Level I Water Quality Inventory - Weir Farm NHS

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Executive Summary

In association with the Baseline Water Quality Data Inventory and Analysis Program of the NPS-Water Resources Division we conducted a Level I water quality inventory for Weir Farm NHS (WEFA). The goal was to sample water quality parameters for key water bodies within park boundaries, identify key water resource management issues at each park and recommend appropriate long-term monitoring strategies.

There are continuing water quality concerns in the Park that may affect the water resources therein. The primary concern is the impact of adjacent residential development on the Weir Pond watershed and the various wetlands. Residential development can lead to nutrient loading in the watershed from septic systems, landscaping activities, and forest clearance that increases runoff A proposed highway expansion project could impact the watershed of the wetlands in the northeast corner of the park. Development projects within the Park unit may also influence aquatic resource water quality. To best address these range of issues, water quality monitoring was done at three sites that were chosen that were representative of the different water resources in the park.

During 1999, a forty-year drought severely limited surface water flow and standing water levels. Both the wetland and the stream had no water in them June to August and the water level in Weir Pond dropped by 0.22m. The minimal freshwater inputs probably had a significant effect on water quality during the summer. This effect, which cannot be quantified in a four-season study, should be kept in mind. Weir Pond and the wetland were lower in alkalinity, pH and total N and P than fifty-six Connecticut lakes in general, and those of the Western Uplands in particular. These differing values indicate that Weir Pond does not have as much buffering capacity as other Connecticut lakes. Weir Pond and the wetland were higher in conductivity and chlorophyll. This would imply that there are a number of non-buffering compounds in the water (such as humics, organic matter, etc). The chlorophyll levels indicate that this shallow basin is susceptible to increased nutrient loading despite total N and P levels below that of other basins in Connecticut. The high dissolved nutrient levels for the wetland and the intermittent stream in January 1999 were probably associated with increased runoff, due to large precipitation events.

The water quality of all water bodies is moderate but reveal a vulnerability of the pond and the wetland to increased nutrient loading. Although nutrient loading level are presently mesotrophic, the shallowness of Weir Pond makes it susceptible to water quality degradation due to changes in watershed loading due to forest clearing, residential development and changes in adjacent land use.

Because of these concerns, we would recommend periodic monitoring of critical water quality parameters to track changes in environmental conditions.

Introduction

Weir Farm NHS is a historic farmstead and reserve in western Connecticut, located in the Norwalk River watershed in the towns of Wilton and Ridgefield (Figure 1). It is comprised of 24.3 hectares; 15.8 of which are maple/oak woodland and 2.4 hectares are historic pasture and meadowland. Water resources include 6.1 hectares of aquatic habitat, including an artificial pond just under 1.6 hectares acres, and the remainder of which is herbaceous or shrub/scrub wetlands. The entire Park is within the geological region known as the Connecticut Western Uplands, an area of upland hills and valleys with granitic soils and underlying schist and gneiss bedrock (Canavan and Siver 1995). This geology influences the chemical composition of the major water bodies making them more alkaline with a higher pH and conductivity than other Connecticut lakes.

Land use adjacent to Weir Farm is low-density residential on 0.8 – 2.0 hectare lots, extensively landscaped, and serviced by on-site septic systems. This land use could result in elevated groundwater nutrient levels, with ultimate discharge to surface waters and wetlands.

In association with the Baseline Water Quality Data Inventory and Analysis Program, the NPS-Water Resources Division has assembled existing water quality data sets in most Park Units. Weir Farm NHS (WEFA) was found to have depauperate water quality databases, thereby requiring Level I water quality inventories (USDOI 1997). As defined by the NPS Inventory and Monitoring Program, a Level I water quality inventory includes sampling basic water quality parameters for key water bodies within park boundaries. Key water bodies are either those essential to the cultural, historical, or natural resource management themes of the park or those that provide habitat for rare plants or animals.

The purpose of this project was to collect water quality data at WEFA to meet the Level I needs. Moreover, this study identifies key water quality management issues at the park and recommends appropriate long-term water quality monitoring strategies.

Water resource issues

There are continuing water quality concerns in the Park that may affect the water resources therein.

- The primary concern is the impact of adjacent residential development on the Weir Pond watershed and associated wetlands. Residential development can lead to nutrient loading in the watershed from septic systems (Valiela et al, 1990), landscaping activities and forest clearing that increases runoff.
- There is a proposal to build an exit ramp to a nearby state highway (Route 7). If this ramp is constructed, the footprint of the ramp as proposed, falls within the watershed of the wetlands in the northeast corner of the park.
- Development projects within the Park unit may also influence aquatic resource water quality. A proposed septic system repair project may lead to increased nutrient loading to adjacent wetlands.
- Extensive clearing of the woodlands in the pond watershed should take into account the impact of increased surface runoff on the water quality.

Sample locations

Three water quality monitoring sites were selected at WEFA to establish a begin serving as a baseline for water resource assessments.

Weir Pond – Weir Pond is an artificial pond created when the farm was first settled. A first or second order stream was impounded by constructing an earthen dam with boulders lining the face in 1896. A natural resource evaluation report (USDA NRCS, 1995) described Weir Pond as follows: "Weir Pond is approximately 3.68 acres in size, with a watershed of 33.6 acres. The pond has a shoreline of 1,774 feet. Three intermittent streams feed the pond during periods of runoff. Groundwater provides most of the inflow during low runoff periods… Buttonbush, willow, red maple, marsh fern and royal fern dominate the pond perimeter at elevations between 1-2 feet above the high water line." Land use throughout much of the pond watershed is residential served by on-site individual septic systems; thus, there is concern for nutrient loading from septic systems and lawn maintenance.

Palustrine wetland – Numerous permanent and intermittent palustrine wetlands are distributed throughout the Park and have been mapped and

described in a natural resource evaluation (USDA NRCS 1995; Metzler and Tiner 1992). One of these wetlands, a complex of palustrine forested, palustrine scrub-shrub, palustrine emergent and palustrine open water, has been identified as an important site for monitoring, and may be representative of the water quality status of wetlands within the park. This wetland receives runoff from a local road and parking area, as well as inputs from adjacent residential development. Preliminary plans are under consideration for placement of the park's new septic system leach field adjacent to this wetland complex.

Un-named intermittent stream – Several small streams flow through associated wetlands within the park. Most of these streams flow year-round, except during extreme drought periods in the summer. A major concern for water quality in these streams is their response to nutrient loading from residential septic systems and lawn maintenance. Additionally, a planned expansion of a nearby highway could impact hydrology and water quality of this stream and associated wetlands. This representative stream was sampled to begin evaluating the impact of these factors and establish a baseline prior to development activities.

Existing water quality data

The US FWS characterized wetland habitat at WEFA as a part of the National Wetland Inventory (Metzler and Tiner. 1992). The Water Resources Division produced a water quality scoping report (USDOI 1997). It found moderately good water quality at the stream that was nearest in hydrological characteristics to those found in the Park (Comstock Brook, Ridgefield, Connecticut). However, no sample sites were located in the Park. The US Geological Survey has a water gauging station in South Wilton and precipitation stations in Bridgeport and at the Stevenson Dam Seymour, Connecticut.

The objective of this water quality-monitoring program is not to assemble a comprehensive database, but rather to obtain a baseline of environmental variables. Should degrading trends in these fundamental variables be observed, then management should implement a more comprehensive program to clearly assess the problem.

PROTOCOL

Sampling schedule and water quality parameters

Samples were collected in the fall (October 1998 and 1999), winter (January 1999), spring (June 1999) and summer (August 1999). Parameters were sampled as outlined in Table 1.

Table 1. Sampling parameters for each station

Station	GPS coordinates	Sampling Parameters
Weir Pond (WEFA-1)	629710.3/ 4568832.9	Alkalinity, chlorophyll a, conductivity, total and dissolved nutrients, dissolved oxygen, pH, turbidity, temperature, water level
Palustrine wetland (WEFA-2)	629297.7/ 4568432.7 (Taken from parking lot)	Alkalinity, conductivity, total and dissolved nutrients, dissolved oxygen, pH, temperature, water level
Un-named stream (WEFA-3)	N/A	Alkalinity, conductivity, total and dissolved nutrients, dissolved oxygen, pH, temperature, discharge

Field sample collection techniques

For Weir Pond, surface to bottom profiles were conducted with a Hydrolab MiniSonde multiprobe at 0.5 m intervals for dissolved oxygen, pH, temperature, conductivity, and turbidity. Discrete water samples were collected just below the surface (0.25 m), unless the Hydrolab profiles indicated a stratified water column. Then surface, mid-depth and bottom samples were collected. Pond samples were collected with a Kemmerer bottle. For the stream and wetland stations, only surface samples were collected with sample bottles submerged below the surface.

For alkalinity, 60-ml sample bottles was filled to overflowing, capped and placed on ice, in the dark, for transport to the laboratory. A one-liter bottle was collected and placed on ice, in the dark, for the chlorophyll a and copper samples. Triplicate 20-ml aliquots were collected in pre-cleaned test tubes and fixed, in the field, with persulfate oxidizing reagent for total nitrogen and phosphorus samples. Sixty-ml sample bottles for dissolved nutrients

was filled with water, filtered in the field through 0.4 μm Millipore filters, preserved with 2-3 drops of 2 N hydrochloric acid and iced for transport to the laboratory. Standardized 60-ml vials were filled and placed on ice for fecal coliform analysis. All samples were kept in the dark at 4°C until analysis. Nutrient samples were not analyzed for four to six months because of mechanical and logistical problems at the CACO laboratory that have since been resolved before processing these samples.

Analytical techniques

Field Methods: A Hydrolab that was calibrated according to manufacturers methods before each sample trip collected dissolved oxygen, pH, temperature, conductivity and turbidity. Water levels were established and monitored using the Hydrolab depth recorder.

Laboratory methods: All laboratory analyses were performed at the North Atlantic Coastal Laboratory at the Cape Cod National Seashore.

Alkalinity: Measurement was by potentiometric titration using a bromcresol indicator (American Public Health Association 1992).

Chlorophyll a: The water samples were filtered through a Whatman GFF filter. The filter was ground up and extracted with acetone. Then chlorophyll levels in the acetone extract were measured on a spectrophotometer (Lorenzen 1966).

Dissolved nutrients: Dissolved inorganic nutrients (nitrate, nitrite, ammonia, and phosphate) were determined colorimetrically on a Lachat autoanalyzer (American Public Health Association 1992; Lachat Instruments 1993, 1994).

Total nitrogen and phosphorus: Total nitrogen and phosphorus were determined simultaneously by potassium persulfate digestions followed by colorimetric analysis on the Lachat autoanalyzer (Valderrama 1981).

Data management and Archiving

All data were entered in the Environmental Protection Agency's national water quality database, STORET.

Results

During 1999, a forty-year drought severely limited surface water flow and standing water levels. In August 1999, USGS precipitation gauges in the vicinity of Weir Farm were at a 40-year low and statewide mean stream flow levels were only 31% of the 30-year monthly mean. Both the wetland and the stream contained no surface water from June to August and the water level in Weir Pond dropped considerably during this drought period. The minimal freshwater inputs probably had a significant effect on water quality-during the summer. This effect, which cannot be quantified in a short-term, four-season study, must be kept in mind when interpreting the water quality results.

Weir Pond.
Weir Pond was lower in alkalinity, pH and total N and P than fifty-six lakes located throughout Connecticut, and more specifically from lakes in the Western Uplands (Canavan and Siver 1995). These differing values indicate that Weir Pond does not have as much buffering capacity as other Connecticut lakes. This is probably a function of its' geomorphology as its shallow depth and small volume would result in higher sedimentation rates and humic levels. In addition, a greater proportion of the bottom would be in the photic zone, which would allow greater water column productivity. Because of this, Weir Pond as a small shallow water body tends to be naturally meso to eutrophic.

Weir Pond and the palustrine wetland were higher in conductivity and chlorophyll. This would imply that there are a number of non-buffering compounds in the water (such as humics, organic matter, etc). The chlorophyll levels indicate that this shallow basin is susceptible to increased nutrient loading despite total N and P levels below that of other basins in Connecticut. The high dissolved nutrient levels for the palustrine wetland and the intermittent stream in January 1999 were probably associated with increased runoff due to large precipitation events.

This water resource has high seasonal levels of chlorophyll and turbidity and low seasonal levels of oxygen and Secchi depth (Table 2). Although Weir Pond is would be classified as a Class A water body (C. Lee, Conn. DEP, personal communication), its' small size and geomorphology precludes an absolute water quality classification based on such a small sample size. However, the trophic status of this pond is approaching eutrophic conditions

(Table I, Wetzel 1982). Although this eutrophication trend is not seen in all parameters, these findings reveal the vulnerability of the pond to water quality degradation. The August alkalinity and pH peaks indicate sulfate reduction occurring at the bottom of the water column (Stumm and Morgan 1981). This is a consequence of the organic loading from high productivity levels during the summer.

Palustrine Wetland. The higher conductivity and variable pH indicate the higher ionic composition (partly due to organic acids and humics) that is typical of palustrine wetlands. A greater concern is the seasonal levels of dissolved nitrogen, implying either substantial input or remineralization. The source of these nutrients cannot be pinpointed without a hydrological analysis of groundwater flow and these pools may contain high levels of nitrogen regenerated from the leaf litter. However, these nutrient highs were found in January during a winter thaw and not in the summer when one would expect higher regenerated nitrogen levels from leaf litter. The position of the wetland in a topographic low may indicate a potential area of collection for surface water runoff. Like Weir Pond, this water body is vulnerable to further water quality degradation from increased watershed nutrient input.

Intermittent stream. This stream contained water for only half the sampling seasons and in fall of 1998, the water level was too low to allow discrete sampling. As with the wetland, the winter sample revealed high levels of dissolved nitrogen. These values implicate high surface water runoff or precipitation.

Conclusions

The watershed land use practices within the vicinity of Weir Farm and the natural eutrophied condition of Weir Pond indicate a vulnerability of the pond and the wetland to increased nutrient loading. The shallowness of Weir Pond makes it susceptible to water quality degradation from changes in watershed loading due to forest clearing, residential development, and other changes in adjacent land use.

Because of these concerns, a periodic monitoring of critical water quality parameters is recommended to track changes in environmental conditions. A minimum effort would consist of sampling spring, summer and fall for Secchi depth, conductivity, pH, dissolved nutrients, and bottom dissolved

oxygen at Weir Pond. At the palustrine wetland, we would recommend early spring and late fall sampling for conductivity, pH and dissolved nutrients.

These parameters would not give a comprehensive survey of the ecological condition of WEFA's water bodies. Instead they would serve as an early warning system that would alert Park resource managers to a sudden change in trophic level or a degradation of water quality.

References Cited

American Public Health Association 1992. Standard methods for the examination of water and wastewater, 17th edition. 1134 pg.

Canavan, R. W. and Siver P. A. 1995. Connecticut Lakes: A study of the chemical and physical properties of fifty-six Connecticut lakes. Connecticut College Arboretum, New London, CT. 299 pages.

Fishman, M. J. and S. C. Downs 1966. Methods for analysis of selected metals in water by atomic absorption. Geological Survey Water-Supply paper 1540C. GPO Wash. DC.

Lachat Instruments 1993. Nitrate in brackish or seawater. QuikChem Method 31-107-04I-A. Lachat Instruments Milwaukee, WI

Lachat Instruments 1993. Orthophosphate in brackish or seawater. QuikChem Method 31-115-01-3-C. Lachat Instruments Milwaukee, WI.

Lachat Instruments 1994. Ammonia in brackish or seawater. QuikChem Method 31-10706-1-A. Lachat Instruments Milwaukee, WI.

Lorenzeo, C. J. 1966. A method for continuous measurement of in vivo chlorophyll concentration. Deep-Sea Research. 13:223-230.

Metzler, K.J. and R. W. Tiner. 1992. Wetlands of Connecticut. State Geological and Natural History Survey of Connecticut, Connecticut Department of Environmental Protection, Hartford, CT. Report Investigations No. 13. 115p.

Stumm, W. and J. J. Morgan 1981. Aquatic chemistry. J. Wiley NY, NY. 780 pages.

U.S. Department of Agriculture 1995. The Weir Farm natural resource evaluation project. #IA 1600-3-9001. USDA Natural Resources Conservation Service. 43 pg.

Valiela, 1., Costa, I, Foreman. K,, Teal, I M,, Howes, B. &. Aubrey, D. (1990). Transport of groundwater-borne nutrients from watersheds and their effects on coastal waters. Biogeochemistry 10:177-197

Valderrama, I C. 1981. The simultaneous analysis of total nitrogen and total phosphorus in natural waters. Marine Chemistry 10: 109-122.

Wetzel, R. G. 1982. Limnology 2nd ed. Saunders Philadelphia, PA. 767 pages.

American Public Health Association 1992. Standard methods for the examination of water and wastewater, 17th edition. 1134 pg.

Fishman, M. J. and S. C. Downs 1966. Methods for analysis of selected metals in water by atomic absorption. Geol. Survey Water-Supply paper 1540-C. GPO Wash. DC.

Lachat Instruments 1993. Nitrate in brackish or seawater. QuikChem Method 31-107-04-1-A. Lachat Instruments Milwaukee, WI.

Lachat Instruments 1993. Orthophosphate in brackish or seawater. QuikChem Method 31-115-01-3-C. Lachat Instruments Milwaukee, WI.

Lachat Instruments 1994. Ammonia in brackish or seawater. QuikChem Method 31-107-06-1-A. Lachat Instruments Milwaukee, WI.

Lorenzen, C. J. 1966. A method for continuous measurement of *in vivo* chlorophyll concentration. Deep-Sea Res. 13:223-230.

U.S. Department of Agriculture 1995. The Weir Farm natural resource evaluation project. #IA 1600-3-9001. USDA Natural Resources Conservation Service. 43 pg.

Valderrama, J. C. 1981. The simultaneous analysis of total nitrogen and total phosphorus in natural waters. Marine Chemistry 10: 109-122.

Figure 1. Weir Farm NHS, with Sampling locations. Shaded areas represent substantial wetlands

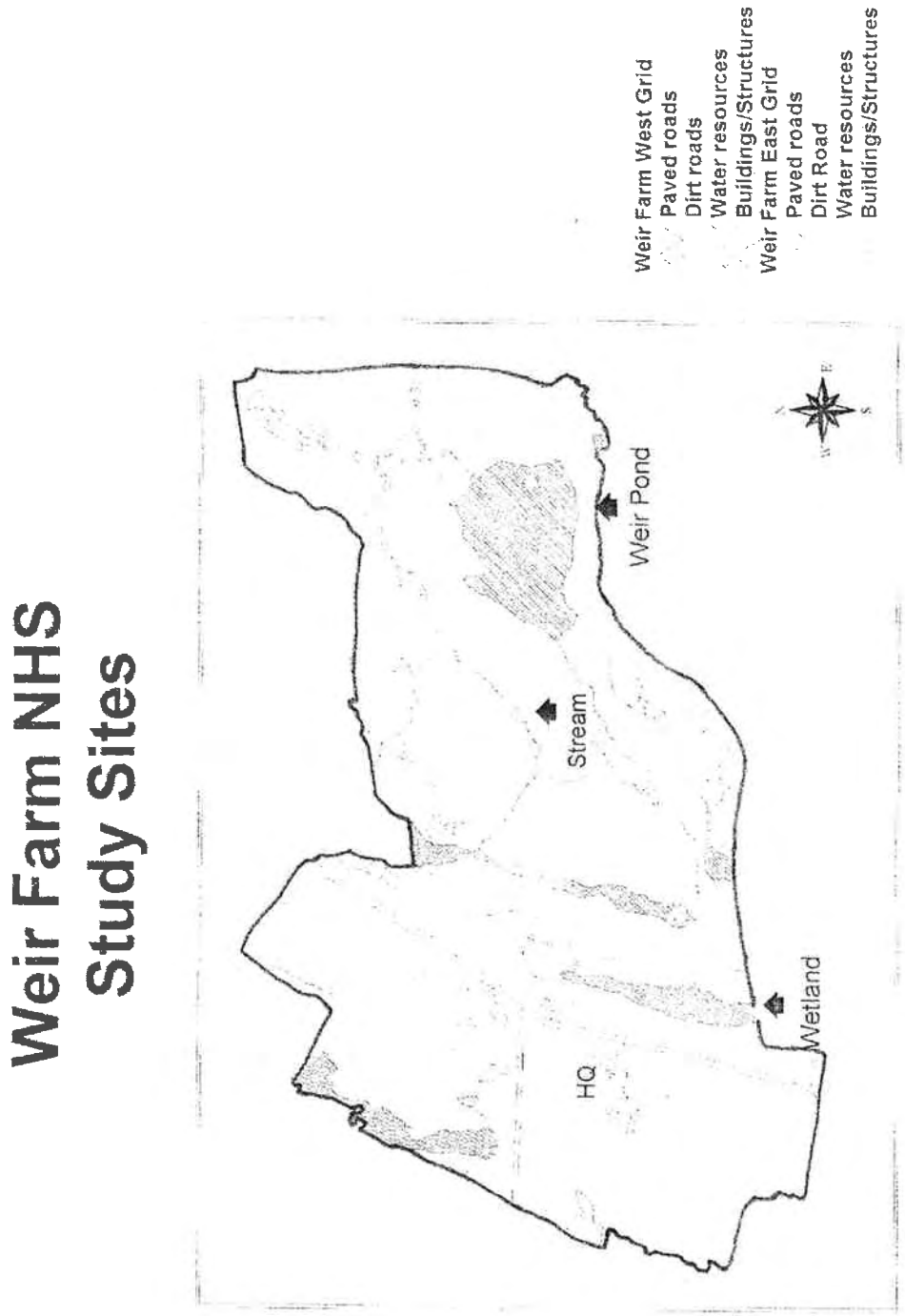

Table 1. Weir Farm water quality results at three Level 1 Sample Locations and Connecticut Water Quality Standards

Station	Date	Alkalinity ($\mu eq\ l^{-1}$)	Chlorophyll ($\mu g\ l^{-1}$)	Specific conductivity ($\mu S\ cm^{-1}$)	dissolved NO3 (μM)	dissolved NH4 (μM)	Total N ($\mu M\ NO_3$)	Total P ($\mu M\ PO_4$)	Bottom DO ($mg\ L^{-1}$)	Bottom DO (% sat.)	pH	Secchi depth (m)	Water depth (m)	Turbidity (NTU)
Weir Pond	October 29, 1998	20	130.83	117	1.95	0.82			0.33	3.1	6.47	1.25	1.75	20.5
	June 17, 1999	16.8	15.219		1.76	1.08	26.61	0.17	0.43	4.4	6.41	1.5	1.9	86
	August 19, 1999	40.35	2.056	129					0.58	6.7	7.25	1.4	1.68	75
	October 14, 1999	13.95	6.24	107	5.05	5.47			5.38	51.2	6.64	1.8	1.8	
Wetland	October 29, 1998	7.05		316					3.58	32.3	5.75	0.1	0.1	37.8
	January 27, 1999	16.65		264	22.57	74.88		1.28	4.3	36.9	5.86		0.09	35
	June 17, 1999	28		247			43.93	2.27	11.58	122	7.25	0.04	0.04	
	October 14, 1999	22.45		269	2.37	3.14			7.63	11.88	6.68		0.25	27.9
Stream	October 29, 1998													

	January 27, 1999	26.05		235	28.43	27.83			12.82	92.3	7.27		0.01	
	June 17, 1999													
	October 14, 1999													
Conn. Lakes Median Values		180	2.7	80			335	27			7.0			
Western Uplands		420	5.1	96			364	33			7.2	3.5	5.4	
				Connecticut	**Water**	**Quality**	**Standards**							
Mesotrophic			2 – 15 (summer)				200 - 600	10 - 30				2-6 m summer		
Eutrophic			15 – 30 (summer)				600 - 1000	30 – 50				1-2 m summer		

where is temperature, fecal col. form, and copper