Irrigation Supply/Demand Analysis

for

Maple Moor Golf Course
1128 North Street
White Plains, New York

Prepared For:

Westchester County Department of Public Works and Transportation
Michaelian Office Building
148 Martine Avenue
White Plains, NY 10601

Prepared By:

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March 2018

LANGAN

Project No.:190022601

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1 Executive Summary

This report provides a cost benefit analysis for the construction of one or more bedrock wells as an alternative source of water for irrigation use (only) to reduce the reliance upon City water. The test well installed on the Maple Moor site produced a safe yield of 15 gallons per minute which equates to approximately 22% of the required irrigation demand for the golf course. To further offset the reliance on City Water, additional wells could be installed. This report provides a cost benefit analysis comparing the cost of installing additional wells versus the cost of relying on City water.

2 Site Description

Maple Moor Golf Course is an 18-hole course owned and operated by the Westchester County Department of Parks, Recreation and Conservation. Maple Moor is a 6,374-yard, Par 71 course situated on 140-acres in White Plains.

The course is north of New York State Route 127, west of the Hutchison River Parkway (Hutch) south bound lanes and south of the Westchester Avenue on-ramp to the Hutch. The Mamaroneck River flows through the northern portion and along the east edge of the property.

3 Existing Water Supply

The golf course utilizes municipal water at the club house, halfway house and for irrigation purposes. There is a ±2,200-feet 6-inch ductile iron water main installed in 2003 that tapped the existing City of White Plains main located within North Street. The ±2,200-feet water main extends from behind the 18^{th} green to the stone pump house along the 8^{th} fairway, where the pressures in the main are recorded to be approximately 100 psi. Prior to the installation of the water main, the course utilized water drawn from the Mamaroneck River that was pumped from the pump house to the irrigation system. This system was abandoned because the intake line from the river was constantly silted and the water quality was unacceptable. The golf course's only water source is currently City water.

4 Sources of Water for Irrigation

The alternative sources of water that could be used to irrigate this course include the following:

A. Bedrock Well(s);
B. Shallow Groundwater Wells;
C. Site Stormwater Collection & Re-Use;
D. City Water.

The County reported that the Mamaroneck River is not a suitable source of water due to excessive sediment, salt content, highway stormwater runoff and the potential for upstream accidental spill sources. Water quality samples were taken by Langan at the Mamaroneck River, which showed high salt content. Based on past problems with using the Mamaroneck

River as a source of water and the poor water quality, it was concluded that the river is not a viable source of irrigation water.

Water quality samples were also taken from the various other sources of surface water and based on these water quality results, we believe the site stormwater and well water can be used for irrigation purposes and will reduce the need to purchase all irrigation water from the City. Please note that depending on the final water quality of the blended water from the well, stormwater runoff and City supply, it may be necessary to modify or amend the water to maximize turf quality. We recommend that regular testing of the final irrigation sources be conducted and turf management activities adjusted accordingly.

4.1 Bedrock Well

A 6-inch diameter open borehole test well (bedrock well) was installed on November 3, 2016 by William Stothoff Company at the northeast corner of the parking lot at Maple Moor Golf Course. The bedrock well was drilled to a depth of 350-feet. The upper 20-feet of the bedrock well was lined with a steel casing. The bedrock well was installed to intercept a mapped potential water-bearing fracture based on Langan's evaluation of the bedrock fracture from stereographical aerial photos. Figure 1 depicts the approximate location of the bedrock well. According to the driller's logs, bedrock fractures were encountered at 50- and 177-feet below the adjacent existing grade. Drilling and well installation were completed and the water well completion report, filed with New York State Department of Environmental Conservation, is provided in Appendix A.

4.1.1 Aquifer Pumping Test

A 24-hour, combined step-drawdown / constant rate aquifer pumping test was performed to establish a viable and safe yield for the bedrock well. Stothoff performed the pumping test under the direction of Langan. Water levels were recorded every 1 minute using an In-Situ™ data logger (i.e., mini-troll) with a pressure transducer rated at 100 pounds per square inch (psi). A hydrograph representing data collected 24 hours prior to, for the duration of the pumping tests, and for recovery period is provided in Appendix B. Water-level data were downloaded from the data loggers using a mobile Rugged Reader equipped with WinSitu software (In-Situ™), formatted, and plotted electronically using Microsoft Excel. There was no precipitation during the pumping test that may have influenced the results.

4.1.2 Background Monitoring

Prior to implementing the pumping test, background conditions were monitored in the bedrock well from 16 November 2016 to 17 November 2016. Aquifer conditions appear to have remained consistent over the course of the background period. Water levels fluctuated approximately 0.35 feet.

4.1.3 Step-Drawdown/Constant Rate Aquifer Pumping Test

The step-drawdown test began at 7:15 AM on 17 November 2016 and ended at 7:15 AM on 18 November 2016. Approximately 23,342 gallons of water was pumped from the bedrock well during the test. The average flow rate, as derived from the 1-inch Sensus iPerl meter, was 16 gpm. The static water level in the pumping well, relative to the measuring point datum at the well head, was approximately 50 feet immediately prior to the pumping test and 240 feet at the completion of the pumping test immediately prior to stopping the pump.

The bedrock well was pumped at flow rates of 5, 10, 15, and 20 gpm, each for a 100-minute interval, to determine the safe rate (yield) that the bedrock well could be pumped at a constant and continuous basis for the remainder of the 24-hour test. Each flow rate remained consistent for the duration of the 100-minute interval (step), confirmed by manual field calculations by the driller using a stopwatch and totalizing flow meter on the discharge pipe. A final step of 22 gpm was tested briefly (8 minutes) and reduced to allow for sufficient head over the pump. A consistent discharge rate of 18.5 gpm was selected for the remainder of the test. The purpose of the constant rate portion of the test was to monitor imposed pumping stress to the formation, as a function of water-level drawdown, during a constant withdrawal for a period of approximately 16 hours. Appendix C presents logarithmic graphs of elapsed time in minutes vs. adjusted drawdown at the bedrock well.

4.1.4 Recovery Period

Upon completion of pumping, water levels in the well recover to pre-pumping or static conditions. The time in which water-levels equilibrate to static conditions after the pumping ceases is called the "recovery period". The data logger was set to record measurements during the recovery period. The data logger was removed from the bedrock well on 18 November 2016 when 99% recovery had been achieved. Appendix C presents summarized recovery measurements and logarithmic graphs of elapsed time in minutes vs. recovery for the bedrock well.

4.1.5 Data Interpretation

The data collected at the various flow rates was manually extrapolated over 6-months as shown on the graph provided in Appendix C. The step-drawdown water level data reveal that the bedrock well is capable of achieving a 15 to 17 gpm long term safe yield. Safe yield of the well is derived by projecting water level drawdown[1] over a period of six months given the long-term available drawdown[2] of the well. The safe yield of 15 to 17 gpm is the flow rate at which the six month projected drawdown is less than the available drawdown.

4.2 Shallow Groundwater Well

Two 2-inch diameter pvc test wells were installed on October 23, 2015 by Summit Well Drillers at Golf Hole Number 9, along the Mamaroneck River banks. The test wells were drilled to a

---

[1] Drawdown is the measured difference in water-level in a well between static or non-pumping conditions versus dynamic or pumping conditions.

[2] The available drawdown of the bedrock well is 200 feet, derived as follows. The well depth is 350 feet and the depth to water is 50 feet. Therefore the saturated water column in the bedrock well is 350 feet – 50 feet = 300 feet. As a general industry practice rule-of-thumb, only 2/3 of the water column in the well should be drawdown, thereby giving the well an adequate measure of safety. 300 feet x 2/3 = 200 feet.

depth of 20-feet and 33-feet. The test wells were installed to intercept acceptable water quality levels of the Mamaroneck River. Figure 2 depicts the location of the shallow groundwater well. According to the boring logs, water was encounter 6- and 6.5-feet below grade. The test well boring logs are provided in the tables below:

Table 1: Test Well Log

Test Well #1

Depth (ft)	Description
0 to 0.5	Topsoil
0.5 to 2	Moist, dark brown silt, trace clay, trace sand
2 to 4	Moist, strong brown silty clay, trace medium sand
4 to 6.5	Moist, light brown, fine sandy clay
6.5	Groundwater
6.5 to 8.5	Wet, brown clay, trace fine sand
8.5 to 14	Wet, light brown clayey sand with fines and cobbles
14 to 14.5	Wet, brown sandy clay with fines and cobbles
14.5 to 17	Wet, tan-brown sand and gravel with fines and cobbles
17 to 18.5	Wet, red, pink, black, and white grains of medium to coarse sand and fine gravel
18.5 to 20	Same as above, but increasing silt content with depth
20	Refusal

Test Well #2

Depth (ft)	Description
0 to 0.5	Topsoil
0.5 to 1.5	Dry to moist, dark brown silt, trace clay, trace coarse sand
1.5 to 2	Same as above, but lighter grayish brown and tan.
2 to 2.5	Moist, light yellowish brown with light gray clayey silt
2.5 to 3	Moist to wet, light gray fine to medium sand
3 to 5.5	Same as above with dark brown to black fine to medium sandy silt
5.5 to 6	Wet, yellowish brown, white gravel fine sand, trace of fine gravel
6	Groundwater
6 to 10	Wet, grayish tan silty clay
10 to 13	Wet, yellowish tan clayey silt
13 to 23.5	Wet, medium brown with black, reddish, and white grains of fine sand with fine gravel
23.5 to 25	Wet, light grayish brown silty fine sand
25 to 26.5	Wet, light grayish with baclk very fine to fine sand
26.5 to 27	Wet, black, gray, tan and red coarse sand and fine gravel
27'to 30	Wet, light grayish with black very fine to fine sand
30 to 31	Wet, medium brownish tan fine to medium sand
31 to 33	Wet, grayish brown fine sand with trace silt
33	Refusal

The pump test for each well was for a period of 2-hours. The estimated flow rate is 5 gallons per minute for each well.

4.2.1 Data Interpretation

Based on the low yield of these test wells, less than 5 gpm it was concluded that shallow wells would not produce a significant source of water.

4.3 Site Stormwater Collection and Re-Use

Stormwater runoff from the proposed project will be collected and conveyed to the proposed irrigation ponds. Stormwater runoff will be stored within the ponds to provide irrigation for the golf course, reducing the reliance on City water.

Although stormwater runoff occurs when the irrigation demand is lowest, the irrigation ponds have been sized to store stormwater runoff for use when irritation demands increase.

The irrigation ponds are proposed to be drawn down a maximum of 2-feet to irrigate the golf course under normal conditions. The storage volume provided within the 2-foot draw down from the permanent pool elevation is provided in the table below:

Table 2: Irrigation Pond Drawdown Volume

Irrigation Pond	Volume Provided (cubic-feet)	Volume Provided (gallons)
A	74,500	557,260
B	16,000	119,680
Total	**90,500**	**676,940**

The anticipated proposed average water demand for the golf course is approximately 98,000 gallons per day. Therefore the irrigation ponds will have approximately 6.9 days of storage based on the estimated water demand of 98,000 gallons per day.

676,940 gallons / 98,000 gallons per day = 6.9 days of storage.

Under extreme conditions, additional volume can be withdrawn from the ponds; however, this will lower the water level in the ponds and could create an unwanted esthetic condition. The overall available storage volume in the two irrigation ponds is approximately 2,500,000 gallons or 25 days of storage based on the projected average daily demand.

4.4 City Water Supply

Because the available source of water do not satisfy the overall irrigation demand for the course maintaining the municipal water connection is necessary, even if the County decides to install additional deep bedrock wells to further offset the reliance on City water. The existing 6-inch ductile iron service line will be extended from the existing pump house to the proposed pump house location on the west side of Golf Hole No. 8. The municipal water supply line will be controlled by a mechanical valve within the pump house. Should the water level in the irrigation ponds drop to a lower elevation than the intended design, the mechanical valve will open and allow municipal water to fill the pond back to the intended water level.

5 Existing Irrigation Water Demand

The existing water use for the golf course has been estimated based on the City of White Plains Water Bills for the billing period from December 28, 2011 through March 25, 2015 as summarized in the Schematic Design Report dated September 4, 2015. The City utilizes a progressive water structure which means that the unit rate escalates with increased usage. In 2014, water customers were charged a starting rate of $1.73 per 100-cubic-feet of water (1-cubic-foot = 7.48-gallons of water, therefore 100-cubic-feet is 748-gallons). The average irrigation use from December 28, 2011 through March 25, 2015 was 9.41 million gallons per year. The estimated cost for using City of White Plains water is shown below:

- 9,410,000 gallons per year / 7.48 gallons per cubic foot = 1,258,021 cubic foot.
- 1,258,021 cubic foot * $1.73 per 100 cubic feet of water = **$21,764** cost per year.

6 Proposed Irrigation Water Demand

In order to evaluate the average daily and peak irrigation demands, we estimated that approximately 60-acres of turf will be irrigated based on the proposed design. The average daily demand according to the City of White Plains water bills and based on evapotranspiration and turf area is approximately 98,000-gallons-per-day with a peak demand expected to be 200,000- to 250,000-gallons-per-day which only occurs periodically during drought conditions or grow in periods.

The anticipated proposed average demand between April and December (9 months out of the year) is:

- 98,000 gallons per day * ±275 days per year = 26,950,000 gallons per year.
- 26,950,000 gallons per year / 7.48 gallons per cubic foot = 3,602,941 cubic foot.
- 3,602,941 cubic foot * $1.73 per 100 cubic feet of water = **$62,331** cost per year.

7 Cost Benefit Analysis

As indicated in this report, the three viable sources of water that can be effectively and efficiently used to satisfy the irrigation demand for the golf course are deep bedrock wells, stormwater runoff and the City supply. The cost benefit of utilizing each of these sources is detailed below.

7.1 Stormwater Runoff

One of the project goals was to upgrade and improve the overall stormwater management system and drainage collection system as part of the golf course improvements. The costs of these improvements are included in the overall project budget. Therefore from a cost benefit analysis relative to providing a source of water for irrigation, the use of stormwater is a cost benefit regardless of the volume of stormwater that can be efficiently collected and stored.

7.2 Deep Bedrock Wells

Based on the yield of the bedrock well installed as part of this task, the irrigation demand for the golf course can be partially met by using onsite wells. The test well produced a safe yield of 15 gpm which equates to approximately 22% of the average daily irrigation demand. This daily yield of approximately 21,600 gallons offsets a cost of equivalent volume from the City supply. That cost equates to a savings of approximately $50.00/day (21,600 gpm/7.48/100x$1.73) or $13,738/year ($50 x 275 watering days). If the cost of installing the initial deep bedrock well is approximately $60,000, then the well will pay for its self in approximately 4.4 years. The cost of this initial well is included in the projection of probable cost of this project and will result in an immediate reduction in the cost of purchasing water from the City to irrigate the course of approximately $13,738.

Based on the fracture trace analysis performed as part of this study, there is a fracture that traverses the golf course, refer to Figure 1. If additional wells were installed along this fracture and if the wells produced similar safe yields, it would require 4 additional wells (in addition to the test well) to satisfy the average daily irrigation demand of the course. Assuming each well would cost approximately $100,000 to install and connect to the system, it would cost an additional $400,000 to install the additional wells necessary to meet the total average daily irrigation demand. The total cost of the wells would be $460,000 and the savings per year would be approximately $62,331, therefore it would take approximately 7.4 years to offset the cost of the wells.

The cost benefit of using onsite deep bedrock wells that yield approximately 15 gpm is summarized as following; the capital improvement cost to install a well is approximately $100,000 and the annual savings from reducing the amount of water purchased from the City is approximately $13,738 per well per year. Therefore each well pays or it's self over a 7.4 year time period, after which the saving to the County is $13,738 per well per year per well, excluding routine well maintenance, repair and replacement of well part.

It is likely that the current budget for this project could not support the installation of these additional 4 wells. However, the County could establish a reserve account using the savings from the initial well to pay for additional wells that could be installed at a later date without significantly disrupting the course.

8 Conclusion

Based on the testing performed as part of this task, we recommend deep bedrock wells, stormwater runoff and to the least extent possible City water be used to meet the irrigation demand for the Maple Moor golf course. It is our opinion that the shallow groundwater wells are not a reliable source of water to be used for irrigation. The shallow wells will likely induce infiltration from the river, which may mimic the river's poor water quality and not be suitable to irrigate the golf course.

The site stormwater collection and re-use system will convey stormwater runoff to the irrigation ponds during wet weather conditions. Stormwater runoff will be stored in the irrigation ponds and available for use during non-wet weather conditions. Because we cannot rely on stormwater runoff, we have not factored it into our calculations; we do believe it will contribute to reducing the amount of City water that must be purchased to irrigate the course.

When the irrigation ponds draw down 2', a float sensor will be triggered and the bedrock well pump will start to fill the irrigation pond. In the event that the bedrock well cannot match the demand and the irrigation pond level falls below 2', a float sensor will open the mechanical valve to the city water supply. This sequence allows us to utilize stormwater runoff first, well water second and City water; only when the demand for irrigation water exceeds both of these first to sources of water.

In summary, the use of stormwater runoff and bedrock wells can greatly offset the reliance on City water to irrigate this golf course. The County will need to assess the cost of installing additional bedrock wells to reduce the reliance on City water.

Maple Moor Golf Course
1128 North Street
White Plains, New York

Figure 1

Rock Well Location

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Legend

- Rock Well
- Interpreted Fracture

250 0 250
SCALE IN FEET

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Langan Engineering & Environmental Services, Inc.
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan International LLC
Collectively known as Langan

NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project	Drawing Title	Project No.	Figure
MAPLE MOOR GOLF COURSE IMPROVEMENTS WHITE PLAINS WESTCHESTER COUNTY NEW YORK	ROCK WELL LOCATION	190022601	1
		Date: 11/29/2016	
		Scale: 1 " = 250 '	
		Drawn By: AOF	
		Last Revised: 11/29/2016	Sheet 1 of 1

Path: \\langan.com\data\WP\data6\190022601\ArcGIS\ArcMap_Documents\Rock Well Installation.mxd Date: 11/29/2016 User: aflaxman Time: 12:50:14 PM

Maple Moor Golf Course
1128 North Street
White Plains, New York

Figure 2

Shallow Groundwater Well Location

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Legend

- Proposed Temporary Well Point/Irrigation Wells
- Site Boundary
- Surface Water
- Principal Aquifer

250 0 250
SCALE IN FEET

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Langan Engineering & Environmental Services, Inc.
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan International LLC
Collectively known as Langan

NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project

MAPLE MOOR GOLF COURSE IMPROVEMENTS

WHITE PLAINS

WESTCHESTER COUNTY NEW YORK

Drawing Title

SHALLOW GROUNDWATER WELL LOCATIONS

Project No. 190022601	Figure 2
Date 8/3/2015	
Scale 1"=250'	
Drawn By AOF	
Last Revised 8/7/2015	Sheet 1 of 1

Path: \\langan.com\data\WP\data6\190022601\ArcGIS\ArcMap_Documents\Proposed Well Locations.mxd Date: 8/7/2015 User: aflaxman Time: 9:37:22 AM

Appendix A

New York State Department of Environmental Conservation Water Well Completion Report

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

(1) COUNTY Westchester

(2) TOWN White Plains

(3) DEC Well Number: WE 6839

WATER WELL COMPLETION REPORT

(4) OWNER: Westchester County Department of Public Works & Transportation

(5) ADDRESS: 148 Martine Avenue, Room 512 White Plains, NY 10605

(6) LOCATION OF WELL (See Instructions On Reverse) Show Lat/Long if available and method used: Off south east corner of parking lot
41.00.05/74.43.34
☐ GPS ☒ Map Interpolation

(7) DEPTH OF WELL BELOW LAND SURFACE (feet): 350

(8) DEPTH TO GROUNDWATER BELOW LAND SURFACE (feet): DATE MEASURED 11/17/16

CASINGS

(9) DIAMETER: 6" sch 40 steel in. | in. | in. | in.

(10) LENGTH: 20 ft. | ft. | ft. | in.

(11) GROUT TYPE / SEALING: Drilled & driven/bentonite

(12) GROUT / SEALING INTERVAL (feet) FROM 0 TO 17.5'

SCREENS

(13) MAKE & MATERIAL: Open bedrock borehole

(14) OPENINGS:

(15) DIAMETER: 6 in. | in. | in. | in.

(16) LENGTH: 17.5'-350' ft. | ft. | ft. | in.

(17) DEPTH TO TOP OF SCREEN, FROM TOP OF CASING (Feet): 17.5 feet

YIELD TEST

(18) DATE: 11/17/16-11/18/16

(19) DURATION OF TEST: 24

(20) LIFT METHOD: ☒ Pump ☐ Air Lift ☐ Bail

(21) STABILIZED DISCHARGE (GPM): 18.5 GPM

(22) STATIC LEVEL PRIOR TO TEST (feet/inches below top of casing): 52'0"

(23) MAXIMUM DRAWDOWN (Stabilized) (feet/inches below top of casing): 243'8"

(24) RECOVERY (Time in hours/minutes):

(25) Was the water produced during the test discharged away from immediate area? Yes X No ___

PUMP INSTALLATION

(26) PUMP INSTALLED? YES ___ NO X

(27) DATE:

(28) PUMP INSTALLER:

(29) TYPE:

(30) MAKE:

(31) MODEL:

(32) MAXIMUM CAPACITY (GPM):

(33) PUMP INSTALLATION LEVEL FROM TOP OF CASING (Feet):

(34) METHOD OF DRILLING: ☒ Rotary ☐ Cable Tool ☒ Other Drill & Drive

(35) USE OF WATER (See instructions for choices): Irrigation

(36) DATE DRILLING WORK STARTED: 11/03/2016

(37) DATE DRILLING WORK COMPLETED: 11/03/2016

(38) DATE REPORT FILED: 11/18/16

(39) REGISTERED COMPANY: William Stothoff Company

(40) DEC REGISTRATION NO.: NYRD 01703

(41) CERTIFIED DRILLER (Print name): Ron Haig

(42) CERTIFIED DRILLER SIGNATURE: Ronald M. Haig III

* Show log of geologic materials encountered with depth below ground surface, water bearing beds and water levels in each; casings; screens; pump; additional pumping tests and other matters of interest, e.g., water quality (sulphur, salt, methane). Describe repair work. Attach separate sheet if necessary.

LOG *

Ground Surface EL. 131 ft. above sea level

Top Of Casing is located 2.5 ft. above (+) or below (-) ground surface

TOP OF WELL +1.5'

Ground Surface

6" dia.

17.5' bottom of casing

0-13 fill/stone
13-16 weathered schist
16-110 schist
110-113 weathered schist
113-175 schist
175-177 fracture
177-350 schist

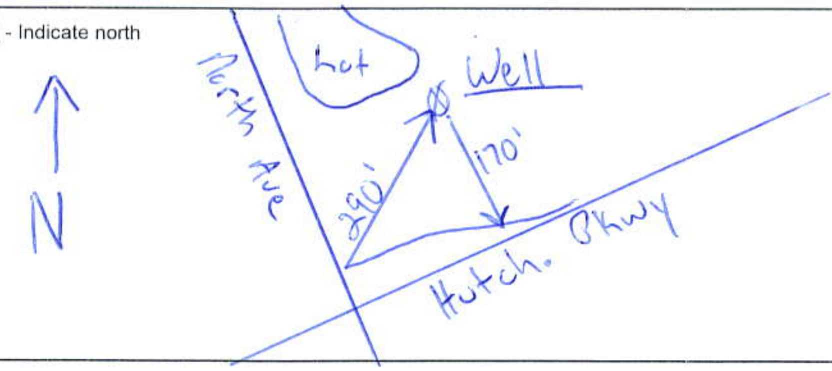
Water at 50' and 177'

350' TD

BOTTOM OF HOLE

NYSDEC COPY

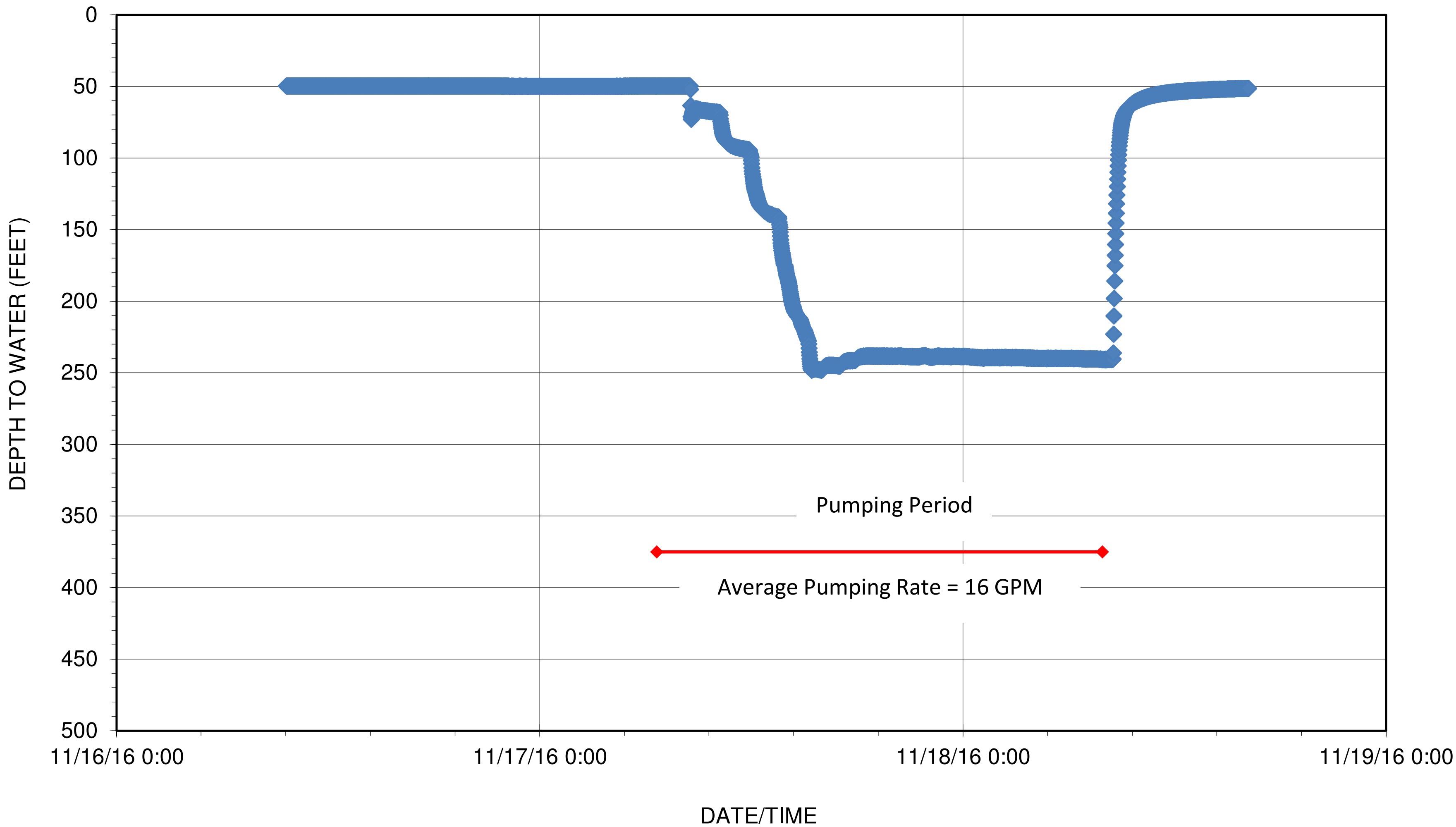
LOCATION SKETCH - Indicate north



Appendix B

Hydrograph Rock Well Pumping Test

MAPLE MOOR GOLF COURSE
WHITE PLAINS, NY
HYDROGRAPH
ROCK WELL PUMPING TEST
11/16/16- 11/18/16



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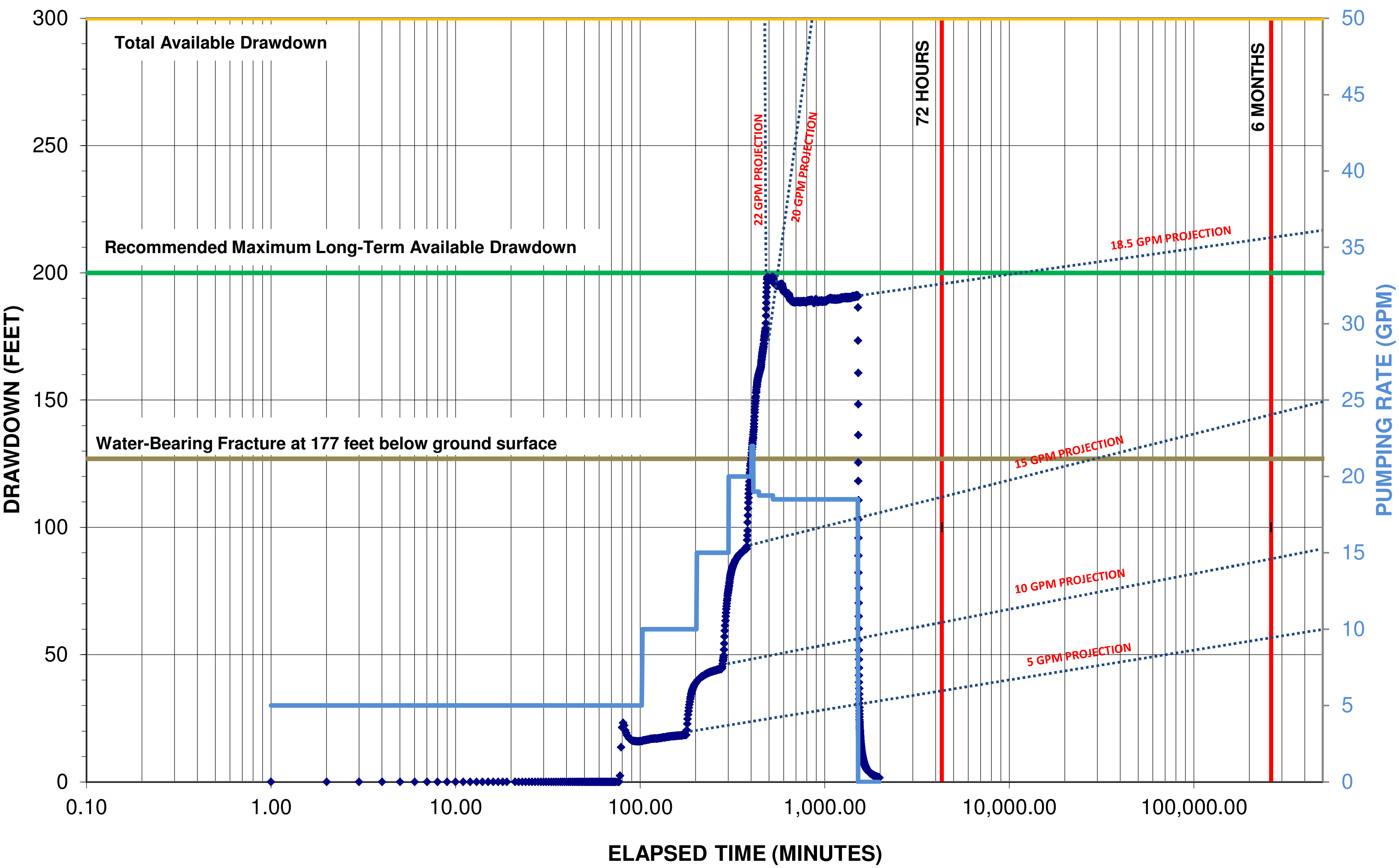
Appendix C

Pumping Test of Rock Well & Rock Well Drawdown

MAPLE MOOR GOLF COURSE
WHITE PLAINS, NY

PUMPING TEST OF ROCK WELL, 11/17/16 - 11/18/16

ROCK WELL DRAWDOWN



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Appendix D

Fracture Trace Study Memo

LANGAN **Memorandum**

300 Kimball Drive Parsippany, NJ 07054 T: 973.560.4900 F: 973.560.4901

To: Robert Lopane, R.L.A.

From: Brian Blum

Info: W. Charles Utschig Jr., PE

Date: September 6, 2016

Re: Fracture Trace Study Memo
Maple Moor Golf Club
White Plains, New York
Langan Project No.: 190022601

Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C. (Langan) is pleased to provide the Maple Moor Golf Club (the "Club") this technical memorandum that documents and summarizes the findings of a bedrock well fracture trace evaluation in support of locating a bedrock irrigation water supply well. Bedrock wells drilled to intercept fractures tend to have greater water-bearing capacity, and the fracture trace evaluation is conducted to locate natural fractures based on the topographic expression of the land as determined by a review of stereographic aerial photos.

Upon review of the literature relating to the bedrock geology and water supply wells in the vicinity of the Club, we understand that the bedrock types has a potential to yield ranging from 0.5 to 60 gallons per minute (gpm). Those bedrock wells that intersect natural fractures result typically produce higher yields and therefore we have recommended drilling along a targeted fracture in an area that also provides reasonable access to drilling equipment without disrupting golf play. Our recommendations for the subsequent steps the Club may consider to for bedrock water-supply exploration are provided below.

Bedrock Geology – *Hartland Formation*

Available bedrock geology maps depict one distinct bedrock unit underlying the Maple Moor Golf Club, the Hartland Formation, which has been tapped by water supply wells in the vicinity of the Club. The Hartland Formation, which is represented as "Oht" is Ordovician in age, is a metamorphic bedrock unit comprised of basal amphibolite overlain by pelitic schists. Based on our experience and as described in the literature, the Hartland formation is a competent bedrock unit (i.e., not well fractured) and therefore is not typically a reliable source of relatively large quantities of water to wells.

Nearby Bedrock Wells

There are five documented water supply wells tapping the Hartland Formation within 5.0 miles of the Club. Well data available from the New York State Department of Environmental Conservation (NYSDEC) indicate that the depths of the wells are 290 to 710 feet deep. The yield of these wells ranges from 0.5 to 60 gpm with an average yield of 17 gpm. The well yielding 60 gpm is 3.5 miles south of the Club. The closest well is 2.0 miles north of the Club and yields 18 gpm. The complete search result for this well that was returned from NYSDEC is provided below:

Town/ City/ Village	County	Well Number	FOIL Address	Latitude (D/M/S)	Longitude (D/M/S)	Well Depth (FT)	Rock Depth (FT)	Ground Water Depth (FT)	Casing Length (FT)	Screen Used?	Yield (GPM)	RegNumber
Harrison	WESTCHESTER	WE6189	PURCHASE ST	41 01 52.8	73 42 36.0	310	50			N	18	NYRD10105
Mamaroneck	WESTCHESTER	WE6206	WEAVER ST	40 57 13.8	73 46 00.6	505	5			N	0.5	NYRD10105
Mamaroneck	WESTCHESTER	WE6217	FENIMORE RD	40 57 58.2	73 45 25.8	290	14			N	4	NYRD10105
Mamaroneck	WESTCHESTER	WE6218	FENIMORE RD	40 58 00.6	73 45 25.8	710	12			N	3.5	NYRD10105
Mamaroneck	WESTCHESTER	WE6259	SOUNDVIEW DR	40 57 03.4	73 43 09.6	405			21	N	60	NYRD01695

Additionally, seven wells are documented by the United States Geological survey (USGS) in the 1955 Ground Water Resources of Westchester County Records of Wells and Test Holes. These wells were installed to depths of 200 to 500 feet below ground surface and produced 5.0 to 50 gpm. However, most of these wells were eventually abandoned due to insufficient sustainable yield.

We reviewed the preliminary brittle structure map of New York provided by the New York State (NYS) Geological Survey and performed a fracture-trace analysis to identify any major faults in the area.

Fracture Trace Analysis

The potential yield of a well tapping a bedrock aquifer such as the one underlying the Club is generally maximized when the intake zone of the well intersects as many ground-water bearing fractures as possible. As such, the selection of location for a potential "test" well intended to tap the bedrock aquifer at the Site, was based upon surficial conditions considered reflective of the potential occurrence of fracture zones in the underlying bedrock aquifer. These conditions were identified primarily through the completion of a "fracture trace" analysis of the Club utilizing stereo-pair aerial photographs and orthophotograph imagery.

Fracture traces, and related larger-scale lineaments, are naturally-occurring linear surficial features which correspond to topographic, vegetative or soil-tonal alignments. These features are considered to potentially be the surface expression of fractures and fracture zones in the underlying bedrock. Such features are typically identified by interpreting aerial photographs and topographic maps. Wells penetrating fractures and fracture zones in bedrock, typically exhibit higher yields than those penetrating non-fractured bedrock. Once identified on aerial photographs, the existence of fracture traces should be verified in the field prior to drilling, in order to confirm that the identified feature is not associated with any man-made structures (e.g., stone wall, road, pipeline, land modifications such as grading, etc.). Depending on the local geologic conditions, the existence of water-bearing fractures associated with respective fracture zone traces can sometimes be confirmed by using surface geophysical techniques.

MEMO

Langan performed the fracture trace analysis using stereo-pair aerial photography obtained from the United States Department of Agriculture Farm Service Agency (USDA-FSA) Aerial Photography Field Office of Salt Lake City, Utah (Figure 1). The USDA-FSA aerial photography of the Club was completed in 1994 at a scale of 1 inch equals 3,000 feet. Based on the review of photography, imagery, and maps, one potential fracture trace was identified at the Club (Figure 2). The identified fracture trace is oriented roughly northeast-southwest, consistent with commonly-identified fractures. The identified fracture trace is coincident with surface tonal variations, as evident and interpreted by an experienced hydrogeologist viewing stereographic photography with a stereoscope.

Recommendations

Despite our reservations regarding the potential for a bedrock well to yield appreciate quantities of water, we understand that the Club is still interested in pursuing a bedrock test well to further evaluate the viability of exploiting an on-site groundwater water supply source. Therefore, we suggest drilling a test well in the Club's parking lot to intercept a mapped potential water-bearing fracture based on the results of the fracture trace evaluation and in an area that can be readily accessed by drilling equipment without interruption to golf play and where restoration will be reasonable (see Figure 2). The well will be drilled and tested in accordance with our 16 September 2014 proposal.

Please feel free to Langan regarding this information and we would be happy to provide the Club with additional explanation on our findings and recommendations.

Notes:
Stereo-pair aerial photography provided by the United States Department of Agriculture Farm Service Agency Aerial Photography Field Office of Salt Lake City, Utah.

Potential fractures identified on aerial imagery shown as solid and dashed red lines.

2,000 0 2,000
SCALE IN FEET

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Langan International LLC
Collectively known as Langan

NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project
MAPLE MOOR GOLF COURSE IMPROVEMENTS
WHITE PLAINS
WESTCHESTER COUNTY NEW YORK

Drawing Title
FRACTURE TRACE IMAGERY

Project No. 190022601	Figure 1
Date 6/30/2016	
Scale 1 " = 2,000 '	
Drawn By AOF	
Submission Date 9/06/2016	Sheet 1 of 2

Path: \\langan.com\data\WP\data6\190022601\ArcGIS\ArcMap_Documents\Fracture Trace-Base.mxd Date: 6/30/2016 User: aflaxman Time: 4:56:23 PM

Legend

- Proposed Test Well
- Interpreted Fracture

250 0 250
SCALE IN FEET

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Project	Drawing Title	Project No.	Figure
MAPLE MOOR GOLF COURSE IMPROVEMENTS WHITE PLAINS WESTCHESTER COUNTY NEW YORK	FRACTURE TRACE FINDINGS	190022601 Date: 6/30/2016 Scale: 1" = 250' Drawn By: AOF Submission Date: 9/06/2016	2 Sheet 2 of 2

Path: \\langan.com\data\WP\data6\190022601\ArcGIS\ArcMap_Documents\Fracture Trace.mxd Date: 6/30/2016 User: aflaxman Time: 4:58:46 PM

Appendix E

30% Design Report including Water Quality test results

Schematic Design Report

for

Improvements to Maple Moor Golf Course
White Plains, New York

Prepared For:

Westchester County Department of Public Works and Transportation
Michaelian Office Building
148 Martine Avenue
White Plains, NY 10601

Prepared By:

Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
707 Westchester Avenue, Suite 304
White Plains, New York 10604

September 4, 2015
190022601

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~~D Boundary & Topographic Survey~~

1 Executive Summary

This report outlines the proposed improvements for the Maple Moor Golf Course based on information provided in the County Request For Proposal (RFP) dated August 2014, subsequent site meetings and site evaluations performed by our project team. The objective of this report is to provide a comprehensive list of all improvements needed at the course and to assist the County with prioritizing these improvements based the project budget. The goal is to develop a prioritized list of improvements which will be used to develop the Bid Documents.

The following is a brief description of the items evaluated during the schematic design phase of the project. These items are described in further detail in the remainder of this report and on the supporting plans and documentation included in Appendix A.

1.1 Drainage

As part of the course evaluation, we assessed the drainage, erosion and grading conditions of the fairways. There are multiple fairways that experience extended periods of flooding and standing water resulting from poor drainage systems, poor soil conditions, improper grading or located within the floodplain. Refer to Section 5.2.1 Fairway Drainage for additional information.

We also evaluated relocating Hole No. 9, but we concluded that this is a costly improvement that would have associated constructability and safety issues. Therefore, we have suggested an alternative solution to improve the drainage conditions on the fairway, as described in Section 5.2.2 Hole No. 9.

1.2 Cart Paths

The conditions of the cart and maintenance paths were assess by our team during our site observations. Based on our site walk and plan review we developed preliminary improvement plans that show all cart path improvements proposed for the course (refer to Appendix A for the preliminary improvement plans). The condition of each cart path and a determination as to whether they should be restored or replaced was based on a visual assessment, discussions with facility staff members and historical data provided by the County. The result of this assessment was the development of preliminary improvement plans (Appendix A) that indicate the recommended removal, relocation, restoration and replacements of all the cart paths on the golf course.

1.3 Golf Course Routing and Sand Traps

We assessed the condition and location of the all the existing bunkers on the golf course. Depending on the location, size and condition of the bunkers relative to the specific hole, we suggest that the bunkers be relocated, reconstructed, reshaped or restored with new sand. For additional information refer to Section 5.2.3 Bunkers.

1.4 Alternative Sources of Water

We have evaluated the alternatives and combinations thereof for course irrigation water supply including the following:

a. Site Stormwater collection and re-use as a supplemental source of water
b. Diversion and retention of two existing surface drainage channels as an intermittent source of water
c. Multiple drilled shallow groundwater wells as a primary source
d. Potential for using the Mamaroneck River as a source of water
e. City water as backup to the other water source options.

Refer to Section 5.3 Alternative Sources of Water for additional information.

1.5 Irrigation System

The proposed irrigation system focuses on replacing the entire existing system. The coverage of the proposed system shall be the following:

a. Greens – full circle green heads and part-circle perimeter heads
b. Fairways – two rows of full circle heads
c. Front tee to fairway (except Fescue areas) – single row full circle heads
d. Tee – Two rows of short radius full circle heads

Refer to Section 5.4 Irrigation System for additional information.

1.6 Pump Station and Electrical Improvements

The pump station will be a fully automated skid-mounted unit, which keeps constant pressure on the irrigation system while meeting the various flow demands of the irrigation programs. There will be 3-HP submersible line maintenance pumps and two larger main pumps in the wet well. Main pumps will be of the vertical turbine type, driven by 1800-RPM electric motors. The station is intended to operate on 480-volt, three phase, 60-hertz power. The pump station will be capable of discharging 1200-GPM at a pressure to be determined after irrigation system design is completed. For additional information refer to Section 5.5 Pump Station and Electrical Improvements.

1.7 Bridge Evaluation

The conditions of the five bridges were assessed by our team during our site observations. We developed a detailed analysis of each bridge based on our site observations, discussions with facility staff members and historical data provided by the County. For additional information refer to Table 10 and Table 11 of this report.

2 Background and Site Description

2.1 History

Maple Moor Golf Course is one of six 18-hole courses owned and operated by the Westchester County Department of Parks, Recreation and Conservation. Maple Moor, which opened to the public in 1927, is a 6,374 yard, Par 71 course that occupies 140 acres in White Plains, New York. Over the past 20 years, the course has deteriorated and is in need of repairs and/or upgrades. Repairs and upgrades include damaged fairways from increased offsite drainage and flooding conditions, poor bunker drainage and placement, deteriorated or insufficient cart paths, structural bridge repairs and abutment protection, and irrigation system and water supply improvements.

2.2 Location

The course is north of New York State Route 127, west of the Hutchison River Parkway (Hutch) south bound lanes and south of the Westchester Avenue on ramp to the Hutch. The Mamaroneck River flows through the northern portion and along the east portion of the property. The flood plain associated with the river encumbers the eastern portion of the property. The river commonly floods an area extending between 40-feet and 400-feet from the river in mostly a westerly direction onto the course.

2.3 Existing Slopes and Drainage Conditions

The site generally slopes from west to east toward the Mamaroneck River. There are isolated areas where surface waters terminate at low points or depressions on the site. The highest elevation of the site is approximately 186-feet and the lowest elevation at approximately 84-feet.

The course has one significant natural surface drainage channel that flows through the golf course. This channel is located between the tee boxes and green of golf Hole No. 2 adjacent to the maintenance facility. This drainage channel appears to be fed from offsite sources and flows almost year round. The offsite flows enter the property through an open channel and are conveyed through the maintenance yard via pipe and headwalls. The piped flows are then discharged to an open channel and to a dual 12-inch corrugated metal pipes and stone headwalls below the cart path on golf Hole No. 2. The flows are then conveyed through the course by a piping system of unknown size that has been extended, modified and repaired over the life of the course. This drainage system, which was at one time an open channel, that outlets on the east side of the fairway to golf Hole #8. The flow discharges to an open channel ditch that drains into the Mamaroneck River. The second and smaller channel originates near golf Hole No.1 fairway and has been diverted from its natural course due to prior work at the golf course.

In addition to the major drainage channel, which has been identified above, directs runoff from a large upstream area through the course. There are other significant offsite areas that drain across the fairways to golf Holes 1, 3 and 4. These offsite areas generally drain in a sheet flow pattern across the referenced fairways towards the golf hole downstream. This creates drainage problems throughout the golf course, specifically under heavy rainfall conditions.

There are two other major drainage features on the golf course, the Mamaroneck River and the existing pond. The Mamaroneck River enters the course at its most northerly end and runs between golf Holes 4 and 5. The river then crosses east through the golf course and runs parallel to golf Holes 6, 8 and 9. The existing pond is located between golf Hole No. 12 and golf Hole No. 9 fairways. This pond was constructed in 2000, and encompasses approximately 16,000-square-feet with an estimated depth of 10-feet at the center. The pond was installed to offer a water feature, provide drainage retention and to alleviate drainage problems along golf Hole 8th fairway. Based on observations made by the golf course staff, the water level of the pond does not fluctuate significantly, therefore indicates the pond is feed by groundwater. During the next phase of the design, a pump test will be performed on the pond to verify its recharge capacity.

The course also experiences ponding water and saturated soil conditions across many of the golf holes. The areas where this drainage problem is most significant areas described below:

Golf Hole No.1: There is an existing depression approximately 265-feet south of the Tee, and ponds water for an extended period of time. It appears the stormwater runoff from the adjacent property to the north concentrates at this location. In addition, there is some form of a drainage collection system that was installed over the years to help alleviate this problem. It appears that this system has deteriorated and is not functioning efficiently at this time.

Golf Holes 3 and 4: These two golf holes are impacted by offsite drainage that sheet flows across these fairways. This problem is further exasperated by poor grading and lack of a formal drainage collection system on these fairways.

Golf Holes 4, 5, 6, 8, and 9: These golf holes are located along the Mamaroneck River and are generally located in the floodplain and below the flood elevation. These golf holes are drain inefficiently due to poor soil conditions and in heavy rainfall events, flood when the Mamaroneck River exceeds its banks. The recovery time after a heavy rainfall event for these fairways to drain is very long and is a significant factor in resuming play on the golf course. Recovery time means the time required to resume its normal condition.

Golf Hole No. 7: There is a natural depression located on the west side of this golf hole that holds stormwater runoff during heavy rainfall events. This area is roughly 17,000-square-feet and will fill approximately 4- to 5-feet before it will discharge east toward the Mamaroneck River by overland flow.

2.4 Existing Water Supply and Irrigation

The golf course utilizes municipal water at the club house, halfway house and for irrigation purposes. There was a ±2,200-feet 6-inch ductile iron water main installed in 2003 that tapped the existing City of White Plains main located within North Street. The ±2,200-feet water main extends from behind the 18th green to the stone pump house along the 8th fairway, where the pressures in the main are recorded to be approximately 100 psi. Prior to the installation of the water main, the course utilized water drawn from the Mamaroneck River that was pumped from the pump house to the irrigation system. This system was abandoned because the intake line from the river was constantly silted and the water quality was unacceptable.

In 1988, upgrades to the irrigation system were made and included installing a Toro Vari-Time II control system with satellite controllers. In 2000, the Tee and Greens project replaced the Vari-Time II with Toro Network 4000 system satellites. The satellites were re-connected to the existing control wiring for the sprinkler heads. A central computer, which is currently outdated, was installed in the Maintenance Building to provide automated control with limited monitoring and graphics.

Tee and Green improvements made in 2000 included replacement of heads around the tees and greens and upgraded irrigation controller re-using the 1988 control wiring. Upgrades to certain Tees and Greens were also made at this time.

3 Site Soils and Drainage Patterns

3.1 Site Soils

The United States Department of Agriculture (USDA) Soil Conservation Service Soil Survey for Westchester County was reviewed. The surficial soil conditions for the study area are shown in Figure 1 – Soils Map. The soil data for each of the soil types are summarized in Table 1 below.

Table 1: USDA Soil Data

Map Symbol	Description	Depth to Groundwater (ft)	Depth to Bedrock (in)	Hydrologic Soil Group
CrC	Charlton-Chatfield complex, rolling, very rocky	>6.0	varies(1)	B
CsD	Chatfield-Charlton complex, hilly, very rocky	>6.0	varies(1)	B
CtC	Chatfield-Charlton-Rock outcrop complex, rolling	>6.0	varies(2)	varies(3)
CuD	Chatfield-Charlton-Rock outcrop complex, hilly	>6.0	varies(2)	varies(3)
Ff	Fluvaquents-Udifuvents complex, frequently flooded	varies(4)	>40	varies(5)
Fr	Fredon silt loam	0-1.5 (Oct-Jun)	>60	C
HnC	Hinckley gravelly loamy sand, 3 to 15% slopes	>6.0	>60	A
LcB	Leicester loam, 3 to 8% slopes, stony	0-1.5 (Nov-May)	>60	C
LeB	Leicester loam, 2 to 8% slopes, very stony	0-1.5 (Nov-May)	>60	C
PnB	Paxton fine sandy loam, 3 to 8% slopes	1.5-2.5 (Feb-Apr)	>60	C
PnC	Paxton fine sandy loam, 8 to 15% slopes	1.5-2.5 (Feb-Apr)	>60	C
Pw	Pompton silt loam, loamy substratum	1.0-2.0 (Oct-May)	>60	B
Ra	Raynham silt loam	0-2.0 (Nov-May)	>60	C
RhB	Riverhead loam, 3 to 8% slopes	>6.0	>60	B
Sh	Sun Loam	+1-0.5 (Nov-Apr)	>60	D
Ub	Udorthents, smoothed	--	--	--(6)
Uc	Udorthents, wet substratum	--	--	--(6)
Uf	Urban Land	>2.0	>10	--(7)
W	Water(8)	--	--	--

(1) The depth to bedrock for the Charlton component is greater than 60-inches and for the Chatfield component is 20 to 40-inches.
(2) The depth to bedrock the for Chatfield component is 20- to 40-inches, for the Hollis component is 10- to 20-inches and rock outcrop is zero inches.
(3) The Hydrological Soil Group for the Chatfield component is B, for the Hollis component is C/D and for rock outcrop is D. For modeling purposes, Hydrological Soil Group D will be used for areas containing rock outcrops and Hydrological Soil Group C will be used for all other areas.
(4) The depth to groundwater for the Fluvaquents component is +0.5 to 1.5 -feet (Oct-June) and for the Udifluvents component is 2.0 to 6.0-feet (Nov-May).
(5) The Hydrological Soil Group for the Fluvaquents component is D and for the Udifluvents component is B. For modeling purposes, Hydrological Soil Group D will be used.
(6) A Hydrologic Soil Group is not given for Udorthents. For modeling purposes, the Hydrologic Soil Group C will be used.

(7) A Hydrologic Soil Group is not given for Urban land, since this soil group consists of areas where the soil surface is covered by impervious materials. For modeling purposes, the Hydrologic Soil Group will be assumed to be the same as the surrounding soil groups. In this instance, the surrounding soil groups have varying Hydrologic Soil Groups; therefore, Hydrologic Soil Group C will be used.
(8) Denotes where open bodies of water are located. For modeling purposes, the Hydrologic Soil Group will be assumed to be the same as the surrounding soil groups. In this instance, the surrounding soil groups have varying Hydrologic Soil Groups; therefore, Hydrologic Soil Group C will be used.

The Soil Conservation Service defines the hydrologic soil groups as follows:

- **Type A Soils**: Soils having a high infiltration rate and low runoff potential when thoroughly wet. These soils consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

- **Type B Soils**: Soils having a moderate infiltration rate when thoroughly wet and consists mainly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately course textures. These soils have a moderate rate of water transmission.

- **Type C Soils**: Soils having a low infiltration rate when thoroughly wet and consists chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine-to-fine texture. These soils have a low rate of water transmission.

- **Type D Soils**: Soils having a very low infiltration rate and high runoff potential when thoroughly wet. These soils consist chiefly of clays that have high shrink-swell potential, soils that have a permanent high water table, soils that have a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very low rate of water transmission.

Figure 1: Site Soils Map

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MAPLE MOOR GOLF COURSE SOILS MAP

City of White Plains **Westchester County** **New York**

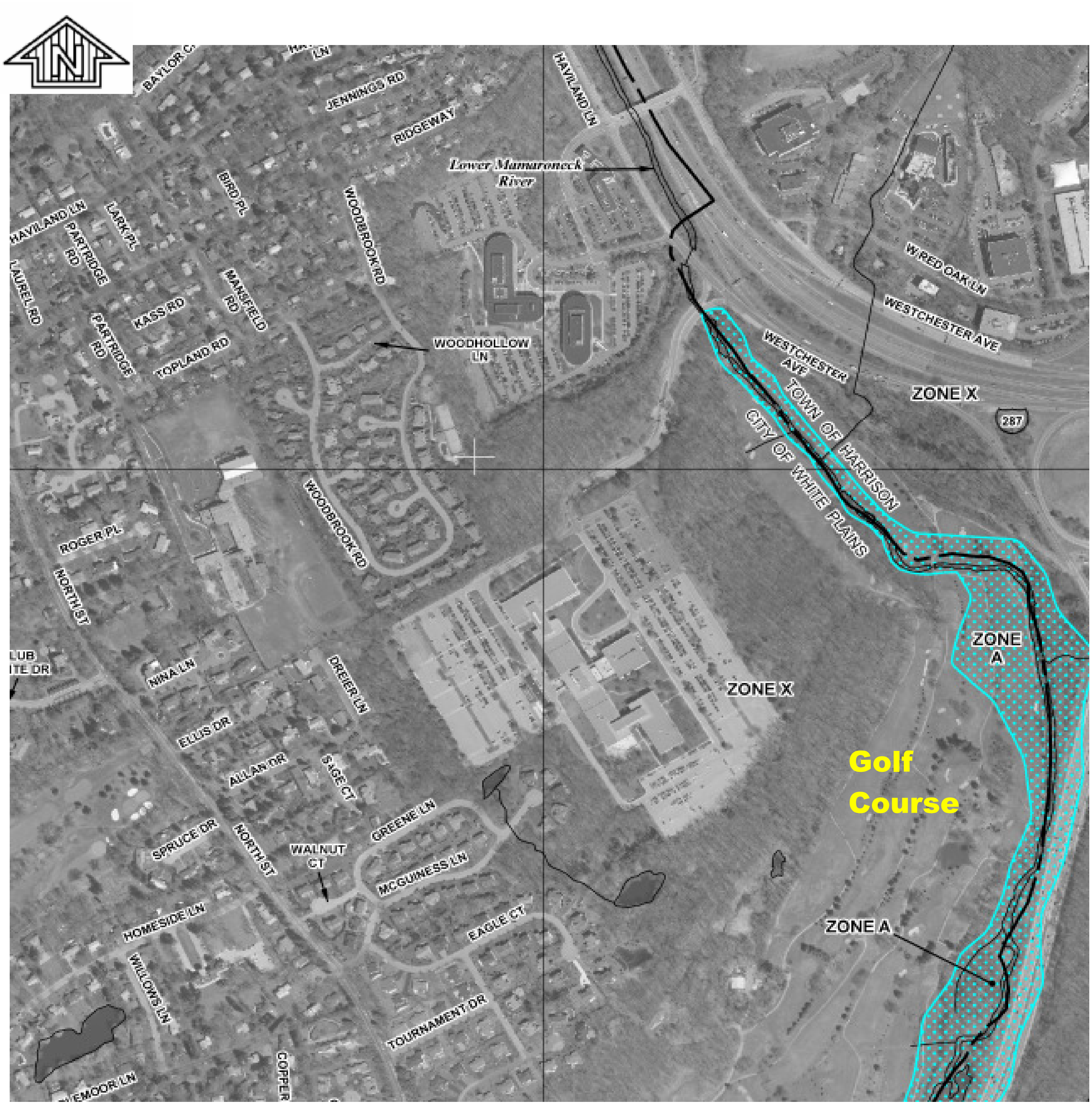
JOB NO.	DATE	SCALE	FIGURE NO.
190022601	**8/13/2015**	**NTS**	**1**

4 Flood Plain Assessment

The property is shown on the Flood Insurance Rate Map (FIRM) for the Town of Harrison and City of White Plains, New York map number 36119C0288F, effective date September 28, 2007. According to the FIRMs, the lower portion of the course is located within Zone A (other flood areas) near the Mamaroneck River. The remaining portions of the course is located in Zone X (other flood areas), which is defined as "areas determined to be outside the 0.2% annual chance floodplain (refer to Figure 2 – FEMA Map (1 of 2) and Figure 3 - FEMA Map (2 of 2).

The flood maps do not indicate that a flood study was performed in this area; therefore, flood elevations are not provided. Based on conversations with Westchester County staff, we understand that the existing pump house was flooded up to 6-feet from the floor slab during Super Storm Sandy. Since the elevation of the pump house slab is approximately 89.5-feet (NAVD 1988) the maximum flood elevation at the site is presumed to be 95.5-feet.

Figure 2: Flood Insurance Rate Map (1 of 2)



MAPLE MOOR GOLF COURSE
FLOOD INSURANCE RATE MAP (1 OF 2)

City of White Plains | Westchester County | New York

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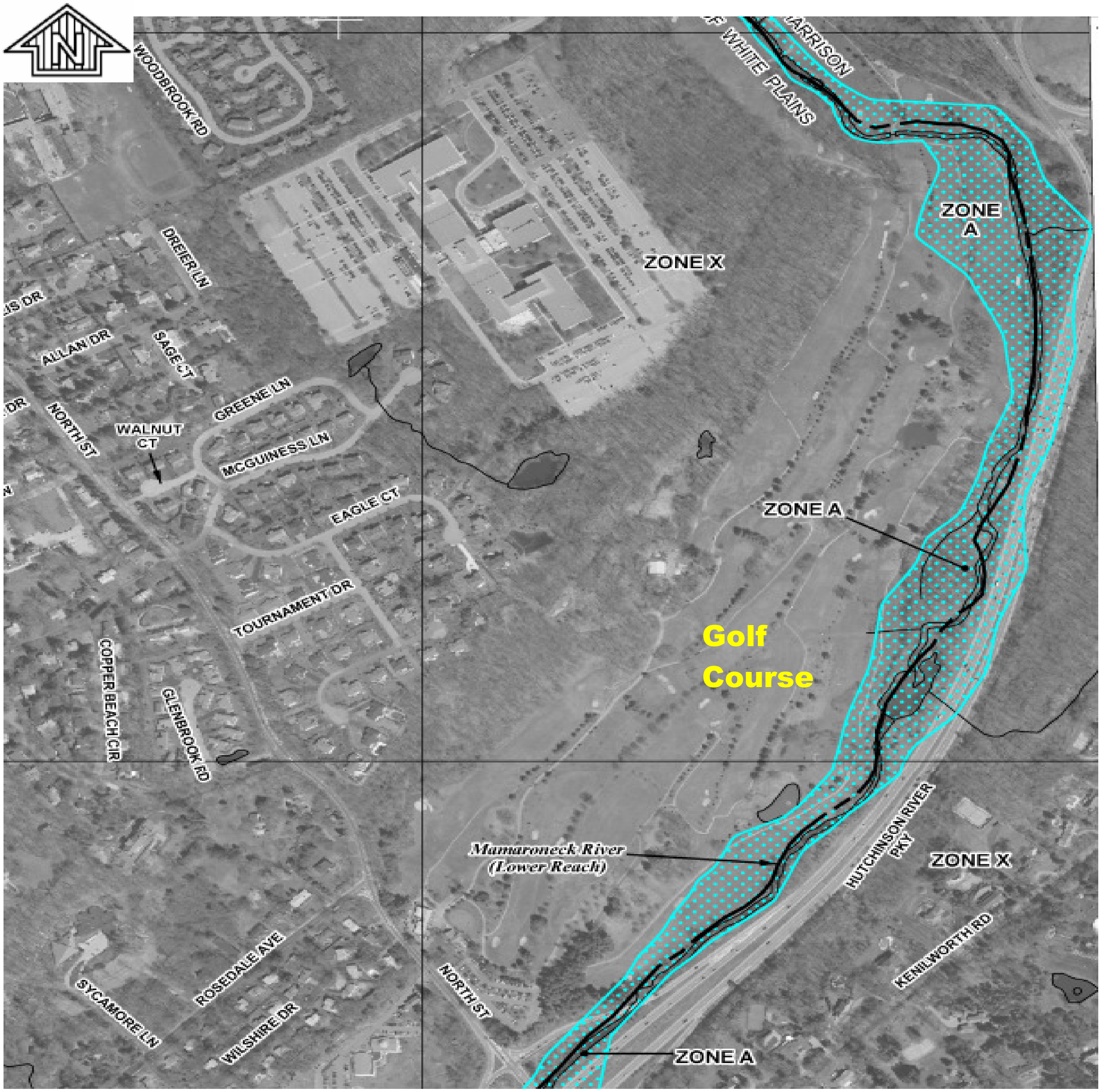
JOB NO.	DATE	SCALE	FIGURE NO.
190022601	8/13/2015	NTS	2

Figure 3: Flood Insurance Rate Map (2 of 2)



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MAPLE MOOR GOLF COURSE
FLOOD INSURANCE RATE MAP (2 OF 2)

City of White Plains	Westchester County		New York
JOB NO.	DATE	SCALE	FIGURE NO.
190022601	8/13/2015	NTS	3

5 Proposed Improvements

5.1 Cart Paths

As stated earlier, the entire course was walked with County representatives to assess the conditions of all cart and maintenance paths. We also reviewed the site survey to identify paths that are less than 8-feet-wide. Based on our site walk and plan review we developed preliminary improvement plans that show all cart path improvements proposed for the golf course (refer to Appendix A). The condition of each cart path was determined by visual assessment, discussions with facility staff members and historical data provided by the County. The outcome of our review resulted in developing the following categories associated with the cart paths:

1. Path widening (8-Feet minimum);
2. Full depth path replacement;
3. Restoration of Gravel Paths for maintenance equipment; and
4. Path removal.

We have also reviewed the existing path locations and provided recommendations for relocating certain cart paths and maintenance paths to improve overall cart circulation and additional signage to better direct the golfers to increase the pace of play. In some cases the cart path relocations/adjustments coincide with wear paths (dirt paths) that have been developed by the golf cart users. These proposed cart path changes are at Holes No. 2, No. 3, No. 4, No. 5, No.10, No 12, and at the halfway house.

In addition to reviewing the path conditions and locations, we assessed areas where stone curbing would be beneficial to prevent carts from impacting the turf, to control stormwater runoff or to facilitate grading.

The overall recommendations relative to the relocation and reconstruction of the cart paths and maintenance paths are shown on the preliminary improvement plans included in Appendix A.

5.1.1 Path Widening

Paths that are less than 8-feet in width will be widened to a minimum of 8-feet. The widening will occur to one side of the path to minimize the impact to the turf, drainage flow, and encroachment in to play area. Prior to issuing the 60-pecent documents, all specific path widening locations will be determined and shown on the improvement plans; however, for the 30-percent documents we have assumed that the less than 8-foot paths will be widened, receive 6-inches of topsoil and seed 5-feet beyond the pavement edge and the existing pavement section will be milled and overlaid. Upon preparation of the 60-precent drawings we may consider areas where the existing asphalt concrete section receives a new asphalt concrete top course and tack coat in lieu of the mill and overlay.

5.1.2 Full Depth Path Replacement

Paths that were visually cracked and damaged beyond repair will be removed to subgrade and a new pavement section installed. The new pavement section will consist of installing subbase material and two layers of asphaltic concrete. All existing material will be removed and disposed offsite. In the event that the existing subbase material is determined to be adequate in the field, we will recommend that the subbase remain and the asphalt concrete layers installed per the detail; however, for purposes of developing the project budget we have assumed the full pavement section will be replaced.

5.1.3 Gravel Path

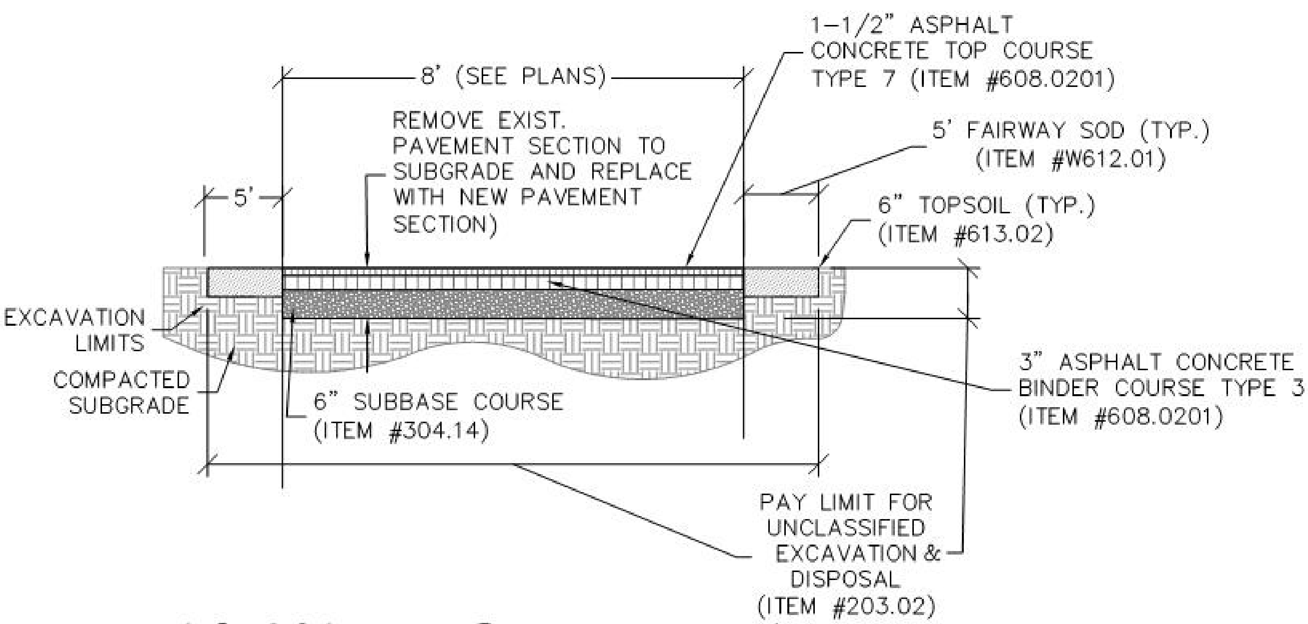
Maintenance access paths that are utilized on a limited basis will be converted to gravel (refer to the preliminary improvement plans for location). The existing asphalt concrete layers will be removed to subbase and 1-1/2" clean gravel will be installed. Metal edging will be installed adjacent to the path to support the gravel section.

5.1.4 Path Removal

Existing paths that are no longer used or that will be relocated will be completely removed to subgrade. The existing asphaltic concrete pavement sections and subbase material will be removed and disposed offsite. The section will be filled with select back fill material; 6-inches of topsoil and the appropriate turf treatment applied (refer to the preliminary improvement plans for the location and scope of these improvements.

The relative details associated with these improvements follow:

Figure 4: Asphalt Concrete Pavement for Cart Paths Detail



ASPHALT CONCRETE PAVEMENT FOR CART PATHS

SCALE: NTS

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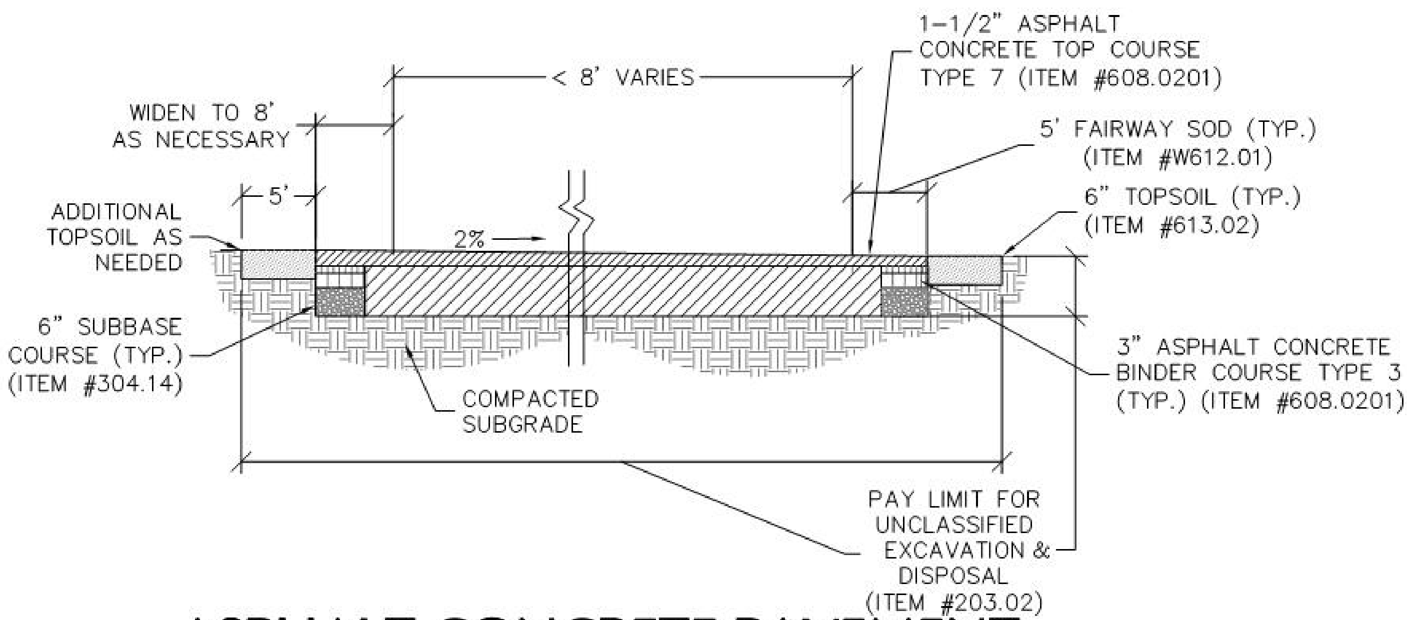
Figure 5: Asphalt Concrete Pavement (to Widen) Cart Paths Detail



ASPHALT CONCRETE PAVEMENT (TO WIDEN) CART PATHS

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MAPLE MOOR GOLF COURSE
ASPHALT CONCRETE PAVEMENT (TO WIDEN) CART PATHS DETAIL

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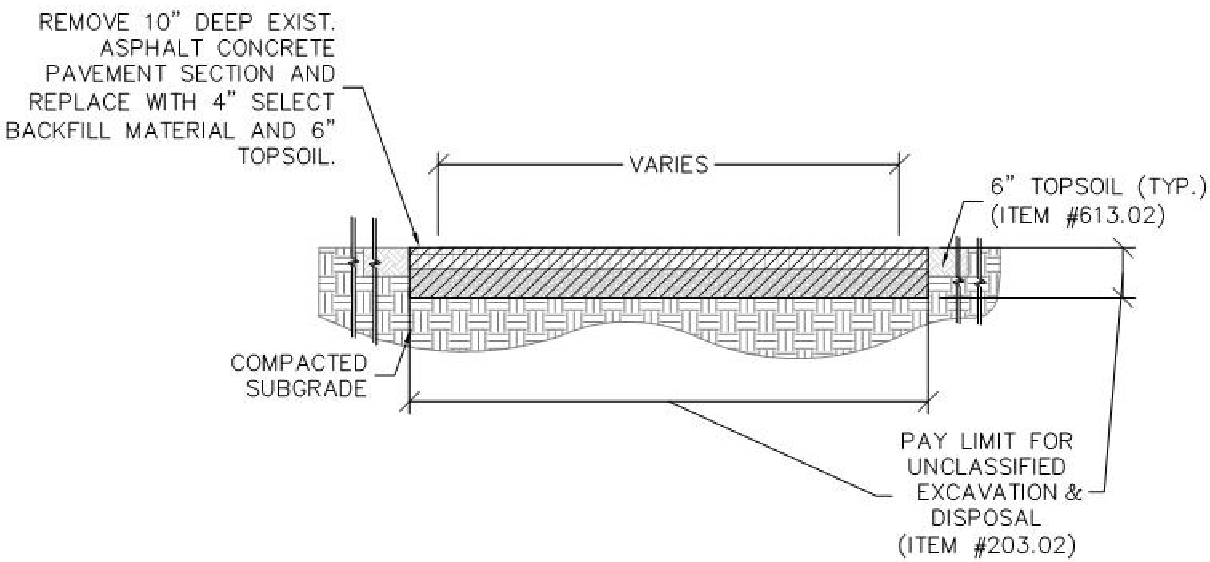
Figure 6: Asphalt Concrete Pavement Removal Detail



ASPHALT CONCRETE PAVEMENT REMOVAL

SCALE: NTS

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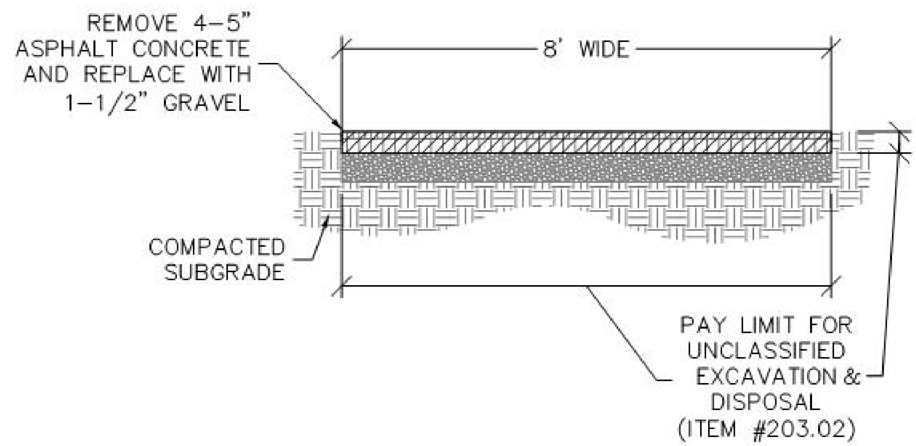
Figure 7: Gravel Path Maintenance Access Detail



GRAVEL PATH MAINT. ACCESS

SCALE: NTS

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5.2 Fairways and Bunkers

As part of the course evaluation, we assessed the drainage, erosion and grading conditions of the fairways throughout the course. There are several fairways that experience extended periods of flooding and/or standing water resulting from poor drainage systems, poor soil conditions, improper grading and located within the floodplain. These holes include No. 1, No. 3, No. 4, No. 5 No. 6, No. 8, No. 9, and No. Refer to 5.2.1 Fairway Drainage section below for additional information.

We also evaluated relocating Hole No. 9, but concluded that this would be a very costly improvement that would have associated with it significant constructability and safety issues. Therefore, we have suggested an alternative solution to improve the drainage conditions on the 9th fairway, as described below.

We have also assessed the condition and location of all the bunkers on the course. Based on this assessment, we have recommended that all the bunkers be relocated, reconstructed or reshaped. These recommendations are on a hole by hole basis and are indicated on the preliminary improvement plans included in Appendix A.

5.2.1 Fairway Drainage

Fairways were assessed in the field on a case by case basis and most require drainage improvements to alleviate ponding water or to reduce flooding duration. Below is a list of these holes and description of the proposed drainage improvements. Please note that not all holes are listed below, because this list represents only those holes that require a significant level of work.

Golf hole No. 1- This hole experiences ponding water near the southern portion of the fairway. There is a bio-filter drainage system located southeast of the cart path that was installed to improve the drainage in this area. The water ponding on the fairway is trapped between the elevated cart paths and the fairway. We recommend the following:

- Remove and replace existing underdrain system. Increase the pipe size to provide more capacity and drainage flow;
- Install a herringbone drainage system to allow surface water to infiltrate; and
- Connect drainage system to proposed Pond D to be located in the vicinity of the tee boxes for Golf hole No. 18.

Golf hole No. 2- The drainage channel that crosses golf Hole 2 will be reconstructed with larger pipes to improve the conveyance of runoff from the adjacent offsite areas through the course to a proposed pond on golf hole 8.

Golf Holes 3, 4, 5, 6, 8, 14 and 15 - These golf holes experience varying degrees of ponding during both small and large storm events. To alleviate these conditions without completely rebuilding the fairways, we are recommending that underdrains be installed in a herringbone configuration connected to a solid drainage pipe that has a positive discharge. The exact location of these systems will be determined in the field during construction. This type of design will handle lower intensity storms with no ponding. For higher intensity storms, the design objective is to significantly reduce the recovery time to allow play to resume quicker. During higher intensity storms, there will be some localize ponding, but the standing water in the fairways will drain quicker.

In addition to improving the drainage throughout most of the fairways, we are also recommending three new ponds be constructed and the existing pond significantly expanded. Refer to Section 5.3.4.4 Proposed Ponds for additional information about these ponds and their intended functions.

5.2.2 Hole No. 9

Hole No. 9 is adjacent to the Mamaroneck River at the south eastern end of the golf course. During rain events, the fairway is inundated with surface water and/or flood water from the river depending on the intensity of the rainfall event. We have discussed the historical conditions on the 9th fairway with the County staff who informed us that the drainage recovery time (as much as a few days) is a significant issue because of the closure of the golf hole or significant delays in play on the course. Over the years, there have been drainage improvements implemented to the fairway that have increased the recovery time; however, the drainage problems persist. Below are two options that were evaluated and our recommendations.

5.2.2.1 Relocated Golf Hole No. 9

We have evaluated the possibility of relocating Golf Hole No. 9 and have concluded that this is not a viable option to solve the drainage issues. When proposing to relocate or modify an entire or portion of an existing golf hole, the design shall incorporate current generally-accepted design parameters. Although there are no established "industry standards' for the design of a golf hole or golf course, there are generally-accepted criteria for many aspects of course design, including hole lengths, green & tee sizes, distances between adjacent holes, distances between a golf hole and a non-golf land use (both within the property and/or next to a property boundary). Achieving today's more spacious and buffered design criteria, when modifying older courses that were designed on smaller footprints is especially difficult and sometimes impossible. This is the case for Hole No. 9.

If the hole is to be relocated, shifting the hole west, to the extent necessary to relocate any meaningful portion of the fairway and left rough from the low-lying and flood-prone areas, also triggers relocation of the following features, in order to assure reasonable spacing between adjacent golf holes / features:

- No. 9 tees must be completely rebuilt to align with the new hole centerline and fairway;
- No. 9 green complex must be rebuilt and re-oriented to properly align with and receive shots played from the new fairway angle;
- No. 8 green complex must be shifted north, approximately 60-yards (new yardage = 315) to avoid any conflict with the new angle of play from No. 9 tees;
- No. 12 tee complex must be relocated 125-yards north, resulting in a 365-yard par four hole. The new landing area would be "blind" from the tee and the large berm

that crosses the fairway (sewer pipe), which cannot be lowered, becomes more of an adverse feature. In addition, because the hole would become a par four, the back nine par would be reduced to 34 and the overall course from a par 71 to a par 70;
- No. 11 green complex must be relocated approximately 10-yards north (new yardage = 132).

Relocation of the hole will also have safety, pace of play, cost and construction related issues, which are as follows:

- The proposed relocation forces the hole directly onto an existing hill comprised entirely of rock;
- Construction will require significant clearing, blasting and shaping to create a desirable and playable fairway that also relates properly to the existing green complex;
- Imported fill and topsoil will be required to "plate" the rock and create a subgrade profile capable of sustaining quality turf (to avoid replicating the existing condition below the fescue mound on the right of No.16 fairway).
- The completed fairway / rough would likely result in a somewhat steep slope / "drop-off" along the left side of the hole. This would likely have an adverse effect on overall playability and pace of play.

We have not developed a detailed estimate of the costs to implement all of the required modifications noted above; however, based on our collective experience we estimated that a general range of anticipated costs would be approximately $1.0M - $1.5M.

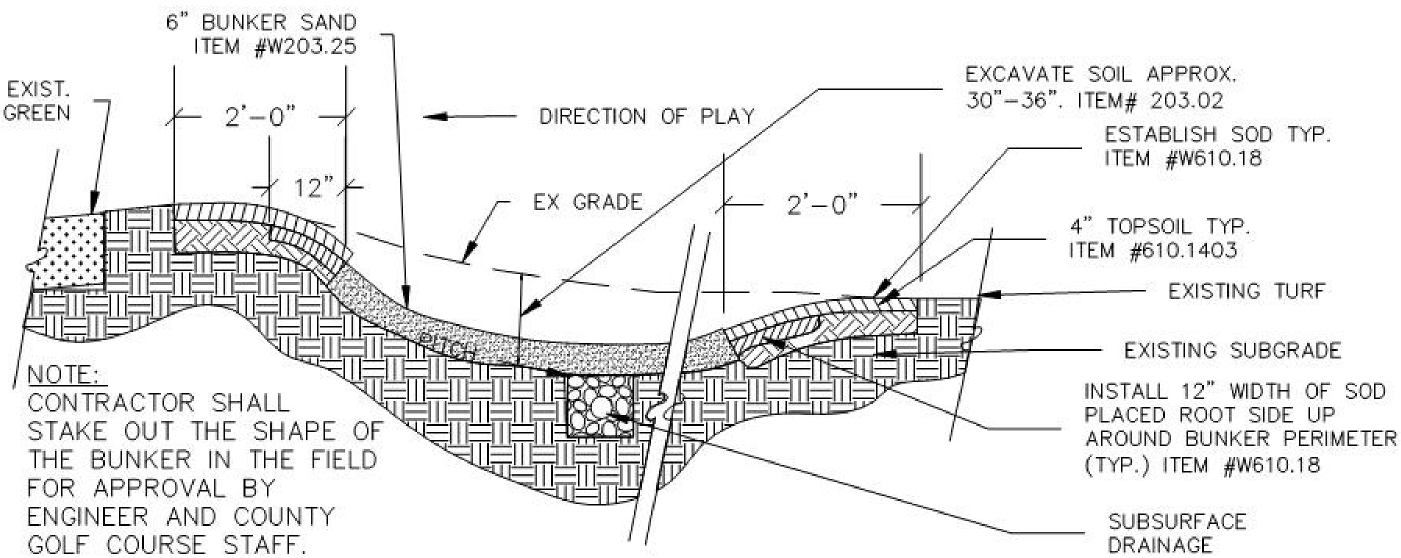
5.2.2.2 Placement of Fill and Drainage Improvements

We recommend installing approximately 2- to 3-feet of well drained fill over a portion of Golf Hole No. 9 to elevate the grade of the fairway and to install a perforated herringbone drainage system with gravel. The fill will allow for positive drainage across the fairway from west to east and will allow the surface waters to freely flow to the Mamaroneck River. The existing conditions of the fairway are generally flat and an existing berm along the river traps water on the fairway. The approximate area of fill is outlined on the Golf Hole #9 Preliminary improvement plan included in Appendix A. Because this area is in a mapped flood plain, there will need to be an equivalent volume of excavation in the flood plain to compensate for the loss of flood storage which is also shown on the Preliminary improvement plans. Excavated soil material from the proposed ponds may be used to elevate Golf Hole No. 9; however, the suitability of this soil will warrant further evaluation.

5.2.3 Bunkers

The County recently reconstructed the bunkers at the Saxon Woods Golf Course and would prefer the bunkers at Maple Moor be reconstructed to conform to the detail provided for that project. We have assessed all of the bunker drainage conditions and are recommending that all the bunkers be reconstructed and in some cases removed or relocated. The preliminary improvement plans show the recommendation for each bunker. These recommendations include relocating some of the bunker, reshape and reconstruction some of the bunker or simply eliminating some of the bunkers. Below is a summary of our review of the County Bunker section and additional recommendations relative to the bunker construction. Refer to the Figures below for additional information for the bunkers.

Figure 8: Sand Bunker Detail (1 of 4)



SAND BUNKER DETAIL (1 OF 4)
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MAPLE MOOR GOLF COURSE
SAND BUNKER DETAIL (1 OF 4)
City of White Plains **Westchester County** **New York**

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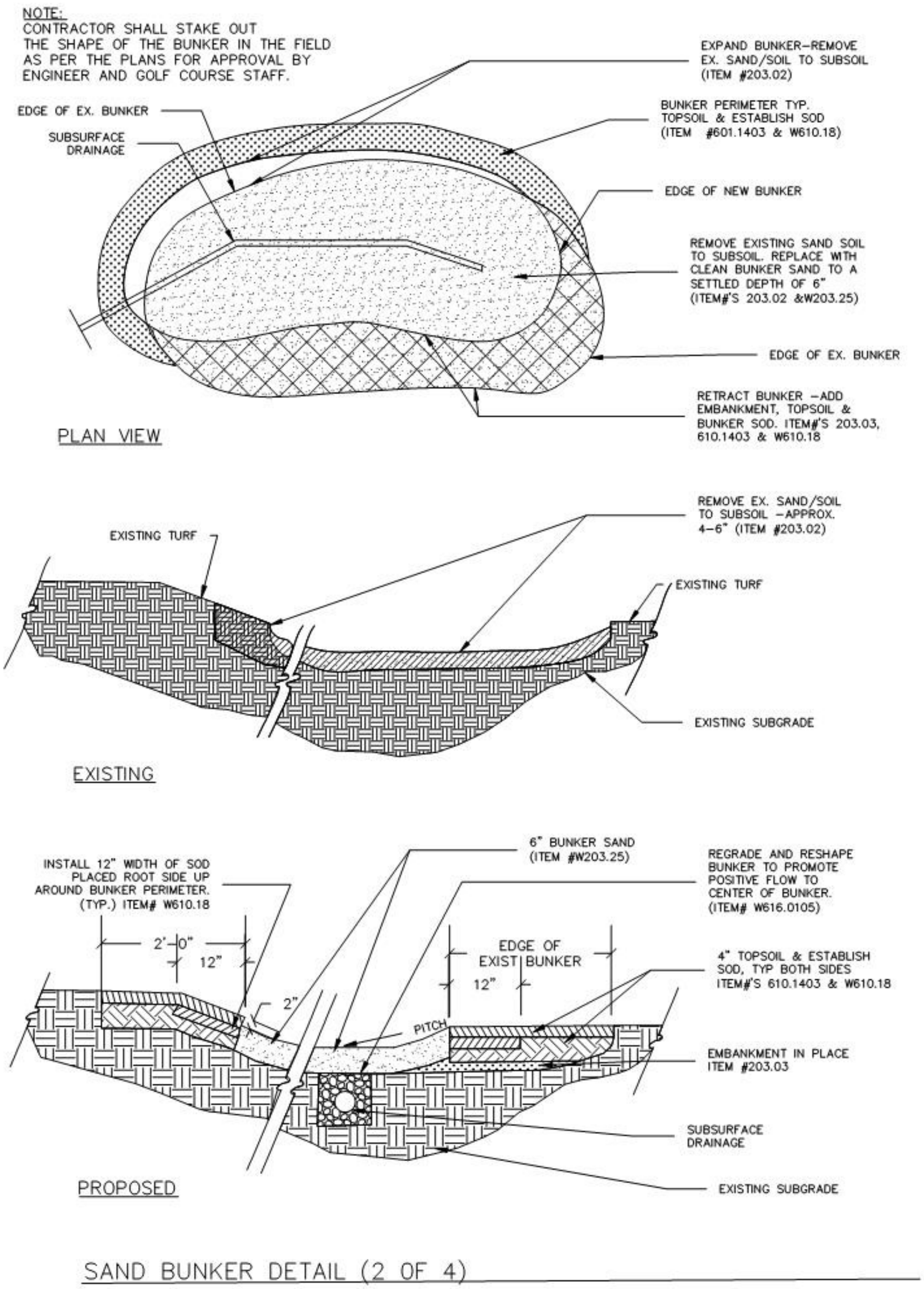
Figure 9: Sand Bunker Detail (2 of 4)



SAND BUNKER DETAIL (2 OF 4)
SCALE: N.T.S.

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Figure 10: Sand Bunker Detail (3 of 4)

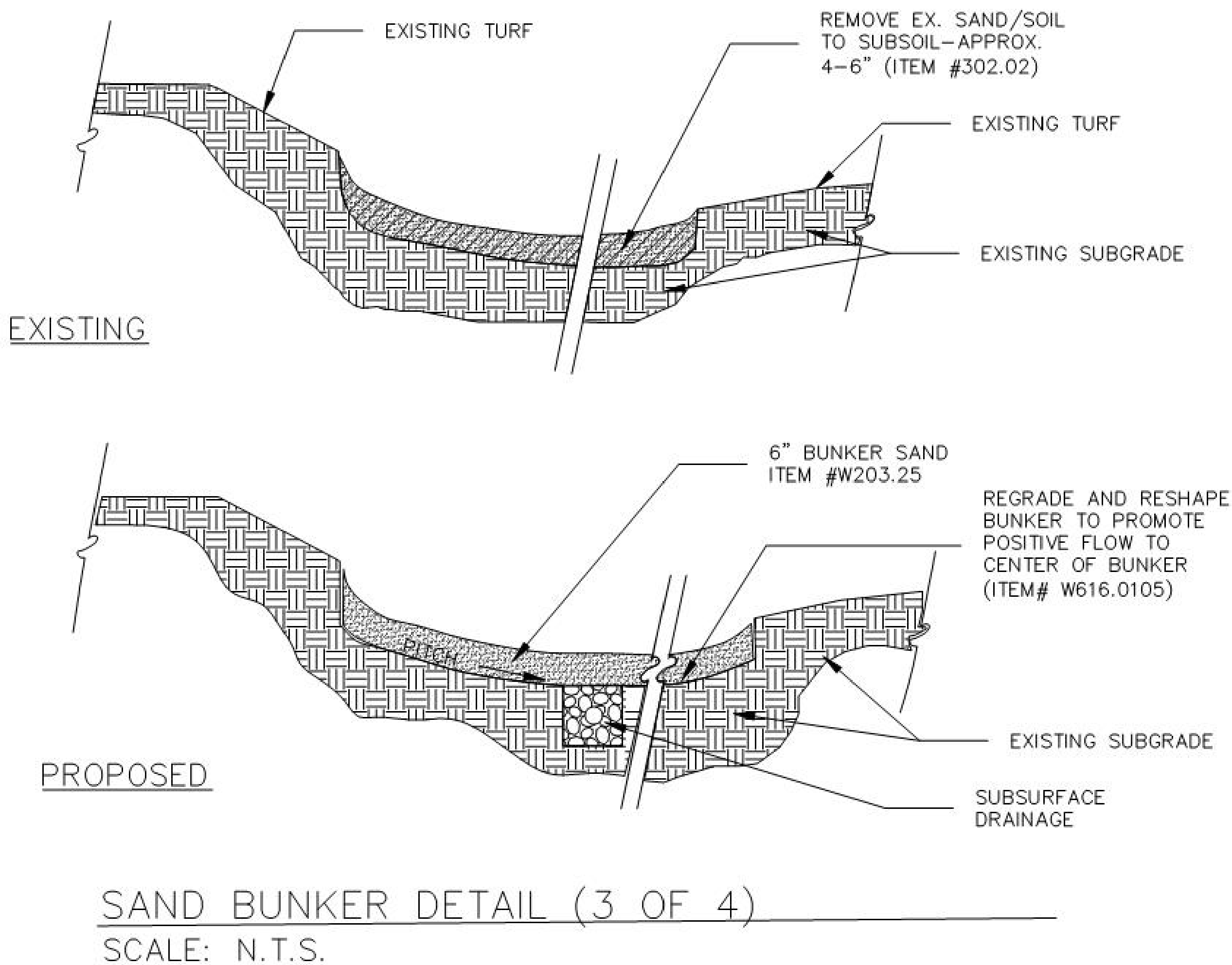

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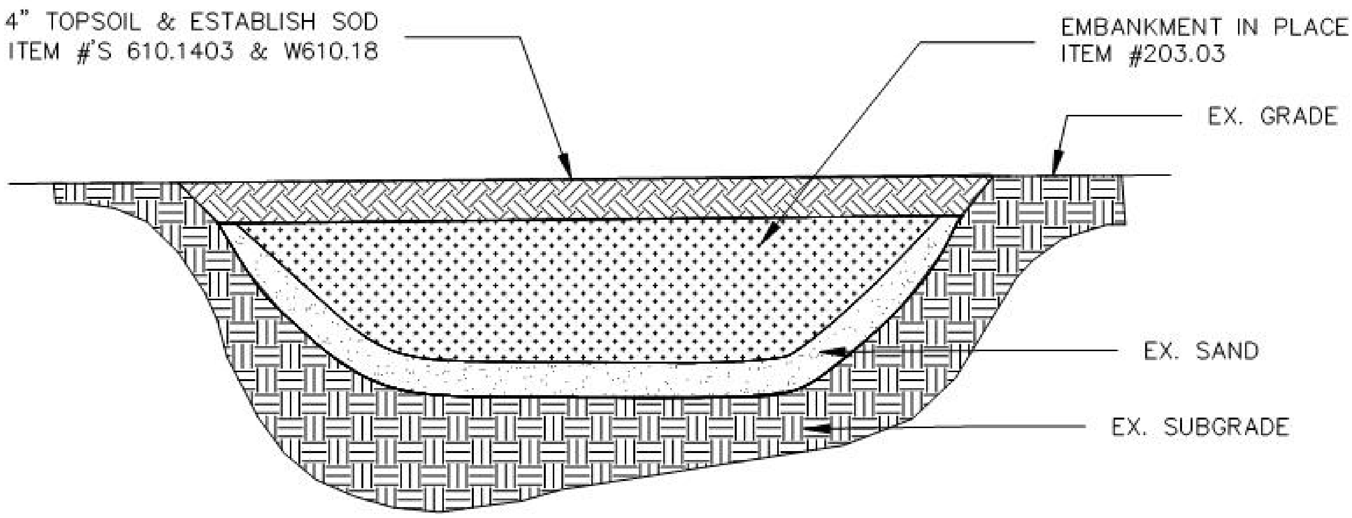
Figure 11: Sand Bunker Detail (4 of 4)



SAND BUNKER DETAIL (4 OF 4)
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LANGAN Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C. 707 Westchester Avenue, Suite 304 White Plains, NY 10604 T: 914.323.7400 F: 914.323.7401	MAPLE MOOR GOLF COURSE **SAND BUNKER DETAIL (4 OF 4)** City of White Plains / Westchester County / New York			
	JOB NO.	DATE	SCALE	FIGURE NO.
	190022601	**8/13/2015**	**NTS**	**11**

5.2.3.1 Recommendations on County Bunker Section

Our team has reviewed the County bunker detail that was utilized at the Saxon Woods Golf Course and we believe that the detail is missing a critical component to ensure the longevity and performance of the bunker. Below is a summary of our review of the bunker detail:

1. The detail does not provide a barrier (i.e. fabric liner or gravel layer) between the native soil and the bunker sand. Barriers have become an important and routine component of bunker construction for at least the last 15-years. The barriers significantly minimize the erosion of sand from bunker faces after a rain or irrigation event. The barriers also preclude potential contamination from underlying native soils, including the migration of rocks / gravel from underlying soils up into the sand.

    - As maintenance crews work to repair erosion that might occur during heavy rainfall events and place the sand back on the slopes, they will inevitably mix the sand and the soil, thereby further negatively affecting the drainage performance of the bunker. This is especially true when the bunkers are reworked and/or routinely maintained with mechanical rakes and push blades (as they are at Maple Moor) compared to the more labor intensive hand raking.

    Without a barrier, the County will incur excessive and unnecessary labor costs to routinely repair bunker erosion. In addition, the life expectancy of the bunker sand, as well as each bunker's internal drainage infrastructure will be greatly reduced, thereby requiring re-construction much sooner than necessary. It's not a question of "if" this will happen; it's more a question of how quickly it will happen.

    The day to day golfer experience will also be adversely affected by bunkers that don't drain or play well. Without some type of barrier, it is only a matter of time before the sand becomes contaminated with soil, thereby reducing drainage performance and eventually requiring premature replacement.

2. The detail does not provide adequate internal drainage. Additional perforated drain pipe should be installed across the actual bunker face / slope. Intercepting the runoff with perforated drain pipe, as soon as possible, reduces sand erosion.

3. The detail identifies sod to be installed "upside down" around the perimeter of the bunker edge. This is not a standard practice and not seen by our team, therefore, we cannot endorse this process without some first-hand knowledge of the effectiveness / success.

5.2.3.2 Fabric Barrier Bunker

Many courses have incorporated fabric liners in bunker construction. Until recently, fabric liners were the best option available to address the contamination issues and to help reduce everyday bunker maintenance costs.

Our concerns about using a fabric liner at Maple Moor include the following:

1. Because the bunkers at Maple Moor are routinely maintained with mechanical bunker rakes and push blades, the machines will inevitably "snag" and rip the liner. When this

happens, it is time consuming and very difficult to successfully "patch" the liner. In effect, the long-term viability and benefits of the barrier are compromised.

2. The fabric liners are secured with "staples". Because the course will experience annual "freeze and thaw", the staples will "heave" thereby compromising the interface between the liner and the soil, increasing the likelihood the liner will be snagged by a bunker rake.

3. The fabric liners can be easily "cut" by weed-eaters or other mechanical devices used to routinely trim or edge the bunkers. When the liner is cut, similar to being snagged, its effectiveness is reduced.

5.2.3.3 Gravel Layer Bunker Section/Better Billy Bunker (Recommended)

In our opinion, the Better Billy Bunker (BBB) is the best bunker construction technique currently available to the industry, in terms of reducing day to day maintenance expense & prolonging the life expectancy of the bunker sand and drainage (www.betterbillybunker.com).

Instead a fabric liner, this technique incorporates a two-inch layer of pea gravel beneath the bunker sand that is sprayed with a patented polymer to create a "pliable" barrier. Benefits of this technique include:

- Maximizing water infiltration rates, which reduces sand erosion & the need to routinely push sand back up on bunker faces
- Provides an effective barrier between underlying soils and bunker sand, thereby preserving sand quality.
- Is not subject to the potential "snagging / tearing" of a fabric liner.
- Is not subject to the potential cutting by trimming and edging operations.
- Is much less affected by soil "heaving", due to the "pliable' nature of the polymer.

The BBB process requires application of the polymer by a certified installer. Bidders that are not certified will typically submit higher bids; however, there are a number of certified installers that work in our area. Also, if the successful bidder is not a certified installer, BBB representatives will apply the polymer.

Installation also requires that the gravel be "dry" and the polymer be applied at a specific temperature. The temperature issue can be easily overcome with inside storage and heating of the drums. If the work is to be completed during the fall / winter, moisture content of the gravel could be a challenge.

The initial installation cost can be higher than a fabric liner, but the long-term payback, in terms of reduced day to day maintenance and prolonging the life of the bunker, as well as enhancing the golfer experience, is unmatched.

5.3 Alternative Sources of Water

We have evaluated potential alternative sources of water for irrigation of this course and possible combinations thereof including the following:

a. Site Stormwater collection and re-use as a supplemental source of irrigation water. This alternative will be more effective if the drainage improvements proposed as part of this project are implemented.
b. Diversion and retention of two existing surface drainage channels
c. Multiple drilled groundwater wells as a primary source. These are shallow wells (up to 50' deep) designed to draw from the existing groundwater.
d. Potential for using the Mamaroneck River water or shallow wells adjacent to the river. Although the potential issues with water quality might make this source unusable.
e. Installation of a deep rock well. Although our preliminary assessment of the hydrology of the areas leads us to the conclusion that a deep bedrock well with not produce an adequate yield.
f. City water as a backup or supplement source to each of the alternative water source options listed above.

The initial input from the County was that the Mamaroneck River is not suitable for use due to excessive sediment, salt content, highway storm water runoff and potential for upstream accidental spill sources. The County has reported that a study of salinity build-up on the turf was previously performed; however, the results have not been provided. We have performed our own sampling of the various water sources and provide our results in the following Water Quality section.

5.3.1 Water Quality

We obtained and submitted water samples from the stream at Golf Hole 2, the existing pond on Golf Hole 8 and Mamaroneck River to evaluate irrigation suitability. The analytical results represent conditions at the specific testing location on June 26, 2015. Surface water quality and suitability for irrigation use may vary seasonally and will likely change from year to year. Please refer to the Table below for the Water Quality Test Results:

Table 2: Water Quality Test Results – Stream at Hole 2

Analysis	Unit of Measure	Unit	Satisfactory	Possible Problem	Probable Problem
Water Characteristics					
Water pH	---	7.01	---	---	---
Hardness	---	49.70	0-125	126-245	>245
Bicarbonate	ppm	31.72	0-111	112-525	>525
Carbonate	ppm	0.00	0-12	13-62	>62
Impact on General Plant Growth					
Electrical Conductivity	mmhos/cm	0.23	0.0-0.75	0.75-3.0	>3.0
Total Soluble Salts	ppm	147.20	0-480	481-1950	>1950
Impact from Root Contact					
Sodium	meq/l	1.24	0.0-2.9	3.0-9.0	>9.0
Chloride	ppm	43.30	0-140	141-360	>360
Boron	ppm	0.02	0.0-0.5	0.6-2.0	>2.0
Impact from Foliage Contact					
Sodium	ppm	28.50	0-70	71-210	>210
Chloride	ppm	43.30	0-100	101-350	>350
Impact on Soil Structure					
Sodium Absorption Ratio	meq/l	1.15	0.0-6.0	6.1-9.0	>9.0
Electrical Conductivity	mmhos/cm	0.23	>0.5	<0.51	---

Table 3: Water Quality Test Results – Pond at Hole 8

Analysis	Unit of Measure	Unit	Satisfactory	Possible Problem	Probable Problem
Water Characteristics					
Water pH	---	6.92	---	---	---
Hardness	---	50.06	0-125	126-245	>245
Bicarbonate	ppm	43.92	0-111	112-525	>525
Carbonate	ppm	0.00	0-12	13-62	>62
Impact on General Plant Growth					
Electrical Conductivity	mmhos/cm	0.34	0.0-0.75	0.75-3.0	>3.0
Total Soluble Salts	ppm	216.32	0-480	481-1950	>1950
Impact from Root Contact					
Sodium	meq/l	1.72	0.0-2.9	3.0-9.0	>9.0
Chloride	ppm	72.37	0-140	141-360	>360
Boron	ppm	0.04	0.0-0.5	0.6-2.0	>2.0
Impact from Foliage Contact					
Sodium	ppm	39.57	0-70	71-210	>210
Chloride	ppm	72.37	0-100	101-350	>350
Impact on Soil Structure					
Sodium Absorption Ratio	meq/l	1.94	0.0-6.0	6.1-9.0	>9.0
Electrical Conductivity	mmhos/cm	0.34	>0.5	<0.51	---

Table 4: Water Quality Test Results – Mamaroneck River

Analysis	Unit of Measure	Unit	Satisfactory	Possible Problem	Probable Problem
Water Characteristics					
Water pH	---	7.07	---	---	---
Hardness	---	155.51	0-125	126-245	>245
Bicarbonate	ppm	97.60	0-111	112-525	>525
Carbonate	ppm	0.00	0-12	13-62	>62
Impact on General Plant Growth					
Electrical Conductivity	mmhos/cm	0.94	0.0-0.75	0.75-3.0	>3.0
Total Soluble Salts	ppm	604.16	0-480	481-1950	>1950
Impact from Root Contact					
Sodium	meq/l	3.62	0.0-2.9	3.0-9.0	>9.0
Chloride	ppm	234.20	0-140	141-360	>360
Boron	ppm	0.04	0.0-0.5	0.6-2.0	>2.0
Impact from Foliage Contact					
Sodium	ppm	83.21	0-70	71-210	>210
Chloride	ppm	234.20	0-100	101-350	>350
Impact on Soil Structure					
Sodium Absorption Ratio	meq/l	4.54	0.0-6.0	6.1-9.0	>9.0
Electrical Conductivity	mmhos/cm	0.94	>0.5	<0.51	---

As shown from the Table above, the Mamaroneck River water is not suitable as the primary source of irrigation. Irrigating with this water could potentially result in the buildup of salts in the root zone and desiccation of tree leaves wherever overspray reaches them. Bicarbonate levels are approaching the point (>120 ppm) where these ions can react with Ca and Mg in the soil and form insoluble calcium carbonate and magnesium carbonate.

Water from the Pond at Hole No. 8 and the Stream at Hole No. 2 meets most of the recommendations from the "Best Management Practices for New York State Golf Courses." However, when irrigation water is very low in salts (ECw<0.5) [Pond sample is 0.34-mmhos/cm and Stream sample is 0.23-mmhos/cm,]; permeability problems can arise at the soil surface even at the low sodium adsorption ratios reported in these samples.

Based on the water quality data, we believe that the onsite channel and pond, supplemented by well water and City water can be used to reduce the need to purchase **all** irrigation water from the City. Further the water quality of the blended sources should be suitable for irrigation. Depending on the final water quality, cultural practices may need to be modified or amendments may be required to maximize turf quality and we recommend that regular testing of the final irrigation sources be conducted and turf management activities adjusted accordingly.

5.3.2 Water Quantity

The course contingently plans to supplement ground water and/or surface water using a municipal source, for the purposes of this evaluation, we assume that the wells must be capable of sustaining a safe yield of 43 gpm with the best well out-of-service. This water quantity evaluation does not consider the implementation of storage systems (e.g., irrigation pond) that would abate peak water supply demand.

An assessment of water quantity relates to two primary considerations:

- Well yield
- Surface water availability.

Well Yield

Our review of geological maps reveals that the site is underlain by unconsolidated or surficial geological deposits that overlie the Hartland Formation, a metamorphic bedrock unit comprised of basal amphibolite overlain by pelitic schists.

According to the USGS water resources investigation report for the lower-Hudson region of upstate New York, the course is located on a portion of a 705-acre principal aquifer. Principal aquifers are identified by NYSDEC as highly productive or whose geology suggests abundant potential water supply. According to the USGS, thick, permeable, well-sorted sand and gravel deposits can produce yields greater than 100-gpm while units containing higher silt and fine sand can yield anywhere from 10- to 100-gpm As compared to till and bedrock wells that often yield less than 10 gpm. Yields in areas adjacent to streams can exceed 100-gpm through pumping-induced infiltration. The course surficial geology is primarily till comprised of silty and sandy loams, and rock outcropping along the western property boundary. Approximately 65-percent (82-Acres) of the course overlies this principal aquifer and the site is bound to the east by the Mamaroneck River.

Five wells are mapped by the New York State Department of Environmental Conservation (NYSDEC) within five miles of the course. The depth of the five wells is 300 to 500 feet deep. The average yield of four of the wells is less than 5 gpm; the average yield of the fifth well is reported to be 60-gpm. Additionally, seven wells are documented by the United States Geological Survey (USGS) in the 1955 Ground Water Resources of Westchester County Records of Wells and Test Holes. These wells were installed to a depth of 200- to 500-feet below ground surface and produced 5- to 50-gpm. However, most of these wells were eventually abandoned due to insufficient sustainable yield. Wells installed within schist are typically designed to intercept fractures that are capable of relatively higher yields. We reviewed the preliminary brittle structure map of New York provided by the New York State (NYS) Geological Survey to identify any major faults in the area. No faults are identified within the course property.

Based on the poor water-producing characteristics of the Hartland Formation and the absence of documented fractures, installation of a bedrock well does not appear to be a viable source of water. However, based on the presence of the principal aquifer of unconsolidated deposits that underlies the golf course adjacent to the Mamaroneck River, a network of shallow ground water wells may be sufficient to satisfy a significant portion of the required irrigation water.

Surface Water Availability

Approximate surface water availability was calculated using two USGS stream gauges installed at the Mamaroneck River, south of the course:

- USGS 01301000 Mamaroneck River at Mamaroneck NY; and
- USGS 013000800 Mamaroneck River at Winfield Ave at Mamaroneck NY.

USGS 01301000 and USGS 013000800 have drainage areas of 23.4- and 14.5-square-miles, respectively. Daily average discharge was recorded at USGS01301000 from 1 October 1944 through 30 September 1989. The average stream flow over the 45-year period was 35.9-cubic-feet-per-second (cfs). Based on USGS stream gauge data, approximate drainage area and average daily discharge were calculated for a potential well location at the southernmost portion of the course adjacent to the Mamaroneck River. The approximate drainage area was calculated to be 13.1-square-miles with an average daily discharge of 20.0-cfs or 12,926,338-gallons-per-day.

However, based on the water quality test results included in table 4 above, which indicated very poor water quality, we have verified that taking water from the Mamaroneck River is not a viable option for reasons the County has already identified. There are high levels of sediment, salinity and highly unpredictable water conditions from season to season, making it difficult to consider the River as a reliable source of water.

5.3.3 Surface and Groundwater Exploratory Program

Langan proposes to implement a surface and ground water exploratory program consisting of the following:

1) Install two temporary well points and conduct a 2-hour pumping tests at each point to determine approximate pumping sustainability; and if the results are favorable,

2) Design and install a well system and conduct a constant pump rate test and step-drawdown test.

The temporary well points will be installed on the southeast side of the golf course along the Mamaroneck River, where a full-scale well system could presumably be installed. A New York-licensed well driller will install the wells. Drilling and aquifer testing will be conducted with oversight provided by Langan.

Temporary Well Point Testing Scope of Work:

- Advance a pilot borehole at the proposed temporary well point location and obtain soil samples at 5-foot intervals to identify textural composition of the substrate.
- A 2-inch diameter, temporary well will be installed to bedrock with a well screen length determined based on field observations and slot size no greater than 0.20-inch.
- A 2-hour pumping test will be conducted to determine the maximum pumping rate that can be sustained.
- Data from the 2-hour pump test will be used to support water quantity and assumed water yield conclusions presented herein.

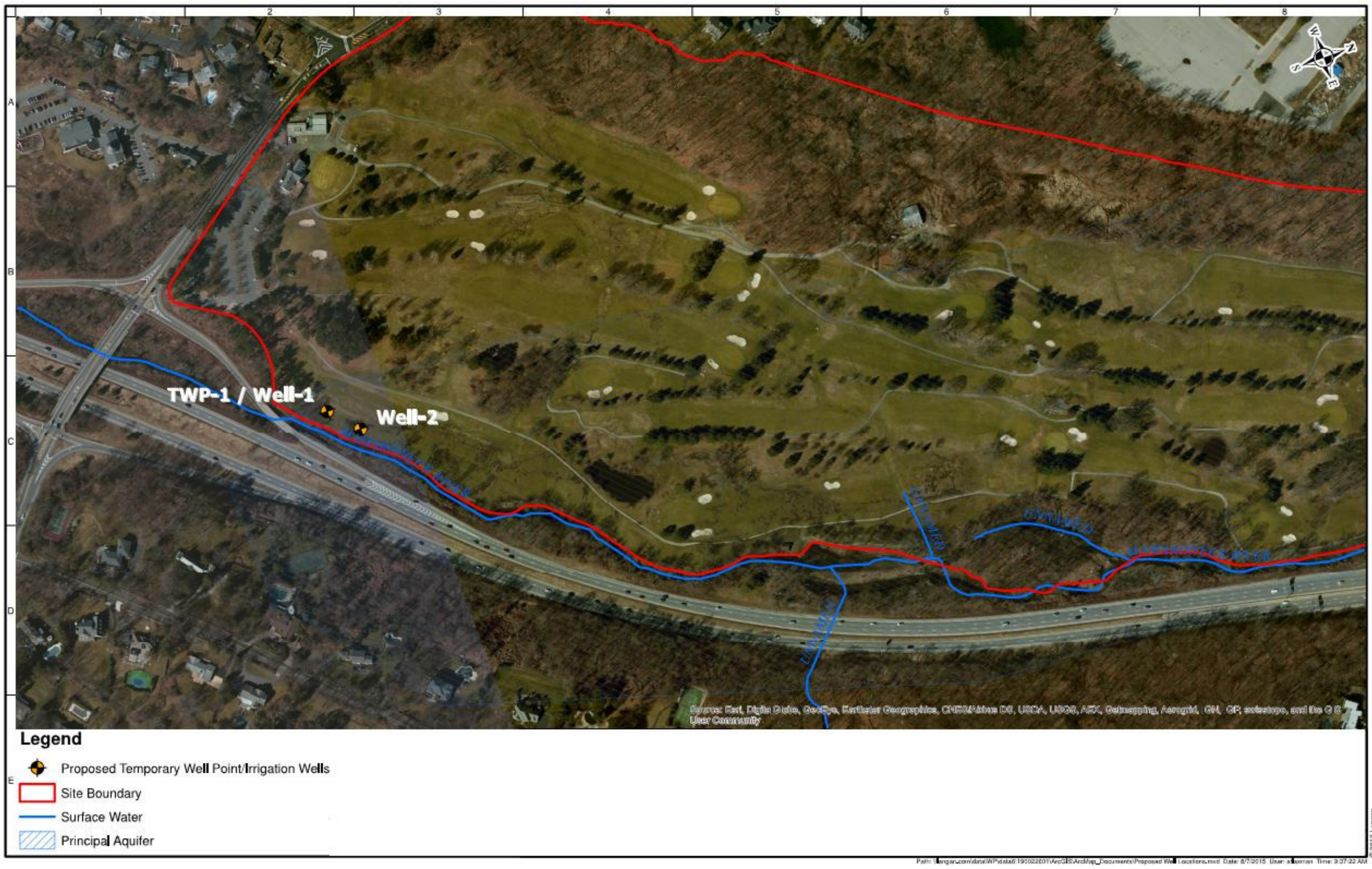
Well-System Testing Scope of Work:

- Develop and design a well system layout based on the findings of the temporary well point investigation.
- Install a well system according to the specifications of the design.
- Conduct constant-rate and step-drawdown pumping tests.
    - Constant-rate pumping tests involve pumping a control well at a constant-rate and measuring water-level response in surrounding observations wells. The results of this test can be used to estimate hydraulic properties of the aquifer system.
    - Step-drawdown tests involve pumping a single well at controlled discharge rates, starting from a low constant rate up to a progressively higher constant rate. The results of this test can be used to evaluate performance of the well.
- If the results of the pumping tests are favorable, the wells can be permitted for use in an irrigation system.

Well Locations

The proposed well locations are shown on Figure 12 of this report. The Mamaroneck River is a Class C water that is not considered navigable and no wetlands are mapped along the Maple Moor golf course river boundary; therefore, any wells installed along the property boundary adjacent to the river are not subject to New York State Department of Environmental Conservation jurisdiction. Although the stream would be subject to United States Army Corp of Engineers (USACE) jurisdiction, USACE do not regulate any buffers or setbacks. Based on presumed ground water yield, it is anticipated that two groundwater wells could satisfy a majority if not all of the required irrigation demand for this course.

Figure 12: Proposed Well Location Map



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MAPLE MOOR GOLF COURSE
PROPOSED WELL LOCATION MAP

City of White Plains	Westchester County		New York
JOB NO.	DATE	SCALE	FIGURE NO.
190022601	8/13/2015	NTS	12

5.3.4 Site Stormwater Collection and Re-use

5.3.4.1 Hydrologic Analysis Methodology

A study area was developed using aerial photographs, topographical survey, soils surveys, and site investigations. The study area consists of an overall watershed that encompasses approximately 271-acres including the entire project site. The southernmost point on the property along the Mamaroneck River was selected as a design point, since the stormwater runoff generated from the study area ultimately discharges to this location.

Since the subject project is a golf course and proposes the disturbance of more than one (1) acre, coverage under the NYSDEC SPDES General Permit No. GP-0-15-002 is required. In order to meet the requirements set forth by this permit, the latest edition of the NYSDEC *New York State Stormwater Management Design Manual* (Design Manual) was referenced for the design of the proposed stormwater management system. The Stormwater Pollution Prevention Plan (SWPPP) shall be prepared for the proposed redevelopment activities with a slight increase in impervious surface. The Design Manual specifies four design criteria, including Water Quality Volume, Stream Channel Protection Volume, Overbank Flood Control, and Extreme Flood Control shall be discussed in detail below. The first of the requirements relates to treating water quality, while the later pertain to stormwater quantity (peak flow) attenuation. The stormwater runoff from the proposed condition will be directed to the proposed ponds for treatment to meet the stormwater quality and quantity requirements. A detailed analysis shall be performed in the project Stormwater Pollution Prevention Plan.

The Water Quality Volume (WQv) is intended to improve water quality by capturing and treating 90-percent of the annual stormwater runoff volumes as required by the General Permit GP-0-15-002. The WQv is directly related to the amount of impervious cover located on the site. A detailed WQv analysis shall be included in the project SWPPP.

Since the redevelopment project has a slight increase in impervious surface the Stream Channel Protection Volume (CPv) criteria must be met. The CPv is intended to protect stream channels from erosion and is accomplished by the 24-hour extended detention of the center-of-mass from the 1-year, 24-hour storm event. The proposed stormwater management system has been designed to meet this requirement. A detailed CPv analysis shall be included in the project SWPPP.

The Overbank Flood Control (Qp) requirement is intended to prevent an increase in the frequency and magnitude of out-of-bank flooding events generated by urban development. Overbank control requires storage to attenuate the post-development 10-year, 24-hour peak discharge to pre-development rates. The Extreme Flood Control (Qf) requirement is intended to prevent the increased risk of flood damage from large storm events, maintain the boundaries of the pre-development 100-year flood plain, and protect the physical integrity of stormwater management practices. Extreme flood control requires storage to attenuate the post-development 100-year, 24-hour peak discharge to pre-development rates. A detailed Qp and Qf analysis shall be included in the project SWPPP.

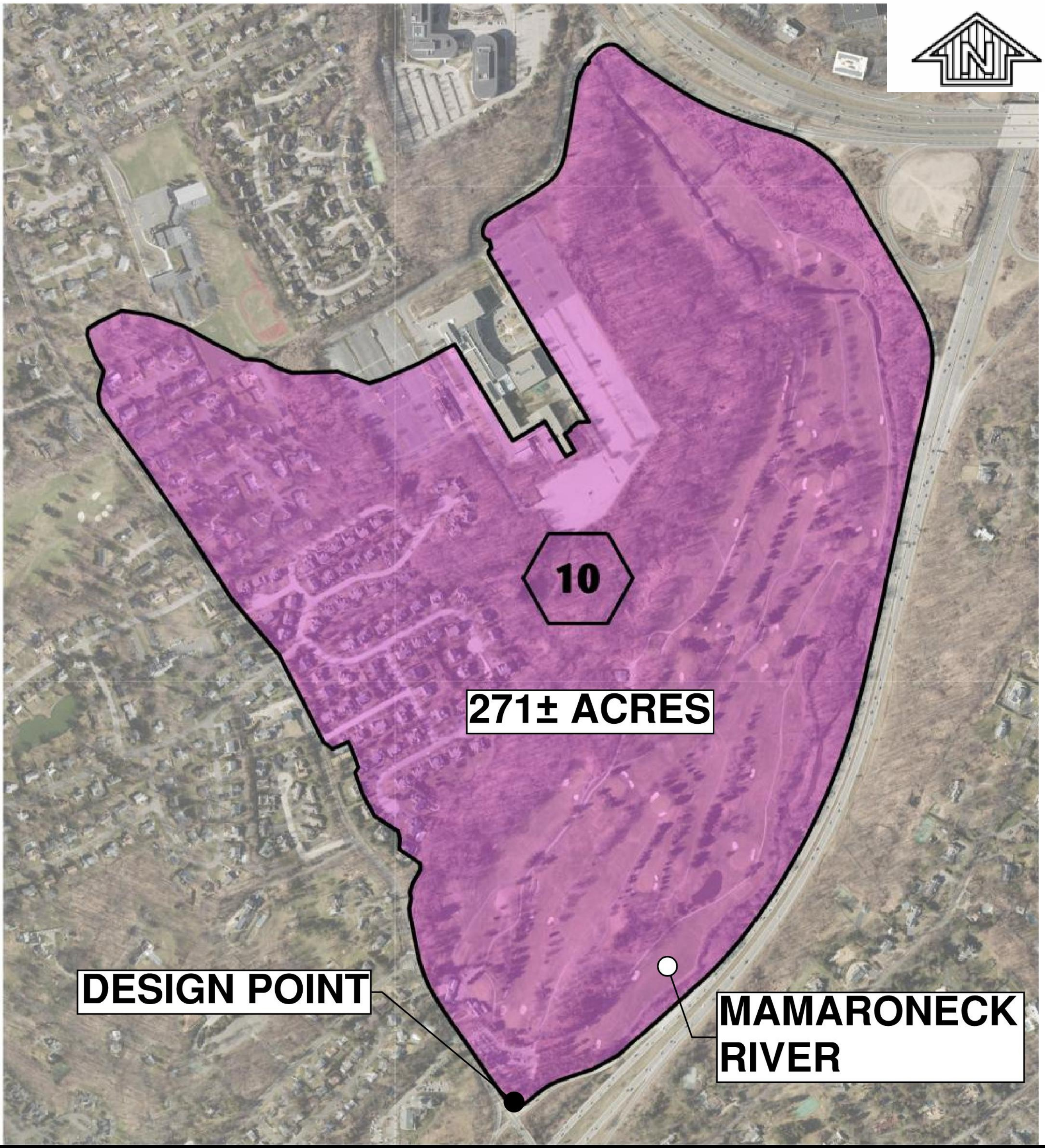
To address the stormwater quantity requirements for NYSDEC, the “HydroCAD” Stormwater Modeling System, by HydroCAD Software Solutions LLC in Tampworth, New Hampshire, was used to analyze the hydrologic characteristics of the post-development watershed conditions. HydroCAD has the capability of computing hydrographs (which represents discharge rates characteristic of specified watershed conditions, precipitation, and geologic factors), combining hydrographs, and routing flows though pipes, streams, channels, and ponds.

5.3.4.2 Existing Drainage Conditions

The existing conditions consist of a single watershed (Subcatchment 10) that contributes to a portion of the Mamaroneck River that runs through the property. The existing watershed ground cover consists of impervious surfaces (e.g., buildings, pavement, sidewalks, and cart paths), gravel access drives, water surfaces (e.g., pools, ponds, streams, and river), grassed and landscaped areas, and woods.

Subcatchment 10 stormwater runoff flows in a southeastern direction into the Mamaroneck River. The existing conditions subcatchment boundary is shown on Figure 13: Existing Condition Drainage Map below and is also provided in Appendix A.

Figure 13: Existing Condition Drainage Map



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MAPLE MOOR GOLF COURSE
EXISTING CONDITION DRAINAGE MAP

City of White Plains | Westchester County | New York

JOB NO.	DATE	SCALE	FIGURE NO.
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5.3.4.3 Proposed Drainage Conditions

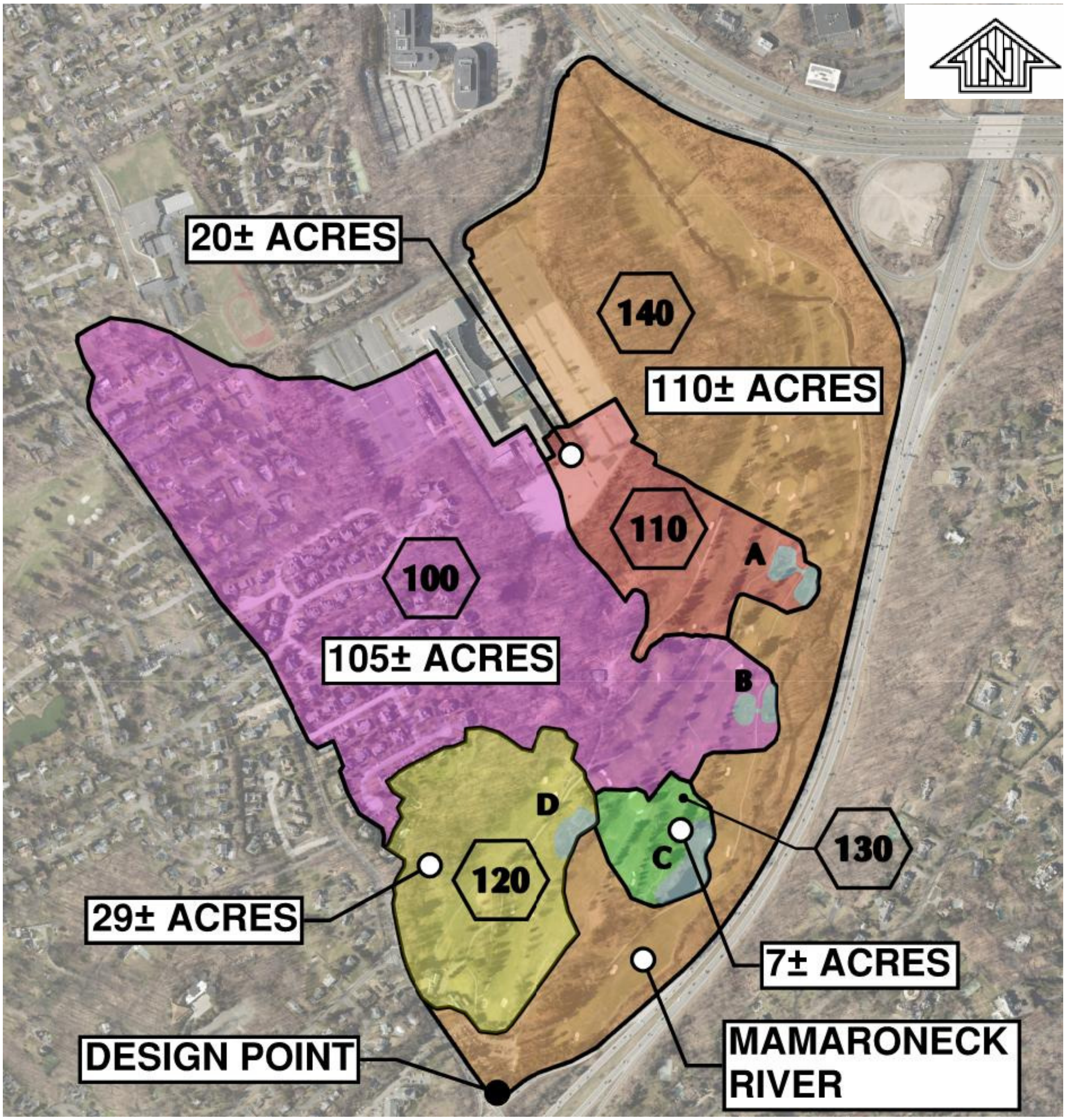
The overall watershed was broken down into smaller watersheds, or subcatchments, to allow for analysis of runoff conditions to each of the ponds (A, B, C, and D) as well as the Mamaroneck River in the proposed conditions. The proposed watershed ground cover consists of impervious surfaces (e.g., buildings, pavement, sidewalks, and cart paths), gravel access drives, water surfaces (e.g., pools, ponds, streams, and river), grassed and landscaped areas, and woods.

The stormwater runoff characteristics for the subcatchment areas are as follows:

- Subcatchment 110 stormwater runoff flows in a southeasterly direction into the proposed Pond A.
- Subcatchment 100 stormwater runoff flows in a southeasterly direction into the proposed Pond B.
- Subcatchment 130 stormwater runoff flows in a southeasterly direction into the expanded Pond C.
- Subcatchment 120 stormwater runoff flows in a southeasterly direction into the proposed Pond D.
- Subcatchment 140 stormwater runoff flows in a southeastern direction into the Mamaroneck River.

The proposed conditions subcatchment boundary is shown on Figure 14: Proposed Condition Drainage Map below and is also provided in Appendix A.

Figure 14: Proposed Condition Drainage Map



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MAPLE MOOR GOLF COURSE
PROPOSED CONDITION DRAINAGE MAP

City of White Plains | Westchester County | New York

JOB NO.	DATE	SCALE	FIGURE NO.
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5.3.4.4 Proposed Ponds

The rainfall data for the required design storms used in the modeling analysis was obtained from the isohyets maps at the Northeast Regional Climate Center. These maps are available online at http://precip.eas.cornell.edu. The values provided are for the extreme precipitation for a 24-hour design storm event. The rainfall data is provided in Table 5: Rainfall Data below.

Table 5: Rainfall Data

Storm Event	24-Hour Rainfall
90%	1.50-inches
1-year	2.80-inches
10-year	5.25-inches

The peak discharge rate to the ponds from their contributing subcatchments is provided in Table 6: Peak Discharge Rates to Ponds below.

Table 6: Peak Discharge Rates to Ponds

Storm Event	Pond A (cfs)	Pond B (cfs)	Pond C (cfs)	Pond D (cfs)
90%	1.84	9.38	0.85	1.46
1-year	13.23	48.00	5.69	15.97
10-year	43.81	144.19	18.17	60.00

5.3.5 Proposed Stormwater Conveyance System

The stormwater collection and conveyance systems for the project will consist of deep sump drain inlets, drainage manholes, and HDPE drainage pipes. The system shall be sized to collect and convey the 10-year, 24-hour design storm using the Rational Method. The Rational Method is a standard method used by engineers to develop flow rates for sizing collection systems. The Rational Method calculates flows based on a 1-hour design storm. A detailed analysis shall be included in the project SWPPP.

5.3.6 Irrigation Water Use

The existing water use for the golf course has been estimated by the City of White Plains Water Bills for the billing period from December 28, 2011 through March 25, 2015. The City utilized a progressive water structure which means that the unit rate escalates with increased usage. In 2014, water customers are charged a starting rate of $1.73 per 100-cubic-feet of water (1-cubic-foot = 7.48-gallons of water, therefore 100-cubic-feet is 748-gallons). The average annual water bill for a family of four is estimated to be $182.00 according to the City of White Plains water use data. The table below shows the water use from the golf course from the reference dates above according to the water meter (#84014074).

Table 7: Irrigation Water Use (1 of 2)

Date	Days of Service	Meter Reading	Water Use (Hundreds of Cubic Feet	Water Use (Gallons)	Reported Avg. Daily Consumption (CCF)	Calculated Average Daily Consumption (Gallons)
28 Dec. 2011	89	47,766	No Reading	----	No Reading	----
26 Mar. 2012	89	47,770	4	2,992	No Reading	34
26 June 2012	92	51,457	3,687	2,757,876	No Reading	29,977
25 Sep. 2012	91	58,911	7,454	5,575,592	No Reading	61,270
17 Dec. 2012	83	59,237	326	243,848	3.93	2,938
26 Mar. 2013	99	59,237	0	0	0.00	0
25 June 2013	89	62,243	3,006	2,248,488	33.03	25,264
24 Sep. 2013	91	70,147	7,904	5,912,192	86.86	64,969
17 Dec. 2013	84	72,134	1,987	1,486,276	23.65	17,694
27 Mar. 2014	100	72,134	0	0	0	0
24 June 2014	89	74,606	2,472	1,849,056	27.78	20,776
24 Sep. 2014	92	85,247	10,641	7,959,468	115.66	86,516
17 Dec. 2014	84	85,507	260	194,480	3.1	2,315
25 Mar. 2015	98	85,507	0	0	0	0

Table 8: Irrigation Water Use (2 of 2)

Date	Amount Paid	Calculated Rate per Gallon	Estimated Annual Use (MGY)
28 Dec. 2011	----	----	----
26 Mar. 2012	$95.89	$0.0320	----
26 June 2012	$28,741.24	$0.0104	----
25 Sep. 2012	$67,067.40	$0.0120	----
17 Dec. 2012	$1,262.76	$0.0052	8.58
26 Mar. 2013	$35.97	$0.0000	----
25 June 2013	$35,853.68	$0.0159	----
24 Sep. 2013	$86,364.88	$0.0146	----
17 Dec. 2013	$16,590.89	$0.0112	9.65
27 Mar. 2014	$171.20	$0.0000	----
24 June 2014	$25,309.50	$0.0137	----
24 Sep. 2014	$132,343.68	$0.0166	----
17 Dec. 2014	$1,868.25	$0.0096	10.00
25 Mar. 2015	$278.87	$0.0000	----
		Avg. MGY (2012-2014)	**9.41**

From 2012 through 2014, the water use from the golf course for irrigation use has been estimated to be 9.41-million-gallons-year.

5.3.7 Water Volume and Storage in Ponds

The irrigation water source is expected to include water from surface flow across the site, well points, groundwater inflow to the ponds and supplement as needed with the City of White Plains water supply. The water will be stored in a series of lined and unlined ponds approximately 3 acres in size integrated in to the existing golf course. At this time, we anticipate that the ponds could provide adequate storage for irrigation water, which will reduce the golf course's reliance on the City water supply. An overall depth of approximately 14-feet has been predicted, pending investigation of soil conditions and ledge.

- Pond A – ±28,500-square-foot pond and will be lined. Water supply shall be a combination of surface water and municipal water.

- Pond B - ±22,650-square-foot pond and will be unlined. Water supply shall be a combination of surface water, groundwater and well water.

- Pond C - ±60,400-square-foot pond and will be unlined. Water supply shall be a combination of surface water, groundwater and well water. Please note, Pond C is an expansion of the existing pond.

- Pond D - ±30,700-square-foot pond and will be lined. Water supply shall be a combination of surface water and municipal water.

The total storage area of approximately 3 acres with a conservative estimate of available water storage of 27-acre-feet is predicted.

Table 9: Pond Volumes

Ponds	Cubic-Feet	Acre-Feet	Million Gallons
A	±235,125	±5.40	1.76
B	±186,863	±4.29	1.40
C	±498,300	±11.44	3.73
D	±253,275	±5.81	1.89

The proposed pond area (8.78-million-gallons of storage) should be adequate assuming water sources include a combination of surface flow, groundwater inflow (to Ponds B & C), groundwater wells and City water.

As referenced above in Table 6: Peak Discharge Rates to Ponds, for the 90% storm event each pond shall receive the following gallons per day:

- Pond A = 1.84-cfs * 646,316.883 = 1,189,223-gpd

- Pond B = 9.38-cfs * 646,316.883 = 6,062,452-gpd

- Pond C = 0.85-cfs * 646,316.883 = 549,370-gpd

- Pond D = 1.46-cfs * 646,316.883 = 943,623-gpd

The approximate total gallons per day that shall be received by the proposed ponds for a 90% storm event is 8,744,668 gpd.

In order to evaluate the average daily and peak irrigation demands, we estimated that approximately 60-acres of turf will be irrigated under future conditions. The average daily demand according to the City of White Plains water bills and based on evapotranspiration and turf area is approximately 102,000-gallons-per-day with a peak demand expected to be 200,000- to 250,000-gallons-per-day.

Without a recharge rate it is not possible to model drawdown in the ponds, but in our opinion the pond area should be adequate assuming water sources include a combination of surface flow, groundwater inflow, groundwater wells that will allow the golf course to significantly reduce the use of City water. Upon further testing in the vicinity of the ponds, we will be able to determine a recharge rate in the area.

5.3.8 City Supplied Water

Based on our current evaluations, we recommend maintaining the municipal water connection to the new water pump station to deal with unpredictable weather and groundwater conditions. Additionally, the City water may be needed to blend the water as indicated under the water quality section. The existing 6-inch ductile iron main will be extended from the current pump house to the proposed location on the west side of Hole No. 8. The appropriate backflow prevention device will be installed within the well house.

5.4 Irrigation System

The proposed irrigation system focuses on replacing the existing system and reducing or eliminating the need for city water as the primary water supply.

5.4.1 Proposed Irrigation System

1. Coverage:
   e. Greens – full circle green heads and part-circle perimeter heads
   f. Fairways – two rows of full circle heads
   g. Front tee to fairway (except Fescue areas) – single row full circle heads
   h. Tee – Two rows of short radius full circle heads
2. Sprinkler Heads – All individually controlled electric valve-in-head units
3. Control System – State-of-the-art PC based central with satellite or two-wire network in field
   a. Specifications will require full approval by County personnel of all hardware and software in control system.
   b. Control system will be compatible, and able to communicate, with pump station, weather station, etc., and will allow for remote monitoring and control
   c. Proper grounding of all components
   d. On-site weather station will be included, although not required for control system
4. Pipe and Fittings :
   a. Pipe will be SDR 21 PVC to keep all options open concerning water source.
   b. Fittings 4-inch and larger will be deep bell, push-on, gasket joint ductile iron, with fusion bond epoxy coating inside and outside
   c. Pipe layout – Mains in rough, 2-inch herringbone laterals to heads in fairways and greens. 2-inch loop at tees
5. Isolation Valves:

   a. Main on each hole isolated with resilient wedge, epoxy coated ductile iron AWWA C509 units with push-on gasket ends for PVC pipe
   b. Laterals at greens will have individual isolation valves
6. Air Release Valves: Will be located as dictated by pipe routing and topography
7. Quick Coupling Valves:
   a. Greens: One on each green lateral
   b. Tee complexes: One every 75-feet inline
   c. Fairways: One at each landing area, one at each fairway bunker

5.5 Pump Station and Electrical Improvements

The pump station will be a fully automated skid-mounted unit, which keeps constant pressure on the irrigation system while meeting the various flow demands of irrigation programs. The station will have a microprocessor controller and variable frequency drive on main pumps. There will be 3-HP submersible line maintenance pumps and two larger main pumps in the wet well. Main pumps will be of the vertical turbine type, driven by 1800-RPM electric motors. The pump station will be capable of discharging 1200-GPM at a pressure to be determined after irrigation system design is completed.

The station is intended to operate on 480-volt, three phase, 60-hertz power.

The pump set will be determined after pump building finished floor and pond bottom elevation are established for the 60-percent submission. The station will include a heat exchanger in an enclosure housing drive unit and their controls.

In addition to standard features, the station will include the following:

1. Flow meter with totalizer
2. Phase failure and low voltage protection for all motors
3. Isolation and check valves in each pump discharge
4. Station discharge isolation valve
5. Touch-screen HMI device
6. Downstream relief valve
7. Automatic alternator
8. Automatic ramp up
9. Remote monitoring capability with radio communication (plus antennas and 50-feet cables) to central irrigation PC and software for latter
10. Automatic diagnostics
11. Variable frequency drive to accommodate main pump HP
12. Main disconnect with 200,000 AIC rating
13. Interface with irrigation system central controller
14. Motor space heaters
15. Lake screen with adapter for SDR 35 PVC flume
16. Lake level control
17. Auto flush wye strainer
18. External J-box for LLC control interface
19. Pressure gauge

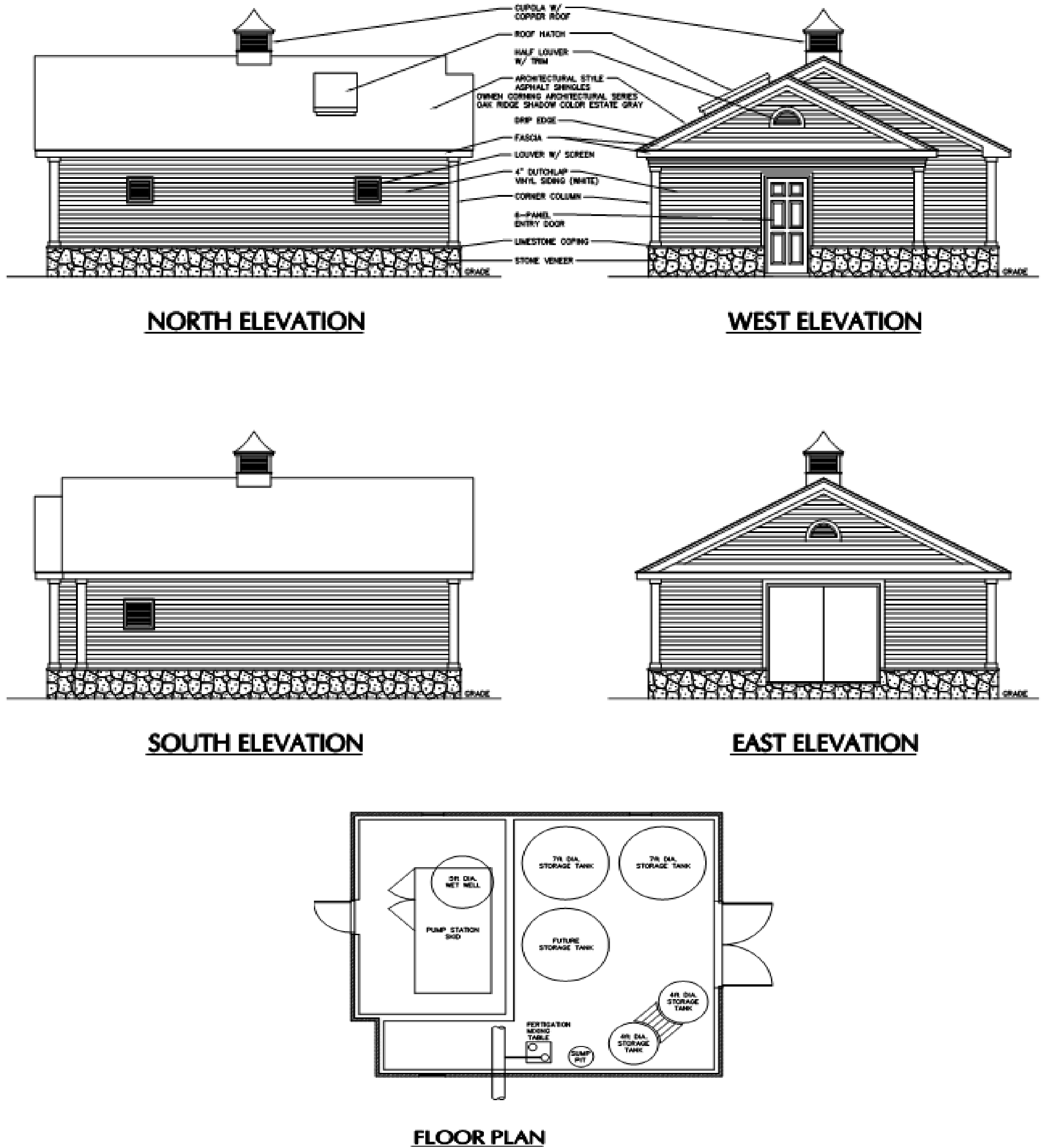
The following safety circuits (all with manual reset and indicator lights) are to be included in station:

1. Low discharge pressure shutdown, with manual over-ride
2. High discharge pressure shutdown
3. Lightning protection
4. Low intake water level

The wet well will be constructed of reinforced concrete manhole sections with an integral 8-inch thick concrete floor meeting ASTM C478. Butyl sealant strips conforming to ASTM C 990 will be installed at section joints. Polypropylene-coated reinforced steel ladder rungs shall be press fit into wet well wall and aligned under access hatch in pump skid. SDR 35 PVC flume pipe shall connect to wet well with Link-Seal modular seal.

The wet well and equipment will be house in a new pump house structure that will be elevated out of the flood plain. The elevation of the new pump house will be approximately 98-feet. The pump house will consist of a stone base with hardy plank or shakes above (refer to Figure 15: Pump House Structure Schematic Plan and Figure 16: Pump House Structure Photographs for additional information).

Figure 15: Pump House Structure Schematic Plan



LANGAN	**MAPLE MOOR GOLF COURSE** **PUMP HOUSE STRUCTURE SCHEMATIC PLAN** **City of White Plains** **Westchester County** **New York**			
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C. **707 Westchester Avenue, Suite 304 White Plains, NY 10604** **T: 914.323.7400 F: 914.323.7401**	JOB NO. **190022601**	DATE **8/13/2015**	SCALE **NTS**	FIGURE NO. **15**

Figure 16: Pump House Structure Photographs

MAPLE MOOR GOLF COURSE
PUMP HOUSE STRUCTURE PHOTOGRAPHS
City of White Plains | Westchester County | New York

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5.6 Bridge Evaluation

There are five (5) bridges that have been evaluated by our team. Refer to Table and Figure below for descriptions and locations of each bridge.

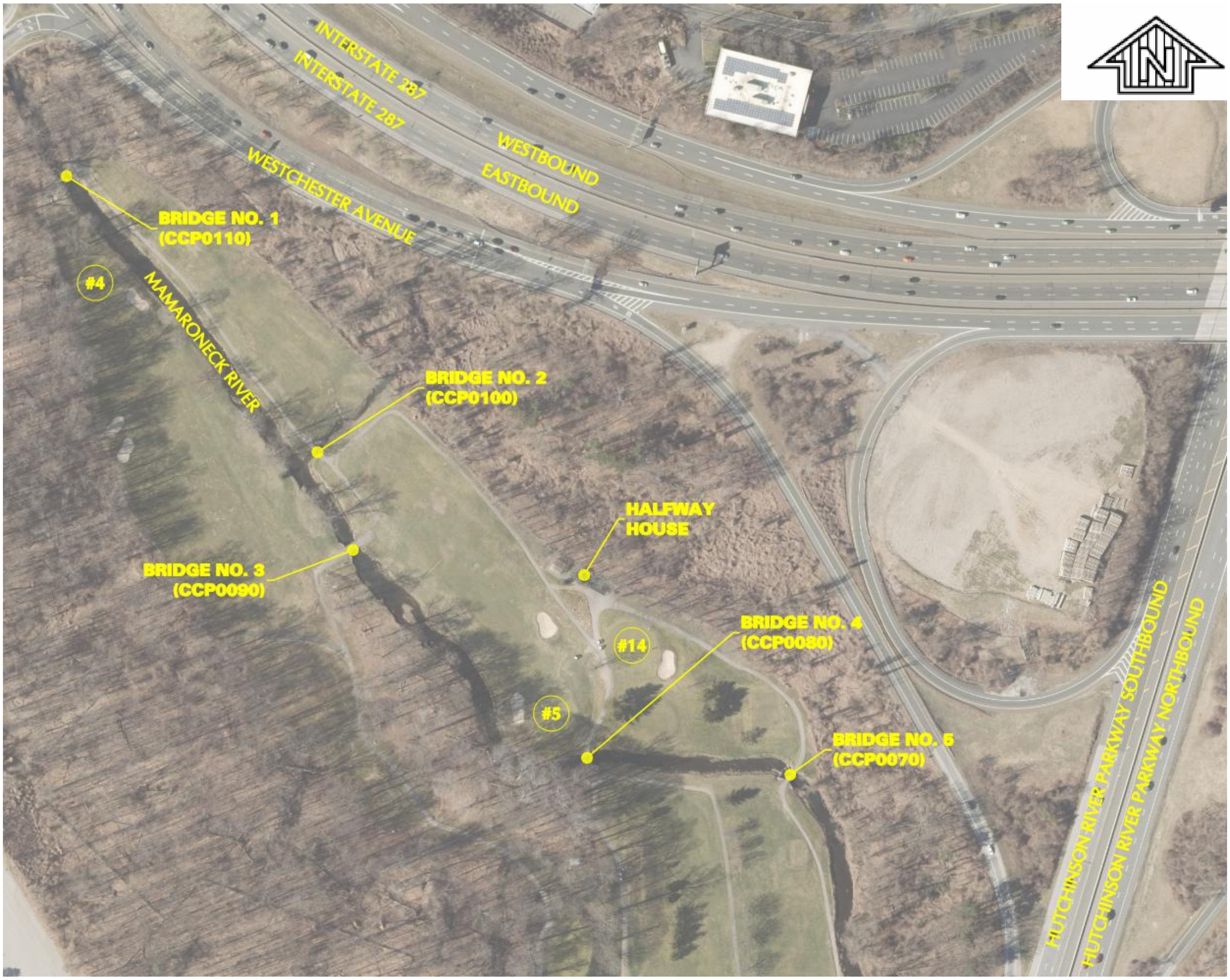
Table 10: Bridge Observations (1 of 2)

<table>
<tr><th colspan="2">Parameter</th><th>Bridge No. 1</th><th>Bridge No. 2</th><th>Bridge No. 3</th></tr>
<tr><th colspan="2">Bridge ID No.</th><th>CCP0110</th><th>CCP0100</th><th>CCP0090</th></tr>
<tr><td rowspan="3">Type of Construction</td><td>Decking Material</td><td>4"x8" Wood Planks</td><td>4" x 8" Wood Planks</td><td>5 - 3 ft. wide x 15' deep Pre-cast Concrete planks w/2" asphalt top tied w/ steel rods.</td></tr>
<tr><td>Support Beams</td><td>6 - Steel beams W15 (B_f=5.5")</td><td>3 - Steel beams W12</td><td>Concrete Grade Beam</td></tr>
<tr><td>Bridge Support</td><td>Supported on concrete Foundation</td><td></td><td>On Gabions</td></tr>
<tr><td colspan="2">Overall Bridge Width (ft)</td><td>9</td><td>10</td><td>15</td></tr>
<tr><td colspan="2">Approximate Bridge Span (ft)</td><td>36.67</td><td>20.17</td><td>21</td></tr>
<tr><td colspan="2">Bridge Curbing (Timber)</td><td>6" x 6"</td><td>8" x 6"</td><td>6" x 6"</td></tr>
<tr><td colspan="2" rowspan="4">Observations</td><td>Wood Curbing in poor condition.</td><td>Wood Curbing in poor condition.</td><td>Wood Curbing in poor condition.</td></tr>
<tr><td>Paint flaking on steel beams</td><td>Rust and Corrosion in Steel beams</td><td></td></tr>
<tr><td>Base under west abutment eroded</td><td>Concrete abutments in poor shape - eroded concrete.</td><td></td></tr>
<tr><td></td><td>Erosion of support under both abutments.</td><td></td></tr>
</table>

Table 11: Bridge Observations (2 of 2)

Parameter		Bridge No. 4	Bridge No. 5
Bridge ID No.		**CCP0080**	**CCP0070**
Type of Construction	Decking Material	3 - 3 ft. wide x 15" deep Pre-cast Concrete planks w/2" asphalt top tied w/ steel rods.	3 - 3 ft. wide x 15" deep Pre-cast Concrete planks w/2" asphalt top tied w/ steel rods.
	Support Beams	Concrete Grade Beam	Concrete Grade Beam
	Bridge Support	On Gabions	On Gabions
Overall Bridge Width (ft)		15	9
Approximate Bridge Span (ft)		22	22
Bridge Curbing (Timber)		8" x 6"	6" x 6"
Observations		Wood Curbing in poor condition.	Wood Curbing in poor condition.
		South gabion upstream and north gabion downstream of bridge breached.	Concrete decking eroded.
			West gabion upstream of bridge breached.
			Found a gabion in the stream acting as an energy dissipator.

Figure 17: Bridge Locations



LANGAN	MAPLE MOOR GOLF COURSE **BRIDGE LOCATIONS** City of White Plains — Westchester County — New York			
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C. 707 Westchester Avenue, Suite 304 White Plains, NY 10604 T: 914.323.7400 F: 914.323.7401	JOB NO. 190022601	DATE 8/13/2015	SCALE NTS	FIGURE NO. 17

Table 12: Bridge Recommendations

Parameter	Bridge No. 1	Bridge No. 2	Bridge No. 3	Bridge No. 4	Bridge No. 5
Bridge ID No.	**CCP0110**	**CCP0100**	**CCP0090**	**CCP0080**	**CCP0070**
Recommendations	Replace wood Curbing in entirety.	Replace the entire bridge with pre-cast concrete culvert	Replace wood Curbing in entirety.	Replace wood Curbing in entirety.	Replace wood Curbing in entirety.
	Install Wooden Handrail	Install Wooden Handrail	Install Wooden Handrail	Install Wooden Handrail	Install Wooden Handrail
	Remove rocks from the stream currently obstructing flow and provide rocks along the west abutment to stabilize base.	Provide concrete wing walls upstream and downstream side of the bridge.	Provide Gabions for side stability	Replace the South gabion upstream and north gabion downstream of bridge.	Provide an additional Gabion on the upstream along west bank of stream
	Paint Steel beams	Provide Gabions for side stability			Patch spalled concrete deck.
	Scour Protection				

5.6.1 Bridge No 1: CCP0110

Inspection of Bridge No. 1 has revealed three issues to be addressed. The wooden curbing along the edges of the bridge is in poor condition, and we recommend they be replaced in their entirety, and wooden handrails added. The steel beams underneath the bridge have flaking paint, and we recommend that these be repainted with scour protection in place to prevent stream contamination. The west abutment base is eroded, and we recommend that rocks from the stream be moved to the west abutment to stabilize the base.

5.6.2 Bridge No 2: CCP0100

Inspection of Bridge No. 2 shows eroded concrete abutments and rust and corrosion along the steel beams supports. We recommend that the entire bridge be replaced with a pre-cast, 3-sided concrete culvert, and provide concrete wing walls both upstream and downstream of the bridge, along with Gabions for side stability. Additionally, wooden handrails should be added to the bridge.

5.6.3 Bridge No 3: CCP0090

Inspection of Bridge No. 3 revealed damage to the wooden curbing and we recommend replacing the wooden curbing and adding handrails to the bridge sides. Additionally, Gabions are recommended to be added for stability on the sides of the bridge.

5.6.4 Bridge No 4: CCP0080

Inspection of Bridge No. 4 reveals that both the south upstream Gabion and the north downstream Gabion have been breached, and we recommend that these be replaced.

Additionally, the wooden curbing has been observed in poor condition, and we recommend to be replaced with wooden handrails added.

5.6.5 Bridge No 5: CCP0070

Inspection of Bridge No. 5 reveals a west bank Gabion has been breached and is acting as an energy dissipator; we recommend that this be replaced and an additional Gabion be added upstream along this bank. There also is erosion on the concrete decking of the bridge, and we recommend that this should be patched. Additionally, the wooden curbing has been observed in poor condition, and it is recommended to be replaced with wooden handrails added.

6 Engineer's Projection of Probable Cost

Included in Appendix B is an Engineer's Projection of Probable Cost. This projection of costs is broken down into the major components of this project and is based on the preliminary improvement plans included in Appendix A as well as the recommendations presented in this report.