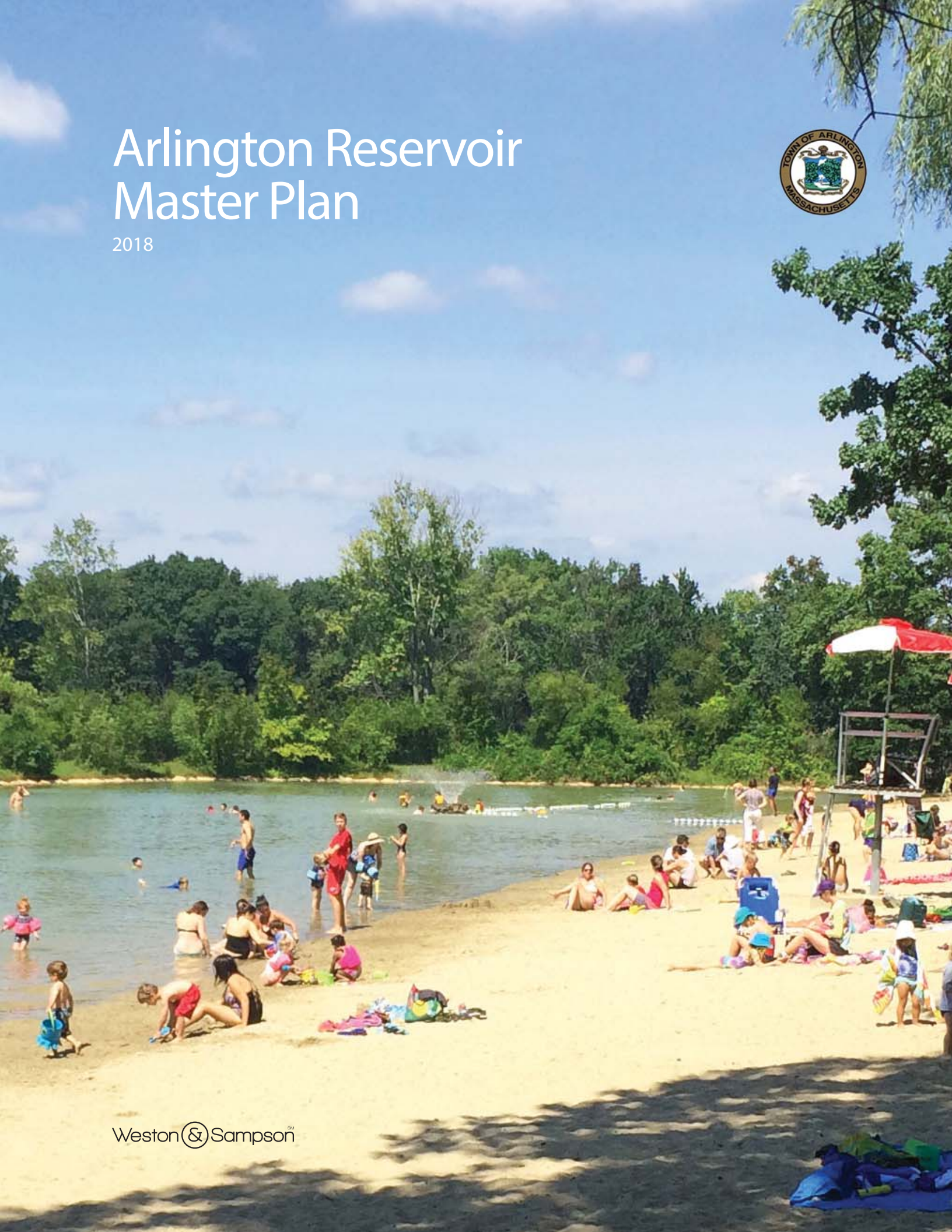
Arlington Reservoir Master Plan

2018



Weston & Sampson

TABLE OF CONTENTS

APPENDICES

ACKNOWLEDGEMENTS

We gratefully recognize the Town of Arlington's dedicated Reservoir Working Group that includes Jon Marshall, Director of Recreation; Lela Shepherd, Environmental Planner/Conservation Agent; Susan Chapnick, Chuck Tirone, and David White of the Conservation Commission; Ann LeRoyer, Master Plan Advisory/Implementation Committee and Open Space Committee member; and Leslie Mayer, Don Vitters, and other members of the Park and Recreation Commission. All of these dedicated people participated in aspects of this comprehensive master planning effort. As key aspects of the master plan are implemented in the coming years, their commitment to the Arlington Reservoir will result in benefits to all seeking recreational outlets and opportunities, as well as resource conservation.

We also wish to extend our gratitude to the many members of the community who came out for the open forums and expressed their thoughts and insights in person and to the many representatives of other Arlington town departments and committees for their sound advice and thoughtful direction. Thanks also to the Town of Lexington for providing both information and guidance as our work progressed. The recommendations contained in the Arlington Reservoir Master Plan represent our best professional judgement and expertise tempered by the unique perspective of the participants in the process.

Cassie Bethoney, RLA, ASLA
Cheri Ruane, RLA, ASLA
Weston & Sampson

April 2018

Adam Chapdelaine, Town Manager
Reservoir Working Group
Park and Recreation Commission
Conservation Commission
Vision 2020 Reservoir Committee
Department of Public Works
Open Space Committee

INTRODUCTION AND EXECUTIVE SUMMARY

Weston & Sampson was retained by the Town of Arlington in the fall of 2017 to complete a comprehensive master plan for the Arlington Reservoir (locally called 'The Res'). The purpose of this master plan is to develop a reservoir improvement plan that reflects the needs of a diverse and densely populated community. This plan will serve as a guide for all future development of this open space resource as well as become a tool to strategize for funding opportunities.

The scope of work undertaken by Weston & Sampson included:

- Carefully review, evaluate, process and validate the extensive prior planning concepts completed by various stakeholder groups including the Institute for Human Centered Design (see document included within Appendix I).
- Complete a land survey to determine exact boundaries of the Town of Arlington owned land. See plan provided in Appendix J.
- Assess water quality, water inflows and outflows, habitat for aquatic animals and water birds.
- Identify measures to control shoreline and bank erosion, while providing controlled access to the water for fishing and other activities.
- Undertake a robust public engagement process in order to solicit new public input, foster dialogue and build consensus.
- Establish a compelling preliminary and final master plan, to be validated, refined and endorsed through public dialogue.
- Establish a final preferred plan that is reflective of the physical capacity of the property and the Town's ability to operate and manage the property going forward.
- Establish a strong and achievable implementation and funding strategy with proritized phases of improvement.

Over the past several months, representatives from the Town, its Reservoir Working Group and Weston & Sampson developed conceptual plans and a final "preferred" master plan for The Res property. These were generated in response to the needs of the Town as expressed by various stakeholders and community members at a series of public meetings. At the outset of the process, and in conjunction with the master planning work, Weston & Sampson representatives frequently toured the property at different times of day in order to assess the existing conditions of all active and passive recreation facilities, current limitations, safety and maintenance issues. Representatives identified the potential to provide new and refurbished facilities and an improved user experience. Existing conditions assessments are included within this document in the form of photographs, plans and narrative summaries.

On April 3, 2018, the final master plan was presented to the Park & Recreation Commission for acceptance. This written report represents the culmination of the master planning process and contains narrative and graphic depictions with descriptions of potential improvements, phasing scenarios, implementation strategies and maintenance considerations. New and refurbished facilities have been identified to meet the needs of various programs and activities. Additional improvements promote environmental stewardship and create new pedestrian linkages between various site facilities, improved parking and site access, and an improved trail system to establish The Res as a first-class park and recreation facility. Implementation of the improvements outlined herein will require significant resources. The Implementation Strategy section of the report identifies a phasing strategy and how the significant financial requirements of the master plan can be broken down to fit within the Recreation Department's annual capital budget and other funding sources to create a financial package that will support the project.

It is important to note that a "master plan" is typically general and that recommendations are not

"cast in stone". It is fully intended that, as particular projects are implemented, the actual scope of improvements contained in this report will again be validated or refined to meet actual conditions at the time the improvements are implemented and through a continuing public participation process.

BACKGROUND AND RESERVOIR HISTORY

This master plan focuses on the Arlington Reservoir and its environs, located in the Arlington Heights neighborhood with Lowell Street forming its eastern edge. Although all of The Res and its shoreline are owned by the Town of Arlington, about half of the area is located in Lexington. It is approximately 65 acres in size, bordered on the north by Lexington Community Farm (Lex Farm), formerly called Busa Farm, Arlington's Hurd/Reservoir Field and the Drake Village Complex to the south, and Lexington's Rindge Park and residential Rindge Avenue to the west. The Res offers both passive and active recreational opportunities for both informal and formal use. It is used by community members and others year-round for walking, jogging, cross-country running and skiing, bird-watching, fishing, non-motorized boating, skating, dog walking and gardening. During the months of June, July and August, the Town operates a gated, chlorinated and filtered sandy bathing beach for resident and non-resident tag holders. The bathing beach area includes a bathhouse, concession stand, pump house with water filtration systems, picnic tables, benches and playground. Beyond the bathing beach area, there is a packed-dirt parking lot, forested area, a habitat garden, a reinforced dam with two outlets for flood mitigation, and a nearly one-mile trail path that encircles the water. Refer to the aerial photograph to the right for the location of various facilities within The Res property.

The Res is part of the watershed connecting Arlington's Great Meadows in Lexington to the Mystic Lakes and Mystic River via Mill Brook. The water body was created in 1871 by damming Munroe Brook to impound water for local water supply purposes. Arlington joined the Metropolitan Water District in 1899, which made the reservoir obsolete for supply purposes. The 28-acre reservoir has been left as aquatic habitat and used for recreational purposes since that time. The land is protected open space through chapter 97 of Massachusetts General Law, as is required by grants awarded through the Land and Water Conservation Fund. The Town significantly improved the beach in the early 1980s, adding a water filtration system and an earthen berm to separate the swimming area from the rest of the reservoir. The design plans showing these improvements have been included in the Appendix K.

In 2002-2003, a collaborative effort between the Arlington Public Schools art/science programs, the Arlington Center for the Arts (ACA) and the Arlington community resulted in the exploration of the ecosystem of the Arlington Reservoir. "A Tour of the Arlington Reservoir" guide was produced and documents issues in the area; it has been included in Appendix D. As part of this efforts, The Res was introduced to several classes of elementary school students as a field study opportunity.

In 2006, the Town successfully completed a major award-winning engineering project to rehabilitate the earthen dam; a handout has been include in Appendix H. This project ensured the dam's continued safe operation, while protecting the natural landscape. In 2010, the Reservoir Committee established a native plant Wildlife Habitat Garden adjacent to the new emergency spillway, which will be discussed in greater detail in the proceeding pages.

Aerial photography showing existing conditions

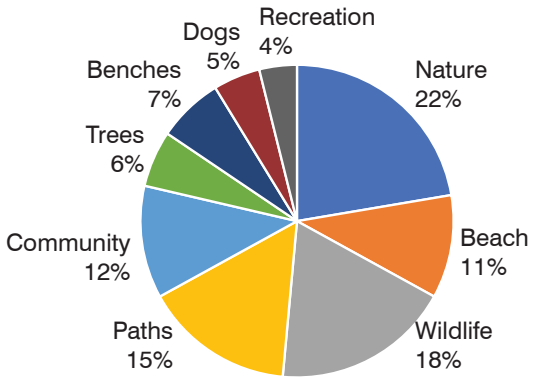
Public Participation and Community Process

The master planning process included a comprehensive amount of community engagement, with primary meetings identified in the chart located below.

Meeting	Subject	Date
Weekend Information Session	On-site meeting to gather community input	Saturday September 23, 2017
Public Input Meeting #1	Review of schedule and master plan scope; charette and walkabout guide results; review of existing conditions and analysis of the site; discussion of design opportunities and feedback regarding current and desired needs of the overall site; next steps; public comment	Thursday October 26, 2017
Walkabout Guide	Paper-based questionnaire asking for feedback on activities and facilities to be improved, the best and worst aspects of The Res, and what is missing. All input received has been included in Appendix C.	September 23 to November 15, 2017
Public Input Meeting #2	Review of Public Input Meeting #1; review of the project schedule and master plan scope; discussion of environmental and pump equipment assessments; review of what has been heard from the public to date; presentation of preliminary concepts and associated cost estimates; discussion of possible priorities and phasing options; next steps; public comment	Thursday November 30, 2017
Public Input Meeting #3	Presentation of the preferred plan, funding opportunities, and next steps for implementation	April 3, 2018

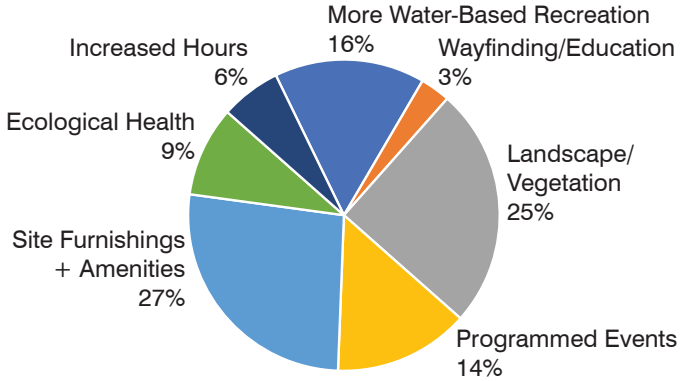
These meetings were held at various locations including The Res itself, the Town Hall Auditorium, and the Senior Center. The attendees included members of the community, abutters, neighborhood residents from both Arlington and Lexington, neighboring organizations and Town representatives. For the public input meetings, Weston & Sampson presented information via a powerpoint slideshow. A series of presentation boards were also displayed and discussed based on the specific subject of the meeting as outlined above. Walkabout guides were distributed at the Weekend Information Session. Comments were encouraged throughout each presentation and welcomed in between meeting via email, which have been included in Appendix A through C. At each meeting, the feedback was positive and the community concluded the process with clear preferences for a plan that best met both passive and active recreational needs.

Weekend Information Session at Arlington Reservoir



BEST THINGS ABOUT THE RES

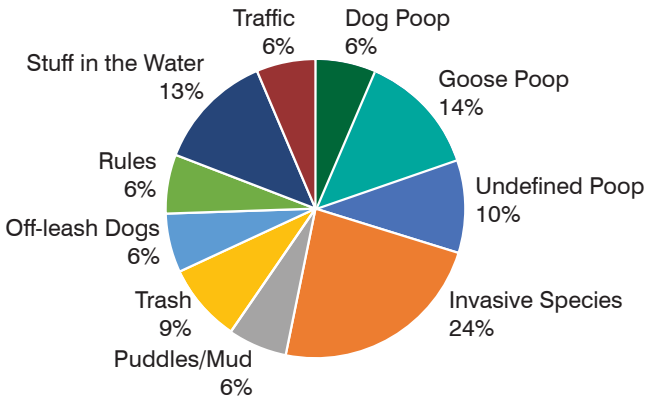
- Swimming!
- Habitat garden, wildlife and trails
- The willow trees
- Shade and grass on the beach
- Nature trail near Lex Farm
- The loop trail
- The shady beach!
- Fall/Winter walks with the dog
- The beach is very affordable



IMPROVEMENTS NEEDED

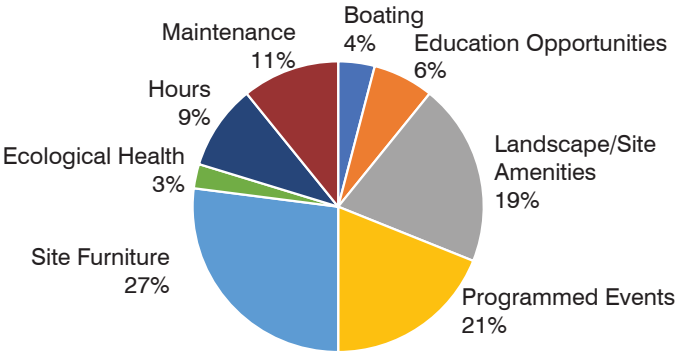
- More tables for lunch
- Bigger swim area
- Better maintenance of trails
- Splash pad!
- Water slide
- More walking/trail options
- More events (concerts, movies, etc.)
- Swimming lessons

Public feedback received through the community outreach process



I WISH THE RES HAD LESS...

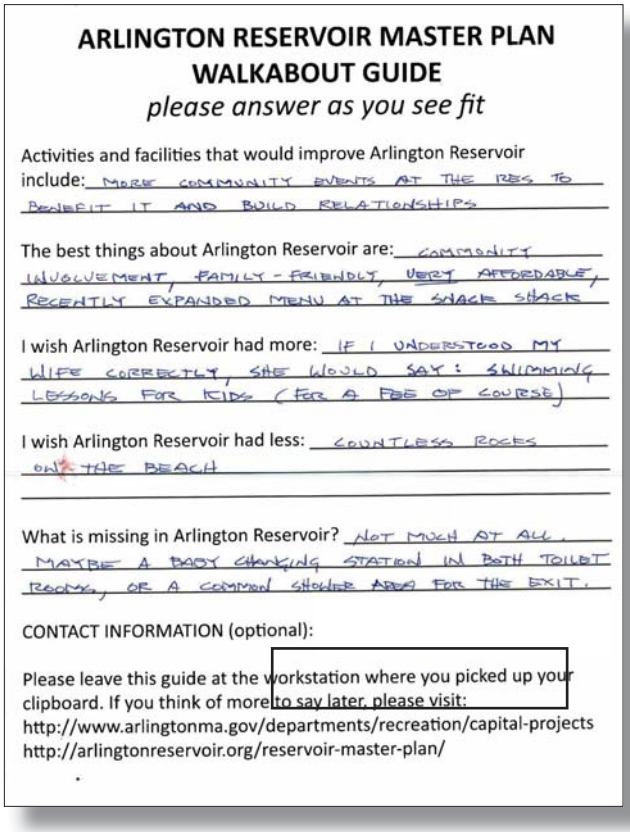
- Invasive plants
- Debris floating in the water
- Fencing along Lowell Street
- Geese!
- Sediment in the swimming water
- Erosion
- Goose and Dog poop
- Snow plowing! (cross country ski)
- Scum on bottom of swim area



I WISH THE RES HAD MORE...

- Seating
- Available beach hours in summer
- Information on wildlife
- Viewing opportunities
- Public art
- Year round access
- Trash cans
- Landscaped vegetation

Public feedback received through community outreach process



ARLINGTON RESERVOIR MASTER PLAN
WALKABOUT GUIDE
please answer as you see fit

Activities and facilities that would improve Arlington Reservoir include: MORE COMMUNITY EVENTS AT THE RES TO BENEFIT IT AND BUILD RELATIONSHIPS

The best things about Arlington Reservoir are: COMMUNITY INVOLVEMENT, FAMILY-FRIENDLY, VERY AFFORDABLE, RECENTLY EXPANDED MENU AT THE SNACK SHACK

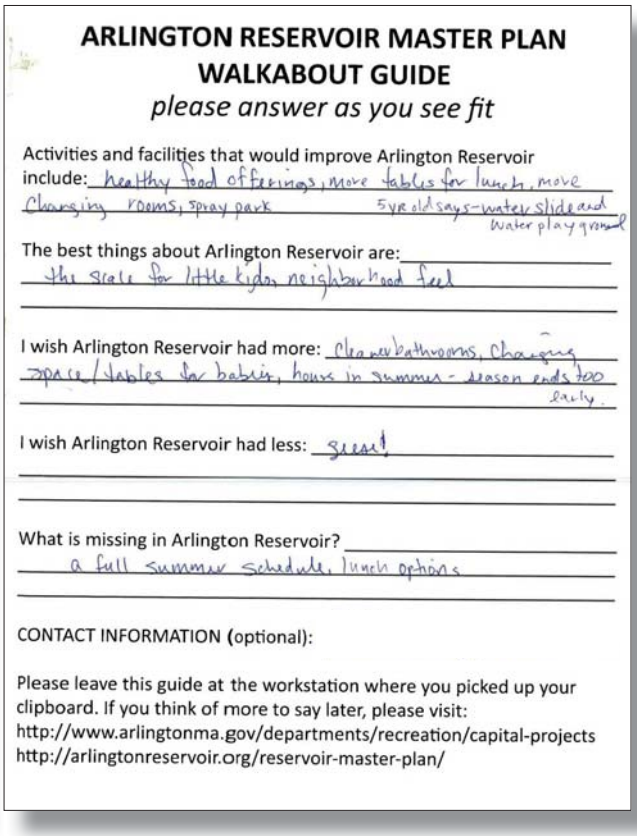
I wish Arlington Reservoir had more: IF I UNDERSTOOD MY WIFE CORRECTLY, SHE WOULD SAY: SWIMMING LESSONS FOR KIDS (FOR A FEE OF COURSE)

I wish Arlington Reservoir had less: COUNTLESS ROCKS ON THE BEACH

What is missing in Arlington Reservoir? NOT MUCH AT ALL. MAYBE A BABY CHANGING STATION IN BOTH TOILET ROOMS, OR A COMMON SHOWER AREA FOR THE EXIT.

CONTACT INFORMATION (optional):

Please leave this guide at the workstation where you picked up your clipboard. If you think of more to say later, please visit:
http://www.arlingtonma.gov/departments/recreation/capital-projects
http://arlingtonreservoir.org/reservoir-master-plan/



ARLINGTON RESERVOIR MASTER PLAN
WALKABOUT GUIDE
please answer as you see fit

Activities and facilities that would improve Arlington Reservoir include: healthy food offerings, more tables for lunch, more Changing rooms, spray park 5yr old says-water slide and water play ground

The best things about Arlington Reservoir are: the scale for little kids, neighborhood feel

I wish Arlington Reservoir had more: Cleaner bathrooms, Changing space/tables for babies, hours in summer - season ends too early.

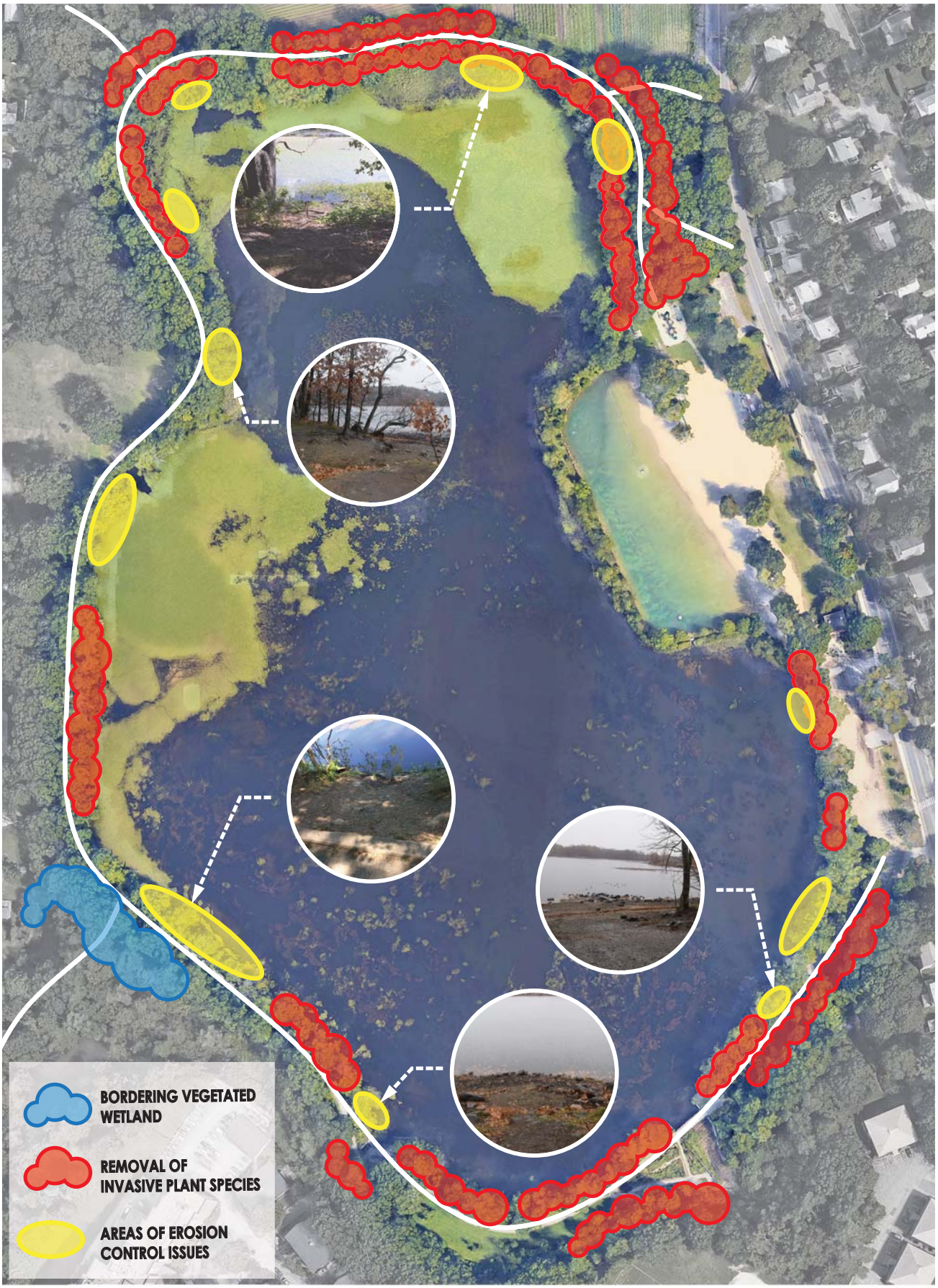
I wish Arlington Reservoir had less: sand!

What is missing in Arlington Reservoir? a full summer schedule, lunch options

CONTACT INFORMATION (optional):

Please leave this guide at the workstation where you picked up your clipboard. If you think of more to say later, please visit:
http://www.arlingtonma.gov/departments/recreation/capital-projects
http://arlingtonreservoir.org/reservoir-master-plan/

Examples of the public input received via the walkabout guide. All input has been included in Appendix C.



Environmental findings at Arlington Reservoir

EXISTING CONDITIONS

As with many beloved neighborhood parks and town destinations that offer a broad range of recreational opportunities, years of continuous use have caused wear and tear to The Res infrastructure, which make the built assets difficult to maintain and ultimately causes a degraded user experience. The regular use, combined with a lack of capital investment and continued deferred maintenance, has led to the current state of general disrepair.

Beyond improvements at the bathing beach facilities, it should be noted that erosion control issues, invasive plant species and trail conditions have been identified as needing improvement and will be discussed in great detail within the Environmental Assessment section of this Master Plan. The analysis diagram on the preceding page illustrates these particular existing conditions and site characteristics that prevail at the property.

Neighborhood Context

BUS ROUTES

Several bus routes that travel through Arlington and connect to Cambridge and Bedford terminate or begin at the Arlington Heights Busway on Massachusetts Avenue. It is less than a half-mile walk from the busway to The Res across the Minuteman Bikeway and the Hurd/Reservoir Fields.

The Town of Lexington operates a neighborhood bus called the Lexpress and Route 1 that takes passengers to Depot Square and East Lexington via Pleasant Street and Massachusetts Avenue. During peak hours, buses on this route travel down Lillian Road, take a right on Lowell Street, and then turn right onto Park Avenue. Peak hours run during morning and evening rush hours. There are two stops along The Res frontage on Lowell Street: at the intersection of Westmoreland Avenue and at Elder Terrace.

FLOW OF WATER

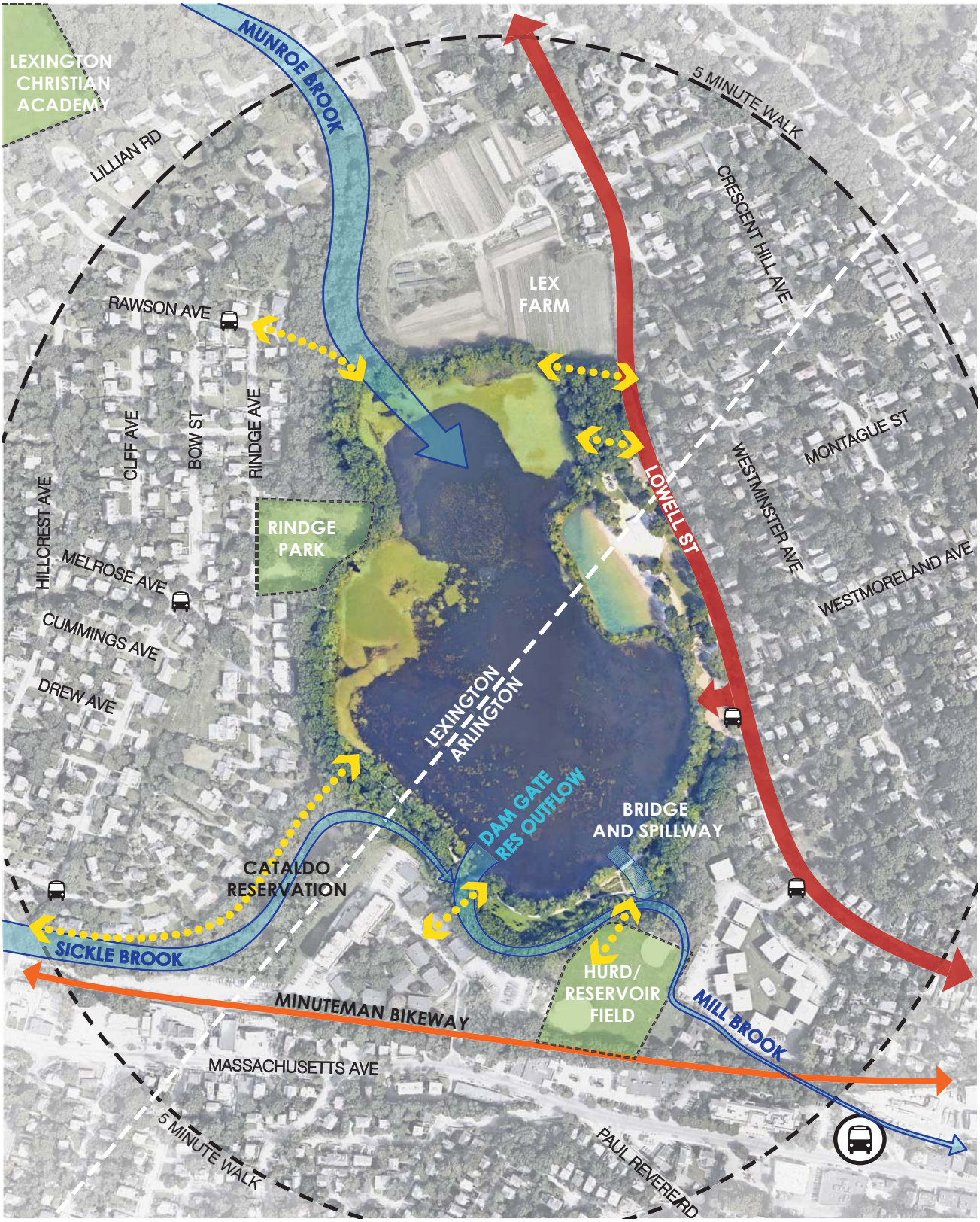
Munroe Brook enters The Res from Lexington in the northwest and feeds The Res. The water within the reservoir discharges in the south via a dam and gate system at the confluence with Sickle Brook (also known as Cataldo Brook and Fottler Brook) to form Mill Brook, which then flows for approximately 2.7 miles through Arlington until it discharges into the Lower Mystic Lake through a culvert under the Mystic Valley Parkway.

The inlet from Munroe Brook, feeding into The Res

TRAIL CONNECTIONS

Along the perimeter path, there are numerous trail connections, as indicated with the yellow dotted arrows diagram on the following page. They include connections to Hurd/Reservoir Fields, the Drake Village Complex, Bow Street, Minuteman Bikeway, Great Meadows, Rawson Avenue, and Lowell Street toward Whipple Hill. These connections vary in quality and many are not traversable for the

average user. The trail connections to the Drake Village Complex and to Hurd/Reservoir Fields are especially difficult to navigate, as noted on the analysis diagram on page 29. The condition of the perimeter pathways will be discussed in greater detail later within this section.



Context diagram showing bus stops, other open space destinations, trail connections, and flow of water

REGIONAL OPEN SPACE DESTINATIONS

Minuteman Bikeway - Running just south of The Res, the Minuteman Bikeway connects Bedford to Cambridge and passes through four communities: Bedford, Lexington, Arlington and Cambridge. Today, the Minuteman Bikeway is an extremely successful and popular rail-trail that is enjoyed for both healthy recreation and transportation. The Res marks the approximate center point of its ten miles. Built on an inactive railroad right-of-way, the Minuteman Bikeway connects to the Alewife "T" Station in Cambridge and provides a means for bicyclists and pedestrians to travel to and from subway and bus lines with less reliance on automobiles.

Hurd/Reservoir Fields - Hurd/Reservoir Fields share a border with The Res by way of Mill Brook. This park is home to two baseball diamonds and a multi-use soccer field and hosts a number of youth and adult leagues throughout the spring, summer, and fall. The large baseball diamond has a large backstop, players benches for both teams and a small bleacher area. The other diamond has a backstop and benches but no bleachers. The Town leaves movable soccer goals at the park for use all summer.

Hurd/Reservoir Fields

Rindge Park (Image courtesy of Facebook)

Rindge Park - Rindge Park is located in Lexington along The Res's western border. It is an asset of the Town of Lexington and is home to a basketball court, tee ball fields, a playground suited for ages two to five and a large open lawn for passive recreation. There are also a few particularly well-beaten paths along the shoreline for views across The Res.

Vehicular Access and Parking

At present, there are two parking areas at The Res. The primary parking lot is located along Lowell Street at the southeast corner of the property. It has two paved asphalt entrances which open to an informal, packed dirt and gravel parking area. The parking area's lack of striping and fixed surfacing has historically led to very muddy conditions after a rain event, a variety of ad hoc parking situations, and unsafe vehicular and pedestrian circulation. Approximately fifty-five to sixty cars find a way to fit into this lot at peak season in sometimes suspect parking orientations. On particularly hot days, parking for the beach overflows onto Lowell Street, which is not permitted. The more southerly entrance leads to a boat launch along The Res, which will be discussed in greater detail in the following paragraphs.

The second parking area is much smaller and is located along Lowell Street next to the playground. This parking area is fully paved and fits just a few cars. This lot is typically used for staff parking, drop off for group parties, and deliveries.

Northernmost entrance to main parking lot

Parking lot at peak season

Boat Launch

The boat launch is currently located just south of the parking lot and off the driveway that becomes the perimeter trail, beyond the bollards and a swing gate controlled by the Department of Public Works. Given that this gate is typically locked, the general public can not drive to and make use of the launch. This driveway is also an extremely sharp one-way loop back to the parking lot and would be difficult to maneuver with a boat hitch. During the community meeting process, many residents requested that the boat launch be publicly accessible and more centrally located to allow for recreational watercraft drop-off. The launch itself is made of a loose gravel material littered with larger rocks. It serves as the launching point for recreational watercrafts as well as the equipment used to perform annual management of invasive water chestnuts.

Existing boat launch

The boat launch is located just off the edge of this photograph on the left. The trailhead shown here marks the start of the perimeter trail and one of the parking lot entrances can be seen in the distance on the right side of this image.

Lowell Street Edge

The Arlington Reservoir is bound by Lowell Street on the east. This street edge is marked by a patchwork of fencing, most of which is in disrepair, with periodic openings for pedestrian or vehicular access. A sidewalk runs along the entire edge with curb cuts for driveway access into the parking lot.

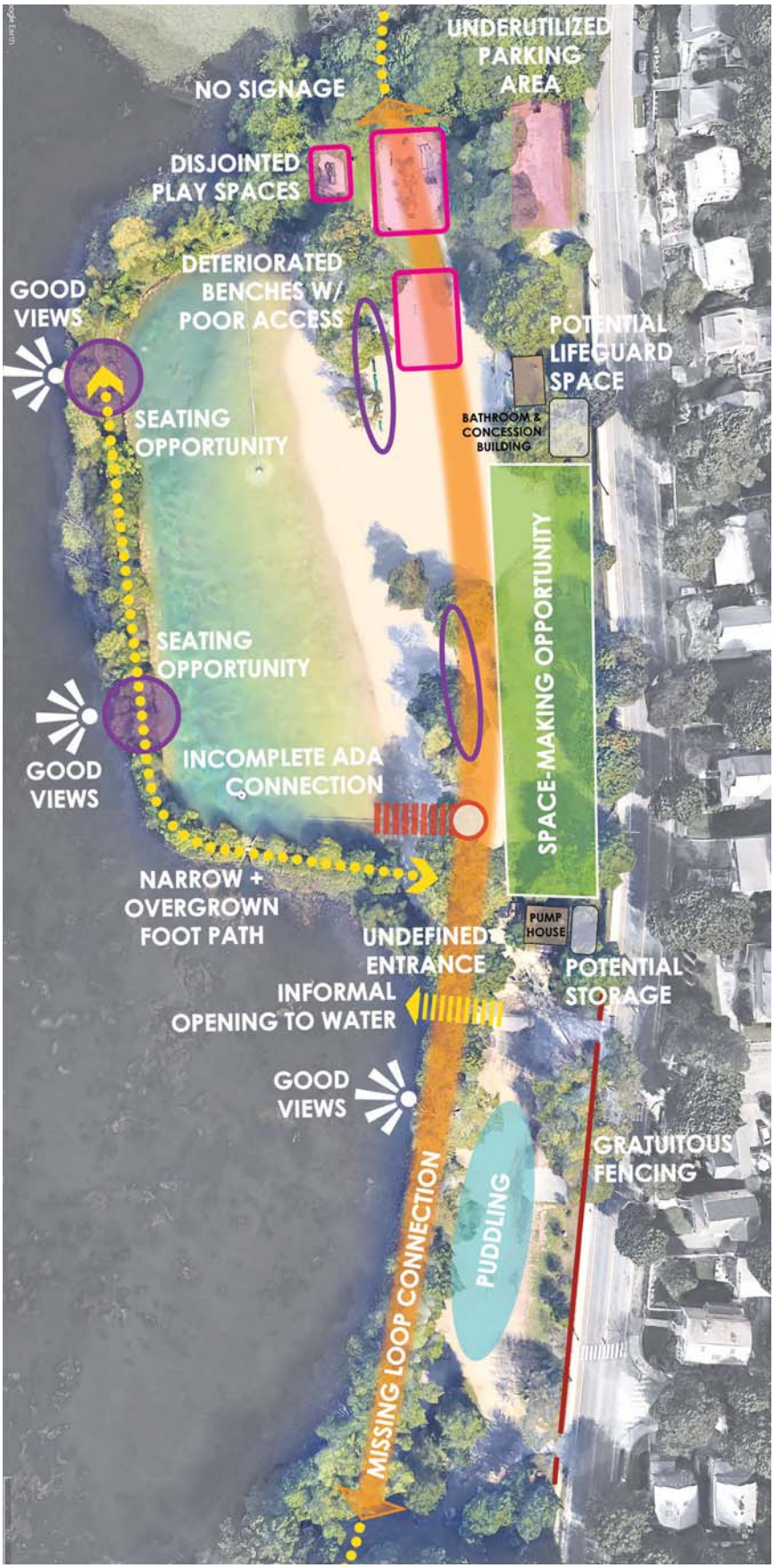
The two openings in the fence at the parking lot are gated such that the parking lot can be secured if needed. The opposite side of Lowell Street does not presently have a sidewalk. Crosswalks are currently located at the intersection of Lowell Street and Westmoreland and West Court Terrace. Overhead wires line The Res side of the street. Any tree canopy cover along the street comes from within The Res or within the residential properties across the street. There are no dedicated street trees within the Lowell Street sidewalk, which does not create the most hospitable streetscape experience for pedestrians passing through.

Bathing Beach

A popular summer spot, the bathing beach was first developed in 1935 and renovated to include the berm and water filtration equipment in 1982. The beach area is enclosed by a perimeter chain link fence and includes a bathhouse and concession building, a pump house, a playground, benches, and picnic tables. It is staffed with certified lifeguards during the bathing beach season from mid-June through late August. The beach area has three points of entry: at the pump house, at the small staff parking lot gate along Lowell Street, and at the start of the perimeter trail at the northern end. During the beach season, these gates are locked and reservoir tags are checked at the pump house entry.

Bathing beach in August 2017

The beach consists of roughly 56,000 square feet of sand. Much of it migrates into the swimming area over the year and, as a result, requires constant monitoring and annual replenishment to maintain the beach in its current size and state. The bathing beach is flanked by scrubby vegetation on its north and south sides, lawn and concession to the east and the swimming area to the west. Three lifeguard stands dot the beach and two lines of benches run along its eastern edge to total nine benches at the southern end and ten benches at the northern end. As a typical condition, each bench post has its own foundation such that each bench has three posts and footings, as opposed to the bench sitting within a concrete slab. In most cases, the earth has eroded around these bench post foundations such that their seating height is no longer comfortable for the average user. At one time, a concrete pathway and handrail system located at the southern end of the beach provided handicap access into the swimming area. The pathway is surrounded by sand, making it inaccessible and non-compliant.



Analysis diagram of the beach and parking area, showing trail conditions, incomplete or non-compliant walking path connections, seating and viewing opportunities, deteriorated perimeter fencing and disjointed programmatic elements

Typical bench condition

Non-ADA compliant concrete pathway and handrail system in foreground; the berm in background.

The table below shows beach usage over the past five years:

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Reservoir Tags					
Adult Resident	423	426	363	279	215
Child Resident	376	364	374	339	198
Senior Citizen	60	59	74	68	53
Non-Resident	6	3	0	0	0
Resident Family	511	470	459	325	272
Non-Resident Family	30	0	0	0	0
Resident Family + 1	74	109	11	79	66
Non-Res. Family +1	0	0	0	0	0
Total Season Passes	1,480	1,431	1,281	1,090	804
Total Daily/Individual Passes	5,375	6,172	9,565	8,806	11,782

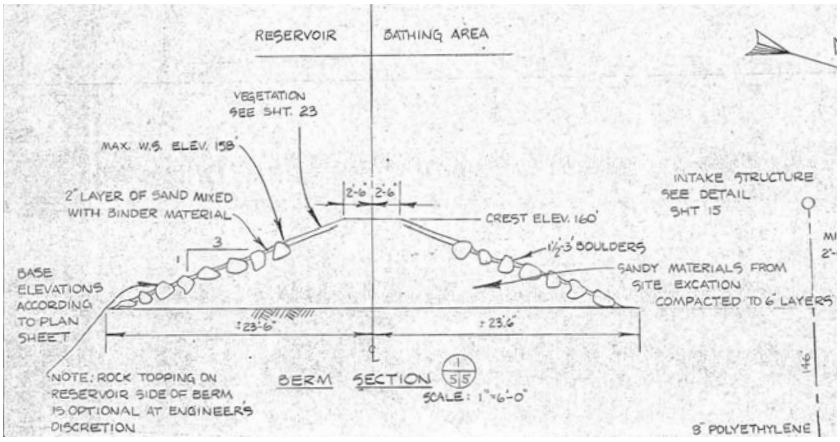
Exposed roots within sandy beach

Mature canopy that shades the beach edge

One of the bathing beach's greatest assets is the row of mature sycamore, maple and willow trees that lines its eastern edge. The trees range in size from 18-inch to 42-inch caliper and provide a

respite from the bright sun during the hot days of summer. Constant sand and soil erosion around these trees, however, has resulted in exposure of the root systems, thus compromising their future viability. Additionally, the roots can pose a tripping hazard.

The swimming area is impounded on three sides by an earthen berm that rises approximately three feet out of the water and tapers back to the water at a 3:1 slope. It is armored on both sides by stone riprap. This berm is interrupted by a sluice gate and concrete spillway on its southern end, which provides the only water flow connection between the swimming area and the rest of the reservoir. An informal walking trail runs along the top of the berm. The trail is overgrown with vegetation, making it barely three feet wide. The surface is very uneven due to tree roots, animal burrows and erosion. The filtered swimming water is fed by a series of inlets spaced evenly north to south along the deepest part of the swimming area. Water is also delivered through a fountain found in the north end of the swimming area.



Berm construction from 1982 Record Plans

Sluice gate and concrete spillway; pathway around the berm beyond

Pump House

The water filtration building is a one-story, 800-square-foot seasonal structure constructed in 1982. Existing drawings by Environmental Design & Planning dated April 1982 are available for review in Appendix K. Overall, the building is in fair condition, but in need of general repairs, upgrades and maintenance. Specific observations are as follows:

North and west elevation of the pump house

BUILDING ENVELOPE

Roof - The roof assembly consists of a built-up tar-and-gravel membrane over a metal deck. It is not known if any thermal insulation or vapor retarder is present in the roof system. There is a single interior drain at the southwest corner of the roof. The condition of the roof is fair to poor, with leakage noted at the interior.

Pump house roof condition

Interior flood condition with intake piping to swimming area

Walls - The 12-inch concrete masonry exterior walls appear to consist of an 8-inch interior CMU (concrete masonry unit) wythe with a 4-inch exterior split-face CMU block veneer. It is assumed that there is no insulation or drainage cavity in this wall assembly. The exterior masonry shows signs of deterioration from moisture intrusion and vegetation growth.

Floor - The interior floor is cast-in-place concrete with a painted finish. Its condition appears to be good, with no observed cracking or displacement. It is assumed that the there is no thermal insulation or vapor barrier in the floor construction, and that thermal bridging exists around the floor slab perimeter. This is not problematic for a warm-season-only building.

Openings - There are no windows or skylights present. There is one double exterior door. The steel doors and frame are showing some corrosion at their lower edges. Hardware operation was acceptable. The door frame is not thermally broken. The presence or condition of weatherstripping was not verified. There are two aluminum louvers at the North wall, which appear to be in good condition. No assessment was made on any dampers associated with these louvers.

INTERIOR CONSTRUCTION AND FINISHES

There is a small enclosed storage/workroom in the southeast corner with CMU walls, and partial-height cast-in-place concrete containment walls for chemical tanks along the east wall. These assemblies are in good condition, although cleaning, surface preparation and re-painting would prolong their useful life. The door and frame to the storage/workroom is corroded at its bottom edges.

POTENTIAL PRESENCE OF HAZARDOUS MATERIALS

Original roofing materials, including mastics, sealants and membranes may contain asbestos,

although the building is relatively recent and thus, the presence of hazardous materials is considered unlikely. PCB-containing sealants, electrical components, lead-based paint etc., may be present, although this is unlikely due to the age of the building.

BUILDING CODE COMPLIANCE

Architectural renovations to the structure will be guided by the International Existing Building Code 2015 as amended by the Massachusetts Building Code 9th Edition, by the current edition of the Massachusetts Architectural Access Board regulations, and by OSHA standards, as applicable.

OSHA COMPLIANCE

As an industrial-process facility, the building is generally not governed by building code requirements for accessibility, egress, protection of openings, etc. OSHA standards typically prevail in such cases. No apparent deficiencies were noted at the time of Weston & Sampson's site visit; however, this observation does not include any evaluation of required clearance or protections around mechanical or electrical equipment. It was assumed that this facility is not classified as a hazardous use in any respect.

STRUCTURAL

Flat roof interior with steel bar joists

Walls showing interior CMU wythe

The flat roof consists of metal roof deck supported by 8-inch deep steel bar joists. The steel bar joists are supported on a 12-inch wide flange beam at the center of the structure and 12-inch concrete masonry at the perimeter. The structure is constructed on shallow concrete foundations. Overall the structure is in fair condition. The existing metal roof deck has areas of corrosion. There is an unframed penetration through the roof for an exhaust fan. The steel bar joists and steel beam also have areas of corrosion. The concrete masonry walls show signs of deterioration from moisture intrusion vegetation growth. There are no signs of settlement of the structure.

Bathing Beach Filter System and Water Quality

The current filter system utilizes a high-rate pressure sand filter, pumps, strainers, and liquid sodium hypochlorite disinfection pumps. The current pump system has been sized for 1800 GPM, but the system may be operating between only 1200-1600 GPM. There was a conversion performed over twenty-five years ago that converted the system from a vacuum suction filter to a pressure sand filter system. With this, there is a flow control structure found outside of the filter building, which retrieves water from the swimming area and suctions from the basin as well as fills the system with reservoir water.

There are many challenges with the current filter system, as noted below:

- The filter sand has not been changed in over ten years. The vessel is rusted. Operation has not been able to properly backwash the vessel and it is unknown how much sand is still in the filter.
- The pump is currently a vertically-mounted pump, however, it is a flood suction pump that is above the static water level, which makes it challenging to prime.
- The chemical controller no longer works and it doesn't appear to have worked for years.
- Instrumentation, such as flow meters and pressure gauges, do not function properly.
- The chemical injection system is not interlocked with the pump.
- The Town uses domestic water to supplement filling the swimming area when the water is too low.
- Site valves either do not open and operate or are difficult to operate.

Chlorine Disinfectant Holding Tanks

Vertically-mounted Pump and Strainer

Currently, the water is circulated by the above-mentioned filtration system and is delivered back to the bathing beach through a series of inlets found in its deeper side. Water is also delivered through a fountain within the swimming area. It is a challenge to keep the water clear and not cloudy. For instance, animals such as ducks and geese land, nest, and contaminate the water. Currently, the water is not skimmed because it requires manual labor. Skimming would remove the dirtiest part of the water.

The water that is delivered through inlets comes into the swimming area at a high velocity, which can impact patrons. These inlets are embedded in rocks, found along the perimeter of the beach at its deepest section, and can be an abrasion hazard for swimmers. The earthen berm edges do not offer a point of refuge for a tired swimmer to hold onto the wall or exit the bathing beach along these edges and may be difficult for lifeguarding staff to navigate. Better identification, such as rope and floats, would help swimmers identify when they are entering an area that is deeper than five feet.

Bathhouse & Concession Building

This park building is a one-story 800-square foot seasonal structure renovated in 1982. The original construction date is unknown. There are concrete masonry screen walls at the restroom doors. Overall, the building is in fair condition, but it is in need of general repairs, upgrades, accessibility improvements and maintenance. Specific observations are included on the following pages.

West elevation of the Bathhouse and Concession building

BUILDING ENVELOPE

Roof - The roof assembly consists of asphalt shingles over a wood deck, with flush-mounted translucent skylighting panels at two locations. No thermal insulation or vapor retarder appears to be present. The roof system is past its useful life and is in need of complete replacement. Unit-type skylights in place of the skylighting panels is recommended. No gutters or downspouts are present, but are recommended as part of any roof replacement project. The rake and eave trim assemblies are painted wood and in fair to poor condition. There is evidence of squirrel and insect damage at several locations.

Walls - The exterior walls consist of a single 8-inch wythe (thickness) of CMU, split-faced at the exterior and smooth surface with paint finish at the interior. There is no apparent insulation or drainage cavity in this wall assembly. The exterior masonry shows minor signs of deterioration from moisture intrusion and age.


Floor and walls inside the concession area


Typical door and frame condition at a restroom

Floor - The interior floor is cast-in-place concrete with a painted finish. Its condition appears to be good, with no observed cracking or displacement. It is assumed that the there is no thermal insulation or vapor barrier in the floor construction, and that thermal bridging exists around the floor slab perimeter. This is not problematic for a warm-season-only building.

Openings - There are translucent skylighting panels in two locations at the west slope of the roof, providing daylight to the Men's and Women's rooms. These panels are installed as part of the shingle roof system, and are not separate skylights as such. There are significant leaks at the lower edges of these panels. There is a single service window at the west wall, which is protected by a roll-up metal shutter. The condition and operation of the shutter was not verified, but it appears to be in serviceable condition. The service window is not accessible, as discussed below.

For door openings, there are three single steel exterior doors. The doors and frames are showing some corrosion at their lower edges. Hardware operation was not verified. The doors and frames are not thermally broken. The presence or condition of weatherstripping was not verified.

West elevation of Concession and skylights

Wood fascia board in poor condition

In terms of louvers, there are rectangular wooden gable vents at each end of the building, which were closed off with exterior plywood panels for the winter. These vents provide direct ventilation of the Men's and Women's rooms, in conjunction with roof-mounted exhaust fans. There are two aluminum louvers at the east wall, which appear to be in good condition. There is no mechanical equipment or dampers associated with these louvers, which only provide passive intake air into the Men's and Women's rooms.

Other Exterior Elements - There are CMU screen walls at each of the Men's and Women's entrances. These appear to be newer additions to the building as the style of CMU does not match and they are not integral to the main building walls. The screen walls are constructed of a double wythe (thickness) of 4-inch thick block, and it could not be verified if any vertical or horizontal reinforcement is present. Unreinforced, un-braced masonry poses a hazard, as noted in the structural review below. There is also a minor degree of deterioration of mortar at the base of these walls.

INTERIOR CONSTRUCTION AND FINISHES

The Bathhouse and Concession Building is subdivided into Men's and Women's toilet/changing rooms and a small food service area. These three areas are not internally connected. Interior walls and partitions are painted CMU. There are furred-out CMU chases behind sinks, urinals and toilets,

which appear to be constructed of 4-inch block. The food service area has a dropped GWB (Gypsum Wall Board) ceiling, while the remaining areas are open to the underside of the roof, which is painted. The food service area is accessed through a small vestibule, which contains some electrical and telephone equipment and small water lines. There are no cooking facilities.

MECHANICAL, ELECTRICAL AND PLUMBING

Domestic Water, Waste Piping - The condition of under-slab and other concealed supply, waste and vent piping was not assessed as part of this investigation. No drainage issues were reported, but water was present at the floor of the Men's room and may have originated at a floor drain. The outdoor shower drains were also flooded. While it requires further investigation, this is assumed to be an off-season issue. Water service in the building was shut off at the time of our visit, and shower heads and flush valves removed. It is understood that adequate domestic water pressure and flow is available at the building for the current fixture needs. We note that water demand is likely to be reduced in the future with the installation of new, code-compliant faucets, flush valves and showers. No domestic water heating equipment, tempering valves or circulators were noted. No gas service to the building was noted.

Plumbing Fixtures - All existing sinks and sanitary fixtures otherwise appeared to be functional and in satisfactory condition, although most are old and recommended for replacement. The condition of fixture carrier chairs concealed in plumbing chases could not be determined, but these should be assessed and replaced as needed. Hinged access panels in the chase walls are corroded.

Women's room partitions and fixtures

Men's room partitions and fixtures

Toilet Partitions & Accessories - Toilet partitions and accessories, including grab bars, mirrors, shelves, hand dryers, soap and toilet paper dispensers, etc., are in fair to good condition, but should be considered for replacement as part of an overall upgrade to the toilet rooms.

Heating & Ventilating - There is a grille at the ceiling of the food service area, but it is not known if this is connected to any mechanical supply or exhaust air system. It appears to terminate in the Men's room. The Men's and Women's rooms each have a roof-mounted exhaust fan, with passive intake louvers at the lower East walls. The type and location of ventilation controls was not noted. There is no heating or cooling equipment.

Electrical System - Electric service enters the building underground, with meter and panelboards inside the food service vestibule. The type, condition, and capacity of the building's electrical systems

were not evaluated as part of this assessment. No known issues were reported. Interior lighting is by fluorescent tubes in moisture-resistant enclosures. Light levels in the Men's and Women's rooms were poor. Exterior lighting fixtures are outdated, but have been fitted with replacement LED bulbs.

Electrical system within the bathhouse & concession

Passive intake louvers within the bathrooms

POTENTIAL PRESENCE OF HAZARDOUS MATERIALS

Original roofing materials, including mastics, sealants and membranes may contain asbestos. PCB-containing sealants, electrical components, etc., may be present. Lead-based paint may be present at interior surfaces.

BUILDING CODE COMPLIANCE

Architectural renovations to the structure will be guided by the International Existing Building Code 2015 as amended by the Massachusetts Building Code 9th Edition, and by the current edition of the Massachusetts Architectural Access Board regulations. No apparent Code violations were noted at the time of our visit, with the exception of structural items noted below and accessibility items described below.

ACCESSIBILITY

The Bathhouse Building is surrounded by a generally-level concrete pad which offers an accessible route to the building doorways and service window. The asphalt walkway leading to this concrete pad from the north and the walkway connection to accessible parking are not compliant. Access to the building from the south and from the bathing beach to the west is across sand or soft ground.

The Men's and Women's toilet rooms are generally accessible and ADA/MAAB-compliant doorways, toilets, partitions, urinals and lavatories are present. The operation of door hardware, including operating force, was not verified. Small privacy cubicles are present in the Women's room. The presence of an ADA/MAAB-accessible cubicle was not verified. Each toilet room has an outdoor

shower adjacent to the entry door. The receptor pads for these showers are recessed and not wheelchair accessible. At the time of our visit, the shower heads and controls had been removed for the winter and could not be evaluated for accessibility, however residents have reported that the exterior shower valves are currently operated by chains that are frequently broken or missing, making the showers difficult to use for younger children. The west service window height (approximately 40-inches above the ground surface) does not meet ADA/MAAB accessibility requirements.

STRUCTURAL

The gable roof structure consists of plywood sheathing supported by 2x6 wood rafters spaced at 20 inches on center. There were 2x6 cross ties every three to four joists located approximately one foot above the top of wall. The rafters are supported by 12-inch concrete masonry walls. The gable end walls are constructed with 8-inch concrete masonry. The structure is assumed to be constructed on shallow foundations, which is not shown on the 1982 drawings. There are concrete masonry screen walls at the restroom doors.

Overall the structure is in fair condition. There is noticeable deterioration on the interior of the roof sheathing, and based on the condition of the roofing, there will likely be more deterioration found on the exterior side of the sheathing. The bases of several roof rafters are significantly deteriorated, along with areas of the wood top plate on the top of the masonry wall. There is some cracking in the masonry walls, but no signs of significant settlement.

Children's Play Area

Large play structure

A small play area and individual play pieces are located within the limits of the bathing beach, which make them unavailable to the general public and neighborhood during beach season. The large play structure shown above serves children from ages 5 to 12 years old and offers multiple slides, a wobbly bridge, climbers, a zipline, and space for imaginative play. There is also a seesaw, a tunnel and benches included within this play zone. Although an accessible route is provided to this large play structure, the surfacing material is generally sand, which is not ADA-compliant. A 2-to-5 year play structure with a slide, a free-standing set of overhead bars and a swing set all sit within separate zones of sand and do not meet Certified Playground Safety Inspector (CPSI) standards. All of these structures are at least fifteen years old and have reached their maximum life expectancy.

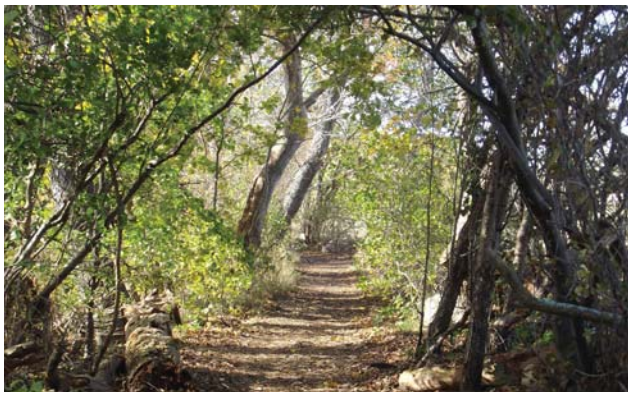

2-5 play structure on sand


Swing set on sand


Overhead bars on sand

Reservoir Perimeter

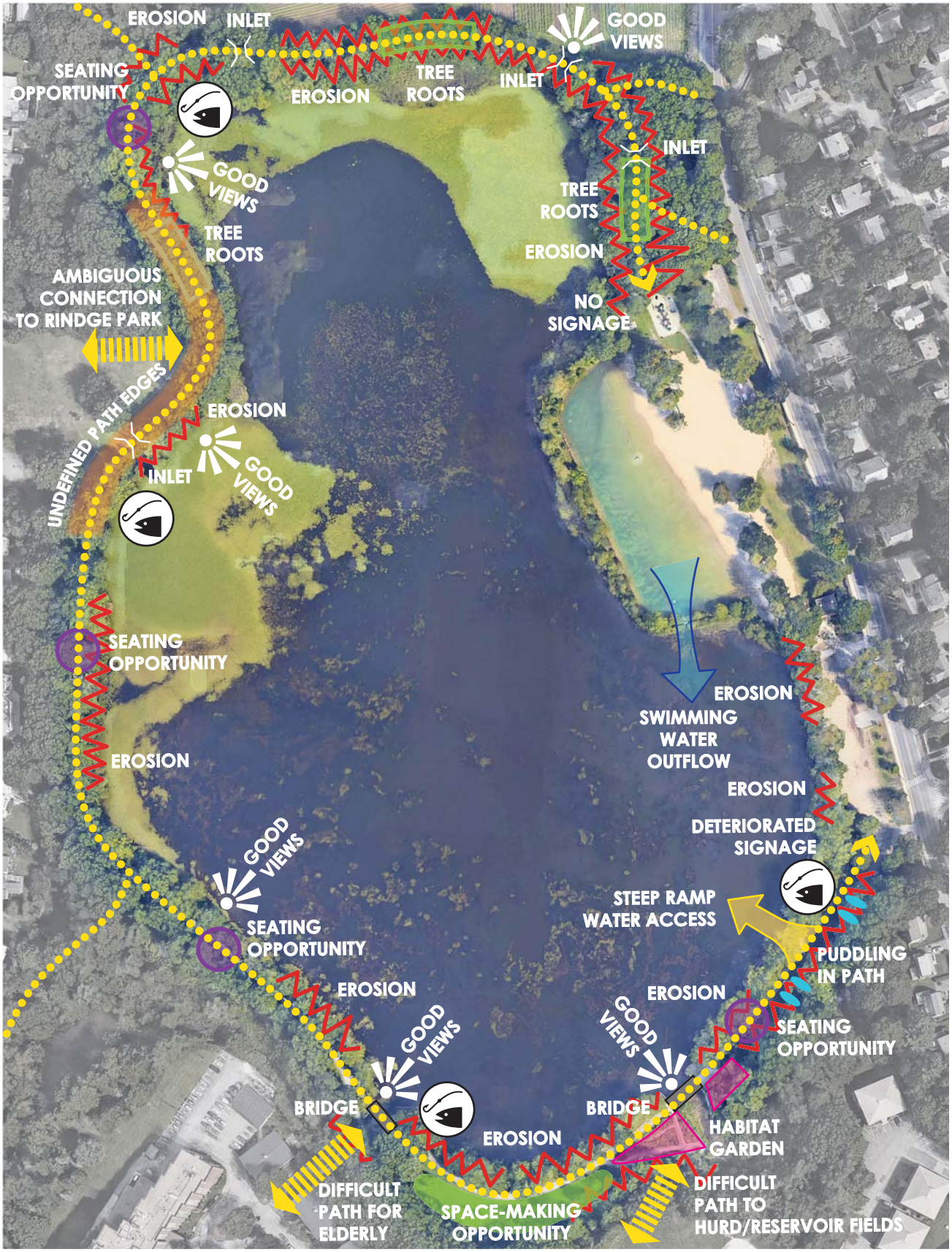
A perimeter path of just under one mile circles the reservoir and is frequented by neighbors, dog walkers, joggers, birders and others looking for fresh air and exercise. The beginning of the loop path is marked by a deteriorated trailhead kiosk and trail map, located just south of the parking lot, which is discussed later in this section. In this area, the 12-foot wide trail is lined with a concrete curb along its reservoir side and consists of stone dust surfacing. The path's generous width and the concrete curb treatment continue until the trail connection at Drake Village Complex. Here vegetation has been cut back off of the path and the trail condition is fairly uniform with few areas requiring regrading. The trail then narrows and continues as a beaten path for the duration of the loop. The path condition is much more variable as it passes next to Rindge Park and moves north. It becomes a beaten path and varies in width as it passes by the outlet and Lex Farm. In this area in particular, vegetation encroaches on the path's width in various locations and tree roots protrude within the path, making the trail non-compliant by accessibility standards. The trail ends at a deteriorated fence and gate leading into the bathing beach at the playground.


Trail condition next to Busa Farm


Ambiguous trail condition next to Rindge Park

PEDESTRIAN EXPERIENCE

The walking experience along the trail is quite varied and tough to navigate in many areas; the trail widens and then narrows, opens up to big sky at some points and at others, the canopy is thick and completely covers overhead. The perimeter path incorporates two bridges that cross over breaks in the embankment: at the new spillways between The Res and Mill Brook to the south and at the old spillway near Drake Village. Additionally, there is an earthen bridge at the inlet from Munroe Brook in the northern part of The Res, which appears to supply most of the water to the reservoir.



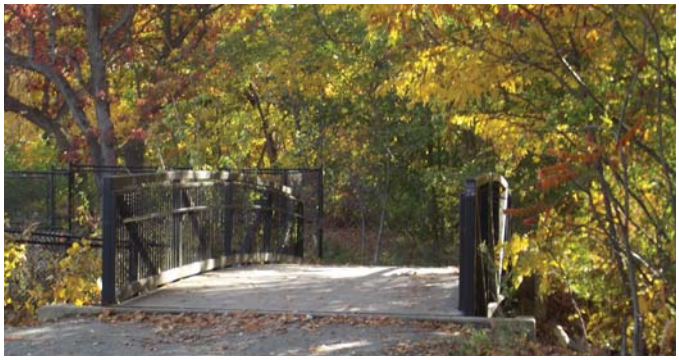
Analysis diagram showing good viewing locations and fishing overlooks, the boat launch and habitat garden locations, the variability of trail conditions, seating and fishing opportunities, and shoreline erosion zones along the perimeter path.

WILDLIFE HABITAT GARDEN

Along the trail is a Wildlife Habitat Garden between the Res trail and the back entry to Hurd/Reservoir Fields. In 1999, the State identified the existing earthen berm enclosing The Res as a potentially high-hazard structure. Instead of the typical engineering solution to remove all the trees along the berm and armor the bank with stone rip-rap, a Reservoir Committee was formed under the Arlington Vision 2020 Committee to pursue alternatives. While a new emergency spillway was still required, a majority of the trees were saved and protected through an innovative engineering strategy. Many more trees were planted and what had been a dump area west of the new spillway was regraded and replanted as part of this construction project, which was completed in 2006. This new space gave way to the development of a native shrub and wildflower garden that attracts local wildlife. The dedicated members of the Reservoir Committee worked with the Arlington Land Trust, the Conservation Commission and the Department of Public Works in the development of this garden, which was constructed in 2011. Preparations for the garden were carried out by Arlington Department of Public Works. The garden was planted and is maintained by the Reservoir Committee.

Although the intent was to make the Habitat Garden accessible, the effort has not yet succeeded. As part of the improvements to The Res, there should be considerations for regrading a pathway such that it meets ADA compliance. In particular, the pathway through the garden from the bridge to the entrance to Hurd/Reservoir Fields is quite steep and highly eroded. This part of the perimeter trail must be regraded and resurfaced with a material that will not continue to erode. An alternate route of steps and pathway should also be considered to ease the grade change.

Trail condition near the Drake Village Complex



One of two bridges along perimeter path

Spillway below bridge shown on left

VEGETATION

Tree species are fairly typical of New England urban forests and include trees such as oak, hickory, maple, beech, and white pine. The upcoming Environmental Assessment section will delve into detail on the understory layer, wildlife, and invasive species found along the shoreline and within the reservoir itself.

SIGNAGE AND WAYFINDING

Many different kinds of signs displaying a range of information can be found along The Res's perimeter trail. There is a lack of consistency in look amongst these signs, which contributes greatly to the sense from residents that there is visual pollution detracting from the tranquillity offered at The Res. The three signs pictured below mark the beginning of the trail at its southern end. The two wooden kiosks have reached beyond their useful lives, especially the one to the right of the granite pillar, which is missing a wooden plank in its center. The kiosk displaying trail maps and community information is useful, but the community would be better served by an all-weather system that provides protection throughout the entire year. The granite pillar is in good condition and denotes overall trail mileage in miles and meters; however, it feels redundant with the two other kiosks in very close proximity.

Community board/trail map kiosk Granite mileage marker and deteriorated wooden kiosk

In addition to the multiple trailhead markers at the southern end of the parking lot, the trail itself is dotted with a variety of both educational signage and 'ACROSS Lexington' signage, which is denoted with the characteristic colonial hat of Lexington. The Res's perimeter trail falls within ACROSS Lexington's network of marked trails and paths for walkers, runners and trail bikers. While Arlington's Conservation Commission approved the installation of these signs, they are visually intrusive and do not offer proper wayfinding through the property. Directional signage does not currently relate to nearby open space and recreational resources, which would be of great value to all visitors of The Res.

Educational signage found around the perimeter trail appears to be installed by community members, school groups, or college students completing course work or conducting experiments. For example, there are three signs that ask visitors to upload digital photos of a particular area of The Res as part of an ongoing phenology and environmental monitoring project. Another example identifies a colony of Jack-in-the-Pulpit and describes the invasive species that harm its health. Both examples have been constructed with a simple wooden stake to which a paper sign covered with plastic is affixed. It is unclear if these projects are ongoing or if these signs remain after the project has been completed.

Examples of educational signage

ACROSS Lexington signage

Bathing beach rules and regulation signage

Wildlife habitat garden signage

Signage hung from the perimeter fence surrounding the bathing beach displays rules and regulations that pertain to use of the beach. This signage has been vandalized and could be located more prominently as part of the improvements to the beach. Finally, a large upright sign at the Wildlife Habitat Garden describes information about the garden, including the plants growing there and why they were chosen. As is the case with all of the signage within the entire property, this sign has its own aesthetic and is distinctly different from the other large kiosk signs located at the trailhead described above.

Surficial Drainage and Other Existing Utilities

It should be noted that, while no drainage structures currently exist within the Arlington side of The Res property, stormwater runoff flows off of surfaces surrounding the reservoir into the water body itself. Additionally, there is an abandoned drinking fountain located behind the Bathhouse and Concession Building. A sanitary sewer and associated manholes are located along the west side of The Res. Stormwater outfalls into the reservoir and their relationship to the reservoir's water quality will be studied during the first phase of improvements to The Res.

Overall Aesthetics and Landscape Qualities

Although The Res has great foundational features, including magnificent shade trees within the bathing beach and canopy cover around The Res perimeter, wildlife diversity, a widened trail and bridge infrastructure along part of the perimeter path, and a large and diverse active user group, the overall aesthetic qualities of the property are generally poor and adversely impacted as follows:

- There is a general lack of site identity, particularly at primary pedestrian entrances to the property. For the 65 acre site, the property is identified as Arlington Reservoir only at the deteriorated trailhead kiosk and on the Bathhouse and Concession Building.
- The formal points of entry are inadequate relative to the size of the property and do not provide sufficient meeting/gathering areas. Current points of access to the pathways, beach, and parking areas are poorly marked and unwelcoming.
- The street edge along Lowell Street is deteriorated and does not indicate an open space asset.
- Some vegetated areas are overgrown and collect debris and trash. These conditions are particularly seen along the berm containing the bathing beach. Existing vegetation impedes views of The Res from the bathing beach, parking lot, and Lowell Street.
- Within the interior of the property, visual qualities suffer from aging or unmaintained facilities. The Pump House and Bathhouse and Concession building are unsightly and deteriorated.
- The pump and filter equipment serving the bathing beach is in dire need of upgrade or complete removal and replacement in order to improve water quality and reintegrate Reservoir water back into the system rather than using domestic water.
- The main parking lot is often dotted with mud puddles.
- The condition of the fencing along Lowell Street parking area and surrounding the beach is deteriorated and in need of repair.
- The play equipment is beyond its useful life and offers little play value. The sand surfacing below the play equipment is dangerous and not ADA-compliant.
- Sand migration within the bathing beach requires constant upkeep. Its movement has resulted in exposure of tree roots, which compromises the long-term health of the large shade trees at the beach.
- Programming at the beach, access to the Wildlife Habitat Garden, and much of the perimeter trail are inaccessible due to structural accessibility barriers, which include slopes than exceed 5%, lack of handrails, tree roots emerging within trails, non-compliant surfacing materials, and lack of ADA-compliant curb cuts at parking areas.
- The perimeter trail condition is wildly variable and lacks consistent accessibility. Trail improvements should address tree roots, ensure positive drainage away from the paths and establish a typical and consistent width along the entire trail.
- The Res shoreline is dotted with areas of erosion and infestations of invasive species. This will be discussed in greater detail within the Environmental Assessment section.
- Trail connections to neighboring properties or open space resources are either extremely difficult to navigate or are ambiguous. Clear wayfinding signage and path improvements will be essential to improving these connections.
- There are minimal site furnishings along the perimeter path that offer a place to sit and enjoy The Res, especially at viewing and fishing overlooks. The seating provided at the bathing beach is generally in disrepair or the sand has pulled away from the foundations such that it is unreachable for the average person.
- There is a lack of information available to the casual visitor about The Res's long and rich history. Educational signage would help to build The Res's identity.

ENVIRONMENTAL ASSESSMENT

Introduction

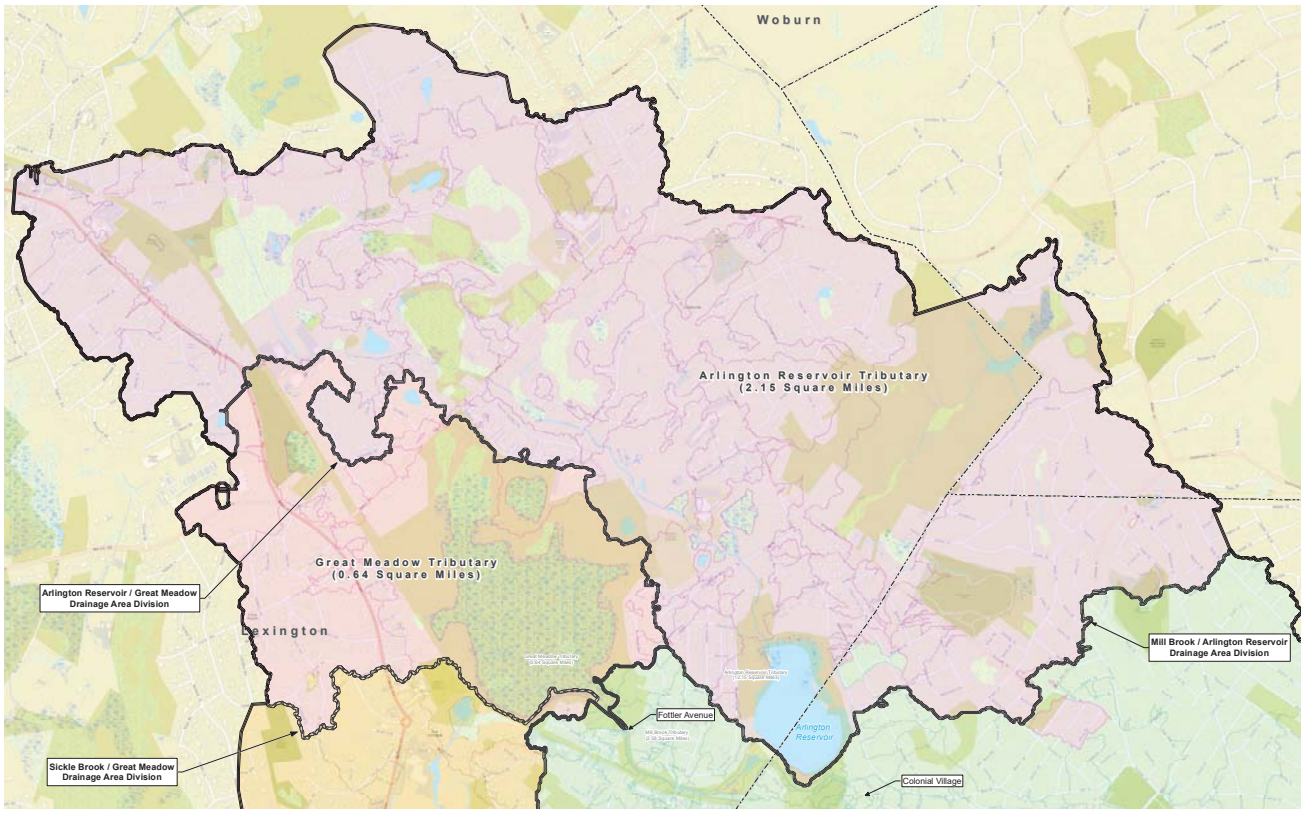
The following sections provide a brief overview of the Arlington Reservoir's watershed, geometry, and surficial recharge and flow characteristics. This report was completed in conjunction with Dr. Ken Wagner of Water Resource Services, who conducted much of the in-pond evaluation.

BRIEF HISTORY OF ARLINGTON RESERVOIR'S IMMEDIATE WATER FLOWS

As noted in the "Existing Conditions" section, the reservoir is impounded by a dam along its southern and western edges. Munroe Brook enters from Lexington in the northwest and feeds the reservoir. Munroe Brook is considered perennial, meaning that it runs year-round. The reservoir discharges via a dam and gate system to Sickle Brook at its confluence with Mill Brook, which then flows through Arlington Heights roughly parallel to the Minuteman Bikeway. The Res supports several species of fish, amphibians, reptiles and many species of birds.

ARLINGTON RESERVOIR WATERSHED

The Arlington Reservoir Watershed comprises just less than 1,400 acres. The map below depicts the approximate boundary of Arlington Reservoir Watershed based on surface topography, although the storm drains on Mount Gilboa direct water elsewhere. This watershed map was created with Geographic Information System (GIS) mapping technology and accounts for flow into stormwater infrastructure and surficial flow into ponds and rivers. The watershed contains approximately 77% pervious surface and 23% impervious. Residential land use comprises just over 52% of the watershed, forest takes up approximately 28%, and wetland is just shy of 8%. The remaining 12% is a mix of institutional, waterbodies, nursery, commercial, open land, cemetery, and cropland, ordered from largest (42 acres) to smallest. (5 acres)



Arlington Res Watershed (c. 2017)

As a technical rule of thumb, watersheds of less than ten times the surface area of their receiving water tend to be lesser pollutant influences, while watersheds of greater than 50 times the area of their receiving water tend to be dominant influences. The tendency is even stronger when the watershed is more urbanized. The Arlington Reservoir Watershed is about 46 times the area of the Res. Water quality issues should be expected in the reservoir given the relative concentration of urban development in its watershed and considering that the watershed's relative size to the waterbody itself.

SIZE, DEPTH, AND RELATED OBSERVATIONS

The image on the following page provides a bathymetric (i.e., depth-contour) map of the Arlington Reservoir. To determine the bathymetry of the reservoir, a total of 50 water depth measurements were collected over the 26 acres. The water level was about 1.5 feet below normal full pool (seasonal drawdown), so the field measurements were corrected to derive water depths at full pool status. Maximum depth is approximately 7 feet, while average depth is 3.8 feet. The total volume of the reservoir is approximately 99 acre-feet, or 32.3 million gallons, or 122,200 cubic meters.

The bottom of the reservoir is somewhat bowl-like, but not completely regular. There is a shallow area on the west side that does not seem to correlate to any inlet point adding sediment; this area is rocky to sandy, suggesting the condition may have been present when the reservoir was constructed in 1871. There is another sandy area in the northeastern part of the reservoir, slightly north of the bermed swimming area, and another directly south of the swim area and west of the parking lot. While much of the bottom is covered by organic matter, which primarily includes decayed plant remains, deposits were not deep.

The normal outlet is located on the reservoir's southwestern side and has a sluice gate that operates a six-foot opening between elevation 153.0 and 159.0. A larger overflow spillway is located on reservoir's southeastern shoreline. The first section of Mill Brook is the connector channel between the two outlets outside of the southern margin of the reservoir.

In terms of refill and drawdown schedule, the reservoir elevation is raised in the spring by May 1st, when practical with respect to heavy rain events, and/or after the bathing beach has been graded at the water line. In the past, an elevation of 158.5 has been obtained for proper function of the swimming area filtration system and facilitating the water vegetation harvesting operations in July. The reservoir elevation is lowered soon after the last official day of swimming at the beach area or when practical with respect to heavy rain events. The lowest elevation obtained is near 153.0. The sluice gate may be raised and or lowered at other times during the year for storm runoff storage or drawdown as needed, such as during a heavy rain event.

Arlington Res Bathymetry

SURFICIAL RECHARGE, FLOW AND EFFECTS ON WATER QUALITY

Based on our review of watershed data and observations during fieldwork, Munroe Brook appears to be Arlington Reservoir's principal surficial source of recharge. Flowing from the northern reaches of the watershed, Munroe Brook discharges to the northwest corner of The Res. The Res certainly receives overland flow, but this is most likely a secondary source of recharge compared to Munroe Brook. During site visits for this project, there were three stormwater outfalls (i.e., discharge pipes) observed on the reservoir's perimeter, which are noted on the analysis diagram on page 29. These outfalls are in poor condition or completely broken and should be evaluated for replacement as part of the improvements to The Res. The area surrounding the outfalls are also severely eroded. Due to uncooperative weather conditions, wet-weather testing was not conducted as part of this master plan effort. It is recommended that this testing is completed during the first phase of improvements made to The Res in order to better understand how the existing stormwater outfalls relate to water quality.

Water Quality during Dry Weather

Users of The Res depend on a healthy waterbody to support swimming and fishing as well as enjoyment of local wildlife and being outdoors. Water quality was assessed during dry-weather conditions with the following goals in mind:

- Managing the overall ecological health of The Res. It should be noted that low water at different times of the year is critical for some species. Certain birds such as sandpipers, dabbling ducks, and herons need the shallows and mudflats, which are conditions present at the reservoir during times of low water levels.
- Ensuring support of existing recreational uses as well as anticipated growing demand following improvements completed at The Res.
- Mitigating the threat and adverse effects of urbanization.

The water quality discussion below provides the results of Weston & Sampson's dry-weather sampling program.

APPROACH AND METHODS

Sampling was conducted at three in-reservoir stations (WQ-1 to WQ-3) sited approximately equidistant from each other between the outlet of Munroe Brook and the outlet of The Res at the dam spillway, as marked on the map below:

Sampling Stations

Table 1. Water Quality Station Locations	
Water Quality Station	Approximate Geolocation
WQ-1	-71.189131 42.430523
WQ-2	-71.189298 42.428963
WQ-3	-71.188911 42.427379

Sampling included the following parameters, methods and equipment:

Table 2. Sampling Parameters, Methods, and Equipment			
Parameter	Methods	Equipment	Reporting Limits
Water temperature	In the field, by probe	Meter and probe	N/A[1]
Dissolved oxygen	In the field, by probe	Meter and probe	N/A
Specific conductivity	In the field, by probe	Meter and probe	N/A
pH	In the field, by probe	Meter and probe	N/A
Turbidity	121, 2130B	Plastic 500 mL, unpreserved	0.20 NTU
Chloroform	In the field, by florescence probe	Meter and probe	N/A
Alkalinity	In the field, by probe	Meter and probe	N/A
Phosphorous (soluble)	121, 4500P-E	Plastic 250 mL, H2SO4 preserved, filtrates	0.010 mg/L
Phosphorous (total)	121, 4500P-E	Plastic 500 mL, H2SO4 preserved	0.010 mg/L
Nitrogen (ammonia-N)	121, 4500NH3-BH	Plastic 500 mL, H2SO4 preserved	0.075 mg/L
Nitrogen (nitrate-N)	121, 4500NO3-H	Plastic 500 mL, H2SO4 preserved	0.100 mg/L
Nitrogen (total Kjeldahl nitrogen)	121, 4500NH3-H	Plastic 500 mL, H2SO4 preserved	0.300 mg/L
Clarity	Secchi Disk Method	Horizontal Secchi disk	N/A

Notes:

1. "N/A" means not applicable as measurements were done in the field without laboratory reporting.

All field instruments were calibrated and cleaned as needed in accordance with manufacturer's instructions.

Alkalinity and Secchi disk measurements were conducted at WQ-2 only. Sampling for phosphorus and nitrogen was conducted at a depth of 0.2 meters.

WEATHER CONDITIONS

Dry-weather water quality sampling of The Res was conducted on September 27, 2017. Water quality sampling was conducted approximately between 11:00 a.m. and 1:00 p.m. During the water quality sampling process, weather conditions ranged from clear to partly cloudy with wind speeds of 6.9 to 11.5 miles per hour, as reported at Hanscom Airport in Bedford, Massachusetts. Air temperature ranged from approximately 82.9 – 86.0ºF (28.3 – 30.0ºC).

FINDINGS

The three tables below summarize the results of dry-weather water quality sampling, all collected on September 27, 2017:

Table 3. Water Quality Field Measurements for Arlington Reservoir

Station	Date	Time (military, EST)	Depth (m)	Temp (ºC)	Dissolved Oxygen		Spec. Cond. (µS/cm)	pH	Turbidity (NTU)	Chlorophyll (µg/L)
					(mg/L)	% Sat.				
WQ-1	9/27/17	12:46:23	0.2	23.0	7.1	83.9	649	6.8	3.1	2.7
	9/27/17	12:47:18	0.5	21.2	6.0	68.2	637	6.9	3.6	4.8
	9/27/17	12:47:56	1.0	20.1	3.3	37.2	645	6.8	9.9	12.5
WQ-2	9/27/17	12:56:11	0.4	23.0	7.9	93.5	671	6.9	17.5	7.0
	9/27/17	12:58:39	1.0	20.3	1.9	21.7	683	6.9	16.8	10.3
WQ-3	9/27/17	13:08:56	0.3	22.8	2.7	31.4	812	6.8	13.0	2.0

Table 4. Alkalinity and Secchi Measurements for WQ-2 at Arlington Reservoir

Alkalinity (mg/L)	Secchi Depth (m)
46	1.3

Table 5. Laboratory Measurements for Arlington Reservoir

Station	Date	Depth (m)	Phosphorus		Ammonia-N (mg/L)	Nitrate-N (mg/L)	Total Kjeldahl Nitrogen (mg/L)
			Soluble (mg/L)	Total (mg/L)			
WQ-1	9/27/17	0.2	ND[1]	ND	ND	ND	0.518
WQ-2	9/27/17	0.2	0.010[2]	ND[2]	ND	ND	0.402
WQ-3	9/27/17	0.2	ND	0.022	ND	ND	0.483

Notes:

1. "ND" means non-detect in the laboratory analysis and reflects a value that is zero or less than the reporting limit.
2. Logically, total phosphorus should be equal to or greater than soluble phosphorus. Soluble phosphorus and total phosphorus were assessed by Alpha labs, both with detection limits of 0.010 mg/L. Methods for lab analysis of these constituents involved different processes that tend to be less reliable at the detection limit. It is likely that total phosphorus is approximately 0.010 mg/L and made up almost entirely of the soluble fraction.
3. Phosphorus and nitrogen samples were analyzed by Alpha Analytical in Westborough, MA and reported on October 4, 2017.

Laboratory water quality measures suggest relatively low nutrient concentrations, somewhat of a surprise in light of watershed features and high apparent productivity in the reservoir. Total phosphorus was low to moderate and dissolved phosphorus was detectable in only one sample. Values declined from inlet to outlet, suggesting that the reservoir sediment is a large sink for phosphorus. Nitrate and ammonium nitrogen were undetectable in all samples. The total Kjeldahl nitrogen, which is the combination of ammonium nitrogen and digestible organic nitrogen, was moderate at 0.4 to 0.5 mg/L. One would not expect algae blooms to be supported by water column nutrients in the reservoir based on these results, but they represent only a single sampling after a period of dry weather with the reservoir undergoing drawdown. It would appear that primary production in the reservoir depends on sediment sources of nutrients, and with the shallow depth, rooted plants can grow anywhere, and algae could grow at the sediment-water interface and rise in the water column to form blooms without elevated nutrient levels in the water column.

Results indicate that the reservoir is stratified, which was not observed ten years ago in the report titled "Arlington Ponds 2007 Baseline Survey" (Appendix G). Dissolved Oxygen was high (near or at saturation) in prior measurements and is now only high at the surface and decreases significantly at depth. There are also potentially significant changes in turbidity from 2007 to 2017. Any turbidity values over 10 ntu are considered high/turbid and will affect the ability of the waterbody to support organisms. As part of this study, results for turbidity at location WQ-2 were very high at 17.5 and 16.8 ntu. Such significant changes in a ten-year span means that more study should be considered on a biannual basis (spring and fall). With the amount of data collected in 2017, it is difficult to draw reliable conclusions about changes from 2007 to 2017.

No analysis of E. coli was conducted as part of this study; however, since swimming occurs only in designated areas that are chlorinated, E. coli should not be an issue at The Res. As part of the maintenance and monitoring consideration described later within this report, a bathing beach monitoring program under the Board of Health should be implemented that addresses E. coli.

Aquatic Habitat

The Res provides habitat for many native plants and animals. There is a rising concern that invasive species are infiltrating The Res and pushing out native species. The Res was assessed for aquatic plants and animals to address the following purposes:

- Identify habitat functions and values provided by The Res.
- Create an inventory of native aquatic plants and animals.
- Create an inventory of invasive aquatic plants and animals that may threaten the overall aquatic health of The Res.

The discussion below provides the results of our field assessment of aquatic habitat.

APPROACH AND METHODS

The following section provides a discussion of sampling and analytical methods for assessing aquatic habitat.

Phytoplankton - Sampling for phytoplankton was conducted on September 27, 2017 between approximately 11:00 a.m. and 1:00 p.m. by Water Resources Science. Phytoplankton were collected from just below the surface (approximately 0.5 feet), avoiding surface scum to the extent practicable, at WQ-2, the central station used for water quality sampling, as it appeared to provide a representative sample. A whole water sample was collected in a 250 mL bottle and preserved with glutaraldehyde to a concentration of 0.5%. The sample was settled in the lab and concentrated before quantitative examination under phase contrast optics at 200-400X. The final multiplication factor for cells observed to cells/mL of raw sample was less than 25.

This analysis was done with a single sample. Results from sampling tend to vary seasonally. While a single sample can provide a meaningful starting point in assessing the overall condition of a surface water, a more comprehensive sampling program would provide more complete and reliable data on which to make management decisions.

Zooplankton - Sampling for zooplankton was conducted on September 27, 2017 between approximately 11:00 a.m. and 1:00 p.m. by Water Resources Science. Zooplankton were collected by towing a net with 80 µm mesh through 30 meters of water from the same station where phytoplankton were collected. With a net diameter of 5 inches, this results in 380 liters of water being filtered. The sample was preserved with glutaraldehyde at a concentration of 2%, settled in the lab, and quantitatively examined under phase contrast optics at 100X magnification. The final multiplication factor for converting observed specimens to density per liter was less than 1.

Aquatic Flora and Fauna - A survey of flora and fauna was conducted on September 27, 2017 between approximately 11:00 a.m. and 1:00 p.m. by Water Resources Science as part of an overall review of watershed and reservoir conditions.

Analysis - Taxonomy for phytoplankton, zooplankton, and cyanobacteria was conducted by Water Resources Science.

WEATHER CONDITIONS

Field data for the aquatic habitat assessment was collected on September 27, 2017 simultaneously with water quality data. Survey conditions are discussed above within the discussion on water quality during dry weather.

FINDINGS

Plankton - This discussion addresses both phytoplankton and zooplankton. Analysis of phytoplankton (algae in the water column) suggests that green algae (chlorophyte) are most abundant in Arlington Reservoir (Table 6) and that cyanobacteria are uncommon. This is consistent with the laboratory water quality data, which suggest a high ratio of nitrogen to phosphorus, which tends to favor growth of green algae. Other algal groups were represented but not abundant and total biomass was moderate to low. Biomass values in excess of 10,000 µg/L are very high, while values <1000 µg/L are considered low. Between 1000 and 3000 µg/L algae issues become more noticeable with variation based on the types of algae dominating. The algae found during our assessment do not represent a threat to human health or ecological integrity; however, this finding is based on only one sample. Notwithstanding the limited nature of the sampling program, data was at a time of year when problems are generally most evident in waterbodies; therefore, our findings indicate low likelihood of algae problems.

Table 6. Phytoplankton Data for Arlington Reservoir at WQ-2
(Collected: September 27, 2017)

Taxon	Cell Count (cells/mL)	Biomass (µg/L)
BACILLARIOPHYTA		
Centric Diatoms		
Cyclotella	40	4.0
Araphid Pennate Diatoms		

Table 6. Phytoplankton Data for Arlington Reservoir at WQ-2 (Collected: September 27, 2017)		
Diatoma	13	18.6
Fragilaria/related taxa	160	47.9
Biraphid Pennate Diatoms		
Cymbella/related taxa	27	26.6
Epithemia	13	63.8
Gomphonema/related taxa	13	13.3
Navicula/related taxa	27	13.3
CHLOROPHYTA		
Coccoid/Colonial Chlorophytes		
Ankistrodesmus	27	2.7
Elakatothrix	27	2.7
Scenedesmus	53	5.3
Desmids		
Closterium	13	53.2
Cosmarium	27	21.3
Euastrum	40	39.9
Micrasterias	13	532.0
Onychonema	705	704.9
Pleurotaenium/related taxa	7	266.0
Straurastrum	27	21.3
Staurodesmus	13	8.0
CYANOPHYTA		
Filamentous Non-Nitrogen		
Limnoraphis	133	26.6
EUGLENOPHYTA		
Trachelomonas	120	119.7

Table 7. Phytoplankton Data for Arlington Reservoir at WQ-2 Density Summary (Collected: September 27, 2017)		
Taxon	Cell Count (cells/mL)	Biomass (µg/L)
BACILLARIOPHYTA	292.6	187.5
Centric Diatoms	39.9	4.0
Araphid Pennate Diatoms	172.9	66.5

Table 7. Phytoplankton Data for Arlington Reservoir at WQ-2 Density Summary (Collected: September 27, 2017)		
Monoraphid Pennate Diatoms	0	0.0
Biraphid Pennate Diatoms	79.8	117.0
CHLOROPHYTA	950.95	1657.1
Flagellated Chlorophytes	0	0.0
Coccoid/Colonial Chlorophytes	106.4	10.6
Filamentous Chlorophytes	0	0.0
Desmids	844.55	1646.5
CHRYSOPHYTA	0	0.0
Flagellated Classic Chrysophytes	0	0.0
Non-Motile Classic Chrysophytes	0	0.0
Haptophytes	0	0.0
Tribophytes/Eustrigmatophytes	0	0.0
Raphidophytes	0	0.0
CRYPTOPHYTA	0	0.0
CYANOPHYTA	133	26.6
Unicellular and Colonial Forms	0	0.0
Filamentous Nitrogen Fixers	0	0.0
Filamentous Non-Nitrogen	133	26.6
EUGLENOPHYTA	119.7	119.7
PYRRHOPHYTA	0	0.0
TOTAL	1496.25	1990.9
CELL DIVERSITY	0.88	0,84
CELL EVENNESS	0.65	0.64

Cell diversity, noted above in Table 7 and below in Table 11, is a measure of the distribution of cells or biomass among the taxa present. Higher values indicate a more even distribution, such that no one taxon is dominant. The diversity value is dependent on the number of taxa present, has no clear upper or lower limit, and can be difficult to interpret. Evenness is calculated as the measured diversity divided by the diversity value that would have been achieved if all cells or biomass were evenly divided among all taxa present. It is assessed on a scale of 0 to 1. Values in excess of about 0.8 are rare; cells and biomass are not often so evenly distributed among taxa. Values from 0.6 to 0.8 indicate a fairly even distribution, while values <0.3 suggest that a few taxa are dominant. In cases of algae blooms, one taxon can dominate and evenness values can be <0.1. The value for the reservoir sample suggests no dominance by any algal taxon.

Zooplankton in the Res were found to be generally scarce, as shown in Table 8 below, with commonly found groups represented but overall low biomass. No large-bodied forms were present and average

body size was low, which is indicative of intense predation by small fish. At the time of year of the assessment, biomass is typical at its lowest point as a consequence of predation by small fish during the summer, however the values Weston & Sampson found actually suggest a minimal food base for small fish and very little capacity for the zooplankton to graze algae and keep them under control. A spring sample would help assess overall zooplankton features, but based on the sample collected under this assessment, the zooplankton community is sub-optimal.

Table 8. Zooplankton Data for Arlington Reservoir at WQ-2
(Collected: September 27, 2017)

Taxon	Count (individuals/L)	Biomass (µg/L)
PROTOZOA		
Ciliophora	0.0	0.0
Mastigophora	0.0	0.0
Sarcodina	4.7	0.1
ROTIFERA		
Asplancha	2.4	2.4
COPEPODA		
Copepoda-Cyclopoida		
Cyclops	0.8	1..9
Copepoda-Calanoida		
Diaptomus	2.4	3.7
CLADOCERA		
Alona	1.6	4.7
Bosmina	6.3	6.2
Ceriopahnia	4.7	12.3
Chydorus	5.5	5.4
OTHER ZOOPLANKTON	0.0	0.0

Table 9. Zooplankton Data for Arlington Reservoir at WQ-2
Density Summary
(Collected: September 27, 2017)

Taxon	Count (individuals/L)	Biomass (µg/L)
PROTOZOA	4.7	0.1
ROTIFERA	2.4	2.4
COPEPODA	3.2	5.6
CLADOCERA	18.2	28.6
OTHER ZOOPLANKTON	0.0	0.0

Table 9. Zooplankton Data for Arlington Reservoir at WQ-2 Density Summary (Collected: September 27, 2017)		
TOTAL DENSITY	28.5	36.7

Table 10. Zooplankton Data for Arlington Reservoir at WQ-2 Summary of Richness (Collected: September 27, 2017)	
Taxon	Types Observed
PROTOZOA	1
ROTIFERA	1
COPEPODA	2
CLADOCERA	4
OTHER ZOOPLANKTON	0
TOTAL RICHNESS	8

Table 11. Zooplankton Data for Arlington Reservoir at WQ-2 Summary of Diversity, Evenness and Length (Collected: September 27, 2017)	
Shannon-Wiener Diversity Index	0.84
Evenness Index	0.93
Mean Length All Forms (mm)	0.36
Mean Length Crustaceans (mm)	0.43

Aquatic Plant Community - The rooted plant community is a dominant feature of The Res and is comprised primarily with three species: water chestnut (Trapa natans), Eurasian watermilfoil (Myriophyllum spicatum), and coontail (Ceratophyllum demersum). The first two are invasive species, and although coontail is native, it has been known to reach nuisance densities. A few other species are present, either as sparse or moderate density growths, including spiny naiad (Najas minor), curly leaf pondweed (Potamogeton crispus), spiral pondweed (Potamogeton spiralis), burreed (Sparganium species), and aquatic clover (Marsilea quadrifolia). Both the spiny naiad and curly leaf pondweed are invasive species and, while aquatic clover is not native, it does not reach nuisance densities that would qualify it as an invasive species. The rooted plant community of The Res is half invasive species by taxonomic breakdown, but much more than half by biomass.

Water chestnut

Eurasian Watermilfoil

Coontail

Filamentous green algae, including both Spirogyra and Cladophora, form mats among the submergent rooted plants. Benthic cyanobacteria mats, most likely Oscillatoria, were also observed. None of these algae were detected in plankton samples; however, floating watermeal (Wolffia columbiana) was observed as a sparse surface cover and gets its nutrition from the water column like most planktonic algae. Peripheral growths of cattail (Typha latifolia) were also observed but form only a narrow fringe at the edge of the reservoir and do not seem to represent any threat at this time.

It is apparent that water chestnut could take over most of the reservoir, but that annual mechanical harvesting has kept it largely in check. However, the Town reported that harvesting is typically completed in late summer after seeds have been deposited. As a result, the ability to have long-term benefits from harvesting is diminished. If harvesting was conducted before seeds were produced, water chestnut can eventually be controlled or even eliminated over time. In the portions of the reservoir not dominated by water chestnut, milfoil and/or coontail are very abundant.

Given that this survey was conducted in late September, it is possible that other species were more abundant earlier in the growing season, most notably curly leaf pondweed, which tends to peak in late spring and die back over the summer. The Res has multiple plant problems that represent the most obvious threat to its designated uses. With a maximum depth of 7 feet, there is no place in the reservoir where plants cannot grow due to depth/light limitations. Only a few areas have coarser substrate that limits plant density. If not for the mechanical harvesting program, water chestnut

might cover nearly all the reservoir. While a substantial amount of plant life can provide desirable habitat for many forms of water-dependent life, the aquatic plant community of The Res is likely to foster ecological imbalance and must be thinned or replaced to provide optimal habitat for those that rely on this waterbody for their survival.

Curly leaf pondweed

Review of photographic evidence dating to the 1990s indicates that water chestnut has been a dominant feature of the plant community for about twenty years or even longer. Weather and management efforts may have varied somewhat, but it should be noted that plant nuisances have plagued The Res for many years.

Aquatic Fauna and Related Habitat - No invertebrate studies were conducted, but the normal complement of invertebrate species was observed, including beetles, dragonflies, damselflies, true bugs, and various fly larvae. Benthic samples were not collected, but it seems very likely that blood chironomids (midges adapted to life with minimal oxygen) would be abundant. No mussels or snails were observed, but collection was limited. Mayflies, stoneflies and caddisflies were not observed, but the nature of the habitat (both plants and water quality) would be expected to minimize those desirable invertebrates.

Fish were not studied explicitly in this investigation, but largemouth bass and bluegill sunfish were observed, which are introduced non-native species. The fish assemblage is typical for the waterbody, but specimens are likely to have low condition factors because of overabundant vegetation. Sunfish are protected from predation by the dense plant growths, leading to overpopulation by that species and small mean size. Inability of bass to feed effectively on small sunfish leads to slower growth rates and possible reproductive failure. Reduced vegetation density would improve the fishery as well as other aspects of the reservoir. Additionally, the oxygen readings suggest that fish may be stressed in water deeper than about three feet, and that visibility is limited by suspended organic matter. A reduction in organic matter production, again linked to plant productivity, would be beneficial. No analysis of fish was conducted to understand if the fish are safe to eat; however, the Arlington Reservoir is an urban waterbody that collects pollutants from a number of different sources upstream, so it should be assumed that no fish should be eaten unless samples are tested to understand if the fish are safe for consumption. At this time, fishing should be catch-and-release only.

Largemouth bass

Painted turtles

A lack of emergent native aquatic vegetation does not fully support the habitat needs of amphibians. Painted turtles were observed in late September 2017 and large snapping turtles can often be seen, especially in the spring. Not many frogs were observed during this time period, but there was no obvious reason why a wider variety were not found. There have been regional issues with frog populations declining, but any relation to The Res is unknown. Residents have reported that amphibians were observed in April 2018, although quantities were not reported.

There is an abundance and diversity of bird life that draws avid birders to The Res and its immediate surroundings. According to the report, "Updated Notes on the Importance of Arlington Reservoir to Birds and to the Arlington Community," by resident and birder Karsten E. Hartel (Appendix E), over 200 species of birds have been recorded around The Res, which is an important migratory area for many waterbirds and the surrounding uplands provide fair to good habitat for songbirds. Some species observed include the green-winged teal, mallard duck, great blue heron, the red-tailed hawk, the mourning dove, the killdeer and the blue jay to name a few. A bald eagle was been spotted by visitors near The Res at Rindge Park. Swans, mallard ducks, Canada geese and great blue herons were observed on September 27, 2017.

The seasonal fluctuation in water level creates habitat for a diverse range of birds; the deep end draws diving ducks and grebes. Shorebirds, dabbling ducks, and herons inhabit the weeds and mudflats in the shallow areas. When the water level is low, the shallow water deposit just south of the bathing beach becomes visible and frequented by ducks and geese. There are no other habitats quite like these in Arlington, especially given the proximity of Lex Farm and Cataldo Reservation which provide valuable open habitat and flowing water, thickets and understory, respectively. There is no shortage of food for a variety of waterfowl in The Res, although birds may have some difficulty accessing some food resources among dense vegetation.


Great Blue Heron


Red-tailed Hawk


Killdeer

Many forms of water-dependent wildlife can thrive in dense plant communities, but most prefer some mid-range of abundance and both richness, or number of species, and diversity, or distribution of individuals among species, would be maximized with a wider range of habitats. This translates into a reduction in plant density and dominance by just a few species.

Invasive Terrestrial Plants Survey

As mentioned above, there is a rising concern that invasive species are infiltrating The Res and pushing native species out. Invasive terrestrial plants are also restricting habitat while adversely affecting recreational opportunities. The study area surrounding the reservoir was assessed for presence of invasive plants and to meet the following goals:

- Identify types of invasive plants.
- Create an inventory of the extent of invasive plants.
- Create an inventory of invasive plants that may threaten recreation, wetlands and terrestrial habitat.

The discussion below provides the results of our field assessment of invasive terrestrial plants.

APPROACH AND METHODS

The presence of invasive species was explored on both sides of the walking path that surrounds the Res, except for the beach area which was secured with a perimeter fence and locked gate, since this the area was closed for the season. Along the walking path, the beginning and ending locations of the invasive species were marked using green flagging. Each flag was provided a unique number which followed the "INV" naming scheme (i.e., the first invasive species flag was labelled "INV-1," the second labelled "INV-2," etc.). The name of each pair of flags was recorded in a field notebook along with the types of invasive species found within the area. The locations of the invasive species

flags were recorded by a survey team. The locations of the flags were later converted to CAD format to be placed on the topographic survey, which has been provided in Appendix J. Additionally, locations are graphically represented on the Environmental Findings diagram on page 11.

WEATHER CONDITIONS

A site field survey of the Res was conducted on August 28, 2017 for invasive plants. The survey was conducted between approximately 10:00 a.m. and 3:00 p.m. Weather conditions during the survey, as reported by Weather Underground at Hanscom Airport in Bedford, Massachusetts, ranged from clear to partly cloudy with wind speeds of 4.6 to 13.8 miles per hour. Air temperature ranged from approximately 68.0 – 77.0.10F (20.0 – 25.00C).

FINDINGS

Several different types of invasive species were noted in the study area. These include:

- Garlic mustard (Alliara petiolata)
- Japanese barberry (Berberis thunbergii)
- Asian bittersweet (Celastrus orbiculatus)
- Winged euonymus (Euonymus alatus)
- Glossy buckthorn (Frangula alnus)
- Morrows honeysuckle (Lonicera morrowii)
- Purple loosestrife (Lythrum salicaria)
- Japanese knotweed (Polygonum cuspidatum)
- Multiflora rose (Rosa multiflora)

Although other invasive species may be present on site, eight of these species were observed on August 28, 2017 in the largest abundance . While this study focused on the larger shrubs, trees and vines, garlic mustard is very common in this area, has been observed by visitors to The Res and members of the Reservoir Working Group, and thus added to the list of invasive species found at The Res. Large stands of Japanese knotweed were noted in the southeastern part of the property with smaller instances near the dam spillway and the northeastern side of the site. Asian Bittersweet was found throughout the site, as was Japanese barberry and multiflora rose. The heaviest population of winged euonymus was noted on the north-eastern edge of the site. Purple loosestrife was noted in the wetland resource area downgradient of the dam and at the reservoir's edge. Additionally, while not invasive, poison ivy (Toxicodendron radicans) has been observed and has been a nuisance in some areas of the property.

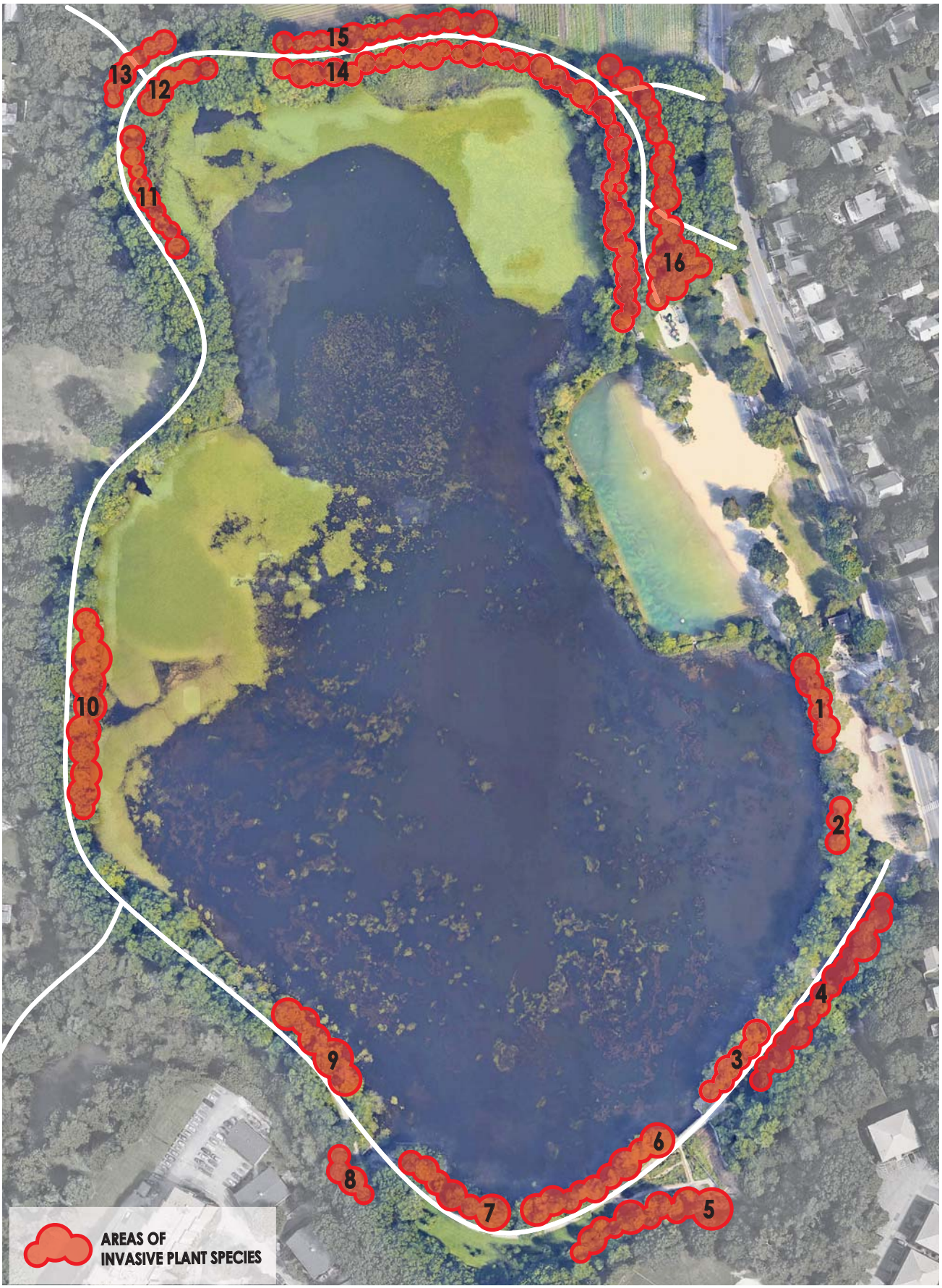


Diagram indicating observed invasive plant species per area, which related to the areas noted in Table 12

The preceding diagram and table below indicate the specific species observed in the numbered areas around The Res:

Table 12. Invasive Species Observed Along the Perimeter Trail (August 28, 2017)									
Area	Japanese Barberry	Asian Bittersweet	Winged Euonymus	Glossy Buckthorn	Morrows Honeysuckle	Purple Loosestrife	Japanese Knotweed	Mulitflora Rose	Tree of Heaven
1	■	■		■				■	
2		■		■					■
3	■	■					■		
4							■		
5							■		
6	■	■				■			
7	■	■			■			■	
8	■	■			■			■	
9		■							
10		■						■	
11		■	■					■	
12	■	■	■		■			■	
13	■	■	■		■			■	
14	■	■	■		■			■	
15	■	■	■		■			■	
16			■						

A brief description of each species is included below:

Japanese barberry (Berberis thunbergii) is a dense, thorny shrub that grows between two and eight feet tall. Leaves grow alternately along the stem, are elliptical in shape, and are usually no larger than five inches in length. Bright red, elliptical berries can be seen between July and October. This species prefers full sun, but can also survive in heavily shaded areas.

Japanese barberry

Asian bittersweet (Celastrus orbiculatus) is a fast-growing woody vine that grows up to 60 feet long and can quickly shade out native plants. Juvenile stems appear brown with warts but change to gray-barked when older. Leaves are alternately arranged. Bright yellow/orange fruit are spread by birds and other animals. This species can grow in full sun to partial shade conditions.

Asian bittersweet

Winged euonymus

Winged euonymus (Euonymous alatus) is a shrub that is usually between five and ten feet tall and wide. This species is easily identifiable because of its wings along its branches. Leaves are elliptical , one to three inches in length, and are arranged oppositely along the stem. In the fall, the green leaves turn to brilliant shades of red and purple. This shrub can grow in full sun to full shade conditions.

Glossy buckthorn (Frangula alnus) is a shrub or small tree that can grow up to twenty feet in height. The gray/brown bark is smooth with white specks throughout. The usually elliptical shaped, dark green leaves are alternately arranged and are one to two-and-a-half inches in length. Small, round fruits change color from red to black as they ripen between July and October. Glossy buckthorn can grow in full sun and full shade alike.

Glossy buckthorn

Morrows honeysuckle

Morrows honeysuckle (Lonicera morrowii) is a multi-stemmed shrub that can grow up to seven feet tall. The elliptical leaves area approximately one to two inches in length and grow oppositely along the stem. The leaf is hairy underneath. White flowers are made of five separate petal lobes and are seen in April or May. This species is mostly spread with the aid of birds ingesting the seeds and dropping them elsewhere.

Purple loosestrife (Lythrum salicaria) is a perennial herb that grows up to five feet tall. The erect-growing stems are four- to six-sided and can be quite hairy. Leaves are located oppositely or in whorls along the stem. Magenta colored flowers in clusters form colorful spikes from July through September. This species prefers moist soils and is often found in wetlands areas. Mature plants can produce an estimated 2.5 million seeds in a year that can persist in wet soils for years, ultimately forming vast, dense stands that restrict native plant species.

Purple loosestrife

Japanese knotweed

Japanese knotweed (Polygonum cuspidatum) is classified as a perennial herb which is often confused as bamboo. The plant grows upright to ten feet high. The stems are round and hollow. Leaves measure up to seven inches long and four inches wide with sharp tips. White or greenish colored flowers appear in August and September in numerous, branched clusters. Japanese knotweed is adaptive to its environment, being able to grow in full sun and full shade. This species spreads both by budding from roots and by seed. It grows in dense thickets.

Multiflora rose (Rosa multiflora) is a shrub with stems that may attain ten to fifteen feet in length. The stems are red to green with thorns. Clusters of white, or sometimes pink, five-petal flowers appear between May and June. This species can adapt and grow in full sunlight to full shade and tolerates a wide variety of moisture conditions.

Multiflora rose

Garlic mustard

Garlic mustard (Alliara petiolata) is a biennial shade-loving herb. It is most often found in the forest understory or along forest edges and tolerates low light levels. Populations of garlic mustard can spread rapidly and advance about twenty feet per year or more. In the first year, seeds germinate in the spring and form low growing rosettes of dark purple to green, kidney-shaped leaves with scalloped edges. Young leaves smell distinctly of garlic or onion when crushed; the odor becomes less intense as plants grow older. Leaves on second year plants are roughly triangular and sharply toothed, a little over one to three inches wide and long, and become gradually smaller towards the top of the stem.

Wetlands Survey

The area surrounding the Res includes substantial areas of wetlands. Wetlands are protected under the Massachusetts Wetlands Protection Act. Wetlands also provide significant ecological, recreational, and water quality functions and values. Wetlands in the study area were assessed with the following goals:

- Creating an inventory of existing wetlands type and extent.
- Delineating wetlands for protection during operation and improvement of The Res property.

The discussion below provides the results of our field assessment of wetland species. The wetlands field map and MassDEP Bordering Vegetated Wetland Delineation Field Data Forms are included as Appendix L.

APPROACH AND METHODS

Wetland resources were identified in the field by a certified PWS, who is trained in the wetland delineation process using the Massachusetts Department of Environmental Protection (MassDEP) manual, Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act, and the US Army Corps of Engineers Wetland Delineation Manual. The locations of the flags were later converted to CAD format and placed on the topographic survey (Appendix J).

WEATHER CONDITIONS

A wetlands survey of The Res was conducted on August 28, 2017 for wetlands resources simultaneously with the invasive plants survey. Weather conditions are discussed in the previous section.

FINDINGS

The Res comprises approximately 24.5 acres in area of land under water. It is surrounded by approximately one mile of bank, all of which is considered steep, allowing for little bordering vegetated wetland (BVW) associated with the reservoir. Based on our survey, wetland areas in the

study area include a constructed wetland east of the Wildlife Habitat Garden, BVW along Munroe, Mill Brook and Sickle Brook, perennial streams (Munroe and Mill Brook) and land under water. The discussion below provides a detailed description of wetland resources in the study area:

Bordering Vegetated Wetlands (BVW) - One BVW area was identified at the site, located south of the Arlington Reservoir dam along Mill Brook. The BVW along Monroe Brook was considered to be outside of the project limits. Wetland flags left in the field to identify this BVW limits were labelled BVW-A1 through BVW-A7.

Dominant vegetation within this resource area included skunk cabbage (Symplocarpus foetidus), sensitive fern (Onoclea sensibilis), and red maple (Acer rubrum), which are all species that thrive in wet conditions. Soils within the BVW were found to be muck. Other indicators of wetland hydrology included standing water.

Skunk cabbage

Sensitive fern

Upland vegetation near the BVW area included black locust (Robinia pseudoacacia) and staghorn sumac (Rhus typhina), which are both upland species. Based on hand cored soil samples, soils in the upland area consisted of dry, sandy soils with no evidence of mottling in the top fourteen inches.

Perennial Stream - Munroe Brook is a perennial stream that discharges at its terminus into the reservoir approximately at its northeast corner. The top of bank for both sides of Munroe Brook's northern section were flagged. The banks were natural with near vertical slope. The transition from stream to upland was almost immediate. The top of bank, which was determined using the first break in slope, was flagged in the field to show the bank of Munroe Brook. Flags left in the field included TOB-B1 through TOB-B3 along the western bank and TOB-C1 through TOB-C3 along the eastern bank. The stream segment, downgradient of the dam spillway, is also considered a natural bank. Flags left in the field included TOB-A1 through TOB-A7 along the northeastern bank of this section. This stream eventually enters the bordering vegetated wetlands area described above. Because Munroe Brook and other streams in the study area are perennial, these bank locations should be used to determine the riverfront area associated with Munroe Brook.

Land Under Water (LUW) - As mentioned above, the LUW is consistent with the reservoir itself. Water assessments of the LUW were conducted and described in detail in within the "Water Quality during Dry-Weather" and "Aquatic Habitat" sections within this assessment.

Review of Erosional Features

There are several areas along the reservoir's banks that are exhibiting erosional features. These features are most likely the cause of foot traffic or other means of access that people use throughout

the park to access the water of the Res. The features are limited in extent and occur in isolated areas, therefore they are not caused by wave action. A few, especially near hard packed areas, may also be the result of stormwater runoff into the Res, which is most prevalent near the parking lot. There are also erosional conditions present around the existing stormwater outfalls, which are in disrepair.

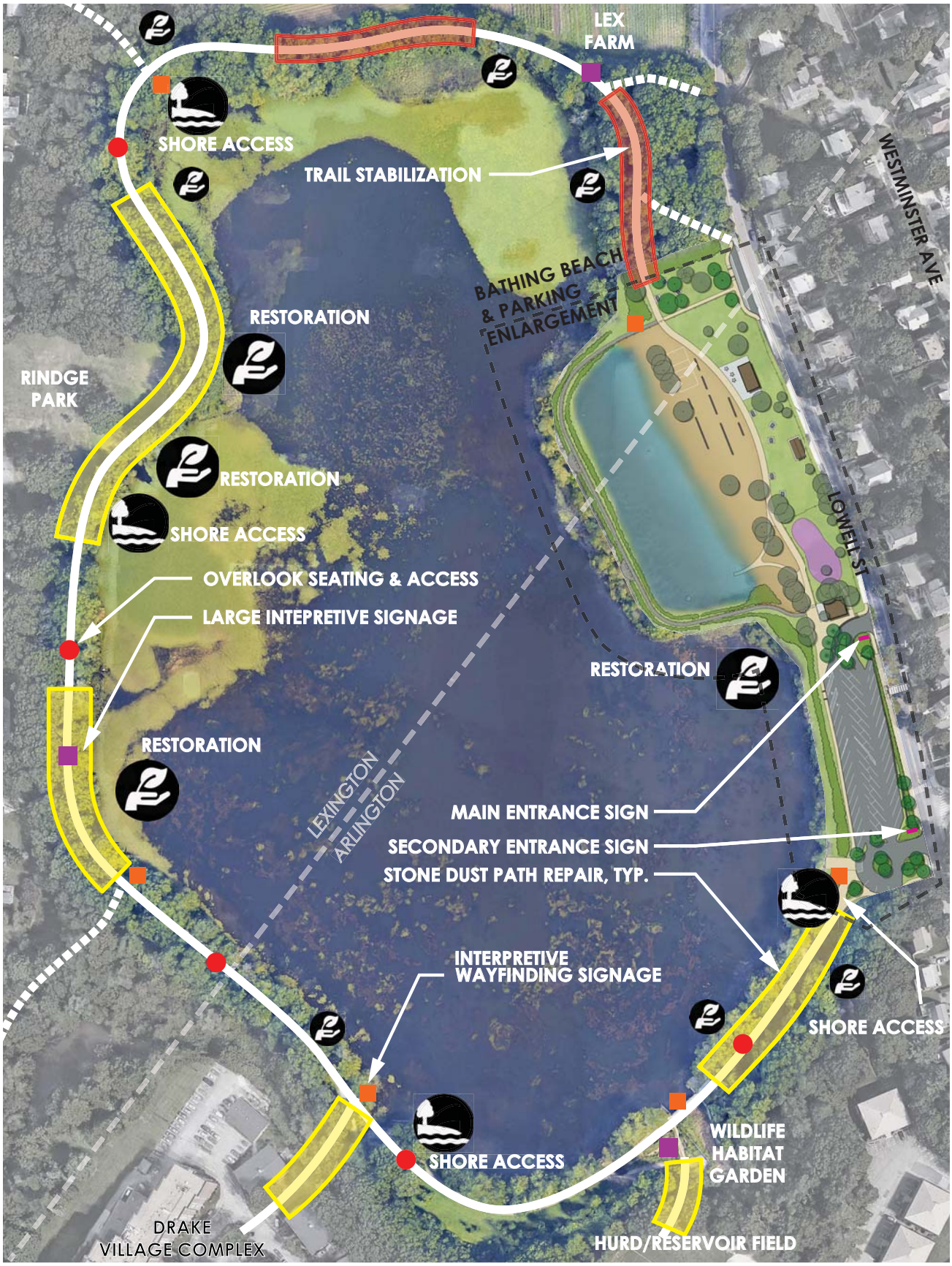
Condition along the northern shoreline

Condition at Rindge Park

Condition along the southwestern shoreline

Condition along the southeastern shoreline

In order to avoid further disturbance/erosion of these areas proper bank stabilization, resource area protection measures, and proper stormwater controls should be implemented. This would include curbing the parking lot to prevent water from running down the banks of the Res. Careful consideration should be made as to how to prevent further erosion from occurring in these and other areas, which will be discussed in the "Preferred Master Plan" section of this report.



Overall perimeter improvement plan for The Res

PREFERRED MASTER PLAN

The master planning effort provided a unique opportunity to comprehensively assess the Arlington Reservoir for the purposes of developing a series of thoughtful and achievable enhancements. These improvements will provide benefits to all members of the surrounding neighborhood and the town as a whole. Working with the community and the Reservoir Working Group, a "Preferred" Master Plan has been developed that identifies the basic scope of desired improvements throughout The Res. In summary, the plan identifies restoration, reconstruction, reorganization or redevelopment of the entire property. The intent is to reestablish this open space gem as a focal point of community life with improved environmental conditions and recreational opportunities for both neighborhood and town-wide use. A number of goals related to the improvement of the property are described below:

- Improve the perimeter trail.
  - Establish a pilot area of the perimeter trail, shoreline erosional mitigation, and invasive species management strategies.
  - Stabilize and repair areas of the perimeter trail that a currently eroding.
  - Formalize critical linkages to important neighboring recreational resources.
  - Repair erosion control issues along the reservoir's shoreline.
  - Remove invasive species and replant the shoreline with native species.
- Establish a pedestrian circulation strategy.
  - Identify primary and secondary entrances with nodes for services (wayfinding, seating).
  - Expand connections between park facilities, amenities, and adjacent streets and sidewalks, which include coordination with the planned traffic improvements on Lowell Street.
  - Create alternative means of travel through the beach area that completes the perimeter trail loop interior to the perimeter fencing.
  - Comply with ADA requirements to accommodate all users while balancing the rustic feel of the trail system
  - Provide strong connections to neighboring open space amenities.
- Establish a vehicular circulation strategy.
  - Identify primary and secondary entrances at the main parking lot and the boat launch entrances.
  - Create clear routes of vehicular travel within the main parking lot and boat launch driveway.
  - Identify a drop-off location for summer programming and service vehicles.
  - Identify specific Department of Public Works and maintenance vehicle access.
- Improve site permeability, visibility, and access.
  - Formalize access for recreational fishing.
  - Create overlook seating that takes advantage of the spectacular views across the water.
  - Provide clear and intuitive wayfinding into and around the property.
  - Improve the pedestrian experience along Lowell Street.
  - Comply with ADA Requirements.
- Improve water quality, filtration and pump equipment system at the bathing beach.
- Improve existing recreational facilities.
  - Improve facilities such that they will meet an increased demand that is anticipated once these improvements are implemented.
  - Improve aesthetic quality, structural integrity, interior and exterior functionality and configuration, and utility upgrades as needed within the Bathhouse and Concession Building and Pump House Building.
  - Provide flexible event space that can accommodate a range of programming.
- Improve the Wildlife Habitat Garden, including more durable fencing.

A reduced version of the plan and an enlargement of the bathing beach and parking area are contained within this section. These two drawings identify in graphic form the configuration of all proposed site features. It is important to note that the vast majority of recommendations suggest the refinement, enhancement or refurbishment of existing facilities within The Res. The plan also recommends the development of a modest level of new site amenities, that both complement existing facilities and provide new opportunities for public use and enjoyment.

Bathing beach and parking area enlargement

Neighborhood Connections

In an effort to improve pedestrian accessibility into and out of The Res property from neighboring residential streets and open space assets, the plan calls to improve path connections and signage. Specifically, these include the connections to the Drake Village Complex and Hurd/Reservoir Fields. There are many barriers in the current ground plane. These would be removed through a combination of trail stabilization, installation of rubber-based flexible pavement, and regrading to create successful and accessible pathways. The methods of improvement are described in greater detail under the Reservoir Perimeter discussion later in this section. Additionally, defining and widening the trail that runs along Rindge Park in Lexington will clearly delineate the bounds of these two distinct properties.

Wayfinding signage will also play a key role in linking The Res to nearby open space resources. A detailed discussion on the signage program is included later within this section.

Vehicular Access and Parking

This plan proposes an upgraded main parking lot paved with porous asphalt, which has the space to provide 45 to 60 striped parking spaces depending on final layout. The parking count includes three handicapped spaces, which are located closest to the arrival plaza. These spaces are aligned at a 30º angle with an 11-foot drive aisle in between each row such that the parking lot can dimensionally fit within the long and narrow strip of land between Lowell Street and the banks of the reservoir as well as meet zoning requirements. The two-way main entrance to this parking lot is proposed to be located at the renovated Check-In/Pump House Building, in a very similar orientation to where the existing entrance is currently located. A town-standard 'Arlington Reservoir' sign will mark this entrance and indicate it as the main vehicular entrance into the property. Porous asphalt will be considered for the pavement. However, vacuum sweeping maintenance requirements and frost heave potential may make this option undesirable.

A secondary driveway will connect to the main parking lot and provide four new parallel parking spaces intended for personal non-motorized watercraft drop-off only. These parking spaces will be marked for 15-minute loading; they are not intended for long-term parking. A sign at this entrance will indicate boat drop-off only, thus distinguishing this driveway from The Res's main vehicular entrance.

Through these improvements, the vehicular circulation pattern will be streamlined and clarified through striping and arrows. Vehicles can both enter and exit at the Check In/Pump House Building. When a vehicle turns into the main entrance, it will keep right and travel down a one-way row of angled parking, as shown in the vehicular circulation diagram on the following page. If all of the spots are taken, there is the option to travel through the roundabout and enter into the next one-way row of parking to look for a space. Vehicles may exit the parking lot either at the main entrance or at the boat launch entrance, since this is also a two-way driveway.

Main parking lot and boat launch vehicular circulation

Drop-off area vehicular circulation

The informal parking lot used for staff parking, deliveries and staging area for group parties located in the northeast corner of the bathing beach area will be transformed into a drop-off for buses and other vehicles to stand temporarily while dropping people off, collecting day campers, making deliveries, or dropping off materials for group parties. This small pull-off has capacity for two school bus lengths, would also be paved with porous asphalt, striped and signed to denote temporary standing only.

Boat Launch

The boat launch will be relocated to connect to this driveway and provide access directly into the water. This new, more accessible location for the boat launch is generous in size such that it will provide water access for the equipment typically used for the management of aquatic invasive plants such as water chestnut. The boat launch itself would be constructed as a poured-in-place concrete slab and the driveway would be porous asphalt. New tree and understory plantings around this driveway entry and in the circular island would be native and match the character of the existing planting found around The Res.

Lowell Street Edge

The existing sidewalk along Lowell Street will be maintained and include new curb cuts for new driveways and the drop-off areas. Separate from this effort, the Town is preparing drawings for pedestrian safety improvements between Westmoreland Avenue and West Court Terrace along Lowell Street. These plans include a new crosswalk and a solar powered pedestrian-activated flashing beacon across Lowell Street at Westmoreland Avenue. Improvements made within The Res will be coordinated with this Town project. Additionally, new black vinyl coated chain link fencing will be provided along the Lowell Street edge between the sidewalk and both the bathing beach and the main parking lot.

Bathing Beach and New Arrival Plaza

A critical component to unify and organize the active and passive recreation at the bathing beach is the implementation of a comprehensive circulation system. The proposed pathway network will link the numerous facilities and provide pedestrians clear and intuitive access to the beach from the parking lot, across the beach, and beyond around the perimeter trail. An arrival plaza is proposed to be adjacent to at the Pump House Building to clearly direct visitors to the bathing beach and amenities. Here, staff at a new check in area would greet tag-holders, collect admission fees, and welcome swimmers and campers with the rules and regulations at the beach. A post-and-beam

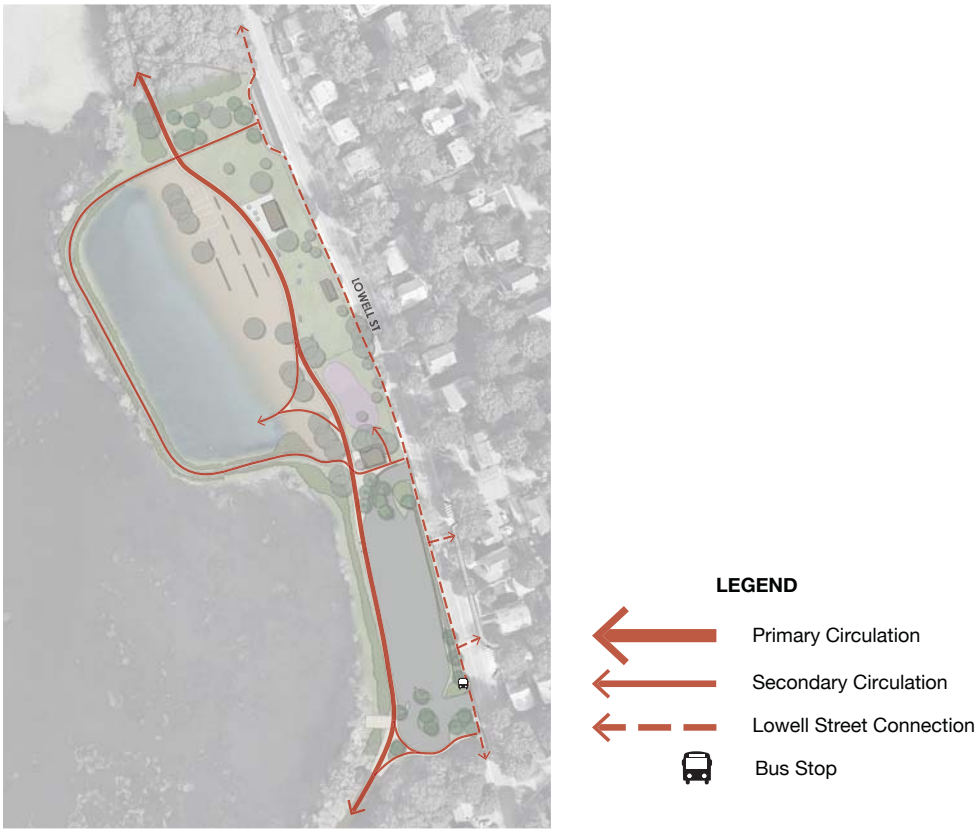
overhang would be affixed to the side of the existing Pump House Building to cover check-in operations. The new arrival plaza would welcome visitors with signage, landscaping, tree planting, and special pavement treatments. The look and feel of this plaza could be fairly informal in keeping with the naturalized feel of The Res property.

Precedent image of an overhang

Precedent image of an arrival plaza

PATHWAY HIERARCHY

Recommendations contained in the preferred master plan include the establishment of a formalized pathway system. Within the bathing beach, a primary 10-foot wide pathway would provide a linear north-south spine through this area and delineate the sandy beach zone from the passive lawn and picnic area. Secondary 5-foot wide pathways connect into this main spine and back to the existing sidewalk along Lowell Avenue. There are new pathway connections along the parking lot and to the entry plaza from Lowell Avenue that also tie into the perimeter path around the Reservoir. A new fully ADA-compliant pathway brings accessibility to the water; the pathway is less than 5% slope, eliminating the need for handrails.



Pedestrian circulation through the bathing beach and parking area

PERIMETER FENCING AND GATED ENTRIES

The preferred plan proposes a perimeter fence that will contain the bathing beach. It would start at the Pump House Building and run along the top of the berm on the bathing beach side such that a widened path and three to four accessible tables would sit outside the bathing beach area. The fence will continue to the proposed drop-off area, along Lowell Street and the relocated play area to tie back into the Pump House Building. Since it is a revenue-generating resource for the Town, there are two gate locations for entry and tag checking into and out of the bathing beach and one gate that secures the new play area. Additionally, a stretch of fence will run along Lowell Street at the parking lot to define that edge and direct pedestrian traffic.

BEACH TERRACING AND SAND REPLENISHMENT

Given the regular replenishment required to maintain the sand within the beach area, this preferred plan proposes a series of terraced seat walls that would hold the sand at different levels up-gradient from the water. Not only would they serve to hold sand in place, they provide valuable space for campers to gather and hold events, groups of people to socialize, and beachgoers to use for sunbathing or as a backrest while sitting on the sand. These seat walls are proposed to be constructed of cast-in-place concrete and would be between 12 inches and 18 inches high on one side and retain sand on the other side.

CONCESSION, PAVILION AND PICNIC AREA

The main pedestrian path serves as the demarcation between the sandy beach and open lawn within the bathing beach area. Surrounding the Bathhouse and Concession Building, a new concrete pad will be poured that can accommodate three to four café tables and chairs and offer accessibility to the Men's and Women's restrooms and concession stand. The concession stand is open during the bathing season, and serves snack type foods. A number of picnic tables will serve as an extension from this expanded concession area. A new pavilion, roughly sized at 15-feet wide by 30-feet long, will be located in the center of this lawn area and sit on a concrete pad. It would offer a covered seating area and be a rentable location to host small parties or group events or a venue for larger town-wide programming.

A multiuse pavilion within a park

BEACH VOLLEYBALL

A formalized beach volleyball court would be located within the beach area just north of the terraced seat walls. Existing trees will provide shade and tucks the court away from the rest of the sandy area

open to beachgoers.

Pump House Building

The recommendations below assume only minor renovations that will not trigger more substantial architectural and structural upgrades.

BUILDING ENVELOPE

As discussed earlier, the proposal would affix an overhang to the side of the Pump House Building, which would provide cover for an outside check-in area for beachgoers. The exterior facade would be improved by cleaning the CMU block walls and potential greening with trellises or evergreen planting. A refreshed look to the park buildings has potential to build identity for The Res as it attracts a wider user group.

Replacement of the roof system with a single-ply membrane and associated new drains, flashings, copings, etc. is also recommended along with cleaning and re-pointing of the exterior. The application of a water-repellent breathable sealer should also be evaluated. The steel doors and frame are showing some corrosion at their lower edges and is recommended for replacement.

INTERIOR CONSTRUCTION AND FINISHES

The preferred master plan calls for adding inside walls in order to reconfigure the interior space and separate filter equipment from other uses inside the building. All existing walls and ceiling would be repainted as part of the building renovation. Additionally, the door and frame to the storage/ workroom is corroded at their bottom edges. Both are recommended for replacement.

STRUCTURAL

The structure was found generally capable of supporting anticipated gravity loads (i.e., dead, live, and snow loads) and lateral loads (i.e., wind and seismic loads). The following are recommended for only minor renovations as noted previously:

- Remove vegetation growth immediately adjacent to the building and repair concrete masonry as necessary.
- Clean exterior of concrete masonry and apply sealer to reduce moisture intrusion. Note that the sealer requires re-application every three to five years. The masonry should be dried by means of heat and/or dehumidification prior to the application of the sealer.
- Clean steel framing, including exposed surfaces of lintels, and metal deck. Coat with corrosion resistant paint system.
- Install steel supports at the edges of the roof penetration.

Bathing Beach Filter System and Water Quality

In order to improve bathing water filtration and clarity, a new filtration system is proposed and includes new piping, filter, pump(s), drive(s), and valves. The existing suction and collector tank system should be renovated to replace the collector tank and install new interconnecting piping between the filter system and bathing beach. Additionally, a new chemical feed system is required as part of this system, which includes new tanks, feeders, controller, and piping. This system introduces the use of reservoir water in lieu of domestic water to supplement the bathing beach. In order to do this, an influent water line from the reservoir side of the bathing beach will be installed

with a pump to bring free water into the system. A new inlet delivery system is needed to reduce the velocity of water injected into the bathing beach.

Example of a new sand and filter system

This new system will also introduce UV treatment, which helps with disinfection and reduces the amount of chlorine used. Finally, a new skimming system will be installed in order to clean the water before it circulates into the swimming area.

Bathhouse & Concession Building

The recommendations below assume only minor renovations that will not trigger more substantial architectural and structural upgrades.

BUILDING ENVELOPE

Replacement of all roof trim is recommended, which would include new skylights, roof trim, gutters, downspouts and gable louvers. Alternate materials such as cellular PVC or fiber-cement board should be considered as more durable options. Cleaning and re-pointing of the exterior is recommended, and the optional application of a water-repellent breathable sealer should be evaluated. All exterior doors, frames, entry screens and associated hardware should be replaced. Further investigation and the possible reconstruction/replacement of these interior walls is recommended.

As well, the coiling shutter requires replacement at the concession window. New exterior lighting and outdoor shower upgrades should also be included. In a similar fashion to approach with the Pump House Building, this facade should be improved by cleaning up the CMU block walls and greening the walls in some way, such as with vines growing up trellises or evergreen planting in front.

INTERIOR CONSTRUCTION AND FINISHES

Hinged access panels in the chase walls are corroded and are recommended for replacement. The use of solid-plastic toilet partitions and screens is recommended. New doors and frames would be installed as part of this improvement plan. The water closets, urinals, lavatories, toilet partitions and screens, and toilet accessories would also be upgraded. Replacement of all lighting fixtures with new LED-type fixtures is recommended as well as a new domestic water heater and gas service or electrical upgrades. Finally, the plan calls for adding inside walls in order to reconfigure the interior

space and capture a larger area for concession.

The long term vision for concessions is to offer simple snacks only, that can be supported by a refridgerator, freezer, sink and microwave.

ACCESSIBILITY

Given that a minimum 30-inches wide portion of the concession window must offer a counter height of 34-inches for ADA compliance, the reconfiguration of the service window is required.

STRUCTURAL

The Bathhouse and Concession Building was found generally capable of supporting anticipated gravity loads (i.e., dead, live, and snow loads) and lateral loads (i.e., wind and seismic loads) with reinforcing noted below. The following are recommended for only minor renovations:

- Repair/replace existing roof sheathing. Provide additional fasteners from existing sheathing to remain to roof rafters for resisting lateral loads and wind uplift.
- Reinforce existing roof rafters by adding new rafters adjacent to the existing rafters (i.e., "sistering"). Provide ties across the width of the building at each rafter to resist horizontal thrust.
- Repair/replace existing wood top plate.
- Provide uplift ties from rafter to top plate. Anchor the top plate to the concrete masonry wall. Provide continuous load path to the foundation.
- Investigate exterior screen walls for vertical reinforcing. Unreinforced cantilevered masonry walls pose a potential hazard and should be removed and rebuilt.

Children's Play Area

The preferred master plan relocates the play area closer to the arrival plaza for a few strategic reasons. First, relocating the playground out of the beach area allows it to be accessed all year round, even during the bathing beach season. Secondly, the playground would be located closer to the parking lot and thus more easily accessible to families, caregivers and small children who are the most likely users of this space. Finally, this new location features the playground visually accessible from Lowell Street, which will make for an inviting view into the property especially it is filled with happy kids running around and playing on new state-of-the-art play structures. This particular location also traverses roughly four feet of grade change, which could be incorporated into the final design and provide a unique play experience for those who come to enjoy the playground. There would be only one gated entry and a perimeter fence would enclose this space. The community expressed an interest in using a more ornamental fence in strategic locations around The Res; the playground could be one of these locations.

Reservoir Perimeter

EROSION AND PROTECTION OF ENVIRONMENTAL RESOURCE AREAS

In order to prevent further erosion along reservoir's banks and to protect the environmental resource areas, improvements to the reservoir perimeter would include the following, as graphically depicted on the Overall Reservoir Improvement Plan:

- Stabilizing sections of the trail
- Repairing sections of stone dust as needed
- Incorporating seating and fishing access at opportune locations
- Installing buffer plantings to prevent off-path access

- Installing educational signage

Trail stabilization efforts will include establishing a typical 6-foot trail width, installing Rubber-based flexible pavement or similar pathway material in selected areas, and directing runoff away from the reservoir. Rubber-based flexible pavement will be implemented strategically in areas that are particularly difficult to traverse due to protruding tree roots and other barriers within the pathway. Rubber-based flexible pavement is very porous, made from recycled material, and has the ability to clean water as it passes through. Rubber-based flexible pavement is slip-resistant and resistant to freeze-thaw due to its flexible nature, so it is extremely durable and can withstand heavy trail use.

Example of rubber-based flexible pavement installation on a trail

Plantings of appropriate species along the reservoir's edge of any pathway would begin to discourage visitors from accessing sensitive areas such as Bordering Vegetated Wetland (BVW) or recently restored banks. Several different plant species could be used; however, they should be selected based on native plantings found on site as well as tolerance for inundation and seasonal drawdown. The plants should also exhibit the following characteristics:

- Generally, woody species perform the best for this purpose. They are difficult to navigate and push aside and provide ample resistance when people try to walk around them.
- Species should be tightly grouped together as to not allow for gaps between individual plants.
- Species should be low in height to avoid obscuring the view across the water. Ideally, shrubs should grow to waist height at full maturity.

By providing designated seating overlooks and fishing spots along the pathway, people may no longer feel the need to create their own access and disturb wetlands and restored areas. These overlooks will consist of one or two new benches set in either stone dust surfacing or on a concrete pad. Their proposed locations are based on particularly spectacular views or opportune fishing locations. Minor tree pruning and understory shrub cleanup will be required to preserve views.

The final piece to protecting the shoreline is education. By educating the public that some of these newly established stabilization and/or habitat areas are sensitive and fragile, most people will choose to protect rather than disturb them. Interpretive signage, as described in the following pages, could be used as a communication tool to achieve this end.

WILDLIFE HABITAT GARDEN

The Wildlife Habitat Garden would be preserved in its current form and protected within a new, durable perimeter fence. The fencing should be fairly minimal in look with the purpose to discourage foot traffic while allowing for wildlife passage. The pathways around the gardens also need to be regraded and stabilized in order to provide accessibility.

SIGNAGE AND WAYFINDING

A well designed signage program, throughout the bathing beach area and along The Res's perimeter trail, could provide stopping points to read about the environment and wayfinding to nearby open space resources. The master plan includes an allocation for three large 24-inch by 36-inch vertical or angled signs and six smaller 8-inch by 10-inch signs of a similar aesthetic. All of these signs would be affixed to power-coated aluminum posts; the signs themselves are graffiti-resistant.

The larger signs are envisioned as interpretive, or educational, in nature and have been located on the Overall Perimeter Improvement Plan contained earlier in this section. These signs could identify environmental resource areas, as well as educate the public on the restoration process of the banks, removal of invasive species and any other important projects within the entire property. There is also an opportunity to use these signs as means to describe The Res's rich history as a cultural and social resource.

Example of large interpretive signage

Example of small wayfinding signage

The smaller signs would be deployed as wayfinding signs that orient visitors to their location within The Res property itself as well as indicate connections to other nearby open space resources, such as Arlington's Great Meadows, Whipple Hill, McClennen Park, Mount Gilboa Conservation Area, Cataldo Reservation, Minuteman Bikeway.

Environmental Recommendations

The following recommendations include methods to stabilize bank erosion, to control aquatic nuisance and invasive plants and to manage terrestrial invasive plants along the reservoir's shoreline.

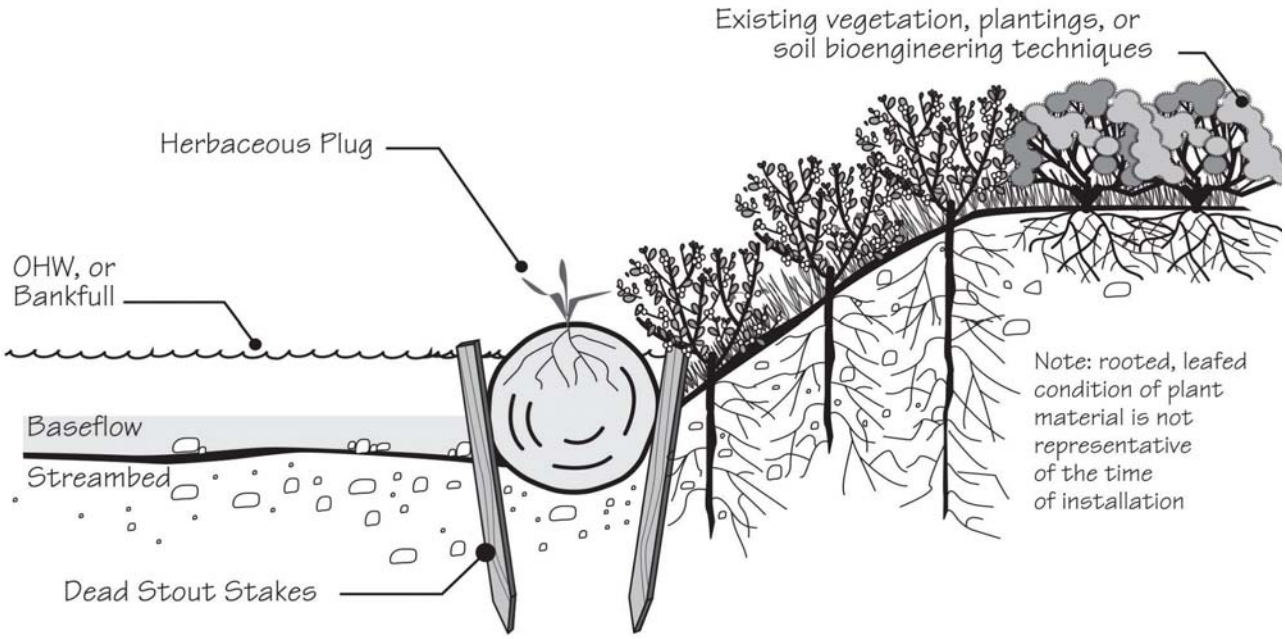
BIO-STABILIZATION OF BANK EROSION

As noted in the Environmental Assessment section, there are several areas along the reservoir's banks that are exhibiting erosion. This master plan carefully considers how to prevent further erosion from occurring in these and other areas while maintaining shoreline access for fishing. As just discussed, enhancing and improving the pathways along the shoreline will also reduce erosion along the shoreline by keeping pedestrians on stable materials.

If erosion is minor and due to foot traffic, only a limited protection measure may be necessary.

However, if the location is subject to heavy wave and wind action, a stronger intervention may be necessary. The proper protection measures should be evaluated on a case-by-case basis, tailored to the specific area of concern and the particular erosional forces at work in that location. The annual drawdown regimen should also be considered when determining the proper protection measures.

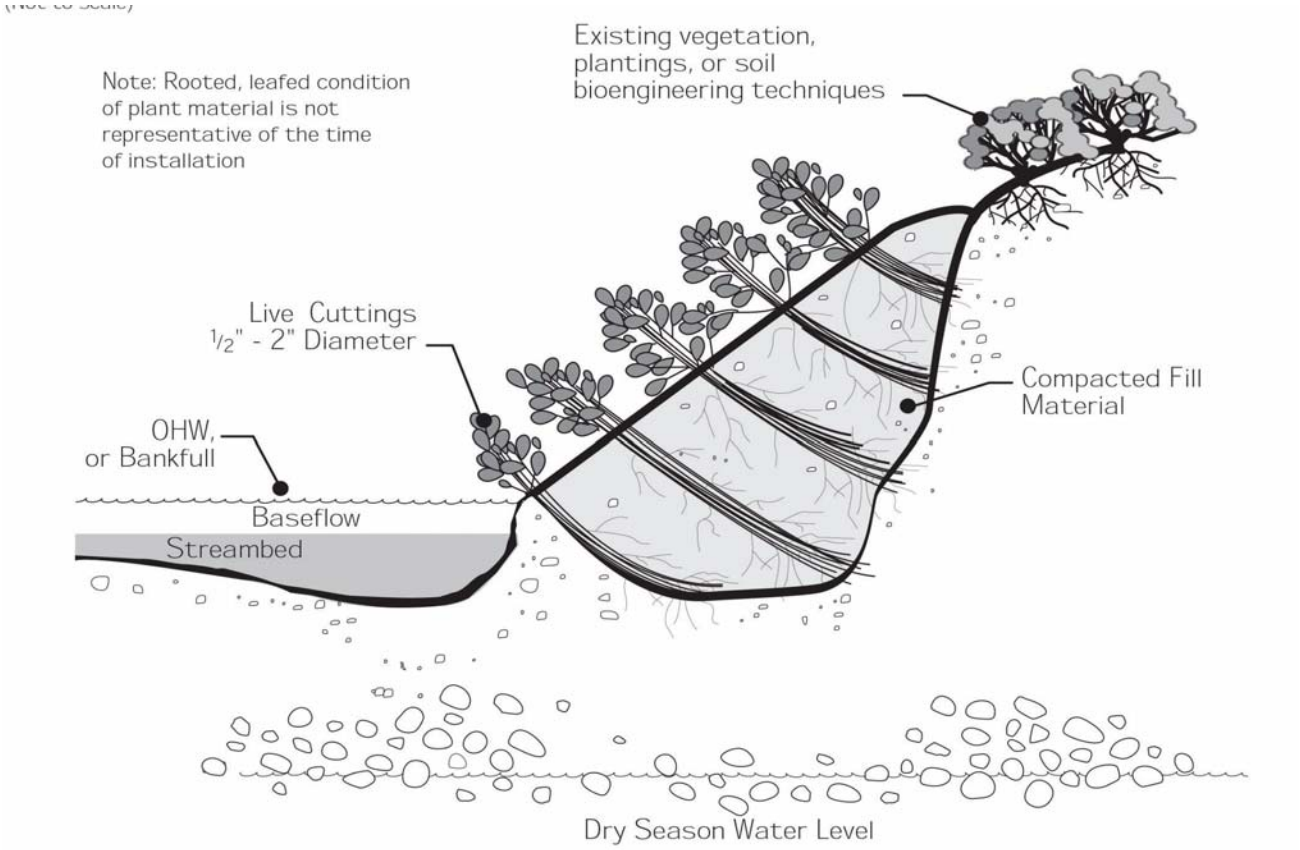
Bio-stabilization practices have been developed and will be installed in accordance with "A Soil Bio-engineering Guide for Streambank and Lakeshore Stabilization," a U.S. Department of Agriculture Forest Services guide. The techniques proposed below were selected not only to provide protection of the shoreline but to also mimic and create a natural riparian environment and provide habitat for riparian and pond species, including fish that currently or could make a home at The Res.



Coconut Fiber Roll

Coconut Fiber Roll - Offering a moderate level of protection the coconut fiber roll (or coir fascine) would be installed parallel with any eroded bank. The roll would be installed with hand driven wooden stakes. Plantings would be placed directly behind and on top of the roll to help restore and stabilize the shoreline. The roll would be placed so that it is not overtopped during times of high water in the reservoir. Multiple rolls would be stacked to achieve the appropriate height. The benefit of this application is that the coconut fiber is a natural material that will eventually decompose and become part of the natural bank. As the vegetation planted behind and within the coconut fiber roll become established, this area will become indistinguishable from its surrounding bank.

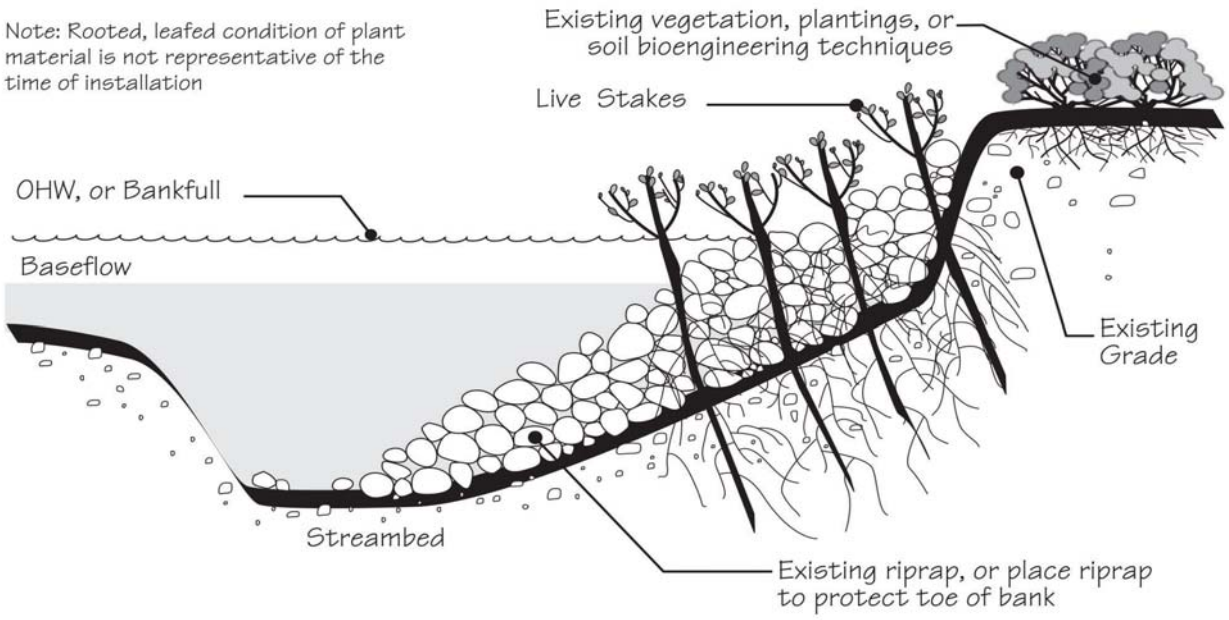
Brush Layering - Utilized in areas of large cavities along the banks, brush layering allows for the ability to jump start the bank regrowth process. Layering live cuttings within horizontal layers along any bank fill will promote both regrowth and bank stabilization. The branches serve as tensile inclusions or reinforcing units to keep the soil in place. Over time, the branches will sprout and establish a root system throughout the fill area. This technique is best used in areas above the ordinary high-water mark; it can be combined with other stabilization techniques, such as the coconut fiber roll, at the water line.



Brush Layering

Joint Plantings - In areas where hard engineering solutions are a "must" due to heavy erosional forces, there are still methods to bioengineer those hard solutions. If the solution is to stabilize a slope with rip rap, joint planting is one of those methods that in which live stakes can be planted in the stone bank. As the live stakes grow they create habitat and help disguise rip rap slopes. Additionally, as they root into the embankment, they also help to stabilize the slope.

Although these are some of the bio-stabilization techniques that could be used at The Res, there are a number of other methods that could also be implemented. A site-by-site evaluation would be required in order to understand what is causing that area's particular erosion and the best methods to not only correct the issue, but to prevent further erosion from occurring. Part of that prevention would be accomplished through proper environmental and pathway design as discussed previously.



Joint Planting

NUISANCE AND INVASIVE AQUATIC PLANT CONTROL

A primary obstacle to its continued capacity to support valuable ecological and recreational function is an overabundance of aquatic plants, dominated by invasive species. Plants cover at least 90% of the reservoir's bottom and fill close to 75% of the water column. Water chestnut covers much of the surface of the reservoir and cloudy water impedes water-bird and aquatic-life feeding, fishing, and looks unappealing. Based on available data, the turbidity appears to arise from resuspension of organic sediment and, while algae do not appear to be a major issue at this time, better control of macrophytes (e.g., water chestnut) could allow algae to proliferate.

Appropriate goals for the reservoir should include the following:

- No more than 20% surface cover by plants
- No more than 50% of the water column filled with plants
- Turbidity <5 NTU for 95% of the time

Reducing plant abundance, particularly invasive species, is the primary focus of this management review. Key considerations for determining the most appropriate approach include cost, technical feasibility, regulatory permissibility, and Town and community acceptance. Four reasonably feasible options for aquatic plant control at The Res are discussed in detail, below:

Draining and Dredging - Draining and dredging The Res would reset the entire system, and could be highly beneficial for many years. However, the permitting process and cost are often untenable. While no study of material quantity and quality has been conducted, it is reasonable to assume that at least half a foot of soft sediment could be removed from at least 20 acres of reservoir area, or 10 acre-feet, which is roughly 16,000 cubic yards. Costs could range from $500,000 to several million depending on the type of material encounters, especially if the sediment is contaminated to a degree that requires special disposal methods. Nearly all urban and suburban lakes in Massachusetts have contamination by metals and hydrocarbons that require controlled disposal, which can raise the cost at least threefold. In order to support this kind of dredging project, additional testing and evaluation would be necessary than what is provided in this assessment. Such a method would represent

true restoration of the reservoir to original conditions when the dam was built, and is analogous to rehabilitating a historic building. The cost is likely to be extreme for this approach.

Partial Drawdown - Partial drawdown is currently practiced annually and involves dropping the water level of the reservoir by about two feet. In the past, the reservoir elevation has been lowered soon after the last official day of swimming at the bathing beach or when practical with respect to heavy rain events, which is sometime in September. The lowest elevation obtained is near 153.0. It should be noted this start time is earlier than recommended for Massachusetts lakes under DEP guidance and it is recommended that the Town consider whether an adjusted drawdown schedule would be appropriate. Drawdown appears to help to flush the reservoir. An approximate 50% decrease in volume would result of a two-foot drawdown from the normal water level. Partial drawdown helps to maintain coarser substrate around the edge; however, only a small portion of the bottom is actually exposed by partial drawdown. A three-acre reduction in area results from a two-foot drawdown. Drawdown has almost no cost and does provide benefits, but the current practice is inadequate to fully control plants throughout the reservoir. Full drawdown is alternative approach that is used at some ponds. Full drawdown would drain the entire reservoir and would kill the invasive plants, but it would also kill the native plants and adversely affect water-dependent wildlife. We also understand that existing reservoir controls do not allow for full drawdown. Given the likelihood of adverse effects and current water-level control infrastructure, we do not recommend further consideration full drawdown at this time.

Mechanical Harvesting - Mechanical harvesting is also currently practiced. In 2017, it was conducted in September long after seeds from water chestnut and any other seed-producing plants were generated and dropped. Plant biomass was removed, but no carry-over benefits would be expected in 2018 because harvesting happened too late in the year. The focus of mechanical harvesting in the past appears to be on water chestnut, which is entirely appropriate. If the Town is paying for such services, the harvesting should be completed in early July in order to reduce seed production, which could potentially lead to a long-term decline in water chestnut abundance. Effective harvesting is usually a twice-per-year operation, with one cut in late spring and one in summer. With water chestnut as a dominant species, it is best to let the plant grow to the point where surface leaves have formed, but not to the point where seeds have been produced, which is usually in July. A single cut in June might be enough, but other species such as milfoil and coontail may grow to nuisance proportions after a June harvesting event. At an expected cost of $1,500 per acre per cut for dense growths, about 20 acres could be harvested for $30,000 on a contract basis. Less area was harvested in 2017 and it may not be necessary to harvest 20 acres to meet all use goals; more intensive and timely harvesting is needed if plant control is to be achieved. At least 10 acres of harvesting is needed twice per year. Other plants in the reservoir could be harvested as well, but the density of coontail and milfoil in the southern portion of the reservoir did not suggest much harvesting was performed there in 2017. In the future, there is ample room to lay out and dry removed plant material along the trail pathway just south of the boat launch. For roughly 100 feet, the pathway is quite generous at 12 to 15 feet wide. If needed, it can be reduced to just 5 feet wide temporarily if needed.

Benthic Barriers and Herbicides - While we do not know the complete management history of The Res, benthic barriers and herbicide techniques do not appear to ever been done. Benthic barriers are not typically deployed over many acres of any given waterbody but could be used to establish lanes for boating or fishing. Non-porous barriers can suppress plant growths for a year or more with no maintenance, but eventually soft sediment accumulates on them and allows growth. It is usually recommended that barriers be removed and cleaned once per year. Fishing lures tend to snag on the benthic barrier; however, there are few other interfering factors.

The cost for these materials is least $30,000 per acre. Sheets are just over 10 feet wide, however, and can be laid end to end to create lanes where plant growth is suppressed. For about $100,000,

it is possible to create a series of runways that will increase edge effect and maximize habitat. This initial investment would return benefits for about ten years. Additional labor costs apply, but the material itself would not have to be replaced for about a decade, making the annual cost much lower when spread over the life of the material. Assuming $10,000 per year in labor, the annual cost would be about $20,000 on a 10-year basis.

TERRESTRIAL INVASIVE PLANT MANAGEMENT

Below is a detailed description of the recommendation for invasive species management and monitoring as it applies to the subject site. As stated in the Environmental Assessment section, several different types of invasive species were noted in the study area. These include:

- Garlic mustard (Alliara petiolata)
- Japanese barberry (Berberis thunbergii)
- Asian bittersweet (Celastrus orbiculatus)
- Winged euonymus (Euonymus alatus)
- Glossy buckthorn (Frangula alnus)
- Morrows honeysuckle (Lonicera morrowii)
- Purple loosestrife (Lythrum salicaria)
- Japanese knotweed (Polygonum cuspidatum)
- Multiflora rose (Rosa multiflora)

Invasive Species Management - As part of improvements to The Res, these invasive species within the work area would be managed and removed. Replanting of these areas with native species is recommended. Out of the species noted above, it is recommended that the most aggressive invasive plants are prioritized. Residents have reported that Asian bittersweet, in particular, has caused severe tree damage and could be the first candidate for removal. However, more observation is necessary to determine which areas around The Res should be of initial focus. There are a number of different applications available for the management and removal of invasive species, which are broken down into the following three categories: mechanical, chemical, and biological.

Each category has its own advantages and disadvantages and each can be applied in specific cases where other methods may not be as applicable. Mechanical methods include any type of physical removal of the plant biomass, including pulling, mowing/cutting, digging and burning. Chemical treatments include the application of herbicides. This technique is often used in conjunction with mechanical removal. For instance, cut and dabbing is the process of cutting invasive species to ground level and then dabbing the stems with an herbicide. Biological control utilizes pest or insects as predators for target species and is much rarer. For The Res, we only recommend the mechanical and chemical methods due to the complexities involved with funding and managing biological treatments.

Mechanical Methods - Mechanical methods are usually the first approach to handle most invasive species because they require no special licensing or handling of chemicals. Most of the work can be done with little to no permitting and with the assistance of either volunteers or a hired landscape crew. However, mechanical removal methods require a long-term commitment and will require continued maintenance of the invasive species zones to ensure that they do not grow back. Depending on the breadth and extent of the population, mechanical methods may also require large areas of disturbance, especially when digging is required. Disturbed areas can become prime breading grounds for re-growth or encroachment of other invasive species. Two types of methods that have proven effective are highlighted below:

- Pull or Dig: Large herbaceous and woody plant species can often be pulled out and have their roots dug up, if found in limited quantities. When utilizing this method, it is important to remove

as much of the plant material as possible including root mass, stolons, and rhizomes. Some species can re-infest an area if as little as a small root is left behind (i.e., Japanese knotweed). Instead of using a shovel, digging with a fork or similar tool may be preferred. Shovels can often cut through a root, leaving a portion behind, where as a fork will tend to pull the entire root system. In some instances where large stands are present, it may be beneficial to work with a small excavator or bobcat to remove large portions of infested soil. This work could be completed in the early spring where seeds have yet to mature and the soil is still moist. The moist soils will allow for easier pulling of most species and, if the seeds are yet to mature, it will reduce the risk of seed transport to other areas.

- Light Barriers: The introduction of light barriers is a method used to remove small seedlings and other small herbaceous plants that can not readily be pulled. This method involves the placement of any light blocking material (usually plastic sheeting or weed block) over the infestation. It should be staked or weighed down and extend outside of the infestation area. Light barriers can either be left in place or loamed and seeded over. This technique will kill all species, both invasive and native, that are trapped under the barrier.

Chemical Methods (i.e.; Herbicides) - Herbicides are one of the most effective ways to treat invasive species, however, careful consideration should be taken when using any chemicals, especially when adjacent to a resource area such as in this case. Chemical methods are usually applied in two ways: large scale spraying (often seen on power line easements) and small scale localized applications.

Due to the location of the invasive species, large scale spraying is not recommended for this project. Instead, localized applications would be more effective, if chemical treatment is at all preferred. Localized applications would be conducted alongside a mechanical method such as cutting. With chemical treatments, it is important to interrupt the life cycle of the species, and therefore timing is paramount to any successful chemical treatment. Two chemical treatment methods that have proven effective are highlighted below:

- Small-scale Spray Applications: Utilizing a backpack sprayer or equivalent, such as a small handheld sprayer, chemical treatments of monocultures or individual invasive plants can be conducted. Spray applications have proven useful against herbaceous species, such as purple loosestrife, that are often tough to manage with mechanical methods. It is also a practical alternative for some woody species, such as Japanese barberry, Japanese honeysuckle, and Asian bittersweet, that grow in dense stands. It is generally recommended that the mixture contain no more than 5% of the active ingredient and that treatment occur in early spring when the plants are growing. This will break up their life cycle and stop future growth. It is also recommended that spraying take place when no rain is forecast for several days afterward to ensure that the treatment does not wash away.

- Cut and Dab: The cut and dab method essentially combines a mechanical and chemical treatment together. The goal is to avoid large ground disturbance caused by digging up roots and to instead apply a chemical treatment to a cut stems or roots. These treatments require a higher concentration of the active ingredient than is used in small scale spray applications. A 25-35% solution of the active ingredient should be used. Stems would be cut as close to the ground as possible and herbicide would be applied directly to the cut surface. This application would be completed as soon as possible after the plant is cut to ensure effectiveness of the herbicide. The herbicide can be applied in many different methods including spray bottle, rag, brush, or sponge. The cut surface must be thoroughly wet such that the herbicide gets into the plant. This technique is most effective in late summer or early fall.

Drainage and Stormwater Systems

The logistics of the property's overall drainage, stormwater management, and other utility systems will need to be engineered to accommodate the new main parking lot and drop-off area, new hardscaped areas such as the arrival plaza, and recreation assets both inside and outside the bathing beach area. It may be necessary for these systems to be modified in order to best fit the site's environment while accommodating optimum drainage patterns and water quality improvement into the reservoir itself. Green infrastructure techniques such as bioretention areas, tree infiltration trenches, and bioswales should be considered as viable options for infiltration. Additionally, all existing drains and outfalls and their relationship to water quality should be thoroughly evaluated as the improvement plans are refined and replaced as necessary.

Vegetation

It is anticipated that a more proactive vegetation management program will yield very positive environmental results as well as recreational and aesthetic benefits. The removal and management of both terrestrial and aquatic invasives has been discussed above. In order to improve visibility and safety, this master plan recommends selective pruning of the mature tree canopy. Pruning around the perimeter path will maintain and enhance existing views and overlook areas and prolong the life of the existing trees.

Tree planting within the bathing beach area will add more shade and opportunities for picnicking within the passive recreation zone. A row of street trees along the Lowell Street sidewalk will establish an inviting aesthetic character and indicate to passersby that The Res is a recreational resource. A greener street edge will also be more hospitable to pedestrians travelling along the stretch of Lowell Street. Tree planting within the arrival plaza would soften the hardscape and provide respite for those gathering in that area. Additional tree and shrub plantings are scattered throughout the bathing beach and parking areas and will enhance the park-like feel of The Res.

Overall Landscape Aesthetics and Environmental Enhancements

There is general agreement that improvement to The Res will be and attractive source of pride to the surrounding neighborhood. To this end, a series of landscape improvements have been identified that will help enhance the property as a beautiful and aesthetically satisfying open space resource envisioned by all master planning participants.

- Improve vehicular circulation and provide specialized areas for drop-off and boat launching.
- Develop attractive edge treatments along Lowell Avenue and alongside adjacent open space resources, specifically Rindge Park that includes wayfinding signage and information, tree plantings, trail improvements and related landscaping.
- Improve visibility and safety through the management of vegetation throughout the property. This includes selectively pruning desirable vegetation, and the removal of dead, diseased or invasive plant species.
- Plant more vegetation, specifically trees that are nut-bearing or provide fruit for wildlife. Consider a management plan for long-term tree viability.
- Provide attractive new recreational assets within the bathing beach, such as a new pavilion, that bring new users to the property and make The Res a regional destination.
- Refurbish all of the existing facilities such that they contribute to the functionality and aesthetic character of The Res property.
- Renovate and install new filter and pump equipment such that water quality within the bathing

beach improves and The Res becomes a healthy and active recreational resource.

- Install furnishings and amenities that include benches, picnic tables, trash receptacles, bike racks and the like.
- Install interpretive signage that presents the unique historical, environmental, recreational and cultural assets of The Res.
- Stabilize difficult terrain and regrade sections of pathway that are under-performing, difficult to navigate, or inaccessible. Cut back overgrown vegetation and standardize the path width.
- Remove and manage aquatic and terrestrial invasives.
- Stabilize erosional issues along the shoreline and replant these area with native species.
- Tailor site drainage and stormwater management system to accommodate new site amenities and enhance existing environmental systems.
- Repair and/or replace drainage structures and outfalls as necessary.