Belchertown High School

Stormwater Harvesting and Reuse Feasibility Evaluation and Concept Design

TOWN OF BELCHERTOWN, MASSACHUSETTS

prepared by
FUSS & O'NEILL

MAY 2020

Financial assistance was provided by the Executive Office of Energy & Environmental Affairs (EEA) under the FY19 Municipal Vulnerability Preparedness (MVP) Grant Program. The MVP Action Grant offers financial resources to municipalities that are seeking to advance priority climate adaptation actions to address climate change impacts resulting from extreme weather, sea level rise, inland and coastal flooding, severe heat, and other climate impacts.

M E M O R A N D U M

TO: Belchertown School District, Belchertown Department of Public Works, and Belchertown Water District

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DATE: May 28, 2020

RE: Stormwater Harvesting and Reuse Feasibility Evaluation and Concept Design
Belchertown High School

1. Introduction

The Belchertown Water District supplies water to residential, commercial, and municipal customers, including the Belchertown School District. Irrigation of the athletic fields at Belchertown High School accounts for a large percentage of the municipal water demand, particularly during periods of peak demand. In 2018, water usage at the High School (3.4 million gallons) was approximately 80% of the overall municipal usage (4.2 million gallons) in Belchertown, and irrigation of the athletic fields (1.1 million gallons of potable water) accounted for approximately one-third of the water used at the school.

Belchertown High School (Source: Belchertown Public Schools, http://www.belchertownps.org/belchertown-high-school).

As part of their ongoing water conservation initiatives, the Town of Belchertown and the Belchertown Water District are considering implementing a stormwater harvesting and reuse system (also referred to as a "rainwater" harvesting and reuse system[1]) for irrigation of the athletic fields at the High School.

[1] Stormwater harvesting and reuse is the practice of collecting and reusing stormwater for a potable or non-potable application. Stormwater is defined as runoff collected from roof and ground surfaces. Rainwater is defined as runoff collected from roof surfaces only. Harvesting is the collection and storage of runoff, and reuse is the potable or non-potable application of runoff.

The stormwater reuse system would reduce the demand on the Town's public water system during times of peak demand and conserve potable water for essential uses, enhancing the reliability of the water system under existing and future climate conditions. The system would also reduce runoff volumes and pollutant loads in the stormwater discharge from the site.

In 2019, the Town received a Municipal Vulnerability Preparedness (MVP) Action Grant from the Massachusetts Executive Office of Energy and Environmental Affairs to evaluate the feasibility of and develop a conceptual design for a stormwater harvesting and reuse system at Belchertown High School. This memorandum outlines the methods and findings of the feasibility evaluation and presents several recommended harvesting and reuse options for further consideration.

2. Site Description

2.1 Project Site – Belchertown High School

Belchertown High School is located at 142 Springfield Road approximately one half mile southwest of the town center in Belchertown, Massachusetts (**Figure 1**). The High School is home to grades 9 through 12 and has an enrollment of approximately 700 students. The school was constructed in 2002 and opened in the 2002-2003 school year. The 46-acre site includes a three-story building with approximately 178,000 gross square feet including a cafeteria, an auditorium, and a gymnasium with an indoor track on the upper floor. The school is served by municipal water and sewer. The building sits near the topographic high point on the site, with several parking lots, an access drive, and athletic fields and facilities situated to the south and east. The site south of the main parking lot is occupied by a series of tiered athletic fields used for field hockey, lacrosse, soccer, football, and other sports programs including the track and stadium. Baseball and softball fields are located on the southeastern portion of the site east of the main driveway. **Figure 2** shows the site layout and existing features.

2.2 Athletic Field Irrigation System

An irrigation system is used to water the High School athletic fields during the growing season. The school currently irrigates five athletic fields: the softball field, baseball field, stadium/football field, and the upper and lower multi-purpose athletic fields between the stadium and parking lot. The irrigation system only serves these athletic fields; no other landscaped areas of the school are currently irrigated. Potable water is supplied to the irrigation system from the incoming municipal water main on Springfield Road. The water line extends from Springfield Road to an on-site pump house and wet well near the main driveway at the eastern end of the track. Water is pumped through irrigation lines that feed sprinkler heads in each of the athletic fields. The irrigation system is shown schematically in **Figure 2**.

The athletic fields are irrigated approximately three times a week during the growing season. The fields are located in three irrigation zones (zone one: baseball field, zone two: softball field, zone three: stadium/football field and upper and lower multi-purpose fields). Each zone has four to five sprinkler heads that run on a timer from approximately 2:00 AM to 5:30 AM at an average rate of approximately seven gallons per minute. The fields are typically irrigated three days per week (at less than system capacity) May through September, with mid-June through August being the driest time of year and the period of highest irrigation demand. The irrigation system is equipped with a wall-mounted rain sensor that is wired into the irrigation controller, but the sensor is currently non-functional and school maintenance staff adjust the irrigation rate based on weather conditions.

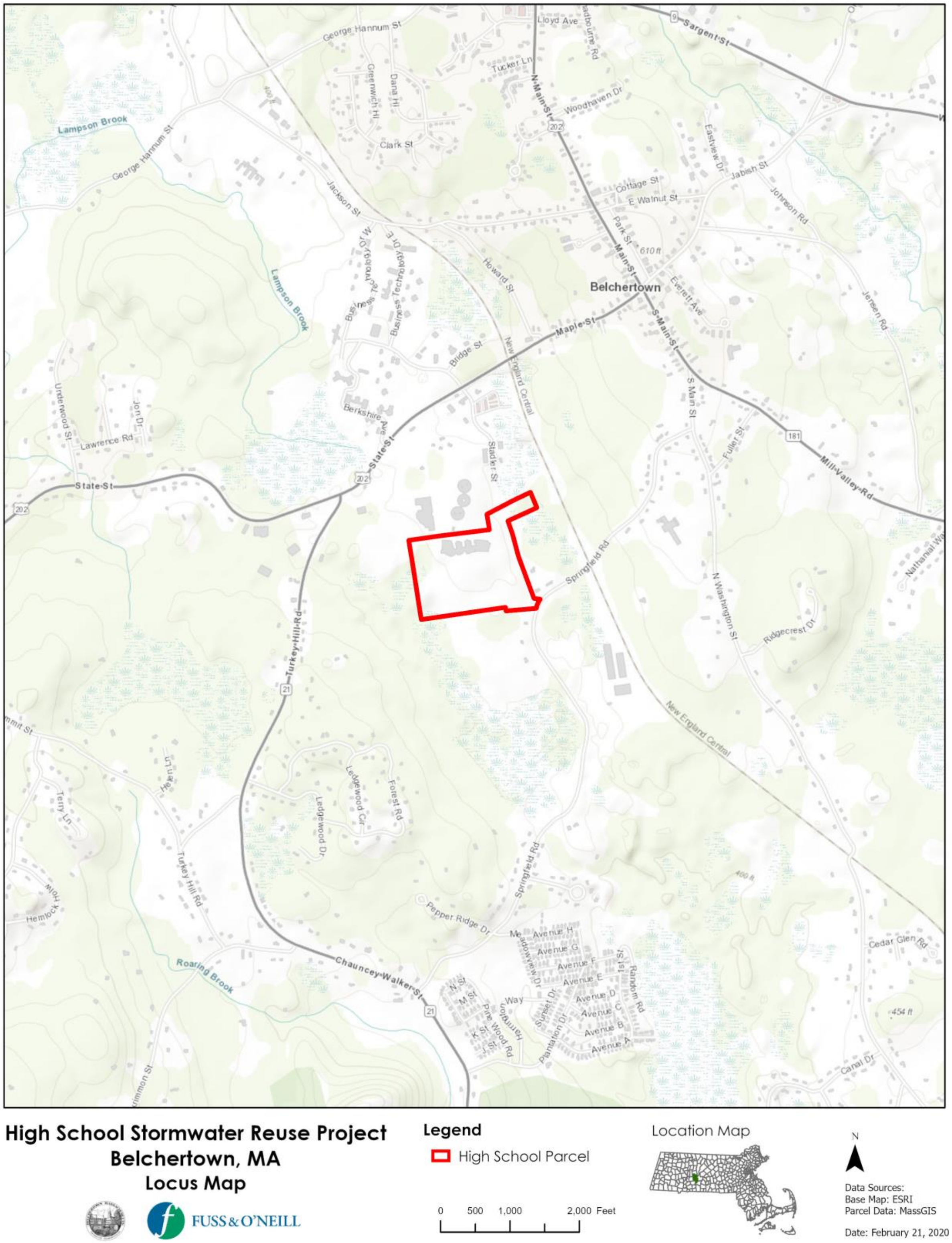


Figure 1. Site Locus Map, Belchertown High School (Belchertown, MA).

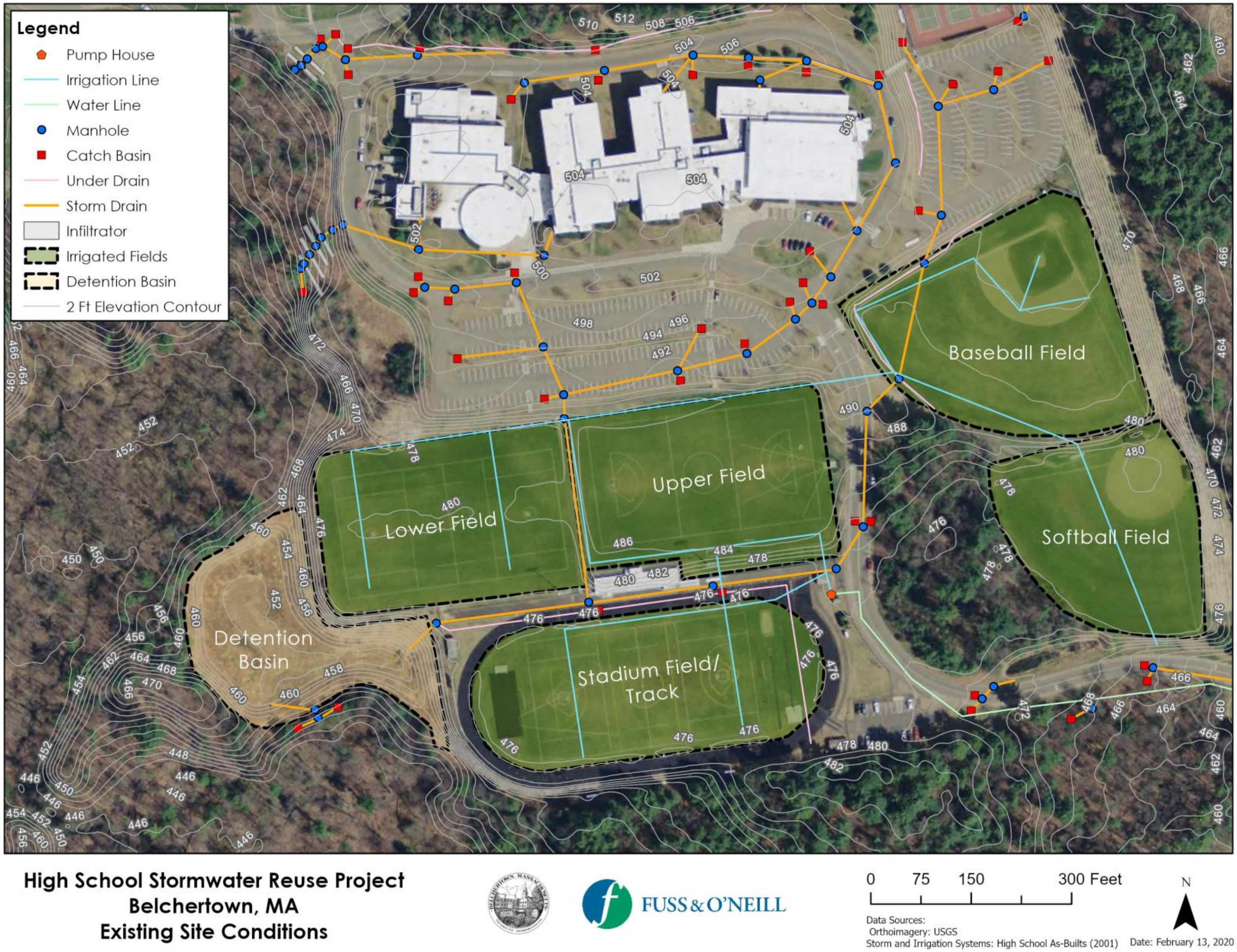


Figure 2. Existing Site Conditions, Belchertown High School.

The Belchertown Water District noted that the irrigation system was designed to operate at a maximum flow and pressure. However, the system is frequently operated above the design flow and pressure in order to provide sufficient irrigation coverage for all portions of the athletic fields. This causes operational issues when the irrigation system is restarted at the beginning of the season, and "brown water" complaints have been reported by residents who are on the same water loop as the High School as a result of the irrigation system.

2.3 Irrigation Water Demand

For this evaluation, historical irrigation water usage data for the High School were used to estimate irrigation water demand. Belchertown High School provided quarterly irrigation water billing records for December 2001 through December 2018. **Figure 3** shows total annual irrigation water usage (in thousands of gallons) for this time period.

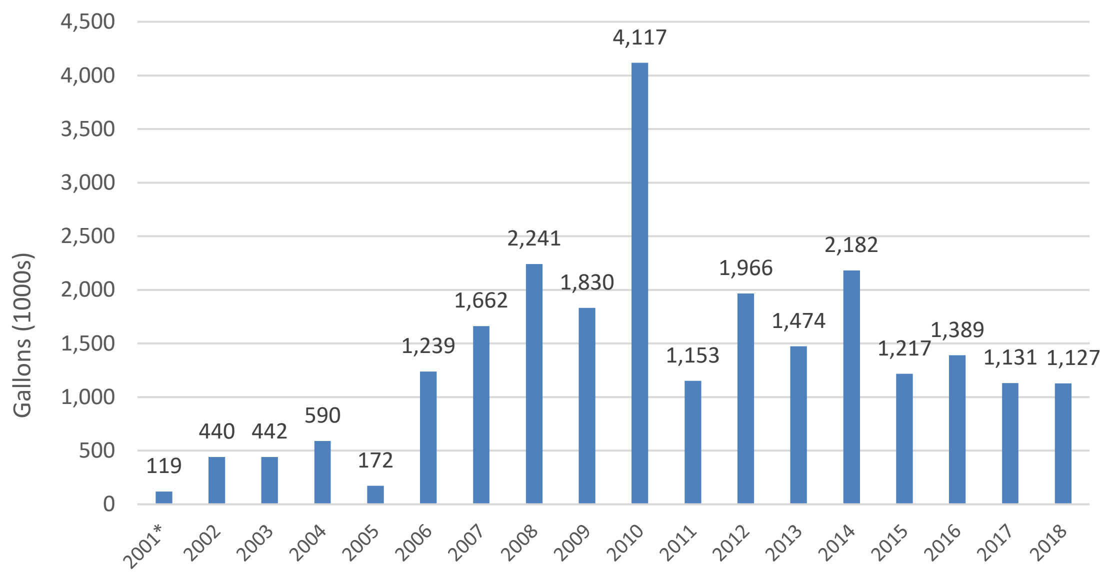


Figure 3. Annual irrigation water usage for Belchertown High School (2001-2018).

The irrigation system was installed in two phases, starting with the first phase around 2005. Prior to 2005, the fields were watered manually with sprinklers and hoses. The second phase was installed in the 2007/2008 timeframe. Prior to installation of the first phase of the irrigation system around 2005 (including in 2001 prior to opening of the school), irrigation water usage was between 100,000 and 600,000 gallons per year, which is significantly lower than the period following installation of the first phase of the irrigation system.

Between 2005 and 2018, annual irrigation water usage varied between 1.1 million gallons and a high of 4.1 million gallons in 2010. Annual irrigation water usage for most years during this timeframe was between 1.1 and 2.2 million gallons, with an average[2] of approximately 1.5 million gallons. Average daily irrigation water usage for the period 2006-2018 was approximately 10,150 gallons per day, with a peak of 34,000 gallons per day.

[2] The average excludes irrigation water usage reported in 2010, which is believed to be an outlier (an irrigation line that went unnoticed, an issue with a controller, etc.) and is not representative of current irrigation practices.

2.4 Site Drainage System

The goal of the harvesting and reuse system is to capture runoff from the site and to store/use it for irrigation of the athletic fields during the growing season, thereby reducing the need for municipal potable water for irrigation and reducing the discharge of runoff from the site. The High School's existing stormwater drainage system is shown schematically in **Figure 2**, based on record drawings that depict "as-built" conditions following completion of construction.

The site consists of several major drainage areas. A portion of the loop road and landscaped areas behind the school drains to a series of underground infiltrators at the northwest corner of the site. Overflow from the infiltrators discharges to a wooded wetland. A second drainage area encompasses approximately the western half of the building's membrane roof. Runoff from the western half of the roof is collected by roof drains that are plumbed through the building interior and discharge to a series of underground infiltrators located west of the driveway at the western end of the school. Overflow from the infiltrators discharges to a wooded wetland.

Runoff from a majority of the eastern half of the building roof is collected by roof drains that are also plumbed through the interior of the building and discharge to a series of underground infiltrators in the landscaped area at the northeast corner of the school behind the gymnasium. Overflow from these infiltrators discharges to the site storm drainage system for the eastern portion of the site, which ultimately joins the drainage system for the parking lot south of the tennis courts, the main driveway and portion of the loop road behind the school, the parking lot in front of the gymnasium and office entrance, and the driveway and main parking lot in front of the school. The site drainage system continues to the south, collecting excess runoff from the three athletic fields west of the driveway, as well as underdrains for the stadium/track field, and ultimately discharges to the large stormwater basin at the southwest corner of the site. Runoff from the softball field and lower portions of the driveway discharge to stormwater basins along the driveway and ultimately to a stream and wetland near the main entrance to the school on Springfield Road.

The site drainage system presents several opportunities to capture rainwater from the building roof and stormwater from paved and landscaped areas of the site. Runoff from rubber membrane roofs is generally considered "clean". While runoff from membrane roofs does contain pollutants (e.g., nutrients from atmospheric deposition, bacteria from bird droppings), they are generally in lower concentrations and absent from many of the pollutants present in runoff from other impervious surfaces. Runoff from parking lots, driveways, and landscaped areas typically contains higher levels of sediment, organic debris, fertilizer, and other pollutants, which can present challenges for reuse with irrigation systems, often requiring greater levels of treatment and expense prior to reuse. Typically, capture of roof runoff alone (i.e., rainwater) is preferred over runoff from ground surfaces (i.e., stormwater) since harvesting and reuse systems that rely on rainwater alone require less pre-treatment and overall system maintenance and have a longer design life. However, roof runoff alone may be insufficient to meet the irrigation goals for a given project, requiring consideration of stormwater capture from other parts of the site.

3. Harvesting and Reuse System Objectives

Based on an initial meeting with representatives of the Town, Water District, and School District, the overall objective of the harvesting and reuse system is to reduce the amount of potable water required to irrigate the athletic fields at the High School, reducing the overall demand for municipal water during periods of peak demand, conserving potable water for essential uses, and increasing the reliability of the irrigation system. A specific reduction goal (e.g., percent irrigation demand met through water reuse) was not initially established. However, the Town, Water District, and School District expressed a desire to replace as much potable irrigation water as possible (i.e., cost-effectively) with harvested water, maintaining the current levels of irrigation to the athletic fields. The system would also support the School District's STEM curriculum and serve as an outdoor classroom to teach students about sustainability, water conservation, and stormwater management.

3.1 Climate Change Considerations

Changes in precipitation and temperature resulting from a changing climate are expected to reduce the availability of runoff for reuse, reduce soil moisture for plant growth, and increase irrigation water demand during the summer and early fall. While rainfall is expected to increase in spring and winter months, increasing consecutive dry days are anticipated in the summer and fall. According to projections for Massachusetts, seasonal drought risk is projected to increase during summer and fall as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt, coupled with more variable precipitation patterns (Massachusetts Climate Change Clearinghouse "resilient MA", https://www.resilientma.org/).

Increasing temperatures are anticipated to favor a shift in turfgrass species to more northern climates, placing additional stress on established fields such as the ones at Belchertown High School. Climate change will also increase biotic stresses on turfgrass related to weeds, insects, and disease.[3] While an increase in atmospheric carbon dioxide will benefit turfgrass growth and improve water use efficiency, it is uncertain to what extent this potential benefit could counteract the potential effects of a more variable precipitation regime and warmer temperatures.

Given the complexities and uncertainty of future climate change impacts on soil moisture, turfgrass growth, and irrigation water demand, and the stakeholders' objective of replacing as much potable water use as is feasible, a conservative approach is taken in this evaluation. In general, larger stormwater reuse storage volumes are recommended to make the irrigation system more resilient to climate change over the next several decades.

4. Water Budget

A water budget tool was developed for the site to evaluate how much of the High School's irrigation demand could be achieved by a harvesting and reuse system. A water budget involves estimating the amount of stormwater/rainwater that can be captured and stored relative to the amount of water that is needed for irrigation. The water budget was used to evaluate the extent to which the irrigation water demand can be met and to help select a cost-effective water storage tank (i.e., cistern) size, weighing the initial construction cost of the harvesting and reuse system and the cost savings associated with a reduction in municipal potable water usage.

[3] J. Hatfield, Turfgrass and Climate Change, International Turfgrass Research Conference, Published June 1, 2017, https://dl.sciencesocieties.org/publications/aj/pdfs/109/4/1708.

The water budget tool was adapted from the Ramsey-Washington Metro Watershed District (RWMWD) Stormwater Reuse Credit Calculator (Version 2.1, released 7/12/2019). Inputs were modified to reflect site-specific conditions at the High School (irrigation rates, precipitation data, runoff coefficients, etc.). The water budget calculations are performed on a daily time-step using historic precipitation data to estimate runoff capture volume, storage volume available for irrigation, irrigation demand met, overflow volume, and change in storage. Irrigation was assumed to occur from May through September, consistent with current irrigation practices at the High School, with complete draw-down of the cistern at the end of each irrigation season.

4.1 Water Budget Input Data

Contributing Drainage Area and Runoff Coefficient

The contributing drainage area for a given harvesting and reuse option was estimated from as-built drawings of the school and aerial imagery. Runoff volumes were estimated through the use of a runoff coefficient. The runoff coefficient is a dimensionless coefficient relating the amount of runoff to the amount of precipitation received. Larger runoff coefficient values are used for areas with low infiltration and high runoff (pavement, roof, steep slopes), and lower values for permeable, well vegetated areas (forest, landscaped areas and turf, flat land). A runoff coefficient of 0.90 was used for impervious surfaces and 0.20 was used for turf and landscaped areas. For drainage areas where both landscaped and impervious surfaces are present, an area-weighted runoff coefficient was calculated.

Precipitation

Precipitation data were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information Climate Data portal.[4] Daily Summaries data, which includes daily precipitation totals, was obtained for January 1, 1988 through December 31, 2018 for the station next to Quabbin Visitor Center at Quabbin Park in Belchertown. A 30-year record was selected to be representative of both historical and present-day conditions and to provide a range of precipitation conditions including wet periods and drought conditions. **Figure 4** presents average annual precipitation for the 30-year period.

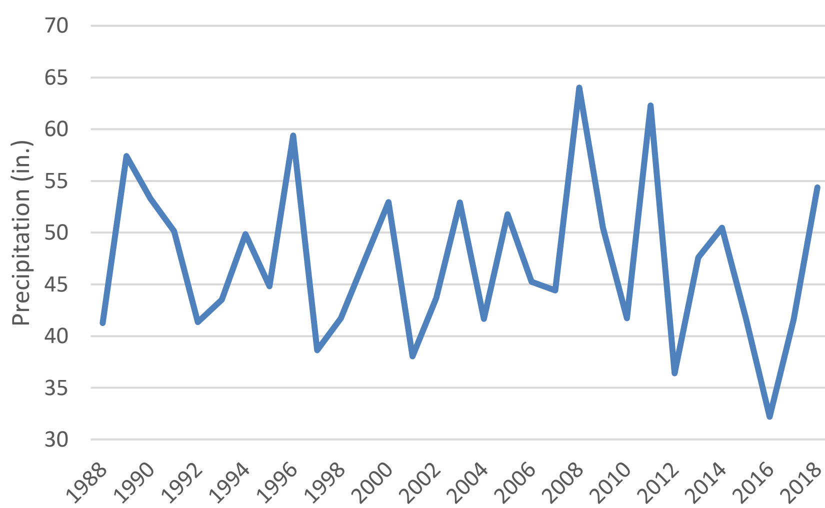


Figure 4. Average annual precipitation, Belchertown, MA (1988-2018).

[4] https://www.ncdc.noaa.gov/cdo-web/datasets

Irrigation Water Demand

Irrigation demand was estimated from the High School irrigation water usage data described previously. Average annual irrigation water usage was calculated for the period 2006-2018, excluding irrigation water usage data for 2010, which was more than twice the average use from 2006 through 2018 and likely not representative of current irrigation practices. Years 2001 through 2005 were also excluded since this period pre-dated the installation of the first phase of the irrigation system and do not reflect current irrigation practices at the school. The average annual irrigation water usage for this period is approximately 1.5 million gallons per year, which is applied uniformly throughout the growing season during periods when irrigation is occurring. An assumption of the water budget tool is that no irrigation occurs on days with measurable precipitation regardless of whether the amount of precipitation is sufficient to water the fields.

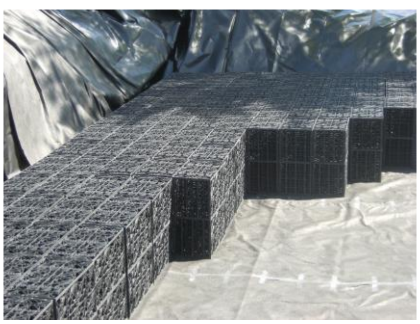
5. Harvesting and Reuse System Feasibility

5.1 Storage Tank Type

The suitability of different storage tank or cistern options depends on the required capacity, potential location, and material type. Certain storage tank types may not provide adequate storage volume for larger capacity systems, while site constraints may limit the tank size and material. **Table 1** summarizes a comparison of tank types and materials.

Table 1. Comparison of different types of water storage tanks for harvesting and reuse systems.

Tank Type/Material	Advantages	Disadvantages
Fiberglass and Fiber Reinforced Polymer  rainharvest.com	• Economical storage solution for larger volumes of water • Protection from UV sunlight degradation • Available in a variety of sizes and capacities • Provides strength and durability for reliable performance • Material is inert to soil compounds which can degrade tanks manufactured with other materials • Accessible for maintenance, minimal maintenance	• Expensive in smaller sizes • Excavation for cistern can be difficult
Polyethylene, Polypropylene, & HDPE Pipe  ads-pipe.com	• Commercially available • Alterable and movable • Affordable • Available in a variety of sizes • Easy to install • Accessible for maintenance, minimal maintenance	• Can be degraded by UV sunlight if aboveground

Tank Type/Material	Advantages	Disadvantages
Galvanized Metal  rainwatermanagement.com	• Commercially available • Alterable and movable • Available in a variety of sizes	• Possible corrosion and rust • Aboveground use only • Must be insulated and heat traced
Concrete  Hillandgriffith.com	• Can be economical storage solution for larger volumes of water • Long life • Load bearing capabilities for use under parking lots and driveways • Can be configured in custom shape and layout • Can neutralize slightly acidic rainwater	• Expensive in smaller sizes • Excavation for cistern can be difficult • Precast concrete cisterns are not readily available and may involve expensive shipping costs • Susceptible to cracks and leaks over time (install liner inside tank)
Modular (Plastic Lattice) Storage Systems  watercache.com	• Can be economical storage solution for larger volumes of water • Low shipping cost compared to other system types • Flexible in shape, layout, and depth • Available in a variety of sizes and capacities • Units can be specified for traffic loading for use under parking lots and driveways • Provides strength and durability for reliable performance	• Requires specific excavation and burial preparation to ensure longevity of system • Internal cleaning is not possible; pretreatment system is extremely important for system longevity

Based on the water budget analysis and preliminary storage tank sizing (see the following section), a harvesting and reuse system with a relatively large water storage volume is required to meet the irrigation demands at the High School. An active system (as opposed to a passive or gravity-fed system) consisting of an underground cistern and submersible pump to deliver the harvested rainwater to the existing irrigation system is recommended. Of the tank options summarized in **Table 1**, a fiber reinforced polymer (FRP) tank is the recommended tank type for an underground cistern at the High School. FRP tanks are commonly used for larger rainwater harvesting applications. In addition to being commercially available and cost-effective for larger sizes, they also require minimal maintenance. Unlike less expensive modular systems (e.g., plastic lattice systems wrapped in an impermeable membrane) that must be replaced when they fill with sediment, an FRP storage tank is equipped with manhole ports to provide access for regular cleanout. FRP tanks are also durable and, unlike concrete storage tanks, are not susceptible to cracking and leaks.

This study also considered the potential reuse/repurposing of the existing elevated steel water storage tank located in the Town center for use at the High School. The Belchertown Water District is in the process of replacing the existing Park Street water storage tank, an elevated steel tank with a 100,000 gallon capacity, with a new modern water storage tank. Given the poor structural condition of the approximately 100-year old existing water storage tank, repurposing the tank for rainwater storage at the High School is not a cost-effective or technically feasible option,

5.2 Storage Tank Location and Preliminary Sizing

Several different contributing drainage areas (runoff capture areas) and a range of storage tank sizes between 5,000 and 100,000 gallons were evaluated using the water budget tool to confirm system feasibility and develop preliminary sizing recommendations to cost-effectively meet irrigation demands.

The site was initially reviewed to identify potential locations for an underground cistern. The following criteria were used to identify potentially suitable locations:

- If possible, intercept and collect as much roof runoff (i.e., "clean" runoff) as possible. Avoid costly and potentially disruptive modifications to the roof drainage system inside the school building. Intercept/divert roof runoff after it leaves the building but before it combines with stormwater runoff from pavement and landscaped areas to reduce pretreatment requirements and added system operation and maintenance.
- Minimize the need for modifications to the site drainage system to divert runoff into the storage tank.
- Locate the storage tank in relatively close proximity to the contributing drainage area to minimize the cost of drainage system modifications to divert the harvested water to the storage system.
- Locate the storage system at higher elevations (i.e., closer to the school building) to reduce the pumping requirements and energy costs for conveying water to the irrigation system. Locating the harvesting and reuse system close to the school building will allow the cistern to supply water to a future landscape irrigation system in the front of the school.
- Avoid potential conflicts with underground utilities.
- Avoid impacts to site activities (traffic circulation, parking, school athletics, etc.) during construction and for inspection and maintenance of the system once operational.
- Areas with vehicle traffic should be avoided or the storage system needs to be structurally capable of supporting the traffic load.

Three potential cistern locations were identified based upon the above siting criteria. The cistern locations and the corresponding contributing drainage areas are shown in **Figure 5** through **Figure 10**. Blue shaded areas indicate the contributing drainage area; underground cistern locations and potential diversion structures and overflows are also shown in the figures. Contributing drainage areas were determined from as-built drawings of the High School and aerial imagery. **Table 2** provides a summary of the three options.

A fourth option was also considered, which involves converting a portion of the existing stormwater basin at the southwest corner of the site (shown in **Figure 2**) to an irrigation pond. This option would require reconfiguring and installing an impervious membrane or liner below a portion of the basin to create a permanent pool from which water could be pumped to the existing irrigation system. This option, however, presents numerous challenges such as high upfront construction costs, variable water quality resulting from large inputs of site runoff and potentially significant pretreatment requirements prior to reuse, the potential for fouling of submersible pumps due to algal growth and vegetation in the pond, and most significantly, the potential for increased mosquito activity and public safety concerns with a permanent pool of water in close proximity to the athletic fields. This option was not evaluated further for these reasons.

Table 2. Summary of potential cistern locations and associated contributing drainage areas.

Cistern Location	Contributing Drainage Area Description	Contributing Drainage Area (acres)	Weighted Runoff Coefficient	Runoff Generated by 1-inch Storm (Gallons)	Runoff Generated Annually (Gallons)
Option 1 West of High School Parking Lot	Western half of the building roof (impervious, rubber membrane roof)	1.20	0.90	29,300	1,500,000
Option 2 Behind High School Gymnasium	Eastern half of the building roof (impervious, rubber membrane roof)	1.16	0.90	28,300	1,400,000
Option 3 In Main Parking Lot	Eastern half of the building roof and surrounding landscaped and paved areas including a large portion of the main parking lot in front of the school	5.95	0.65*	105,000	5,400,000

*Accounts for existing infiltrators serving eastern half of building roof.

Option 1 – Underground Cistern West of High School Parking Lot

Option 1 involves capturing runoff from the western half of the building roof, or approximately 1.20 acres of impervious surface. As depicted in **Figure 5**, the rainwater harvesting and reuse system would divert runoff from the existing roof drainage system to an underground cistern located in a clearing between the tree line and the driveway at the western end of the site. This area is currently unused and does not contain any utilities or other site constraints. A cleared path for ambulance access to the lower athletic field is located in this general area. The area is level and located at the base of a 2.5:1 slope, roughly 8 feet lower than the elevation of the adjacent driveway and within approximately 100 feet of the downgradient wetlands.

A diversion manhole and overflow structure would be required to divert runoff into the cistern and allow for overflow back into the drainage system when the tank is full. The overflow would discharge to the existing subsurface infiltrators. Runoff from rubber membrane roofs is generally considered clean. Only minimal pretreatment (i.e., a pre-filter) is necessary to remove debris and organic matter, such as leaves and bird droppings, from the runoff before it enters the cistern. The proposed cistern location, diversion/overflow structures, and invert elevations are shown in **Figure 5**.

A submersible pump and level transducer inside the cistern would deliver harvested water to the existing pump house and wet well via a new irrigation water line installed beneath the existing sidewalks between the parking lot and athletic fields and along the driveway (**Figure 6**). The system would also be equipped with a water meter to measure and record the amount of harvested water used, a control system, and a gate valve to drain and close off the cistern during the winter.

Table 3 presents a summary of the potential for Option 1 to meet the High School irrigation demand (1.5 million gallons over the growing season) for various cistern sizes ranging from 5,000 gallons to 100,000 gallons, based on the water budget analysis described previously.

Option 1. View of potential underground cistern location (flat area at bottom of slope).

Table 3. Summary of performance of Option 1 relative to irrigation demand.

Option 1 – Underground Cistern West of High School Parking Lot				
Cistern Size (gal)	**Average Annual Amount Available for Reuse (gal)**	**Average Annual Dry Days***	**Average Annual Overflow Days****	**Percent of Annual Irrigation Demand Met*****
5,000	119,884	65	41	8%
10,000	209,800	65	33	14%
20,000	335,155	56	24	22%
30,000	421,045	55	17	27%
50,000	524,482	49	11	34%
75,000	588,293	46	7	38%
100,000	625,410	45	5	40%

*Average days during the irrigation season where the tank is empty (no amount available for reuse)
**Average days during the irrigation season where the runoff exceeds the capacity of the tank (overflows to the stormwater system)
*** Annual irrigation demand of 1.5 million gallons over the growing season

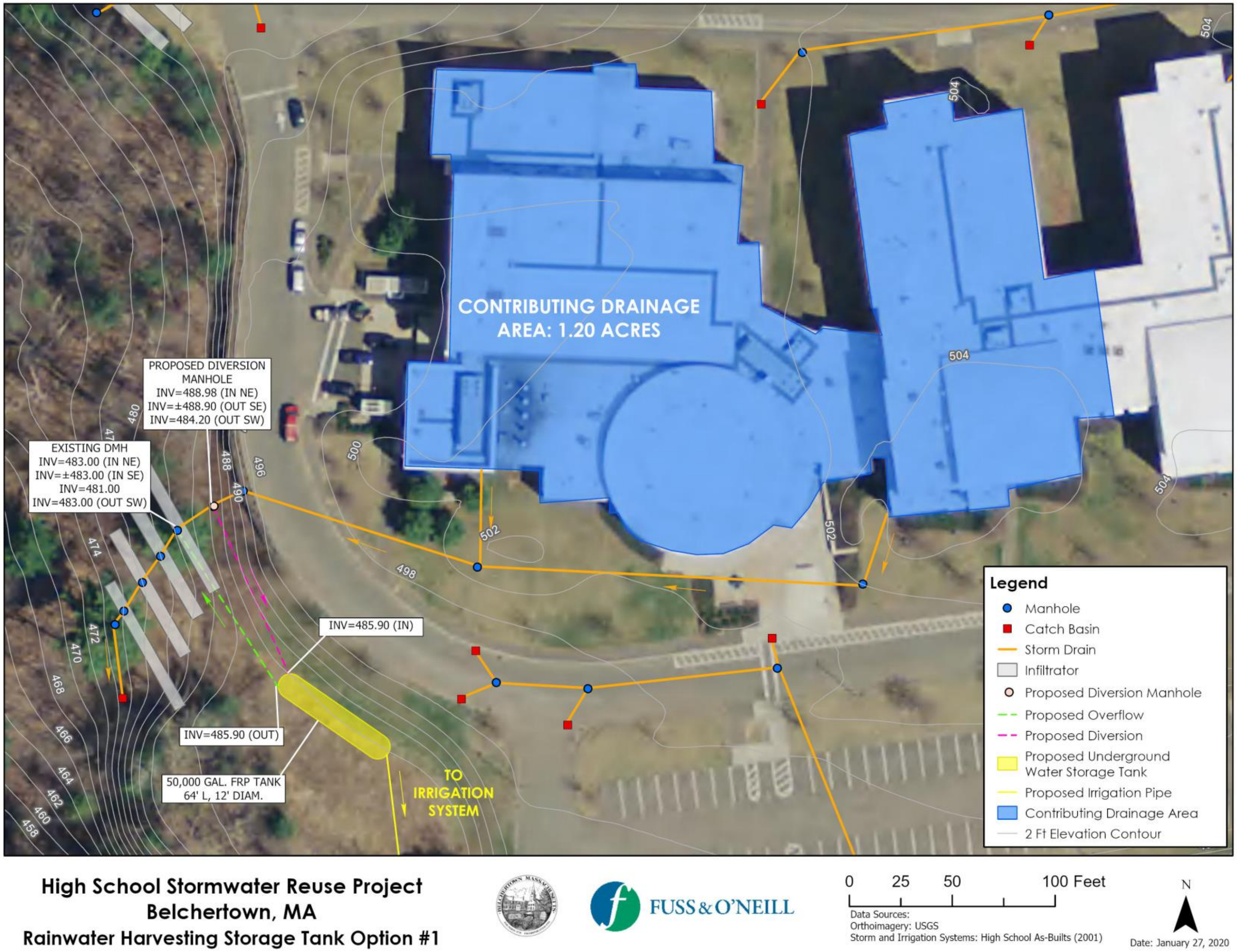


Figure 5. Option 1— harvesting and reuse system, cistern location and contributing drainage area.

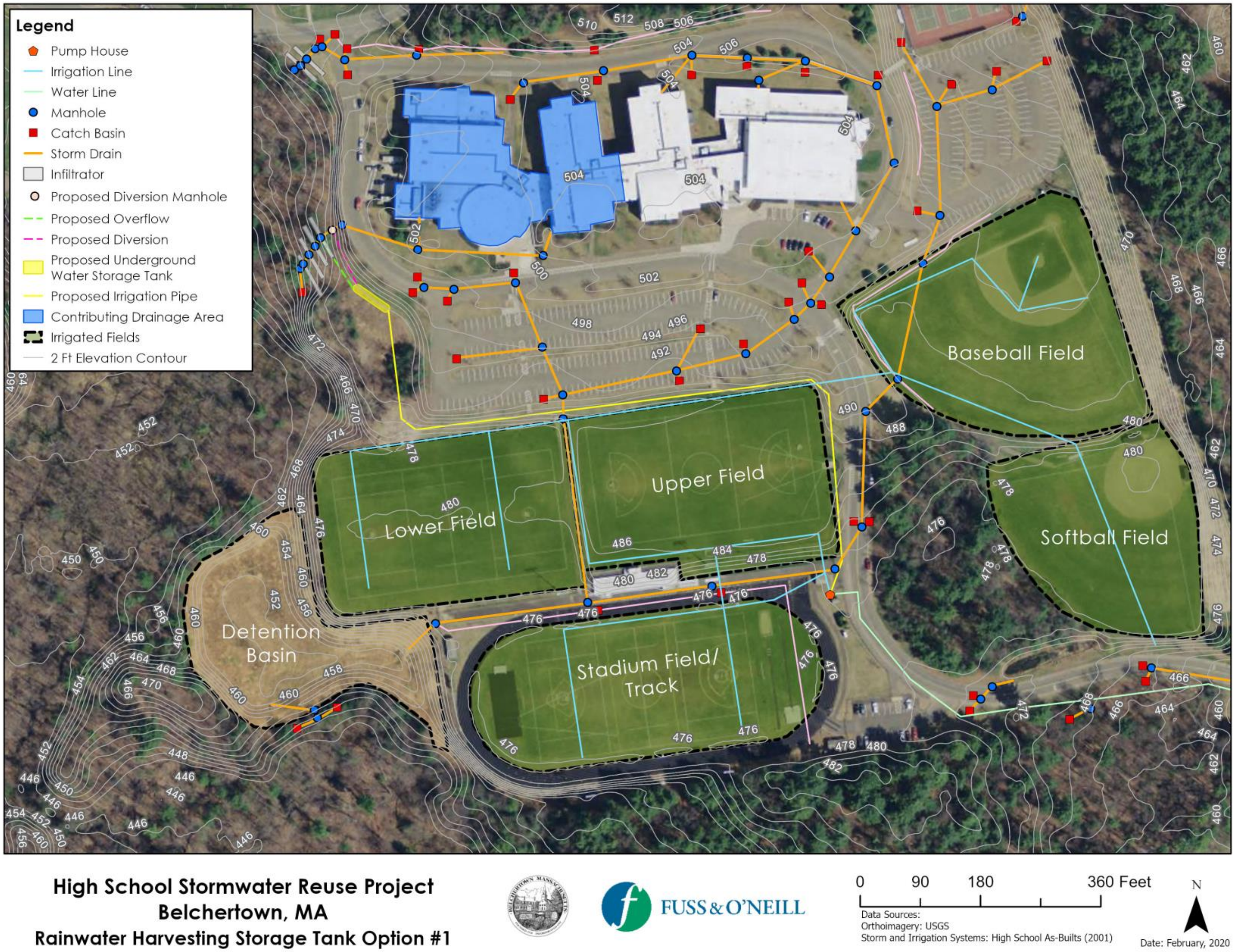


Figure 6. Option 1— harvesting and reuse system layout.

Option 2 – Underground Cistern Behind High School Gymnasium

Option 2 involves capturing runoff from the eastern half of the building roof, or approximately 1.16 acres of impervious surface. As depicted in **Figure 7,** the rainwater harvesting and reuse system would divert runoff from the existing roof drainage system to an underground cistern located behind the gymnasium. This area of lawn is situated between the building and the existing stand of pine trees along the driveway. The subsurface infiltrators that currently receive runoff from the building roof are also located adjacent to or beneath stand of pine trees. Two diversion manholes, one on each incoming drain line, and an overflow structure would be required to divert runoff into the cistern and allow for overflow back into the drainage system when the tank is full. The overflow would discharge to the existing subsurface infiltrators. Runoff from rubber membrane roofs is generally considered clean. Only minimal pretreatment (i.e., a pre-filter) is necessary to remove debris and organic matter, such as leaves and bird droppings, from the runoff before it enters the cistern. The proposed cistern location, diversion/overflow structures, and invert elevations are shown in **Figure 7**.

A submersible pump and level transducer inside the cistern would deliver harvested water to the existing pump house and wet well via a new irrigation water line installed along the school driveway and sidewalks (**Figure 8**). The system would also be equipped with a water meter to measure and record the amount of harvested water used, a control system, and a gate valve to drain and close off the cistern during the winter.

Table 4 presents a summary of the potential for Option 2 to meet the High School irrigation demand (1.5 million gallons over the growing season) for various cistern sizes ranging from 5,000 gallons to 100,000 gallons, based on the water budget analysis.

Table 4. Summary of performance of Option 2 relative to irrigation demand.

Option 2 – Underground Cistern Behind High School Gymnasium				
Cistern Size (gal)	**Average Annual Amount Available for Reuse (gal)**	**Average Annual Dry Days***	**Average Annual Overflow Days****	**Percent of Annual Irrigation Demand Met*****
5,000	119,181	65	41	8%
10,000	207,956	65	32	13%
20,000	331,393	56	24	21%
30,000	414,928	55	17	27%
50,000	515,022	49	11	33%
75,000	575,937	47	6	37%
100,000	611,248	45	4	39%

*Average days during the irrigation season where the tank is empty (no amount available for reuse)
**Average days during the irrigation season where the runoff exceeds the capacity of the tank (overflows to the stormwater system)
*** Annual irrigation demand of 1.5 million gallons over the growing season

Option 2. View of potential underground cistern location between school building (gymnasium) and stand of pine trees along driveway.

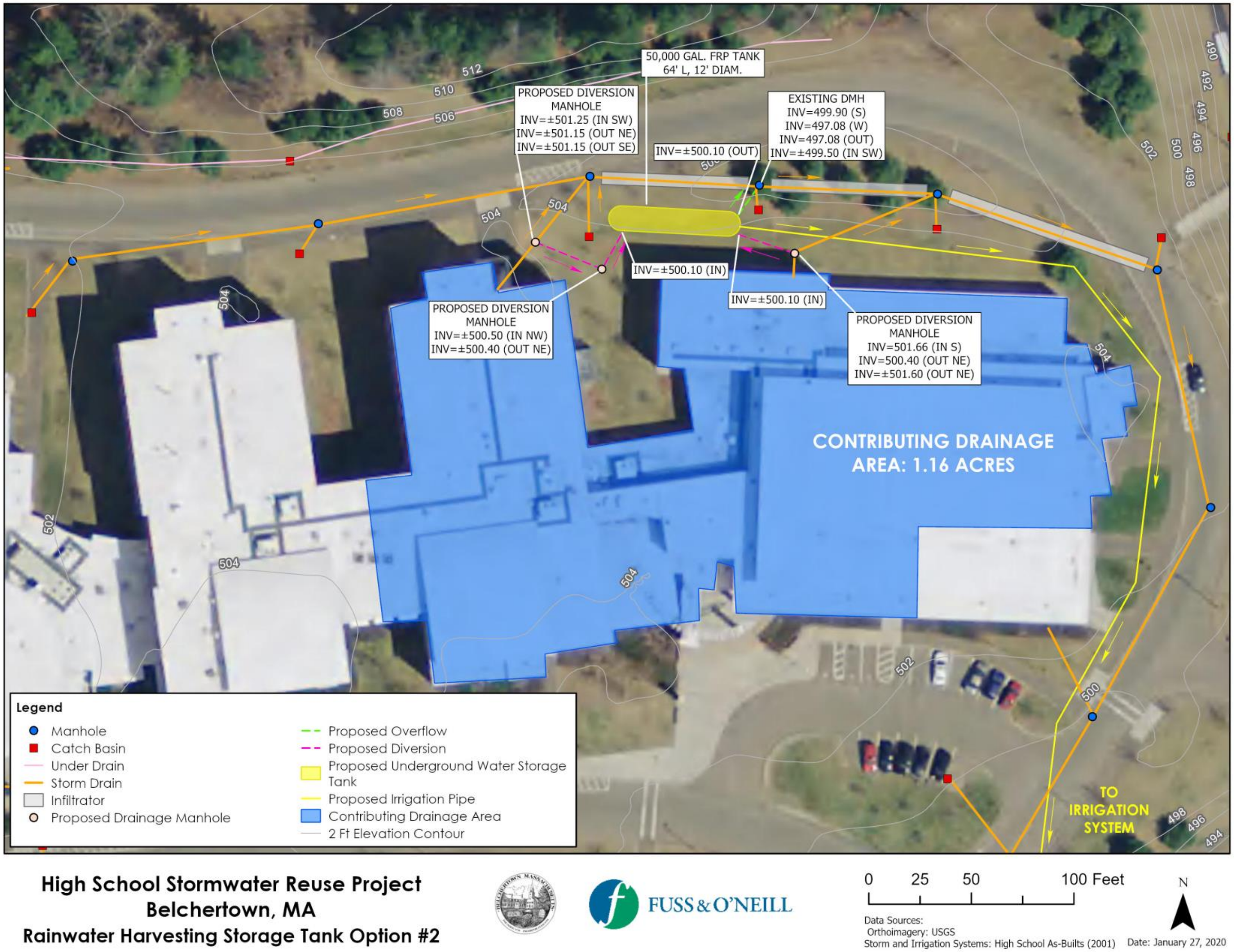


Figure 7. Option 2—harvesting and reuse system, cistern location and contributing drainage area.

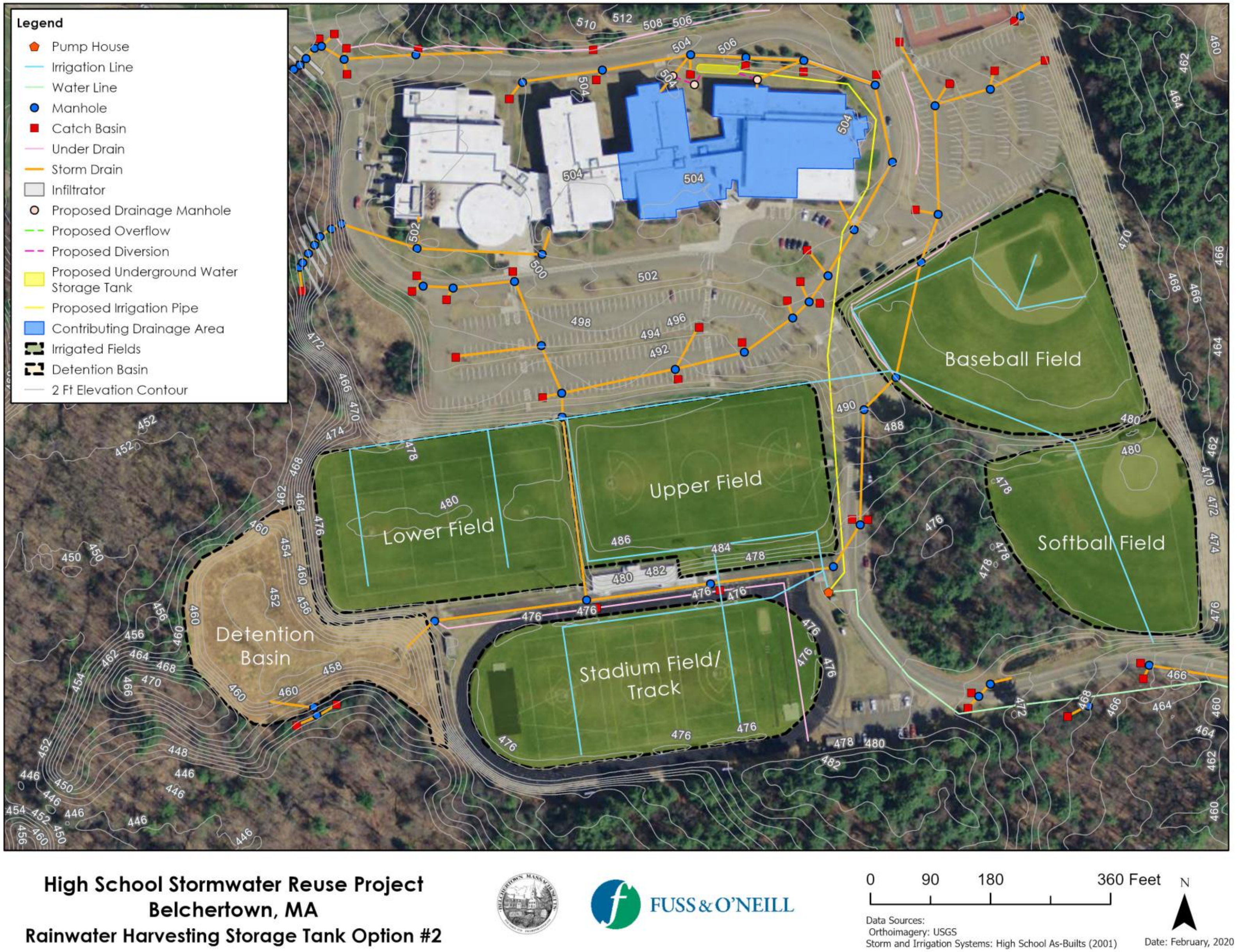


Figure 8. Option 2—harvesting and reuse system layout.

Option 3 – Underground Cistern in Main Parking Lot

Option 3 involves capturing runoff from the entire eastern portion of the building roof and the surrounding landscaped and paved areas, including a majority of the driveway and parking lots in front of the building, and diverting it to an underground cistern below the lower portion of the main parking lot. The objective of this option was to evaluate a larger contributing drainage area that includes a combination of roof runoff and stormwater runoff from ground surfaces to provide larger reuse water volumes and meet a higher percentage of the school's irrigation demands. The contributing drainage area, approximately 5.95 acres, is shown in **Figure 9**.

A portion of the roof runoff and runoff captured by the yard drains in the lawn area behind the school was assumed to infiltrate into the ground via the existing infiltrators behind the gymnasium and would be unavailable for harvesting and reuse. 25% of the annual roof runoff was assumed to infiltrate via the existing infiltrators, which are located in Hydrologic Soil Group C soils.

Two diversion manholes, one on each incoming storm drain line, and an overflow structure would be required to divert runoff into the cistern and allow for overflow back into the drainage system when the tank is full. The overflow would discharge to the existing drainage system, which ultimately flows to the stormwater basin at the southwest corner of the site. Because the cistern would be located in the parking lot, the tank would need to be installed at a greater depth to provide sufficient cover over the tank to support traffic loads. Under this option, the harvesting and reuse system would capture significant quantities of stormwater runoff from landscaped and paved areas of the site, which typically contains higher levels of pollutants. Therefore, more aggressive pretreatment would be required, such as hydrodynamic separators or similar treatment systems, to remove sediment, oil and grease, and trash and other debris from the stormwater runoff. The proposed cistern location, diversion/overflow/treatment structures, and invert elevations are shown in **Figure 9**.

A submersible pump and level transducer inside the cistern would deliver harvested water to the existing pump house and wet well via a new irrigation water line installed beneath the existing sidewalks between the parking lot and athletic fields and along the driveway (**Figure 10**). The system would also be equipped with a water meter to measure and record the amount of harvested water used, a control system, and a gate valve to drain and close off the cistern during the winter.

This option would have a larger up-front construction cost associated with the additional stormwater pretreatment structures and pavement repair, and would require more frequent and expensive long-term maintenance.

Table 5 presents a summary of the potential for Option 3 to meet the High School irrigation demand (1.5 million gallons over the growing season) for various cistern sizes ranging from 5,000 gallons to 100,000 gallons, based on the water budget analysis.

Option 3. View of potential underground cistern location beneath the lower portion of the main parking lot in front of the school. The upper, lower, and stadium athletic fields are in the background.

Table 5. Summary of performance of Option 3 relative to irrigation demand.

Option 3 – Underground Cistern in Main Parking Lot				
Cistern Size (gal)	**Average Annual Amount Available for Reuse (gal)**	**Average Annual Dry Days***	**Average Annual Overflow Days****	**Percent of Annual Irrigation Demand Met*****
5,000	135,994	65	51	9%
10,000	259,096	65	46	17%
20,000	449,013	51	39	29%
30,000	592,754	50	35	38%
50,000	789,067	37	30	51%
75,000	937,170	31	27	60%
100,000	1,039,360	26	24	67%

*Average days during the irrigation season where the tank is empty (no amount available for reuse)
**Average days during the irrigation season where the runoff exceeds the capacity of the tank (overflows to the stormwater system)
*** Annual irrigation demand of 1.5 million gallons over the growing season

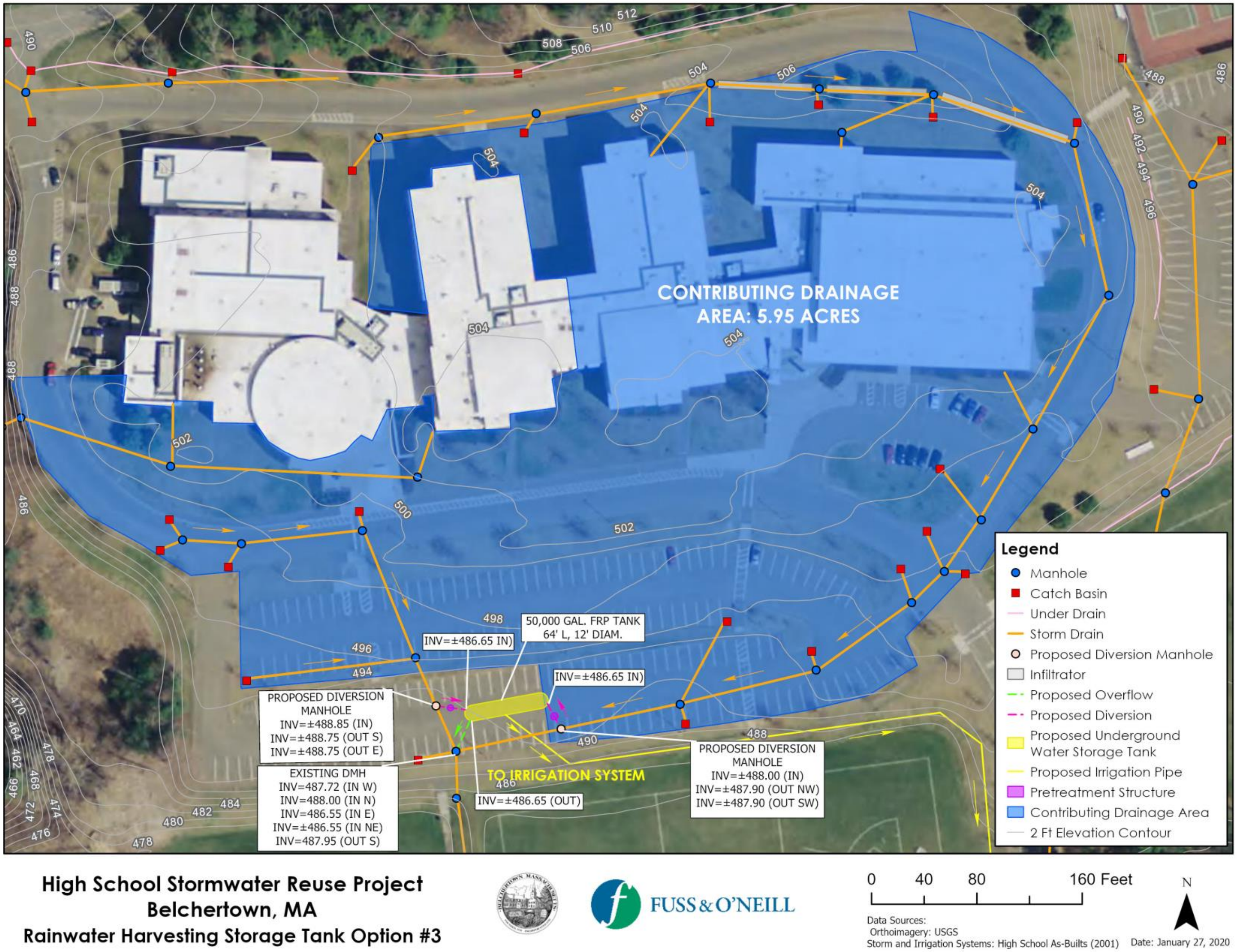


Figure 9. Option 3—harvesting and reuse system, cistern location and contributing drainage area.

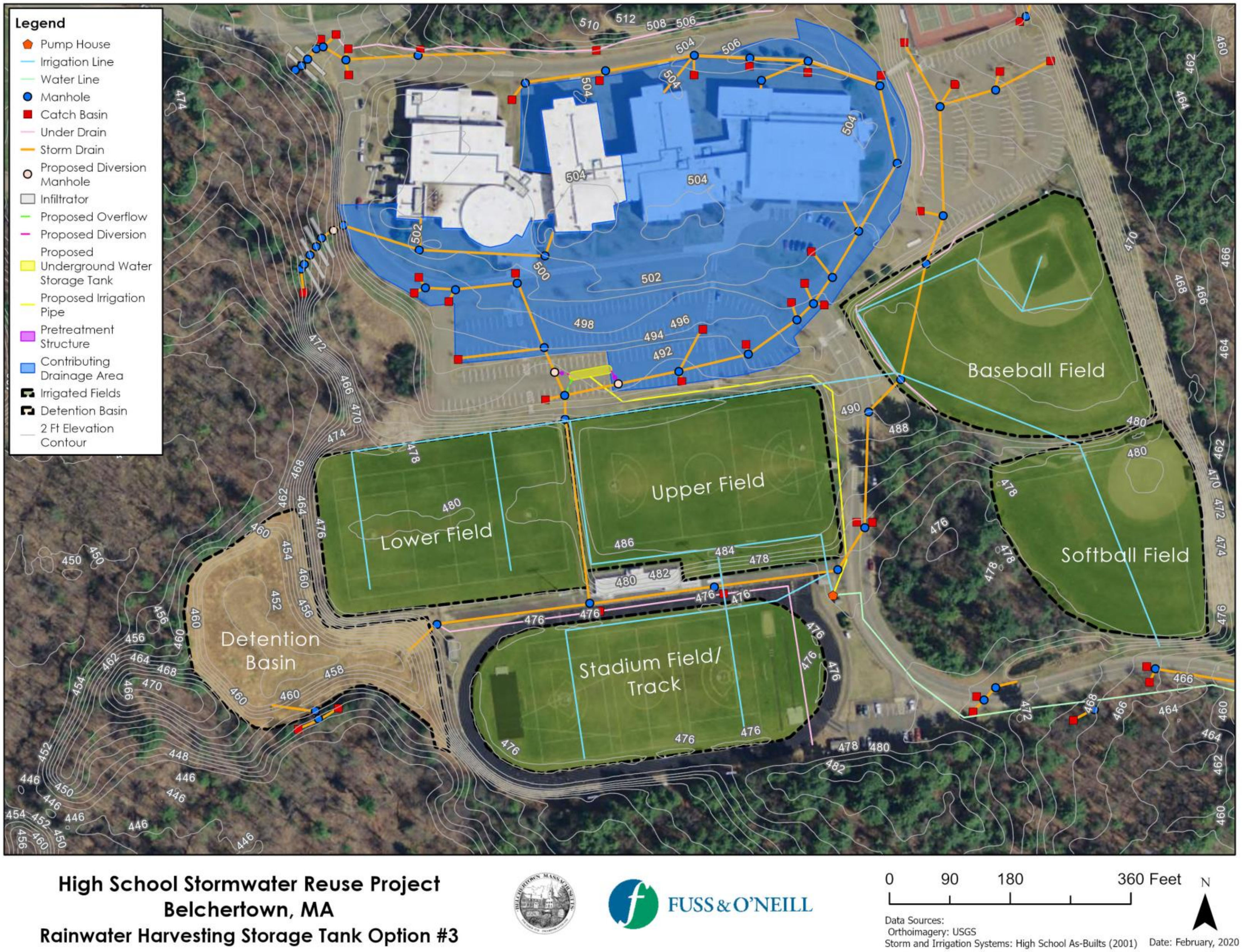


Figure 10. Option 3—harvesting and reuse system layout.

Comparison of Harvesting and Reuse System Options

Table 6 presents a summary comparison of the three harvesting and reuse system options for a range of cistern sizes. The table summarizes the ability of each option to meet annual irrigation demand (1.5 million gallons) for various tank sizes based on the results of the water budget analysis. **Figure 11** illustrates the results graphically, with each curve representing a different option for the range of tank sizes considered.

Table 6. Summary comparison of harvesting and reuse system options relative to irrigation demand.

Percent of Annual Irrigation Demand Met*			
Cistern Size (gal)	**Option 1**	**Option 2**	**Option 3**
5,000	8%	8%	9%
10,000	14%	13%	17%
20,000	22%	21%	29%
30,000	27%	27%	38%
50,000	34%	33%	51%
75,000	38%	37%	60%
100,000	40%	39%	67%
150,000	43%	42%	76%
200,000	44%	42%	81%

*Annual irrigation demand of 1.5 million gallons over the growing season

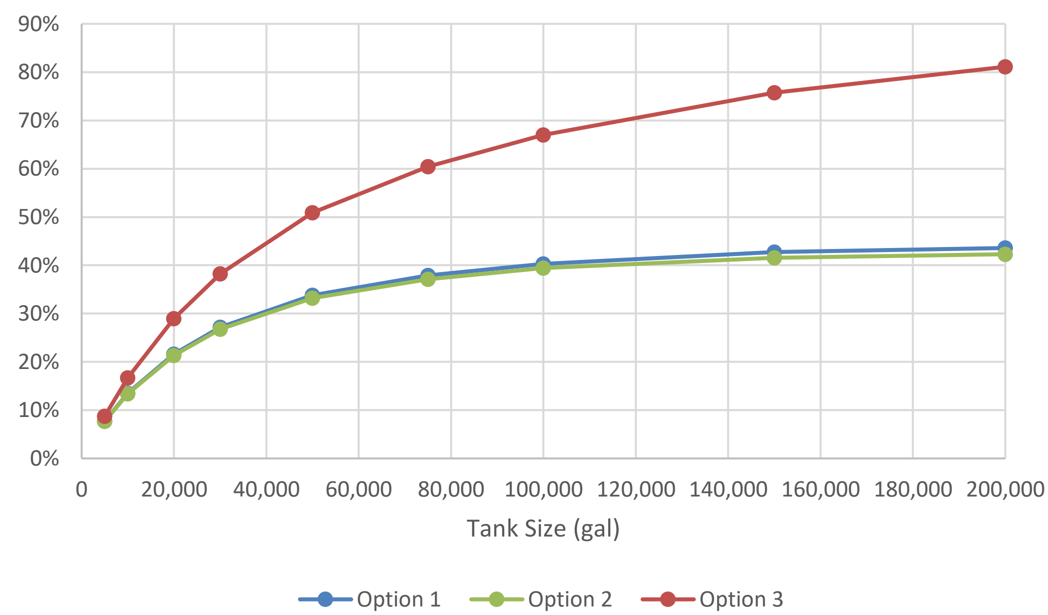


Figure 11. Cistern size versus percent annual irrigation demand met for harvesting and reuse options.

As shown in **Table 6** and **Figure 11**, all three options are predicted to result in similar performance for smaller cistern sizes (10,000 gallons or less), but only provide harvested water to meet 10% to 20% of the annual irrigation demand. As tank size increases, a larger percentage of the annual irrigation demand is met, with Option 3 out-performing Options 1 and 2 due to the substantially larger contributing drainage area for Option 3. As tank size is increased further, the curves begin to flatten out, and beyond a certain tank size, the benefits of increased storage begin to diminish. For all three options, the size of the contributing drainage area and amount of harvested water available for reuse from these sources are the limiting factors given the comparatively large irrigation demand of 1.5 million gallons. For all three options, the optimal cistern size is between 20,000 and 50,000 gallons, near the inflection point on the curves.

A 50,000-gallon tank size was selected for further evaluation for its ability to meet a greater percentage of the annual irrigation water demand and to provide a measure of resilience against potential future increases in irrigation water demand due to climate change. A 50,000-gallon cistern can also potentially store and provide sufficient quantities of harvested water to meet the approximately 35,000-gallon peak daily irrigation water demand experienced during the period 2006-2018.

5.3 Cost Considerations

The harvesting and reuse system options were also evaluated in terms of estimated capital cost, operation and maintenance cost, and cost savings associated with reduced municipal water usage.

Capital Cost

Preliminary opinions of cost (order-of-magnitude) were developed for each of the three options with a 50,000-gallon cistern. Costs were estimated based on a review of unit costs for similar items in past projects, applicable reference cost data (RS Means), and current Massachusetts Department of Transportation weighted bid prices.

Costs associated with contractor general requirements (building permits, contractor insurance, general conditions, and contractor overhead and profit) are estimated at approximately 23% of construction costs. Engineering design is estimated at 10% of total construction costs. A 25% contingency is also included to account for uncertainty associated with bidding and construction, future changes in the unit costs, and scope or design changes. Preliminary opinions of cost for all three options are provided in **Attachment A** and are summarized in **Table 7**.

Options 1 and 2 have similar total estimated costs, $444,000 and $426,000 respectively, while Option 3 is considerably higher at a total estimated cost of $532,000. The higher cost of Option 3 is due to the more extensive drainage system modifications that are required to divert and treat larger volumes of combined stormwater and rainwater (versus rainwater only for Options 1 and 2).

Table 7. Summary of preliminary opinions of cost for harvesting and reuse options.

Preliminary Opinion of Cost (rounded to nearest $1,000)			
Item	**Option 1**	**Option 2**	**Option 3**
Underground Cistern (50,000 gallon) and Tank Appurtenances	$106,000	$106,000	$106,000
Drainage System Modifications and HDPE Irrigation Pipe	$69,000	$65,000	$116,000
Site Work, Survey, As-built Drawings	$93,000	$86,000	$98,000
SUBTOTAL OPINION OF CONSTRUCTION COST	*$268,000*	*$257,000*	*$320,000*
Contractor General Requirements	$61,000	$59,000	$74,000
TOTAL OPINION OF CONSTRUCTION COST	*$329,000*	*$316,000*	*$394,000*
Engineering (10%)	$33,000	$31,000	$39,000
Contingency (25%)	$82,000	$79,000	$99,000
TOTAL OPINION OF COST	**$444,000**	**$426,000**	**$532,000**

The cistern and tank accessories account for approximately 25% to 33% of the total estimated construction cost, while the remainder of the construction costs are associated with drainage system modifications, a new water line to connect the cistern to the irrigation system, and associated site work. The total estimated cost for Options 1 and 2 equates to approximate $8.50 - $8.88 per gallon of water storage capacity, while Option 3 has an estimated cost of $10.64 per gallon of storage.

These cost estimates are generally consistent with costs for active rainwater harvesting systems as reported in the U.S. EPA publication *Rainwater Harvesting: Conservation, Credit, Codes, and Cost Literature Review and Case Studies*.[5] This U.S. EPA study reports that cistern costs are typically between $1.50 and $3.00 per gallon of storage capacity, with per gallon costs generally decreasing with increasing tank size. Systems requiring significant filtration or distribution can add $2 - $5 per gallon of harvesting system capacity for large, complicated systems. Converting these 2013 costs to equivalent 2020 costs, the total cost for a harvesting and reuse system for Belchertown High School could range from $4.30 to $9.80 per gallon of storage capacity.

Operation and Maintenance Cost

Maintenance costs for active harvesting and reuse systems are generally low for well-designed systems.[5] Operational costs include electricity to pump harvested water to the irrigation system and periodic pump replacement. Electrical costs associated with pumping harvested water to the irrigation system are expected to be minimal given the elevation difference (available head) between the cistern locations and the topographically lower irrigation system. The additional energy costs associated with the harvesting and reuse system may be offset by the reduction in energy use (and carbon emissions) associated with treating and distributing municipal water.

Routine maintenance typically involves winter drawdown of the cistern, periodic cleanout of the cistern to remove accumulated sediment and debris, and regular cleaning of inflow filters for rainwater harvesting systems that collect roof runoff (i.e., Options 1 and 2). For systems that capture and store

[5] U.S. EPA. *Rainwater Harvesting: Conservation, Credit, Codes, and Cost Literature Review and Case Studies.* EPA-841-R-13-002. January 2013.

stormwater runoff from ground surfaces, regular cleanout of the stormwater pretreatment devices with a vacuum-truck is also required. Routine maintenance frequencies will vary depending on the amount of sediment and debris contained in the harvested water. Routine maintenance costs typically do not exceed $1,000 annually.

With routine maintenance, a submersible pump, sensors, and other equipment associated with the proposed system may last up to 20 years, although more frequent replacement of equipment or parts may be required. A replacement pump, for example, could cost $9,400 (1.25 times the current cost of the pump). The potential costs of replacement equipment and parts are not included in the estimated total cost or payback period listed in **Table 7**.

Water Conservation Benefit – Savings from Reduced Municipal Water Usage

The three harvesting and reuse options were also evaluated in terms of anticipated cost savings associated with reduced municipal water usage. Annual cost savings was calculated for each option based on the modeled percentage of annual irrigation demand (1.5 million gallons) met by each option and the associated cost savings associated with the corresponding reduction in potable water use. The municipal water rate in Belchertown is $5.75 per 100 cubic feet of water. A rate of $6.00 per 100 cubic feet ($0.008 per gallon) of water was used in the analysis to account for a potential increase in the municipal water rate consistent with historical trends. **Table 8** presents a summary of the average annual irrigation savings, estimated annual operation and maintenance costs, and payback period for each of the harvesting and reuse options considered. (Note that the average annual cost of irrigation at the High School using potable water is approximately $12,000.) The payback period calculation (initial capital investment divided by the estimated annual savings) assumes a 3% annual increase in municipal water rates and no financing of the initial capital cost.

Table 8. Average annual savings and payback period for harvesting and reuse options.

	Option 1	Option 2	Option 3
Average Annual Amount of Harvested Water Available for Reuse (gallons)	524,482	515,022	789,067
Percent Average Annual Irrigation Demand Met	34%	33%	51%
Average Annual Savings in 2020 (rounded to nearest $100)	$4,200	$4,100	$6,300
Estimated Annual Operation and Maintenance Cost*	$500	$500	$1,000
Total Opinion of Cost (Capital Cost)	$444,000	$426,000	$532,000
Payback Period (No Grant Funding)**	50 years	50 years	46 years
Payback Period (75% Grant Funding)**	21 years	21 years	19 years

*Excludes costs associated with replacement of equipment and parts (submersible pump, sensors, control panel, etc.) associated with the harvesting and reuse system.

**Assumes a 3% annual increase in municipal water rates and annual operation and maintenance costs, and no financing of the initial capital cost.

Payback periods are estimated for two funding scenarios. In the first scenario, the Town and/or Water District pay for the full up-front cost to construct a harvesting and reuse system. In the second scenario, the Town and/or Water District obtains a grant (e.g., MVP Action Grant) to pay for 75% of the capital cost of constructing a harvesting and reuse system, reducing the local share to 25% of the capital cost. The payback period, assuming no grant funding, is 46 to 50 years, while the payback period is reduced to between 19 and 21 years assuming 75% of the capital cost is paid for with a grant.

From a strictly financial perspective, implementing an active harvesting and reuse system at the High School is only practical and cost-effective if grant funding can be secured for a significant portion of the capital cost of the system. Without a grant, the estimated 50-year payback period exceeds the design life of the system and the remaining useful life of the school itself. With a 75% grant, the 20-year payback period is within the design life of the system and potentially within the remaining useful life of the school.

Other Benefits

Implementing a stormwater harvesting and reuse system at Belchertown High School would provide other benefits that are difficult to quantify such as opportunities to integrate the system and concepts related to the water cycle, water conservation, and water quality into Belchertown School District's STEM curriculum, as well as opportunities for living classroom approaches and public outreach. A harvesting and reuse system would reduce stress on the municipal water system during peak usage by providing an alternative to potable water during peak demand. A reduction in potable water usage also translates to a reduction in overall energy footprint of water infrastructure and reduced carbon emissions. The harvesting and reuse system would also further reduce stormwater discharges and stormwater pollutant loads from the site and would help the Town meets its compliance requirements pursuant to the municipal separate storm sewer system discharge permit (MS4 Permit). The Town of Belchertown is also in the process of implementing a stormwater utility fee based on the amount of impervious area on each parcel of land in Town. A stormwater harvest and reuse system could potentially qualify the High School site for discounted stormwater fees once a stormwater utility is established.

5.4 Applicable Codes and Required Permits/Approvals

Massachusetts has no statutes or regulations concerning rainwater harvesting. Design and construction of stormwater/rainwater harvesting and reuse systems in Massachusetts is governed by:[6,7]

- The International Association of Plumbing and Mechanical Officials (IAPMO) Green Plumbing and Mechanical Code Supplement (GPMCS), which contains requirements for green building and water efficiency applicable to plumbing and mechanical systems. The GPMCS addresses "Non-potable Rainwater Catchment Systems", including provisions for collection surfaces, storage structures, drainage, pipe labeling, use of potable water as a back-up supply (provided by air-gap only), and other design and construction criteria.

- The GPMCP refers to and incorporates information from the ARCSA/ASPE Rainwater Catchment Design and Installation Standard, a document published in 2008 under a joint effort by the American Rainwater Catchment Systems Association (ARCSA) and the American Association of Plumbing Engineers (ASPE).

[6] U.S. EPA. *Rainwater Harvesting: Conservation, Credit, Codes, and Cost Literature Review and Case Studies.* EPA-841-R-13-002. January 2013.

A building permit would be required for a stormwater harvesting and reuse system at the High School. State code allows the direct plumbing of municipal water supply to a rainwater harvesting system as a back-up water supply provided an approved reduced pressure backflow preventer is installed and included in a required maintenance plan.[7] These fixtures have a physical air gap inside the device that prevents harvested water from potentially contaminating the municipal water supply. Approval may also be required from the Belchertown Water District for any modifications to the irrigation system that would affect the existing backflow preventer.

The location of the proposed underground cistern for Option 1 is within approximately 100 feet of mapped wetlands, as shown on the Belchertown High School as-built drawings. Installation of the cistern in this area may require review and approval by the Belchertown Conservation Commission for proposed activities within the 100-foot buffer zone to the resource area. An updated wetland delineation and filing under the Massachusetts Wetlands Protection Act and Belchertown Wetland Bylaw would be required for jurisdictional activities.

The project may also require review and approval pursuant to the Belchertown Stormwater Management Bylaw, which is also administered by the Conservation Commission, for Options 1, 2 or 3.

5.5 Water Conservation Measures

As this feasibility evaluation has shown, for a stormwater harvesting and reuse system to be cost-effective, it should be sufficiently large relative to existing irrigation demand and be combined with water conservation measures to further reduce irrigation demand. The water budget tool was also used to evaluate the harvesting and reuse options in combination with two hypothetical water conservation scenarios, a 33% and 50% reduction in current annual irrigation demand. **Figures 12-14** illustrate the modeled performance of the harvesting and reuse systems relative to current annual irrigation demand (1.5 million gallons), a 33% reduction in annual irrigation demand (1.0 million gallons), and a 50% reduction in annual irrigation demand (750,000 gallons).

For Option 1, a 50,000-gallon cistern is predicted to meet 34% of the current annual irrigation demand of 1.5 million gallons. If annual water usage were reduced to 1.0 million gallons a year, the harvesting and reuse system could meet 48% of annual irrigation demand. Similarly, the system could meet 59% of an annual irrigation demand of 750,000 gallons. Water conservation measures are predicted to have similar results when implemented in conjunction with Options 2 and 3.

[7] Understanding Rainwater Harvesting. Pioneer Valley Sustainability Toolkit. Pioneer Valley Planning Commission. http://www.pvpc.org/sites/default/files/files/PVPC-Rain%20Water%20Harvesting.pdf

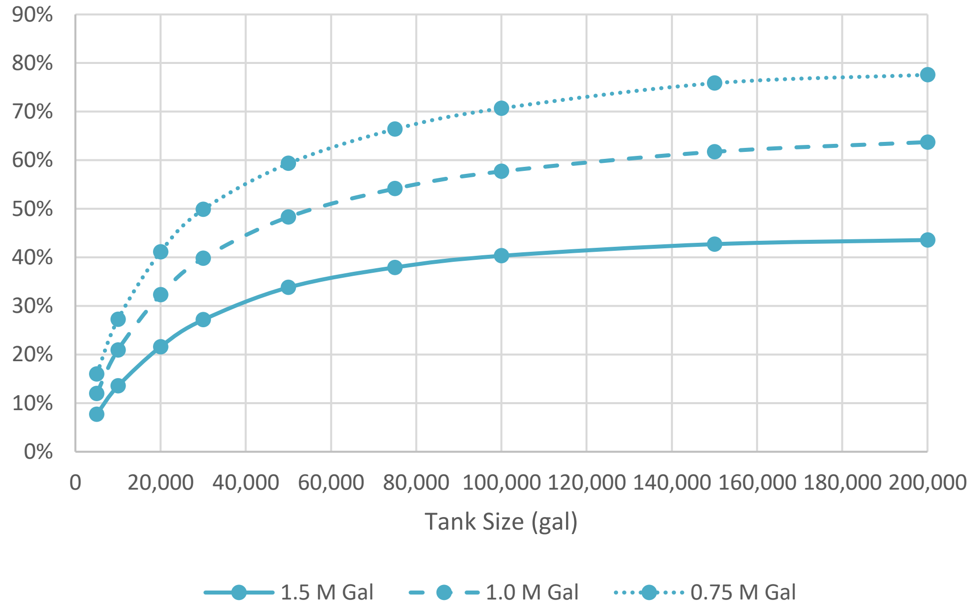


Figure 12. Option 1: percent annual irrigation demand met under existing demand (1.5 million gallons – solid line), a 33% reduction in demand (1.0 million gallons – dashed line), and a 50% reduction in demand (750,000 gallons – dotted line).

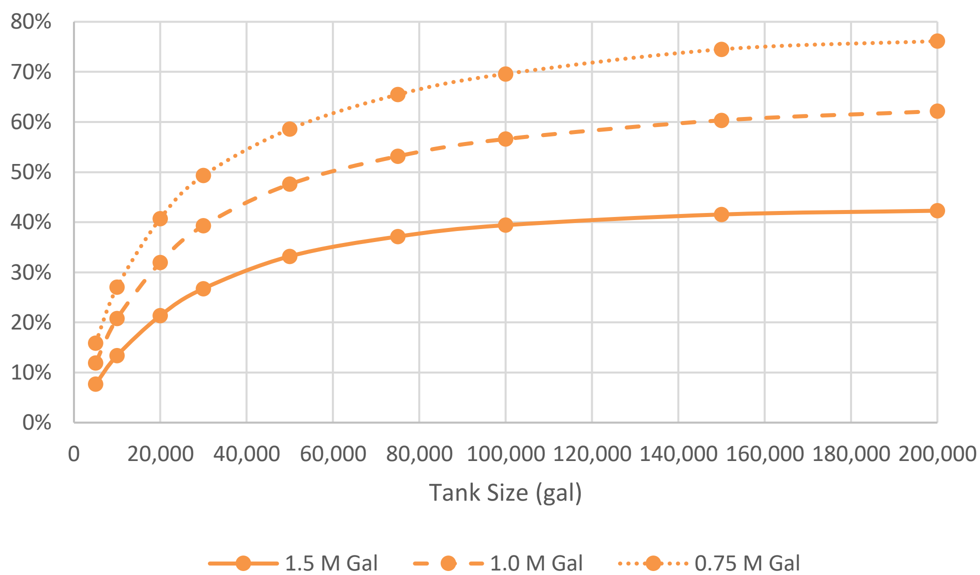


Figure 13. Option 2: percent annual irrigation demand met under existing demand (1.5 million gallons – solid line), a 33% reduction in demand (1.0 million gallons – dashed line), and a 50% reduction in demand (750,000 gallons – dotted line).

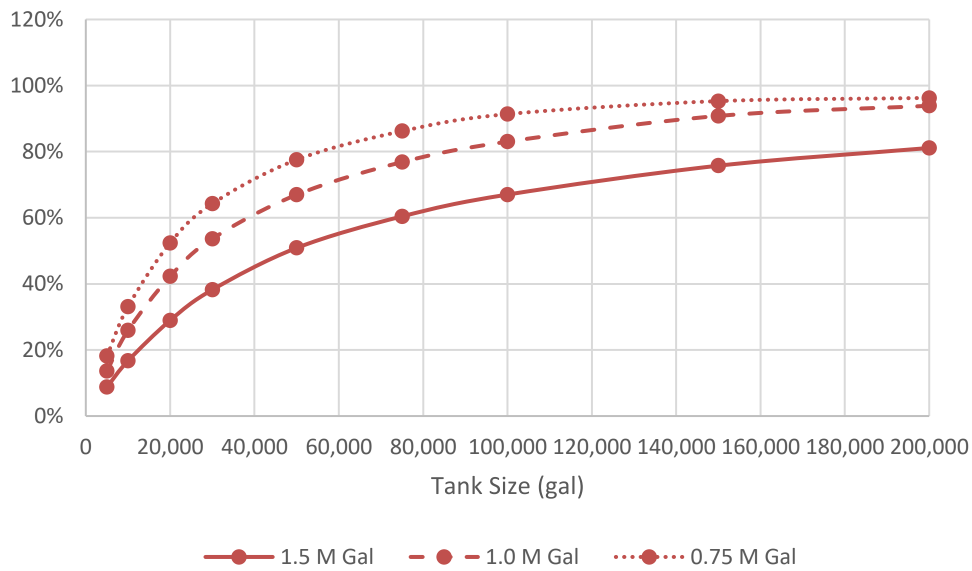


Figure 14. Option 3: percent annual irrigation demand met under existing demand (1.5 million gallons – solid line), a 33% reduction in demand (1.0 million gallons – dashed line), and a 50% reduction in demand (750,000 gallons – dotted line).

The following water conservation/demand management measures are recommended for consideration in combination with a possible harvesting and reuse system for Belchertown High School.

Controllers and Sensors

The existing irrigation system is operated manually or with a clock-timer, as the rain sensor is currently non-functional. The existing irrigation system could be optimized by retrofitting or replacing the existing clock-timer control mechanism with a more advanced control system to prevent irrigation of the athletic fields during periods of sufficient rainfall. This could include implementing plans to repair or replace the non-functional rain sensor in 2020 at a cost of several hundred dollars, or replacing it with a more current weather-based irrigation controller technology such as EPA WaterSense labeled irrigation controllers,[8] which typically cost under $300.

Soil moisture-based control technologies can be inserted into the soil to measure moisture and regulate irrigation so that it only occurs when soil moisture falls below a set threshold. The soil moisture sensors can be connected to an existing controller or be installed in a new system to enable irrigation as needed by plants. Studies have shown that soil moisture-based control technologies can result in water savings of 20 percent or more.[9]

[8] A list of EPA WaterSense labelled irrigation controllers can be found here: https://lookforwatersense.epa.gov/Product-Search-Results-IrrigationController.html

[9] EPA's WaterSense program. Soil Moisture-Based Control Technologies. www.epa.gov/watersense/soil-moisture-based-control-technologies

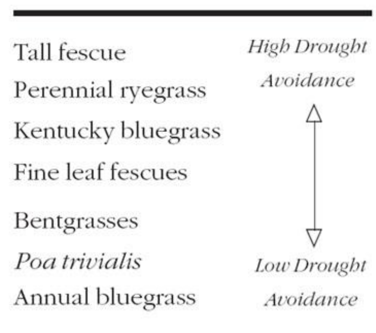
Soil Amendments

A soil amendment is organic matter or other materials that are added to or mixed with soil to enable the soil to hold water for longer periods of time, thereby reducing the need for irrigation. In 2007, the Massachusetts Department of Conservation and Recreation partnered with the Town of North Reading to study whether adding zeolite, a soil mineral additive that retains water, at a town athletic field would reduce the field's need for irrigation. The study results showed that the addition of zeolite resulted in an average water use reduction of 37%, indicating that soil amendments can have a dramatic impact on moisture retention, and can significantly reduce water demand of athletic fields and lawns.[10]

The cost of soil amendments varies depending on the type and quantity of the amendment. Soil testing should be conducted to determine the optimal amendment quantity based on the characteristics of the soil (e.g., pH, organic matter content, and nutrient content) and to help determine whether organic matter (compost, peat, fertilizer, biosolids, etc.) or inorganic matter (perlite, vermiculite, hydrogels, etc.) should be used. For reference, the cost of 20 tons of zeolite soil amendments for the North Reading demonstration project was $15,000 (in 2006/2007 dollars).

Drought Resistance and Water Use Efficient Turfgrass

Certain species of turfgrass are more drought resistant than others. For example, tall fescue has the highest drought avoidance and is able to maintain growth and green color for longer periods between rainfall and irrigation events when compared to other cool-season species (see adjacent chart). Even within species, different varieties of turfgrass can vary in rooting characteristics and evapotranspiration rates, which can result in differences in drought resistance.[11]



Synthetic Turf Field

There have been informal discussions about converting the High School stadium field to a synthetic turf field, which would reduce the annual irrigation water demand by roughly 20% by eliminating the need for watering the field. Drainage from a synthetic turf field could also be harvested and reused for irrigation of the remaining turfgrass athletic fields, further reducing the school's reliance on municipal water. The typical installation cost for an 80,000 square foot artificial turf soccer or football field generally ranges from $500,000 to $1 million.

Irrigation Well

An irrigation well could be installed at the school to augment the harvested water and further reduce the remaining demand for potable irrigation water. The well could be sized to remain below the MADEP Water Management Act permit threshold (100,000 gpd on average for three consecutive months during the year, or 9 million unregistered gallons over a three month period) to avoid additional permitting and compliance costs. The well could be used to fill the underground cistern during dry periods or between storms and serve as the primary backup water source to harvested rainwater/stormwater rather than municipal potable water. A solar well pump could also be considered to reduce energy costs. The typical

[10] Ipswich River Targeted Watershed Grant Fact Sheet: Water Conservation Case Studies. Massachusetts Department of Conservation and Recreation and The Ipswich River Watershed Association. http://www.mass.gov/dcr/watersupply/ipswichriver/index.htm

[11] Turf Irrigation and Water Conservation. University of Massachusetts Extension Turf Program. https://ag.umass.edu/turf/fact-sheets/turf-irrigation-water-conservation

installation cost for a commercial irrigation well is $50,000; the cost of the well will vary depending on a number of factors, including the depth of the well. The addition of a solar well pump would increase this cost by a few thousand dollars.

Although an irrigation well would reduce the High School's reliance on the municipal water supply, it would not change overall irrigation demand or water usage—rather, this option would shift demand from one aquifer to another. Therefore, this option should only be considered in conjunction with stormwater reuse and water conservation measures.

6. Summary of Findings

The major findings of this feasibility evaluation are summarized below along with recommended harvesting and reuse options for further consideration.

- Irrigation of the athletic fields at Belchertown High School using potable water accounts for a large percentage of the annual municipal water demand, which coincides with periods of peak demand. In 2018, irrigation water usage at the High School accounted for approximately 25% of the municipal water usage in the Belchertown Water District.

- Average annual (seasonal) irrigation water usage is approximately 1.5 million gallons, with an average daily irrigation water use of just over 10,000 gallons per day and a peak of 35,000 gallons per day.

- The feasibility of a stormwater/rainwater harvesting and reuse system for Belchertown High School was evaluated to reduce the amount of potable water required to irrigate the athletic fields, reducing the overall demand for municipal water during periods of peak demand, conserving potable water for essential uses, and increasing the reliability of the irrigation system.

- A water budget tool was developed for the site to evaluate how much of the High School's irrigation demand could be met by a harvesting and reuse system and to help select a cost-effective water storage tank (i.e., cistern) size.

- Three underground cistern locations and contributing drainage areas were identified. A range of tank sizes were evaluated for each option, including a rainwater-only (roof runoff) system located at the western end of the main parking lot (Option 1), a rainwater-only system located behind the gymnasium (Option 2), and a combined stormwater/rainwater system located beneath the main parking lot (Option 3).

- The optimal size for an underground cistern for the site is generally between 20,000 and 50,000 gallons. A 50,000-gallon tank was chosen for further evaluation for its ability to meet a greater percentage of the average annual irrigation demand and to provide a measure of resilience against potential future increases in irrigation water demand due to climate change.

- The estimated capital cost for the rainwater-only systems (Options 1 and 2) is $426,000 to $444,000 or approximately $8.50 - $8.88 per gallon of water storage capacity. The estimated capital cost for the Option 3 stormwater harvesting and reuse system is higher at $532,000

($10.64 per gallon of storage) due to more extensive drainage system modifications required to divert and treat larger volumes of combined stormwater and rainwater.

- The anticipated payback period for each option was calculated based upon the estimated capital cost, annual irrigation savings, and annual operation and maintenance cost. Assuming the Town and/or Water District pay for the full up-front cost to construct a harvesting and reuse system, the payback period is between 46 and 50 years. If the Town obtains a 75% grant for construction of the system, the payback period is reduced to between 19 and 21 years.

- From a strictly financial perspective, implementing an active harvesting and reuse system at the High School is only practical and cost-effective if grant funding can be secured for a significant portion of the capital cost of the system. Without a grant, the estimated 50-year payback period exceeds the design life of the system and the remaining useful life of the school itself. With a 75% grant, the 20-year payback period is within the design life of the system and potentially within the remaining useful life of the school.

- Implementing a stormwater harvesting and reuse system at Belchertown High School would provide other benefits that are difficult to quantify such as education and public awareness, reduced stress on the municipal water system during peak usage, reduction in overall energy footprint and reduced carbon emissions, and reduced stormwater discharge and MS4 Permit compliance benefits.

- For a stormwater harvesting and reuse system to be cost-effective, it should be implemented in combination with other water conservation/demand management measures to further reduce irrigation demand. At a minimum, the Town should consider:
    - Replacing the non-functional rain sensor with a new sensor or a weather-based irrigation controller technology such as EPA WaterSense labeled irrigation controllers,
    - Incorporating soil moisture sensors to measure moisture and regulate irrigation so that it only occurs when soil moisture falls below a set threshold
    - Adding soil amendments (e.g., zeolite) and overseeding with more drought resistant turfgrass.

- If the Town proceeds with the design and implementation of a water harvesting and reuse system, the design should also:
    - Address the current operational issues related to the existing irrigation system (i.e., the need to operate the system above its design flow and pressure to provide full coverage of the athletic fields)
    - Include provisions for future expansion of the harvesting and reuse system to increase storage capacity (and further reduce municipal water demand) and/or to provide irrigation water for the landscaped area in front of the school building.

ATTACHMENT A

Preliminary Opinions of Cost
Stormwater Harvesting and Reuse Systems

FUSS & O'NEILL

FUSS & O'NEILL, INC.

1550 Main Street
Springfield, MA 01103

OPINION OF COST- Option 1	DATE PREPARED : 02/12/20	SHEET 1 OF 1	
PROJECT : 20170390.A53	BASIS : MADOT Weighted Bid Prices & Similar Engineering Projects		
LOCATION : Belchertown, MA			
DESCRIPTION: Belchertown, MA- High School Stormwater Reuse			
DRAWING NO. :	ESTIMATOR : AHW	CHECKED BY : KF	

Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Cost are made on the basis of Fuss & O'Neill's experience and qualifications and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

ITEM NO.	ITEM DESCRIPTION	UNIT MEAS.	NO. UNITS	PER UNIT	TOTAL COST
	Clearing and Grubbing	L.S.	1	$ 5,000.00	$ 5,000.00
	Erosion and Sedimentation Maintenance	L.S.	1	$ 10,000.00	$ 10,000.00
	Individual Tree Protection	E.A.	2	$ 285.00	$ 570.00
	Earth Excavation	C.Y.	986	$ 21.20	$ 20,894.31
	Rock Excavation	C.Y.	96	$ 105.00	$ 10,061.33
	Dewatering Control	L.S.	1	$ 10,000.00	$ 10,000.00
	Pavement Repair	S.Y.	117	$ 157.00	$ 18,316.67
	Pipe Bedding	C.Y.	169	$ 50.00	$ 8,441.16
	Borrow	C.Y.	99	$ 22.00	$ 2,168.28
	Diversion Manhole	E.A.	1	$ 4,000.00	$ 4,000.00
	3" HDPE Irrigation Pipe	L.F.	1,122	$ 50.00	$ 56,100.00
	Overflow Pipe	L.F.	90	$ 50.00	$ 4,521.50
	Diversion Pipe	L.F.	90	$ 50.00	$ 4,496.00
	Underground Storage Tank	L.S.	1	$ 60,000.00	$ 60,000.00
	Meter/Meter Pit	L.S.	1	$ 3,240.00	$ 3,240.00
	Pump	E.A.	1	$ 7,500.00	$ 7,500.00
	Level Transducer	E.A.	1	$ 1,500.00	$ 1,500.00
	Control System with Panel	L.S.	1	$ 25,000.00	$ 25,000.00
	Gate Valve and Actuator	E.A.	1	$ 7,500.00	$ 7,500.00
	Gate Valve	E.A.	2	$ 750.00	$ 1,500.00
	Restoration	S.Y.	492	$ 3.50	$ 1,723.64
	Survey/As-Built Mapping	L.S.	1	$ 5,000.00	$ 5,000.00
	SUBTOTAL OPINION OF CONSTRUCTION COST				**$ 267,532.89**
	Building Permits	%	0.25%	$669	$669
	Builders Risk Insurance	%	0.25%	$669	$669
	General Liability Insurance	%	1.50%	$4,013	$4,013
	Intellution System Upgrade / Licenses	%	1.00%	$2,675	$2,675
	GC Field General Conditions	%	10.00%	$26,753	$26,753
	Contractor's Overhead and Profit	%	10.00%	$26,753	$26,753
	TOTAL OPINION OF CONSTRUCTION COST				**$ 329,065.45**
	CONTINGENCY (25%)				**$ 82,266.36**
	ENGINEERING (10%)				**$ 32,906.54**
	TOTAL OPINION OF COST (ROUNDED TO NEAREST $1,000)				**$ 444,000.00**

FUSS & O'NEILL

FUSS & O'NEILL, INC.

1550 Main Street
Springfield, MA 01103

OPINION OF COST- Option 2	DATE PREPARED : 02/12/20	SHEET 1 OF 1
PROJECT : 20170390.A53	BASIS : MADOT Weighted Bid Prices & Similar Engineering Projects	
LOCATION : Belchertown, MA		
DESCRIPTION: Belchertown, MA- High School Stormwater Reuse		
DRAWING NO. :	ESTIMATOR : AHW	CHECKED BY : KF

Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Cost are made on the basis of Fuss & O'Neill's experience and qualifications and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

ITEM NO.	ITEM DESCRIPTION	UNIT MEAS.	NO. UNITS	PER UNIT	TOTAL COST
	Clearing and Grubbing	L.S.	1	$ 5,000.00	$ 5,000.00
	Erosion and Sedimentation Maintenance	L.S.	1	$ 10,000.00	$ 10,000.00
	Earth Excavation	C.Y.	893	$ 21.20	$ 18,941.20
	Rock Excavation	C.Y.	96	$ 105.00	$ 10,061.33
	Dewatering Control	L.S.	1	$ 10,000.00	$ 10,000.00
	Pavement Repair	S.Y.	72	$ 157.00	$ 11,356.33
	Pipe Bedding	C.Y.	138	$ 50.00	$ 6,905.69
	Borrow	C.Y.	223	$ 22.00	$ 4,913.99
	Diversion Manhole	E.A.	3	$ 4,000.00	$ 12,000.00
	3" HDPE Irrigation Pipe	L.F.	961	$ 50.00	$ 48,050.00
	Overflow Pipe	L.F.	18	$ 50.00	$ 899.00
	Diversion Pipe	L.F.	86	$ 50.00	$ 4,323.50
	Underground Storage Tank	L.S.	1	$ 60,000.00	$ 60,000.00
	Meter/Meter Pit	L.S.	1	$ 3,240.00	$ 3,240.00
	Pump	E.A.	1	$ 7,500.00	$ 7,500.00
	Level Transducer	E.A.	1	$ 1,500.00	$ 1,500.00
	Control System with Panel	L.S.	1	$ 25,000.00	$ 25,000.00
	Gate Valve and Actuator	E.A.	1	$ 7,500.00	$ 7,500.00
	Gate Valve	E.A.	2	$ 750.00	$ 1,500.00
	Restoration	S.Y.	445	$ 6.50	$ 2,890.39
	Survey/As-Built Mapping	L.S.	1	$ 5,000.00	$ 5,000.00
	SUBTOTAL OPINION OF CONSTRUCTION COST				**$ 256,581.44**
	Building Permits	%	0.25%	$641	$641
	Builders Risk Insurance	%	0.25%	$641	$641
	General Liability Insurance	%	1.50%	$3,849	$3,849
	Intellution System Upgrade / Licenses	%	1.00%	$2,566	$2,566
	GC Field General Conditions	%	10.00%	$25,658	$25,658
	Contractor's Overhead and Profit	%	10.00%	$25,658	$25,658
	TOTAL OPINION OF CONSTRUCTION COST				**$ 315,595.17**
	CONTINGENCY (25%)				**$ 78,898.79**
	ENGINEERING (10%)				**$ 31,559.52**
	TOTAL OPINION OF COST (ROUNDED TO NEAREST $1,000)				**$ 426,000.00**

FUSS & O'NEILL

FUSS & O'NEILL, INC.

1550 Main Street
Springfield, MA 01103

OPINION OF COST- Option 3		DATE PREPARED : 02/12/20		SHEET 1 OF 1	
PROJECT :	20170390.A53	BASIS : MADOT Weighted Bid Prices & Similar Engineering Projects			
LOCATION :	Belchertown, MA				
DESCRIPTION:	Belchertown, MA- High School Stormwater Reuse				
DRAWING NO. :		ESTIMATOR : AHW		CHECKED BY : KF	

Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Cost are made on the basis of Fuss & O'Neill's experience and qualifications and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

ITEM NO.	ITEM DESCRIPTION	UNIT MEAS.	NO. UNITS	PER UNIT	TOTAL COST
	Clearing and Grubbing	L.S.	1	$ 5,000.00	$ 5,000.00
	Erosion and Sedimentation Maintenance	L.S.	1	$ 10,000.00	$ 10,000.00
	Earth Excavation	C.Y.	776	$ 21.20	$ 16,451.46
	Rock Excavation	C.Y.	96	$ 105.00	$ 10,061.33
	Dewatering Control	L.S.	1	$ 10,000.00	$ 10,000.00
	Pavement Repair	S.Y.	189	$ 157.00	$ 29,640.03
	Pipe Bedding	C.Y.	131	$ 50.00	$ 6,536.31
	Borrow	C.Y.	194	$ 22.00	$ 4,268.07
	Diversion Manhole	E.A.	2	$ 4,000.00	$ 8,000.00
	3" HDPE Irrigation Pipe	L.F.	693	$ 50.00	$ 34,650.00
	Overflow Pipe	L.F.	26	$ 50.00	$ 1,286.50
	Diversion Pipe	L.F.	45	$ 50.00	$ 2,236.50
	Treatment Structures Entering Tank	E.A.	2	$ 35,000.00	$ 70,000.00
	Underground Storage Tank	L.S.	1	$ 60,000.00	$ 60,000.00
	Meter/Meter Pit	L.S.	1	$ 3,240.00	$ 3,240.00
	Pump	E.A.	1	$ 7,500.00	$ 7,500.00
	Level Transducer	E.A.	1	$ 1,500.00	$ 1,500.00
	Control System with Panel	L.S.	1	$ 25,000.00	$ 25,000.00
	Gate Valve and Actuator	E.A.	1	$ 7,500.00	$ 7,500.00
	Gate Valve	E.A.	2	$ 750.00	$ 1,500.00
	Restoration	S.Y.	211	$ 3.50	$ 737.72
	Survey/As-Built Mapping	L.S.	1	$ 5,000.00	$ 5,000.00
	SUBTOTAL OPINION OF CONSTRUCTION COST				**$ 320,107.93**
	Building Permits	%	0.25%	$800	$800
	Builders Risk Insurance	%	0.25%	$800	$800
	General Liability Insurance	%	1.50%	$4,802	$4,802
	Intellution System Upgrade / Licenses	%	1.00%	$3,201	$3,201
	GC Field General Conditions	%	10.00%	$32,011	$32,011
	Contractor's Overhead and Profit	%	10.00%	$32,011	$32,011
	TOTAL OPINION OF CONSTRUCTION COST				**$ 393,732.75**
	CONTINGENCY (25%)				**$ 98,433.19**
	ENGINEERING (10%)				**$ 39,373.27**
	TOTAL OPINION OF COST (ROUNDED TO NEAREST $1,000)				**$ 532,000.00**

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