546 FINAL REPORT

Project Team: EWB Northern Virginia Professional Chapter

Project Name: Preliminary Engineering Report for Hollin Meadows Farm

Community: Hollin Meadows Partnership for Outdoor Education

State: Virginia

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List of Acronyms

CEC	Community Engineering Corps
CFR	Code of Federal Regulation
DEQ	Department of Environmental Quality
EPA	Environmental Protection Agency
ET	Evapotranspiration
EWB	Engineers Without Borders
GPM	Gallons per minute
HMES	Hollin Meadows Elementary School
IRP	Independent Review Panel
NOVA	Northern Virginia
NRCS	Natural Resources Conservation Service
PE	Polyethylene
PVC	Polyvinyl Chloride
PWR	Plant Water Requirement
REIC	Responsible Engineer in Charge
USDA	United States Department of Agriculture

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1. Executive Summary

Hollin Meadows Elementary School (HMES) is a Title I school in Fairfax, VA that hosts 606 students as of the 2019 - 2020 school year (Appendix A). With approximately 57% of pre-kindergarten to sixth grade students qualifying as economically disadvantaged, HMES actively aims to close the achievement gap for a historically underserved population. The Title I elementary schools in the same district as HMES serve students with even greater needs, with the highest free or reduced lunch percentage being 91%. In 2016, HMES embarked on a major renovation project that involved the refurbishment of existing school buildings and added additional classrooms. This construction project reconfigured the outdoor spaces previously used for the school's Outdoor Education Program and required the school's gardens to go fallow during construction. One such space is the empty tract of land where the HMES Partnership for Outdoor Education is planning a project to develop a productive and educational farm for students and staff.

The farm developed through this project will be a unique educational opportunity for students who normally do not have access to hands-on interactive learning. The vegetables produced on the farm can be used to supplement food in the school cafeteria, packaged for students to take home, or gifted on field days. The HMES Partnership is also planning to coordinate with nearby schools to send extra vegetables to supply their school cafeteria.

To help the HMES Partnership embark on this process, the Engineers Without Borders – Norther Virginia Professional Chapter (EWB-NOVA) team performed a feasibility study to determine the technical and logistical requirements to provide water to the envisioned farm. Sections of this report can be used by the HMES Partnership to assist with project development and to determine which recommendations to prioritize. The purpose of this report is to:

- Evaluate irrigation requirements and alternatives for water sources,
- Identify regulatory requirements for construction related to the farm project,
- Assess stormwater considerations,
- Provide preliminary costs and logistical considerations for installation and operation,
- Identify irrigation components and other infrastructure required.

Three alternatives were evaluated for irrigation sources:

- Rainwater collection diverted from the rooftop that discharges directly to the field,
- Water spigots connected to the current potable water supply,
- New water meter connection from Fairfax Water.

The suggestions were evaluated based on protection of human health and the environment, compliance with regulatory standards, short- and long-term effectiveness, implementation process, social considerations, and cost. The justification and evaluation for each alternative are provided in detail in Section 4.0.

2. Community Information

2.1 Participating Parties

The school has had a thriving Outdoor Education Program since 2005. In 2010, HMES parents established a nonprofit—the Hollin Meadows Partnership for Science and Math Education, as it was then known—to bridge the funding gap for STEM education. For the next six years, the Partnership and HMES worked together to enhance the school's environmental education curriculum and provide new hands-on learning opportunities for all students, which resulted in significant student achievement gains in math and science. In 2016, HMES embarked on a major renovation project that involved the refurbishing of existing school buildings as well as adding additional classrooms. This construction project reconfigured the outdoor spaces previously used for the school's Outdoor Education Program and as such, required that the school's gardens go fallow during construction. The Hollin Meadows Partnership for Outdoor Education (HMES Partnership) was re-established by HMES parents in November 2018, a few months after the school hired Jessica Buchanan to re-start the Outdoor Education Program and cultivate the newly configured outdoor spaces. The information presented in this report will inform the HMES Partnership of the necessary resources and regulations for starting a community farm in the HMES field.

2.2 Purpose and Scope

This report provides an alternatives analysis of water supply sources with considerations for stormwater management and irrigation components for the school farm. The alternatives include utilizing the potable water supply from city water through a new or existing water meter and installing rainfall collection. For stormwater management, the report will assess the need for site grading and any additional landscape improvements. For irrigation considerations, this report will identify irrigation components and infrastructures where applicable.

This assessment also includes an analysis of water access, drainage, and building materials for the HMES Partnership's consideration. The scope of this project does not include providing capital, fundraising, legal support, final engineering design, or construction services. Section 4.0 summarizes the feasibility of each alternative and estimated costs.

2.3 Project Team

The EWB-NOVA project team for the HMES farm project utilizes two groups: a Project Team and an Independent Review Panel (IRP). The project team includes engineers specializing in water supply systems, as well as individuals with backgrounds in civil engineering, environmental engineering, agricultural engineering, and project management.

The EWB-NOVA project team is led by a Responsible Engineer in Charge (REIC), Angeline Cione, P.E, and a technical project lead, Owen Julius Duncan, E.I.T. Angeline Cione previously served three years with the Peace Corps and currently works as a sustainability consultant. Angeline's strong technical background includes work in water and environmental engineering. Julius also served three years with the Peace Corps and brings both technical and project management expertise to the team, with five years of experience as an irrigation specialist under the U.S. Environmental Protection Agency's (EPA)

WaterSense program. The Project Team is also supported by Tessa Roscoe, E.I.T., an environmental engineer for six years focusing on wastewater treatment research projects as a contractor to the U.S. EPA, Emilio Arquitola, an equipment planner of three years at HDR, Inc, and Ha Dao, E.I.T, who brings two years of experience as an assistant civil engineer at CHA Consulting, Inc. All three currently serve on the EWB-NOVA Executive Committee (EC).

The IRP consists of James Breuninger. James has nine years of experience in the program and systems engineering and analysis industry. James has previously served as Project Manager for the EWB-NOVA El Sauce, Honduras International water supply and treatment project as well as in several EWB-NOVA EC positions.

3. Project Information

3.1 Project Background and Current Conditions

Since a structural renovation at the school in 2016 removed portable classrooms from the field behind the school, the HMES Partnership has been working with the school to develop an educational farm for students and staff. The total outdoor area, including the field, covers approximately 2.4 acres with a sidewalk around the perimeter (Appendix B). Near the southeast side of the field is a playground and basketball court that the students use during recess. The field is relatively flat, with a slight grade to direct stormwater and prevent pooling of water. There are three open grates for storm drains along the south border of the field (the north wall of the school). The storm drain discharges outside the west border of the field. There are also two storm drain access points near the discharge area.

The field also has one above ground obstruction, an access point box for cable/internet. Before doing any digging on the field, the HMES Partnership will need to identify the locations of all underground utility lines. If underground utility lines are not located before digging, it could result in damage. In Virginia, this can be accomplished by contacting Miss Utilities to identify underground utility lines and can be contacted at 1-800-552-7001 for more information. The HMES Partnership can submit a dig request by going to https://www.va811.com. Once the dig request is submitted, a representative from Miss Utilities will survey the field and identify any underground utility lines. Virginia 811 is the not-for-profit organization created by Virginia's utilities to protect their underground facilities.

3.1.1 HMES Site Visits

EWB-NOVA has met with the HMES Partnership several times. The project team originally met with the HMES Partnership in 2019 as the school expressed interest in partnering with EWB-NOVA. During that period, the EWB-NOVA team spoke with staff about the scope of work and gathered general information about the project area. The team also introduced the EWB and CECorps programs, described the project scope, and conducted an initial site review. In 2020, the project team conducted one site visit to photograph and inspect the landscape to aid in the engineering analysis of the current site conditions and conducted further research in a remote capacity in collaboration with HMES staff. In May 2021, the project team conducted a second site visit to test the water pressure and flow rate from outdoor spigots and gather a sample of soil to for a quality test. The general location of the project site within Fairfax County is shown in Image 1b.

3.2 Regulatory Requirements

The regulatory requirements applicable to the project were assessed for potential impact to the alternatives being considered. Hollin Meadows Elementary School is located in Fairfax County, Virginia and all federal water regulations, State of Virginia regulations, and Fairfax County regulations will apply to the project. Summaries of relevant federal, state, and county requirements are provided below.

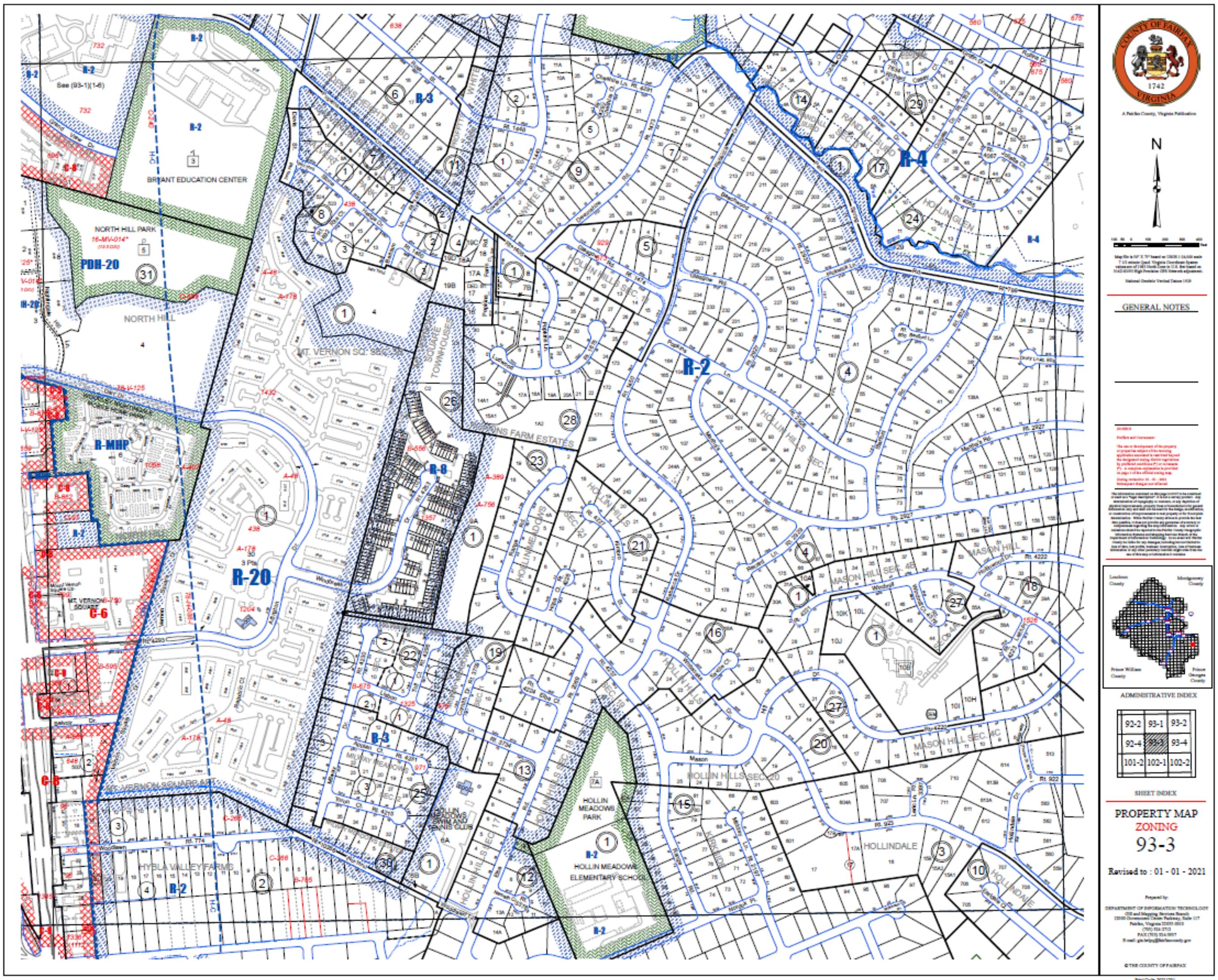
Fairfax County Water Authority is the regulating body directly responsible for water development and maintenance. Fairfax County Water Authority works to ensure that the system meets all regulations for pipe capacity, supply, storage, drinking water, and fire protection flow. The water regulations for Fairfax County can be found online (https://www.fairfaxwater.org/rules-and-regulations) and are on file at the Authority's General Offices (Fairfax Water, Rules and Regulations: Fairfax Water, n.d.).

In addition, Agency 25, State Water Control Boards from the Virginia Administrative Code applies. Federal and State laws and regulations govern the activities of this program, which include protecting the State’s natural resources, water supply, and water distribution.

Fairfax County also regulates the establishment of community gardening, defined as,

> *“A community garden can be either a piece of land or a planting area on a rooftop, gardened collectively by a group of people. Community gardens use either individual or shared plots on private or public land for growing herbs, fruits, flowers, vegetables or ornamental plants. Anyone can run a community garden: schools, places of worship, neighborhood associations, non-profit organizations, private landowners, clubs, community agencies and municipalities.”*

Fairfax County provides a list of districts where community gardens can be set up. Community gardens fall under Group 8 - Special Permit Uses according to the planning development zoning document (Fairfax County Zoning Ordinance: Article 8, n.d.). From the County GIS, the school is in the R-2 zoning district (Image 1a) in the eastern region of Fairfax County. Group 8 users may be located in the R-2 district; thus, a community garden is allowed to be built at the school.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NORTH HILL PARK
PDH-20
R-MHP
R-20
R-2
R-3
R-4
C-6
HOLLIN MEADOWS PARK
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HYBLA VALLEY FARMS
GENERAL NOTES
ADMINISTRATIVE INDEX
SHEET INDEX
PROPERTY MAP
ZONING
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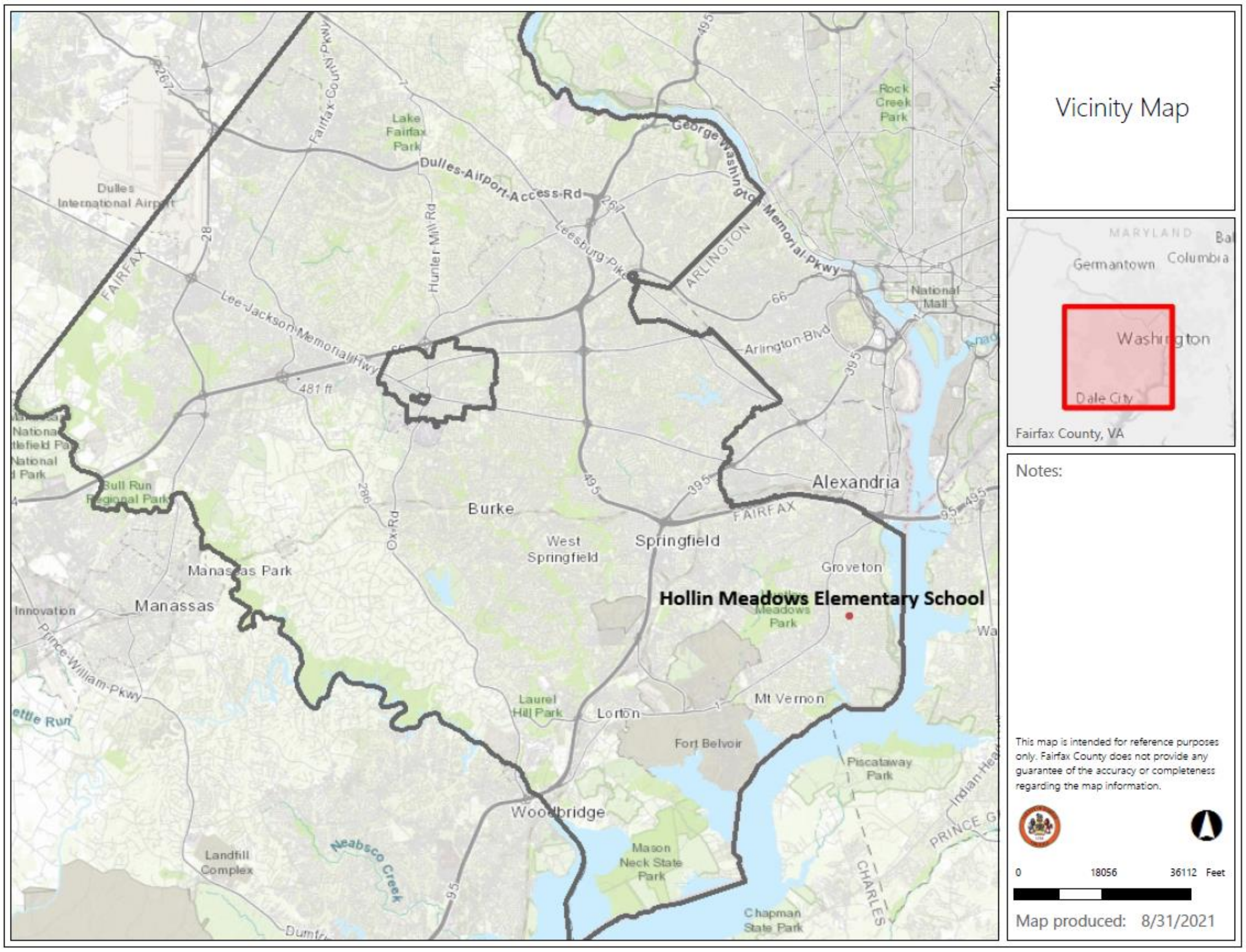

Image 1a (top) and 1b (bottom): Zone Map of HMES and location withing Fairfax County (Fairfax County, 2021)

Use of rainwater collection tanks is covered in the Virginia Rainwater Harvesting and Use Guidelines (Virginia Department of Health, 2011) developed by the Virginia Department of Health. Additional regulations for rainwater harvesting are covered by the Virginia Uniform Statewide Building Code, the Water Reclamation and Reuse Regulations, Virginia's Stormwater Management Regulations, and the Virginia DCR Stormwater Design Specification Number 6. Leaves and other debris from the rooftop can clog the rainwater tank and use of screens, strainers, first-flush diverters, and roof washers are recommended to prevent contamination. The federal Safe Drinking Water Act also covers the water quality regulations for rainwater harvesting. At a local level, according to the City of Alexandria government website on Rain Barrels and Water Harvesting, the city highly recommends their residents to install rain barrels to reduce storm runoff, conserve water, and save money (City of Alexandria, 2020). Thus, even though the school is outside of the city limit, given their proximity, it is safe to assume that there are no additional regulations and no known environmental impact from rainwater harvesting. Locations of rainwater collection tanks around the school may be limited by Fairfax County Public

Schools (FCPS) based on student safety. The EWB-NOVA team reached out to the FCPS office multiple times without response, and the HMES Partnership would need to confirm directly with the FCPS office about any construction to be done on the school grounds.

The garden also may require a zoning permit, which can include a Soil and Water Quality Conservation Plan, depending on location and size. Since the proposed site is greater than 10,000 square feet, additional erosion and sediment controls will be required. The Zoning Administration Division can be contacted for assistance in obtaining the correct permit.

When vegetables are harvested for use as foods in the school cafeteria, all applicable regulations by The Food and Food Handling Code (Fairfax County Health Department, 2006) should be followed. The Fairfax County Health Department may be contacted if any additional change in permits or inspections may be required.

3.3 Design Basis

This section provides an assessment of site conditions, including water usage, system storage capacity, system infrastructure, and water quality. These conditions will be used as the input into the comparative analysis of the various distribution system alternatives.

The field area behind HMES covers approximately 2.4 acres. According to a survey of the HMES Partnership (Appendix C), they anticipate using up to 75% of the field area for the farm (1.8 ac), with the remaining 25% reserved as play area for the students. During and after the school renovation, the field was used to hold portable classrooms and covered with turfgrass. Presently the field has available space for baseball, football, or soccer for the students. The field does not currently have an in-ground irrigation system and is not irrigated.

3.3.1 Water Usage

Although there are three outdoor water taps, they are not currently in use. According to Fairfax County, the school is connected to a single water meter and does not have a separate meter for outdoor water (Jackson, 2021).

The average daily irrigation demand expresses the amount of water that needs to be supplied for crop growth, including potential losses during water transport and application (Wada, 2013). For design purposes, the irrigation demand is determined by estimating the plant type, soil type, evapotranspiration (ET), and rainfall based on historical data. The average monthly rainfall and ET in Virginia are shown in Table 1.

Table 1: Average Weekly Rainfall and ET for Virginia (University of Virginia Climatology Office)

	Jan	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
ET (in/wk)	0.018	0.04	0.20	0.533	0.968	1.38	1.63	1.46	1.02	0.538	0.22	0.055
Precip (in/wk)	0.69	0.66	0.87	0.732	0.87	0.838	0.97	1.1	0.81	0.73	0.71	0.80
Precip – ET (in/wk)	0.68	0.62	0.67	0.2	-0.098	-0.54	-0.66	-0.36	-0.21	0.19	0.49	0.74

Based on using a field area of 1.8 ac, the EWB-NOVA team provided irrigation estimates based on a densely planted crop and a well-spaced crop. Since crop spacing within rows can depend on the crop, the EWB-NOVA team used plant spacing estimates from The Old Farmer's Almanac (https://www.almanac.com, (Almanac, 2021)). A dense crop, such as corn, is estimated using a spacing of 0.5 ft between plants in a row. A well-spaced crop, such as tomato, is estimated using a space of 3 ft between plants in a row. In both cases, it is estimated that rows are 4 ft apart, which allows space for walking between rows during harvesting. It is also estimated that between 15% and 50% of the field space is reserved for walking paths and space for equipment to pass through. The estimate also assumes the use of drip irrigation, which is a low-flow-rate irrigation that delivers water directly to the root zone of plants, thus the irrigated area only accounts for the root zone of plants and not the empty area between plants. Drip irrigation lines are also flexible and can be adjusted to meet the need of different spacing requirements. A summary of the area of the field to be irrigated based on the density of crop spacing is shown in Table 2.

Table 2. Summary of irrigated area based on plant spacing

	With 15% walking paths	**With 50% walking paths**
Dense crop spacing, smaller crops (0.5 ft between plants)	8330 SF	4900 SF
Larger crops, greater crop-spacing (3 ft between plants)	5554 SF	3267 SF

Based on the Old Farmer's Almanac (Almanac, 2021), plant water requirements can vary between 1 inch per week (in/wk) and 2 in/wk, depending on the crop. Irrigation is used to meet the plant water requirement after rainfall and ET are accounted for. As shown in Table 1, rainfall and ET can vary throughout the year, thus, the irrigation requirement can also vary throughout the year. Based on the different layouts, it is estimated that the irrigation requirement could range from 529 gallons per week (gal/wk) for a well-spaced crop irrigated at 1 in/wk during the cool season to 13,800 gal/wk for a densely planted crop irrigated at 2 in/wk during the summer (Image 2).

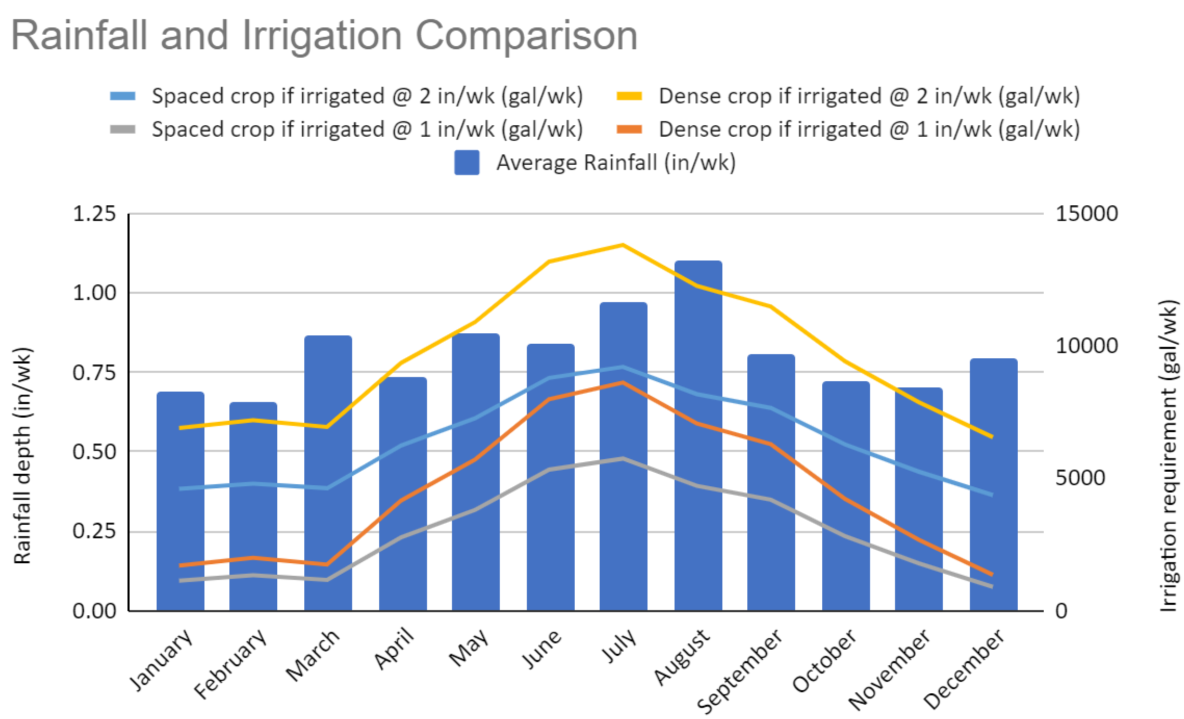

Image 2: Comparison of the range of weekly rainfall to the weekly irrigation requirement

Table 3: Daily irrigation requirement (gal/day)

	Dense crop irrigated 1 in/wk	**Spaced crop irrigated 1 in/wk**	**Dense crop irrigated 2 in/wk**	**Spaced crop irrigated 2 in/wk**
Jan	242.95	161.97	984.80	656.53
Feb	285.61	190.41	1027.45	684.97
Mar	248.52	165.68	990.36	660.24
Apr	593.47	395.65	1335.32	890.21
May	814.17	542.78	1556.01	1037.34
Jun	1140.58	760.39	1882.42	1254.95

Jul	1229.60	819.74	1971.45	1314.30
Aug	1008.91	672.60	1750.75	1167.17
Sep	897.63	598.42	1639.47	1092.98
Oct	602.75	401.83	1344.59	896.39
Nov	382.05	254.70	1123.89	749.26
Dec	192.88	128.59	934.72	623.15

3.3.2 Water Access and Storage

Water supply options were evaluated to determine their ability to meet the weekly irrigation demand of the field area available for plantings. Rainwater storage in tanks was also considered as an option to reduce the demand on the potable water supply.

Installation of an onsite well comes with two major challenges: acquiring an additional permit from Fairfax County (County of Fairfax, VA, 2020), Chapter 70.1, and completing an extensive site feasibility study. The site feasibility involves test hole drilling and identifying any potential nearby contaminant sources. Most importantly, the test results need to show adequate water quantity and acceptable water quality. Lastly, it is difficult to estimate the cost of installing an irrigation water well since the estimate depends heavily on the drilling depth required to reach the water source. However, since the well would need to supply at least 2.55 gpm to be comparable to the other alternatives, similarly sized residential wells can cost from about $9,000 to $15,000. Ultimately, this option involves much higher risk of unacceptable water quantity and quality, and thus was determined infeasible and will not be included as an alternative.

<u>City water access</u>

HMES is currently connected to the Fairfax County potable water supply (supplied by Fairfax Water and sourced from the Occoquan Reservoir and the Potomac River). They have a single water meter that supplies both indoor water and outdoor water spigots. Indoor water use includes bathroom faucets and toilets, kitchen sinks, and water fountains. Outdoor water use includes the small garden areas.

At the field area behind the school, where the farm will be built, there are three outdoor water taps on the wall facing the field. The flow rate from the water taps is 2.55 gallons per minute (gpm). The water taps are threaded to accept a ¾" water hose. If the school connects an irrigation system to the water spigots, Fairfax Water and the Virginia Construction Code require the installation of a backflow prevention device to avoid contamination of the potable water supply. There are several ways the school could use the water spigots to irrigate the field:

1. Connecting a water hose to water plants by hand.
2. Connecting a hose-end system of irrigation lines to supply irrigation.

The school can also choose to connect a new line directly from the city water line for outdoor water. This would first require approval from Fairfax Water. There are two options for connecting directly to the city water line. The options are installing a new water meter or tapping a new line off the existing water meter. For a new connection, to install a new ⅝" x ¾" meter, Fairfax Water requires a payment of $25,440. To tap a new line off the existing water meter, the school does not pay a fee to Fairfax Water (Jackson, 2021).

Irrigation water can come from connecting directly to the water meter, the existing outdoor water spigots, or a combination of both. Both water sources can connect directly to an irrigation system or can be used to fill water storage tanks. The benefit of connecting either of these water sources directly to an irrigation system is that the water supply pressure is high enough that a booster pump is not needed to irrigate areas on the far side of the field. The EWB-NOVA team measured the water pressure from the water taps as 78 pounds per square inch (PSI), which is higher than the recommended 30 to 45 psi recommended for irrigation systems but could be managed with pressure reducing valves (U.S. EPA W. , 2020). Alternatively, the water lines can be used to fill one or more water tanks around the field. The benefit of routing water to water storage tanks is that they can be filled during hours that the school is not using as much water indoors, reducing peak water demand. Subsequently, the water tanks can independently irrigate sections of the field, reducing the need for staff to be available to water by hand.

Rainfall collection and storage

Rainfall collection uses above ground or below ground tanks that are connected to rooftop downspouts to collect the rainfall that falls on a rooftop. The rainwater collection tank must be sized correctly based on the influence of rainfall, roof area, irrigation demand, and required storage in a rainfall event (Ghisi, 2010). The total potential rainfall that can be collected depends on the total area of the rooftop and the number of downspouts connected to the water tank. If the tank is not directly next to the downspout, or if multiple downspouts need to be connected, the gutter can be used to route the rainwater to the tanks and should be sloped to allow for even flow of the water.

HMES currently has two rainfall collection tanks installed in two gardens within the inner perimeter of the school. These rainwater collection tanks were installed by Fairfax County Storm and Drain during the full renovation of the building in 2016. One tank supplies water to a small garden in the school, and the second tank is currently not in use but is planned to perform a similar function in the future. A single tank can hold up to 3,100 gallons with a diameter of 9 ft. and a height of 7 ft. A concrete pad with steel bolts supports the tank providing an even, flat surface, as seen in (Image 3). The tank that is currently in use is connected to a single downspout from the roof (Image 4). On the opposite side of that same rooftop are downspouts that could supply any rainwater collection for the farm (Appendix B). Once the tank is full, it has an overflow spout that sends water into the storm drain that was initially used for the downspout (Image 5).

Image 3: Concrete pad supporting rainfall collection tank

Image 4: Rainfall collection tank and downspout from roof

Image 5: Stormwater drain for rainwater collection tank overflow

3.3.4 Stormwater Management

Soils

According to the USDA-NRCS Web Soil Survey (United States Department of Agriculture, 2019), the primary soil type present at the school is Grist Mill sandy loam. Present in the surrounding area is Grist Mill-Mattapex complex soil, Mattapex loam, and Urban land use.

During the 2016 renovation of the school, the soil in the field was not replaced or amended, but turfgrass was replaced. At the May 2021 site visit, the EWB-NOVA team visually inspected the soil profile and noted that it was rocky and compacted (Image 6). This compaction could reduce infiltration and increase runoff. If crops were planted directly into the soil (as opposed to using raised beds) the soil would likely need to be tilled to increase infiltration.

Image 6: Visual inspection of soil profile

The soil test conducted by the Virginia Cooperative Extension highlighted that phosphorus levels were high and potassium levels were moderate. They recommend a phosphorus free fertilizer with a potential N-P-K ratio of 25-0-7. Lastly, the pH and percent organic matter are both in ranges sufficient for the landscape or agricultural production. The soil test report is included in Appendix D.

If HMES chooses to directly plant in the soil, they can apply soil amendments as recommended for a specific crop type and till the soil to maintain a healthy soil. If they choose to use raised beds or planter boxes, soil from the field can be used if sifted, along with compost or mulch. Raised beds allow for more control over soil quality and can additionally help with irrigation efficiency.

Slope

The slope on the site is low and the area has been converted for gardening purposes, so the site should have no runoff concerns or erosion concerns. Edible plants are sensitive to being submerged and do not grow well in wet soil, so a minimum slope of 2% or 1/4 in per foot is recommended for drainage. Typically, the site should have a slope of no more than 3:1 to permit easy grass maintenance and no more than 1:12 to be manageable by both people walking and wheelchair users. Areas with slopes steeper than 3:1 must be planted with ground cover or constructed with materials specifically designed to control erosion.

The current slope at the site is less than 5%, which is flat and should not cause runoff problems but may cause ponding problems. Image 7 shows a topographic map from Fairfax County GIS. Using raised beds can mitigate the problem as the plants are elevated and soil in raised beds warms faster and dries out more quickly than soil at ground level. Regardless of the alternatives chosen for the farm, site grading is not recommended.

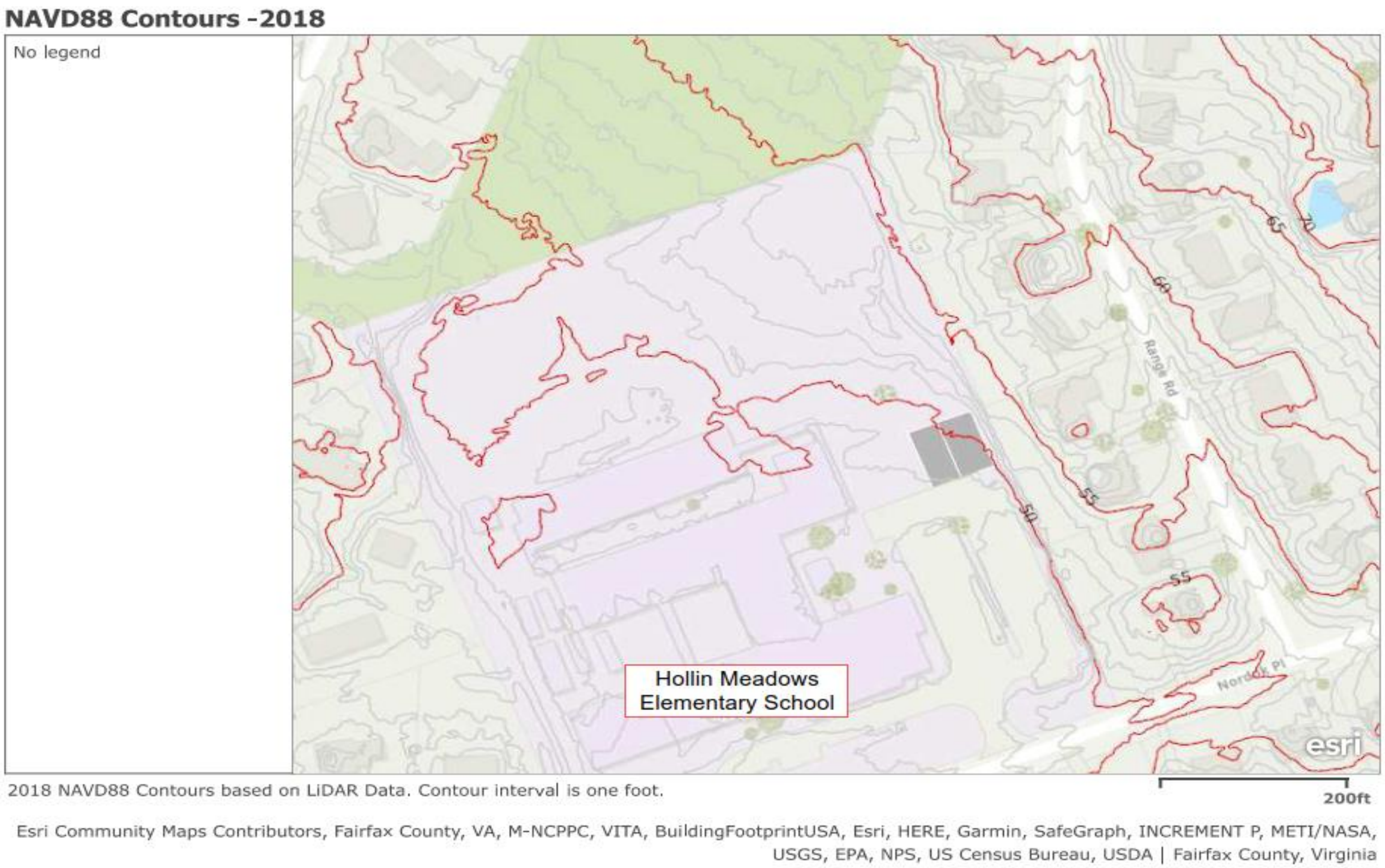

Image 7: Topographic Map of HMES

Current drainage and site conditions

Storm grates and a single underground storm water pipe carries runoff from the field towards a vegetated area outside the fence. Current conditions on the site do not show issues with standing water or lack of drainage. Runoff is expected to be lower when plants are added and existing soil is converted to gardening soil, so this storm drain is not expected to handle any additional flow. While increases to the potential for stormwater runoff are not anticipated, if the changes do increase runoff, the site must comply with Chapter 124, Article 4 of the Fairfax County, Virginia Code of Ordinances - Stormwater Management Ordinance 2020 (County of Fairfax, VA, 2020).

If rainwater capture is incorporated, the downspouts would divert runoff from the roof to rain barrels instead of sending it to the storm sewer. This would help ensure that stormwater runoff was decreased and not increased by this project.

4. Alternative Analysis

The alternatives analysis investigates the following water supply options for irrigating the farm:

1. Rainwater Capture & Storage
2. Existing Outdoor Water Spigots
3. New Water Meter
4. Rainwater Capture & Existing Water Spigots
5. New Water Meter with Rainwater Capture and Existing Spigots

The factors considered in the alternative analysis for the HMES Farm are:

- volume of water available,
- potential area irrigated,
- cost,
- maintenance,
- level of effort,
- relevant codes and regulations.

The feasibility of each alternative was determined based on the amount of time needed to meet the minimum (529 gal/wk) and maximum (13,800 gal/wk) weekly irrigation requirements. A summary of alternatives is provided in Table 4 below and the details of each alternative are explained in sections 4.1 through 4.5.

Table 4: Summary of Alternatives

Alt #	Description	Assumptions	Water Source	Potential storage or flow rate	Daily runtime required to meet maximum weekly irrigation requirement	Installation Cost	Monthly Cost
1	Rainwater capture and storage	Only half of the rooftop would be available to divert rainfall to collection tanks due to downspout locations. Additional collection potential would be dependent on walkways built in the field.	Rainfall diverted from the rooftop.	4,600 gal of storage	There is not enough potential storage to meet the maximum irrigation demand.	$25,000	None
2	Existing outdoor water spigots (minimal input option)	All three spigots would be available for full-time use.	Connected to the school potable water supplied by Fairfax Water.	Flow rate from each water spigot is 2.55 gpm	4 hr/day.	None	$177
3	New dedicated outdoor water line from water meter	New line will supply water directly for outdoor use. The line will be split off the existing water meter rather than installing a new water meter.	Fairfax Water potable water supply.	Flow rate would be approximately 15 gpm	3 hr/day.	None	$177

Alt #	Description	Assumptions	Water Source	Potential storage or flow rate	Daily runtime required to meet maximum weekly irrigation requirement	Installation Cost / Monthly Cost
4	Rainwater capture and existing water spigots	The spigots will be used as the primary water source and supplemental water can be provided by the rainfall collection tank(s).	The school potable water from water spigots supplied by Fairfax Water and additional water diverted from the rooftop.	Flow rate from each water spigot is 2.55 gpm with additional storage of 4,600 gal.	3 hr/day.	$25,000 $115
5	New water meter with rainwater capture and existing spigots	Each method could be installed in phases. All water sources have ability to connect to an automated controller. Connecting to the water meter will be done only to connect to an in-ground irrigation system	Rainfall collection from the rooftop, water spigots connected to the outside wall of the school, and a new connection to the existing water meter.	Has a potential to store 4,600 gal and a combined flow rate of 17.65 gpm.	58 min/day	$25,000 $115

4.1 Alternative 1: Rainwater Capture and Storage

Description of alternative:

Under this scenario, rainfall collection tanks would be installed to collect water from the north-most rooftop of the school. It is recommended to install a 3,100-gal tank, the same capacity as the existing tanks in the educational garden. Alternatively, smaller tanks can be used on each end of the rooftop or distributed throughout the field. Currently, the rooftop already has one downspout that is diverted to the existing collection tank, which only leaves half the rooftop area available for additional water collection. A similar set up for the proposed tank can be implemented, so water is collected by diverting the downspouts from the rooftop to proposed tank. For additional potential rainfall collection, the school could include gravel paths through the farm with covered overhangs (covered walkways) that divert water to smaller barrels.

If one or more tanks are installed for the field, the downspouts would need to be disconnected from the underground stormwater sewer and the gutter re-routed to the new tank. For the estimates of rainfall collection, the EWB-NOVA team is assuming a maximum of only half of the rooftop area is available for rainfall collection for the farm. Since the other half of the rooftop faces the internal garden, those downspouts can't be routed to the field and won't be used for the calculation. Parameters for the calculation of potential volume of rainfall collection based on the rooftop area is provided in Table 5 below and the trend of potential rainfall collection throughout the year is shown in Image 8.

Table 5: Parameters for Rainfall Collection Potential

Total rooftop area (sq. ft.)	13,674
50% Rooftop area available for rainfall collection (sq. ft.)	6,837.2
Number of downspouts (-)	7
Maximum potential rainfall collection (gal/wk)	4,687.9

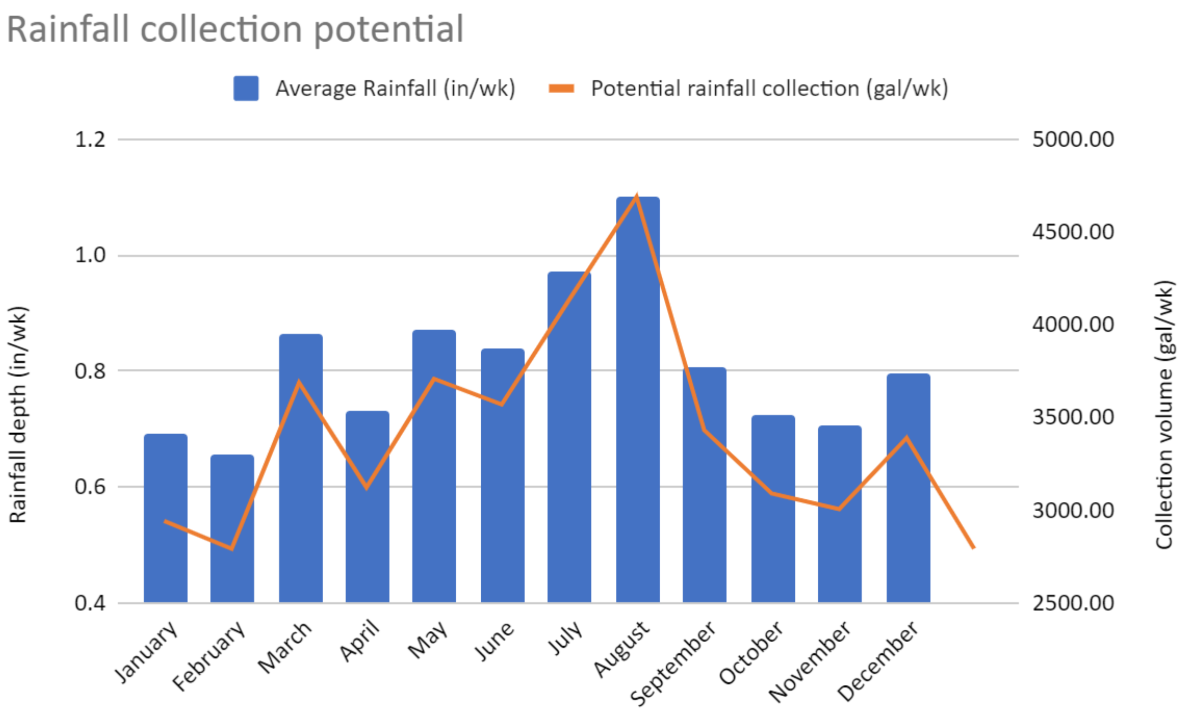

Image 8: Trend of yearly rainfall collection potential

Due to the size of the farm and the relatively flat slope, the water tanks would need a water pump to provide enough water pressure to an irrigation system. Without a pump, the water tanks are not elevated high enough to overcome the head loss that exists in the system for water to reach the farthest point in the irrigation system.

Feasibility breakdown:

Volume of water available for irrigation: From half of the rooftop area there is a potential collection of between 2,700 and 4,600 gal/wk, depending on rainfall (Image 8). Covered walkways 4 ft wide can divert an additional 1.87 gal/wk for each foot of length of the walkway. Covered walkways could divert between 642 and 1078 gal/wk depending on the total area of coverage and weekly rainfall.

Runtime required to meet irrigation requirement: Runtime from a water tank would depend on the pump used and the length of water lines, and because those factors vary by manufacturer, this alternative will be evaluated on whether the storage volume could reach the total irrigation requirement. Rainfall collection could meet the minimum irrigation requirement during the time of year that the field does not need as much water (Image 8). The potential for rainfall collection would not meet the maximum irrigation requirement during the hottest time of the year. A 13-ft long covered walkway could meet the irrigation requirement of a single planter box (4 ft x 8 ft).

Feasibility: Rainfall collection from the rooftop could be used to irrigate a small section of the field or dedicated to a section of planter boxes. A covered walkway with rainfall capture and storage would provide a minor addition to the rainfall collection potential and would only be feasible for supplying water for small areas.

Benefits, limitations, and considerations:

Installation cost: According to Fairfax County Storm and Drain, the cost of the concrete support pad for the previously installed 3,100-gallon water storage tank was $10,000 and the cost of the steel water tank was $15,000.

Maintenance cost: The cost of maintenance would be fairly low and would need to cover yearly cleaning of debris. There would not be additional cost to the water bill since the tank would not require connection to Fairfax Water.

Installation level of effort: Due to the size of the tank, a professional crew would be needed to install the tank. Installation would include construction of a concrete pad for stability, placing the tank, diverting the downspouts to the tank, and installing any additional plumbing for first flush removal and irrigation. Covered walkways would need skilled labor as well to ensure stability.

Maintenance considerations: Primary maintenance includes regular inspection to ensure that debris is not accumulating to avoid clogging. Yearly cleaning and disinfection of the internal surface is also recommended to avoid buildup. It is also recommended that the school prepare a maintenance plan to ensure the entire system continues to work.

Flexibility in design: Different sized tanks can be used to lower costs or allow for maneuverability. Covered walkways can be organized anywhere throughout the field. Plastic tanks can also be used to lower the cost of materials.

Regulatory requirements: According to the Alexandria Stormwater Utility Fee Credit Manual, a cistern must be sized large enough to capture at least the first 1-in of rainwater to qualify for a stormwater credit. Design and installation requirements are covered in the Alexandria Stormwater Utility Fee Credit Manual (https://www.alexandriava.gov/uploadedFiles/tes/Stormwater/SWU_Credit_Manual.pdf). FCPS has mentioned safety concerns about children having access to water tanks; as such, a barrier such as a fence may need to be included in the design.

According to the 2012 Virginia Plumbing Code Section 1303, rainwater collection tanks should be no less than 5-ft from the lot line adjoining adjacent lots, sewage systems, and septic tanks. Additionally, Fairfax County Land Development Services highlights that rainwater should only be collected from impervious roof surfaces, surface diversion should bypass the first 0.04 in of each rain event to reduce contamination, and pre-tank filtration should filter all materials larger than 0.015 in. The rooftop that is planned to be used for rainfall collection is an impervious surface, which meets the recommendation of Fairfax County Land Development Services. Lastly, the HMES Partnership would need approval from FCPS to install rainwater collection tanks at the school and to disconnect any downspouts. Due to the risk of students climbing on the tank in the field, appropriate safety measures should be taken.

4.2 Alternative 2: Existing Outdoor Water Spigots

Description of alternative:

The lowest-effort option for irrigation is to utilize the three existing outdoor water taps (also called spigots or hose bibs). They are located on the north-facing outside wall of the school (facing the planned farm area) and are connections off the school's potable water supplied by Fairfax Water.

A ¾-inch water hose connected to the spigot can be used for hand watering or could be connected to a more permanent, installed irrigation system. It is worth noting that the proposed water hose must cross the sidewalk along the length of the wall and potentially obstructs access and becomes a trip hazard. Furthermore, if an irrigation system is connected to the water spigots, a backflow preventer is required to avoid contamination of the potable water supply.

Feasibility breakdown:

Volume of water available for irrigation: A single water spigot flows at a rate of 2.55 gpm. Using all three available spigots at the same flow rate yields 7.7 gpm. The water pressure has been measured at 78 psi. Because it is connected to the same water line as indoors, during the peak use hours, this flow rate may be lower.

Runtime required to meet irrigation requirement: Based on using a single water spigot, the field would need to be irrigated for 30 minutes per day to meet the minimum irrigation requirement and for 13 hr/day to reach the maximum. Based on using all three water spigots during each irrigation cycle, this method could reasonably meet the minimum irrigation requirement if irrigated for 10 minutes per day and the maximum irrigation requirement at 4 hours and 18 minutes per day.

Feasibility: Using all three water spigots can reach the maximum irrigation requirement for the farm. It can also be accomplished in a reasonable amount of time that the staff could monitor the operation of the system. Having water spigots in three locations along the outside wall gives the flexibility to organize plants based on the nearest water spigot. If automatic control was connected to the water spigots to allow for more flexibility and control over the irrigation schedule, this method could meet the weekly irrigation requirement of the full field with minimal oversight from staff.

Benefits, limitations, and considerations:

Installation cost: This is the lowest cost option. The water spigots are already installed on the wall at the school and only watering hoses and accessories would be needed. To connect to an irrigation system, it will need a water hose long enough to reach from the spigot to the field, a hose-end irrigation controller, filter, backflow preventer, and pressure regulator. Cost of these components can vary between $100 and $200 total based on prices at Home Depot. For an automatic irrigation system, the installation cost would be higher, including controllers, tubing, and possibly underground pipe installation, which might require deconstruction and reconstruction of the sidewalk.

Maintenance cost: These components would need to be monitored yearly and replaced as necessary. Use of water from Fairfax Water could increase the monthly water bill between $11 and $177 when meeting the irrigation requirement of the entire field based on current water pricing.

Installation level of effort: Since the hose bibs are already installed on the wall, the only installation consideration would be connecting the water hose to the tap. There is a sidewalk along the outside wall and any connected water hose would cross the sidewalk. It is recommended to include safety measures to avoid a tripping hazard. An in-ground piped system and/or automatically controlled system would require a contractor.

Maintenance considerations: The connection of the water hose to the wall would need to be monitored in case it is damaged. During the winter, the hose should be disconnected, and the system should be winterized.

Flexibility in design: Because there are three spigots on the wall, the choice in which to use can be based on the most convenient distance to the grow beds. Additionally, as the farm grows, the HMES Partnership can choose to attach to multiple spigots.

Regulatory requirements: Fairfax Water requires a backflow prevention device to be installed on permanent irrigation to prevent the contamination of potable water sources.

4.3 Alternative 3: New Fairfax Water Meter

Description of alternative:

To allow for higher irrigation flow rates, a new water line from Fairfax Water main could be installed with its own meter. Splitting a new line from the existing water meter allows for direct water flow from the County water main which will experience minimal disruption during peak indoor use. Additionally, as a comparison to alternative 2, installing a line larger than ¾" provides more flow to the field. This alternative also considers installing another water meter independent of the water source for indoor use. If the school desires to separate water usage or concerns about low flow to the garden during peak demand indoor, a new water meter is recommended. Nevertheless, the operating hours can always be set up to stagger to make sure low flow is not encountered.

Feasibility breakdown:

Volume of water available for irrigation – The flow rate can vary 15 to 60 gpm depending on meter size. Based on the conversation with Fairfax Water, the school has a ¾" x ⅝" water meter, which can supply from 15 to 20 gpm. Currently, that flow is divided between all water uses. Installing a new water meter directly from the Fairfax Water line will supply the full flow rate of 15- 20 gpm for irrigation.

Runtime required to meet irrigation requirement: Assuming at least 15 gpm, the water line could meet the minimum irrigation demand if the system was run for 5 min/day 0.13 hr/day and the maximum irrigation demand at 2 hours and 11 minutes per day.

Feasibility: The water line could irrigate the entire field during the warm season and the cool season. If used along with an automatic irrigation control system, it could be run with minimal oversight to irrigate the entire field.

Benefits, limitations, and considerations:

Installation cost: The cost to connect a new ⅝ x ¾" meter is $25,440 paid to Fairfax Water. To tap the existing water meter, no cost is paid to the city and can be installed by Fairfax Water for water lines smaller than 3-in in diameter. The installation of the in-ground irrigation system would be at the expense of HMES.

Maintenance cost: An additional water line once installed will not require any maintenance. Using the Fairfax Water schedule of rates (Fairfax Water, Schedule of Rates, 2021), it will cost an additional $11 to $177 monthly to meet the total irrigation demand depending on how long the irrigation system is run.

Installation level of effort: Connecting to the water meter would be done by Fairfax Water and could include using a small excavator for a 2-ft wide trench with at least 3 to 4 ft of ground cover for the pipe to reach from the water meter to the field.

Maintenance considerations: A dedicated irrigation line allows for ease of installing an automated, underground irrigation system and would be metered separately, allowing for ease of tracking water usage. An in-ground irrigation system will need to be winterized before freezing weather and then checked again during the spring.

Flexibility in design: As stated above, a new line adds flexibility for installing an automated irrigation system, with higher flowrates available.

Regulatory requirements: "Service connections for meters less than 3 inch will be installed by the Authority and the Authority will specify the location, kind, and quality of all materials… Service connections for meters 3 inch and larger will be installed by the Builder subject to inspection and approval by the Authority." - Fairfax Water: Rules and Regulations (https://www.fairfaxwater.org/index.php/rules-and-regulations).

Fairfax Water requires a backflow prevention device to be installed on permanent irrigation to prevent the contamination of potable water sources.

4.4 Alternative 4: Rainwater Capture and Existing Water Spigots

Description of alternative:

Alternative 4 is a combination of Alternatives 1 and 2. The spigots on the outside wall would be the primary source of irrigation water. Rainfall collection would collect the maximum available water from the rooftop and several additional walkways with overhangs could provide additional collection around the field. Rainfall collection can reduce the volume of potable water used for irrigation.

Feasibility breakdown:

Volume of water available for irrigation: Rooftop rainwater collection would collect a potential of 2,700 and 4,600 gal/wk, and the three spigots on the wall provide a combined flow rate of 7.65 gpm.

Runtime required to meet irrigation requirement: Rainfall collection on its own could meet the minimum irrigation requirement. Combining the use of rainwater collection and three spigots could meet the maximum irrigation requirement if run for 3 hr/day.

Feasibility: The combination of these two methods gives the ability to irrigate the field using both the school water supply and rainfall collection. Using the spigots gives access to irrigation water throughout the season, even when rainfall is low. Using the rainfall collection saves water on rainy days that can be used later to increase how much of the field is irrigated.

Benefits, limitations, and considerations:

Installation cost: According to Fairfax County Storm and Drain, the cost of the concrete support pad is $10,000 and the cost of the steel water tank is $15,000. The hose bib is already on the wall and would only need to connect to the irrigation system.

Maintenance cost: Cost of maintenance would be to remove debris from the tank and disinfect it once a year to minimize algal/mold build-up. Using rainwater collection will offset the water bill during the rainy season but would increase the water bill by $115 during the dry season.

Installation level of effort: The rainwater collection system would need to be installed with pipes that would divert water from the rooftop to the tank(s). The hose bib has a threaded connection that can connect directly to an irrigation system. Any connection to a hose bib would need to consider avoiding the sidewalk which could cause a tripping hazard.

Maintenance considerations: Rainwater collection tanks need to be regularly cleared of debris and disinfected annually. During the winter, the connection to the hose bib should be winterized to avoid breaks from freezing.

Flexibility in design: This approach combines two methods of sourcing water for irrigation. There are three hose bibs on the outside wall and any combination can be selected to supply water. Rainwater collection tanks can be sized based on the volume of potable water they intend to offset.

Regulatory requirements: According to the Alexandria Stormwater Utility Fee Credit Manual, a cistern must be sized large enough to capture at least the first 1-inch of rainwater to qualify for a stormwater credit. Design and installation requirements are covered in the Alexandria Stormwater Utility Fee Credit Manual (https://www.alexandriava.gov/uploadedFiles/tes/Stormwater/SWU_Credit_Manual.pdf). Fairfax Water requires a backflow prevention device to be installed on permanent irrigation to prevent the contamination of potable water sources. For student safety concerns, FCPS does not recommend rainwater collection tanks installed on the outside grounds of the school.

4.5 Alternative 5: New Water Meter with Rainwater Capture and Existing Spigots

Description of alternative:

Alternative 5 looks at the possibility to combine all three methods of Alternatives 1, 2, and 3 – rainfall collection, water spigots, and a new Fairfax Water line. The school may choose to use each method based on the area to be irrigated, the desired operating hours, and phase of garden development.

Feasibility breakdown:

Volume of water available for irrigation: Combining all three methods would have up to 4,600 gallons of rainfall collection storage, 7.7 gpm from the water spigots, and 15 gpm from the water meter.

Runtime required to meet irrigation requirement: Combining all three sources of water could meet the minimum irrigation requirement if run for 4 min/day and the maximum irrigation requirement in 58 min/day.

Feasibility: All three water sources allow for flexibility in the area that can be irrigated and shortens the time it would take to meet the weekly irrigation requirement. Using rainfall collection reduces the need to rely on the indoor water supply during peak hours. Because of the shorter irrigation time, the days for irrigation can be staggered to avoid the need to run the system daily.

Benefits, limitations, and considerations:

Installation cost: Costs of installation for this method would include the $25,440 cost to Fairfax Water for a new water line as well as the cost of installing the rain capture system. A professional to install the water tank and support pad and an irrigation professional that could connect an in-ground irrigation system to the water meter. According to Fairfax County Storm and Drain, the cost of the concrete support pad is $10,000 and the cost of the steel water tank is $15,000.

Maintenance cost: Costs of maintenance would primarily be to pay for yearly cleaning of the rainfall collection tank. This method could eliminate the potable water cost during the rainy season but also increase the monthly water bill up to $115 per month during the dry season.

Installation level of effort: The rainwater collection tanks would need to connect to the downspouts from the rooftop. There is no cost to connect to the water spigots. There is also no fee to pay to Fairfax Water to connect to the water meter, but there will be a cost for an irrigation professional to connect an irrigation system to the water meter.

Maintenance considerations: Each year it is necessary to clear any debris from the rainfall collection tank. During the winter it is recommended to winterize any irrigation lines to prevent freezing and breaking.

Flexibility in design: This approach combines two new water sources that could be instituted in phases. Because there are already water spigots facing the field, the school could begin to use them without any additional installation. Rainwater collection tanks can be smaller to lower the cost and can be placed in different locations depending on need. The highest level of effort would be to connect the new water line and is recommended once the school is ready to irrigate a larger area.

Regulatory requirements: According to the Alexandria Stormwater Utility Fee Credit Manual, a cistern must be sized large enough to capture at least the first 1-inch of rainwater to qualify for a stormwater credit. Design and installation requirements are covered in the Alexandria Stormwater Utility Fee Credit Manual (https://www.alexandriava.gov/uploadedFiles/tes/Stormwater/SWU_Credit_Manual.pdf). Fairfax Water requires a backflow prevention device to be installed on permanent irrigation to prevent the contamination of potable water sources.

"Service connections for meters less than 3 inch will be installed by the Authority and the Authority will specify the location, kind, and quality of all materials… Service connections for meters 3 inch and larger will be installed by the Builder subject to inspection and approval by the Authority." - Fairfax Water: Rules and Regulations (https://www.fairfaxwater.org/index.php/rules-and-regulations).

5. Additional Design Consideration

Although not covered in the scope of this report, the following sections identify additional considerations for a community farm.

5.1 Financial Considerations

In 2019, the HMES Partnership submitted an application to Dominion Energy's community grants program for a request of $24,900. Although they were not awarded in 2019, they plan to apply again in a future round. The budget included a new chain link fence with a gate, training by the Arcadia program in Washington, DC, and soil amendments.

The Alliance for Water Efficiency offers a Learning Landscapes Grant program each year for the development of qualified school gardens. The grant can be used to support building or improving educational outdoor spaces (Alliance for Water Efficiency, 2021). The 2021 grant program is open for applications until July 30, 2021, awarding five grants with $5,000 each.

5.2 Crop planting methods

The land area available allows HMES Partnership to select from several different methods of planting crops. According to the HMES survey (Appendix C), they plan to use a combination of raised beds and row crops. The most direct method is to plant row crops that run the length of the field separated by furrows. The benefit of planting row crops is that plants can be directly planted and there is no need to build additional structures. The disadvantage to row crops is that over the winter the rows may get overgrown with weeds and will need to be handled the following spring.

Alternatively, raised beds require building a planter box that will hold the growing media. The benefit of using planter boxes is that they reduce the likelihood of pest and weed infestation along with reducing the irrigation requirement compared to row crops. The disadvantage to planter boxes is that they need to be constructed, which takes time and materials, and they require additional soil beyond what is available in the field.

In either scenario, it is suggested that HMES Partnership develops the farm in segments over a period of several years. This will reduce the individual workload and allow time to fully develop each segment.

5.3 Other structures

5.3.1 Greenhouse

Some of the area for the farm could be set aside to be used for a greenhouse or nursery. There are several variations on the size of a greenhouse and would depend on the area required, construction materials, and whether it would be a permanent or temporary structure. The simplest method would be to dig raised beds in the ground and cover them with nursery plastic. The plastic should be elevated to allow for the growth of the seedlings, approximately one to two feet. A large, plastic hoop house is another method for building a nursery with relatively inexpensive materials. PVC pipe can provide the overall structure of the greenhouse and can be covered with nursery plastic. A permanent greenhouse would require expensive construction materials, such as cement and glass, to build the full structure of the greenhouse along with a permit to do construction on school grounds. These structures can also be built with other climate-control settings and fans for a customizable environment. Due to the high up-front cost of a permanent greenhouse, this method is not recommended.

One of the benefits of a greenhouse is that it provides a controlled environment for starting plants from seeds, including seeds that would normally not sprout due to lower temperatures earlier in the growing season. Seeds that are purchased from local nurseries are less expensive than purchasing seedlings, saving the school money over the season. Lastly, with additional plants available in the greenhouse, the school could choose to sell those seedlings during the year as a fundraiser.

5.3.2 Composting

A designated area for composting could provide a method for collecting plant matter from the farm that would normally go into a waste bin and reuse it as organic matter the following year. A compost pile consists of layers of fresh plant matter, dried plant matter, and often a layer of discarded paper products. As the bottom layers continue to decompose, more layers are added on top. Compost can also be collected in a rotating compost bin. The size of the compost bin can vary and can be rotated with a handle for easier use. Vermicompost is a third method for processing compost using worms. Using this method, it is important to use a secure container to avoid the worms entering the surrounding environment.

Composting provides an environmentally friendly solution to the disposal of plant matter on the farm. Normally, compost is purchased from the garden center and the volume of compost can become expensive quickly. By utilizing compost collection, the school could offset some of the cost of purchasing compost throughout the year. It is expected that HMES would keep any compost piles small to reduce concerns for high temperature, contaminants, or pests.

5.3.3 Walkways

Because the farm will be used as an interactive space for students, it is recommended that walking paths are distributed throughout the farm to allow for reasonable access. Paths can be built between planting rows, used to section off planting zones, or to allow easier access to planter boxes. The easiest method to develop a walkway is to clear a path through the existing soil. This can be accomplished with a shovel to clear and flatten the soil but comes with the disadvantage of becoming muddy during the rain and requires constant maintenance to avoid weed overgrowth.

One method to reduce weed growth along the soil pathways is to develop a gravel walkway. This will have the added benefit of providing a walkable surface that will not be as muddy in the rain. If it is desired to adjust the direction of the walkway in the future, that can be done by gathering the gravel and moving it to the new location. The disadvantage to gravel walkways and paths is they do not allow for wheelchair access.

The final method is to develop a walkway out of cement or tile. This method can be expensive depending on the total length desired. Unlike the soil or the gravel walkway, a cement walkway would become a permanent structure and could not be moved if the HMES Partnership desired to redirect areas of the farm in the future. As a public space, HMES will need to provide ADA accessible space for students and visitors to reach spaces throughout the farm. Walkways may also need to meet ADA standards for minimum width, slope, or handrails.

5.3.4 Rain gardens

According to the U.S. EPA, rain gardens are shallow, vegetated basins that collect and absorb runoff from hardscapes that mimic the natural environment by infiltrating stormwater runoff. Rain gardens are especially recommended around the existing storm drain grate inlets. The existing inlets could be elevated, with the rain garden constructed around it. The field is a 1.5-acre vegetated space, but around the school are streets, rooftops, parking lots, and sidewalks that contribute to the total runoff profile of the school. Additionally, based on the current land cover and soil condition, large storms can still result in runoff from the field, discharging to the storm drain. Installing rain gardens could reduce runoff and allow more rainfall to infiltrate into the soil. Fairfax County Storm and Drain offers a program to help develop rain gardens.

The dimensions of a rain garden would be based on the total desired area that would be diverted to the rain garden and the peak storm size. Other dimensions of width or depth can vary based on the desired footprint of the garden. Rain garden materials are a combination of porous soil that allows for infiltration, mulch that provides additional protection to plants and soils, flood-tolerant plants that can handle instantaneously high water levels, and shrubs or taller grasses that help to provide a protective border. Plants selected should be native to Virginia and the larger Chesapeake Bay region as they are more adapted to the local climate.

5.3.5 Hand watering stations

Depending on the desired size and layout of the farm, rather than installing an intricate in-ground irrigation system, the school could install several pipes in the ground that end at standpipes that conveniently connect to a water hose for watering plants by hand. A hose with a length of 100 ft connected to a standpipe could be used to reach an area of 31,415 square feet. That is long enough to need no more than two standpipes in the field. Along with an ability to connect a water hose to the outdoor spigots, this could provide a method to irrigate the farm in sections by hand. Due to the location of the project, frost-proof standpipes, typically equipped with weephole to provide continual use of water supply during winter time is recommended.

5.3.6 ADA Compliance

Although the ADA and the 2010 ADA Standards for Accessible Design do not specifically require gardens be accessible, a few suggestions for the design of an accessible garden are:

- Providing smooth and even (ideally concrete) walkways with 36 inches of width at the minimum
- Using raised bed garden boxes to allow for gardening without bending over or kneeling down
- For wheelchair gardeners, providing garden boxes with knee space underneath
- Minimizing or eliminating any trip hazard, fence, or concrete barriers

5.3.6 Irrigation System Infrastructure

The specific layout and design of an irrigation system is outside the scope of this report. The HMES Outdoor Partnership can use the information in this report to understand the considerations involved in selecting the pipes and irrigation emitters. As described above, the system will need to provide irrigation for up to 1.8 acres of row crops, planter beds, or grow boxes. According to the HMES survey, they expect to use a combination of raised beds and row crops, which can impact the layout of irrigation lines. They also expect to have some area of the field reserved for compost, which can reduce the irrigated area and the total irrigation requirement (Appendix C).

<u>Breakdown of components</u>

Irrigation Pipes

If an irrigation system is to be installed, it will consist of pipes that deliver water from the source to the plants. The pipes can either be installed permanently underground or above ground for temporary use. Connected directly to the water source is the main line that must be sized large enough to carry the total volume of water that will flow through the system. For a permanent structure, the main line can be PVC and can be buried to avoid damage. The submain line is the start of dividing the flow of water to each of the irrigation zones. There can be multiple submain lines that connect to the main line, and their location will depend on the layout of the field. Each irrigation zone will have a dedicated manifold line that connects to the submain line and is responsible for providing the flow to each irrigation zone. Lateral lines go through the plant bed and can be sprinkler irrigation or drip irrigation. The collection of later lines along a manifold is an irrigation zone, and they will connect to the same manifold line. The lengths and diameters of the lateral and manifold pipes should be designed based on the best position of the manifold and the inlet pressure of the lateral to satisfy the emission uniformity and pressure head of the emitters (Ma, Hu, & Liu, 2019).

Additional accessories

A water pump might be necessary for the system to pull water from water tanks. The purpose of the pump is to increase the water pressure in the irrigation system for water to flow continuously. Because the field is relatively flat, the water tanks do not have enough elevation to maintain a consistent internal pressure at the emitters of the distribution lines. A pump may not be necessary if the HMES Partnership chooses to irrigate only the area near where the tank is installed.

An irrigation controller can automate the operation of the irrigation system. The controller can be programmed to start and end the irrigation cycle, open and close valves, and smart controllers can adjust the irrigation cycle to prevent overwatering if rainfall is expected. A rain sensor can connect to the controller to track daily rainfall and bypass an irrigation cycle if rainfall is sufficient. An ET sensor can connect to the controller to estimate the water lost from the field due to ET and bypass the irrigation cycle if soil water is sufficient. A soil moisture sensor can connect to the controller to track the current water available in the soil and will bypass the irrigation cycle if soil water is sufficient.

Valves, backflow preventers, and pressure regulators control the volume and pressure of flow through the pipe system. Valves can open or close to allow or prevent flow respectively. Electronic valves can be connected to the irrigation controller for customized control. Backflow preventers ensure that the direction of flow is maintained and prevent the flow from reversing. Backflow preventers on slopes prevent reverse flow when pressure is lost and can also prevent irrigation water from returning to the potable water supply. Pressure regulators ensure that the water pressure throughout the system does not exceed the determined maximum. If the water pressure is too high, it can burst pipes and cause leaks. Even small elevation changes can cause the water pressure to increase so it is suggested to use pressure regulators throughout the system. The types of materials that can be used for the major components of an irrigation system are listed in Table 6.

Table 6: Components and Materials of an Irrigation System

Component	**Material description**
Mainline	PVC (Polyvinyl Chloride) or PE (Polyethylene) pipe material. Can be installed above ground or below ground. Does not need to be as flexible because it is a permanent structure. Must be sized to handle a higher flow and pressure.
Submain line	PVC or PE pipe material. PVC is preferred when the farm has a grid layout and can adjust direction with fittings. PE is preferred if the shape of the farm is not a grid or if the shape may change each year.
Manifold line	In most cases, PE pipe is preferred to follow the shape of the irrigation zone. PE pipe also allows for the lateral line to be installed at any interval.
Lateral line	Drip irrigation is generally PE pipe for flexibility and ease. Microsprinklers have a line-source pipe that connects from the lateral pipe to the sprinkler body.
Valves	Mechanical valves can automatically open and close, controlling flow. They must

	be connected to a power source and a controller to operate. In-line valve manifold assemblies can also be used to control multiple irrigation zones. Plastic valves are an inexpensive option that can be opened and closed by hand.
Fittings	Fittings connect sections of pipe and can also change the direction. PVC fittings connect two ends of PVC pipe with the use of PVC glue. PE fittings either slide into the pipe and are held by friction or use a clamp.
Pump	The type of pump should be based on flow rate, required pressure head, available power source, and ability to be kept outside or in a housing. Flow rate is dependent on the total number of drip or sprinkler emitters. Microsprinklers require between 20 and 30 psi to operate properly, and drip emitters require between 15 and 25 psi to operate properly.

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Community
Engineering Corps

Prepared by: EWB NOVA Hollin Meadows Project Team
Submitted on: September 3, 2021

Appendix A: Hollin Meadows Elementary School Demographics

Student Membership Demographics and Supplemental Programs (as of June for each school year)

Enrollment	2017-18		2018-19		2019-20	
	#	%	#	%	#	%
General Education	575	88.06	593	86.95	606	87.32
Advanced Academics - Level IV	23	3.52	45	6.60	40	5.76
Elementary Advanced Academics - Levels II,III	70	10.72	69	10.12	95	13.69
English Learner Services	232	35.53	249	36.51	262	37.75
Special Education Services	114	17.46	102	14.96	98	14.12

Gender	2017-18		2018-19		2019-20	
	#	%	#	%	#	%
Female	320	49.00	332	48.68	342	49.28
Male	333	51.00	350	51.32	352	50.72

Gender Graph

Ethnicity	2017-18		2018-19		2019-20	
	#	%	#	%	#	%
Asian	48	7.35	53	7.77	59	8.50
Black (Not Of Hispanic Origin)	175	26.80	191	28.01	178	25.65
Hispanic Or Latino	258	39.51	260	38.12	280	40.35
White (Not Of Hispanic Origin)	131	20.06	140	20.53	140	20.17
Other	41	6.28	38	5.57	37	5.33

Ethnicity Graph

Grade Level	2017-18		2018-19		2019-20	
	#	%	#	%	#	%
Grade 1	85	13.02	115	16.86	100	14.41
Grade 2	93	14.24	78	11.44	115	16.57
Grade 3	108	16.54	91	13.34	72	10.37
Grade 4	96	14.70	101	14.81	78	11.24
Grade 5	64	9.80	103	15.10	99	14.27
Grade 6	90	13.78	69	10.12	107	15.42
Head Start	14	2.14	14	2.05	18	2.59
Kindergarten	103	15.77	111	16.28	105	15.13

Grade Level Graph

English Proficiency	2017-18		2018-19		2019-20	
	#	%	#	%	#	%
English Learner	233	35.68	249	36.51	262	37.75
English Proficient	420	64.32	433	63.49	432	62.25

English Proficiency Graph

Free/Reduced - Priced Meals	2017-18		2018-19		2019-20	
	#	%	#	%	#	%
Free Or Reduced Fees	374	57.27	414	60.70	440	63.40
No Fee Waiver	279	42.73	268	39.30	254	36.60

Free/Reduced - Priced Meals Graph

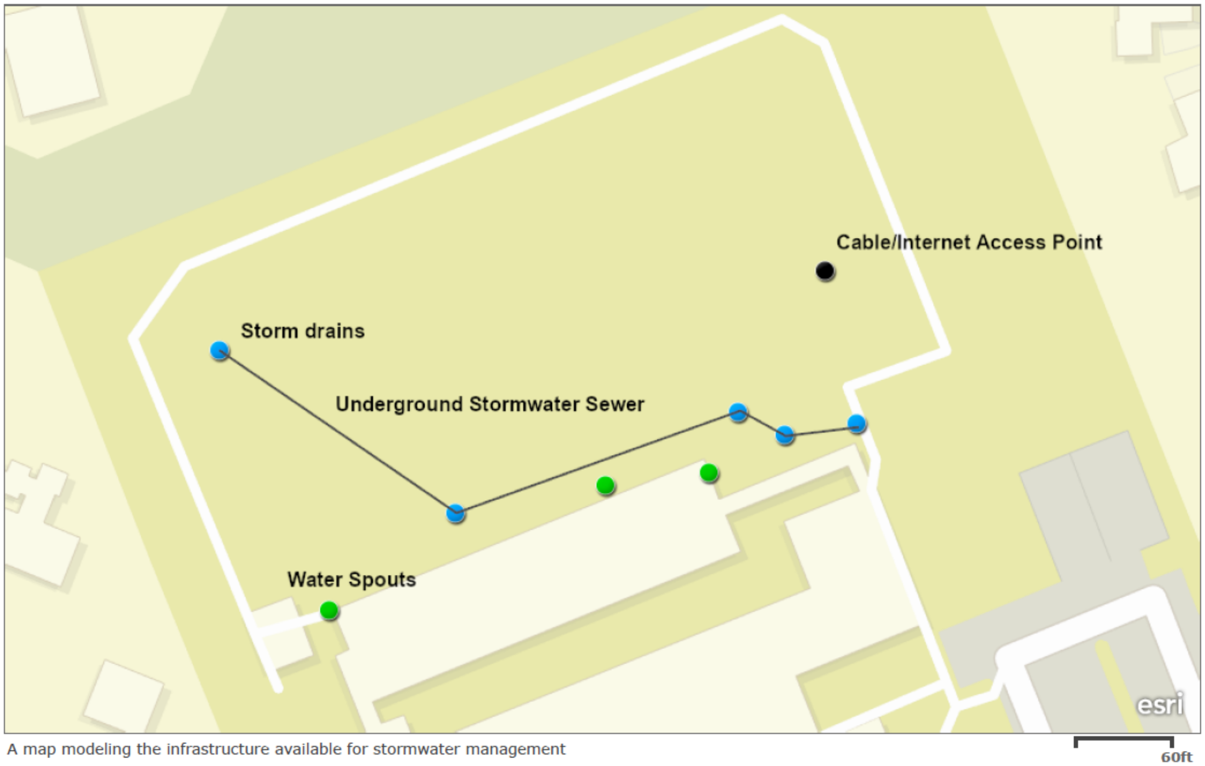
Mobility Rate	2017-18	2018-19	2019-20
	%	%	%
Division	11.07	11.74	
School	22.36	21.42	

Mobility Rate Graph

Appendix B: Hollin Meadows Elementary School Stormwater management Infrastructure

2/2/2021 School sewer infrastructure

School sewer infrastructure



A map modeling the infrastructure available for stormwater management

Esri Community Maps Contributors, Fairfax County, VA, M-NCPPC, VITA, BuildingFootprintUSA, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA

Appendix C: Community Survey

1. How much of the field would you like to be allocated as farm?
    a. ¼ of the field
    b. ½ the field
    c. ¾ of the field
    d. The entire field
    e. Other: ____

2. How much field space do students currently use as play area on a regular basis?
    a. Less than ¼ of the field
    b. Nearly ½ the field
    c. Over ¾ of the field
    d. The whole field
    e. Other: ___

3. How much field space should be left as play area for students after farm area is planted?
    a. Less than ¼ of the field
    b. Nearly ½ the field
    c. Over ¾ of the field
    d. The whole field
    e. Other:

4. Do you envision utilizing (answer as many as appropriate):
    a. Raised beds
    b. Row crops
    c. Greenhouse
    d. Compost
    e. Other:
    ____
    ____
    ____

5. Do you plan to access the farm during the weekends?
    a. Yes
    b. No

6. How would you like to approach controlling weeds and turning soil (open answer)?

7. Will the farm be used year-round or only during the warm season (open answer)?

8. Do you envision a specific section for trees?
    a. No trees

   b. Groups of trees
   c. Trees around the perimeter
   d. No preference
   e. Other: ____

9. How do you envision managing water (answer as many as appropriate)?
   a. Automatic irrigation with timer
   b. Manual with hoses
   c. Combination of automatic and manual
   d. Other: ____

Appendix D: Soil Test Results

SAMPLE HISTORY

Sample ID	Field ID	LAST CROP		LAST LIME APPLICATION		SOIL INFORMATION				
		Name	Yield	Months Prev.	Tons/Acre	SMU-1 %	SMU-2 %	SMU-3 %	Yield Estimate	Productivity Group
2528										

LAB TEST RESULTS (see Note 1)

Analysis	P (lb/A)	K (lb/A)	Ca (lb/A)	Mg (lb/A)	Zn (ppm)	Mn (ppm)	Cu (ppm)	Fe (ppm)	B (ppm)	S.Salts (ppm)
Result	41	170	2940	386	2.9	39.1	1.7	56.3	0.8	64
Rating	H-	M+	VH	VH	SUFF	SUFF	SUFF	SUFF	SUFF	L

Analysis	Soil pH	Buffer Index	Est.-CEC (meq/100g)	Acidity (%)	Base Sat. (%)	Ca Sat. (%)	Mg Sat. (%)	K Sat. (%)	Organic Matter (%)
Result	6.6	6.30	9.7	6.1	93.9	75.3	16.3	2.2	3.7

FERTILIZER AND LIMESTONE RECOMMENDATIONS

Crop: LAWN MAINTENANCE - BLUEGRASS, FESCUE (202)

619. Lime recommendations: NONE NEEDED.

991. "Explanation of Soil Tests, Note 1" and other referenced notes are viewable at www.soiltest.vt.edu under Report Notes.

208. FERTILIZER RECOMMENDATIONS: Use any phosphorus free maintenance "turf-type" fertilizer according to the instructions in the note on lawn fertilization. (A "turf-type" fertilizer is typically high in nitrogen, and has little or no phosphorus and potassium, e.g., 25-0-7.)

677. Soluble Salts are not high enough to cause salt injury.