Crystal Lake/Elginwood Pond Water Quality Study

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City of Peabody, Massachusetts

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Executive Summary

Through an inter-departmental agreement between the City of Peabody's Department of Community Development & Planning and Department of Public Services, a water quality study was conducted in the area around Crystal Lake and Elginwood Pond. The purpose of this study was to look at the physical and chemical properties of the water entering the aforementioned water bodies. These properties contribute to vegetation growth and euthrophic conditions.

Using topographical and watershed data from MassGIS, eighteen sites were isolated for sampling. During each sampling event, samples were collected and tested for the following physical and chemical properties: temperature, pH, conductivity, turbidity, ammonia (nitrogen), nitrate (nitrogen), and reactive & total phosphorus.

Sampling events were conducted in July, August, November, & December 2008 at each location, unless otherwise noted.

Summary of Findings:

Data from these sampling events suggest there are significant nutrients entering Crystal Lake & Elginwood Pond from the following locations:

- Crystal Lake from Goodale Street
- Elginwood Pond from Devil's Dishfull and the Old Kennedy School Sports Field between Pine Street and Elginwood Drive.

Results showed that sites # 7 & 13 are of particular interest with regards to the concentrations of phosphates and nitrates (Figure 2 & 3 respectfully). Despite the varying precipitation amounts across the entire study, these location had higher average levels. In addition, upstream of site # 17 should be investigated to determine the specific role that Devil's Dishfull and Lynnfield has on the eutrophication of Elginwood Pond.

Section 1: Introduction

During the spring of 2008, an inter-departmental agreement between the City of Peabody's Department of Community Development and Department of Public Services was reached to conduct a water quality study in the area surrounding Crystal Lake and Elginwood Pond.

The following deliverables were agreed upon:

1. Collect and test for the following analytes:
   Temperature, pH, Conductivity, Turbidity, Ammonia & Nitrate Nitrogen, and Reactive & Total Phosphorus.

2. Mapping of sample locations with GPS/GIS tools and identification of potential sources of nutrient concentrations.

The aforementioned analytes were chosen for the following reasons:

- **Temperature** – regulates the rates of reactions between all physical and chemical properties in water. (i.e. The higher the temperature, the faster reactions occur).

- **pH** – the effective concentration (or activity) of hydrogen ions expressed as the negative base-10 log of the concentration. It is also an effective measure of the status of equilibrium reactions[1]. Pure water @ 25^{o}C has a pH of 7.00. Anything higher (< 7) is considered acidic, while lower (> 7) is basic.

- **Conductivity** – the ability to conduct an electrical current through a substance. This is due to dissolve ions ability to make the solution conductive. As ion concentration increases, the conductance also increases. By measuring conductivity, it provides a direct indication of ion concentration[2].

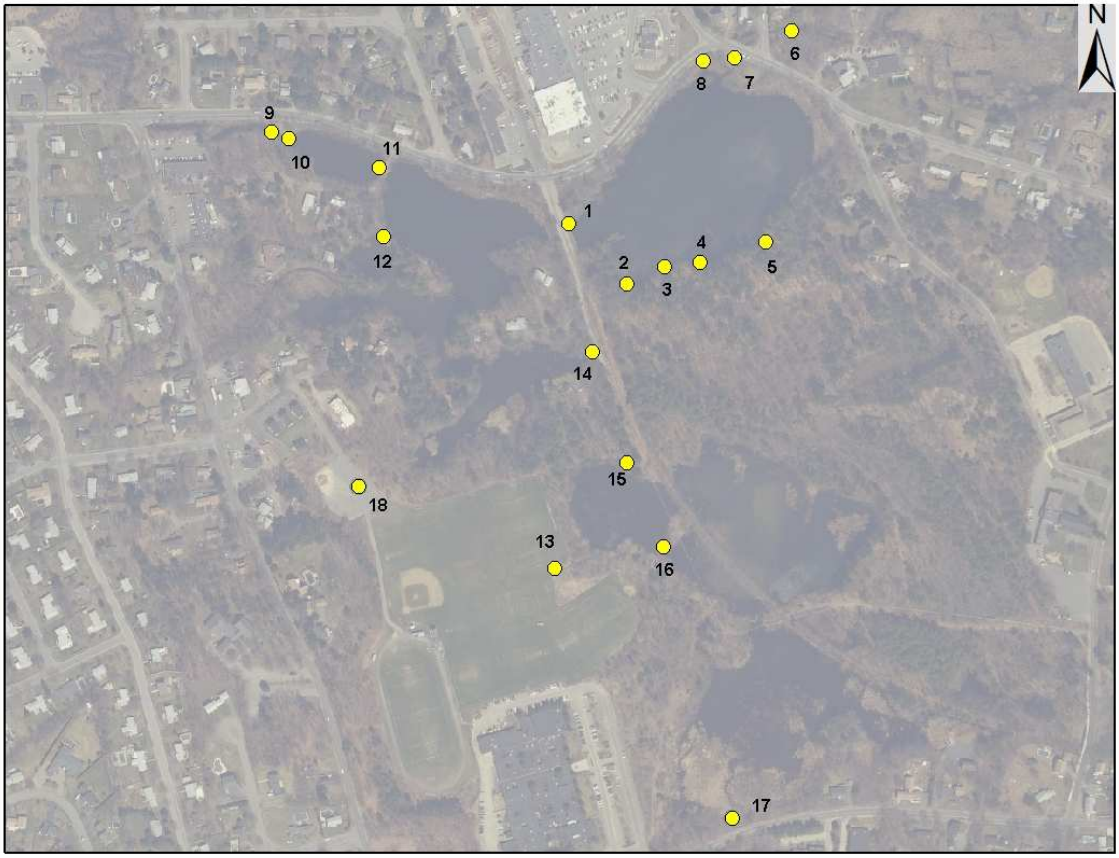
- **Turbidity** – an expression of the cloudiness of a solution. This cloudiness is caused by solids suspended in the water such as clay, silt, algae, finely dispersed organic material, or any other colloidal material[3].

Essential Plant Nutrients:

- **Nitrogen:** most plentiful out of the two nutrients[4]
  - **Ammonia –** naturally introduced from atmospheric rainwater or excreted from fish & amphibians.
  - **Nitrate –** formed by nitrification/oxidation of nitrogen gas, ammonia, and nitrites. It is also introduced by nitrogen-based fertilizers

- **Phosphorus**: more scarce in aquatic environments, naturally introduced from mineral erosion, presence is believed be a critical factor in eutrophication of a water body[5]. Occurs various forms, including total & reactive. Reactive (or Orthophosphate) is free ions that have been recently released from minerals, animal waste, or fertilizers[6]. Total phosphorus includes both inorganic ions and organically bound phosphorus.

Site Overview of Crystal Lake and Elginwood Pond:



Section 2: Description of Findings

Material & Methods:

During the week of July 22, 2008, field exploration and mapping began for the water quality study. Using existing Geographical Information System (GIS) data provided by the City of Peabody, State of Massachusetts, and the United States Geological Survey, possible sampling sites around Crystal Lake & Elginwood Pond were analyzed. From this data, the sampler went out with a Garmin GPS meter (with meter accuracy) to get latitude and longitude points for each site to be sampled.

Following the determination of sites, samples were taken at each site and analyzed for the fore mentioned analytes. Temperature, pH, and conductivity were measured on-site and the other five analytes were analyzed on the day of collection. Chemical analysis was completed with a Hach DR/2800 spectrophotometer or appropriate meter.

Over the course of the water quality study four sampling events took place between July and December 2008.

The weather during the week of July 22 was very wet with a total rainfall of 3.85 inches during the week. By contrast, the weather for the week of August 25 had no recordable precipitation. The four days prior to November 10 had 1.12 in of rain, and December 12 had 3.04 in of rain.

Also due to the lack of flow at Site 18 during the initial sampling events, Site 17 was later added as a replacement sampling site.

Field Results and Findings:

Results show that Sites 6 & 7 had the greatest influence on the flow into Crystal Lake, and Site 14 has the greatest impact on Elginwood Pond. These are the main inlets to theses water bodies.

Section 3: Conclusion

From the various sampling events, the data suggests that there is significant levels of nutrients following into Crystal Lake & Elginwood Pond. While activities in the immediate area do not appear to be the cause of the eutrophication of these water bodies, the cause is more likely the result of flow from a large area is being concentrated within the confines of this area.

In addition, the nutrient flow appears to be seasonal. The presence of nitrogen and phosphorus compounds are more abundant in the spring and summer, than the autumn and winter.

For areas of potential non-point sources of pollution to Crystal Lake & Elginwood Pond, sites # 7 & 13 are areas that should be looked into with more detail. Also, upstream of site # 17 (from Devil's Dishfull & Lynnfield) should be further investigated in its role in the eutrophication of Elginwood Pond.

Sources & Additional Information:

Hem, John D. "Study and Interpretation of the Chemical Characteristics of Natural Water" Third Edition US Geological Survey, US Government Printing Office, 1985

#1. - pg.61, #2. - pg.66, #4. - pg.125&126, #5 - pg.128

Clesceri, Greenberg, & Eaton Standard Methods for the Examination of Water and Wastewater United Book Press, Inc. 1998

3 - pg. 2-8, # 6 - pg. 4-139

Analyte Methods are as followed:

pH - SM 4500H+B **Conductivity** - SM2510B **Turbidity** - SM 2130B
Ammonia - Hach 10205 **Nitrate** - Hach 10206 **Phosphorus** - Hach 10209

Data must not be used for EPA/MADEP regulatory purposes. Data is in no way meant to be representative of the city's drinking water or raw water reservoirs.

Table 1: July 22-25, 2008 Sampling Results

BRL- Below Reportable Limit

Site	Date	Temperature	pH	Conductivity	Turbidity	Ammonia	Nitrate	Reactive Phosphate	Total Phosphorus
		Celsius	SU	uS/cm	NTU	mg/L	mg/L	mg/L	mg/L
1	22-Jul	22	7.2	474	1.7	0.115	BRL	BRL	0.078
2	22-Jul	26	7.4	485	1.9	0.105	BRL	BRL	0.070
3	22-Jul	23	6.4	425	2.7	0.208	0.348	BRL	0.053
4	22-Jul	27	8.4	470	2.1	0.103	BRL	BRL	0.107
5	22-Jul	23	6.9	464	4.3	0.108	0.238	BRL	0.133
6	22-Jul	23	6.5	438	2.1	0.157	0.244	0.20	0.248
7	22-Jul	23	6.5	441	2.3	0.157	0.260	0.19	0.296
8	22-Jul	26	7.0	491	3.1	0.097	BRL	BRL	0.127
9	24-Jul	24	7.3	311	2.5	0.184	0.333	BRL	0.091
10	24-Jul	24	7.1	304	26	0.158	0.303	BRL	0.077
11	24-Jul	24	7.0	356	2.6	0.168	0.230	BRL	0.094
12	24-Jul	25	7.0	319	2.3	0.202	0.346	BRL	0.151
13	25-Jul	25	6.6	169.4	6.5	0.189	1.310	0.68	1.300
14	25-Jul	27	6.9	378	1.7	0.147	0.309	4.17	4.362
15	25-Jul	27	7.0	410	1.9	0.138	0.283	2.19	2.251
16	25-Jul	27	7.1	366	2.1	0.180	0.435	1.23	1.902
18		no flow							

Reporting Limits:
Ammonia- 0.015 mg/L as N Nitrate- 0.23 mg/L as N Total & Reactive Phosphate- 0.05 mg/L as P

Table 2: August 25, 2008 Sampling Results *BRL- Below Reportable Limit*

Site	Date	Temperature	pH	Conductivity	Turbidity	Ammonia	Nitrate	Reactive Phosphate	Total Phosphorus
		Celsius	SU	uS/cm	NTU	mg/L	mg/L	mg/L	mg/L
1	26-Aug	26	7.1	499	0.81	0.111	BRL	BRL	BRL
2	26-Aug	28	7.5	450	0.79	0.130	0.262	BRL	0.285
3	26-Aug	24	7.0	480	6.6	0.104	0.283	BRL	0.053
4	26-Aug	28	7.2	494	0.93	0.114	0.229	BRL	BRL
5	26-Aug	25	7.2	507	8.4	0.217	0.251	BRL	0.409
6	26-Aug	25	6.7	650	1.2	0.211	BRL	BRL	0.138
7	26-Aug	26	6.9	678	1.9	0.225	0.251	0.16	0.192
8	26-Aug	28	7.0	544	1.7	0.108	0.291	BRL	0.100
9	26-Aug	26	7.1	552	1.1	0.168	0.440	BRL	BRL
10	26-Aug	26	7.0	544	1.2	0.126	0.329	BRL	BRL
11	26-Aug	26	7.3	539	1.6	0.130	0.321	BRL	BRL
12	26-Aug	26	7.1	546	1.8	0.136	0.328	BRL	BRL
13	26-Aug	28	6.8	445	3.4	0.201	0.412	0.22	0.374
14	26-Aug	28	6.9	572	2.7	0.188	BRL	BRL	0.057
15	26-Aug	25	7.0	482	1.5	0.148	BRL	BRL	BRL
16	26-Aug	27	7.0	493	1.8	0.133	BRL	BRL	BRL
17	26-Aug	25	7.4	411	0.98	0.124	0.584	BRL	BRL
18	26-Aug	no flow							

Reporting Limits:
Ammonia- 0.015 mg/L as N Nitrate- 0.23 mg/L as N Total & Reactive Phosphate- 0.05 mg/L as P

Table 3: November 10, 2008 Sampling Results *BRL- Below Reportable Limit*

Site	Date	Temperature	pH	Conductivity	Turbidity	Ammonia	Nitrate	Reactive Phosphate	Total Phosphorus
		Celsius	SU	uS/cm	NTU	mg/L	mg/L	mg/L	mg/L
1	10 Nov	12	7.4	509	1.6	0.086	BRL	BRL	BRL
2	10 Nov	10	7.3	506	8.7	0.113	0.287	0.22	0.602
3	10 Nov	11	6.7	338	14	0.295	0.467	0.29	0.462
4	10 Nov	10	6.9	499	2.3	0.111	BRL	1.26	1.29
5	10 Nov	10	7.1	495	1.6	0.114	BRL	0.68	0.702
6	10 Nov	10	7.1	583	1.2	0.126	0.256	BRL	0.051
7	10 Nov	12	7.0	592	0.83	0.125	0.258	BRL	0.052
8	10 Nov	No Flow							
9	10 Nov	12	7.2	485	1.4	0.176	0.327	BRL	0.101
10	10 Nov	12	7.0	480	1.7	0.161	0.315	BRL	BRL
11	10 Nov	12	7.2	548	0.74	0.08	1.32	BRL	BRL
12	10 Nov	12	7.1	492	1.4	0.151	0.494	BRL	BRL
13	10 Nov	12	7.0	285	2.4	0.229	0.796	0.21	0.412
14	10 Nov	13	6.9	530	2.5	0.178	0.276	BRL	BRL
15	10 Nov	12	7.0	481	2.2	0.155	0.324	BRL	BRL
16	10 Nov	11	7.0	476	3.4	0.055	0.295	BRL	BRL
17	10 Nov	12	7.2	407	1.6	0.126	0.482	BRL	BRL
18	10 Nov	11	7.0	542	0.89	0.097	2.09	BRL	BRL

Reporting Limits:
Ammonia- 0.015 mg/L as N Nitrate- 0.23 mg/L as N Total & Reactive Phosphate- 0.05 mg/L as P

Table 4: December 12, 2008 Sampling Results *BRL- Below Reportable Limit*

Site	Date	Temperature	pH	Conductivity	Turbidity	Ammonia	Nitrate	Reactive Phosphate	Total Phosphorus
		Celsius	SU	uS/cm	NTU	mg/L	mg/L	mg/L	mg/L
1	Dec 12	6	7.1	438	1.6	0.093	0.391	BRL	BRL
2	Dec 12	6	7.2	175	0.86	0.094	0.250	BRL	BRL
3	Dec 12	6	6.7	265	17	0.408	0.483	BRL	BRL
4	Dec 12	6	6.8	368	1.7	0.249	0.403	BRL	BRL
5	Dec 12	6	6.8	469	1.6	0.148	0.619	BRL	BRL
6	Dec 12	6	6.8	452	0.71	0.133	0.884	BRL	BRL
7	Dec 12	6	7.0	440	1.4	0.150	0.823	BRL	BRL
8	Dec 12	6	6.4	33	4.9	0.190	0.792	0.05	0.103
9	Dec 12	6	6.5	457	2.2	0.188	0.374	BRL	BRL
10	Dec 12	6	5.6	470	2.1	0.180	0.533	BRL	BRL
11	Dec 12	6	6.6	461	2.2	BRL	0.541	BRL	BRL
12	Dec 12	6	6.7	435	1.3	0.121	0.508	BRL	BRL
13	Dec 12	6	6.8	115	1.5	0.123	1.36	BRL	0.167
14	Dec 12	8	6.7	403	3.7	0.239	0.706	BRL	BRL
15	Dec 12	6	6.8	398	3.4	0.230	0.486	BRL	BRL
16	Dec 12	6	6.9	378	4.6	0.233	0.470	BRL	BRL
17	Dec 12	6	7.0	400	1.5	0.145	0.535	BRL	BRL
18	Dec 12	6	7.2	18	2.2	0.102	BRL	BRL	BRL

Reporting Limits:
Ammonia- 0.015 mg/L as N Nitrate- 0.23 mg/L as N Total & Reactive Phosphate- 0.05 mg/L as P

Figure 1: Map of Crystal Lake & Elginwood Pond with Physical Resources

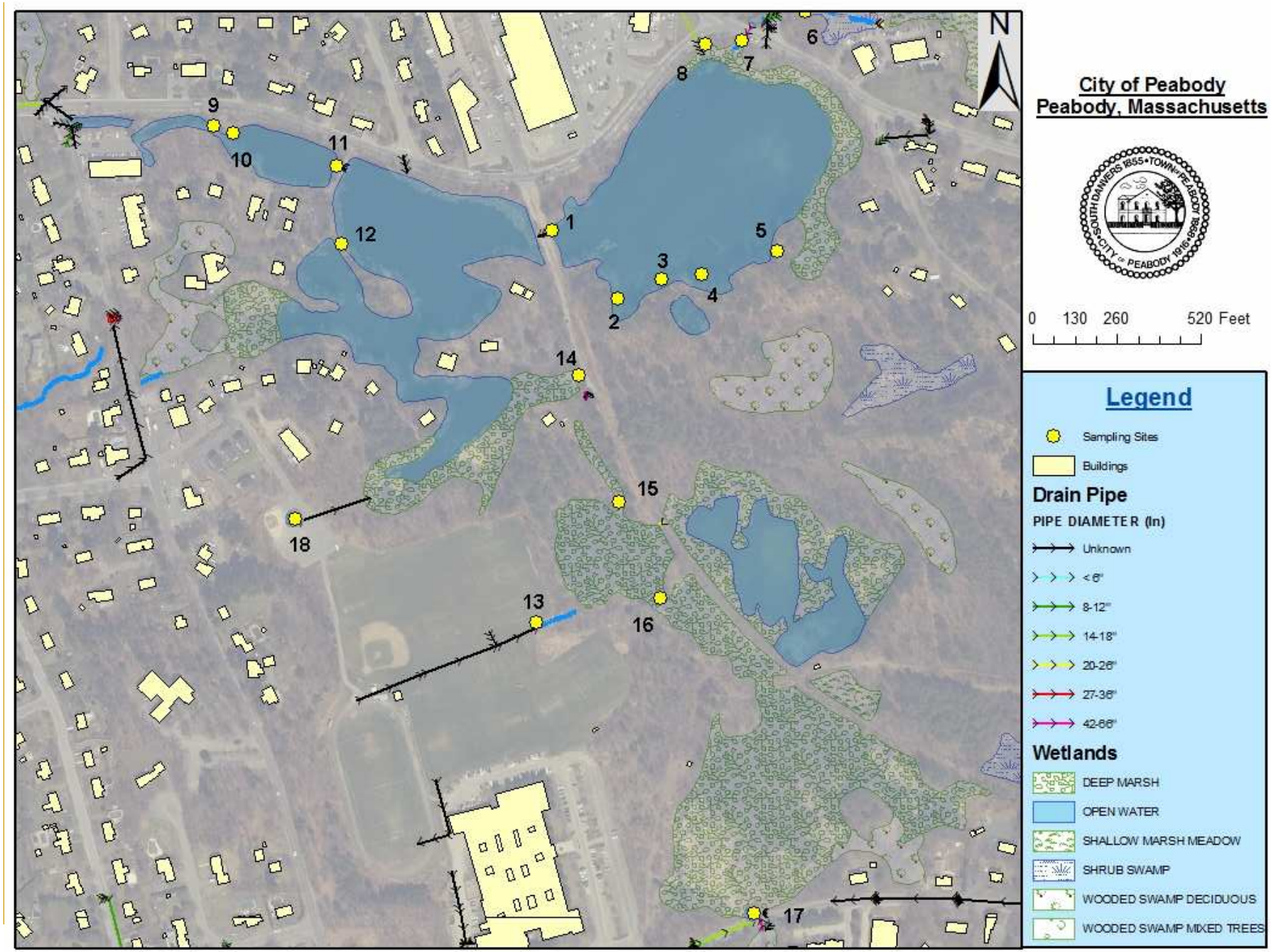


Figure 2: Map of Crystal Lake with Physical Resources

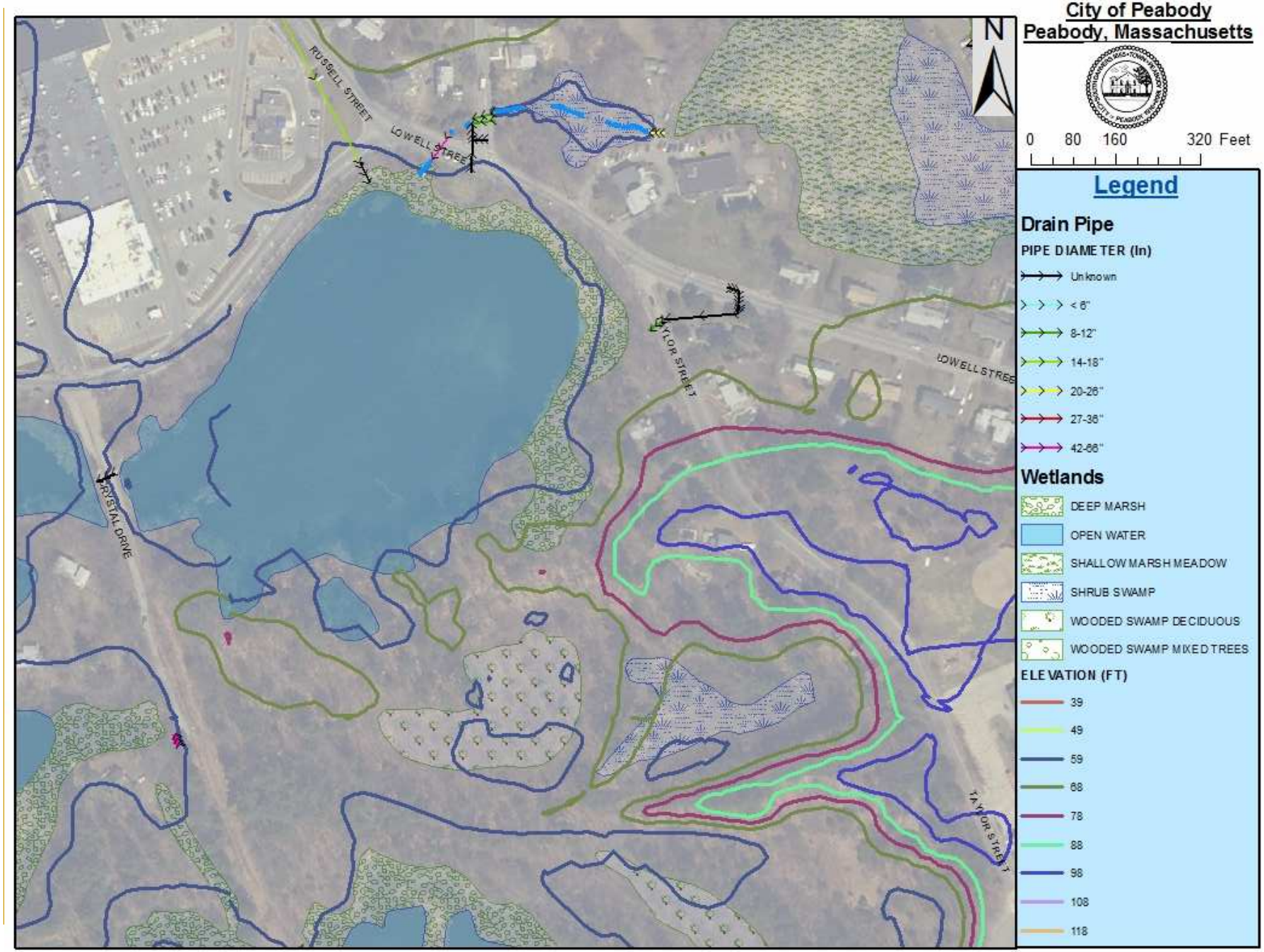


Figure 3: Map of Elginwood Pond with Physical Resources