PREPARED FOR: THE TOWN OF MILLBURY

# SCHEMATIC DESIGN REPORT

## RAMSHORN POND DAM
**MA00145 / 3-14-186-21**
MILLBURY, MASSACHUSETTS


PREPARED BY:

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PARE PROJECT NO. 13072.00

November 2013


PARE
CORPORATION

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*prepared for:* Town of Millbury
127 Elm Street
Millbury, MA 01527

*prepared by:* Pare Corporation
10 Lincoln Road Suite 103
Foxboro, MA 02035

**Authority**

The Town of Millbury has retained Pare Corporation (PARE) to further evaluate the condition of the Ramshorn Pond Dam in Millbury, Massachusetts. This inspection, report, and evaluations were performed in accordance with MGL Chapter 253, Sections 44-50 of the Massachusetts General Laws.

# EXECUTIVE SUMMARY

This report for the Ramshorn Pond Dam in Millbury, Massachusetts presents the studies performed as part of the Schematic Design completed to identify the extent of repairs required to bring the dam into compliance with current dam safety regulations. The services provided by Pare Corporation (PARE) as part of these studies included subsurface investigations, topographic and bathymetric surveys, wetland delineation, stability and seepage analyses, and a hydraulic and hydrologic (H&H) study. Based upon the findings of these investigations and evaluations, PARE developed a schematic design for a repair program to bring the dam into compliance with current state regulations. The services provided by PARE were performed in accordance with Chapter 253, Sections 44-50 of the Massachusetts General Laws.

Ramshorn Pond Dam is an approximately 585-foot long earthen dam oriented primarily north to south. The dam has a maximum structural and hydraulic height of approximately 25-feet and 20-feet, respectively. The dam is currently classified as a Large sized, High (Class I) hazard potential dam. Based upon previous inspections and the findings of the current evaluations, the dam is in Poor condition due to significant deterioration including: sinkholes behind the walls and apparent seepage/leakage beneath the spillway; scour and erosion along the downstream channel eroding the toe of the dam; apparently collapsed and dysfunctional toe drain systems; deterioration of the low level outlet system including corroded corrugated metal pipes, leakage, and sinkholes along the alignment of the pipe; displaced slope protection; and growth of trees and other unwanted vegetation.

In accordance with 302 CMR 10 and based upon the current size and hazard potential classification, the spillway design flood (SDF) for the structure is one half of the Probable Maximum Flood (1/2 PMF) event. Hydraulic and hydrologic studies performed as part of this evaluation indicate that the spillway can accommodate the SDF if the low level outlet is fully opened and the spillway stop logs are removed; However, under these operating conditions, the pond will rout to the crest of the dam with zero freeboard remaining.

Based upon findings of the subsurface exploration program completed as part of this evaluation, stability analyses were completed upon a modeled cross section of the embankment. The stability analyses indicated that some areas of the dam embankment do not meet the required factors of safety for slope stability based upon loading criteria dictated by current state dam safety regulations.

Based upon the observed conditions and findings of this evaluation, the following generally summarizes the repair approach recommended by PARE:

- Cut, clear, and grub all trees, vegetation, and roots systems within 20 feet of the dam.
- Stabilize the upstream slope through the installation of a sheet pile wall. Design the sheet pile wall to address noted seepage concerns and provide public access opportunities.
- Provide curbs along the roadway to prevent runoff on the embankment slopes; Rehabilitate/repair the drainage system and outfalls with associated BMP improvements.
- Resurface the roadway.
- Replace the existing toe drain with a new toe drainage system.
- Remove the existing spillway in its entirety and install, in its place, embankment fill.
- Construct a new spillway designed to provide operational options and freeboard during the spillway design flood. Locate the spillway near the low level outlet to reduce requirements for channel scour protection along the existing spillway channel.

- Remove/abandon the existing low level outlet. Install a new low level outlet system with an upstream control chamber and an increased draw down capacity.
- Regrade the downstream slope to a stable, uniform section.
- **Total Schematic Opinion of Cost (Recommended Approach): $ 1.48m - $ 1.90m**

## PREFACE

The assessment of the condition of the dam is based upon available data, visual inspections, subsurface investigations, hydrologic and hydraulic studies, topographic surveys and stability analyses as well as supplemental information developed by others during previous evaluations of the dam.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team and other information collected as part of the evaluation.

It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Allen R. Orsi, P.E.
*Massachusetts License No.: 46904*
*Managing Engineer*
Pare Corporation

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# 1.0 PROJECT INFORMATION

## 1.1 General

### 1.1.1 Authority

The Town of Millbury, Massachusetts has retained Pare Corporation (PARE) to further evaluate the condition of the Ramshorn Pond Dam in Millbury, Massachusetts. This inspection and report was completed in accordance with MGL Chapter 253, Sections 44-50 of the Massachusetts General Laws

### 1.1.2 Purpose of Work

The purpose of this investigation is to inspect and evaluate the present condition of the dam and appurtenant structures in accordance with 302 CMR10.07 and to provide information that will assist in both prioritizing dam repair needs and planning/conducting maintenance and operation.

This investigation consisted of six parts: 1) Review available reports, investigations, and data previously submitted to the owner pertaining to the dam and appurtenant structures; 2) Complete a field review of existing conditions of the spillway and other areas of the dam; 3) Complete a subsurface investigation to assess the condition of the dam; 4) Complete stability and seepage evaluations of the dam; 5) Complete hydrologic/hydraulic evaluations; and 6) Prepare and submit a final report presenting the results of the detailed evaluations, recommended schematic designs, and associated opinion of probable costs.

### 1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in Appendix G. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) size classification; 4) hazard classification; 5) general; and, 6) condition rating.

## 1.2 Description of Project

### 1.2.1 General

Sections of this report are based upon available documentation, including previous inspection reports and other available information as identified in Appendix F. Other historical information obtained during the inspection, including information provided by the caretaker, has also been incorporated in this report. This material is intended to provide general information. The accuracy of this referenced information was verified to the extents possible through the investigations and evaluations completed as part of this study.

Elevations that are included in this evaluation reference the North American Vertical Datum of 1988 (NAVD88) based upon the topographic survey plan prepared by Heritage Design Group, LLC, of Whitinsville, Massachusetts.

### 1.2.2 Location

Ramshorn Pond Dam is located within Worcester County in the Town of Millbury, Massachusetts. The dam is located approximately 3 miles southwest of the town center of Millbury. Flow from the dam runs in a northernly direction creating Ramshorn Brook, which eventually turns into Kettle Brook in Auburn, Massachusetts. The structure and impoundment are shown on the Worcester South, Massachusetts USGS quadrangle map near coordinates 42.16177ºN/71.80477ºW[1].

To reach the dam from Interstate I-90, take Exit 10A toward MA 146/U.S. 20/Worcester/Providence. Turn right onto the MA 146 South ramp to Millbury/Providence RI. Take exit 8 toward West Main Street/Millbury and turn right at the second stop sign onto West Main Street; continue approximately 2.5 miles. Turn left onto South Oxford Road and take the second left onto Dolan Road. Dolan Road passes over the crest of the dam. The dam is located at the north end of the impoundment, as indicated on Figure 1: Locus Plan.

### 1.2.3 Owner/Operator

The dam is currently owned by the Town of Millbury. The Town of Millbury Department Public of Works is responsible for the inspection, maintenance, and operation of the dam.

**Table 1.1: Owner/Operator Information**

| | Dam Owner | Dam Caretaker |
|---|---|---|
| Name | Town of Millbury | Town of Millbury DPW<br>Robert D. McNeil III, P.E. |
| Mailing Address | 127 Elm Street | 127 Elm Street |
| Town | Millbury, MA 01527 | Millbury, MA 01527 |
| Daytime Phone | 508-865-9143 | 508-865-9143 |
| Emergency Phone | 508-865-3521 (Police) | 508-865-3521 (Police) |
| Email Address | rmcneil@townofmillbury.net | rmcneil@townofmillbury.net |

### 1.2.4 Purpose of Dam

According to the 2011 Phase I Inspection Evaluation Report prepared by Weston & Sampson, Ramshorn Pond Dam was originally constructed to impound water for the generation of power by the Massachusetts Electric Company. The dam currently impounds water for recreational purposes.

### 1.2.5 Description of the Dam and Appurtenances

The following is paraphrased from the 2011 Phase I Inspection Evaluation Report by Weston and Sampson.

> Ramshorn Pond Dam is an earthen embankment dam with a primary spillway and low level outlet (LLO). The dam impounds Ramshorn Pond. Ramshorn Pond reportedly has an average depth of 12 ft. and a maximum depth of 30 ft. according to the MassLakes.com website. No records documenting the materials of the earthen embankment or foundation materials were available. The dam was reportedly originally constructed in 1825, but it has undergone numerous modifications since original construction. The existing primary spillway system was reportedly installed in [1985]. The dam is approximately 585 ft. long with a structural height of 25 ft.

[1] As indicated in the MADCR Dam Safety Database.

The left abutment is located approximately 125 ft. to the left of the primary spillway. The right abutment is located approximately 435 ft. to the right of the primary spillway. The abutments appear to be keyed into natural grades of equal or greater elevation.

The upstream slope is inclined at approximately 1.5 to 2H:1V (Horizontal:Vertical) and armored with randomly placed riprap ranging in size from 6 in. to 3 ft. in diameter. The upper portion of the slope near the crest is earthen and vegetated.

The crest is approximately 33 ft. wide and surfaced with bituminous pavement of Dolan Road, which extends across the dam. The crest is lined along the upstream and downstream sides with steel guardrails. A chain link fence extends across the crest of the dam along the upstream side. A surface water drainage system with catch basins was observed on the crest of the dam.

The downstream slope is inclined at approximately 2.3H:1V. Steeper areas were observed immediately to the right of the primary spillway. The slope is surfaced with grass to the downstream toe of the dam where the slope contacts natural grades. A manhole structure was observed near the toe of the downstream slope on the right side of the dam. [The manhole appears to be connected to the catch basin on the crest of the dam. Asphalt coated corrugated metal pipe toe drains extend from the headwall at the low level outlet to 86 feet left of the headwall and 232 feet right of the headwall.]

The primary spillway consists of two reinforced concrete culverts approximately 5 ft.-7 in. high by 9 ft. [wide]. A concrete approach slab is present upstream of the culverts. Reinforced concrete headwalls are present at the intake and discharge ends of the culverts. Timber stop logs 1.5 ft. high and 3 in. thick are installed in steel stop log slots along the intake end of the culverts. The culverts discharge to a stepped concrete lined channel with concrete channel walls. At the end of the concrete channel is a cascading stone masonry channel with mortared stone masonry channel walls. The discharge channel downstream of the dam bends to the right and flows along the toe of the dam before bending to the left near the center of the embankment and flowing downstream away from the dam.

The low level outlet (LLO) reportedly consists of a 24 in. diameter cast iron pipe that extends through the dam. Information on the intake of the LLO was not available. On the downstream side of the dam near the middle of the slope is a reinforced concrete gatehouse building that overlies a dry-set stone masonry wet well. The LLO valve is located in the wet well area. The LLO is operated by a wheel mounted on a bracket inside the gatehouse. Reportedly, it takes 110 turns of the wheel to fully open or close the gate. A 6 in. dry hydrant is tapped into the LLO upstream of the valve. The dry hydrant extends through the gatehouse and up to the crest of the dam.

The LLO discharges through a reinforced concrete headwall in the discharge channel. The headwall also consists of two wing walls to the right and left of the LLO discharge pipe. A 12 in. diameter corrugated metal pipe (CMP) extends through each wing wall.

## 1.3 Pertinent Data

### 1.3.1 Size Classification

Ramshorn Pond Dam has a maximum structural height of approximately 25 feet and a reported maximum storage capacity of 2,300 acre-feet[1]. Therefore, in accordance with Department of Conservation and Recreation Office of Dam Safety classification, under Commonwealth of Massachusetts dam safety rules and regulations stated in 302 CMR 10.00, Ramshorn Pond Dam is a **Large** sized structure.

[1] As indicated in the 2011 Phase I Inspection/Evaluation Report and checked for order of magnitude accuracy

### 1.3.2 DCR Hazard Classification

Ramshorn Pond Dam is located upstream of streets such as West Main Street, Carleton Road, Route 20, areas such as West Millbury, Pondville Pond, and other residential properties. Failure of the dam at maximum pool will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s). Therefore, in accordance with Department of Conservation and Recreation classification procedures, under Commonwealth of Massachusetts dam safety rules and regulations stated in 302 CMR 10.00, Ramshorn Pond Dam is classified as a **High** (Class I) hazard potential dam.

# 2.0 ENGINEERING DATA

## 2.1 General

### 2.1.1 Drainage Area

The drainage area for the Ramshorn Pond Dam is approximately 2.4 square miles and includes portions of the communities of Millbury, Sutton, and Oxford. The drainage area extends south and west of the pond, and primarily consists of undeveloped hilly terrain that includes small tributary streams. Several wetland areas and smaller ponds exist upstream of Ramshorn Pond. Small residential areas exist along the pond. While no other inventoried control structures were noted within the drainage area, an unnamed pond with an apparent dam is located to the northwest of Ramshorn Pond.

### 2.1.2 Reservoir Information

The following information is based upon scaled dimensions from available topographic mapping, aerial photography, and other information available during the preparation of this report, unless otherwise noted.

**Table 2.1: Reservoir Information**

| | Length (ft) | Width (ft) | Surface Area (acres) | Storage Volume (acre-feet)[1] |
|---|---|---|---|---|
| Normal Pool | 4,000 ± | 2,700 ± | 131 ± | 1600 ± |
| Maximum Pool | 4,500 ± | 2,800 ± | 149 ± | 2300 ± |
| SDF Pool | 4,500 ± | 2,800 ± | 149 ± | 2300 ± |

The impoundment is generally irregular in shape, somewhat resembling a ram's horn, with the dam located at the northern end of the impoundment. The impoundment becomes wider approximately 1,600 feet upstream from the dam. The shoreline of the pond primarily consists of residential developments followed by undeveloped woodland. The surrounding slopes are mild approximately 2-5 %.

### 2.1.3 Discharges at the Dam Site

No records of discharges at the dam site were made available during the preparation of this report. However, the gate is operated seasonally to control the level of the impoundment. The valve is typically opened around the second week of October to lower the level of the impoundment by approximately 6 feet for the winter drawdown months. The gate is also operated to maintain the impoundment levels in the event of high rainfall. There is no formal operations and maintenance plan for this dam.

### 2.1.4 General Elevations (feet)

Elevations are based upon a topographic survey completed by Heritage Design Group as part of this evaluation. Elevations reference NAVD 1988 based upon a NOAA NGS OPUS Session completed as part of the survey. The elevations reported in the previous Phase I Report reference the National

[1] As indicated in the NID database and checked for magnitude of accuracy

Geodetic Vertical Datum (NGVD) with a top of stop log elevation of 625.5 feet (GZA, 2005). To convert the previously referenced elevations to those included within this report, add 5.24 feet.

| | |
|---|---|
| A. Top of Dam | 635.5 ± min |
| B. Normal Pool (top of stop logs) | 630.7 ± |
| C. Spillway Crest | 629.25 ± |
| D. Streambed at Toe of the Dam | 612 ± |
| E. Low Point along Toe of the Dam | 612 ± |

**2.1.5 Spillway**

| | |
|---|---|
| A. Type | twin reinforced concrete box culverts |
| B. Size | 5.6 ft high by 9 ft wide |
| C. Control | 18 in high by 3 in wide stop logs |
| D. Length | 18 ft |
| E. Invert In | 629.25 ± (ungated) |
| | 630.7 ± (top stop logs) |
| F. Downstream Channel | 613 ± |
| G. Downstream Water | 613 ± |

**2.1.6 Low Level Outlet**

| | |
|---|---|
| A. Type | cast iron pipe |
| B. Size | 24 in |
| C. Invert | 610.4 ± (outlet); inlet not known |

## 2.2 Design and Construction Records

The dam was reportedly originally constructed in 1825. No records of the original construction were located during the preparation of this report.

The dam has reportedly undergone a number of rehabilitations, including a repair project in 1957. Details and the scope of the 1957 repair were not made available for review.

The Dolan Roadway Reconstruction Project Plans, dated 1985, were made available during the preparation of this report. The plans describe updates to the road and associated improvements to the dam embankment. The scope of the roadway project included:

- Removal of the existing roadway bridge and replacing it with the twin box culverts that exist today
- Removal of the previously existing field stone spillway channel and construction of a stepped concrete channel
- Installation of a toe drain system
- Extension of the low level outlet pipe downstream and construction of a cast in place concrete headwall
- Installation of the roadway drainage system and associated outfalls
- Widening of the embankment crest
- Regrading of the downstream slope to 2.5H:1V
- Regrading the upstream slope to1H:1V and installing a 2-foot thick riprap layer
- Installation of the two dry hydrants

# 3.0 INSPECTION

## 3.1 2011 Phase I Dam Inspection

Weston and Sampson completed a Phase I Inspection of the Ramshorn Pond Dam on April 6, 2011. The dam was found to be in **POOR** condition at the time of the inspection with the following significant deficiencies noted.

- Excessive uncontrolled seepage (e.g., upwelling of water, evidence of fines movement, flowing water, erosion, etc.)
- Missing riprap with resulting erosion of slope
- Sinkholes, particularly behind retaining walls and above outlet pipes, possibly indicating loss of soil due to piping, rather than animal burrows
- Excessive vegetation and tree growth
- Deterioration of concrete structure (e.g. exposed rebar, tilted walls, large cracks with or without seepage, excessive spalling. etc.)
- Inoperable outlets (gates and valves that have not been operated for many years and are broken)

## 3.2 Current Evaluation Program

As part of the current evaluation program, PARE completed a number of site visits primarily for data collection. Based upon a general overview of observed conditions, the dam appears to be in a condition similar to that previously noted. In addition to the previously noted deficiencies, the following observations were also made:

- Excessive erosion of the downstream slope at the downstream toe between the spillway and the low level outlet was observed. The erosion appears to be the result of a redirection of the downstream channel into the embankment. At the time of the site visit, the exposed slope exceeded 6 feet in height with loose embankment materials and near vertical surfaces present. While no immediate seepage was observed at the time of the site visit, the toe of the erosion area was saturated, possibly due to seepage or flow through the spillway channel.
- An upwelling of water was noted at the low level outlet headwall. The upwelling is presumed to be the result of leakage through the low level outlet pipe, which was submerged during the site visit.
- Vegetation along the downstream third of the slope prevented access to many areas of the slope and downstream area.
- Water was observed flowing through the spillway culverts and into a joint between the culverts and the downstream concrete channel. Flow is presumed to be associated with the saturated area on the downstream slope and the observed leakage through the stone masonry steps at the toe of the concrete channel.

## 3.3 Topographic Survey

A topographic survey was completed by Heritage Design Group, of Whitinsville, Massachusetts. The survey, which references the NAVD88 datum and NAD83 State Plane Coordinates, included the above water portions of the dam and spillways, a limited bathymetric survey upstream of the dam, and a topographic survey in the vicinity of the dam. The survey base plan was utilized to develop Figure 3: Existing Site Plan.

### 3.4 Wetland and Resource Area Delineation

Wetland resource areas in the vicinity of the Ramshorn Pond Dam were defined and delineated in accordance with the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00, referred to as the Regulations) and the methodology specified in the publication entitled *Delineating Bordering Vegetated Wetlands under the Massachusetts Wetlands Protection Act* (Jackson, 1995). Inspection and the delineation of wetlands were completed on July 2, 2013 by Pare Corporation personnel. A copy of the delineation report is included in Appendix D.

# 4.0 OPERATIONAL PROCEDURES

## 4.1 Operational Procedures

The following operational procedures were presented in the 2011 Phase I Report.

> The LLO valve is operated seasonally to manipulate the water level in Ramshorn Pond. The gate is generally opened the second weekend in October and the pond is lowered approximately 6 feet during the winter months. The gate is reportedly opened with 125 turns of the operator wheel, although this is not believed to be fully open. The gate becomes difficult to operate at approximately 100 turns of the wheel.

### 4.1.1 Operating Records

No operating records were made available for this dam during this evaluation and the preparation of this report.

There is no formal Operations and Maintenance manual available for this dam.

## 4.2 Maintenance Procedures

There is no formal Maintenance Plan for the dam. Maintenance is generally performed on an as needed basis. Recent reported maintenance includes work on the low level outlet gate completed several years ago. Routine maintenance generally includes the control of vegetation along the length of the embankment. Mowing/brush cutting is reportedly completed once per year.

## 4.3 Emergency Action Plan

The latest Emergency Action Plan (EAP) for the Ramshorn Pond Dam was prepared by GZA GeoEnvironmental in 2007. This EAP was not reviewed during the preparation of this report. No updates to this EAP are known to exist and a copy is reportedly on file with the DCR ODS.

# 5.0 HYDROLOGY/HYDRAULICS

Based upon the current state classification system, Ramshorn Pond Dam is a **Large** size, **High** hazard potential structure. Therefore, in accordance with current Commonwealth of Massachusetts regulations, the spillway design flood (SDF) for the site is one half of the probable maximum flood (1/2 PMF).

## 5.1 Previous Evaluations

A previous hydrologic and hydraulic study was reportedly conducted by Cleverdon, Varny, & Pike (CVP) as part of the 1987 DEM Inspection Report. The calculations of this study were not made available during the preparation of this report. According to previous summaries of this inspection report, the spillway without stop logs has the capacity to pass a flow of approximately 800 cfs. With stop logs in place, the spillway can pass a flow of approximately 500 cfs.

## 5.2 Current Evaluations

### 5.2.1 Hydrologic and Hydraulic Evaluations

A hydrologic and hydraulic analysis was performed for the Ramshorn Pond Dam to determine the performance of the reservoir and dam under existing conditions. Runoff computations were performed in accordance with the Natural Resources Conservation Service (NRCS) Curve Number methodology using the NRCS triangular unit hydrograph. Design rainfall events were modeled using the SCS Type III hydrograph for 24-hour duration storm events. The computations for this analysis are based on the ½ PMF return period storms. Rainfall depth values were obtained from: the website entitled "Extreme Precipitation in New York and New England" (http://precip.eas.cornell.edu), a joint collaboration between the Northeast Regional Climate Center (NRCC) and the Natural Resources Conservation Service (NRCS); values provided by "Probable Maximum Storm (Eastern United States)" Hydrologic Engineering Center publication HMR-52 prepared by the U.S. Army Corps of Engineers. Flow rates generated by the design storms were evaluated using TR-55 methodology and HydroCAD Version 10.00 software. HydroCAD was used to evaluate the hydraulic capacity of the existing spillway. Computations were completed using a steady state flow analysis for the peak flow rates calculated for the design storms previously mentioned.

Using USGS Topographic Maps and data available from MassGIS, the contributing watershed to the dam was determined to be approximately 1,537 acres (2.4 square miles). For evaluation purposes, the overall watershed was evaluated as a single watershed, as shown on Figure 1. The watershed area is predominantly wooded with some residential, agricultural, and commercial development. The watershed was calculated to be approximately 14% impervious. Soil types in the area were identified to be within Hydrologic Soil Groups A through D using the NRCS soil surveys. The SCS Curve Number (CN) method was used to simulate runoff from land cover/soil type mapping. Based on soil types in the project area and aerial photography, a composite CN of 72 was modeled for the drainage area.

The SCS triangular Unit Hydrograph (UH) method was used to estimate the surface runoff. The SCS UH method utilizes a best-approximate hydrograph that is scaled by the time lag to produce the unit hydrograph for the simulation. The lag is defined as the length of time between the centroid precipitation mass and the peak flow of the resulting hydrograph. Utilizing the USGS topographic maps and the NRCS lag equation, a 4.6 hour lag time was calculated.

A reservoir elevation-storage relationship was developed to simulate the Ramshorn Pond routing, and is presented in Table 5.1. At normal pool elevation, with stop logs in (630.7), the pond is estimated to have a surface area of approximately 131 acres. The initial water surface elevation in the modeling for the pond was set at the normal pool elevation of 630.7 feet.

The elevation-discharge relationship is also presented in Table 5.1. Two evaluations were completed as a part of this study. One evaluation included no stop logs with the low level outlet gate open (with operation), and the second evaluation contained stop logs in place and the low level outlet closed (no operation).

**Table 5.1: Elevation-Storage-Discharge Relationship**

| Pond Elevation (ft) | Description | Approximate Storage (ac-ft) | Discharge (cfs) | |
|---|---|---|---|---|
| | | | No Operation | With Operation |
| 610.4 | Low Level Invert | 0 | 0 | 0 |
| 630.7 | Normal Pool | 1600 ± | 0 | 66 ± |
| 635.5 | Top Dam | 2300 ± | 1500 ± | 2250 ± |

The results of the analysis for the modeled storm events are summarized in the following table. Both the 100 year and ½ PMF storm events were modeled with a starting pond elevation of 630.7 feet (top of stop logs).

**Table 5.2: H&H Summary Table**

| | 100 year | | ½ PMF | |
|---|---|---|---|---|
| | No Operation | With Operation | No Operation | With Operation |
| Rainfall (in) | 8.79 | 8.79 | 12.75 | 12.75 |
| Peak Inflow (cfs) | 1344 | 1344 | 2251 | 2251 |
| Peak Outflow (cfs) | 314 | 400 | 709 | 697 |
| Peak Routed Elevation (ft) | 634.1 | 632.9 | 636.0 | 634.9 |
| Overtopping Depth (ft) | None | None | 0.5 | None |
| Overtopping Duration (hr) | None | None | ± 6 | None |

The simulation demonstrates that the existing spillway at the dam can accommodate the 100-year storm event under both operational conditions considered. The existing spillway can accommodate the ½ PMF storm event with the stop logs removed and the low level outlet gate open. If the stop logs remain, or the low level outlet gate is closed, overtopping of the dam may occur. Based on the model, if the gate is closed and the stop logs remain in place, the dam would be overtopped for a duration of approximately 6 hours to a maximum depth of 0.5 feet.

### 5.2.2 Freeboard Analysis

As part of the current evaluations, PARE completed a freeboard analysis to evaluate the available freeboard at the dam during both normal operating and maximum pool conditions. To evaluate the recommended freeboard for the dam, PARE undertook a wave height and setup determination in general accordance with ACOE ETL 1110-2-221 "Wave Run-up and Wind Setup on Reservoir Embankments" and by methodologies developed by the Army Corps of Engineers "Shore Protection Manual".

***Methodology***

In undertaking this evaluation, the maximum wave height and setup were determined for the reservoir at the location of the dam. The effective fetch, which represents a weighted measurement of the surface area of the impoundment upstream of the dam over which wind and waves may development, was calculated for the dam location. The Ramshorn Pond Dam is located on the northern end of an open body of water with its long axis running south to north. For evaluation purposes, the center of the dam was selected as representative of the typical effective fetch at the dam.

Maximum wind speeds and durations were calculated for the site based upon regional isographs provided within ETL 1110-2-221 for the spring, summer, fall, and winter months. The peak wind speeds for the Ramshorn Pond are presented below in Table 5.3.

**Table 5.3: Peak Wind Speeds**

| | Wind Speed (mph) | Season |
|---|---|---|
| Fastest Mile (1 Min. Duration) | 62 | Fall |
| Maximum 1 hr. Wind Velocity | 60 | Fall |

Based upon peak wind speeds corrected for open water influences, design factors for freeboard analysis were calculated. The wave run up that would be calculated using the peak design wind speed indicated in Table 5.3 is conservative since it is unlikely that the peak wind speed would occur during the maximum impoundment elevation. Therefore, a design wind speed of 50 mph with a design duration of 8 minutes was used. The effective fetch was calculated to be 0.365 miles.

Utilizing a design wind speed of 50 mph, wave heights and wave run-up were calculated based upon an approximately 1.8H:1V slope and an assumed average depth of impoundment of 12 feet upstream of the dam. The normal pool elevation was assumed to be El. 630.7 feet, with a top of dam at El. 635.5 feet, as determined by the site survey completed as part of this evaluation. With the stop logs removed and the low level outlet gate open, the peak routed pond elevations during the 100-year and ½ PMF storm events are El. 632.9 and El. 634.9, respectively, as indicated in the H&H analysis completed as part of this evaluation.

***Model Results***

During normal operating conditions the level of the impoundment is approximately 6 feet below the top of the embankment. Therefore, adequate freeboard is currently provided during normal pool conditions.

Adequate freeboard for the 100-year storm event is not provided. It is expected that wave action will be breaking over the crest of the dam during this event.

During the spillway design flood event, the level of the impoundment is expected to rise to an elevation of approximately 634.9 feet with the stop logs removed and the low level outlet opened. There is 0.6 feet of freeboard at the dam during the ½ PMF spillway design flood event. Therefore, any wave action or setup occurring simultaneously with the peak routed pond elevation will result in overtopping of the dam.

### 5.2.3 Pond Drain Evaluation

A drawdown analysis was completed as part of this evaluation in order to estimate the drawdown capacity of the low level outlet. To evaluate the drawdown capacity of the low level outlet, PARE determined the rate of drawdown. This rate of drawdown is based upon variable pond elevations, the extent the gate is open, and assumed inflow conditions. The analysis was performed considering no stop logs in place.

A stage-storage relationship was developed based upon available reservoir information, as presented in Tables 2.1 and 5.1. The pond stage-storage relationship was linearly extrapolated between known data points to generate storage volumes over the range of the draw down analysis. The model was run starting with water levels at the top of the dam elevation and terminating when the pond was considered to be empty.

A base inflow to the impoundment was assumed based upon the average low flow of 0.5 cubic feet per square mile (cfsm) of drainage area, or approximately 1.15 cfs. Additional base inflow resulting from springs or other ground water sources were not modeled, as accurate information for these flow rates was not available.

***Model Results***

Based upon the modeled inflow, stage-storage relationship of the pond, and the discharge capacity of the outlet structures at the dam, rating curves for the drawdown rate were developed, as presented in Chart 5.1.

The chart indicates that drawdown from the maximum pool elevation of 635.5 feet to the spillway crest elevation of 629.25 feet would take approximately 40 hours with the low level outlet pipe fully open.

The chart indicates that it would take approximately 20 hours to lower the impoundment by 0.5 feet from elevation 629.25 feet to 628.75 feet. This increase in drawdown time is attributed to the fact that at elevations below the spillway crest elevation of 629.25 feet, the low level outlet is the only structure contributing to the discharge capacity.

The total time required to drawdown the pond from elevation 635.5 feet to elevation 610.4 feet (empty pond) is approximately 19 days with the low level outlet pipe fully opened. Based upon the drawdown model, the winter draw down from a pond elevation of 630.7 feet to 624.7 is expected to take approximately 5 days, with the gate fully open.

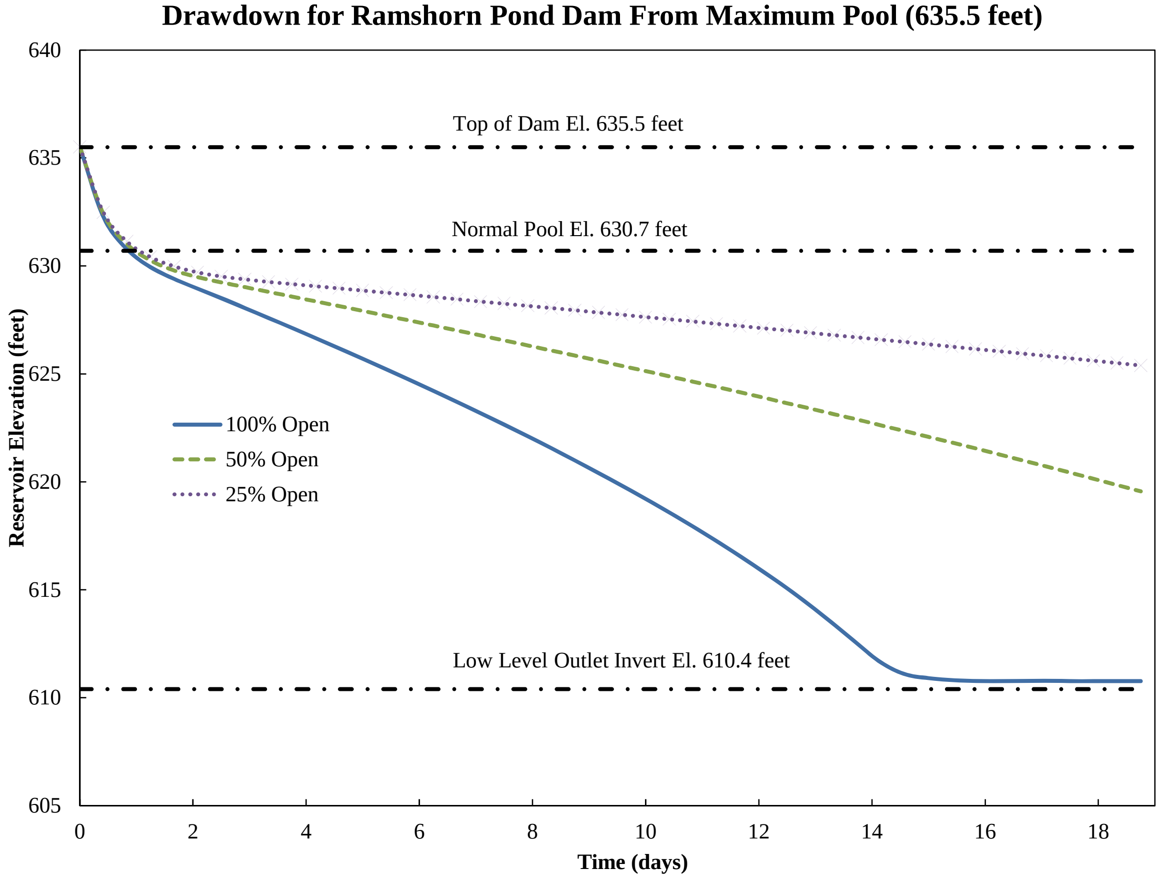



**Chart 5.1: Drawdown for Ramshorn Pond Dam**

Based upon the calculated draw down rates, the low level outlet is capable of drawing down the level of the impoundment for seasonal drawdowns in a reasonable period of time. However, the outlet may not have sufficient capacity to lower the level of the impoundment rapidly enough in the event of emergency conditions developing at the dam.

# 6.0 SUBSURFACE INVESTIGATION

## 6.1 Subsurface Explorations Program

A subsurface exploration program was completed on July 17, 2013. The exploration program consisted of three (3) borings completed by Northern Drill Service, Inc of Northborough, Massachusetts and observed by PARE personnel. The explorations were performed to determine the soil condition at the dam. The exploration program is summarized in Table 6.1. The location of each boring is indicated upon Figure 3: Existing Site Plan.

All borings were undertaken from a truck mounted drill rig. Borings were advanced utilizing 4-inch casing with wash and drive techniques. Split spoon samples were obtained continuously through the fill materials and every 5 feet within the foundation/natural soils. Samples were collected in accordance with ASTM D-1586, the Standard Penetration Test (SPT), utilizing a donut hammer to obtain an indication of the relative density and consistency of the underlying soils. The boring logs are attached in Appendix C.

During the explorations, subsurface soils were visually classified utilizing the Burmister Classification System. This systems describes soil composition based upon the percentage of soil particle size present by weight in the sample with the major soil particle size listed first following other soil components described as “trace” indicating 0-10% by weight, “little” indicating 10-20% by weight, “some” indicating 20-35% by weight, or “and” indicating 35-50% by weight.

Upon completion, Boring B13-1 was sealed by pumping grout from the bottom of the borehole to the ground surface. Groundwater monitoring wells were installed in both Boring B13-2 and Boring B13-3. Upon completion of drilling in these locations, the boring holes were grouted to a depth of 20-feet below the ground surface utilizing tremie grout procedures. Grout was allowed to set overnight, with approximately 2 feet of settling observed after grout set. The well installations consisted of bentonite seals placed to approximately 1 foot below the ground surface with the last foot filled with sand. A 2 inch diameter slotted PVC screen was installed from 18 feet to 8 feet b.g.s., with a solid riser from 8 feet to the ground surface with a flush mounted road box.

## 6.2 Subsurface Conditions

The generalized conditions encountered during the subsurface exploration are summarized in Table 6.1.

**Table 6.1: Summary of Subsurface Explorations**

| Boring ID | Approximate Ground Surface Elevation (ft) | Depth of Exploration (ft) | Thickness of Fill (ft) | End of Exploration Type | Depth to Water (ft) Impoundment at Normal Pool ± 7/16-17/13 | 8/19/13 |
|---|---|---|---|---|---|---|
| B13-1 | 636.7 | 30.4 | 12 | Design Depth Reached | Not Measured | |
| B13-2 | 635.9 | 40.1 | 26 | Design Depth Reached | 13 | 14 |
| B13-3 | 635.8 | 31 | 22 | Terminated in Foundation Soil | 7.2 | 6.6 |

Notes: 1) All elevations reference NAVD88

### 6.2.1 Fill

Fill was encountered in each of the borings. Based upon a visual inspection of split spoon samples obtained during the advancement of the borings, the Fill material generally consists of tan, fine to medium SAND, with “little” to “some” fine gravel, and “little” to “some” silt. The layer of fill was 12 feet thick at B13-1, 26 feet thick at B13-2, and 22 feet thick at B13-3. The density of the material encountered varied from loose to dense based upon uncorrected SPT values. Areas of loose material were observed in B13-2 and B13-3. The loose soil was observed at depths of 22 to 26 feet in B13-2 and 19 to 20 feet in B13-3.

### 6.2.2 Native Sand

A layer of Native Sand was encountered in borings B13-1 and B13-3. The Native Sand layer extended from depths of approximately 12 to 26 feet below ground surface in B13-1, and 22 to 31 feet below the ground surface in B13-3. The material generally consisted of gray to tan fine to medium SAND, with “little” to “some” fine gravel, and “little” to “some” silt. The density of the material encountered was generally medium dense to very dense based upon uncorrected SPT values.

### 6.2.3 Glacial Till

A layer of Glacial Till was encountered from approximately 26 to 30.5 feet below the ground surface in B13-1, and 26 to 34 feet below the ground surface in B13-2. The Glacial Till was encountered underlying the Native Sand in B13-2, and the loose Fill in B13-2. The material generally consisted of gray to tan, fine to coarse SAND, “little” fine gravel, “little” silt. The density of the material encountered was generally very dense based upon the uncorrected SPT values. As B13-3 terminated within the Native Sand stratum, glacial till was not encountered.

### 6.2.4 Bedrock

Weathered Rock was encountered within B13-2 at a depth of approximately 34 feet. The Weathered Rock can generally be described as highly weathered, very weak, SCHIST, sampled as dark gray and brown, very dense SAND, with “some” gravel. The density of the Weathered Rock was determined to be very dense based upon the uncorrected SPT values.

## 6.3 Laboratory

A laboratory testing program consisting of grain size analyses was completed on selected samples as part of this evaluation. A total of 4 samples were selected for grain size distribution analysis. A summary of the results are shown in Table 6-1. Gradation curves are included in Appendix C.

**Table 6.2: Results of Grain Size Analyses**

| Test No. | Boring No. | Sample No. | Depth (Ft.) | Representative Soil Strata | % Gravel | % Sand | % Fines |
|---|---|---|---|---|---|---|---|
| 1 | B13-1 | S-9 | 16’-18’ | SAND | 18 | 56 | 38 |
| 2 | B13-2 | S-3 | 4’-6’ | FILL | 5 | 53 | 42 |
| 3 | B13-2 | S-12 | 22’-24’ | FILL | 15 | 52 | 33 |
| 4 | B13-3 | S-6 | 10’-12’ | FILL | 22 | 40 | 38 |

# 7.0 STRUCTURAL STABILITY

## 7.1 General

An evaluation of the structural stability of the dam was completed based upon the findings of the visual inspection, a review of available historic information, as well as additional information collected as part of this evaluation. The objectives were to determine the existence of conditions that are currently hazardous or overtime could potentially become hazardous.

### 7.1.1 Visual Observations

During the visual inspection of the dam, several observations were made which may be indicative of stability concerns developing at the dam. These include:

1. Excessively steep upstream slope with several scarps and areas of displaced riprap.
2. A scarp face and over-steepening area downstream at the depression to the right of the primary spillway.
3. Sinkholes behind the primary spillway, and the left and right downstream walls.
4. Several sinkholes along the alignment of the low level outlet.
5. Sinkholes/erosion observed around the gatehouse structure.
6. Flow appears to leak through the steps of the downstream primary spillway channel rather than flow over the steps.
7. Excessive scarping along the toe of the dam in the downstream channel.

As part of the subsurface explorations, it was noted that the transition from embankment fill material to the natural foundation soils was free of any indications of a residual loam layer at the base of the dam. As such, it appears that, during original construction, the foundation of the dam was properly stripped of organic matter or other unsuitable materials.

### 7.1.2 Design and Construction Data

There were no records of the original construction of the dam available for review during the preparation of this report.

Dolan Road Reconstruction Plans, dated 1985, were available for review during the preparation of this report. The drawings show details of roadway and embankment improvements completed at that time, as described in Section 2.2.

### 7.1.3 Post Construction Changes

Based upon a review of the 1985 Dolan Road Reconstruction Plans, several additions and upgrades were made to the dam including the installation of twin box culverts in the area of the spillway in replacement of the previously existing bridge. Other additions included the installation of a toe drain, manhole structure, chain link fence around the gatehouse, and hydrant pipes.

## 7.2 Soil Modeling

For the purposes of this evaluation, a generalized cross section of the dam was developed to represent critical embankment cross sections based upon completed topographic survey, findings of the subsurface exploration program, and information located within available existing documents that were reviewed as part of this investigation. In support of the seepage and slope stability evaluation, one section of the earthen embankment was considered for detailed evaluation near Borings B13-2 and B13-3, approximately 135 feet right of the primary spillway.

Based upon the topographic survey and visual observations at the site, the embankment model consisted of an approximately 1.8H:1V upstream slope, a 33-foot wide crest, and an approximately 2.6H:1V downstream slope.

To undertake the stability and seepage analysis, six soil units were developed based upon the subsurface exploration program: embankment fill (Layer 1 Fill); loose embankment fill (Layer 2 Loose Fill); a sand layer to represent the silty sand, sandy gravel, alluvial sand deposits encountered (Layer 3 Sand); glacial till material (Layer 4); weathered rock (Layer 5); and riprap (Layer 6).

For each of the soil units, shear strength, unit weight and saturated hydraulic conductivity were developed. The modeled layer properties are presented in Table 7.1. Soil properties were developed based upon available data collected during the subsurface exploration program.

**Table 7.1: Modeled Soil Properties**

| Layer | Classification | $(N_1)_{60}$ (bpf) | $D_r$[1] (%) | Angle of Internal Friction | Saturated Unit Weight ($lb/ft^3$)[2] | $K_{sat}$[3] (ft/sec) | e[2] | $w_{sat}$ (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | Embankment Fill/SM | 19 | 43.5 | 31 | 121.7 | 3.94-4 | 0.75 | 30 |
| 2 | Loose Embankment Fill/SM | 5 | 5 | 27 | 118.4 | 5.00e-4 | 0.89 | 30 |
| 3 | Till/SW | 63 | 95 | 40 | 139 | 3.28e-7 | 0.36 | 10 |
| 4 | Sand (SM-SP) | 27 | 55 | 33 | 128.4 | 3.28e-5 | 0.58 | 20 |
| 5 | Weathered Rock | 65 | 95 | 41 | 145.3 | 3.28e-8 | 0.27 | 10 |
| 6 | Riprap | NA | NA | 45 | 150 | 1 | NA | NA |

The embankment fill, loose embankment fill, sand, till, weathered rock, and riprap were modeled as a saturated only material. The volumetric water content functions were estimated using the assumed soil types and grain size analysis with saturated water content based on the estimated void ratio (e) and a specific gravity of 2.65. The fill layers were analyzed as isotropic materials. The hydraulic conductivities were analyzed as anisotropic with a conductivity ratio of 0.2 and were initially assumed. The resulting phreatic surface was compared to the available observation well data. The hydraulic conductivities were modified as needed until the phreatic surface correlated with the observation well data.

## 7.3 Liquefaction

A detailed analysis of the liquefaction potential of the silts and sands within the embankment and underlying the dam was undertaken in accordance with the procedure developed by Seed *et al.*[4]. The procedure developed by Seed *et al.* is based upon nomographs established for varying silt and sand

[1] Das, Principles of Geotechnical Engineering, 5th Edition, Table 2.4
[2] gsat = gdry + (e/(1+e))gw
[3] Holtz, Kovacs, and Sheahan, An Introduction to Geotechnical Engineering, 2nd Edition, Figure 7.7
[4] Seed, H. B., Idriss, I. M., and Arango, I. (1983), "Evaluation of Liquefaction Potential Using Field Performance Data, " Journal of Geotechnical Engineering, ASCE, Vol. 109, No. 3.

gradations and is known as the “Simplified Procedure”. Updates to this approach were made during the 1996 National Center for Earthquake Engineering Research (NCEER) convention. The updates were published in Youd et al.[1], and included magnitude scaling factors, and correction factors for both overburden pressures and sloping ground. These updates were incorporated into this analysis.

This analysis assumes that the information obtained during the subsurface exploration program is an accurate representation of the actual insitu material on this site. Furthermore, it was assumed that the groundwater was as generally observed in the boreholes during normal pool conditions.
*Based upon this method, in the event of an earthquake or sufficient ground motion, soil liquefaction is not expected to occur.*

## 7.4 Seepage Analysis

A seepage analysis of the embankment was performed utilizing the computer analysis program GeoStudio 2007 Seep/W. Dam Safety Regulations, as provided in 302 CMR 10.00, indicates that all high hazard potential dams shall have a flow net analysis completed in order to determine the location of the phreatic surface, flow lines, and equipotential lines within the embankment and foundation.

### 7.4.1 Boundary Conditions

Normal pool and maximum pool impoundment levels were considered for the seepage evaluation. The normal and maximum pool impoundment levels were modeled at elevations of 630 feet and 636 feet, respectively. The tailwater at the downstream toe for both conditions was modeled at an elevation of 615 feet.

The upstream slope and upstream toe were assigned a total head of 636 feet for maximum pool conditions and 630 feet for normal pool conditions. Seepage waters were assumed to infiltrate the embankment with a potential seepage face along the downstream slope and toe. This represented the downstream boundary condition. This condition was assumed to represent the worst case seepage conditions that are likely to develop at this site.

### 7.4.2 Model Results

Based upon the dam embankment geometry, the analysis yielded an exit gradient of 1.1, resulting in a factor of safety of 0.9 for the impoundment at normal pool. For maximum pool, the analysis yielded an exit gradient of 1.3 resulting in a factor of safety of 0.8. Unstable or quick conditions occur when the exit gradient is greater than or equal to 1. Therefore, the soil at the toe of the slope is considered to be subject to instability under both normal and maximum pool conditions.

Due to errors associated with the convergence of data at “sharp points” at the boundaries of the model, for example where the downstream slope meets the toe of the dam, the seepage gradient was inspected immediately downstream of the toe at several locations and an approximate average value was considered for this assessment.

Seepage at the toe of the dam was estimated to be approximately 6.8e-5 $ft^2$/sec/ft under normal pool conditions, and 5.0e-4 $ft^2$/sec/ft under maximum pool conditions.

[1] Youd et al. (2001), “Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops of Evaluation of Liquefaction Resistance of Soils, Journal of Geotechnical and Geoenvironmental Engineering, 127(4),pp297-313.

## 7.5 Slope Stability Analyses

### 7.5.1 Previous Evaluations

No formal stability evaluations have been completed for this structure. No records of the original design computations were available for review during the preparation of this report.

### 7.5.2 Current Evaluations

Stability analyses of the embankment slopes were performed utilizing the computer analysis program GeoStudio 2007 Slope/W with the pore pressures and phreatic surface generated from the seepage analysis discussed previously.

#### 7.5.2.1 Evaluation Method

Grid and radius tangents were used to generate the potential slip surfaces. The Morgenstern-Price method was used to compute the factor of safety for each potential slip surface. This method is considered to be a rigorous method, as moments and inter-slice forces are considered in the limit equilibrium computations.

The phreatic surfaces generated from the seepage analysis previously discussed were used in the stability analyses. Normal pool was assumed to be near the spillway crest elevation of ± 630 feet. The cases of rapid drawdowns were analyzed assuming full drawdown with full drainage of the riprap layer and no draining of the embankment. This is a conservative representation as sand is a free draining material, and will likely partially drain during a rapid drawdown event.

#### 7.5.2.2 Loading Criteria

Stability analyses were completed to determine the minimum factors of safety under loading conditions specified by current state regulations. Table 7.2 summarizes the required minimum factors of safety for varying loading conditions for slope stability as indicated within 302 CMR 10.14.

**Table 7.2: Minimum Slope Stability Factors of Safety**

| Loading Condition | Minimum Factor of Safety | Slope to be Analyzed |
|---|---|---|
| End of construction condition | 1.3 | Upstream and Downstream |
| Sudden drawdown from maximum pool | >1.1 | Upstream |
| Sudden drawdown from spillway crest | 1.2 | Upstream |
| Steady seepage with normal pool | 1.5 | Upstream and Downstream |
| Steady seepage with maximum pool | 1.4 | Downstream |
| Earthquake (steady seepage with seismic loading using seismic coefficient method) | >1.0 | Upstream and Downstream |

A surcharge load of 250 pcf was added to the middle 24.5 feet (upstream to downstream) of the roadway area to simulate traffic loading for upstream and downstream analyses under the impoundment condition of normal pool.

A seismic evaluation was completed for the upstream and downstream slopes as part of the slope stability analysis. The seismic evaluation was completed by applying a previously determined horizontal ground acceleration coefficient of 0.08g[1] to the slope stability model under steady state seepage at normal pool. A vertical coefficient was not applied.

#### 7.5.2.3 Model Results

Review of model results indicates some factors of safety lower than those required by current state regulations. As such, results were inspected and evaluated on the basis of the potential for significant damage to the embankment to occur. A number of failure types were identified, including shallow failures and deep failures. Sloughing failures were not considered during this evaluation, as the controls within Slope/W were set to only present failure surfaces with slip surface greater than 2-feet in depth.

- A "shallow" failure was considered to be a failure that extends more than 2-feet into the embankment cross section with significant movement of embankment materials that resemble a rotational failure of the slope. This type of failure is characterized by significant damage to the slopes. However, based upon the engineer's judgment, immediate progression or the potential for the embankment to lose structural integrity and the ability to retain water is not expected.
- A "deep" failure was considered to be a deep seated failure of the embankment section that is expected to impact the overall stability of the embankment section and may potentially lead to failure of the dam.

Results of the stability analyses are summarized in the following table:

**Table 7.3: Results of Slope Stability Analyses**

| | Required Factor of Safety | Upstream Slope | Downstream Slope |
|---|---|---|---|
| Sudden Drawdown from Normal Pool/Spillway Crest | 1.2 | **0.8** | N/A |
| Sudden Drawdown from Maximum Pool/Top of Dam | 1.1 | **0.8** | N/A |
| Steady Seepage at Maximum Storage Pool/Spillway Crest | 1.5 | **1.3** | **1.2** |
| Steady Seepage at Surcharge Pool/Top of Dam | 1.4 | N/A | **1.0** |
| Earthquake Loading | > 1.0 | **1.0** | **0.9** |

**Note: Bold values indicated those not meeting the required factors of safety

Based upon the model results, the modeled section ***does not*** meet the required factor of safety for any of the loading conditions. In addition, the stability evaluation indicated that the embankment slope ***is not*** stable with regard to sudden drawdown loading (upstream slope) and under earthquake loading (downstream)

## 7.6 Spillway Stability Analyses

A complete stability evaluation of the existing spillway structure was not completed as part of the scope of work. However, deficiencies were noted in the area of the spillway.

- Cracking and settlement was observed in the spillway approach apron

[1] In accordance with 302 CMR 10.14 (9)(i)

- Leakage was observed at the cold joint between the roadway culvert and the downstream spillway channel. This may possibly cause settlement and displacement of the downstream channel structure due to the transportation of soils under the structure.
- Multiple depressions were observed behind both downstream channel walls.
- Severe erosion and soil displacement was observed behind the downstream portion of the right wall.
- Deterioration, voids, settlement, and missing mortar were observed in the downstream steps. At the time of the evaluation, the downstream steps appeared to have settled with the lower portion of the step rotated upstream. This was allowing flow under or behind the steps instead of over them as designed.

In reviewing the construction drawings from the Dolan Road reconstruction project, it was noted that the current spillway culverts and downstream channel are installed above a 1 foot thick layer of gravel borrow material. Generally, this type of material is permeable and does not effectively resist seepage forces along the spillway structures. Flow from the cold joint between the roadway culverts and the downstream channel may cause transport of soil, which would result in voids, depressions, and settlement around the downstream channel walls.

It should be noted that the spillway and concrete channel sections appear stable. However, remedial measures have been suggested to improve the design life and functionality of the spillway structure. Furthermore, the stone masonry stepped portions at the downstream end of the channel are deteriorated with loss of mortar, shifting stones, and areas of apparent leakage noted.

# 8.0 ASSESSMENTS, RECOMMENDATIONS, AND REMEDIAL MEASURES

## 8.1 Dam Assessments

In general, the overall condition of the Ramshorn Pond Dam is **Poor**. The dam was found to have the following deficiencies:

1. Unwanted vegetation growth along both the upstream and downstream slopes.
2. Missing or displaced riprap along the upstream slope.
3. Areas of erosion, scarping, sloughing, sinkholes, and vertical irregularities throughout the dam. These areas included undermining of the concrete swales along the top of the upstream slope, excessive scarping at the toe of the dam near the downstream channel, and depressions along the alignment of the low level outlet.
4. Cracked/settled spillway approach apron.
5. Possible flow under or around the spillway causing depressions and vertical irregularities.
6. Possibly collapsed, broken, or clogged outlet or drainage structures. Catch basin and manhole structures with reported leakage and seepage issues.
7. Calculated factors of safety for slope stability below required minimums.
8. Possible uncontrolled seepage or leakage causing saturated areas at the toe.
9. Continued deterioration of the concrete spillway structure, including exposed aggregates, undermining of the downstream masonry steps, and possible leakage through the right channel wall causing erosion and the transportation of soils in the area.

In general, these deficiencies appear similar in extent and degree of degradation to those reported during the 2012 Follow-up Inspection performed by Tighe & Bond, and the 2011 Phase I Inspection performed by Weston & Sampson of the dam.

As part of the current evaluations, seepage and stability analyses were completed for a representative section of the embankment. These analyses indicate that the modeled cross section of the embankment does not meet the current minimum factors of safety for slope stability established by current state dam safety regulations. The model also suggests potential seepage instability at the toe of the dam.

Based upon hydrologic and hydraulic analyses completed as part of this evaluation, the dam can only accommodate the ½ PMF spillway design flood with the stop logs removed and the low level outlet gate open. In this scenario the level of the reservoir would rise to approximately 6 inches below the dam crest elevation. If the stop logs remain in place and the low level outlet gate remains closed, the dam may be overtopped by approximately 6 inches in the event of a ½ PMF storm.

## 8.2 Proposed Rehabilitation Program

Through coordination with the Owner, an ultimate project goal for the rehabilitation project has been defined as a project that will cost consciously upgrade the condition of the dam into full compliance with current state dam safety regulations. The proposed improvements should be designed to provide a stable dam that is expected to have a design life consistent with new construction. While it is understood that alternative approaches may be available to extend the life of existing structures, they would not be the preferred approachs given the probability of the need for future repairs.

In considering this project goal and the findings of the evaluations completed as part of this study, the following generally summarizes the scope of the proposed rehabilitation program.

### 8.2.1 Spillway Replacement

Based upon the completed hydrologic and hydraulic evaluations, the outlet structures at the dam can accommodate the SDF if fully open in the early stages of the ½ PMF storm event. However, little freeboard will remain, subjecting the dam to over wash as a result from wave action of the pond. Furthermore, if operations are not completed in time, or if operations cannot be completed due to high water or inoperability, the dam may be subject to overtopping.

In addition to the capacity concerns, structural concerns have also been identified. These include sinkholes developing along the channel walls, deterioration of the stone steps, leakage through joints in the spillway and beneath the spillway, potential unsuitable fill beneath the spillway, and significant scarping of the downstream toe as a result of flow through the downstream channel.

Given these concerns, it is recommended that a complete replacement of the spillway be considered. Two options for a replacement have been identified, as shown on Figure 4 and Figure 6.

- Option 1, as shown on Figure 4, includes the complete demolition and removal of the existing spillway and backfilling of the resulting excavation with suitable embankment fill. A new spillway would be designed and constructed near the center of the embankment. The spillway would be sized larger than the existing spillway in order to provide appropriate freeboard at the dam during the SDF to accommodate wave action.
- Option 2, as shown on Figure 6, includes the demolition and removal of the existing concrete channel and the construction of a new spillway chute. The chute would be designed to continue along the toe of the downstream slope and would convey flows to the downstream channel. During final design, a determination as to the extent of the repairs and/or the replacement of the existing spillway culvert and approach slab would need to be evaluated.

Once an approach is selected, several additional design features will need to be developed. These include but are not limited to:

- Energy Dissipation
- Scour Protection
- Level Control
- Final Geometry / Capacity
- Seepage Control

### 8.2.2 Low Level Outlet Replacement

The existing low level outlet includes a presumed 24-inch diameter conduit regulated by a valve in a wet well located on the downstream slope. The existing conduit consists of a cast iron pipe, assumed to have been installed as part of the original dam construction, upstream of the control chamber and a corrugated metal pipe downstream of the control chamber. The control chamber consists of a masonry well that is typically flooded during normal conditions, submerging the operating deck. The configuration of the intake and the presence of a trash rack is unknown.

Given the age of the conduit, particularly the corrugated metal pipe, it is likely to be deteriorated with open joints, corrosion, and other structural concerns. Furthermore, the configuration of the control structure and the masonry wet well introduces the potential for water pressure to permeate beyond the pipe into the downstream sections of the embankment. The valve also has a history of operational concerns and an inability to completely seal off flow.

Based upon the observed conditions, a complete replacement of the low level outlet is recommended. The new low level outlet is schematically proposed to include the following:

- Excavation and removal of the existing low level outlet. Backfill the resulting excavation with appropriate embankment fill materials.
- Installation of a new low level outlet consisting of:
    - A flared end intake with trash rack. The flared end will be designed to reduce approach velocity in order to reduce the potential for intake of debris. A trash rack will be provided to further reduce this potential.
    - A PVC or other rigid material pipe with a prolonged design life.
    - A cast-in-place concrete pipe cradle to reduce the seepage potential along the conduit.
    - A control chamber located along the upstream edge of the crest. The control chamber is anticipated to consist of precast concrete riser sections. The control chamber can be designed to include the following:
        - A low level outlet gate to enable draining of the impoundment
        - A level control gate that can provide a means to implement the seasonal drawdown without concerns for over lowering the impoundment

      While a gatehouse structure can be considered, the control chamber can also be designed to be level with the adjacent crest surface with operations completed from the crest elevation through the use of a T-wrench or other operating device.

During final design, it is recommended that the size of the low level outlet conduit be increased to provide additional discharge capacity. This increased capacity will not only allow for the low level outlet to accommodate the SDF with allowing appropriate freeboard to remain, but will also facilitate more rapid drawdowns in the event that emergency conditions are detected. Final design will also incorporate energy dissipation at the outlet, seepage control, and final layout.

### 8.2.3 Upstream Slope Stabilization

Current slope stability evaluations indicate that the upstream slope does not meet the minimum required factors of safety. In addition, the existing riprap appears ineffective with areas of exposed embankment soils, erosion, and the apparent displacement of stones. As such, remedial measures are required to provide an acceptable upstream slope section.

- Option 1 - Regrade: Remove and stockpile existing riprap. Regrade the slope to a stable section. Regrading will likely require relocating the toe of the slope as much as 10 feet upstream of the existing toe. Upon completion of regrading, install a geotextile fabric and bedding stone. Reset and supplement the stockpiled riprap to provide a uniform slope protection system.
- Option 2 - Replace: Remove the existing upstream riprap from the top of the slope, down to an elevation of approximately El. 629.0. Reset the removed stone along the lower portions of

the slope to provide additional buttressing at the toe of the slope and below the normal pool elevation. Install a sheet pile wall system along the upstream side of the dam.

Based upon the project goals and the preliminary opinions of probable cost, it appears that the sheet pile wall will provide a more cost effective and desirable solution to slope stability concerns. In addition to increasing the stability of the upstream slope to comply with dam safety regulations, the wall will also provide a number of secondary benefits, including:

- Reducing seepage through the embankment. The upstream wall, if installed to a sufficient depth, will act as a cutoff wall that will assist in addressing identified seepage concerns.
- Widening the crest. While not a consideration to dam safety aspects of the project, widening the crest could provide a vehicular parking area that will increase accessibility to the pond for Town residents.

Once an approach is selected, several additional design features will need to be developed. These features include but are not limited to:

- Wall penetrations for the low level outlet and spillway
- Wall location / alignment
- Ramp configuration for public access
- Final installation depth
- Type of sheet pile. While steel sheeting is traditionally used, PARE recommends the consideration of a hollow PVC cellular sheet pile filled with reinforced concrete. This type of sheet pile is anticipated to provide a longer design life, improved aesthetics, and lower maintenance concerns.
- Wall cap and public safety improvements (railings, etc.)
- Surface treatment for the parking area on the crest

### 8.2.4 Downstream Slope Stabilization

Current slope stability evaluations indicate that the downstream slope does not meet the required minimum factors of safety. In addition, the existing toe drain system appears deteriorated with possible collapses and ineffective transport of seepage and drainage flow to the downstream channel. Therefore, remedial measures are required to provide an acceptable slope section. The slope improvements proposed include the following:

- Clearing and grubbing existing vegetation
- Stripping of existing loam
- Replacement of the existing toe drain with an appropriately designed toe drain system
- Regrading of the downstream slope to a uniform stable section
- Loaming and seeding of the slope

### 8.2.5 Additional Site Improvements

In addition to the improvements discussed in the preceding sections, the proposed dam improvement will also require a number of additional design features. These features may include:

- Storm Water Management: Dependent upon final changes in the total area of impervious features on the site, new storm water management features will be required. At a minimum, it is recommended that the existing catch basins and conduits within the embankment be replaced with new structures installed in accordance with dam safety practice. The outlet to the existing spillway channel will also need to be relocated to a suitable discharge area. If permittable, the drainage systems could connect to the proposed toe drain, similar to the existing conditions, or outlet to the spillway channel. However, given other site improvements, specifically the potential for increased impervious area, additional storm water features may be required. These features may include TSS removal, infiltration, and/or detention systems.
- Roadway Improvements: Given the scope of work and level of activity, it is likely that existing pavement will need to be replaced in its entirety. Upon repaving of the roadway, installation of curbing is recommended to contain roadway runoff within the roadway and towards drainage structures.
- Public Access: While the upstream wall will provide parking areas, a ramp and canoe launch facility will need to be incorporated into the design. The ramp will likely be located at the right end of the upstream wall with a 6-foot wide sloped ramp to the water's edge. Final design should be coordinated with applicable canoe access and handicapped fishing standards of the Massachusetts Department of Fish and Game.

## 8.3 Routine Dam Safety Activities

The following activities should be completed on a routine basis and included within yearly budgets. The completion of these activities are recommended to keep the dam in compliance with dam safety regulations, maintain the dam in a satisfactory condition, identify minor maintenance items before they become costly repairs, and prolong the life expectancy of the system.

1. Develop and implement a formal operations and maintenance (O&M) manual. The manual should provide recommendations and schedules for the completion of routine maintenance and operations at the dam. The O&M is recommended to provide guidance for:
    a. Complete regular maintenance activities including:
        i. Regular mowing of grass on the embankment.
        ii. Routine clearing of vegetation from areas of the dam
        iii. Periodic repair to areas of erosion or other surface deficiencies
        iv. Clearing of debris from the spillway and outlet structures
    b. Complete regular operation activities including:
        i. Exercising the low level outlet gate through the full range of motion twice per year.
        ii. Annual adjustment of the low level outlet to implement seasonal drawdown
        iii. Operations, as required, in anticipation of rainfall and in response to elevated impoundment conditions.
    c. Complete regular inspection activities including:
        i. Regular informal inspection by Town personnel
        ii. Periodic inspection by qualified Town personnel. Personnel familiar with the dam should visit the site quarterly to assess the overall dam condition and collect data from any instrumentation.
        iii. Formal inspection in accordance with current dam safety regulations. As the dam is currently classified as a high hazard potential dam, inspection is required every 2 years.

2. Routine reviews, updates, and exercise of the Emergency Action Plan. The 2007 Emergency Action Plan developed by GZA should be reviewed, and updates to the emergency contact flow chart should be completed. Possible new downstream hazards such as residential developments should be assessed and added to the EAP as necessary. Updates to the EAP are recommended to be completed annually to ensure that contact information remains accurate and up to date.

### 8.4 Opinion of Probable Cost

The following conceptual opinions of probable cost have been developed for the recommendations noted above. The costs shown herein are based on a limited investigation and are provided for general information only. This should not be considered an engineer's estimate, as actual construction costs may be somewhat less or considerably more than indicated. Combination and overlap of more than one repair may also result in overall project cost savings. For more detailed information utilized for the development of the opinions of probable cost, refer to Appendix E.

*Recommended Repair Program*

| | | | |
|---|---|---|---|
| 1. Spillway Replacement | | | |
| i. Option 1: New Spillway | $ 294,000 | | |
| ii. Option 2: Existing Spillway Improvement | $ 450,000 | | |
| 2. Low Level Outlet Replacement | | | |
| i. With Spillway Option 1: | $ 148,000 | | |
| ii. With Spillway Option 2: | $ 169,000 | | |
| 3. Upstream Slope Stabilization | | | |
| i. Option 1: Sheet Pile Wall | $ 713,000 | | |
| ii. Option 2: Regrade | $ 380,000 | | |
| 4. Downstream Slope Stabilization | | | |
| i. With Spillway Option 1: | $ 37,000 | | |
| ii. With Spillway Option 2: | $ 29,000 | | |
| 5. Additional Site Improvements | | | |
| i. Tree Removal | $ 20,000 | | |
| ii. Erosion Control | $ 23,000 | | |
| iii. Roadway Improvements/ Storm Water Management | $ 94,000 | | |
| iv. Public Access | *Included in Repair 3(i); None in 3(ii)* | | |
| v. Loam and Seed/Site Finishing | $ 18,000 | | |
| **Total Construction Costs** | **$ 1,350,000** | - | **$ 1,500,000** |
| Contingencies, Bonds, Etc. | $ 458,000 | - | $ 509,000 |
| Additional Engineering & Design | $ 25,000 | - | $ 30,000 |
| Construction Administration | $ 60,000 | - | $ 80,000 |
| **Total Schematic Opinion of Probable Cost** | **$ 1,893,000** | - | **$ 2,119,000** |

Note: Opinions of cost do not includes costs for control of water. As part of the schematic design, control of water is assumed to be accomplished by full pond drawdown as required to complete the work. Dependent upon options selected, some control of water and cofferdams are likely to be required. However, this cost is currently carried within the cost contingency.

*Ongoing Dam Safety Activities*

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Operations & Maintenance | | | | | |
| | i. Regular Maintenance | *Town Forces* | | | | |
| | ii. Regular Operations | *Town Forces* | | | | |
| | iii. Regular Inspection | $ | 2,000 | - | $ | 4,000 / yr |
| 2. | Emergency Action Plan Updates | $ | 1,000 | - | $ | 2,000 / yr |

When comparing costs, the total cost including design, engineering, permitting, construction and long-term maintenance should be considered. The applicability of environmental permits needs to be determined prior to undertaking maintenance activities that may occur within resource areas under the jurisdiction of MADEP, local conservation commissions, or other regulatory agencies.

## 8.5 Proposed Repair Approach

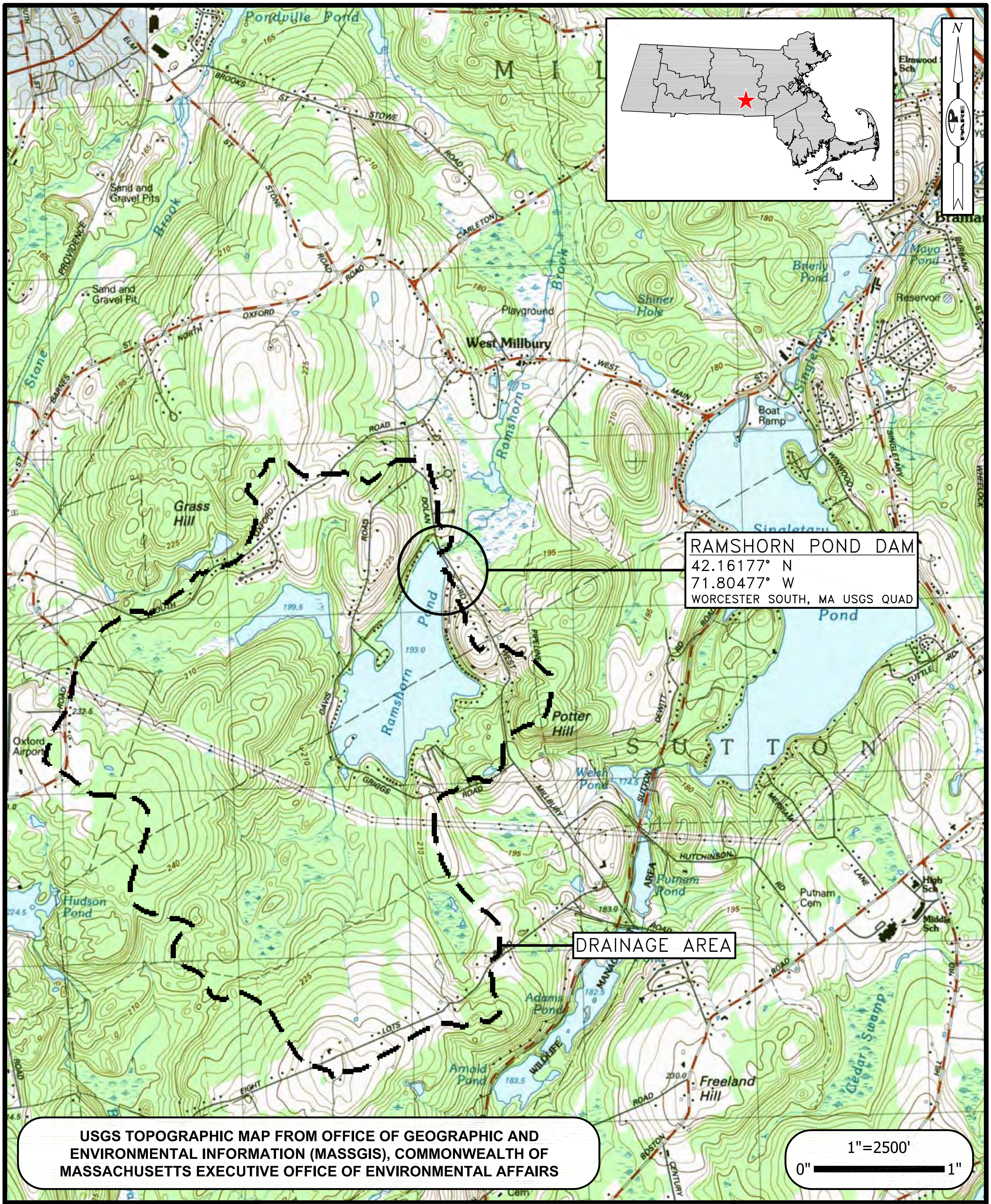
Based upon the observed conditions and the findings of this evaluation, a number of repairs are required to be completed at the Ramshorn Pond Dam to bring the dam into compliance with current state dam safety regulations. While a number of repair alternatives have been identified, repair options would likely have a limited design life. The Owner of the dam has indicated project goals to provide a safe dam structure that will provide repair solutions with design lives comparable to a new structure without the need to implement additional repairs and/or improvements in the near future. Given the identified project goals, PARE has developed the following summary of the recommended approach to achieve these goals, incorporate public access opportunities, and meet minimum dam safety design requirements.

- Clear, grub, and strip all trees, vegetation, and roots systems within 20 feet of the dam.
- Stabilize the upstream slope through the installation of a sheet pile wall. Design the sheet pile wall to address noted seepage concerns and provide public access opportunities.
- Provide curbing along the roadway to prevent runoff on the embankment slopes. Rehabilitate/repair the drainage system and outfalls with associated BMP improvements.
- Resurface the roadway.
- Replace the existing toe drain with a new toe drainage system.
- Remove the existing spillway in its entirety and replace with embankment fill.
- Construct a new spillway designed to provide operational options and freeboard during the spillway design flood. Locate the spillway near the low level outlet to reduce the requirements for channel scour protection along the existing spillway channel.
- Remove/abandon the existing low level outlet. Install a new low level outlet system with an upstream control chamber and increased capacity to improve draw down capacity.
- Regrade the downstream slope to a stable, uniform section.

# FIGURES

*Ramshorn Pond Dam*

***Millbury, Massachusetts***




PARE CORPORATION

# RAMSHORN POND DAM

MA00145 / 3-14-186-21

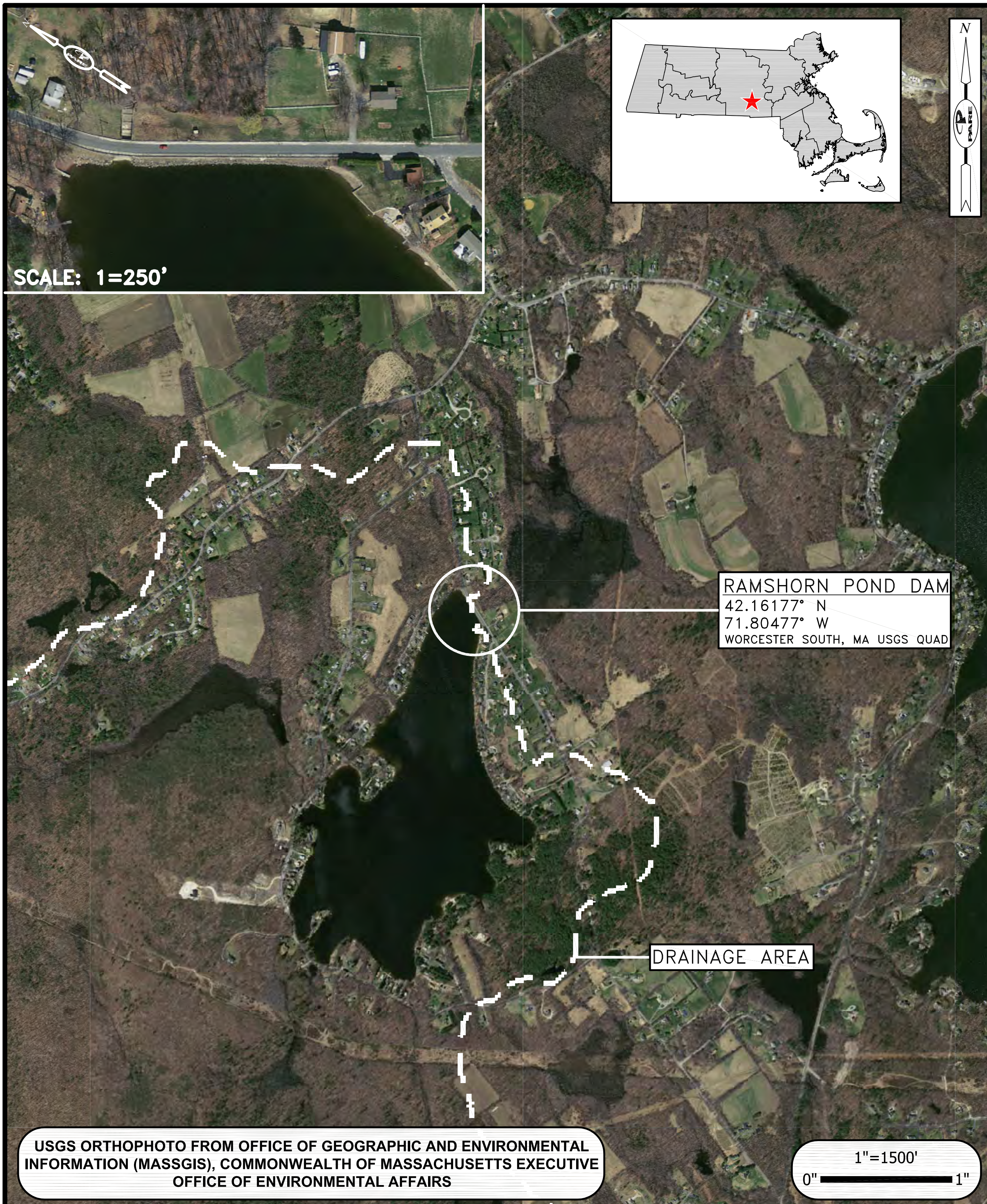
MILLBURY, MASSACHUSETTS

TOWN OF MILLBURY PUBLIC WORKS

LOCUS PLAN

OCTOBER 2013

FIGURE 1




PARE CORPORATION

# RAMSHORN POND DAM

MA00145 / 3-14-186-21

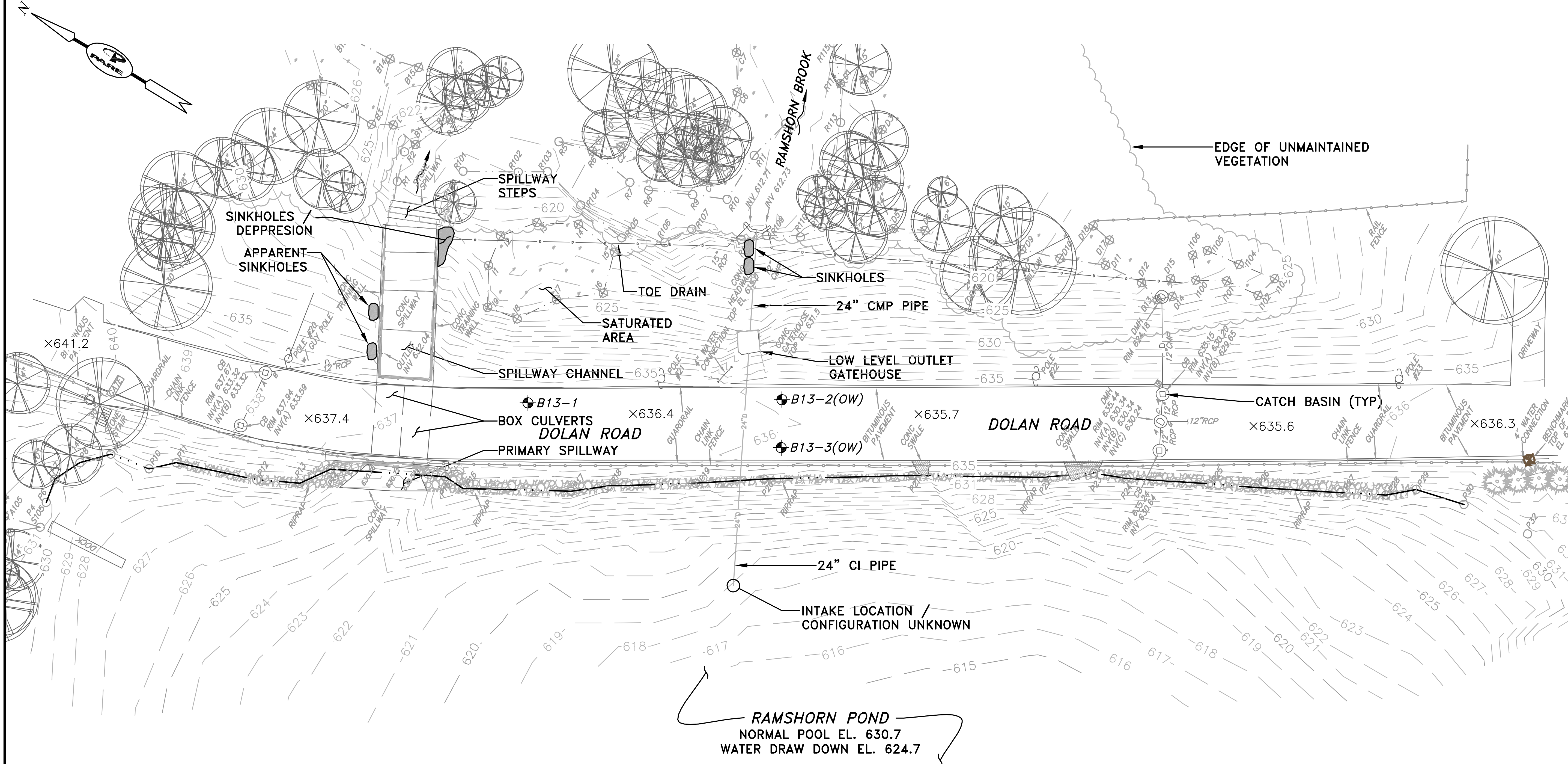
MILLBURY, MASSACHUSETTS

TOWN OF MILLBURY PUBLIC WORKS

AERIAL PLAN

OCTOBER 2013

FIGURE 2




## SITE SKETCH

SCALE: 1"=40'

## NOTES AND LEGEND

1. PLAN DEVELOPED BASED UPON A TOPOGRAPHIC AND BATHYMETRIC SURVEY COMPLETED BY HERITAGE DESIGN GROUP OF WHITTINSVILE, MA DATED JULY 2013.

B13–2 — BORING COMPLETED BY NORTHERN DRILL SERVICE OF NORTHBOROUGH, MA FROM JULY 15 TO 17, 2013, AND OBSERVED BY PARE PERSONNEL.

TREE / DIAMETER

WETLAND FLAGS


PARE

PARE CORPORATION
ENGINEERS - SCIENTISTS - PLANNERS
10 LINCOLN ROAD, SUITE 103
FOXBORO, MA 02035
508-543-1755


SCALE ADJUSTMENT GUIDE

0" 1"

BAR IS ONE INCH ON ORIGINAL DRAWING.

# RAMSHORN POND DAM

MA00145 / 3-14-186-21

MILLBURY, MASSACHUSETTS

TOWN OF MILLBURY PUBLIC WORKS

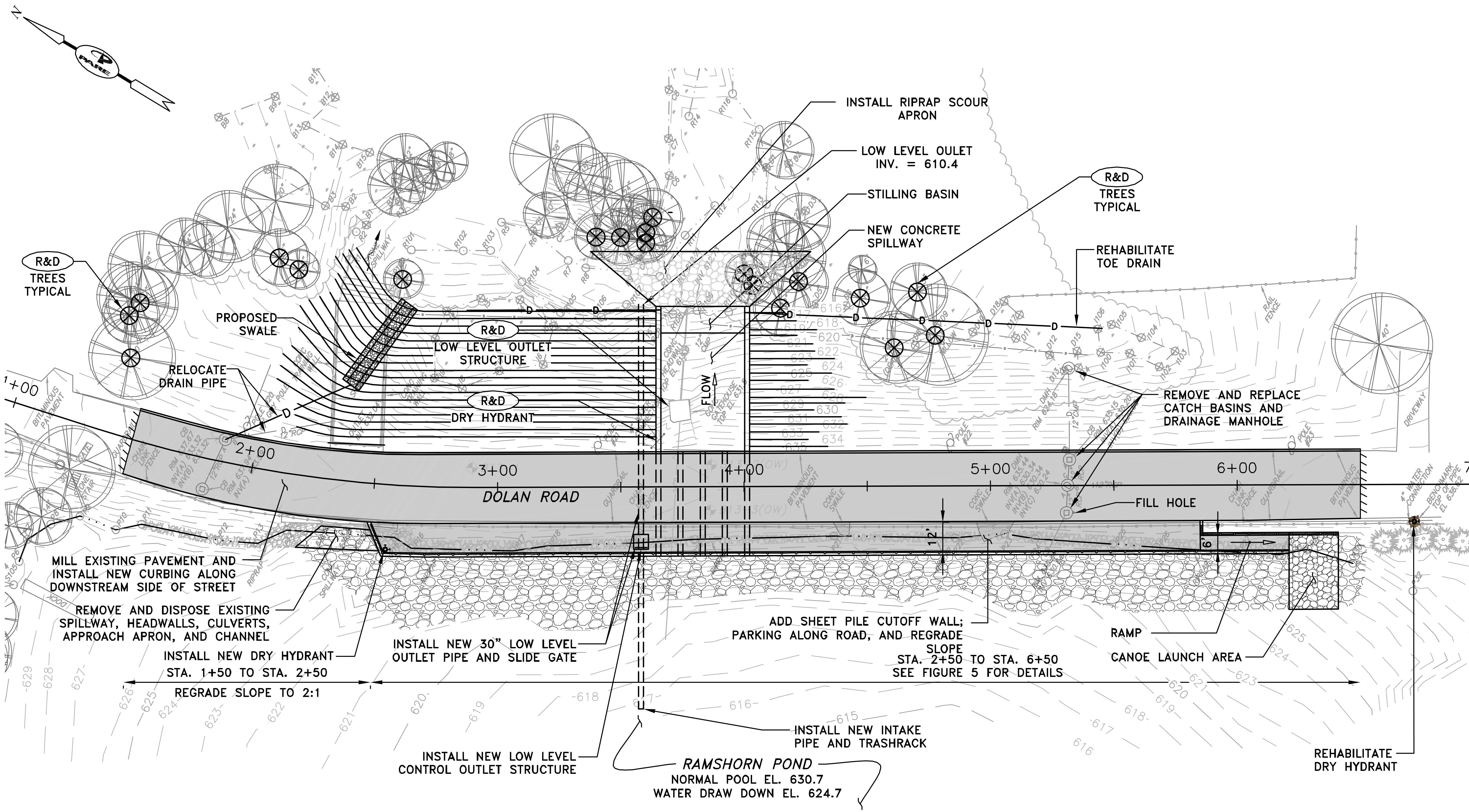
REVISIONS:

| | |
|---|---|
| PROJECT NO.: | 13072.00 |
| DATE: | OCTOBER 2013 |
| SCALE: | AS NOTED |
| DESIGNED BY: | JMC |
| CHECKED BY: | ARO |
| DRAWN BY: | JHG |
| APPROVED BY: | JMB |

EXISTING SITE PLAN

FIGURE NO.: 3

Z:\JOBS\13 Jobs\13072.00 Ramshorn Pond Dam Design & Permitting\dwg\Figure 3.dwg




## CONCEPTUAL REPAIRS

SCALE: 1"=40'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508-543-1755


SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

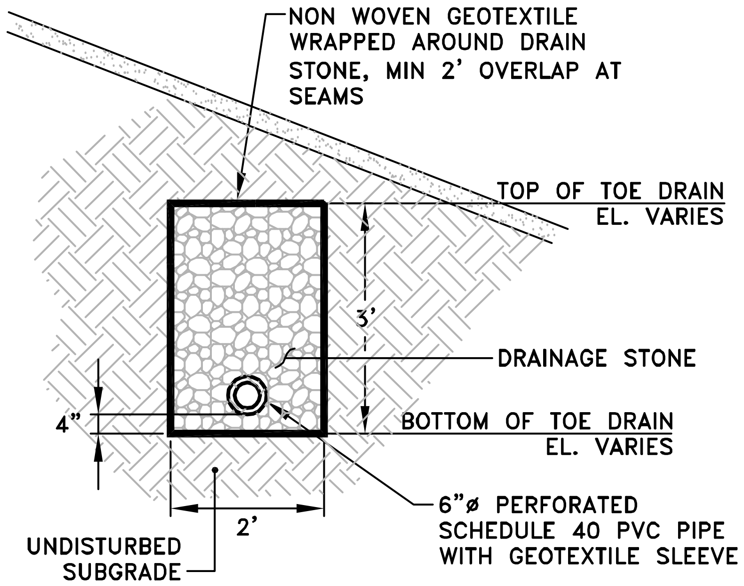
RAMSHORN POND DAM
MA00145 / 3-14-186-21
MILLBURY, MASSACHUSETTS
TOWN OF MILLBURY PUBLIC WORKS

REVISIONS:

| | |
|---|---|
| PROJECT NO.: | 13072.00 |
| DATE: | OCTOBER 2013 |
| SCALE: | AS NOTED |
| DESIGNED BY: | JMC |
| CHECKED BY: | ARO |
| DRAWN BY: | JHG |
| APPROVED BY: | JMB |

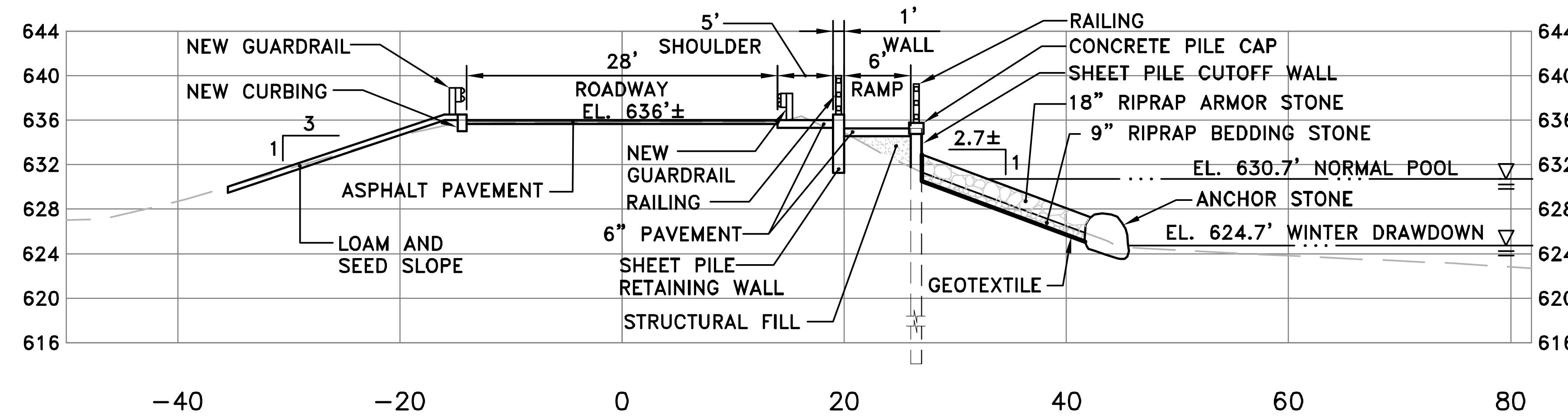
SCHEMATIC SITE PLAN

FIGURE NO.: 4



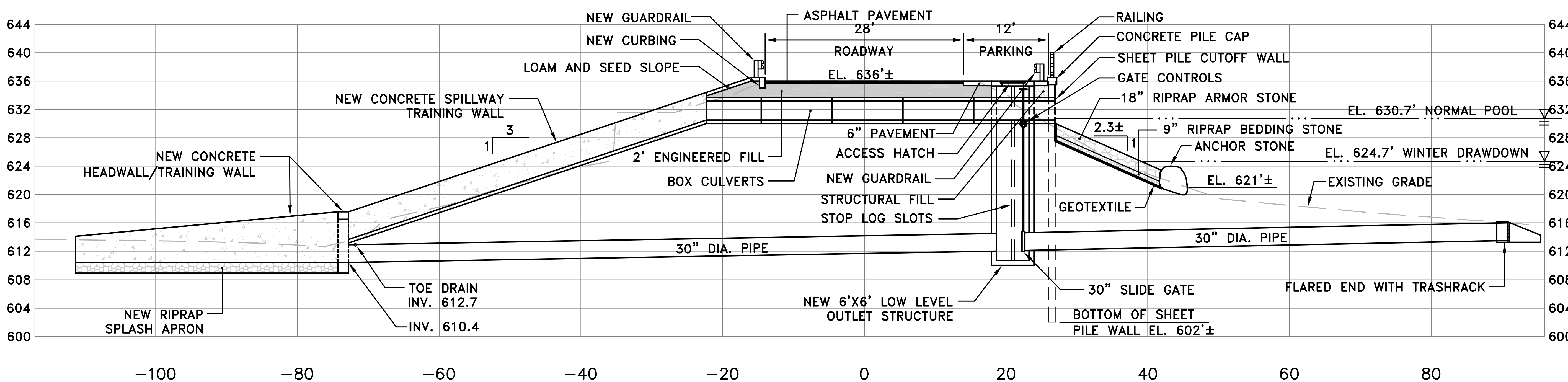

## TOE DRAIN DETAIL

NOT TO SCALE




## SECTION AT RAMP TO CANOE LAUNCH AREA

SCALE: 1"=15'




## SECTION AT LOW LEVEL OUTLET STRUCTURES

SCALE: 1"=15'

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508-543-1755

SCALE ADJUSTMENT GUIDE

0" 1"

BAR IS ONE INCH ON ORIGINAL DRAWING.

# RAMSHORN POND DAM

MA00145 / 3-14-186-21
MILLBURY, MASSACHUSETTS
TOWN OF MILLBURY PUBLIC WORKS

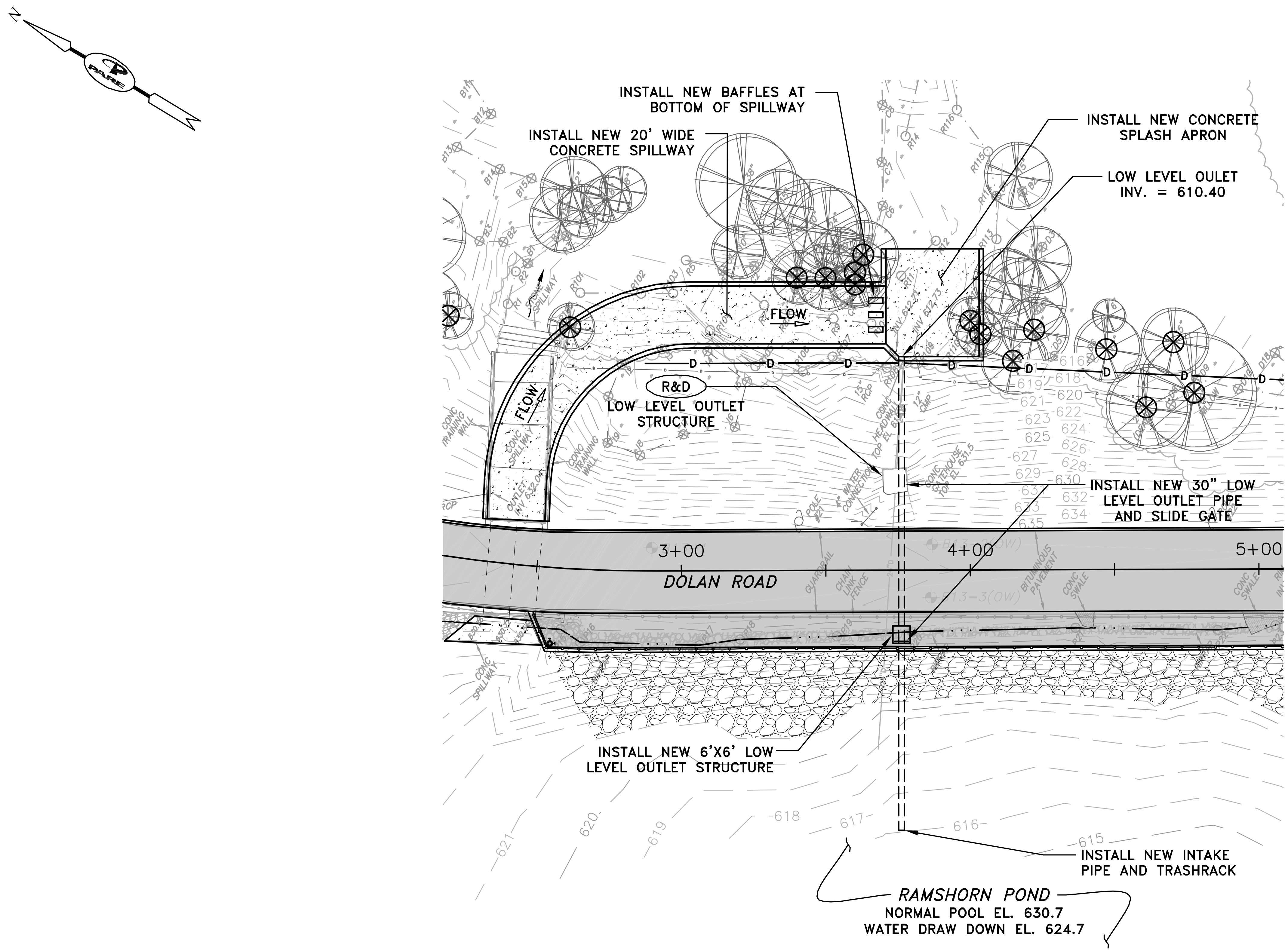
REVISIONS:

| | |
|---|---|
| PROJECT NO.: | 13072.00 |
| DATE: | OCTOBER 2013 |
| SCALE: | AS NOTED |
| DESIGNED BY: | JMC |
| CHECKED BY: | ARO |
| DRAWN BY: | JHG |
| APPROVED BY: | JMB |

SCHEMATIC SECTION AND DETAILS

FIGURE NO.: 5

Z:\JOBS\13 Jobs\13072.00 Ramshorn Pond Dam Design & Permitting\dwg\Figure 5.dwg




## ALTERNATE SCHEMATIC DESIGN

SCALE: 1"=40'

PARE CORPORATION
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10 LINCOLN ROAD, SUITE 103
FOXBORO, MA 02035
508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

# RAMSHORN POND DAM
MA00145 / 3-14-186-21
MILLBURY, MASSACHUSETTS
TOWN OF MILLBURY PUBLIC WORKS

REVISIONS:

| | |
|---|---|
| PROJECT NO.: | 13072.00 |
| DATE: | OCTOBER 2013 |
| SCALE: | AS NOTED |
| DESIGNED BY: | JMC |
| CHECKED BY: | ARO |
| DRAWN BY: | JHG |
| APPROVED BY: | JMB |

ALTERNATE SCHEMATIC DESIGN

FIGURE NO.: 6

Z:\JOBS\13 Jobs\13072.00 Ramshorn Pond Dam Design & Permitting\dwg\Figure 6.dwg

# APPENDIX A
# June 29, 2012 Follow-Up Inspection Report
*Ramshorn Pond Dam*
***Millbury, Massachusetts***

Tighe&Bond
www.tighebond.com

22.0736.20.34
June 29, 2012

William Salomaa, Dam Safety Director
Commonwealth of Massachusetts
Department of Conservation and Recreation
Office of Dam Safety
251 Causeway Street
Boston, MA 02114-1449

**Re: MA00145 – Ramshorn Pond Dam**
**Millbury, MA**
**Follow-up Inspection Report *(Revised)***

Dear Bill:

Per your request, Tighe & Bond has prepared the attached follow-up inspection report for Ramshorn Pond Dam, located in Millbury, Massachusetts.

The follow-up inspection was ordered by DCR, Office of Dam Safety, to assess the current condition of the dam in response to an email sent to your office that the dam was being overtopped.

Tighe & Bond visited the dam the same day the inspection was ordered and found that water was not overtopping the dam and was in fact below the spillway elevation. Noted observations made during this inspection were similar to those reported previously.

Please review this report and contact the undersigned at 508-471-9645, if you have any questions or need additional information.

Very truly yours,

**TIGHE & BOND, INC.**

Christopher D. Haker, P.E.
Senior Engineer

Cc: Mr. Bob Spain – Millbury Town Manager

\\SRV\Projects\M\M0736 MA DCR Engineering Services MSA\ODS FY12\Assignment 4\Follow-Ups\MA00145 Ramshorn Pond Dam\Report Docs\DCR cover letter.doc

**Department of Conservation and Recreation**
**Office of Dam Safety Poor Condition Dam Follow-up Inspection Form**

| | |
|---|---|
| **Dam Name:** | Ramshorn Pond Dam |
| **Dam Owner:** | Town of Millbury |
| **Nat. ID Number:** | MA00145 |
| **Location of Dam:** | Millbury, MA |
| **Coordinate location:** | 42.16176891N, 71.80476902W |
| **Date of Inspection:** | June 28, 2012 |
| **Weather:** | Sunny, 80s° |
| **Consultant Inspector:** | Christopher D. Haker, P. E.<br>Tighe & Bond Inc. |
| **Others In Attendance:** | Bob Spain – Millbury Town Manager<br>Steve Kosiba – Millbury Emergency Manager |
| **Attachments:** | Locus plan, site sketch and current photos |

## I. PREVIOUS DATA / OVERALL CONDITION OF DAM:

Weston & Sampson performed a Phase 1 inspection at this dam on April 6, 2011. The dam is **Large** in size and classified as **High Hazard (Class I**) in accordance with 302 CMR 10.00, Dam Safety Regulations and was considered to be in **Poor** condition based on Office of Dam Safety's rating guidelines.

## II. OVERALL CONDITION OF DAM AT TIME OF LAST INSPECTION DATED April 6, 2011

A visual Phase 1 inspection of Ramshorn Pond Dam was conducted by Weston & Sampson on April 6, 2011.

At the time of inspection, the weather was clear with temperatures in the 50's°F. Photos to document the conditions of the dam were taken during the inspection and are included as an attachment to that report. The impoundment was approximately 3 feet below the top of the spillway flashboards.

Below is summary of the key deficiencies noted in Weston & Sampson's report:

1. Erosion, scarps, and sloughing were observed on the earthen portion of the slope causing over-steeping of the upstream slope.
2. Upstream riprap had slid down the slope and large voids were observed between the riprap.
3. Upstream concrete armoring along the top of slope was undermined.
4. Standing water with wetland vegetation was observed within a large depression to the right of the spillway on the downstream slope.
5. Sinkholes and erosion were observed along the alignment of the low-level outlet (LLO) downstream of the gatehouse, around the gatehouse, and behind both spillway training walls.

6. Erosion was observed along the downstream toe of slope due to flow from spillway discharge channel that runs parallel to the slope until it reaches the LLO discharge channel.
7. Brush and trees were encroaching the downstream slope.
8. The spillway approach slab was cracked, settled, and undermined along the upstream edge.
9. Exposed aggregate and rebar was observed within the cast-in-place portion of the spillway channel.
10. Portions of the stepped stone masonry channel were undermined.
11. The LLO gate is on the downstream end of the pipe causing much of the pipe to be under full reservoir head pressure that could cause seepage and/or piping within the embankment if the pipe were to leak.
12. The valve stem is reportedly bent preventing proper operation of the valve.

## III. OVERALL CONDITION OF DAM AT TIME OF FOLLOW-UP INSPECTION DATED June 28, 2012:

A visual follow-up inspection of Ramshorn Pond Dam was conducted by Tighe & Bond on June 28, 2012. This inspection was ordered by DCR the same day due to an email DCR indicating water was overtopping the dam and there was threat of dam failure. Upon arrival, water was not overtopping the dam and there was no evidence that the dam overtopped recently.

At the time of inspection, the weather was clear with temperatures in the 80's°F. Photos to document the current conditions of the dam were taken during the inspection and are included as an attachment to this report. The impoundment elevation at the time of inspection was approximately two feet below the top of the wood flashboards in the spillway.

The following observations were made during the inspection:

1. Standing water with wetland vegetation was observed within a large depression to the right of the spillway on the downstream slope.
2. Sinkholes and erosion were observed along the alignment of the low-level outlet (LLO) downstream of the gatehouse, around the gatehouse, and behind both spillway training walls.
3. Erosion was observed along the downstream toe of slope due to flow from spillway discharge channel that runs parallel to the slope until it reaches the LLO discharge channel.
4. Brush and trees were encroaching the downstream slope.
5. The spillway approach slab was cracked, settled, and undermined along the upstream edge.
6. Exposed aggregate and rebar was observed within the cast-in-place portion of the spillway channel.
7. Portions of the stepped stone masonry channel were undermined.
8. The LLO gate is on the downstream end of the pipe causing much of the pipe to be under full reservoir head pressure that could cause seepage and/or piping within the embankment if the pipe were to leak.

It is suspected that the other deficiencies noted by Weston & Sampson in their 2011 Phase 1 inspection are still present, but could not be observed during this inspection as the fence with locked gates along the upstream slope and thick grass and brush growth on the downstream slopes prevented access for proper inspection.

## IV. COMPARISON OF CONDITIONS TO PREVIOUS INSPECTION:

Based on visual observations made during the June 28, 2012 follow-up inspection, it appears that the dam has not undergone any visibly significant changes since the 2011 Phase 1 inspection by Weston & Sampson. It also appears that no repairs or maintenance has been performed at the dam since the 2011 Phase 1 inspection.

Reference is made to the April 2011 Phase 1 Report by Weston & Sampson for a detailed discussion of the deficiencies. The Phase 1 Report also provides detailed recommendations for repairing the dam.

## V. DAM SAFETY ORDERS:

1. Information not made available to Tighe & Bond at the time report was prepared.

## VI MAINTENANCE:

1. There is no formal Operation & Maintenance Plan for this dam.
2. The embankments were reported mowed periodically; however, it doesn't appear that any mowing has been performed yet this year. The LLO valve is reportedly opened annually for a winter drawdown.

## VII RECOMMENDATIONS AND FOLLOW-UP ACTION TO BE TAKEN:

As indicated in the April Phase 1 report, a Phase 2 inspection and report should be performed to better understand the condition and performance of the dam. As a typical Phase 2, the following evaluations/analyses should be performed:

- Subsurface explorations and instrumentation to support a seepage and stability analyses.
- Seepage and stability analyses to evaluate the need for seepage cutoff and/or seepage collection, and the factor of safety for slope stability under various loading conditions.
- Detailed hydrologic and hydraulic analysis to evaluate the spillway capacity to safely pass the spillway design flood, which is the ½ probable maximum flood.
- Prepare conceptual design alternatives to improve the condition and performance of the dam based on the results of the above analyses.

## IX ALTERNATIVES

Repair alternatives should be prepared as part of a Phase 2 inspection.

## X OTHER COMMENTS OR OBSERVATIONS:

Based on this follow-up inspection, and the fact that no remedial measures have been implemented to date, the dam remains in **Poor** condition.

Follow up inspections, on a six month interval, should be performed at the dam until the dam is properly repaired or removed. A modified inspection schedule should include a spring and fall inspection to avoid winter snow conditions.

j:\m\m0736 ma dcr engineering services msa\ods fy12\assignment 4\follow-ups\ma00145 ramshorn pond dam\report text 06-28-12.doc

## XI SITE SKETCH WITH PHOTO LOCATIONS:

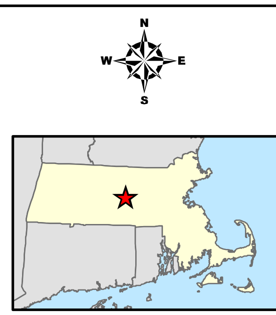

1 Photo Location and Direction

1:1,200

0 100

Feet

Based on MassGIS Color Orthophotography (April 2009)
Orthophoto Sheet ID # 17428795




# PHOTO LOCATION PLAN

Ramshorn Pond Dam
Millbury, Massachusetts

Tighe&Bond
July 2012

## XII PHOTOGRAPHS:


Photo 1 – Overview of impoundment


Photo 2 -View of dam crest/Dolan Road from left abutment.

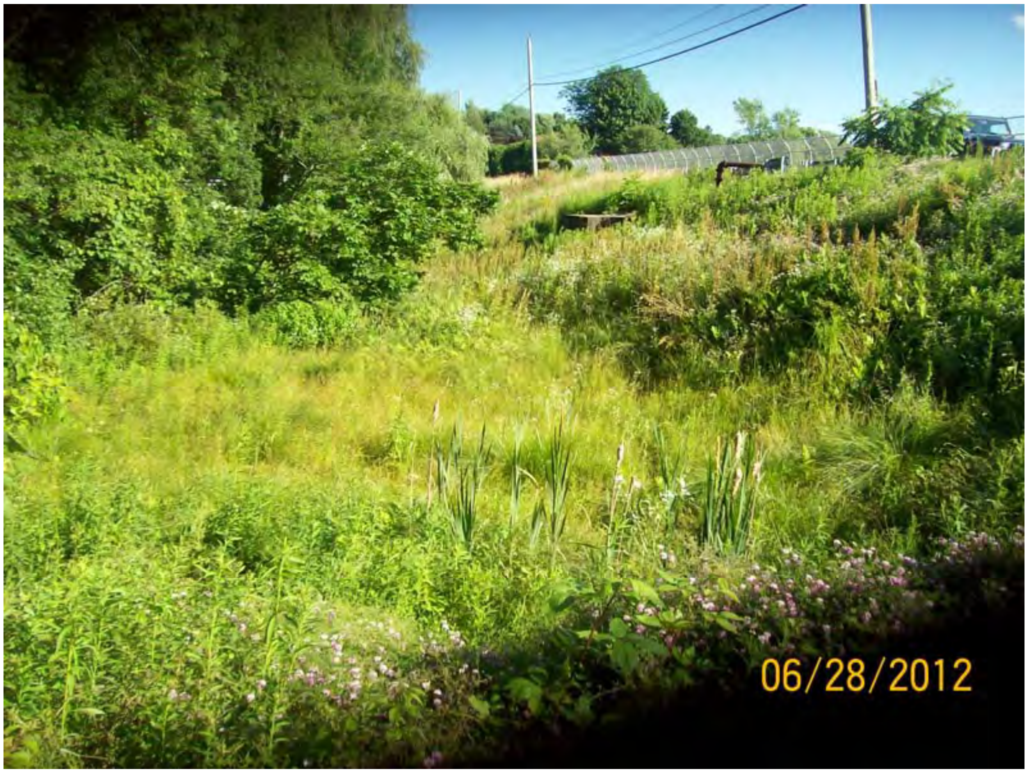


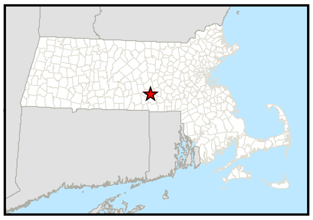

Photo 3 – Downstream slope from spillway channel. Note wetland vegetation at toe of slope due to seepage


Photo 4 – Downstream slope from right abutment. Note heavy grass growth and large willow tree


Photo 5 – Spillway flashboards and concrete approach slab.


Photo 6 – Looking upstream at twin box culvert spillway. Note flashboards at upstream end

# XIII LOCUS MAP:

## LEGEND

1-Mile Radius

Municipal Boundary

Source: U.S Geological Survey (ESRI's online US Topo Maps), in cooperation with Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs

N

1 inch = 2,000 feet

0 1,000 2,000 Feet

# FIGURE 1
# SITE LOCATION MAP

Ramshorn Pond Dam

(MA00145)

Millbury, Massachusetts

Tighe&Bond

July 2012

Y:\Site_Locus_Figures\MA\MillburyMA\RamshornPondDam_SiteLocus.mxd Date Saved: 7/6/2012 User: ncd

# APPENDIX B
# Visual Dam Inspection Limitations

*Ramshorn Pond Dam*

***Millbury, Massachusetts***

**VISUAL DAM INSPECTION**
**LIMITATIONS**

## Visual Inspection

1. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of this report.

2. In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

3. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

4. It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

## Use of Report

1. The applicability of other environmental permits (ie., NOI, PGP, Water Quality Certificate, etc.) needs to be determined prior to undertaking maintenance activities that may occur within resource areas under the jurisdiction of MADEP, the local conservation commission or other regulatory agency.

2. This report has been prepared for the exclusive use of the Town of Millbury for specific application to the reference dam site in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made.

3. This report has been prepared for this project by PARE. This report is for preliminary evaluation purposes only and is not necessarily sufficient to support design or repairs or recommendations or to prepare an accurate bid.

# APPENDIX C
## Subsurface Exploration Data

*Ramshorn Pond Dam*

***Millbury, Massachusetts***

# PARE CORPORATION

10 LINCOLN ROAD, SUITE 103, FOXBORO, MASSACHUSETTS
ENGINEERS *** PLANNERS *** CONSULTANTS

BORING NO. **B13-1**
SHEET 1 OF 1

PROJECT: Ramshorn Pond Dam, Millbury, MA
PROJECT NO.: 13072.00
CHKD. BY: ARO

BORING CO.: Northern Drilling
FOREMAN: Chip Tucker
INSPECTOR: A. Judge
BORING LOCATION: DOWNSTREAM SIDE OF ROAD, 40' RIGHT OF SPILLWAY
GROUND SURFACE ELEVATION: 636.7 DATUM: NAVD88
DATE START: 7/17/2013 DATE END: 7/17/2013

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. SAFETY HAMMER FALLING 30 in.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING 300 lb. HAMMER FALLING 24 IN.

CASING SIZE: 4" OTHER: Donut Hammer

GROUNDWATER READINGS

| DATE | TIME | WATER AT | CASING AT | STABILIZATION TIME |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

| DEPTH (ft) | CASING (bl/ft) | SAMPLE NO. | PEN. (in.)/ REC. | DEPTH (FT) | BLOWS/6" | TONS/FT² OR KG/CM² | SAMPLE DESCRIPTION (Burmister CLASSIFICATION) | REMARKS | STRATUM DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 18/3 | 0.5-2 | 26 34 | | Moist, very dense, brown, fine to coarse SAND, little silt, trace fine gravel. | | 4" ASPHALT |
| | | | | | 34 32 | | | | |
| | | S-2 | 24/18 | 2-4 | 32 42 | | Moist, very dense, fine to medium SAND, some fine gravel, little silt, little asphalt. | | |
| | | | | | 30 24 | | | | |
| 5 | | S-3 | 24/10 | 4-6 | 8 6 | | Moist, medium dense, tan, fine to medium SAND, little silt, little fine gravel. | | FILL |
| | | | | | 7 10 | | | | |
| | | S-4 | 24/14 | 6-8 | 12 20 | | Moist, dense, tan, fine to medium SAND, little silt, little fine gravel. | | |
| | | | | | 20 24 | | | | |
| | | S-5 | 24/14 | 8-10 | 14 16 | | Moist, medium dense to dense, tan, fine to medium SAND, little silt, little fine gravel. | | |
| 10 | | | | | 14 19 | | | | |
| | | S-6 | 24/14 | 10-12 | 14 15 | | Moist, dense, tan, fine to medium SAND, little silt, little fine gravel. | | |
| | | | | | 22 27 | | | 1. | |
| | | S-7 | 24/20 | 12-14 | 16 36 | | Wet tan, very dense, fine to medium SAND, little silt, little fine gravel. | | |
| | | | | | 45 48 | | | | |
| 15 | | S-8 | 24/18 | 14-16 | 40 100 | | Wet, very dense, tan, fine to medium SAND, little fine gravel, little silt. | | |
| | | | | | 56 45 | | | | |
| | | S-9 | 24/12 | 16-18 | 42 43 | | Wet, very dense, tan, fine to medium SAND, little fine gravel, little silt. | | SAND |
| | | | | | 42 42 | | | | |
| | | | | | | | | | |
| 20 | | S-10 | 22/18 | 19-20.3 | 28 44 | | Wet, very dense, tan, fine to medium SAND, little fine gravel, little silt. | | |
| | | | | | 68 80/4" | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | 2. | |
| 25 | | S-11 | 16/12 | 24-25.3 | 72 76 | | Wet, very dense, tan, fine to medium SAND, some fine gravel, little silt. | | |
| | | | | | 80/4" | | | | |
| | | | | | | | | | TILL |
| | | | | | | | | | |
| | | | | | | | | | |
| 30 | | S-12 | 17/12 | 29-30'5" | 62 70 | | Wet, very dense, tan, fine to medium SAND, some fine gravel, little silt. | | |
| | | | | | 80/5" | | | | |
| | | | | | | | END OF EXPLORATION @ 30'5". | | |

| GRANULAR SOILS BLOWS/FT | DENSITY | COHESIVE SOILS BLOWS/FT | DENSITY |
|---|---|---|---|
| 0 - 4 | V. LOOSE | <2 | V.SOFT |
| 4 - 10 | LOOSE | 2 - 4 | SOFT |
| 10 - 30 | M.DENSE | 4 - 8 | M.STIFF |
| 30 - 50 | DENSE | 8 - 15 | STIFF |
| >50 | V.DENSE | 15 - 30 | V.STIFF |
| | | >30 | HARD |

REMARKS:
1. Changing stratum @ 12'.
2. Changing stratum @ 24'.
3. Tremie grouted upon completion.

| BURMISTER CLASSIFICATION | |
|---|---|
| TRACE | 0 - 10% |
| LITTLE | 10 - 20% |
| SOME | 20 - 35% |
| AND | 35 - 50% |

PERCENT BY WEIGHT

NOTES:
1) THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

BORING NO. B13-1

# PARE CORPORATION

10 LINCOLN ROAD, SUITE 103, FOXBORO, MASSACHUSETTS
ENGINEERS *** PLANNERS *** CONSULTANTS

BORING NO. **B13-2**
SHEET 1 OF 2

PROJECT: Ramshorn Pond Dam, Millbury, MA
PROJECT NO. 13072.00
CHKD. BY ARO

BORING CO. Northern Drilling
FOREMAN Chip Tucker
INSPECTOR A. Judge

BORING LOCATION DOWNSTREAM SIDE OF ROAD, 135' RIGHT OF SPILLWAY
GROUND SURFACE ELEVATION 635.9 DATUM NAVD88
DATE START 7/15/2013 DATE END 7/15/2013

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. SAFETY HAMMER FALLING 30 in.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING 300 lb. HAMMER FALLING 24 IN.

CASING SIZE: 4"
OTHER: Donut Hammer

GROUNDWATER READINGS

| DATE | TIME | WATER AT | CASING AT | STABILIZATION TIME |
|---|---|---|---|---|
| 7/16/13 | 7:00 | 13' | Out | 16 Hrs. |
| 8/19/13 | 10:00 | 14' | Out | 1 Month |
| | | | | |

| DEPTH (ft) | CASING (bl/ft) | SAMPLE NO. | PEN. (in.)/ REC. | DEPTH (FT) | BLOWS/6" | TONS/FT$^2$ OR KG/CM$^2$ | SAMPLE DESCRIPTION (Burmister CLASSIFICATION) | REMARKS | STRATUM DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 18/7 | 0.5-2 | 13 16 | | Moist, dense, tan, fine to medium SAND, trace silt, trace coarse sand. | | 4" ASPHALT |
| | | | | | 16 23 | | | | |
| | | S-2 | 24/12 | 2-4 | 25 16 | | Moist, medium dense, tan, fine to coarse SAND, little fine gravel, trace silt. | | |
| | | | | | 16 12 | | | | |
| 5 | | S-3 | 24/6 | 4-6 | 13 28 | | Moist, very dense, tan, fine SAND, some silt, trace fine gravel. | | |
| | | | | | 29 26 | | | | |
| | | S-4 | 24/12 | 6-8 | 11 22 | | Moist, medium dense, tan, fine SAND, some silt, little fine gravel. | 1. | |
| | | | | | 13 14 | | | | |
| | | S-5* | 24/0 | 8-10 | 44 25 | | No Recovery. | | |
| 10 | | | | | 52 39 | | | | |
| | | S-6 | 24/12 | 10-12 | 22 26 | | Moist, dense, tan, fine SAND, some silt, little fine gravel. | | |
| | | | | | 18 17 | | | | FILL |
| | | S-7 | 24/16 | 12-14 | 22 21 | | Wet, dense, tan, fine to medium SAND, some silt, little fine gravel. | | |
| | | | | | 16 14 | | | | |
| 15 | | S-8* | 24/12 | 14-16 | 13 12 | | Wet, dense, tan, fine to medium SAND, some silt, little fine to coarse gravel. | | |
| | | | | | 9 7 | | | | |
| | | S-9 | 24/20 | 16-18 | 14 8 | | Wet, medium dense, tan, fine to medium SAND, some silt, little fine to coarse gravel. | | |
| | | | | | 13 13 | | | | |
| | | S-10 | 24/0 | 18-20 | 21 22 | | No Recovery. | | |
| 20 | | | | | 17 12 | | | | |
| | | S-11 | 24/18 | 20-22 | 17 17 | | Wet, medium dense, tan, fine to medium SAND, some silt, little fine gravel. | | |
| | | | | | 10 10 | | | | |
| | | S-12 | 24/6 | 22-24 | 6 4 | | Wet, loose, tan, fine to medium SAND, some silt, little fine to coarse gravel. | | |
| | | | | | 3 6 | | | | |
| 25 | | S-13* | 24/14 | 24-26 | 10 4 | | Wet, loose, tan, fine to medium SAND, some silt, little fine to coarse gravel. | | |
| | | | | | 3 2 | | | 2. | ---------- |
| | | S-14 | 24/24 | 26-28 | 38 37 | | Moist, very dense, gray, fine to coarse SAND, little fine gravel, little silt. | | |
| | | | | | 43 33 | | | | |
| | | | | | | | | | TILL |
| 30 | | S-15 | 24/18 | 29-31 | 25 67 | | Wet, very dense, gray to tan, fine to coarse SAND, little fine gravel, little silt. | | |
| | | | | | 66 98 | | | | |
| | | | | | | | | | |

| GRANULAR SOILS BLOWS/FT | DENSITY | COHESIVE SOILS BLOWS/FT | DENSITY |
|---|---|---|---|
| 0 - 4 | V. LOOSE | <2 | V.SOFT |
| 4 - 10 | LOOSE | 2 - 4 | SOFT |
| 10 - 30 | M.DENSE | 4 - 8 | M.STIFF |
| 30 - 50 | DENSE | 8 - 15 | STIFF |
| >50 | V.DENSE | 15 - 30 | V.STIFF |
| | | >30 | HARD |

REMARKS:
*Used 3" Split Spoon sampler driven using a 300 lb. hammer.
1. Soil is very loose based on driving the casing from 6'-6.5'.
2. Changing stratum @ 26.3'.

BURMISTER CLASSIFICATION

| | |
|---|---|
| TRACE | 0 - 10% |
| LITTLE | 10 - 20% |
| SOME | 20 - 35% |
| AND | 35 - 50% |

PERCENT BY WEIGHT

NOTES:
1) THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

BORING NO. B13-2

**PARE CORPORATION**
10 LINCOLN ROAD, SUITE 103, FOXBORO, MASSACHUSETTS
ENGINEERS *** PLANNERS *** CONSULTANTS

BORING NO. **B13-2**



PROJECT: Ramshorn Pond Dam, Millbury, MA
PROJECT NO. 13072.00
CHKD. BY ARO

| DEPTH (ft) | CASING (bl/ft) | SAMPLE NO. | PEN. (in.)/ REC. | DEPTH (FT) | BLOWS/6" | TONS/FT² OR KG/CM² | SAMPLE DESCRIPTION (Burmister CLASSIFICATION) | REMARKS | STRATUM DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 3. | TILL |
| 35 | | S-16 | 6/4 | 34-34.5 | 100/6" | | Moist, very dense, brown, fine to medium SAND and SILT, little fine gravel. | | |
| | | | | | | | Moist, highly weathered SCHIST, very weak recovered as dark gray and brown, very dense SAND, some gravel. | | WEATHERED ROCK |
| 40 | | S-17 | 14/10 | 39-40.1 | 37 37 100/2" | | | 4. | |
| | | | | | | | END OF EXPLORATION @ 40'2". | | |
| 45 | | | | | | | | | |
| 50 | | | | | | | | | |
| 55 | | | | | | | | | |
| 60 | | | | | | | | | |
| 65 | | | | | | | | | |
| 70 | | | | | | | | | |

| GRANULAR SOILS BLOWS/FT | DENSITY | COHESIVE SOILS BLOWS/FT | DENSITY |
|---|---|---|---|
| 0 - 4 | V. LOOSE | <2 | V.SOFT |
| 4 - 10 | LOOSE | 2 - 4 | SOFT |
| 10 - 30 | M.DENSE | 4 - 8 | M.STIFF |
| 30 - 50 | DENSE | 8 - 15 | STIFF |
| >50 | V.DENSE | 15 - 30 | V.STIFF |
| | | >30 | HARD |

REMARKS:
3. Changing stratum @ 34'.
4. Tremie grouted to 20', allowed grout to set up overnight, grout settled to 22', placed bentonite seal, to 19', 1' of sand, 2" PVC slotted screen from 18' to 8' with a solid riser to the ground surface, placed a flush mounted roadbox.

| BURMISTER CLASSIFICATION | |
|---|---|
| TRACE | 0 - 10% |
| LITTLE | 10 - 20% |
| SOME | 20 - 35% |
| AND | 35 - 50% |

PERCENT BY WEIGHT

NOTES:
1) THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

BORING NO. B13-2

| PARE CORPORATION<br>10 LINCOLN ROAD, SUITE 103, FOXBORO, MASSACHUSETTS<br>ENGINEERS *** PLANNERS *** CONSULTANTS | BORING NO. B13-3<br>SHEET 1 OF 1 |
|---|---|

| | | | |
|---|---|---|---|
| PROJECT | Ramshorn Pond Dam<br>Millbury, MA | PROJECT NO. | 13072.00 |
| | | CHKD. BY | ARO |

| | | | |
|---|---|---|---|
| BORING CO. | Northern Drilling | BORING LOCATION | UPSTREAM SIDE OF ROAD, 135' RIGHT OF SPILLWAY |
| FOREMAN | Chip Tucker | GROUND SURFACE ELEVATION | 635.8 DATUM NAVD88 |
| INSPECTOR | A. Judge | DATE START | 7/16/2013 DATE END 7/16/2013 |

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. SAFETY HAMMER FALLING 30 in.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING 300 lb. HAMMER FALLING 24 IN.

CASING SIZE: 4" OTHER: Donut Hammer

GROUNDWATER READINGS

| DATE | TIME | WATER AT | CASING AT | STABILIZATION TIME |
|---|---|---|---|---|
| 7/17/13 | 7:00 | 7.2' | Out | 16 Hr. |
| 8/19/13 | 10:00 | 6.6' | Out | 1 Month |

| DEPTH (ft) | CASING (bl/ft) | SAMPLE NO. | PEN. (in.)/ REC. | DEPTH (FT) | BLOWS/6" | TONS/FT$^2$ OR KG/CM$^2$ | SAMPLE DESCRIPTION Burmister CLASSIFICATION | REMARKS | STRATUM DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1* | 18/8 | 0.5-2 | 8 67 | | Moist, very dense, brown, fine to coarse SAND, little fine | | 4" ASPHALT |
| | | | | | 67 42 | | gravel. | | |
| | | S-2 | 24/6 | 2-4 | 34 28 | | Moist, dense, tan to black, fine to coarse SAND, little fine | | |
| | | | | | 20 12 | | gravel, little silt, little asphalt. | | |
| 5 | | S-3* | 24/12 | 4-6 | 10 9 | | Moist, medium dense, tan, fine to medium SAND, some fine | | |
| | | | | | 6 7 | | to coarse gravel, some silt. | | |
| | | S-4 | 24/3 | 6-8 | 8 4 | | Moist, loose, tan, fine to medium SAND, some fine to coarse | | |
| | | | | | 5 9 | | gravel, some silt. | | |
| | | S-5 | 24/12 | 8-10 | 18 46 | | Moist, very dense, tan, fine to medium SAND, some silt, little | | |
| 10 | | | | | 17 21 | | fine gravel. | | FILL |
| | | S-6* | 24/12 | 10-12 | 23 13 | | Moist, medium dense, tan, fine to medium SAND, some fine | | |
| | | | | | 13 22 | | to coarse gravel, some silt. | | |
| | | S-7 | 24/10 | 12-14 | 14 12 | | Wet, medium dense, tan, fine to medium SAND, little fine | | |
| | | | | | 11 9 | | gravel. | | |
| 15 | | S-8 | 18/2 | 14.5-16 | 23 16 | | Wet, medium dense, tan, fine to medium SAND and fine | 1. | |
| | | | | | 16 13 | | GRAVEL, some silt. | | |
| | | S-9 | 24/12 | 16-18 | 28 8 | | Wet, medium dense, tan, fine to medium SAND, some silt, | | |
| | | | | | 10 12 | | little fine gravel. | | |
| | | S-10* | 24/12 | 18-20 | 18 5 | | Wet, loose to medium dense, tan, SAND, some fine to coarse | | |
| 20 | | | | | 5 6 | | gravel, some silt. | | |
| | | S-11 | 24/10 | 20-22 | 24 12 | | Wet, medium dense, tan, fine to medium SAND and fine | | |
| | | | | | 11 7 | | GRAVEL, little silt. | 2. | |
| | | S-12 | 24/18 | 22-24 | 8 12 | | Wet, medium dense, tan/gray, fine to medium SAND, some | | |
| | | | | | 13 24 | | fine gravel, little silt. | | |
| 25 | | S-13 | 24/10 | 24-26 | 33 24 | | Moist, dense, gray, fine to medium SAND, some silt, some | | |
| | | | | | 24 27 | | fine gravel. | | |
| | | S-14 | 24/14 | 26-28 | 24 26 | | Moist, very dense, gray, fine to medium SAND, some silt, | | SAND |
| | | | | | 33 40 | | some fine gravel. | | |
| | | | | | | | | | |
| 30 | | S-15 | 24/20 | 29-31 | 37 45 | | Wet to moist, very dense, gray, fine to medium SAND, some | | |
| | | | | | 44 69 | | silt, little fine gravel. | | |
| | | | | | | | END OF EXPLORATION @ 31'. | | |

| GRANULAR SOILS BLOWS/FT | DENSITY | COHESIVE SOILS BLOWS/FT | DENSITY |
|---|---|---|---|
| 0 - 4 | V. LOOSE | <2 | V.SOFT |
| 4 - 10 | LOOSE | 2 - 4 | SOFT |
| 10 - 30 | M.DENSE | 4 - 8 | M.STIFF |
| 30 - 50 | DENSE | 8 - 15 | STIFF |
| >50 | V.DENSE | 15 - 30 | V.STIFF |
| | | >30 | HARD |

REMARKS:
*3" Split Spoon sample driven using a 300 lb. hammer.
1. Advanced through cobbles @ 14'.
2. Changing stratum @ 22'.
Tremie grouted to 20', allowed grout to set up overnight, grout settled to 22', placed bentonite seal, to 19', 1' of sand, 2" PVC slotted screen 18' to 8', with a solid riser to the ground surface, placed a flush mounted roadbox.

| BURMISTER CLASSIFICATION | |
|---|---|
| TRACE | 0 - 10% |
| LITTLE | 10 - 20% |
| SOME | 20 - 35% |
| AND | 35 - 50% |
| PERCENT BY WEIGHT | |

NOTES:
1) THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

BORING NO. B13-3

# APPENDIX D
# Wetland Delineation Report and Data Forms

*Ramshorn Pond Dam*

***Millbury, Massachusetts***

**PROJECT TITLE:** Ramshorn Pond Dam Flagging **REPORT DATE:** 7/5/13

**LOCATION:** Millbury, Massachusetts **WEATHER:** Partly cloudy, 80 degrees

**PARE JOB NO.: 13072.00** **PERFORMED BY:** Lauren Hastings

## DISCUSSIONS AND COMMENTS

Wetland resource areas in the vicinity of the Ramshorn Pond Dam were defined and delineated in accordance with the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00, referred to as the Regulations), the methodology specified in the publication entitled Delineating Bordering Vegetated Wetlands under the Massachusetts Wetlands Protection Act (Jackson, 1995), and The Regional Supplement to the Corps of Engineers Wetland Delineation Manual: North Central and Northeast Region, Version 2.0 (U.S. Army Corps of Engineers, January 2012). Inspection and delineation of wetlands were completed on July 2, 2013.

The Ramshorn Pond Dam is located at the northeastern edge of Ramshorn Pond, an irregularly-shaped impoundment in southwestern Millbury. The Town of Millbury Department of Public Works is the owner and primary caretaker. The dam's primary spillway outlet passes flow beneath Dolan Road to Ramshorn Brook, a perennial stream that flows south along the dam's toe for a short distance before turning to the east. Several freshwater wetland areas associated with the impoundment and the outlet are located within the vicinity of the work area.

According to the most recent MassGIS data, the site does not contain any Certified or Potential Vernal Pools, Priority or Estimated Habitats of Rare Species, Outstanding Resource Waters, or Areas of Critical Environmental Concern, (MassGIS data layers PRIHAB_POLY and ESTHAB_POLY, 2008, ORW_POLY, 2010; and ACECS_POLY, 2009)

Pink field flags were placed at appropriate intervals along the wetland/upland borders on the site. Primary parameters evaluated in wetland delineation included vegetation, hydric soil indicators, and visual indicators of wetland hydrology. Banks of Ramshorn Pond, Ramshorn Brook, and an unnamed stream in the vicinity of the dam were delineated according to the first observable break in slope and water marks. Observed wetland hydrologic indicators and soils are described in the following sections and within the USACE Wetland Determination Data Forms. Wetland resource areas within the vicinity of the site include the following: **Bordering Vegetated Wetlands, Land Under Water Bodies/Waterways, Bank, 100-Foot Buffer Zone, 200-Foot Riverfront Area,** and **Bordering Land Subject to Flooding.**

## WETLAND DESCRIPTIONS

### Ramshorn Pond

The edges of Ramshorn Pond are defined in section 10.54 (2) of the Regulations as **bank**. Flag series P-1 to P-32 were placed along the northern edge of the impoundment in the vicinity of the dam. During PARE's delineation, the water level of the pond appeared close to normal pool. The entire length of the Bank within the upstream work area consists of manmade features, including riprap slope protection and stone wall, and in this location the Bank was delineated according to water marks. Areas of earthen bank exist beyond the left and right abutment, and these areas were delineated according to first observable break in slope.

Between flags P-1 and P-4, the Bank is located on a gradual, forested slope to the northwest of the dam, and is bordered by forested wetland. A small intermittent stream channel, to be described in a later section, enters the north side of the pond between Bank flags P-3 and P-4. Between flags P-5 and P-9, the Bank consists of a low stone wall located at the edge of a maintained lawn area surrounding a small boat dock. Between P-14 and P28, the Bank is located at the toe of a riprap armored slope along the upstream side of the dam embankment. Most of the riprap slope appears to be periodically maintained and is is sparsely vegetated with early-successional saplings, shrubs, and herbaceous vegetation. Between flags P-28 and P-32, the riprap slope is overgrown with larger saplings and shrubs.

Typical species of vegetation located along the delineated bank include, but are not limited to, the following:

| Common Name | Scientific Name | Indicator Status |
|---|---|---|
| Gray Birch | *Betula populifolia* | FAC |
| Red Oak | *Quercus rubra* | FACU- |
| Silky Dogwood | *Cornus amomum* | FACW |
| Arrowood | *Viburnum dentatum* | FAC |
| Speckled Alder | *Alnus rugosa* | FACW+ |
| Buttonbush | *Cephlanthus occidentalis* | OBL |
| Sweet Pepperbush | *Clethra alnifolia* | FAC+ |
| Mountain Laurel | *Kalmia latifolia* | FACU |
| Blackberry | *Rubus sp.* | Assume FACU |
| Oriental Bittersweet | *Celastrus orbiculatus* | UPL |
| Virginia Creeper | *Parthenocissus quinquefolia* | FACU |
| Deertongue | *Dichanthelium clandestinum* | FAC+ |

According to 10.56 (2) of the Regulations, land under Ramshorn Pond is classified as **Land Under Water Bodies**. The pond appears to be relatively shallow in the vicinity of the dam. The pond with an unconsolidated rocky bottom that was mostly unvegetated at the time of delineation.

## Ramshorn Brook

Ramshorn Pond Dam discharges flow beneath Dolan Road and over a concrete step spillway into the channel of Ramshorn Brook, a perennial stream. Directly downstream of the spillway, the stream turns in a southerly direction. The dam flows due south along the base of the dam slope for about 450 feet before turning to the east and entering a large wetland complex downstream.

The edges of the stream are defined in section 10.54 (2) of the Regulations as **Bank**. Directly downstream of the dam, the Banks consist of vertical concrete and stone masonry walls along the sides of the concrete step spillway, and no flags were placed in this location. The Banks of the downstream channel were delineated according to first observable break in slope. Flag series R-1 through R-16 define the Bank on the north/east side of the channel, and R-100 to R-118 on the south/west side. Directly downstream of the spillway, the Banks are armored with placed stone that appears to have fallen into the channel in some locations. Further downstream, the Banks consist of defined earthen slopes.

A majority of the delineated Bank is forested, and has a variable understory of shrubs and climbing vines. The western Bank of the stream bordering the toe of the dam embankment is extremely steep and erosive, and is overgrown with climbing vines. The Bank is bordered by wetlands in several locations, and these areas are described in later sections. Typical species of vegetation located along the delineated bank include, but are not limited to, the following:

| Common Name | Scientific Name | Indicator Status |
|---|---|---|
| Red Maple | *Acer rubrum* | FAC |
| Slippery Elm | *Ulmus rubra* | FAC- |
| Wild Black Cherry | *Prunus serotina* | FACU |
| Red Oak | *Quercus rubra* | FACU- |
| White Ash | *Fraxinus americana* | FACU |
| Norway Maple | *Acer platanoides* | NI |
| Arrowood | *Viburnum dentatum* | FAC |
| Silky Dogwood | *Cornus amomum* | FACW |
| Highbush Blueberry | *Vaccinium corymbosum* | FACW- |
| Multiflora Rose | *Rosa multiflora* | FACU |
| Oriental Bittersweet | *Celastrus orbiculatus* | UPL |
| Fox Grape | *Vitis labrusca* | NI |
| Poison Ivy | *Toxicodendron radicans* | FAC |
| Sensitive Fern | *Onoclea sensibilis* | FACW |

According to 10.56 (2) of the Regulations, land within the stream channel is classified as **Land Under Waterways**. In the vicinity of the dam, river bottom consists of an unconsolidated and unvegetated rocky substrate. Offsite to the According to Rule 10.58 (2) of the Regulations, Ramshorn Brook is a perennial stream, and thus has an associated **200-foot Riverfront Area**. The Riverfront Area encompasses the entire dam, portions of the adjacent forested areas, and surrounding developed areas.

## Bordering Vegetated Wetlands

Four **Bordering Vegetated Wetlands** (section 10.55 (2) of the Regs.) were identified in the vicinity of the dam. These include the A series area located along the pond edge to the northwest of the dam; and the B, C, and D series located adjacent to Ramshorn Brook. According to section 10.02 (2)(b), each of these wetlands has a 100-foot buffer zone. USACE Wetland Determination Data Forms for each wetland area are attached. The delineated areas are described below.

### *Wetland A*

An area of forested BVW is located along the edge of Ramshorn Pond to the north of the dam, in the wooded area between the pond and Bayberry Lane to the north. Flag series A-1 through A-5 defines the western edge of the wetland, and series A-100 to A-105 defines the eastern edge bordering a small foot path leading to the pond. The wetland borders a small intermittent stream channel that flows in a southerly direction from a culvert beneath Bayberry Lane into the north side of Ramshorn Pond. At the time of delineation, the area had saturated soils and it appears to have a saturated hydrology, and likely experiences some temporary flooding from to the stream. Wetland vegetation observed included, but is not limited to, the following species*:*

| Common Name | Scientific Name | Indicator Status |
|---|---|---|
| Red Maple | *Acer rubrum* | FAC |
| White Ash | *Fraxinus americana* | FACU |
| Arrowood | *Viburnum dentatum* | FAC |
| Silky Dogwood | *Cornus amomum* | FACW |
| Jewelweed | *Impatiens capensis* | FACW |
| Sensitive Fern | *Onoclea sensibilis* | FACW |

*Wetland B*

An area of forested BVW is located along the northeastern Bank of Ramshorn Brook a short distance downstream of the spillway. This area extends upslope into the wooded area to the north of the stream, and appears to be fed primarily by groundwater discharge. Flag series B-1 through B-17 defines the edges of the BVW, beginning and ending at the edge of Ramshorn Brook. At the time of delineation, the area had saturated soils with pockets of standing water and it appears that the area is likely seasonally flooded. Wetland vegetation observed included, but is not limited to, the following species:

| Common Name | Scientific Name | Indicator Status |
|---|---|---|
| White Ash | *Fraxinus americana* | FACU |
| Norway Maple | *Acer platanoides* | NI |
| Red Maple | *Acer rubrum* | FAC |
| Arrowood | *Viburnum dentatum* | FAC |
| Silky Dogwood | *Cornus amomum* | FACW |
| Jewelweed | *Impatiens capensis* | FACW |
| Jack in the Pulpit | *Arisaema triphyllum* | FACW- |
| Sensitive Fern | *Onoclea sensibilis* | FACW |
| Poison Ivy | *Toxicodendron radicans* | FAC |

*Wetland C*

Flag series C-1 through C-10 defines the eastern edge of a forested BVW located along the north and east sides of Ramshorn Brook in the vicinity of the dam. The series begins at flag R-6 along the east side of the stream, and follows along the toe of a defined slope a short distance upgradient of the Bank. At the time of delineation, most of the area had saturated soils. The area appears to have a seasonally flooded hydrology, and appears to be fed by groundwater as well as overflow from the stream. Wetland vegetation observed included, but is not limited to, the following species:

| Common Name | Scientific Name | Indicator Status |
|---|---|---|
| Red Maple | *Acer rubrum* | FAC |
| Slippery Elm | *Ulmus rubra* | FAC- |
| Arrowood | *Viburnum dentatum* | FAC |
| Silky Dogwood | *Cornus amomum* | FACW |
| Jewelweed | *Impatiens capensis* | FACW |
| Skunk Cabbage | *Symplocarpus foetidus* | OBL |
| Sensitive Fern | *Onoclea sensibilis* | FACW |

*Wetland D*

Flag series D-1 through D-18 defines the edge of a BVW bordering the southern side of Ramshorn Brook in the vicinity of the dam. The series begins along the Bank of the stream at flag R-114, and extends in a westerly direction toward the south end of the dam embankment. A small pipe, which is reportedly a toe drain, outfalls within a small retaining wall is located between flags D-13 and D-14. At the time of delineation, a small amount of water flowed from the pipe into the wetland. The wetland also appears to receive overland flow from surrounding uplands. A majority of the wetland area is forested, with the exception of the western area of the wetland surrounding the toe drain which is dominated by shrubs. Wetland vegetation observed included, but is not limited to, the following species*:*

| Common Name | Scientific Name | Indicator Status |
|---|---|---|
| Red Maple | *Acer rubrum* | FAC |
| Willow | *Salix sp.* | Assume FAC |
| Slippery Elm | *Ulmus rubra* | FAC- |
| Silky Dogwood | *Cornus amomum* | FACW |
| Jewelweed | *Impatiens capensis* | FACW |
| Fox Grape | *Vitis labrusca* | NI |
| Sensitive Fern | *Onoclea sensibilis* | FACW |
| Cinnamon Fern | *Osmunda cinnamomea* | FACW |

## Isolated Vegetated Wetlands

Two small, isolated wetland areas are located within the maintained area at the downstream side of the dam embankment slope. These areas do not appear to meet the size and depth-of-flooding criteria to qualify as jurisdictional wetlands under the Wetlands Protection Act. However, they possess wetland plant communities, hydric soils, and visual indicators of hydrology, and therefore appear to be federally jurisdictional as **Isolated Vegetated Wetlands**. USACE Wetland Determination Data Forms for each wetland area are attached. The delineated areas are described below.

Flag series I-1 to I-9 defines a small, isolated area of emergent wetland located a short distance south of the spillway at the downstream toe of the dam embankment. The area appears to have a seasonally flooded hydrology. At the time of delineation, the entire area had saturated soils, and the lower spots within the area held several inches of standing water. The area was colonized by a variety of herbaceous species, including Common Rush (*Juncus effusus*), Tussock Sedge (*Carex stricta*), Sensitive Fern (*Onoclea sensibilis*), White Clover (*Trifolium repens*), and planted grass. The area appears to be periodically mowed.

Flag series I-001 to I-106 defines a small, linear-shaped isolated area of emergent wetland located a short distance south of the toe drain outfall defined by series D. The area appears to have a saturated hydrology, although it may be temporarily flooded following heavy rain events. At the time of delineation, the entire area had saturated soils. The area has a limited vegetation community similar to the other I-series area, this area was colonized by a variety of herbaceous species, and also appears to be periodically mowed.

## Bordering Lands Subject to Flooding

According to the FEMA Flood Insurance Rate Map (FIRM) for Worcester County, Massachusetts (community-panel no. 25027C0816E, effective date July 4, 2011), an area of **Bordering Land Subject to Flooding** (defined under Rule 10.57 (2)(a) of the Regulations) encompasses a narrow band of land bordering the impoundment and outlet. Floodplain on the site is located within Zone AE, areas with 1% annual chance of flooding. Flood elevations are shown as 632 feet directly upstream of the dam, and 619 feet downstream of the spillway (NAVD 88). Upland areas surrounding the pond and outlet are located within Zone X.

LMH

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**VEGETATION** - Use scientific names of plants

**Sampling Point:** B6 upland

| Tree Stratum | Plot Size ( 30' ) | Absolute % Cover | Dominant Species | Indicator Status |
|---|---|---|---|---|
| 1 | *Fraxinus americana* | 30 | Y | FACU |
| 2 | *Prunus serotina* | 20 | Y | FACU |
| 3 | *Abutilon theophrasti* | | | FACU |
| 4 | | | | |
| 5 | | 10 | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| | | 60 | = Total Cover | |

| Sapling/Shrub Stratum | Plot Size ( 15' ) | Absolute % Cover | Dominant Species | Indicator Status |
|---|---|---|---|---|
| 1 | *Ilex verticillata* | 20 | Y | FACW |
| 2 | *Impatiens capensis* | 10 | Y | FACW |
| 3 | *Fraxinus americana* | 5 | N | FACU |
| 4 | *Betula populifolia* | 5 | N | FAC |
| 5 | *Acalypha rhomboidea* | 5 | N | FACU |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| | | 45 | = Total Cover | |

| Herb Stratum | Plot Size ( 5' ) | Absolute % Cover | Dominant Species | Indicator Status |
|---|---|---|---|---|
| 1 | *Geranium maculatum* | 20 | Y | FACU |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |
| 13 | | | | |
| 14 | | | | |
| 15 | | | | |
| | | 20 | = Total Cover | |

| Woody Vine Stratum | Plot Size ( 30' ) | Absolute % Cover | Dominant Species | Indicator Status |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| | | 0 | = Total Cover | |

**50/20 Thresholds**

| | 20% | 50% |
|---|---|---|
| Tree Stratum | 12 | 30 |
| Sapling/Shrub Stratum | 9 | 23 |
| Herb Stratum | 4 | 10 |
| Woody Vine Stratum | 0 | 0 |

**Dominance Test Worksheet**

Number of Dominant Species that are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across all Strata: 5 (B)

Percent of Dominant Species that are OBL, FACW, or FAC: 40.00% (A/B)

**Prevalence Index Worksheet**

| Total % Cover of: | | | | |
|---|---|---|---|---|
| OBL species | 0 | x 1 = | 0 | |
| FACW species | 30 | x 2 = | 60 | |
| FAC species | 5 | x 3 = | 15 | |
| FACU species | 80 | x 4 = | 320 | |
| UPL species | 0 | x 5 = | 0 | |
| Column totals | 115 | (A) | 395 | (B) |

Prevalence Index = B/A = 3.43

**Hydrophytic Vegetation Indicators:**

___ Rapid test for hydrophytic vegetation
___ Dominance test is >50%
___ Prevalence index is ≤3.0*
___ Morphogical adaptations* (provide supporting data in Remarks or on a separate sheet)
___ Problematic hydrophytic vegetation* (explain)

*Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

**Definitions of Vegetation Strata:**

**Tree** - Woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

**Sapling/shrub** - Woody plants less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

**Herb** - All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

**Woody vines** - All woody vines greater than 3.28 ft in height.

**Hydrophytic vegetation present?** N

Remarks: (Include photo numbers here or on a separate sheet)

**SOIL** **Sampling Point:** B6 wetland

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

| Depth | Matrix | | Redox Features | | | | Texture | Remarks |
|---|---|---|---|---|---|---|---|---|
| (Inches) | Color (moist) | % | Color (moist) | % | Type* | Loc** | | |
| 1-1/2" | 10YR 3/2 | 100 | | | | | Gravel | Gravelly sediment/washout |
| 1/2"-0" | 10YR 2/1 | 100 | | | | | sapric | O |
| 0-14" | 10YR 2/1 | | | | | | sandy loam | A |
| 14+" | --- | | | | | | Rock | Rock layer encountered 14" |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

*Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains
**Location: PL=Pore Lining, M=Matrix

**Hydric Soil Indicators:**

___ Histisol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Stratified Layers (A5)
___ Depleted Below Dark Suface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
_X_ Dark Surface (S7) (**LRR R, MLRA 149B**)
___ Polyvalue Below Surface (S8) (**LRR R, MLRA 149B**)
___ Thin Dark Surface (S9) (**LRR R, MLRA 149B**
___ Loamy Mucky Mineral (F1) (**LRR K, L**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

**Indicators for Problematic Hydric Soils:**

___ 2 cm Muck (A10) (**LRR K, L, MLRA 149B**
___ Coast Prairie Redox (A16) (**LRR K, L, R**)
___ 5 cm Mucky Peat or Peat (S3) (**LRR K, L, R**)
___ Dark Surface (S7) (**LRR K, L**
___ Polyvalue Below Surface (S8) (**LRR K, L**)
___ Thin Dark Surface (S9) (**LRR K, L**)
___ Iron-Manganese Masses (F12) (**LRR K, L, R**)
___ Piedmont Floodplain Soils (F19) (**MLRA 149B**)
___ Mesic Spodic (TA6) (**MLRA 144A, 145, 149B**)
___ Red Parent Material (F21)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

*Indicators of hydrophytic vegetation and weltand hydrology must be present, unless disturbed or problematic

Restrictive Layer (if observed):
Type: ______
Depth (inches): ______

**Hydric soil present?** _Y_

Remarks:
Downgradient of the breached area. Saturated, mucky mineral soil over rock layer.

# DEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

**Applicant:** Town of Millbury **Prepared by:** Pare Corporation **Project location:** Ramshorn Pond Dam, Millbury
**DEP File #:** None L. Hastings

Check all that apply:

__ Vegetation alone presumed adequate to delineate BVW boundary: fill out section I only.
X Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II.
__ Method other than dominance test used (attach additional information).

**Section I.** Observation Plot Number: 2 Transect Number: A (Upland Station) 5'± U/G WF A-102 Date of Delineation: July 2, 2013

| **A. Sample Layer and Plant Species** (by common/ scientific name) | | **B. Percent Cover** (or basal area) | **C. Percent Dominance** | **D. Dominant Plant** (Yes or No) | **E. Wetland Indicator** Category * |
|---|---|---|---|---|---|
| **Tree** | Red Maple (*Acer rubrum*) | 26-50 (38.0) | 55 | Y | FAC* |
| | White Ash (*Fraxinus americana*) | 16-25 (20.5) | 30 | Y | FACU |
| | Red Oak (*Quercus rubra*) | 6-15 (10.5) | 15 | N | |
| | **Total** | 69.0 | 100 | | |
| | | | | | |
| **Sapling** | Red Oak (*Quercus rubra*) | 6-15 (10.5) | 28 | Y | FACU- |
| | Red Maple (*Acer rubrum*) | 6-15 (10.5) | 28 | Y | FAC* |
| | Norway Maple (*Acer platanoides*) | 0-5 (3.0) | 8 | N | |
| | Wild Black Cherry (*Prunus serotina*) | 6-15 (10.5) | 28 | Y | FACU |
| | Quaking Aspen (*Populus tremuloides*) | 0-5 (3.0) | 8 | N | |
| | **Total** | 37.5 | 100 | | |
| | | | | | |
| **Shrub** | Arrowood (*Viburnum dentatum*) | 16-25 (20.5) | 66 | Y | FAC* |
| | Mountain Laurel (*Kalmia latifolia*) | 6-15 (10.5) | 34 | Y | FACU |
| | **Total** | 31.0 | 100 | | |
| | | | | | |
| **Herb** | Virginia Creeper (*Parthenocissus quinquefolia*) | 16-25 (20.5) | 66 | Y | FACU |
| | New York Fern (*Thelypteris noveboracensis*) | 6-15 (10.5) | 34 | Y | FAC* |
| | **Total** | 31.0 | 100 | | |

*Use an asterisk to mark wetland indicator plants species listed in the Wetlands Protection Act ( MGL c. 131, s. 40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological adaptations, describe the adaptation next to the asterisk.

## Vegetation Conclusion:

Number of dominant wetland indicator plants: 4 Number of dominant non-wetland indicator plants: 5

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? YES [NO]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

**Section II. Indicators of Hydrology**

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [Yes] No

Title/Date: Soil Survey of Worcester County, Southern Part (on web soil survey: http://websoilsurvey.nrcs.usda.gov/app)

Map Number: N/A

Soil type mapped: Ridgebury fine sandy loam, 3 - 8 % slopes

Hydric Soil Inclusions: Whitman

Are field observations consistent with soil survey? [Yes] No

Remarks:

2. Soil Description

| Horizon | Depth (in) | Matrix Color | Mottles Color |
|---|---|---|---|
| O | 1/2”-0” | 10YR 2/2 | |
| A | 0”-4” | 10YR 3/3 | |
| B | 4”-12+” | 10YR 4/3 | |

Remarks:

3. Other:

Conclusion: Is soil hydric? Yes [No]

Other Indicators of Hydrology: (check all that apply and describe)

☐ Site inundated:

☐ Depth to free water in observation hole:

☐ Depth to soil saturation in observation hole:

☐ Water Marks:

☐ Drift lines:

☐ Sediment deposits:

☐ Drainage patterns in BVW:

☐ Oxidized rhizospheres:

☐ Water-stained leaves:

☐ Recorded data (stream, lake, or tidal gauge; aerial photo; other):

☐ Other:

**Vegetation and Hydrology Conclusion**

| | Yes | No |
|---|---|---|
| Number of wetland indicator plants ≥ number of non-wetland indicator plants | ☐ | ☒ |
| Wetland hydrology present: | | |
| hydric soil present | ☐ | ☒ |
| other indicators of hydrology present | ☐ | ☒ |
| **Sample location is in a BVW** | ☐ | ☒ |

Submit this form with the Request for Determination of Applicability or Notice of Intent

# DEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

**Applicant:** Town of Millbury **Prepared by:** Pare Corporation **Project location:** Ramshorn Pond Dam, Millbury
**DEP File #:** None L. Hastings

Check all that apply:
__ Vegetation alone presumed adequate to delineate BVW boundary: fill out section I only.
X Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II.
__ Method other than dominance test used (attach additional information).

**Section I.** Observation Plot Number: 1 Transect Number: A (Wetland Station) 5'± D/G WF A-102 Date of Delineation: July 3, 2013

| **A. Sample Layer and Plant Species** (by common/ scientific name) | | **B. Percent Cover** (or basal area) | **C. Percent Dominance** | **D. Dominant Plant** (Yes or No) | **E. Wetland Indicator** Category * |
|---|---|---|---|---|---|
| **Tree** | Red Maple (*Acer rubrum*) | 16-25 (20.5) | 66 | Y | FAC* |
| | White Ash (*Fraxinus americana*) | 6-15 (10.5) | 34 | Y | FACU |
| | **Total** | 31.0 | 100 | | |
| | | | | | |
| **Sapling** | Red Maple (*Acer rubrum*) | 6-15 (10.5) | 39 | Y | FAC* |
| | Norway Maple (*Acer platanoides*) | 6-15 (10.5) | 39 | Y | NI |
| | Wild Black Cherry (*Prunus serotina*) | 0-5 (3.0) | 11 | N | |
| | Quaking Aspen (*Populus tremuloides*) | 0-5 (3.0) | 11 | N | |
| | **Total** | 27.0 | 100 | | |
| | | | | | |
| **Shrub** | Arrowood (*Viburnum dentatum*) | 26-50 (38.0) | 100 | Y | FAC* |
| | **Total** | 38.0 | 100 | | |
| | | | | | |
| **Herb** | Jewelweed (*Impatiens capensis*) | 26-50 (38.0) | 61 | Y | FACW* |
| | Sensitive Fern (*Onoclea sensibilis*) | 6-15 (10.5) | 17 | N | |
| | Poison Ivy (*Toxicodendron radicans*) | 6-15 (10.5) | 17 | N | |
| | Virginia Creeper (*Parthenocissus quinquefolia*) | 0-5 (3.0) | 5 | N | |
| | **Total** | 62.0 | 100 | | |

*Use an asterisk to mark wetland indicator plants species listed in the Wetlands Protection Act ( MGL c. 131, s. 40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological adaptations, describe the adaptation next to the asterisk.

## Vegetation Conclusion:

Number of dominant wetland indicator plants: 4 Number of dominant non-wetland indicator plants: 2

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [YES] NO

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

**Section II. Indicators of Hydrology**

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [Yes] No

Title/Date: Soil Survey of Worcester County, Southern Part (on web soil survey: http://websoilsurvey.nrcs.usda.gov/app)

Map Number: N/A

Soil type mapped: Ridgebury fine sandy loam, 3 - 8 % slopes

Hydric Soil Inclusions: Whitman

Are field observations consistent with soil survey? [Yes] No

Remarks:

2. Soil Description

| Horizon | Depth (in) | Matrix Color | Mottles Color |
|---|---|---|---|
| O | 2"-0" | 10YR 2/1 | |
| A | 0"-6" | 10YR 3/2 | 7.5YR 4/6 |
| B | 6"-12+" | 10YR 4/2 | 10YR 2/1<br>7.5YR 5/8 |

Remarks: Saturated soils with strong redox concentrations

3. Other:

Conclusion: Is soil hydric? [Yes] No

Other Indicators of Hydrology: (check all that apply and describe)

- ☐ Site inundated:
- ☐ Depth to free water in observation hole:
- ☒ Depth to soil saturation in observation hole: 6"
- ☐ Water Marks:
- ☐ Drift lines:
- ☐ Sediment deposits:
- ☐ Drainage patterns in BVW:
- ☐ Oxidized rhizospheres:
- ☒ Water-stained leaves:
- ☐ Recorded data (stream, lake, or tidal gauge; aerial photo; other):
- ☒ Other: Buttressed tree roots

**Vegetation and Hydrology Conclusion**

| | Yes | No |
|---|---|---|
| Number of wetland indicator plants ≥ number of non-wetland indicator plants | ☒ | ☐ |
| Wetland hydrology present: | | |
| hydric soil present | ☒ | ☐ |
| other indicators of hydrology present | ☒ | ☐ |
| **Sample location is in a BVW** | ☒ | ☐ |

Submit this form with the Request for Determination of Applicability or Notice of Intent

# DEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

**Applicant:** Town of Millbury **Prepared by:** Pare Corporation **Project location:** Ramshorn Pond Dam, Millbury
**DEP File #:** None L. Hastings

Check all that apply:

__ Vegetation alone presumed adequate to delineate BVW boundary: fill out section I only.
X Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II.
__ Method other than dominance test used (attach additional information).

**Section I.** Observation Plot Number: 2 Transect Number: A (Upland Station) 5'± U/G WF A-102 Date of Delineation: July 2, 2013

| **A. Sample Layer and Plant Species** (by common/ scientific name) | | **B. Percent Cover** (or basal area) | **C. Percent Dominance** | **D. Dominant Plant** (Yes or No) | **E. Wetland Indicator** Category * |
|---|---|---|---|---|---|
| **Tree** | Red Maple (*Acer rubrum*) | 26-50 (38.0) | 55 | Y | FAC* |
| | White Ash (*Fraxinus americana*) | 16-25 (20.5) | 30 | Y | FACU |
| | Red Oak (*Quercus rubra*) | 6-15 (10.5) | 15 | N | |
| | **Total** | 69.0 | 100 | | |
| | | | | | |
| **Sapling** | Red Oak (*Quercus rubra*) | 6-15 (10.5) | 28 | Y | FACU- |
| | Red Maple (*Acer rubrum*) | 6-15 (10.5) | 28 | Y | FAC* |
| | Norway Maple (*Acer platanoides*) | 0-5 (3.0) | 8 | N | |
| | Wild Black Cherry (*Prunus serotina*) | 6-15 (10.5) | 28 | Y | FACU |
| | Quaking Aspen (*Populus tremuloides*) | 0-5 (3.0) | 8 | N | |
| | **Total** | 37.5 | 100 | | |
| | | | | | |
| **Shrub** | Arrowood (*Viburnum dentatum*) | 16-25 (20.5) | 66 | Y | FAC* |
| | Mountain Laurel (*Kalmia latifolia*) | 6-15 (10.5) | 34 | Y | FACU |
| | **Total** | 31.0 | 100 | | |
| | | | | | |
| **Herb** | Virginia Creeper (*Parthenocissus quinquefolia*) | 16-25 (20.5) | 66 | Y | FACU |
| | New York Fern (*Thelypteris noveboracensis*) | 6-15 (10.5) | 34 | Y | FAC* |
| | **Total** | 31.0 | 100 | | |

****Total does not equal 100 due to rounding**

*Use an asterisk to mark wetland indicator plants species listed in the Wetlands Protection Act ( MGL c. 131, s. 40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological adaptations, describe the adaptation next to the asterisk.

## Vegetation Conclusion:

Number of dominant wetland indicator plants: 4 Number of dominant non-wetland indicator plants: 5

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? YES [NO]

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

**Section II. Indicators of Hydrology**

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [Yes] No

Title/Date: Soil Survey of Worcester County, Southern Part (on web soil survey: http://websoilsurvey.nrcs.usda.gov/app)

Map Number: N/A

Soil type mapped: Ridgebury fine sandy loam, 3 - 8 % slopes

Hydric Soil Inclusions: Whitman

Are field observations consistent with soil survey? [Yes] No

Remarks:

2. Soil Description

| Horizon | Depth (in) | Matrix Color | Mottles Color |
|---|---|---|---|
| O | 1/2”-0” | 10YR 2/2 | |
| A | 0”-4” | 10YR 3/3 | |
| B | 4”-12+” | 10YR 4/3 | |

Remarks:

3. Other:

Conclusion: Is soil hydric? Yes [No]

Other Indicators of Hydrology: (check all that apply and describe)

☐ Site inundated:

☐ Depth to free water in observation hole:

☐ Depth to soil saturation in observation hole:

☐ Water Marks:

☐ Drift lines:

☐ Sediment deposits:

☐ Drainage patterns in BVW:

☐ Oxidized rhizospheres:

☐ Water-stained leaves:

☐ Recorded data (stream, lake, or tidal gauge; aerial photo; other):

☐ Other:

**Vegetation and Hydrology Conclusion**

| | Yes | No |
|---|---|---|
| Number of wetland indicator plants ≥ number of non-wetland indicator plants | ☐ | ☒ |
| Wetland hydrology present: | | |
| hydric soil present | ☐ | ☒ |
| other indicators of hydrology present | ☐ | ☒ |
| **Sample location is in a BVW** | ☐ | ☒ |

Submit this form with the Request for Determination of Applicability or Notice of Intent

# DEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

**Applicant:** Town of Millbury **Prepared by:** Pare Corporation **Project location:** Ramshorn Pond Dam, Millbury
**DEP File #:** None L. Hastings

Check all that apply:
__ Vegetation alone presumed adequate to delineate BVW boundary: fill out section I only.
X Vegetation and other indicators of hydrology used to delineate BVW boundary: fill out Sections I and II.
__ Method other than dominance test used (attach additional information).

**Section I.** Observation Plot Number: 1 Transect Number: A (Wetland Station) 5'± D/G WF A-102 Date of Delineation: July 3, 2013

| **A. Sample Layer and Plant Species** (by common/ scientific name) | | **B. Percent Cover** (or basal area) | **C. Percent Dominance** | **D. Dominant Plant** (Yes or No) | **E. Wetland Indicator** Category * |
|---|---|---|---|---|---|
| **Tree** | Red Maple (*Acer rubrum*) | 16-25 (20.5) | 66 | Y | FAC* |
| | White Ash (*Fraxinus americana*) | 6-15 (10.5) | 34 | Y | FACU |
| | **Total** | 31.0 | 100 | | |
| | | | | | |
| **Sapling** | Red Maple (*Acer rubrum*) | 6-15 (10.5) | 39 | Y | FAC* |
| | Norway Maple (*Acer platanoides*) | 6-15 (10.5) | 39 | Y | NI |
| | Wild Black Cherry (*Prunus serotina*) | 0-5 (3.0) | 11 | N | |
| | Quaking Aspen (*Populus tremuloides*) | 0-5 (3.0) | 11 | N | |
| | **Total** | 27.0 | 100 | | |
| | | | | | |
| **Shrub** | Arrowood (*Viburnum dentatum*) | 26-50 (38.0) | 100 | Y | FAC* |
| | **Total** | 38.0 | 100 | | |
| | | | | | |
| **Herb** | Jewelweed (*Impatiens capensis*) | 26-50 (38.0) | 61 | Y | FACW* |
| | Sensitive Fern (*Onoclea sensibilis*) | 6-15 (10.5) | 17 | N | |
| | Poison Ivy (*Toxicodendron radicans*) | 6-15 (10.5) | 17 | N | |
| | Virginia Creeper (*Parthenocissus quinquefolia*) | 0-5 (3.0) | 5 | N | |
| | **Total** | 62.0 | 100 | | |

****Total does not equal 100 due to rounding**

*Use an asterisk to mark wetland indicator plants species listed in the Wetlands Protection Act ( MGL c. 131, s. 40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological adaptations, describe the adaptation next to the asterisk.

## Vegetation Conclusion:

Number of dominant wetland indicator plants: 3 Number of dominant non-wetland indicator plants: 3

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? [YES] NO

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

**Section II. Indicators of Hydrology**

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? [Yes] No

<u>Title/Date</u>: Soil Survey of Worcester County, Southern Part (on web soil survey: http://websoilsurvey.nrcs.usda.gov/app)

<u>Map Number</u>: N/A

<u>Soil type mapped</u>: Ridgebury fine sandy loam, 3 - 8 % slopes

Hydric Soil Inclusions: Whitman

Are field observations consistent with soil survey? [Yes] No

Remarks:

2. Soil Description

| **Horizon** | **Depth (in)** | **Matrix Color** | **Mottles Color** |
|---|---|---|---|
| O | 2”-0” | 10YR 2/1 | |
| A | 0”-6” | 10YR 3/2 | 7.5YR 4/6 |
| B | 6”-12+” | 10YR 4/2 | 10YR 2/1<br>7.5YR 5/8 |

Remarks: Saturated soils with strong redox concentrations

3. Other:

Conclusion: Is soil hydric? [Yes] No

Other Indicators of Hydrology: (check all that apply and describe)

☐ Site inundated:

☐ Depth to free water in observation hole:

☒ Depth to soil saturation in observation hole: 6”

☐ Water Marks:

☐ Drift lines:

☐ Sediment deposits:

☐ Drainage patterns in BVW:

☐ Oxidized rhizospheres:

☒ Water-stained leaves:

☐ Recorded data (stream, lake, or tidal gauge; aerial photo; other):

☒ Other: Buttressed tree roots

**Vegetation and Hydrology Conclusion**

| | Yes | No |
|---|---|---|
| Number of wetland indicator plants ≥ number of non-wetland indicator plants | ☒ | ☐ |
| Wetland hydrology present: | | |
| hydric soil present | ☒ | ☐ |
| other indicators of hydrology present | ☒ | ☐ |
| **Sample location is in a BVW** | ☒ | ☐ |

Submit this form with the Request for Determination of Applicability or Notice of Intent

# APPENDIX E
# Opinion of Probable Costs

*Ramshorn Pond Dam*

***Millbury, Massachusetts***

PARE CORPORATION

PROJECT : Ramshorn Pond Dam Repairs | PROJECT NUMBER: 13072.00
SUBJECT: Opinion of Probable Cost
COMPUTATIONS BY: JMC | DATE: October 2013
CHECKED BY: ARO | DATE: October 2013

## Spillway Option 1 Opinion of Probable Cost

| Item | Quantity | Unit | Unit Price | Total | Source/Notes |
|---|---|---|---|---|---|
| **Erosion Control** | | | | | |
| Hay bales | 315 | EA | $ 8.00 | $ 2,520.00 | |
| Silt Fence | 944 | LF | $ 5.00 | $ 4,720.00 | Recent Project Costs |
| Turbidity Barrier | 530 | LF | $ 30.00 | $ 15,900.00 | |
| **Subtotal** | | | | $ 23,140.00 | |
| **Clearing and Grubbing** | | | | | |
| Clearing and grubbing | 1160 | SY | $ 3.70 | $ 4,292.00 | 201.0321 RIDOT WAUP/2009 |
| mowing downstream slope | 1 | LS | $ 300.00 | $ 300.00 | Engineers Judgment |
| Tree Cutting | 22 | EA | $ 600.00 | $ 13,200.00 | |
| Embankment Fill | 30 | CY | $ 50.00 | $ 1,500.00 | |
| **Subtotal** | | | | $ 19,292.00 | |
| **Upstream Slope - Assume Sheet Pile Wall (preferred)** | | | | | |
| From Upstream Slope Repair OPC | 1 | LS | $ 712,900.00 | $ 712,900.00 | |
| **Subtotal** | | | | $ 712,900.00 | |
| **Crest** | | | | | |
| Install Curbing Along Length of Crest | 500 | LF | $ 16.50 | $ 8,250.00 | Based on RSMEANS Heavy Construction 32 16 13 |
| Remove Existing Pavement | 1650 | SY | $ 5.65 | $ 9,323.00 | RSMEANS Heavy Construction 02 41 13.17 5010 |
| Fill Hole with Grout | 1 | LS | $ 500.00 | $ 500.00 | Engineers Judgment |
| Repave Road | 2200 | SY | $ 22.00 | $ 48,400.00 | RSMEANS Heavy Construction 32 12 16.13 |
| Hauling | 275 | CY | $ 20.00 | $ 5,500.00 | RSMEANS Heavy Construction 02 41 16 4250 |
| Excavation for Catch Basin/manhole/pipes | 140 | CY | $ 8.00 | $ 1,120.00 | RSMEANS Heavy Construction 31 23 16.13 1300 |
| Backfill for Catch Basin/manhole/pipes | 140 | CY | $ 15.00 | $ 2,100.00 | Engineers Judgment |
| Remove Catch Basins/manhole | 3 | EA | $ 460.00 | $ 1,380.00 | RSMEANS Heavy Construction 02 41 13.33 0020 |
| Install New/rehabilitate Catch Basins | 3 | EA | $ 1,800.00 | $ 5,400.00 | RSMEANS Heavy Construction 33 47 13.10 1120 |
| Install Stormceptor | 1 | EA | $ 10,000.00 | $ 10,000.00 | Recent Project Costs/Engineers Judgment |
| Install New Concrete Pipe | 60 | LF | $ 22.00 | $ 1,320.00 | RSMEANS Heavy Construction 33 46 16.20 3060 |
| **Subtotal** | | | | $ 93,293.00 | |
| **R&D Existing Spillway Channel** | | | | | |
| Demolition/Removal | 180 | CY | $ 160.00 | $ 28,800.00 | RSMEANS Heavy Construction 03 05 05.10 0060 |
| Disposal | 180 | CY | $ 20.00 | $ 3,600.00 | RSMEANS Heavy Construction 02 41 16 4250 |
| Earth Excavation & Backfill | 490 | CY | $ 30.00 | $ 14,700.00 | Recent Project Costs |
| Drain from Catch Basin | 45 | LF | $ 10.00 | $ 450.00 | Romans Heavy Construction 02 41 13.38 0090 |
| **Subtotal** | | | | $ 47,550.00 | |
| **R&D Low Level Outlet** | | | | | |
| Headwall Demolition/Removal | 4 | CY | $ 160.00 | $ 640.00 | RSMEANS Heavy Construction 03 05 05.10 0060 |
| R&D Outlet Pipe | 160 | LF | $ 24.50 | $ 3,920.00 | RSMEANS Heavy Construction 02 41 13.38 1500 |
| Excavation | 2600 | CY | $ 15.00 | $ 39,000.00 | Recent Project Costs |
| R$D Structure and Wet well | 1 | LS | $ 3,000.00 | $ 3,000.00 | Engineers Judgment |
| R&D Dry Hydrant | 1 | LS | $ 700.00 | $ 700.00 | RSMEANS Heavy Construction 02 41 13.33 0900 |
| R&D Gate | 1 | LS | $ 2,000.00 | $ 2,000.00 | Engineers Judgment |
| **Subtotal** | | | | $ 49,260.00 | |
| **Downstream Slope** | | | | | |
| **Install/rehabilitate toe drains** | | | | | |
| Filter Fabric | 384 | SY | $ 6.00 | $ 2,304.00 | Engineers Judgment |
| Crushed Stone | 260 | CY | $ 36.00 | $ 9,360.00 | RSMEANS Heavy Construction 33 46 26 |
| Perforated Pipe | 288 | LF | $ 28.50 | $ 8,208.00 | RSMEANS Heavy Construction 33 46 16 |
| Rehab Manhole | 1 | LS | $ 3,000.00 | $ 3,000.00 | Engineers Judgment, remove and replace |
| Regrade to 3H:1V Slope | 4000 | SY | $ 2.20 | $ 8,800.00 | |
| **channel protection/riprap** | | | | | |
| geogrid | 280 | SY | $ 8.00 | $ 2,240.00 | RSMEANS Heavy Construction 31 32 19.16 1510/recent costs |
| New Riprap | | SY | $ 55.00 | $ - | RSMEANS Heavy Construction 31 37 13.10 0200 |
| Downstream Bedding Stone | | TON | $ 45.00 | $ - | Recent Project Costs |
| **Swale Construction Left Side** | | | | | |
| Geogrid | 36 | SY | $ 8.00 | $ 288.00 | |
| Riprap | 36 | SY | $ 55.00 | $ 1,980.00 | RSMEANS Heavy Construction 31 37 13.10 0200 |
| Drain From Left Catch Basin | 50 | LF | $ 25.00 | $ 1,250.00 | RSMEANS Heavy Construction 33 46 16.20 3080 |
| **Subtotal** | | | | $ 37,430.00 | |
| **New Spillway** | | | | | |
| Culverts | 24 | EA | $ 600.00 | $ 14,400.00 | RSMEANS Heavy Construction 33 41 13 |
| Set up charge at plant | 1 | LS | $ 6,000.00 | $ 6,000.00 | RSMEANS Heavy Construction 33 41 14 |
| Backfill | 1510 | CY | $ 15.00 | $ 22,650.00 | Recent Project Costs |
| Structural fill | 80 | CY | $ 45.00 | $ 3,600.00 | 1 ft * 36 wide *60 long thick recent project costs |
| Downstream stilling Basin | 10 | CY | $ 750.00 | $ 7,500.00 | 1ft thick Recent Project Costs |
| Spillway Slabs | 160 | CY | $ 800.00 | $ 128,000.00 | 1.5' thick Recent Project Costs |
| Spillway Walls | 75 | CY | $ 850.00 | $ 63,750.00 | 1.5' thick Recent Project Costs |
| **Subtotal** | | | | $ 245,900.00 | Recent Project Costs |
| **New Low Level Outlet** | | | | | |
| Trashrack | 1 | LS | $ 500.00 | $ 500.00 | Engineers Judgment |
| Inlet pipe | 80 | LF | $ 30.00 | $ 2,400.00 | RSMEANS Heavy Construction 33 46 16.20 3060 |
| Gate | 2 | LS | $ 10,000.00 | $ 20,000.00 | Engineers Judgment |
| Structure | 1 | LS | $ 17,000.00 | $ 17,000.00 | old castle precast structures |
| Shipping | 1 | LS | $ 3,000.00 | $ 3,000.00 | marc.price@oldcastle.com |
| Outlet pipe | 80 | LF | $ 20.00 | $ 1,600.00 | RSMEANS Heavy Construction 33 46 16.20 3060 |
| Backfill | 1200 | CY | $ 15.00 | $ 18,000.00 | Recent Project Costs |
| Concrete Cradle | 75 | CY | $ 400.00 | $ 30,000.00 | Engineers Judgment |
| Dry hydrant | 1 | LS | $ 3,000.00 | $ 3,000.00 | RSMEANS Heavy Construction 33 12 19.10 1420 |
| Crane | 1 | DAY | $ 3,000.00 | $ 3,000.00 | RSMEANS |
| **Subtotal** | | | | $ 98,500.00 | |
| **Loam & Seed / Site Finishing** | | | | | |
| Loam & Seed | 3000 | SY | $ 6.00 | $ 18,000.00 | |
| **Subtotal** | | | | $ 18,000.00 | RSMEANS Heavy Construction 33 01 30.16 |
| | | | **SUBTOTAL** | $ 1,350,000.00 | Engineers Judgment |
| | | | Contract Bonds | $ 41,000.00 | (Rounded to the nearest $1,000) |
| | | 30% | Contingency | $ 417,000.00 | |
| | | | Additional Engineering & Design | $ 25,000.00 | |
| | | | Construction Adminstration | $ 65,000.00 | |
| | | | **OPINION OF CONSTRUCTION COST** | **$ 1,898,000.00** | |

PARE CORPORATION

PROJECT : Ramshorn Pond Dam Repairs | PROJECT NUMBER: 13072.00
SUBJECT: Opinion of Probable Cost
COMPUTATIONS BY: JMC | DATE: October 2013
CHECKED BY: ARO | DATE: October 2013

## Spillway Option 2 Opinion of Probable Cost

| Item | Quantity | Unit | Unit Price | Total | Source/Notes |
|---|---|---|---|---|---|
| **Erosion Control** | | | | | |
| Hay bales | 315 | EA | $ 8.00 | $ 2,520.00 | |
| Silt Fence | 944 | LF | $ 5.00 | $ 4,720.00 | Recent Project Costs |
| Turbidity Barrier | 530 | LF | $ 30.00 | $ 15,900.00 | |
| **Subtotal** | | | | **$ 23,140.00** | |
| **Clearing and Grubbing** | | | | | |
| Clearing and grubbing | 1160 | SY | $ 3.70 | $ 4,292.00 | 201.0321 RIDOT WAUP/2009 |
| mowing downstream slope | 1 | LS | $ 300.00 | $ 300.00 | Engineers judgment |
| Tree Cutting | 22 | EA | $ 600.00 | $ 13,200.00 | |
| Embankment Fill | 30 | CY | $ 50.00 | $ 1,500.00 | |
| **Subtotal** | | | | **$ 19,292.00** | |
| **Upstream Slope - Assume Sheet Pile Wall (preferred)** | | | | | |
| From Upstream Slope Repair OPC | 1 | LS | $ 712,900.00 | $ 712,900.00 | |
| **Subtotal** | | | | **$ 712,900.00** | |
| **Crest** | | | | | |
| Install Curbing Along Length of Crest | 500 | LF | $ 16.50 | $ 8,250.00 | Based on RSMEANS Heavy Construction 32 16 13 |
| Remove Existing Pavement | 1650 | SY | $ 5.65 | $ 9,323.00 | RSMEANS Heavy Equipment 02 41 13.17 5010 |
| Fill Hole with Grout | 1 | LS | $ 500.00 | $ 500.00 | Engineers Judgment |
| Repave Road | 2200 | SY | $ 22.00 | $ 48,400.00 | RSMEANS Heavy Equipment 32 12 16.13 |
| Hauling | 275 | CY | $ 20.00 | $ 5,500.00 | RSMEANS Heavy Construction 02 41 16 4250 |
| Excavation for Catch Basins/manhole/pipes | 140 | CY | $ 8.00 | $ 1,120.00 | RSMEANS Heavy Equipment 31 23 16.13 1300 |
| Backfill for Catch Basins/manhole/pipes | 140 | CY | $ 15.00 | $ 2,100.00 | Engineers Judgment |
| Remove Catch Basins/manhole | 3 | EA | $ 460.00 | $ 1,380.00 | RSMEANS Heavy Equipment 02 41 13.33 0020 |
| Install New/rehabilitate Catch Basins | 3 | EA | $ 1,800.00 | $ 5,400.00 | RSMEANS Heavy Equipment 33 47 13.10 1120 |
| Install Stormceptor | 1 | EA | $ 10,000.00 | $ 10,000.00 | Recent Project Costs/Engineers Judgment |
| Install New Concrete Pipe | 60 | LF | $ 22.00 | $ 1,320.00 | RSMEANS Heavy Equipment 33 46 16.20 3060 |
| **Subtotal** | | | | **$ 93,293.00** | |
| **R&D Existing Spillway Channel** | | | | | |
| Demolition/Removal | 180 | CY | $ 160.00 | $ 28,800.00 | RSMEANS Heavy Construction 03 05 05.10 0060 |
| Disposal | 180 | CY | $ 20.00 | $ 3,600.00 | RSMEANS Heavy Construction 02 41 16 4250 |
| Earth Excavation & Backfill | 490 | CY | $ 30.00 | $ 14,700.00 | Recent Project Costs |
| Drain from Catch Basin | 45 | LF | $ 10.00 | $ 450.00 | RSMEANs Heavy Construction 02 41 13.38 0090 |
| **Subtotal** | | | | **$ 47,550.00** | |
| **R&D Low Level Outlet** | | | | | |
| R&D Headwall | 4 | CY | $ 160.00 | $ 640.00 | Engineers Judgment |
| R&D Outlet Pipe | 160 | LF | $ 24.50 | $ 3,920.00 | RSMEANS Heavy Construction 02 41 13.38 1500 |
| Excavation | 2600 | CY | $ 15.00 | $ 39,000.00 | Recent Project Costs |
| R$D Structure and Wet well | 1 | LS | $ 3,000.00 | $ 3,000.00 | Engineers Judgment |
| R&D Dry Hydrant | 1 | LS | $ 700.00 | $ 700.00 | RSMEANS Heavy Construction 02 41 13.33 0900 |
| R&D Gate | 1 | LS | $ 2,000.00 | $ 2,000.00 | Engineers Judgment |
| **Subtotal** | | | | **$ 49,260.00** | |
| **Downstream Slope** | | | | | |
| **Install/rehabilitate toe drains** | | | | | |
| Filter Fabric | 384 | SY | $ 6.00 | $ 2,304.00 | Engineers Judgment |
| Crushed Stone | 260 | CY | $ 36.00 | $ 9,360.00 | RSMEANS Heavy Construction 33 46 26 |
| Perforated Pipe | 288 | LF | $ 28.50 | $ 8,208.00 | RSMEANS Heavy Construction 33 46 16 |
| Rehab Manhole | 1 | LS | $ 3,000.00 | $ 3,000.00 | Engineers Judgment, remove and replace |
| Regrade to 3H:1V Slope | 3000 | SY | $ 2.20 | $ 6,600.00 | |
| Downstream Retaining Wall | | LF | $ 200.00 | $ - | Engineers Judgment |
| **channel protection/riprap** | | | | | |
| geogrid | | SY | $ 8.00 | $ - | RSMEANS Heavy Construction 31 32 19.16 1510/recent costs |
| New Riprap | | SY | $ 55.00 | $ - | RSMEANS Heavy Construction 31 37 13.10 0200 |
| Downstream Bedding Stone | | TON | $ 45.00 | $ - | Recent Project Costs |
| **Subtotal** | | | | **$ 29,472.00** | |
| **New Spillway** | | | | | |
| Regrade for new spillway | 610 | SY | $ 2.20 | $ 1,342.00 | 220' long 25' wide |
| Structural fill | 163 | CY | $ 45.00 | $ 7,335.00 | 1 ft thick recent project costs |
| Upstream scour apron | 16 | CY | $ 750.00 | $ 12,000.00 | 1 ft thick Recent Project Costs |
| Rehabilitate Upstream headwall | 1 | LS | $ 3,000.00 | $ 3,000.00 | Engineers Judgment |
| Downstream scour channel | 81 | CY | $ 750.00 | $ 60,750.00 | 6" thick Recent Project Costs |
| CIP Channel Slab | 250 | CY | $ 800.00 | $ 200,000.00 | 1.5' thick Recent Project Costs |
| CIP left downstream wall | 65 | CY | $ 850.00 | $ 55,250.00 | 1.5' thick Recent Project Costs |
| CIP right downstream wall | 65 | CY | $ 850.00 | $ 55,250.00 | 1.5' thick Recent Project Costs |
| Baffles In Downstream channel | 5 | EA | $ 1,500.00 | $ 7,500.00 | Engineers Judgment |
| **Subtotal** | | | | **$ 402,427.00** | Recent Project Costs |
| **New Low Level Outlet** | | | | | |
| Trashrack | 1 | LS | $ 500.00 | $ 500.00 | Engineers Judgment |
| Inlet pipe | 80 | LF | $ 30.00 | $ 2,400.00 | RSMEANS Heavy Construction 33 46 16.20 3060 |
| Gate | 2 | LS | $ 10,000.00 | $ 20,000.00 | Engineers Judgment |
| Structure | 1 | LS | $ 17,000.00 | $ 17,000.00 | old castle precast structures |
| Shipping | 1 | LS | $ 3,000.00 | $ 3,000.00 | marc.price@oldcastle.com |
| Outlet pipe | 80 | LF | $ 20.00 | $ 1,600.00 | RSMEANS Heavy Construction 33 46 16.20 3060 |
| Backfill | 2600 | CY | $ 15.00 | $ 39,000.00 | Recent Project Costs |
| Concrete Cradle | 75 | CY | $ 400.00 | $ 30,000.00 | Engineers Judgment |
| Dry hydrant | 1 | LS | $ 3,000.00 | $ 3,000.00 | RSMEANS Heavy Construction 33 12 19.10 1420 |
| Crane | 1 | DAY | $ 3,000.00 | $ 3,000.00 | RSMEANS |
| **Subtotal** | | | | **$ 119,500.00** | |
| **Loam & Seed / Site Finishing** | | | | | |
| Loam & Seed | 3000 | SY | $ 6.00 | $ 18,000.00 | |
| **Subtotal** | | | | **$ 18,000.00** | RSMEANS Heavy Construction 33 01 30.16 |
| | | | | | Engineers Judgment |
| | | | **SUBTOTAL** | $ 1,500,000.00 | (Rounded to the nearest $1,000) |
| | | | Contract Bonds | $ 45,000.00 | |
| | | 30% | Contingency | $ 464,000.00 | |
| | | | Additional Engineering & Design | $ 25,000.00 | |
| | | | Construction Adminstration | $ 65,000.00 | |
| | | | **OPINION OF CONSTRUCTION COST** | **$ 2,099,000.00** | |

PARE CORPORATION

PROJECT : Ramshorn Pond Dam Repairs
PROJECT NUMBER: 13072.00
SUBJECT: Opinion of Probable Cost
COMPUTATIONS BY: JMC
DATE: October 2013
CHECKED BY: ARO
DATE: October 2013

## Opinion of Probable Cost Regrade Slope Vs. Sheet Pile Wall

| Item | Quantity | Unit | Unit Price | Total | Source/Notes |
|---|---|---|---|---|---|
| **Regrade Upstream Slope Option 1** | | | | | |
| Remove Existing Guardrail | 390 | LF | $ 17.65 | $ 6,884.00 | RSMEANS Heavy Construction 02 41 13.20 0700 |
| Remove and Reset Fencing | 390 | LF | $ 26.40 | $ 10,296.00 | RSMEANS Heavy Construction 02 41 13.60 1750 |
| Remove Existing Riprap | 1300 | TON | $ 50.00 | $ 65,000.00 | RSMEANS Heavy Construction 02 41 13.70 400 |
| Regrade to 2H:1V | 3500 | SY | $ 2.20 | $ 7,700.00 | RSMEANS Heavy Construction 31 22 16, finish grading |
| Place & Compact Fill | 2000 | CY | $ 15.00 | $ 30,000.00 | Recent Project Costs, 480ftx20ftx1ft |
| Imported Fill | 2000 | CY | $ 45.00 | $ 90,000.00 | Recent Project Costs |
| Geotextile | 2250 | SY | $ 8.00 | $ 18,000.00 | RSMEANS Heavy Construction 31 32 19.16 1510/recent costs |
| Riprap | 1000 | TON | $ 55.00 | $ 55,000.00 | Recent Project Costs |
| Anchor Stone | 350 | TON | $ 65.00 | $ 22,750.00 | Recent Project Costs |
| Upstream Bedding Stone | 922 | TON | $ 50.00 | $ 46,100.00 | Recent Project Costs |
| Install Guardrail | 390 | LF | $ 60.00 | $ 23,400.00 | RSMEANS Heavy Construction 34 71 13 0900 |
| Concrete Sidewalk | 6 | CY | $ 750.00 | $ 4,500.00 | Recent Project Costs |
| **Subtotal** | | | | **$ 379,630.00** | |
| **Upstream Slope Sheet Pile Wall** | | | | | |
| Remove Existing Guardrail | 390 | LF | $ 17.65 | $ 6,884.00 | RSMEANS Heavy Construction 02 41 13.20 0700 |
| Remove and Reset Fencing | 390 | LF | $ 26.40 | $ 10,296.00 | RSMEANS Heavy Construction 02 41 13.60 1750 |
| Remove and Reset Existing Riprap | 1000 | TON | $ 30.00 | $ 30,000.00 | Engineer's Judgment |
| Install PVC Sheet Pile Wall with Concrete and Steel | 410 | LF | $ 1,300.00 | $ 533,000.00 | Spoke to Shawn from Truline 12395916234, 36' tall (12 exposed 24 below)--no labor |
| Labor and Crane | 12 | DAYS | $ 4,000.00 | $ 48,000.00 | 3 Laborers, Crane Operator, Oiler, and Crane |
| Backfill Behind Sheet pile Wall | 650 | CY | $ 45.00 | $ 29,250.00 | RSMEANS Heavy Construction 31 23 23.13 |
| Structural Fill | 500 | CY | $ 45.00 | $ 22,500.00 | Recent Project Costs |
| Install Guardrail | 390 | LF | $ 60.00 | $ 23,400.00 | RSMEANS Heavy Construction 34 71 13 0900 |
| Concrete Sidewalk | 6 | CY | $ 750.00 | $ 4,500.00 | Recent Project Costs |
| Regrade Portion of Slope to 2H:1V | 400 | SY | $ 2.20 | $ 880.00 | RSMEANS Heavy Construction 31 22 16 |
| New Riprap | 0 | TON | $ 55.00 | $ - | RSMEANS Heavy Construction 31 37 13.10 0350 |
| Anchor Stone | 0 | TON | $ 55.00 | $ - | Recent Project Costs |
| Upstream Bedding Stone | 91 | TON | $ 45.00 | $ 4,095.00 | Recent Project Costs (MHD 983.1) |
| **Subtotal** | | | | **$ 712,805.00** | |

# APPENDIX F
# Previous Reports and References
*Ramshorn Pond Dam*
***Millbury, Massachusetts***

## PREVIOUS REPORTS AND REFERENCES

The available MADCR Office of Dam Safety files were reviewed by PARE personnel. The following documents were located during that review:

1. Follow-up Inspection Report (revised), prepared by Tighe & Bond, Dated June 29th, 2012.

2. Inspection Report titled, "Ramshorn Pond Dam Phase I Inspection/Evaluation", prepared by Weston & Sampson Engineers, Inc., dated April 6th, 2011.

3. Inspection Report titled, "Ramshorn Pond Dam (MA00145) – Millbury, MA", prepared by Tighe & Bond, dated October 16, 2009.

4. Inspection Report Titled, "Summary of Visual Dam Inspection: Ramshorn Pond Dam," prepared by GZA GeoEnvironmental, Inc., dated August 26, 2005.

5. Dolan Road Reconstruction Project Plans Dated 1985 by SEA Consultants Inc., Boston, MA

During the development of the report PARE also reviewed available information included within the following databases:

1. MADCR – Dams Viewer Database http://maps.massgis.state.ma.us/dams/viewer.htm

The following references were utilized during the preparation of this report and the development of the recommendations presented herein:


1. "Design of Small Dams", United States Department of the Interior Bureau of Reclamation, 1987
2. "ER 110-2-106 - Recommended Guidelines for Safety Inspection of Dams", Department of the Army, September 26, 1979.
3. "Guidelines for Reporting the Performance of Dams" National Performance of Dams Program, August 1994.
4. "Soil Mechanics Design Manual 7.1", Department of the Navy, Naval Facilities Engineering Command, September 1986.
5. 302 CMR: Department of Conservation and Recreation Section 10.00 Dam Safety
6. Massachusetts State Building Code Sec. 1612.4.9
7. "Principles of Foundation Engineering; 5th Edition, Das, Braja M., 2004.
8. "Shore Protection Manual", Department of the Army Waterways Experiment Station, 1984.
9. "An Introduction to Geotechnical Engineering Second Edition" Holtz, Robert D., Kovacs, William D, Sheahan, Thomas C., 2011.
10. NCEER (1997). Proceeding of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils, (T.L. Youd and I.M. Idriss, eds.), Technical Report NCEER-97-0022, National Center for Earthquake Engineering Research, State University of New York at Buffalo, 276pp.
11. Green, Russell A. Energy-Based Evaluation and Remediation of Liquefiable Soils. Diss. Virginia Polytechnic Institute and State University, 2001. Blacksburg: n.p., 2001.
12. Massachusetts Wetlands Protection Act Regulations 310 CMR 10.00

# APPENDIX G
# Definitions

*Ramshorn Pond Dam*
***Millbury, Massachusetts***

# COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to 302 CMR10.00 Dam Safety, or other reference published by FERC, Dept. of the Interior Bureau of Reclamation, or FEMA. Please note should discrepancies between definitions exits, those definitions included within 302 CMR 10.00 govern for dams located within the Commonwealth of Massachusetts.

## Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

## Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate therefrom. including but not be limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

## Size Classification

(as listed in Commonwealth of Massachusetts, 302 CMR 10.00 *Dam Safety*)

Large – structure with a height greater than 40 feet or a storage capacity greater than 1,000 acre-feet.

Intermediate – structure with a height between 15 and 40 feet or a storage capacity of 50 to 1,000 acre-feet.

Small – structure with a height between 6 and 15 feet and a storage capacity of 15 to 50 acre-feet.

Non-Jurisdictional – structure less than 6 feet in height or having a storage capacity of less than 15 acre-feet.

## Hazard Classification

(as listed in Commonwealth of Massachusetts, 302 CMR 10.00 *Dam Safety*)

High Hazard (Class I) – Shall mean dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).

Significant Hazard (Class II) – Shall mean dams located where failure may cause loss of life and damage to home(s), industrial or commercial facilities, secondary highway(s) or railroad(s), or cause the interruption of the use or service of relatively important facilities.

Low Hazard (Class III) – Dams located where failure may cause minimal property damage to others .Loss of life is not expected.

## General

EAP – Emergency Action Plan - Shall mean a predetermined plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam break.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. On million U.S. gallons = 3.068 acre feet

Height of Dam – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

## Condition Rating

Unsafe - Major structural, operational, and maintenance deficiencies exist under normal operating conditions.

Poor - Significant structural, operation and maintenance deficiencies are clearly recognized for normal loading conditions.

Fair - Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. Can be used when uncertainties exist as to critical parameters.

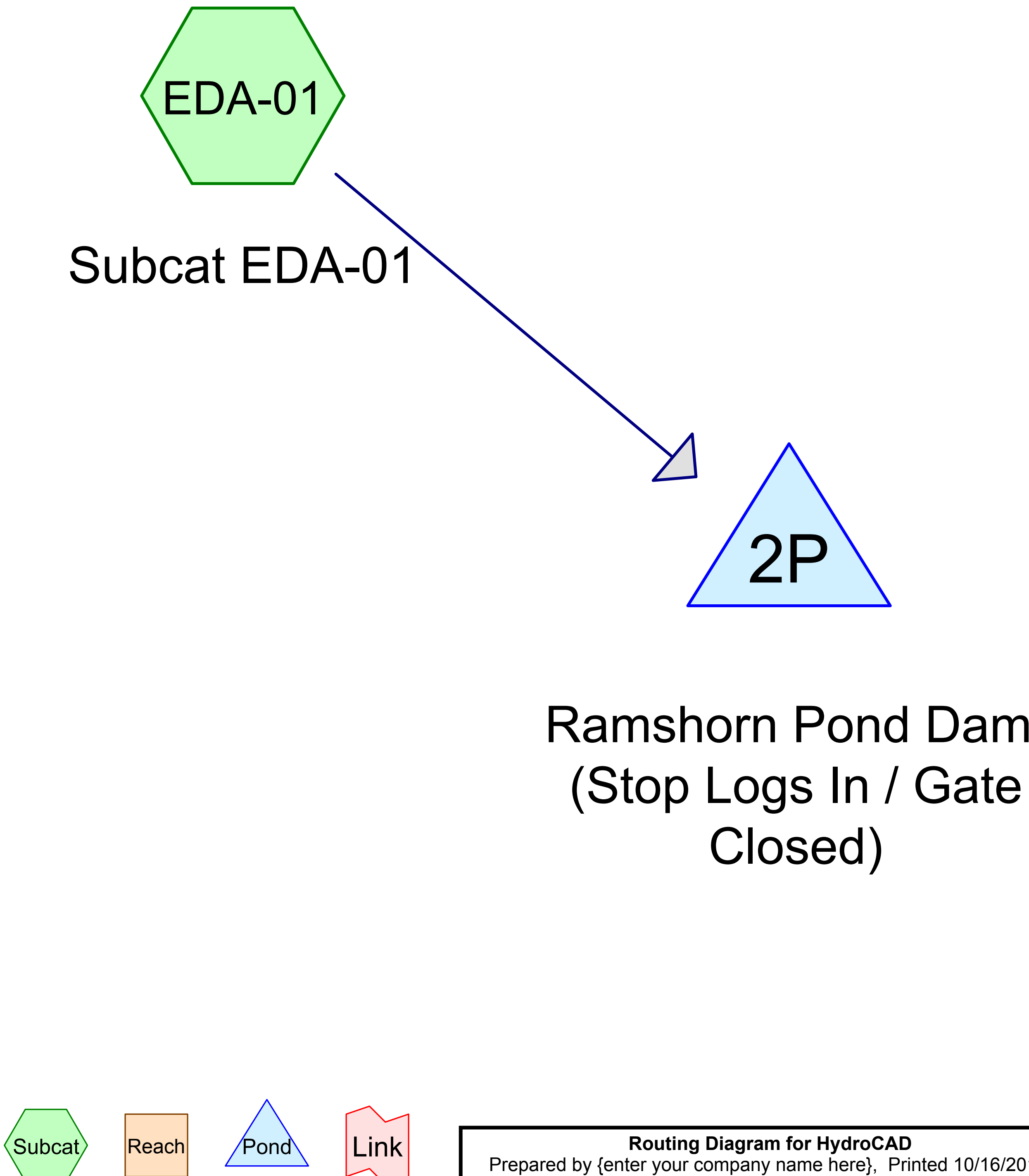
Satisfactory - Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result in deficiencies.

Good - No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF.

# APPENDIX H
## Supporting Information

*Ramshorn Pond Dam*
***Millbury, Massachusetts***

1. Hydrologic and Hydraulic Analyses Output




**Routing Diagram for HydroCAD**
Prepared by {enter your company name here}, Printed 10/16/2013
HydroCAD® 10.00 s/n 04883 © 2013 HydroCAD Software Solutions LLC

## Area Listing (selected nodes)

| Area (acres) | CN | Description (subcatchment-numbers) |
|---|---|---|
| 7.323 | 68 | 1 acre lots, 20% imp, HSG B (EDA-01) |
| 47.295 | 79 | 1 acre lots, 20% imp, HSG C (EDA-01) |
| 0.382 | 84 | 1 acre lots, 20% imp, HSG D (EDA-01) |
| 12.645 | 70 | 1/2 acre lots, 25% imp, HSG B (EDA-01) |
| 22.851 | 80 | 1/2 acre lots, 25% imp, HSG C (EDA-01) |
| 0.268 | 85 | 1/2 acre lots, 25% imp, HSG D (EDA-01) |
| 0.433 | 72 | 1/3 acre lots, 30% imp, HSG B (EDA-01) |
| 5.967 | 81 | 1/3 acre lots, 30% imp, HSG C (EDA-01) |
| 0.013 | 86 | 1/3 acre lots, 30% imp, HSG D (EDA-01) |
| 1.165 | 75 | 1/4 acre lots, 38% imp, HSG B (EDA-01) |
| 1.566 | 83 | 1/4 acre lots, 38% imp, HSG C (EDA-01) |
| 0.486 | 85 | 1/8 acre lots, 65% imp, HSG B (EDA-01) |
| 0.237 | 90 | 1/8 acre lots, 65% imp, HSG C (EDA-01) |
| 0.062 | 92 | 1/8 acre lots, 65% imp, HSG D (EDA-01) |
| 9.893 | 65 | 2 acre lots, 12% imp, HSG B (EDA-01) |
| 35.540 | 77 | 2 acre lots, 12% imp, HSG C (EDA-01) |
| 0.247 | 82 | 2 acre lots, 12% imp, HSG D (EDA-01) |
| 8.773 | 48 | Brush, Good, HSG B (EDA-01) |
| 32.488 | 65 | Brush, Good, HSG C (EDA-01) |
| 1.697 | 73 | Brush, Good, HSG D (EDA-01) |
| 1.075 | 96 | Gravel surface, HSG B (EDA-01) |
| 4.950 | 96 | Gravel surface, HSG C (EDA-01) |
| 3.685 | 58 | Meadow, non-grazed, HSG B (EDA-01) |
| 77.382 | 71 | Meadow, non-grazed, HSG C (EDA-01) |
| 1.146 | 78 | Meadow, non-grazed, HSG D (EDA-01) |
| 2.260 | 61 | Pasture/grassland/range, Good, HSG B (EDA-01) |
| 34.695 | 74 | Pasture/grassland/range, Good, HSG C (EDA-01) |
| 3.533 | 98 | Paved parking, HSG B (EDA-01) |
| 13.240 | 98 | Paved parking, HSG C (EDA-01) |
| 0.294 | 98 | Paved parking, HSG D (EDA-01) |
| 0.808 | 92 | Urban commercial, 85% imp, HSG B (EDA-01) |
| 0.458 | 94 | Urban commercial, 85% imp, HSG C (EDA-01) |
| 0.632 | 91 | Urban industrial, 72% imp, HSG C (EDA-01) |
| 0.870 | 98 | Water Surface, HSG B (EDA-01) |
| 145.169 | 98 | Water Surface, HSG C (EDA-01) |
| 21.221 | 98 | Water Surface, HSG D (EDA-01) |
| 6.009 | 30 | Woods, Good, HSG A (EDA-01) |
| 189.599 | 55 | Woods, Good, HSG B (EDA-01) |
| 728.802 | 70 | Woods, Good, HSG C (EDA-01) |
| 112.558 | 77 | Woods, Good, HSG D (EDA-01) |

## Area Listing (selected nodes) (continued)

| Area (acres) | CN | Description (subcatchment-numbers) |
|---|---|---|
| **1,537.718** | **72** | **TOTAL AREA** |

## Soil Listing (selected nodes)

| Area (acres) | Soil Group | Subcatchment Numbers |
|---|---|---|
| 6.009 | HSG A | EDA-01 |
| 242.550 | HSG B | EDA-01 |
| 1,151.271 | HSG C | EDA-01 |
| 137.888 | HSG D | EDA-01 |
| 0.000 | Other | |
| **1,537.718** | | **TOTAL AREA** |

## Ground Covers (selected nodes)

| HSG-A (acres) | HSG-B (acres) | HSG-C (acres) | HSG-D (acres) | Other (acres) | Total (acres) | Ground Cover | Subcatchment Numbers |
|---|---|---|---|---|---|---|---|
| 0.000 | 7.323 | 47.295 | 0.382 | 0.000 | 55.000 | 1 acre lots, 20% imp | ED A-01 |
| 0.000 | 12.645 | 22.851 | 0.268 | 0.000 | 35.765 | 1/2 acre lots, 25% imp | ED A-01 |
| 0.000 | 0.433 | 5.967 | 0.013 | 0.000 | 6.413 | 1/3 acre lots, 30% imp | ED A-01 |
| 0.000 | 1.165 | 1.566 | 0.000 | 0.000 | 2.731 | 1/4 acre lots, 38% imp | ED A-01 |
| 0.000 | 0.486 | 0.237 | 0.062 | 0.000 | 0.785 | 1/8 acre lots, 65% imp | ED A-01 |
| 0.000 | 9.893 | 35.540 | 0.247 | 0.000 | 45.679 | 2 acre lots, 12% imp | ED A-01 |
| 0.000 | 8.773 | 32.488 | 1.697 | 0.000 | 42.958 | Brush, Good | ED A-01 |
| 0.000 | 1.075 | 4.950 | 0.000 | 0.000 | 6.025 | Gravel surface | ED A-01 |
| 0.000 | 3.685 | 77.382 | 1.146 | 0.000 | 82.214 | Meadow, non-grazed | ED A-01 |
| 0.000 | 2.260 | 34.695 | 0.000 | 0.000 | 36.955 | Pasture/grassland/range, Good | ED A-01 |
| 0.000 | 3.533 | 13.240 | 0.294 | 0.000 | 17.067 | Paved parking | ED A-01 |
| 0.000 | 0.808 | 0.458 | 0.000 | 0.000 | 1.266 | Urban commercial, 85% imp | ED A-01 |
| 0.000 | 0.000 | 0.632 | 0.000 | 0.000 | 0.632 | Urban industrial, 72% imp | ED A-01 |
| 0.000 | 0.870 | 145.169 | 21.221 | 0.000 | 167.259 | Water Surface | ED A-01 |

## Ground Covers (selected nodes) (continued)

| HSG-A (acres) | HSG-B (acres) | HSG-C (acres) | HSG-D (acres) | Other (acres) | Total (acres) | Ground Cover | Subcatchment Numbers |
|---|---|---|---|---|---|---|---|
| 6.009 | 189.599 | 728.802 | 112.558 | 0.000 | 1,036.968 | Woods, Good | ED A- 01 |
| **6.009** | **242.550** | **1,151.271** | **137.888** | **0.000** | **1,537.718** | **TOTAL AREA** | |

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment EDA-01: Subcat EDA-01** Runoff Area=1,537.718 ac 13.97% Impervious Runoff Depth=5.39"
Flow Length=11,300' Tc=276.8 min CN=72 Runoff=1,343.68 cfs 691.216 af

**Pond 2P: Ramshorn Pond Dam** Peak Elev=634.14' Storage=548.225 af Inflow=1,343.68 cfs 691.216 af
Outflow=314.39 cfs 613.218 af

**Total Runoff Area = 1,537.718 ac Runoff Volume = 691.216 af Average Runoff Depth = 5.39"**
**86.03% Pervious = 1,322.966 ac 13.97% Impervious = 214.752 ac**

## Summary for Subcatchment EDA-01: Subcat EDA-01

Runoff = 1,343.68 cfs @ 15.69 hrs, Volume= 691.216 af, Depth= 5.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.79"

| Area (ac) | CN | Description |
|---|---|---|
| 8.425 | 77 | Woods, Good, HSG D |
| 0.273 | 78 | Meadow, non-grazed, HSG D |
| 0.000 | 84 | 1 acre lots, 20% imp, HSG D |
| 1.355 | 70 | Woods, Good, HSG C |
| 0.698 | 65 | Brush, Good, HSG C |
| 3.065 | 70 | Woods, Good, HSG C |
| 0.022 | 65 | Brush, Good, HSG C |
| 0.148 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.025 | 98 | Paved parking, HSG C |
| 0.014 | 98 | Water Surface, HSG C |
| 0.323 | 98 | Water Surface, HSG C |
| 1.450 | 98 | Water Surface, HSG C |
| 10.748 | 70 | Woods, Good, HSG C |
| 0.498 | 55 | Woods, Good, HSG B |
| 0.476 | 98 | Paved parking, HSG B |
| 2.799 | 55 | Woods, Good, HSG B |
| 0.327 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.238 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.277 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.578 | 68 | 1 acre lots, 20% imp, HSG B |
| 3.500 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 4.044 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.012 | 98 | Paved parking, HSG B |
| 0.301 | 98 | Water Surface, HSG B |
| 12.253 | 77 | Woods, Good, HSG D |
| 0.109 | 98 | Paved parking, HSG D |
| 0.157 | 77 | Woods, Good, HSG D |
| 0.873 | 78 | Meadow, non-grazed, HSG D |
| 0.007 | 84 | 1 acre lots, 20% imp, HSG D |
| 0.062 | 92 | 1/8 acre lots, 65% imp, HSG D |
| 0.312 | 98 | Water Surface, HSG D |
| 5.188 | 77 | Woods, Good, HSG D |
| 0.251 | 73 | Brush, Good, HSG D |
| 13.278 | 98 | Water Surface, HSG D |
| 1.976 | 71 | Meadow, non-grazed, HSG C |
| 0.483 | 71 | Meadow, non-grazed, HSG C |
| 3.826 | 98 | Water Surface, HSG D |
| 1.244 | 98 | Water Surface, HSG D |
| 0.025 | 98 | Water Surface, HSG D |
| 0.013 | 86 | 1/3 acre lots, 30% imp, HSG D |
| 0.268 | 85 | 1/2 acre lots, 25% imp, HSG D |
| 0.247 | 82 | 2 acre lots, 12% imp, HSG D |
| 0.145 | 98 | Paved parking, HSG D |
| 15.857 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 5.976 | 77 | Woods, Good, HSG D |
| 1.296 | 73 | Brush, Good, HSG D |
| 77.304 | 70 | Woods, Good, HSG C |
| 13.578 | 77 | Woods, Good, HSG D |
| 0.886 | 65 | Brush, Good, HSG C |

| | | |
|---|---|---|
| 7.779 | 65 | Brush, Good, HSG C |
| 7.953 | 70 | Woods, Good, HSG C |
| 1.881 | 65 | Brush, Good, HSG C |
| 5.663 | 65 | Brush, Good, HSG C |
| 10.415 | 70 | Woods, Good, HSG C |
| 3.987 | 70 | Woods, Good, HSG C |
| 1.795 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.009 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.004 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.116 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.359 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.036 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.330 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.037 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.011 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.173 | 70 | Woods, Good, HSG C |
| 28.188 | 70 | Woods, Good, HSG C |
| 0.045 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 0.212 | 70 | Woods, Good, HSG C |
| 0.102 | 70 | Woods, Good, HSG C |
| 0.054 | 70 | Woods, Good, HSG C |
| 0.044 | 70 | Woods, Good, HSG C |
| 0.006 | 70 | Woods, Good, HSG C |
| 0.817 | 70 | Woods, Good, HSG C |
| 0.095 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.043 | 70 | Woods, Good, HSG C |
| 0.411 | 70 | Woods, Good, HSG C |
| 0.000 | 70 | Woods, Good, HSG C |
| 0.299 | 98 | Paved parking, HSG C |
| 3.242 | 98 | Paved parking, HSG C |
| 67.114 | 70 | Woods, Good, HSG C |
| 0.145 | 70 | Woods, Good, HSG C |
| 171.240 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.241 | 70 | Woods, Good, HSG C |
| 0.002 | 70 | Woods, Good, HSG C |
| 0.009 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 0.010 | 70 | Woods, Good, HSG C |
| 0.031 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.000 | 70 | Woods, Good, HSG C |
| 0.105 | 70 | Woods, Good, HSG C |
| 16.574 | 55 | Woods, Good, HSG B |
| 0.219 | 98 | Water Surface, HSG C |
| 0.005 | 98 | Water Surface, HSG C |

| | | |
|---|---|---|
| 0.579 | 98 | Water Surface, HSG C |
| 0.046 | 98 | Water Surface, HSG C |
| 11.283 | 70 | Woods, Good, HSG C |
| 87.275 | 70 | Woods, Good, HSG C |
| 0.149 | 73 | Brush, Good, HSG D |
| 31.112 | 77 | Woods, Good, HSG D |
| 2.536 | 98 | Water Surface, HSG D |
| 0.040 | 98 | Paved parking, HSG D |
| 0.375 | 84 | 1 acre lots, 20% imp, HSG D |
| 8.249 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 35.868 | 77 | Woods, Good, HSG D |
| 0.006 | 98 | Paved parking, HSG B |
| 0.000 | 98 | Paved parking, HSG B |
| 0.163 | 98 | Paved parking, HSG C |
| 0.006 | 98 | Paved parking, HSG C |
| 0.457 | 98 | Paved parking, HSG C |
| 0.001 | 98 | Paved parking, HSG C |
| 0.837 | 98 | Paved parking, HSG B |
| 0.179 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.966 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.327 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.000 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.003 | 68 | 1 acre lots, 20% imp, HSG B |
| 4.100 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.074 | 58 | Meadow, non-grazed, HSG B |
| 0.044 | 70 | Woods, Good, HSG C |
| 1.189 | 70 | Woods, Good, HSG C |
| 1.933 | 55 | Woods, Good, HSG B |
| 0.000 | 55 | Woods, Good, HSG B |
| 0.101 | 55 | Woods, Good, HSG B |
| 0.016 | 70 | Woods, Good, HSG C |
| 4.196 | 70 | Woods, Good, HSG C |
| 0.006 | 70 | Woods, Good, HSG C |
| 0.256 | 55 | Woods, Good, HSG B |
| 0.454 | 55 | Woods, Good, HSG B |
| 0.394 | 98 | Water Surface, HSG B |
| 0.175 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 1.165 | 75 | 1/4 acre lots, 38% imp, HSG B |
| 0.669 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.058 | 58 | Meadow, non-grazed, HSG B |
| 0.622 | 58 | Meadow, non-grazed, HSG B |
| 0.023 | 70 | Woods, Good, HSG C |
| 0.010 | 70 | Woods, Good, HSG C |
| 0.055 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 14.294 | 70 | Woods, Good, HSG C |
| 0.031 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 23.662 | 55 | Woods, Good, HSG B |
| 6.009 | 30 | Woods, Good, HSG A |

| | | |
|---|---|---|
| 0.098 | 98 | Paved parking, HSG B |
| 0.046 | 98 | Paved parking, HSG C |
| 0.112 | 98 | Paved parking, HSG C |
| 0.133 | 98 | Paved parking, HSG B |
| 0.022 | 98 | Paved parking, HSG C |
| 1.187 | 98 | Paved parking, HSG C |
| 0.374 | 98 | Paved parking, HSG B |
| 0.037 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.298 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.849 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.563 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.302 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.035 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.047 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.665 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.016 | 74 | Pasture/grassland/range, Good, HSG C |
| 3.444 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.011 | 61 | Pasture/grassland/range, Good, HSG B |
| 0.017 | 70 | Woods, Good, HSG C |
| 7.092 | 55 | Woods, Good, HSG B |
| 0.006 | 55 | Woods, Good, HSG B |
| 2.752 | 70 | Woods, Good, HSG C |
| 0.025 | 70 | Woods, Good, HSG C |
| 1.116 | 55 | Woods, Good, HSG B |
| 1.024 | 55 | Woods, Good, HSG B |
| 0.205 | 98 | Paved parking, HSG B |
| 0.706 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.190 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.384 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.249 | 61 | Pasture/grassland/range, Good, HSG B |
| 0.454 | 58 | Meadow, non-grazed, HSG B |
| 0.947 | 58 | Meadow, non-grazed, HSG B |
| 1.163 | 58 | Meadow, non-grazed, HSG B |
| 0.023 | 55 | Woods, Good, HSG B |
| 0.338 | 55 | Woods, Good, HSG B |
| 0.019 | 55 | Woods, Good, HSG B |
| 0.433 | 72 | 1/3 acre lots, 30% imp, HSG B |
| 0.697 | 68 | 1 acre lots, 20% imp, HSG B |
| 2.388 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.308 | 58 | Meadow, non-grazed, HSG B |
| 0.632 | 48 | Brush, Good, HSG B |
| 1.693 | 70 | Woods, Good, HSG C |
| 3.529 | 70 | Woods, Good, HSG C |
| 0.127 | 70 | Woods, Good, HSG C |
| 15.057 | 55 | Woods, Good, HSG B |
| 0.175 | 98 | Water Surface, HSG B |
| 0.037 | 98 | Paved parking, HSG C |
| 0.464 | 98 | Paved parking, HSG C |
| 1.392 | 98 | Paved parking, HSG B |
| 1.075 | 96 | Gravel surface, HSG B |
| 0.808 | 92 | Urban commercial, 85% imp, HSG B |

| | | |
|---|---|---|
| 0.137 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.614 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.821 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.005 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.048 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 3.340 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.622 | 68 | 1 acre lots, 20% imp, HSG B |
| 15.443 | 65 | Brush, Good, HSG C |
| 0.078 | 65 | Brush, Good, HSG C |
| 7.163 | 48 | Brush, Good, HSG B |
| 0.977 | 48 | Brush, Good, HSG B |
| 0.037 | 70 | Woods, Good, HSG C |
| 0.026 | 70 | Woods, Good, HSG C |
| 0.037 | 70 | Woods, Good, HSG C |
| 0.097 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 0.176 | 70 | Woods, Good, HSG C |
| 0.050 | 70 | Woods, Good, HSG C |
| 0.087 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 20.504 | 55 | Woods, Good, HSG B |
| 1.932 | 55 | Woods, Good, HSG B |
| 166.461 | 70 | Woods, Good, HSG C |
| 86.903 | 55 | Woods, Good, HSG B |
| 0.137 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.242 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.315 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.059 | 58 | Meadow, non-grazed, HSG B |
| 9.307 | 55 | Woods, Good, HSG B |
| 0.101 | 70 | Woods, Good, HSG C |
| 0.818 | 70 | Woods, Good, HSG C |
| 0.456 | 70 | Woods, Good, HSG C |
| 10.414 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 0.039 | 70 | Woods, Good, HSG C |
| 3.007 | 70 | Woods, Good, HSG C |
| 1.704 | 70 | Woods, Good, HSG C |
| 3.962 | 70 | Woods, Good, HSG C |
| 0.042 | 70 | Woods, Good, HSG C |
| 6.320 | 70 | Woods, Good, HSG C |
| 0.153 | 70 | Woods, Good, HSG C |
| 0.148 | 70 | Woods, Good, HSG C |
| 0.038 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.038 | 65 | Brush, Good, HSG C |
| 1.122 | 71 | Meadow, non-grazed, HSG C |

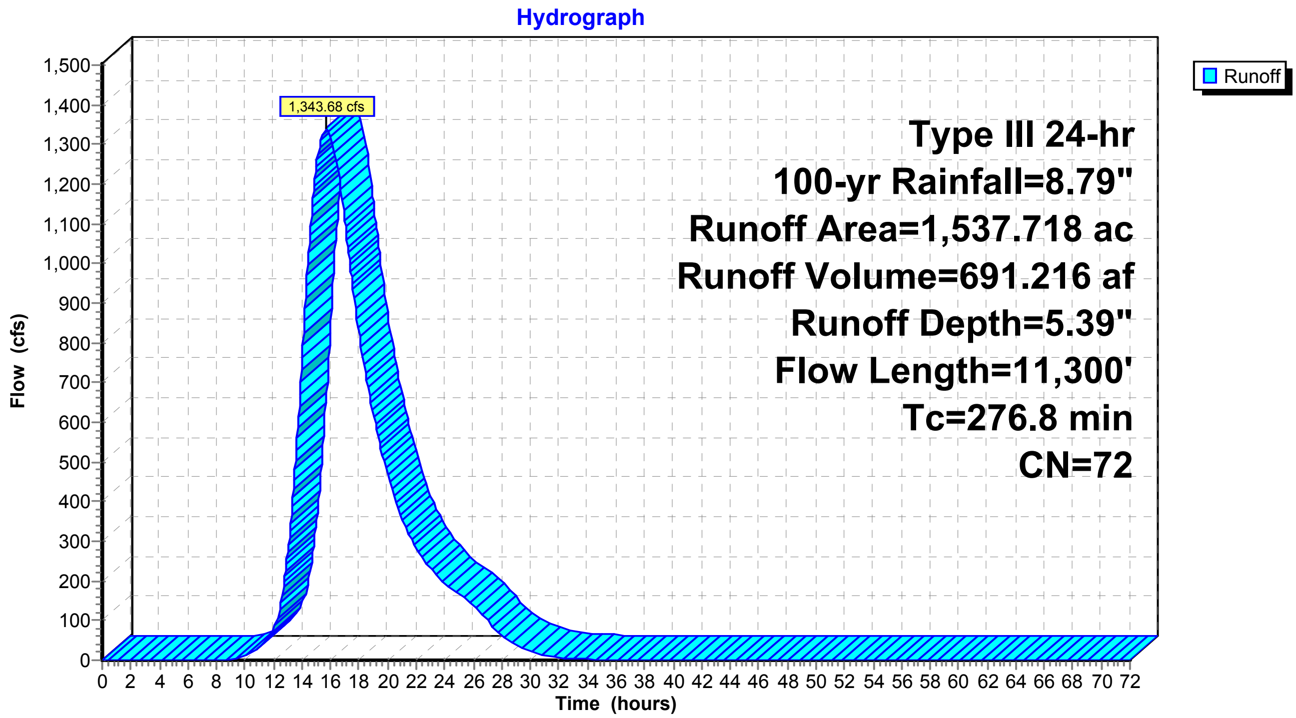
| | | |
|---|---|---|
| 0.109 | 71 | Meadow, non-grazed, HSG C |
| 1.365 | 71 | Meadow, non-grazed, HSG C |
| 10.877 | 71 | Meadow, non-grazed, HSG C |
| 4.101 | 71 | Meadow, non-grazed, HSG C |
| 0.504 | 71 | Meadow, non-grazed, HSG C |
| 0.233 | 71 | Meadow, non-grazed, HSG C |
| 0.020 | 71 | Meadow, non-grazed, HSG C |
| 0.341 | 71 | Meadow, non-grazed, HSG C |
| 0.657 | 71 | Meadow, non-grazed, HSG C |
| 0.206 | 71 | Meadow, non-grazed, HSG C |
| 0.902 | 71 | Meadow, non-grazed, HSG C |
| 2.991 | 71 | Meadow, non-grazed, HSG C |
| 0.144 | 71 | Meadow, non-grazed, HSG C |
| 0.431 | 71 | Meadow, non-grazed, HSG C |
| 2.758 | 71 | Meadow, non-grazed, HSG C |
| 12.700 | 71 | Meadow, non-grazed, HSG C |
| 0.842 | 71 | Meadow, non-grazed, HSG C |
| 0.657 | 71 | Meadow, non-grazed, HSG C |
| 0.366 | 71 | Meadow, non-grazed, HSG C |
| 7.832 | 71 | Meadow, non-grazed, HSG C |
| 4.144 | 71 | Meadow, non-grazed, HSG C |
| 7.707 | 71 | Meadow, non-grazed, HSG C |
| 2.530 | 71 | Meadow, non-grazed, HSG C |
| 11.385 | 71 | Meadow, non-grazed, HSG C |
| 0.630 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.640 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.499 | 74 | Pasture/grassland/range, Good, HSG C |
| 13.839 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.627 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.343 | 74 | Pasture/grassland/range, Good, HSG C |
| 5.380 | 74 | Pasture/grassland/range, Good, HSG C |
| 5.277 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.973 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.397 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.305 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.393 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.514 | 77 | 2 acre lots, 12% imp, HSG C |
| 2.524 | 77 | 2 acre lots, 12% imp, HSG C |
| 2.394 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.189 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.468 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.871 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.100 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.354 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.571 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.505 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.717 | 77 | 2 acre lots, 12% imp, HSG C |
| 3.826 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.915 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.534 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.770 | 77 | 2 acre lots, 12% imp, HSG C |

| | | |
|---|---|---|
| 3.858 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.574 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.281 | 77 | 2 acre lots, 12% imp, HSG C |
| 7.505 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.572 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.975 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.064 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.008 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.728 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.158 | 79 | 1 acre lots, 20% imp, HSG C |
| 4.048 | 79 | 1 acre lots, 20% imp, HSG C |
| 5.884 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.343 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.603 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.637 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.343 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.018 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.013 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.271 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.676 | 79 | 1 acre lots, 20% imp, HSG C |
| 4.173 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.718 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.650 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.391 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.502 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.951 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.101 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.729 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.213 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.913 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.682 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.329 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.195 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.151 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.769 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.778 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.568 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.556 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.929 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.373 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.959 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.846 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.247 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 2.760 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.368 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 3.192 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.198 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.532 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.696 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 1.923 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 4.241 | 80 | 1/2 acre lots, 25% imp, HSG C |

| | | |
|---|---|---|
| 0.416 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.100 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 2.333 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 5.698 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.035 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.234 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.273 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.768 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.140 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.236 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.149 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.114 | 90 | 1/8 acre lots, 65% imp, HSG C |
| 0.123 | 90 | 1/8 acre lots, 65% imp, HSG C |
| 0.632 | 91 | Urban industrial, 72% imp, HSG C |
| 0.458 | 94 | Urban commercial, 85% imp, HSG C |
| 4.350 | 96 | Gravel surface, HSG C |
| 0.600 | 96 | Gravel surface, HSG C |
| 0.084 | 98 | Paved parking, HSG C |
| 0.838 | 98 | Paved parking, HSG C |
| 0.888 | 98 | Paved parking, HSG C |
| 1.068 | 98 | Paved parking, HSG C |
| 2.929 | 98 | Paved parking, HSG C |
| 0.085 | 98 | Paved parking, HSG C |
| 0.041 | 98 | Paved parking, HSG C |
| 0.595 | 98 | Paved parking, HSG C |
| 0.083 | 98 | Paved parking, HSG C |
| 0.290 | 98 | Paved parking, HSG C |
| 0.279 | 98 | Paved parking, HSG C |
| 127.500 | 98 | Water Surface, HSG C |
| 14.980 | 98 | Water Surface, HSG C |
| 0.019 | 98 | Water Surface, HSG C |
| 0.033 | 98 | Water Surface, HSG C |
| 1,537.718 | 72 | Weighted Average |
| 1,322.966 | | 86.03% Pervious Area |
| 214.752 | | 13.97% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 42.9 | 100 | 0.0140 | 0.04 | | **Sheet Flow,**<br>Woods: Dense underbrush n= 0.800 P2= 3.24" |
| 33.8 | 600 | 0.0140 | 0.30 | | **Shallow Concentrated Flow,**<br>Forest w/Heavy Litter Kv= 2.5 fps |
| 27.4 | 700 | 0.0290 | 0.43 | | **Shallow Concentrated Flow,**<br>Forest w/Heavy Litter Kv= 2.5 fps |
| 48.5 | 1,800 | 0.0611 | 0.62 | | **Shallow Concentrated Flow,**<br>Forest w/Heavy Litter Kv= 2.5 fps |
| 23.6 | 500 | 0.0200 | 0.35 | | **Shallow Concentrated Flow,**<br>Forest w/Heavy Litter Kv= 2.5 fps |
| 93.3 | 1,400 | 0.0100 | 0.25 | | **Shallow Concentrated Flow,**<br>Forest w/Heavy Litter Kv= 2.5 fps |
| 2.6 | 2,200 | | 13.90 | | **Lake or Reservoir,**<br>Mean Depth= 6.00' |
| 2.0 | 800 | 0.0210 | 6.74 | 67.36 | **Channel Flow,**<br>Area= 10.0 sf Perim= 11.0' r= 0.91' n= 0.030 |
| 2.7 | 3,200 | | 19.66 | | **Lake or Reservoir,**<br>Mean Depth= 12.00' |
| 276.8 | 11,300 | Total | | | |

## Subcatchment EDA-01: Subcat EDA-01



## Hydrograph for Subcatchment EDA-01: Subcat EDA-01

| Time (hours) | Precip. (inches) | Excess (inches) | Runoff (cfs) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 |
| 1.00 | 0.09 | 0.00 | 0.00 |
| 2.00 | 0.18 | 0.00 | 0.00 |
| 3.00 | 0.27 | 0.00 | 0.00 |
| 4.00 | 0.38 | 0.00 | 0.00 |
| 5.00 | 0.50 | 0.00 | 0.00 |
| 6.00 | 0.63 | 0.00 | 0.00 |
| 7.00 | 0.80 | 0.00 | 0.00 |
| 8.00 | 1.00 | 0.01 | 0.08 |
| 9.00 | 1.28 | 0.06 | 1.66 |
| 10.00 | 1.66 | 0.16 | 9.52 |
| 11.00 | 2.20 | 0.38 | 31.94 |
| 12.00 | 4.39 | 1.74 | 82.25 |
| 13.00 | 6.59 | 3.48 | 274.98 |
| 14.00 | 7.13 | 3.94 | 763.85 |
| 15.00 | 7.51 | 4.27 | **1,246.01** |
| 16.00 | 7.79 | 4.51 | **1,320.22** |
| 17.00 | 7.99 | 4.69 | 1,109.36 |
| 18.00 | 8.16 | 4.83 | 820.46 |
| 19.00 | 8.29 | 4.95 | 618.58 |
| 20.00 | 8.41 | 5.06 | 467.50 |
| 21.00 | 8.52 | 5.15 | 358.77 |
| 22.00 | 8.62 | 5.24 | 283.18 |
| 23.00 | 8.71 | 5.32 | 231.50 |
| 24.00 | **8.79** | **5.39** | 194.37 |
| 25.00 | 8.79 | 5.39 | 166.72 |
| 26.00 | 8.79 | 5.39 | 138.00 |
| 27.00 | 8.79 | 5.39 | 100.43 |
| 28.00 | 8.79 | 5.39 | 63.78 |
| 29.00 | 8.79 | 5.39 | 37.21 |
| 30.00 | 8.79 | 5.39 | 21.55 |
| 31.00 | 8.79 | 5.39 | 12.52 |
| 32.00 | 8.79 | 5.39 | 7.18 |
| 33.00 | 8.79 | 5.39 | 4.13 |
| 34.00 | 8.79 | 5.39 | 2.34 |
| 35.00 | 8.79 | 5.39 | 1.29 |
| 36.00 | 8.79 | 5.39 | 0.68 |
| 37.00 | 8.79 | 5.39 | 0.33 |
| 38.00 | 8.79 | 5.39 | 0.12 |
| 39.00 | 8.79 | 5.39 | 0.02 |
| 40.00 | 8.79 | 5.39 | 0.00 |
| 41.00 | 8.79 | 5.39 | 0.00 |
| 42.00 | 8.79 | 5.39 | 0.00 |
| 43.00 | 8.79 | 5.39 | 0.00 |
| 44.00 | 8.79 | 5.39 | 0.00 |
| 45.00 | 8.79 | 5.39 | 0.00 |
| 46.00 | 8.79 | 5.39 | 0.00 |
| 47.00 | 8.79 | 5.39 | 0.00 |
| 48.00 | 8.79 | 5.39 | 0.00 |
| 49.00 | 8.79 | 5.39 | 0.00 |
| 50.00 | 8.79 | 5.39 | 0.00 |

| Time (hours) | Precip. (inches) | Excess (inches) | Runoff (cfs) |
|---|---|---|---|
| 51.00 | 8.79 | 5.39 | 0.00 |
| 52.00 | 8.79 | 5.39 | 0.00 |
| 53.00 | 8.79 | 5.39 | 0.00 |
| 54.00 | 8.79 | 5.39 | 0.00 |
| 55.00 | 8.79 | 5.39 | 0.00 |
| 56.00 | 8.79 | 5.39 | 0.00 |
| 57.00 | 8.79 | 5.39 | 0.00 |
| 58.00 | 8.79 | 5.39 | 0.00 |
| 59.00 | 8.79 | 5.39 | 0.00 |
| 60.00 | 8.79 | 5.39 | 0.00 |
| 61.00 | 8.79 | 5.39 | 0.00 |
| 62.00 | 8.79 | 5.39 | 0.00 |
| 63.00 | 8.79 | 5.39 | 0.00 |
| 64.00 | 8.79 | 5.39 | 0.00 |
| 65.00 | 8.79 | 5.39 | 0.00 |
| 66.00 | 8.79 | 5.39 | 0.00 |
| 67.00 | 8.79 | 5.39 | 0.00 |
| 68.00 | 8.79 | 5.39 | 0.00 |
| 69.00 | 8.79 | 5.39 | 0.00 |
| 70.00 | 8.79 | 5.39 | 0.00 |
| 71.00 | 8.79 | 5.39 | 0.00 |
| 72.00 | 8.79 | 5.39 | 0.00 |

## Summary for Pond 2P: Ramshorn Pond Dam (Stop Logs In / Gate Closed)

Inflow Area = 1,537.718 ac, 13.97% Impervious, Inflow Depth = 5.39" for 100-yr event
Inflow = 1,343.68 cfs @ 15.69 hrs, Volume= 691.216 af
Outflow = 314.39 cfs @ 21.53 hrs, Volume= 613.218 af, Atten= 77%, Lag= 350.5 min
Primary = 314.39 cfs @ 21.53 hrs, Volume= 613.218 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs / 2
Starting Elev= 630.70' Surf.Area= 131.000 ac Storage= 91.700 af
Peak Elev= 634.14' @ 21.53 hrs Surf.Area= 134.967 ac Storage= 548.225 af (456.525 af above start)

Plug-Flow detention time= 1,133.4 min calculated for 521.518 af (75% of inflow)
Center-of-Mass det. time= 877.9 min ( 1,945.5 - 1,067.6 )

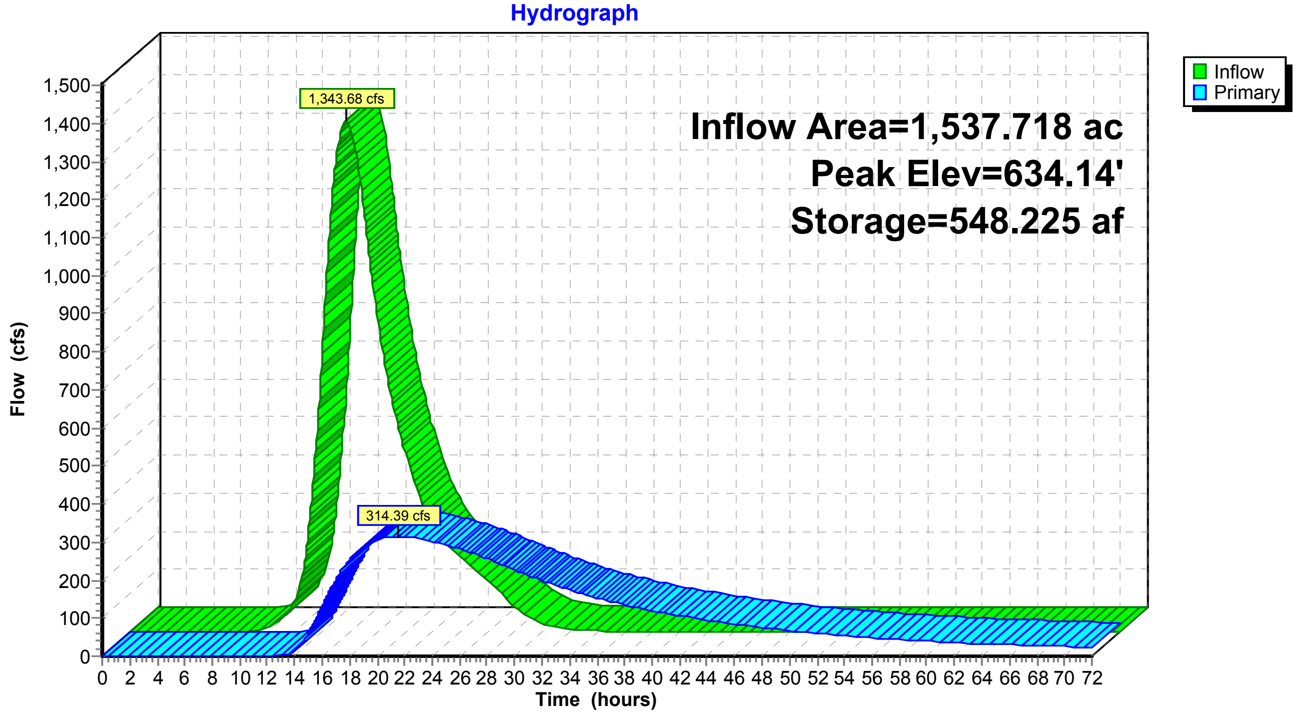
| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 630.00' | 1,876.500 af | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (acres) | Inc.Store (acre-feet) | Cum.Store (acre-feet) |
|---|---|---|---|
| 630.00 | 131.000 | 0.000 | 0.000 |
| 631.50 | 131.000 | 196.500 | 196.500 |
| 643.50 | 149.000 | 1,680.000 | 1,876.500 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 630.75' | **108.0" W x 67.2" H Box Culvert X 2.00 w/ 18.0" inside fill**<br>L= 28.0' Box, headwall w/3 square edges, Ke= 0.500<br>Inlet / Outlet Invert= 629.25' / 628.95' S= 0.0107 '/' Cc= 0.900<br>n= 0.013, Flow Area= 36.90 sf |
| #2 | Primary | 635.50' | **100.0' long (Profile 1) Broad-Crested Rectangular Weir**<br>Head (feet) 0.49 0.98 1.48<br>Coef. (English) 2.92 3.37 3.59 |

**Primary OutFlow** Max=314.35 cfs @ 21.53 hrs HW=634.14' (Free Discharge)
├─**1=Culvert** (Barrel Controls 314.35 cfs @ 6.86 fps)
└─**2=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

## Pond 2P: Ramshorn Pond Dam (Stop Logs In / Gate Closed)



### Hydrograph for Pond 2P: Ramshorn Pond Dam (Stop Logs In / Gate Closed)

| Time (hours) | Inflow (cfs) | Storage (acre-feet) | Elevation (feet) | Primary (cfs) |
|---|---|---|---|---|
| 0.00 | 0.00 | 91.700 | 630.70 | 0.00 |
| 2.50 | 0.00 | 91.700 | 630.70 | 0.00 |
| 5.00 | 0.00 | 91.700 | 630.70 | 0.00 |
| 7.50 | 0.01 | 91.700 | 630.70 | 0.00 |
| 10.00 | 9.52 | 92.143 | 630.70 | 0.00 |
| 12.50 | 141.75 | 102.578 | 630.78 | 0.47 |
| 15.00 | **1,246.01** | 233.747 | 631.78 | 60.80 |
| 17.50 | **950.11** | 456.047 | 633.46 | 230.27 |
| 20.00 | 467.50 | **539.011** | **634.08** | **305.63** |
| 22.50 | 254.86 | **545.781** | **634.13** | **312.06** |
| 25.00 | 166.72 | 525.517 | 633.98 | 292.97 |
| 27.50 | 81.19 | 494.091 | 633.74 | 264.06 |
| 30.00 | 21.55 | 452.727 | 633.43 | 227.38 |
| 32.50 | 5.46 | 411.843 | 633.13 | 192.73 |
| 35.00 | 1.29 | 375.736 | 632.86 | 163.55 |
| 37.50 | 0.21 | 344.637 | 632.62 | 139.56 |
| 40.00 | 0.00 | 317.922 | 632.42 | 119.79 |
| 42.50 | 0.00 | 294.907 | 632.25 | 103.51 |
| 45.00 | 0.00 | 274.978 | 632.10 | 89.74 |
| 47.50 | 0.00 | 257.710 | 631.97 | 77.56 |
| 50.00 | 0.00 | 242.817 | 631.85 | 66.99 |
| 52.50 | 0.00 | 229.907 | 631.75 | 58.18 |
| 55.00 | 0.00 | 218.646 | 631.67 | 50.99 |
| 57.50 | 0.00 | 208.771 | 631.59 | 44.83 |
| 60.00 | 0.00 | 200.056 | 631.53 | 39.64 |
| 62.50 | 0.00 | 192.340 | 631.47 | 35.22 |
| 65.00 | 0.00 | 185.454 | 631.42 | 31.50 |
| 67.50 | 0.00 | 179.296 | 631.37 | 28.17 |
| 70.00 | 0.00 | 173.777 | 631.33 | 25.37 |

## Stage-Discharge for Pond 2P: Ramshorn Pond Dam (Stop Logs In / Gate Closed)

| Elevation (feet) | Primary (cfs) | Elevation (feet) | Primary (cfs) |
|---|---|---|---|
| 630.00 | 0.00 | 637.65 | 1,908.29 |
| 630.15 | 0.00 | 637.80 | 2,041.06 |
| 630.30 | 0.00 | 637.95 | 2,177.63 |
| 630.45 | 0.00 | 638.10 | 2,317.88 |
| 630.60 | 0.00 | 638.25 | 2,461.70 |
| 630.75 | 0.00 | 638.40 | 2,609.01 |
| 630.90 | 3.36 | 638.55 | 2,759.71 |
| 631.05 | 9.49 | 638.70 | 2,913.72 |
| 631.20 | 17.44 | 638.85 | 3,070.97 |
| 631.35 | 26.85 | 639.00 | 3,231.38 |
| 631.50 | 37.53 | 639.15 | 3,394.89 |
| 631.65 | 49.33 | 639.30 | 3,561.44 |
| 631.80 | 62.17 | 639.45 | 3,730.97 |
| 631.95 | 75.95 | 639.60 | 3,903.43 |
| 632.10 | 90.13 | 639.75 | 4,078.75 |
| 632.25 | 103.64 | 639.90 | 4,256.90 |
| 632.40 | 117.67 | 640.05 | 4,437.83 |
| 632.55 | 132.21 | 640.20 | 4,621.49 |
| 632.70 | 147.23 | 640.35 | 4,807.83 |
| 632.85 | 162.72 | 640.50 | 4,996.83 |
| 633.00 | 178.67 | 640.65 | 5,188.44 |
| 633.15 | 195.06 | 640.80 | 5,382.63 |
| 633.30 | 211.89 | 640.95 | 5,579.35 |
| 633.45 | 229.15 | 641.10 | 5,778.58 |
| 633.60 | 246.82 | 641.25 | 5,980.28 |
| 633.75 | 264.89 | 641.40 | 6,184.43 |
| 633.90 | 283.37 | 641.55 | 6,390.99 |
| 634.05 | 302.23 | 641.70 | 6,599.93 |
| 634.20 | 321.47 | 641.85 | 6,811.22 |
| 634.35 | 341.09 | 642.00 | 7,024.85 |
| 634.50 | 361.07 | 642.15 | 7,240.77 |
| 634.65 | 381.42 | 642.30 | 7,458.97 |
| 634.80 | 402.12 | 642.45 | 7,679.43 |
| 634.95 | 423.16 | 642.60 | 7,902.12 |
| 635.10 | 444.56 | 642.75 | 8,127.01 |
| 635.25 | 466.29 | 642.90 | 8,354.08 |
| 635.40 | 488.35 | 643.05 | 8,583.32 |
| 635.55 | 514.01 | 643.20 | 8,814.71 |
| 635.70 | 559.57 | 643.35 | 9,048.21 |
| 635.85 | 616.95 | 643.50 | **9,283.82** |
| 636.00 | 683.40 | | |
| 636.15 | 764.22 | | |
| 636.30 | 851.08 | | |
| 636.45 | 957.36 | | |
| 636.60 | 1,067.84 | | |
| 636.75 | 1,184.71 | | |
| 636.90 | 1,300.49 | | |
| 637.05 | 1,417.90 | | |
| 637.20 | 1,534.07 | | |
| 637.35 | 1,654.64 | | |
| 637.50 | 1,779.43 | | |

## Stage-Area-Storage for Pond 2P: Ramshorn Pond Dam (Stop Logs In / Gate Closed)

| Elevation (feet) | Surface (acres) | Storage (acre-feet) | Elevation (feet) | Surface (acres) | Storage (acre-feet) |
|---|---|---|---|---|---|
| 630.00 | 131.000 | 0.000 | 637.65 | 140.225 | 1,030.517 |
| 630.15 | 131.000 | 19.650 | 637.80 | 140.450 | 1,051.567 |
| 630.30 | 131.000 | 39.300 | 637.95 | 140.675 | 1,072.652 |
| 630.45 | 131.000 | 58.950 | 638.10 | 140.900 | 1,093.770 |
| 630.60 | 131.000 | 78.600 | 638.25 | 141.125 | 1,114.922 |
| 630.75 | 131.000 | 98.250 | 638.40 | 141.350 | 1,136.107 |
| 630.90 | 131.000 | 117.900 | 638.55 | 141.575 | 1,157.327 |
| 631.05 | 131.000 | 137.550 | 638.70 | 141.800 | 1,178.580 |
| 631.20 | 131.000 | 157.200 | 638.85 | 142.025 | 1,199.867 |
| 631.35 | 131.000 | 176.850 | 639.00 | 142.250 | 1,221.187 |
| 631.50 | 131.000 | 196.500 | 639.15 | 142.475 | 1,242.542 |
| 631.65 | 131.225 | 216.167 | 639.30 | 142.700 | 1,263.930 |
| 631.80 | 131.450 | 235.867 | 639.45 | 142.925 | 1,285.352 |
| 631.95 | 131.675 | 255.602 | 639.60 | 143.150 | 1,306.808 |
| 632.10 | 131.900 | 275.370 | 639.75 | 143.375 | 1,328.297 |
| 632.25 | 132.125 | 295.172 | 639.90 | 143.600 | 1,349.820 |
| 632.40 | 132.350 | 315.007 | 640.05 | 143.825 | 1,371.377 |
| 632.55 | 132.575 | 334.877 | 640.20 | 144.050 | 1,392.968 |
| 632.70 | 132.800 | 354.780 | 640.35 | 144.275 | 1,414.592 |
| 632.85 | 133.025 | 374.717 | 640.50 | 144.500 | 1,436.250 |
| 633.00 | 133.250 | 394.687 | 640.65 | 144.725 | 1,457.942 |
| 633.15 | 133.475 | 414.692 | 640.80 | 144.950 | 1,479.667 |
| 633.30 | 133.700 | 434.730 | 640.95 | 145.175 | 1,501.427 |
| 633.45 | 133.925 | 454.802 | 641.10 | 145.400 | 1,523.220 |
| 633.60 | 134.150 | 474.908 | 641.25 | 145.625 | 1,545.047 |
| 633.75 | 134.375 | 495.047 | 641.40 | 145.850 | 1,566.907 |
| 633.90 | 134.600 | 515.220 | 641.55 | 146.075 | 1,588.802 |
| 634.05 | 134.825 | 535.427 | 641.70 | 146.300 | 1,610.730 |
| 634.20 | 135.050 | 555.668 | 641.85 | 146.525 | 1,632.692 |
| 634.35 | 135.275 | 575.942 | 642.00 | 146.750 | 1,654.687 |
| 634.50 | 135.500 | 596.250 | 642.15 | 146.975 | 1,676.717 |
| 634.65 | 135.725 | 616.592 | 642.30 | 147.200 | 1,698.780 |
| 634.80 | 135.950 | 636.967 | 642.45 | 147.425 | 1,720.877 |
| 634.95 | 136.175 | 657.377 | 642.60 | 147.650 | 1,743.008 |
| 635.10 | 136.400 | 677.820 | 642.75 | 147.875 | 1,765.172 |
| 635.25 | 136.625 | 698.297 | 642.90 | 148.100 | 1,787.370 |
| 635.40 | 136.850 | 718.807 | 643.05 | 148.325 | 1,809.602 |
| 635.55 | 137.075 | 739.352 | 643.20 | 148.550 | 1,831.868 |
| 635.70 | 137.300 | 759.930 | 643.35 | 148.775 | 1,854.167 |
| 635.85 | 137.525 | 780.542 | 643.50 | **149.000** | **1,876.500** |
| 636.00 | 137.750 | 801.187 | | | |
| 636.15 | 137.975 | 821.867 | | | |
| 636.30 | 138.200 | 842.580 | | | |
| 636.45 | 138.425 | 863.327 | | | |
| 636.60 | 138.650 | 884.108 | | | |
| 636.75 | 138.875 | 904.922 | | | |
| 636.90 | 139.100 | 925.770 | | | |
| 637.05 | 139.325 | 946.652 | | | |
| 637.20 | 139.550 | 967.568 | | | |
| 637.35 | 139.775 | 988.517 | | | |
| 637.50 | 140.000 | 1,009.500 | | | |

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment EDA-01: Subcat EDA-01** Runoff Area=1,537.718 ac 13.97% Impervious Runoff Depth=9.04"
Flow Length=11,300' Tc=276.8 min CN=72 Runoff=2,251.52 cfs 1,158.008 af

**Pond 2P: Ramshorn Pond Dam** Peak Elev=636.05' Storage=807.858 af Inflow=2,251.52 cfs 1,158.008 af
Outflow=709.22 cfs 1,066.058 af

**Total Runoff Area = 1,537.718 ac Runoff Volume = 1,158.008 af Average Runoff Depth = 9.04"**
**86.03% Pervious = 1,322.966 ac 13.97% Impervious = 214.752 ac**

## Summary for Subcatchment EDA-01: Subcat EDA-01

Runoff = 2,251.52 cfs @ 15.68 hrs, Volume= 1,158.008 af, Depth= 9.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr Half PMF Rainfall=12.75"

| Area (ac) | CN | Description |
|---|---|---|
| 8.425 | 77 | Woods, Good, HSG D |
| 0.273 | 78 | Meadow, non-grazed, HSG D |
| 0.000 | 84 | 1 acre lots, 20% imp, HSG D |
| 1.355 | 70 | Woods, Good, HSG C |
| 0.698 | 65 | Brush, Good, HSG C |
| 3.065 | 70 | Woods, Good, HSG C |
| 0.022 | 65 | Brush, Good, HSG C |
| 0.148 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.025 | 98 | Paved parking, HSG C |
| 0.014 | 98 | Water Surface, HSG C |
| 0.323 | 98 | Water Surface, HSG C |
| 1.450 | 98 | Water Surface, HSG C |
| 10.748 | 70 | Woods, Good, HSG C |
| 0.498 | 55 | Woods, Good, HSG B |
| 0.476 | 98 | Paved parking, HSG B |
| 2.799 | 55 | Woods, Good, HSG B |
| 0.327 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.238 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.277 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.578 | 68 | 1 acre lots, 20% imp, HSG B |
| 3.500 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 4.044 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.012 | 98 | Paved parking, HSG B |
| 0.301 | 98 | Water Surface, HSG B |
| 12.253 | 77 | Woods, Good, HSG D |
| 0.109 | 98 | Paved parking, HSG D |
| 0.157 | 77 | Woods, Good, HSG D |
| 0.873 | 78 | Meadow, non-grazed, HSG D |
| 0.007 | 84 | 1 acre lots, 20% imp, HSG D |
| 0.062 | 92 | 1/8 acre lots, 65% imp, HSG D |
| 0.312 | 98 | Water Surface, HSG D |
| 5.188 | 77 | Woods, Good, HSG D |
| 0.251 | 73 | Brush, Good, HSG D |
| 13.278 | 98 | Water Surface, HSG D |
| 1.976 | 71 | Meadow, non-grazed, HSG C |
| 0.483 | 71 | Meadow, non-grazed, HSG C |
| 3.826 | 98 | Water Surface, HSG D |
| 1.244 | 98 | Water Surface, HSG D |
| 0.025 | 98 | Water Surface, HSG D |
| 0.013 | 86 | 1/3 acre lots, 30% imp, HSG D |
| 0.268 | 85 | 1/2 acre lots, 25% imp, HSG D |
| 0.247 | 82 | 2 acre lots, 12% imp, HSG D |
| 0.145 | 98 | Paved parking, HSG D |
| 15.857 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 5.976 | 77 | Woods, Good, HSG D |
| 1.296 | 73 | Brush, Good, HSG D |
| 77.304 | 70 | Woods, Good, HSG C |
| 13.578 | 77 | Woods, Good, HSG D |
| 0.886 | 65 | Brush, Good, HSG C |

| | | |
|---|---|---|
| 7.779 | 65 | Brush, Good, HSG C |
| 7.953 | 70 | Woods, Good, HSG C |
| 1.881 | 65 | Brush, Good, HSG C |
| 5.663 | 65 | Brush, Good, HSG C |
| 10.415 | 70 | Woods, Good, HSG C |
| 3.987 | 70 | Woods, Good, HSG C |
| 1.795 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.009 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.004 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.116 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.359 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.036 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.330 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.037 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.011 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.173 | 70 | Woods, Good, HSG C |
| 28.188 | 70 | Woods, Good, HSG C |
| 0.045 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 0.212 | 70 | Woods, Good, HSG C |
| 0.102 | 70 | Woods, Good, HSG C |
| 0.054 | 70 | Woods, Good, HSG C |
| 0.044 | 70 | Woods, Good, HSG C |
| 0.006 | 70 | Woods, Good, HSG C |
| 0.817 | 70 | Woods, Good, HSG C |
| 0.095 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.043 | 70 | Woods, Good, HSG C |
| 0.411 | 70 | Woods, Good, HSG C |
| 0.000 | 70 | Woods, Good, HSG C |
| 0.299 | 98 | Paved parking, HSG C |
| 3.242 | 98 | Paved parking, HSG C |
| 67.114 | 70 | Woods, Good, HSG C |
| 0.145 | 70 | Woods, Good, HSG C |
| 171.240 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.241 | 70 | Woods, Good, HSG C |
| 0.002 | 70 | Woods, Good, HSG C |
| 0.009 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 0.010 | 70 | Woods, Good, HSG C |
| 0.031 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.000 | 70 | Woods, Good, HSG C |
| 0.105 | 70 | Woods, Good, HSG C |
| 16.574 | 55 | Woods, Good, HSG B |
| 0.219 | 98 | Water Surface, HSG C |
| 0.005 | 98 | Water Surface, HSG C |

| | | |
|---|---|---|
| 0.579 | 98 | Water Surface, HSG C |
| 0.046 | 98 | Water Surface, HSG C |
| 11.283 | 70 | Woods, Good, HSG C |
| 87.275 | 70 | Woods, Good, HSG C |
| 0.149 | 73 | Brush, Good, HSG D |
| 31.112 | 77 | Woods, Good, HSG D |
| 2.536 | 98 | Water Surface, HSG D |
| 0.040 | 98 | Paved parking, HSG D |
| 0.375 | 84 | 1 acre lots, 20% imp, HSG D |
| 8.249 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 35.868 | 77 | Woods, Good, HSG D |
| 0.006 | 98 | Paved parking, HSG B |
| 0.000 | 98 | Paved parking, HSG B |
| 0.163 | 98 | Paved parking, HSG C |
| 0.006 | 98 | Paved parking, HSG C |
| 0.457 | 98 | Paved parking, HSG C |
| 0.001 | 98 | Paved parking, HSG C |
| 0.837 | 98 | Paved parking, HSG B |
| 0.179 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.966 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.327 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.000 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.003 | 68 | 1 acre lots, 20% imp, HSG B |
| 4.100 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.074 | 58 | Meadow, non-grazed, HSG B |
| 0.044 | 70 | Woods, Good, HSG C |
| 1.189 | 70 | Woods, Good, HSG C |
| 1.933 | 55 | Woods, Good, HSG B |
| 0.000 | 55 | Woods, Good, HSG B |
| 0.101 | 55 | Woods, Good, HSG B |
| 0.016 | 70 | Woods, Good, HSG C |
| 4.196 | 70 | Woods, Good, HSG C |
| 0.006 | 70 | Woods, Good, HSG C |
| 0.256 | 55 | Woods, Good, HSG B |
| 0.454 | 55 | Woods, Good, HSG B |
| 0.394 | 98 | Water Surface, HSG B |
| 0.175 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 1.165 | 75 | 1/4 acre lots, 38% imp, HSG B |
| 0.669 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.058 | 58 | Meadow, non-grazed, HSG B |
| 0.622 | 58 | Meadow, non-grazed, HSG B |
| 0.023 | 70 | Woods, Good, HSG C |
| 0.010 | 70 | Woods, Good, HSG C |
| 0.055 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 14.294 | 70 | Woods, Good, HSG C |
| 0.031 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 23.662 | 55 | Woods, Good, HSG B |
| 6.009 | 30 | Woods, Good, HSG A |

| | | |
|---|---|---|
| 0.098 | 98 | Paved parking, HSG B |
| 0.046 | 98 | Paved parking, HSG C |
| 0.112 | 98 | Paved parking, HSG C |
| 0.133 | 98 | Paved parking, HSG B |
| 0.022 | 98 | Paved parking, HSG C |
| 1.187 | 98 | Paved parking, HSG C |
| 0.374 | 98 | Paved parking, HSG B |
| 0.037 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.298 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.849 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.563 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.302 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.035 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.047 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.665 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.016 | 74 | Pasture/grassland/range, Good, HSG C |
| 3.444 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.011 | 61 | Pasture/grassland/range, Good, HSG B |
| 0.017 | 70 | Woods, Good, HSG C |
| 7.092 | 55 | Woods, Good, HSG B |
| 0.006 | 55 | Woods, Good, HSG B |
| 2.752 | 70 | Woods, Good, HSG C |
| 0.025 | 70 | Woods, Good, HSG C |
| 1.116 | 55 | Woods, Good, HSG B |
| 1.024 | 55 | Woods, Good, HSG B |
| 0.205 | 98 | Paved parking, HSG B |
| 0.706 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.190 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.384 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.249 | 61 | Pasture/grassland/range, Good, HSG B |
| 0.454 | 58 | Meadow, non-grazed, HSG B |
| 0.947 | 58 | Meadow, non-grazed, HSG B |
| 1.163 | 58 | Meadow, non-grazed, HSG B |
| 0.023 | 55 | Woods, Good, HSG B |
| 0.338 | 55 | Woods, Good, HSG B |
| 0.019 | 55 | Woods, Good, HSG B |
| 0.433 | 72 | 1/3 acre lots, 30% imp, HSG B |
| 0.697 | 68 | 1 acre lots, 20% imp, HSG B |
| 2.388 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.308 | 58 | Meadow, non-grazed, HSG B |
| 0.632 | 48 | Brush, Good, HSG B |
| 1.693 | 70 | Woods, Good, HSG C |
| 3.529 | 70 | Woods, Good, HSG C |
| 0.127 | 70 | Woods, Good, HSG C |
| 15.057 | 55 | Woods, Good, HSG B |
| 0.175 | 98 | Water Surface, HSG B |
| 0.037 | 98 | Paved parking, HSG C |
| 0.464 | 98 | Paved parking, HSG C |
| 1.392 | 98 | Paved parking, HSG B |
| 1.075 | 96 | Gravel surface, HSG B |
| 0.808 | 92 | Urban commercial, 85% imp, HSG B |

| | | |
|---|---|---|
| 0.137 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.614 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.821 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.005 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.048 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 3.340 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.622 | 68 | 1 acre lots, 20% imp, HSG B |
| 15.443 | 65 | Brush, Good, HSG C |
| 0.078 | 65 | Brush, Good, HSG C |
| 7.163 | 48 | Brush, Good, HSG B |
| 0.977 | 48 | Brush, Good, HSG B |
| 0.037 | 70 | Woods, Good, HSG C |
| 0.026 | 70 | Woods, Good, HSG C |
| 0.037 | 70 | Woods, Good, HSG C |
| 0.097 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 0.176 | 70 | Woods, Good, HSG C |
| 0.050 | 70 | Woods, Good, HSG C |
| 0.087 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 20.504 | 55 | Woods, Good, HSG B |
| 1.932 | 55 | Woods, Good, HSG B |
| 166.461 | 70 | Woods, Good, HSG C |
| 86.903 | 55 | Woods, Good, HSG B |
| 0.137 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.242 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.315 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.059 | 58 | Meadow, non-grazed, HSG B |
| 9.307 | 55 | Woods, Good, HSG B |
| 0.101 | 70 | Woods, Good, HSG C |
| 0.818 | 70 | Woods, Good, HSG C |
| 0.456 | 70 | Woods, Good, HSG C |
| 10.414 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 0.039 | 70 | Woods, Good, HSG C |
| 3.007 | 70 | Woods, Good, HSG C |
| 1.704 | 70 | Woods, Good, HSG C |
| 3.962 | 70 | Woods, Good, HSG C |
| 0.042 | 70 | Woods, Good, HSG C |
| 6.320 | 70 | Woods, Good, HSG C |
| 0.153 | 70 | Woods, Good, HSG C |
| 0.148 | 70 | Woods, Good, HSG C |
| 0.038 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.038 | 65 | Brush, Good, HSG C |
| 1.122 | 71 | Meadow, non-grazed, HSG C |

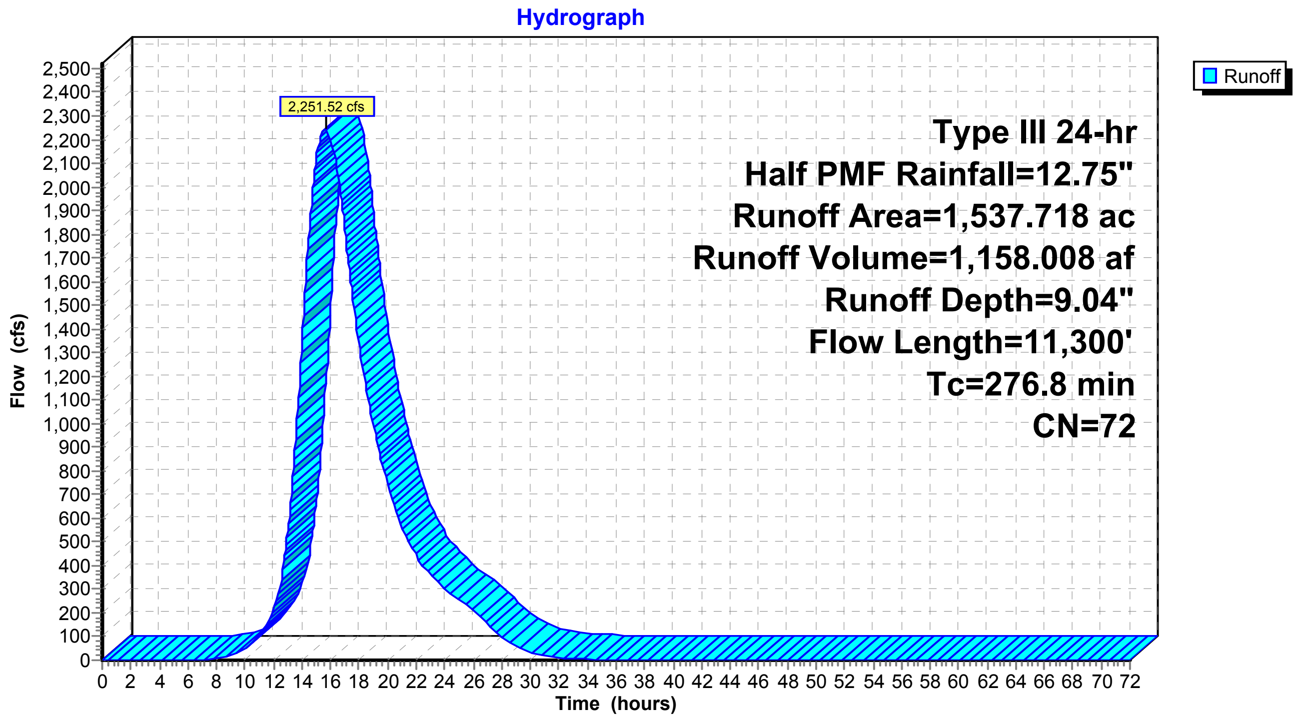
| | | |
|---|---|---|
| 0.109 | 71 | Meadow, non-grazed, HSG C |
| 1.365 | 71 | Meadow, non-grazed, HSG C |
| 10.877 | 71 | Meadow, non-grazed, HSG C |
| 4.101 | 71 | Meadow, non-grazed, HSG C |
| 0.504 | 71 | Meadow, non-grazed, HSG C |
| 0.233 | 71 | Meadow, non-grazed, HSG C |
| 0.020 | 71 | Meadow, non-grazed, HSG C |
| 0.341 | 71 | Meadow, non-grazed, HSG C |
| 0.657 | 71 | Meadow, non-grazed, HSG C |
| 0.206 | 71 | Meadow, non-grazed, HSG C |
| 0.902 | 71 | Meadow, non-grazed, HSG C |
| 2.991 | 71 | Meadow, non-grazed, HSG C |
| 0.144 | 71 | Meadow, non-grazed, HSG C |
| 0.431 | 71 | Meadow, non-grazed, HSG C |
| 2.758 | 71 | Meadow, non-grazed, HSG C |
| 12.700 | 71 | Meadow, non-grazed, HSG C |
| 0.842 | 71 | Meadow, non-grazed, HSG C |
| 0.657 | 71 | Meadow, non-grazed, HSG C |
| 0.366 | 71 | Meadow, non-grazed, HSG C |
| 7.832 | 71 | Meadow, non-grazed, HSG C |
| 4.144 | 71 | Meadow, non-grazed, HSG C |
| 7.707 | 71 | Meadow, non-grazed, HSG C |
| 2.530 | 71 | Meadow, non-grazed, HSG C |
| 11.385 | 71 | Meadow, non-grazed, HSG C |
| 0.630 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.640 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.499 | 74 | Pasture/grassland/range, Good, HSG C |
| 13.839 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.627 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.343 | 74 | Pasture/grassland/range, Good, HSG C |
| 5.380 | 74 | Pasture/grassland/range, Good, HSG C |
| 5.277 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.973 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.397 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.305 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.393 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.514 | 77 | 2 acre lots, 12% imp, HSG C |
| 2.524 | 77 | 2 acre lots, 12% imp, HSG C |
| 2.394 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.189 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.468 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.871 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.100 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.354 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.571 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.505 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.717 | 77 | 2 acre lots, 12% imp, HSG C |
| 3.826 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.915 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.534 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.770 | 77 | 2 acre lots, 12% imp, HSG C |

| | | |
|---|---|---|
| 3.858 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.574 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.281 | 77 | 2 acre lots, 12% imp, HSG C |
| 7.505 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.572 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.975 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.064 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.008 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.728 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.158 | 79 | 1 acre lots, 20% imp, HSG C |
| 4.048 | 79 | 1 acre lots, 20% imp, HSG C |
| 5.884 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.343 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.603 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.637 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.343 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.018 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.013 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.271 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.676 | 79 | 1 acre lots, 20% imp, HSG C |
| 4.173 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.718 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.650 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.391 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.502 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.951 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.101 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.729 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.213 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.913 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.682 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.329 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.195 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.151 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.769 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.778 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.568 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.556 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.929 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.373 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.959 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.846 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.247 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 2.760 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.368 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 3.192 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.198 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.532 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.696 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 1.923 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 4.241 | 80 | 1/2 acre lots, 25% imp, HSG C |

| | | |
|---|---|---|
| 0.416 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.100 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 2.333 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 5.698 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.035 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.234 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.273 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.768 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.140 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.236 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.149 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.114 | 90 | 1/8 acre lots, 65% imp, HSG C |
| 0.123 | 90 | 1/8 acre lots, 65% imp, HSG C |
| 0.632 | 91 | Urban industrial, 72% imp, HSG C |
| 0.458 | 94 | Urban commercial, 85% imp, HSG C |
| 4.350 | 96 | Gravel surface, HSG C |
| 0.600 | 96 | Gravel surface, HSG C |
| 0.084 | 98 | Paved parking, HSG C |
| 0.838 | 98 | Paved parking, HSG C |
| 0.888 | 98 | Paved parking, HSG C |
| 1.068 | 98 | Paved parking, HSG C |
| 2.929 | 98 | Paved parking, HSG C |
| 0.085 | 98 | Paved parking, HSG C |
| 0.041 | 98 | Paved parking, HSG C |
| 0.595 | 98 | Paved parking, HSG C |
| 0.083 | 98 | Paved parking, HSG C |
| 0.290 | 98 | Paved parking, HSG C |
| 0.279 | 98 | Paved parking, HSG C |
| 127.500 | 98 | Water Surface, HSG C |
| 14.980 | 98 | Water Surface, HSG C |
| 0.019 | 98 | Water Surface, HSG C |
| 0.033 | 98 | Water Surface, HSG C |
| 1,537.718 | 72 | Weighted Average |
| 1,322.966 | | 86.03% Pervious Area |
| 214.752 | | 13.97% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 42.9 | 100 | 0.0140 | 0.04 | | **Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.24" |
| 33.8 | 600 | 0.0140 | 0.30 | | **Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps |
| 27.4 | 700 | 0.0290 | 0.43 | | **Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps |
| 48.5 | 1,800 | 0.0611 | 0.62 | | **Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps |
| 23.6 | 500 | 0.0200 | 0.35 | | **Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps |
| 93.3 | 1,400 | 0.0100 | 0.25 | | **Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps |
| 2.6 | 2,200 | | 13.90 | | **Lake or Reservoir,** Mean Depth= 6.00' |
| 2.0 | 800 | 0.0210 | 6.74 | 67.36 | **Channel Flow,** Area= 10.0 sf Perim= 11.0' r= 0.91' n= 0.030 |
| 2.7 | 3,200 | | 19.66 | | **Lake or Reservoir,** Mean Depth= 12.00' |
| 276.8 | 11,300 | Total | | | |

## Subcatchment EDA-01: Subcat EDA-01



## Hydrograph for Subcatchment EDA-01: Subcat EDA-01

| Time (hours) | Precip. (inches) | Excess (inches) | Runoff (cfs) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 |
| 1.00 | 0.13 | 0.00 | 0.00 |
| 2.00 | 0.26 | 0.00 | 0.00 |
| 3.00 | 0.39 | 0.00 | 0.00 |
| 4.00 | 0.55 | 0.00 | 0.00 |
| 5.00 | 0.72 | 0.00 | 0.00 |
| 6.00 | 0.92 | 0.00 | 0.01 |
| 7.00 | 1.15 | 0.03 | 0.66 |
| 8.00 | 1.45 | 0.10 | 4.96 |
| 9.00 | 1.86 | 0.23 | 18.99 |
| 10.00 | 2.41 | 0.48 | 49.84 |
| 11.00 | 3.19 | 0.92 | 107.54 |
| 12.00 | 6.37 | 3.30 | 211.50 |
| 13.00 | 9.56 | 6.09 | 548.11 |
| 14.00 | 10.34 | 6.80 | 1,355.78 |
| 15.00 | 10.89 | 7.31 | **2,120.20** |
| 16.00 | 11.30 | 7.68 | **2,199.79** |
| 17.00 | 11.60 | 7.96 | 1,819.41 |
| 18.00 | 11.83 | 8.18 | 1,328.52 |
| 19.00 | 12.03 | 8.36 | 991.44 |
| 20.00 | 12.20 | 8.52 | 742.58 |
| 21.00 | 12.36 | 8.67 | 565.43 |
| 22.00 | 12.50 | 8.81 | 443.20 |
| 23.00 | 12.63 | 8.93 | 360.13 |
| 24.00 | **12.75** | **9.04** | 300.79 |
| 25.00 | 12.75 | 9.04 | 256.96 |
| 26.00 | 12.75 | 9.04 | 212.08 |
| 27.00 | 12.75 | 9.04 | 153.95 |
| 28.00 | 12.75 | 9.04 | 97.59 |
| 29.00 | 12.75 | 9.04 | 56.92 |
| 30.00 | 12.75 | 9.04 | 32.96 |
| 31.00 | 12.75 | 9.04 | 19.15 |
| 32.00 | 12.75 | 9.04 | 10.98 |
| 33.00 | 12.75 | 9.04 | 6.32 |
| 34.00 | 12.75 | 9.04 | 3.57 |
| 35.00 | 12.75 | 9.04 | 1.97 |
| 36.00 | 12.75 | 9.04 | 1.04 |
| 37.00 | 12.75 | 9.04 | 0.50 |
| 38.00 | 12.75 | 9.04 | 0.19 |
| 39.00 | 12.75 | 9.04 | 0.03 |
| 40.00 | 12.75 | 9.04 | 0.00 |
| 41.00 | 12.75 | 9.04 | 0.00 |
| 42.00 | 12.75 | 9.04 | 0.00 |
| 43.00 | 12.75 | 9.04 | 0.00 |
| 44.00 | 12.75 | 9.04 | 0.00 |
| 45.00 | 12.75 | 9.04 | 0.00 |
| 46.00 | 12.75 | 9.04 | 0.00 |
| 47.00 | 12.75 | 9.04 | 0.00 |
| 48.00 | 12.75 | 9.04 | 0.00 |
| 49.00 | 12.75 | 9.04 | 0.00 |
| 50.00 | 12.75 | 9.04 | 0.00 |

| Time (hours) | Precip. (inches) | Excess (inches) | Runoff (cfs) |
|---|---|---|---|
| 51.00 | 12.75 | 9.04 | 0.00 |
| 52.00 | 12.75 | 9.04 | 0.00 |
| 53.00 | 12.75 | 9.04 | 0.00 |
| 54.00 | 12.75 | 9.04 | 0.00 |
| 55.00 | 12.75 | 9.04 | 0.00 |
| 56.00 | 12.75 | 9.04 | 0.00 |
| 57.00 | 12.75 | 9.04 | 0.00 |
| 58.00 | 12.75 | 9.04 | 0.00 |
| 59.00 | 12.75 | 9.04 | 0.00 |
| 60.00 | 12.75 | 9.04 | 0.00 |
| 61.00 | 12.75 | 9.04 | 0.00 |
| 62.00 | 12.75 | 9.04 | 0.00 |
| 63.00 | 12.75 | 9.04 | 0.00 |
| 64.00 | 12.75 | 9.04 | 0.00 |
| 65.00 | 12.75 | 9.04 | 0.00 |
| 66.00 | 12.75 | 9.04 | 0.00 |
| 67.00 | 12.75 | 9.04 | 0.00 |
| 68.00 | 12.75 | 9.04 | 0.00 |
| 69.00 | 12.75 | 9.04 | 0.00 |
| 70.00 | 12.75 | 9.04 | 0.00 |
| 71.00 | 12.75 | 9.04 | 0.00 |
| 72.00 | 12.75 | 9.04 | 0.00 |

## Summary for Pond 2P: Ramshorn Pond Dam (Stop Logs In / Gate Closed)

Inflow Area = 1,537.718 ac, 13.97% Impervious, Inflow Depth = 9.04" for Half PMF event
Inflow = 2,251.52 cfs @ 15.68 hrs, Volume= 1,158.008 af
Outflow = 709.22 cfs @ 20.16 hrs, Volume= 1,066.058 af, Atten= 69%, Lag= 269.1 min
Primary = 709.22 cfs @ 20.16 hrs, Volume= 1,066.058 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs / 2
Starting Elev= 630.70' Surf.Area= 131.000 ac Storage= 91.700 af
Peak Elev= 636.05' @ 20.16 hrs Surf.Area= 137.823 ac Storage= 807.858 af (716.158 af above start)

Plug-Flow detention time= 933.1 min calculated for 974.358 af (84% of inflow)
Center-of-Mass det. time= 778.4 min ( 1,831.4 - 1,053.0 )

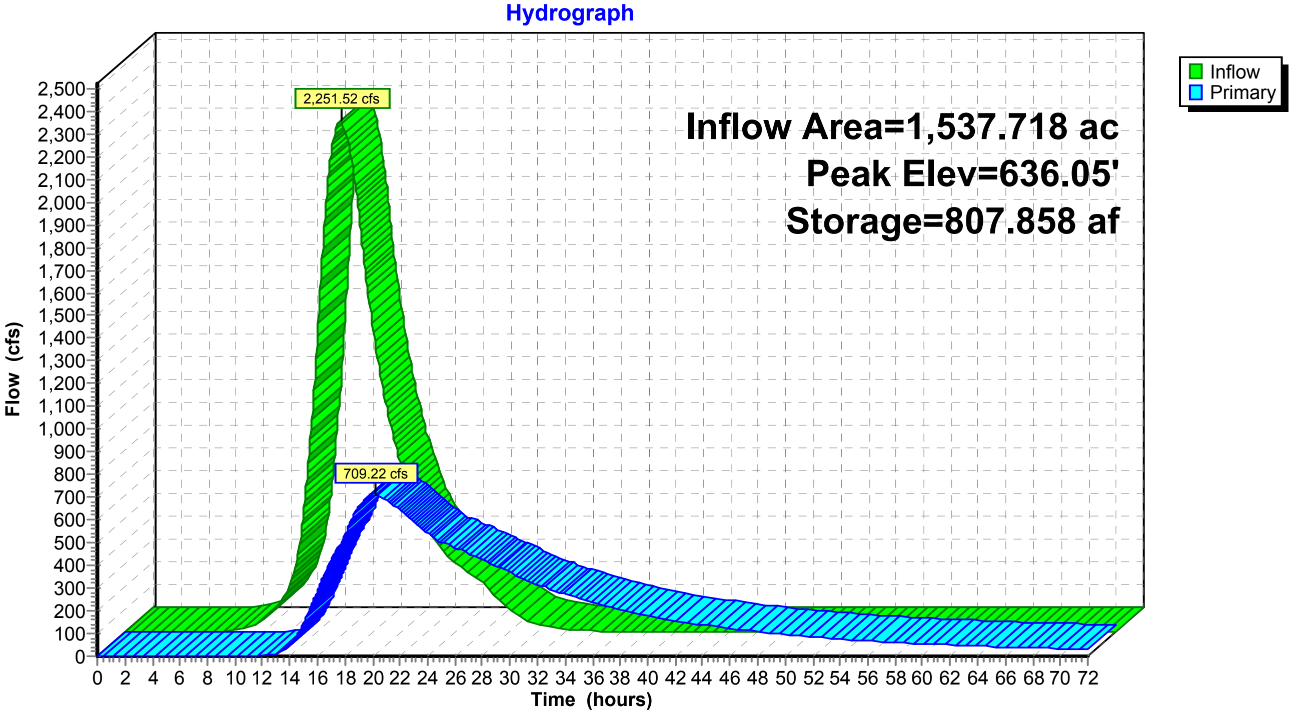
| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 630.00' | 1,876.500 af | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (acres) | Inc.Store (acre-feet) | Cum.Store (acre-feet) |
|---|---|---|---|
| 630.00 | 131.000 | 0.000 | 0.000 |
| 631.50 | 131.000 | 196.500 | 196.500 |
| 643.50 | 149.000 | 1,680.000 | 1,876.500 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 630.75' | **108.0" W x 67.2" H Box Culvert X 2.00 w/ 18.0" inside fill**<br>L= 28.0' Box, headwall w/3 square edges, Ke= 0.500<br>Inlet / Outlet Invert= 629.25' / 628.95' S= 0.0107 '/' Cc= 0.900<br>n= 0.013, Flow Area= 36.90 sf |
| #2 | Primary | 635.50' | **100.0' long (Profile 1) Broad-Crested Rectangular Weir**<br>Head (feet) 0.49 0.98 1.48<br>Coef. (English) 2.92 3.37 3.59 |

**Primary OutFlow** Max=708.19 cfs @ 20.16 hrs HW=636.05' (Free Discharge)
├─**1=Culvert** (Barrel Controls 587.44 cfs @ 8.21 fps)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 120.75 cfs @ 2.20 fps)

## Pond 2P: Ramshorn Pond Dam (Stop Logs In / Gate Closed)



## Hydrograph for Pond 2P: Ramshorn Pond Dam (Stop Logs In / Gate Closed)

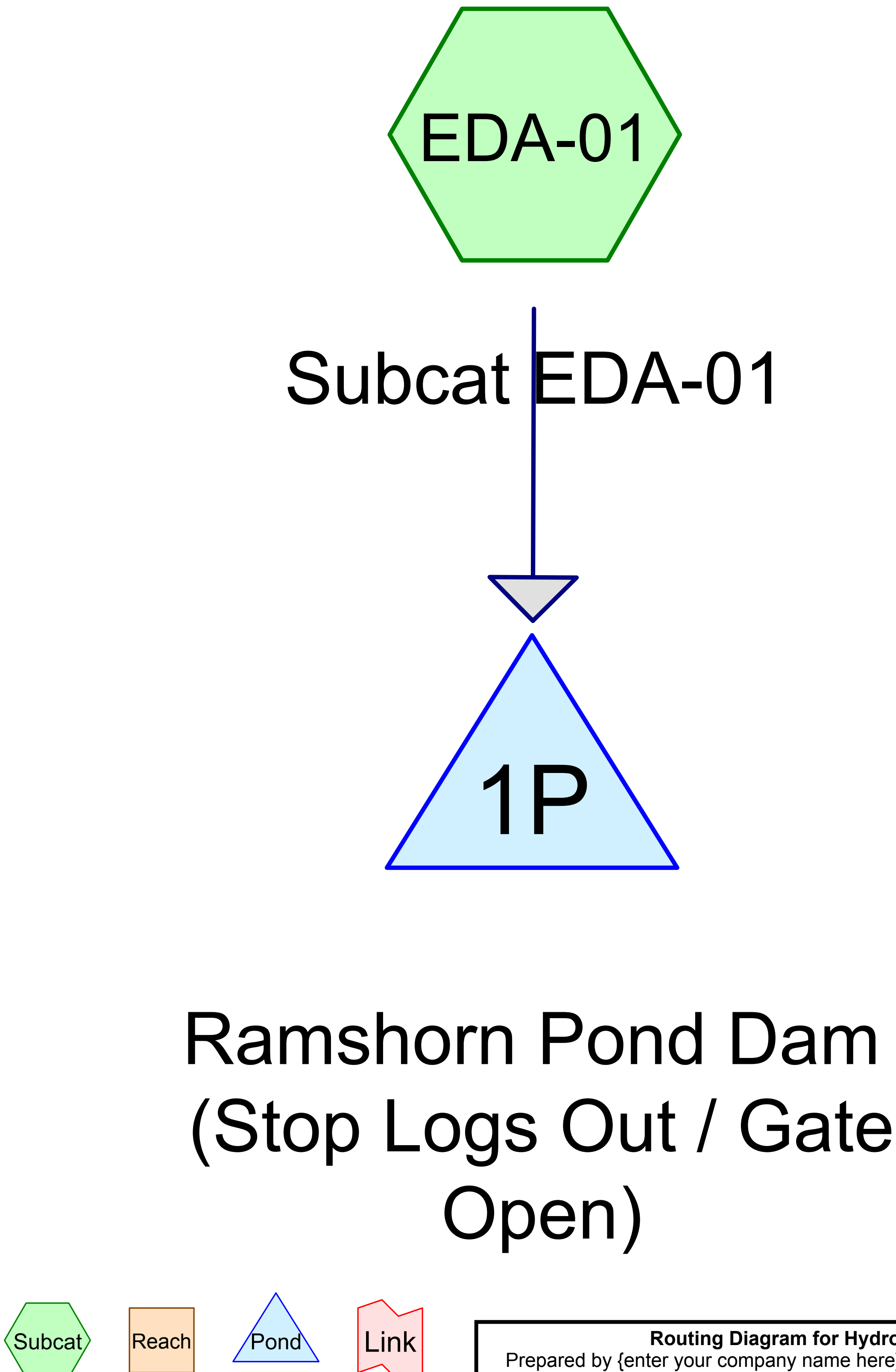
| Time (hours) | Inflow (cfs) | Storage (acre-feet) | Elevation (feet) | Primary (cfs) |
|---|---|---|---|---|
| 0.00 | 0.00 | 91.700 | 630.70 | 0.00 |
| 2.50 | 0.00 | 91.700 | 630.70 | 0.00 |
| 5.00 | 0.00 | 91.700 | 630.70 | 0.00 |
| 7.50 | 2.06 | 91.769 | 630.70 | 0.00 |
| 10.00 | 49.84 | 95.503 | 630.73 | 0.00 |
| 12.50 | 319.84 | 124.873 | 630.95 | 5.34 |
| 15.00 | **2,120.20** | 355.340 | 632.70 | 147.66 |
| 17.50 | **1,547.33** | 709.799 | 635.33 | 478.65 |
| 20.00 | 742.58 | **807.630** | **636.05** | **708.39** |
| 22.50 | 397.62 | **780.388** | **635.85** | **617.24** |
| 25.00 | 256.96 | 731.654 | 635.49 | 502.32 |
| 27.50 | 124.31 | 674.364 | 635.07 | 440.95 |
| 30.00 | 32.96 | 605.048 | 634.56 | 369.85 |
| 32.50 | 8.34 | 539.166 | 634.08 | 305.78 |
| 35.00 | 1.97 | 482.499 | 633.66 | 253.60 |
| 37.50 | 0.32 | 434.765 | 633.30 | 211.96 |
| 40.00 | 0.00 | 394.564 | 633.00 | 178.59 |
| 42.50 | 0.00 | 360.541 | 632.74 | 151.70 |
| 45.00 | 0.00 | 331.541 | 632.52 | 129.77 |
| 47.50 | 0.00 | 306.651 | 632.34 | 111.75 |
| 50.00 | 0.00 | 285.156 | 632.17 | 96.77 |
| 52.50 | 0.00 | 266.524 | 632.03 | 83.90 |
| 55.00 | 0.00 | 250.415 | 631.91 | 72.29 |
| 57.50 | 0.00 | 236.504 | 631.80 | 62.68 |
| 60.00 | 0.00 | 224.413 | 631.71 | 54.67 |
| 62.50 | 0.00 | 213.831 | 631.63 | 47.91 |
| 65.00 | 0.00 | 204.529 | 631.56 | 42.31 |
| 67.50 | 0.00 | 196.304 | 631.50 | 37.42 |
| 70.00 | 0.00 | 188.998 | 631.44 | 33.42 |

## Stage-Discharge for Pond 2P: Ramshorn Pond Dam (Stop Logs In / Gate Closed)

| Elevation (feet) | Primary (cfs) | Elevation (feet) | Primary (cfs) |
|---|---|---|---|
| 630.00 | 0.00 | 637.65 | 1,908.29 |
| 630.15 | 0.00 | 637.80 | 2,041.06 |
| 630.30 | 0.00 | 637.95 | 2,177.63 |
| 630.45 | 0.00 | 638.10 | 2,317.88 |
| 630.60 | 0.00 | 638.25 | 2,461.70 |
| 630.75 | 0.00 | 638.40 | 2,609.01 |
| 630.90 | 3.36 | 638.55 | 2,759.71 |
| 631.05 | 9.49 | 638.70 | 2,913.72 |
| 631.20 | 17.44 | 638.85 | 3,070.97 |
| 631.35 | 26.85 | 639.00 | 3,231.38 |
| 631.50 | 37.53 | 639.15 | 3,394.89 |
| 631.65 | 49.33 | 639.30 | 3,561.44 |
| 631.80 | 62.17 | 639.45 | 3,730.97 |
| 631.95 | 75.95 | 639.60 | 3,903.43 |
| 632.10 | 90.13 | 639.75 | 4,078.75 |
| 632.25 | 103.64 | 639.90 | 4,256.90 |
| 632.40 | 117.67 | 640.05 | 4,437.83 |
| 632.55 | 132.21 | 640.20 | 4,621.49 |
| 632.70 | 147.23 | 640.35 | 4,807.83 |
| 632.85 | 162.72 | 640.50 | 4,996.83 |
| 633.00 | 178.67 | 640.65 | 5,188.44 |
| 633.15 | 195.06 | 640.80 | 5,382.63 |
| 633.30 | 211.89 | 640.95 | 5,579.35 |
| 633.45 | 229.15 | 641.10 | 5,778.58 |
| 633.60 | 246.82 | 641.25 | 5,980.28 |
| 633.75 | 264.89 | 641.40 | 6,184.43 |
| 633.90 | 283.37 | 641.55 | 6,390.99 |
| 634.05 | 302.23 | 641.70 | 6,599.93 |
| 634.20 | 321.47 | 641.85 | 6,811.22 |
| 634.35 | 341.09 | 642.00 | 7,024.85 |
| 634.50 | 361.07 | 642.15 | 7,240.77 |
| 634.65 | 381.42 | 642.30 | 7,458.97 |
| 634.80 | 402.12 | 642.45 | 7,679.43 |
| 634.95 | 423.16 | 642.60 | 7,902.12 |
| 635.10 | 444.56 | 642.75 | 8,127.01 |
| 635.25 | 466.29 | 642.90 | 8,354.08 |
| 635.40 | 488.35 | 643.05 | 8,583.32 |
| 635.55 | 514.01 | 643.20 | 8,814.71 |
| 635.70 | 559.57 | 643.35 | 9,048.21 |
| 635.85 | 616.95 | 643.50 | **9,283.82** |
| 636.00 | 683.40 | | |
| 636.15 | 764.22 | | |
| 636.30 | 851.08 | | |
| 636.45 | 957.36 | | |
| 636.60 | 1,067.84 | | |
| 636.75 | 1,184.71 | | |
| 636.90 | 1,300.49 | | |
| 637.05 | 1,417.90 | | |
| 637.20 | 1,534.07 | | |
| 637.35 | 1,654.64 | | |
| 637.50 | 1,779.43 | | |

## Stage-Area-Storage for Pond 2P: Ramshorn Pond Dam (Stop Logs In / Gate Closed)

| Elevation (feet) | Surface (acres) | Storage (acre-feet) | Elevation (feet) | Surface (acres) | Storage (acre-feet) |
|---|---|---|---|---|---|
| 630.00 | 131.000 | 0.000 | 637.65 | 140.225 | 1,030.517 |
| 630.15 | 131.000 | 19.650 | 637.80 | 140.450 | 1,051.567 |
| 630.30 | 131.000 | 39.300 | 637.95 | 140.675 | 1,072.652 |
| 630.45 | 131.000 | 58.950 | 638.10 | 140.900 | 1,093.770 |
| 630.60 | 131.000 | 78.600 | 638.25 | 141.125 | 1,114.922 |
| 630.75 | 131.000 | 98.250 | 638.40 | 141.350 | 1,136.107 |
| 630.90 | 131.000 | 117.900 | 638.55 | 141.575 | 1,157.327 |
| 631.05 | 131.000 | 137.550 | 638.70 | 141.800 | 1,178.580 |
| 631.20 | 131.000 | 157.200 | 638.85 | 142.025 | 1,199.867 |
| 631.35 | 131.000 | 176.850 | 639.00 | 142.250 | 1,221.187 |
| 631.50 | 131.000 | 196.500 | 639.15 | 142.475 | 1,242.542 |
| 631.65 | 131.225 | 216.167 | 639.30 | 142.700 | 1,263.930 |
| 631.80 | 131.450 | 235.867 | 639.45 | 142.925 | 1,285.352 |
| 631.95 | 131.675 | 255.602 | 639.60 | 143.150 | 1,306.808 |
| 632.10 | 131.900 | 275.370 | 639.75 | 143.375 | 1,328.297 |
| 632.25 | 132.125 | 295.172 | 639.90 | 143.600 | 1,349.820 |
| 632.40 | 132.350 | 315.007 | 640.05 | 143.825 | 1,371.377 |
| 632.55 | 132.575 | 334.877 | 640.20 | 144.050 | 1,392.968 |
| 632.70 | 132.800 | 354.780 | 640.35 | 144.275 | 1,414.592 |
| 632.85 | 133.025 | 374.717 | 640.50 | 144.500 | 1,436.250 |
| 633.00 | 133.250 | 394.687 | 640.65 | 144.725 | 1,457.942 |
| 633.15 | 133.475 | 414.692 | 640.80 | 144.950 | 1,479.667 |
| 633.30 | 133.700 | 434.730 | 640.95 | 145.175 | 1,501.427 |
| 633.45 | 133.925 | 454.802 | 641.10 | 145.400 | 1,523.220 |
| 633.60 | 134.150 | 474.908 | 641.25 | 145.625 | 1,545.047 |
| 633.75 | 134.375 | 495.047 | 641.40 | 145.850 | 1,566.907 |
| 633.90 | 134.600 | 515.220 | 641.55 | 146.075 | 1,588.802 |
| 634.05 | 134.825 | 535.427 | 641.70 | 146.300 | 1,610.730 |
| 634.20 | 135.050 | 555.668 | 641.85 | 146.525 | 1,632.692 |
| 634.35 | 135.275 | 575.942 | 642.00 | 146.750 | 1,654.687 |
| 634.50 | 135.500 | 596.250 | 642.15 | 146.975 | 1,676.717 |
| 634.65 | 135.725 | 616.592 | 642.30 | 147.200 | 1,698.780 |
| 634.80 | 135.950 | 636.967 | 642.45 | 147.425 | 1,720.877 |
| 634.95 | 136.175 | 657.377 | 642.60 | 147.650 | 1,743.008 |
| 635.10 | 136.400 | 677.820 | 642.75 | 147.875 | 1,765.172 |
| 635.25 | 136.625 | 698.297 | 642.90 | 148.100 | 1,787.370 |
| 635.40 | 136.850 | 718.807 | 643.05 | 148.325 | 1,809.602 |
| 635.55 | 137.075 | 739.352 | 643.20 | 148.550 | 1,831.868 |
| 635.70 | 137.300 | 759.930 | 643.35 | 148.775 | 1,854.167 |
| 635.85 | 137.525 | 780.542 | 643.50 | **149.000** | **1,876.500** |
| 636.00 | 137.750 | 801.187 | | | |
| 636.15 | 137.975 | 821.867 | | | |
| 636.30 | 138.200 | 842.580 | | | |
| 636.45 | 138.425 | 863.327 | | | |
| 636.60 | 138.650 | 884.108 | | | |
| 636.75 | 138.875 | 904.922 | | | |
| 636.90 | 139.100 | 925.770 | | | |
| 637.05 | 139.325 | 946.652 | | | |
| 637.20 | 139.550 | 967.568 | | | |
| 637.35 | 139.775 | 988.517 | | | |
| 637.50 | 140.000 | 1,009.500 | | | |




**Routing Diagram for HydroCAD**
Prepared by {enter your company name here}, Printed 10/16/2013
HydroCAD® 10.00 s/n 04883 © 2013 HydroCAD Software Solutions LLC

## Area Listing (selected nodes)

| Area (acres) | CN | Description (subcatchment-numbers) |
|---|---|---|
| 7.323 | 68 | 1 acre lots, 20% imp, HSG B (EDA-01) |
| 47.295 | 79 | 1 acre lots, 20% imp, HSG C (EDA-01) |
| 0.382 | 84 | 1 acre lots, 20% imp, HSG D (EDA-01) |
| 12.645 | 70 | 1/2 acre lots, 25% imp, HSG B (EDA-01) |
| 22.851 | 80 | 1/2 acre lots, 25% imp, HSG C (EDA-01) |
| 0.268 | 85 | 1/2 acre lots, 25% imp, HSG D (EDA-01) |
| 0.433 | 72 | 1/3 acre lots, 30% imp, HSG B (EDA-01) |
| 5.967 | 81 | 1/3 acre lots, 30% imp, HSG C (EDA-01) |
| 0.013 | 86 | 1/3 acre lots, 30% imp, HSG D (EDA-01) |
| 1.165 | 75 | 1/4 acre lots, 38% imp, HSG B (EDA-01) |
| 1.566 | 83 | 1/4 acre lots, 38% imp, HSG C (EDA-01) |
| 0.486 | 85 | 1/8 acre lots, 65% imp, HSG B (EDA-01) |
| 0.237 | 90 | 1/8 acre lots, 65% imp, HSG C (EDA-01) |
| 0.062 | 92 | 1/8 acre lots, 65% imp, HSG D (EDA-01) |
| 9.893 | 65 | 2 acre lots, 12% imp, HSG B (EDA-01) |
| 35.540 | 77 | 2 acre lots, 12% imp, HSG C (EDA-01) |
| 0.247 | 82 | 2 acre lots, 12% imp, HSG D (EDA-01) |
| 8.773 | 48 | Brush, Good, HSG B (EDA-01) |
| 32.488 | 65 | Brush, Good, HSG C (EDA-01) |
| 1.697 | 73 | Brush, Good, HSG D (EDA-01) |
| 1.075 | 96 | Gravel surface, HSG B (EDA-01) |
| 4.950 | 96 | Gravel surface, HSG C (EDA-01) |
| 3.685 | 58 | Meadow, non-grazed, HSG B (EDA-01) |
| 77.382 | 71 | Meadow, non-grazed, HSG C (EDA-01) |
| 1.146 | 78 | Meadow, non-grazed, HSG D (EDA-01) |
| 2.260 | 61 | Pasture/grassland/range, Good, HSG B (EDA-01) |
| 34.695 | 74 | Pasture/grassland/range, Good, HSG C (EDA-01) |
| 3.533 | 98 | Paved parking, HSG B (EDA-01) |
| 13.240 | 98 | Paved parking, HSG C (EDA-01) |
| 0.294 | 98 | Paved parking, HSG D (EDA-01) |
| 0.808 | 92 | Urban commercial, 85% imp, HSG B (EDA-01) |
| 0.458 | 94 | Urban commercial, 85% imp, HSG C (EDA-01) |
| 0.632 | 91 | Urban industrial, 72% imp, HSG C (EDA-01) |
| 0.870 | 98 | Water Surface, HSG B (EDA-01) |
| 145.169 | 98 | Water Surface, HSG C (EDA-01) |
| 21.221 | 98 | Water Surface, HSG D (EDA-01) |
| 6.009 | 30 | Woods, Good, HSG A (EDA-01) |
| 189.599 | 55 | Woods, Good, HSG B (EDA-01) |
| 728.802 | 70 | Woods, Good, HSG C (EDA-01) |
| 112.558 | 77 | Woods, Good, HSG D (EDA-01) |

## Area Listing (selected nodes) (continued)

| Area (acres) | CN | Description (subcatchment-numbers) |
|---|---|---|
| **1,537.718** | **72** | **TOTAL AREA** |

## Soil Listing (selected nodes)

| Area (acres) | Soil Group | Subcatchment Numbers |
|---|---|---|
| 6.009 | HSG A | EDA-01 |
| 242.550 | HSG B | EDA-01 |
| 1,151.271 | HSG C | EDA-01 |
| 137.888 | HSG D | EDA-01 |
| 0.000 | Other | |
| **1,537.718** | | **TOTAL AREA** |

## Ground Covers (selected nodes)

| HSG-A (acres) | HSG-B (acres) | HSG-C (acres) | HSG-D (acres) | Other (acres) | Total (acres) | Ground Cover | Subcatchment Numbers |
|---|---|---|---|---|---|---|---|
| 0.000 | 7.323 | 47.295 | 0.382 | 0.000 | 55.000 | 1 acre lots, 20% imp | EDA-01 |
| 0.000 | 12.645 | 22.851 | 0.268 | 0.000 | 35.765 | 1/2 acre lots, 25% imp | EDA-01 |
| 0.000 | 0.433 | 5.967 | 0.013 | 0.000 | 6.413 | 1/3 acre lots, 30% imp | EDA-01 |
| 0.000 | 1.165 | 1.566 | 0.000 | 0.000 | 2.731 | 1/4 acre lots, 38% imp | EDA-01 |
| 0.000 | 0.486 | 0.237 | 0.062 | 0.000 | 0.785 | 1/8 acre lots, 65% imp | EDA-01 |
| 0.000 | 9.893 | 35.540 | 0.247 | 0.000 | 45.679 | 2 acre lots, 12% imp | EDA-01 |
| 0.000 | 8.773 | 32.488 | 1.697 | 0.000 | 42.958 | Brush, Good | EDA-01 |
| 0.000 | 1.075 | 4.950 | 0.000 | 0.000 | 6.025 | Gravel surface | EDA-01 |
| 0.000 | 3.685 | 77.382 | 1.146 | 0.000 | 82.214 | Meadow, non-grazed | EDA-01 |
| 0.000 | 2.260 | 34.695 | 0.000 | 0.000 | 36.955 | Pasture/grassland/range, Good | EDA-01 |
| 0.000 | 3.533 | 13.240 | 0.294 | 0.000 | 17.067 | Paved parking | EDA-01 |
| 0.000 | 0.808 | 0.458 | 0.000 | 0.000 | 1.266 | Urban commercial, 85% imp | EDA-01 |
| 0.000 | 0.000 | 0.632 | 0.000 | 0.000 | 0.632 | Urban industrial, 72% imp | EDA-01 |
| 0.000 | 0.870 | 145.169 | 21.221 | 0.000 | 167.259 | Water Surface | EDA-01 |

## Ground Covers (selected nodes) (continued)

| HSG-A (acres) | HSG-B (acres) | HSG-C (acres) | HSG-D (acres) | Other (acres) | Total (acres) | Ground Cover | Subcatchment Numbers |
|---|---|---|---|---|---|---|---|
| 6.009 | 189.599 | 728.802 | 112.558 | 0.000 | 1,036.968 | Woods, Good | ED A-01 |
| **6.009** | **242.550** | **1,151.271** | **137.888** | **0.000** | **1,537.718** | **TOTAL AREA** | |

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**Subcatchment EDA-01: Subcat EDA-01** Runoff Area=1,537.718 ac 13.97% Impervious Runoff Depth=5.39"
Flow Length=11,300' Tc=276.8 min CN=72 Runoff=1,343.68 cfs 691.216 af

**Pond 1P: Ramshorn Pond Dam** Peak Elev=632.94' Storage=386.611 af Inflow=1,343.68 cfs 691.216 af
Outflow=399.87 cfs 783.212 af

**Total Runoff Area = 1,537.718 ac Runoff Volume = 691.216 af Average Runoff Depth = 5.39"**
**86.03% Pervious = 1,322.966 ac 13.97% Impervious = 214.752 ac**

## Summary for Subcatchment EDA-01: Subcat EDA-01

Runoff = 1,343.68 cfs @ 15.69 hrs, Volume= 691.216 af, Depth= 5.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.79"

| Area (ac) | CN | Description |
|---|---|---|
| 8.425 | 77 | Woods, Good, HSG D |
| 0.273 | 78 | Meadow, non-grazed, HSG D |
| 0.000 | 84 | 1 acre lots, 20% imp, HSG D |
| 1.355 | 70 | Woods, Good, HSG C |
| 0.698 | 65 | Brush, Good, HSG C |
| 3.065 | 70 | Woods, Good, HSG C |
| 0.022 | 65 | Brush, Good, HSG C |
| 0.148 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.025 | 98 | Paved parking, HSG C |
| 0.014 | 98 | Water Surface, HSG C |
| 0.323 | 98 | Water Surface, HSG C |
| 1.450 | 98 | Water Surface, HSG C |
| 10.748 | 70 | Woods, Good, HSG C |
| 0.498 | 55 | Woods, Good, HSG B |
| 0.476 | 98 | Paved parking, HSG B |
| 2.799 | 55 | Woods, Good, HSG B |
| 0.327 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.238 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.277 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.578 | 68 | 1 acre lots, 20% imp, HSG B |
| 3.500 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 4.044 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.012 | 98 | Paved parking, HSG B |
| 0.301 | 98 | Water Surface, HSG B |
| 12.253 | 77 | Woods, Good, HSG D |
| 0.109 | 98 | Paved parking, HSG D |
| 0.157 | 77 | Woods, Good, HSG D |
| 0.873 | 78 | Meadow, non-grazed, HSG D |
| 0.007 | 84 | 1 acre lots, 20% imp, HSG D |
| 0.062 | 92 | 1/8 acre lots, 65% imp, HSG D |
| 0.312 | 98 | Water Surface, HSG D |
| 5.188 | 77 | Woods, Good, HSG D |
| 0.251 | 73 | Brush, Good, HSG D |
| 13.278 | 98 | Water Surface, HSG D |
| 1.976 | 71 | Meadow, non-grazed, HSG C |
| 0.483 | 71 | Meadow, non-grazed, HSG C |
| 3.826 | 98 | Water Surface, HSG D |
| 1.244 | 98 | Water Surface, HSG D |
| 0.025 | 98 | Water Surface, HSG D |
| 0.013 | 86 | 1/3 acre lots, 30% imp, HSG D |
| 0.268 | 85 | 1/2 acre lots, 25% imp, HSG D |
| 0.247 | 82 | 2 acre lots, 12% imp, HSG D |
| 0.145 | 98 | Paved parking, HSG D |
| 15.857 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 5.976 | 77 | Woods, Good, HSG D |
| 1.296 | 73 | Brush, Good, HSG D |
| 77.304 | 70 | Woods, Good, HSG C |
| 13.578 | 77 | Woods, Good, HSG D |
| 0.886 | 65 | Brush, Good, HSG C |

| | | |
|---|---|---|
| 7.779 | 65 | Brush, Good, HSG C |
| 7.953 | 70 | Woods, Good, HSG C |
| 1.881 | 65 | Brush, Good, HSG C |
| 5.663 | 65 | Brush, Good, HSG C |
| 10.415 | 70 | Woods, Good, HSG C |
| 3.987 | 70 | Woods, Good, HSG C |
| 1.795 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.009 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.004 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.116 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.359 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.036 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.330 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.037 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.011 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.173 | 70 | Woods, Good, HSG C |
| 28.188 | 70 | Woods, Good, HSG C |
| 0.045 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 0.212 | 70 | Woods, Good, HSG C |
| 0.102 | 70 | Woods, Good, HSG C |
| 0.054 | 70 | Woods, Good, HSG C |
| 0.044 | 70 | Woods, Good, HSG C |
| 0.006 | 70 | Woods, Good, HSG C |
| 0.817 | 70 | Woods, Good, HSG C |
| 0.095 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.043 | 70 | Woods, Good, HSG C |
| 0.411 | 70 | Woods, Good, HSG C |
| 0.000 | 70 | Woods, Good, HSG C |
| 0.299 | 98 | Paved parking, HSG C |
| 3.242 | 98 | Paved parking, HSG C |
| 67.114 | 70 | Woods, Good, HSG C |
| 0.145 | 70 | Woods, Good, HSG C |
| 171.240 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.241 | 70 | Woods, Good, HSG C |
| 0.002 | 70 | Woods, Good, HSG C |
| 0.009 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 0.010 | 70 | Woods, Good, HSG C |
| 0.031 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.000 | 70 | Woods, Good, HSG C |
| 0.105 | 70 | Woods, Good, HSG C |
| 16.574 | 55 | Woods, Good, HSG B |
| 0.219 | 98 | Water Surface, HSG C |
| 0.005 | 98 | Water Surface, HSG C |

| | | |
|---|---|---|
| 0.579 | 98 | Water Surface, HSG C |
| 0.046 | 98 | Water Surface, HSG C |
| 11.283 | 70 | Woods, Good, HSG C |
| 87.275 | 70 | Woods, Good, HSG C |
| 0.149 | 73 | Brush, Good, HSG D |
| 31.112 | 77 | Woods, Good, HSG D |
| 2.536 | 98 | Water Surface, HSG D |
| 0.040 | 98 | Paved parking, HSG D |
| 0.375 | 84 | 1 acre lots, 20% imp, HSG D |
| 8.249 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 35.868 | 77 | Woods, Good, HSG D |
| 0.006 | 98 | Paved parking, HSG B |
| 0.000 | 98 | Paved parking, HSG B |
| 0.163 | 98 | Paved parking, HSG C |
| 0.006 | 98 | Paved parking, HSG C |
| 0.457 | 98 | Paved parking, HSG C |
| 0.001 | 98 | Paved parking, HSG C |
| 0.837 | 98 | Paved parking, HSG B |
| 0.179 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.966 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.327 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.000 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.003 | 68 | 1 acre lots, 20% imp, HSG B |
| 4.100 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.074 | 58 | Meadow, non-grazed, HSG B |
| 0.044 | 70 | Woods, Good, HSG C |
| 1.189 | 70 | Woods, Good, HSG C |
| 1.933 | 55 | Woods, Good, HSG B |
| 0.000 | 55 | Woods, Good, HSG B |
| 0.101 | 55 | Woods, Good, HSG B |
| 0.016 | 70 | Woods, Good, HSG C |
| 4.196 | 70 | Woods, Good, HSG C |
| 0.006 | 70 | Woods, Good, HSG C |
| 0.256 | 55 | Woods, Good, HSG B |
| 0.454 | 55 | Woods, Good, HSG B |
| 0.394 | 98 | Water Surface, HSG B |
| 0.175 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 1.165 | 75 | 1/4 acre lots, 38% imp, HSG B |
| 0.669 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.058 | 58 | Meadow, non-grazed, HSG B |
| 0.622 | 58 | Meadow, non-grazed, HSG B |
| 0.023 | 70 | Woods, Good, HSG C |
| 0.010 | 70 | Woods, Good, HSG C |
| 0.055 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 14.294 | 70 | Woods, Good, HSG C |
| 0.031 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 23.662 | 55 | Woods, Good, HSG B |
| 6.009 | 30 | Woods, Good, HSG A |

| | | |
|---|---|---|
| 0.098 | 98 | Paved parking, HSG B |
| 0.046 | 98 | Paved parking, HSG C |
| 0.112 | 98 | Paved parking, HSG C |
| 0.133 | 98 | Paved parking, HSG B |
| 0.022 | 98 | Paved parking, HSG C |
| 1.187 | 98 | Paved parking, HSG C |
| 0.374 | 98 | Paved parking, HSG B |
| 0.037 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.298 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.849 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.563 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.302 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.035 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.047 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.665 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.016 | 74 | Pasture/grassland/range, Good, HSG C |
| 3.444 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.011 | 61 | Pasture/grassland/range, Good, HSG B |
| 0.017 | 70 | Woods, Good, HSG C |
| 7.092 | 55 | Woods, Good, HSG B |
| 0.006 | 55 | Woods, Good, HSG B |
| 2.752 | 70 | Woods, Good, HSG C |
| 0.025 | 70 | Woods, Good, HSG C |
| 1.116 | 55 | Woods, Good, HSG B |
| 1.024 | 55 | Woods, Good, HSG B |
| 0.205 | 98 | Paved parking, HSG B |
| 0.706 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.190 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.384 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.249 | 61 | Pasture/grassland/range, Good, HSG B |
| 0.454 | 58 | Meadow, non-grazed, HSG B |
| 0.947 | 58 | Meadow, non-grazed, HSG B |
| 1.163 | 58 | Meadow, non-grazed, HSG B |
| 0.023 | 55 | Woods, Good, HSG B |
| 0.338 | 55 | Woods, Good, HSG B |
| 0.019 | 55 | Woods, Good, HSG B |
| 0.433 | 72 | 1/3 acre lots, 30% imp, HSG B |
| 0.697 | 68 | 1 acre lots, 20% imp, HSG B |
| 2.388 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.308 | 58 | Meadow, non-grazed, HSG B |
| 0.632 | 48 | Brush, Good, HSG B |
| 1.693 | 70 | Woods, Good, HSG C |
| 3.529 | 70 | Woods, Good, HSG C |
| 0.127 | 70 | Woods, Good, HSG C |
| 15.057 | 55 | Woods, Good, HSG B |
| 0.175 | 98 | Water Surface, HSG B |
| 0.037 | 98 | Paved parking, HSG C |
| 0.464 | 98 | Paved parking, HSG C |
| 1.392 | 98 | Paved parking, HSG B |
| 1.075 | 96 | Gravel surface, HSG B |
| 0.808 | 92 | Urban commercial, 85% imp, HSG B |

| | | |
|---|---|---|
| 0.137 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.614 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.821 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.005 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.048 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 3.340 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.622 | 68 | 1 acre lots, 20% imp, HSG B |
| 15.443 | 65 | Brush, Good, HSG C |
| 0.078 | 65 | Brush, Good, HSG C |
| 7.163 | 48 | Brush, Good, HSG B |
| 0.977 | 48 | Brush, Good, HSG B |
| 0.037 | 70 | Woods, Good, HSG C |
| 0.026 | 70 | Woods, Good, HSG C |
| 0.037 | 70 | Woods, Good, HSG C |
| 0.097 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 0.176 | 70 | Woods, Good, HSG C |
| 0.050 | 70 | Woods, Good, HSG C |
| 0.087 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 20.504 | 55 | Woods, Good, HSG B |
| 1.932 | 55 | Woods, Good, HSG B |
| 166.461 | 70 | Woods, Good, HSG C |
| 86.903 | 55 | Woods, Good, HSG B |
| 0.137 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.242 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.315 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.059 | 58 | Meadow, non-grazed, HSG B |
| 9.307 | 55 | Woods, Good, HSG B |
| 0.101 | 70 | Woods, Good, HSG C |
| 0.818 | 70 | Woods, Good, HSG C |
| 0.456 | 70 | Woods, Good, HSG C |
| 10.414 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 0.039 | 70 | Woods, Good, HSG C |
| 3.007 | 70 | Woods, Good, HSG C |
| 1.704 | 70 | Woods, Good, HSG C |
| 3.962 | 70 | Woods, Good, HSG C |
| 0.042 | 70 | Woods, Good, HSG C |
| 6.320 | 70 | Woods, Good, HSG C |
| 0.153 | 70 | Woods, Good, HSG C |
| 0.148 | 70 | Woods, Good, HSG C |
| 0.038 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.038 | 65 | Brush, Good, HSG C |
| 1.122 | 71 | Meadow, non-grazed, HSG C |

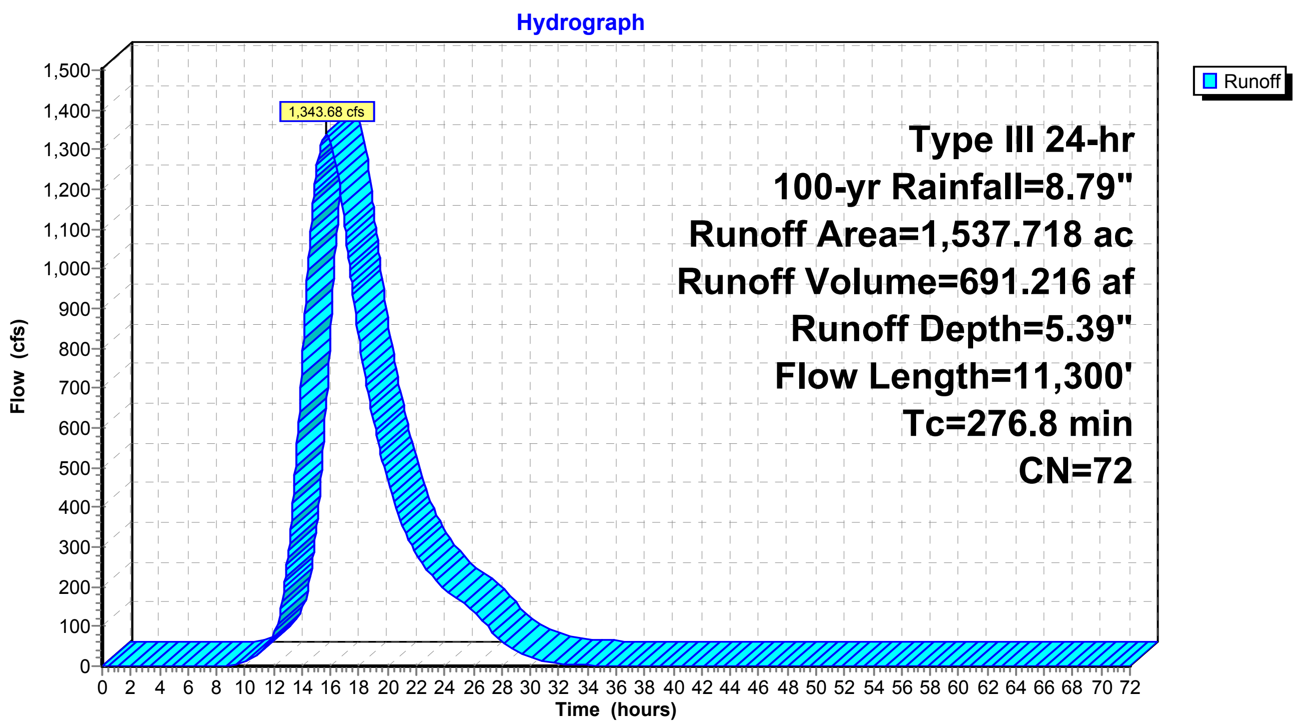
| | | |
|---|---|---|
| 0.109 | 71 | Meadow, non-grazed, HSG C |
| 1.365 | 71 | Meadow, non-grazed, HSG C |
| 10.877 | 71 | Meadow, non-grazed, HSG C |
| 4.101 | 71 | Meadow, non-grazed, HSG C |
| 0.504 | 71 | Meadow, non-grazed, HSG C |
| 0.233 | 71 | Meadow, non-grazed, HSG C |
| 0.020 | 71 | Meadow, non-grazed, HSG C |
| 0.341 | 71 | Meadow, non-grazed, HSG C |
| 0.657 | 71 | Meadow, non-grazed, HSG C |
| 0.206 | 71 | Meadow, non-grazed, HSG C |
| 0.902 | 71 | Meadow, non-grazed, HSG C |
| 2.991 | 71 | Meadow, non-grazed, HSG C |
| 0.144 | 71 | Meadow, non-grazed, HSG C |
| 0.431 | 71 | Meadow, non-grazed, HSG C |
| 2.758 | 71 | Meadow, non-grazed, HSG C |
| 12.700 | 71 | Meadow, non-grazed, HSG C |
| 0.842 | 71 | Meadow, non-grazed, HSG C |
| 0.657 | 71 | Meadow, non-grazed, HSG C |
| 0.366 | 71 | Meadow, non-grazed, HSG C |
| 7.832 | 71 | Meadow, non-grazed, HSG C |
| 4.144 | 71 | Meadow, non-grazed, HSG C |
| 7.707 | 71 | Meadow, non-grazed, HSG C |
| 2.530 | 71 | Meadow, non-grazed, HSG C |
| 11.385 | 71 | Meadow, non-grazed, HSG C |
| 0.630 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.640 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.499 | 74 | Pasture/grassland/range, Good, HSG C |
| 13.839 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.627 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.343 | 74 | Pasture/grassland/range, Good, HSG C |
| 5.380 | 74 | Pasture/grassland/range, Good, HSG C |
| 5.277 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.973 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.397 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.305 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.393 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.514 | 77 | 2 acre lots, 12% imp, HSG C |
| 2.524 | 77 | 2 acre lots, 12% imp, HSG C |
| 2.394 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.189 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.468 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.871 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.100 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.354 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.571 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.505 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.717 | 77 | 2 acre lots, 12% imp, HSG C |
| 3.826 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.915 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.534 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.770 | 77 | 2 acre lots, 12% imp, HSG C |

| | | |
|---|---|---|
| 3.858 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.574 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.281 | 77 | 2 acre lots, 12% imp, HSG C |
| 7.505 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.572 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.975 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.064 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.008 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.728 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.158 | 79 | 1 acre lots, 20% imp, HSG C |
| 4.048 | 79 | 1 acre lots, 20% imp, HSG C |
| 5.884 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.343 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.603 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.637 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.343 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.018 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.013 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.271 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.676 | 79 | 1 acre lots, 20% imp, HSG C |
| 4.173 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.718 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.650 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.391 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.502 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.951 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.101 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.729 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.213 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.913 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.682 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.329 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.195 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.151 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.769 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.778 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.568 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.556 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.929 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.373 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.959 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.846 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.247 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 2.760 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.368 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 3.192 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.198 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.532 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.696 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 1.923 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 4.241 | 80 | 1/2 acre lots, 25% imp, HSG C |

| | | |
|---|---|---|
| 0.416 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.100 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 2.333 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 5.698 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.035 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.234 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.273 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.768 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.140 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.236 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.149 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.114 | 90 | 1/8 acre lots, 65% imp, HSG C |
| 0.123 | 90 | 1/8 acre lots, 65% imp, HSG C |
| 0.632 | 91 | Urban industrial, 72% imp, HSG C |
| 0.458 | 94 | Urban commercial, 85% imp, HSG C |
| 4.350 | 96 | Gravel surface, HSG C |
| 0.600 | 96 | Gravel surface, HSG C |
| 0.084 | 98 | Paved parking, HSG C |
| 0.838 | 98 | Paved parking, HSG C |
| 0.888 | 98 | Paved parking, HSG C |
| 1.068 | 98 | Paved parking, HSG C |
| 2.929 | 98 | Paved parking, HSG C |
| 0.085 | 98 | Paved parking, HSG C |
| 0.041 | 98 | Paved parking, HSG C |
| 0.595 | 98 | Paved parking, HSG C |
| 0.083 | 98 | Paved parking, HSG C |
| 0.290 | 98 | Paved parking, HSG C |
| 0.279 | 98 | Paved parking, HSG C |
| 127.500 | 98 | Water Surface, HSG C |
| 14.980 | 98 | Water Surface, HSG C |
| 0.019 | 98 | Water Surface, HSG C |
| 0.033 | 98 | Water Surface, HSG C |
| 1,537.718 | 72 | Weighted Average |
| 1,322.966 | | 86.03% Pervious Area |
| 214.752 | | 13.97% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 42.9 | 100 | 0.0140 | 0.04 | | **Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.24" |
| 33.8 | 600 | 0.0140 | 0.30 | | **Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps |
| 27.4 | 700 | 0.0290 | 0.43 | | **Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps |
| 48.5 | 1,800 | 0.0611 | 0.62 | | **Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps |
| 23.6 | 500 | 0.0200 | 0.35 | | **Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps |
| 93.3 | 1,400 | 0.0100 | 0.25 | | **Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps |
| 2.6 | 2,200 | | 13.90 | | **Lake or Reservoir,** Mean Depth= 6.00' |
| 2.0 | 800 | 0.0210 | 6.74 | 67.36 | **Channel Flow,** Area= 10.0 sf Perim= 11.0' r= 0.91' n= 0.030 |
| 2.7 | 3,200 | | 19.66 | | **Lake or Reservoir,** Mean Depth= 12.00' |
| 276.8 | 11,300 | Total | | | |

## Subcatchment EDA-01: Subcat EDA-01



## Hydrograph for Subcatchment EDA-01: Subcat EDA-01

| Time (hours) | Precip. (inches) | Excess (inches) | Runoff (cfs) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 |
| 1.00 | 0.09 | 0.00 | 0.00 |
| 2.00 | 0.18 | 0.00 | 0.00 |
| 3.00 | 0.27 | 0.00 | 0.00 |
| 4.00 | 0.38 | 0.00 | 0.00 |
| 5.00 | 0.50 | 0.00 | 0.00 |
| 6.00 | 0.63 | 0.00 | 0.00 |
| 7.00 | 0.80 | 0.00 | 0.00 |
| 8.00 | 1.00 | 0.01 | 0.08 |
| 9.00 | 1.28 | 0.06 | 1.66 |
| 10.00 | 1.66 | 0.16 | 9.52 |
| 11.00 | 2.20 | 0.38 | 31.94 |
| 12.00 | 4.39 | 1.74 | 82.25 |
| 13.00 | 6.59 | 3.48 | 274.98 |
| 14.00 | 7.13 | 3.94 | 763.85 |
| 15.00 | 7.51 | 4.27 | **1,246.01** |
| 16.00 | 7.79 | 4.51 | **1,320.22** |
| 17.00 | 7.99 | 4.69 | 1,109.36 |
| 18.00 | 8.16 | 4.83 | 820.46 |
| 19.00 | 8.29 | 4.95 | 618.58 |
| 20.00 | 8.41 | 5.06 | 467.50 |
| 21.00 | 8.52 | 5.15 | 358.77 |
| 22.00 | 8.62 | 5.24 | 283.18 |
| 23.00 | 8.71 | 5.32 | 231.50 |
| 24.00 | **8.79** | **5.39** | 194.37 |
| 25.00 | 8.79 | 5.39 | 166.72 |
| 26.00 | 8.79 | 5.39 | 138.00 |
| 27.00 | 8.79 | 5.39 | 100.43 |
| 28.00 | 8.79 | 5.39 | 63.78 |
| 29.00 | 8.79 | 5.39 | 37.21 |
| 30.00 | 8.79 | 5.39 | 21.55 |
| 31.00 | 8.79 | 5.39 | 12.52 |
| 32.00 | 8.79 | 5.39 | 7.18 |
| 33.00 | 8.79 | 5.39 | 4.13 |
| 34.00 | 8.79 | 5.39 | 2.34 |
| 35.00 | 8.79 | 5.39 | 1.29 |
| 36.00 | 8.79 | 5.39 | 0.68 |
| 37.00 | 8.79 | 5.39 | 0.33 |
| 38.00 | 8.79 | 5.39 | 0.12 |
| 39.00 | 8.79 | 5.39 | 0.02 |
| 40.00 | 8.79 | 5.39 | 0.00 |
| 41.00 | 8.79 | 5.39 | 0.00 |
| 42.00 | 8.79 | 5.39 | 0.00 |
| 43.00 | 8.79 | 5.39 | 0.00 |
| 44.00 | 8.79 | 5.39 | 0.00 |
| 45.00 | 8.79 | 5.39 | 0.00 |
| 46.00 | 8.79 | 5.39 | 0.00 |
| 47.00 | 8.79 | 5.39 | 0.00 |
| 48.00 | 8.79 | 5.39 | 0.00 |
| 49.00 | 8.79 | 5.39 | 0.00 |
| 50.00 | 8.79 | 5.39 | 0.00 |

| Time (hours) | Precip. (inches) | Excess (inches) | Runoff (cfs) |
|---|---|---|---|
| 51.00 | 8.79 | 5.39 | 0.00 |
| 52.00 | 8.79 | 5.39 | 0.00 |
| 53.00 | 8.79 | 5.39 | 0.00 |
| 54.00 | 8.79 | 5.39 | 0.00 |
| 55.00 | 8.79 | 5.39 | 0.00 |
| 56.00 | 8.79 | 5.39 | 0.00 |
| 57.00 | 8.79 | 5.39 | 0.00 |
| 58.00 | 8.79 | 5.39 | 0.00 |
| 59.00 | 8.79 | 5.39 | 0.00 |
| 60.00 | 8.79 | 5.39 | 0.00 |
| 61.00 | 8.79 | 5.39 | 0.00 |
| 62.00 | 8.79 | 5.39 | 0.00 |
| 63.00 | 8.79 | 5.39 | 0.00 |
| 64.00 | 8.79 | 5.39 | 0.00 |
| 65.00 | 8.79 | 5.39 | 0.00 |
| 66.00 | 8.79 | 5.39 | 0.00 |
| 67.00 | 8.79 | 5.39 | 0.00 |
| 68.00 | 8.79 | 5.39 | 0.00 |
| 69.00 | 8.79 | 5.39 | 0.00 |
| 70.00 | 8.79 | 5.39 | 0.00 |
| 71.00 | 8.79 | 5.39 | 0.00 |
| 72.00 | 8.79 | 5.39 | 0.00 |

## Summary for Pond 1P: Ramshorn Pond Dam (Stop Logs Out / Gate Open)

Inflow Area = 1,537.718 ac, 13.97% Impervious, Inflow Depth = 5.39" for 100-yr event
Inflow = 1,343.68 cfs @ 15.69 hrs, Volume= 691.216 af
Outflow = 399.87 cfs @ 20.58 hrs, Volume= 783.212 af, Atten= 70%, Lag= 293.5 min
Primary = 399.87 cfs @ 20.58 hrs, Volume= 783.212 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs / 2
Starting Elev= 630.70' Surf.Area= 131.000 ac Storage= 91.700 af
Peak Elev= 632.94' @ 20.58 hrs Surf.Area= 133.159 ac Storage= 386.611 af (294.911 af above start)

Plug-Flow detention time= 603.5 min calculated for 691.032 af (100% of inflow)
Center-of-Mass det. time= 441.8 min ( 1,509.3 - 1,067.6 )

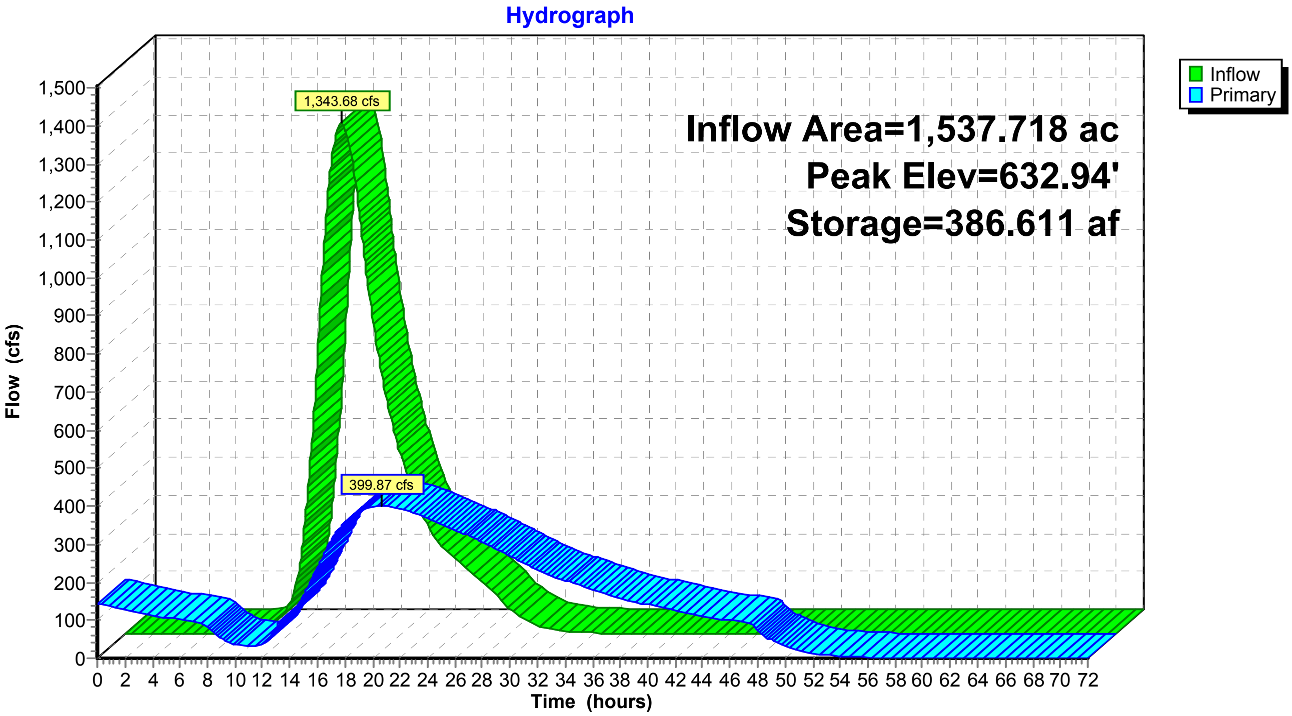
| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 630.00' | 1,876.500 af | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (acres) | Inc.Store (acre-feet) | Cum.Store (acre-feet) |
|---|---|---|---|
| 630.00 | 131.000 | 0.000 | 0.000 |
| 631.50 | 131.000 | 196.500 | 196.500 |
| 643.50 | 149.000 | 1,680.000 | 1,876.500 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 610.40' | **24.0" Round 24" CMP LLO**<br>L= 100.0' RCP, square edge headwall, Ke= 0.500<br>Inlet / Outlet Invert= 610.40' / 609.80' S= 0.0060 '/' Cc= 0.900<br>n= 0.025 Corrugated metal, Flow Area= 3.14 sf |
| #2 | Primary | 629.25' | **108.0" W x 67.2" H Box Culvert X 2.00**<br>L= 28.0' Box, headwall w/3 square edges, Ke= 0.500<br>Inlet / Outlet Invert= 629.25' / 628.95' S= 0.0107 '/' Cc= 0.900<br>n= 0.013, Flow Area= 50.40 sf |
| #3 | Primary | 635.50' | **100.0' long (Profile 1) Broad-Crested Rectangular Weir**<br>Head (feet) 0.49 0.98 1.48<br>Coef. (English) 2.92 3.37 3.59 |

**Primary OutFlow** Max=399.84 cfs @ 20.58 hrs HW=632.94' (Free Discharge)
├─**1=24" CMP LLO** (Barrel Controls 46.90 cfs @ 14.93 fps)
├─**2=Culvert** (Barrel Controls 352.95 cfs @ 7.09 fps)
└─**3=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

## Pond 1P: Ramshorn Pond Dam (Stop Logs Out / Gate Open)



## Hydrograph for Pond 1P: Ramshorn Pond Dam (Stop Logs Out / Gate Open)

| Time (hours) | Inflow (cfs) | Storage (acre-feet) | Elevation (feet) | Primary (cfs) |
|---|---|---|---|---|
| 0.00 | 0.00 | 91.700 | 630.70 | 143.43 |
| 2.50 | 0.00 | 64.110 | 630.49 | 123.90 |
| 5.00 | 0.00 | 40.342 | 630.31 | 106.83 |
| 7.50 | 0.01 | 19.735 | 630.15 | 93.12 |
| 10.00 | 9.52 | 7.156 | 630.05 | 37.14 |
| 12.50 | 141.75 | 10.183 | 630.08 | 52.85 |
| 15.00 | **1,246.01** | 122.610 | 630.94 | 165.75 |
| 17.50 | **950.11** | 322.809 | 632.46 | 337.11 |
| 20.00 | 467.50 | **385.020** | **632.93** | **398.27** |
| 22.50 | 254.86 | **374.433** | **632.85** | **387.61** |
| 25.00 | 166.72 | 340.130 | 632.59 | 353.80 |
| 27.50 | 81.19 | 297.396 | 632.27 | 313.12 |
| 30.00 | 21.55 | 246.890 | 631.88 | 267.20 |
| 32.50 | 5.46 | 198.524 | 631.52 | 225.64 |
| 35.00 | 1.29 | 156.169 | 631.19 | 191.37 |
| 37.50 | 0.21 | 119.726 | 630.91 | 163.64 |
| 40.00 | 0.00 | 88.338 | 630.67 | 141.08 |
| 42.50 | 0.00 | 61.207 | 630.47 | 121.75 |
| 45.00 | 0.00 | 37.838 | 630.29 | 105.08 |
| 47.50 | 0.00 | 17.552 | 630.13 | 91.09 |
| 50.00 | 0.00 | 6.007 | 630.05 | 31.17 |
| 52.50 | 0.00 | 2.056 | 630.02 | 10.67 |
| 55.00 | 0.00 | 0.704 | 630.01 | 3.65 |
| 57.50 | 0.00 | 0.241 | 630.00 | 1.25 |
| 60.00 | 0.00 | 0.082 | 630.00 | 0.43 |
| 62.50 | 0.00 | 0.028 | 630.00 | 0.15 |
| 65.00 | 0.00 | 0.010 | 630.00 | 0.05 |
| 67.50 | 0.00 | 0.003 | 630.00 | 0.02 |
| 70.00 | 0.00 | 0.001 | 630.00 | 0.01 |

### Stage-Discharge for Pond 1P: Ramshorn Pond Dam (Stop Logs Out / Gate Open)

| Elevation (feet) | Primary (cfs) | Elevation (feet) | Primary (cfs) |
|---|---|---|---|
| 630.00 | 0.00 | 637.65 | 2,319.58 |
| 630.15 | 93.03 | 637.80 | 2,456.01 |
| 630.30 | 106.04 | 637.95 | 2,596.21 |
| 630.45 | 120.00 | 638.10 | 2,740.05 |
| 630.60 | 134.36 | 638.25 | 2,887.44 |
| 630.75 | 148.05 | 638.40 | 3,038.28 |
| 630.90 | 162.25 | 638.55 | 3,192.48 |
| 631.05 | 176.96 | 638.70 | 3,349.96 |
| 631.20 | 192.15 | 638.85 | 3,510.65 |
| 631.35 | 207.82 | 639.00 | 3,674.48 |
| 631.50 | 223.94 | 639.15 | 3,841.38 |
| 631.65 | 240.51 | 639.30 | 4,011.29 |
| 631.80 | 257.51 | 639.45 | 4,184.15 |
| 631.95 | 274.93 | 639.60 | 4,359.91 |
| 632.10 | 292.77 | 639.75 | 4,538.52 |
| 632.25 | 311.02 | 639.90 | 4,719.92 |
| 632.40 | 329.66 | 640.05 | 4,904.08 |
| 632.55 | 348.69 | 640.20 | 5,090.95 |
| 632.70 | 368.10 | 640.35 | 5,280.49 |
| 632.85 | 387.88 | 640.50 | 5,472.65 |
| 633.00 | 408.04 | 640.65 | 5,667.40 |
| 633.15 | 428.55 | 640.80 | 5,864.71 |
| 633.30 | 449.41 | 640.95 | 6,064.53 |
| 633.45 | 470.62 | 641.10 | 6,266.84 |
| 633.60 | 492.18 | 641.25 | 6,471.61 |
| 633.75 | 514.07 | 641.40 | 6,678.79 |
| 633.90 | 536.30 | 641.55 | 6,888.37 |
| 634.05 | 558.85 | 641.70 | 7,100.31 |
| 634.20 | 581.73 | 641.85 | 7,314.59 |
| 634.35 | 604.93 | 642.00 | 7,531.17 |
| 634.50 | 628.44 | 642.15 | 7,750.05 |
| 634.65 | 652.26 | 642.30 | 7,971.18 |
| 634.80 | 676.38 | 642.45 | 8,194.55 |
| 634.95 | 700.81 | 642.60 | 8,420.13 |
| 635.10 | 725.54 | 642.75 | 8,647.90 |
| 635.25 | 750.56 | 642.90 | 8,877.83 |
| 635.40 | 775.87 | 643.05 | 9,109.92 |
| 635.55 | 804.74 | 643.20 | 9,344.13 |
| 635.70 | 853.48 | 643.35 | 9,580.45 |
| 635.85 | 913.99 | 643.50 | **9,818.85** |
| 636.00 | 983.54 | | |
| 636.15 | 1,067.43 | | |
| 636.30 | 1,163.01 | | |
| 636.45 | 1,270.46 | | |
| 636.60 | 1,383.39 | | |
| 636.75 | 1,497.02 | | |
| 636.90 | 1,630.59 | | |
| 637.05 | 1,765.79 | | |
| 637.20 | 1,899.11 | | |
| 637.35 | 2,036.23 | | |
| 637.50 | 2,177.04 | | |

## Stage-Area-Storage for Pond 1P: Ramshorn Pond Dam (Stop Logs Out / Gate Open)

| Elevation (feet) | Surface (acres) | Storage (acre-feet) |
|---|---|---|
| 630.00 | 131.000 | 0.000 |
| 630.15 | 131.000 | 19.650 |
| 630.30 | 131.000 | 39.300 |
| 630.45 | 131.000 | 58.950 |
| 630.60 | 131.000 | 78.600 |
| 630.75 | 131.000 | 98.250 |
| 630.90 | 131.000 | 117.900 |
| 631.05 | 131.000 | 137.550 |
| 631.20 | 131.000 | 157.200 |
| 631.35 | 131.000 | 176.850 |
| 631.50 | 131.000 | 196.500 |
| 631.65 | 131.225 | 216.167 |
| 631.80 | 131.450 | 235.867 |
| 631.95 | 131.675 | 255.602 |
| 632.10 | 131.900 | 275.370 |
| 632.25 | 132.125 | 295.172 |
| 632.40 | 132.350 | 315.007 |
| 632.55 | 132.575 | 334.877 |
| 632.70 | 132.800 | 354.780 |
| 632.85 | 133.025 | 374.717 |
| 633.00 | 133.250 | 394.687 |
| 633.15 | 133.475 | 414.692 |
| 633.30 | 133.700 | 434.730 |
| 633.45 | 133.925 | 454.802 |
| 633.60 | 134.150 | 474.908 |
| 633.75 | 134.375 | 495.047 |
| 633.90 | 134.600 | 515.220 |
| 634.05 | 134.825 | 535.427 |
| 634.20 | 135.050 | 555.668 |
| 634.35 | 135.275 | 575.942 |
| 634.50 | 135.500 | 596.250 |
| 634.65 | 135.725 | 616.592 |
| 634.80 | 135.950 | 636.967 |
| 634.95 | 136.175 | 657.377 |
| 635.10 | 136.400 | 677.820 |
| 635.25 | 136.625 | 698.297 |
| 635.40 | 136.850 | 718.807 |
| 635.55 | 137.075 | 739.352 |
| 635.70 | 137.300 | 759.930 |
| 635.85 | 137.525 | 780.542 |
| 636.00 | 137.750 | 801.187 |
| 636.15 | 137.975 | 821.867 |
| 636.30 | 138.200 | 842.580 |
| 636.45 | 138.425 | 863.327 |
| 636.60 | 138.650 | 884.108 |
| 636.75 | 138.875 | 904.922 |
| 636.90 | 139.100 | 925.770 |
| 637.05 | 139.325 | 946.652 |
| 637.20 | 139.550 | 967.568 |
| 637.35 | 139.775 | 988.517 |
| 637.50 | 140.000 | 1,009.500 |
| 637.65 | 140.225 | 1,030.517 |
| 637.80 | 140.450 | 1,051.567 |
| 637.95 | 140.675 | 1,072.652 |
| 638.10 | 140.900 | 1,093.770 |
| 638.25 | 141.125 | 1,114.922 |
| 638.40 | 141.350 | 1,136.107 |
| 638.55 | 141.575 | 1,157.327 |
| 638.70 | 141.800 | 1,178.580 |
| 638.85 | 142.025 | 1,199.867 |
| 639.00 | 142.250 | 1,221.187 |
| 639.15 | 142.475 | 1,242.542 |
| 639.30 | 142.700 | 1,263.930 |
| 639.45 | 142.925 | 1,285.352 |
| 639.60 | 143.150 | 1,306.808 |
| 639.75 | 143.375 | 1,328.297 |
| 639.90 | 143.600 | 1,349.820 |
| 640.05 | 143.825 | 1,371.377 |
| 640.20 | 144.050 | 1,392.968 |
| 640.35 | 144.275 | 1,414.592 |
| 640.50 | 144.500 | 1,436.250 |
| 640.65 | 144.725 | 1,457.942 |
| 640.80 | 144.950 | 1,479.667 |
| 640.95 | 145.175 | 1,501.427 |
| 641.10 | 145.400 | 1,523.220 |
| 641.25 | 145.625 | 1,545.047 |
| 641.40 | 145.850 | 1,566.907 |
| 641.55 | 146.075 | 1,588.802 |
| 641.70 | 146.300 | 1,610.730 |
| 641.85 | 146.525 | 1,632.692 |
| 642.00 | 146.750 | 1,654.687 |
| 642.15 | 146.975 | 1,676.717 |
| 642.30 | 147.200 | 1,698.780 |
| 642.45 | 147.425 | 1,720.877 |
| 642.60 | 147.650 | 1,743.008 |
| 642.75 | 147.875 | 1,765.172 |
| 642.90 | 148.100 | 1,787.370 |
| 643.05 | 148.325 | 1,809.602 |
| 643.20 | 148.550 | 1,831.868 |
| 643.35 | 148.775 | 1,854.167 |
| 643.50 | **149.000** | **1,876.500** |

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

**SubcatchmentEDA-01: Subcat EDA-01** Runoff Area=1,537.718 ac 13.97% Impervious Runoff Depth=9.04"
Flow Length=11,300' Tc=276.8 min CN=72 Runoff=2,251.52 cfs 1,158.008 af

**Pond 1P: Ramshorn Pond Dam** Peak Elev=634.93' Storage=654.329 af Inflow=2,251.52 cfs 1,158.008 af
Outflow=697.18 cfs 1,249.999 af

**Total Runoff Area = 1,537.718 ac Runoff Volume = 1,158.008 af Average Runoff Depth = 9.04"**
**86.03% Pervious = 1,322.966 ac 13.97% Impervious = 214.752 ac**

## Summary for Subcatchment EDA-01: Subcat EDA-01

Runoff = 2,251.52 cfs @ 15.68 hrs, Volume= 1,158.008 af, Depth= 9.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr Half PMF Rainfall=12.75"

| Area (ac) | CN | Description |
|---|---|---|
| 8.425 | 77 | Woods, Good, HSG D |
| 0.273 | 78 | Meadow, non-grazed, HSG D |
| 0.000 | 84 | 1 acre lots, 20% imp, HSG D |
| 1.355 | 70 | Woods, Good, HSG C |
| 0.698 | 65 | Brush, Good, HSG C |
| 3.065 | 70 | Woods, Good, HSG C |
| 0.022 | 65 | Brush, Good, HSG C |
| 0.148 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.025 | 98 | Paved parking, HSG C |
| 0.014 | 98 | Water Surface, HSG C |
| 0.323 | 98 | Water Surface, HSG C |
| 1.450 | 98 | Water Surface, HSG C |
| 10.748 | 70 | Woods, Good, HSG C |
| 0.498 | 55 | Woods, Good, HSG B |
| 0.476 | 98 | Paved parking, HSG B |
| 2.799 | 55 | Woods, Good, HSG B |
| 0.327 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.238 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.277 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.578 | 68 | 1 acre lots, 20% imp, HSG B |
| 3.500 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 4.044 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.012 | 98 | Paved parking, HSG B |
| 0.301 | 98 | Water Surface, HSG B |
| 12.253 | 77 | Woods, Good, HSG D |
| 0.109 | 98 | Paved parking, HSG D |
| 0.157 | 77 | Woods, Good, HSG D |
| 0.873 | 78 | Meadow, non-grazed, HSG D |
| 0.007 | 84 | 1 acre lots, 20% imp, HSG D |
| 0.062 | 92 | 1/8 acre lots, 65% imp, HSG D |
| 0.312 | 98 | Water Surface, HSG D |
| 5.188 | 77 | Woods, Good, HSG D |
| 0.251 | 73 | Brush, Good, HSG D |
| 13.278 | 98 | Water Surface, HSG D |
| 1.976 | 71 | Meadow, non-grazed, HSG C |
| 0.483 | 71 | Meadow, non-grazed, HSG C |
| 3.826 | 98 | Water Surface, HSG D |
| 1.244 | 98 | Water Surface, HSG D |
| 0.025 | 98 | Water Surface, HSG D |
| 0.013 | 86 | 1/3 acre lots, 30% imp, HSG D |
| 0.268 | 85 | 1/2 acre lots, 25% imp, HSG D |
| 0.247 | 82 | 2 acre lots, 12% imp, HSG D |
| 0.145 | 98 | Paved parking, HSG D |
| 15.857 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 5.976 | 77 | Woods, Good, HSG D |
| 1.296 | 73 | Brush, Good, HSG D |
| 77.304 | 70 | Woods, Good, HSG C |
| 13.578 | 77 | Woods, Good, HSG D |
| 0.886 | 65 | Brush, Good, HSG C |

| | | |
|---|---|---|
| 7.779 | 65 | Brush, Good, HSG C |
| 7.953 | 70 | Woods, Good, HSG C |
| 1.881 | 65 | Brush, Good, HSG C |
| 5.663 | 65 | Brush, Good, HSG C |
| 10.415 | 70 | Woods, Good, HSG C |
| 3.987 | 70 | Woods, Good, HSG C |
| 1.795 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.009 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.004 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.116 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.359 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.036 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.330 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.037 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.011 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.173 | 70 | Woods, Good, HSG C |
| 28.188 | 70 | Woods, Good, HSG C |
| 0.045 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 0.212 | 70 | Woods, Good, HSG C |
| 0.102 | 70 | Woods, Good, HSG C |
| 0.054 | 70 | Woods, Good, HSG C |
| 0.044 | 70 | Woods, Good, HSG C |
| 0.006 | 70 | Woods, Good, HSG C |
| 0.817 | 70 | Woods, Good, HSG C |
| 0.095 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.043 | 70 | Woods, Good, HSG C |
| 0.411 | 70 | Woods, Good, HSG C |
| 0.000 | 70 | Woods, Good, HSG C |
| 0.299 | 98 | Paved parking, HSG C |
| 3.242 | 98 | Paved parking, HSG C |
| 67.114 | 70 | Woods, Good, HSG C |
| 0.145 | 70 | Woods, Good, HSG C |
| 171.240 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.241 | 70 | Woods, Good, HSG C |
| 0.002 | 70 | Woods, Good, HSG C |
| 0.009 | 70 | Woods, Good, HSG C |
| 0.001 | 70 | Woods, Good, HSG C |
| 0.010 | 70 | Woods, Good, HSG C |
| 0.031 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.000 | 70 | Woods, Good, HSG C |
| 0.105 | 70 | Woods, Good, HSG C |
| 16.574 | 55 | Woods, Good, HSG B |
| 0.219 | 98 | Water Surface, HSG C |
| 0.005 | 98 | Water Surface, HSG C |

| | | |
|---|---|---|
| 0.579 | 98 | Water Surface, HSG C |
| 0.046 | 98 | Water Surface, HSG C |
| 11.283 | 70 | Woods, Good, HSG C |
| 87.275 | 70 | Woods, Good, HSG C |
| 0.149 | 73 | Brush, Good, HSG D |
| 31.112 | 77 | Woods, Good, HSG D |
| 2.536 | 98 | Water Surface, HSG D |
| 0.040 | 98 | Paved parking, HSG D |
| 0.375 | 84 | 1 acre lots, 20% imp, HSG D |
| 8.249 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 35.868 | 77 | Woods, Good, HSG D |
| 0.006 | 98 | Paved parking, HSG B |
| 0.000 | 98 | Paved parking, HSG B |
| 0.163 | 98 | Paved parking, HSG C |
| 0.006 | 98 | Paved parking, HSG C |
| 0.457 | 98 | Paved parking, HSG C |
| 0.001 | 98 | Paved parking, HSG C |
| 0.837 | 98 | Paved parking, HSG B |
| 0.179 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.966 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.327 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.000 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.003 | 68 | 1 acre lots, 20% imp, HSG B |
| 4.100 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.074 | 58 | Meadow, non-grazed, HSG B |
| 0.044 | 70 | Woods, Good, HSG C |
| 1.189 | 70 | Woods, Good, HSG C |
| 1.933 | 55 | Woods, Good, HSG B |
| 0.000 | 55 | Woods, Good, HSG B |
| 0.101 | 55 | Woods, Good, HSG B |
| 0.016 | 70 | Woods, Good, HSG C |
| 4.196 | 70 | Woods, Good, HSG C |
| 0.006 | 70 | Woods, Good, HSG C |
| 0.256 | 55 | Woods, Good, HSG B |
| 0.454 | 55 | Woods, Good, HSG B |
| 0.394 | 98 | Water Surface, HSG B |
| 0.175 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 1.165 | 75 | 1/4 acre lots, 38% imp, HSG B |
| 0.669 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.058 | 58 | Meadow, non-grazed, HSG B |
| 0.622 | 58 | Meadow, non-grazed, HSG B |
| 0.023 | 70 | Woods, Good, HSG C |
| 0.010 | 70 | Woods, Good, HSG C |
| 0.055 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 14.294 | 70 | Woods, Good, HSG C |
| 0.031 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 23.662 | 55 | Woods, Good, HSG B |
| 6.009 | 30 | Woods, Good, HSG A |

| | | |
|---|---|---|
| 0.098 | 98 | Paved parking, HSG B |
| 0.046 | 98 | Paved parking, HSG C |
| 0.112 | 98 | Paved parking, HSG C |
| 0.133 | 98 | Paved parking, HSG B |
| 0.022 | 98 | Paved parking, HSG C |
| 1.187 | 98 | Paved parking, HSG C |
| 0.374 | 98 | Paved parking, HSG B |
| 0.037 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.298 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.849 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.563 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.302 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.035 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.047 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.665 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.016 | 74 | Pasture/grassland/range, Good, HSG C |
| 3.444 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.011 | 61 | Pasture/grassland/range, Good, HSG B |
| 0.017 | 70 | Woods, Good, HSG C |
| 7.092 | 55 | Woods, Good, HSG B |
| 0.006 | 55 | Woods, Good, HSG B |
| 2.752 | 70 | Woods, Good, HSG C |
| 0.025 | 70 | Woods, Good, HSG C |
| 1.116 | 55 | Woods, Good, HSG B |
| 1.024 | 55 | Woods, Good, HSG B |
| 0.205 | 98 | Paved parking, HSG B |
| 0.706 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.190 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.384 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.249 | 61 | Pasture/grassland/range, Good, HSG B |
| 0.454 | 58 | Meadow, non-grazed, HSG B |
| 0.947 | 58 | Meadow, non-grazed, HSG B |
| 1.163 | 58 | Meadow, non-grazed, HSG B |
| 0.023 | 55 | Woods, Good, HSG B |
| 0.338 | 55 | Woods, Good, HSG B |
| 0.019 | 55 | Woods, Good, HSG B |
| 0.433 | 72 | 1/3 acre lots, 30% imp, HSG B |
| 0.697 | 68 | 1 acre lots, 20% imp, HSG B |
| 2.388 | 65 | 2 acre lots, 12% imp, HSG B |
| 0.308 | 58 | Meadow, non-grazed, HSG B |
| 0.632 | 48 | Brush, Good, HSG B |
| 1.693 | 70 | Woods, Good, HSG C |
| 3.529 | 70 | Woods, Good, HSG C |
| 0.127 | 70 | Woods, Good, HSG C |
| 15.057 | 55 | Woods, Good, HSG B |
| 0.175 | 98 | Water Surface, HSG B |
| 0.037 | 98 | Paved parking, HSG C |
| 0.464 | 98 | Paved parking, HSG C |
| 1.392 | 98 | Paved parking, HSG B |
| 1.075 | 96 | Gravel surface, HSG B |
| 0.808 | 92 | Urban commercial, 85% imp, HSG B |

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|---|---|---|
| 0.137 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.000 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.614 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.821 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.005 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.048 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.001 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 3.340 | 70 | 1/2 acre lots, 25% imp, HSG B |
| 0.622 | 68 | 1 acre lots, 20% imp, HSG B |
| 15.443 | 65 | Brush, Good, HSG C |
| 0.078 | 65 | Brush, Good, HSG C |
| 7.163 | 48 | Brush, Good, HSG B |
| 0.977 | 48 | Brush, Good, HSG B |
| 0.037 | 70 | Woods, Good, HSG C |
| 0.026 | 70 | Woods, Good, HSG C |
| 0.037 | 70 | Woods, Good, HSG C |
| 0.097 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 0.176 | 70 | Woods, Good, HSG C |
| 0.050 | 70 | Woods, Good, HSG C |
| 0.087 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 20.504 | 55 | Woods, Good, HSG B |
| 1.932 | 55 | Woods, Good, HSG B |
| 166.461 | 70 | Woods, Good, HSG C |
| 86.903 | 55 | Woods, Good, HSG B |
| 0.137 | 85 | 1/8 acre lots, 65% imp, HSG B |
| 0.242 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.315 | 68 | 1 acre lots, 20% imp, HSG B |
| 0.059 | 58 | Meadow, non-grazed, HSG B |
| 9.307 | 55 | Woods, Good, HSG B |
| 0.101 | 70 | Woods, Good, HSG C |
| 0.818 | 70 | Woods, Good, HSG C |
| 0.456 | 70 | Woods, Good, HSG C |
| 10.414 | 70 | Woods, Good, HSG C |
| 0.003 | 70 | Woods, Good, HSG C |
| 0.039 | 70 | Woods, Good, HSG C |
| 3.007 | 70 | Woods, Good, HSG C |
| 1.704 | 70 | Woods, Good, HSG C |
| 3.962 | 70 | Woods, Good, HSG C |
| 0.042 | 70 | Woods, Good, HSG C |
| 6.320 | 70 | Woods, Good, HSG C |
| 0.153 | 70 | Woods, Good, HSG C |
| 0.148 | 70 | Woods, Good, HSG C |
| 0.038 | 70 | Woods, Good, HSG C |
| 0.004 | 70 | Woods, Good, HSG C |
| 0.038 | 65 | Brush, Good, HSG C |
| 1.122 | 71 | Meadow, non-grazed, HSG C |

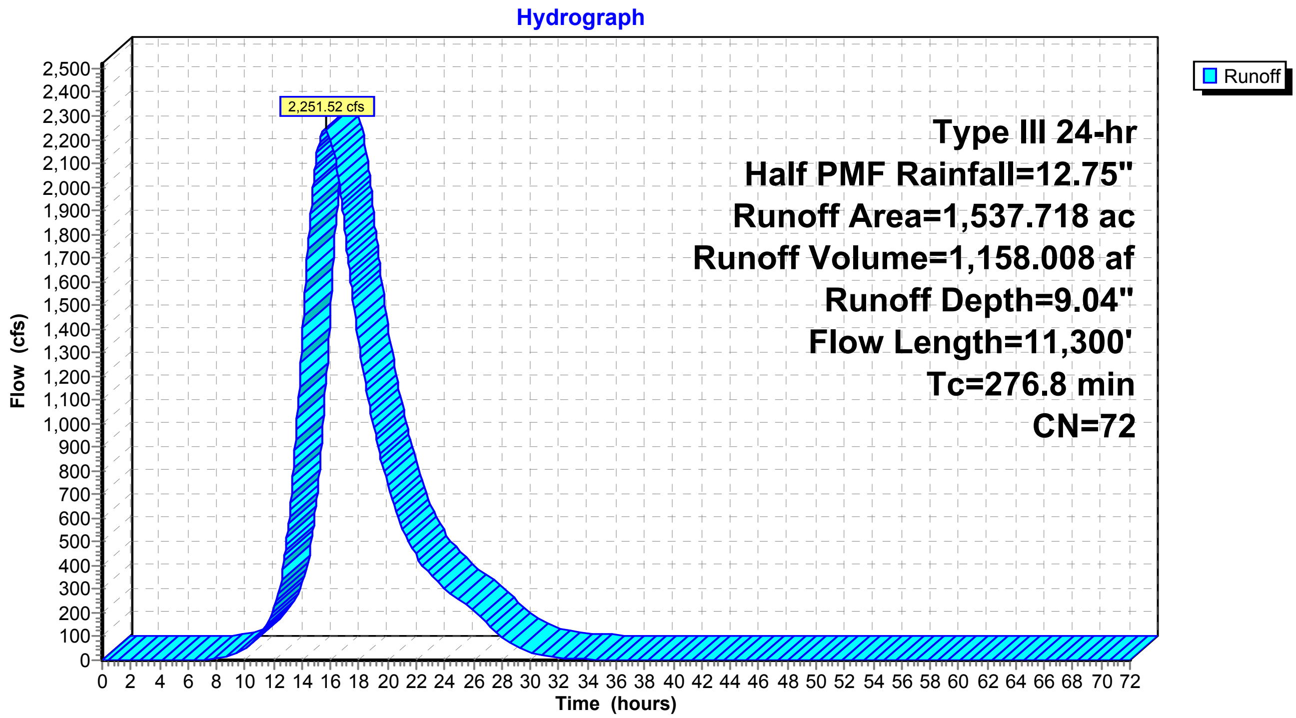
| | | |
|---|---|---|
| 0.109 | 71 | Meadow, non-grazed, HSG C |
| 1.365 | 71 | Meadow, non-grazed, HSG C |
| 10.877 | 71 | Meadow, non-grazed, HSG C |
| 4.101 | 71 | Meadow, non-grazed, HSG C |
| 0.504 | 71 | Meadow, non-grazed, HSG C |
| 0.233 | 71 | Meadow, non-grazed, HSG C |
| 0.020 | 71 | Meadow, non-grazed, HSG C |
| 0.341 | 71 | Meadow, non-grazed, HSG C |
| 0.657 | 71 | Meadow, non-grazed, HSG C |
| 0.206 | 71 | Meadow, non-grazed, HSG C |
| 0.902 | 71 | Meadow, non-grazed, HSG C |
| 2.991 | 71 | Meadow, non-grazed, HSG C |
| 0.144 | 71 | Meadow, non-grazed, HSG C |
| 0.431 | 71 | Meadow, non-grazed, HSG C |
| 2.758 | 71 | Meadow, non-grazed, HSG C |
| 12.700 | 71 | Meadow, non-grazed, HSG C |
| 0.842 | 71 | Meadow, non-grazed, HSG C |
| 0.657 | 71 | Meadow, non-grazed, HSG C |
| 0.366 | 71 | Meadow, non-grazed, HSG C |
| 7.832 | 71 | Meadow, non-grazed, HSG C |
| 4.144 | 71 | Meadow, non-grazed, HSG C |
| 7.707 | 71 | Meadow, non-grazed, HSG C |
| 2.530 | 71 | Meadow, non-grazed, HSG C |
| 11.385 | 71 | Meadow, non-grazed, HSG C |
| 0.630 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.640 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.499 | 74 | Pasture/grassland/range, Good, HSG C |
| 13.839 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.627 | 74 | Pasture/grassland/range, Good, HSG C |
| 2.343 | 74 | Pasture/grassland/range, Good, HSG C |
| 5.380 | 74 | Pasture/grassland/range, Good, HSG C |
| 5.277 | 74 | Pasture/grassland/range, Good, HSG C |
| 0.973 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.397 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.305 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.393 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.514 | 77 | 2 acre lots, 12% imp, HSG C |
| 2.524 | 77 | 2 acre lots, 12% imp, HSG C |
| 2.394 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.189 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.468 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.871 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.100 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.354 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.571 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.505 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.717 | 77 | 2 acre lots, 12% imp, HSG C |
| 3.826 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.915 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.534 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.770 | 77 | 2 acre lots, 12% imp, HSG C |

| | | |
|---|---|---|
| 3.858 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.574 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.281 | 77 | 2 acre lots, 12% imp, HSG C |
| 7.505 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.572 | 77 | 2 acre lots, 12% imp, HSG C |
| 1.975 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.064 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.008 | 77 | 2 acre lots, 12% imp, HSG C |
| 0.728 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.158 | 79 | 1 acre lots, 20% imp, HSG C |
| 4.048 | 79 | 1 acre lots, 20% imp, HSG C |
| 5.884 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.343 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.603 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.637 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.343 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.018 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.013 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.271 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.676 | 79 | 1 acre lots, 20% imp, HSG C |
| 4.173 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.718 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.650 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.391 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.502 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.951 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.101 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.729 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.213 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.913 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.682 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.329 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.195 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.151 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.769 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.778 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.568 | 79 | 1 acre lots, 20% imp, HSG C |
| 0.556 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.929 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.373 | 79 | 1 acre lots, 20% imp, HSG C |
| 3.959 | 79 | 1 acre lots, 20% imp, HSG C |
| 1.846 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.247 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 2.760 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.368 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 3.192 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.198 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.532 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.696 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 1.923 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 4.241 | 80 | 1/2 acre lots, 25% imp, HSG C |

| | | |
|---|---|---|
| 0.416 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 0.100 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 2.333 | 80 | 1/2 acre lots, 25% imp, HSG C |
| 5.698 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.035 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.234 | 81 | 1/3 acre lots, 30% imp, HSG C |
| 0.273 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.768 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.140 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.236 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.149 | 83 | 1/4 acre lots, 38% imp, HSG C |
| 0.114 | 90 | 1/8 acre lots, 65% imp, HSG C |
| 0.123 | 90 | 1/8 acre lots, 65% imp, HSG C |
| 0.632 | 91 | Urban industrial, 72% imp, HSG C |
| 0.458 | 94 | Urban commercial, 85% imp, HSG C |
| 4.350 | 96 | Gravel surface, HSG C |
| 0.600 | 96 | Gravel surface, HSG C |
| 0.084 | 98 | Paved parking, HSG C |
| 0.838 | 98 | Paved parking, HSG C |
| 0.888 | 98 | Paved parking, HSG C |
| 1.068 | 98 | Paved parking, HSG C |
| 2.929 | 98 | Paved parking, HSG C |
| 0.085 | 98 | Paved parking, HSG C |
| 0.041 | 98 | Paved parking, HSG C |
| 0.595 | 98 | Paved parking, HSG C |
| 0.083 | 98 | Paved parking, HSG C |
| 0.290 | 98 | Paved parking, HSG C |
| 0.279 | 98 | Paved parking, HSG C |
| 127.500 | 98 | Water Surface, HSG C |
| 14.980 | 98 | Water Surface, HSG C |
| 0.019 | 98 | Water Surface, HSG C |
| 0.033 | 98 | Water Surface, HSG C |
| 1,537.718 | 72 | Weighted Average |
| 1,322.966 | | 86.03% Pervious Area |
| 214.752 | | 13.97% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|---|---|---|---|---|---|
| 42.9 | 100 | 0.0140 | 0.04 | | **Sheet Flow,**<br>Woods: Dense underbrush n= 0.800 P2= 3.24" |
| 33.8 | 600 | 0.0140 | 0.30 | | **Shallow Concentrated Flow,**<br>Forest w/Heavy Litter Kv= 2.5 fps |
| 27.4 | 700 | 0.0290 | 0.43 | | **Shallow Concentrated Flow,**<br>Forest w/Heavy Litter Kv= 2.5 fps |
| 48.5 | 1,800 | 0.0611 | 0.62 | | **Shallow Concentrated Flow,**<br>Forest w/Heavy Litter Kv= 2.5 fps |
| 23.6 | 500 | 0.0200 | 0.35 | | **Shallow Concentrated Flow,**<br>Forest w/Heavy Litter Kv= 2.5 fps |
| 93.3 | 1,400 | 0.0100 | 0.25 | | **Shallow Concentrated Flow,**<br>Forest w/Heavy Litter Kv= 2.5 fps |
| 2.6 | 2,200 | | 13.90 | | **Lake or Reservoir,**<br>Mean Depth= 6.00' |
| 2.0 | 800 | 0.0210 | 6.74 | 67.36 | **Channel Flow,**<br>Area= 10.0 sf Perim= 11.0' r= 0.91' n= 0.030 |
| 2.7 | 3,200 | | 19.66 | | **Lake or Reservoir,**<br>Mean Depth= 12.00' |
| 276.8 | 11,300 | Total | | | |

## Subcatchment EDA-01: Subcat EDA-01



## Hydrograph for Subcatchment EDA-01: Subcat EDA-01

| Time (hours) | Precip. (inches) | Excess (inches) | Runoff (cfs) |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 |
| 1.00 | 0.13 | 0.00 | 0.00 |
| 2.00 | 0.26 | 0.00 | 0.00 |
| 3.00 | 0.39 | 0.00 | 0.00 |
| 4.00 | 0.55 | 0.00 | 0.00 |
| 5.00 | 0.72 | 0.00 | 0.00 |
| 6.00 | 0.92 | 0.00 | 0.01 |
| 7.00 | 1.15 | 0.03 | 0.66 |
| 8.00 | 1.45 | 0.10 | 4.96 |
| 9.00 | 1.86 | 0.23 | 18.99 |
| 10.00 | 2.41 | 0.48 | 49.84 |
| 11.00 | 3.19 | 0.92 | 107.54 |
| 12.00 | 6.37 | 3.30 | 211.50 |
| 13.00 | 9.56 | 6.09 | 548.11 |
| 14.00 | 10.34 | 6.80 | 1,355.78 |
| 15.00 | 10.89 | 7.31 | **2,120.20** |
| 16.00 | 11.30 | 7.68 | **2,199.79** |
| 17.00 | 11.60 | 7.96 | 1,819.41 |
| 18.00 | 11.83 | 8.18 | 1,328.52 |
| 19.00 | 12.03 | 8.36 | 991.44 |
| 20.00 | 12.20 | 8.52 | 742.58 |
| 21.00 | 12.36 | 8.67 | 565.43 |
| 22.00 | 12.50 | 8.81 | 443.20 |
| 23.00 | 12.63 | 8.93 | 360.13 |
| 24.00 | **12.75** | **9.04** | 300.79 |
| 25.00 | 12.75 | 9.04 | 256.96 |
| 26.00 | 12.75 | 9.04 | 212.08 |
| 27.00 | 12.75 | 9.04 | 153.95 |
| 28.00 | 12.75 | 9.04 | 97.59 |
| 29.00 | 12.75 | 9.04 | 56.92 |
| 30.00 | 12.75 | 9.04 | 32.96 |
| 31.00 | 12.75 | 9.04 | 19.15 |
| 32.00 | 12.75 | 9.04 | 10.98 |
| 33.00 | 12.75 | 9.04 | 6.32 |
| 34.00 | 12.75 | 9.04 | 3.57 |
| 35.00 | 12.75 | 9.04 | 1.97 |
| 36.00 | 12.75 | 9.04 | 1.04 |
| 37.00 | 12.75 | 9.04 | 0.50 |
| 38.00 | 12.75 | 9.04 | 0.19 |
| 39.00 | 12.75 | 9.04 | 0.03 |
| 40.00 | 12.75 | 9.04 | 0.00 |
| 41.00 | 12.75 | 9.04 | 0.00 |
| 42.00 | 12.75 | 9.04 | 0.00 |
| 43.00 | 12.75 | 9.04 | 0.00 |
| 44.00 | 12.75 | 9.04 | 0.00 |
| 45.00 | 12.75 | 9.04 | 0.00 |
| 46.00 | 12.75 | 9.04 | 0.00 |
| 47.00 | 12.75 | 9.04 | 0.00 |
| 48.00 | 12.75 | 9.04 | 0.00 |
| 49.00 | 12.75 | 9.04 | 0.00 |
| 50.00 | 12.75 | 9.04 | 0.00 |
| 51.00 | 12.75 | 9.04 | 0.00 |
| 52.00 | 12.75 | 9.04 | 0.00 |
| 53.00 | 12.75 | 9.04 | 0.00 |
| 54.00 | 12.75 | 9.04 | 0.00 |
| 55.00 | 12.75 | 9.04 | 0.00 |
| 56.00 | 12.75 | 9.04 | 0.00 |
| 57.00 | 12.75 | 9.04 | 0.00 |
| 58.00 | 12.75 | 9.04 | 0.00 |
| 59.00 | 12.75 | 9.04 | 0.00 |
| 60.00 | 12.75 | 9.04 | 0.00 |
| 61.00 | 12.75 | 9.04 | 0.00 |
| 62.00 | 12.75 | 9.04 | 0.00 |
| 63.00 | 12.75 | 9.04 | 0.00 |
| 64.00 | 12.75 | 9.04 | 0.00 |
| 65.00 | 12.75 | 9.04 | 0.00 |
| 66.00 | 12.75 | 9.04 | 0.00 |
| 67.00 | 12.75 | 9.04 | 0.00 |
| 68.00 | 12.75 | 9.04 | 0.00 |
| 69.00 | 12.75 | 9.04 | 0.00 |
| 70.00 | 12.75 | 9.04 | 0.00 |
| 71.00 | 12.75 | 9.04 | 0.00 |
| 72.00 | 12.75 | 9.04 | 0.00 |

## Summary for Pond 1P: Ramshorn Pond Dam (Stop Logs Out / Gate Open)

Inflow Area = 1,537.718 ac, 13.97% Impervious, Inflow Depth = 9.04" for Half PMF event
Inflow = 2,251.52 cfs @ 15.68 hrs, Volume= 1,158.008 af
Outflow = 697.18 cfs @ 20.22 hrs, Volume= 1,249.999 af, Atten= 69%, Lag= 272.7 min
Primary = 697.18 cfs @ 20.22 hrs, Volume= 1,249.999 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs / 2
Starting Elev= 630.70' Surf.Area= 131.000 ac Storage= 91.700 af
Peak Elev= 634.93' @ 20.22 hrs Surf.Area= 136.141 ac Storage= 654.329 af (562.629 af above start)

Plug-Flow detention time= 636.5 min calculated for 1,157.495 af (100% of inflow)
Center-of-Mass det. time= 533.9 min ( 1,586.9 - 1,053.0 )

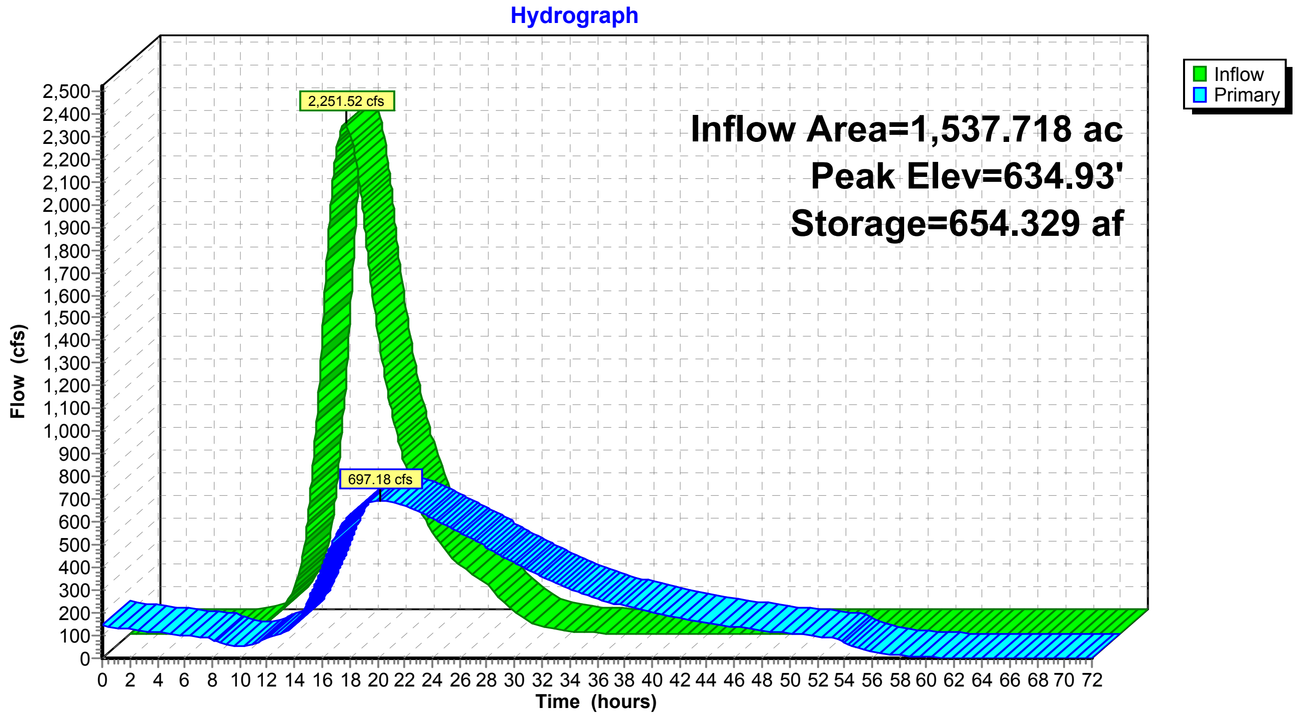
| Volume | Invert | Avail.Storage | Storage Description |
|---|---|---|---|
| #1 | 630.00' | 1,876.500 af | **Custom Stage Data (Prismatic)** Listed below (Recalc) |

| Elevation (feet) | Surf.Area (acres) | Inc.Store (acre-feet) | Cum.Store (acre-feet) |
|---|---|---|---|
| 630.00 | 131.000 | 0.000 | 0.000 |
| 631.50 | 131.000 | 196.500 | 196.500 |
| 643.50 | 149.000 | 1,680.000 | 1,876.500 |

| Device | Routing | Invert | Outlet Devices |
|---|---|---|---|
| #1 | Primary | 610.40' | **24.0" Round 24" CMP LLO**<br>L= 100.0' RCP, square edge headwall, Ke= 0.500<br>Inlet / Outlet Invert= 610.40' / 609.80' S= 0.0060 '/' Cc= 0.900<br>n= 0.025 Corrugated metal, Flow Area= 3.14 sf |
| #2 | Primary | 629.25' | **108.0" W x 67.2" H Box Culvert X 2.00**<br>L= 28.0' Box, headwall w/3 square edges, Ke= 0.500<br>Inlet / Outlet Invert= 629.25' / 628.95' S= 0.0107 '/' Cc= 0.900<br>n= 0.013, Flow Area= 50.40 sf |
| #3 | Primary | 635.50' | **100.0' long (Profile 1) Broad-Crested Rectangular Weir**<br>Head (feet) 0.49 0.98 1.48<br>Coef. (English) 2.92 3.37 3.59 |

**Primary OutFlow** Max=697.14 cfs @ 20.22 hrs HW=634.93' (Free Discharge)
├─**1=24" CMP LLO** (Barrel Controls 49.05 cfs @ 15.61 fps)
├─**2=Culvert** (Barrel Controls 648.09 cfs @ 8.46 fps)
└─**3=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

## Pond 1P: Ramshorn Pond Dam (Stop Logs Out / Gate Open)



## Hydrograph for Pond 1P: Ramshorn Pond Dam (Stop Logs Out / Gate Open)

| Time (hours) | Inflow (cfs) | Storage (acre-feet) | Elevation (feet) | Primary (cfs) |
|---|---|---|---|---|
| 0.00 | 0.00 | 91.700 | 630.70 | 143.43 |
| 2.50 | 0.00 | 64.110 | 630.49 | 123.90 |
| 5.00 | 0.00 | 40.342 | 630.31 | 106.83 |
| 7.50 | 2.06 | 19.802 | 630.15 | 93.17 |
| 10.00 | 49.84 | 9.634 | 630.07 | 50.00 |
| 12.50 | 319.84 | 24.857 | 630.19 | 96.48 |
| 15.00 | **2,120.20** | 234.670 | 631.79 | 256.49 |
| 17.50 | **1,547.33** | 565.443 | 634.27 | 592.91 |
| 20.00 | 742.58 | **653.910** | **634.92** | **696.67** |
| 22.50 | 397.62 | **624.609** | **634.71** | **661.73** |
| 25.00 | 256.96 | 561.121 | 634.24 | 587.97 |
| 27.50 | 124.31 | 488.283 | 633.70 | 506.72 |
| 30.00 | 32.96 | 407.004 | 633.09 | 420.64 |
| 32.50 | 8.34 | 331.808 | 632.53 | 345.76 |
| 35.00 | 1.97 | 267.725 | 632.04 | 285.85 |
| 37.50 | 0.32 | 213.934 | 631.63 | 238.62 |
| 40.00 | 0.00 | 168.659 | 631.29 | 201.28 |
| 42.50 | 0.00 | 130.265 | 630.99 | 171.50 |
| 45.00 | 0.00 | 97.402 | 630.74 | 147.48 |
| 47.50 | 0.00 | 69.038 | 630.53 | 127.55 |
| 50.00 | 0.00 | 44.588 | 630.34 | 109.80 |
| 52.50 | 0.00 | 23.433 | 630.18 | 95.54 |
| 55.00 | 0.00 | 8.323 | 630.06 | 43.19 |
| 57.50 | 0.00 | 2.848 | 630.02 | 14.78 |
| 60.00 | 0.00 | 0.975 | 630.01 | 5.06 |
| 62.50 | 0.00 | 0.334 | 630.00 | 1.73 |
| 65.00 | 0.00 | 0.114 | 630.00 | 0.59 |
| 67.50 | 0.00 | 0.039 | 630.00 | 0.20 |
| 70.00 | 0.00 | 0.013 | 630.00 | 0.07 |

## Stage-Discharge for Pond 1P: Ramshorn Pond Dam (Stop Logs Out / Gate Open)

| Elevation (feet) | Primary (cfs) | Elevation (feet) | Primary (cfs) |
|---|---|---|---|
| 630.00 | 0.00 | 637.65 | 2,319.58 |
| 630.15 | 93.03 | 637.80 | 2,456.01 |
| 630.30 | 106.04 | 637.95 | 2,596.21 |
| 630.45 | 120.00 | 638.10 | 2,740.05 |
| 630.60 | 134.36 | 638.25 | 2,887.44 |
| 630.75 | 148.05 | 638.40 | 3,038.28 |
| 630.90 | 162.25 | 638.55 | 3,192.48 |
| 631.05 | 176.96 | 638.70 | 3,349.96 |
| 631.20 | 192.15 | 638.85 | 3,510.65 |
| 631.35 | 207.82 | 639.00 | 3,674.48 |
| 631.50 | 223.94 | 639.15 | 3,841.38 |
| 631.65 | 240.51 | 639.30 | 4,011.29 |
| 631.80 | 257.51 | 639.45 | 4,184.15 |
| 631.95 | 274.93 | 639.60 | 4,359.91 |
| 632.10 | 292.77 | 639.75 | 4,538.52 |
| 632.25 | 311.02 | 639.90 | 4,719.92 |
| 632.40 | 329.66 | 640.05 | 4,904.08 |
| 632.55 | 348.69 | 640.20 | 5,090.95 |
| 632.70 | 368.10 | 640.35 | 5,280.49 |
| 632.85 | 387.88 | 640.50 | 5,472.65 |
| 633.00 | 408.04 | 640.65 | 5,667.40 |
| 633.15 | 428.55 | 640.80 | 5,864.71 |
| 633.30 | 449.41 | 640.95 | 6,064.53 |
| 633.45 | 470.62 | 641.10 | 6,266.84 |
| 633.60 | 492.18 | 641.25 | 6,471.61 |
| 633.75 | 514.07 | 641.40 | 6,678.79 |
| 633.90 | 536.30 | 641.55 | 6,888.37 |
| 634.05 | 558.85 | 641.70 | 7,100.31 |
| 634.20 | 581.73 | 641.85 | 7,314.59 |
| 634.35 | 604.93 | 642.00 | 7,531.17 |
| 634.50 | 628.44 | 642.15 | 7,750.05 |
| 634.65 | 652.26 | 642.30 | 7,971.18 |
| 634.80 | 676.38 | 642.45 | 8,194.55 |
| 634.95 | 700.81 | 642.60 | 8,420.13 |
| 635.10 | 725.54 | 642.75 | 8,647.90 |
| 635.25 | 750.56 | 642.90 | 8,877.83 |
| 635.40 | 775.87 | 643.05 | 9,109.92 |
| 635.55 | 804.74 | 643.20 | 9,344.13 |
| 635.70 | 853.48 | 643.35 | 9,580.45 |
| 635.85 | 913.99 | 643.50 | **9,818.85** |
| 636.00 | 983.54 | | |
| 636.15 | 1,067.43 | | |
| 636.30 | 1,163.01 | | |
| 636.45 | 1,270.46 | | |
| 636.60 | 1,383.39 | | |
| 636.75 | 1,497.02 | | |
| 636.90 | 1,630.59 | | |
| 637.05 | 1,765.79 | | |
| 637.20 | 1,899.11 | | |
| 637.35 | 2,036.23 | | |
| 637.50 | 2,177.04 | | |

## Stage-Area-Storage for Pond 1P: Ramshorn Pond Dam (Stop Logs Out / Gate Open)

| Elevation (feet) | Surface (acres) | Storage (acre-feet) | Elevation (feet) | Surface (acres) | Storage (acre-feet) |
|---|---|---|---|---|---|
| 630.00 | 131.000 | 0.000 | 637.65 | 140.225 | 1,030.517 |
| 630.15 | 131.000 | 19.650 | 637.80 | 140.450 | 1,051.567 |
| 630.30 | 131.000 | 39.300 | 637.95 | 140.675 | 1,072.652 |
| 630.45 | 131.000 | 58.950 | 638.10 | 140.900 | 1,093.770 |
| 630.60 | 131.000 | 78.600 | 638.25 | 141.125 | 1,114.922 |
| 630.75 | 131.000 | 98.250 | 638.40 | 141.350 | 1,136.107 |
| 630.90 | 131.000 | 117.900 | 638.55 | 141.575 | 1,157.327 |
| 631.05 | 131.000 | 137.550 | 638.70 | 141.800 | 1,178.580 |
| 631.20 | 131.000 | 157.200 | 638.85 | 142.025 | 1,199.867 |
| 631.35 | 131.000 | 176.850 | 639.00 | 142.250 | 1,221.187 |
| 631.50 | 131.000 | 196.500 | 639.15 | 142.475 | 1,242.542 |
| 631.65 | 131.225 | 216.167 | 639.30 | 142.700 | 1,263.930 |
| 631.80 | 131.450 | 235.867 | 639.45 | 142.925 | 1,285.352 |
| 631.95 | 131.675 | 255.602 | 639.60 | 143.150 | 1,306.808 |
| 632.10 | 131.900 | 275.370 | 639.75 | 143.375 | 1,328.297 |
| 632.25 | 132.125 | 295.172 | 639.90 | 143.600 | 1,349.820 |
| 632.40 | 132.350 | 315.007 | 640.05 | 143.825 | 1,371.377 |
| 632.55 | 132.575 | 334.877 | 640.20 | 144.050 | 1,392.968 |
| 632.70 | 132.800 | 354.780 | 640.35 | 144.275 | 1,414.592 |
| 632.85 | 133.025 | 374.717 | 640.50 | 144.500 | 1,436.250 |
| 633.00 | 133.250 | 394.687 | 640.65 | 144.725 | 1,457.942 |
| 633.15 | 133.475 | 414.692 | 640.80 | 144.950 | 1,479.667 |
| 633.30 | 133.700 | 434.730 | 640.95 | 145.175 | 1,501.427 |
| 633.45 | 133.925 | 454.802 | 641.10 | 145.400 | 1,523.220 |
| 633.60 | 134.150 | 474.908 | 641.25 | 145.625 | 1,545.047 |
| 633.75 | 134.375 | 495.047 | 641.40 | 145.850 | 1,566.907 |
| 633.90 | 134.600 | 515.220 | 641.55 | 146.075 | 1,588.802 |
| 634.05 | 134.825 | 535.427 | 641.70 | 146.300 | 1,610.730 |
| 634.20 | 135.050 | 555.668 | 641.85 | 146.525 | 1,632.692 |
| 634.35 | 135.275 | 575.942 | 642.00 | 146.750 | 1,654.687 |
| 634.50 | 135.500 | 596.250 | 642.15 | 146.975 | 1,676.717 |
| 634.65 | 135.725 | 616.592 | 642.30 | 147.200 | 1,698.780 |
| 634.80 | 135.950 | 636.967 | 642.45 | 147.425 | 1,720.877 |
| 634.95 | 136.175 | 657.377 | 642.60 | 147.650 | 1,743.008 |
| 635.10 | 136.400 | 677.820 | 642.75 | 147.875 | 1,765.172 |
| 635.25 | 136.625 | 698.297 | 642.90 | 148.100 | 1,787.370 |
| 635.40 | 136.850 | 718.807 | 643.05 | 148.325 | 1,809.602 |
| 635.55 | 137.075 | 739.352 | 643.20 | 148.550 | 1,831.868 |
| 635.70 | 137.300 | 759.930 | 643.35 | 148.775 | 1,854.167 |
| 635.85 | 137.525 | 780.542 | 643.50 | **149.000** | **1,876.500** |
| 636.00 | 137.750 | 801.187 | | | |
| 636.15 | 137.975 | 821.867 | | | |
| 636.30 | 138.200 | 842.580 | | | |
| 636.45 | 138.425 | 863.327 | | | |
| 636.60 | 138.650 | 884.108 | | | |
| 636.75 | 138.875 | 904.922 | | | |
| 636.90 | 139.100 | 925.770 | | | |
| 637.05 | 139.325 | 946.652 | | | |
| 637.20 | 139.550 | 967.568 | | | |
| 637.35 | 139.775 | 988.517 | | | |
| 637.50 | 140.000 | 1,009.500 | | | |