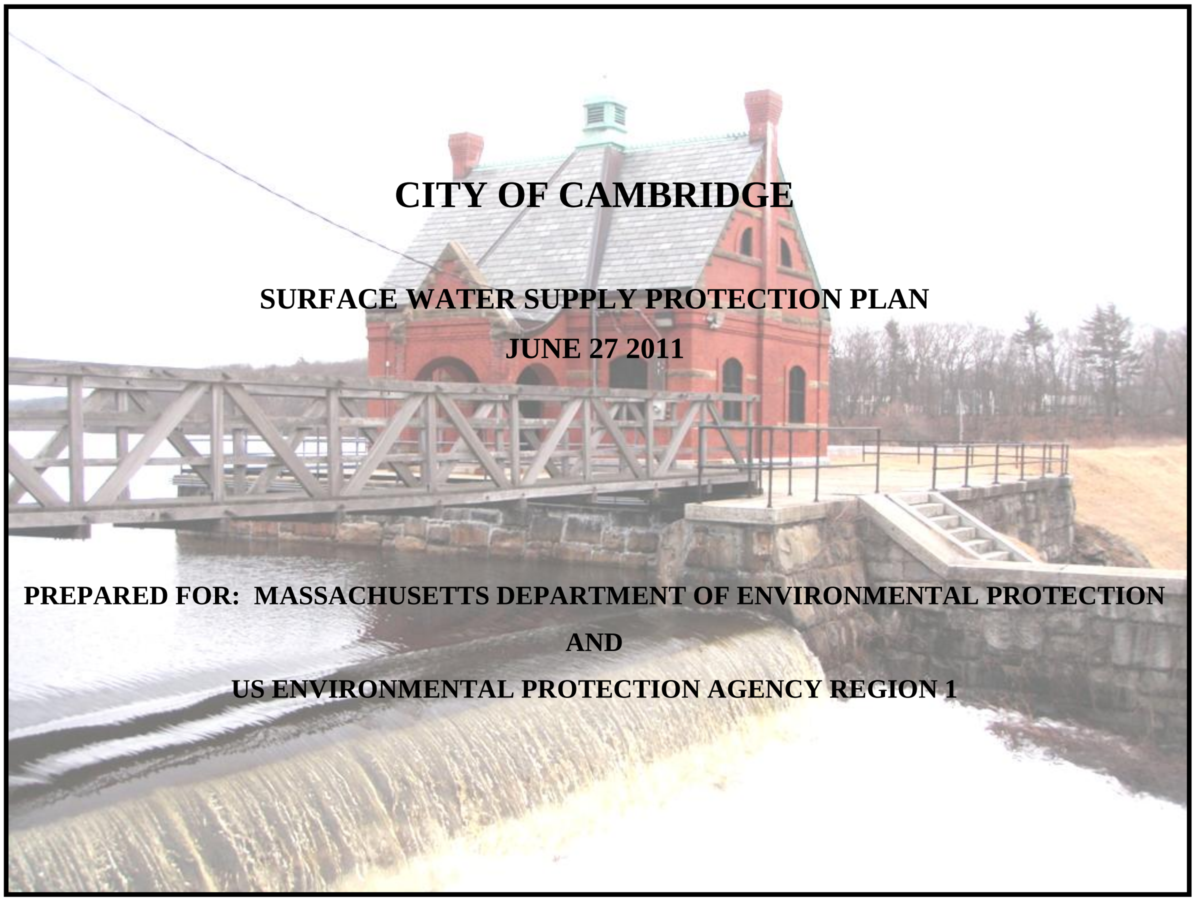

CITY OF CAMBRIDGE

SURFACE WATER SUPPLY PROTECTION PLAN

JUNE 27 2011

PREPARED FOR: MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

AND

US ENVIRONMENTAL PROTECTION AGENCY REGION 1

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INTRODUCTION

The City of Cambridge (City) recognizes the importance of watershed management as an integral step in protecting the City's drinking water supply. Based on recommendations in the 1996 Amendments to the Federal Safe Drinking Water Act (SDWA), and subsequent Massachusetts Department of Environmental Protection's (MassDEP) 2003 Source Water Assessment Program (SWAP), the City has prepared the following Surface Water Supply Protection Plan (Plan). The Plan will serve as a synopsis of susceptibility to water supply contamination, what is currently being done to address and assuage threats, and a time-lined action plan on retooling existing and creating new programs to better manage the City's water supply.

The Water Department Watershed Division's mission is to "Preserve, protect, and manage the City's watersheds and reservoirs to maximize and control the quality and quantity of raw water provided to the water system" and has taken responsibility for writing this Plan. The Water Department sees this opportunity as a means to reassess threats and programs designed around them, and to develop a more updated, structured vision. By developing and implementing this plan, the City will work towards decreasing susceptibility to waterborne disease, reducing long-term treatment costs and minimizing disinfection by-products through effective treatment of stormwater at its source; Also by reducing deicing salt loads, establishing productive relationships with all watershed constituents and stakeholders, optimizing dam operations for quality and quantity, and improving safeguard measures. Upon approval, this document will also qualify the City for disinfection log credits under the Surface Water Treatment Rule and government-funded source water protection grants.

Water quality impacts are related to the amount, type, and intensity of development in a water body's watershed. An ideal water supply watershed is an undisturbed landscape with ownership in fee title. Existing conditions of the City's surface water supply illustrate a rapidly changing, suburban watershed, that under current zoning, has the potential to be completely built out, and of which, the City owns and controls only five percent of the land. However, with proper planning and controls, development-related impacts can be minimized. The City's water supply watershed has a long history of agricultural land uses, which have since become residential, commercial, industrial and transportation dominated. Roughly 20,000[1] people live within the watershed boundaries, with many more coming and going on a daily basis for work and commerce.

With little control over watershed land, the City relies heavily on federal, state, and local regulations to ensure development happens in a way that minimizes water quality impacts

[1] Estimated from a MassGIS datalayer partitioning year 2000 census data into appropriate 1999 land-use categories

and preserves natural resources, as well as water quality monitoring to identify pollution sources and water chemistry changes over time.

In the past 20 years, the City has invested considerable resources to assess, characterize and reduce source water pollution, develop and implement emergency response plans, work with neighboring municipalities, review site plans, work with developers to improve stormwater quality, patrol the watershed, and conduct general operation and maintenance of City-owned structures and properties. Without this plan, the City would continue to move forward protecting the watershed, but with it, more efficiently and effectively.

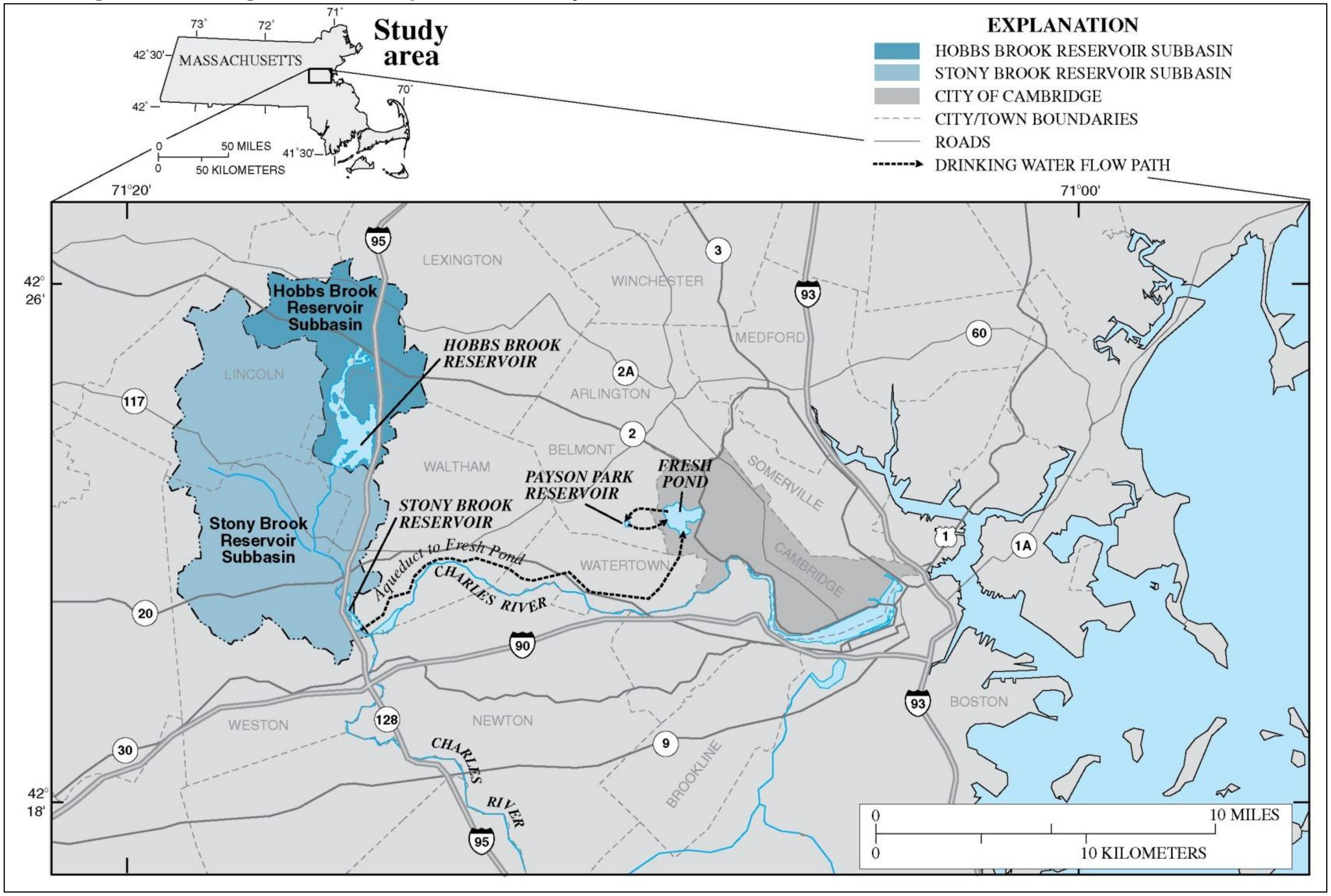
OVERVIEW

WATER SUPPLY

WATER SUPPLY WATERSHED

The City of Cambridge obtains its water from the 24 square mile Stony Brook watershed located in the towns of Lincoln, Weston, and Lexington and the City of Waltham. This "upcountry" watershed is nested within the Charles River Basin and contains two impoundments constructed in the 1890's, the Hobbs Brook and Stony Brook Reservoirs. Hobbs Brook Reservoir (also known as the Cambridge Reservoir) receives water from a 7 square mile watershed and discharges into Hobbs Brook through a gatehouse on Winter Street in Waltham. Hobbs Brook joins Stony Brook further downstream, which flows into the Stony Brook Reservoir on the Weston, Waltham town line. From the Stony Brook Reservoir, water is fed by gravity through a 7.7 mile underground pipeline to Fresh Pond, a kettle pond in western Cambridge, located in the Mystic River Basin. The Walter J. Sullivan Water Purification Facility within the Fresh Pond Reservation treats water from the Fresh Pond Reservoir. Treated water is pumped to Payson Park underground storage/treatment facility in Belmont, then gravity fed to the City's distribution system. Capacity at full pool for the Hobbs, Stony, and Fresh Pond reservoirs is roughly 2.8 billion, 418 million, and 1.5 billion gallons respectively.

Figure 1: Cambridge Source Water System: Extracted from Waldron and Bent, 2001



Fresh Pond Reservoir's 1,297 acre topographical watershed has been artificially restricted to 205 acres by intercepting and redirecting local drainage in order to reduce the inflow of polluted urban runoff. The drainage area includes the reservoir water sheet and a narrow border entirely within Fresh Pond Reservation. Under normal operating levels, most of the water in Fresh Pond comes from the Stony Brook Conduit, with only approximately 7 – 11% of average daily demand from its small overland drainage plus groundwater flows from the larger, historic Fresh Pond topographical watershed[2].

Throughout most of the year, the City's water demand (~14 million gallons per day, mgd) can be met from the Stony Brook Reservoir and its watershed. During summer and fall, or under drought conditions, water demand must be supplemented from the Hobbs Brook Reservoir. In addition to supplying Cambridge with drinking water, the headwaters of the Stony Brook feed Flint's Pond (also known as Sandy Pond) which is the primary water source for the Town of Lincoln.

In 1904, the Metropolitan District Commission (now the Massachusetts Water Resources Authority, MWRA) laid a 48-inch main through Cambridge. This main was connected to the Cambridge distribution system at Cambridge Common for emergency use. In 1951, this connection was renewed and two additional connections were made in Porter Square and Norfolk Street. The Norfolk Street connection links the Cambridge system to a second 48-inch MWRA main following a route roughly parallel to the first main. Under normal operation, these connections are not used, but remain for periods of high demand, stress on the distribution system, and emergency use. Most recently, the City was supplying its customers with MWRA water during the construction of the new water treatment facility at the turn of the millennium and briefly during a major 30" water main repair in 2005.

TREATMENT PROCESS

Water purification for drinking water begins with source water protection. Vigilance and proper management in and around the watershed safeguards the production of the highest quality raw water.

Three, two-thousand foot perforated air lines are located on the bottom of Fresh Pond Reservoir. These air lines are used to artificially mix the pond and prevent the lower levels of the reservoir from becoming anoxic during periods of thermal stratification. Under these more oxidized conditions, naturally occurring metals in the pond sediments like iron and manganese do not enter the water column, facilitating the treatment process. Water from Fresh Pond is pumped into the Walter J. Sullivan Water Purification Facility where it is pre-mixed with ozone to ensure an oxidized state.

In a process called flocculation, raw, oxidized water is mixed with the chemical coagulant aluminum sulfate to trap 99% of both the suspended (solids, algae, bacteria, etc) and dissolved (organic acids, metals, etc) impurities in the water. The coagulated material or "floc" is removed by floating it to the surface using air-saturated water. The clarified water

[2] Estimated from "Groundwater Impacts to Fresh Pond Reservoir", CDM, 1997.

is drawn off the bottom. Waste floc is discharged into the MWRA sewer system. The sewer discharge is regulated by one of three MWRA Sewer Use Permits issued to the facility. Although energy-intensive, this Dissolved Air Floatation (DAF) process has a very small footprint and would be effective in removing the pathogens, Giardia and Cryptosporidium if present.

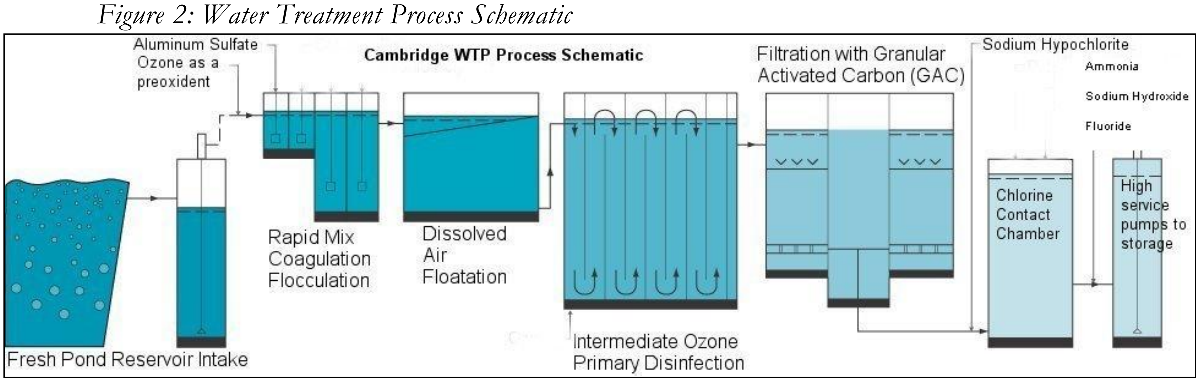
Once clarified, the water is disinfected with ozone. Ozone is an extremely potent oxidizer and serves to break long-chain organics and kill bacteria, viruses and other pathogens by cell wall effects. This both disinfects the water and removes organic carbon in conjunction with the following treatment step. Water is then channeled through four-foot deep granular activated carbon filters to remove any suspended particles and serve as a contactor for a population of "friendly" bacteria adhering to the media. This process is known as Biologically Active Carbon (BAC) Filtration. The bacteria that clings to the media consumes ozone disinfection byproducts (aldehydes and ketones) as a food source.

Water is then disinfected again using chlorine in the form of sodium hypochlorite. At this point, the water has remaining chlorine (free residual chlorine) and it is converted to chloramines with the introduction of ammonia. Chloramines are a very stable disinfectant that serves to keep any further potential biological activity in the distribution system in check. The ammonia reaction (chloramination) serves to halt any further reaction between organic molecules and free chlorine that could form potentially harmful trihalomethanes and haloacetic acids, both federally regulated disinfection byproducts.

At this point the water is very corrosive. Adjusting the pH to 9.0 with sodium hydroxide renders the water chemically stable and non-corrosive given the water's alkalinity, minerals, calcium hardness and temperature. Fluoride is added to the treated water to prevent dental caries (cavities).

Treated water is pumped uphill to two 16 million gallon tanks located on Payson Road in Belmont to allow for disinfection chemical contact time and hydraulic attenuation. From there, water is fed by gravity to the distribution system.

Figure 2: Water Treatment Process Schematic



TOPOGRAPHY

The major topographic features of the watershed were formed by bedrock weathering and erosion during pre-glacial times. These were later modified by glacial forces. Watershed elevations range from around 86 feet (Cambridge City Datum, CCD) at the Stony Brook Gatehouse to 491 ft. CCD at Prospect Hill in Waltham. There are 22 hills over 261 ft. CCD, the majority of which are in Waltham and Weston. The average watershed slope is eight percent, but there are a few areas with steep slopes (greater than 25 percent) from natural formations as well as engineered developments.

GEOLOGY

Watershed bedrock geology consists of a granitic, mafic (high in magnesium and ferric oxides) mix, overlain by a surficial geology dominated by glacial till, sand, and gravel. The Bloody Bluff fault line traverses northeast through the center of the watershed.

Table 1: Upper Watershed Surficial Geology[3]

Surficial Geology	Acres	Percent by Area
Sand and Gravel	6,596.66	43.62%
Till or Bedrock	8,031.70	53.10%
Fine-Grained Deposit	88.25	0.58%
Floodplain Alluvium	408.07	2.70%
Grand Total	*15,124.67*	*100%*

SOILS

Most soils are developed from and closely related to their geologic parent material, but in developed areas, can exhibit a wide range of characteristics. There are 91 soil types identified in the watershed by the USDA's Natural Resources Conservation Service's "SSURGO" soils database. Soils can have a significant influence over area hydrology and water quality affecting rainwater storage, runoff, erodibiliy, sedimentation, groundwater and septic infiltration/percolation rates, and water chemistry.

[3] Geology calculated from EEA MassGIS 1:24K Surficial Geology datalayer, 2009

Table 2: Hydrologic Characteristics of Watershed Soils

Hydrologic Group	Acres	Percent	Soil Type	Infiltration Rate (in/hr)
A	1,026.5	17.2%	sand, loamy sand	2.41 - 8.27
B	3,023.1	50.6%	sandy loam, loam	0.52 - 1.02
C	1,185.2	19.8%	silt loam, sandy clay loam	0.17 - 0.27
C/D	596.3	10.0%		0.09 - 0.17
D	144.0	2.4%	clay loam, silty clay loam, sandy clay, silty clay or clay	0.02 - 0.09
Total Assigned	5,975.1	100%		
Urban, Water, No Group Assigned	9,149.4			

Table 3: Dominant Watershed Soils

Soil Type	Area in Acres	Percent by Area
Narragansett-Hollis-Rock outcrop complex, 3 to 15 percent slopes	1096.77	**7.25%**
Water	933.4	**6.17%**
Freetown muck, 0 to 1 percent slopes	921.31	**6.09%**
Udorthents-Urban land complex	885.8	**5.86%**
Narragansett silt loam, 3 to 8 percent slopes	825.21	**5.46%**
Haven silt loam, 3 to 8 percent slopes	724.15	**4.79%**
Narragansett-Hollis-Rock outcrop complex, 15 to 25 percent slopes	567.23	**3.75%**
Swansea muck, 0 to 1 percent slopes	511.78	**3.38%**
Urban land	415.33	**2.75%**
Haven silt loam, 0 to 3 percent slopes	350.68	**2.32%**
Scarboro mucky fine sandy loam, 0 to 3 percent slopes	343.58	**2.27%**
Canton fine sandy loam, 3 to 8 percent slopes	341.42	**2.26%**
Hollis-Rock outcrop-Charlton complex, 15 to 25 percent slopes	311.7	**2.06%**
Hollis-Rock outcrop-Charlton complex, 3 to 15 percent slopes	284.6	1.88%
Charlton-Urban land-Hollis complex, 3 to 15 percent slopes, rocky	264.74	1.75%
Charlton-Hollis-Rock outcrop complex, 3 to 8 percent slopes	263.54	1.74%
Narragansett silt loam, 8 to 15 percent slopes	247.45	1.64%
Hinckley loamy sand, 3 to 8 percent slopes	217.08	1.44%
Hinckley loamy sand, 8 to 15 percent slopes	209.22	1.38%
Deerfield loamy sand, 3 to 8 percent slopes	182.36	1.21%
Whitman fine sandy loam, 0 to 5 percent slopes, extremely stony	181.92	1.20%
Woodbridge-Urban land complex, 3 to 15 percent slopes	179.58	1.19%
Scituate fine sandy loam, 3 to 8 percent slopes	177.91	1.18%
Merrimac fine sandy loam, 3 to 8 percent slopes	173.77	1.15%
Canton fine sandy loam, 8 to 15 percent slopes	172.46	1.14%
Charlton-Hollis-Rock outcrop complex, 8 to 15 percent slopes	171.34	1.13%
Narragansett silt loam, 8 to 15 percent slopes, very stony	167.34	1.11%
Montauk fine sandy loam, 8 to 15 percent slopes, extremely stony	160.15	1.06%
+ 63 other types all less than 1% of total area	**3,842.77**	**25.41%**

WATER RESOURCES

Water Supply

The upper watershed has two high yield (>250 gallons per minute) and five medium yield (50 – 250 gpm) aquifers totaling 680 acres. These aquifers are almost completely in the Stony Brook watershed and follow the course of the major tributaries.

There are approximately 34.6 miles of streams and 1,000 acres of lentic water bodies in the watershed including the two reservoirs. Wetlands, both forested and non-forested, account for nearly 1,900 acres of watershed lands. Many of these wetlands are in headwater areas which are a benefit to downstream water quality and flood control.

Water Demand

The Cambridge Water Department must ensure that there is sufficient water supply to meet demand from city residents and institutions on both an annual and maximum day basis. In the 1960's, average annual water demand peaked at 22 million gallons per day (mgd). 1960's water use forecasts predicted water use to 26.8 mgd for 1990 (Cambridge, Massachusetts Report On Needed Improvement to the Cambridge Water system, July 1970). During the 1970's, high demand for water often required supplemental water from MWRA.

Since the passage of the Water Management Act in 1985 and stricter building code requirements for low flow plumbing appliances, water demand has decreased. By 1990, instead of using the projected 26.8 mgd, the City's water usage had dropped to 13.5 mgd and has continued in the range of 13.5 mgd to 15.5 mgd since that time. Escalating water treatment energy costs, water and sewer billing rate increases, newer leak detection technologies, and increased public awareness of the importance of conservation and impacts of irrigation are likely to further reduce demand over the coming years.

Watershed Water Budget

Lexington, Lincoln, Weston, and Waltham account for 9%, 38%, 36%, and 17% of watershed lands respectively. Waltham, Weston and Lexington import drinking water into the watershed from central Massachusetts via the MWRA system. Being sewered, Waltham and Lexington export most of that water as wastewater to the MWRA Deer Island Treatment Facility and ultimately to Massachusetts Bay. In addition to wastewater, local water that would otherwise feed into watershed water bodies is lost to sewerage in the form of precipitation inflow and groundwater infiltration (I/I). Latest MWRA I/I estimates for Lexington and Waltham are 3.21 and 4.74 mgd or roughly 53% and 46% of their average daily wastewater flows respectively.[4]

Weston discharges imported water into the watershed via septic systems, and according to recent Water Management Act data, has minor permitted groundwater withdrawals by the

[4] FY2010 MWRA Annual Infiltration and Inflow Reduction Report 8/20/2010. Retrieved from http://www.mwra.state.ma.us/harbor/pdf/infinf.pdf 12/17/2010

town's Water Division and the Weston Golf Club within the watershed. Lincoln uses water from Sandy Pond, a natural kettle pond at the Stony Brook headwaters, and a series of wells for its drinking water. Nonconsumptive water uses are returned to the watershed through Lincoln's septic systems.

Water Supply Management

Standard operating procedure is designed to maximize water supply and quality from the two upper watershed reservoirs. Stony Brook Reservoir has a limited storage capacity of 418 million gallons, equivalent to approximately 15 days of average flow from its 17 square mile watershed. In wet weather, the reservoir fills up quickly, often discharging through the spillway or requiring a managed discharge to the Charles River to maintain safe water levels.

In contrast, the upstream Hobbs Brook Reservoir has approximately seven times the Stony Brook Reservoir's capacity from a watershed less than half the size. To maximize the available water supply, most of the water from the Hobbs Brook Reservoir is held back during the winter and spring months, and is released to the Stony Brook Reservoir during the summer and early fall periods. During the late winter and spring, especially during wet years, Hobbs Brook Reservoir cannot retain all water inputs, and the excess is discharged downstream to the Stony Brook.

FRESH POND WATERSHED

Fresh Pond is the terminal water supply reservoir of the City's three-reservoir system. Relatively little of the reservoir's water comes from its small watershed, which is only slightly greater than one percent the size of the upper watershed. A series of dikes, drainage channels, and stormwater pipes have reduced the historic topographic watershed of 1,297 acres to the current 229 acres, which includes the 155 acre Fresh Pond water sheet. The reservoir level is kept slightly higher than the surrounding water table to reduce groundwater inflow and potential groundwater contamination from areas immediately surrounding the reservoir and from the heavily industrialized northern portion of the historic watershed. On a daily basis, most of the water in Fresh Pond comes from the Stony Brook Reservoir via the conduit, with only an estimated 0.4 mgd coming from local groundwater sources (CDM, 1994), which is equivalent to 0.03% of the volume of Fresh Pond at 16 feet (Cambridge City Datum), or 3% of average daily withdrawals.

That being said, stormwater and groundwater from the Fresh Pond watershed have little influence over reservoir water quality. Rather, pollution from the upper watershed is the most serious threat to reservoir water quality. Fresh Pond Reservoir actually improves the quality of the water from the upper watershed by settling out solids, diluting dissolved pollutants, stabilizing pH, and decreasing turbidity and color of the incoming water. Over time, if pollution inputs increase, they could potentially exceed the reservoir's assimilative capacity and pose costly problems for the water treatment facility.

The Fresh Pond watershed has been extensively studied resulting in many written reports over the years. Two most recent reports include recommendations that have guided watershed protection efforts for the past 15 years: "Fresh Pond Water Supply Protection Plan", May 1994 and "Fresh Pond Reservoir, Final Report Groundwater Quality Impacts to Fresh Pond Reservoir", May, 1997.

WATERSHED IMPACTS

The practice of watershed protection comes from the concept that what is done on land has impacts on water resources. The City's water supply reservoirs and tributaries drain densely urbanized areas supporting industrial activities and several major highways, as well as minimally disturbed forests and sparsely populated areas.

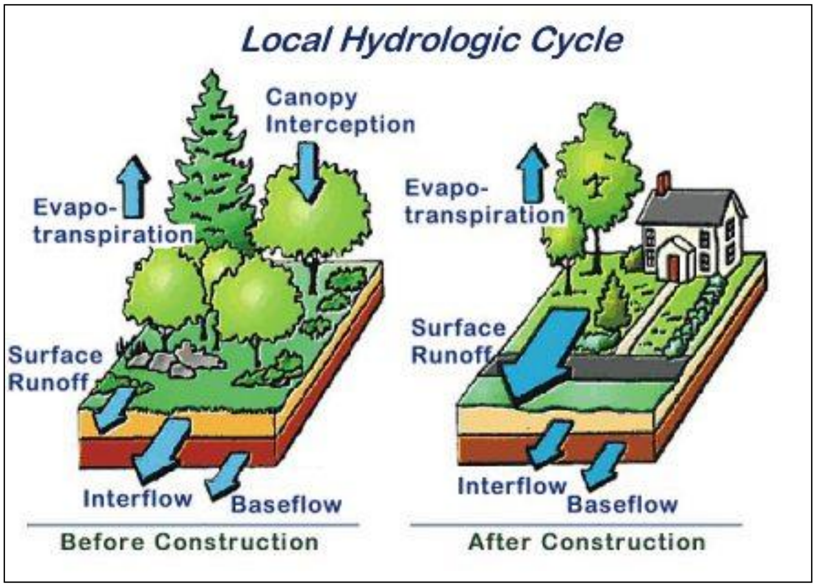
UPPER WATERSHED IMPACTS

Reservoirs and their tributaries receive storm and groundwater flows carrying pollutants at highly variable concentrations including, but not limited to, petroleum products, Polycyclic aromatic hydrocarbons (PAHs), metals, deicing salts and sand, phosphorus, and other contaminants from roads and parking lots; potentially pathogenic bacteria, ammonia, persistent household chemicals, excreted and flushed pharmaceuticals, and organic matter from failed sewerage and failed or improperly-maintained septic systems; exposed soils from construction sites; nutrients, pesticides and herbicides from landscaping activities; and a wide range of chemicals from industrial solvents to caffeine.

Immediate water quality is threatened by potential spills of hazardous materials from transport trucks on heavily trafficked highways that drain directly to the water supply through storm drains. The average daily traffic (ADT) for Routes 128 and 2 within the watershed account for over 200,000 vehicles trips each day. Potential spills could temporarily cripple the water supply and render source waters unusable. Long-term water quality is threatened by cumulative impacts from stormwater pollution, accelerated reservoir eutrophication, groundwater contamination from hazardous materials release sites, failed underground storage tanks and septic systems, landfill leachate, and mobile dissolved pollutants like chloride from deicing salts.

In undeveloped watersheds, the small fraction of runoff from a rain event is filtered and cleaned through duff and vegetation as it travels overland to water bodies. Instead of running off, most of the rain is lost to canopy interception and evapotranspiration, the rest percolates through soils and into groundwater that supplies streams more evenly throughout the year (Figure 3).[5] Stormwater pollution, loss of groundwater recharge, and groundwater contamination issues are a direct result of the type and intensity of land use and land cover in the watershed. The figure below illustrates how watershed development can alter the natural hydrologic cycle.

Figure 3: Hydrologic Cycle



LAND USE/ZONING

The farming community in which the Cambridge water supply watershed was established has transformed to a highly developed commercial and residential area with many transportation corridors. Roughly 20,000 people live within the watershed boundaries, with many more coming and going on a daily basis for work and commerce. Forests and wetlands, the best land cover for water quality, account for 55% of the land use in the watershed. Twenty percent of the watershed is residential, and 9% of the watershed has been developed for commercial, industrial, institutional, and transportation uses [Appendix A]. According to the latest MassGIS protected and recreational open space data (updated November, 2010)[6], approximately 25% of land within the Cambridge water supply watershed is protected from development through fee-simple ownership or conservation restrictions

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[5] Retrieved from http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/SedimentandStormwaterHome/Pages/Programs/WaterPrograms/sedimentandstormwater/home/index.aspx 12/17/2010

[6] Retrieved from http://www.mass.gov/mgis/osp.htm and intersected with the 2010 watershed boundary

[Appendix A]. Assuming current zoning, the majority of the watershed could potentially be developed under build-out conditions. Comparatively, 84% of the expansive DCR-managed MWRA water supply watershed system is forests and wetlands, and 55% has been permanently protected from development.

Table 4: 2005 Watershed Land Use

Land Use Type	Acres	Percent by Area	Associated Impacts
Undeveloped, Lightly Developed	**10,263**	**67.2%**	
Forest	6,578	43.06%	DOC, THMFP*, neglibible stormwater impacts
Forested Wetland	1,436	9.40%	DOC, THMFP, neglibible stormwater impacts
Water	979	6.41%	Internal cycling
Cropland	426	2.79%	Sedimentation, nutrients, chemical applications
Non-Forested Wetland	419	2.74%	DOC, THMFP, neglibible stormwater impacts
Pasture	166	1.09%	Sedimentation, nutrients, pathogens
Open Land	127	0.83%	DOC, THMFP, neglibible stormwater impacts
Participation Recreation	104	0.68%	Nutrients, chemical applications
Brushland/Successional	9	0.06%	DOC, THMFP, neglibible stormwater impacts
Spectator Recreation	8	0.05%	Nutrients, chemical applications
Orchard	7	0.05%	Sedimentation, nutrients, chemical applications
Water-Based Recreation	3	0.02%	Oil and grease, aquatic invasives
Developed	**5,014**	**32.8%**	
Low Density Residential	2,083	13.63%	Nutrients, pathogens, chemical applications, deicing salts, PPCPs**
Commercial	530	3.47%	Metals, oil and grease, nutrients, pathogens, thermal loading, chemical applications, deicing salts
Very Low Density Residential	415	2.72%	Nutrients, pathogens, chemical applications, deicing salts, PPCPs
Medium Density Residential	399	2.61%	Nutrients, pathogens, chemical applications, deicing salts, PPCPs
Industrial	343	2.25%	Metals, solvents/other industry-related chemicals, oil and grease, nutrients, pathogens, thermal loading, salt
Transportation	337	2.20%	Metals, nutrients, PAHs, oil and grease, chemical applications, thermal loading, deicing salts
Urban Public/Institutional	280	1.83%	Nutrients, chemical applications
High Density Residential	200	1.31%	Nutrients, pathogens, chemical applications, deicing salts, PPCPs
Multi-Family Residential	137	0.89%	Nutrients, pathogens, chemical applications, deicing salts, PPCPs
Golf Course	107	0.70%	Nutrients, pesticides, herbicides
Powerline/Utility	93	0.61%	Chemical applications
Cemetery	41	0.27%	Nutrients, pesticides, herbicides
Mining	34	0.22%	Sedimentation, metals, pH
Waste Disposal	6	0.04%	Metals, chemicals
Junkyard	6	0.04%	Metals, chemicals
Transitional	2	0.01%	Erosion, Sedimentation
Total	**15,277**	**100%**	From 2005 Land Use, EEA MassGIS
			* Dissolved Organic Carbon, Trihalomethane Forming Potential, ** Pharmaceuticals and Personal Care Products

STORMWATER/IMPERVIOUS SURFACES

In the Hobbs and Stony Brook watersheds, stormwater is the greatest contributor to water quality degradation. Its cumulative impacts are the most significant long-term threat to the water supply. In developed areas, rapid, polluted storm flows arrive in bursts, scouring stream channels, encouraging erosion and sedimentation, and compromising habitat quality and pollutant-attenuating ecosystem functionality. Due to the Stony Brook Reservoir's limited size and relatively large drainage area, larger rain events result in an increased proportion of water discharged to the Charles River, thus reducing the available water supply and potentially intensifying flood conditions.

Developed watershed land use is characterized by a high percentage of impervious surfaces such as roads, parking lots, roofs, sidewalks and other paved areas that are directly connected to draining water bodies via storm drains. This increases stormwater velocity, volume, and pollutant loadings and reduces groundwater recharge. Because groundwater primarily feeds the water supply during the drought-prone summer, impervious surface proliferation without compensatory recharge mitigation could, over time, reduce the available water supply and exacerbate droughts.

310 CMR 22.00 defines three waters supply protection zones, Zones A, B, and C, each delineating an area of or surrounding a reservoir or tributary [Appendix A]. Zone A is the area of a Class A [as defined in 314 CMR 4.05(3)(a)] water body to the top of its bank, plus a 400 foot distance from a reservoir's top of bank, or 200 foot distance from a feeding tributary's top of bank. Zone B is the area within ½ mile of the top of a Class A surface water source's bank, or to the edge of the watershed, whichever is less. Zone C is defined as the remaining watershed area. MassDEP prohibits or requires conditional permits for certain new land use activities within these protection zones, but many existing uses are grandfathered in.

Together, the Hobbs Brook and Stony Brook watersheds are over 14% impervious by area. Surface water supply protection Zones A and B are 10% and 22% impervious, respectively. One 214-acre subbasin located in Waltham is 65% impervious and the draining tributary is considerably impacted by stormwater.[7] Generally accepted, peer-reviewed research shows threshold effects at 10% impervious area with measurable stream impacts.

Despite Massachusetts surface water quality and stormwater standards requiring Zone A stormwater outfall removal/setbacks and a high degree of treatment, CWD is unaware of any regulations requiring immediate retrofits of existing outfalls. In certain instances, stormwater retrofits are required under site redevelopment, yet redevelopment work can fall under thresholds requiring implementation.

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[7] Impervious surface percentages calculated by CWD in a GIS with spatial data developed by MassGIS, EEA. Zone B calculations are the mean percent impervious areas of both Hobbs and Stony Brook Reservoir Zone Bs

Regulated Sites

The Massachusetts Department of Environmental Protection (MassDEP) and US Environmental Protection Agency (USEPA) regulate sites through various programs managing for environmental and public health risks. The levels of governmental oversight are proportionate to the type, amount, and extent of chemicals handled or released into the environment.

Today, the upper watershed contains 17 open "21E" (governed under MGL c. 21E) sites tracked by the MassDEP Bureau of Waste Site Cleanup (BWSC).[8] These are sites where toxic releases have been identified and require remediation. There are many other 21E sites where mitigation has been completed and no significant risk remains, and other sites are still in the process of treating known contaminants.

The site identified by a 1989 MWRA-commissioned Metropolitan Area Planning Council (MAPC)-authored Cambridge Reservoir Watershed Protection Plan as most threatening, the Exxon Storage Terminal, has been razed, redeveloped into office space, and is actively treating groundwater contaminants. Similarly, the Mass Broken Stone quarry and asphalt plant located on the bank of Stony Brook and less than one thousand feet upstream from Stony Brook Reservoir is now inactive and has been remediated (with an associated Activity and Use Limitation) as part of its redevelopment into office space. Most of the other 21E sites are fuel leaks from underground storage tanks that are being remediated and tracked by Watershed Management staff. Water quality sampling and monitoring indicate that none of the active sites pose an imminent threat to the water supply.

Also managed by the MassDEP and local fire departments are underground storage tanks. According to MassDEP data, there remain 29 mapped underground storage tanks (containing transportation fuel and other hazardous chemicals) which represent a significant risk if improperly managed. These are monitored only on an exception basis by the Watershed Protection staff.

There are other sites in the watershed that are registered chemical users, but there have been no reports of major releases into the environment. These sites remain a potential threat, but only in the event of a spill. Existing regulations ensure that safeguards are in place to minimize the possibility of release. MassDEP Source Water Assessment Program (SWAP) report identified 214 permitted activities on 95 sites [Appendix A]. Primarily, these sites are registered chemical users, fuel dispensers, and sites with discharges to municipal sewer lines.

The US EPA regulates sites within the watershed under a variety of programs. The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) or Superfund program is administered to locate, investigate and clean up hazardous waste sites throughout the country. The Permit Compliance System (PCS) accounts for wastewater discharges regulated under the National Pollutant Discharge Elimination System (NPDES) program. The Toxics Release Inventory (TRI) was developed as part of the Emergency Planning and Community Right-to-Know Act to account for

[8] Information retrieved from http://db.state.ma.us/dep/cleanup/sites/search.asp 10/28/2010

chemical releases and transfers. The Resource Conservation and Recovery Act (RCRA) program tracks hazardous wastes, their handlers and movements. Many of these sites overlap with MassDEP programs, but some do not. As of February, 2010, 3 sites in the watershed are regulated under the CERCLIS program, 4 sites under the NPDES PCS program, 12 sites under the TRI program, and 135 sites under RCRA.

ROADWAYS

The watershed contains 209 miles of roads including several highways: Route 128 (Interstate 95), Route 2, Route 2A, Route 117 and Route 20. The eight-lane highway, Route 128, traverses the entire length of the watershed, comes within a few feet of Hobbs Brook Reservoir for a distance of about a third of a mile, and bisects the Stony Brook Reservoir. Route 2 cuts across Hobbs Brook Reservoir, creating the upper and middle reservoirs bordered also by the Route 2/Route 128 interchange. MassDOT owns between 250 and 300 stormwater outfalls draining directly or eventually to watershed waterbodies.

In total, roads cross the tributaries or the reservoirs 87 times in the watershed. Vehicles traveling on these roads deposit heavy metals from brake wear, phosphorus from exhaust, and petroleum byproducts, which are subsequently washed into the water supply. Copious amounts of sand and salt are deposited on roads to enable high-speed travel during the winter, with a larger amount on the 5 major interstate interchanges in the watershed. Due to its dissolved nature and mobility, salts cannot be removed with water quality treatment basins, but most other pollutants can be managed and kept out of source waters through the use of properly maintained structural and non-structural best management practices (BMPs).

SALT

Salt, mostly in the form of sodium and calcium chloride is generously applied to roadways and parking lots as a common deicing practice. Chlorides can impact aquatic life at high concentrations (between 230 and 800mg/L), and be noticed as a "salty" taste in drinking water at concentrations near 250 mg/L. Salt loading can also affect reservoir stratification by increasing resistance to seasonal mixing and exacerbating anoxic conditions in deeper water. Anoxic conditions mobilize ammonia, and metals and nutrients otherwise bound to sediments.

Between 1972 and 1985, sodium levels in Hobbs Brook Resevoir averaged 42 milligrams per liter (mg/L), well above natural background levels of 5 mg/L [MAPC, 1989]. A 1985 study commissioned by Cambridge Water and MassDOT (then as MassDPW) conducted by Geotechnical Engineers concluded that road salt application on Routes 128, 2, and 2A contributes 72% of the sodium input to Hobbs Brook Reservoir, while municipal road salting in Lexington, Lincoln, and Waltham accounts for about 13%. Leaching from the

Massachusetts Department of Transportation (MassDOT) salt depot at the intersection of Routes 128 and 2A in Lexington contributes 8%, and the remaining 7% percent is from commercial and residential use.

A reduced salting program by MassDOT during the winter of 1986-87 resulted in a 61 percent reduction in the amount of sodium chloride applied to state-maintained roadways in the watershed. However, the Geotechnical Engineers sodium chloride study estimated that it would take the Hobbs Brook Reservoir 15 years to reach a sodium level of 9 mg/L if sodium chloride application were completely eliminated from the watershed. Despite reduced and alternative deicing strategies, sodium and chloride levels in watershed water bodies continue to climb. Most recent estimates show that despite low-salt practices, nearly 3 times more NaCl is applied to watershed highways and the sodium concentration in Hobbs Brook Reservoir is nearly 3 times higher than observed in the 1985 study.

HAZARDOUS MATERIALS RELEASES

Hazardous materials spills from trucks on roadways pose a serious threat to the water supply. Some of the products routinely transported through the watershed could incapacitate the water supply should they be allowed to enter the reservoirs. Several major roads pass close to and are hydraulically connected to watershed water bodies by drainage infrastructure. Route 128 has no hazmat travel restrictions and provides the greatest threat. Recent roadwork by MassDOT has triggered the construction of three strategically placed detention basins with emergency shut-off valves to increase runoff treatment and decrease contamination threats to the Stony Brook Reservoir. Similar roadwork planned in the Stony Brook and Hobbs Brook watersheds will trigger similar, additional protection from highway runoff and spills. Several smaller spills have been prevented from contaminating the reservoirs through fast action by primary responders following the Watershed Protection Division's Hazardous Material Emergency Response Plan and Atlas.

RAILROADS

The MBTA Fitchburg Line commuter railroad passes through the watershed for a distance of about five miles, crosses Stony Brook seven times and comes within 500 feet of Stony Brook Reservoir. In addition to the potential for spills and accidents, normal operation deposits petroleum products and metals, and there is a potential for wash off of improperly or excessively applied herbicides during maintenance of the railway right-of-way. Untreated stormwater discharges from commuter rail parking lots also impact watershed streams.

CONSTRUCTION

Although contractors attempt to follow best management practices, sediment runoff during storms is frequently associated with road and building construction. Given the close proximity of major roads and commercial developments, this is a constant threat to the reservoirs and their tributaries. Despite federal and state permitting and associated stormwater controls, there have been many instances where BMPs were not properly inspected and maintained, or even cases where controls are removed to promote drainage and better working conditions, all causing contaminated water to enter streams and reservoirs. The EPA estimates that sediment runoff from construction sites is 10 to 20 times that from a farm and 1,000 to 2,000 times that from a forest. The Watershed Management Division monitors all large construction projects, but avoidable failures in protection practices or non-compliance with stormwater pollution prevention plans are common.

SEWERAGE/SEPTIC SYSTEMS

Within the watershed, the town of Lexington and City of Waltham are served by the MWRA sewer system while Weston and Lincoln treat and release their wastewater through septic systems. Old, leaky, and damaged sewerage can communicate with stormwater pipes or cause sanitary sewer backups and overflows (SSO) that introduce bacteria, nutrients and other contaminants to the water supply. Old sewerage can also intercept rainwater and clean groundwater destined for surface water bodies, exacerbating drought impacts and reducing water availability. This is commonly known as "Inflow and Infiltration (I/I)".

Septic systems can be a source of excessive nutrients and household chemicals, especially if they are poorly maintained or sited, and cleaned with inappropriate chemicals. Although the state and both towns have regulations restricting septic systems to appropriate sites, variances are commonly granted in watershed protection zones to avoid takings issues or to fix failed, grandfathered systems. Pollutants of emerging concern such as endocrine disrupting compounds (EDCs) and pharmaceuticals and personal care products (PPCPs) can be water-soluble and move readily through the water table. Current septic systems are not designed to treat or sequester these chemicals and their environmental impacts are just now being studied.

Potential leaks in sewerage and illicit connections of sanitary to stormwater pipes present water quality issues. Only the southwest corner of Lexington is within the Cambridge Watershed, serving primarily residential subdivisions in a small portion of town. A more significant portion of Waltham is within the watershed and that area is highly urbanized with large office parks, industrial complexes, and residential subdivisions all serviced by municipal sewers. Aging sewer lines in Waltham and Lexington have led to spills and releases of raw sewage on a site-specific basis. Special receiving water quality investigations are conducted where sewage problems are known to exist. Data has been used in support of formal requests to Waltham to conduct investigations and subsequent maintenance activities of problematic sewer lines. The potential for illicit connections of sanitary sewers to storm drains remains a problem and could be a cause of elevated bacteria, nutrients and other chemicals from stormwater discharge points. Waltham is under a consent order by the MassDEP to eliminate sewer system overflows and reduce I/I.

In addition to many smaller sewers, the Bear Hill Valley trunk line runs parallel to the Hobbs Brook Reservoir on the east side almost entirely within 200 feet of the reservoir, and in some stretches, 10-15 from the water sheet. This is a potential source of contamination and also groundwater infiltration for waters destined for or leaving the reservoir. When sewer lines break, and there is a release in the watershed, Waltham will notify CWD, and provides technical input on the containment or cleanup of the released sewage; Waltham provides CWD with a maintenance, or repair report post-event.

There are no known wastewater treatment plants discharging directly to surface water bodies within the watershed. MassDEP regulates 4 ground water discharges of treated sanitary wastewater within the watershed permitted for ~90,000 gallons per day in total. This total does not include the newly redeveloped Weston Corporate Center (formerly Mass Broken Stone) septic system ground water discharge.

IN-LAKE PROBLEMS

Sediments

Sediment deposition in the reservoirs can affect storage capacity, dam stability, and introduce adhered contaminants. The Hobbs and Stony Brook reservoir sediments show high concentrations of heavy metals such as iron, zinc, and manganese. Reservoir sediments were sampled by the USGS in 1998 and compared to the Lower Charles River Basin with highlights summarized in the table below.

Table 5: Selected Sediment Results, Recreated from Waldron and Bent, 2001

		Hobbs Brook Reservoir			Stony Brook Reservoir	Lower Charles River
Analyte	MRL	Upper basin	Middle basin	Lower basin	Deep Hole	135 Site Median
Calcium (g/kg)	0.1	6.9	8	4.2	7.4	6.4
Phosphorus (g/kg)	0.1	0.9	0.9	0.9	2.7	1.6
Aluminum (g/kg)	0.1	10.7	12.4	12.2	29	18.1
Arsenic (mg/kg)	3	5	4	6	14	3
Iron (g/kg)	0.1	20.2	22.5	18.1	71.7	31.5
Lead (mg/kg)	2	68	178	90	651	642
Manganese (mg/kg)	2	265	320	256	1100	466

Although settling and adhesion reduces water contaminants reaching the treatment plant and ultimately drinking water, metals can be resuspended and remobilized under anoxic conditions, then distributed throughout the water column during reservoir turnover events. Low oxygen levels have been observed particularly in the deeper reservoir "holes" during the summer. Many factors, including nutrients and salt inflows, contribute to a reduction in oxygen levels. An aeration system in the Stony Brook Reservoir operates during periods of thermal stratification, facilitating mixing, increasing benthic oxygen concentrations and reducing the remobilization of metals and nutrients into the water column. No such system exists for the Hobbs Brook reservoir.

Upper Basin Impairments

The Hobbs Brook reservoir Upper Basin is relatively shallow (average depth ~6ft) and receives flow from the Hobbs Brook main branch, two unnamed tributaries, and highway runoff from Route 2. In MassDEP's Charles River Watershed 1997/1998 Water Quality Assessment Report, the Upper Basin (MA72156) was assessed as a Category-5 Impaired Waterway requiring a Total Maximum Daily Load (TMDL) analysis for excessive turbidity and noxious plants. The basin remains on the 2008 Integrated List of Waters. A TMDL is a pollution loading analysis determining the water body's assimilative capacity for specific pollutants while still being able to meet its designated use. The spread of invasive aquatic plants, sediment and nutrient loads from runoff, and internal nutrient cycling are the most likely contributors to this type of impairment. A TMDL analysis has not been conducted, but the Upper Basin watershed will be subject to any future Federal or State regulatory action on stormwater permit holders in the Charles River watershed, which should address the impairment.

During the growing season, the upper basin is more biologically productive than the middle and lower basins, resulting in turbid water with visible algal presence. Because this basin can become shallow from summertime peak demand and under dryer summer conditions, wave action can resuspend nutrient-rich bed sediments for algae and plants. In addition, shallow water allows for light to penetrate the entire water column, which further encourages the growth of algae and aquatic plants. Under drought conditions, the basin can become a large mud-flat which exposes decaying organic matter to the air, causing odors to emanate from the basin. This condition could potentially be alleviated after the Trapelo Road Gatehouse is repaired (Spring, 2012). This would allow the CWD to hold water in the upper basin until later in the summer season, maximizing the basin's depth and stormwater retention/treatment capacity.

LANDSCAPING: LAWNS, GOLF COURSES, RIGHT-OF-WAYS

Fertilizers used to promote growth of lawns and golf courses add nutrients, most importantly phosphorus, to streams and reservoirs. High levels of nutrients promote the growth of aquatic vegetation and algae, increasing the organic content of the water. This organic matter must be removed by the treatment plant to avoid an interaction with chlorine that produces trihalomethanes and other disinfection byproducts. After aquatic vegetation dies and sinks to the bottom, its decomposition demands oxygen from the water, potentially causing anaerobic conditions, which can cause fish kills and transform and mobilize otherwise sequestered metals and nutrients from sediments into the water column. A USGS study of the reservoir system identified and quantified the release of ammonia-nitrogen, orthophosphate-phosphorus, and dissolved iron and manganese from hypoxic zones. These pollutants are bio-available and cause treatment problems for drinking water systems [Waldron and Bent, 2001].

Chemicals including insecticides, fungicides, herbicides and rodenticides, are used to control vegetation along railroad tracks and in utility right-of-ways, to maintain commercial, institutional and residential lawns and gardens, and to protect golf course fairways and greens. Several of these chemicals have been detected in the watershed tributaries in trace amounts during routine USGS water quality sampling, but none in a concentration assumed to affect human health. A yet unpublished data and interpretive report summarizing a USGS watershed stormwater study will go into further detail and help guide watershed protection efforts. All preliminary and published data are publicly available and can be retrieved on a site-specific basis through the USGS website (see Water Quality Monitoring section).

In areas draining overland, maintaining a cleansing, 200-foot buffer of woody vegetation on either side of the stream would help protect habitat and in-stream water quality. However, many residents prefer lawns and a clear view of the water and remove vegetation up to river or lake banks. Some of this activity is overseen by Massachusetts Riverfront Area regulations, but regulations do not necessarily apply to intermittent streams, lakes, and ponds. This accelerates the movement of nutrients and contaminants into the streams. In areas draining to piped stormwater infrastructure, CWD advocates for and promotes property owners' treating stormwater at its source through filtration or infiltration measures to ensure that stormwater discharging into the water supply is clean and slow moving.

PUBLIC ACCESS/RECREATION/PHYSICAL SECURITY

Although the reservoirs are closed to the public, they are surrounded by populated areas. Trespassing often for the purposes of fishing, swimming and teenage partying is observed and dealt with by regular patrolling. Some of these areas are isolated by fencing, and the proximity of Route 128 discourages pedestrian access, but staff encounter trespassers several times per week. Additional fencing may help, but frequent policing must continue. "No

Trespassing" and other signage directed towards limiting access are posted throughout Cambridge-owned land.

Access to the tributaries is less controlled; the tributaries are exposed by many road crossings, walking and horse riding trails, residential lawns and commercial parking lots. The Water Department is currently undergoing a feasibility study for public access and education opportunities in three Cambridge–owned parcels in Lincoln and Lexington. Encouraging controlled, limited access could decrease unwanted, illicit uses near the water supply and increase the number of citizen advocates.

MOSQUITO DREDGING

Dredging is conducted to encourage drainage of stagnant, mosquito breeding waters for public health reasons. So far, mosquito dredging has only been conducted in Weston and Waltham. This activity has little long-term impact on the water supply since it involves deliberate debris and sediment removal from stream beds. Care is taken to limit the extent of downstream sedimentation as a result of this work. Middlesex Mosquito Control carries out the work, and reviews their dredging plan with CWD prior to implementation. The CWD monitors any mosquito dredging that occurs in the watershed.

WILDLIFE

Wildlife and pets deposit nutrient-rich waste and potentially pathogenic bacteria and other pathogens, such as giardia and cryptosporidium. Open water of the upcountry reservoirs and well-manicured lawns of the abutting office parks attract flocks of waterfowl, especially in the winter, when large numbers of gulls settle on the reservoirs and domesticated, non-migrating populations of Canada Geese feed. Many mammals including beaver, coyote, muskrat, deer and fox have been observed around the reservoirs. Beaver have impacted tributary flows in some areas to nuisance levels and consequently, have been properly controlled. Many households keep dogs and cats as pets, and horses are popular in Weston and Lincoln. The Massachusetts Department of Conservation and Recreation (DCR), responsible for managing and protecting MWRA source water, has identified pet waste disposal in residential areas abutting tributaries as a significant pollution source and has launched a public education . Given the potential sensitivity of the reservoirs to increased phosphorus loading, it may be necessary to keep track of waterfowl abundances on the reservoirs and take steps to discourage their presence if populations increase. Stony Brook and Hobbs Brook Reservoirs are managed through regulated egg-addling programs to minimize Canada goose habitat and major year-to-year trends in waterfowl are noted.

LANDFILLS

The risk from solid waste has also subsided as both the Lincoln and Weston landfills in the watershed are now inactive and capped. The Watershed Management staff continues to review reports from the groundwater monitoring at the Weston landfill just above Stony Brook reservoir. The area is closely and routinely monitored and the risk of contamination from landfills has been substantially reduced.

FRESH POND WATERSHED IMPACTS

LAND USE/ZONING

Because the Fresh Pond watershed has been re-engineered to divert storm flows, land use is more of an indicator of potential groundwater rather than stormwater impacts [Appendix A]. The restricted Fresh Pond Reservoir watershed lies mostly to the north and is mostly wooded, indicating good runoff quality. The abutting golf course would be the largest land-use specific potential threat to the reservoir, but has minimal hydrologic connectivity. The golf course is further discussed in a following section. Otherwise, the historic, topographical watershed is dominated by residential development.

Table 6: Historic Fresh Pond Watershed Land Use

Land Use Type	Acres	Percent by Area
Undeveloped, Lightly Developed	**287.7**	**22.18%**
Forest	62.5	4.81%
Forested Wetland	3.2	0.25%
Water	166.7	12.85%
Cropland	7.2	0.56%
Non-Forested Wetland	0.4	0.03%
Open Land	8.6	0.66%
Participation Recreation	39.2	3.02%
Developed	**1,009.5**	**77.82%**
Multi-Family Residential	353.1	27.22%
High Density Residential	297.9	22.96%
Medium Density Residential	9.1	0.70%
Commercial	60.1	4.63%
Industrial	29.6	2.28%
Transitional	4.1	0.32%
Transportation	6.7	0.52%
Golf Course	103.2	7.96%
Urban Public/Institutional	42.4	3.27%
Cemetery	103.2	8.0%
Total	**1,297.3**	**100%**

STORMWATER/IMPERVIOUS SURFACE

Fresh Pond Reservoir's small contributing watershed and natural land cover results in minimal stormwater impacts. Stormwater impacts in Fresh Pond are primarily realized from influences in water quality from the upper watershed. Locally, erosion and sedimentation are occurring from steep western (Glacken) and south-eastern (Kingley) slopes that drain directly to the reservoir. Glacken slope conveys flows from the golf course clubhouse, tennis and basketball courts, and a portion of a managed ball field. Kingsley slope drains portions of the main perimeter path, but is otherwise forested. Impacts are currently being addressed through stormwater improvement and slope-stabilization projects discussed in detail later. All other surrounding impervious areas, excluding the perimeter path, drain away from the reservoir via storm drains. The small areas that remain are in the process of being mitigated through construction projects.

GROUNDWATER FLOW

The historic watershed still contributes groundwater to the water supply primarily from the south, with additional inputs possible from the east and west under low reservoir operating levels [CDM, 1994]. The area to the north of Fresh Pond Reservation is highly developed with roads and railroads, residential, commercial, and industrial land uses. However, the lack of surface flow from these areas and the northerly direction of groundwater flow make it highly unlikely that contaminants could reach the reservoir from this area.

Groundwater flow has been monitored through a series of eleven monitoring wells. A 1997 CDM groundwater study determined that the direction of flow roughly follows surface topography migrating northward towards Alewife Brook. The historic watershed still contributes groundwater flow to Fresh Pond Reservoir amounting to roughly three-percent of the daily water supply [CDM, 1997]. Fortunately, inflowing groundwater from the south was found to have very low levels of potential contaminants.

The groundwater under the industrial area further to the north may contain contaminants, but this has not been tested for the very low risk of contribution. The natural direction of flow combined with high operating levels ensure that any contaminants from that area will not reach the reservoir. According to the 1997 CDM groundwater study, maintaining the reservoir elevation at a minimum of 15 feet CCD will protect the reservoir from inflow from the highly developed area to the north. If it is lowered below 15 feet for a period greater than two months, groundwater monitoring wells around the reservoir should be sampled monthly to ensure that no contaminants are reaching the reservoir.

REGULATED SITES

Although there are several sites with contaminated groundwater near Fresh Pond Reservoir, they are primarily located to the north. Under normal operating conditions, natural groundwater flow carries these contaminants away from the reservoir as described above in the section on groundwater flow.

The threat from 21E sites is further reduced by existing remediation activities underway at service stations to the east and north. Additional contaminants are removed by a groundwater pump between the reservoir and the capped landfill, now Danehy Park, which lies northeast of the reservoir. Sites within City limits report regularly to the MassDEP and the CWD as required under the Massachusetts Contingency Plan with assessment and water quality monitoring results.

According to recent MassDEP data, there are 33 21E sites, about half of which have received a Response Action Outcome compliance status implying clean-up is completed and no significant risk remains. Other sites are conducting or have had site remediation activities completed. 16 DEP-regulated sites have an Activity and Use Limitation where contamination has not been reduced to background levels, but a permanent solution has been arranged.

MassDEP Source Water Assessment Program report identified 59 permitted activities on a total of 41 sites surrounding the historic watershed's regulated zones [Appendix A]. Primarily, these sites are registered chemical users, fuel dispensers, and sites with discharges to municipal sewer lines. Most recent MassDEP data identifies 22 underground storage tanks in the historic watershed.

Regulated EPA sites within 500 feet of the Fresh Pond Reservoir historic watershed boundary include 3 sites regulated under the TRI program, 32 RCRA sites, and 2 PCS sites.

PUBLIC ACCESS

Fresh Pond Reservation, the largest open space in the city, is heavily used by joggers, walkers and bicyclists. Human use is primarily limited to constructed pathways, but off path use can exacerbate erosion, compact soils, and disturb vegetation. Many dog walkers, including commercial dog walkers, use the reservation. Heavy off-path use has caused soil compaction and erosion, carrying sediments, nutrients, organic matter, and animal feces into the reservoir during runoff-generating storm events. Animal feces can contain pathogenic bacteria and persistent cysts of Giardia and Cryptosporidium which challenge water treatment plants in their removal. In localized, heavy dog-use areas, dog urine has altered soil chemistry and eroded tree bark, limiting and stressing the growth of reservation vegetation.

GOLF COURSE

In general, golf courses are documented sources of nutrients, pesticides, herbicides in both surface and groundwaters. In general, fertilizers and chemicals are applied in high rates in order to maintain an aesthetic that enhances the golfing experience. The City of Cambridge owns and operates a 65 acre golf course abutting Fresh Pond Reservoir on the western side. The golf course drains to Little Fresh Pond, Black's Nook, and North Pond, three Class B waterbodies that have limited groundwater connectivity and controlled surface water connections to the Fresh Pond Reservoir. Black's Nook is TMDL-listed for nutrients and noxious plants, and all have relatively high levels of bio-available phosphorus and chlorophyll-a, are very productive, and show signs of possible cultural eutrophication.

The 1994 CDM report reviewed the potential threat from pesticides and fertilizers used on the golf course. Based on the characteristics of the materials used, the procedures followed, and a literature review of studies of other golf courses near water supplies, the report concluded: 1) it is unlikely that the pesticide and fertilizer use in the golf course is impacting the water quality in Fresh Pond significantly; but 2) there is insufficient monitoring data to ascertain definitively whether the drinking water has been impacted. The 1997 CDM study found no significant pesticide contamination in groundwater, posing no appreciable threat.

RAILROAD

B&M maintains a railroad that passes around the southern rim of Fresh Pond Reservoir. Recently, there has been limited and even no activity on these tracks. They are in poor condition and derailments near the reservoir were fairly common. Because these tracks drain to the reservoir, derailments and potential resulting releases were a threat to water quality. In the near future, these tracks may no longer act as railway and could be incorporated into proposed rail-trails.

Historically, this corridor was maintained through herbicide spraying and physical methods. Although the use of herbicides by the B&M Railroad appeared to be minimal, the actual frequency, chemicals used, and procedures followed were unknown. Spraying along this right-of-way is currently permitted through the MA Department of Agriculture and the local Conservation Commission. "No-spray" areas surround the reservoir and abutting wetlands.

WILDLIFE

As with domesticated animals, wildlife can contaminate the water with pathogens and excessive nutrients in their wastes. The size of the wildlife population has not been censused, but gulls, Canada geese, ducks and muskrats are observed in Fresh Pond, and other birds and animals, including geese, ducks, coyotes, raccoons, squirrels, chipmunk opossum, rabbits and various rodents populate the Reservation. The impact of geese has been eased by the fence surrounding Fresh Pond, isolating the pond from the grassy areas geese require.

FRESH POND IN-LAKE PROBLEMS

Fresh Pond is a phosphorus-limited, oligotrophic to mesotrophic (characterized by low to medium productivity) reservoir. Efforts must be made to limit phosphorus entering the pond from the Stony Brook Conduit, otherwise internal nutrient cycling, algae blooms, and general accelerated eutrophication could eventually play a larger role in affecting water quality.

Like other reservoirs, Fresh Pond thermally stratifies as temperatures warm in the summer and cool in the winter. Its sediments contain high levels of manganese and other metals that can be released under anoxic conditions. To keep the reservoir mixed and oxygenated, an aeration system consisting of perforated pipes lining the reservoir bottom operates during summer periods of thermal stratification.

WATER QUALITY MONITORING

The Water Quality Monitoring Program consists of four major elements: (1) routine discrete and continuous-record monitoring of reservoirs and tributary streams during dry weather, (2) event-based monitoring of streams, storm drains, and other outfalls during wet weather, (3) continuous recording of stage and selected water-quality characteristics at critical sites within the drainage basin, and (4) periodic monitoring of ground water in the vicinity of Fresh Pond. The City employs a full-time water quality monitoring engineer, who is assisted by the two caretakers, a watershed protection fellow, and a laboratory technician.

The monitoring program was developed with the assistance of the United States Geological Survey (USGS) based on a comprehensive watershed assessment (Waldron and Bent, 2001). Through an annually renewed Joint-Funding Agreement (JFA), the USGS continues to assist and monitor the watershed conducting water quality studies, maintaining a "real-time" water quality and quantity data network, and publishing publically-available year-end data summaries and reports. The USGS works closely with the CWD on the technical aspects of the water quality-monitoring program. The CWD has set up its own long-term program that uses USGS scientific methods and quality assurance protocols to ensure data accuracy and quality [Appendix C].

ROUTINE RESERVOIR AND TRIBUTARY MONITORING

At regular intervals throughout the year, under base-flow (dry-weather) conditions, CWD staff collect discrete grab samples and measure stream flow and *in situ* parameters at several locations in the Stony and Hobbs Brook watersheds, and throughout the Fresh Pond Reservation. In the reservoirs, CWD staff measure Secchi disk transparency and record depth profiles of specific conductance, pH, water temperature, turbidity, and dissolved oxygen concentration. Under stratified conditions, discrete samples are taken at different depths.

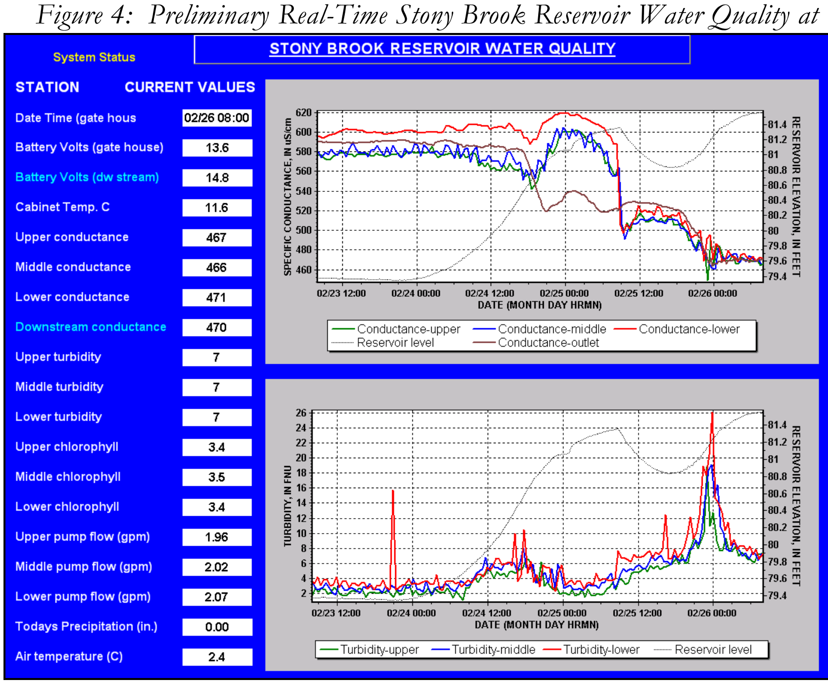
Tributary streams are routinely monitored at 12 primary and 4 secondary monitoring stations. Specific conductance, pH, water temperature, turbidity, and dissolved oxygen concentration are measured on site. Discrete water samples (at both tributary and reservoir sites) are analyzed in the CWD and contracted laboratories for sewage-related bacteria, alkalinity, major ion concentrations, nutrients, chlorophyll *a* (reservoirs only), total organic carbon, color, and selected metals.

CONTINUOUS-RECORD SURFACE WATER MONITORING

Continuous (15 minute interval), unattended monitoring is conducted at seven primary tributary, three reservoir, and one Fresh Pond Reservation sites. The USGS and CWD operate and maintain these stations for continuous measurements of stream and reservoir stage, discharge, specific conductance, and temperature. Precipitation is also monitored at the three reservoir stations, and site 01104455 is outfitted with a turbidity probe to monitor particulate inputs. Continuous stream-stage data are converted to discharge by the use of stage-discharge relationships and the specific conductance records are converted to yields of sodium, calcium, and chloride in a similar fashion [Granato and Smith, 1999].

Late in 2001, a more elaborate water quality monitoring system was installed at Stony Brook that measured *in-situ* parameters at the corresponding depths of the upper, middle, and lower gates to the conduit and ultimately Fresh Pond Reservoir, but was immediately wrought with technical problems. Just recently, the system was repaired and is now functioning properly. The system collects temperature, turbidity, chlorophyll, and specific conductance cycling through three water depths on a continuous basis. Data will be used to better understand seasonal and storm-induced reservoir mixing, and ultimately to manage gates to maximize water quality to Fresh Pond. Real-time data from continuously monitored stations are uploaded at regular intervals for public online viewing at
http://waterdata.usgs.gov/ma/nwis/current/?type=cambrid&group_key=basin_cd

Figure 4: Preliminary Real-Time Stony Brook Reservoir Water Quality at Three Depths



USGS Water Quality Studies

Also through the JFA, the USGS publishes detailed water quality studies in several sub-basins throughout the source-water area. The first intensive study conducted by the USGS was completed in 1998 and characterized water quality in tributaries and the three reservoirs. This study established automated, unattended water-quality and flow monitoring equipment at key reservoir and stream locations. Since 1998, some of these monitoring locations have been discontinued (although infrastructure remains) while others have been maintained for subsequent studies and reservoir management. Data collected by the USGS undergo a thorough quality control program and are published annually. These reports are available to the public through the USGS Water Resources of Massachusetts and Rhode Island website http://ma.water.usgs.gov/ and http://wdr.water.usgs.gov/. Spreadsheet - importable data can be retrieved at http://nwis.waterdata.usgs.gov/ma/nwis/qwdata.

The USGS has conducted stormwater sampling events using automated samplers programmed to collect samples throughout an entire storm event. As there can be tremendous variability in in-stream pollutant concentrations throughout a storm, collecting and averaging multiple samples more accurately reflects in-stream stormwater quality and wet-weather pollution loading. Results, expressed as event-mean concentrations, are available online.

The USGS is continuing its study of baseflow and stormwater quality in several urbanized tributary sub-basins in the Upper Watershed and the Stony Brook Gatehouse. This study, scheduled to be completed by Winter, 2011 will provide a baseline for the increasingly important microcontaminants, such as pharmaceuticals, pesticides and petroleum-derived chemicals.

USGS, funded by the US Department of Transportation Federal Highway Administration, and MassDOT recently published a report characterizing stormwater quality from Massachusetts highway surfaces[9]. Two of the study's monitoring sites were in the Cambridge watershed which will help CWD identify, prioritize, and target pollutants contributing to the water supply. MassDOT is also working with the University of Massachusetts to conduct studies on the effects of deicing practices in the watershed.

Event-Based (Wet Weather) Surface-Water Monitoring

CWD staff conduct storm-event sampling at primary and secondary stream-monitoring stations, Fresh Pond Reservation, and at major pipes and other discharges to them. The goal of storm-event sampling is to capture in-stream or end of pipe "first flush" conditions from storms producing 0.5 inches or more of rain after a period of at least 3 days of dry weather.

[9] USGS Scientific Investigations Report 2009-5269

SPECIAL WATER QUALITY INVESTIGATIONS

The water quality monitoring program includes the investigation of specific point-source locations that contribute contaminants to the water supply. These locations are not tributary sampling stations, rather outfalls, or illicit discharges that enter tributaries whose sources were detected by routine or stormwater sampling in the tributaries and traced back upstream to find their specific location and eliminate the problem.

GROUNDWATER MONITORING AT FRESH POND RESERVATION

Twelve groundwater monitoring wells, some active, some preexisting and some constructed for the 1997 CDM Fresh Pond groundwater study, surround Fresh Pond Reservoir. After the study was completed, groundwater level monitoring and quality sampling has been limited to responsible parties in areas of known contamination. Under the Massachusetts Contingency Plan, independent contractors evaluate the extent of groundwater contamination to ensure that no such contaminants are migrating from these adjacent properties to the surface water supply of Fresh Pond. These consultants regularly report the analytical results to and work with CWD to locate potential additional monitoring wells and to coordinate sampling efforts on the Reservation.

SITE MONITORING

The Watershed Division monitors every major and most minor construction projects (Sites) in the watershed. Site monitoring incorporates community outreach, partnership development, onsite inspections, and reviewing proposals and construction plans for projects that could impact the water supply. Watershed staff visit construction sites regularly and compliance is tracked in a database. Staff meet regularly with developers to voice concerns, discuss how best to minimize watershed impacts, and to cultivate mutually beneficial relationships. It is crucial that the CWD's interests are incorporated into the planning of major construction projects throughout the watershed in order to ensure the following:

- All parties involved are aware that they are working near a water supply;
- No significant impacts on source-water tributaries and reservoirs will occur as a result of these projects;
- Improvements to existing conditions will be implemented as a result of these projects.

A good example is the Exxon Tank Farm Site, formerly situated within a few yards of Stony Brook just upstream of the reservoir. As part of this site's redevelopment into an office park, a major cleanup of hazardous waste was accomplished, ecological improvements to Stony Brook were made, and stormwater from on and off-site is now treated.

CONSTRUCTION SITES

CWD is notified of new construction in the watershed primarily through regulatory processes or on regular patrols. Developers are required to file with the local Conservation Commissions when working in a water resource area. Larger projects could trigger the Massachusetts Environmental Policy Act (MEPA), also involving a public review process. Through these processes our involvement entails the following:

- Reviewing permits and plans and providing written comments;
- Attending public hearings and providing written comments;
- Attending pre-construction field meetings;
- Regular monitoring of construction progress, especially during wet weather.

CWD keeps detailed records of construction-related activities in a spatial database that provides a comprehensive overview of watershed activities. Progress is regularly updated for each project noting any follow-up actions needed to protect the water supply.

In a watershed where parcel price is at a premium, redevelopments that replace aging commercial or industrial structures and clean up contaminated sites can provide more benefits to the water supply than land acquisition. These projects implement best management practices (BMPs), such as retention basins that slow, "polish", and recharge stormwater. Considerable improvements have been made to mitigate development impacts, and these can be expected to continue.

DAM INSPECTIONS

The Massachusetts Department of Conservation and Recreation (DCR) Office of Dam Safety requires biannual inspections on both the Stony Brook and Hobbs Brook reservoir dams. Both dams are characterized as "Large", "High" hazard potential dams in "Fair" condition with no evidence of immediate instability. Watershed division staff regularly inspect dams for seepage, rodent burrows, or other maintenance-triggering cues and generate in-house summary reports.

CARETAKERS

Two full time watershed caretakers cover a seven-day-a-week shift for surveillance, gate operations, security, facilities maintenance, and assistance with implementing the surface water supply protection plan. Activities that the CWD has not been notified of through the regulatory process are usually discovered by the reservoir caretakers, or other staff patrols thus ensuring CWD's involvement with various projects when necessary.

LAND ACQUISITION

Of the 15,277 acres in the upper watershed, 34% has already been developed for residential, commercial, industrial and transportation use and 27% has been protected from development. The City has developed a Land Acquisition Strategy to protect key portions of the remaining 4,289 acres, or 30%, that has not yet been developed nor protected. This strategy focuses on parcels within the DEP defined Surface Water Protection Area Zone A and Title 5 buffer zones.

Most of the land owned by the City was acquired at the end of the nineteenth century surrounding and including the created reservoirs [Appendix A]. Although the City has not established a formal program to acquire land in the watershed, it has identified priority parcels and actively pursues opportunities. The City acquired a 57-acre property in 1998, and in 2005, the City used Community Preservation Act and a state Self-Help grant to acquire an additional 16 acres. In both cases, the parcels lie mostly in the target watershed protection Zone A along tributaries or wetlands. The City worked closely with the Town of Lincoln, in particular the Lincoln Rural Land Foundation (RLF) for both acquisitions. In fact, the second acquisition was part of a larger deal put together by RLF that protects 53 acres, mostly in Zone A, which increases the positive impact of the City's acquisition.

EMERGENCY RESPONSE PLANNING

Since the original watershed protection plan recommendations were made in 1989, the City has developed and implemented an Emergency Response Plan for the entire Water Department. Related to the watershed, these subcomponents include the Hazardous Materials Emergency Response Plan and Atlas, and the Dam Emergency Action Plans which have been completed, shared with local fire departments, and are updated on a routine basis.

Hazardous materials response equipment is available to responders at six locations in the upper watershed. The Waltham Fire Department, which would be the first responder for most of the area around the two reservoirs, is trained and drilled on the use of the equipment. Yearly updates inventory equipment, and their locations are shared with local fire departments and other responders. For access to the reservoirs, the Water Department has provided Waltham Fire with a boat and trailer. The Water Department has acquired and positioned equipment and boom-deployment rigs in strategic locations throughout the watershed. The department regularly hosts training sessions and tours to primary responders.

In addition, a Hazmat Atlas showing all highway outfalls, stormwater/spill retention basins and equipment storage locations has been developed and distributed to all watershed Fire Departments. This atlas is updated on a regular basis to reflect additions or changes to the local drainage infrastructure.

Over the past 15 years, considerable resources have been devoted to restoring the Fresh Pond Reservation. Projects follow recommendations from the 1994 Fresh Pond Watershed Protection Plan [CDM, 1994] and the Fresh Pond Master Plan[10], created through a comprehensive public process and published in 2002. The plan embodies a vision and sets a framework for the preservation of water quality, recreational open spaces, natural green spaces, wildlife habitat, and a refuge from hectic urban life. In restoring the reservation, the City is committed to the use of natural systems-based approaches, including "bioengineering" and adaptive management practices that mimic historic ecological form and function.

HIGHLIGHTED COMPLETED PROJECTS

Northeast Sector Project

This project, funded jointly by the Community Preservation Act and the City of Cambridge, was designed to improve the health of Fresh Pond Reservation and reservoir. The project was completed in 2007 and reduced erosion, enhanced natural stormwater filtration processes, reduced invasive species while increasing biodiversity, and created universally accessible and inviting passive and active use areas.

Erosion issues were addressed through targeted re-grading and using removed invasive trees and shrubs as erosion control structures. Degraded soils throughout the Northeast Sector were gathered and revitalized with a mixture of compost and sand, and then reused. A wet meadow that had been filled in over the years was restored to a more natural state and designed to capture and treat local runoff.

To increase biodiversity, invasive trees were replaced with natives and a butterfly meadow was constructed to establish habitat for native pollinators. The increased biodiversity at Fresh Pond has served to invite a greater variety of birds to the Reservation, and in turn new seating areas and additional passive use areas have been established along the perimeter road and within Lusitania Meadow, encouraging visitors to relax and enjoy the wildlife.

Multiple pathways were constructed within the Northeast Sector to further promote universal accessibility. The City also created several active use areas at the Reservation,

[10] Available online http://www2.cambridgema.gov/CWD/fresh_pond_master_plan.cfm

located further from the Reservoir. This includes William G. Maher Park, which is located to the west of Neville Place and contains a youth soccer field and a universally accessible community garden.

Little Fresh Pond Restoration

Located along the western shoreline of Fresh Pond and adjacent to the municipal golf course, Little Fresh Pond was identified within the Fresh Pond Reservation Master Plan as a high priority restoration project. The project was a joint endeavor between the City of Cambridge Water, Public Works, and Recreation Departments, with help from the Cambridge Conservation Commission. Funding was provided in part through the Community Preservation Act. The goals of this project were to improve Little Fresh Pond's water quality and stabilize its shoreline. Work was also conducted to stabilize nearby reservoir banks.

To stabilize the shoreline, the banks of Little Fresh Pond were fitted with coir fascines (coconut fiber logs), re-graded, stabilized with erosion control fabric and planted with native riparian groundcovers, shrubs, and canopy trees. A vegetated forebay and wetland were constructed to improve water quality entering the pond. On Earth Day 2006, volunteers planted the constructed wetland and coir logs with over 2,000 native wetland plugs.

Two elevated golf course tee boxes directly adjacent to the pond were removed and relocated. The area was re-graded and seeded with native meadow vegetation. This adjustment provided a continuous vegetated buffer along the entire length of Little Fresh Pond's western shoreline. Native canopy trees such as American Sycamore and Atlantic White Cedar were planted along the shoreline of Little Fresh Pond, which provide additional shade, enhancing fish habitat and deterring purple loosestrife. New timber boardwalks enable pedestrians and golfers access while minimizing impacts to the restored wetland areas.

Additional information on these and additional completed projects can be accessed through the Cambridge Water Department website www.cambridgema.gov/CWD/.

ONGOING PROJECTS

Blacks Nook Restoration

The restoration of Black's Nook is geared toward improving access and native habitat to the eastern side of Black's Nook Pond. Funding for this project was provided in part by the Community Preservation Act. Project goals include improving the environment around this small pond by eliminating invasives and fostering native plant growth while preserving the sense of wildness that makes Black's Nook unique. The restoration project will enhance the use of the pond as a resource/study area for children, and allow for universal accessibility while minimizing user conflict.

The first phase of this project began in Fall, 2010, when invasive trees and vines around Black's Nook were removed. Future phases will include shoreline stabilization, wetland restoration, soil improvements, re-planting native vegetation, installing ADA-compliant trails, observational platforms along the shoreline, and passive use seating areas.

Glacken Slope Stabilization

The improvement of Glacken Slope, which extends from the back of the Fresh Pond golf course clubhouse to the perimeter pond road, is an ongoing project which aims to improve water quality by addressing severe erosion issues on the slope. The slope has become severely degraded over the years due to compaction and increased runoff from impervious surfaces. This leads to slope erosion resulting in reduced infiltration and lack of plant diversity. This area negatively impacts water quality, as runoff from the slope drains directly to Fresh Pond. A restoration plan was developed for this area, which will address severe erosion and compaction, aim to stabilize the slope, improve soil infiltration and drainage, control runoff, increase native species and diversity while controlling for non-native invasives, and enhance views from the top of the slope.

The first phase of the project was completed in Fall 2010, and included the removal of invasive species, removal of the a degraded concrete walkway, development of an infiltration trench and water quality swale, rain garden with level spreader, and pervious pavement. The next phase will include gully and slope stabilization and re-planting with native woodland species.

PUBLIC OUTREACH AND EDUCATION

VOLUNTEER-BASED PROGRAMS

The Watershed Division has created various volunteer-based programs to involve the public in managing the Fresh Pond Reservation. Programs include the Fresh Pond Reservation Volunteer Monitoring and Maintenance Program which is a partnership with the non-profit groups Friends of Fresh Pond and the New England Wildflower Society. This program focuses on invasive species identification and removal to restore and improve the reservation's ecological integrity. Activities include, but aren't limited to monthly plant identification sessions and organized weeding activities in the spring and summer months.

Volunteers have also assisted with the Cambridge Water Department's ongoing Purple Loosestrife bio-control program, helping to build "beetle nurseries" for the Galerucella beetle that feeds on invasive Purple Loosestrife, and participating in bi-annual monitoring of Purple Loosestrife at the reservation.

Larger groups interested in volunteering at the reservation can participate in the Pond Partners Program, working with a full-time Ranger on a regular basis to assist with trail maintenance, planting flower beds, and monitoring various parts of the reservation.

For more information, email Friends of Fresh Pond fpr@cambridgema.gov, or the Reservation Ranger jrogers@cambridgema.gov.

WEBSITE

The Fresh Pond Website (http://www.cambridgema.gov/CWD/freshpond.cfm) is an interactive tool which allows the public to learn about our ongoing restoration projects and monitoring activities. Updated on a regular basis, there are informative pages about each of the projects at Fresh Pond, including the Northeast Sector Restoration, Little Fresh Pond Shoreline Restoration, Fresh Pond Drainage and Habitat Improvement, as well as rules and regulations, information regarding volunteer programs and a calendar of events and activities at the water department and on the reservation.

TOURS

Throughout the spring, summer, and fall, the Cambridge Water Department leads monthly tours of the Walter J. Sullivan Water Purification Facility as a way of educating residents about their drinking water. Water Department staff provide tours of the building, and explain the processes involved as rain that falls in the western suburbs is transported to Cambridge, purified into drinking water, and piped to local homes and businesses.

The Watershed Division also leads monthly "Fresh Pond Walkabouts" during which groups are lead on an information tour of Fresh Pond Reservation's newly restored conservation and recreational areas. Monthly Upper Watershed tours allow the public to view the Cambridge owned watershed lands and private developments that benefit the water supply.

Water Week is a week-long open house in the beautiful lobby of the Water Treatment Plant. The public are invited in to view various displays and exhibits, and partake in tours and informational sessions. Water Week includes a "School Day" attended by hundreds of Cambridge schoolchildren who spend the day engaged in fun and education activities related to water quality, the water distribution system, and the natural environment around Fresh Pond. The culmination of Water Week is Fresh Pond Day, which is an opportunity for numerous City departments and non-profit groups to celebrate Fresh Pond, focusing on environmental awareness and sustainability.

OUTLINE FOR PROPOSED PROGRAMS

Despite existing resources and watershed protection progress, addressing complicated watershed issues and working to improve water quality and security will require the implementation of additional projects and programs, and securing additional resources.

The following structure represents a revised approach to categorizing programs and their projects under umbrella programs, some of which are existing, and some proposed. This organizational strategy will compartmentalize existing and proposed activities for better resource allocation and maximizing project effectiveness. The following section includes program needs and goals and a detailed spreadsheet with further information and projected implementation schedule.

Proposed Umbrella Program Organizational Structure

1. Water Quality Monitoring
2. Stormwater
3. Site Monitoring
4. Conduit Monitoring
5. Water Supply
6. Land Acquisition
7. Emergency Response
8. Invasive Species
9. Private/Public Partnership Program
10. Natural Resources Restoration
11. Security and Enforcement
12. Volunteer Program
13. MassDOT Partnership Program

WATER QUALITY MONITORING

Given the City's lack of ownership and control of watershed lands, water quality monitoring continues to be a necessary and effective means of identifying sources of pollution and tracking water quality changes over time. Monitoring organization, mobilization, and implementation falls on the Watershed Protection Supervisor. Additional and targeted stormwater and groundwater monitoring is a necessary component in measuring the success of upcoming municipal and MassDOT stormwater permit compliance, and to identify and track areas of groundwater contamination. Additional sampling and data analysis needs support from the Watershed Division.

The water quality monitoring program will continue as outlined in the existing programs section, but will be reassessed after a comprehensive review of water quality data. Data will be used to potentially revise sampling locations, sampling frequency, and parameters of concern. Needs for groundwater monitoring will be assessed based on known, historic issues and potential threats.

Proposed Projects

1. Water Quality Data Review
   a. Consolidate, digitize, organize, and analyze all historic water quality data
   b. Use results to reassess sampling locations, frequency, and parameters
2. Identify Groundwater Monitoring Needs
   a. Possible groundwater salt monitoring locations
      i. Lexington Salt Depot
         1. Assess plume migration from 1985 Study
         2. Estimate salt contributions to water supply
      ii. Urbanized Areas
      iii. Highway Corridors
   b. Revisit 1997 Fresh Pond Groundwater Study
      i. Locate, map, rehabilitate, reactivate groundwater monitoring wells
      ii. Conduct 1 year of seasonal groundwater altitude, chemistry sampling
      iii. Compare to 1997 Results
3. Monitor Additional Parameters
   a. Work with the CWD Lab to identify and quantify cyanobacteria in watershed waterbodies
   b. Continue to sample for pollutants of emerging concern (PPCPs, EDCs)
   c. Pilot a macroinvertebrate assessment project for select in-stream locations
4. Perform targeted stormwater monitoring to support proposed Stormwater Program

STORMWATER

The USEPA has identified stormwater pollution as the largest threat to long term water quality. In-house and USGS stormwater sampling results in watershed waterbodies show that stormwater runoff contributes significant pollutant loads and high pollutant concentrations.

Through total maximum daily load analyses, the regulatory community has identified the Charles River Watershed as a stormwater-impacted basin. Recent efforts by the federal and state governments to address stormwater pollution in NPDES MS4 permits and under the Massachusetts Wetlands Protection Act outline the regulatory communities' strategy to mitigate stormwater impacts. Using a yet-unpublished USGS stormwater study and in-house water quality data, the City will identify and quantify pollutants of concern and develop a comprehensive stormwater mitigation and management strategy/program, beginning with a pilot project in a representative subwatershed to assess BMP effectiveness and costs, prior to extending to the remaining subwatershed on a priority basis. Program effectiveness will be determined through ongoing and additional monitoring.

Proposed Projects

1. Develop a subbasin-scale comprehensive stormwater management strategy
2. Develop and consolidate geospatial stormwater infrastructure and BMP data
3. Develop a preferred BMP list for the Cambridge watershed
4. Identify and target BMPs and Zone A outfalls for stormwater quality monitoring
5. Identify potential Grant and Loan Programs that identify opportunities for watershed protection planning and implementation
6. Develop draft municipal bylaw sections that identify achievable performance standards for Zone A source water protection areas
7. Develop a recommended plant list for stormwater applications

SITE MONITORING

For many watershed construction and/or redevelopment sites, management conditions are issued by local Conservation Commissions and other regulatory bodies governing long-term operation and maintenance. These activities include, but are not necessarily limited to regular inspection, maintenance and reporting regarding stormwater management systems, limits on deicing chemicals, fertilizers, or other turf management chemicals, and street sweeping. Proper and continued site maintenance is critical to water supply resource protection. To ensure all sites continue to abide by their conditions in perpetuity, there is a real, outstanding need for CWD to create a stormwater assets inventory and compliance tracking tool.

The site monitoring program has been successful in reducing construction and post-construction-related water supply impacts. CWD will continue with this monitoring program as the watershed is developed. CWD will work with local Conservation Commissions and Municipalities to develop a watershed spatial database that locates and characterizes stormwater management systems and their BMPs, identifies sites with conditions, and tracks operation and maintenance activities benefiting downstream water quality.

Proposed Projects

1. Develop a private property stormwater assets spatial database
2. Organize, manage, and monitor property-specific management conditions (i.e. Wetlands Protection Act Orders of Conditions) geared towards reducing watershed impacts
3. Work with the Fresh Pond Golf Course to fine-tune existing integrated management to improve water quality

STONY BROOK CONDUIT MONITORING

The Stony Brook Conduit is an essential piece of infrastructure without which, the City would be reliant upon other drinking water sources. Without the ability to continuously bring water down from the Stony Brook Reservoir, under normal Fresh Pond operating levels, the City has an estimated three week supply. Recent work in the conduit right of way has reinforced the need to assess the Stony Brook Conduit's condition and identify areas for above-ground maintenance (tree removal, etc.), and underground pipe repairs and rehabilitation. Conduit assessment and maintenance are ongoing, but there is additional need for a groundwater threat assessment and monitoring program.

Proposed Projects

1. Work with other Department Divisions to assess the entire conduit's condition with CCTV cameras
2. Identify areas of potential and real groundwater inflow and assess water quality and surrounding threats
3. Develop a GIS-based groundwater threat assessment
4. Identify potential pollutants and create a baseline water quality sampling program

WATER SUPPLY

Possible new water supply regulations under the Water Management Act will require a better understanding of how gate operations affect downstream water quality and quantity. Small changes in sluice gate levels have variable influences on downstream flows, depending on reservoir levels. Since the release of this document, contracts have been awarded for Winter Street and Trapelo Road gatehouse improvements (Hobbs Brook Reservoir), which will rehabilitate old gates and allow CWD more control over downstream flows.

Proposed Projects

1. Conduct needed repairs to the Winter Street and Trapelo Road gatehouses
2. Update Hobbs Brook and Stony Brook Gatehouse and develop a Trapelo Road Gatehouse operation and maintenance plans
3. Investigate opportunities for water quality improvements and aquatic invasive species management through Trapelo Road gatehouse operations
4. Identify and prioritize areas for redundant in-house continuous data collection to provide "real-time" reservoir levels and waters supply flows in case of internet failures

LAND ACQUISITION

Ownership and control over watershed lands will continue to be the best way to ensure water supply security. Using a GIS, priority parcels have been identified, and maps have been created. CWD will continue to work with watershed communities to look for land acquisition opportunities and funding as they become available.

EMERGENCY RESPONSE

Emergency Response preparedness is critical to water supply security. Ongoing tasks will continue to include the following

Proposed Projects

1. Update the Hazmat Emergency Response Plan, Emergency Action Plan for Dams, and Atlas
2. Conduct Phase 1 Dam Safety Inspections as required by law
3. Conduct routine dam inspections (10/year)
4. Maintain and inventory spill response materials
5. Maintain working relationships with primary responders, conduct outreach to watershed communities, state and local police departments
6. Conduct training sessions with Waltham FD and other primary responders in accident response, rescue

INVASIVE SPECIES

Currently, terrestrial and aquatic invasive species are dealt with on a piecemeal, as-needed basis. CWD proposes to develop a Comprehensive Invasive Species Management Program for Cambridge-owned properties. The City will pull together information on common invasive species found in the watershed and Fresh Pond reservation, map species locations when feasible, and document efforts in their management. Information will be kept in a spatial database to help organize and map efforts and assess their effectiveness.

Proposed Projects

1. Collect baseline and information on past efforts
2. Create a master list of observed invasive species and map their locations
3. Develop species-specific action plans
4. Identify and coordinate management efforts

PRIVATE/PUBLIC OUTREACH PROGRAM

The City has identified three major target watershed communities upon which to focus outreach and education efforts and partnering opportunities. 1) Citizens, including both Cambridge and watershed residents, 2) private office/industrial parks and their facilities managers, and 3) municipalities. Each outreach program will be catered to the target community and associated impacts.

Proposed Projects

1. Work with municipalities and office parks on developing environmentally sound and cost-efficient snow and ice management programs and training
2. Develop a "Water-Friendly" certification program for watershed businesses, residents, farms and municipalities and generate community buy-in.
3. Work with municipalities to develop and distribute stormwater education materials to watershed residents
4. Work with municipalities to prioritize and target the Cambridge drinking watershed for stormwater improvement projects

NATURAL RESOURCES RESTORATION PROGRAM

As discussed earlier, the City has spent considerable time and resources in improving water and habitat quality in the Fresh Pond watershed through on-the-ground restoration projects, with guidance from the Fresh Pond Master Plan and various steering committees. Using the restoration approach applied in the Fresh Pond Reservation, the City will identify and scope potential water resources restoration projects Cambridge-owned watershed lands. The City has recently completed a Community Preservation Act-funded survey of three City-owned watershed parcels identifying and mapping natural and cultural resources. Using results and recommendations identified in the final report, the City will identify areas for restoration and public access improvements.

Proposed Projects

1. Release "Hobbs Brook Headwaters Natural and Cultural Resources Inventory" to the public
    a. Maps and data made available through CWD website
    b. Present findings to stakeholders
    c. Identify partnering opportunities
2. Identify degraded streams, wetlands in Cambridge-owned parcels and rank on restoration potential

Security and Enforcement

The Reservoir Caretakers and watershed staff will continue to conduct regular patrols and identify any illicit activities in the watershed. Gatehouse improvements will include security enhancements such as the addition of closed circuit cameras viewable on the existing water treatment plant SCADA operating system or the Department's security video system. Areas in need of fencing, signage, or repairs to either will be assessed and routinely monitored. After 9/11/2001, the Federal government required all large water suppliers to conduct a "vulnerability assessment". The City of Cambridge has completed this assessment and is currently implementing the report's recommendations.

Proposed Projects

1. Continue regular patrolling of watershed lands.
    a. Identify and track routes using GPS
    b. Notify proper authorities for severe violations
2. Maintain and improve existing fencing/signage and identify areas in need
3. Continue to build relationships and communicate needs with state and local police departments
4. Continue to implement overall security upgrades

Volunteer Program

Working together with the Friends of Fresh Pond, CWD has conducted many successful invasive species removal "weeding" sessions and public outreach and education projects to promote local buy-in and stewardship of the Fresh Pond Reservation. Using this model, CWD will follow recommendations from the recently completed "Hobbs Brook Headwaters Natural and Cultural Resources Inventory" to identify and coordinate volunteer efforts to improve Cambridge-owned watershed lands. CWD will look to partner with neighboring stakeholders to maximize efforts.

Proposed Projects

1. Continue and improve volunteer programs around Fresh Pond Reservation
    a. Improve volunteer event turnout
    b. Attract involvement from younger generations
2. Review and implement recommendations from Hobbs Brook Headwaters report
    a. Identify and organize volunteer projects
        i. Certifying potential vernal pools
        ii. Invasive species management
        iii. Asian Longhorned beetle surveys
        iv. Streambank surveys/assessments
        v. Possibly aid in macroinvertebrate assessments
        vi. Clean-up activities

MassDOT Partnership Program

In 1999, under direction from the state Executive Office of Energy and Environmental Affairs (EEA), MassDOT developed a comprehensive management program to reduce highway impacts to the water supply. This project was filed and under the Massachusetts Environmental Policy Act (MEPA) as the "Hobbs Brook and Stony Brook Watersheds Highway Drainage Improvement Project", EEA file number 8263. The report identified threats to the water supply and developed a time-lined action plan to mitigate their impacts. Threats addressed included spill containment, stormwater runoff, and deicing practices. Using this report as a guide, CWD has partnered with MassDOT District 4 and their Environmental Department to ensure continued implementation of the action plan and incorporation of the most current research and technology.

<u>Proposed Projects</u>

1. Continue to work with MassDOT on expeditiously implementing MEPA Section 61 Findings
2. Identify priority outfalls for stormwater quality improvements overlooked by previous projects triggering Massachusetts Stormwater Standards
3. Continue to advocate for DOT's adopting the latest technologies that regulate and quantify deicing chemical and traction sand applications in the watershed
    a. There is no way to track efforts to reduce salt without first understanding how much is actually applied
    b. Develop regular reporting schedule
4. Develop updated stormwater inspection and performance criteria and define a structured reporting schedule to CWD
    a. Catch basins
    b. Outfalls
    c. Stormwater Basins
5. Ensure upcoming Route 128 roadway improvements in Waltham do not impact the water supply during construction
6. Implement proposed improvements at the Route 2A Rest Area
7. Conduct meetings with District 4 to review management plans
8. Update MassDOT Hazmat Atlases, incorporating Routes 20 and 117 drainage, recent drainage modifications, and BMPs

REFERENCES

Geotechnical Engineers Inc., November 1985, Hobbs Brook Reservoir Sodium Chloride Study.

Metropolitan Area Planning Council, December 1989, Cambridge Reservoir Watershed Protection Plan.

Camp, Dresser & McKee, May 1994, City of Cambridge Fresh Pond Watershed Protection Plan.

Fugro East, Inc., August 1996, Limnological Investigations of the Cambridge Reservoir System: Impacts of Watershed Inputs and Alum Sludge Discharge.

Camp, Dresser & McKee, May 1997, Fresh Pond Reservoir Final Report Groundwater Quality Impacts to Fresh Pond Reservoir.

Waldron, Marcus C. and Bent, Gardner C., 2001 Factors Affecting Reservoir and Stream-Water Quality in the Cambridge, Massachusetts, Drinking-Water Source Area and Implications for Sourve-Water Protection: USGS Water-Resource Investigation Report 00-4262.

Waldron, Marcus C., Cooke, Matthew G. and Ragnelli, Christopher M., August, 2002, Storms, Streams, and Reservoirs – Assessing Water Quality in the Cambridge, Massachusetts, Drinking-Water Source Area: USGS Fact Sheet FS-056-02, pp. 6.

Massachusetts Department of Environmental Protection, May 2009, Massachusetts Year 2008 Integrated List of Waters.

Smith, Kirk P., 2005, Hydrologic, Water-Quality, Bed-Sediment, Soil-Chemistry, and Statistical Summaries of Data for the Cambridge, Massachusetts, Drinking-Water Source Area, Water Year 2004: USGS Open-File Report 2005-1383, pp. 110.

Smith, K.P., and Granato, G.E., 2010, Quality of stormwater runoff discharged from Massachusetts highways, 2005–07: U.S. Geological Survey Scientific Investigations Report 2009–5269, 198 p., with CD-R (Also available at http://pubs.usgs.gov/sir/2009/5269/.)

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APPENDIX A: MASTER LIST OF RECOMMENDED ACTIONS

Master List of Recommended Actions

UID	Project	Program	Type of Work	Scope of Work	Existing/Proposed	Priority	Feasibility	Conducted	MassDEP Surface Water Protection Zone	Time frame (yrs to completion)
1	Develop a comprehensive stormwater assessment and monitoring program	Stormwater	Program Development	Assess USGS Watershed Stormwater Study (to be published), identify priority outfalls for monitoring, develop spatial databases, develop strategies for reducing priority pollutant loads	Proposed Program	Top	Medium	In-House	Prioritized by Zone	0 - 3
2	Work with Municipalities and Businesses on reducing salt applications	Private/Public Outreach	Education and Outreach	Conduct meetings with constituents to develop BMPs, strategies to reduce sodium and chloride loading	Proposed Program, Existing Project	Top	Medium	In-House	Entire Watershed	Ongoing
3	Optimize gatehouse operations for water, environmental quality	Water Supply	Capital Improvement	Repair Trapelo Road, Winter Street gatehouses, assess depth profile water quality at Trapelo Road and Stony Brook reservoirs, manage gate operations to optimize water quality	Proposed Project	Top	Medium	Outsourced	Reservoirs	0 - 3
4	Existing tasks	Water Quality Monitoring	Miscellaneous	Sample collection, equipment maintenance, database management, data analysis, GIS mapping, reporting, general management, QA/QC, oversee Joint Funding Agreement with USGS	Existing Program, Project	Top	High	In-House	Entire Watershed	Ongoing
5	Existing tasks	Site Monitoring	Miscellaneous	Monitor development in the watershed, work with landowners to reduce water quality impacts during development and redevelopment projects, Review site plans, draft comment letters, assess permitting compliance	Existing Program, Project	Top	High	In-House	Prioritized by Zone	Ongoing
6	Existing tasks	Emergency Response	Miscellaneous	Review and update Haz-Mat Emergency Response Plan, Emergency Action Plan, and Haz-Mat Atlas, conduct routine dam inspections, maintain and inventory spill response materials, train primary responders in accident response, rescue	Existing Program	Top	High	Both	Entire Watershed	Ongoing
7	Existing tasks	Land Acquisition	Miscellaneous	Identify parcels for purchase and/or conservation restrictions to increase open space and water quality in the watershed	Proposed Program, Existing Project	Top	Low	In-House	Prioritized by Zone	Ongoing
8	Develop a Fresh Pond Reservation Shared-Use Plan	Capital Improvement	Assessment/ Reporting	Assess current scale of reservation use, identify and resolve user conflicts, propose strategies to protect water quality	Existing Program, Proposed Project	Top	High	Outsourced	Fresh Pond	0 - 3
9	Develop and maintain a comprehensive stormwater infrastructure spatial database (MassDOT, Municipalities, Property Owners)	Stormwater	Data Development/GIS	Synthesize a comprehensive spatial database from multiple sources, redefining subwatershed boundaries on both engineered drainage and topography	Proposed Program, Project	High	High	Both	Prioritized by Zone	0 - 2
10	Develop and Implement a Stony Brook Conduit Assessment, Maintenance, and Monitoring Program	Conduit Monitoring	Program Development	Conduct video monitoring to assess structural integrity, identify leaks. Conduct pollutant threat assessment in conduit right of way, identify pilot sights for water quality monitoring. Maintain and mark conduit right of way	Proposed Program	High	High	Both	A	0 - 2

Master List of Recommended Actions

UID	Project	Program	Type of Work	Scope of Work	Existing/Proposed	Priority	Feasibility	Conducted	MassDEP Surface Water Protection Zone	Time frame (yrs to completion)
11	Reassess Fresh Pond groundwater monitoring program	Water Quality Monitoring	Groundwater Monitoring	Identify and map existing and possible groundwater monitoring sites. Conduct a sampling event and compare with 1997 results	Existing Program, Proposed Project	High	High	Outsourced	Prioritized by Zone	0 - 2
12	Update municipal contact and website information	Private/Public Outreach	Education and Outreach	Update contacts with local DPWs, Conservation Commissions, Fire Departments, etc. to improve work flow outside Cambridge city limits	Proposed Program, Existing Project	High	High	In-House	Entire Watershed	Ongoing
13	Work with Municipalities on pollution reduction to MS4s	Private/Public Outreach	Education and Outreach	Following new NPDES permits, Use GIS to identify high risk, priority engineered "stormsheds" and develop strategies for retrofits and loading reductions	Proposed Program, Existing Project	High	Medium	In-House	Prioritized by Zone	0 - 2
14	Assess existing stormwater BMP effectiveness	Stormwater	Assessment/ Reporting	Use developed GIS BMP database and assess theoretical effectiveness through lit. reviews and sources like the BMP database www.bmpdatabase.org. Develop a BMP sampling program and assess/monitor actual effectiveness	Proposed Program/Project	High	High	Outsourced	Entire Watershed	0 - 3
15	Assess baseline conditions for reservoir cyanobacteria	Water Quality Monitoring	Surface Water Monitoring	Sample three reservoirs for cyanobacteria, cell counts and toxins. Identify the need to establish routine sampling program	Existing Program, Proposed Project	High	High	Outsourced	Reservoirs	0 - 2
16	Working with the Fresh Pond golf course towards a sustainable, environmentally-sensitive integrated management plan	Site Monitoring	Education and Outreach	Work with the Fresh Pond Golf Course on finding affordable, feasible, environmentally sensitive alternatives with respect to fertilization and pest/weed management	Proposed Program, Project	High	Low	Both	Fresh Pond	0 - 5
17	Analyze historic water quality data	Water Quality Monitoring	Assessment/ Reporting	Consolidate data, track trends, reassess pollutants of concern, identify hot-spots, review and revise sample locations, frequency of sampling	Proposed	High	High	In-House	Entire Watershed	0 - 2
18	Develop and implement a MassDOT Master Plan, long-term pollution reduction strategy	MassDOT	Miscellaneous	Work with MassDOT to Implement and Maintain MEPA Commitments to minimizing watershed impacts including salt, stormwater, haz-mat emergency response	Proposed Program, Existing Project	High	Medium	Both	Prioritized by Zone	Ongoing
19	Revise, update surface water supply protection areas for MassDEP, MassGIS	Site Monitoring	Assessment/ Reporting	Provide DEP evidence to expand or otherwise update protection zones	Existing Program, Proposed Project	High	High	In-House	A	0 - 1
20	Develop an illicit activity security gap analysis	Security and Enforcement	Assessment/ Reporting	Identify areas for fencing, guardrails, security cameras, and other trespassing deterrents	Existing Program, Proposed Project	High	High	Both	Prioritized by Zone	0 - 2
21	Develop a watershed BMP spatial database component for the site monitoring program	Site Monitoring	Data Development/GIS	Create a BMP spatial database for the Site Monitoring program. Analyze for and target BMP gaps, identify performance monitoring sites, track maintenance activities	Existing Program, Proposed Project	Medium	High	In-House	Prioritized by Zone	0 - 1

Master List of Recommended Actions

UID	Project	Program	Type of Work	Scope of Work	Existing/Proposed	Priority	Feasibility	Conducted	MassDEP Surface Water Protection Zone	Time frame (yrs to completion)
22	Develop CWD Preferred BMP List	Stormwater	Education and Outreach	Assess BMP's pollutant removal efficiencies through literature reviews, communicate findings with watershed property owners	Proposed Program, Project	Medium	High	In-House	Entire Watershed	0 - 1
23	Assess watershed groundwater salt concentrations	Water Quality Monitoring	Groundwater Monitoring	Target former exposed NaCl depots, traffic corridors, parking lots, and areas surrounding reservoirs for groundwater monitoring	Existing Program, Proposed Project	Medium	Medium	Outsourced	Prioritized by Zone	Ongoing
24	Create Inventory of all Groundwater Monitoring Wells	Water Quality Monitoring	Data Development/GIS	Create a monitoring well spatial database	Existing Program, Proposed Project	Medium	Medium	In-House	Prioritized by Zone	0 - 1
25	Develop and distribute land-use specific educational outreach materials for landowners on reducing stormwater pollution	Private/Public Outreach	Education and Outreach	Work with Municipalities to develop or use existing educational materials on stormwater pollution, target mailings of education materials, public meetings, web-based fact sheets, workshops.	Proposed Program/Project	Medium	Medium	In-House	Prioritized by Zone	0 - 2
26	Survey existing and post effective signage for drinking water reservoirs	Security and Enforcement	Education and Outreach	Develop spatial database, identify gaps, and post signs at strategic points	Proposed Program, Existing Project	Medium	High	In-House	Entire Watershed	0 - 5
27	Water supply sufficiency	Water Supply	Assessment/ Reporting	Revise water supply strategy, develop operations protocols to minimize water supply waste	Proposed Program/Project	Medium	Medium	Outsourced	Entire Watershed	0 - 5
28	Develop a comprehensive invasive species management program for terrestrial and aquatic plants in Cambridge-owned lands, waters	Invasive Species	Assessment/ Reporting	Tasks to include consolidating and documenting previous efforts, conducting surveys, GIS-mapping, developing new and organizing existing spatial data, developing species-specific action plans	Proposed Program	Medium	High	Both	Prioritized by Zone	0 - 5
29	Create a watershed signage spatial database	Security and Enforcement	Data Development/GIS	GPS existing watershed signage. Identify gaps	Existing Program, Proposed Project	Medium	High	Outsourced	Entire Watershed	0 - 2
30	Develop a watershed natural resources restoration program	Natural Resources Restoration	Program Development	Model after Fresh Pond Restoration Program. Identify stream, wetland, upland resource areas for restoration and concurrent water quality and habitat improvement opportunities. Identify partnering and funding opportunities	Proposed Program, Project	Medium	Medium	Both	Prioritized by Zone	0 - 5
31	Develop a sewage assessment and monitoring program	Water Quality Monitoring	Assessment/ Reporting	Work with town DPHs to develop a comprehensive septic spatial database, identify "sewer sheds" with high probability of cross connections of sewer to storm drains to target outfall sampling, review bacteria data to identify suspect areas	Existing Program, Proposed Project	Low	Low	Both	Prioritized by Zone	0 - 5
32	Pilot a volunteer-based macroinvertebrate assessment	Volunteer	Education and Outreach	Identify a monitoring site, train volunteers, collect and assess macroinvertebrate information and implications on stream health	Proposed Program, Project	Low	Medium	Outsourced	Tributaries	0 - 5

APPENDIX B: WATERSHED PROTECTION MAPS

WATERSHED

DEP Protection Zones

Land Use

Water Quality Monitoring

Zoning

Cambridge Parcels, Infrastructure

Protected Open Space

Risks

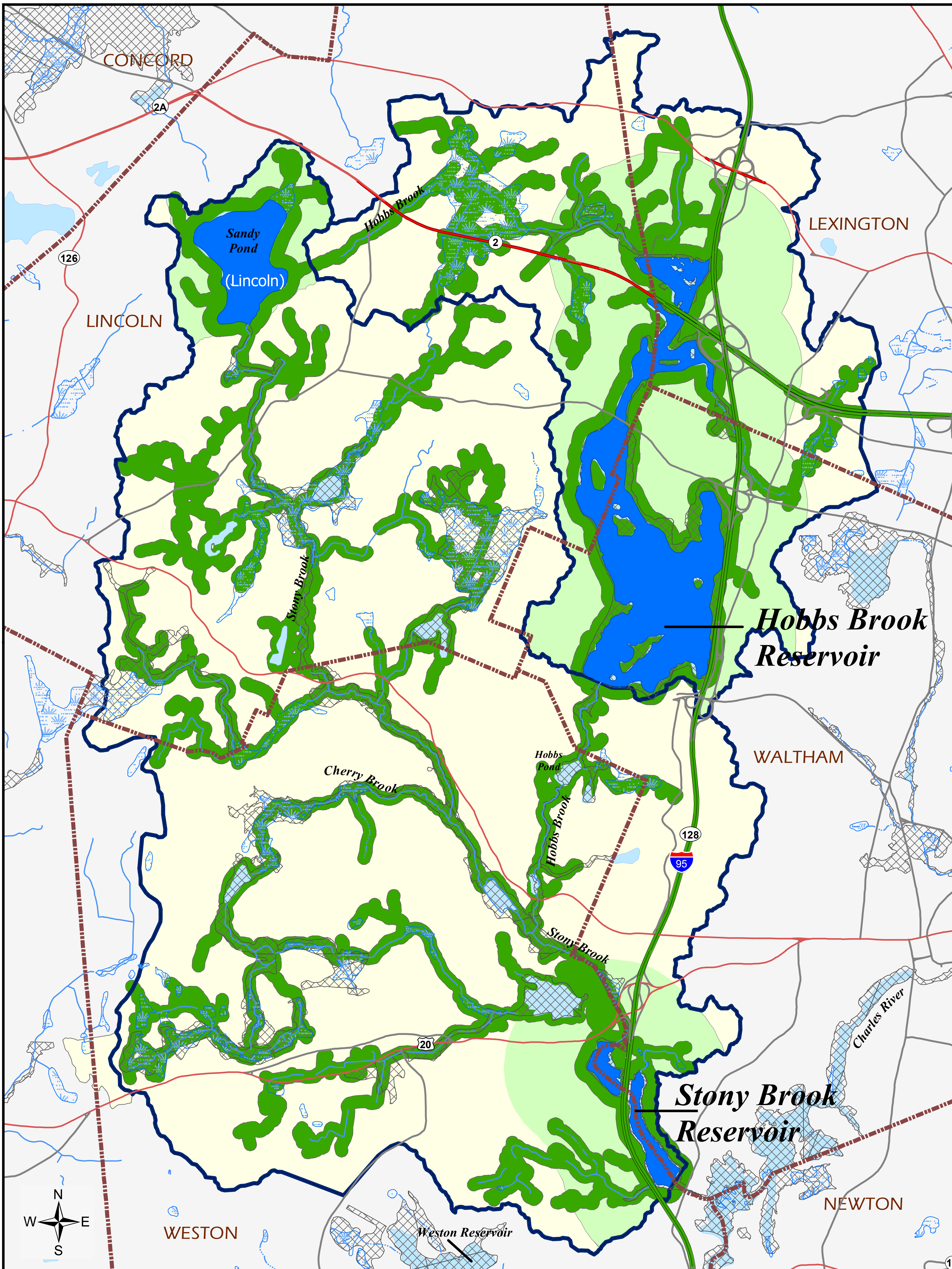
FRESH POND

DEP Protection Zones

Land Use

Zoning

Risks and Monitoring



Legend

ZONE A	Town Boundary	Limited Access Highway
ZONE B	Reservoir	Multi-lane Hwy, not limited access
ZONE C	Wetland	Other Numbered Highway
FEMA 100-Year Flood Zone	Submerged Wetland	Major Road, Collector
	Lakes and Ponds	
	Rivers and Streams	

0 0.25 0.5 0.75 1 2 Miles

0 0.25 0.5 0.75 1 Kilometers

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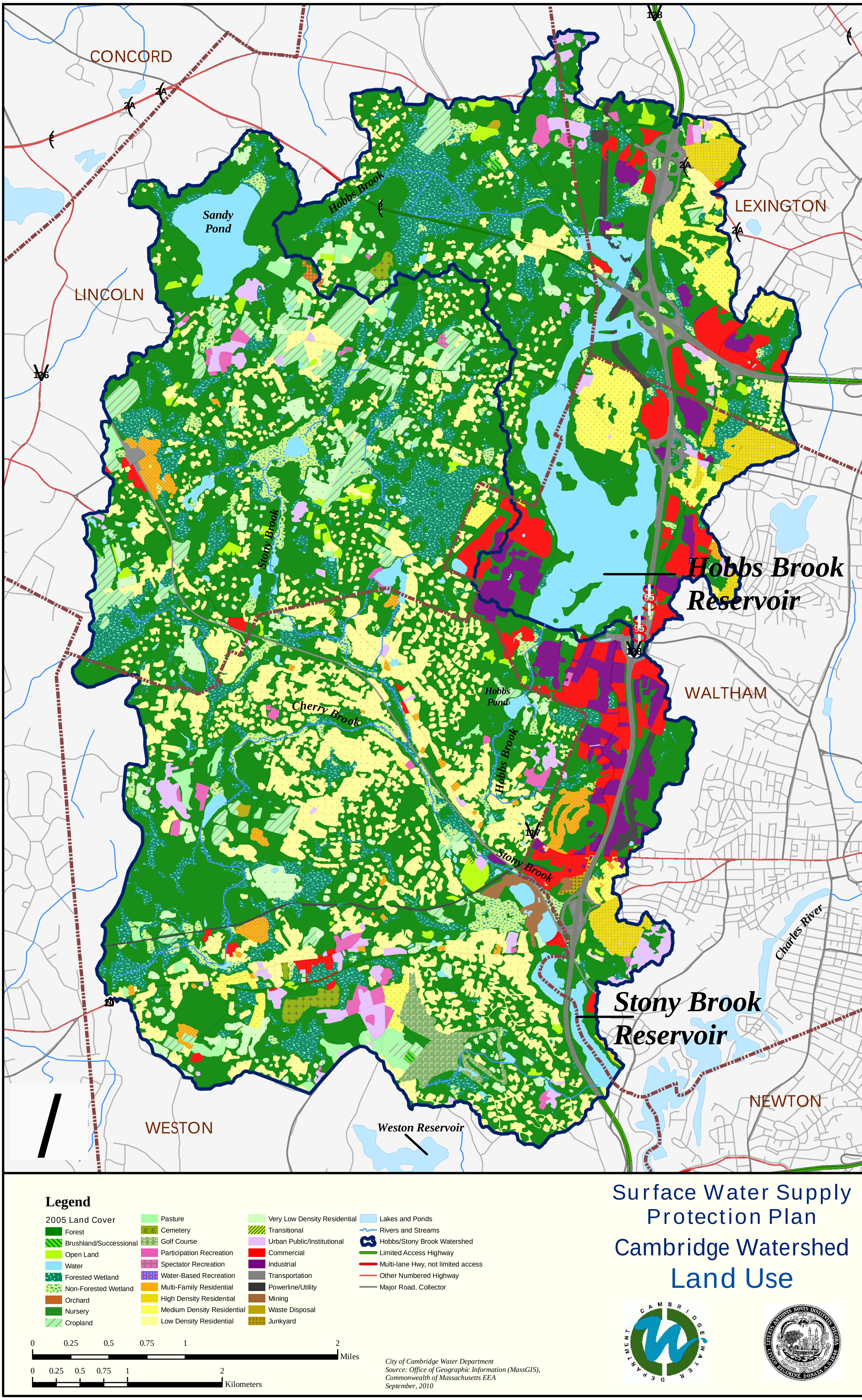
City of Cambridge Water Department
Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts EEA
March, 2011

Surface Water Supply Protection Plan

Cambridge Watershed

DEP Protection Zones

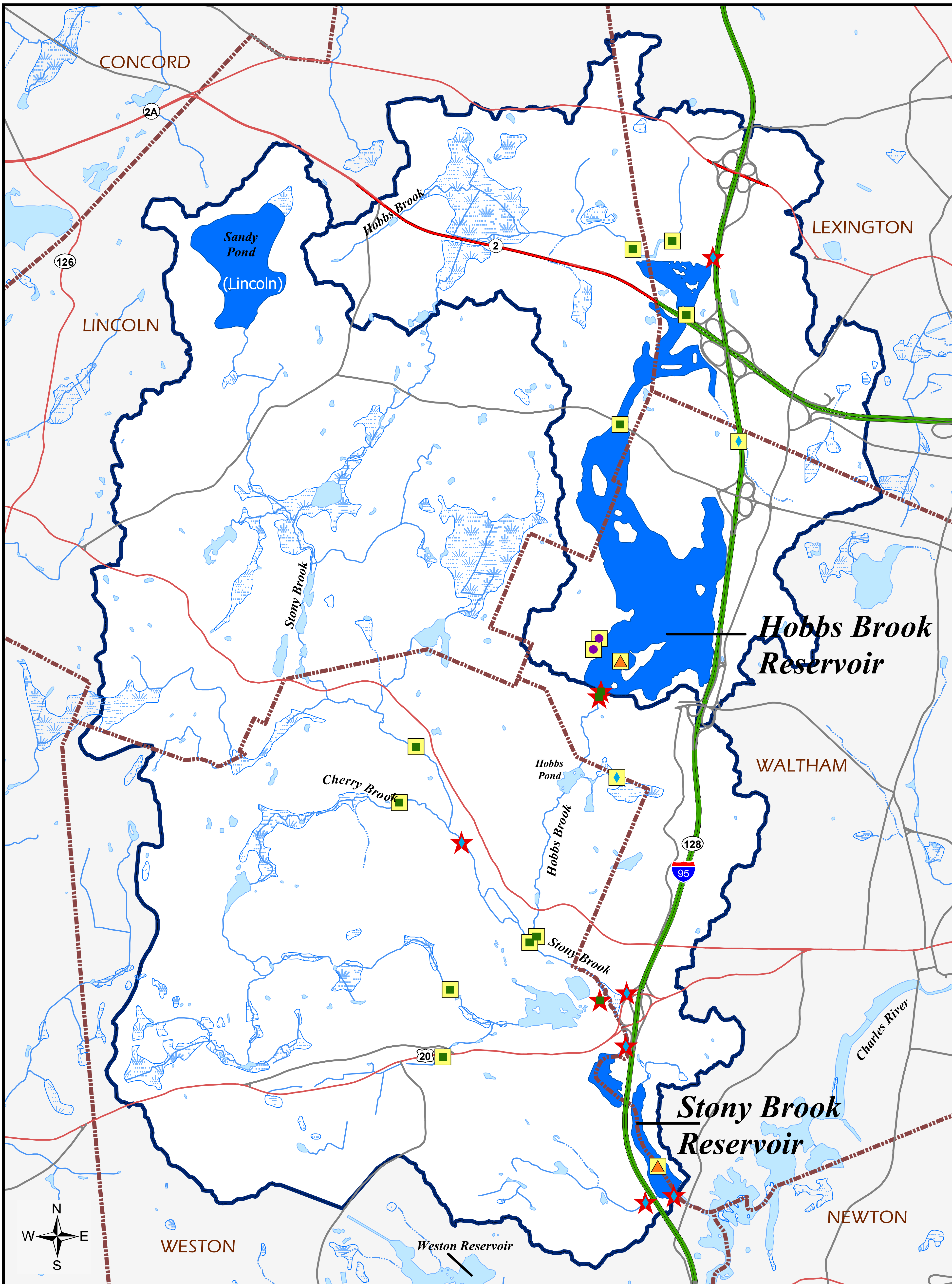


City of Cambridge Water Department
Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts EEA
September, 2010

Surface Water Supply Protection Plan

Cambridge Watershed

Land Use



Surface Water Supply Protection Plan

Cambridge Watershed

Water Quality Monitoring

Legend

Sampling Sites

- Baseflow
- Storm
- Storm & Baseflow
- Buoy

Online

Manual

- Town Boundary
- Limited Access Highway
- Multi-lane Hwy, not limited access
- Other Numbered Highway
- Major Road, Collector
- Hobbs/Stony Brook Watershed
- Perennial Stream
- Intermittent Stream
- Pond, Lake
- Reservoir
- Wetland
- Submerged Wetland

0 0.25 0.5 0.75 1 2 Miles

0 0.25 0.5 0.75 1 2 Kilometers

City of Cambridge Water Department
Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts EEA
March, 2011

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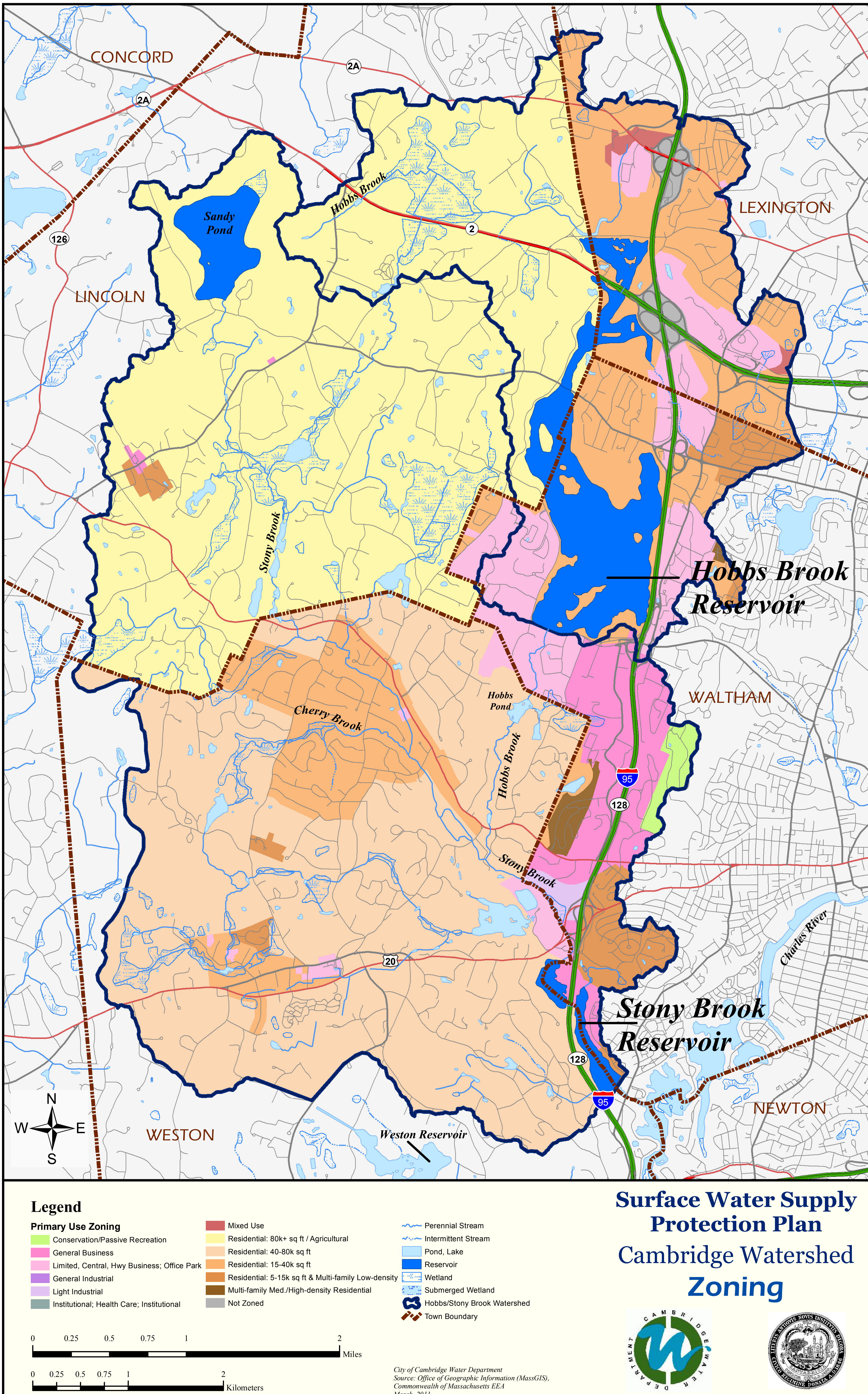
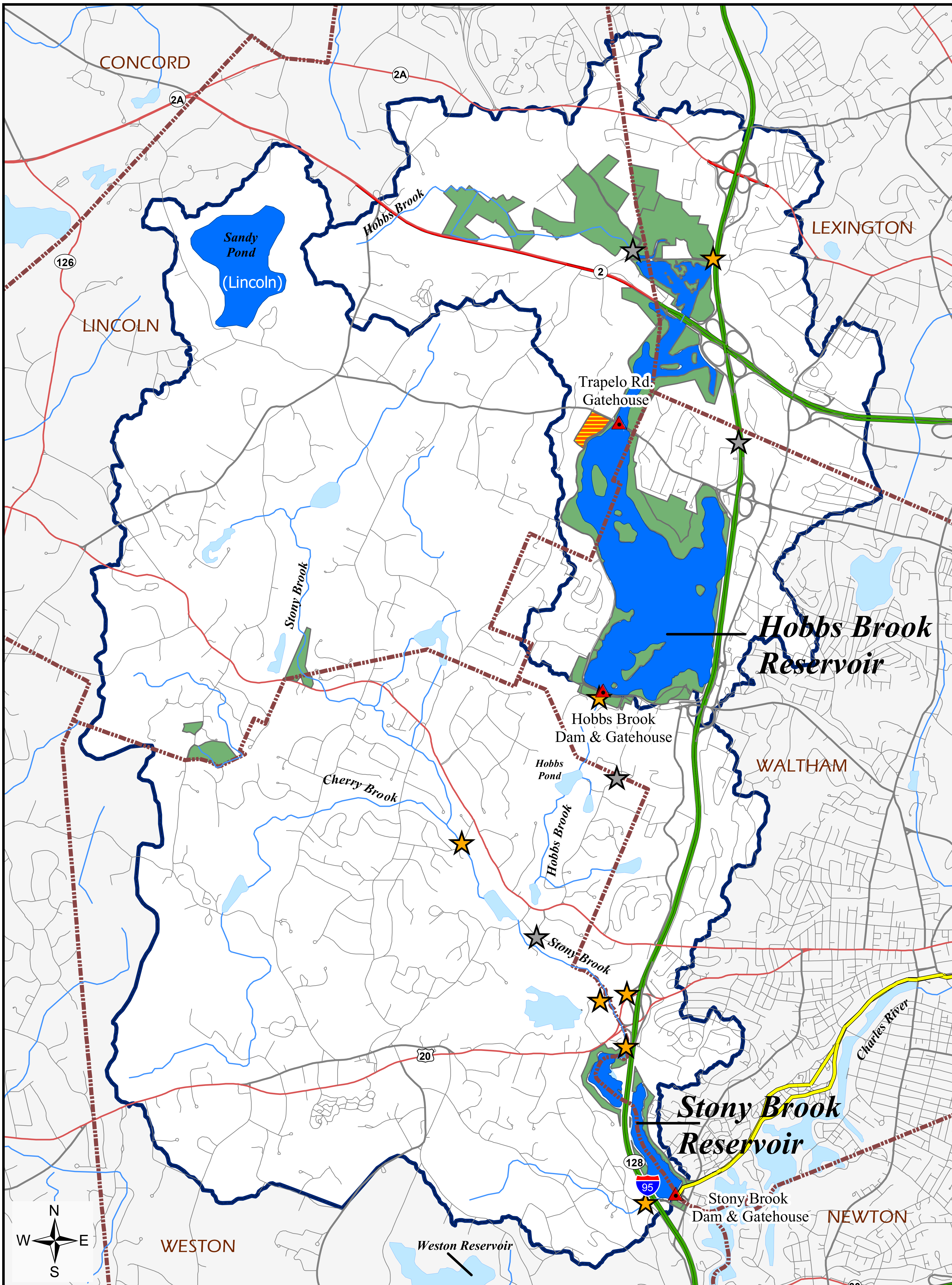

CONCORD
LEXINGTON
LINCOLN
WALTHAM
WESTON
NEWTON
2A
2
126
20
95
128
Sandy Pond
Hobbs Brook
Stony Brook
Cherry Brook
Hobbs Pond
Hobbs Brook Reservoir
Stony Brook Reservoir
Weston Reservoir
Charles River
N
E
S
W
Legend
Primary Use Zoning
Conservation/Passive Recreation
General Business
Limited, Central, Hwy Business; Office Park
General Industrial
Light Industrial
Institutional; Health Care; Institutional
Mixed Use
Residential: 80k+ sq ft / Agricultural
Residential: 40-80k sq ft
Residential: 15-40k sq ft
Residential: 5-15k sq ft & Multi-family Low-density
Multi-family Med./High-density Residential
Not Zoned
Perennial Stream
Intermittent Stream
Pond, Lake
Reservoir
Wetland
Submerged Wetland
Hobbs/Stony Brook Watershed
Town Boundary
0 0.25 0.5 0.75 1 2 Miles
0 0.25 0.5 0.75 1 2 Kilometers
City of Cambridge Water Department
Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts EEA
March, 2011
Surface Water Supply Protection Plan
Cambridge Watershed
Zoning



Legend

- Gatehouses, Dams
- Stony Brook Conduit
- Cambridge Owned Parcels
- Watershed Field Office
- Reservoirs
- Hobbs/Stony Brook Watershed
- Lakes and Ponds
- Rivers and Streams

CWD/USGS Gaging Stations

- Active
- Discontinued

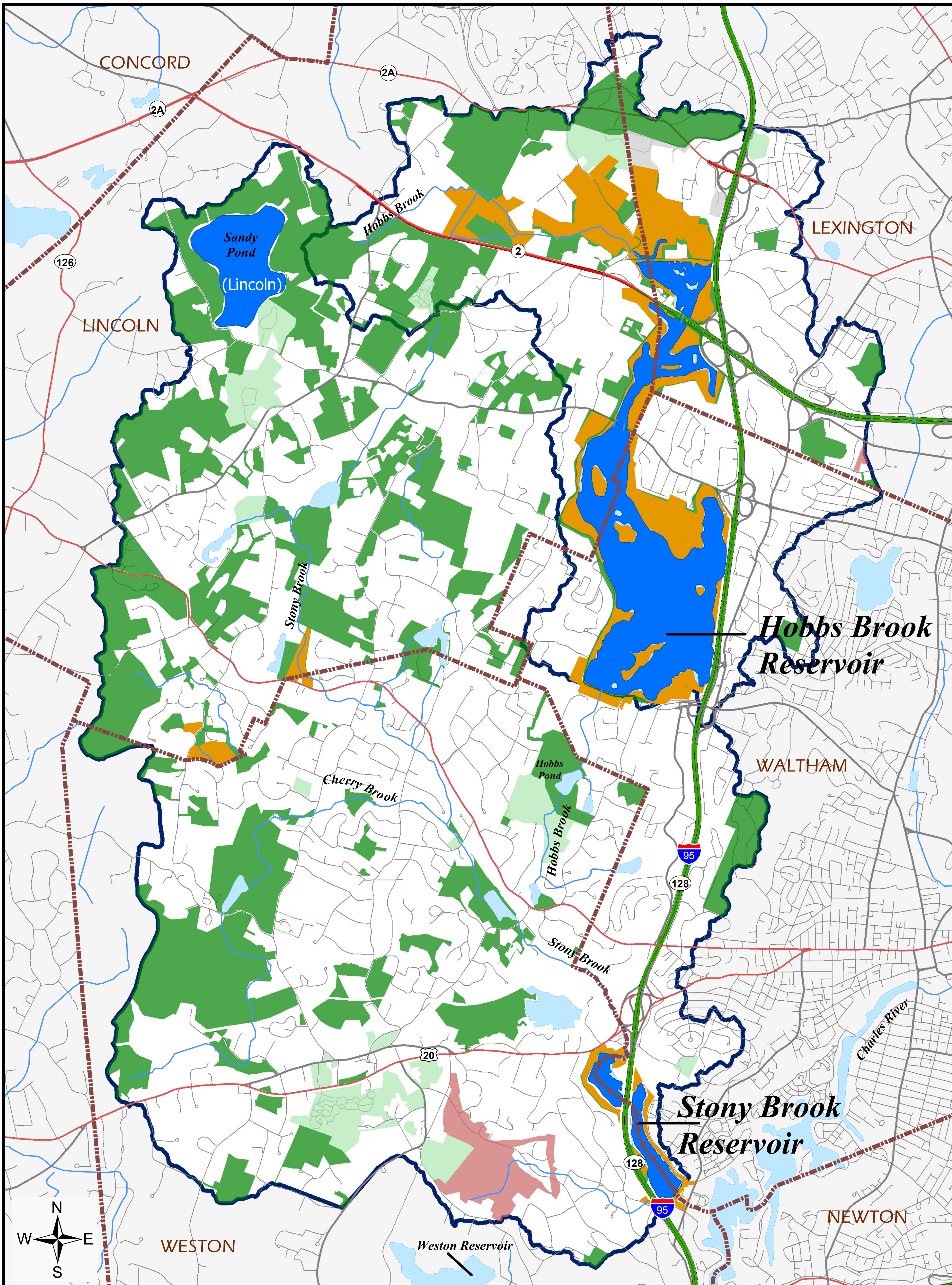
0 0.25 0.5 0.75 1 2 Miles

0 0.25 0.5 0.75 1 2 Kilometers

City of Cambridge Water Department
Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts EEA
February, 2011

Surface Water Supply Protection Plan

Cambridge Parcels, Infrastructure



Legend

OpenSpace by Level of Protection

- In Perpetuity
- Limited
- None
- Unknown
- Cambridge Owned Parcels

- Hobbs/Stony Brook Watershed
- Reservoirs
- Lakes and Ponds
- Rivers and Streams
- Town Boundary

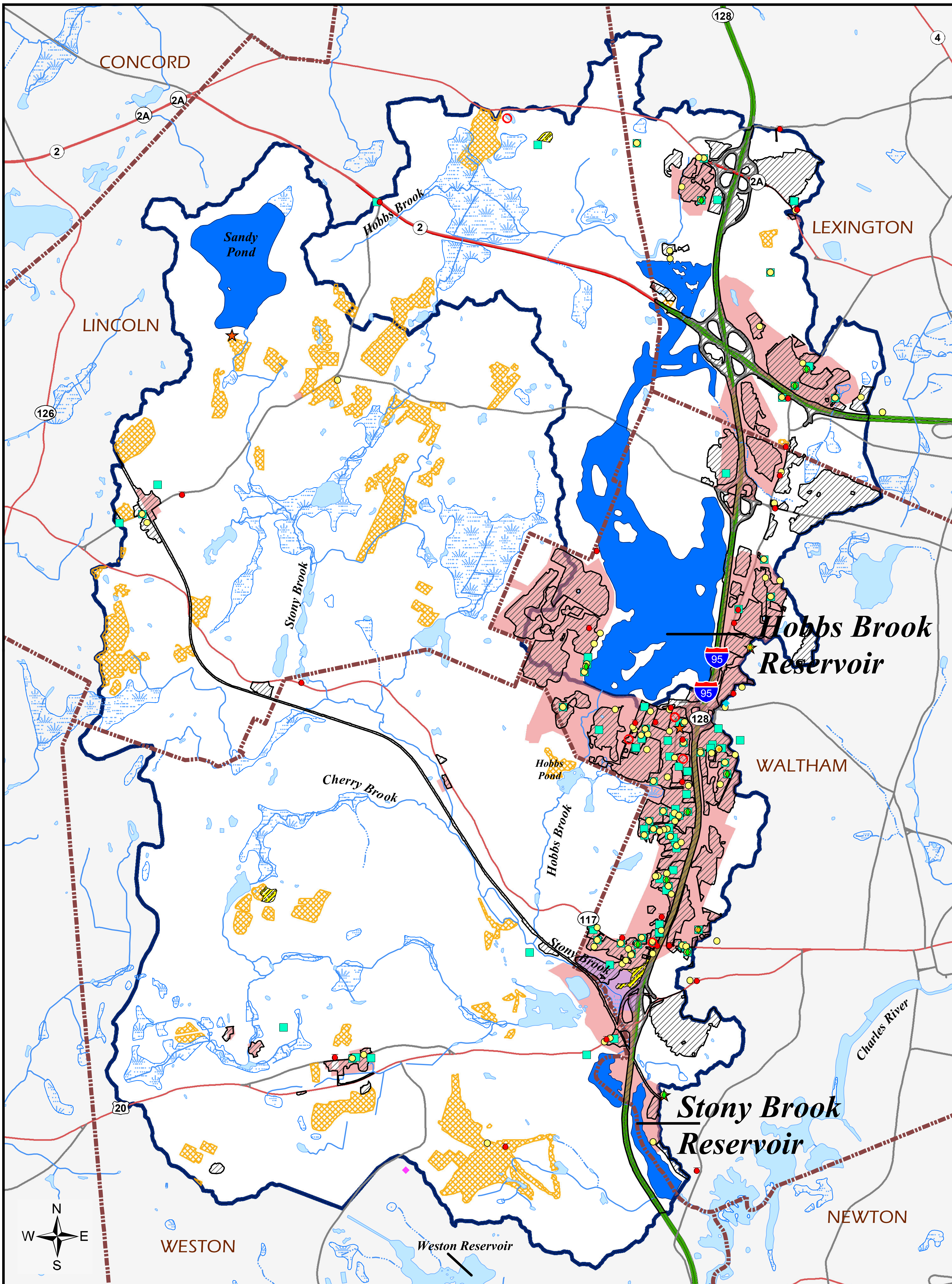
0 0.25 0.5 0.75 1 2 Miles

0 0.25 0.5 0.75 1 2 Kilometers

City of Cambridge Water Department
Source: Office of Geographic Information (MassGIS),
Commonwealth of Massachusetts EEA
February, 2011

Surface Water Supply Protection Plan Cambridge Watershed

Protected Open Space



Legend

- Potential Chemical and/or Fertilizer Applications
- High Intensity Land Use
- Junkyard or Waste Disposal Site
- High Density Zoning
  - Commercial
  - Industrial
- Town Boundary
- Hobbs/Stony Brook Watershed

21E Tier Classified Sites

- Tier 1D
- Tier II
- DEP SWAP Facilities
- AUL Sites
- Underground Storage Tanks

- EPA CERCLIS
- EPA PCS
- EPA TRI
- EPA RCRA
- Limited Access Highway
- Multi-lane Hwy, not limited access
- Other Numbered Highway
- Major Road, Collector

0 0.25 0.5 0.75 1 2 Miles

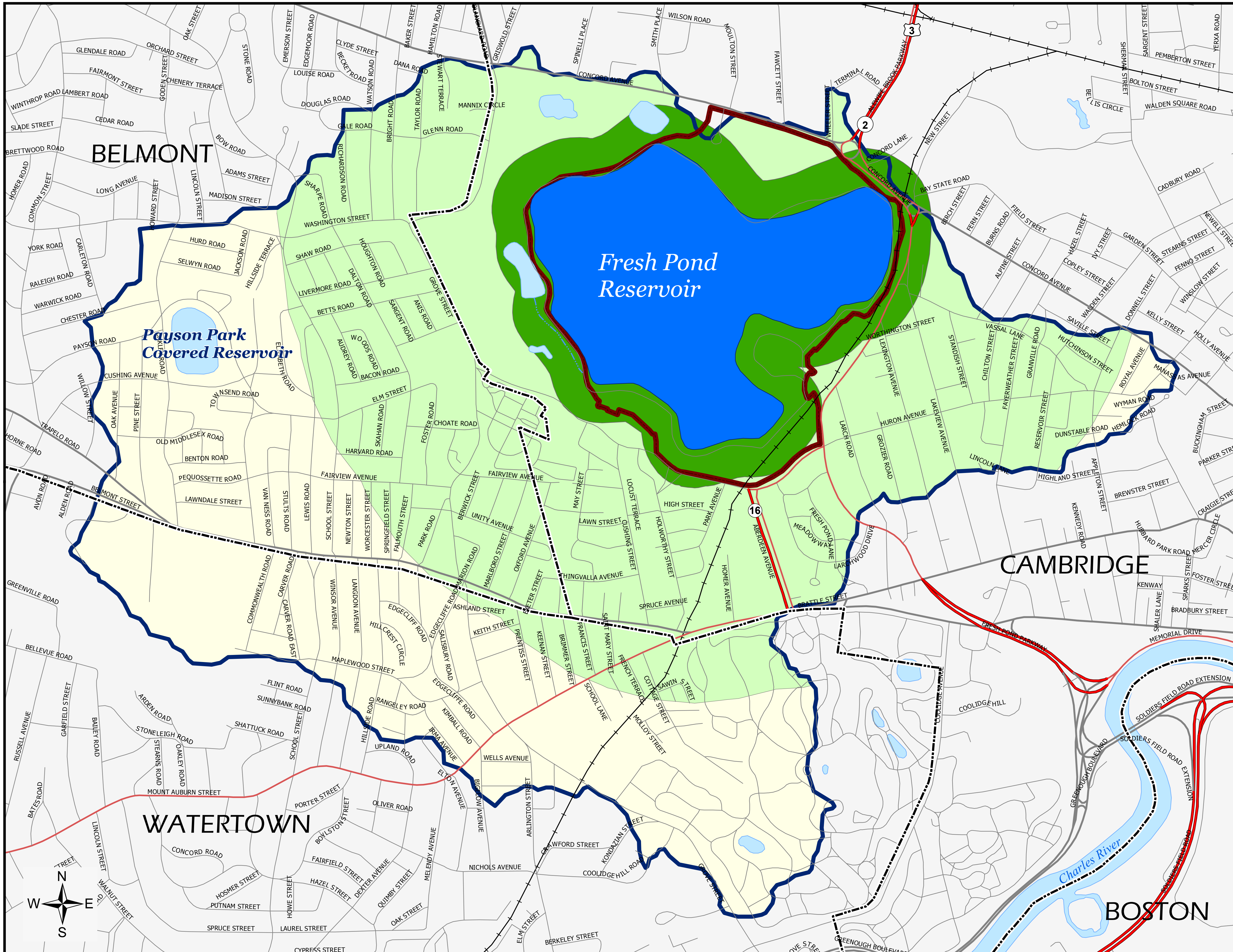
0 0.5 1 2 Kilometers

Surface Water Supply Protection Plan

Cambridge Watershed

Risks

City of Cambridge Water Department
Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts EEA
March, 2011, US EPA, MassDEP



Surface Water Supply Protection Plan

Cambridge Watershed

Historic Fresh Pond Subbasin

DEP Protection Zones

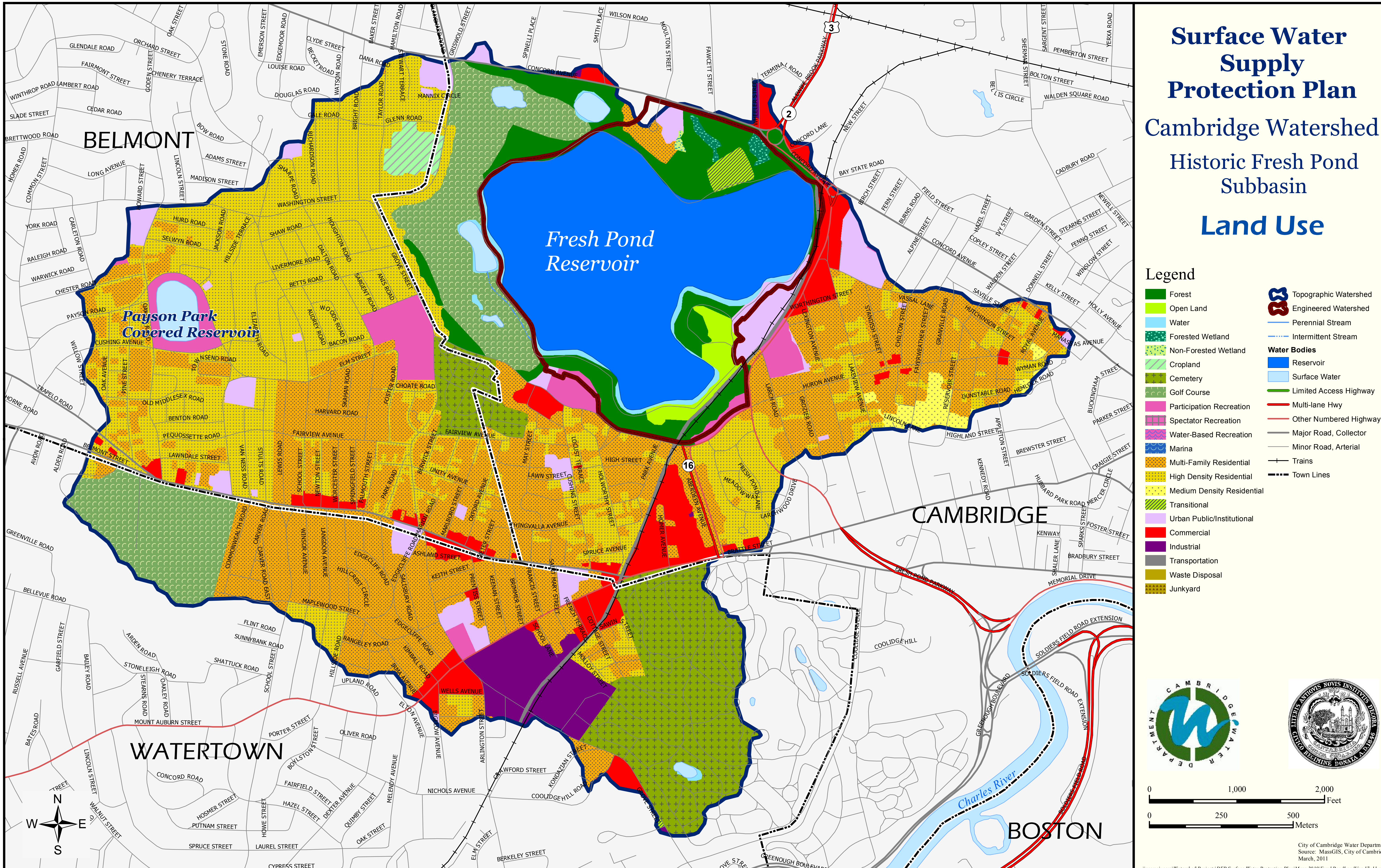
Legend

- Town Lines
- Limited Access Highway
- Multi-lane Hwy
- Other Numbered Highway
- Major Road, Collector
- Minor Road, Arterial
- Trains
- Open Water
- Reservoir
- Engineered Watershed
- Topographic Watershed
- DEP Protection Zone A
- DEP Protection Zone B
- DEP Protection Zone C

0 500 1,000 1,500 2,000 Feet

0 250 500 Meters

City of Cambridge Water Department
Source: MassGIS, City of Cambridge
March, 2011


Surface Water Supply Protection Plan
Cambridge Watershed
Historic Fresh Pond Subbasin
Land Use
Legend
Forest
Open Land
Water
Forested Wetland
Non-Forested Wetland
Cropland
Cemetery
Golf Course
Participation Recreation
Spectator Recreation
Water-Based Recreation
Marina
Multi-Family Residential
High Density Residential
Medium Density Residential
Transitional
Urban Public/Institutional
Commercial
Industrial
Transportation
Waste Disposal
Junkyard
Topographic Watershed
Engineered Watershed
Perennial Stream
Intermittent Stream
Water Bodies
Reservoir
Surface Water
Limited Access Highway
Multi-lane Hwy
Other Numbered Highway
Major Road, Collector
Minor Road, Arterial
Trains
Town Lines
Fresh Pond Reservoir
Payson Park Covered Reservoir
BELMONT
CAMBRIDGE
WATERTOWN
BOSTON
Charles River
0 1,000 2,000 Feet
0 250 500 Meters
City of Cambridge Water Department
Source: MassGIS, City of Cambridge
March, 2011
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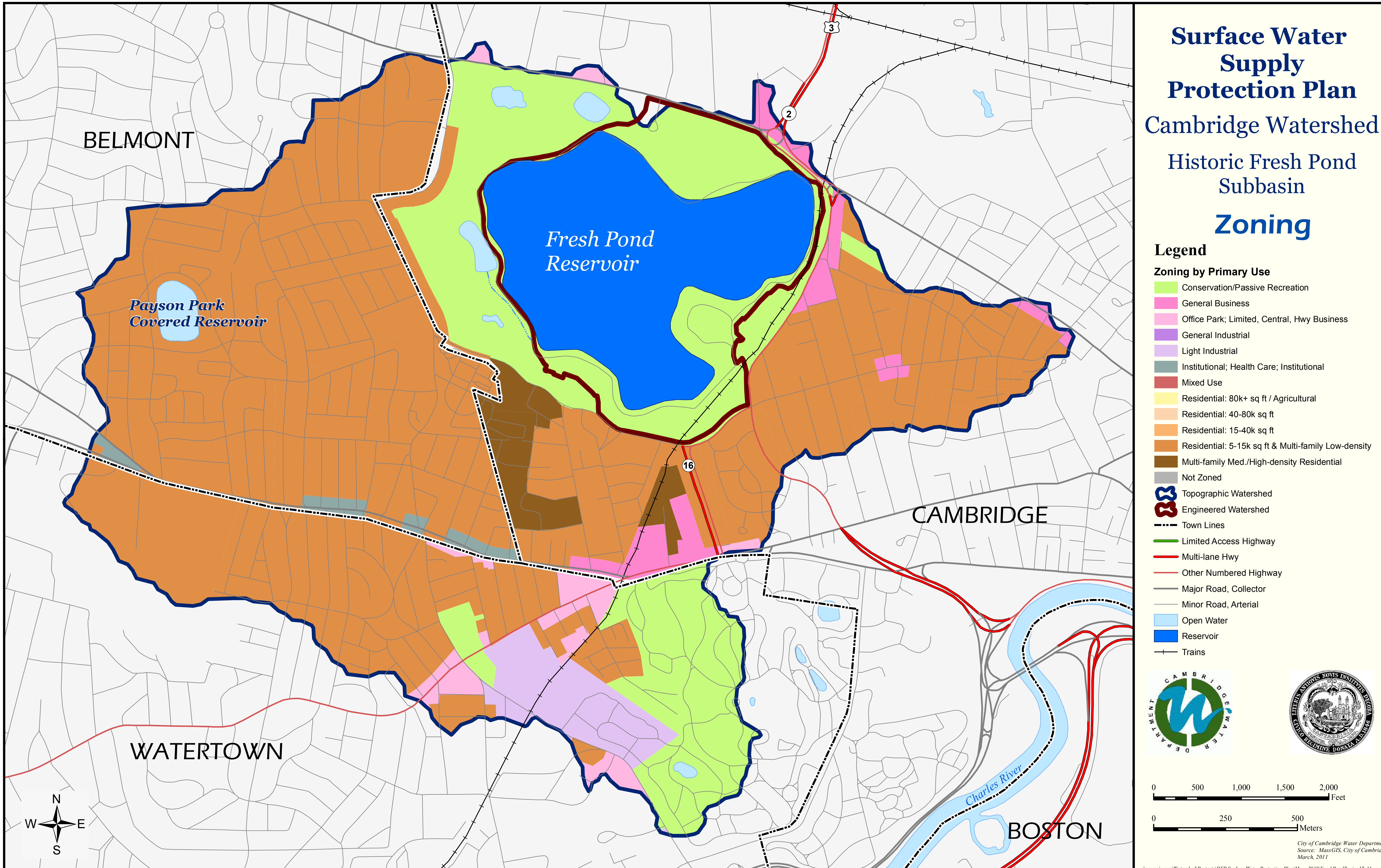
Surface Water Supply Protection Plan
Cambridge Watershed
Historic Fresh Pond Subbasin
Zoning
Legend
Zoning by Primary Use
Conservation/Passive Recreation
General Business
Office Park; Limited, Central, Hwy Business
General Industrial
Light Industrial
Institutional; Health Care; Institutional
Mixed Use
Residential: 80k+ sq ft / Agricultural
Residential: 40-80k sq ft
Residential: 15-40k sq ft
Residential: 5-15k sq ft & Multi-family Low-density
Multi-family Med./High-density Residential
Not Zoned
Topographic Watershed
Engineered Watershed
Town Lines
Limited Access Highway
Multi-lane Hwy
Other Numbered Highway
Major Road, Collector
Minor Road, Arterial
Open Water
Reservoir
Trains
BELMONT
CAMBRIDGE
WATERTOWN
BOSTON
Fresh Pond Reservoir
Payson Park Covered Reservoir
Charles River
3
2
16
N
W
E
S
0 500 1,000 1,500 2,000 Feet
0 250 500 Meters
City of Cambridge Water Department
Source: MassGIS, City of Cambridge
March, 2011
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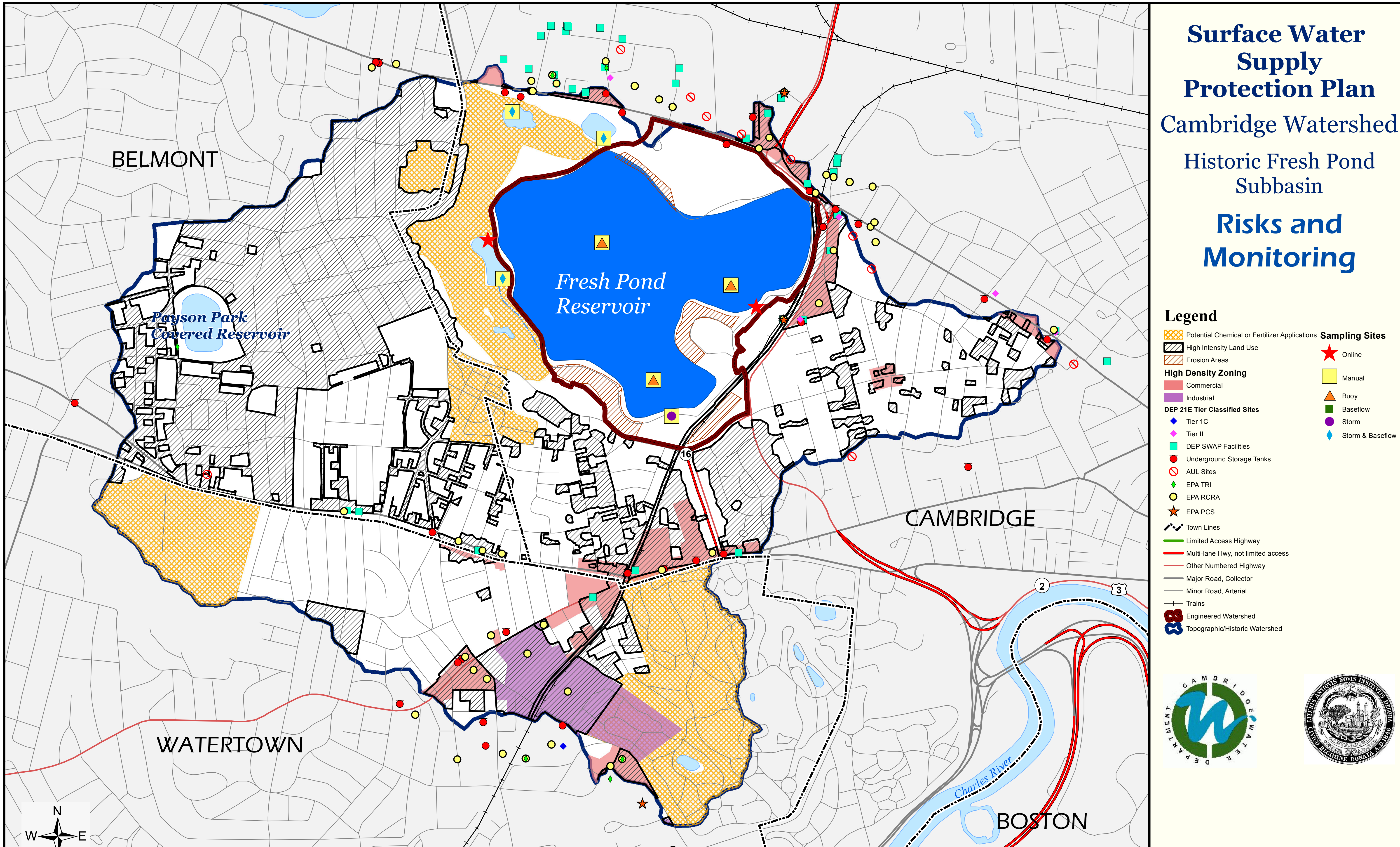
Surface Water Supply Protection Plan

Cambridge Watershed

Historic Fresh Pond Subbasin

Risks and Monitoring



City of Cambridge Water Department
Source: MassGIS, City of Cambridge
March, 2011

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DEP Surface Water Protection Plan\Maps 2010\FreshPondRisksMonitoring17x11.mxd

APPENDIX C: WATERSHED PROTECTION PROGRESS

This section will review recommendations from older watershed protection plans and the MassDEP Source Water Assessment and Protection report from 2003. Recommendations are paraphrased from the referenced plan.

CAMBRIDGE RESERVOIR WATERSHED PROTECTION PLAN RECOMMENDATIONS , 1989

Stormwater Runoff Recommendations

Recommendation (R)1: MassDEP to upgrade tributary surface waters to Class A
Status (S)1: Completed. Spatial data updated March, 2010 (MassGIS). Minor error noticed in Stony Brook Reservoir Zones A and B. Comments sent to MassDEP and should be rectified.

R2: MassDEP should further regulate stormwater discharges from watershed contributors, requiring NPDES permits setting chemical concentration limitations
S2: MassDEP and US EPA are proposing new stormwater permits and regulations, reflecting completed TMDL-derived waste load allocations for MS4 communities.

R3: MassDEP to further regulate Exxon terminal in Weston for stormwater runoff
S3: Facility removed, remediated to DEP Bureau of Waste Site Cleanup (BWSC) standards and is now an office park with a DEP-compliant stormwater management system.

R4: MassDEP to receive support from EPA Region 1 in tightening stormwater regulations
S4: Ongoing

R5: Waltham and Weston should adopt local wetland protection measures to control peak discharges and chemical applications, including sodium chloride
S5: Work triggering the Wetlands Protection Act is regulated through Orders of Conditions issued by the local Conservation Commissions. Standard issued orders in Waltham and Weston include these provisions.

R6: The four watershed towns to amend site plan review regulations to require erosion and sediment control plans, stormwater drainage controls, pollution control devices, and restrictions on road salt.
S6: Sites are regulated through NPDES Construction General Permits, BRP WM09 MassDEP review, Wetlands Protection Act, and Class-A Water Quality Standards. Cambridge Water Department works closely with all involved parties to ensure high stormwater quality during and after construction.

R7: The Massachusetts Department of Public Works (today's MassDOT) should control runoff from abutting highways to the reservoirs.
S7: MassDOT has developed a comprehensive watershed protection plan outlined in

Section 61 Findings of a 1999 FEIR MEPA document. Work includes constructing and maintaining MassDEP-approved water quality basins, adopting and implementing low-salt management technologies and strategies, and implementing other "good-house keeping" practices such as routine catch basin inspections and cleanings, street sweeping and garbage/debris removal. Cambridge Water Department is in close contact with MassDOT to facilitate implementation of this plan and to identify areas of improvement.

Underground Storage Tanks

R8: Watershed Towns should adopt stricter underground storage tank bylaws that require registration of existing and new USTs, prohibition of new residential USTs, existing unprotected tanks must be removed after 30 years, tanks of unknown age are assumed to be 20 years old.
S8: USTs are regulated by MassDEP under 527 CMR 9.00, 527 CMR 5.06, and 310 CMR 22.20B. CWD will continue to work with the State, and local agencies to develop the most comprehensive inventory, develop and maintain a watershed-specific spatial database, and prioritize remediation and removal of old tanks.

Hazardous Wastes and Materials

R9: Encourage watershed communities to adopt a bylaw further limiting the types and quantities of hazardous materials allowed in the watershed, adopting a emergency coordinator and an emergency contingency plan, and setting standards for proper materials storage.
S9: City of Cambridge continues to rely on existing federal, state, and local regulations to control potential impacts.

Road Salt

R10: MassDOT should implement a sodium reduction policy.
S10: MassDOT currently follows a State-approved reduced salt policy (available online[11]). CWD continues to work with MassDOT District 4 to ensure proper policy implementation and to encourage their adopting technologies that quantify materials use in the watershed, and minimize and target applications.

R11: MassDOT should carefully manage deicing materials stored at the Rte 2A maintenance yard.
S11: MassDOT has taken steps to properly store deicing materials and treat stormwater runoff through structural BMPs.

[11] http://www.mhd.state.ma.us/downloads/snowIce/saltpolicy/salt_policy.pdf

R12: MassDOT should institute measures to mitigate sodium chloride contamination at the Route 2A maintenance yard which is discharging into Hobbs Brook Reservoir.
S12: No remediation activities were implemented. The hyper saline groundwater plume continues to migrate towards and contribute to the Hobbs Brook Reservoir.

R13: Waltham should continue its sodium reduction program in the Hobbs Brook (Trapelo Road, Smith Street, and Wyman Street), and expand the program to Bear Hill Road and Main Street in the Stony Brook watershed.
S13: Waltham continues implementing its low salt program. No recent efforts have been made to expand its coverage.

R14: Watershed communities should restrict the use of deicing salts on commercial roadways and parking lots.
S14: The Cambridge Water Department recommends and communicates to proponents that all projects triggering WPA and MEPA review include low salt strategies and management plans.

Wastewater

R15: MAPC recommended increasing inspection frequency, setback distances from water supply water bodies, increasing leach field sizes in lower-percolating soils, prohibition of septic cleaners containing chlorinated hydrocarbons.
S15: Current Title 5 regulations and additional Town bylaws comply with recommendations

Landfills

R16: Weston and Lincoln should establish a long term groundwater monitoring program for existing landfills.
S16: Weston currently monitors groundwater surrounding the transfer station bordering the confluence of the Hobbs and Stony Brooks to track potential leachate contamination, sending copies of reports to CWD for review.

R17: Watershed communities should prohibit the siting of any new landfills or junkyards in the watershed through the adoption of a Watershed Protection overlay zoning district.
S17: No new landfills have been sited in the watershed, and no watershed protection overlay zoning districts have been developed.

Protection Overlay District

R18: Develop a watershed protection overlay zoning district to be amended to existing zoning codes. The overlay district should incorporate the entire watershed boundary and prohibit or further regulate high-risk land uses in the watershed. Model bylaw language

given.
S18: No watershed protection overlay zoning districts have been developed.

Wetlands Protection

R19: Adopt recommended guidelines and standards for wetland replication
S19: MassDEP has detailed criteria and performance standards for wetland replication

Emergency Response

R20: The possibility of making Cambridge's equipment and expertise available to respond to a spill in the watershed should be pursued.
S20: Completed, see Emergency Response Planning section

Intercommunity Coordination

R21: Under a Memorandum of Understanding, a Watershed Advisory Committee should be established as a permanent standing committee to facilitate watershed community communication and coordination.
S21: Was established, but now defunct due to funding lapses. Watershed Manager and Watershed Protection Supervisor now serve as primary watershed community liaisons. Watershed Protection Supervisor uses a suite of tools and communicates regularly with town officials to find out about developments in the watershed.

Watershed Monitoring

R22: The Cambridge Water Department should consider establishing a watershed monitoring program which is designed to evaluate key indicators of watershed status, and provide an early warning of problems
S22: Completed. See Water Quality Monitoring Section

Environmental Reviews

R23: MWRA and MassDEP should review any watershed project undergoing MEPA review.
S23: CWD reviews and comments on all watershed projects requiring MEPA review. See Site Monitoring section. History shows MassDEP involvement in watershed MEPA projects, but CWD is unaware of their requirements. Watershed advocates and the MWRA Water Supply Citizens Advisory Council often comment on watershed projects.

Land Acquisition

R24: The Water Board should consider the purchase of land or easements on selected key parcels critical to water supply resources.
S24: CWD has an informal land acquisition program. See Land Acquisition section.

MWRA Local Source Protection Policies

R25: Extend MWRA policy of promoting action on the part of "contract" communities to protect local sources of water which may be used to supplement available supplies and reduce demand on the Authority's sources to Weston, Lexington, and Waltham, which rely on MWRA for 100% of their water supply.
S25: Never extended. Communities do show incentive to protect their water resources, regardless of their not using them for water supply.

FRESH POND WATER SUPPLY PROTECTION PLAN RECOMMENDATIONS, 1994

Administrative Actions

Recommendation (R)1: Cambridge Water Board to adopt formal goals.
Status(S)1: Using the recommendations from the protection plan, goals were created and communicated in the Fresh Pond Master Plan

R2: Prepare annual Fresh Pond Watershed and Water Quality Report
S2: With some staff-transition years omitted, the Watershed Protection Supervisor prepares an annual report.

R3: Consider water supply protection ordinance and/or deed restrictions
S3: Considered and deemed unnecessary based on the City's level of control.

Fresh Pond Reservoir

R4: Manage Fresh Pond water levels
S4: CWD immediately implemented this recommendation and continues to manage Fresh Pond reservoir water levels in a way that minimizes groundwater inflow from the surrounding developed areas.

R5: Discontinue water treatment plant residuals discharge.
S5: CWD has implemented this recommendation with the construction of the new treatment facility in 2001 and currently discharges residuals into regional sewerage in compliance with MWRA Sewer Use Regulations. Clarified filter backwash water is returned to Fresh Pond under conditions of a Federal NPDES Permit.

R6: Monitor recreation, animal, and wildlife activity and impacts
S6: Recreation and animal impacts are being addressed through the process of implementing the Fresh Pond Master Plan. No formal wildlife census program exists as indicator bacteria levels remain within Class A water quality standards. CWD will continue to consider developing a census program for Fresh Pond and the upcountry watershed.

R7: Develop a watershed stormwater management program
S7: Stormwater quality is being monitored throughout the watershed and stormwater impacts are addressed through Fresh Pond Reservation restoration projects. See Water Quality Monitoring and Stormwater sections of this report for more detail.

R8: Improve emergency response capabilities
S8: Implemented, see Emergency Response Planning Section

R9: Improve public education and CWD presence in Fresh Pond Reservation
S9: A Ranger position was created at the same time as the recommendations were made. Ranger responsibilities include improving public education and CWD presence in the reservation. In addition, two reservation groundskeepers are a constant presence for the water department. See this report's public outreach and education section for existing programs.

R10: Develop an agreement with Guilford Railroad
S10: An agreement was developed, and the railroad was managed to minimize water quality impacts. At this time, the railroad is no longer used.

Groundwater Protection Area

R11: Develop golf course management guidelines
S11: CWD and the golf course communicate regularly about best management practices to protect the water supply. No formal management plan has been created at this time. CWD is working with the golf course to develop and implement a plan.

R12: Review monitoring activities/clean-up activities at 21E sites.
S12: CWD and the Cambridge Board of Health review monitoring results. Reports are either mailed directly or available online through the MassDEP website.

R13: Consider ordinance for mandatory replacement or monitoring of unregulated underground storage tanks.
S13: CWD will work with the Cambridge Fire Department to update lists of and map unregulated USTs in Fresh Pond groundwater contributing zones.

R14: Conduct annual sanitary survey to include unregulated commercial/industrial facilities, conduct education, technical assistance activities
S14: CWD monitors facilities on a regular basis, see Site Monitoring section.

R15: Assess road salting/develop road salting and snow dumping guidelines.
S15: Although groundwater sampling indicates higher than background levels of sodium, no

low-salt areas are designated around major roadways surrounding Fresh Pond Reservation. No salt is used in deicing the perimeter road or areas draining directly to the reservoir. Low-salt programs are currently focused on upcountry areas as the majority of salt impacts are realized in the Hobbs and Stony Brook reservoirs, which account for the majority of water in Fresh Pond.

Water Quality Monitoring

R16: Develop golf course management guidelines
S16: CWD and the golf course communicate regularly about best management practices to protect the water supply. No formal management plan has been created at this time. CWD is working with the golf course to develop and implement a plan.

DEP SWAP RECOMMENDATIONS

Zone A Recommendations

Recommendation (R)1: Develop a Management Plan to minimize the impact that visitors will have within the Zone A of Fresh Pond Reservation.
Status (S)1: There is a Fresh Pond Master Plan which addresses mitigating Zone A impacts, and is currently being implemented as funding becomes available

R2: Actively monitor new or expanded land uses within the Zone A according to your watershed protocol submitted to DEP.
S2: Component of the Site Monitoring Program

R3: To the extent possible, remove all activities from the Zone As to comply with DEP's Zone A requirements.
S3: Component of the Site Monitoring and Land Acquisition Programs

R4: Control stormwater and erosion within the Zone A.
S4: Primarily using redevelopment projects as triggers for these improvements, but will investigate CPA, and watershed restoration grant opportunities in City-owned degraded areas

R5: Control aquatic wildlife within the Zone A as necessary.
S5: Currently working with reservoir-abutting businesses to conduct Canada geese population control projects. A recent USGS bathymetry survey has identified the estimated extent of Eurasian milfoil and other aquatic vegetation.

R6: Continue to work with local emergency response teams to practice containment of spills within the Zone A.
S6: We have working relationships with local fire departments. Training is scheduled for 2011 - 2012

R7: Continue to conduct regular inspections of the Zone A for illegal dumping and spills.
S7: Inspections done during water quality and site monitoring in addition to routine caretaker patrols

R8: Install water supply protection area signs as needed around the Zone A.
S8: Developing a signage spatial database and location maps. Work towards identifying gaps and high use areas for signage

Residential Land Use Recommendations

R9: Work cooperatively with Boards of Health to develop an inventory of septic systems in Lincoln and Weston.
S9: Will be part of proposed sewage threat assessment and monitoring program

R10: Educate residents on best management practices (BMPs) for protecting water supplies. Distribute the fact sheet
S10: Will be part of proposed comprehensive, land-use specific outreach and education program

R11: Work with planners to control new residential developments in the water supply protection areas.
S11: Development projects are and will continue to be reviewed

R12: Promote BMPs for stormwater management and pollution controls.
S12: Will be a component of developing a recommended list of BMPs. "Residents Protect Drinking Water" available on http://www.mass.gov/dep/water/drinking/spres.htm, provides BMPs for common residential issues.

Transportation Corridor Recommendations

R13: Continue to work cooperatively with the Massachusetts Highway Department on a hazardous materials management plan, on a salt use reduction strategy, and on the implementation of structural and maintenance of BMP.
S13: Component of proposed MassDOT Partnership Program

R14: Work with the Towns and State to have catch basins inspected, maintained, and cleaned on a regular schedule. Street sweeping reduces the amount of potential contaminants in runoff.
S14: Component of existing NPDES Stormwater Permit. Will work with Towns to develop priority management areas

R15: Continue to work with local emergency response teams to ensure that any spills within the watersheds can be effectively contained.
S15: Ongoing

R16: Review storm drainage maps with emergency response teams. Work with town officials to investigate mapping options such as the upcoming Phase II Stormwater Rule requiring some communities to complete stormwater mapping.
S16: Much of this work has been done for the emergency response plan**.** Data gaps will be addressed in proposed Stormwater Program

R17: Work with local officials during their review of the railroad right of way Yearly Operating Plans to ensure that water supplies are protected during vegetation control.
S17: Ongoing

Hazardous Materials Storage and Use Recommendations

R18: Continue to educate local businesses on best management practices for protecting water supplies. Distribute the fact sheet "Businesses Protect Drinking Water" available on http://www.mass.gov/dep/water/drinking/spbus.htm, which provides BMP's for common business issues.
S18: Will distribute as part of Private/Public Partnership Program

R19: Work with local businesses to register those facilities that are unregistered generators of hazardous waste or waste oil. Partnerships between businesses, water suppliers, and communities enhance successful public drinking water protection practices.
S19: No know unregistered generators in the watershed.

R20: Educate local businesses on Massachusetts floor drain requirements. See brochure "Industrial Floor Drains" for more information.
S20: Will continue to work with watershed municipalities in outreach and education.

Oil or Hazardous Material Contamination Sites Recommendation

R21: Monitor progress on any ongoing remedial action conducted for the known oil or contamination sites.
S21: Ongoing. Component of the Site Monitoring Program

Aquatic Wildlife Recommendations

R22: Monitor wildlife populations in and around reservoirs.
S22: No formal wildlife surveys are currently conducted

R23: Where necessary, discourage and control aquatic wildlife. See http://www.mass.gov/dep/about/organization/aboutbrp1.htm for guidance and permits.
S23: Conducting Canada geese population control projects

Protection Planning Recommendations

R24: Complete the City's Surface Water Supply Protection Plan. Refer your protection team to http://mass.gov/dep/brp/dws/protect.htm for a copy of DEP's guidance, "Developing a Surface Water Supply Protection Plan".
S24: Completed

R25: Encourage watershed towns to adopt controls that meet 310 CMR 22.20 (b) and (c). For more information on DEP land use controls see http://mass.gov/dep/brp/dws/protect.htm.
S25: Ongoing

R26: Continue to work with town boards to review and provide recommendations on proposed development within your water supply protection areas. To obtain information on build-out analyses for the towns, see the Executive Office of Environmental Affairs' community preservation web site, http://commpres.env.state.ma.us/ .
S26: Site-plan review is a component of the Site Monitoring Program

Cambridge Water Department is commended

for taking an active role in promoting source protection measures through:

- Working cooperatively with watershed towns on emergency response and stormwater management.
- Placing spill kits at strategic points within the watersheds.
- Actively monitoring source water quality throughout the watersheds and using the data to target source protection.
- Working cooperatively with businesses within the watersheds to encourage source protection.
- Adopting the Fresh Pond Master Plan, which includes long term source protection measures.
- Dedicating staff resources to inspections, public education, and coordinating source protection efforts.

APPENDIX D: USGS CWD PARTNERSHIP – BASELINE ASSESSMENT SUMMARY

USGS
science for a changing world

Storms, Streams, and Reservoirs– Assessing Water Quality in the Cambridge, Massachusetts, Drinking-Water Source Area

From September 1997 through November 1998, the U.S. Geological Survey (USGS), in cooperation with the City of Cambridge, Massachusetts, Water Department (CWD), studied the water quality of Cambridge's three drinking-water supply reservoirs and their tributary streams. Although highway and urban stormwater runoff adversely affected some tributaries, the reservoir system ultimately delivered high-quality water to the treatment plant. Using data from this study, the USGS and CWD developed a comprehensive monitoring program for the drinking-water source area and designed a new investigation that examines how storm-water runoff affects tributary- and reservoir-water quality.

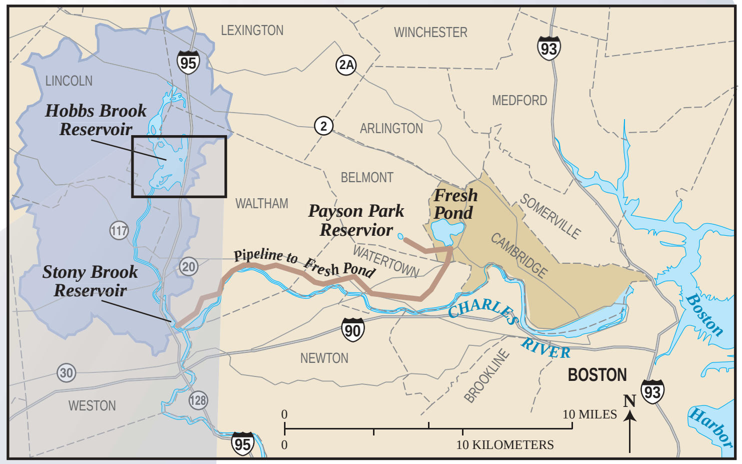

Figure 1. Location and extent of the Cambridge, Massachusetts, drinking-water-supply system.

Figure 2. Aerial photo of Hobbs Brook Reservoir in the Cambridge, Massachusetts, drinking-water source area. Photo by Joseph R. Melanson, Aero Photo, Inc.,Wareham, Massachusetts.

The USGS and CWD Partnership

Every day, the CWD supplies roughly 15 million gallons of water to more than 100,000 customers. A system of reservoirs in Cambridge and in parts of five other suburban Boston communities supplies most of this water (fig. 1). The heavily developed drainage basin that contributes water to these reservoirs contains major highways, secondary roads, and areas of residential, commercial, and industrial land use that could adversely affect the water supply. The City of Cambridge, however, owns less than 5 percent of the land in the basin. Consequently, the CWD relies heavily on water-quality monitoring to determine if contaminants enter the water supply from land it does not own.

As part of its mission to understand and help protect the quality of our Nation's water resources, the U.S. Geological Survey conducts investigations that help municipal water suppliers manage their local drinking-water resources. One such study, begun in 1997 in cooperation with the City of Cambridge and completed in 1998, was designed to identify sources of contaminants in the city's drinking-water source area. Data from this study were then used to select sampling stations for a water-quality monitoring network in the source area.

In beginning the study, the USGS and CWD outlined three objectives. We planned to characterize current water-quality conditions in the drinking-water source area, to identify tributaries most likely to transport contaminants to the reservoirs, and to provide baseline information about contaminant loads, which will help evaluate the effectiveness of watershed best-management practices. Waldron and Bent (2001) provide details of the water-quality study and completely describe the water-quality monitoring program.

This Fact Sheet summarizes the major findings of the study and briefly describes the water-quality monitoring program developed from them. It also provides an overview of the current (2002) USGS cooperative investigation with the CWD that is examining the effects of stormwater runoff on the water supply.

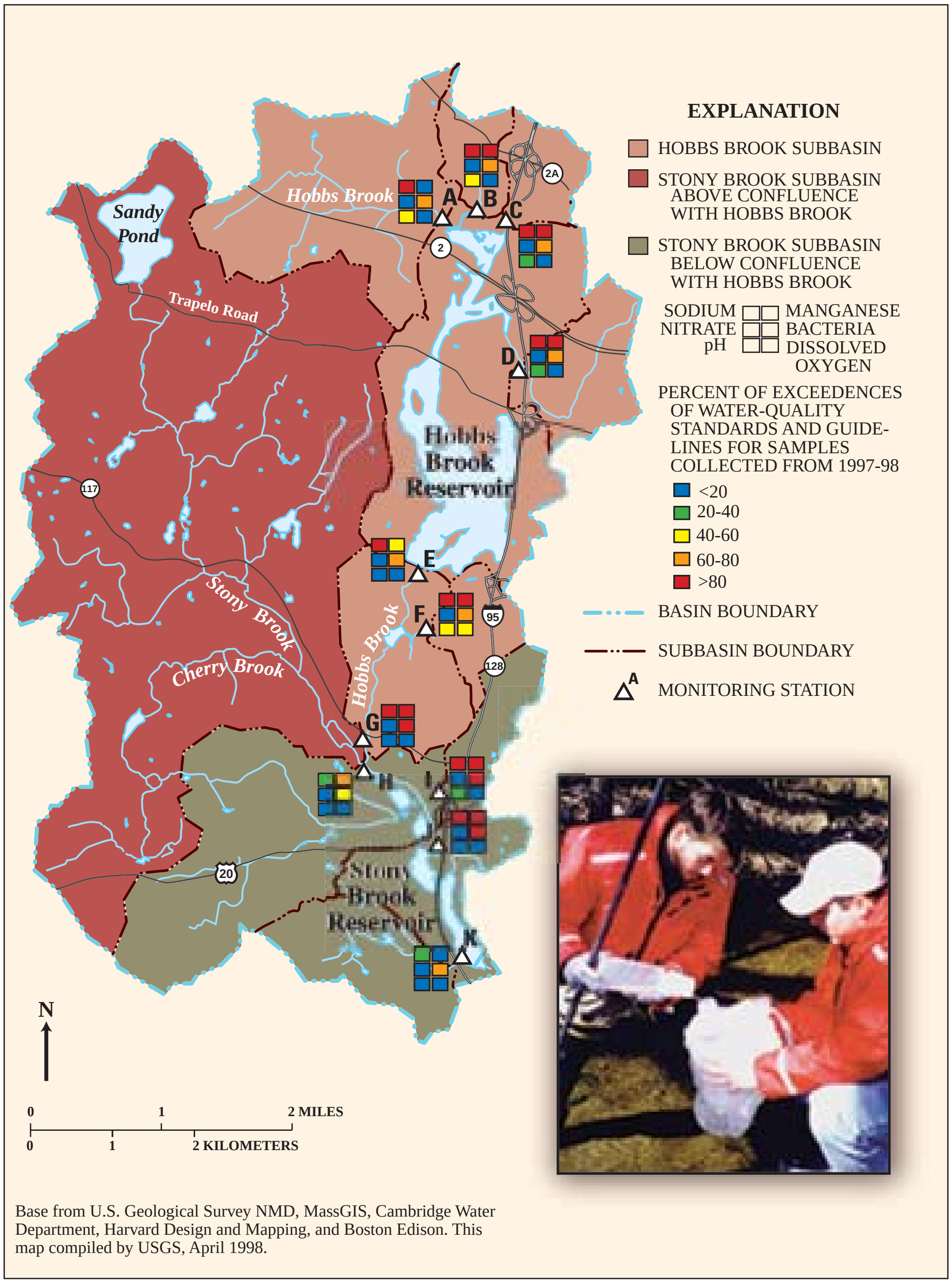

Figure 3. Concentrations of selected contaminants in the study area in relation to applicable State and Federal water-quality standards. Photo inset shows U.S. Geological Survey and Cambridge Water Department staff collecting stream samples.

Cambridge's Drinking-Water Supply System

The Cambridge drinking-water supply system consists of Hobbs Brook and Stony Brook Reservoirs, which drain 15,200 acres in Lexington, Waltham, and Weston, and Fresh Pond, a 155-acre kettle-hole lake in Cambridge (fig. 1). Several tributaries and storm drains associated with State Routes 128 and 2, secondary roads, and commercial and industrial parking areas feed Hobbs Brook Reservoir (fig. 2). Drainage from the Stony Brook Subbasin, outflow from Hobbs Brook Reservoir, and other small tributaries flow into Stony Brook Reservoir. The CWD pipes water from Stony Brook Reservoir to Fresh Pond, where it remains before treatment. After treatment, the CWD pumps the finished water to Payson Park Reservoir in Belmont. From there, it flows by gravity through a 190-mile distribution system.

Study Design

To achieve the study objectives, a dual sampling strategy was developed. First, 11 streams that carry water to Hobbs Brook and Stony Brook Reservoirs were sampled for streamflow and water-quality conditions. These data demonstrated how land use, land cover, and other drainage-basin characteristics affected the sources, transport, and fate of potential drinking-water contaminants. The second part of the study was an ecological assessment of the three primary storage reservoirs—Hobbs Brook Reservoir, Stony Brook Reservoir, and Fresh Pond. These assessments provided baseline information and helped determine the reservoirs' vulnerability to increased loads of nutrients and other contaminants.

Tributary Water Quality

Concentrations of potential drinking-water contaminants varied throughout the Hobbs Brook and Stony Brook Subbasins, and the subbasins differed in their relative contributions to total contaminant loads. Waldron and Bent (2001) provide details on streamflow estimates for the 11 streams sampled and discuss methods for sampling and calculating annual contaminant loads.

Concentrations of Fecal-Coliform Bacteria Higher in Streams in the Hobbs Brook Subbasin than in Streams in the Stony Brook Subbasin

Water samples from streams in the heavily developed Hobbs Brook Subbasin generally had higher concentrations of fecal-coliform bacteria than those found in samples from the more residential Stony Brook Subbasin. When total annual contributions of bacteria were compared, however, the two subbasins, which are about equal in area, contributed about the same amount of bacteria to the water supply.

At all monitoring stations, fecal-coliform concentrations frequently exceeded the State drinking-water source-area standard of 20 CFU/100 mL (colony-forming units per 100 milliliters). Specifically, between 60 and 80 percent of samples from streams that flow to Hobbs Brook Reservoir (stations A, B, C, and D) exceeded the State standard (fig. 3). More than 80 percent of samples collected at the mouth of Hobbs Brook (station G), at Stony Brook downstream from the Hobbs Brook confluence (station J), and at one small tributary to Stony Brook (station I) exceeded the standard. In contrast, 40 to 60 percent of samples collected from Stony Brook upstream from the mouth of Hobbs Brook (station H) had bacteria concentrations above the standard.

Higher bacteria concentrations from the Hobbs Brook Subbasin most likely result from the subbasin's large surface area that is impervious to water. This subbasin contains more roads, buildings, and parking lots, and more densely populated residential areas, than the Stony Brook Subbasin. Precipitation falling on these surfaces is more likely to carry bacteria from bird and animal waste, as well as other contaminants, directly to the streams.

The total mass of a contaminant that is transported downstream past a monitoring station in one year is defined as the annual contaminant load for the stream. By expressing the loads on a per-square-mile basis, contaminant loads for streams that drain large subbasins can be compared with those for streams draining smaller subbasins. This value, which is an indication of the relative magnitude of a contamination problem, is referred to as the subbasin yield.

The subbasin yield of fecal-coliform bacteria at station E, which represents the outflow from Hobbs Brook Reservoir, was small relative to the yields of the inflowing tributaries (A, B, C, and D, fig. 4*A*), indicating that the reservoir attenuated the effects of the relatively high bacteria loads from the tributaries, probably through dilution, settling, and death. Interestingly, the subbasin yield at station G was much larger than that at station E or station F, which are directly upstream from station G. This indicates that there may have been additional sources of fecal-coliform bacteria in the lower Hobbs Brook Subbasin downstream from the reservoir. Subbasin yields were greatest at station I, which drains a section of State Route 128 and a steeply sloped industrial area. Yields were smallest at station K, which drains primarily low-density residential areas with only locally maintained roads.

Most Streams Meet Dissolved Oxygen Standard

Except for a small tributary (station F) that drains a heavily developed area south of Hobbs Brook Reservoir, streams in the study area rarely had dissolved oxygen concentrations lower than the State standard of 6 mg/L (milligrams per liter) (fig. 3). Dissolved oxygen concentrations lower than the standard can indicate the presence of organic wastes or excess plant nutrients, such as nitrogen and phosphorus, which would impair water quality.

pH Values below State Standard in Several Streams

Although most streams had adequate dissolved oxygen concentrations, several streams had pH values below the State standard of 6.5. Forty to sixty percent of pH values from stations A, B, and F, and 20-40 percent of those from stations C, D, and I were below the State standard (fig. 3). Most of these low pH values reflect the presence of naturally occurring organic acids leached from wetlands in the tributary drainage basins.

Unlike for pH, no State or Federal standards govern concentrations of sodium, nitrate, or manganese in surface waters. The U.S. Environmental Protection Agency (USEPA), however, has established a drinking-water equivalent (DWEL) guideline of 20 mg/L for sodium, a drinking-water maximum contaminant level (MCL) of 10 mg/L for nitrate, and secondary maximum contaminant levels (SMCL) of 250 mg/L for chloride and 50 µg/L (micrograms per liter) for manganese (U.S. Environmental Protection Agency, 1998; 2001). Because these constituents often are difficult and expensive to remove during drinking-water treatment, it helps to compare the finished water guidelines with measured concentrations from stream samples.

Sodium and Chloride Concentrations Linked to Application of Road-Deicing Salt

Dissolved sodium concentrations from the Hobbs Brook Subbasin frequently exceeded the USEPA's DWEL. When annual subbasin yields of dissolved sodium were compared, the Hobbs Brook Subbasin (station G) contributed more than three times the amount of dissolved sodium than that contributed by the Stony Brook Subbasin (station H) (fig. 4*B*).

At all but two monitoring stations, H and K, which drain low-density residential parts of the Stony Brook Subbasin, 80 percent of sodium concentrations exceeded the USEPA guideline (fig. 3). The stations with the highest concentrations (B, C, and D) were heavily affected by runoff from State Routes 2 and 128. In fact, annual subbasin yields of sodium and chloride were statistically highly correlated with the percentage of subbasin area occupied by roads (Waldron and Bent, 2001).

This correlation indicates that the application of sodium chloride in road salt was a significant source of these ions. The greater contribution from the Hobbs Brook Subbasin also reflects the relatively high density of State-maintained highways in that subbasin (4.3 percent of total area) in comparison to that of the Stony Brook Subbasin (0.4 percent of total area.)

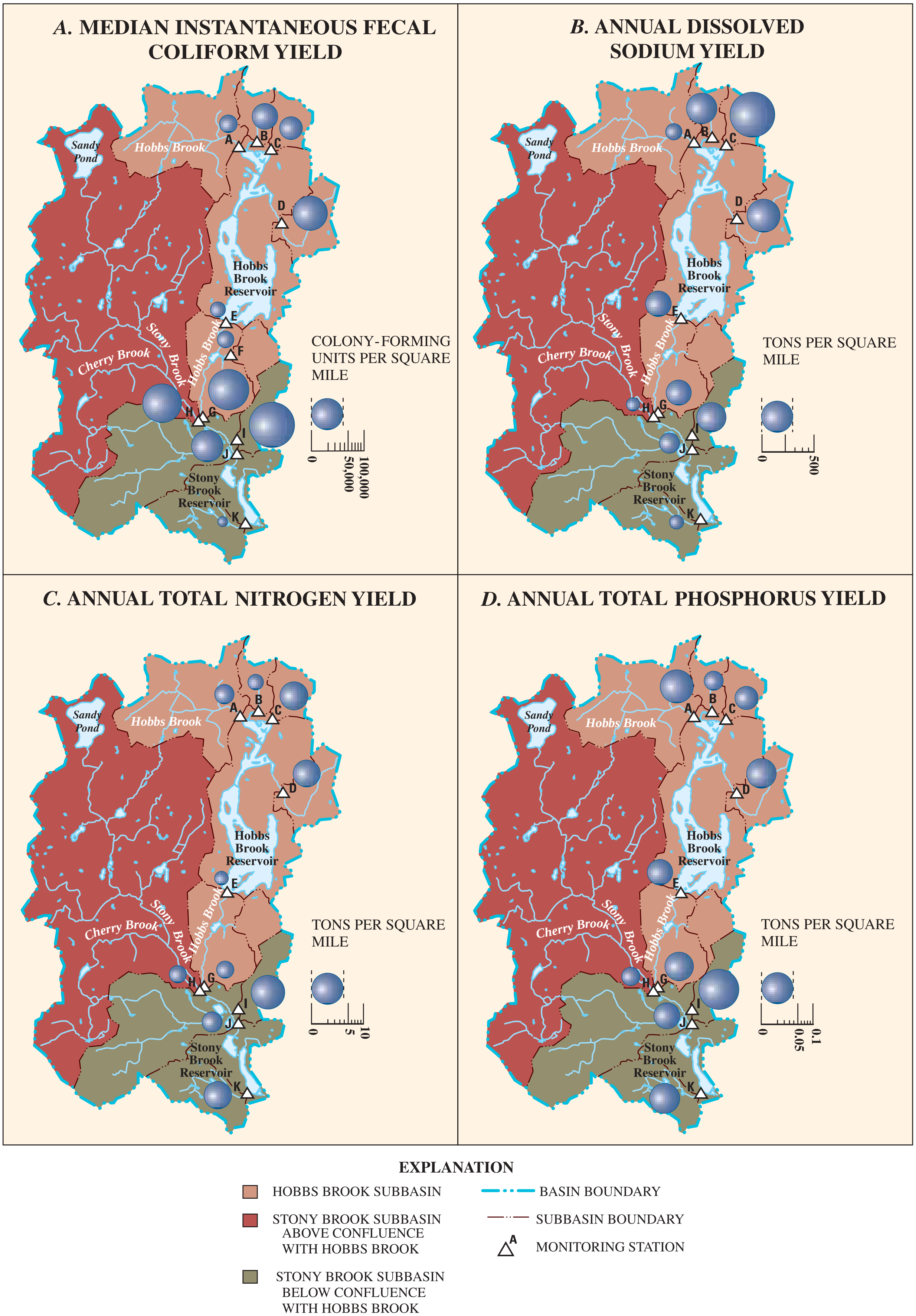

Figure 4. Median instantaneous subbasin yields of fecal-coliform bacteria (*A*) and annual subbasin yields of (*B*) dissolved sodium, (*C*) total nitrogen, and (*D*) total phosphorus for streams in the Cambridge, Massachusetts, drinking-water source area.

Nitrate Levels Low throughout System, but Phosphorus High in Hobbs Brook Subbasin

Nitrate concentrations did not exceed the USEPA's MCL at any station during the study period. Typically, concentrations were less than one tenth of the MCL.

Total annual subbasin yields of total nitrogen from the Hobbs Brook Subbasin (station G) and the Stony Brook Subbasin above the Hobbs Brook confluence (station H) differed little (fig. 4*C*). In contrast, the annual subbasin yield of total phosphorus for the Hobbs Brook Subbasin was nearly three times that of the Stony Brook Subbasin (fig. 4*D*). Subbasin yields of both constituents from a small, largely residential subbasin (station K) that discharges directly into Stony Brook Reservoir were unexpectedly high, as were those from a largely industrial subbasin (station I). The high subbasin yield from station K probably reflected excessive use of lawn and plant fertilizers in the subbasin. The subbasin represented by station I is steeply sloped and largely paved, and so would be expected to convey contaminated stormwater rapidly to the tributary.

Nitrogen and phophorus, which enter streams in agricultural and urban runoff, atmospheric deposition, and wastewater discharges, can cause algal blooms and excessive growth of higher aquatic plants. Nitrate-nitrogen can cause health problems in infants.

Manganese Concentrations High in Hobbs Brook Subbasin

Many samples from streams in the Hobbs Brook Subbasin had manganese concentrations above the USEPA's SMCL. Of the two subbasins, the Hobbs Brook Subbasin contributed more manganese to the source area than did the Stony Brook Subbasin.

Manganese concentrations exceeded the USEPA's SMCL in more than 80 percent of samples collected at stations B, C, D, F, and G in the Hobbs Brook Subbasin. Forty to sixty percent of samples collected in the outflow from Hobbs Brook Reservoir (station E) exceeded the SMCL (fig. 3). Samples from station A, also in the Hobbs Brook Subbasin, and samples from station K, a small tributary discharging directly to Stony Brook Reservoir, rarely exceeded the SMCL.

Manganese occurs naturally in the study area and enters the streams in ground-water discharge. The differences in manganese concentrations may relate to the amount of oxygen-depleted ground water that enters the streams near the sampling points. Manganese is highly soluble in oxygen-depleted water, but precipitates out when the water becomes oxygenated.

Reservoir Water Quality

A water-quality and ecological assessment of the system's three reservoirs identified seasonal variations in sodium, chloride, and other constituent concentrations in the reservoirs, and showed that ecological conditions improve as water moves through the system. Waldron and Bent (2001) discuss sample collection and analysis of physical, chemical, and biological data from the reservoirs.

U.S. Geological Survey and Cambridge Water Department staff collecting reservoir samples.

Seasonal Patterns Evident in Reservoir Water Quality

In many reservoirs, the cooler bottom water becomes isolated from the warmer surface water during spring and summer. In Stony Brook Reservoir and Fresh Pond, air hoses mix the water to prevent this seasonal temperature layering and subsequent loss of dissolved oxygen from the stagnant bottom layer. Despite this mixing, some deep parts of both reservoirs remained isolated from the mixed surface layer. Loss of dissolved oxygen from these deep areas resulted in releases of ammonia-nitrogen, orthophosphate-phosphorus, and dissolved iron and manganese from the reservoir-bed sediments.

The highest reservoir concentrations of sodium and chloride were found in winter and spring, which suggests that winter and spring applications of road salt contributed most of the sodium and chloride in the system. The concentrations of sodium and chloride were higher in the Hobbs Brook Reservoir than in the Stony Brook Reservoir, but water from the less heavily developed Stony Brook Subbasin dilutes outflow from Hobbs Brook Reservoir and improves this condition to some extent.

Median concentrations of sodium exceeded the USEPA's DWEL of 20 mg/L in all three reservoirs. Concentrations of chloride, however, were consistently below the drinking-water SMCL.

Ecological Conditions Improve as Water Moves through the System

Throughout the Cambridge reservoir system, sedimentation and incorporation of nutrients and other potential contaminants into bottom sediments greatly affects water quality. Water from the Hobbs Brook Reservoir cascades through three basins before flowing into Stony Brook Reservoir. As water moves through each basin, nutrients and contaminants settle out of it. As a result, water from the Stony Brook Reservoir is of higher quality than the water entering the Hobbs Brook Reservoir.

Calculations of the reservoirs' ecological condition, as indicated by the Trophic State Index (Carlson, 1977), show the effects of the cascading. According to the calculations, the upper and middle basins of Hobbs Brook Reservoir were the most likely to produce blooms of nuisance algae. Although these basins were moderately to highly productive, the lower basin of Hobbs Brook Reservoir and Stony Brook Reservoir were intermediate in productivity. Fresh Pond was relatively unproductive and unlikely to produce algal blooms.

Concentrations of orthophosphate-phosphorus likely control the growth of nuisance algae in these water bodies. In inland waters, phosphorus usually is the nutrient in shortest supply relative to the nutritional requirements of algae, and the molar ratio of nitrogen to phosphorus is a good indicator of the extent to which phosphorus may limit algal growth (Cooke and others, 1986). Ratios measured in Hobbs Brook and Stony Brook Reservoirs, and in Fresh Pond, indicate that algae in these water bodies run out of phosphorus long before they run out of nitrogen. As a result, it is likely that small increases in phosphorus loading from the drainage basins could stimulate algal blooms in the reservoirs, but increases in nitrogen loading alone probably will not.

Nitrogen and phosphorus may enter the water supply from bird and animal waste, precipitation, bank erosion, fertilizer, and stormwater runoff. They may cause increased turbidity, depletion of dissolved oxygen, and mobilization of contaminants from reservoir sediments (Cooke and others, 1986). During the study period, waterfowl and precipitation contributed insignificant amounts of nitrogen to Hobbs Brook Reservoir, but they contributed significant amounts of phosphorus relative to other sources.

Study Results Aid Development of Innovative Water-Quality Monitoring Program

From the results of this study, 10 of the tributary stations were selected for the water-quality monitoring program. These stations represent streams that contribute water directly to the reservoirs and major tributaries, or integrate large areas of the drainage basin. Also, eight monitoring stations representative of the three reservoirs were identified and incorporated into the program.

In this program, the CWD is using established USGS protocols and standards for sample collection. By using these methods, the CWD can compare their data with previously collected USGS baseline data. This progressive program has made the CWD unique among local water-resource managers in the Northeast.

The monitoring program has four main elements. They include: (1) routine monitoring of reservoirs and tributary streams during dry weather, (2) monitoring of streams, storm drains, and other outfalls, during storms, (3) continuous recording of stage and selected water-quality characteristics at critical sites, and (4) periodic monitoring of ground-water quality near Fresh Pond.

The CWD staff analyzes the samples at the CWD Laboratory (fig. 5), which is in a new water-treatment plant on Fresh Pond. The laboratory1 supports the CWD's Watershed, Treatment, and Distribution Divisions. A wide range of analytical equipment in the facility supports the increased demands of both the new treatment plant and the expanded watershed-monitoring program.

USGS and CWD Team Up on Stormwater Runoff

The USGS and the CWD are also studying the effects of stormwater runoff on water quality in the tributaries and reservoirs. Roads, buildings, and other structures impervious to precipitation cover more than 8 percent of the Cambridge drinking-water source area. Rather than soaking into the ground, rain and snow that fall on the drainage basin may flow across these surfaces directly to the streams. As it flows, the water picks up and transports a variety of contaminants, including oil, grease, gasoline, cleaning agents, pesticides, plant nutrients from fertilizers, and bacteria from bird and animal waste.

This new study will measure changes in streamflow and the amounts of contaminants transported to the streams in stormwater runoff from many sources in the drainage basin. This information will be combined with records of continuously monitored stream conditions to provide real-time predictions of stormwater-contaminant loads. This will enable the CWD to monitor the effects of stormwater runoff on the water supply and to quickly identify contamination problems that may occur during storms. The CWD also will use this information as an "early warning system" to help guide management decisions in the event of an accidental release of hazardous material.

Figure 5. Cambridge Water Department Laboratory

References Cited

Carlson, R.E., 1977, A trophic state index for lakes: Limnology and Oceanography, vol. 22, no. 2, p. 361-369.

Cooke, G.D., Welch, E.B., Peterson, S.A., and Newroth, P.R., 1986, Lake and reservoir restoration: Butterworths, Boston, Mass., 392 p.

Waldron, M.C., and Bent, G.C., 2001, Factors affecting reservoir and stream-water quality in the Cambridge, Massachusetts, drinking-water source area and implications for source-water protection: U.S. Geological Survey Water-Resources Investigations Report 00-4262, 89 p.

U.S. Environmental Protection Agency, 1998, Safe drinking water–Sodium in drinking water: Accessed online March 30, 2002, at http://www.epa.gov/safewater/ccl/sodium.html/.

U.S. Environmental Protection Agency, 2001, Current drinking water standards–National secondary drinking-water regulations: Accessed online March 30, 2002 at http://www.epa.gov/safewater/mcl.html/.

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