Feasibility Study
Mamaroneck Reservoir Dam
NYSDEC ID #233-0866
Village of Mamaroneck, NY

September 2015

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1. Introduction

Available records indicate that the Mamaroneck Reservoir Dam, as it was called, was constructed around 1900. The original dam was constructed of earth, rock, and timbers for the purpose of water supply. The dam was replaced by a concrete structure around 1930. Additional ancillary facilities were constructed at that time, which consisted of a pump house, an intake structure, and a filter house. By the mid-1970s, the water supply facilities were abandoned or converted to other uses, and the dam was left in place to control runoff. The dam is classified as C-High Hazard due to the number of homes located downstream of the dam.

The Westchester Joint Water Works (WJWW) owns the Mamaroneck Reservoir Dam, and the Village of Mamaroneck is under contract to maintain the dam. Based on available information, the reservoir appears to operate as a flow control structure during spring thaw or heavy rainfall events. The runoff produced by the larger, less-frequent rainfall events discharges over the top of the dam, thus providing no further flood control. The dam structure is about 150 feet long and 15 to 17 feet high, with 2-foot high wooden flashboards. The overflow section of the dam is a 130-foot long hollow concrete shell with reinforced concrete buttresses, referred to as an Ambursen dam. There is an embankment portion of the dam that is earthfill with concrete core wall on the south side of the dam. A low flow outlet is located upstream of the dam and is reportedly inoperable. The earthen embankment section is about 55 feet long and 15 feet high (elevation 44 msl). According to previous reports, the embankment contains a concrete core wall at its downstream crest edge, and the crest is covered with a 7-foot wide concrete slab. The gatehouse located within the earthen embankment was originally used to regulate flow to the downstream water treatment facilities. Neither the regulating facilities nor the treatment facilities are operated, since the reservoir is no longer used for water supply.

In the late 1970s, two conduits were installed through the dam to maintain a lower, normal pool elevation in the reservoir. This was done to dampen the effects of small storm events. In past visual inspections performed by New York State Department of Environmental Conservation (NYSDEC) personnel, the following conditions were noted: (1) the conduits were partly clogged; (2) the low level outlet drain was reportedly open and flowing and inoperable; (3) the concrete of the dam showed some surficial spalling and cracking; and (4) the filter house was deteriorating and was covered with woody vegetation.

A recent routine inspection conducted by NYSDEC on March 30, 2015, resulted in the Department issuing a Notice of Violation (NOV) to both the Village of Mamaroneck and Westchester Joint Water Works (Table 1 in Section 3). As a result of the NOV, a decision as to whether the dam should be remediated or decommissioned is now required.

1.1 Purpose of Report

The purpose of this Feasibility Report is to evaluate and present the existing condition of the dam, describe the aspects of the two options for resolving the current violations (remediation or decommissioning of the dam), and to develop an opinion of the probable costs for each option.

1.2 Assumptions and Previous Reports

A request to NYSDEC for the reclassification of the Mamaroneck Reservoir Dam from a Class C dam to a Class B dam is planned based on preliminary information from previous reports and

evaluations performed for this dam. If the option to decommission the dam is proposed, the effort to change the classification will not be necessary. This report has been developed assuming that the dam will be reclassified to a Class B dam after the submittal of appropriate documentation. A full evaluation of the downstream flood control requirements will not be performed; therefore, assumptions will be made for the known areas of concern.

The following reports have been available for our evaluation:

1. Long Island Basin, Mamaroneck Reservoir Dam, Westchester County, NY, Inventory No. N.Y. 111, Phase I Inspection Report National Dam Safety Program, July 1981 by New York District Corps of Engineers.
2. Report to Department of Planning, County of Westchester, NY, Mamaroneck and Sheldrake River Basin Flood Management Study, Part A, Feasibility of Using Westchester Joint Water Works Reservoir for Mamaroneck River Flood Control, August 1977, by Hazen and Sawyer.
3. Final Environmental Statement for Flood Control Project at Mamaroneck and Sheldrake Rivers Basin and the Byram River Basin, for the Town and Village of Mamaroneck, NY, by U.S. Army Engineer District, New York.
4. Flood Insurance Study, Village of Mamaroneck, NY Westchester County June 1977, by U.S. Department of Housing & Urban Development Federal Insurance Administration.
5. Westchester County, New York State, Department of Public Works, Division of Engineering, Office of the Commissioner of Public Works, Information for Bidders, General and Special Clauses, Specifications and Proposal for Modifications of Westchester Joint Water Works Dam, Village of Mamaroneck, NY, January 1978.
6. Recommendation Report for Westchester Joint Waterworks Reservoir Dam and Village of Mamaroneck, Stearns & Wheler (now GHD), January 2005
7. Emergency Action Plan for Westchester Joint Waterworks Reservoir Dam and Village of Mamaroneck, Stearns & Wheler (now GHD), January 2005
8. Maintenance Plan for Westchester Joint Waterworks Reservoir Dam and Village of Mamaroneck, Stearns & Wheler (now GHD), January 2005
9. Emergency Action Plan for the Mamaroneck Reservoir Dam NYSDEC I.D. #233-0866 Village of Mamaroneck, NY, Stearns & Wheler (now GHD), June 2010.

2. Dam Data

Dam Name	Mamaroneck Reservoir Dam
Dam Hazard Classification	C – High Hazard
Dam State Identification No.	NYSDEC ID #233-0866 (Federal NID NY111)
Location of Dam Inspection and Maintenance Plan	Village of Mamaroneck Department of Public Works Village of Mamaroneck Manager
Dam Type	Run of River Ambursen concrete dam and earthen embankment with concrete core wall
Dam Location	County: Westchester City: Mamaroneck Latitude: 40° 58' 5.46"N Longitude: 73° 44' 19.63"W
Quad Sheet	Mamaroneck
Nearest City/Town	Village of Mamaroneck
Dam Use(s) and Normal Operation	Run of River dam where water level is maintained by the uncontrolled conduits and spillway crest. The impoundment created by the dam is used for non-contact recreation.
Stream Name and Classification	Mamaroneck River – Stream Class C
Associated Wetlands or Other Natural Resources of Special Concern	No known wetlands or other resources of special concern. None are shown on the NYSDEC Environmental Resource Mapper.
Dam Height	19 feet concrete buttress (Ambursen) and 15 feet embankment
Dam Crest Length	130 feet concrete section and 55 feet earthen embankment with concrete core wall
Spillway Width	Two conduits, concrete box culverts through center of concrete dam: 3 feet high by 6 feet wide until flow reaches top of flashboards and goes over 130-foot overflow section of concrete dam (Ambursen dam)
Spillway Capacity	Two conduits, concrete box culverts through center of concrete dam: 3 feet high by 6 feet wide until flow reaches top of flashboards and goes over 130-foot overflow section of concrete dam (Ambursen dam) Conduits (culverts): 560 cfs Ambursen Dam: 4,240 cfs (discharge over the overflow section with water surface at 44.0 feet (MSL)
Normal Pool Impoundment Volume	107 ac-ft, (33.5 acres at elevation 33, flow through conduits)

Maximum Impoundment Volume	320 ac-ft
Drainage Area	15.24 square miles
Normal Pool Elevation	At conduit invert elevation: 33 feet
Flashboards	2.5 feet high; consist of wooden planks supported by vertical metal posts. Elevation at top of flashboards: 42.5 feet
Outlet	Reportedly, 24-inch steel or cast iron pipe regulated by a 24-inch gate valve serves as a reservoir drain and is located in the buttress dam
Instrumentation	None

3. Existing Condition of Dam

According to NYSDEC's NOV, the Mamaroneck Reservoir Dam has been assigned a condition rating of "unsound-fair." The Notice of Violation letter details the dam as being "generally neglected" and shows a lack of maintenance and inspection. NYSDEC also reports the dam to have general concrete deterioration and a spillway capacity that is inadequate to pass the spillway design flood as required by dam safety guidelines. The NYSDEC has indicated that the violation includes four requirements of Part 673 of their Chapter X Division of Water Regulations. The violations are listed in order of section in Table 1 below.

Table 1 List of Violations

Citation	Requirement	Status as of March 30, 2015	Status as of July 31, 2015
673.6	Develop and implement an Inspection & Maintenance Plan	Plan not implemented	June 2015 Plan implemented and sent to NYSDEC.
673.7	Develop and distribute Emergency Action Plan (EAP).	EAP not distributed/ reviewed with responders and not annually reviewed	Updated EAP distributed June 12, 2015. An orientation meeting was held in 2010.
673.8	Submit Annual Certification	None submitted since March 2013	Submitted June 2015.
673.13	Complete and submit Engineering Assessment (EA)	Not submitted	This Feasibility Report is a precursor to determine if the engineering assessment is necessary.

3.1 Structural Stability

The structural stability of the existing dam structure was completed for the Phase I Inspection Report completed in July 1981. TAMS Engineers and Architects completed the stability analyses for four loading conditions in accordance with recommended Corps of Engineers guidelines. The four conditions were:

- Case I normal loading with lake level at El 42.5 and full uplift
- Case II normal loading with lake level at El 40, k/ft ice load at 0.5 feet below the crest of the dam and full uplift
- Case III unusual loading (1/2 PMF) with lake level at El 50.91, tailwater at 12.5 feet, and no flashboards
- Case IV extreme loading (PMF) with lake level at El 58.35, tailwater at 15 feet, and no flashboards

The 1981 results indicated “that the stability of the section analyzed is adequate in overturning for all the loading conditions considered and inadequate in sliding under the half (1/2) PMF and PMF events.” Visual observations during the 1981 Phase I inspection reportedly did not indicate conditions that would adversely affect the structural stability of the dam.

Visual observations made during a GHD (formerly Stearns & Wheler) site visit (October 7, 2004) were similar to the observations noted in the Phase I Inspection Report. The overall condition of the embankment of the dam appears good, but has changed. The concrete apron at the embankment crest is further deteriorated and covered in vegetation. The area directly surrounding the gatehouse (filter house) has been backfilled to continue the upstream slope to the dam. The earthen embankment is now covered with vegetation and trees.

Photographs were taken of the Mamaroneck Reservoir Dam by the NYSDEC during the March 30, 2015 inspection. Visual observations of these photos are similar to the observations noted in the Phase I Inspection Report and the GHD (formerly Stearns & Wheler) site visit. The condition of the embankment has continued to change. Vegetation on and near the dam continues to grow, and moss on the dam is spreading. Figures 1 and 2 show evidence of moss growth. At the time of the 2004 site visit (Figure 1), moss was growing only on most of the downstream side of the dam, compared to the 2015 DEC inspection picture (Figure 2) that shows moss growing on all of the downstream side and parts of the upstream side. It is also clear from these photos that trees have not been removed and continue to grow. Evidence of structural change from the 2004 and 2015 site visits is not apparent.

Figure 1 Photo of moss on crest in 2004

Figure 1 Photo of moss on crest in 2015
(Taken from NYSDEC letter dated 3/30/2015)

As presented in the 2005 Recommendation Report by GHD (formerly Stearns & Wheler), the visual observations made during the 2015 inspection did not indicate visual problems that would adversely affect the adequacy of the dam at the present time.

The NYSDEC Guidelines for Design of Dams requirements for a structural stability analysis include a seismic loading condition. Typically, the structural analysis is completed for modifications and rehabilitation of the dam. When the analysis was completed in 1981 by the Army Corp of Engineers, a seismic analysis was not required. Therefore, the stability analysis for the seismic loading condition should be completed for the dam.

3.2 Hydraulic Analysis

Information pertaining to a hydraulic analysis has been derived from the 2004 recommendation report by GHD (formerly Stearns & Wheler). A hydraulic modeling program (HydroCad Stormwater

Modeling System) was used to create a hydraulic model of potential heavy storm events in the Mamaroneck area. The model enabled the comparison of estimated flow data and water elevations for specific points within the drainage basin for two scenarios – with and without the dam in place.

Table 2 Summary of HydroCad Results – Confluence of Mamaroneck and Sheldrake Rivers

Rainfall Event*	Rainfall (inches)	With Dam		Without Dam		Percent Increase in Flow Without Dam	Increase in Depth of Water (feet)
		Peak Flow Rate (cfs)	Time (hours)	Peak Flow Rate (cfs)	Time (hours)		
1-yr, 24-hr	3	807	22.60	1,110	21.87	38%	0.43
2-yr, 24-hr	3.5	1,439	22.96	1,525	21.36	6%	0.1
5-yr, 24-hr	4.5	2,430	21.65	2,450	21.29	>1%	0.01
10-yr, 24-hr	5	2,925	21.45	2,946	21.74	>1%	0
25-yr, 24-hr	6	3,952	21.90	3,985	21.62	>1%	0
50-yr, 24-hr	7	5,030	21.78	5,078	21.50	>1%	0
100-yr, 24-hr	8	6,140	21.70	6,207	21.38	>1%	0.01

*Rainfall data obtained from U.S. National Weather Service Technical Paper No. 40, Rainfall Frequency Atlas of the Eastern United States

For example, from Table 2, a 5-year, 24-hour storm deposits 4.5 inches of rain over the watershed which generates a volume flow rate of approximately 2,400 cubic feet per second (cfs) at the confluence of Mamaroneck and Sheldrake Rivers. When using this data to compare the peak depth of the water at this location, the increase in depth of the water is less than 1/2 foot for a 1-year event, 1/10 foot for a 2-year event, and no discernible change for greater events.

Based on available information (without the cross-sectional information) and the 2005 Recommendation Report, the percent increase in flow at the confluence of the Mamaroneck and Sheldrake Rivers is minimal for storm events beyond a 2-year, 24-hour rainfall. However, the model from the 2005 Recommendation Report indicates that the removal of the dam will result in increased flows for both the 1-year, 24-hour storm (38 percent increase) and the 2-year, 24-hour storm (6 percent increase). The magnitude and impact of this increase in flow on the flooding of downstream facilities can only be determined with more detailed cross-sectional information.

There was an approximate 10-year, 24-hour event in September 2004 with a rainfall of 5.25 inches. There was flooding within Columbus Park, and surrounding homes required evacuation. Based on our analysis, this flooding would have occurred whether or not the dam was in place.

We recommend that a surveyor be procured to survey cross sections along the river at specific "trouble spots." These trouble spots should be selected based on conversations with local residents, business owners, and historical data. This information could be used to approximate the level of flooding for the 1- to 2-year storm events with the dam being decommissioned. In addition, the cross-sectional data would be used to make recommendations for modifications necessary to minimize flooding in the trouble spots for the 1- to 2-year storm events. These recommendations could support decommissioning of the dam and making modifications to minimize flooding to those areas that flood, such as the Columbus Park area.

4. Potential Options

Based on the information reviewed and the results of the GHD (Stearns & Wheler) hydraulic analysis, it can be concluded that the Mamaroneck Reservoir Dam provides limited flood control for the downstream areas up to a 3-year, 24-hour rainfall event (4 inches). There is insufficient data available to determine what effect the removal of the dam would have on flood-prone areas for the lesser storm events and on the upstream portion of the reservoir. If the dam was removed, further study would be required to determine the amount of necessary stream restoration. The stream erosion control or armouring features necessary for the downstream portion of the Mamaroneck River would need to be determined.

There have been previous recommendations for flood control along the Mamaroneck and Sheldrake Rivers. Alon Dominitz of the NYSDEC Dam Safety Unit stated that decommissioning of the dam would be completed through the permit process and may be similar to a stream restoration project if the complete dam was to be removed. Another option would be to create a breached dam that could then be classified as a low hazard dam. These potential options could be reviewed further as part of the approach for the decommissioning of the dam.

In addition, structural and hydraulic analyses completed in 1981 identified inadequate spillway capacity and potential sliding concerns for the dam at the higher loading conditions (1/2 PMF). The remedial activities for these conditions should be analyzed to determine the need for further action and potential costs. The NYSDEC Dam Safety Unit will approve dams where it can be resolved that there are limited remedial actions that will provide adequate safety at the higher loading conditions.

Two options are outlined below: (1) maintaining the dam structure; and (2) decommissioning the dam. For both options, there are recommended further analyses and remediation efforts. We recommend further analysis of the river downstream of the dam to determine what effect the removal of the dam would have on specific flood prone areas.

4.1 Option 1: Remediating the Dam

The option of remediation and maintaining the Mamaroneck Dam would include the following:

- Reclassification of the dam to a Class B or A
- First Engineering Assessment and Safety Inspection
- Seismic analysis
- Dam rehabilitation design and permitting
- Dam rehabilitation construction
- Ongoing maintenance

Some of the activities that are required for the ongoing maintenance would include:

- Follow Inspection & Maintenance Plan
- Safety inspections by a professional engineer (every 4 years for hazard Class B)
- Engineering Assessments by a professional engineer (every 10 years)
- Annual certification form
- Annual Emergency Action Plan training/recordkeeping

4.2 Option 2: Decommissioning the Dam

For the option of decommissioning the dam, a more detailed survey and analysis of the cross sections at specific downstream flooding areas should be completed. The analysis of the downstream sections of the river will determine what modifications will be necessary to minimize the impacts of the lesser storm events. The larger storm events would not be influenced by a dam breach. This analysis should include the identification of potential problem areas, detailed surveyed cross sections of the potential problem areas, a hydraulic analysis to determine what hydraulic elevation is to be utilized for the recommended improvements, and a cost analysis identifying all costs associated with the decommissioning.

To decommission the dam, permits from NYSDEC Dam Safety, ACOE, NYSDEC Environmental Assessment Process, Federal Environmental Assessment Process, and local regulatory agencies will be necessary.

Construction activities for the removal of the dam will include demolition of the existing dam and associated structures, channel modifications above the dam, removal of sediment from the existing reservoir, restoration/armouring of the surrounding area, flood control measures may be required downstream from the dam and erosion control measures. Plans and specifications, including drawings and contract documents, will be required in order to complete these activities.

5. Opinion of Probable Cost

An opinion of probable cost for these options is provided based on order of magnitude project costs. Preparation of an opinion of probable cost estimate at this point in the project requires making a number of assumptions as to the actual conditions that will be encountered onsite, the actual construction methods that will be necessary to perform the recommended activities, and other factors over which we currently have no control. The opinions of probable costs presented in Tables 3 and 4 are values that correspond to the major components outlined under Options 1 and 2. A more accurate opinion of probable cost can be determined after the analyses have been completed for each option.

5.1 Option 1: Remediating the Dam

For the option of maintaining the dam, the necessary remediation will be dependent on the conditions under which the dam will slide, overturn, or erode to failure. The dam could remain as is without meeting guidelines if NYSDEC Dam Safety personnel agree with the recommendations from the hydraulic evaluation and the sliding and overturning evaluation. Since the remediation requirements are not known at this time, an allowance has been established for each remediation task. The allowances are based on the possibility of placing rock anchors for remediation of dam sliding, adding mass concrete for remediation of dam sliding, further increasing the spillway depth by creating larger conduits, or another method of modifying the dam for greater spillway capacity. The allowances are meant to be order-of-magnitude costs.

Table 3 Opinion of Probable Cost for Option 1 (Remediation)

Description	Allowances
Mobilization and Demobilization, General Conditions	$200,000 to $300,000
Remediation for Dam Sliding	$200,000 to $300,000
Removal/Secure Gatehouse	$150,000 to $250,000
Remediation of Spillway	$500,000 to $800,000
Tree Removal	$30,000 to $50,000
Remediation of Trash Rack	$30,000 to $50,000
Flashboard Maintenance	$30,000 to $50,000
Subtotal	$1,140,000 to $1,800,000
Contingency	$500,000
TOTAL PROBABLE CONSTRUCTION COST	**$1,640,000 to $2,300,000**
Fiscal, Legal, Administration, & Engineering	$300,000 to $500,000
TOTAL PROBABLE PROJECT COST	**$1,940,000 to $2,800,000**

5.2 Option 2: Decommissioning the Dam

For the option of decommissioning the dam, the effort required for the permitting and environmental impact assessment will be dependent on the local and public participation necessary to obtain or secure approval to decommission the dam. The effort required for the dam removal plans and specifications, downstream flood control construction, and dam removal construction would be dependent on the recommendations resulting from the downstream section analysis. In addition, downstream flood controls necessary for the dam decommissioning will be dependent on public input as to flooding concerns. Dam removal construction costs will be dependent on the number of stream restoration measures necessary for the reservoir and immediate downstream reach of the Mamaroneck River. The allowances provided for decommissioning the dam are meant to be order-of-magnitude costs.

Table 4 Opinion of Probable Cost for Option 2 (Decommissioning)

Description	Allowances
Mobilization and Demobilization, General Conditions	$200,000 to $400,000
Survey of River Channel	$40,000 to $50,000
Tree Removal	$30,000 to $50,000
Demolition of Concrete Dam and Appurtenances	$200,000 to $500,000
Channel Modification(s) Upstream and Downstream	$300,000 to $800,000
Sediment Removal	$30,000 to $50,000
Subtotal	$800,000 to $1,850,000
Contingency	$500,000
TOTAL PROBABLE CONSTRUCTION COST	**$1,300,000 to $2,350,000**
Fiscal, Legal, Administration, & Engineering	$300,000 to $500,000
TOTAL PROBABLE PROJECT COST	**$1,600,000 to $2,850,000**

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