DEVENS

Water Resources Protection Report

Prepared for

The Joint Boards of Selectmen

- **Town of Ayer**
- **Town of Harvard**
- **Town of Lancaster**
- **Town of Shirley**

The Massachusetts Government Land Bank

Prepared by

Vanasse Hangen Brustlin, Inc.

Watertown, Massachusetts

and

Haley & Aldrich, Inc.

Cambridge, Massachusetts

November 1994

WATER RESOURCES PROTECTION REPORT

Ayer, Harvard, Lancaster and Shirley, Massachusetts

Prepared for

The Massachusetts Government Land Bank
Joint Boards of Selectmen

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November, 1994

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INTRODUCTION

The preparation of a Water Resources Protection Report as part of the Devens reuse planning process has presented a unique opportunity for the Commonwealth of Massachusetts and Towns of Ayer, Harvard, Shirley, and Lancaster to develop a comprehensive management framework that protects ground and surface water resources while allowing active redevelopment of Devens. The information in this report is the result of input from the Water Resources Task Force, a group of private citizens and interest group representatives concerned with the protection and ongoing management of the water resources at Devens; data gathered by the Army in its preparation of the Environmental Impact Statement (EIS); guidance from the Massachusetts Department of Environmental Protection (MADEP), feedback from the public workshop process, and efforts by the Devens Reuse Center. The report was prepared for the Massachusetts Government Land Bank and the Joint Boards of Selectmen.

This report represents the final phase of water resources protection planning. It consists of an evaluation of existing water resources in the subwatersheds that encompass Devens, including the geology and ecology of the area. It reviews the water supply systems and protection measures currently in place for Devens and the Towns of Ayer, Harvard, and Shirley. The report identifies current and potential ground and surface water contamination sources, and discusses the watershed hydrology and exisiting water supply systems. For existing contamination sources, response measures that have been implemented are reviewed and additional measures are discussed. Protective measures that could be put in place to prevent potential contamination sources from impacting existing and/or future water supply are explored. Projections regarding potential future water supply development, and a risk assessment and management framework are included. The report concludes with the presentation of the Water Resources Protection Plan (WRPP), the culmination of water resources planning efforts over the past year.

PURPOSE

The communities that are affected by the closure of the Main and North Posts of Devens have expressed concerns about adequately protecting the supply of water from the aquifer underlying portions of the base. Therefore, water resource research and planning efforts were undertaken to formulate a Water Resources Protection Plan to protect this vital resource. Because the protection of groundwater resources is linked to surface water quality, the WRPP includes all areas of Devens and deals with both surface and ground water resources.

The purpose of this report is to present the findings of the research and planning efforts which guided the development of the WRPP, and to present the final WRPP to enable the communities, citizens, special interest organizations and state agencies to make informed decisions on the development of the Devens Regional Enterprise Zone, Water Resources Protection Bylaws. These Bylaws will ultimately be developed into regulations which will guide the implementation Reuse Plan.

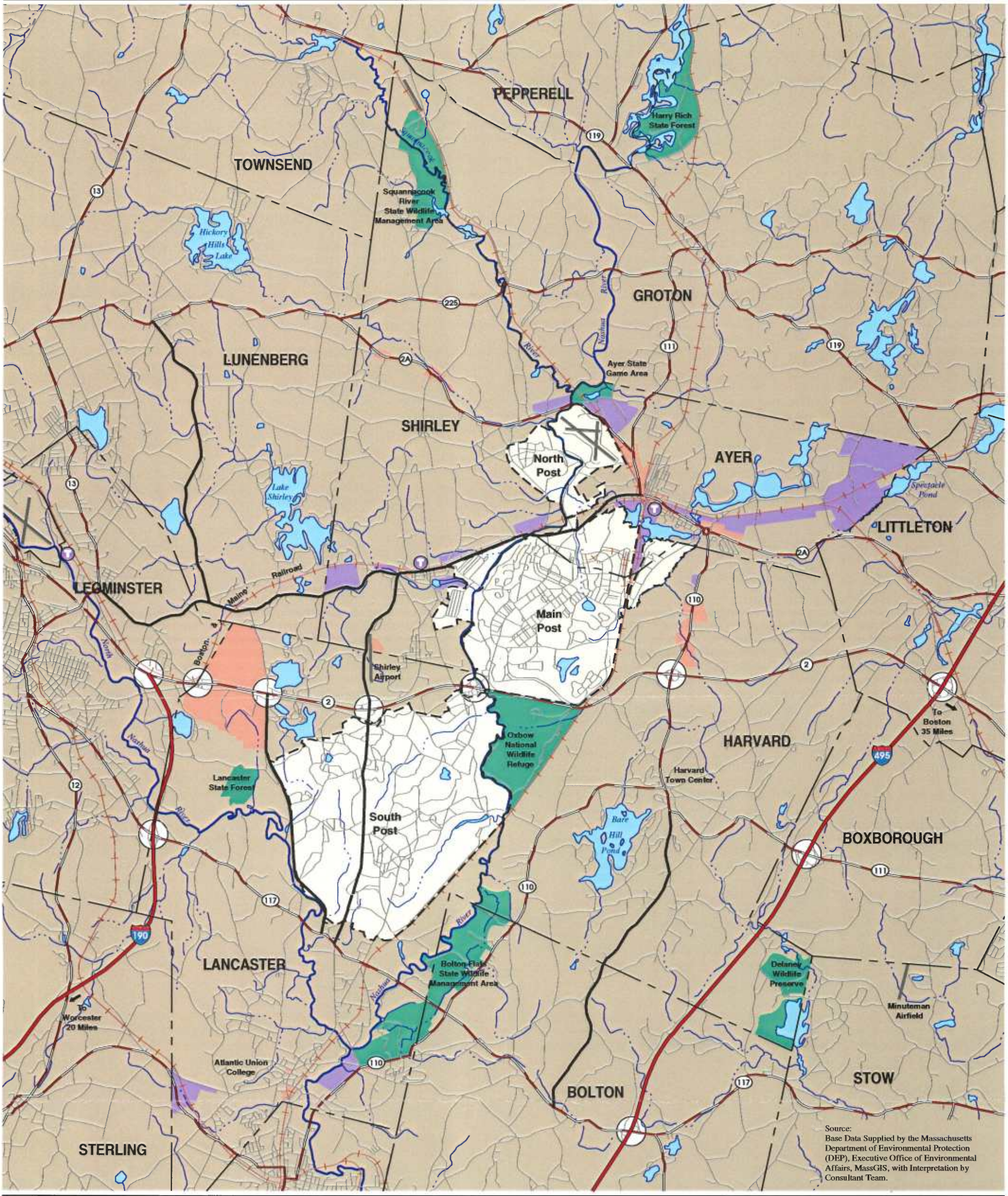
BACKGROUND

Devens is in the north central region of Massachusetts, bordered by the Towns of Ayer and Shirley in Middlesex County and the Towns of Harvard and Lancaster in Worcester County (see Figure 1). When Fort Devens was established in 1917, the surrounding municipalities were required to surrender control of over 9,300 acres of land to the military. Since that time the land has been used by the U.S. Army and, as a result, has been extensively developed. Today Devens resembles a small city with a daytime population in recent years of approximately 15,000 people.

Devens is composed of three distinct land areas commonly referred to as the Main, North, and South Posts. Portions of the Main and North Posts which total approximately 4,400 acres, will be deactivated in 1995 as a result of the 1991 recommendation by the Federal Base Realignment and Closure Commission. South Post, approximately 4,900 acres south of Route 2, will remain under the control of the U.S. Army to be used for training purposes.

Although the population has fluctuated over time, Devens developed the necessary infrastructure to support a population of 30,000. The installation has evolved into a self-sufficient community with over 7 million square feet of building plus ancillary facilities. Because Devens was designed to operate in a self-sufficient manner, the infrastructure and public works facilities, including water supply and distribution, were separate from the surrounding communities.

Historic operations at Devens required the use of underlying aquifers for water supply. Today four wells draw water from this aquifer to supply the installation, however only three of these wells are currently active. The Army's development of the land has resulted in extensive impervious surfaces over the aquifer and surrounding watersheds, with few measures taken to protect water quality or recharge runoff to the ground. Extensive areas of potential and existing contamination have been found in areas overlying the aquifer. The Devens Water Resources Protection Plan, developed by the Joint Boards of Selectmen, Harvard, Shirley, Ayer and the Land Bank, addresses ways in which future uses of Devens can maintain increased protection of the aquifer and provides guidance on protection of the aquifer during site cleanup and development.



- Federal or State Conservation Area
- Industrial *(Proposed or Existing)*
- Commercial/Business *(Proposed or Existing)*
- Existing Fort Devens Reservation
- River
- Town Boundary
- Interstate Highway
- Major Road
- Railroad Line
- Commuter Rail Station

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Devens Base Reuse Center

Ayer • Harvard • Lancaster • Shirley

Figure 1
Regional Context

November, 1994

0 3500 7000 Feet

15 130 Acres

REGMAP

WATERSHED CHARACTERISTICS

The following section describes the existing watershed characteristics of the portion of the Nashua River Watershed that encompasses Devens, including the underlying geologic deposits, existing natural systems, and the potential contamination sources. This information is used to develop management strategies to protect the ground water resources at Devens.

GEOLOGIC SETTING

The site is just east of the Worcester County Plateau within the Upland Subprovince of the New England Physiographic Province. Bedrock in the region consists of low to medium grade quartzofeldspathic metamorphic rocks, which are highly folded in some areas. Bedrock units underlying Devens include the Worcester, Oakdale, Berwick, Chelmsford Granite, and Ayer Granite Formations. The site is approximately 2 miles west of the Clinton-Newbury/Bloody Bluff Fault Zone, which follows a northeast-southwest trending arc across eastern Massachusetts. Depth to bedrock is generally fairly shallow in the upland areas, and is generally greatest near the center of the Nashua River valley, and along the valleys of the tributaries to the Nashua. Surficial geologic deposits are dominated by stratified glacial deposits associated with the drainage of Glacial Lake Nashua; and glacial till, a dense, heterogeneous mixture of boulders, cobbles, gravel, sand, and silt, which was deposited directly on bedrock by glacial ice as it advanced over the region during the Pleistocene Period (approximately 10,000 to 12,000 years ago). The stratified deposits include glacial outwash deposits and glaciolacustrine deposits, which are found in broad, low-lying areas, and along many river and tributary valleys (1,2,3,4).

The glacial outwash deposits generally consist of coarse to fine sand and gravel. These materials were deposited by glacial meltwater streams, which generally drained east and south as the ice receded to the north, exposing outlets for the various stages of Glacial Lake Nashua (4). The thickest sequences (up to 200 ft.) of these deposits are typically found along a bedrock valley that is parallel to, and slightly west of, the Nashua River (5). Glaciolacustrine deposits are typically fine-grained, comprised of fine sand, silt, and clay which settled out of the still waters of the deeper portions of Glacial Lake Nashua.

Surface Water

Devens is within the 538 square mile Nashua River Basin. The Nashua River flows along the western border of the Main Post, and bisects the North Post. It flows from south to north through Devens to the Merrimac River at Nashua, New Hampshire. The Massachusetts DEP has classified the Nashua River as a Class B waterway, suitable for swimming and fishing.

Tributaries to the Nashua River within Devens include: Cold Spring Brook, Bowers Brook, Willow Brook, and Nonacoicus Brook. Willow Brook has been extensively channelized and culverted over the years. The Nashua River also receives surface water flows from the west via Catacoonamug Brook, Trout Brook, and Walker Brook. Open waters on or near the site include Mirror Lake and Little Mirror Lake, Robbins Pond, Plow Shop Pond, and Grove Pond.

Wetlands

The Nashua River and its tributaries are important wetland resources for the region. The majority of wetlands on the Main and North Posts are Palustrine forested wetlands occurring along the stream and floodplain corridors. Also present are flood oxbows, emergent wetlands, shrub wetlands, and a small area of red spruce bog. Based on digital mapping supplied by the DEP and reported in the EIS, these wetlands, including open water, total approximately 438 acres.

In addition to their important water quality and stormwater management functions, these wetlands have been found to have significant wildlife resources by the U.S. Fish and Wildlife Service (USFWS). The USFWS has moved to further protect these resources by requesting land for expansion of the Oxbow National Wildlife Refuge and including land along the Nashua River corridor. These wetland resources represent an opportunity for open space, habitat and recreation purposes.

Vegetation

The transformation of the Devens landscape from its early twentieth century agricultural use to its current developed land areas and successional forest cover types is the result of Army facilities development and forest management practices. The Main and North Posts contain a variety of vegetation types that can provide diverse landscape settings for reuse, development, recreation, and open space.

The Main and North Posts are dominated by developed land cover types associated with the Army cantonment and airfield areas. The vegetation patterns are typically campus-like with open lawns and mature specimen trees associated with various building complexes, interspersed with forest areas in various stages of succession. Other major open areas include the golf courses, Rogers Field parade grounds and open areas in the industrial precinct. Much of the forest cover coincides with the Nashua River floodplain and the various stream corridors that course through the site.

Rare and Endangered Flora and Fauna

The U.S. Army Corps of Engineers has recently prepared a biological and endangered species baseline study of Devens. According to this study, there is no known occurrence of federally listed threatened or endangered plant or animal species on the North or Main Posts.

There are areas of potential habitat for rare and endangered flora and fauna under the Commonwealth of Massachusetts Endangered Species Act. Approximately 430 acres of the Main and North Posts are potential habitat for rare and endangered flora and fauna. The majority of the potential habitat occurs in areas that are currently protected by wetlands regulations, or in areas along stream corridors and the Nashua River floodplain that are proposed for inclusion in the USFWS property requests.

POTENTIAL CONTAMINATION SOURCES

Devens is a National Priority List (NPL) site, a Comprehensive Environmental Response Compensation, Liability Information System (CERCLIS) site and a confirmed Massachusetts Department of Environmental Protection (DEP) disposal site. The site was added to the final NPL list on November 21, 1989, and became a confirmed, state-listed disposal site on October 15, 1989. Soil, ground water and surface water have been contaminated with heavy metals, VOCs, petroleum products, asbestos and explosive residue from 59 separate source areas, identified as of December 1993. Source areas include an 8 acre maintenance yard, a 50 acre sanitary landfill, historic gas stations, and a firefighter training area. Areas of Contamination (AOCs), Study Areas (SAs), and Base Realignment and Closure (BRAC) Cleanup Sites at Devens are shown in Figure 2. These designations are based on an Army database dated December 1993.

A potential contamination source in the region is stormwater runoff from private and public roads, including Route 2, which borders the southern boundary of the Main Post. Stormwater runoff contributes nutrients, dissolved and suspended solids, heavy metals, sodium chloride, and low concentrations of volatile organic compounds (VOCs) to surface water and ground water resources (6). More importantly, if containment structures are not in place, stormwater drainage systems can provide a conduit for transport of oil or hazardous material in the event of an accident.

Potential contaminants from railroad yards and maintenance areas include acids, bases, chloride, metals, nitrate, pesticides and herbicides, phenols, sodium, sulfate, surfactants, and VOCs (6). The B&M/Springfield Terminal Railway Company owns and operates a rail yard (the Hill Yard) adjacent to the Industrial Zone of the Main Post, in proximity to Grove Pond. The B&M Railroad has been identified as a potentially responsible party for a spill area along the rail line between Plow Shop and Grove Ponds (7).

The Moore Airfield, on the North Post, is a potential contamination source given that airports typically have fuel tanks and solvent storage areas for aircraft service and maintenance. Runoff from airports commonly contains metals, pesticides and herbicides, VOCs, and surfactants (6).

Devens' sanitary sewer service areas are shown in Figure 3. Leakage from municipal sewer lines can be considered a threat to public water supply, where piping is old and in poor condition. Sanitary sewers at Devens are reported to be in good condition and therefore are not expected to influence water quality. Sewage from Devens flows to the wastewater treatment plant west of the Nashua River on the North Post. The system discharges primary-treated wastewater to open-air rapid sand infiltration beds, which recharge the effluent to the ground. Common contaminants that may be contributed by municipal sewage include metals (including iron and manganese), nitrate, pathogens (viruses and bacteria), sodium, solvents, and surfactants (6).

The South Post, which is partially in the North Nashua watershed, is not part of the Reuse Plan, but reportedly, spills of petroleum, oil and lubricants occurred where fueling or fuel storage was involved in training exercises (7). Two landfill sites, which received household waste prior to 1930 are also on the South Post (7).

In addition to the above, seven state-listed confirmed disposal sites are within one half mile of Devens (8), as shown in Figure 2. The regulatory status of the sites and the types of contaminants encountered are summarized below:

A. FMC/Tulco, Inc., 9 Bishop Rd, Ayer: Priority disposal site in Phase II (Comprehensive Site Assessment Phase) of the MCP (confirmation date: 15 January 1987). Soil and ground water were contaminated with arsenic, organics and pesticides from a landfill and pit.

B. Exxon gas station, 20-30 Park St, Ayer: Priority disposal site in Phase I (Initial Site Assessment Phase) of the Massachusetts Contingency Plan (MCP) (confirmation date: 15 July 1993). Soil and ground water were impacted from a leaking underground storage tank (UST).

C. Mr. Mike's Citgo, Harvard Rd, Ayer: Priority disposal site in Phase II of the MCP.

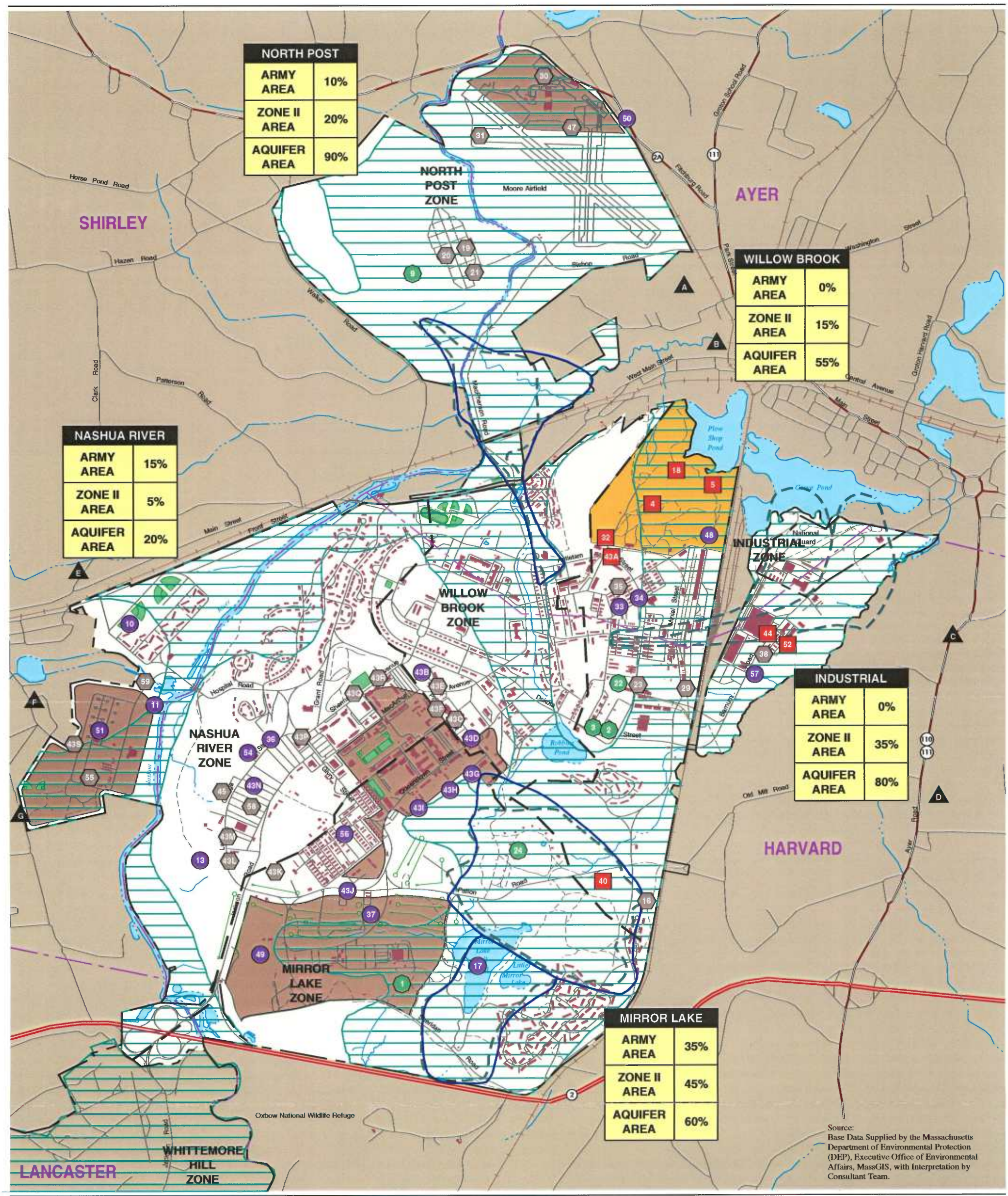
D. Calahan Property, 262 Ayer Rd, Harvard: Unclassified site in Phase I of the MCP. Soil and ground water were contaminated with volatile organic compounds from a leaking UST and other identified source(s).

E. Shirley Highway Department, 26 Clark St, Shirley: Unclassified site in Phase I of the MCP (confirmation date: 15 July 1993). Soil was contaminated by gasoline from a leaking UST.

F. Samson Ocean Systems, Inc., Shaker Rd, Shirley: Published non-priority site in Phase II of the MCP (confirmation date: 15 April 1987). Soil and ground water were contaminated with metals, petroleum products and volatile organic compounds from unidentified sources.

G. MCI Shirley Department of Correction, Harvard Rd., Shirley: Unclassified site in Phase I of the MCP (confirmation date: 15 July 1993). Soil and ground water were contaminated with petroleum products from a leaking UST.

Confirmed DEP Disposal Site C which is proximate to the limit of the aquifer areas, is approximately one half mile south of Grove Pond, and is likely upgradient of the Grove Pond area. While Site D may also be upgradient, it is



54 Study Areas (SA)

32 Areas of Contamination (AOC)

58 No Further Action (NFA)

9 BRAC Closure Actions (NFA - CERCLA)

A State Listed Confirmed Disposal Sites

Department of Defense Enclave

Approximate Limits of Aquifer

CERCLA SA's & AOC's in Vicinity of Shepley's Hill Landfill

Zone Lines

Zone II Safe Yield Pumpage, ETA 1994

Zone II Permitted Pumpage, ETA 1994

Note:
The number of AOC's, SA's, NFA's NFA's-Closure required, based on AEC database, December 1993.

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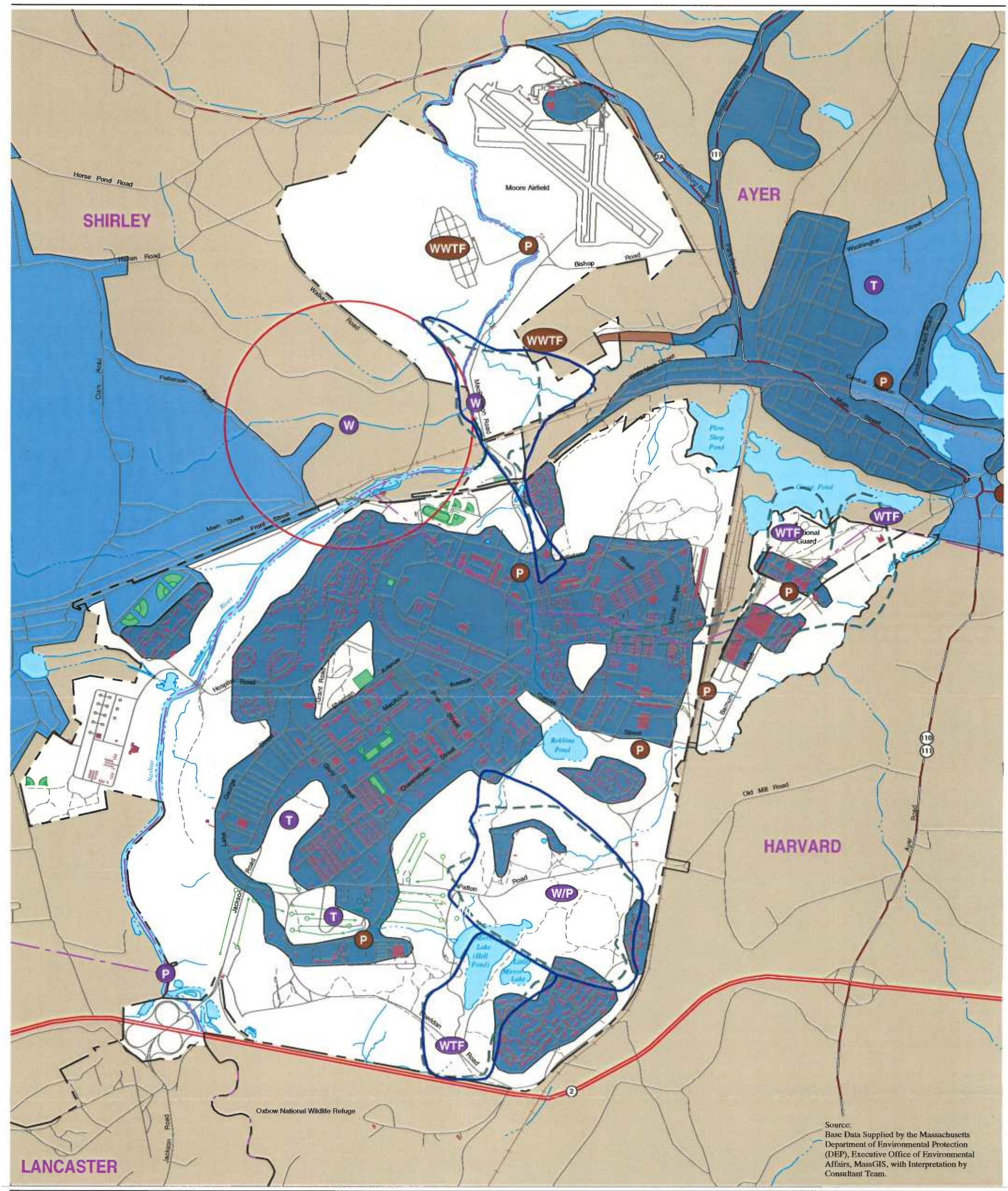
Figure 2
Reuse Implications From Superfund Sites & Aquifers

November, 1994

0 1000 2000 Feet

1 10 Acres

3598SUP



- WWTF Wastewater Treatment Facility
- P Sanitary Sewer Pump Station
- WTF Well and Water Treatment Facility
- P Water Pump Station
- W Well
- T Water Tank or Standpipe
- Region Serviced by Both Water and Sewer Systems
- Region Serviced by Public Water System
- Region Serviced by Sanitary Sewer System
- Zone II Safe Yield Pumpage, ETA 1994
- Zone II Permitted Pumpage, ETA 1994
- Interim Zone II

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Figure 3
Water & Sanitary Sewer Service Areas

November, 1994

0 1000 2000 Feet

1 10 Acres

3598WS

within the till/bedrock areas, and is over one mile from Grove Pond, and therefore unlikely to be a significant source of contamination.

Erosion of steep, poorly vegetated slopes can result in siltation of surface water bodies, but is generally not regarded as a potential threat to ground water supplies. In general, the site is not characterized by steeply sloping topography. Areas with slopes that are greater than 15 percent include the Nashua River corridor, Shepley's Hill, and the southeast portion of the Main Post, in the Mirror Lake/Robbins Pond region, and just south of Cutler Army Hospital. These areas generally are forested, except for a gravel mining operation on the western banks of Big Mirror Lake (7).

While extensive sources of potential contamination have been identified at and near Devens, minimal impact on water quality at the on-site water supply wells has been identified, based on water quality data collected to date. In future water supply planning work, locations of USTs and other Confirmed Disposal Sites or Locations To Be Investigated (LTBIs) in aquifer areas may be further documented, if additional water supply well sites are to be investigated. Care will have to be taken during site cleanup and future development to avoid contamination of ground water resources. Measures to promote continued protection of the water resource are provided later in this report.

GROUND WATER PROTECTION DURING REMEDIATION

There is general concern that remediation measures may adversely impact the aquifer. Remediation measures implemented in aquifer areas should be undertaken in a manner that will minimize potential impacts on the underlying aquifer, and impacts to surface water runoff that drains into the aquifer. As on-going remediation efforts continue, we recommend inclusion of the following components in management plans geared toward aquifer protection:

- Description of the site history and site conditions including types of contaminants encountered, concentrations and standards, and lateral and vertical extent of contamination.

- Field screening and analytical methods for evaluating contaminant levels in soil and ground water.

- Decontamination methods for personnel and equipment, designated decontamination areas, and containerization methods for contaminated clothing and wash water.

- Criteria for segregating contaminated soils, and methods for containing the soils. For example, excavated contaminated material should be stockpiled and covered with impervious material, or transferred to covered rolloff containers. In addition, open excavations should be covered so that precipitation will not reach excavated areas.

- Methods for treating or containerizing contaminated water generated on projects where dewatering is required.

- Methods for controlling runoff during site remediation. For example, sediment transport in surface water runoff from remediation sites should be

mitigated by typical siltation controls such as placement of hay bales and silt fence between the work areas and surface water bodies.

- Criteria for evaluating reuse, treatment and disposal options for contaminated soil and ground water.

- List of applicable local, state, and federal regulations, and referenced documents.

On contaminated sites where remediation may not be practical or feasible, aquifer protection measures could include capping contaminated areas to prevent infiltration of precipitation through contaminated soils. To maintain or increase aquifer recharge rates at these sites, runoff from the capped areas could be directed to on-site recharge basins in areas underlain by clean soil or fill materials. Installation of oil/water separators at recharge basins or stormwater discharge points could also be implemented on contaminated sites where runoff may contain petroleum or solvent compounds.

PROPOSED REUSE PLAN

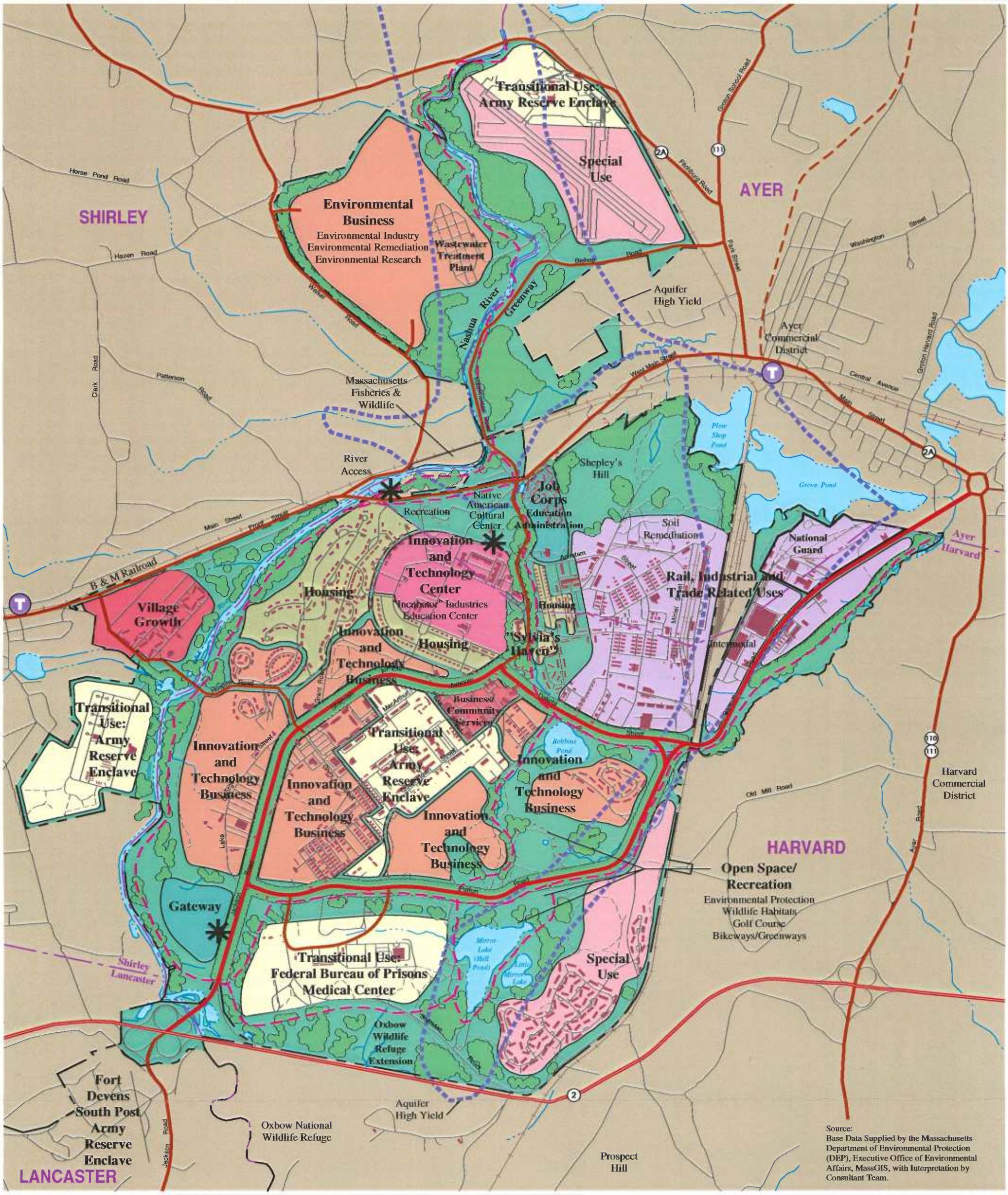
The Reuse Plan for Devens offers a program that balances the protection and enhancement of the natural resource base with the provision for economic opportunity for this region of Massachusetts. The Reuse Plan contains land uses that reflect federal government requests, enhancement of the site's natural resources, development of innovation and technology businesses, and development of rail-related industries. Taking advantage of an existing system of infrastructure and access, the Devens Reuse Plan (Figure 4) proposes a mix of land uses that will generate employment opportunities. In addition, the plan incorporates the needs and interests of the federal, state, and local governments.

Land Use

The inclusion of open space zones, innovation and technology business areas, rail-related/industrial uses, residential areas, and a variety of other uses in the Reuse Plan, reflects the commitment to diversity. The open space system presented in the Reuse Plan, includes all land proposed for active and passive open space, as an integrated network of open space, rather than one managed by individual land owners. A water resources protection plan has been developed and will be implemented for all uses that locate on Devens regardless of whether they occupy land over the medium and high yield aquifers.

Open Space

The Reuse Plan provides for the retention of over 33 percent of the site as dedicated open space. The open space system provides protection to Devens' environmentally sensitive areas and encourages the creation of active and passive recreational areas throughout the site. A north to south open space corridor along the Nashua River is proposed as part of the request of the USFWS to acquire the river's associated floodplain. The USFWS also has requested the parcel to the north of Route 2. Both land areas will become an extension of the Oxbow Wildlife Refuge. An open space "necklace" is created by extending open space northerly around Mirror Lake and along Willow Brook,



- Open Space & Recreation
- Innovation & Technology Business
- Rail, Industrial & Trade-Related Uses
- Environmental Business
- Housing
- Business/Community Services
- Transitional Use Army Reserve Enclave & Federal Bureau of Prisons Medical Center
- Innovation & Technology Center
- Gateway
- Special Use
- High Yield Aquifer
- Conceptual Trails & Bikeways
- Commuter Rail

Note:
See Parcel Maps for Delineation of Zoning Districts.

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Figure 4
Devens Reuse Plan

November, 1994

0 1000 2000 Feet

1 10 Acres

connecting to the recreation areas near the Verbeck Gate. As a result, an open space system is created with a variety of natural and man-made features along its course.

The Reuse Plan calls for the development of an open space plan within one year after adoption. As part of this plan, active and passive recreation areas will be identified and sensitive resources such as valuable wetlands will be studied and mapped. Legal methods will be identified and implemented to place permanent protection on these sensitive resources.

Devens and the surrounding area are within the Upland Subprovince of the New England physiographic province, and are characterized by gently rolling terrain intersected by the Nashua River and several smaller stream valleys. The geology of the Upland Subprovince consists of unconsolidated glacial till and outwash deposits overlying folded and faulted bedrock. Throughout a significant portion of Devens and the surrounding area, these unconsolidated glacial deposits have proved conducive to the development of highly productive aquifers. Devens and the Towns of Ayer and Shirley all obtain their potable water supply from these aquifers.

WATERSHED BOUNDARIES AND DRAINAGE PATTERNS

Devens lies within the Nashua River drainage basin, which occupies approximately 538 square miles in central Massachusetts and south-central New Hampshire. The Nashua River is made up of two main branches, the North Branch and the South Branch, which merge just south of Lancaster in the vicinity of the Devens South Post, to form the Main Stem. The Main Stem flows northward, towards Nashua, New Hampshire, where it discharges into the Merrimac River. The Nashua River watershed is subdivided into twenty subwatersheds. The three subwatersheds that encompass Devens include: the North Nashua, the Main Stem, and the Bowers Brook/Nonacoicus subwatershed (see Figure 5). According to 314 CMR 1.00-7.00, the Nashua River has been classified as a Class B waterway, suitable for fishing and swimming.

The North Nashua watershed extends from West Fitchburg, where the North Nashua originates, to Lancaster, where it meets with the South Branch. Tributaries along the segment of the river that originate near or on the South Post include McGovern Brook, Spectacle Brook, and Ponakin Brook (which originates on the South Post). Surface water bodies include Little Spectacle Pond, Spectacle Pond and Oak Hill Pond (a kettle pond on the South Post). The 7-day low flow (with a 10 percent annual probability) of the north branch of the Nashua River at a stream gauging station in Leominster is reportedly 35 cubic ft. per second (cfs) (5).

The Main Stem subwatershed extends from the convergence point of the south and north branches northward to Nashua, New Hampshire. Devens abuts the southern third of this subwatershed (from the convergence point of the North and South Branches to the discharge point of Mulpus Brook). The South Branch provides water to the Wachusett Reservoir, located south and upstream of Devens. Flow of the South Branch, downstream of the reservoir, is approximately 12 million gallons per week (on average approximately 2.6 cfs),

which is released from the reservoir by the Metropolitan District Commission (MDC) under a mandate established when the reservoir was constructed. The Main Stem flows northward through the South Post proximate to the Oxbow National Wildlife Refuge and along the western border of the Main Post and bisects the North Post. Tributaries along this segment include the Still River, three unidentified streams (which originate on the South Post), Catacoonamug Brook, Trout Brook, Walker Brook, Nonacoicus Brook, Mulpus Brook, and the Squannacook River. The only pond in this portion of the subwatershed is Cranberry Pond, which is a kettle pond on the South Post. The 7-day low flow reported for a stream gauging station on the Main Stem, approximately 4 miles north of the site in Pepperell, is 43 cfs (5).

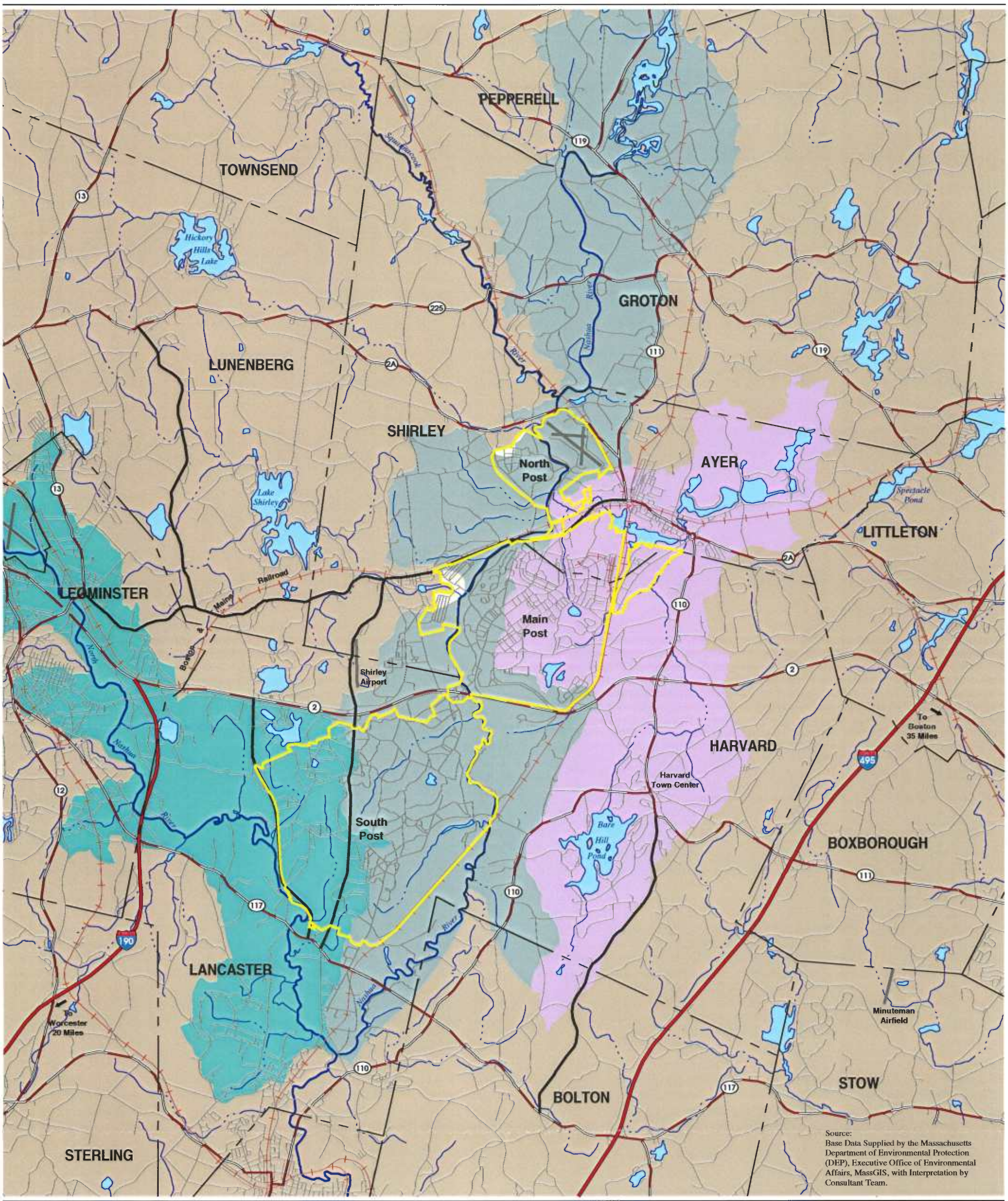
The flow rate at this gauging station is affected by storage of water behind dams, such as the Ayer Ice House dam, which is located upstream of the Pepperell gauging station near the northern tip of the Main Post at Fort Devens. The Ice House dam is not actively used to generate electricity; however, it does restrict stream flow, affecting the streamflow duration characteristics of downstream gauging stations.

The Bowers Brook/Nonacoicus (BB/N) subwatershed extends from the Vaughn Hills in the south (where Bowers Brook originates), to Long Pond in the east, and to the confluence of Nonacoicus Brook and the Nashua River in the west. Nonacoicus Brook receives flow from Willow Brook and from a series of interconnected ponds - Plow Shop Pond, Grove Pond, Flannagan Pond, and Sandy Pond. Bowers Brook, which originates south of Harvard and Bare Hill Pond, flows through Bare Hill Pond and discharges into Cold Spring Brook, which flows in a northeasterly direction until it discharges into Grove Pond. Other surface water bodies in the BB/N subwatershed include Robbins Pond, Mirror Lake, and Little Mirror Lake on the Main Post. Robbins Pond drains into Willow Brook. Mirror Lake and Little Mirror Lake are isolated kettle ponds, which have no connection to the various tributaries. The 7-day low flow reported for Nonacoicus Brook near its confluence with the Nashua River is 0.3 cfs (5).

Published information indicates the region receives approximately 40 to 42 inches of precipitation annually, of which less than 20 inches, on average, is lost to evaporation and evapotranspiration (5,9). The remainder is transported to surface water bodies as surface runoff, or infiltrates the ground and flows as ground water, eventually discharging to the streams and rivers as baseflow. The percentage of streamflow that is comprised of ground water baseflow varies seasonally, and is typically highest in the summer months, when rainfall and snowmelt are minimal, and evapotranspiration rate is high.

AQUIFER AREAS AND WATER SUPPLY WELLS

Ground water supplies in the region have primarily been developed from glacial outwash deposits. The amount of water available from surficial deposits generally depends upon the grain size, degree of sorting (a well sorted material has a very consistent grain size; a poorly sorted material has a wide range of grain sizes, from clay-sized particles to boulders), and saturated thickness. The glacial outwash deposits in the vicinity of Devens are well suited for aquifer development because they are generally coarse-grained, well sorted, and frequently in low-lying areas where ground water discharges to surface water bodies such as rivers, lakes, and wetlands. Saturated thickness is therefore



Fort Devens Boundary

North Nashua
(To Leominster)

Main Stem

Bowers Brook / Nonaicoicus

River

Town Boundary

Interstate Highway

Major Road

Railroad Line

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Figure 5
Drainage Divides

November, 1994

0 3500 7000 Feet

15 130 Acres

BASINS

generally greatest in these low-lying areas where the water table is shallow and typically similar in elevation to surface water bodies. Ground water recharge to these aquifers is estimated to range from approximately 13 to 20 in./yr. (5,9).

The areal extent of glacial outwash deposits and locations of municipal water supply wells in the region are shown in Figure 6. Previous reports have only illustrated aquifer areas that have been classified by the U.S. Geological Survey as medium-yield and high-yield (10,11). For this report, however, the entire aquifer area is of interest. The aquifer areas classified as low-yield may have limited saturated thickness, but they generally have hydraulic conductivity that is similar to the medium and high-yield areas, and they are typically contiguous with these higher yield aquifer areas. The low-yield is also attributable to their position in the watershed, which is typically along the upgradient fringes of the aquifer. The low-yield aquifers are, therefore, significant from a water supply planning perspective because they contribute ground water flow to the more transmissive downgradient aquifer areas.[1]

The direction of ground water flow through the aquifers generally follows topography and surface water drainage. Because the aquifer areas have higher hydraulic conductivity, and more moderate slopes than the surrounding glacial till and bedrock upland areas, ground water recharge and ground water baseflow contributions to surface water are typically greater in the aquifer areas. Therefore, watersheds that contain substantial area overlain by aquifer materials will have proportionately greater potential baseflow than watersheds that are predominantly comprised of glacial till and bedrock.

In general, bedrock in the region has a considerably lower transmissivity than the glacial outwash deposits. Most bedrock wells drilled in the region have provided yields of less than 30,000 gallons per day (gpd); however, the bedrock generally yields enough water for domestic use. Many areas in the Towns of Harvard, Shirley, and Lancaster utilize bedrock water supply wells.

The municipal water supply well for the Town of Harvard, in the vicinity of Bare Hill Pond, is drilled in bedrock and yields approximately 20,000 gpd. In contrast, the other municipal wells in the Main Stem and BB/N subwatersheds, including the four wells at Devens, are screened in glacial outwash deposits and have a potential cumulative yield of approximately 5 million gallons per day (mgd). This includes the Grove Pond Wells which are for emergency purposes only. Hydraulic data for municipal wells and well fields in the vicinity of Devens, including well depths, aquifer types, average and maximum withdrawal rates, and estimated aquifer transmissivity are summarized in Table 1.

1/ Transmissivity is defined as the product of aquifer saturated thickness and hydraulic conductivity, which is a measure of the ease with which water flows through saturated soil or rock.

Table 1 **SUMMARY OF MUNICIPAL WATER SUPPLY WELL DATA**

Well Field	Sub-Watershed	Aquifer Type	Average Withdrawal Rate (mgd)	Maximum Withdrawal Rate (mgd)	Transmissivity (ft^2/day)	Well Depths (ft)
Devens-MacPherson	Main Stem (39%); Bowers Bk./Non. (61%)	glacial deposits	0.34	1.4	4,000+	93
Devens-Grove Pond	Bowers Bk./Non.	glacial deposits	0.02	1.0	4,000+	35-43
Devens-Patton	Bowers Bk./Non.	glacial deposits	0.82	1.4	4,000+	67
Devens-Sheboken	Main Stem (40%); Bowers Bk./Non. (60%)	glacial deposits	0.37	1.4	4,000+	76
Ayer-Grove Pond	Bowers Bk./Non.	glacial deposits	1.89	2.02	21,000-51,600	60-60.5
Harvard-Pond Road	Bowers Bk./Non.	bedrock	0.02	0.04	NA	147
Harvard-DPW Well	Bowers Bk./Non.	glacial deposits	0.001	0.007	NA	<50
Harvard-Bolton Rd.	Bowers Bk./Non.	NA	NA	0.02	NA	NA
Shirley-MCI	Main stem	glacial deposits	0.24	0.39	28,650-57,300	40-60
Shirley-Patterson	Main stem	glacial deposits	0.3	0.72	NA	50

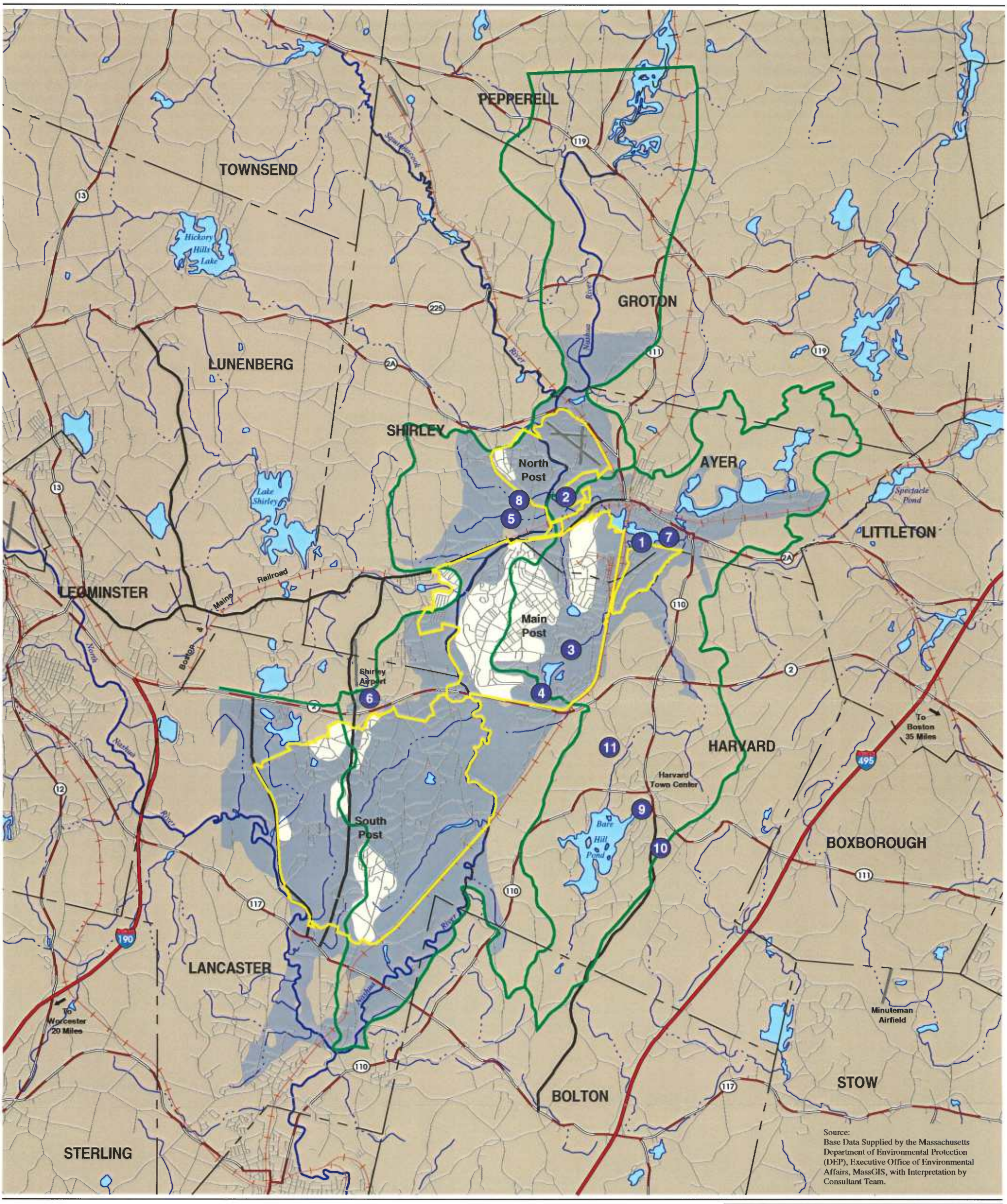
Notes:
1. Data derived from NRWA publications, ENSR report (March 1993), CDM report (January 1993), ETA report (September 1994), and inquiries with local officials.
2. The MacPherson and Sheboken wells are located on the boundary between two subwatersheds. Their location in the subwatersheds is based on the percentage of preliminary Zone IIs, as defined by ETA in the 9/16/94 Report, which fall into each subwatershed.
3. NA: Data not available or not assessed.

WATER SUPPLY WELLS

The following section describes the water supply wells within the Towns of Ayer, Harvard, and Shirley which are outside the limits of Devens. Devens' water supplies are described separately. These are presented to provide a general understanding of the regional water supplies and consumption trends which have the potential to impact the available ground water resources within and surrounding Devens.

Town of Ayer

The Town of Ayer, through its Water and Public Works Departments, currently operates and maintains an extensive water supply system that serves approximately 95 percent of the community. The water supply and distribution system consists of: two active wells and a treatment plant at the Spectacle Pond aquifer outside the Nashua River watershed on the east end of the town; two inactive wells and a treatment plant, for emergency use only, adjacent to Grove Pond in proximity to Devens (see Figure 3); two water storage tanks with a capacity of 844,000 gallons; and approximately 33 miles of transmission and



- Fort Devens Boundary
- Outwash Area
- Limit of Sub-Watersheds
- 1 Grove Pond Well Field
- 2 McPherson Well
- 3 Patton Well
- 4 Sheboken Well
- 6 Massachusetts Correctional Institute Wells
- 5 Shirley Village - Patterson Well
- 7 Ayer - Grove Pond Wells (Two Wells) (Emergency Backup)
- 8 Shirley Village - Walker Road Well (Proposed)
- 9 Harvard - Pond Road Well
- 10 Harvard - Bolton Road Well (Emergency Backup)
- 11 Harvard - DPW Well

EDAW / VHB

LAND BANK

Devens Base Reuse Center

Ayer • Harvard • Lancaster • Shirley

Figure 6
Surficial Geology

November, 1994

0 3500 7000 Feet

15 130 Acres

REGAQ

distribution piping. The system has approximately 1,860 connections serving over 6,500 in the community. In addition, over 275 hydrants throughout the town are connected to the system. For emergency needs, in addition to the Grove Pond wells, Ayer has water supply connections to Devens and the Town of Littleton. Neither of these connections has been used in the past fifteen years.

The wells at Spectacle Pond have been pumping at or near their approved combined maximum daily rate of 2.5 million gallons per day (mgd) since 1990. A history of Ayer's water use, from the Spectacle Pond wells, since 1980 is provided in Table 2. The two wells at Grove Pond have a combined pumping capacity of approximately 1.9 mgd, however this water is restricted to emergency use. Based on 1992 data, approximately 34 percent of the town's water use is for residential use, 23 percent for commercial use, 28 percent for industrial use and 9 percent for municipal use.

Table 2 **TOWN OF AYER - HISTORICAL WATER USE**

Year	Average Daily Demand (mgd)*	Maximum Daily Demand (mgd)
1980	1.38	1.40
1981	1.19	1.30
1982	1.30	1.67
1983	1.36	2.64
1984	1.48	1.68
1985	1.43	1.57
1986	1.47	1.96
1987	No data	No data
1988	1.79	No data
1989	1.60	1.82
1990	1.67	2.66
1991	1.59	1.88
1992	1.79	2.31

Note: * million gallons per day
Source: Massachusetts Department of Environmental Management, Division of Resource Conservation (DEM-DRC)

Limitations to Ayer's water supply system, include pumping capacity restrictions on the wells at Spectacle Pond, inadequate amount of available water storage for fire fighting purposes, and need to replace aged and corrosion susceptible pipes. The Ayer Grove Pond well is high in iron and manganese which is why it is presently used only as an emergency backup supply (12). The treatment facility at the Grove Pond wells is currently incapable of removing the higher than acceptable levels of iron and manganese present in the water from these wells. Additionally, to serve the remaining 5 percent of the town's population and to provide full coverage for fire fighting, extension of the existing transmission and distribution piping is necessary.

As noted above, Ayer's Spectacle Pond wells are operating at or near their permitted maximum pumping capacity. This leaves little room for increased service needs as the town's population grows or as expanded service is desired in areas of the town already served. Ayer's projected population growth and service increase is shown in Table 3. The Spectacle Pond aquifer, which is

separate from the Devens aquifer, is shared with the Town of Littleton. Littleton's wells can operate at an estimated 1.5 mgd capacity (13).

Table 3 **TOWN OF AYER - PROJECTED SERVICE**

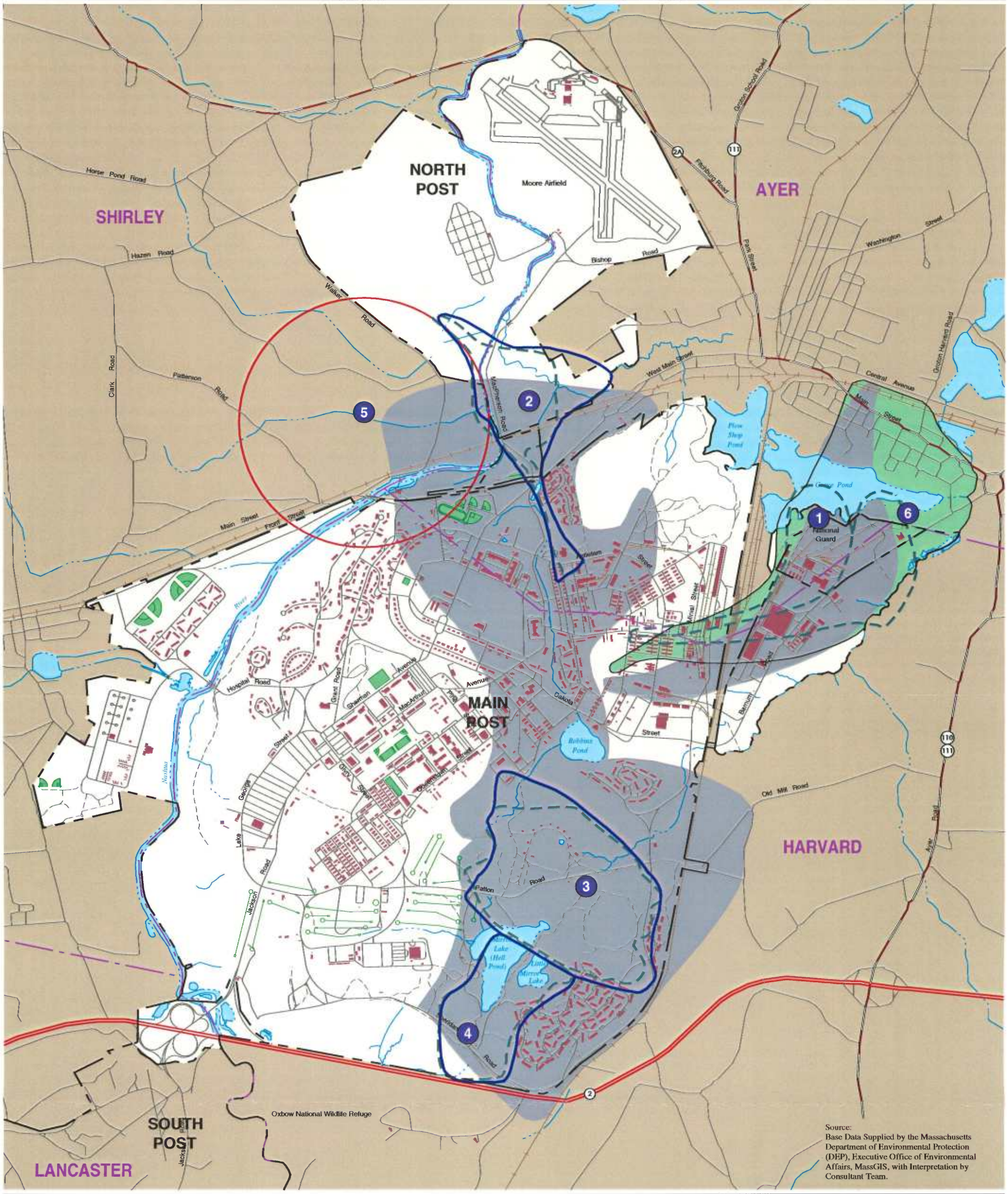
Year	Projected Population*	Percent Served	Service Population
1990	6,871	95	6,527
1995	7,057	97	6,845
2000	7,243	100	7,243
2010	7,377	100	7,377
2020	7,498	100	7,498

Note: * Population projections provided by the Metropolitan Area Planning Council.
Source: DEM-DRC

Expansion of the water supply system, including identifying additional sources, for the Town of Ayer is being investigated. The town has hired the consulting firm of Camp Dresser & Mckee, Inc. (CDM) to conduct a study on reactivating the Grove Pond wells (12). The purpose of this study is to address the treatment methods needed to remove the iron and manganese in the wells and to meet other federal and state water quality standards. Also being investigated is the possibility of adding a third well at Grove Pond that could provide an additional 1 mgd capacity to the current Grove Pond capacity of nearly 2 mgd. In addition to reactivating the Grove Pond wells, Ayer is proposing increasing the pump size on one of the Spectacle Pond wells from 700 to 1000 gallons per minute (gpm) and adding a third well at this site.

The town owns the land within Zone I for all of its public wells. Zone II for the Grove Pond wells has been delineated as shown in Figure 7. Potential contamination sources for the Grove Pond wells include four sites currently within the military reservation: the National Guard motor pool, Shepley's Hill and Cold Spring Brook landfills, and the motor pool at Devens. Other potential contamination sources include the former Hartnett Tannery and the B&M Railroad tracks and yard. Ground water modeling studies performed by the U.S. Army concluded that the Shepley's Hill landfill should not affect Ayer's wells at Grove Pond.

Ayer does not have a wellhead protection plan or any other protective measure beyond controlling the land under Zone I to safeguard the water supply aquifers it currently uses or plans to use in the future. To deal somewhat with the potential of hazardous materials spills, the Water Department informally works with the Fire Department on emergency response planning. Since 1991 Ayer has proposed the addition of a Water Supply Protection District section to their Zoning Bylaw, however passage of this measure has consistently been rejected by the town, at town meeting. The proposed measure contains language that provides for a cooperative effort in protecting the Spectacle Pond aquifer it shares with the Town of Littleton. The Town of Littleton has an aggressive aquifer protection strategy in place, and therefore similar measures undertaken by the Town of Ayer could provide a significantly enhanced protection level to this aquifer that is currently Ayer's primary water source.



ENSR & ETA Combined Preliminary Zone II

Town of Ayer Delineated Zone II

Interim Zone II

Zone II Safe Yield Pumpage, ETA 1994

Zone II Permitted Pumpage, ETA 1994

Well Locations

1. Grove Pond Well Field
2. McPherson Well
3. Patton Well
4. Sheboken Well
5. Shirley Village - Patterson Well
6. Ayer - Grove Pond Wells (Two Wells) (Emergency Backup)

EDAW / VHB

LAND BANK

Devens Base Reuse Center

Ayer • Harvard • Lancaster • Shirley

Figure 7
Zone II Delineations

November, 1994

0 1000 2000 Feet

1 10 Acres

3598ZONE

Town of Harvard

The Town of Harvard maintains the smallest of the four water distribution systems presented in this report. The public system for potable water and fire fighting is limited to the core business and municipal center of the town. Harvard's Department of Public Works provides 71 water connections that serve approximately 200 people year-round. This increases to nearly 1,000 during the portion of the year when the system's largest single user, the public school system, is in session. The last major improvement to the system occurred over 10 years ago.

Harvard's public water system consists of one active well, a 340,000 gallon storage tank and a very limited distribution system of water mains. The active well, Pond Road Well, has an estimated maximum pumping rate of 0.043 mgd and can maintain a constant supply rate of about 0.029 mgd if required. In recent years, their average daily demand has typically been 0.015 mgd and can be traced in most part to the public school system. Approximately 37 households are tied into the municipal water system. Remaining households (up to 3000) receive potable water from private, residential wells. A second municipal well, which is reserved for emergency use only, is located off of Bottom Road. The well, which has never been used, can pump water at a maximum rate of 0.028 mgd. Ground water in the well reportedly has high levels of iron.

Harvard has a small third well that only serves two connections, the Department of Public Works building and one private residence. The well is located off Depot Road and pumps less then 1,200 gpd.

The town has very limited resources to maintain or expand their system. The Department of Public Works provides only the most basic maintenance and repair service. In the event that large scale repairs are needed, Harvard typically summons the Town of Littleton for assistance. Physical limitations such as shallow depths to bedrock combined with extensive relief throughout the town make expansion of the system expensive. The Harvard Water Commission has tried unsuccessfully for several years to pass a budget request through the town council to install a new well and pump station. Due to these and other circumstances, the town has suspended the installation of any new public water connections except for those for emergency purposes.

Harvard has not designated any Zone II for its wells and provides no protective measures to assure the quality of any high yield aquifer within the town. It has no agreements with the Town of Ayer to protect the Zone II around Ayer's Grove Pond wells, which falls within Harvard's town limits. Septic systems and road salts are probably are the most likely contamination sources for the Harvard wells and the portion of the Ayer Grove Pond wells Zone II that falls within Harvard. Other potential or existing contamination sources have not been identified.

Town of Shirley

Water supply needs in the Town of Shirley are provided by the Shirley Water District, an autonomous body with nearly a ninety year history. It serves approximately one-half of the community; an estimated service population of nearly 3,100 people. The water supply system consists of two active wells, two

intermediate booster pump stations, one 250,000 gallon standpipe, one 647,000 gallon reservoir and nearly 27 miles of water distribution mains. In addition, there are approximately 200 district-owned or privately-owned fire hydrants connected to the water supply system. There is a single water main connection to Devens water supply distribution system for emergency purposes only. This emergency connection has not been used in some time, if at all.

The district's wells, Catacoonamug and Patterson Road, (see Figure 5) have had a combined daily average of 0.28 mgd in recent years. The average use per capita has typically been below 100 gallons/day. The average and maximum daily water use demand history is provided in Table 4. The Catacoonamug Well typically contributes 26 percent of the district's water supply and the Patterson Road Well contributes the remaining 74 percent. For 1992, the district reported water use distribution as approximately 76 percent for residential use, three percent for commercial use, two percent for industrial use, and one percent for municipal use. The remaining eighteen percent was unaccounted for by the district.

Table 4 **TOWN OF SHIRLEY - HISTORICAL WATER USE**

Year	Average Daily Demand (mgd)*	Maximum Daily Demand (mgd)
1980	0.23	0.64
1981	0.25	0.42
1982	0.24	0.32
1983	0.24	0.31
1984	0.23	0.33
1985	0.24	0.32
1986	0.27	0.38
1987	0.25	0.35
1988	0.24	0.52
1989	0.24	0.39
1990	0.27	0.55
1991	0.28	0.40
1992	0.28	0.49

Note: * million gallons per day
Source: DEM-DRC

The Shirley Water District performs a regular maintenance program which maintains its water supply system in good repair. The town is also planning to expand its water supply system to residents which have recently petitioned for public water due to private well troubles. The projected population and expected service increase are shown in Table 5.

Table 5 **TOWN OF SHIRLEY - PROJECTED SERVICE**

Year	Projected Population*	Percent Served	Service Population
1990	6,118	50	3,059
1995	6,423	50	3,219
2000	6,728	50	3,372
2010	7,032	50	3,524
2020	7,128	50	3,572

Note: * Population projections provided by the Metropolitan Area Planning Council.
Source: DEM-DRC

Shirley is also seeking other improvements in an effort to expand its current supply system. To meet future needs, Shirley may purchase additional property between Patterson and Walker Roads in order to develop a new well field adjacent to the existing well in this area. At a minimum, this purchase will aid in protecting the existing aquifer.

The Shirley Planning Board is seeking to amend the town's Water Supply Protection Overlay District bylaw (Section 4.13). The town's bylaw, in effect, restricts certain land uses within delineated zones around each of the water supply wells. The Patterson well, which is outside Devens, is on property owned by the Shirley Water District. The water district also owns several of the lots around this well. Shirley has established a protective radius of 800 feet (Zone I) around the Catacoonamug Well, and a radius of 1,000 feet around the Patterson Well and the proposed well sites. Shirley has identified future town well sites, including the Catacoonamug Well in Shirley Village. Shirley has not identified any specific sources of contamination affecting the wells. In addition to the Town of Shirley municipal water wells, the Massachusetts Correctional Institute (MCI) in Shirley maintains two potable water production wells. Only one of the wells is typically used; the second well is reserved as an emergency back-up well only. The average pumping rate of the MCI well is 0.24 mgd. Iron levels are reportedly high; however, the water is not treated prior to distribution.

Devens

Devens presently maintains and operates a water supply, treatment and distribution system separate from Shirley, Ayer, and Harvard. The water supply system includes four ground water well sources, 145 miles of distribution mains, two elevated steel storage tanks with a capacity of 1,000,000 gallons each, wellhead treatment equipment and fire hydrants. The fire hydrants are typically located along each main at a spacing of no more than 500 feet. The Sheboken, MacPherson, and Patton wells also have 30,000 gallon retention tanks at their respective locations. The sources for Devens water supply system, which include the Grove Pond, Sheboken, MacPherson, and Patton Wells are presented in Table 6.

Table 6 **DEVENS WATER SUPPLY SOURCES**

Well Name	Yield (mgd)	Location
Grove Pond	1.0	Ayer
Sheboken	1.4	Harvard
MacPherson	1.4	Ayer
Patton	1.4	Harvard

Source: ETA, 1994

The Massachusetts Department of Environmental Protection Division of Water Supply (DEP-DWS) has authorized Devens to withdraw approximately 1.3 mgd. This figure is based on historic withdrawal rates between 1981 and 1985. Historic consumption rates at Devens are included in Table 7.

Table 7 **DEVENS AVERAGE DAILY WATER CONSUMPTION RATES**

Year	Population Served Winter/Summer	Avg. Daily Use
1990	13,500/16,500	1.01 mgd
1989	13,500/16,000	1.18 mgd
1988	13,000/15,000	1.97 mgd

Source: Ebasco Infrastructure

Approximately 90 percent of the water from the four wells is used for residential purposes, while the remaining 10 percent is used for municipal purposes. Ninety percent of the distribution mains lie in Harvard, 6 percent in Ayer and 4 percent in Shirley.

Average withdrawal rates have been below DEP-DWS permitted yields and, according to Army records, water quality results in the four Devens wells have been in compliance with DEP-DWS drinking water standards with the exception of the MacPherson well, which has had elevated levels of sodium, and the Patton well, which has had elevated levels of manganese (14). Up to 44 mg/l of sodium has been detected in the MacPherson well, which exceeds the Office of Research and Standards guideline (ORSG) of 28 mg/l. Up to 0.42 mg/l of manganese has been detected in the Patton well, which exceeds the Secondary Maximum Contaminant Level (SMCL) of 0.05 mg/l. The water quality data are summarized in Table 8. Trace levels of volatile organic compounds have been detected; however, the levels were below the U.S. Environmental Protection Agency and DEP Maximum Contaminant Levels (MCLs).

Table 8 **GROUND WATER QUALITY DATA**

Date	Sodium (mg/l)	Potassium (mg/l)	Sulfate (mg/l)	Chloride (mg/l)	Nitrogen (NO3) (mg/l)	Iron (Fe) (mg/l)	Manganese (Mn) (mg/l)
Grove Pond Well							
2/18/81	11	2.8	13	21	1.1	0.03	0.04
1/27/82	--	1.0	22	24	1.3	0.03	--
1/18/84	14	2.2	6	22	1.5	0.09	0
4/22/86	15	2.1	18	21	1.2	0.14	<0.02
3/31/94	--	2.24	23	29	--	<0.02	<0.02
Patton Well							
2/18/81	11	2.8	1	22	0.3	0.1	0.33
1/27/82	--	1.8	13	21	0.3	0.11	0.01
1/28/83	12	2.7	13	28	0.3	0.09	0.31
1/18/84	16	2.4	14	33	0.3	0.11	0.2
2/04/85	10	2.3	17	24	0.2	0.03	0.26
4/22/86	16	2.5	23	30	0.3	0.12	0.19
4/21/87	13	2.3	12	26	0.2	<0.04	0.42
4/19/88	12	2.3	10	23	0.3	0.07	0.28
1/19/89	17	2	12	25	1.7	0.2	<0.03
3/31/94	--	2.48	19	29	--	0.2	0.36
Sheboken Well							
2/18/81	5.3	2.3	13	16	0.1	0.15	0.22
1/27/82	12	2.3	13	17	0.1	0.17	--
1/28/83	7.1	2.3	13	17	0.1	0.17	0.19
1/18/84	7.1	2.0	3	17	0.1	0.12	0.17
2/04/85	8.2	2.0	8	16	0.1	0.06	0.13
4/22/86	8.5	2.5	14	17	0.1	0	0.13
4/21/87	7.3	2.1	4	17	0.1	<0.04	0.11
3/31/94	--	1.94	<1.0	16	--	0.12	0.15
MacPherson Well							
2/18/81	3	2.6	61	61	0.3	0	0
1/27/82	6.5	1.9	48	59	0.5	0.13	--
1/28/83	30	2.3	45	69	0.5	0.03	0
1/18/84	42	2.1	24	67	0.5	0.02	0.01
2/04/85	38	2.0	40	67	0.4	0	0.02
4/22/86	41	2.3	46	75	0.6	<0.04	<0.02
4/21/87	24	2.1	35	49	0.5	0.06	0.03
4/19/88	40	2.4	38	66	0.6	0.04	<0.03
1/19/89	44	2.3	42	75	0.8	0.04	0.03
3/31/94	--	1.5	44	32.9	--	0.04	0.09
Standards-All Wells							
MMCLs	--	--	--	--	10	--	--
SMCLs	--	--	250	250	--	0.3	0.05
ORSGs	28	--	--	--	--	--	--

Notes: MMCLs = Massachusetts Maximum Contaminant Levels.
SMCLs = Secondary Maximum Contaminant Levels.
ORSGs = Office of Research and Standards Guidelines.

Source: Water quality data provided by the Army Environmental Center in a data package, 20 July 1994.

In the event the system requires an increase in permitted withdrawals or a change in ownership, the state approval process (the Water Management Act)

would require a revised application for greater withdrawal, an assessment of the impact of the increased withdrawal on the aquifer and ecological systems, delineation of well capture and influence zones, review of aquifer protection policies and clean-up efforts, and a general inspection of wells, treatment, and distribution system components. If additional wells are installed, new Zone II delineations would also be required for those wells. This information would be required as part of the application process to gain approval through the DEP-DWS upon a change of ownership or an increase in withdrawal rates regarding the existing wells at Devens.

DEVENS WELLS SAFE YIELD ANALYSIS

Constant rate pumping tests were conducted by ETA on three of the Devens wells: the MacPherson, Patton, and Sheboken wells. The purpose of the pumping test program was to develop aquifer parameters for ground water modeling in support of Zone II delineations, and to develop estimates of well safe yield in accordance with DEP-DWS Guidelines and Policies. Well safe yield is a function of the aquifer properties, the available drawdown in the well bore, and the well efficiency. The results from the pumping test reports (15,16,17) indicate the following:

- In the vicinity of the MacPherson well, the aquifer was classified as a confined/unconfined aquifer with a single recharge boundary (the Nashua River) within the radius of influence. The transmissivity and storativity of the aquifer were calculated to be 40,291 ft^2/day and 0.0012, respectively. The estimated safe yield of the well was 1.85 mgd.

- In the vicinity of the Patton well, the aquifer was classified as a leaky, semi-confined aquifer with drawdown in the confining layer, and which is bounded laterally by impermeable barrier boundaries (till and bedrock). The transmissivity and storativity of the aquifer were calculated to be 23,900 ft^2/day and 0.006, respectively. The estimated safe yield of the well was 1.54 mgd.

- In the vicinity of the Sheboken well, the aquifer was classified as a leaky, semi-confined aquifer with drawdown in the overlying layer. The transmissivity and storativity of the aquifer were calculated to be 24,600 ft^2/day and 0.00001, respectively. The estimated safe yield of the well was 1.79 mgd.

The safe yield of the Devens aquifer, which provides water to these wells, is described in a subsequent section of this chapter. The cumulative safe yield of the three wells does not exceed the estimated safe yield of the Devens aquifer.

ZONE II DELINEATIONS

General

Zone II areas are delineated to protect wells from potential sources of contamination within the area of land contributing water to the well under long-term pumping conditions. Zone II delineations were prepared and accepted by the DEP for the Town of Ayer Grove Pond wells and Shirley MCI wells (12,18). Conceptual Zone II delineations were prepared for the Devens wells by ENSR

Consulting and Engineering for the Fort Devens Environmental Management Office, and have recently been revised by Engineering Technologies Associates (ETA), on behalf of the Army Environmental Center (9,19). Zone II delineations were not available for the Town of Shirley wells, and have not been developed for the Harvard wells. Approved, conceptual, and proposed Zone II delineations are shown in Figure 7 along with Interim Wellhead Protection Areas (IWPAs), labeled in the figure as "Interim Zone IIs" which are based on a fixed radius of 1/2 mile around the wellhead. IWPAs are not based on hydrogeologic analysis.

Devens Wells

It is important to note that Zone II delineations are significant to the protection of contributory areas to a specific well site. For the purposes of the Reuse Plan, however, protection of the entire watershed and aquifer, which may contribute to water supply in the future, will be important. The delineation of Zone IIs will aid in the process of drawing aquifer protection zones which will be included in the full extent of glacial outwash deposits which represent future water resources. Different levels of protection may be appropriate for different areas of the aquifer.

The Conceptual Zone II delineations prepared by ENSR were defined based on incorporation of published information and historical pumping data in a two-dimensional, steady-state ground water flow model. The model was used to predict the "capture zone" over which the wells draw their water under severe pumping conditions that could be encountered in a drought (180 days of pumping with no recharge). Hydrologic parameters were not developed by field testing.

The Zone II delineations were revised by ETA (19) which calibrated a three-dimensional, finite difference ground water flow model for the project. The model simulated ground water flow in the glacial drift water table aquifer and the underlying bedrock aquifer. Data from previous site and remedial investigations and recent field investigations were incorporated into the model (9,15,16,17,20). Hydrologic data were obtained from field investigations which included pumping tests, streamflow monitoring, precipitation monitoring and ground water level monitoring.

Pumping tests were conducted at the Sheboken, MacPherson, and Patton water supply wells, and at a bedrock monitoring well at Shepley's Hill Landfill. Piezometers were drilled at these sites to observe ground water levels during the pumping tests. To develop estimates of baseflow in streams, stream stages (stream elevation) and precipitation were monitored during the fall of 1993 and the spring of 1994 at stations along Willow Brook and Cold Spring Brook. Continuous monitoring of water levels was conducted at Willow Brook and Cold Spring Brook gauging stations, two stream-side piezometers, and one monitoring well during this same time period.

Ground water flow was simulated using MODFLOW, a three-dimensional, finite difference computer model. The computer model is capable of simulating a heterogeneous aquifer with evapotranspiration, variable well pumpage, drains, streams, ponds, wetlands, variable recharge, and different boundary conditions under either water table or artesian conditions. Flow in the glacial drift and bedrock aquifers was simulated using a three layer model, with the bottom layer identified as the bedrock aquifer and the upper two layers identified as the

Table 10 **SUMMARY OF STREAMFLOW DATA, NASHUA RIVER**

Time (Percent Chance of Occurrence)	N. Nashua (Flow-cfs)	South Branch (Flow-cfs)	Main Stem (Flow-cfs)	Bowers Bk./Non (Flow-cfs)	Total Flow (cfs)	Total Flow (mgd)	Total Flow Safe Yields (mgd)
1	1,100	2.6	115.5	192.9	1,411	912	903
2	820	2.6	109	150.5	1,082	699	690
5	550	2.6	87.2	106	746	482	473
10	400	2.6	67.6	82.7	553	357	348
20	250	2.6	50.1	59.4	362	234	225
30	195	2.6	43.6	42.4	284	183	174
40	150	2.6	34.9	33.9	221	143	134
50	110	2.6	28.3	27.6	169	109	100
60	91	2.6	26.2	19.1	139	90	80
70	72	2.6	24	13.4	112	72	63
80	60	2.6	20	10.6	93	60	51
90	48	2.6	15.3	6.6	73	47	37
95	41	2.6	13.1	4.5	61	40	30
99	35	2.6	9.4	2.8	50	32	23

Notes:
1. Safe yield = 9.4 mgd = existing withdrawals plus the estimated safe yield withdrawal rates from the MacPherson, Patton, Sheboken, Grove Pond and Ayer-Grove Pond wells.
2. Flow from the South Branch of the Nashua River is regulated and set at approximately 2.6 cfs.
3. North Nashua streamflow data from U.S. Geological Survey Hydrologic Atlas HA276.
4. Main Stem and Bowers Brook/Nonacoicus streamflow estimated from drainage basin area and the percentage of area underlain by stratified drift (glaciofluvial deposits).
5. The Main Stem drainage basin represents the portion of the watershed upstream of the northern border of Devens.

Figure 8 indicates the projected hydrograph for the Nashua River. Under most flow conditions, except for extreme low flow conditions such as 99 percent time of occurrence, the safe yield withdrawal rate comprises a small percentage of the total potential streamflow in the Nashua River. However, based on estimates of aquifer area in the two subwatersheds (summarized in Table 11), the Main Stem subwatershed provides more baseflow to the Nashua River, and can therefore sustain a higher rate of ground water withdrawal without adverse impacts to streamflow in tributaries to the Nashua River. This should be considered if additional water supply wells are developed in the future.

ENVIRONMENTAL CONSTRAINTS

For purposes of facilitating implementation of base cleanup, Devens has been subdivided into five "zones", including the Industrial zone, the North Post zone, the Willow Brook zone, the Nashua River zone, and the Mirror Lake zone. These zones are illustrated in Figure 2. Environmental constraints on redevelopment in each of these areas include the presence of high-yield and medium-yield aquifers (as defined by the U.S.G.S and DEP), Zone II areas for municipal wells, wetlands, floodplains, and areas of known and potential contamination. In general, soils underlying the aquifer areas are well-drained coarse to fine sand and gravel with high hydraulic conductivity. These soils typically are encountered within approximately five feet below ground surface (below fill materials or topsoil), and extend to depths of approximately 25 to over 100 feet. Because the aquifer areas are confined primarily to low-lying areas, often adjacent to surface water bodies, depth to ground water is generally shallow, ranging from zero feet in wetlands to approximately 50 feet in small hills comprised of well-drained outwash deposits.

Less permeable, poorly-drained fine-grained soils and organic deposits overlie the aquifer soils in narrow zones along the Nashua River and its tributaries, and in some wetlands. These less permeable soils are beneficial with respect to aquifer protection because they impede the infiltration of contaminants and attenuate contaminants by adsorption and biodegradation. A summary of the primary environmental constraints in each of the zones is provided below (10):

- Industrial Zone: 80 percent of this zone overlies the medium-yield and high-yield aquifer areas and portions of Zone IIs for three well systems (the Grove Pond well field, the Ayer Water Department - Grove Pond well field, and the Patton well) occupy 35 percent of this zone. Three conservation/recreation resource areas (Grove Pond, Plow Shop Pond, Cold Spring Brook) and wetland buffer zone (310 CMR 10 et. seq.) abut the zone to the north and east. Potential sources of contamination include eight known Areas of Contamination (AOCs) and four Study Areas (SAs) under investigation including a vehicle maintenance/storage area, a battery repair building, releases from underground storage tanks, and two landfills (Shepley's Hill and Cold Spring Brook). In addition, the B&M Railroad Right of Way, and related rail yards bisect this zone.

- North Post Zone: 90 percent of this zone is underlain by medium and high yield aquifer areas. In addition, 20 percent of the southwestern section of this zone is covered by Zone II of the MacPherson Well and the Interim Wellhead Protection Area (IWPA) of the Shirley Village Water District -

Patterson Well. The conservation/recreation resource segment of the Nashua River and associated wetland buffer zone (310 CMR 10 et. seq.) along the river also traverse this zone. One SA in the Moore Airfield and the Fort Devens Wastewater Treatment Plant (WWTP) with sludge drying beds are within this zone, west of the Nashua River.

- Willow Brook Zone: 55 percent of this zone is comprised of medium and high yield aquifer areas and a portion of the Zone II for the MacPherson well occupies approximately 15 percent of this zone. Two petroleum release sites (SAs) are near the southwest boundary of this zone.

- Nashua River Zone: 15 percent of this zone is comprised of medium and high yield aquifer area, and approximately 5 percent is comprised of the IWPA of the Shirley Patterson well. The conservation/recreation resource segment of the Nashua River, and associated wetlands and buffer zones along its banks transect this area. SAs within the zone include three landfills, and three petroleum sites.

- Mirror Lake Zone: 35 percent of this zone is underlain by medium and high yield aquifer areas and 45 percent is comprised of Zone IIs for two wells (Patton and Sheboken). There are eight potential contamination sources (SAs) in this zone, including the Mirror Lake landfill.

In general, the Industrial zone of Devens appears to contain the greatest sensitivity relative to potential sources of contamination to aquifers. A number of AOCs have been identified within this zone. Utilization of this area for industrial purposes is likely to continue, due to the historic use of this area and the presence of the Railroad Right-of-Way and railyard.

REGIONAL LAND USE IN AQUIFER AREAS

Regionally, aquifer areas outside of Devens in the BB/N watershed generally fall within forested or wetland areas (24). Most of the BB/N subwatershed outside of Devens is comprised of glacial till and shallow rock which are undeveloped. Industrial and commercial properties are located along Rte. 110/11 in Harvard, which overlies a thin width of the aquifer along Bowers Brook.

The majority of the Main Stem subwatershed upgradient of Devens is underlain by aquifer areas. Most of the area along the Nashua River is comprised of wetlands or forested buffer zones, including two conservation areas - the Oxbow National Wildlife Refuge and the Bolton Flats State Wildlife Management area. The South Post is largely open land. The Reuse Plan does not include this area, which has been used for military exercises, and which reportedly will remain as a military enclave (10).

The South Branch of the B&M Railroad runs through the southern portion of the watershed. Presently, land along the rail is largely undeveloped. Most industrial development is concentrated along the East-West branch, which follows the northern boundary of the Main Post.

SUMMARY OF POTENTIAL AQUIFER VULNERABILITY

Based on regional land uses, aquifer areas, and directions of ground water flow and surface water drainage, the aquifer areas that have the potential to be the most vulnerable to contamination are within the North Post area and the southern portion of the Main Post, both of which are in the Main Stem subwatershed; and the northeast portion of the Main Post, which is in the BB/N subwatershed.

The aquifer in the North Post area is overlain by potential contamination sources including the Devens Airport and the waste water treatment facility infiltration beds. The northeast portion of the Main Post has a concentration of industrial use along the B&M railroad right-of-way and rail yard, and several AOCs and SAs over the aquifer that supplies water to the Grove Pond wells.

The southern portion of the Main Post is upgradient of most potential contamination sources at Devens, but is bisected by Route 2, which is less than 1000 ft. from the Sheboken well. While outside the study area, there is a potential that accidents resulting in a release of petroleum along Route 2 could have an impact on the aquifer that supplies water to the Sheboken and Patton wells.

WATER QUALITY MONITORING PROGRAM

The Army has installed numerous monitoring wells in the vicinity of SAs and AOCs as part of site investigations, feasibility studies, and remedial investigation programs. In addition, observation wells have been installed proximate to existing water supply wells to support the Zone II delineation refinements. These observation and monitoring wells are, therefore, located in areas of critical importance from the standpoint of water supply protection, and should be incorporated in future monitoring programs geared toward performance-based water resource protection. At present, the Army conducts a quarterly monitoring program to document ground water and surface water levels.

The existing water quality database developed from these studies, and maintained by the Army, has been evaluated to develop current water resource protection strategies, and can be used to evaluate effectiveness of proposed protection strategies. Land use controls for protection of water supplies, must consider regional contaminant loadings in a watershed in order to predict how much development of a given land use can be allowed while maintaining drinking water standards in the resource. This can be achieved through mass balance analysis that considers typical contaminant loadings from the specific land uses, ground water flowrate through the watershed, and background water quality, which is influenced by existing land use.

The Fort Devens Base Realignment and Closure (BRAC) Cleanup Plan (BCP) has been completed for the Army Environmental Center by The Earth Technology Corporation. One important element of the BCP is the cleanup standards for SAs and AOCs which are developed through evaluation of Applicable or Relevant and Appropriate Requirements (ARARs) or risk assessment-based standards. This work is being conducted in accordance with the National Environmental Policy Act (NEPA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as

amended by the Community Environmental Response Facilitation Act (CERFA); the Resource Conservation and Recovery Act (RCRA); and other pertinent state and local regulations. Background levels have also been proposed by the Army based on compilation of chemical data from SAs and AOCs on-site. The cleanup standards and background levels will be considered in aquifer protection relative to estimating allowable increases in contaminant concentrations over existing, background conditions.

Any water resource protection plan will include protection and on-going sampling of existing ground water wells for the purposes of measuring ground water quality changes over time. This will allow the evaluation of the effectiveness of the program and will allow future fine tuning of regulations to achieve the desired effects.

WETLANDS MONITORING PROGRAM

Proposed wetland monitoring should be conducted to determine effects on wetlands from increased ground water withdrawal rates. Sampling stations should be established at those locations that may be affected by changes in ground water hydrology. These areas are defined as any wetland community where the average change in ground water elevation is predicted to be greater than 1.5 feet, as changes less than this are within the normal range of year-to-year variation and have a low probability of affecting vegetation.

Wetlands monitoring should include measurement of species composition, abundance, and cover along sampling transects. Three replicate plots along each transect should be sampled annually, and statistical analysis of data should be performed to detect changes in vegetation.

Sampling Station Locations

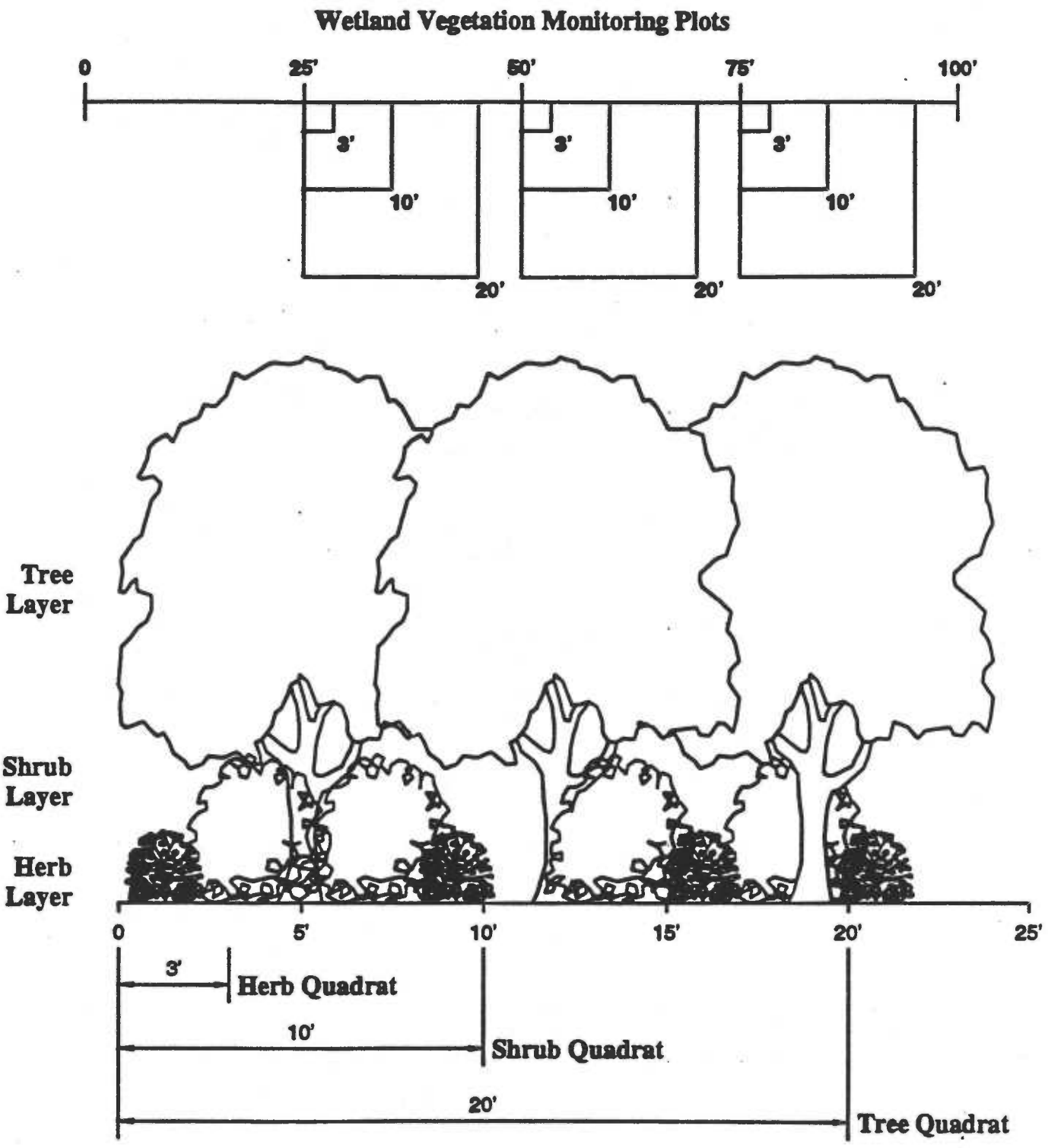
Vegetation should be sampled in square nested quadrats and by layers (Figure 9).

- The herbaceous layer is defined as all plants less than 3 feet tall, and includes seedlings of tree and shrub species as well as herbaceous species. Quadrat size is three feet on each side.

- The shrub layer is defined as all plants more than 3 feet, and less than 15 ft tall, and includes seedling or sapling tree species as well as shrubs. Quadrat size is ten feet on each side.

- The tree layer is defined as all plants more than 15 ft tall, and includes very tall shrubs as well as trees. Quadrat size is twenty feet on each side.

A 100-foot long baseline should be established at each sampling location. Nested sample plots should be located at 25 feet, 50 feet, and 75 feet along this baseline, as shown in Figure 9. This will provide three replicates for each sampling station, which will enable sampling dates to be compared statistically and should reduce the effects of random variation within plots.



Not to Scale

Vegetation Monitoring
Nested Sampling Plots

Figure 9

Frequency of Sampling

Sampling should occur once per year, at the time when species diversity and abundance is at a maximum. In New England, the optimal time for vegetation sampling is during July and August, preferably during the 30-day interval following July 15th.

Analysis

The most applicable measurement for terrestrial vegetation is the "Importance Value", a composite measurement of the frequency, density, and abundance of a species. This statistic is most informative and least subject to random fluctuation or distortion due to inherent differences in plant sizes. It is proposed that the Importance Value for each species in each sampling station be determined, as well as the overall density, percent cover, and diversity within each sampling station. These results can be compared among years, and will identify any measurable changes in vegetation.

Within each plot, data recorded for each species should include the number of stems and percent cover. From these data, relative frequency, relative density, and relative dominance can be calculated. The Importance Value is the sum of the following three measures of vegetation:

- Relative frequency = the number of plots a species occurs in, divided by the total number of plots in that sample station.
- Relative density = the number of stems of that species divided by the total number of stems in that sample station.
- Relative abundance = the percent cover of that species divided by the total percent cover within that sample station.

For analysis of data, the importance values of individual species, total density, total diversity, and total abundance can be directly compared between sampling dates, as can species composition of the vegetation. In addition, analysis of each sampling station by similarity analysis can detect more subtle changes in the plant community as a whole.

Results of the vegetation monitoring analysis should be used to assess vegetation changes. Potential changes, based on available models, include an increase in the cover of woody species; an increase in the abundance of upland herbaceous plants; and a decrease in the abundance of obligate wetland herbaceous species. Caution should be used in drawing conclusions as these are only indicators that the wetland is becoming drier.

Thresholds should be established for the determination of adverse impacts. These thresholds should be based on professional judgment, as there is no standard literature that provides comparable studies to serve as models. For example:

- A change in Importance Value of more than 25% for at least 25% of the species within the wetland community could be considered an indicator of a change in the plant community structure;

- The addition, or loss, of any species with more than 10% of the total density, dominance, or abundance could be considered an indicator of a change in the plant community composition.

LEGISLATIVE FRAMEWORK

The Massachusetts legislature enacted the Devens Enterprise Commission legislation in January 1994. The legislation established Devens as a regional enterprise zone and created the Devens Enterprise Commission with regulatory authority over matters of land use. Furthermore, the legislature empowered the Massachusetts Government Land Bank as the development agent and the provider of public services. The legislature also established $200 million of bonding authority for use by the Land Bank in the implementation of the Reuse Plan. This funding is available upon approval of the Reuse Plan and bylaws by Ayer, Harvard, and Shirley, as well as the Land Bank Board and the Commissioner of the State Division of Capital Planning and Operations. An important element of the Reuse Plan and bylaws will be the delineation of aquifer protection zones and related protection measures.

Under the Devens Enterprise Zone Legislation the Massachusetts Government Land Bank undertook the first phase of a Water Resources Protection Plan (WRPP) to determine the extent of the existing ground water resources at Devens, to identify potential contamination sources, and to develop preliminary recommendations for the management and protection of the ground water resources. The Phase II work for the project assessed how future water demands could be met. A final WRPP and Water Resource Protection Bylaws were developed. Regulations will ultimately be developed from the Bylaws.

WATER RESOURCES PROTECTION PLAN

This final section of the Water Resource Protection Report is the result of cumulative efforts by the communities in the region of Devens, the Water Resources Task Force, the Devens Reuse Center Staff, and the consultant team. This group has invested much time and effort into establishing the goals of the Water Resource Protection Plan, researching water resource protection plans from other communities, structuring a unique approach to water resource protection, and ensuring that the water resources at Devens will be protected in the future.

A unique approach was taken to water resource protection at Devens. Whereas many communities employ a performance-based standard approach to water resource protection, the water resources planning team decided to develop a resource protection hierarchy, based on activities in and overlying the defined resource areas, rather than performance standards, which typically allow pollution and contamination up to "acceptable" thresholds. The approach used combines land use controls, resource management area guidelines, and best management practices to promote the protection of all ground water and surface water resources.

The resource areas established have been refined since the distribution of the Phase I report, which was based on Interim Zone II wellhead protection districts. Although the definitive Zone II delineations have not yet been approved by the Department of Environmental Protection (DEP), better resource protection and planning decisions can be made, in order to guide the reuse planning process.

WATER RESOURCES PROTECTION PLAN GOALS

The goal of the Water Resources Protection Plan (WRPP) is to provide an appropriate level of protection for all water resources (surface and ground water) within the Devens Enterprise Zone while allowing economic development in an environmentally responsible manner. Consistent with that goal, the protection plan should provide protection of water resources and present straightforward requirements which are easily understood and implementable by the development community and enforceable by the the Devens Enterprise Commission. The intent of this plan is to preserve the high quality of surface and ground water in the aquifer underlying the Devens area in order to protect its future use, and to promote statewide goals for surface water quality in the Nashua River Basin.

To assist in the long term preservation of both surface and ground water resources, conservation and recycling measures should be encouraged for all users of the site. The effect of the implementation of these measures will not only be the protection of the water resources, but will also include protection of the associated wildlife, fisheries and wetland habitat.

The WRPP serves as a planning level document that has been used to develop the Devens Enterprise Zone Bylaws. Certain federal and state regulations have been paraphrased in the WRPP to promote public understanding of those regulations. However, to avoid misinterpretation of the federal and state regulations which apply to activities at Devens, the paraphrased regulations in the WRPP have been replaced in the bylaw with language indicating that all federal and state regulations apply. Whether explicit or implicit, all requirements and restrictions which are contained in the WRPP, are included in the Devens Regional Enterprise Zone Bylaws, Section XI Water Resources Protection Requirements.

Wetland protection issues have arisen during the water resources protection planning process. Although wetland issues are being addressed separately from water resource issues in the Devens Regional Enterprise Zone reuse planning process and in the Land Use By-Laws, it is important to note that there are certain sensitive wetland resources at Devens which merit protection above that guaranteed by the State of Massachusetts Wetlands Protection Act. In developing the overall Reuse Plan for Devens, great efforts were made to take into consideration the protection of sensitive natural environments. The result is a Reuse Plan that avoids, to a great extent, wetlands on the Main and North Posts.

WATER RESOURCE PLANNING AREA GUIDELINES

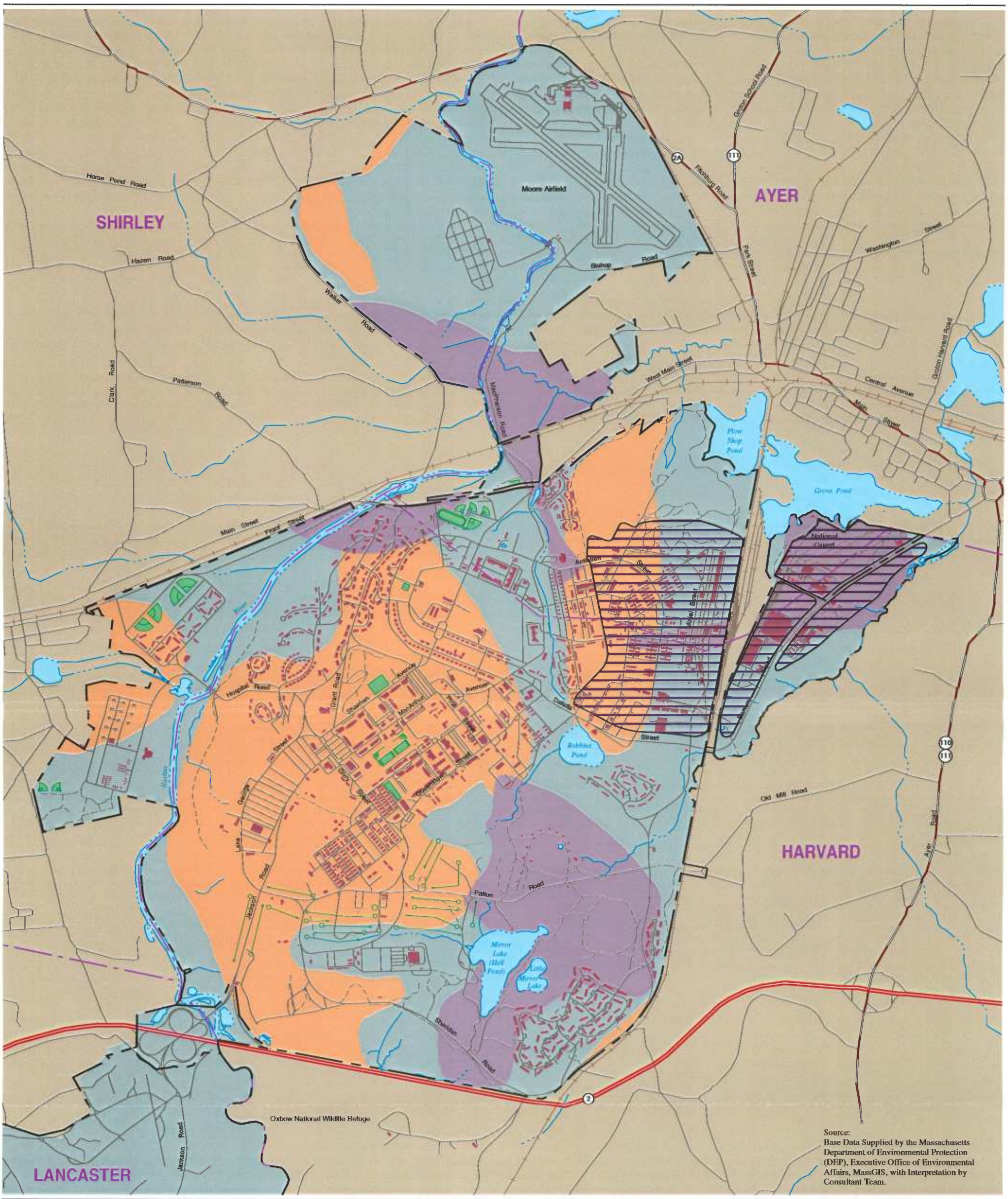
1. The Devens Enterprise Zone should be divided into four Water Resource Planning Areas over which differing levels of water resource protection would be applied (see Figure 10). These zones should be delineated as an overlay on the Reuse Plan. Interim delineations should be used for Zone II delineations in this plan where no more definitive information is available. When definitive Zone II delineation is available and accepted by the appropriate regulatory agencies it should be automatically adopted for this plan.

    - Zone I--area within 400 feet of a well. Activities limited to those relating to the water system operation only.

    - Zone II--areas which contribute ground water to existing wells. Best information on Zone IIs would be used as an interim delineation. When definitive Zone IIs are available they would be automatically adopted.

    - Aquifer Zone--areas over the aquifer which are not included in Zone I or Zone II.

    - Watershed Areas--all remaining areas of the Devens Enterprise Zone outside the Aquifer Zone, Zone I, and Zone II.



Zone II, ETA 1994

Aquifers

Watersheds

Rail Industrial

Ayer and Grove Pond Zone II's based on permitted yield because safe yield data are not available.

EDAW / VHB

LAND BANK

Devens Base Reuse Center

Ayer • Harvard • Lancaster • Shirley

Figure 10
Water Resources Protection Zones

November, 1994

0 1000 2000 Feet

1 10 Acres

3598PRT2

2. The protective measures over each of these zones should be described in a separate section of the bylaws.

3. Varying levels of protection should be provided for each zone based on its level of sensitivity with the highest levels of control established for Zone I and Zone II. Lesser levels of control, with specific standards, should be established for the Aquifer Zone and Watershed Areas.

4. The Rail -Related Use area overlies the aquifer, is adjacent to surface waters of Plow Shop and Grove Ponds, and therefore requires additional protective measures. A specific plan should be provided for the Rail/Industrial area including an area-wide stormwater management system designed to improve water quality.

5. Water resource protection should be evaluated for each development proposal through the approval process established in the bylaws. All development proposals, except minor proposals requiring only Land Use Administrator approval, must be reviewed for consistency with the Water Resources Protection Plan (WRPP) as part of the Development Permit process. Approval of activities as part of the Development Permit will run with the use.

Rail-Related Use Area

For this particular location within the Devens Enterprise Zone, specific controls and design measures have been proposed to assure compatibility with and protection of existing water resources. These controls and design measures will allow the generation, transportation, storage, and treatment of hazardous waste, associated with the ongoing operations of rail/industrial and trade-related businesses, while providing necessary protection to existing water resources. Acknowledging the sensitivity of the site, efforts will be made to mitigate existing conditions which threaten the ground water, and to establish best management practices using the best available technology to prevent future contamination. All provisions which apply to the Water Resources Protection Plan zones apply to the Rail-Related Use Area, with the exception that the provisions allow generators of hazardous waste beyond the level of Very Small Quantity Generators (VSQGs).

- Establish a stormwater utility to manage and maintain the predesigned area-wide system for stormwater treatment and control where none now exists.

- Prohibit on-site disposal of hazardous wastes.

- Provide detention, treatment, and on-site recharge for pavement and roof runoff to hold peak runoff rates below current rates.

- Design the stormwater treatment system to preserve and improve current water quality conditions.

- Design the stormwater system to intercept and isolate potential spills and provide for timely clean-up.

- Provide on-site response capabilities to respond to releases.

- Phase in the area-wide stormwater system, in advance of sites as they are developed.

GENERAL DESIGN/PLANNING PROVISIONS

The following provisions are to be applied throughout the Devens Enterprise Zone.

Best Management Practices (BMPs)

All Zones

BMPs should be required for both the construction and operation of facilities within the Devens Enterprise Zone. It is likely that additional BMPs will come about as redevelopment proposals are submitted. BMPs should include, but are not limited to, the following measures:

- The standard Devens Spill Prevention Control and Countermeasure Plan (DSPCC) will be required as part of each development proposal for all users. A prototype DSPCC will be prepared and provided to users to facilitate implementation by users.

- For all pesticide applications on land area greater than 1 acre, an approved Integrated Pest Management Program (IPMP) will be required. A prototype IPMP will be prepared and provided to users, to facilitate implementation.

- Groundwater monitoring should be utilized as needed to establish ambient water quality conditions.

- Public education programs for business and industries within the Devens Enterprise Zone to promote practices which will protect water resources will be provided.

- Household hazardous waste collection will be provided on a regular basis, for the Devens Enterprise Zone to reduce the chances of inappropriate disposal.

- Loading areas for both rail and new facilities will have safeguards to ensure the safe transfer of goods and commodities.

- Motorized off-road recreational vehicles will be precluded in all non-developed areas of the Devens Enterprise Zone.

Construction Requirements

All Zones

- Each development requiring a Development Permit will develop a site-specific erosion and sedimentation control plan.

- A Devens Stormwater Pollution Prevention Plan will be developed for all future construction to guide individual development proposals.

- Machinery maintenance and refueling will be restricted to designated areas.

- Each development must designate construction debris containment and temporary storage areas.

- Construction planning for new development should be prepared to use pre-existing disturbed sites and to minimize new site clearing and disturbance.

- If the development site is within 100 feet of an edge of wetland, the applicant shall file a Notice of Intent or equivalent document with the Devens Enterprise Commission for purposes of review with respect to wetlands protection, which shall be in accordance with federal, state, and Devens Enterprise Zone regulations.

Water Conservation Plan

All Zones

Encourage water conservation through the following:

- Increase efficiency of all users through the promotion of water conservation measures for business and residential users.

- Provide public education on water conservation.

- Require water conserving plumbing fixtures consistent with Massachusetts plumbing code.

Stormwater Management

Watershed Area

- Each development must employ stormwater control measures to reduce peak rates of runoff to pre-development conditions and to maintain or improve water quality. The area-wide stormwater management system will be phased-in on a site by site basis, coincident with development at each individual site. Where appropriate, systems must include:

    - Catch basins with traps and sumps

    - Oil/water separators

    - Flood controls/runoff controls

    - Ground water recharge facilities

    - Source reduction of sand and other debris on roads and in parking lots through sweeping and other maintenance measures

- A plan and process for the ongoing maintenance of stormwater facilities

- Plans and calculations should be provided with development proposals.

- The Devens Enterprise Commission shall enforce the ongoing maintenance of stormwater facilities and provide periodic inspection of facilities.

Aquifer Zone

All watershed provisions apply in addition to, or as modified by, the following provisions, for each development:

- Stormwater controls must provide for suspended solids removal and the interception of spills.

- Stormwater recharge must be provided to maintain or exceed current levels of recharge.

- Measures should be considered that help direct runoff away from sensitive surface water areas.

- Development proposals in the case of previously developed sites must demonstrate that water quality is being maintained or improved.

Zone II

All watershed and aquifer provisions apply in addition to, or as modified by, the following provisions, for each development:

- Filtration should be provided for ground water recharge areas.

- Development plans must include stormwater recharge to reduce or maintain total volume of runoff.

Storage and Application of Deicing Materials

The use of deicing agents is necessary to provide a high level of safety on Devens roads during winter months. Specific measures have been recommended for the water resource planning areas identified for the reuse of the base.

Watershed Area

- Piles of sodium chloride (road salt), chemically treated abrasive, and other chemicals used for the removal of ice and snow (collectively referred to as deicing materials) on roads should be stored under a roof on flat, impervious surfaces protected from runoff. Drainage controls should be in place to prevent direct runoff away from deicing material storage areas.

- Keep deicing materials dry through proper storage.

- Outfit deicing material spreading equipment with calibrated deicing material delivery systems for optimal control of the deicing material application rate. Calibrations shall be periodically checked to assure they are working properly.

- Provide education for operators of spreading equipment.

- Encourage a reduced salt application rate.

- Prohibit the direct application of 100 percent road salt to parking areas.

Aquifer Zone

All watershed provisions apply in addition to, or as modified by, the following provisions, for each development:

- Use of deicing materials for roadways is not to exceed the low-salt application rate of 150 lbs./lane mile.

- Encourage the use of alternative deicing materials for parking areas.

- Prohibit the direct application of 100 percent road salt to roads.

- Prohibit the stockpiling and/or disposal of snow or ice containing deicing materials from outside the Aquifer Zone.

Zone II

All watershed and aquifer provisions apply in addition to, or as modified by, the following provisions, for each development:

- Prohibit the stockpiling and/or disposal of snow or ice containing deicing materials from outside Zone II.

OPERATIONAL ACTIVITIES

Transportation of Hazardous Materials and Wastes

The control of movement of vehicles that transport hazardous materials and wastes, within the Devens Enterprise Zone, is necessary to minimize potential incidents. The following measures are required:

Watershed

- Transportation of hazardous materials and wastes must be in accordance will all federal and state regulations.

- Specific roadways within the Devens Enterprise Zone will be designated as primary access for use by carriers to deliver or remove products. These roadways include MacArthur, Sherman, Jackson, Patton, and Barnum

Roads. All of these roadways will be clearly marked and designated to facilitate safe transport of hazardous materials.

Aquifer Zone

All watershed provisions apply in addition to, or as modified by, the following provisions, for each development:

- As all designated primary routes are reconstructed, catch basins equipped to intercept floating product shall be installed and maintained.

Zone II

All watershed and aquifer provisions apply in addition to, or as modified by, the following provisions, for each development:

- For all designated primary routes, as roads are reconstructed spill interception and containment methods will be installed.

Hazardous Wastes and Materials

Watershed Area

Each development using hazardous materials and/or generating hazardous wastes must comply with these provisions:

- All activities associated with the generation, use, storage, and registration of, and emergency planning for hazardous wastes and materials must be in accordance with state and federal regulations.
- Secondary containment is required for all aboveground and underground storage tanks.
- Aboveground storage tanks and containers must be stored on a surface that does not have any cracks or gaps and is sufficiently impervious to contain leaks, spills, and accumulated precipitation.
- Any release must be promptly removed and reported to local and state authorities.
- Areas of storage and generation must be secured against unauthorized entry.
- Areas of storage must be clearly marked and separate from points of generation.
- Areas of storage and generation must be posted with a sign, "HAZARDOUS WASTES" or "HAZARDOUS MATERIALS," waste must be identified in words, and the date upon which accumulation began must be indicated.
- Separate containers of incompatible wastes by a berm, dike or similar structure.

- Each container and storage tank and each larger container into which smaller containers are packed must be clearly and visibly labeled throughout the period of accumulation.

- Each tank and storage container must be maintained in good condition.

- Each container holding hazardous wastes must be covered with a secure lid.

- Each development must allow periodic inspection of containers and storage tanks containing hazardous wastes and materials.

- Outside storage of hazardous wastes and materials is allowed in accordance with applicable federal, state, and Devens Enterprise Zone regulations.

- All hazardous wastes generated within the Devens Enterprise Zone must be disposed of or recycled at a licensed hazardous waste disposal facility.

- A registration and inspection program for hazardous materials should be established.

Aquifer Zone

All watershed provisions apply in addition to, or as modified by, the following provisions for each development:

- Requirements for storage of hazardous wastes and materials will be established and will remain in force as long as the use exists.

- Additional requirements for storage of hazardous wastes and materials may be established on an individual development basis.

- Each development storing hazardous materials or generating hazardous wastes beyond a specified amount, will be required to provide a materials-specific, storage-specific, and usage-specific addendum to the standard Devens Spill Prevention Control and Countermeasure Plan (DSPCC).

- Outdoor aboveground storage areas are allowed but must be covered wherever possible, have secondary containment with an impermeable layer, and have a berm or dike to hold any spills or leaks with capacity to hold 110 percent of the maximum volume stored.

Zone II

All watershed and aquifer provisions apply in addition to, or as modified by, the following provisions for each development:

- Those who generate, treat, store, or dispose of hazardous waste will be limited to Very Small Quantity Generators (VSQGs) as defined under state regulations.

- Outdoor storage of hazardous waste is prohibited.

Pesticides and Herbicides

Watershed Area

- State and federal regulations apply.
- For all non-residential application, chemicals stored on site must be registered in accordance with federal, state, and local regulations.
- Chemicals must be applied in accordance with authorized uses, label directions and other state or federal requirements.
- Spray equipment must be properly calibrated and maintained.
- Indoor storage areas must be clearly marked.
- Disposal of wastes and waste collected in a holding tank must be disposed of through a licensed waste transporter.
- Buildings used for storage must have a spill collection system in place.
- Mixing areas for pesticides should be located away from floor drains such that leaks or spills cannot enter floor drains. All indoor and outdoor mixing areas should be self-contained so they cannot drain into the wastewater or stormwater systems.
- Personnel training regarding storage, use, and handling of pesticides and herbicides should be ongoing.

Aquifer Zone

All watershed provisions apply in addition to, or as modified by, the following provisions, for each development:

- Outdoor storage facilities must be covered and must have secondary containment.
- Restrict the use of pesticides and herbicides contained in the state Pesticide Board Groundwater Protection List (GPL).

Zone II

All watershed and aquifer provisions apply in addition to, or as modified by, the following provisions, for each development:

- Require approval of a Pesticide Management Plan (PMP) in order to apply any product on the GPL.

Fertilizers

All Zones

- Encourage the use of fertilizer alternatives.
- Investigate the use time-release fertilizers.
- Encourage limited application of any type of fertilizer.
- Ensure proper storage of fertilizers to protect from runoff.
- Establish a monitoring program for fertilizer application to sites that are ten acres or greater.
- Test soil annually to determine annual fertilizer needs.

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