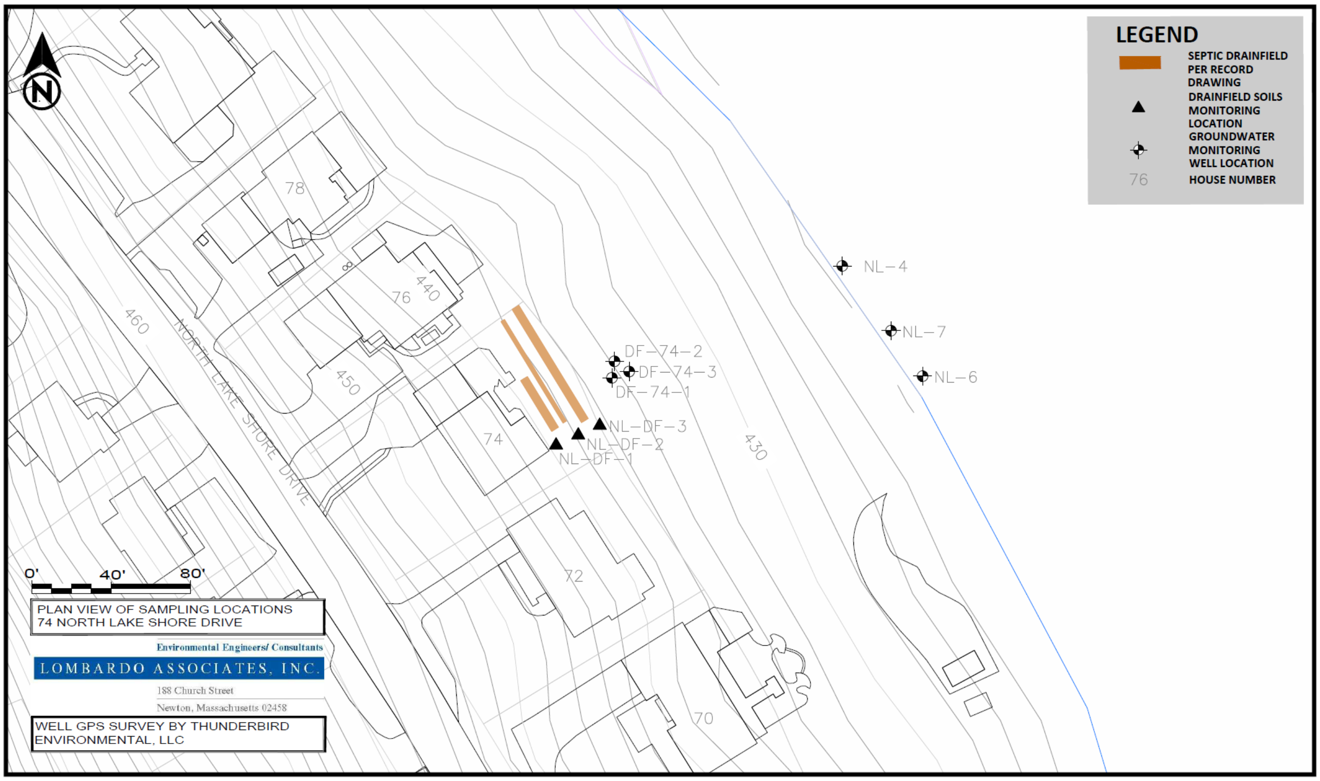


Figure 2-6 Site Plan – 74 North Lake Shore Drive

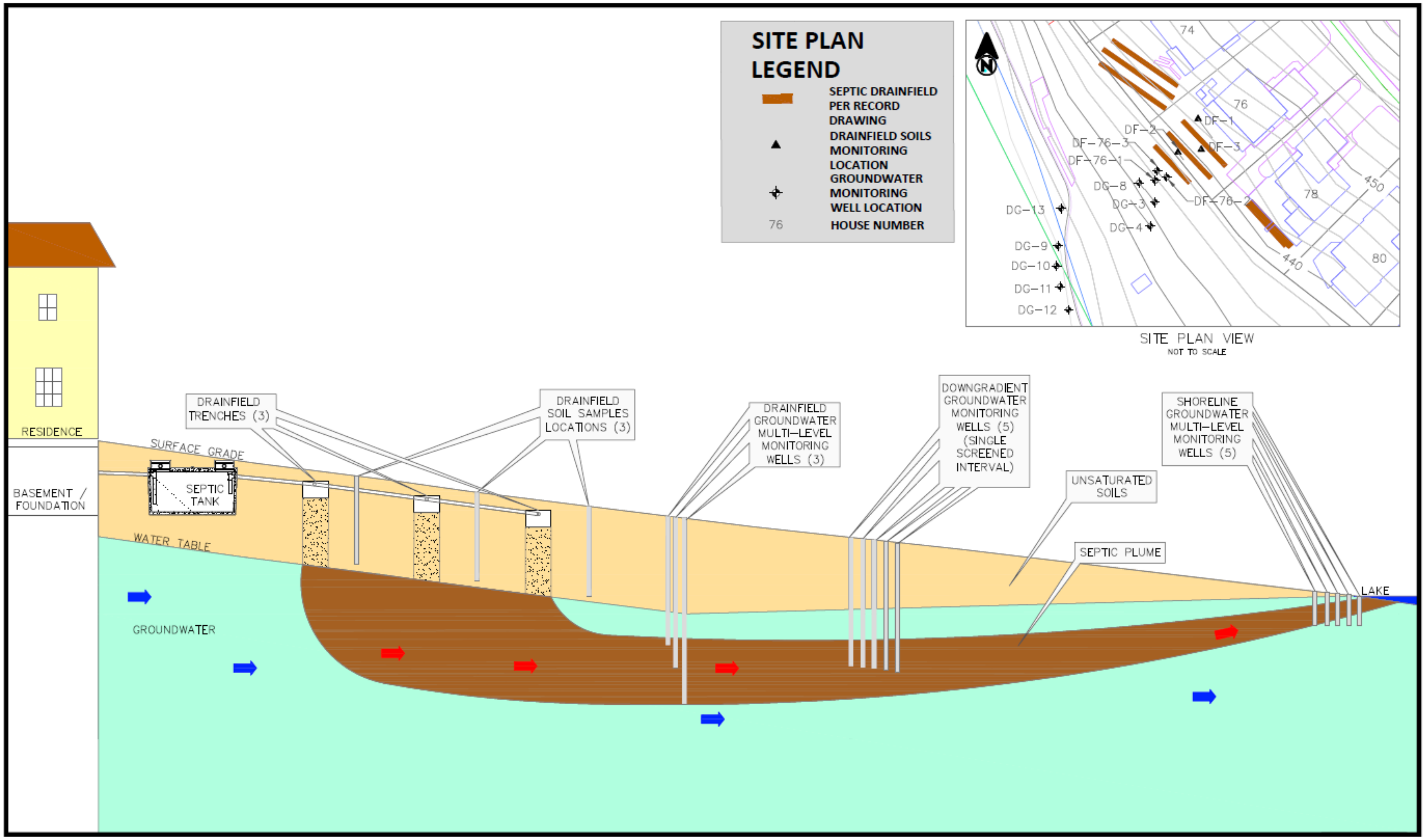


Figure 2-7 Section View of Sampling Locations - 76 South Lake Shore Drive

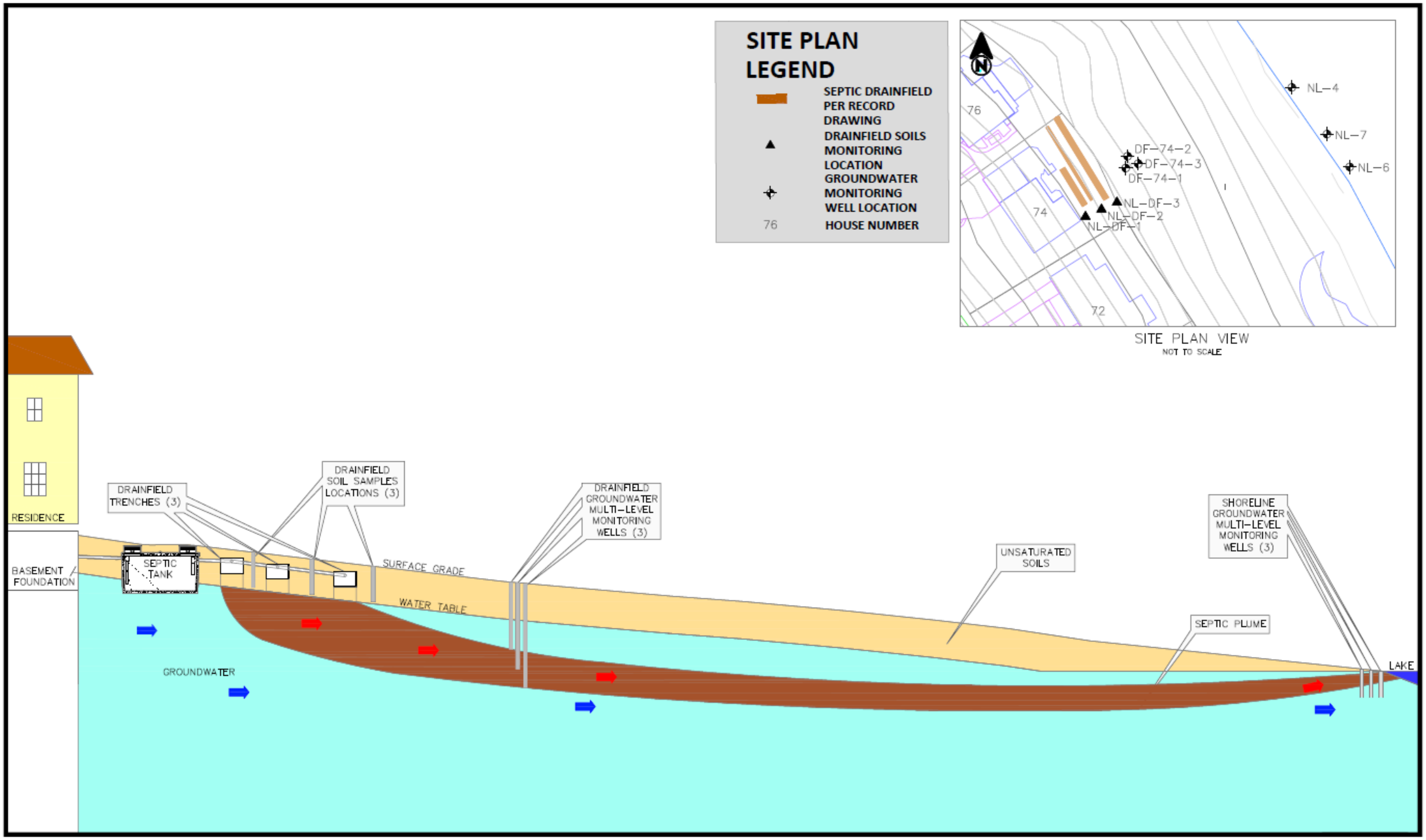


Figure 2-8 Section View of Sampling Locations – 74 North Lake Shore Drive

Data

A.1 Drinking Water Aquifer

Table 2-1 presents the results of water supply sampling with Table 2-2 presenting the drinking water quality data from the water suppliers annual reports. The Chain of Custodies and laboratory reports for the drinking water sampling program are presented in Appendix I.

Septic system influence is strongly suggested by the nitrate-N and PFOA/PFOS concentrations. While determining the amount of the water supplies that is wastewater derived is beyond the scope of this project, the phosphorus concentrations suggest very high levels of septic wastewater phosphorus removal by soils. In accordance with CT guidance, PFOA/PFOS was sampled for twice to confirm concentrations.

Table 2-1 Drinking Water Supply Quality Data

Candlewood Lake Water Supplies - Drinking Water Analysis								
Water Source / Utility			Candlewood Shores	Arrowhead	Aquarion Western	Lake		
Sampling Date			14-Aug-19	22-Aug-19	16-Sep-19	16-Sep-19	18-Dec-19	
	Units	Det. Lim.				@ 76SLSD	@ 76SLSD	
Alkalinity	mg/L as $CaCO_3$	2	166	180				
Chloride	mg/L	10	94	93			33.1	35.1
pH	SU	n/a	7.1	7.5				
Nitrate-N	mg/L	0.100	6.99	6.85			0.67	0.99
TP	mg/L	0.010	0.015	0.017				
ortho-P	mg/L	0.005	0.016	0.018			<0.01	<0.01
Boron (1)	mg/L	0.030	0.054	0.038	ND	ND	<0.05	<0.05
Acesulfame K (2)	ppt-ng/L	100	532	1,040	204	102		
Sucralose	ppt-ng/L	1,000			1,900	ND		
Saccharin	ppt-ng/L	100			ND	ND		
PFOA	ppt-ng/L	1.72	24.6	8.14				
PFOS	ppt-ng/L	1.72	28.3	5.73				
PFOA/PFOS Total	ppt-ng/L	1.72	52.9	13.87				
Sampling Date			04-Sep-19	04-Sep-19	04-Sep-19	04-Sep-19		
PFOA	ppt-ng/L	1.72	20.3	8.69	10.7	3.71		
PFOS	ppt-ng/L	1.72	24.7	7.5	13.1	2.14		
PFOA/PFOS Total	ppt-ng/L	1.72	45.0	16.19	23.8	5.85		

(1) Sampled 4 Sept 2019 (2) Level of Quantification (LOQ) ND=Non Detect

Table 2-2 Study Area Water Supply Quality from Annual Reports

Water System		Nitrate (NO_3-N) Conc. (mg/L)		Sodium (Na) Conc. (mg/L)		Chloride (Cl) Conc. (mg/L)	
No.		MCL	Latest Actual	NL	Latest Actual	NL	Latest Actual
1	Aquarion - Candlewood Acres	10	0.7	28	16.2	250	7
2	Aquarion of Western Brookfield		3.5		53		53
3	Arrowhead Point HO Ass'n		7.9		24.8		100
4	Candlewood Lake Club		1.3		6.46		8.4
5	Candlewood Orchards		0		9.9		3.4
6	Candlewood Shores Tax District		7.5		31		31
7	Food establishments on well -TNC						
8	Hickory Hills - Aquarion		0.5		8.1		7.1
9	Woodcreek Village Condo Ass'n		0.7		18.7		129
	MCL = Maximum Contaminant Level						
	NL = State of Connecticut customer notification level. Elevated levels of sodium, coupled with dietary intake, can potentially affect those on a sodium-restricted diet.						

A.2 Candlewood Lake Water Quality - Septic Tracers Sampling

Table 2-1 also presents the results of Candlewood Lake water sampling for septic tracers of boron, ACE and PFOA/PFOS. The Chain of Custodies and laboratory reports for the Candlewood Lake septic tracers sampling program are presented in Appendix II.

A.3 Septic Wastewater Purification

Table 2-3 presents the chronology of data collection. Detailed information on installed wells is presented in Section 2.2.

To identify plumes from nearby property septic systems along 74-84 SLSD and septic influences from further upgradient sources, groundwater quality data was collected along an approximate 500 foot cross section of a large area owned by FirstLight – located between the properties along 74 – 84 South Lake Shore Drive (SLSD) and Candlewood Lake. The data is presented on Table 2-4.

Tables 2-4 and 2-5 present septic tank and groundwater quality data for the sampling events of 17 Oct 2019, 4 Nov 2019 and 18-23 Dec 2019 for 76 SLSD / 4 Longview and 74 NLSD, respectively. The Chain of Custodies and laboratory reports for the septic wastewater purification sampling program are presented in Appendix III.

Table 2-6 presents groundwater pH and Electric Conductivity (EC) field measurements at the shoreline down gradient wells.

Figure 2-9 presents the Groundwater Seep Location Map & Quality Data that has been collected by FirstLight. The data is owned by FirstLight Power and was collected by North East Aquatic Research at the request of FirstLight Power.

Appendix V presents the report on septic drainfield soils retention at the three study sites.

Table 2-3 Chronology of Field Data Collection

Chronology of Candlewood Lake Drainage Area Wastewater Data Collection

Reporting Date	Activity	Locations	76 SLSD	4 LVD	74 NLSD	Water Supply	CL
8/22/2019	Samples collected for: Chloride, pH, Ammonia, Nitrate-N, Ortho-phosphate, Total Phosphorus, Alkalinity	CL					✓
8/29/2019	Samples collected for: PFOA/PFOS, Chloride, pH, Ammonia, Nitrate-N, Ortho-phosphate, Total Phosphorus, Alkalinity	CS				✓	
9/10/2019	Samples collected for: PFOA/PFOS, Chloride, pH, Ammonia, Nitrate-N, Ortho-phosphate, Total Phosphorus, Alkalinity	AR				✓	
9/11/2019	Samples collected for: Boron	AR, CS, CL, WA				✓	✓
9/12/2019	Samples collected for: Acesulfame K	AR				✓	✓
9/23/2019	Samples collected for: PFOA/PFOS, Boron	AR, CS, CL, WA				✓	
9/27/2019	Samples collected for: Acesulfame K	WA, CL				✓	✓
9/30/2019	Installation of Down Gradient wells	SLDS 74 to 84					
10/4/2019	Samples collected for: Nitrate-N, Total Phosphate, Total Phosphorus	[1]	✓	✓	✓		
10/18/2019	Installationof shore line wells and drain field soil sample collection	76 SLSD + 74 NLSD					
10/23/2019	Samples collected for: Chloride, Ammonia, TKN, Nitrate-N, Ortho-phosphate, Total Phosphorus, Boron	[2]	✓	✓	✓		
10/24/2019	Installation of Drain Field monitoring wells	76 SLSD + 74 NLSD					
11/7/2019	Samples collected for: Acesulfame K	[3]	✓		✓		
11/12/2019	Samples collected for: Chloride, Ammonia, TKN, Nitrate-N, Ortho-phosphate, Total Phosphorus, Boron	[4]	✓		✓		
11/15/2019	Samples collected for: Acesulfame K	[5]	✓		✓		
11/20/2019	Installation of ground water elevation continuous monitoring equipment at 76 SLSD & 74 NLSD	76 SLSD + 74 NLSD					
12/18/2019 12/23/2019	Samples collected for: PFOA/PFOS, Acesulfame K, Chloride, pH, Ammonia, Nitrate-N, Ortho-phosphate, Total Phosphorus, Alkalinity	76 SLSD, 4 LVD + 74 NLSD	✓	✓	✓		✓

Foot Notes

[1] SLSD (DG-1, DG-2, DG-3, DG-4, DG-5, DG-6, DG-7, DG-8)

[2] SLSD (Septic Tank, DG-13-2, DG-13-3), LV (Septic Tank), NL (Septic Tank, NL4-1, NL7-1)

[3] SLSD (Septic Tank, DG-9-2, DG-13-2, DG-13-3), LV(Septic Tank), NL(Septic Tank, NL-4-1, NL-6-1.5, NL-7-1)

[4] SLSD (DF-76-1, DF-76-2, DF-76-3, DG-9-2, DG-10-2, DG-13-2, DG-13-3), NL(DF-74-1, DF-74-2, DF-74-3, NL-4-1, NL-6-1.5)

[5] SLSD (DF-76-1, DF-76-2, DF-76-3), 74 NL (DF-74-1, DF-74-2, DF-74-3)

Legend

CL: Candlewood Lake

CS: CandleWood Shores

AR: Arrowhead

WA: Western Aquarion

Table 2-4 76 SLSD & 4 LV Consolidated ST and Groundwater Quality Data

76 South Lake Shore Drive Site											
	EC^2 (uS/cm)	pH^2	SRP (mg/L)	TP (mg/L)	Cl (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	TKN (mg/L)	ACE (ng/L)	B (mg/L)
STE Oct 17, 2019	14,000	6.1	2.36	2.56	200	1.6		19.5	21.2	60,800	0.71
STE Dec 18, 2019			4.12	6.63	228	<0.02		63	83.4	131,000	<0.25
Drainfield Wells Dec 18, 2019											
76-DF1	1,358	7.4	0.01	0.01	331	11.4		0.83		14,400	0.12
76-DF2	1,374	7.6	0.01	0.01	370	8.6		1.01		16,300	0.15
76-DF3	1,392	7.6	0.01	0.01	354	12.3		1.02		11,500	0.2
Drainfield Wells Dec 18, 2019											
76-DF1			<0.01		312	9.7	1.3			11,400	0.18
76-DF2			<0.01		405	6.73	0.417			14,200	0.18
76-DF3			<0.01		304	9.65	1.25			10,900	0.25
Down Gradient wells Oct 2, 2019											
76-DG1			0.04			11.5					
76-DG2			0.58			14.5					
76-DG3			0.11			9.5					
76-DG4			0.03			4.9					
76-DG5			0.04			5.5					
76-DG6			0.04			5.6					
76-DG7			0.09			4.8					
76-DG8			0.72			14.6					
Average			0.21			8.86					
Down Gradient wells Dec 18, 2019											
76-DG1			0.01			12.2	<0.01				
76-DG2			<0.01			12.3	<0.01				
76-DG3			<0.01			5.85	<0.01				
76-DG4			<0.01			5.7	0.058				
76-DG5			0.02			0.79	<0.01				
76-DG6			0.02			0.47	<0.01				
76-DG7			0.01			4.87	<0.01				
76-DG8			<0.01			5.6	<0.01				
Down Gradient (lakeshore) Wells Oct 17, 2019											
76-DG9-2	631	6.7								2.4	
9-3	660	6.2									
9-4PVC	720	7.1									
76-DG10-1	225	6.4									
10-2	212	6.1								<0.1	
10-3	250	6.7									
10-3PVC											
76-DG11-1	248	6.9									
-2	288	6.6									
-3	280	7									
-3PVC	318	7.1									
76-DG12-1	298	6.7									
-2	265	7.1									
-2PVC	297	7.4									
76-DG13-2	207	7	0.04	0.05	21	3.4		ND		5.4	ND
-3	654	6.2	0.02	0.03	100	6.1		ND		8.3	0.07
-4	542	6.2									

76 South Lake Shore Drive Site											
	EC[2] (uS/cm)	pH[2]	SRP (mg/L)	TP (mg/L)	Cl (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	TKN (mg/L)	ACE (ng/L)	B (mg/L)
Down Gradient (lakeshore) Wells Nov 4, 2019											
76-DG9 -2	684	6.1	0.011	0.016	163	7.5		<0.05			0.07
76-DG10-2	170	6.2	0.011	0.017	23	12.4		<0.05			0.09
76-DG13-2	1,073	6.1	0.011	0.013	270	12.4		<0.05			0.09
76-DG13-3	1,025	6	<0.01	0.022	299	14.1		<0.05			0.1
Down Gradient (lakeshore) Wells Dec 18, 2019											
76-DG9 -2			0.01		198	11.4	<0.01				0.06
76-DG10-2			<0.01		38	4.98	<0.01				<0.03
76-DG13-2			<0.01		304	13.5	<0.01				0.09
76-DG13-3			0.01		316	14.7	<0.01				0.09

LV Site											
	EC[2] (uS/cm)	pH[2]	SRP (mg/L)	TP (mg/L)	Cl (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	ACE (ng/L)	TKN (mg/L)	B (mg/L)
Tank Effluent (1) Oct 17/19	1,377	7	6.1	5.5	140	ND		40	27,000	44	0.076
Tank Effluent (2) Dec 18, 19			4.71	5.9	136	<0.02	0.014	43.7	2,000	54	0.07

Table 2-5 74 NLSD Consolidated ST and Groundwater & Lake Quality Data

NL Site (74 North Lake Shore Drive)											
	EC[2] (uS/cm)	pH[2]	SRP (mg/L)	TP (mg/L)	Cl (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	TKN (mg/L)	ACE (ng/L)	B (mg/L)
Tank Effluent (1) Oct 17/19	1,252	6.8	4.3	4.8	140	0.3		14.2	37.4	57,000	0.062
Tank Effluent (2) Dec 18, 19			3.83	4.37	135	<0.02	<0.01	43.3	47.5	39,000	0.06
Drainfield Wells, Nov 4, 2019											
NL-DF1	588	7.6	0.01	0.03	38	10.3		<0.1		906	<0.05
NL-DF2	634	7.1	0.01	0.01	62	6.4		<0.1		3,620	<0.05
NL-DF3	642	7.1	0.01	0.05	70	4.9		<0.1		6,240	<0.05
Drainfield Wells, Dec 23, 2019											
NL-DF1			0.01		36	10.7	0.011			1	<0.05
NL-DF2			0.01		62.2	6.05	<0.01			6	<0.05
NL-DF3			0.01		85	2.63	<0.01			12	<0.05
Down Gradient (lakeshore) wells Oct 17, 2019											
NL4-1	660	6.7	0.02	0.02	44	3.2		ND		454	0.044
4-2											
4-2.5PVC	698	7.3									
NL6-1	906	7.1									
6-1.5	872	6.9								198	
6-2PVC	700	7									
NL7-1	958	6.6	0.02	0.02	84	0.88		0.09		2,600	0.12
7-1.5											
7-2PVC	965	6.8									
Down Gradient (lakeshore) wells Nov 4, 2019											
NL4-1	403	7	0.012	0.016	38	1.7		0.07			<0.05
6-1.5	752	7	0.013	0.014	63	5.8		<0.05			0.06
Down Gradient (lakeshore) wells Dec 23, 2019											
NL7-1			0.01		76.1	1.14	<0.01				0.01

Candlewood Lake												
		EC[2] (uS/cm)	pH[2]	SRP (mg/L)	TP (mg/L)	Cl (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	B (mg/L)	PFOA ng/L	PFOA ng/L	Total PFOA+PFOS ng/L
at 76 SLSD	18-Dec-19			<0.01		33.1	0.67	0.011	<0.05	2.95	3.27	6.22
at 74 NLSD	23-Dec-19			<0.01		35.1	0.99	0.011	<0.05			

Table 2-6 Septic Tank & Shoreline Groundwater pH and EC data

ST & Shoreline Groundwater pH & EC Data October 17, 2019				
76 South Lake Shore Drive - Field Measurements				
Well ID	DBGS (feet)	Yield*	EC (uS/cm)	pH
Septic Tank			14,000	6.1
DG-9	2	G	631	6.1
	3	G	660	6.2
	4	P	720	7.1
DG-10	1	G	225	6.4
	2	G	212	6.1
	3	F	250	6.7
	3	P		
DG-11	1	G	248	6.9
	2	G	288	6.8
	3	P	280	7
	3	F	318	7.1
DG-12	1	G	298	6.7
	2	G	265	7.1
	2	P	297	7.4
DG-13	2	G	207	7
	3	G	654	6.2
	4	G	542	6.1
74 North Lake Shore Drive - Field Measurements				
Septic Tank	DBGS		1,252	6.8
NL-4	1	G	660	6.7
	2	P		
	2.5	P	698	7.3
NL-6	1	F-G	906	7.1
	1.5	F-G	872	6.9
	2	F-G	700	7
NL-7	1	G	958	6.6
	1.5	P		
	2	G	965	6.8
4 Longview Drive - Field Measurements				
Septic Tank			1,377	7.2
Notes: DBGS = Depth Below ground surface				
* Yield of Well P=Poor; F=Fair; G=Good; VG = Very Good				

Study Area Groundwater Seeps Water Quality Data[1]
(parts/million - mg/L)

Date	Seep # / Location	NO_X	TN	TP
4-Feb-19	9	2.7	3.24	0.030
	12	1.59	2.13	0.061
	17	4.79	5.27	0.035
	18	9.12	7.26	0.013
	19	9.66	7.38	0.017
	20	8.11	7.08	0.014
	21	6.54	6.49	0.009
	23	2.14	2.53	0.022

(1) Data provided by Firstlight Power

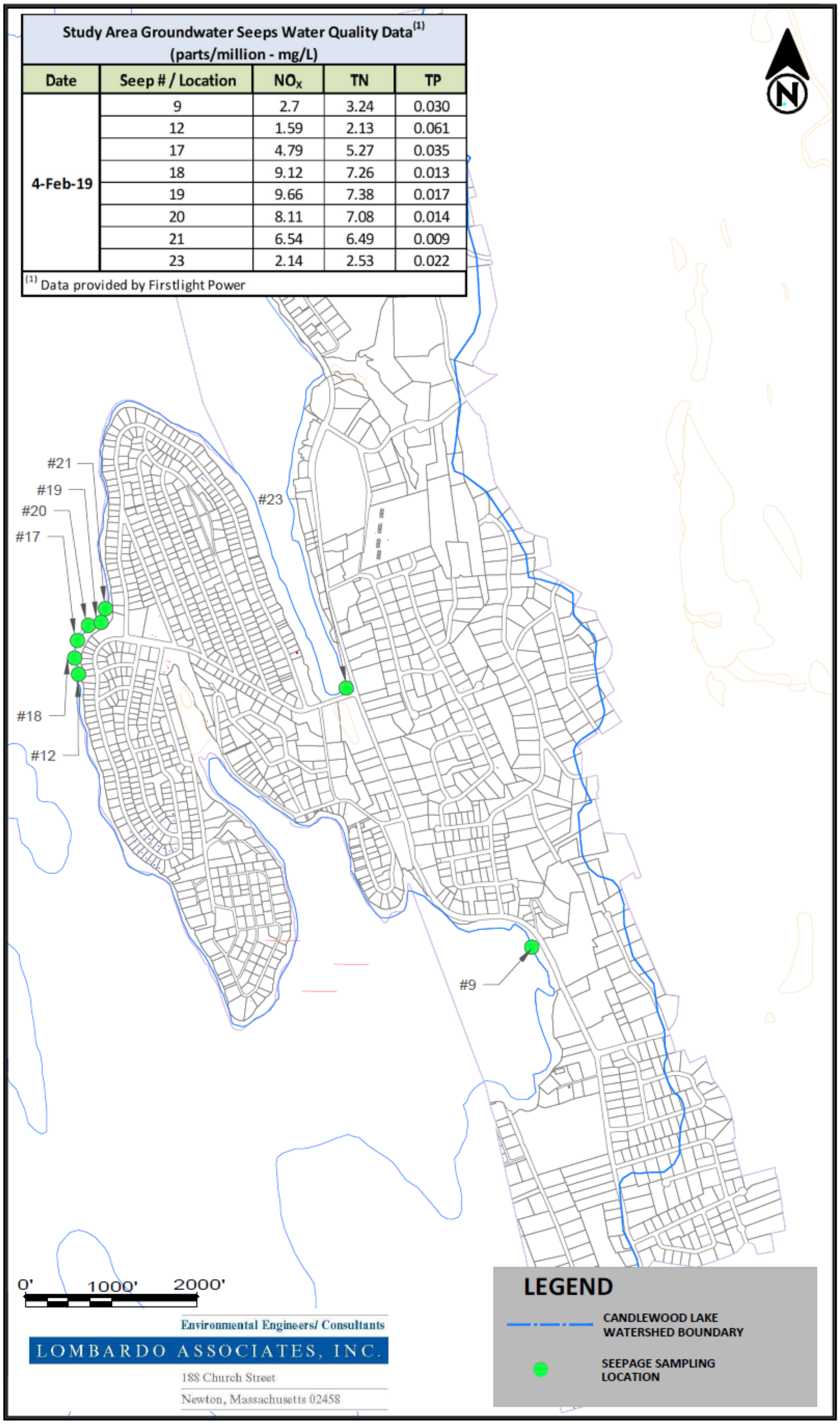


Figure 2-9 Groundwater Seep Location Map & Quality Data

2.2 GROUNDWATER CONTOURS, SLOPES AND FLOW

To estimate groundwater flow direction and rate, the following was performed:

- groundwater monitoring wells top of casings were surveyed by CCA Engineering of Brookfield,
- depth to groundwater measurements were continuously monitored using a Hobo data logger at 76 SLSD well DF-76-1 and 74 NLSD well DF-74-1,
- manual depth to groundwater measurements were taken periodically at wells DG-76-1 through DG-76-8,
- Candlewood Lake elevations were obtained periodically from Firstlight at Lake Level 24 Hour Phone Line: 888-417-4837 and adjusted to NAVD 88

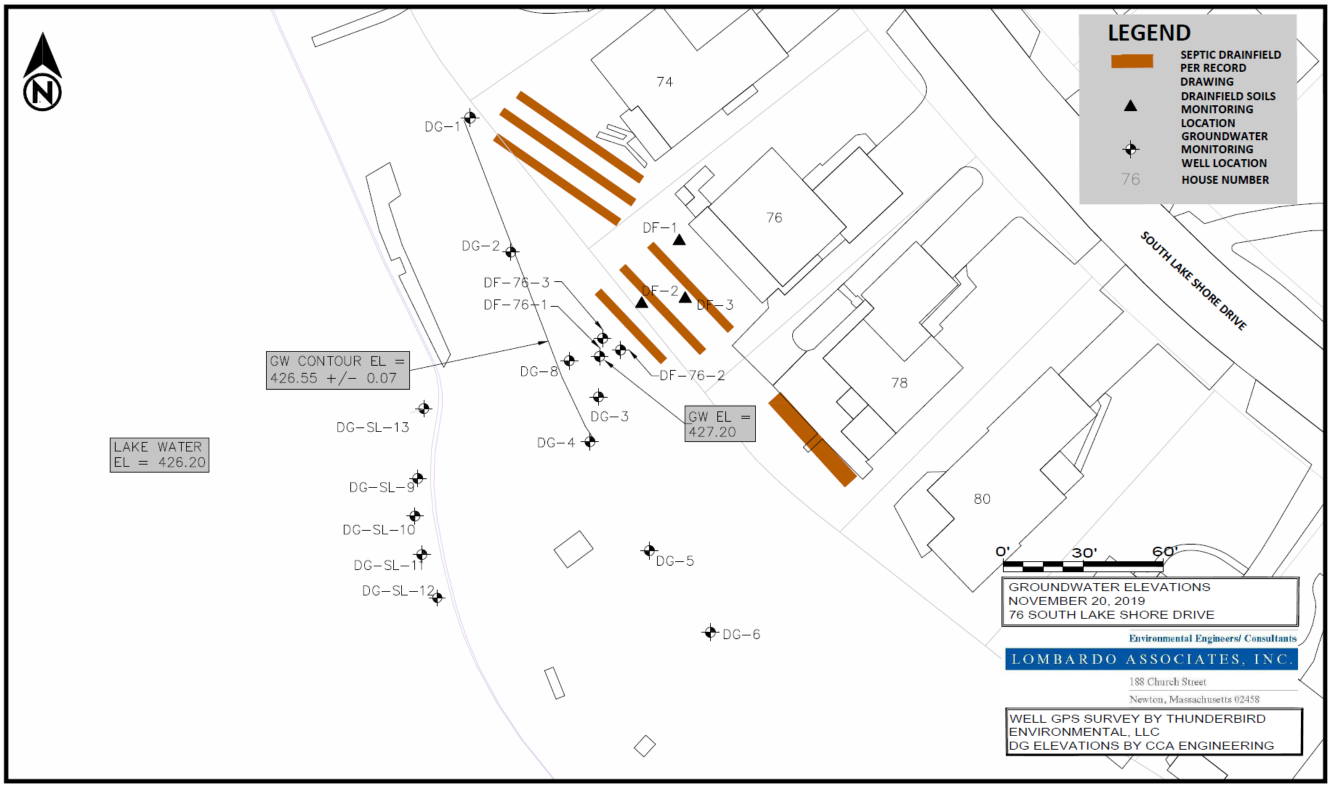
Table 2-7 presents the groundwater and Candlewood Lake elevation data and calculated groundwater slopes for 76 South Lake Shore Drive and 74 North Lake Shore Drive sites for various measurement dates. **Based upon the groundwater and Lake elevation data, groundwater linear velocity range for the examined period was approximately 0.2 to 3.5 feet/day at 76 SLSD and 1.07 to 1.27 feet/day at 74 NLSD.**

Table 2-7 Groundwater Elevation Data 76 SLSD & 74 NLSD

Groundwater Elevation Data - 76 South Lake Shore Drive													
K	6	porosity	0.25	20-Nov-19	Lake Elev.	426.20			18-Dec-19	Lake El.	426.40		
Well Name	TOC Elev	Screened Interval (feet into GW)	Distance to Lake (feet)	TOC Depth to GW (ft)	GW Elevation (ft)	GW Slope to Lake (%)	GW slope - DF to DG	GW Linear Velocity (ft/day)	TOC Depth to GW (ft)	GW Elevation (ft)	GW Slope (%)	GW slope to DG	GW Linear Velocity (ft/day)
DF-76-1	437.72	0-1.5	74.01	10.52	427.20	1.35%	6.37%	1.53		430.10	5.00%	14.42%	3.46
DF-76-2		1.5-3	82.25										
DF-76-3		3-5	77.26										
DG-76-1	435.22	5	60.36	8.61	426.61	0.68%		0.16	7.35	427.87	2.44%		0.58
DG-76-2	432.74	5	54.80	6.21	426.53	0.60%		0.14	5.56	427.18	1.42%		0.34
DG-76-3	432.48	5	68.85	5.91	426.57	0.54%		0.13	4.05	428.43	2.95%		0.71
DG-76-4	430.76	5	60.50	4.17	426.59	0.64%		0.15	2.51	428.25	3.06%		0.73
DG-76-5	431.89	5	68.76						3.22	428.67	3.30%		0.79
DG-76-6	432.41	5	80.82						3.65	428.76	2.92%		0.70
DG-76-7	432.12	5	63.92						4.19	427.93	2.39%		0.57
DG-76-8	432.44	5	62.71	5.96	426.48	0.45%		0.11	3.97	428.47	3.30%		0.79

Groundwater Elevation Data - 74 North Lake Shore Drive										
K	6	porosity	0.25	20-Nov-19	Lake Elev.	426.2		18-Dec-19	Lake Elev.	426.4
Well Name	TOC Elev	Screened Interval (feet into	Distance to Lake (feet)	TOC Depth to GW (ft)	GW Elevation (ft)	GW Slope (%)	GW Linear Velocity (ft/day)	GW Elevation (ft)	GW Slope (%)	GW Linear Velocity (ft/day)
DF-74-1	436.68	0-1.5	122.89	5.00	431.68	4.46%	1.07	432.90	5.29%	1.27
DF-74-2		1.5-3	117.12							
DF-74-3		3-5	113.94							

Figure 2-10 presents groundwater contour maps for 76 South Lake Shore Drive and 74 North Lake Shore Drive sites on November 20, 2019.



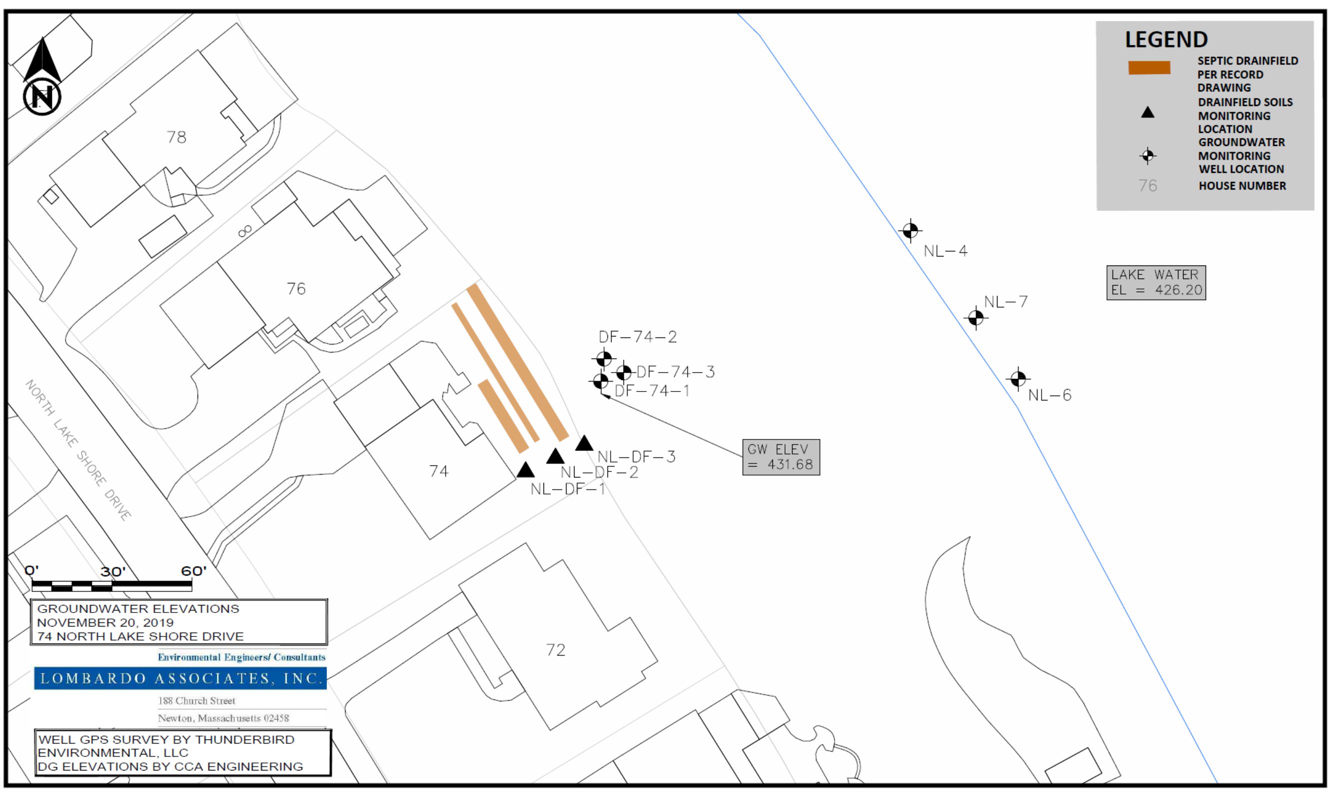


Figure 2-10 Groundwater Contour Maps – 76 SLSD & 74 NLSD – Nov. 20, 2019

3 SYSTEM QUESTIONNAIRE – FUNCTIONAL PERFORMANCE ANALYSIS

A septic system questionnaire, with a representative copy along with the response statistics as prepared by the WPCA in Appendix IV, was sent to all property owners in the Study Area. A summary of the questionnaire results is presented on Table 3-1 with details in Appendix IV.

Table 3-1 Septic System Questionnaire Results

Questionnaire Responses Summary			
	No.	Percentage of Developed Properties	Properties with a Septic Issue as % of Responses
Developed Properties	1,338		
Responses	550	41.1%	
Properties Reporting a Septic Issue	148		26.9%

4 AVAILABLE AREA ANALYSIS – SPACE NEEDS

Each Study Area lot was analyzed to determine whether there is sufficient space to site a CT DoH code compliant conventional onsite wastewater treatment system (OWTS), i.e. septic system – with no changes to the building footprint and no code variances.

For analytical purposes, for a parcel to be classified as having sufficient space for a Code compliant OWTS, the available area must be greater than the total required area plus a reasonable safety factor. Available and required area are defined as follows:

Available Area is calculated as the area remaining after buildings and applicable setbacks from property lines, buildings and other items are subtracted from the total parcel area. The remaining area is termed the parcel's Available Area**.**

Required Area is the OWTS footprint per Code for the site's use plus required Reserve Area. The required septic tank and drainfield area is determined by using DoH code, the site's design wastewater flow and percolation rate. For properties without percolation data, soil texture is used to estimate an approximate percolation rate. As Study Area soils are predominately fine sandy loams, a percolation rate of 20 mpi is used. Reserve area equal to 50% of the required drainfield area is used.

Available Area Determination

The available area on a parcel is defined as the area on a parcel that is not used by a building and is not within a setback buffer area from a building or property line. The minimum separation requirements for OWTS are listed below.

- Property line 10'
- Building 10'
- Groundwater Drain 25'
- Stormwater Catch Basin/MH 25'
- Wetlands 75'
- Streams 100'
- Public Water Supply Wells 200'

While the Town has jurisdiction for activities within 200' of Candlewood Lake shoreline, no minimum separation distances of the septic system components to the shoreline are being used. There are approximately 215 Study Area properties within 200' of Candlewood Lake and approximately 193 Peninsula properties within 200' of Candlewood Lake.

Properties were categorized in the following 3 categories:

- ***<u>Code Compliant System Not Feasible – Off-site Solution Likely Required</u>***. Properties in this category have available area that is less than 120% of the required area. While the total available area may exceed the required area, the likelihood of engineering a Code compliant layout within the available footprint is very low.

- ***<u>Code Compliant System Potentially Feasible – Case by Case Analysis</u>*** Properties in this category have available area between 120% - 200% of required area. These properties are better candidates for a code complaint system. However, the shape and location of the available area may not be conducive for a Code compliant system.

- ***Code Compliant System Likely Feasible*** Properties in this category have available area that is greater than 200% of the required area. These properties have a high likelihood of being able to site a Code compliant system.

Tables 4-1 and 4-2 present summaries of Study Area developed parcels within each of the above categories for the entire Study Area and Peninsula – where the vast majority of the problem sites are located - respectively.

Table 4-1 OWTS Available Area – Study Area Property Totals

OWTS Space Analysis Category - Study Area	# of Developed Parcels	% of Developed Parcels
Code Compliant Septic System Not Feasible - Off-site Solution Likely Required	266	19.8%
Code Compliant Septic System Potentially Feasible - Case by Case Analysis	169	12.6%
Code Compliant Septic System Likely Feasible	911	67.7%
Total	1,346	100%

Table 4-2 OWTS Available Area – Peninsula Parcels Only

OWTS Space Analysis Category - Peninsula Properties Only	# of Developed Parcels	% of Developed Parcels
Code Compliant Septic System Not Feasible - Off-site Solution Likely Required	229	32.6%
Code Compliant Septic System Potentially Feasible - Case by Case Analysis	143	20.3%
Code Compliant Septic System Likely Feasible	331	47.1%
Total	703	100%

Required Area Determination

In order to design a Code compliant septic system, the required effective area must be calculated. This area is defined as the minimum area into which wastewater can be disposed of. The required area is a function of:

- Required Effective Leaching Area
- Leaching system effective area (ft^2 / LF)
- # of trenches/rows required

- Required minimum spacing between the rows

Minimum effective leaching areas are based on Code defined criteria. For residential systems, it is based on the percolation rate of the soils and the number of bedrooms in the residence. Table 4-3 presents the Code required minimum effective leaching area as a function of percolation rate and number of bedrooms.

Table 4-3 Code Required Effective Leaching Area for Residential Buildings

Percolation Rate	Square Feet of Required Effective Leaching Area (ELA)				
(Minutes to Drop One Inch)	2-Bedroom Building	3-Bedroom Building	4-Bedroom Building	For Each Bedroom Above 4	
				Single Family	Multi-family
LESS THAN 10.1	375	495	660	82.5	165
10.1-20.0	500	675	900	112.5	225
20.1-30.0	565	750	1000	125	250
30.1-45.0	675	900	1200	150	300
45.1-60.0	745	990	1320	165	330

Non-residential buildings are divided into two categories:

- Problematic Sewage, which covers restaurants, bakeries, food service establishments, residential institutions, laundromats, beauty salons and similar uses
- Non-Problematic Sewage, which covers all other uses.

Tables 4-4 and 4-5 present the hydraulic loading rate (HLR) based on percolation rate for the above two categories. The effective leaching area is calculated by dividing the design flow by the HLR as presented in the following formula:

Minimum Effective Leaching Area = Design Wastewater Flow / Hydraulic Loading Rate

Table 4-4 Code Application Rate for Problematic Sewage

Percolation Rate (Minutes to Drop One Inch)	Application Rate (GPD per square foot of ELA)
LESS THAN 10.1	0.8
10.1 to 20.0	0.7
20.1 to 30.0	0.6
30.1 to 45.0	0.5
45.1 to 60.0	0.4

Table 4-5 Code Application Rate for Problematic Sewage

Percolation Rate (Minutes to Drop One Inch)	Application Rate (GPD per square foot of ELA)
LESS THAN 10.1	1.5
10.1 to 20.0	1.2
20.1 to 30.0	0.9
30.1 to 45.0	0.7
45.1 to 60.0	0.6

Once the minimum effective leaching area has been determined, a conceptual layout is required to calculate the footprint that a Code complaint system will require. To do this, the following was assumed for each property:

- Eljen Mantis System with a linear loading rate of 11-gpd/ft^2 used
- Trench Length assumed to be 35-ft
- 12-ft spacing required between each trench

To calculate the minimum required area, the following steps were taken:

- Effective Leaching Area was divided by 11-gpd/ft^2 to determine the total length of trench needed
- Total trench length was divided by 35-ft to determine the number of rows required
- Total required area was calculated using the Mantis trench width of 3-ft, spacing at 12-ft and the total number of rows required

The septic tank and distribution box represent a small portion of the total required area. The required area for these components was assumed to be 150-ft^2.

The final piece of required area is reserve area. The Code requires "an acceptable reserve leaching area of suitable soil" without defining the exact amount. For the purpose of this analysis, a 50% reserve area is assumed to be required for future expansion / trench replacement. The total required area is calculated as follows:

Total Required Area = Septic Tank / D-Box + Minimum Leaching Area + Reserve Area

Tables 4-1 and 4-2 presented the number of properties that fall into the three defined available area categories. Figures 4-1 and 4-2 illustrate the results of the Available Area Analysis on a parcel by parcel basis, for the entire Study Area and Peninsula – where the vast majority of the problem sites are located - respectively.

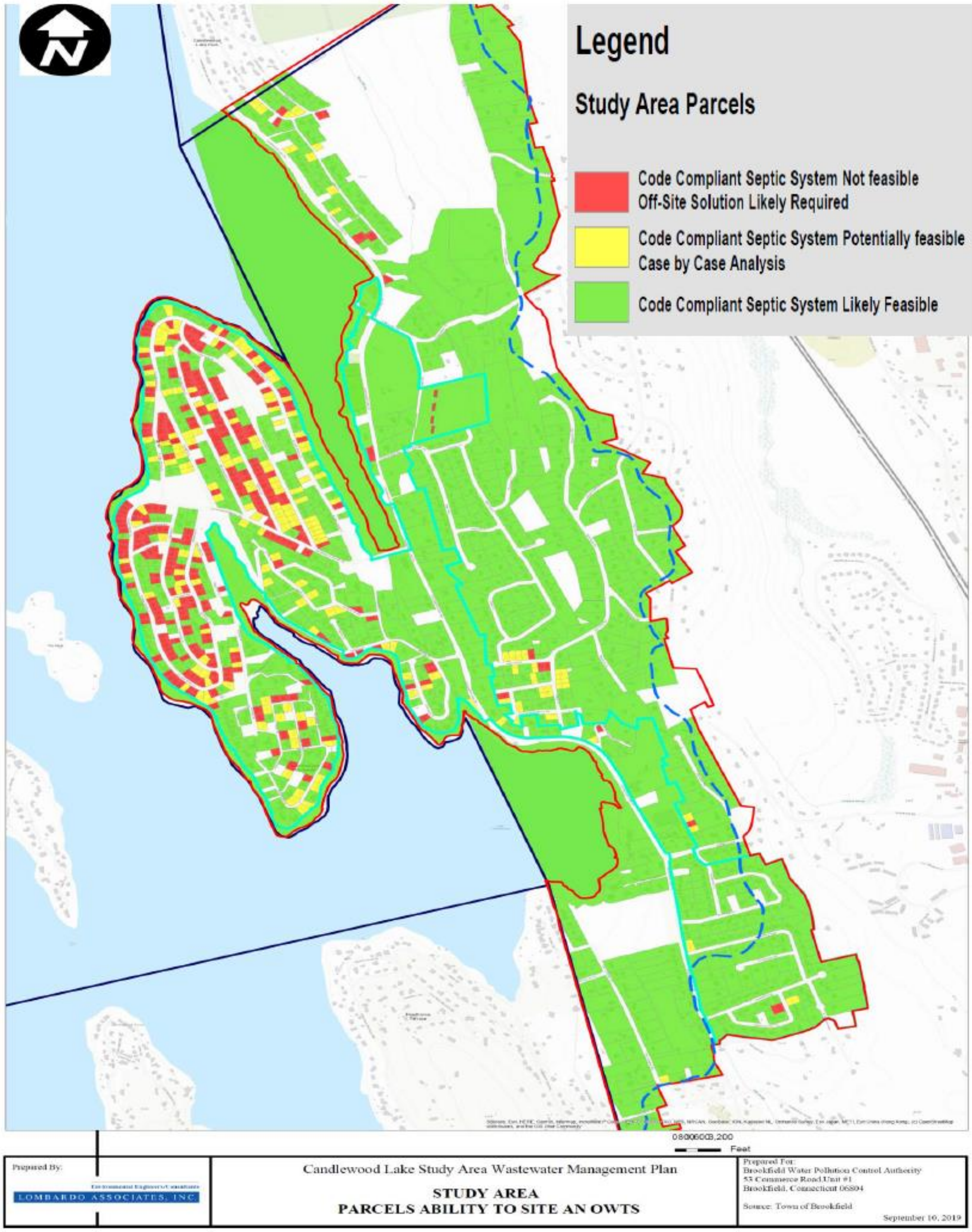


Figure 4-1 Parcels Space Ability to Site an OWTS

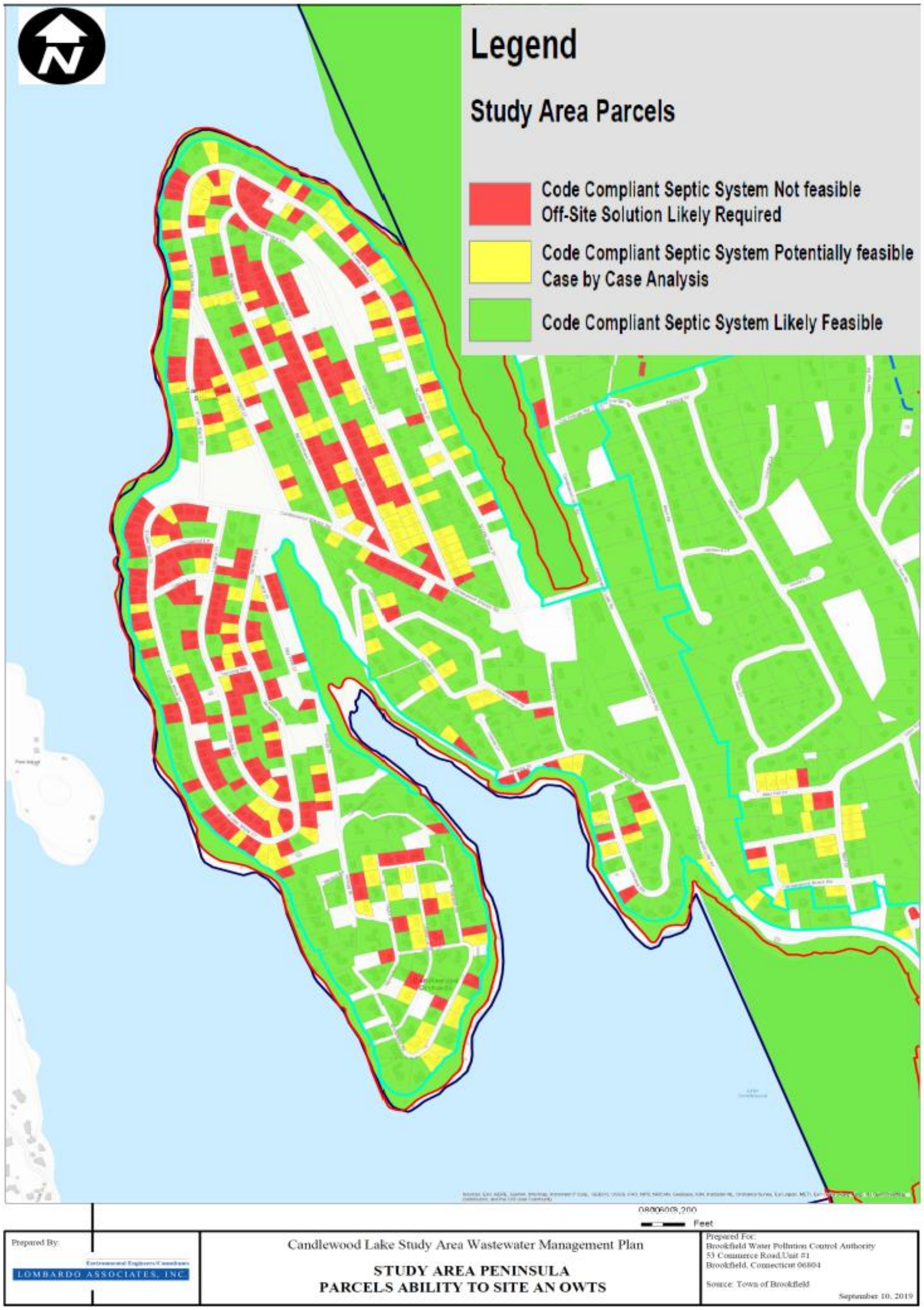


Figure 4-2 Peninsula Parcels Space Ability to Site an OWTS

5 CONCLUSIONS – NEEDS ANALYSIS

5.1 PERFORMANCE NEED

5.1.1 IMPACT ON QUALITY OF CANDLEWOOD LAKE

Table 5-1 presents the incremental increase in phosphorus and nitrogen concentrations based upon the soils removal / attenuations as described in Chapter 2.

Table 5-1 Septic N & P Discharges to & Impact on Candlewood Lake

Estimated Household N & P dischares to Drainfield & Lake		
Flow (gpd)	100	
	Phosphorus	**Nitrogen**
Septic Tank Effluent Nutrient Conc. (mg/L)	7	65
Nutrient Loading (lbs/yr)	2.1	19.8
Estimated Percent Attenuation/Removal	90%	50%
Nutrient Loading to Lake (lbs/yr)	0.21	9.9
(1) Phosphorus STE conc. average of 10 years of data for MA sites		
Brookfield Contributions to Candlewood Lake P & N Levels		
Number of Households	1,346	
Nutrient Loading to Lake (lbs/yr)	287	13,316
Nutrient Loading to Lake (kg/day)	0.4	16.6
Lake Volume Annual Turnover (gal)	15,690,909,000	
Incremental P & N conc. (ug/L) due to septic discharges	2.2	102
All Towns Contributions to Candlewood Lake P & N Levels		
Brookfield Septics as % of Total in Watershed	25%	
Watershed wide Incremental P & N conc. (ug/L) due to septic discharges	8.8	407

Table 5-1 illustrates that with 90% P removal by soils, septic wastewater will increase Lake P levels by approximately 9 ppb. As the target Lake P concentration for good water quality is 10 +/- ppb, this Needs analysis conclusion is that septic wastewater P needs to be reduced.

Lake studies over the years, which are summarized in Section 4 of the Task 1 Report show that

1. Phosphorus is the limiting nutrient
2. Sediments are a major contributor to P levels in the Lake, in particular in late summer. It is noted that many Lake blooms occur in late summer – early fall, appear to be fed by phosphorus and nitrogen from deep waters that are released from sediments.
3. Sediment nutrients are a legacy problem – caused by decades of algae growth which was accelerated / enhanced by septic phosphorus discharges since 1950s – for over 60 years.

Removing septic discharges will arrest to some extent the eutrophication process. Coupled with a plan for reducing sediment phosphorus release is this study's recommendation for Candlewood Lake water quality restoration and protection.

This recommendation has been submitted to a group of Lake water quality experts for peer review on December 18, 2018 who opined that removing septic wastewater discharges would have a positive impact on the milfoil weed and its negative impacts in the Lake. Limnologist Dr. Kenneth Wagner of Water Resource Services LLC opined as follows:

"Wastewater represents a major source of nitrogen (N) and a significant but non-dominant source of phosphorus (P) to Candlewood Lake. Inputs of each are likely to be maximal in the littoral zone of the lake and likely promote the growths of milfoil and green algae mats in that area. The high ratio of N to P in groundwater inputs does not favor cyanobacteria, which are more likely to grow over deeper water where internal loading of P from sediment can be elevated and is likely to have a low ratio of N to P. However, the N and P recycled from the sediment ultimately came from the watershed, including the wastewater inputs, over many years, so management of watershed sources remains a valid approach to improving lake conditions.

Consequently, it is likely that the internal load from sediments will have to be addressed separately, but in answer to the central question of the influence of wastewater on lake water quality, wastewater is a major source of N and a minor source of P and its removal would be a benefit to the lake."

Limnologist George Knoecklein of North East Aquatic Research opined that removing septic wastewater would have a positive impact on milfoil control.

5.1.2 Impact on Groundwater Drinking Water Aquifer

The groundwater aquifer is the water supply and partial recipient of wastewater discharges for much of the study area. As shown on Tables 2-1 and 2-2, the groundwater aquifer water supply for Candlewood Shores (CS) and Arrowhead are negatively impacted by septic discharges. Table 5-2 presents a water balance that strongly suggests that wastewater is a significant percent of the groundwater which is used for water supply and also discharges to the Lake. Based upon soils hydraulic conductivity of 6 feet/day, depth to refusal of 6 +/- feet and the expected significantly lower bedrock hydraulic conductivity, it is expected that the amount of septic wastewater and rainfall infiltration that reaches the water supply bedrock aquifer is a relatively small percent of septic wastewater and rainfall infiltration.

It is noted that the Table 2-1 water supply data and groundwater weep data of Figure 2-9 reasonably agree with the Table 5-2 estimate for nitrogen, while the phosphorus data is approximately 1/3 to 1/10 the Table 5-2 estimate. However, it is noted that the average phosphorus concentration of the eight (8) DG monitoring wells sampled on October 12, 2019 matches the rainfall dilution estimate.

However, it is noted that the CS and AR water supplies have very high nitrate-N levels and nitrate-N public health violations have occurred in the past. Also, the PFOA/PFOS levels are very high. While not violating existing CT and US EPA standards, those standards are under review. Many states have or are considering lowering the standard such that if adopted by US EPA and/or CT, would cause the CS and AR water supplies, and possibly others, to be in violation.

Table 5-2 Septic N & P Discharges & Rainfall Dilution

Brookfield Candelwood Lake Drainage Area Wastewater - Peninsula Only		
Rainfall Dilution of Wastewater		
# Developed Properties		703
	Acres	320
Rainfall Infiltration	(feet/year)	1.0
	gpd	285,700
	gpd/property	410
Average Wastewater Flow (gpd)		70,300
Wastewater + Rain Infil Flow (gpd)		356,000
Average Wastewater Flow (gpd/property)		100
Groundwater Conc. as % of WW Conc.		20%
Wastewater Dilution Factor by Rain		510%
Estimated Groundwater Quality Due to Septic Wastewater		
	Phosphorus	Nitrogen
Wastewater (mg/L)	7	65
Attenuation	90%	50%
Rain Dilution Factor	5.1	5.1
Est. GW Quality	0.14	6.4
Measured Avg. DG wells at 76 SLSD - 10-12-19	0.21	8.9
Measured Avg. DG wells at 76 SLSD - 12-18-19	0.02	6.0
Estimated Average Daily Peninsula Groundwater Quantity Discharge to Candlewood Lake (gpd)		
Shoreline length (ft)	20,000	
Aquifer thickness (ft)	6	
Groundwater (GW) Slope	1%	5%
GW Lake Discharge (gpd)	53,856	269,280

Tables 5-2A and 5-2B present nitrogen and phosphorus removal rates using chloride (Cl) as the tracer for 76 South Lake Shore Drive and 74 North Lake Shore Drive sites.

Table 5-2A Nitrogen & Phosphorus Removal Rates – 76 S. Lake Shore Drive

Mean N and P concentrations, concentrations corrected for dilution using a conservative tracer (Cl) and percent removal, in the septic system plume core zone extending from the drainfield to the Candlewood Lake shoreline.									
				TIN (NH4 + NO3-N)			SRP/TP		
76 South Lake Shore Drive, Brookfield, CT	Distance[4] (ft)	Cl (mg/L)	Dilution Factor	TIN (mg/L)	Corr. TIN (mg/L)	Remove %	SRP (mg/L)	Corr. SRP (mg/L)	Remove %
Septic Tank Effluent Oct 17, Dec18/19 (n=2)	0	346[(1)]	1	41	41	0	4.6	4.6	0
Drainfield Wells, DF1-3 Nov 4, Dec 18/19 (n =6)	5 - 10	346[(1)], +/-38	1	10	10	76	0.01	0.01	> 99
Downgradient Wells, DG1-8, Dec 18[3] (n =8)	20-50	No data	?	6	62		0.015	0.0152	> 99
Shore Wells, DG13-2,3, Oct 17, Nov 4, (n = 4)	60	297	0.86	14	16	61	0.01	0.012	> 99
1) Considering that the three Drainfield wells had uniformly high Cl values averaging 346 mg/L, during two sampling episodes, values that were much high than background values of 20-30 mg/L, it is likely that these wells more accurately represent the mean effluent Cl value, than the Cl values measured in the tank, which was only sampled twice and showed relatively lower Cl values of 200 and 228 mg/L.									
2) assumed undiluted									
3) Oct 2/19 samples are excluded because these were collected shortly after well installation when drilling disturbance may have affected results.									
4) Distance from the drainfield									

Table 5-2BA Nitrogen & Phosphorus Removal Rates – 74 N. Lake Shore Drive

Mean N and P concentrations, concentrations corrected for dilution using a conservative tracer (Cl) and percent removal, in the septic system plume core zone extending from the drainfield to the Candlewood Lake shoreline.									
				TIN (NH4 + NO3-N)			SRP/TP		
764 North Lake Shore Drive, Brookfield, CT	Distance[4] (ft)	Cl (mg/L)	Dilution Factor	TIN (mg/L)	Corr. TIN (mg/L)	Remove %	SRP (mg/L)	Corr. SRP (mg/L)	Remove %
Septic Tank Effluent Oct 17, Dec18/19 (n=2)	0	138	1	42	42	0	4.6	4.6	0
Drainfield Wells, DF1-3 Nov 4, Dec 18/19 (n =6)	15 - 20	59	0.43	6.8	16	62	0.02	0.046	99
Downgradient Wells, DG1-8, Dec 18[3] (n =8)	150	61	0.44	2.5	5.7	86	0.02	0.045	99
1) Distance from the drainfield									

As a point of reference, the US EPA Ambient Water Quality Criteria Recommendations for Lakes and Reservoirs in Nutrient Ecoregion XIV, with Candlewood Lake being located in subregion 59, https://www.epa.gov/sites/production/files/documents/lakes14.pdf are:

Total phosphorus (ug/L)	8 – 20
Total nitrogen (mg/L)	0.32 – 0.41
Chlorophyll a (ug/L)	2.1 – 6
Secchi (meters)	1.2 – 4.9

As stated in the US EPA document, “The values presented in this document generally represent nutrient levels that protect against the adverse effects of nutrient over enrichment.” Candlewood Lake’s N and P concentration ranges (see Task 1 Report Chapter 4) for 2018 are:

Total phosphorus (ug/L)	3 – 79
Total nitrogen (mg/L)	0.44 – 1.45

Also, for reference, Table 5-3 presents the Candlewood Lake 2018 Water Quality Data by Month.

5.1.3 Functional Need

As shown in Section 3, approximately 13 % of properties who have returned the septic system questionnaire have reported a problem. Approximately 22% of properties returned the questionnaire.

5.1.4 Insufficient Space

As shown in Section 4, between 23% to 36% have insufficient space to accommodate a CT Department of Health (DoH) code compliant septic system with the vast majority of those difficult sites on the Peninsula. Also, the Brookfield Health Department by its letter of January 2018 (see Figure 5-1), recommended a sewer system for the Peninsula.

TOWN OF BROOKFIELD

BROOKFIELD, CT 06804

COPY

January 24, 2018

John Siclari
Director, Brookfield Water Pollution Control Authority
Brookfield Town Hall
100 Pocono Road
Brookfield, CT 06804

Re: Sanitary sewers for Brookfield's Candlewood Shores Lake communities

John:

The Brookfield Health Department recommends the Brookfield Water Pollution Control Authority (WPCA) take the necessary steps to provide sanitary sewers to the Candlewood Shores peninsula including the Candlewood Shores Tax District (CSTD), Arrowhead Point, Hickory Hills and Candlewood Orchards. The area has been highlighted in red as an "area of concern," on the WPCA's sewer map for several years now and with good reason. The small average lot size, the age of most of the homes, the fact that the vast majority of the homes were built for seasonal use and are now occupied year-round, and the environmental sensitivity associated with managing the relatively large volume of sewage on the relatively densely populated peninsula surrounded by Candlewood Lake must all be considered moving forward.

Average lot size on the peninsula is less than three-tenths of an acre. Due to the relatively restrictive sized lots, repairing septic systems often requires exceptions to technical standards of the Connecticut Public Health Code. In some of these repair instances, the final permits issued are required to state that the systems are undersized for the total number of bedrooms in the homes. Housing stock in the Shores is generally between 40 and 70 years old and homes still served by their original septic systems are likely near the end of their useful life, while many of the rest are on their second system. Most of the original septic systems were designed for seasonal use only and today most of the homes are occupied throughout the year. This means that many of the original systems are undersized relative to use expectancy. State and local health officials have recognized a significant rise in blue-green algal blooms in recent years. These blooms have the potential for causing harm to humans and wildlife. Nutrients such as phosphorus and nitrogen both sourced from septic system drain fields, along with landscape fertilizers, feed these blooms. Home values are tied to the recreational value of the lake which is impacted by water quality. Though sewage management is only one of several concerns regarding lake water quality, it is not the least important, especially when considering several of the factors cited above.

TOWN OF BROOKFIELD

BROOKFIELD, CT 06804

John Siclari
Director, Brookfield WPCA
January 24, 2018
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The Health Department does not make this recommendation lightly. Four other neighboring municipalities, including the City of Danbury, all with homes bordering Candlewood Lake and therefore within the lake watershed, must also consider long term sewage management moving forward. The company that owns the lake, First Light, is determined to eliminate all septic systems that are on their property as some are, and this presents another concern for the Towns. At a recent seminar sponsored by First Light, an engineer for the company highlighted five Connecticut lakes that have been ordered by the State to sewer their lake communities. Now is the time for Brookfield to take up sanitary sewer expansion on behalf of our largest lake communities, those within the Candlewood Shores area, and on behalf of the lake itself.

Do not hesitate to call us at the number below with any questions or concerns moving forward.

Sincerely,

Paul Avery, R.S.
Town Sanitarian

Dr. Raymond Sullivan
Director of Health

cc: Steve Dunn, Brookfield First Selectman
Alice Dew, Brookfield Land Use Director

Figure 5-1 Brookfield Health Department Letter Recommending Sewers for Peninsula

Table 5-3 Candlewood Lake 2018 Water Quality Data by Month

Table 6. Summary statistics (mean ± standard deviation) of nutrient data collected at Candlewood Lake in the 2018 season by month. All data are in mg/L with the exception of TP which is in µg/L and TN:TP which is a ratio. NH4 = Ammonia; NO_3^- = Nitrate; TKN = Total Kjeldahl Nitrogen; TN = Total Nitrogen; TP = Total Phosphorus; and TN:TP = the Redfield ratio of Total Nitrogen to Total Phosphorus. Epi = epilimnion; Meta = metalimnion; and Hypo = hypolimnion.

NH_4	May	June	July	Aug	Sep	Oct	Season
Epi	0.0±0.0	0.12±0.01	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.02±0.05
Meta	0.0±0.0	0.13±0.02	0.0±0.0	0.0±0.0	0.0±0.0	0.09±0.18	0.04±0.08
Hypo	0.0±0.0	0.16±0.04	0.05±0.09	0.18±0.12	0.36±0.24	0.77±0.21	0.25±0.29

NO_3^-	May	June	July	Aug	Sep	Oct	Season
Epi	0.01±0.03	0.06±0.00	0.0±0.0	0.03±0.03	0.0±0.0	0.0±0.0	0.02±0.03
Meta	0.05±0.06	0.07±0.01	0.01±0.03	0.01±0.03	0.0±0.0	0.0±0.0	0.02±0.03
Hypo	0.15±0.05	0.15±0.15	0.08±0.17	0.10±0.17	0.0±0.0	0.0±0.0	0.08±0.12

TKN	May	June	July	Aug	Sep	Oct	Season
Epi	0.50±0.16	0.94±0.34	0.44±0.02	1.20±0.27	0.16±0.04	0.66±0.16	0.65±0.39
Meta	0.44±0.02	0.92±0.34	0.45±0.08	0.89±0.13	0.17±0.03	0.80±0.15	0.61±0.32
Hypo	0.40±0.04	1.11±0.15	0.50±0.22	1.34±0.58	0.53±0.04	1.20±0.17	0.85±0.45

TN	May	June	July	Aug	Sep	Oct	Season
Epi	0.51±0.16	1.00±0.34	0.44±0.02	1.22±0.28	0.16±0.04	0.66±0.16	0.66±0.40
Meta	0.48±0.05	0.99±0.35	0.47±0.06	0.90±0.15	0.17±0.03	0.80±0.15	0.63±0.33
Hypo	0.55±0.06	1.26±0.21	0.59±0.38	1.45±0.67	0.53±0.04	1.20±0.17	0.93±0.49

TP	May	June	July	Aug	Sep	Oct	Season
Epi	16.3±15.1	13.0±5.0	20.0±1.6	20.8±2.9	23.0±5.9	19.3±2.4	18.7±7.1
Meta	12.8±5.7	7.3±2.4	25.3±5.0	24.8±2.2	31.5±3.4	20.3±3.8	20.3±9.0
Hypo	9.5±3.7	3.0±1.4	25.5±4.8	40.8±14.8	79.0±14.7	49.3±13.0	34.5±27.7

TN:TP	May	June	July	Aug	Sep	Oct	Season
Epi	47±25	78±14	22±3	60±19	7±1	36±14	42±28
Meta	43±18	136±10	19±5	37±7	5±1	41±15	47±44
Hypo	73±53	506±253	26±23	46±42	7±1	25±5	114±204

6 RECOMMENDATIONS

Based upon the numerous factors that point to the need for a Peninsula wide wastewater solution, it is recommended that a Peninsula community-wide sewer system be implemented with sewer system type and treatment/discharge option be determined based technical and economic/financial optimization analysis to be performed in subsequent project Reports. Associated with a Peninsula (approximately 703 developed properties) community-wide wastewater system, Candlewood Lake studies should be performed to document improvements associated with the wastewater improvements. The degree to which wastewater improvements need to be implemented for the 643 +/- developed properties in the remaining Brookfield Candlewood Lake drainage area should be evaluated as part of implementation the Peninsula wastewater improvement project.

APPENDIX I - CHAIN OF CUSTODIES AND LABORATORY REPORTS – WATER SUPPLY

TABLE OF CONTENTS:

SAMPLING LOCATIONS

- Candlewood Shores Community Site Center (CS)
- Arrowhead Road (AR)
- Candlewood Lake (CL)
- Western Aquarion residential property (WA)