Prepared For:

Regional Water Authority

South Central Connecticut Regional Water Authority

A BIOLOGICAL ASSESSMENT OF UPPER LAKE WHITNEY

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AECOM

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Introduction

Lake Whitney is a public water supply reservoir that had been inactive since 1991 until a new water treatment facility went online in April 2005. Lake Whitney's lower watershed is heavily urbanized and the South Central Connecticut Regional Water Authority (SCCRWA) is implementing a number of watershed management actions to control water quality impacts caused by nonpoint sources of contaminants. In addition, the SCCRWA is operating the treatment plant in accordance with a Management Plan designed to balance the water needs of the region with those of the environment. The shallow nature of Lake Whitney's upper basin makes it susceptible to substantial exposure of bottom sediments when lake drawdown exceeds two feet.

In response to public concerns raised about the effect of future water withdrawals on the shallow upper basin, the SCCRWA commissioned the upper Lake Whitney Management Study in 2000 to determine the most environmentally sensitive and cost effective way to manage upper Lake Whitney as a water supply while maintaining the ecological and aesthetic quality of the area (Milone and MacBroom, Inc. et al., 2002). The study concluded that watershed management actions should take priority over dredging of accumulated sediments, as dredging would provide minimal water quality benefits while damaging potentially valuable habitat. Hydrologic modeling of water levels under various scenarios conducted as part of the study concluded that drawdowns as a result of public water supply withdrawals will be extremely infrequent. However, extended lake drawdowns of noticeable extent and duration related to maintenance of the dam and various town and state bridges crossing the lake will occur just as they did in the period from August 1991 to April 2005 when the reservoir was out of service as a public water supply.

As part of an ongoing effort to document existing conditions and to provide baseline information for ongoing environmental monitoring after water withdrawals resume, the SCCRWA requested that ENSR conduct biological assessments of upper Lake Whitney after the initial 2000 investigation. The 2004 evaluation included a period with a large drawdown for maintenance, but without active water withdrawal. AECOM (formerly ENSR) evaluated biological features of upper Lake Whitney in 2005 through 2009, during the first five years of water withdrawal. This report summarizes the biological features of upper Lake Whitney in 2009, during the fifth year of water withdrawal, with consideration of events in the recent past that have bearing on overall reservoir conditions. It should be noted that the plant was only operated one day per week for all of 2009, resulting in an average daily withdrawal that was 1.4% of the maximum allowable withdrawal.

Beginning in 2000, the reservoir was drawn down for maintenance activities on multiple occasions. From August to November 2000, Lake Whitney was drawn down by a maximum of about 1.6 ft for dam maintenance (Figure 1). Water levels were unaffected by SCCRWA operations in 2001 and 2002 (Figures 2 and 3). In October and November 2003 the reservoir was drawn down by a maximum of 3.9 ft, also for dam maintenance (Figure 4). In 2004 the reservoir's water level was again lowered from early July to late August, reaching a maximum drawdown of about 6 feet below spillway elevation (Figure 5). In 2005, the lake's water level was slightly below spillway elevation during the first half of September due to water withdrawals and downstream releases to the Mill River, coupled with an extended period of low precipitation (Figure 6). The lake was again drawn down in July/August 2006 to facilitate a wetland construction project to help protect the water quality of the lake (Figure 7). Brief drawdowns of less than 1 foot below spillway elevation occurred during June and October 2007 for dam inspection and maintenance (Figure 8). In 2008 and 2009, water levels exceeded spillway elevation at all times (Figures 9 and 10).

Public water supply withdrawals since 2005 do not appear to have had a significant effect on water levels, but continued monitoring has provided data on the impact of changing water levels on basic biological components that help present a picture of conditions under the range of water levels in the lake.

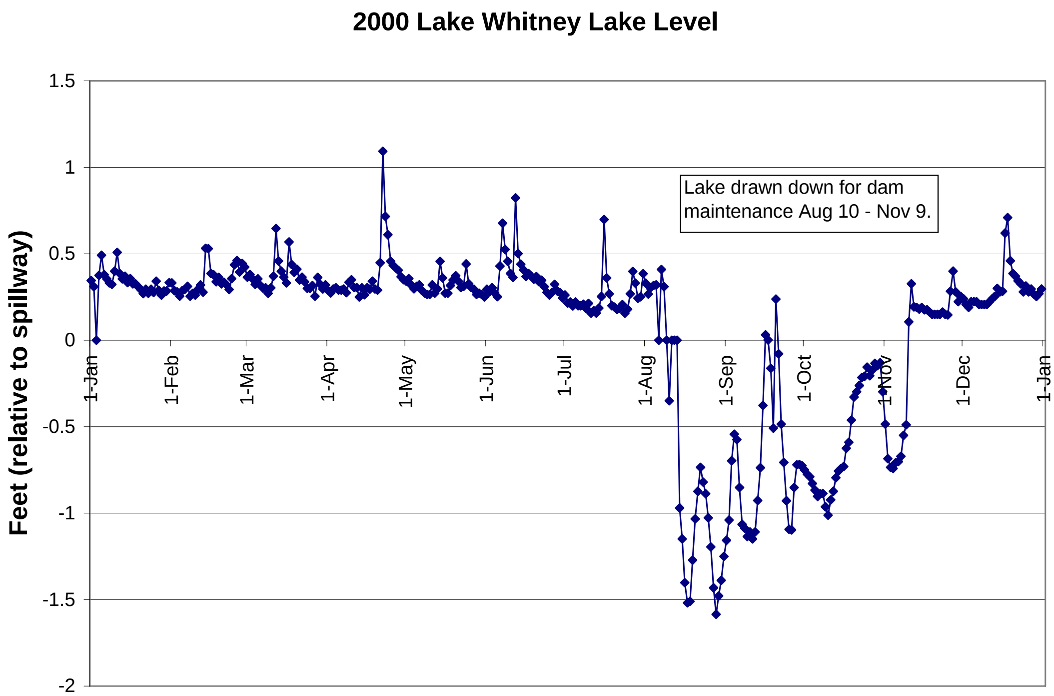


Figure 1. Water level graph for Lake Whitney during 2000.

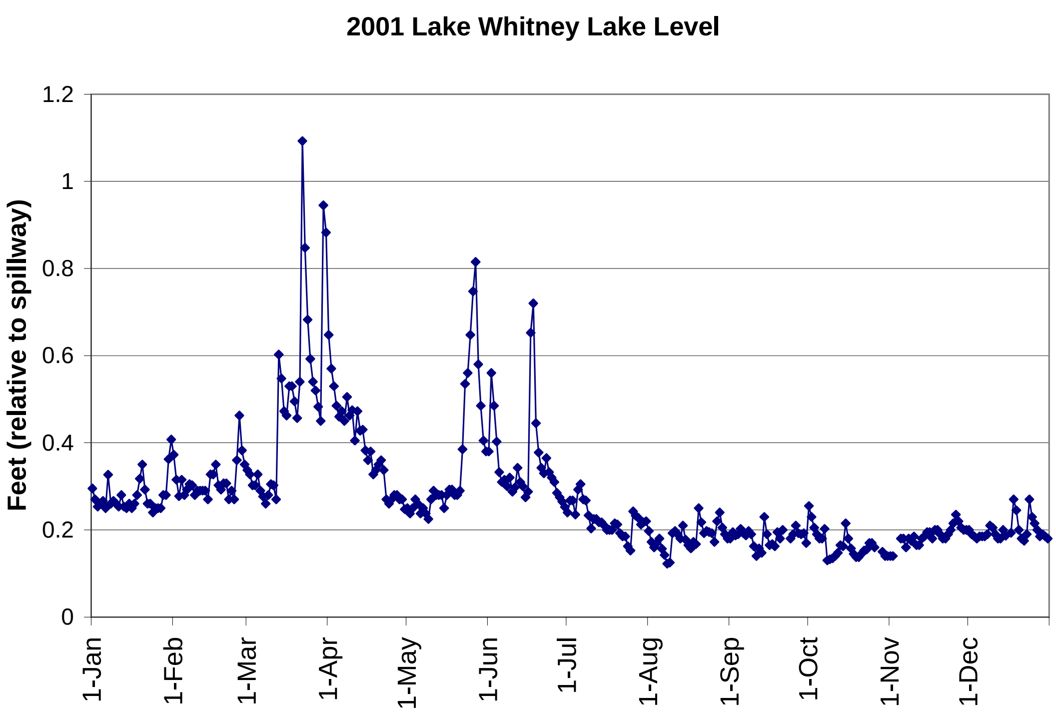


Figure 2. Water level graph for Lake Whitney during 2001.

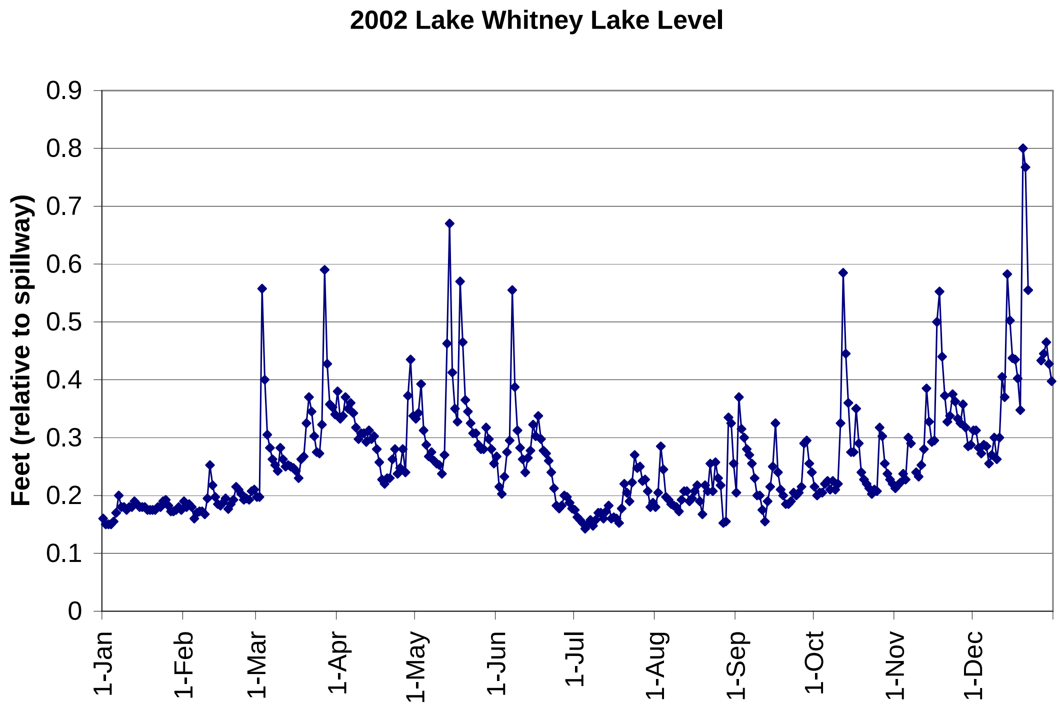


Figure 3. Water level graph for Lake Whitney during 2002.

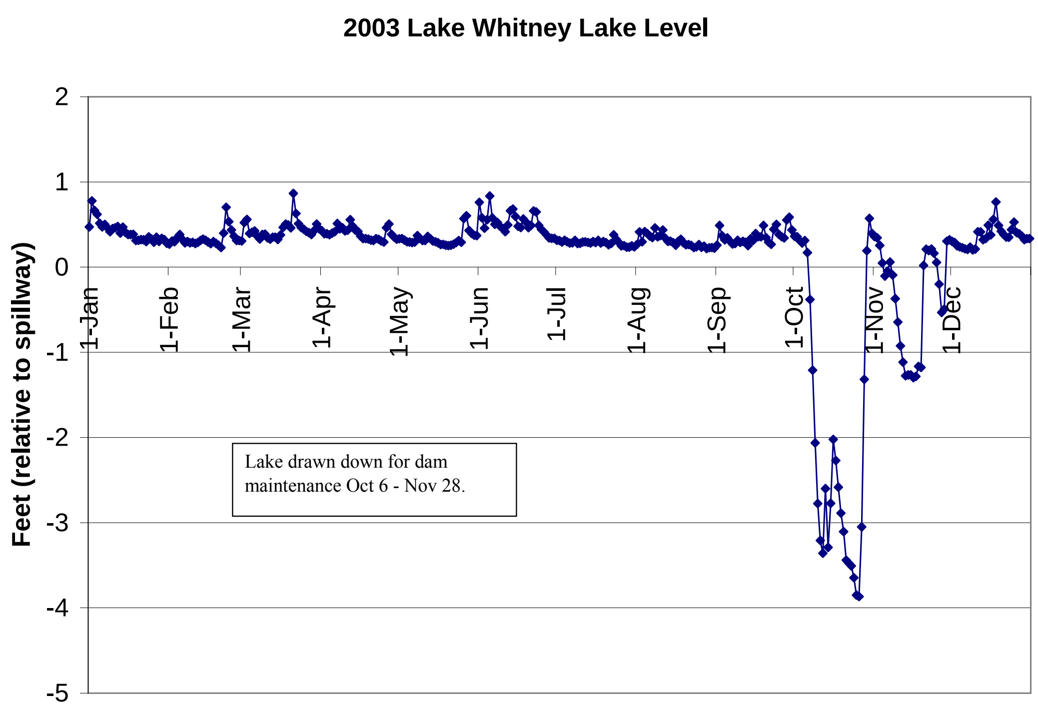


Figure 4. Water level for Lake Whitney during 2003.

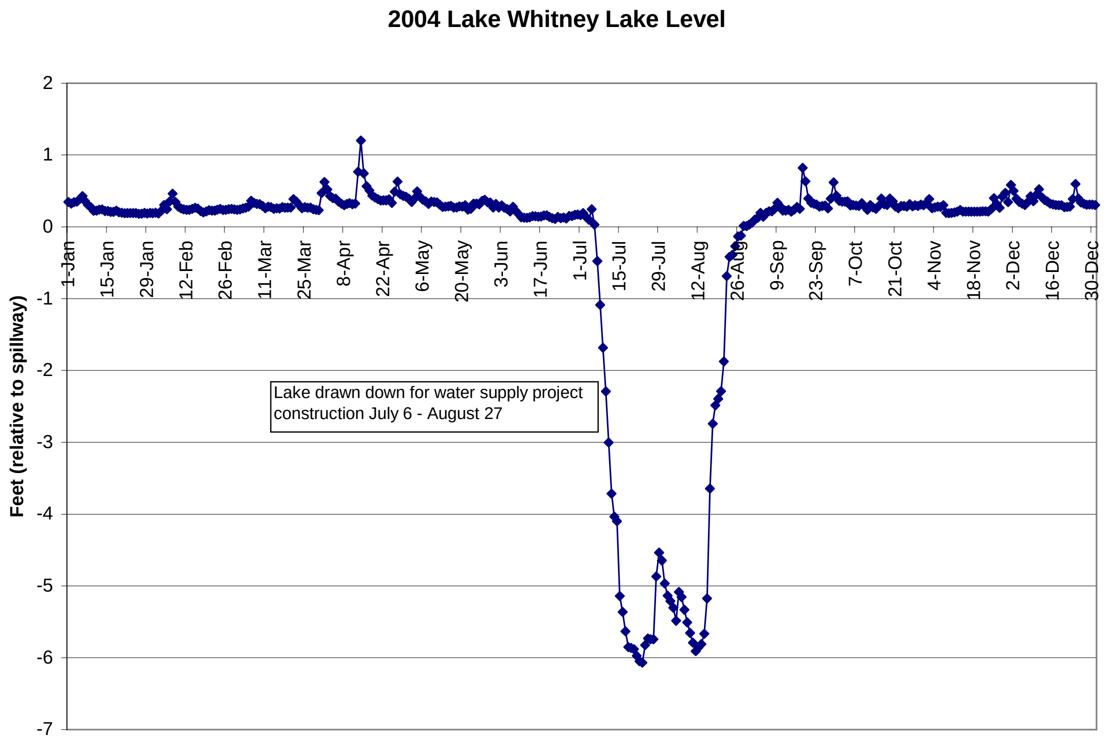


Figure 5. Water level for Lake Whitney during 2004.

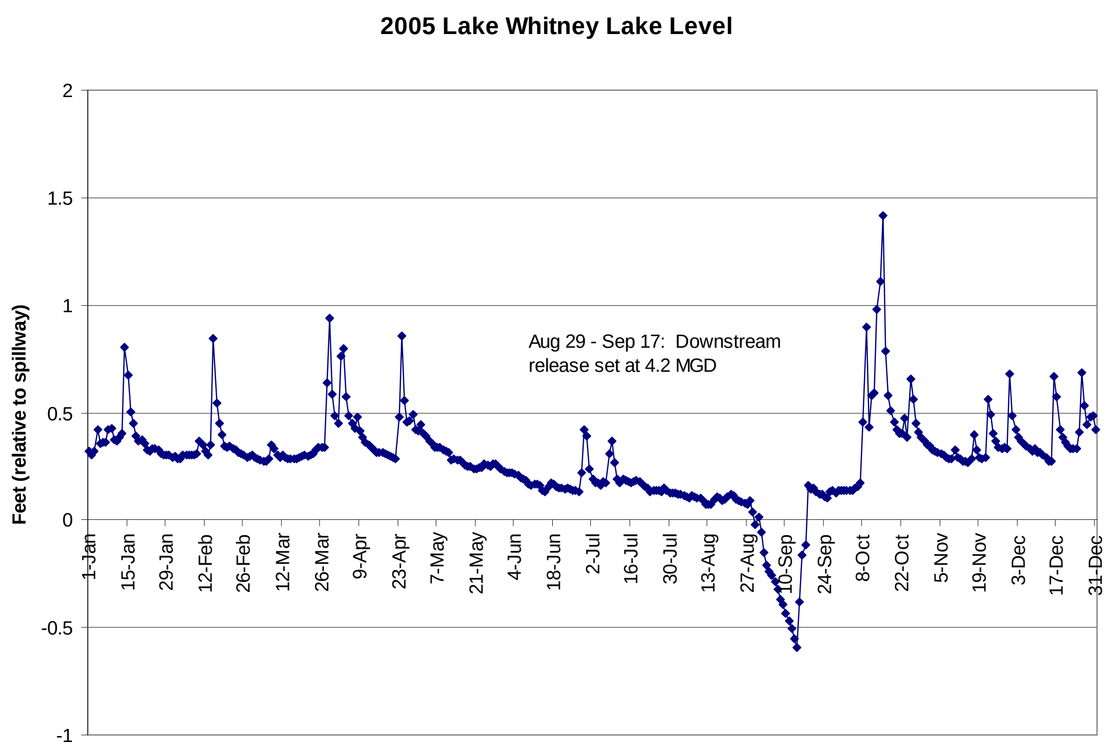


Figure 6. Water level for Lake Whitney during 2005.

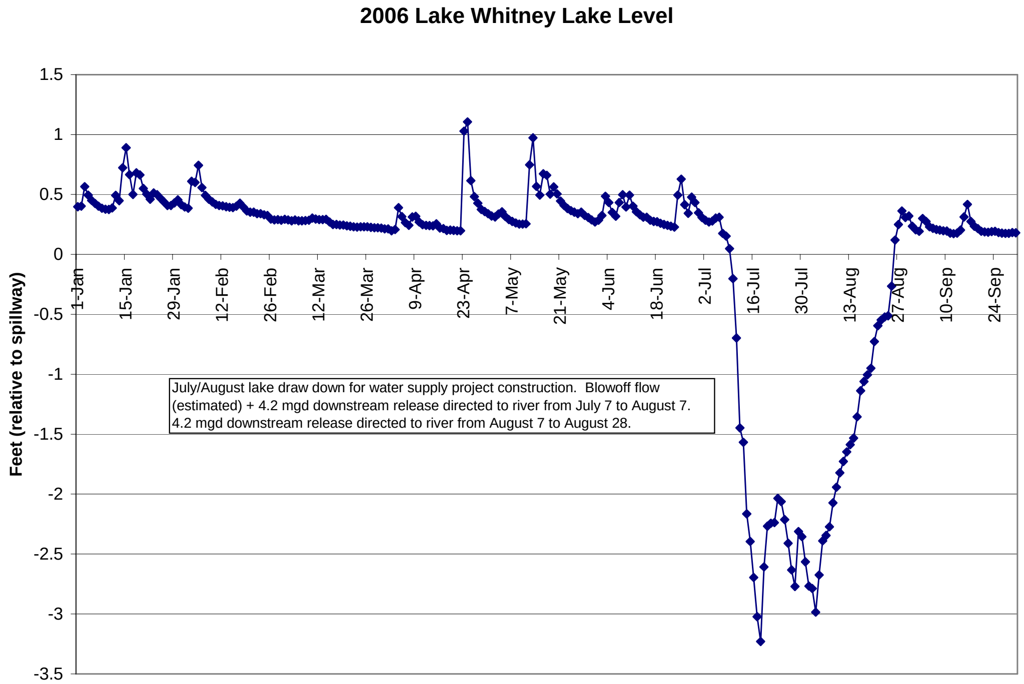


Figure 7. Water level for Lake Whitney during 2006.

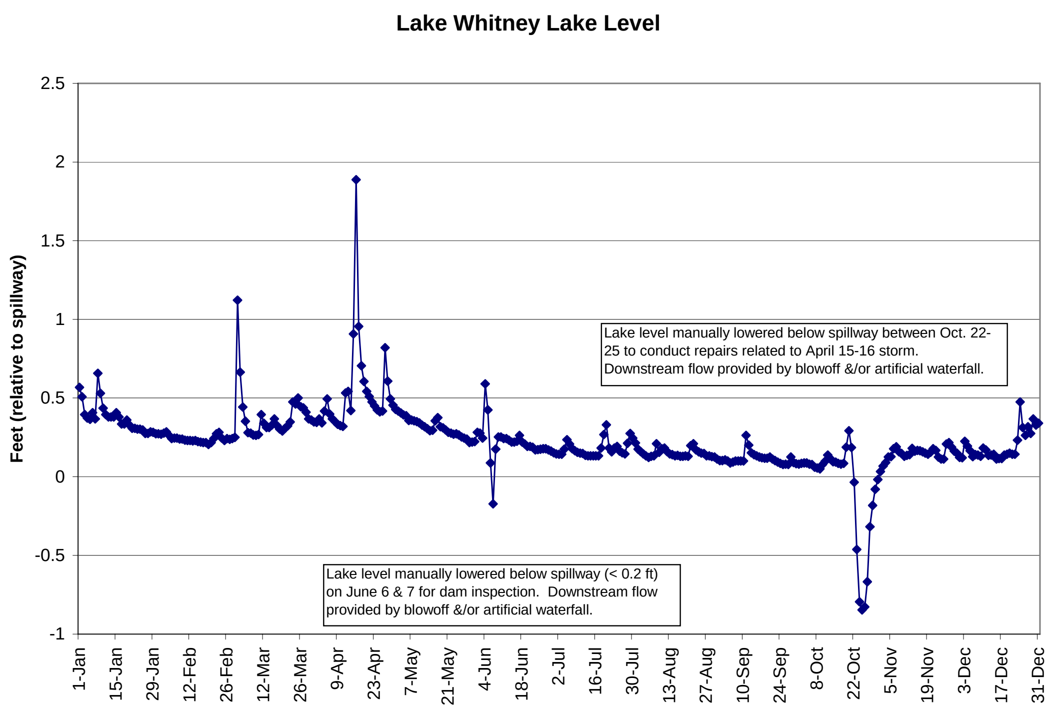


Figure 8. Water level for Lake Whitney during 2007.

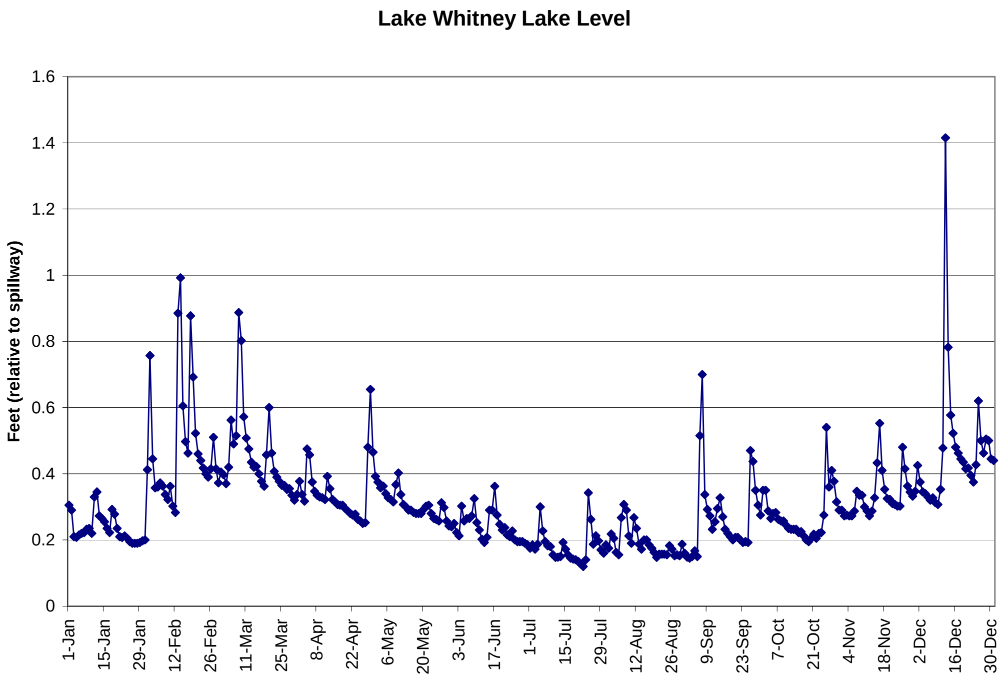


Figure 9. Water level for Lake Whitney during 2008.

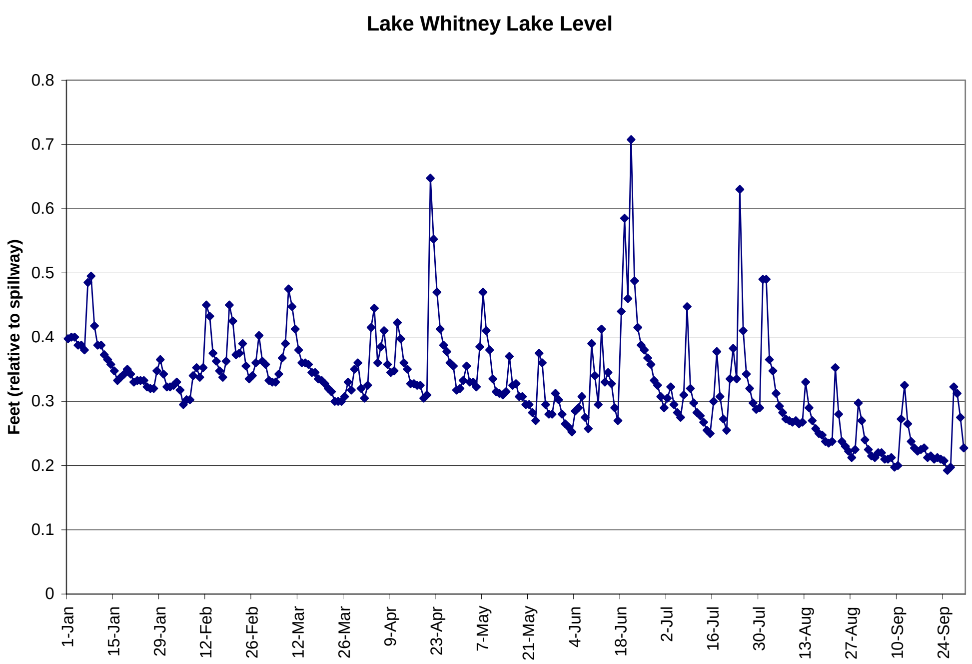


Figure 10. Water level for Lake Whitney during 2009.

Methods

This assessment incorporates evaluations of phytoplankton, zooplankton, aquatic macrophytes, benthic macroinvertebrates, fish, and water quality in upper Lake Whitney (Figure 11). The same sampling methods and sampling stations employed in previous years were again used in 2009. Phytoplankton were assessed from a whole water sample collected as a near-surface grab sample once on June 29, 2009. Samples were preserved in gluteraldehyde, concentrated by settling, and examined under phase contrast optics at 400X. Cell counts were converted to biomass estimates on a volumetric basis based on cell measurements.

Zooplankton were collected with a 53 micron mesh net towed through up to 30 meters of water on an oblique angle, yielding a sample of about 100 ml that represents nearly 1000 liters of lake water. One sample was collected at the June 29, 2009 phytoplankton sampling site. The sample was preserved and settled in the same manner as the phytoplankton, and examined at 100X under brightfield optics. Individual counts were converted to biomass estimates based on measured organism dimensions.

Macrophytes were mapped by assessing composition and density at numerous points along multiple transects across the lake on June 29, 2009. In addition to recording the species of plants and their overall and relative abundance, water depth and sediment type were also noted. A rating system was used to evaluate cover (two dimensions) and biovolume or biomass (three dimensions). In this system, a 0 represents no plants, while a 5 represents complete cover or filling of the water column. Ratings of 1 through 4 correspond to quartiles in between (i.e., 1-25%, 26-50%, 51-75%, and 76-99%).

Benthic macroinvertebrates were collected on June 29, 2009 with a D-frame dip net according to Rapid Bioassessment Protocols (EPA 1999). Basically, all habitats within the area of the selected stations are sampled for a timed interval and the collected invertebrates are identified and counted. The dip net was used in water up to 5 ft deep, generally in areas of plants and soft sediments. Invertebrates were sorted, and identified with the help of dichotomous keys.

Fish were assessed on June 29, 2009 by visual observation and through the use of gill nets. Sinking 1.0 inch bar monofilament gill nets were used to sample the fish community in Lake Whitney. Gill nets were set and checked approximately every hour. Each captured fish was measured to the nearest mm before being released.

Results

Water quality as measured on June 29, 2009 using digital meters and water grab test kits, are presented in Table 1.

Table 1. Water quality data for four stations at Lake Whitney collected on June 29, 2009.

Date	Depth (meters)	Temp °C	Dissolved Oxygen (% saturation)	Dissolved Oxygen (mg/L)	Turbidity (NTUs)	pH	Conductivity (µS/cm)
6/29/2009	0.1	21.6	99.8	8.9	4.1	7.4	239
6/29/2009	1.0	20.5	90.0	8.0		7.4	248
6/29/2009	2.0	19.4	75.3	7.0		7.3	259
6/29/2009	3.0	19.1	69.3	6.0		7.2	258
6/29/2009	3.4	17.8	28.7	4.1		7.1	241

Phytoplankton

The location of phytoplankton sampling is indicated in Figure 11. Phytoplankton cell counts and biomass estimates are provided in Table 2. Golden algae (Chrysophyta) were the major component of the phytoplankton at the time of sampling in 2009, with smaller amounts of algae from three other divisions. The blue-green *Anabaena* (more properly cyanobacteria), several diatoms, and the chlorophyte *Sphaerocystis* were present in the plankton sample, but not at abundant levels. Biomass and taxonomic richness were low on the 2009 sampling date, relative to other years since 2005, probably as a result of high flushing. Concentrations of algae were well below any threshold for concern in a water supply operation.

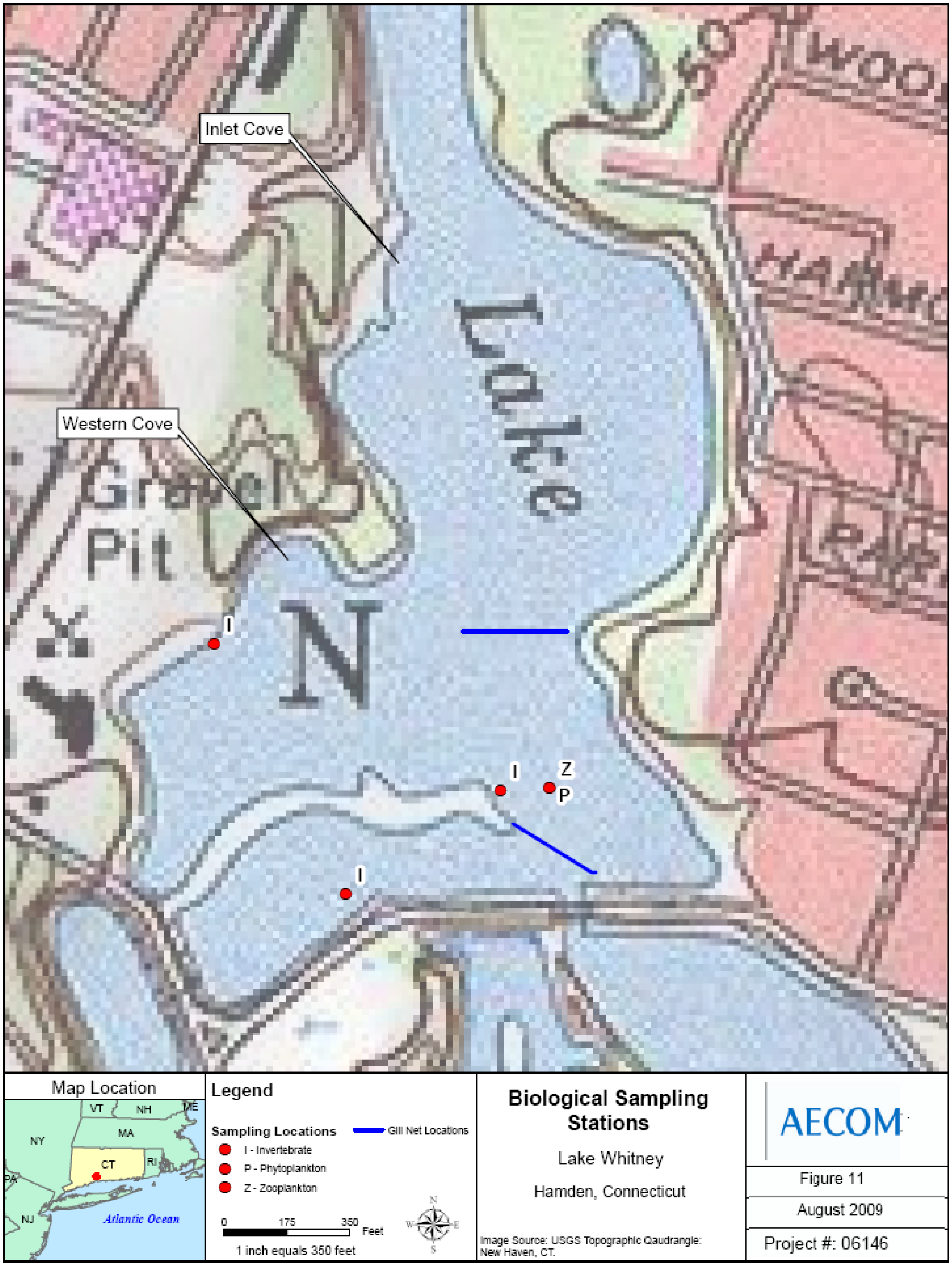


Figure 11. Map of upper Lake Whitney including sampling locations for phytoplankton, zooplankton, invertebrates and gill net set locations.

Table 2. Phytoplankton density (cells/mL) and biomass (µg/L) for the sample collected in upper Lake Whitney in June 29, 2009.

	Density (cells/mL) LW-1 06/29/09		Biomass (µg/L) LW-1 06/29/09
TAXON		**TAXON**	
BACILLARIOPHYTA		**BACILLARIOPHYTA**	
Centric Diatoms		**Centric Diatoms**	
Aulacoseira	90	*Aulacoseira*	27
Araphid Pennate Diatoms		**Araphid Pennate Diatoms**	
Asterionella	45	*Asterionella*	9
Synedra	30	*Synedra*	24
Tabellaria	30	*Tabellaria*	24
CHLOROPHYTA		**CHLOROPHYTA**	
Coccoid/Colonial Chlorophytes		**Coccoid/Colonial Chlorophytes**	
Sphaerocystis	120	*Sphaerocystis*	24
CHRYSOPHYTA		**CHRYSOPHYTA**	
Flagellated Classic Chrysophytes		**Flagellated Classic Chrysophytes**	
Dinobryon	120	*Dinobryon*	360
CYANOPHYTA		**CYANOPHYTA**	
Filamentous Nitrogen Fixers		**Filamentous Nitrogen Fixers**	
Anabaena	210	*Anabaena*	42
DENSITY (CELLS/ML) SUMMARY		**BIOMASS (UG/L) SUMMARY**	
BACILLARIOPHYTA	**195**	**BACILLARIOPHYTA**	**84**
CHLOROPHYTA	**120**	**CHLOROPHYTA**	**24**
CHRYSOPHYTA	**120**	**CHRYSOPHYTA**	**360**
CRYPTOPHYTA	**0**	**CRYPTOPHYTA**	**0**
CYANOPHYTA	**210**	**CYANOPHYTA**	**42**
EUGLENOPHYTA	**0**	**EUGLENOPHYTA**	**0**
PYRRHOPHYTA	**0**	**PYRRHOPHYTA**	**0**
TOTAL	**645**	**TOTAL**	**510**
CELL DIVERSITY	**0.75**	**BIOMASS DIVERSITY**	**0.48**
CELL EVENNESS	**0.89**	**BIOMASS EVENNESS**	**0.57**
NUMBER OF TAXA			
BACILLARIOPHYTA	**4**		
CHLOROPHYTA	**1**		
CHRYSOPHYTA	**1**		
CRYPTOPHYTA	**0**		
CYANOPHYTA	**1**		
EUGLENOPHYTA	**0**		
PYRRHOPHYTA	**0**		
TOTAL	**7**		

Zooplankton

The location of zooplankton sampling is indicated in Figure 11. Zooplankton counts and biomass estimates are provided in Table 3. In 2009, zooplankton included rotifers, copepods, and cladocerans, all at very low abundance. *Daphnia galeata*, a large-bodied cladoceran that filters algae from the water column and is considered desirable food for small fish, comprised the largest biomass fraction, but was still only present at a very low density. Overall biomass was very low, most likely a function of high flushing. Predation also influences zooplankton abundance, but the very low levels encountered are probably more influenced by the high flows through spring of 2009. Diversity and evenness were relatively high, but taxonomic richness was low; that is, only a few types of zooplankton were present, but none was especially dominant. Mean length was moderate, but the very low abundance of zooplankton provides limited food for the fish community and almost no grazing pressure on algae.

Table 3. Zooplankton density (#/L) and biomass (μg/L) for the sample collected in upper Lake Whitney during June 29, 2009. S-W is Shannon-Wiener diversity index.

	Density (#/L) LW-1Z 6/29/09		Biomass (μg/L) LW-1Z 6/29/09
TAXON		**TAXON**	
ROTIFERA		**ROTIFERA**	
Keratella	0.2	*Keratella*	0.0
COPEPODA		**COPEPODA**	
Copepoda-Cyclopoida		**Copepoda-Cyclopoida**	
Mesocyclops	0.4	*Mesocyclops*	0.5
Copepoda-Calanoida		**Copepoda-Calanoida**	
Diaptomus	0.4	*Diaptomus*	0.2
Other Copepoda-Nauplii	0.2	**Other Copepoda-Nauplii**	0.5
CLADOCERA		**CLADOCERA**	
Bosmina	0.2	*Bosmina*	0.2
Daphnia galeata	0.4	*Daphnia galeata*	2.3
SUMMARY STATISTICS		**SUMMARY STATISTICS**	
DENSITY		**BIOMASS**	
PROTOZOA	0.0	**PROTOZOA**	0.0
ROTIFERA	0.2	**ROTIFERA**	0.0
COPEPODA	1.0	**COPEPODA**	1.2
CLADOCERA	0.6	**CLADOCERA**	2.5
OTHER ZOOPLANKTON	0.0	**OTHER ZOOPLANKTON**	0.0
TOTAL ZOOPLANKTON	1.8	**TOTAL ZOOPLANKTON**	3.8
TAXONOMIC RICHNESS		**S-W DIVERSITY INDEX**	0.75
PROTOZOA	0	**EVENNESS INDEX**	0.97
ROTIFERA	1		
COPEPODA	3	**MEAN LENGTH (mm): ALL FORMS**	0.57
CLADOCERA	2	**MEAN LENGTH: CRUSTACEANS**	0.63
OTHER ZOOPLANKTON	0		
TOTAL ZOOPLANKTON	6		

Macrophytes

Macrophytes are a visibly dominant feature of upper Lake Whitney in the summer. Mapping points and transects are shown in Figure 12. Collected macrophyte data are provided in Table 4. Maps of total plant cover and total plant biovolume are presented in Figures 13 and 14. Maximum water depth in upper Lake Whitney is only about 10 ft, with much of the upper basin less than 5 ft deep. Surficial sediments in upper Lake Whitney are primarily mucks and sands, with some larger rocks and various leaf litter and other woody debris. Plant growth could therefore be expected almost anywhere, with lower light limiting density and surface cover in the deeper areas.

Cover by macrophytes varied throughout the lake, with the densest cover generally in the northern portion of the lake, and part of the western cove. Increased plant cover was observed in the inlet cove in 2009 compared to the previous three years. Plant cover in this area is approaching 2004 and 2005 levels, where the inlet cove experienced cover between 75 and 100%. The western cove of the lake has largely recovered since the major 2004 drawdown and is approaching pre-drawdown levels. The southern portion of the lake experienced an increase in plant cover between 2008 and 2009 on the western side and a slight decrease for the same time period on the eastern side.

As expected, macrophyte coverage was greatest near shore, and decreased with increased distance from the shore. The dominant species in deeper water were filamentous green algae, *Elodea canadensis*, and *Ceratophyllum demersum*. Biovolume followed a similar pattern compared to the previous four years and was almost identical to 2008 levels, except for a few areas that experienced increases in plant biovolume. In 2009, two areas within Lake Whitney exceeded 50% biovolume. One area was located in the inlet cove and a second, smaller area was located in the southeast corner of the lake. Macrophyte biovolume in the western cove and southern portion of the lake have returned to pre-drawdown levels.

The presence of largely floating (e.g., duckweed, watermeal) or floating leaved (e.g., lilies) species gives an impression of greater plant biomass than really exists in this lake. Areas of densest cover and biovolume contained both water lilies and the submergent waterweed (*Elodea*), coontail (*Ceratophyllum*) or algal mats. The 2004 lake level drawdown for dam maintenance is the likely cause for general decrease in cover and biovolume of floating leaved plants observed during the 2005-2008 surveys. In 2009, floating leaved plants returned to pre-drawdown levels in some areas. From an ecological perspective, the lower density in places compared to pre-2004 drawdown currently represents an improvement compared to the overly high densities of plants present before the drawdown, by providing enhanced light penetration and oxygen transfer.

In general, upper Lake Whitney hosts relatively few plant species, with swamp and purple loosestrife, European water clover and small pondweed being the only aquatic plants noted other than the more abundant plants mentioned above. Although present in 2007, no benthic blue-green algae mats were observed in 2008 or 2009 surveys. Blue-green algae, or cyanobacteria, are photosynthetic, aquatic bacteria. In 2009 macrophyte diversity was similar to the previous three years. All species present are tolerant of low light or prefer shallow water (where low light is less of an issue).

During the June 29, 2009 survey, non-native plants European water clover and purple loosestrife were observed. The 2009 survey was the fourth time European water clover was observed by AECOM, although European water clover has been observed within Lake Whitney on previous occasions by employees of the South Central Connecticut Regional Water Authority (J. Hudak, personal communication). Purple loosestrife is a fringing emergent species, and not typically encountered at the inlake transect stations.

Duckweed (*Lemna minor*) was found mainly in the northern portion of the lake. This floating vascular plant depends upon the water column for nutrition and is an indicator of high nutrient levels, especially for nitrate. As it is not anchored to the sediment, this plant can be flushed through the system readily, and probably is delivered to upper Lake Whitney on a regular basis from upstream ponds and wetlands.

Waterweed (*Elodea canadensis*) is a rooted submergent vascular plant that tolerates low light and high sediment loads. It is present throughout the entire upper Lake Whitney except for the western coves. Waterweed abundance in 2009 was similar to 2006-2008 levels but is below the levels observed in 2004. While the 2004 drawdown may be partially responsible, natural variability is also a factor in shallow systems such as this.

Waterlilies (*Nymphaea odorata* and *Nuphar variegata*) are mainly peripheral species in upper Lake Whitney, but provide the densest surface cover and dominate the plant assemblage where they occur. Lilies cover nearly all the inlet channel and occupy a major portion of the western cove. Lily cover and abundance in 2009 was decreased compared to the 2004 survey for most areas, and appears to have been impacted by several of the drawdowns.

Benthic algal mats are not obvious in upper Lake Whitney, as they are submergent growths at the sediment-water interface. Algal mats are the dominant macrophytes in areas without vascular plants, but do not achieve the densities sometimes associated with nutrient rich sediments in shallow areas. The filamentous green alga *Spirogyra* was especially abundant. Low light and high flushing rate are probably major factors in controlling these mats, as with the phytoplankton.

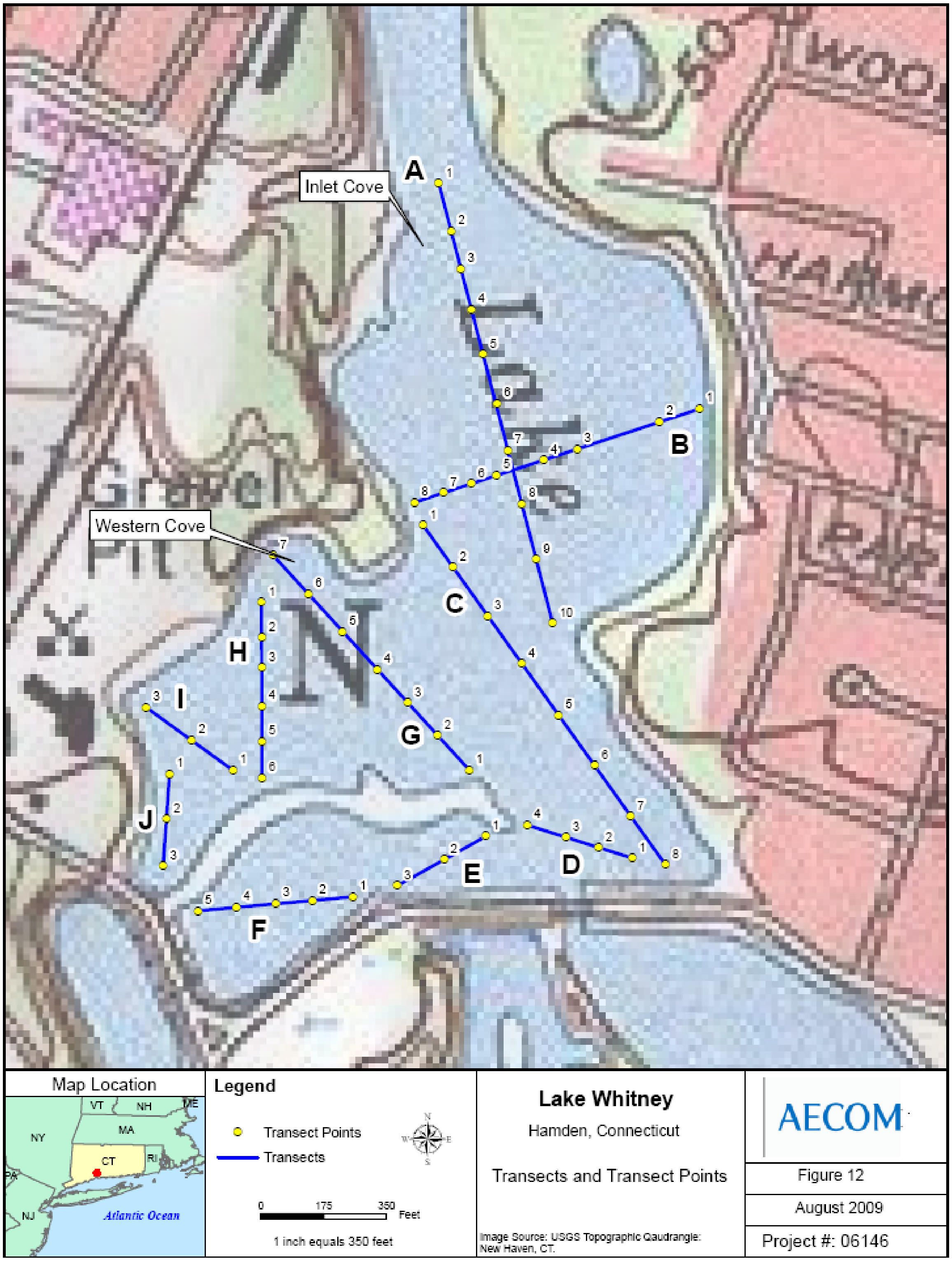


Figure 12. A map of upper Lake Whitney containing aquatic macrophyte survey transects and points.

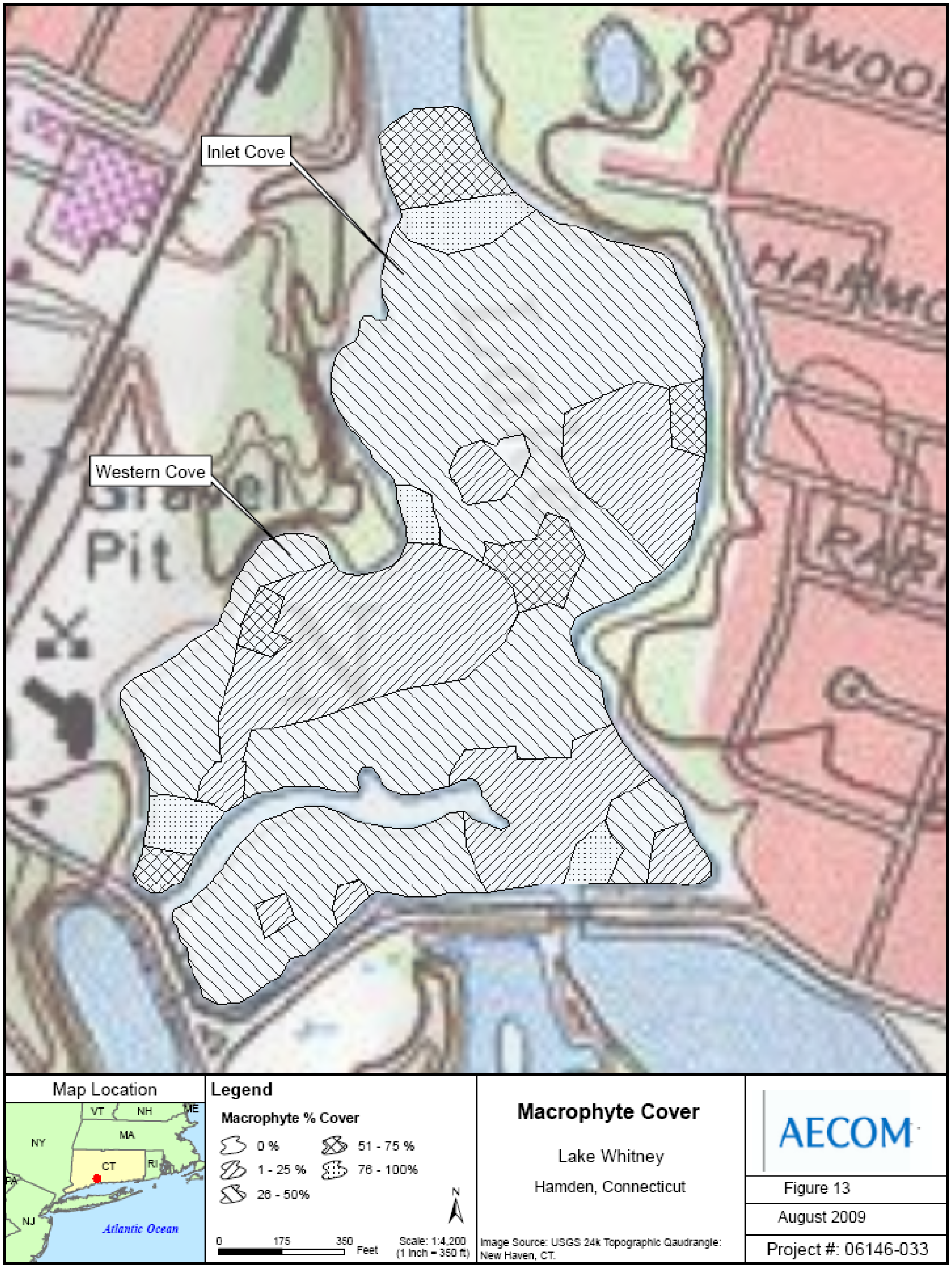


Figure 13. A map of upper Lake Whitney and corresponding plant cover on June 29, 2009.

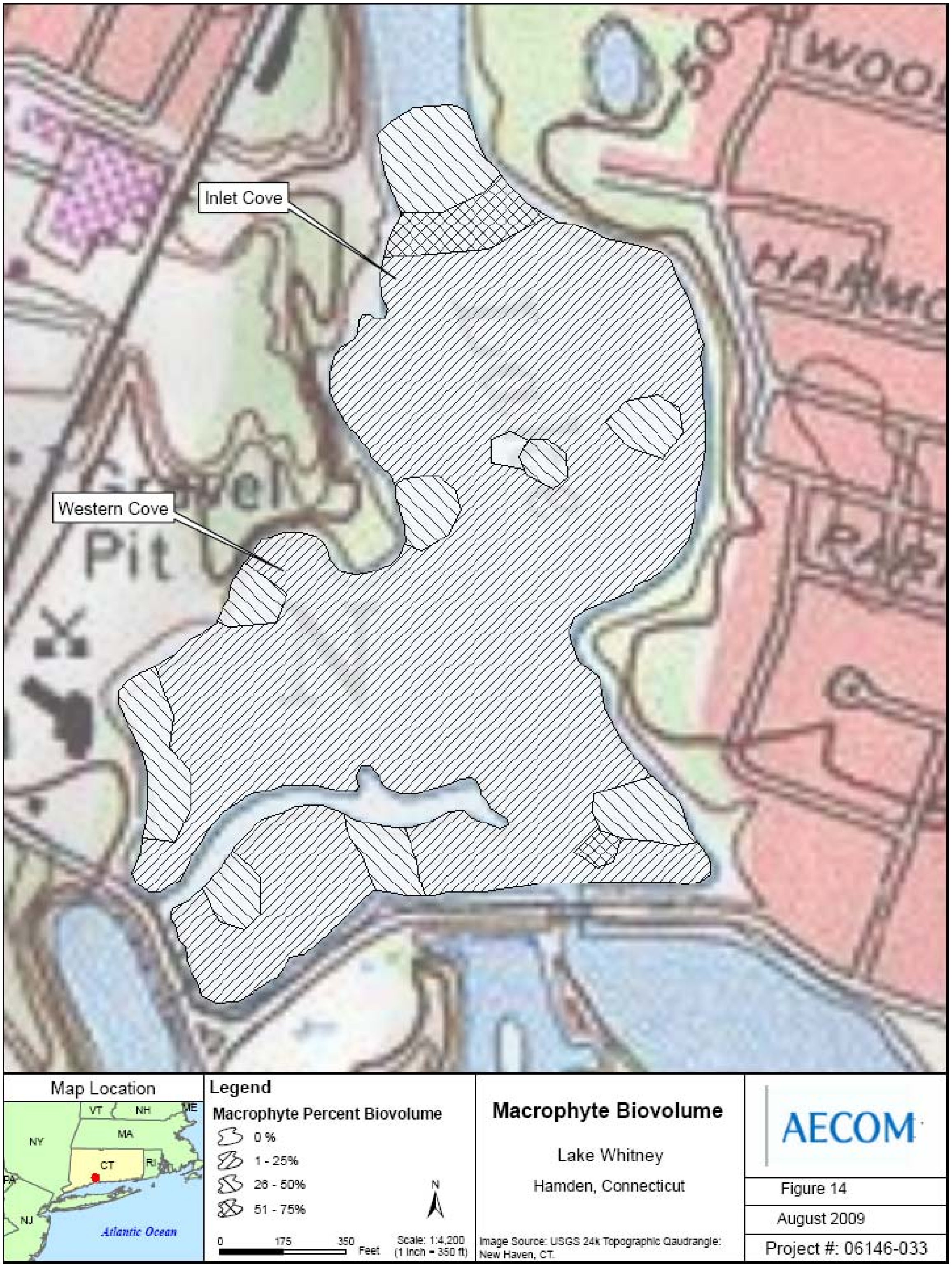


Figure 14. A map of upper Lake Whitney and corresponding plant biovolume on June 29, 2009.

Table 4. Physical characteristics (water depth, sediment type), total plant percent cover and biovolume, and plant taxa recorded at each transect point during the survey (29-June-2009). Plant taxa are reported left to right from the most abundant to the least abundant for each transect point. For full names of plant taxa, sediment type codes, and total plant percent cover and biovolume codes, see notes at the end of table.

trans. pt. ID	water depth m	water depth ft	sediment type	total plant % cover	total plant % biovol.	plant taxa (% relative abundance)
A-1	0.6	2.0	mu,sa	3	2	nod
A-2	0.6	2.0	mu	4	3	nod, eca, cde
A-3	0.6	2.0	mu	2	1	nod, eca, cde
A-4	0.5	1.5	mu	2	1	cde, ecg
A-5	0.3	1.0	mu	2	1	nod, eca, lma, wco
A-6	0.5	1.5	mu	2	1	alg, nod
A-7	0.6	2.0	mu	0	0	
A-8	0.9	3.0	mu	2	1	alg, nod, cde
A-9	1.5	5.0	mu	3	1	eca, alg, cde, nod
A-10	1.7	5.5	mu	2	1	alg
B-0	0.3	1.0	sa	3	1	alg, lmi
B-1	0.9	3.0	mu	3	1	alg, eca, wco
B-2	1.2	4.0	mu	1	2	eca, cde
B-3	0.9	3.0	mu	1	1	nod, eca
B-4	0.9	3.0	mu	2	2	alg, eca, nod
B-5	1.1	3.5	mu	1	1	alg
B-6	1.2	4.0	mu	1	1	eca, alg
B-7	1.2	4.0	mu	2	2	nod, eca
B-8	1.5	5.0	mu,sa,ro	4	2	nod, alg, cde
C-1	1.2	4.0	mu,sa	4	2	eca, nod, cde
C-2	1.4	4.5	mu	1	1	eca
C-3	1.2	4.0	mu	1	1	alg
C-4	1.5	5.0	mu	2	1	alg, cde
C-5	1.1	3.5	mu,sa	2	1	alg, eca
C-6	1.4	4.6	mu,sa	1	1	alg, eca, cde, nod
C-7	1.5	5.0	mu	2	2	nod, eca, cde
C-8	1.8	6.0	mu	1	1	nod, cde, lmi
D-1	1.8	5.8	mu	2	1	alg, eca, nod
D-2	1.8	5.8	mu	4	3	eca
D-3	2.7	8.8	mu	1	1	alg, eca
D-4	2.1	7.0	mu	1	1	eca, nod, lmi, wco, lma
E-1	0.9	3.0	mu	1	1	alg, ppu, nod, wco
E-2	2.7	9.0	mu	2	1	alg, ppu
E-3	0.9	3.0	sa, ro	2	2	ppu, alg, mqu
F-1	0.9	3.0	sa, ro	1	1	eca, alg, nod
F-2	2.4	8.0	mu	2	1	nod, eca, alg
F-3	2.1	7.0	mu	1	1	alg, cde
F-4	2.0	6.5	mu	2	2	cde
F-5	1.5	5.0	mu	2	1	cde, eca

Table 4 (continued). Physical characteristics (water depth, sediment type), total plant percent cover and biovolume, and plant taxa recorded at each transect point during the survey.

trans. pt. ID	water depth m	water depth ft	sediment type	total plant % cover	total plant % biovol.	plant taxa (% relative abundance)
G-1	1.7	5.5	mu	1	1	eca, alg
G-2	1.8	6.0	mu	2	1	nod, eca, alg
G-3	1.5	5.0	mu	2	1	alg, eca
G-4	1.8	5.9	mu	1	1	alg, mqu
G-5	1.8	5.9	mu	1	1	alg, eca
G-6	0.8	2.5	mu	1	1	alg, eca
G-7	1.1	3.5	mu	2	1	nod, alg
H-1	1.0	3.2	mu,sa	3	2	nod, alg
H-2	1.2	4.0	mu,sa	3	1	alg, nod, eca
H-3	1.0	3.2	mu	1	1	alg, eca
H-4	0.9	3.0	mu	1	1	nod, eca, cde
H-5	1.0	3.2	mu	2	1	eca
H-6	0.6	2.0	mu,sa	2	1	alg, nod, eca
I-1	0.6	2.0	mu	1	1	alg, nod, eca
I-2	1.2	4.0	mu	2	1	alg
I-3	1.4	4.5	mu	2	2	alg, nod, lmi
J-1	1.2	4.0	mu	2	2	mqu
J-2	1.0	3.2	mu	4	2	alg, nva, eca, lmi, wco
J-3	1.1	3.5	mu	3	1	alg, eca, wco, lmi

Notes:

sediment type: **co** - cobble; **gr** - gravel; **ll** - leaf liter; **mu** - muck; **ro** - rock; **sa** - sand

plant taxa: **alg** - green algae (Chlorophyta); **cya** - blue-green algae (Cyanophyta)
dve - *Decodon verticillatum* (swamp loosestrife);
eca - *Elodea canadensis* (waterweed);
lmi - *Lemna minor* (duckweed);
lma - *Lemna major* (duckweed);
nod - *Nymphaea odorata* (fragrant or white-flower waterlily);
nva - *Nuphar variegata* (yellow-flower waterlily);
wco - *Wolfia columbiana* (watermeal);
mqu - *Marsilea quadrafolia (* european waterclover*)*
lsa - *Lythrum salicaria* (purple loosestrife);
cde - *Ceratophyllum demersum* (coontail);
pcr - *Potamogeton crispus* (curly-leaf pondweed).
ppu - *Potamogeton pusillis* (small pondweed)

Benthic Macroinvertebrates

Locations of benthic invertebrate sampling are shown in Figure 11. Data for the types of organisms found are provided in Table 5.

Overall low habitat quality (mucky bottom, low density of truly submerged vascular plants) and possibly high fish predation could limit macroinvertebrate communities in Lake Whitney.

The types of species present in 2009 were similar to previous years. AECOM biologists noted that overall abundance in 2009 was higher than the previous three years, although numbers of organisms present was not quantified. Most of the invertebrate taxa found in Lake Whitney were tolerant of impacted environments and/or opportunistic species (e.g., pulmonate snails; sowbugs, and scuds such as *Gammarus*). Scarcity of large-bodied invertebrate taxa in Lake Whitney suggests possible strong predation by fish. With a depressed zooplankton community, invertebrates may represent a large portion of the prey available for the fish community. In particular, common carp (abundant in Upper Lake Whitney) is known to cause drastic reductions in invertebrate densities.

Total macroinvertebrate species diversity was moderate in 2009. Taxonomic richness in 2009 (13) was higher than in 2008 (12) or, 2007 (11), the same as 2006 (13), but lower than in 2005 (14), 2004 (18) or 2000 (26); however, the same taxa were most abundant in all years. So the community is fairly stable, not comprised of an especially large number of taxa of invertebrates, but no one taxon is dominant.

The macroinvertebrate community of Lake Whitney was characterized by dominance by primary consumers, and a small but relatively diverse assemblage of predators (e.g., damselfly larvae, the Dobsonfly larva *Corydalus*) indicates that Lake Whitney supports multiple trophic levels within the benthic invertebrate community. Overall low invertebrate density, diversity, and body size once more suggest that fish predation may be high in Lake Whitney. In the absence of intense predation, it is possible that a relatively complex benthic food web would develop.

Table 5. Taxonomic and ecological (feeding ecology) characterization of each benthic macroinvertebrate taxon found in Upper Lake Whitney on June 29, 2009. For those taxa with multiple feeding mode, primary and secondary modes are given. Generalist primary consumers feed on both living and dead plant tissues with no evident preference. Feeding ecology obtained from several sources, mainly Thorp and Covich (1991), Merrit and Cummins (1995), and direct observations by ENSR staff.

					feeding group(s)	
phylum or subphylum	class	order or subclass	family	taxon	primary	secondary
Mollusca	Gastropoda	Pulmonata	Physidae	Physa gyrina	generalist	
Mollusca	Gastropoda	Pulmonata	Planorbidae	Gyraulus parvus	generalist	
Annelida	Oligochaeta					
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	predator	
Crustacea	Malacostraca	Amphipoda	Gammaridae	Gammarus sp.	generalist	
Uniramia	Insecta	Odonata	Zygoptera	Enallagma sp.	predator	
Uniramia	Insecta	Megaloptera	Corydalidae	Corydalus sp.	predator	detritivore
Uniramia	Insecta	Hemiptera	Corixidae	Palmacorixa sp.	generalist	
Uniramia	Insecta	Coleoptera	Haliplidae	Peltodites sp.	herbivore	
Uniramia	Insecta	Diptera	Chironomidae	Tanypodinae spp.	predator	
Uniramia	Insecta	Diptera	Chironomidae	Chironominae spp.	generalist	
Uniramia	Insecta	Hemiptera	Veliidae			
Uniramia	Insecta	Diptera	Psychodidae			

Fish

Locations of gill net sets are shown in Figure 11, and fish data are presented in Table 6. In addition to the species listed in Table 6, several sunfish species, largemouth bass (*Micropterus salmoides*) and common carp (*Cyprinus carpio*) were visually observed. Centrarchids are adept at avoiding gill nets and other sampling was not possible within the physical constraints of the lake and the time allotted for assessment. Common carp appeared to be concentrated in the northern cove; these larger fish are not often captured in 1.0 inch gill nets, but are easily visible in the shallow areas that they frequent in upper Lake Whitney.

White perch (*Morone americana*) were once again the most abundant species collected in 2009 (Figure 15). Numerous large carp specimens were visually observed jumping and swimming in the shallow north cove, and in the central part of the lake. Despite no carp being captured in 2009 and only limited captures over the last few years, common carp may still dominate fish biomass in the lake as seen in 2000. Three species of fish were captured during the 2009 survey. These included white perch, yellow perch (*Perca flavescens*) and golden shiner (*Notemigonus crysoleucas*). All fish appeared healthy, and only a few of the perch captured appeared to be hosting the parasitic fungus seen in past years. The total number of fish collected in 2009 was similar to previous years, although richness was reduced.

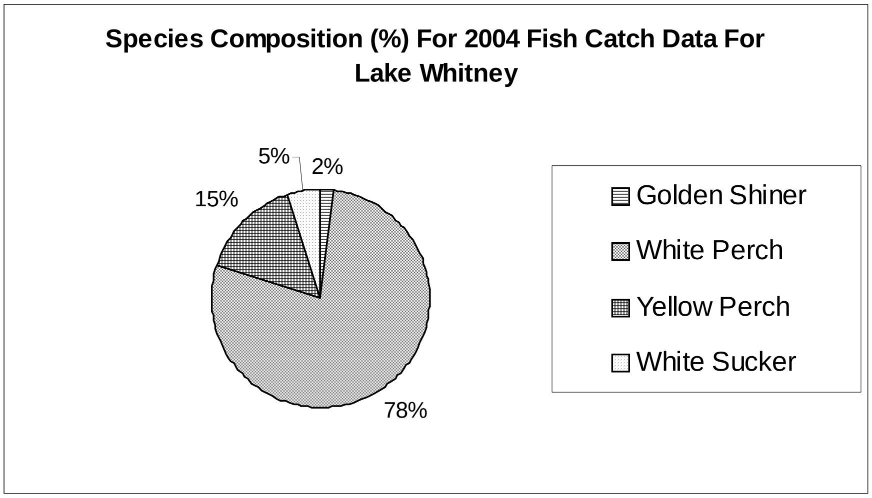
Although the zooplankton community structure is similar to lakes with landlocked alewife (i.e., few individuals, small body size), no clupeid fishes (e.g., alewife, shad) have been captured or observed in upper Lake Whitney since monitoring began, nor have they been found in Connecticut Department of Environmental Protection electrofishing surveys in other segments of this chain of reservoirs. Other factors could also lead to this structure, including high flushing rate and predation by other planktivorous fishes such as golden shiner. In 2009, six golden shiners were captured, but it does not appear that they are present in large numbers. The lack of numbers and size of zooplankton may result in some planktivorous fishes moving out of the area in search of more abundant food sources.

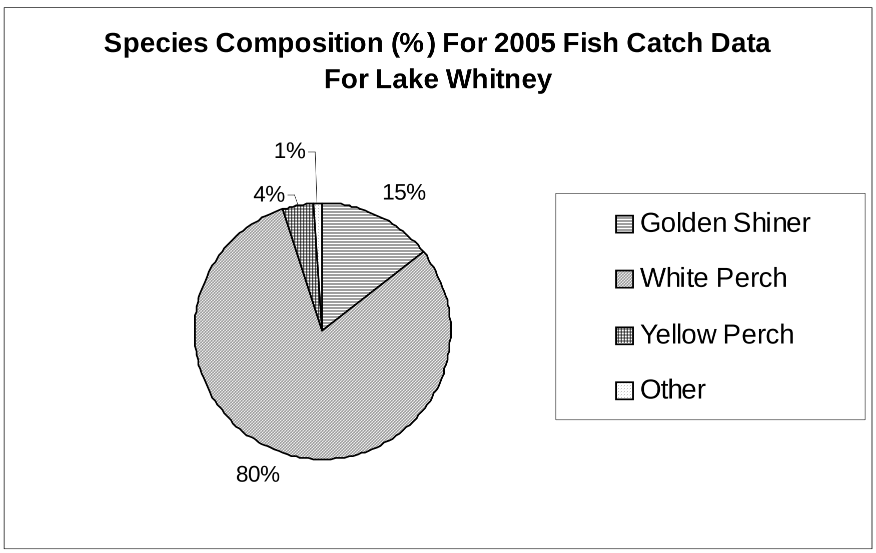
Upper Lake Whitney supports a substantial warmwater fish community. Coldwater species would not be expected to inhabit Lake Whitney. The unhindered connection to the lower portion of Lake Whitney allows fish to move freely between the lake segments, so rapid re-population after any times of stressful conditions in upper Lake Whitney is expected. Daily movements in response to food resource availability may also occur. Zooplankton resources in upper Lake Whitney might constrain planktivorous fish growth, but captured individuals appeared to have average condition factors (length vs. weight). Visually, fish appeared abundant in upper Lake Whitney; shallow depth makes many fish easy to spot. Habitat conditions are not ideal for fish, but are sufficient to sustain a thriving warmwater fish community that would be accessible to piscivorous wildlife, most notably wading birds.

Table 6. Results of the gill net fish survey in upper Lake Whitney on June 29, 2009. These data do not include visual observations of species that were not collected in the gill net

Golden Shiner	**White Perch**		**Yellow Perch**
TL(mm)	TL (mm)	TL (mm)	TL (mm)
112	117	188	131
121	120	193	149
165	131	198	158
170	144	206	162
188	147	208	177
199	147	208	188
	158	210	201
	158	211	
	161	212	
	161	216	
	162	218	
	162	218	
	170	222	
	171	225	
	171	226	
	177	231	
	184	241	
	184		

Figure 15. A graphical representation of species composition (number of fish) for the 2004, 2005, 2006, 2007, 2008 and 2009 sampling events.





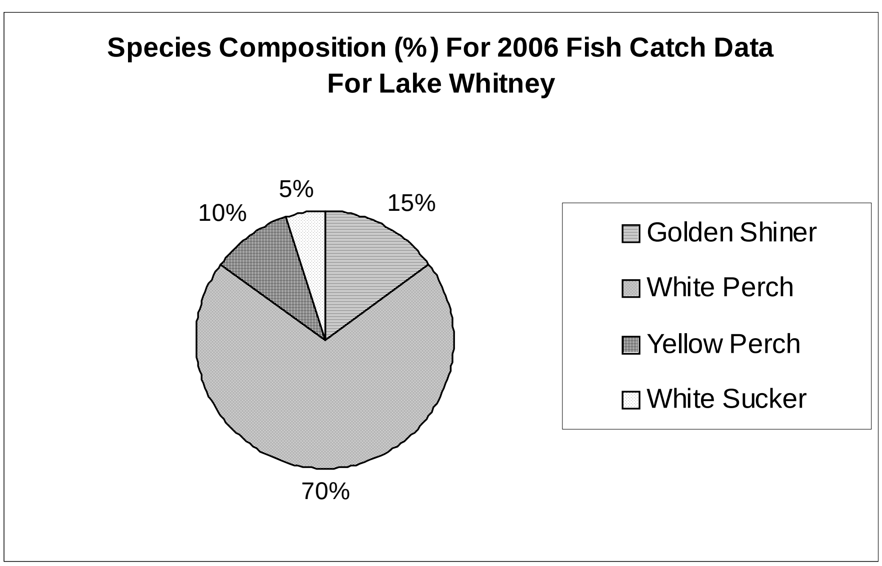
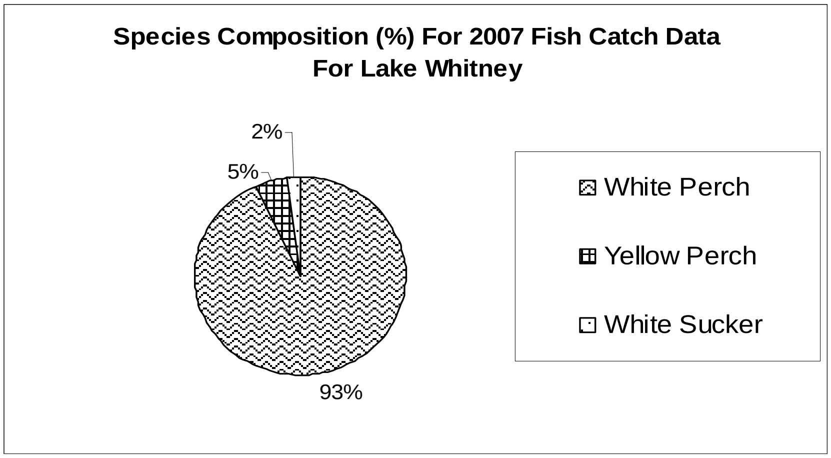
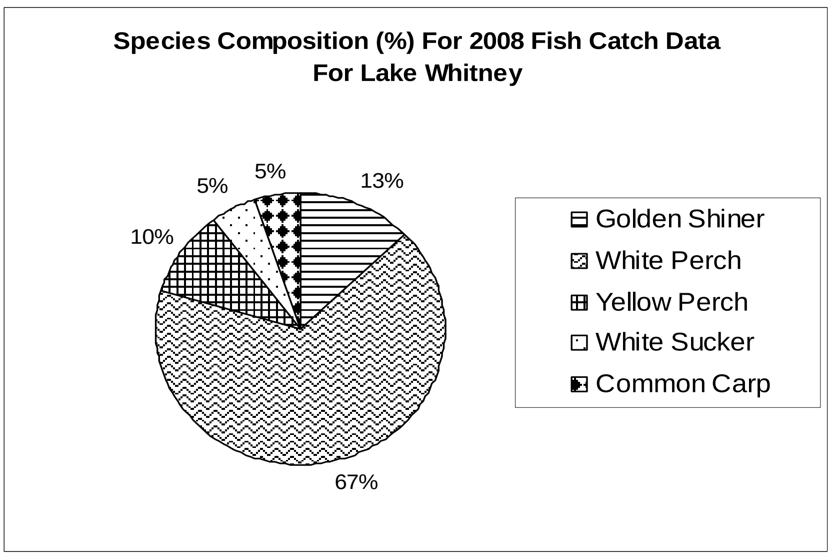
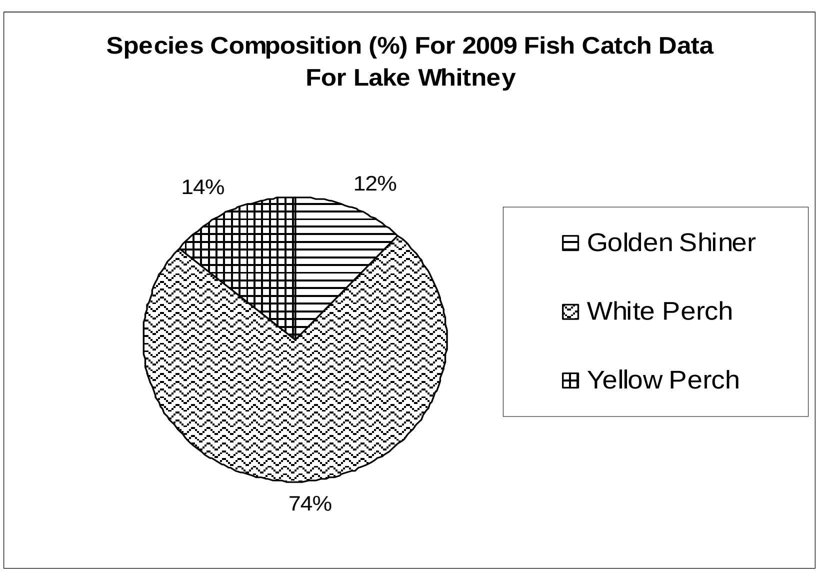


Figure 15 (continued). A graphical representation of species composition (number of fish) for the 2004, 2005, 2006, 2007, 2008 and 2009 sampling events.







Discussion

Phytoplankton, zooplankton, macroinvertebrate and fish communities assessed in 2009 were compositionally similar to those observed in 2004-2008. A drawdown ranging up to six feet that lasted over a month in summer of 2004 was performed to allow construction at the Lake Whitney dam, and appears to have had slight impacts on most biological components of the system, but a larger and prolonged impact on aquatic macrophytes, which have not fully returned to pre-drawdown abundance levels. Smaller drawdowns in following years may have also had some impact, but the 2004 drawdown appears to have been the main factor in plant changes, consistent with experiences at other lakes (Holdren et al. 2001), where drawdown is used to control plant biomass.

Phytoplankton and zooplankton communities are largely dependent on flushing, water quality, and predation influences. Flushing of upper Lake Whitney appears to be the dominant influence over the last two years, and is still substantial on average in most years, as the reservoir is small relative to its watershed. During prolonged dry periods, algal blooms would be possible based on elevated nutrient levels and low grazing pressure by zooplankton, but assessment in June of five successive years indicates no problems at that time, which usually follows a period of elevated flushing in the spring. Zooplankton are also influenced by predation by fish, likely to be intense in upper Lake Whitney, so higher zooplankton biomass is not expected in this reservoir even during periods of reduced flushing.

While the plant community appears to be regaining stability after a substantial decrease in response to the 2004 drawdown, there are still fluctuations among years that are representative of largely natural variability. For example, although coontail was present in Lake Whitney in 2009, it was much less abundant than in 2008. Small areas still contained growths of coontail that nearly reached the surface of the water, but overall abundance of coontail decreased between 2008 and 2009. In general, the reduced coverage and biovolume of plants observed over the last 4 years represents an ecological improvement over pre-drawdown levels. The current macrophyte community is adequate to support fish and wildlife functions without overwhelming shallow water areas and inlets.

Macroinvertebrate richness has been similar from 2006-2009, varying between 11 and 14 taxa. Small fluctuations in richness could be due to hydrology, the plant community shift, and/or predation and physical disturbances by fish. Physical disturbances to the macroinvertebrate community, including predation and suspension of sediments and macroinvertebrates into the water column would likely be a result of the large carp present in Lake Whitney. Macroinvertebrate abundance is patchy, so changes in species richness by a small margin is not cause for concern. Overall, there were no major changes in the macroinvertebrate features of upper Lake Whitney during 2009 from past years.
The fish community is dominated by planktivores (perch, shiners) and detritovores (carp), although bass and other warmwater species are present. Easy movement into downstream

reservoirs limits any impacts from changing water level on the fish community, which appears fairly stable based on five years of assessment.

Overall, upper Lake Whitney is influenced by fluctuating water levels, but only the rooted plant community appears susceptible to more than transient impacts as the result of major drawdown. In that case, the reduced density of plants appears to represent habitat enhancement, or at least has not resulted in any substantial changes in other biological components of the system. Plant densities have increased over several years following the initial reduction in coverage after the 2004 drawdown. Subsequent drawdowns may have prolonged some effects, and other influences lead to variation in conditions over subsequent years, but the overall condition of upper Lake Whitney appears similar to that prior to the period of multiple drawdowns conducted for reservoir and water supply management.

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