Geotechnical Engineering Evaluation Report
EXECUTIVE SUMMARY

Waban Hill Reservoir Dam
NID # MA 01111
Newton, Massachusetts

Stantec

Prepared for:
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Newton, Massachusetts 02459

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EXECUTIVE SUMMARY

The Waban Hill Reservoir Dam is regulated by the Commonwealth of Massachusetts, Department of Conservation and Recreation (DCR), Office of Dam Safety per 302 CMR 10.00 "Dam Safety." The dam is classified as Intermediate Size, (22 feet high, maximum storage of 60 acre-feet at the top of the dam) and High Hazard (located in an urban area where a failure would cause loss of life and/or significant property damage to commercial and residential buildings, secondary highways or railroads or cause interruption of use).

The Waban Hill Reservoir is an off stream impoundment that was used by the Massachusetts Water Resources Authority (MWRA) to provide high service pressure. It was filled via water pumped through a water supply pipeline to provide a water source to provide backpressure in a connecting pipeline to start an emergency pump at the Chestnut Hill Reservoir Pump Station. The reservoir is now a redundant feature in the water supply system and has been decommissioned from service. The 20-inch diameter pipeline used to fill the reservoir has been disconnected making it impossible to fill the reservoir beyond the current levels other than by rainfall. The drainage area of the reservoir is limited to the interior of the embankments and encompasses approximately 2.9 acres of the 5 acre property. There is no overflow spillway at the reservoir. The outlet works at the gatehouse serve as the only discharge structure at the dam.

Waban Hill is drumlin, a small hill composed of glacial till. The reservoir was formed by the construction of a 1,300 feet long earthen embankment that was cut into the hillside at the northeast corner with a maximum height of 22 feet and a maximum storage capacity of 60 acre-feet. The historic normal pool elevation for the reservoir is at elevation (El) 259 Boston City Base. The bottom of the reservoir is at El 246 and the top of the embankment is at El 270. The current reservoir level is at El 255± one foot leaving a water depth of 9 feet. The upstream slope is armored with hand placed granite block riprap at a 1.5 horizontal (H) to 1 vertical (V) slope. The crest of the embankment is flat; grass covered, and is about 15 feet wide. The downstream slope is also grass covered at 1.7H to 1V and varies in height from 0 feet at the northeast corner to 22 feet at the southeast corner of the reservoir. The gatehouse is located at the southwest corner of the reservoir. The primary inlet/outlet to/from the gatehouse was a 20-inch diameter cast iron pipe that has been permanently disconnected from the MWRA system. A secondary outlet is an 8-inch diameter cast iron drain which can be used to manually control the reservoir elevation. This 8-inch drain discharges to an 8-inch diameter cast iron pipe in Ward Street and is the only means for lowering and controlling the water level within the reservoir. With the disconnection from the MWRA system, the reservoir impoundment is only effected by rainfall and evaporation. If the impoundment level increases, the water surface can be manually lowered by discharging water into the City of Newton storm water drainage system.

Eight test borings (B-1 through B-8) were drilled to determine the internal makeup of the embankment in January 2014. The test borings generally encountered a surficial topsoil layer underlain by embankment fill and glacial till. Embankment fill samples primarily consisted of dense brown fine silty sand and extended to a depth of about 20 feet or El 250 in each of the four borings drilled from the dam crest. Beneath the embankment fill , a stratum of glacial till approximately 17.5 feet to 24 feet in thickness was encountered and described as a very dense gray/brown, fine to coarse sandy silt, trace clay. Bedrock was

not encountered during the drilling of the borings to the depth investigated. It is assumed that the embankments were constructed from the materials excavated from within the reservoir.

A design drawing obtained from the MRWA dated May 31, 1944 indicated the presence of an existing puddled fill core located along the upstream side of the dam crest that was 4 feet wide at El 267 (top) and 8 feet wide at the base at El 242. It is probable that during the construction of the embankment, the core zone was saturated (i.e. puddled) in contrast to the upstream and downstream shell sections and may be the only major differing feature associated with the core zone. Puddle without qualification is defined as clayey and gravelly earth thoroughly wetted and mixed, having a consistency of stiff mud or mortar.

The surface displacement of riprap along the upstream face of the dam observed in several locations was determined to be a relatively shallow type failure rather than a deep seated (global type failure). The northwest slope where bulging along the downstream toe of slope was noted exhibited a similar shallow type failure due to the relatively shallow depth to the very dense glacial till and the presence of an overlying loose soil layer.

An analyses was performed to evaluate the dam embankment for slope stability and seepage with the reservoir at normal pool (El 256); approximately 14 feet below the top of the dam. The loading conditions evaluated included steady state seepage under normal reservoir levels and earthquake. Although the reservoir has been disconnected from the MWRA system, the rapid drawdown from normal pool condition was evaluated to determine whether the observed sloughing along areas of the upstream slope was the result of the sudden lowering of the water level that may have occurred during the 100+ years that the reservoir was used to provide high service pressure and storage. The results of the stability analyses indicate safety factors are less than the required values for the steady seepage from normal pool condition for the upstream slope but are mainly due to the steepness of the slope and not due to instability of the embankment itself.

Along the upstream slope of the reservoir, a number of observed surficial sloughs are believed to have occurred from a sudden drawdown condition when the water in the reservoir was used to fill a high service pipeline to provide the necessary backpressure to allow a pump to start at the Chestnut Hill Reservoir. This condition was modeled for an upstream slope with the reservoir at El 262 with a sudden drawdown of 10 feet to El 252 with a low permeability puddled fill core located along the top of the upstream slope. A factor of safety of less than one was calculated and provides an indication as to why the displacement/sloughing of the stone paving along the upstream slope occurred. Under the current conditions at the reservoir, with the disconnection from the MWRA supply system, this condition cannot reoccur.

No evidence of seepage or wet spots along the toe of the embankment was noted during Phase I Dam Safety Inspection/Evaluation Reports conducted in 1980, 2010, and 2012. The subsurface investigation program results indicate that the material that makes up the embankment is dense sandy silt to silty sand. Based on the lowered elevation of the water level within the reservoir (El 255±) and the disconnection from the MWRA system, the water level within the reservoir can vary only by rainfall and evaporation. There is no additional drainage area other than the interior of the reservoir. The upstream (1.5H to 1V) and downstream (1.7H to 1V) embankment slopes are very steep. However, due to the density and makeup of the embankment the dam is considered to be stable under the current conditions. The bottom of the reservoir is at El 246 and the maximum water level in the reservoir cannot exceed the current levels at El 256. The toe of slope at the maximum sections along Reservoir Drive and Ward Street range

between El 251 to 248, respectively. Although the results of the slope stability analyses did not meet the minimum failure requirement for the steady state condition, it is believed that the embankment will remain basically stable under the current conditions. The potential failure surfaces identified in the stability analyses are surficial and relatively shallow. A substantial embankment would remain if a slide did occur minimizing the impact of a release of the stored water within the reservoir. With the reservoir maintained at El 255, the water storage is limited to 17 acre-feet which is further reduced due to the toe of the embankment at the maximum section near the intersection of Ward Street and Manet Road being at El 248.

The following items were discussed during the presentation of the Waban Hill Reservoir Embankment Dam Investigation and Evaluation Results on April 1, 2014.

If the reservoir and embankment are maintained in its present condition, the annual maintenance costs would amount to mowing of the grass on the embankments one or two times per year (approximately $2,000 to $4,000). Because the dam is currently rated as High Hazard Dam, a Phase I Dam Inspection/Evaluation Report is required to be submitted to the Office of Dam Safety every 2 years. The next inspection is due in September 2014. The cost for the inspection and report is approximately $4,000 to $5,000 every other year. In addition, an update to the Emergency Action Plan (EAP) prepared for the dam is required to be submitted to the Office of Dam Safety annually. Assuming MWRA has a plan in place, the initial update of the EAP will require the inclusion of current City emergency responders. The cost for the update would range between between$8,000 to $12,000. Thereafter, the annual EAP update would be approximately $1,000 and could be performed by City personnel.

Regarding the repairs outlined in the 2012 Phase I Dam Inspection/Evaluation Report, the vegetation growth along the upstream slope of the dam should be removed. The estimated cost for this maintenance item was between $5,000 to $10,000 and could be performed by City personnel. Based upon the results of the stability analyses performed, the heaving/bulging on the granite block slope protection along the upstream slope of the embankment does not need to be reconstructed. It appears that the observed movement was the result of a sudden drawdown of the water surface within the reservoir for the startup of the emergency pump at the Chestnut Hill reservoir, a condition that can no longer occur due to the decommissioning of the reservoir from the MWRA system. The blocks do not need to be reset or grouted. The blocks do enhance the stability of the upstream slope and should be left in place.

Filling of the voids beneath the steps to the gatehouse does not have an impact on the stability/performance of the reservoir. It is a potential safety issue that should be addressed by the City if opened to public use. The estimated cost for the repairs to the steps ranged between $10,000 to $25,000. There were no active animal burrow holes observed along the downstream slope of the embankment. If noted the animals should be trapped and removed. Active use of the reservoir by the public and regular maintenance of the embankment with grass mowing will discourage burrowing animals.

Repairs to the gatehouse would include roof replacement and the installation of a new slide gate to allow the City to maintain a maximum water surface elevation within the reservoir no higher than El 256 (current levels) via the 8-inch diameter drain pipe to the City storm water drainage system in Ward Street. A copy of the gatehouse/valve locations is attached. New resilient seated gate valves were installed along

this pipeline in November 2001 by MWRA. There are two; 2 feet square sluice gates within the gatehouse with inverts at El 246.8 and El 261.0 that were last operated by MWRA in 2000. The 2010 Phase I Inspection Evaluation Report stated that the sluice gates were inoperable.

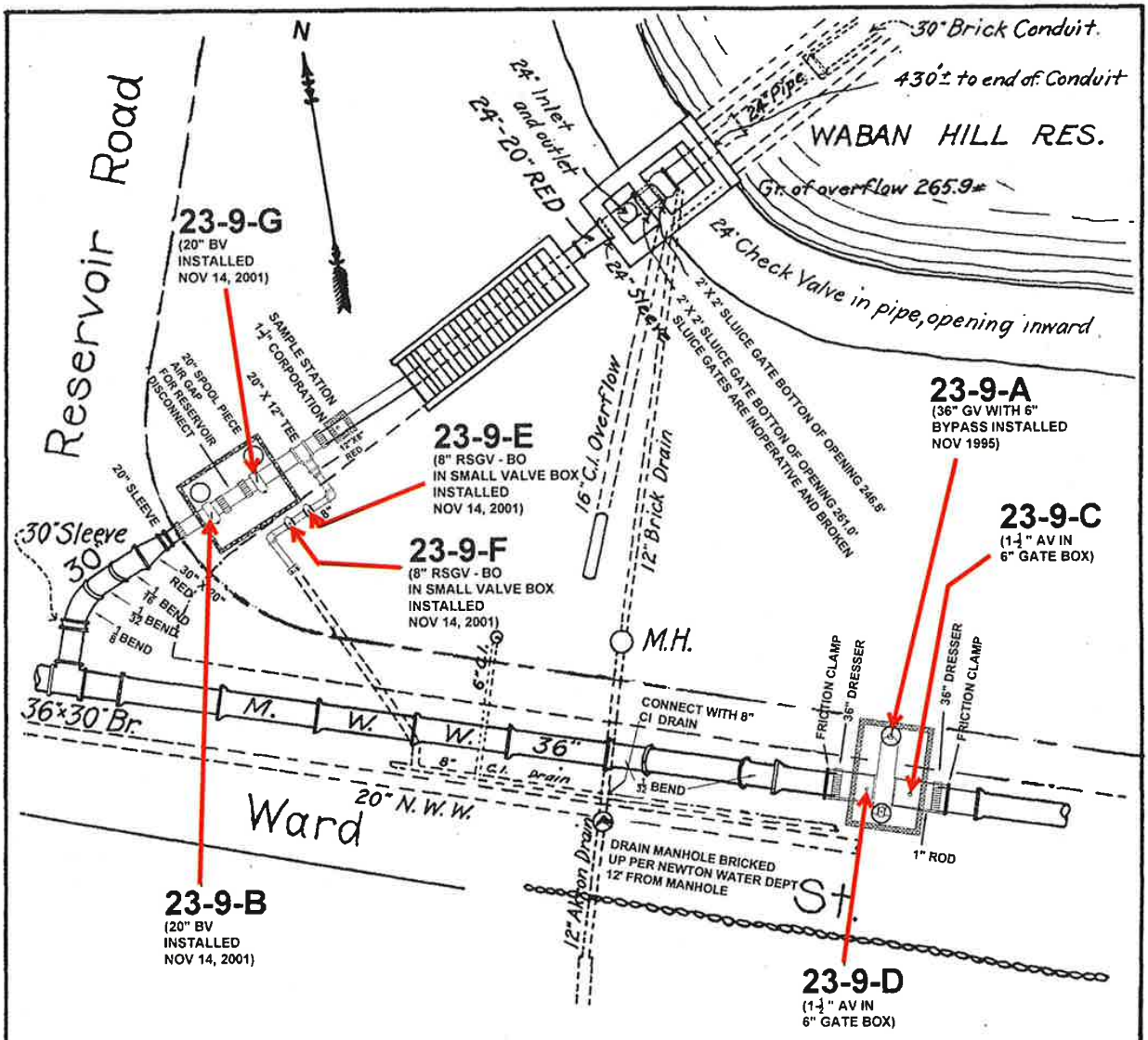
The high hazard category of the embankment is based on the assumption that "if" the dam failed, what would be the consequences. It is possible to have the hazard category of the dam reduced based upon the fact that the reservoir is a pumped storage facility and with the removal of the connection to the MWRA system, the variation of the water level will be limited to rainfall and evaporation. A new slide gate would need to be installed within the gatehouse with an invert at about El 255± to ensure the reservoir level could be maintained no higher than this water surface elevation. The cost to cut a new opening in the 2 feet thick separation wall within the gatehouse and installation of a new slide gate and operator would range between $20,000 to $25,000. A diver would need to be retained to inspect the condition of the bottom sluice gate to ensure that it is properly seated.

Additional stairs or ramps added to the downstream slope would be acceptable. The addition of trees or shrubs to the embankment crest or slopes is discouraged by the Office of Dam Safety and is not recommended. Flowers and plantings with shallow root systems are acceptable.

A terrace could be installed along the exterior slope without a change in the embankment height. Due to space limitations, a terrace could be added to the west side of the embankment adjacent to Reservoir Drive.

Reducing the height of the embankment is not a viable option due to the presence of the gatehouse at the southwest corner of the reservoir near the intersection of Ward Street and Woodlawn Drive. If the gatehouse superstructure was to be removed, the existing embankment height could be lowered which would not have a detrimental impact on the structural integrity of the embankment. However, the outlet that would be used to control the water level within the reservoir (i.e. sluice gates which transmits flow to the 8-inch diameter pipeline that discharges into the City storm drain pipeline) is housed within the gatehouse and a modified structure over the below grade portion of the gatehouse structure would be necessary to provide access to this slide gate as previously discussed. The Waban Hill Resevoir Embankment Dam must still conform to the requirements of 302 CMR 10.00, "Dam Safety." The Office of Dam Safety would require some form of water level control within the reservoir.

It is recommended that the City of Newton request the most recent version of the Emergency Action Plan and Operation and Maintenance Plan in electronic form (Microsoft Word) as part of the acquisition of this property from the MWRA/DCAMM.



240 FT. ABOVE BOSTON CITY BASE
PROFILE

36" GATE VALVE WITH 6" BY-PASS INSTALLED NOV 1995
20" BUTTERFLY VALVES, 8" BLOW OFF RETROFIT AND RESERVOIR DISCONNECT INSTALLED NOVEMBER 2001
GATE HOUSE AT WABAN HILL RESERVOIR - WARD STREET NEWTON

10' 0 10' 20' 30' 40'

JAN 1901
CORRECTED FEB 1913

DRAFTED MARCH 13, 2006

From Chestnut Hill Res. Sta. 79+18 A.V.

Detail Record 23-9

1/27/2007 checked Maximo & GIS