Stormwater Asset Management Plan

Ayer, Massachusetts

November 2022

Tighe&Bond

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Section 1
Introduction

The Town of Ayer is responsible for operating and maintaining the municipal separate storm sewer system (MS4) to manage rainwater that travels off land surfaces during storms and from snowmelt (known as stormwater runoff), as well as protecting public health and safety and preserving environmental resources. Historically, the primary goals of managing stormwater runoff were to prevent immediate threats to life and property due to flooding and to maintain safe and passable streets. In the last decade, federal and state regulations (e.g., the Environmental Protection Agency's [EPA's] Phase II Small MS4 Program and permits, and Massachusetts Stormwater Management Standards and Handbook) have imposed increasingly stringent requirements on communities to locally manage stormwater runoff in order to address the serious adverse impacts that increased runoff quantity, temperature, and pollutants such as nutrients, bacteria, and sediment, carried by this runoff are having on local waterbodies. Likewise, land development and increasing storm intensity have increased the rate and volume of runoff that drainage systems must convey.

The Town recognizes that the stormwater system, much like the Town's water distribution and wastewater collection systems, is a necessary public utility that should be managed to benefit residents and local businesses. However, drainage systems are typically only repaired and replaced as problems arise. The Town is a Municipal Vulnerability Preparedness (MVP) community and, through the MVP process, one of its identified High Priority projects was to develop a Stormwater Asset Management Plan. For these reasons, a Massachusetts Department of Environmental Protection (MassDEP) Asset Management Plan (AMP) Grant application was completed by Tighe & Bond and the Town on August 21, 2020 to establish an asset management program for the Town's stormwater system. In April 2021, MassDEP notified Tighe & Bond on behalf of the Town that they qualified for the AMP Grant on the Massachusetts Clean Water State Revolving Fund's (CWSRF) Final Intended Use Plan (IUP) and on September 10, 2021, the Town was issued a Notice to Proceed. This grant covers 60% of the cost associated with the Town's development of an AMP plan.

The Town's objectives of the AMP project are as follows:

- Further asset inventory work completed to date;
- Understand condition of the existing drainage system;
- Move from a reactive program to a consistently proactive program;
- Coordinate with water quality programs (MS4, lakes and ponds, etc.) and resiliency planning completed; and
- Create a risk-based AMP and capital improvement planning methodology that is defendable to the public and decision makers.

1.1 Ayer's Stormwater System

The Town's stormwater system is composed of 22 miles of drainage pipes located within the Merrimack and Nashua River Basins. As of the date of this report, the Town of Ayer owns, operates, and maintains the following stormwater infrastructure assets [1]:

- 22 miles of drainage pipe;
- 1,082 catch basins;
- 373 drain manholes;
- 143 outfalls;
- 84 culverts totaling approximately 1 mile in length;
- 14 natural drainage conveyances; and
- 21 mapped treatment units and detention basins.

The DPW currently uses several tools and technologies to proactively manage their stormwater assets.

- **Geographic Information System (GIS)**. The DPW uses GIS to manage its stormwater assets. The Town has a GIS stormwater system map that includes outfalls, drainage pipes, manholes, catch basins, open channel conveyances, rain gardens, detention basins, and culverts. The DPW maintains this GIS map and has also assigned some attribute data (e.g., size, material) to the stormwater assets within the database. GIS gives the DPW the ability to keep a well-maintained record of its available assets.
- **Maintenance**. The DPW monitors and maintains its stormwater system by completing catch basin cleaning and inspections, street sweeping, and outfall and BMP inspections.

The Town complies with the Municipal Separate Storm Sewer Systems (MS4) Permit requirements and outlines its work in yearly Annual Reports. The Town's most recent Annual Report is for Year 4 of the MS4 Permit, with a reporting period of July 1, 2021 to June 30, 2022. Maintenance activities include street sweeping, refining the GIS database based on field work, and public education. The Town also updates its Stormwater Management Plan (SWMP) yearly, which describes and details the activities and measures that it will be implementing to meet the terms and conditions of the permit.

Much like the Town's water and wastewater systems, drainage infrastructure has a monetary value. **The replacement value of Ayer's drainage system is over $90 Million**.[2] This Asset Management Plan puts forth a strategy to safeguard the Town's investment.

1.2 Overview of Asset Management Principles

The United States Environmental Protection Agency (USEPA) defines asset management as **"maintaining a desired level of service for what you want your assets to provide at the lowest life cycle cost. Lowest life cycle cost refers to the best**

[1] Quantities were obtained from the Town's GIS mapping as of the date of this report.
[2] Refer to Appendix C for details and assumptions.

appropriate cost for rehabilitating, repairing or replacing an asset."[3] Utilities that use asset management planning as a tool to help them in the economic delivery of services, find it beneficial in terms of maximizing the value of assets. Asset management includes the planning, design, construction, operation, maintenance, rehabilitation, and replacement of infrastructure that performs a function for the Town in a cost-effective manner. There are numerous benefits of asset management that include but are not limited to:

- Understanding the Town's stormwater system assets, desired level of services, and costs associated with operation and maintenance.
- Communicating with transparency, justifying investments to the community, and demonstrating a responsible investment in infrastructure.
- Budgeting based on improved understanding about the timing and expense of rehabilitation, repair, and/or replacement needs.
- Prolonging asset life.
- Meeting level of service expectations.
- Addressing regulatory requirements.
- Improving responses to emergencies.
- Providing methodologies for determining replacement of existing equipment prior to failure.
- Providing DPW staff with the necessary tools by acquiring equipment for recording and transfer to new or existing software systems.
- Outlining predetermined schedules for equipment replacement prior to failure.
- Identifying annual budget line item costs and the effects on existing rate charge systems for implementation of Asset Management Plans.

The general process of asset management is shown in Figure 1-1 and involves defining the following items:

[3] EPA, "Asset Management: A Best Practices Guide," April 2008. https://www.epa.gov/sites/production/files/2015-02/documents/asset_management_best_practices_guide.pdf

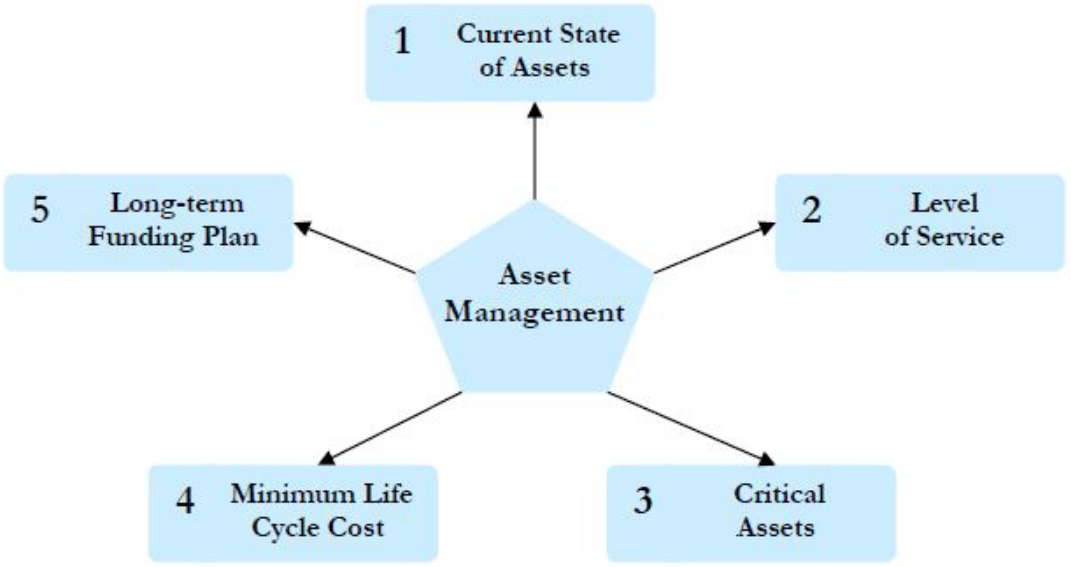


Figure 1-1 The Five Core Questions for Implementing Asset Management[4]

1. **Current State of Assets**: Inventory the available assets throughout the stormwater system. The inventory list consists of asset location, condition, maintenance history, service life, and value, if possible.

2. **Level of Service**: Determine a system operation that is sustainable by considering water quality, water quantity, system reliability, regulatory requirements, and environmental standards.

3. **Critical Assets**: Assign criticality scores to the assets required for continued sustainable system operation. An asset's risk of failing due to their condition, consequences in the event of failure and cost of repair or replacement in the event of failure may dictate the criticality score.

4. **Minimum Life Cycle Cost**: Analyze existing operation and maintenance (O&M) procedures and activities to determine how they may be optimized based on cost, criticality, and level of service.

5. **Long-Term Funding Plan**: Establish the financial capital necessary to maintain a desired level of service by proactively evaluating rate structure and available funding opportunities.

Often communities conduct O&M activities on a reactive basis, with resources allocated to emergency response and rehabilitation or replacement of failed assets. This is classified as a Run-to-Failure Management Model, as shown in Figure 1-2.

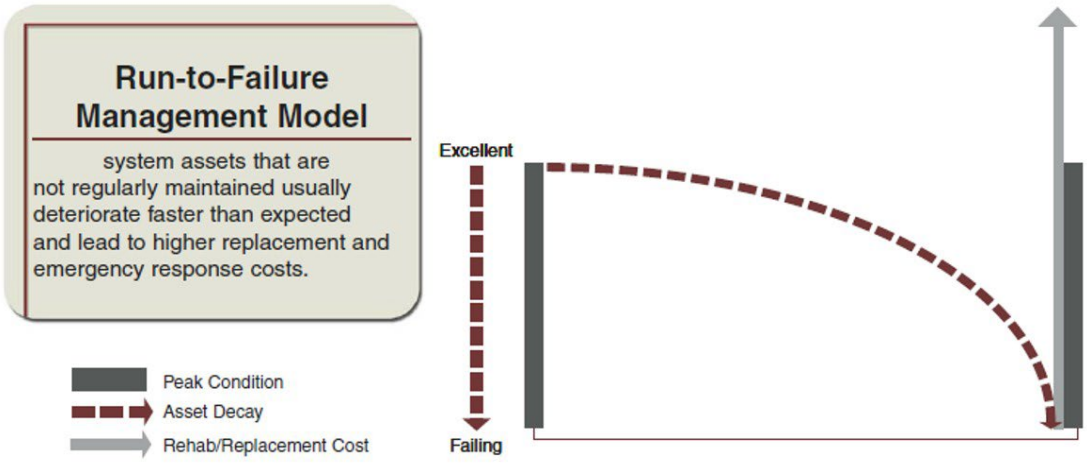


Figure 1-2 Run-to-Failure Management Model[5]

Under this model, assets that have not yet failed are aging, defects are worsening, and future problems are developing. Ultimately, this can lead to higher costs for maintenance and replacement or repair. Alternatively, utilizing an asset management approach, as shown in Figure 1-3, allows aging infrastructure to be maintained and replaced prior to failure. This prevents adverse consequences of failure and distributes costs over the service life of the asset.

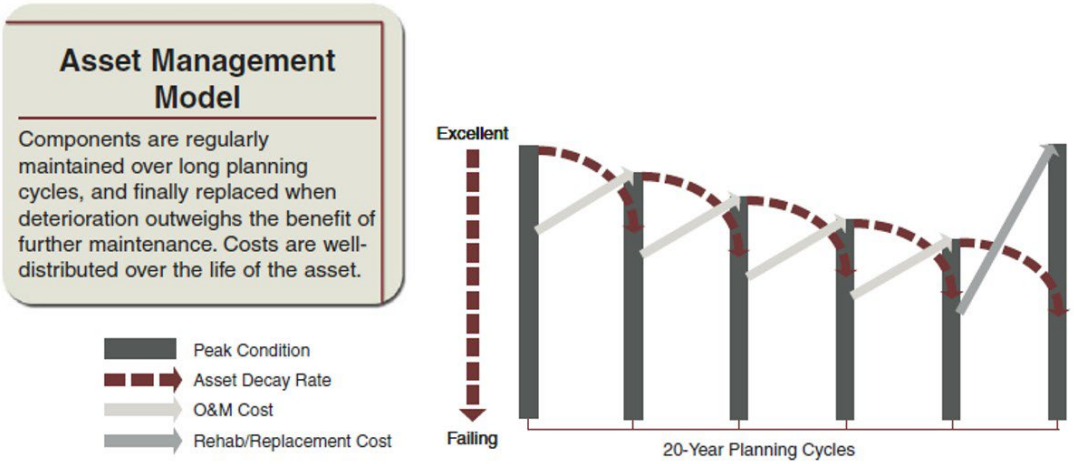


Figure 1-3 Asset Management Model[6]

1.3 Development of Stormwater AMP

Tighe & Bond worked closely with the Town of Ayer staff to develop this criticality-based stormwater AMP to provide the Town with its desired level of service based on the goals presented above. Drain lines, catch basins, manholes and culverts were evaluated for the Town's stormwater asset inventory. The plan was developed through the following major steps, which are described in detail in subsequent sections.

1. Develop an initial "desktop" inventory of all stormwater assets in Ayer (Section 2);

2. Create drainage system and culvert assessment procedures and field forms (Section 3 and 4);
3. Complete drainage system condition assessment field work and collect inventory information (Section 3 and 4);
4. Determine risk-based prioritization based (Section 5); and
5. Develop a written AMP that includes:
    - A description of the drainage system and culvert inventories and results of the inventory (Section 2 through 4);
    - The risk-based prioritization process (Section 5);
    - Recommendations for capital improvements, further investigation, maintenance, programmatic improvements, and funding (Section 6 and 7);
    - A Five-Year Culvert Action Plan (Section 8); and
    - Plan for ongoing program updates.

Section 2 Development of the Asset Inventory

2.1 Initial "Desktop" Inventory

Tighe & Bond developed an initial asset inventory in ESRI ArcGIS® using the Town's existing stormwater GIS system to quantify Ayer's stormwater assets. This inventory was expanded to identify potential culvert locations based on discussion with Town staff at the September 2021 Kick-off meeting. Tighe & Bond identified potential areas using a desktop assessment by intersecting the MassGIS MassDOT 2021 Roads layer with the 2019 MassDEP Hydrography layer and eliminating any areas with known culverts in Town. The potential culvert locations identified in the "desktop" assessment were reviewed by the Town and subsequently visited and assessed in the field to confirm they existed.

This information was used to create a book of 1" = 1,800' scaled maps (i.e., "map book") and a referenced index sheet with a grid that allowed Tighe & Bond and Town staff to review and refine the locations of existing and additional culverts. Figure 2-1 shows an example page from the initial map book. The complete map book as updated in November 2021 is included in Appendix A.

Figure 2-1: Example Page from Preliminary Culvert Inventory Map Book

2.2 Components of Asset Inventory

Using the results of Section 2.1 Tighe & Bond created field forms to collect additional data during field assessments for both the drainage infrastructure and culverts. The following characteristics were added to the drainage system's manholes, catch basins and drain pipe inventory and populated during field assessments to determine criticality and recommend improvements where applicable:

- Structure Condition
- Maintenance Needs
- Cover Grate Condition
- Frame Condition
- Corbel Condition
- Wall Condition
- Floor Condition
- Pipe Condition
- Pipe Size
- Amount of Sediment (% full)
- Pipe Maintenance

The following six major "assessment categories" were included to the culvert inventory during field assessments to identify existing conditions, which were used to determine the criticality, and recommended improvements:

- Roadway
- Upstream
- Culvert Inlet
- Culvert Outlet
- Downstream
- Operation and Maintenance Concerns

The assessment identified characteristics such as shape, dimensions, materials, and condition. The following components of the culvert systems were evaluated for inclusion in the risk-based prioritization and likelihood of failure ratings.

- Overall roadway condition
- Condition of headwall/wingwall
- Invert deterioration
- Joints and seams
- Cracking
- Upstream and downstream embankments
- Apron condition
- Scour
- Cross-section deformation
- Footing condition
- Armoring
- Obstructions

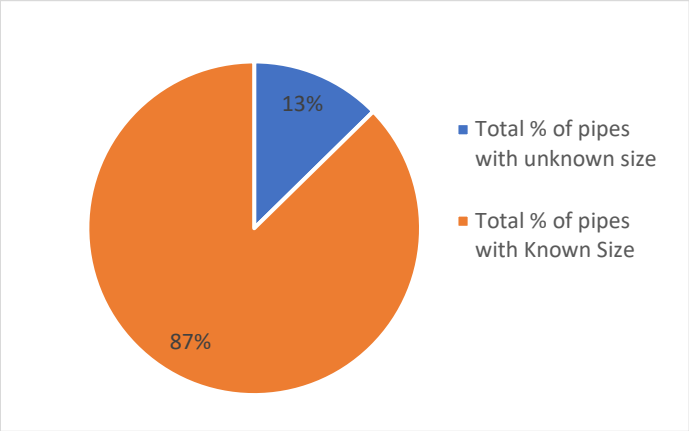
Operation and maintenance concerns, including excess trash, bulk dumping/yard waste, illicit discharges, tree growth, obstructions, nearby beaver dams, and other maintenance, were also noted as part of completing the inventory. Some of the culverts and drain infrastructure rated as high risk and/or high likelihood of failure may be improved by performing specific maintenance.

More detail of the methodology, procedures and results of the field assessments are described in Sections 3 and 4. Scoring for the assessed stormwater assets was based on probability of Failure and Consequence of Failure, which are discussed in Section 5.

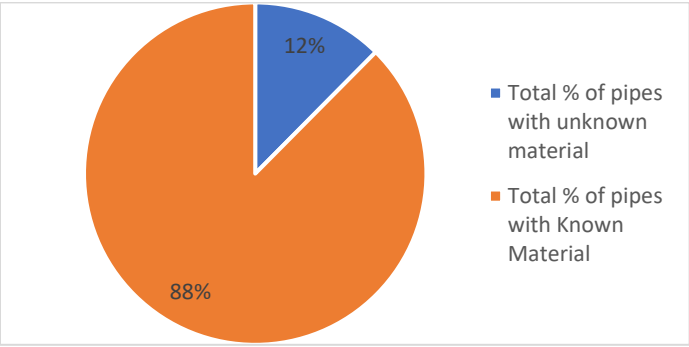
2.2.1 Summary Statistics

Based on review of available mapping in GIS to date, the following presents key statistics about Ayer's drainage system:

- Nearly all (87%) of Ayer's drainage pipes have a size associated with them, as seen in the figure below.



- Nearly all (88%) of Ayer's drainage pipes have a material associated with them, as seen in the figure below.



2.3 Age of Assets

Implementing an asset management program requires knowledge about the age of infrastructure. Currently, the GIS contains year of installation for only approximately 2% of the culverts and 4% of the drain system assets (manholes, catch basins and drain pipes).

For comprehensive asset management, it is also important to understand the typical service life of an asset. Table 2-1 summarizes the expected service life for a variety of infrastructure in Ayer's stormwater system. Expected service live is based on Tighe & Bond experience, manufacturer recommendations, and guidance from professional organizations.

TABLE 2-1
Estimated Service Life for Drainage Assets[4]

Asset	Estimated Service Life (years)
Gravity Main/Culvert *(Concrete, Brick, Vitrified Clay, Ductile Iron)*	100
Gravity Main *(HDPE/CPP, PVC, Truss Pipe, Cast Iron)*	75
Gravity Main/Catch Basin Lateral/Culvert *(Corrugated Metal)*	65
Catch Basin Lateral *(Concrete, Brick, Vitrified Clay, Ductile Iron, HDPE, PVC, Truss Pipe)*	50
Pressurized Main	75
Manhole/Catch Basin *(Brick, Concrete, Block, Precast, Fieldstone)*	100
Outfall	50
Infiltration Basin	100

It must be noted that installed infrastructure components will have longer or shorter service lives depending on the original quality of the infrastructure and installation, the specific environment and conditions, and operation and maintenance. For example, some pipes are assumed to have a service life of 100 years, but if a 95-year-old pipe is inspected and found to be in excellent condition, the service life could be adjusted to 125 years.

Because only a small percentage of the system has an associated age more meaningful age information needs to be obtained to assess the expected service life of the majority of Ayer's drainage system.

[4] Infrastructure Optimization (IO) Toolset software developed by Woolpert, Inc. (ESRI® ArcGIS extension package), documented in the City of Grand Rapids, MI Environmental Protection Services Department, "Stormwater Asset Management and Capital Improvement Plan," May 2013.

Section 3
Stormwater System Condition Assessment

Tighe & Bond and the Town completed stormwater system condition assessments to collect additional inventory information to determine Probability of Failure and Criticality (See Section 5). The following section describes the process, procedures and results completed as part of these assessments.

3.1 Methodology and Procedures

As part of the Stormwater Asset Management Program, Tighe & Bond completed ten (10) days of video assessments of the drainage system during October and November 2021. This effort provided condition information on a variety of manholes, catch basins and drain pipes of various sizes and materials since condition of the Town's drainage assets were largely unknown at the start of the project

Prior to the fieldwork, Tighe & Bond with input from Town Staff, selected areas of known concern to focus field investigations. Criteria used to select these areas included:

- Downtown area: old system, poor mapping
- Devens crest neighborhood: poor drainage area
- Areas of known flooding identified by the Town
- Areas of concern identified by the town
- Drainage systems with outfalls with dry weather screening results with Illicit Discharge Detection and Elimination (IDDE), submerged, debris or other maintenance concerns

A rapid condition assessment was completed using an Envirosight QuickView zoom inspection camera, as shown in Figure 3-1. This camera allows high-resolution video logs of pipes and structures to be obtained without confined space entry. The zoom camera also allows for rapid inspection of pipelines and does not require any cleaning prior to inspecting the line. Renting this zoom camera presents a significant cost savings when compared to CCTV.

Figure 3-1 Envirosight QuickView Zoom Camera

The inspections were completed following simplified National Association of Sewer Service Companies (NASSCO) Pipeline/Manhole Assessment Certification Program (PACP/MACP) protocols. Following the PACP/MACP guidelines and using the zoom inspection camera allowed for a quick, in-field determination of size, condition, material, and general connectivity of the drainage system, as well as the identification of any visible pipe defects or instances of obstructed flow. Note that the QuickView camera does not allow the user to inspect beyond bends in a drain pipe or past any blockages or obstructions, so occasionally connectivity cannot be verified.

During the field inspections, Tighe & Bond and Town staff collected data in GIS using ESRI's Field Maps and Survey123 tablet applications. Appendix B includes a copy of the field form. These applications were used to initially identify, locate and review applicable targeted structures in the field, as shown in Figure 3-2. The inspectors inserted the QuickView zoom camera into a structure and aimed the camera down the first pipe to be inspected. The camera was controlled by staff to visually zoom down the pipe as far as possible while the camera recorded. Once the inspection footage was captured, the camera was zoomed out and rotated to the next pipe to be inspected, where the process was repeated. In this way, each pipe within a structure was inspected. A photograph was also taken of each structure during the inspection to document the condition of the structure, as well as any apparent structural issues or sediment buildup issues.

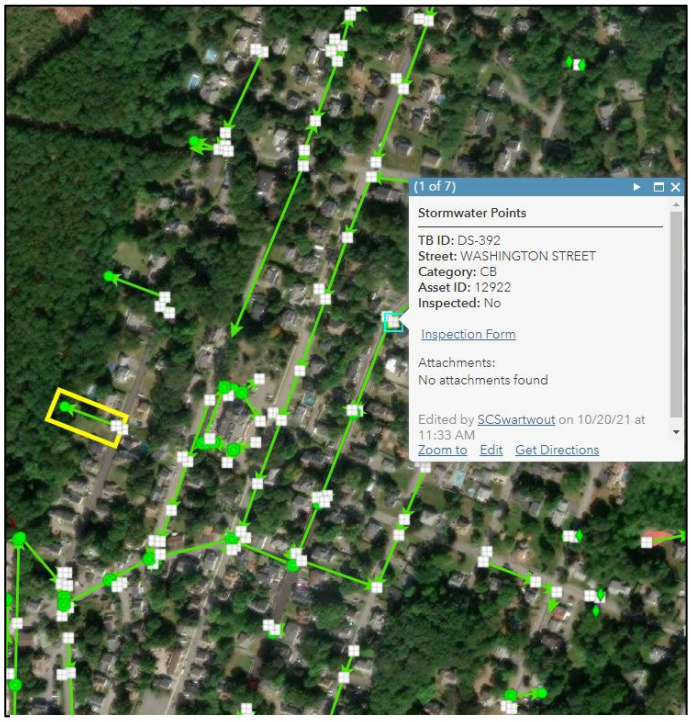


Figure 3-2 Example of Drainage Structure Identification on Tablet GIS Application

Condition of inspected drain structures and pipes were recorded using Survey123 and included the following information:

- Date and time of inspection;
- Weather conditions;
- Inspector;
- Location and identification number of inspected asset;
- General structure observations (condition, maintenance needs, etc.)
- Internal structure observations (cover/grate, frame, corbel, wall, etc. material and condition);
- Pipe observations (material, diameter, condition, debris, etc.);
- Observations of any illicit connection or odor;
- Photos and videos; and
- Any notes about the inspected structures and/or pipes.

3.2 Results

As shown in Table 3-1, over 200 drain manholes and catch basins and the connecting drainage pipes were inspected over ten days in October and November 2021. Of the 494 pipe segments visited, 49 pipes were inspected from both the upstream and the downstream ends of the pipe, and seventy four (74) pipe segments could not be video

inspected because they were submerged, covered by a hood, or otherwise could not be accessed.

TABLE 3-1
Quantity of Drainage System Assets Inspected During Rapid Condition Assessment

	Oct 25	Oct 28	Oct 29	Nov 1	Nov 2	Nov 3	Nov 4	Nov 5	Nov 8	Nov 9	Total
Number of Catch Basins Assessed	3	7	13	13	17	22	8	14	38	2	**137**
Number of Drain Manholes Assessed	13	9	3	5	5	6	11	6	2	11	**71**
Number of Pipes Visited	46	50	46	52	51	55	52	43	56	43	**494**
Total Number of Assets Visited	**62**	**66**	**62**	**70**	**73**	**83**	**71**	**63**	**96**	**56**	**702**

Appendix C includes a map showing the locations visited during the ten days of condition assessments.

Approximately 31% of the drainage pipes and 14% of the drain structures (catch basins and manholes) in the entire system were assessed as part of the rapid condition assessment, as shown in Table 3-2. Note that the quantity of pipe segments, instead of length of pipe, was used in this table and all subsequent discussions about pipe segments, because the zoom camera used for inspections is unable to precisely measure the total linear footage of assessed pipe.

TABLE 3-2
Percent of Drainage System Assets Inspected During Rapid Condition Assessment

	Number of Pipes	Number of Structures[1]
Total Assets Mapped	1,343	1455
Total Assets Inspected	420	208
% System Inspected	**31%**	**14%**

[1] Structures only include manholes and catch basins

While completing the field work, six (6) new drain structures and twenty-three (23) new pipe segments were added to the stormwater inventory in GIS that was not in the Town's existing mapping. This was because:

- There were additional pipes in a catch basin or drain manhole that are not mapped; and/or
- We inspected an unmapped structure in close proximity to the structure we intended to inspect which was not included in the existing mapping.

The new TB-IDs for the six (6) mapped structures were as follows: DS-1447B, New Jackson, DS-1509B, DS1099B, DS-722B, DS242B. The new TB-IDs for the 23 new pipe

segments were as follows: New P-500B, P-57B, P-1668B, P-1670B, P-1675B, P-1214B, P-217B, P-1029B, P-400B, P-1238B, P-1152B, P-1151B, P-109B, P-1538B, P-1717B, P-1717C, P-1717D, P-78B, P-78C, P-76B, P-646B, P-1704B, and P-1704U.

Additionally, nine structures (9) and fourteen (14) pipes were deleted from the GIS because they did not exist. The Stormwater IDs for the four (4) outfalls, three (3) manholes and two (2) catch basin points that did not exist were: 3DO02, 4DO15, 6DO23, 6DO36, 2DM24, 2DM26, 2DM07, 3DM02, 2CB28, 4CB144. The Object IDs for the fourteen pipes removed from the GIS are as follows: 24, 56, 113, 138, 233, 489, 582, 586, 1051, 1316, 1514, 1517, 4804, and 8108.

As described above, this field effort completed a condition assessment of 208 drain structures and 420 drain pipe segments in Town. The following tables and charts include information about the assets that were inspected during the field effort.

Table 3-3 and Figure 3-3 demonstrate the distribution of material of the inspected pipe segments. Most of the inspected pipelines (51%) were reinforced concrete pipes, 24% were high density polyethylene (HDPE) pipes, and 15% were corrugated metal pipes.

The diameters of the inspected pipes are included in Table 3-4 and Figure 3-4. 57% of the inspected pipes were 12 inches and 31 percent were 18 inches in diameter. Pipe diameter could not be determined for approximately 1% of the pipes inspected.

TABLE 3-3
Distribution of Inspected Pipes by Material

Pipe Material	Number of Inspected Pipes	% Total Inspected Pipes
RCP	216	51.43%
HDPE	99	23.57%
VC	9	2.14%
CMP	62	14.67%
PVC	20	4.76%
Unknown	5	1.19%
Other	9	2.14%
Total	**420**	**100%**

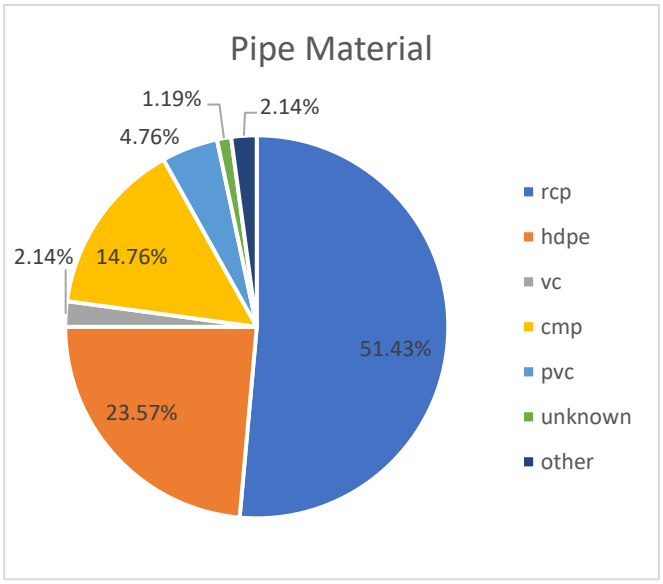


Figure 3-3 Distribution of Inspected Pipes by Material

TABLE 3-4
Distribution of Inspected Pipes by Size

Pipe Size	Number of Inspected Pipes	% Total Inspected Pipes
1	1	0.24%
6	18	4.29%
8	3	0.71%
10	4	0.95%
12	239	56.9%
15	130	30.95%
18	13	3.10%
24	4	0.95%
30	2	0.48%
48	1	0.24%
Unknown	5	1.19%
Total	**420**	**100%**

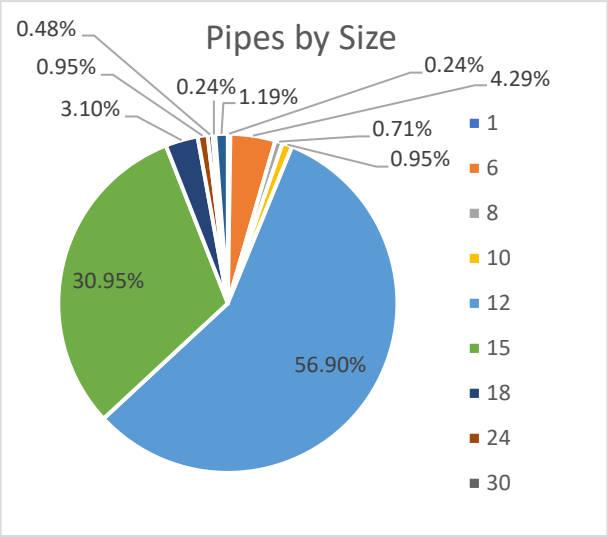


Figure 3-4 Distribution of Inspected Pipes by Size

Of the 49 pipes assessed at both ends, 4 pipes displayed size differences between the two ends. The larger of the two sizes is accounted for in Table 3-4. These size differences were observed at P-1479, P-309, P-13, P-493.

3.2.1 Condition of Inspected Drainage Structures

Of the 208 structures that were inspected, approximately two-thirds were catch basins and the rest were manholes.

During the rapid condition assessment, Tighe & Bond observed the wall material of each drain structure and included that information in the Drainage Structure Inspection Reports included in the Town's GIS. About 48% of the inspected structures were block and an additional 36% were concrete. Of the remaining structures approximately 13% were brick structures and approximately 3% has an unknown wall material. Condition varied by material within the study area, which may or may not be representative of the entire drainage system. The following proportion of structures were considered to be in good or excellent condition:

- Concrete: 21%
- Block: 60%
- Brick: 63%

Figure 3-5 Example of a Precast Drain Manhole (Left) and Brick/Block Catch Basin (Right)

The condition of various components of each structure (including frame and grate/cover, corbel, steps, walls, floors, and inverts, when applicable) was recorded in the field inspection reports during the inspection. The overall condition of the structure was also noted on the inspection reports.

Figure 3-5, above, includes an example of a drain structure that is in good condition (the precast drain manhole on the left) and an example of a drain structure that is in fair condition (the brick/block catch basin on the right). While some repairs could be made to improve the structure in fair condition, it can still perform its intended function for the stormwater system unless the structure was undermining the roadway.

Table 3-5 and Figure 3-6 includes the distribution of the condition of each of the inspected drain structures. Approximately 71% of the inspected structures were in good or excellent condition. Approximately 17% were in fair condition, and less than 3% of the structures were in poor condition.

TABLE 3-5
Distribution of Inspected Structures by Condition

Structure Condition	Number of Inspected Structures	% Total Inspected Structures
Excellent	49	23.56%
Good	99	47.6%
Fair	35	16.83%
Poor	19	9.13%
Immediate	5	2.40%
Unknown*	1	0.48%
Total	**208**	**100%**

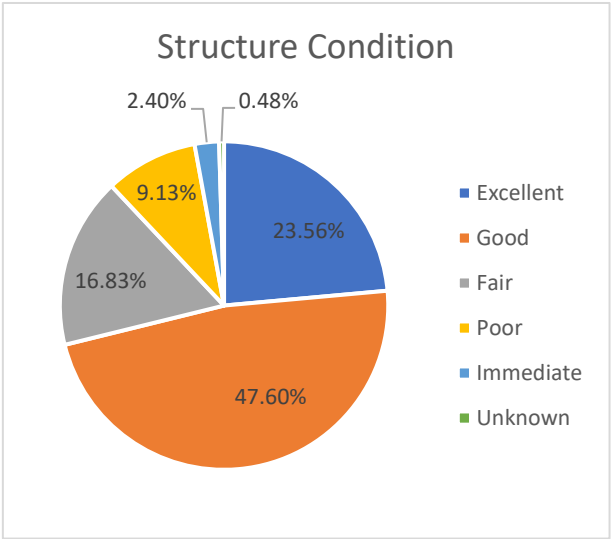


Figure 3-6 Distribution of Inspected Structures by Condition

Appendix C includes a summary of inspected drain manholes and catch basins where operation and/or maintenance issues were noted. Information regarding potential illicit discharges/connections identified during the inspections is discussed in Section 5 of this report.

3.2.2 Condition of Inspected Pipes

Figure 3-7 includes an example of a reinforced concrete drain pipe that is in excellent condition and a corrugated metal pipe that is in poor condition due to root intrusion.

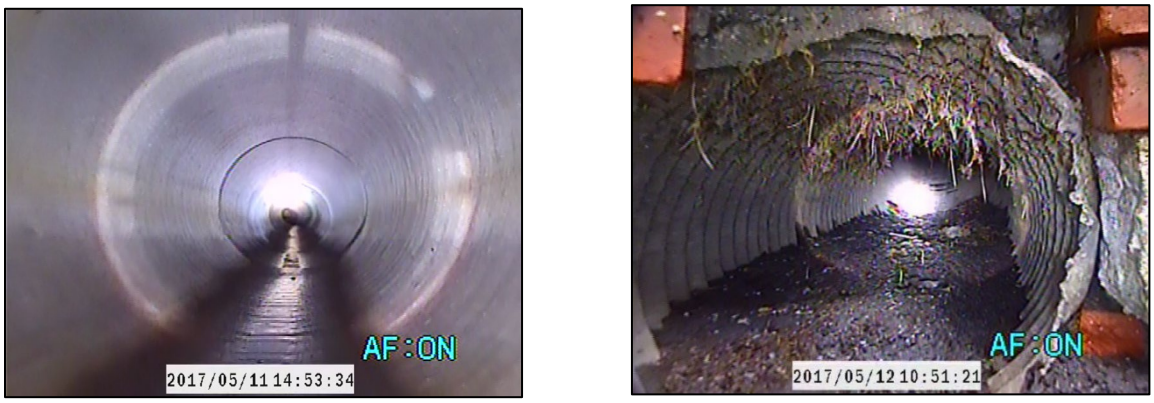


Figure 3-7 Example of a RCP in Excellent Condition (Left) and CMP in Poor Condition (Right)

Table 3-6 and Figure 3-8 includes the distribution of the condition of each of the assessed drain pipes. Approximately 62% of the drainage pipes inspected during the rapid condition assessment were in good or excellent condition.

The GIS mapping delivered to the Town will have the most updated pipe condition information. Note that the condition of a pipe was not evaluated in the field or post-processing if it was too small to video (i.e., 4-inch diameter), submerged or blocked.

TABLE 3-6
Distribution of Pipes by Condition

Pipe Condition	Number of Inspected Pipes	% Total Inspected Pipes
Excellent	168	40.0%
Good	90	21.4%
Fair	62	14.8%
Poor	69	16.4%
Immediate	21	5.0%
Unknown	10	2.4%
Total	**420**	**100%**

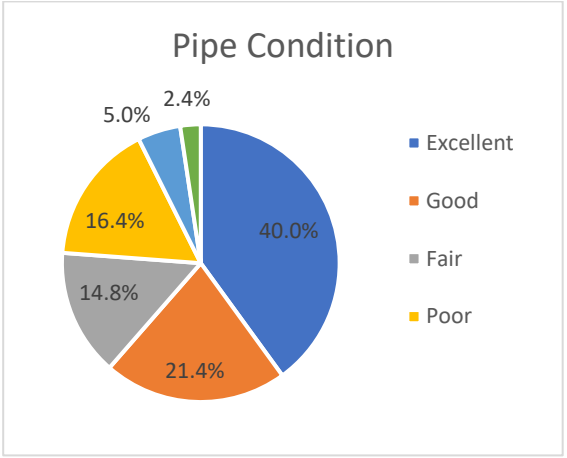


Figure 3-8 Distribution of Inspected Pipes by Condition

3.2.2.1 Discussion of Condition by Pipe Material

Table 3-7 and Figure 3-9 include the distribution of pipe condition of inspected high density polyethylene (HDPE) pipes. Almost all (92%)% of the inspected HDPE pipes were in good or excellent condition.

TABLE 3-7
Distribution of Inspected HDPE Pipes by Condition

Pipe Condition	Number of Inspected Pipes	% Total Inspected Pipes
Excellent	76	80%
Good	11	12%
Fair	5	5%
Poor	1	1%
Immediate	1	1%
Unknown	1	1%
Total	**95**	**100%**

Note: These quantities include all pipes that were noted to have at least a portion HDPE, even if the majority of the pipe was another material.

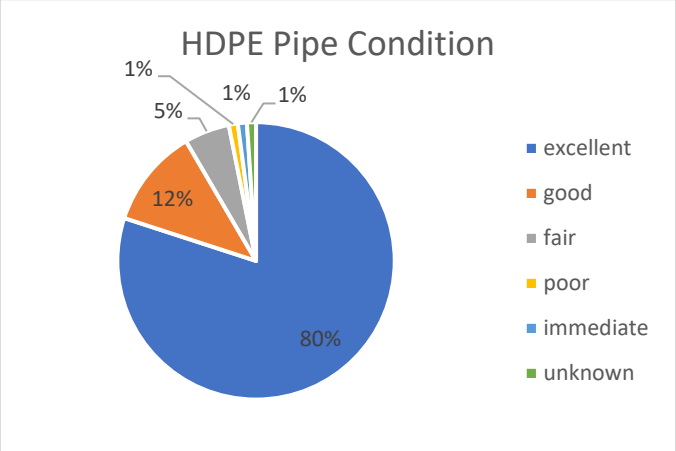


Figure 3-9 Distribution of Inspected HDPE Pipes by Condition

Table 3-8 and Figure 3-10 include the distribution of pipe condition of inspected reinforced concrete pipes. Approximately 60% of all the inspected RCP were in good or excellent condition.

TABLE 3-8
Distribution of Inspected RCP Pipes by Condition

Pipe Condition	Number of Inspected Pipes	% Total Inspected Pipes
Excellent	68	37%
Good	43	23%
Fair	24	13%
Poor	41	22%
Immediate	9	5%
Unknown	1	1%
Total	**186**	**100%**

Note: These quantities include all pipes that were noted to have at least a portion RCP, even if the majority of the pipe was another material.

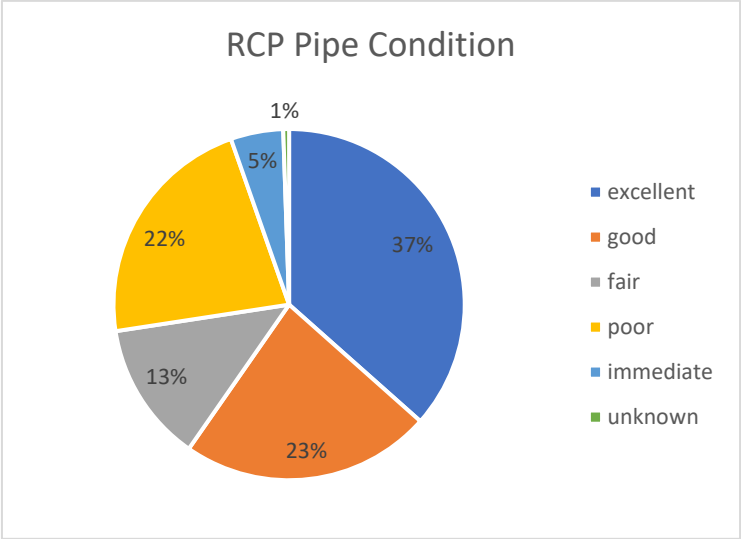


Figure 3-10 Distribution of Inspected RCP Pipes by Condition

Table 3-9 and Figure 3-11 include the distribution of pipe condition of inspected corrugated metal pipes. Approximately 30% of the inspected CMP were in good or excellent condition whereas 70% were in fair or poor condition.

TABLE 3-9
Distribution of Inspected CMP Pipes by Condition

Pipe Condition	Number of Inspected Pipes	% Total Inspected Pipes
Excellent	1	2%
Good	15	28%
Fair	21	40%
Poor	15	28%
Immediate	1	2%
Unknown	0	0%
Total	**53**	**100%**

Note: These quantities include all pipes that were noted to have at least a portion CMP, even if the majority of the pipe was another material.

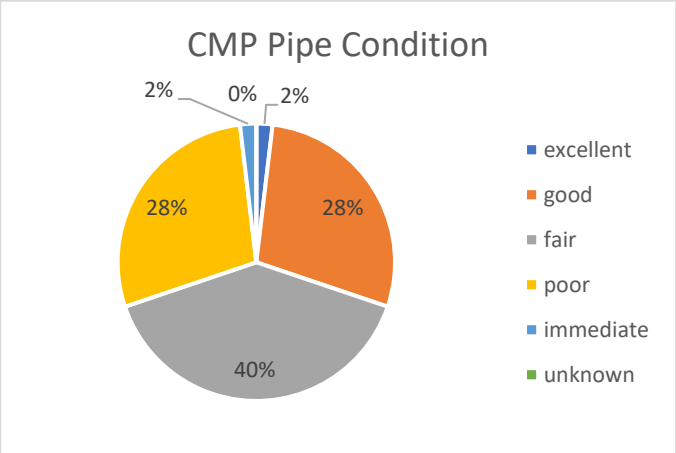


Figure 3-11 Distribution of Inspected CMP Pipes by Condition

In sum, the following streets had pipe sections with immediate condition ranking: West Main Street (P-149), Willow Road (P-1538, P-1538B), Willard Street (P-174, P-182), Grove Street (P-224), Hatch Street (P-305, P-307), Jackson Street (P-415), Hatch Street (DS-237), Snake Hill Road (DS-902, P-972), Columbia Street (P-1029), Western Drive (P-1240), Highland Avenue (P-136), Cambridge Street (P-643), and Sandy Pond Road (P-840).

Areas containing multiple poor/immediate condition pipe segments are located on the following streets: Atherton Street, Columbia Street, Grove Street, Hatch Street, Jackson Street, Nashua Street, Oak Ridge Drive, Pleasant Street, Snake Hill Road, West Main Street, Willard Street, and Willow Road.

Areas containing multiple poor/immediate condition drainage structures are located on the following streets: Hatch Street, Markham Circle, Pearl Street, Pleasant Street, Sandy Pond Road, Snake Hill Road, West Main Street, and Willard Street.

Cross examining these two lists, there are 5 streets of the highest priority for repairs. These streets include Hatch Street, Pleasant Street, Snake Hill Road, West Main Street, and Willard Street.

3.2.2.2 Inventory of Pipes with Pipe Issues

Table 3-10 lists the drain pipes that were noted to have pipe issues during inspection. Often, drain pipes were classified as fair or poor condition when mineral deposits, rusting, or root intrusion were observed during the inspection.

Table 3-10
Drainage Pipes with Maintenance Needs

Pipe	Location	Condition	Notes
P-17	Groton School Road	fair	Root Intrusion
P-334	Groton School Road	good	Root_Intrusion

Table 3-10
Drainage Pipes with Maintenance Needs

Pipe	Location	Condition	Notes
P-1289	Washington Street	fair	Root_Intrusion
P-1555	Washington Street	good	Root_Intrusion
P-130	Nashua Street	poor	Cracked,Root_Intrusion
P-497	Nashua Street	poor	Root Intrusion
P-131	Nashua Street	fair	Root_Intrusion
P-132	Nashua Street	poor	Root_Intrusion
P-134	Nashua Street	good	Root_Intrusion
P-417	Groton Street	immediate	Broken
P-1431	Pleasant Street	immediate	Collapse
P-1490	Faulkner Street	poor	Cracked
P-215	Forest Street	poor	Root_Intrusion
P-216	Forest Street	poor	Root_Intrusion
P-219	Grove Street	poor	Broken
P-220	Grove Street	fair	Root_Intrusion
P-226	Grove Street	poor	Cracked
P-1484	Maple Streets	poor	Root_Intrusion
P-565	Pearl Street	poor	Cracked,Broken
P-572	West Street	poor	Caving_In
P-1025	Columbia Street	poor	Cracked
P-1026	Columbia Street	poor	Cracked
P-1029	Columbia Street	immediate	Cracked,Broken,Caving_In,Collapse
P-405	Pleasant Street	poor	Cracked
P-402	Pleasant Street	poor	Root_Intrusion
P-403	Pleasant Street	fair	Root_Intrusion
P-173	Willard Street	poor	Caving_In
P-289	Willard Street	fair	Root_Intrusion
P-291	Willard Street	fair	Root_Intrusion
P-315	Atherton Street	poor	Cracked
P-316	Atherton Street	poor	Cracked
P-319	Atherton Street	fair	Root_Intrusion
P-725	Maple Street	poor	Root_Intrusion
P-726	Maple Street	poor	Cracked,Root_Intrusion
P-1470	East Street	poor	Root_Intrusion
P-1471	East Street	poor	Root_Intrusion
P-721	Fletcher Street	fair	Root_Intrusion
P-273	Fletcher Street	fair	Root_Intrusion
P-274	Fletcher Street	poor	Cracked,Root_Intrusion
P-395	Pleasant Street	poor	Cracked
P-396	Pleasant Street	poor	Broken
P-398	Pleasant Street	poor	Caving_In
P-400B	Pleasant Street	poor	Cracked
P-485	Washington Street	immediate	Caving_In
P-489	Washington Street	immediate	Broken
P-1233	Groton Harvard Road	poor	Root_Intrusion
P-93	Oak Ridge Drive	poor	Caving_In
P-89	Pine Ridge Drive	fair	Root_Intrusion

Table 3-10
Drainage Pipes with Maintenance Needs

Pipe	Location	Condition	Notes
P-88	Pine Ridge Drive	poor	Root_Intrusion
P-1047	Oak Ridge Drive	fair	Cracked
P-104	Oak Ridge Drive	fair	Cracked
P-105	Oak Ridge Drive	poor	Broken
P-1008	Oak Ridge Drive	good	Root_Intrusion
P-1009	Oak Ridge Drive	good	Root_Intrusion
P-1010	Oak Ridge Drive	good	Root_Intrusion
P-970	Snake Hill Road	fair	Root_Intrusion
P-282	Samantha Lane	fair	Root_Intrusion
P-283	Samantha Lane	fair	Root_Intrusion
P-181	Willard Street	poor	Collapse
P-1732	Willard Street	poor	Root_Intrusion
P-305	Hatch Street	immediate	Collapse
P-306	Hatch Street	poor	Root_Intrusion,Broken
P-307	Hatch Street	immediate	Collapse
P-310	Myrick Street	poor	Caving_In
P-311	Myrick Street	fair	Root_Intrusion
P-168	Willard Street west	poor	Broken
P-199	Nemco Way	fair	Root_Intrusion
P-1100	Willow Road	fair	Root_Intrusion
P-1538	Willow Road	immediate	Cracked,Broken,Caving_In
P-1538B	Willow Road	immediate	Broken,Caving_In
P-1486	Grove Street	fair	Root_Intrusion
P-1226	Groton Harvard Road	fair	Root_Intrusion
P-136	Highland Avenue	immediate	Cracked,Broken,Caving_In
P-415	Jackson Street	immediate	Collapse,Cracked
P-454	Jackson Street	poor	Cracked
P-455	Jackson Street	poor	Cracked
P-78C	Jackson Street	poor	Cracked
P-76B	Jackson Street	fair	Root_Intrusion
P-61	Jackson Street	poor	Root_Intrusion
P-135	Nashua Street	good	Root_Intrusion
P-1277	Nashua Street	fair	Root_Intrusion,Cracked
P-638	Williams Street	poor	Broken
P-639	Williams Street	fair	Cracked
P-646	Washington Street	poor	Root_Intrusion
P-1738	Washington Street	poor	Root_Intrusion
P-635	Washington Street	good	Root_Intrusion
P-636	Washington Street	fair	Root_Intrusion
P-1240	Western Drive	immediate	Caving_In
P-137	Highland Avenue	fair	Root_Intrusion
P-1469	East Street	poor	Root_Intrusion
P-149	West Main Street	immediate	Collapse,Broken
P-174	Willard Street	immediate	Caving_In,Collapse
P-182	Willard Street	immediate	Caving_In,Broken
P-290	Willard Street	poor	Root_Intrusion,Caving_In

Table 3-10
Drainage Pipes with Maintenance Needs

Pipe	Location	Condition	Notes
P-840	Sandy Pond Road	poor	Collapse,Cracked
P-90	Pine Ridge Drive	poor	Caving In,Root Intrusion

3.2.2.3 Discussion of Sediment and Obstructions in Pipes

When debris or sediment buildup was noted during the rapid condition assessment, it was noted on the Field Inspection Reports. This will allow Town staff to identify priority areas for cleaning by locating the pipelines with the most debris (i.e., pipes with a higher percentage of the pipe full). Figure 3-12 includes the distribution of pipelines with sediment/debris buildup. The photos in the chart demonstrate examples of pipelines that were observed to be empty or have minimal sediment buildup (0-5% full of debris), moderate sediment buildup (6-40% full of debris), and significant sediment buildup (40-100% full of debris) during the field inspections. As shown in Figure 3-13, approximately 55% of the pipes that were inspected during the rapid condition assessment contained 0%-5% debris or sediment. The locations of the 12% of pipes with sediment buildup greater than 40% are listed for cleaning in Appendix C.

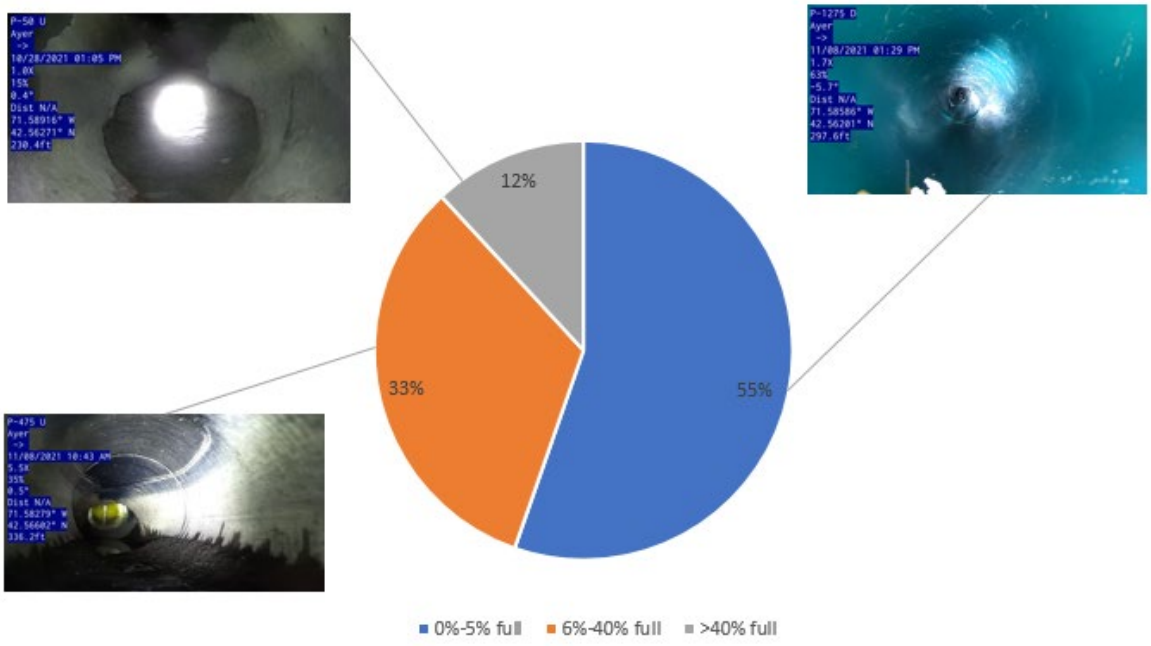


Figure 3-12 Distribution of Inspected Pipes with Debris/Sediment Buildup

Section 4 Culvert Assessment

Tighe & Bond completed culvert assessments to collect inventory and condition information to be used in the risk-based prioritization. The following section describes the process, procedures and results completed as part of these assessments.

4.1 Methodology and Procedures

As part of the Stormwater Asset Management Program, Tighe & Bond completed six (6) days of field assessments of municipally owned and operated culverts in November 2021. This effort provided information on the number, location, and general condition of the culverts, which were largely unknown at the start of the project.

Prior to beginning field work, Tighe & Bond worked with town staff to identify town-owned culverts. Tighe & Bond developed a culvert inspection protocol and field form to be used during field inspections. These documents were developed using Tighe & Bond's experience with culvert assessments and the following resources:

- *Culvert Condition Assessment Manual,* developed by UMass Transportation Center, the Nature Conservancy, North Atlantic Aquatic Connectivity Collaborative, and the Center for Agriculture, Food, and the Environment, 2019
- *NAACC Stream Culvert Survey Data Form Instruction Guide,* developed by the North Atlantic Aquatic Connectivity Collaborative, May 2016 and *NAACC Stream Culvert Survey Data Form*

Appendix B includes a copy of the field form. Staff from Tighe & Bond utilized this assessment protocol to complete the culvert mapping, collect inventory information, and assess culvert condition. Similar to the drainage data, ESRI's Field maps and Survey123 tablet applications were used to collect and store data. These applications allow photos of the culvert's condition to be stored in the survey and linked to its location is GIS. Data collected during assessment includes, but is not limited to the following fields:

- Date and time of inspection;
- Weather conditions;
- Assessor;
- Location and identification number of culvert;
- General roadway observations;
- General structure condition and dimensions at the inlet and outlet;
- Operation and maintenance concerns (sediment in culvert, illicit discharge, etc.);
- General upstream and downstream conditions and bankfull widths;
- Photos; and
- Any additional notes

During the mapping and inventory process, we coordinated with Town staff including daily notifications of field presence, monitoring on-going data collection, and provided urgent findings to Town staff.

4.2 Results

During the 6-day field effort, Tighe & Bond staff assessed 61 culverts Appendix C includes the location of the 61 culverts assessed during this field effort. Upstream and downstream information was collected, including bankfull width. The inlet and outlet of the structure was assessed with respect to structural deficiencies (such as corrosion, deformation of structure, and condition of joints and seams) and hydraulic deficiencies (such as inlet and outlet elevation and scour). As each of these crossings were assessed, they were field located in ArcGIS.

11 previously mapped culverts were not assessed during this effort because they were recently assessed (P-1171), did not exist (P-707, P-1181, P-1284, P-1540, P-1545), part of MassDOT database (P-1172, P-1178), sections of one long culvert already assessed (P-1712, P-1713) or suspected to be under private ownership (P-769).

12 new culverts were located and added to the Town's GIS, which will need to be assessed in a subsequent effort. Upon confirmation of town ownership, Tighe & Bond recommends completing assessments of the additional 12 new and culverts mapped in the field.

4.2.1 Condition of Assessed Culverts

Table 4-1 and Figure 4-1 demonstrate the distribution of culverts by size. There are a wide variety of culvert sizes in the Town of Ayer, with the majority (33%) of culverts measuring 2 to 4 feet.

TABLE 4-1
Distribution of Culverts by Size

Pipe Size	Number of Inspected Pipes	% Total Inspected Pipes
≤1'	9	15%
1'-2'	15	25%
2'-4'	20	33%
4'-6'	4	6%
≥6'	13	21%
Total	**61**	**100%**

Note: These quantities are based on the size of the culvert upstream.

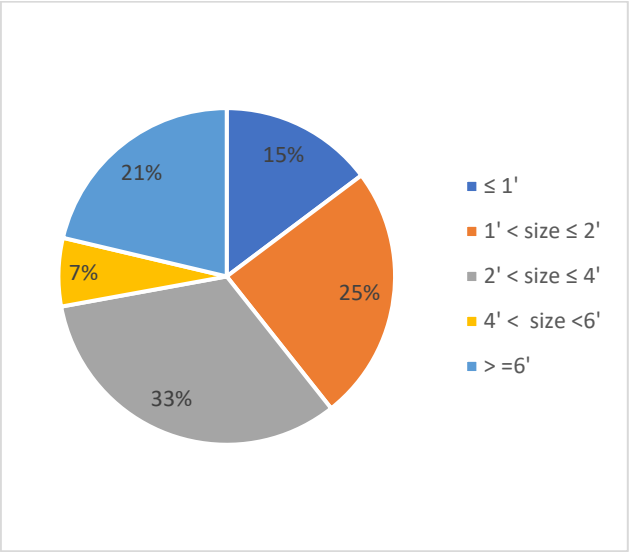


Figure 4-1 Distribution of Culverts by Size

Table 4-2 and Figure 4-2 demonstrate the distribution of culverts by the severity of its deterioration. Approximately one third of Ayer's culverts demonstrate medium to high deterioration. Approximately 21% of culverts assessed demonstrate low deterioration and 25% demonstrate no deterioration. The deterioration of approximately 21% of assessed culverts is unknown due to high water or inability to access the culvert. It should be noted that these figures were developed based on the observed deterioration at the upstream end of the culvert.

TABLE 4-2
Distribution of Culverts by Deterioration Severity

Pipe Deterioration	Number of Inspected Pipes	% Total Inspected Pipes
High	8	13%
Medium	12	20 %
Low	13	21%
Unknown	13	21%
None	15	25 %
Total	**61**	**100%**

Note: These quantities are based on the condition of the upstream end of the culvert.

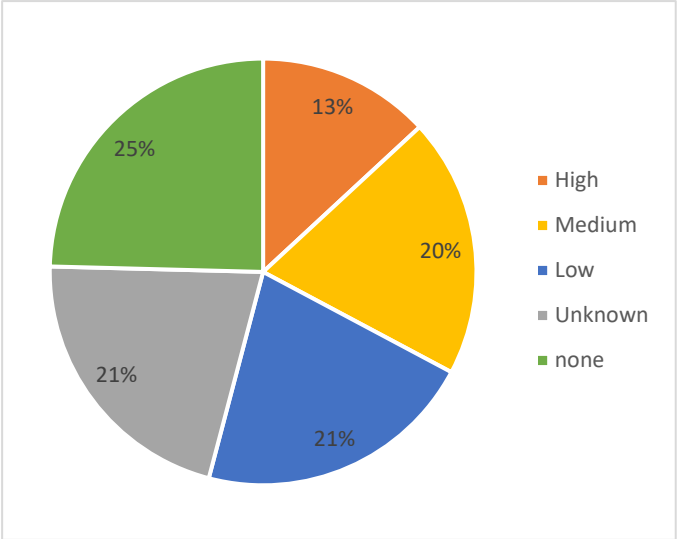


Figure 4-2 Distribution of Culverts by Deterioration Severity

Table 4-3 and Figure 4-3 demonstrate the distribution of culverts by material. Approximately one third (31%) of culverts assessed were corrugated metal and approximately one third (30%) were reinforced concrete. The remaining culverts had various material types such as noncorrugated metal, stone, corrugated plastic, and uncorrugated plastic. It should be noted that these figures were developed based on the observed deterioration at the upstream end of the culvert.

TABLE 4-3
Distribution of Culverts by Material

Pipe Condition	Number of Inspected Pipes	% Total Inspected Pipes
Concrete	18	30%
Corrugated Metal	19	31%
Non-Corrugated Metal	4	7%
Stone	4	7%
Corrugated Plastic	1	2%
Non-Corrugated Plastic	7	11%
Other	3	5%
Unknown	5	8%
Total	**61**	**100%**

Note: These quantities are based on the upstream end of the culvert.

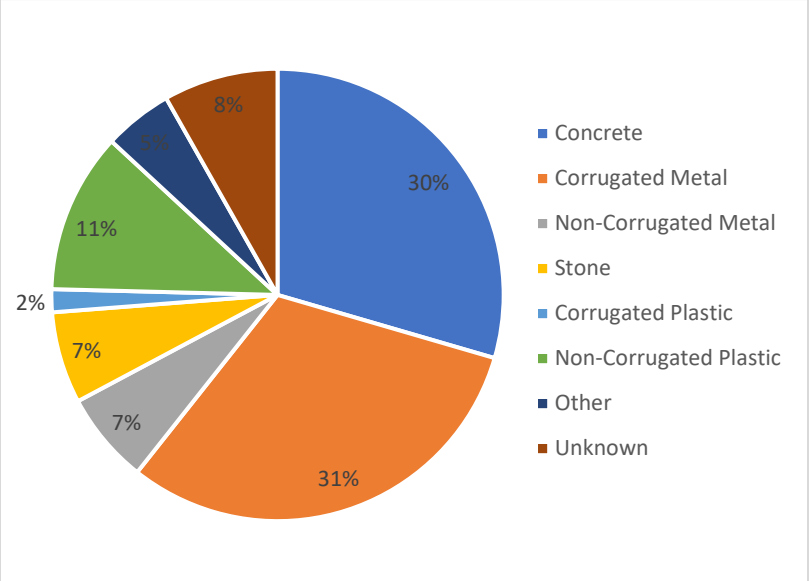


Figure 4-3 Distribution of Culverts by Material

4.2.2 Operation and Maintenance Statistics

During inspections, O&M concerns were noted, such as excess trash, bulk dumping/yard waste, illicit discharges, tree growth, obstructions, and nearby beaver dams. This section summarizes those issues.

Two culverts were noted as having an illegal dumping concern consisting of yard waste, at or near the inlet/outlet.

TABLE 4-4
Summary of Culverts with Illegal Dumping Concerns

Tighe & Bond Culvert ID	Address	Location	Notes
P-976	Calvin St	Inlet	Yard waste at upstream side
Potential-7	Bennet's Brook Lane	Inlet	Culvert blocked on upstream end. Water level much higher than downstream end.

A beaver dam was observed near the inlet at one culvert, as listed below.

TABLE 4-5
Summary of Culverts with Beaver Dams

Tighe & Bond Culvert ID	Address	Dam Location	Notes
Potential-9	Bennetts Crossing	Inlet	Bear dam near inlet

Obstructions were noted at 26 culverts. Obstructions included items such as debris, stones, logs, trees, leaves, vegetation, etc. This raw data was delivered separately to the Town electronically.

During inspections, 29 culverts were noted as having material/substrate present in the culvert (e.g., rock, gravel, sand). This raw data was delivered separately to the Town electronically.

Of the inspected culverts, 30 had a tree present near the upstream and/or downstream headwall/wingwall. Trees and their roots, if too close to culverts, can cause damage to the headwall/wingwalls and culverts. A summary of culverts with nearby trees is provided below. These culverts should be further assessed, monitored, and trees removed when needed to prevent future damage.

TABLE 4-6
Summary of Culverts with Trees near Headwalls/Wingwalls

Tighe & Bond Culvert ID	Address	Tree Location
P-58	Victor Drive	Downstream
P-345	Jonathan Road	Upstream/Downstream
P-140	Highland Avenue	Upstream/Downstream
P-141	Lincoln Street	Downstream
P-1265	Wear Main Street	Downstream
P-143	High Street	Downstream
P-144	Williams Street	Upstream/Downstream
P-550	Oak Ridge Drive	Upstream/Downstream
P-1170	Central Street	Downstream
P-1176	N/A	Downstream
P-589	Copeland Drive	Downstream
Potential-6	Bonnet's Brook Road	Downstream
P-1539	Willow road	Upstream/Downstream
P-1096	Willow road	Downstream
P-New1	Willow Road	Upstream/Downstream

TABLE 4-6
Summary of Culverts with Trees near Headwalls/Wingwalls

Tighe & Bond Culvert ID	Address	Tree Location
P-915	Pingry Way	Upstream/Downstream
Potential-9	Bennetts Crossing	Upstream/Downstream
P-1711	Douglas Drive	Upstream
P-338	Mark Street	Upstream
P-1510	RAILROAD	Upstream
P-1180	Sculpt Road	Upstream
P-1247	Bligh Street	Upstream
P-1508	Central Avenue	Upstream
P-1714	Groton Harvard Road	Upstream
P-1173	Harvard Street	Upstream
P-1744	Old Sandy Pond Road	Upstream
P-1743	N/A	Upstream
P-1175	Sandy Pond Road	Upstream
P-71	Mulberry Circle	Upstream
P-1179	Shirley St	Upstream

Section 5
Evaluation of Drainage System Condition and Performance

5.1 The Case for Asset Management

Ayer historically has managed their stormwater system by relying on its existing technology and tools, as well as the in-depth system knowledge of personnel, to plan for capital projects that they judge to be the highest priority. However, priority is often given to immediate problems as they arise. By approaching capital projects in this way Ayer could be underestimating the urgency of other stormwater system upgrades. For example, are there aging stormwater mains in need of proactive maintenance at risk of failure? Are there maintenance issues or water quality issues that could be proactively addressed? For this reason, a more proactive, data-driven decision-making process (discussed below) would help target stormwater assets that should be prioritized before they run to failure and become an emergency. The current funding prioritization process for maintenance and capital projects does not consider "criticality" of drainage system components. **The relationship between the probability and consequence of failure determines the criticality of an asset**, as demonstrated in Figure 5-1. An asset in new condition (low probability of failure) with a low consequence of failure is considered a low risk asset. Conversely, an asset that is in poor condition (high probability of failure) and has a high consequence of failure is considered a critical asset with a high risk for the Town, and should be at the top of the priority list. **Adopting an asset management approach for strategic maintenance and risk-based capital improvements will save Ayer time and money in the long-term.**

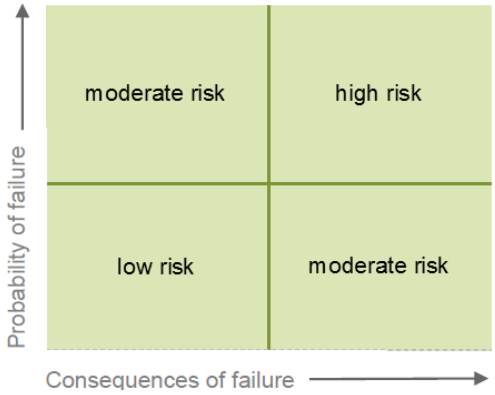


Figure 5-1 Criticality Matrix

5.2 Priority Ranking of Inspected Assets

Tighe & Bond utilized the drainage system and culvert assessment results as components in assessing the criticality of each asset. To determine an asset's criticality, there are two important questions:

1. How likely is the asset to fail?

2. If the asset does fail, what will be the consequence?

In the context of asset management, criticality is defined as an asset's probability of failure (PoF) multiplied by the severity and extent of the consequences of that failure (CoF). **Criticality allows the Town to manage its overall risk and provides a logical framework for allocation of operation and maintenance dollars and capital expenditures.**

The likelihood that an infrastructure component will fail is a function of the component's condition, performance, reliability, and maintenance history. Failure refers to the state of not meeting a desirable or intended objective. There are several modes of failure[5] that may occur, including:

- **Mortality** – The asset stops functioning due to a physical condition or break;
- **Capacity** – The asset is functioning but will not provide the quantity of service required;
- **Level of service** – Changes in needs or in regulations demand a higher level of service than the asset can deliver; and
- **Financial inefficiency** – The asset is costing more to repair than it would to replace.

If a component of Ayer's stormwater system fails, the consequences widely differ in severity and impact to the Town and its residents. It is important to consider all of the possible costs of failure, including cost of repair/replacement, collateral damage, social costs, legal costs (i.e., injuries or damages caused by failure), environmental costs, and other considerations such as inability to deliver desired level or service or loss of confidence in the stormwater system.

Tighe & Bond's methodology for determining PoF and CoF and subsequently criticality for Ayer's stormwater system is described below. The Criticality Analysis for stormwater pipes, culverts and drainage structures (manholes and catch basins) was completed and ranked together using customized criteria described below. It should be noted, that additional factors such as age could be used in the Town's CoF and PoF analysis, however since Ayer is in the early stages of their asset management program and data is limited, we used the data available supplemented with visual inspections.

5.3 Probability of Failure (PoF)

This section discusses the various factors and methodology to determine PoF. The raw data of the inventory and associated PoF ranking for each of the assessed structures was delivered separately to the Town electronically. The parameters used to calculate PoF for stormwater assets vary by type of asset assessed (i.e., drainage structure, drainage pipe, or culvert). Tables 5-1 through 5-3 list the various criteria, ranking, weight and maximum points for dertmining each assets PoF. A total PoF "deficiency score" was calculated by summing the ranking points for each asset's criteria and dividing that number by total possible points to normalize the PoF for each drainage asset on a 0-1 scale, with a minimum score of 0 and a maximum score of 1.

[5] Modes of failure adapted from University of Southern Maine. Issue Brief, "Asset Management for Stormwater," April 2014. Available at: http://digitalcommons.usm.maine.edu/cgi/viewcontent.cgi?article=1000&context=sustainable_communities.

TABLE 5-1
Pipe PoF Evaluation Criteria

Category/Item	PoF Rating System	Weight	Max Score
Pipe Condition	Excellent = 1 Good = 2 Fair = 3 Unknown = 3 Poor = 4 Immediate = 5	2	10
Pipe Sediment[1]	0%-5% full = 1 6%-40% full = 3 >40% full = 5	1	5
Maintenance Needs	No Need = 0 Need Identified = 3	1	3
Max Score			**18**

(1) Pipes were assessed for amount of sediment or obstruction.

TABLE 5-2
Structure[1] PoF Evaluation Criteria

Category/Item	PoF Rating System	Weight	Max Score
Structure Condition	Excellent = 1 Good = 2 Fair = 3 Unknown = 3 Poor = 4 Immediate = 5	2	10
Maintenance Needs	No Need = 0 Need Identified = 3	1	3
Cover/Grate Condition	Excellent = 1 Good = 2 Fair = 3 Unknown = 3 Poor = 4 Immediate = 5	1	5

TABLE 5-2
Structure[1] PoF Evaluation Criteria

Category/Item	PoF Rating System	Weight	Max Score
Frame Condition	Excellent = 1 Good = 2 Fair = 3 Unknown = 3 Poor = 4 Immediate = 5	1	5
Corbel Condition	Excellent = 1 Good = 2 Fair = 3 Unknown = 3 Poor = 4 Immediate = 5	1	5
Wall Condition	Excellent = 1 Good = 2 Fair = 3 Unknown = 3 Poor = 4 Immediate = 5	1	5
Floor Condition	Excellent = 1 Good = 2 Fair = 3 Unknown = 3 Poor = 4 Immediate = 5	1	5
Invert Condition	Excellent = 1 Good = 2 Fair = 3 Unknown = 3 Poor = 4 Immediate = 5	1	5
Max Score			**43**

(1) Catch basins and manholes.

TABLE 5-3
Culvert PoF Evaluation Criteria

Category/Item	PoF Rating System	Weight	Max Score
Roadway:			
Overall Roadway Condition	N/A = 0 Satisfactory = 1 Fair = 2 Unknown = 2 Poor = 4 Critical/Failing = 5	1	5
Culvert Inlet and Culvert Outlet:			
Guardrail Condition	N/A = 0 Satisfactory = 1 Fair = 2 Unknown = 2 Poor = 4 Critical/Failing = 5	1	5
Condition of Embankment	N/A = 0 Satisfactory = 1 Fair = 2 Unknown = 2 Poor = 4 Critical/Failing = 5	1	5
Condition of Wingwall	N/A = 0 Satisfactory = 1 Fair = 2 Unknown = 2 Poor = 4 Critical/Failing = 5	1	5
Culvert Deterioration	None = 0 Low = 1 Unknown = 2 Medium = 3 High = 5	2	10
Apron Condition	N/A = 0 Satisfactory = 1 Fair = 2 Unknown = 2 Poor = 4 Critical/Failing = 5	0.5	2.5

TABLE 5-3
Culvert PoF Evaluation Criteria

Category/Item	PoF Rating System	Weight	Max Score
Scour Damage	None = 0 Low = 1 Unknown = 2 Medium = 3 High = 5	1	5
Cross-Section Deformation	None = 0 Low = 1 Unknown = 2 Medium = 3 High = 5	2	10
Tree Present	No = 0 Unknown = 3 Yes = 5	0.25	1.25
Obstructions	If Yes, Low = 1 Medium = 3 High = 5	0.75	3.75
Material Present in Crossing	None = 0 Low = 1 Unknown = 2 Medium = 3 High = 5	0.75	3.75
Max Score			**56.25**

5.3.1 Corrugated Metal Pipes and Culverts

It was noted during inspections that corrugated metal pipes and culverts had significant invert deterioration, which in some cases lead to additional indicators of potential failure such as poor headwall or roadway condition. Approximately 28% of the Town's inspected CMP culverts had a condition of either poor or critical/immediate attention.

CMP culverts and pipes should be considered a high priority and will need an enhanced monitoring and maintenance program, as discussed in Section 6.4.

5.3.2 PoF Results and Conclusions

Appendix D provides an summary table of the PoF result in a "heat map" format, where a darker color indicates a higher percentage of assets found to be a certain condition or severity.

5.4 Consequence of Failure (CoF)

A Consequence of Failure assessment typically considers hypothetical failure scenarios and the cost or impact of failure on the community, local government, or to regulatory compliance. Typical CoF for drainage infrastructure considers extent and severity of

flooding and associated impact on the community (e.g., disruption of emergency services due to decreased access or reroute required, impaired ability for residents to egress from their homes/roadway to a main road, or impact to sensitive populations such as schools or nursing homes) and the extent and severity of water quality degradation (e.g., impact on drinking water supply, sensitive species, or public bathing or recreational uses). In many ways the CoF rating is subjective since it is often difficult to foresee all the direct and indirect consequences of a failure of an individual piece of equipment or infrastructure.

Because the scope of this project was limited and the asset inventory is still under development, CoF categories and ratings for stormwater assets were simplified and determined based on Town staff input and the data available at this time. The raw data of the inventory and associated CoF ranking for each of the assessed structures was delivered separately to the Town electronically.

Six fields were used to inform the CoF ranking of culverts, five were used to inform CoF of drainage pipes, and 3 fields were used to inform the CoF rankings of drainage structures. These fields and their associated rankings and weights are listed in Tables 5-4 through 5-6 below.

TABLE 5-4
Distribution of Criticality Points for Drainage Structures

Category/Item	CoF Rating System	Weight	Max Score
FEMA Flood Zone	Not in 100- or 500-Year Flood Zone = 0 Within 100- or 500-Year Flood Zone = 3	0.5	1.5
Natural Heritage and Endangered Species (NHESP) Priority or Estimated Habitat	In Habitat = 0 Not Within Habitat = 3	0.5	1.5
Clean Water Act Compliance: Potential IDDE Concern	No = 0 Yes = 3	1	3
Max Score			**6**

TABLE 5-5
Distribution of Criticality Points for Culverts

Category/Item	CoF Rating System	Weight	Max Score
Culvert Size	≤ 1' = 1 1' < size ≤ 2' = 2 2' < size ≤ 4' = 3 4' < size ≤ 6' = 4 > 6' = 5	1	5

Category/Item	CoF Rating System	Weight	Max Score
FEMA Flood Zone	Not in 100 or 500 Year Flood Zone = 0 Within 100 or 500 Year Flood Zone = 3	0.5	1.5
Detour/Dead End	<1 mile or < 5 houses = 1 1-2 miles or 5-9 houses = 2 2-3 miles or 10-14 houses = 3 3-4 miles or 15-19 houses = 4 > 4 miles or ≥ 20 houses = 5 Not a road = 0	2	10
Roadway Class or Type	6 - Minor street or road = 1 5 -Minor street or road = 2 Unknown or N/A= 2 4 - Major road = 3 3 - Other # route = 4 Railroad Crossing = 5	2	10
Natural Heritage and Endangered Species (NHESP) Priority or Estimated Habitat	In Habitat = 0 Not Within Habitat = 3	0.5	1.5
Watermain Crossing	No = 0 Yes = 3	1	3
Max Score			**31**

TABLE 5-6
Distribution of Criticality Points for Drainage Pipes

Category/Item	CoF Rating System	Weight	Max Score
Pipe Size	≤ 6" = 1 6" < size ≤ 12” = 2 12" < size ≤ 18" = 3 Unknown = 3 18" < size ≤ 24" = 4 > 24" = 5	1	5
FEMA Flood Zone	Not in 100- or 500-Year Flood Zone = 0 Within 100- or 500-Year Flood Zone = 3	0.5	1.5

Category/Item	CoF Rating System	Weight	Max Score
Roadway Class or Type	6 - Minor street or road = 1 5 -Minor street or road = 2 Unknown or N/A= 2 4 - Major road = 3 3 - Other # route = 4 Railroad Crossing = 5	2	10
Natural Heritage and Endangered Species (NHESP) Priority or Estimated Habitat	In Habitat = 0 Not Within Habitat = 3	0.5	1.5
Watermain Crossing	No = 0 Yes = 3	1	3
Max Score			**21**

Unlike PoF, CoF factors were weighted based on the severity of the impact. Assets were evaluated for each criterion and assigned rankings based on the determined weighting factor. The value of each CoF category was summed and divided by the maximum possible CoF value to determine a normalized CoF for each culvert.

The following tables provide an overview of the CoF results located within the areas evaluated. These tables summarize the CoF results for culverts, stormwater structures and drainage pipes.

Roadway Class or Type: Failure of culverts on major roadways will have a greater impact on public safety, residents, and commuters, and require greater construction and traffic control coordination depending on the criticality of the road. We utilized MassGIS's field class[6] for MassDOT roadways:

- **1** - Limited Access Highway (none in the study area)
- **2** - Multi-lane Highway, not limited access (none in the study area)
- **3** - Other numbered route (e.g., Route 40, Route 110, etc.)
- **4** - Major road - arterials and collectors
- **5** - Minor street or road (with Road Inventory information, not class 1-4)
- **6** - Minor street or road (with minimal Road Inventory information and no street name)
- **Railroad Crossing.**

Tables 5-7 and 5-8 show the distribution of drainage pipes and culverts associated with each roadway type or class.

TABLE 5-7
Drainage Pipe by Roadway Type

Road Class	Quantity	Percent
3	9	2%
4	5	1%
5	354	84%
6	12	3%
Railroad Crossing	0	0%
N/A or Unknown	40	10%
Total	**420**	**100%**

TABLE 5-8
Culvert by Roadway Type

Road Class	Quantity	Percent
3	2	3%
4	4	7%
5	41	67%
6	5	8%
Railroad Crossing	2	3%

[6] https://docs.digital.mass.gov/dataset/massgis-data-massachusetts-department-transportation-massdot-roads

N/A or Unknown	7	11%
Total	**61**	**100%**

Traffic Detour Length or Number of Houses Impacted if No Reroute Available (i.e., culvert serves dead end): Tighe & Bond utilized ArcGIS to estimate the shortest re-route distance if each culvert were to collapse. Failure of a culvert on a dead-end road will have a greater consequences and impact on a limited number of houses. Ranking was based on the number of houses on the dead end. Tables 5-9 and 5-10 show the distribution of culverts by detour length and number of houses on dead end streets.

TABLE 5-9
Culvert by Length of Detour

Detour Length	Quantity	Percent
< 1 mile	22	36%
1 to 2 miles	6	10%
2 to 3 miles	8	13%
3 to 4 miles	6	10%
> 4 miles	3	5%
Dead End/Not a Road	16	26%
Total	**61**	**100%**

TABLE 5-10
Culvert by Number of Houses on Dead End Streets

Number of Houses	Quantity	Percent
Not a Dead End	49	80%
< 5	1	2%
5 to 9	1	2%
10 to 14	3	5%
15 to 19	0	0%
≥ 20	7	11%
Total	**61**	**100%**

Proximity to Floodplains: A failure within a floodplain will have a greater impact during a flooding event, leading to exacerbated flooding. We used the 100 Year Federal Emergency Management Agency (FEMA) Flood Zone and 500 Year FEMA Flood Zone from most recent mapping for this analysis. Tables 5-11, 5-12 and 5-13 show the distribution of culverts, drainage pipes and structures within FEMA flood zones.

TABLE 5-11
Drainage Pipe by Proximity to Floodplains

Flood Zone	Quantity	Percent
100 Year/500 year	29	7%
None	391	93%
Total	**420**	**100%**

TABLE 5-12
Culvert by Proximity to Floodplains

Flood Zone	Quantity	Percent
100 Year	6	9.8%
500 year	9	14.8%
100 Year and 500 year	1	1.6%
None	45	73.8%
Total	**61**	**100%**

TABLE 5-13
Drainage Structure CoF by Proximity to Floodplains

Flood Zone	Quantity	Percent
100 Year/500 year	9	4%
None	199	96%
Total	**208**	**100%**

Water Main Crossing a Culvert: A drainage pipe or culvert that has a water main crossing and fails has the potential to negatively impact the public drinking water distribution system. We used the Town's water system GIS mapping to determine structures where a water main crosses the pipe. Tables 5-14 and 5-15 show the distribution of culverts and pipes with a water main crossing.

TABLE 5-14
Drainage Pipe by Water Main Crossings

Crossing Present	Quantity	Percent
Yes	263	63%
No	157	37%
Total	**420**	**100%**

TABLE 5-15
Culvert by Water Main Crossings

Crossing Present	Quantity	Percent
Yes	46	75%
No	15	25%
Total	**61**	100%

Natural Heritage and Endangered Species (NHESP) Priority or Estimated Habitat: A failure in mapped habitat area could have a detrimental impact to an endangered, threatened, or special concern species or the natural communities that make up their habitats. Tables 5-16, 5-17 and 5-18 show the distribution of culverts, drainage pipes and structures within a NHESP habitat.

TABLE 5-16
Culvert by NHESP Habitat

In Habitat	Quantity	Percent
Yes	9	15%
No	52	85%
Total	**61**	**100%**

TABLE 5-17
Drainage Pipe by NHESP Habitat

In Habitat	Quantity	Percent
Yes	6	1%
No	414	99%
Total	**420**	**100%**

TABLE 5-18
Drainage Structure by NHESP Habitat

In Habitat	Quantity	Percent
Yes	2	1%
No	206	99%
Total	**208**	**100%**

Size: Larger culverts and pipes typically convey a more substantial flow than smaller ones and present a higher consequence if they are to fail. Tables 5-19 and 5-20 show the distribution of culverts and drainage pipes by pipe size.

TABLE 5-19
Drainage Pipe by Size

Size (in)	Quantity	Percent
≤ 6	19	5%
6 < size ≤ 12	246	59%
12 < size ≤ 18	130	31%
18 < size ≤ 24	17	4%
> 24	4	1%
Unknown	4	1%
Total	**420**	**100%**

TABLE 5-20
Culvert by Size

Size (ft)	Quantity	Percent
≤ 1	9	15%
1 < size ≤ 2	15	25%
2 < size ≤ 4	20	33%
4 < size <6	4	7%
> =6	13	21%
Total	**61**	**100%**

Potential IDDE Concerns: Structures with potential IDDE concerns present a higher consequence of failure because of the risk to public and ecosystem health. Table 5-20 shows the distribution of drainage structures with an IDDE concern.

TABLE 5-21
Drainage Structure CoF by IDDE Concern

Potential IDDE	Quantity	Percent
Yes	5	2%
No	203	98%
Total	**208**	**100%**

5.5 Overall Criticality or "Risk"

Overall criticality for each stormwater structure was determined by evaluating the normalized PoF and CoF, as follows:

- **High criticality** culverts = CoF and PoF greater than or equal to 0.5
- **Medium criticality** culverts = CoF or PoF greater than or equal to 0.5
- **Low criticality** culverts = CoF and PoF less than 0.5

Risk factor values fall into a "high," "medium," and "low" category with a recommended action for each according to Table 5-22.

TABLE 5-22
Risk Factor Category Ratings

Risk Category	Value	Action
High	If CoF > 0.5 and PoF > 0.5	Immediate Attention
Medium	If CoF ≤ 0.5 and PoF ≥ 0.5 Or If CoF ≥ 0.5 and PoF ≤ 0.5	Aggressive Maintenance Aggressive Monitoring
Low	If CoF < 0.5 and PoF < 0.5	Routine Maintenance

Asset risk matrices were created within Excel and the results are shown in Figures 5-2 through 5-4 below. Each asset is shown per its risk category assigned based on the Consequence and Probability of Failure. The Stormwater System Inventory and Evaluation, Attachment E, identifies the high, medium and low risk assets, and the priority ranking. Note that each dot in Figure 5-2 through 5-4 below may represent multiple assets with the same score.

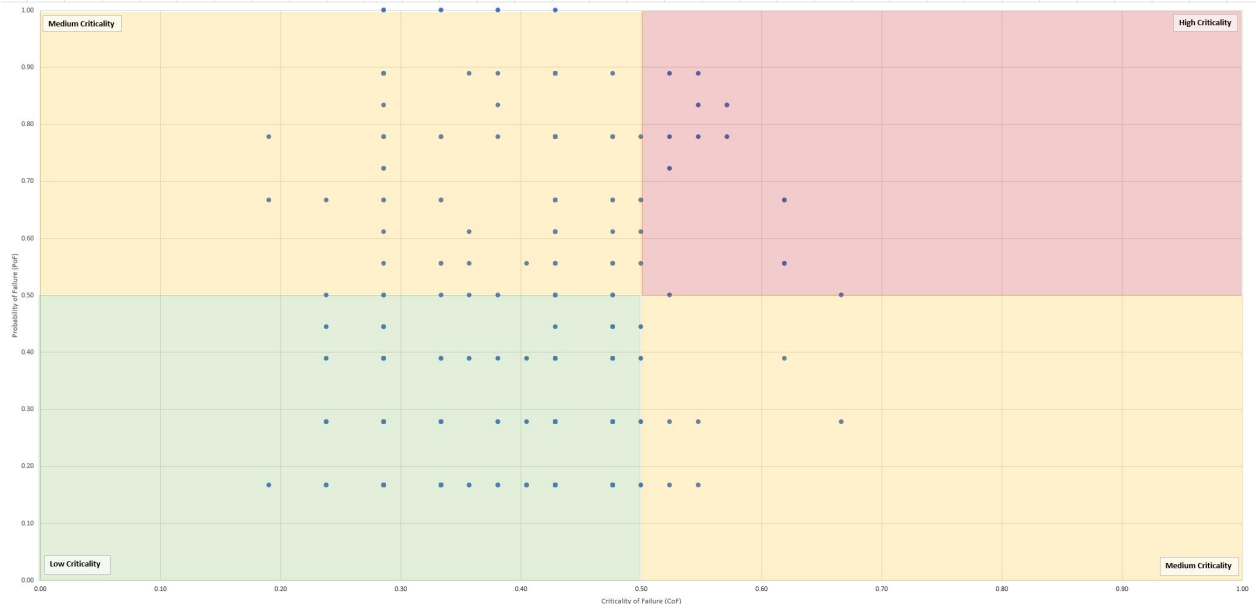


Figure 5-2 Drainage Pipe Risk Matrix

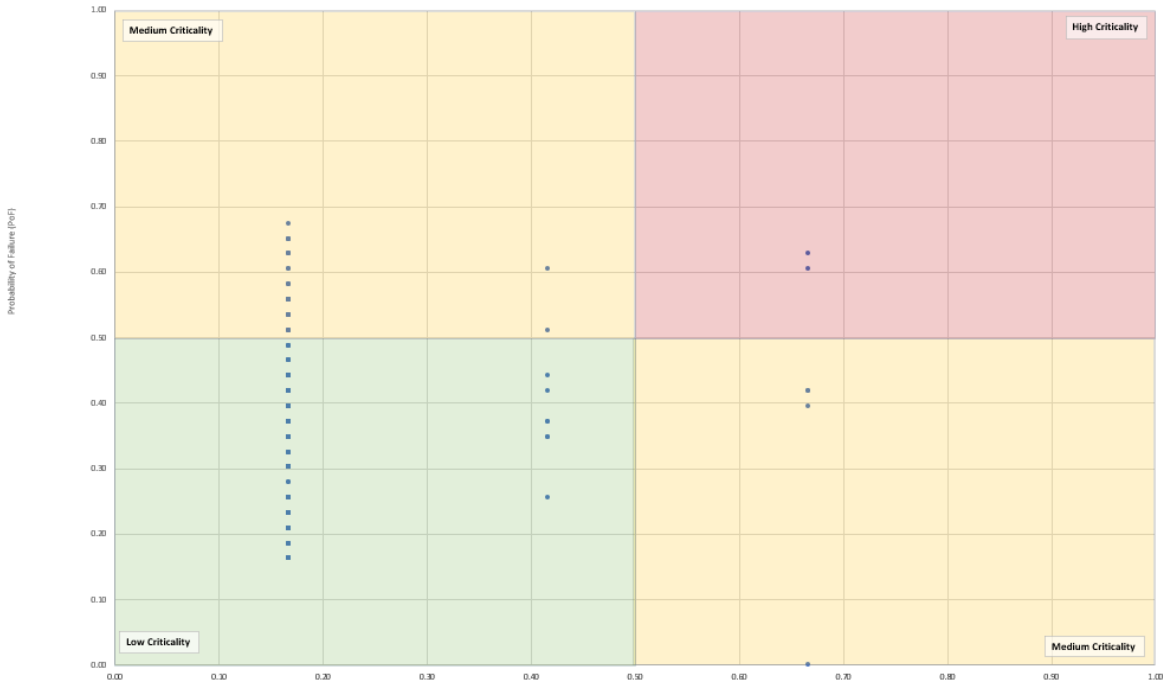


Figure 5-3 Structure Risk Matrix

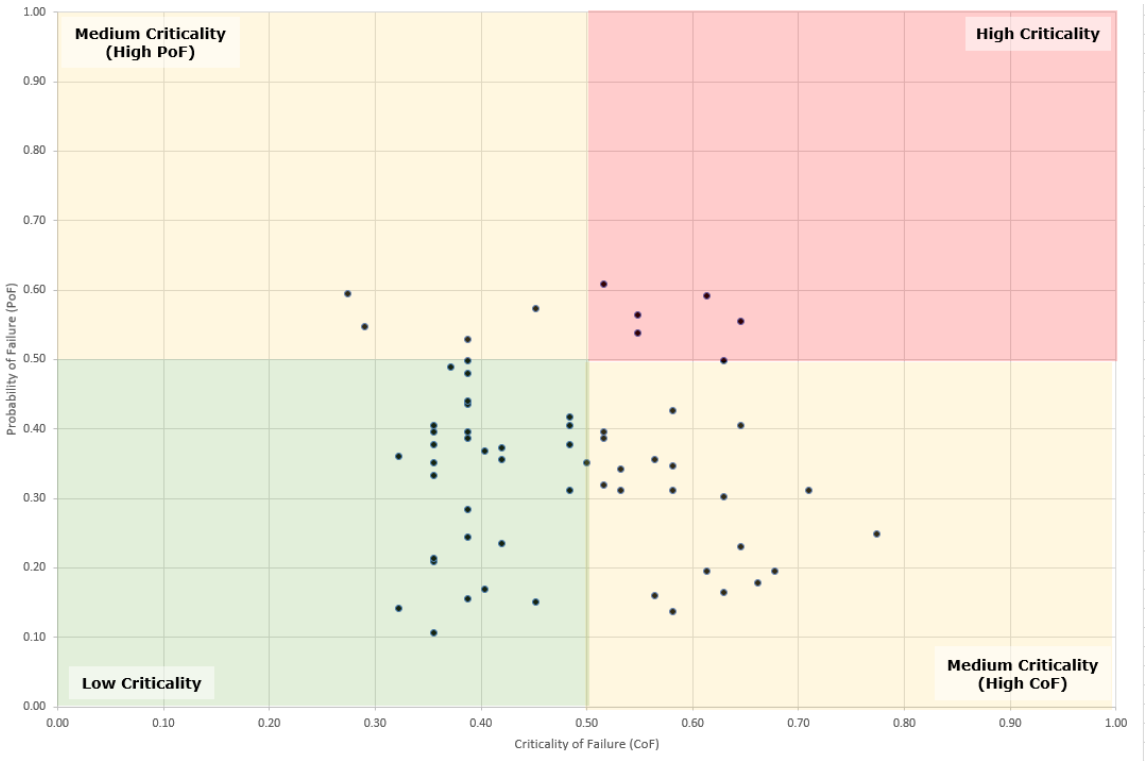


Figure 5-4 Culvert Risk Matrix

5.6 Priority List of Assets (PLA)

A Priority List of Assets was developed that reflects the highest priority maintenance or replacement activities that should be targeted in the **first five years of the asset management plan implementation**. This prioritization was based on the risk-based assessment of each inspected asset's criticality or risk category. There are 26 (19 drain pipes, 5 culverts, 2 structures) total assets on the Priority List of Assets in Appendix E. Details about each culvert and recommended action is included in the summary sheets attached (Appendix F).

5.7 Secondary List of Assets (SLA)

The Secondary List of Assets (SLA) reflects the next tier of asset renewal in terms of prioritized risk. This list is a natural extension of the PLA. It is recommended that assets in the SLA be closely monitored due to either increased risk of failure or high consequence of failure (but not both) and repair or replacement may be necessary within the next five to ten years of the asset management plan implementation. In addition, **the risk score was used to help rank and prioritize assets within the SLA by identifying which ones had a high PoF and should be addressed relatively quickly and ones that had a high CoF and should be aggressively monitored instead**. Many of the drainage assets listed as having O&M needs in Section 3 are in the SLA. There are 223 total assets (26 culverts, 38 structures, and 159 drain pipes) on the Secondary List of Assets. The complete SLA is presented in Attachment E.

5.8 Opportunistic Asset Repair or Replacement

Separate roadway or water and sewer system projects offer a cost effective opportunity to replace or repair stormwater infrastructure that are within the proposed project extents.

Specific roadway and water and sewer system improvement projects did not influence the prioritization analysis completed herein. The Town should evaluate whether a drainage structure replacement or repair is necessary during planning a construction to assess feasibility to include additional stormwater system upgrades as part of the project. In some cases, a lower priority asset could be proactively addressed during a planned capital project.

Section 6
Recommendations

The following section presents recommendations to further refine and implement the Town's Asset Management Program based on work completed to date, including capital improvements, further investigation/study, maintenance needs, and overall programmatic improvements.

For Ayer to proceed with a comprehensive stormwater Asset Management Program, we provide the following recommendations to help the Town plan and schedule key asset management activities with the goal of implementing the asset management program in the near-term.

Recommendations fall into the following categories to address program goals and key concepts:

- **Inventory and Inspections**: The goal of this action item is to complete an inventory and inspection for the remaining stormwater system assets. This information will provide a complete picture of the condition of all the Town's stormwater infrastructure.
- **GIS Information Management Software:** The goal of this action item is to decide and implement one data management program to manage the Town's stormwater assets. We recommend all departments in Town use the same data management software, preferably GIS, to manage their respective datasets related to the municipal stormwater program. This will provide consistency in managing data throughout Town and it will also save the Town from spending unnecessary funds on multiple software licenses.
- **Workflow and Records Management:** The goal of this action item is to adopt a consistent workflow and record management process for stormwater management. The Town should evaluate the current process to identify any changes or updates. An updated workflow and records management process should be instated, utilizing GIS and maintained accordingly.
- **Risk Assessment**: The goal of this action item is to rank all stormwater assets into a PLA, SLA, and low priority list to help inform future stormwater capital improvement projects. The ranking should be updated continuously as infrastructure is replaced and/or rehabilitated.
- **Asset Rehabilitation and Replacement:** The goal of this action item is to plan and complete stormwater system maintenance, rehabilitation, and replacement in the next five years from information gained in the PLA. The Town should also review the SLA for high PoF assets (such as buried catch basins and blocked culverts and pipes) for short-term maintenance. As new information is obtained from the Inventory and Inspections, new projects will be added to the PLA and others will be moved to "Low Priority" as work is completed.
- **Training**: The goal of this action item is to have all Town staff annually trained on how to properly adopt the various components in the asset management program including workflow, record management, and data collection. The training should

be included annually for all necessary employees and the program's effectiveness should be evaluated at the end of the five years.

6.1 Capital Improvements

Based on this study, the following drainage assets in the PLA and SLA were the highest ranked for repair or replacement. Additional information about the culverts is located in the Project Summaries in Appendix F and Opinions of Probable Project Costs have been provided in Appendix G. The schedule to complete these projects is included in the Five-Year Action Plan in Section 8.

TABLE 6-1
Recommended Repair or Replacement Capital Improvements

Tighe & Bond ID	Asset type	Address	Summary of Recommendations	Criticality Rank
P-1539	Culvert	Willow Road	Replacement	High
P-550	Culvert	Oak Ridge Drive	Replacement	High
P-711	Culvert	Madigan Lane	Replacement	High
Potential -11	Culvert	Spectacle Road	Replacement	High
P-1096	Culvert	Willow Road	Replacement	High
P-93	Pipe	Oak Ridge Drive	Repair	High
P-840	Pipe	Sandy Pond Road	Repair	High
P-1490	Pipe	Faulkner Street	Repair	High
P-1404	Pipe	Markham Circle	Repair	High
P-1029	Pipe	Columbia Street	Repair	Medium
P-415	Pipe	Jackson Street	Repair	Medium
P-1538	Pipe	Willow Road	Repair	Medium
P-307	Pipe	Hatch Street	Repair	Medium
P-1538B	Pipe	Willow Road	Repair	Medium
P-149	Pipe	West Main Street	Repair	Medium
P-227	Pipe	Grove Street	Repair	Medium
P-304	Pipe	Hatch Street	Repair	Medium
P-638	Pipe	Williams Street	Repair	Medium
P-1431	Pipe	Pleasant Street	Repair	Medium
P-78C	Pipe	Jackson Street	Repair	Medium
P-417	Pipe	Groton Street	Repair	Medium
P-395	Pipe	Pleasant Street	Repair	Medium
P-1025	Pipe	Columbia Street	Repair	Medium
P-1026	Pipe	Columbia Street	Repair	Medium
P-297	Pipe	Grosvenor Street	Repair	Medium

Tighe & Bond ID	Asset type	Address	Summary of Recommendations	Criticality Rank
P-315	Pipe	Atherton Street	Repair	Medium
P-174	Pipe	Willard Street	Repair	Medium
P-398	Pipe	Pleasant Street	Repair	Medium
P-105	Pipe	Oak Ridge Drive	Repair	Medium
P-148	Pipe	West MainStreet	Repair	Medium
P-565	Pipe	Pearl Street	Repair	Medium
P-636	Pipe	Washington Street	Repair	Medium

6.2 Further Investigation or Study

Stormwater assets that could not be assessed because of sediment, debris or water, should be cleaned in order to update the inventory and determine whether there are any deficiencies. For some assets, Tighe & Bond was able to obtain enough condition information to determine a high PoF; however, additional CCTV investigation is recommended prior to design to provide additional information about the condition and identify possible construction constraints.

The 12 additional culverts identified during field investigations should be revisited and assessed.

We recommend completing CCTV inspection at the high priority stormwater pipes included in the Five-Year Action Plan in Section 8. Additionally $30,000 per year was carried for FY2025 through FY2028 to clean pipes listed in the SLA. The Town should use additional information from future inspections to revise the PoF score and overall criticality rank. For example, additional evidence of risk of failure for a high CoF culvert would increase the Criticality Rank to High and require expedited improvements at the asset.

6.3 Complete Targeted Maintenance and Repairs

Many of the more significant O&M concerns noted during inspections are summarized in Section 4.2.2 *Operation and Maintenance Statistics*. Additional information is included in the inventories and the GIS. A suggested schedule of targeted maintenance with identified maintenance or repair needs is provided below, which can be modified and adapted to best fit the Town's needs.

Once maintenance or repairs are completed, the Town should update the GIS with a record of the work complete and log updated photos.

TABLE 6-2:
Recommended Targeted Maintenance Schedule

Maintenance Item	Schedule
Targeted Maintenance Recommendations	In FY2024 the DPW should plan to clean all 15 High Criticality pipes with maintenance needs that are significantly obstructing flow. This cost is included in the Five-Year Culvert Action Plan.
Targeted Culvert Replacement Recommendations	5 High Criticality Culverts: FY2024 through FY2028. This cost is noted Five-Year Culvert Action Plan and the OPCCs in Appendix G.
Targeted Repairs and Replacement Recommendations	All High/Medium Criticality Pipes in need of Repair: FY2024 through FY2028. An annual cost is noted Five-Year Action Plan.
Remove illegally dumped items (Table 4-4)	2 culverts in Table 4-4 in FY2024. Ongoing as needed, during inspections and maintenance.
Remove beaver dams (Table 4-5)	Annually beginning in FY2024.
Remove trees after additional assessment (Table 4-6)	Assess tree growth at 6 culverts per year in Table 4-6 starting in FY2024 and remove trees damaging the culvert with concurrence from Conservation Commission. Inspect annually after removal.
Remove obstructions	Target 26 culverts with obstructions, in FY2024-FY2026.
Remove material/substrate buildup	Target 29 culverts for removal of substrate. Six per year FY2024-FY2028.

6.4 Programmatic Recommendations

Based on the work completed as part of developing this program, Tighe & Bond is providing the following programmatic recommendations.

6.4.1 Coordinate with MassDOT on Small Bridges Identified

The Town of Ayer DPW should coordinate with the MassDOT BIMS system by providing a list and coordinates for culverts with 10-foot or larger span and the inventory of small bridges identified during this project (see below). Ayer staff can coordinate directly with the District 3 Engineer. The benefit of doing this is that MassDOT will ultimately provide an inventory and complete inspections of the small bridges consistent with the State's system, and those locations are eligible for funding under the Small Bridge Program.

Crossings whose spans qualify as a bridge are listed below:

- P-741 on Amandrey Way
- P-1174 on Marshall Street
- P-841 on Mountain Laurel Road
- Potential-9 on Bennetts Crossing
- P-1179 on Shirley Street

6.4.2 Develop a Routine Inspection Program

The Town of Ayer should develop a routine drainage system inspection program. Re-inspections do not need to consist of a full inventory, but instead should be completed to collect comparative information and to continue to monitor drainage asset condition over time. Photographs and limited notes are critical to follow up. The Town should inspect the 53 CMP culverts on a routine basis, targeting 18 culverts per year on a 3-year rotating basis.

6.4.3 Staff Training

Applicable Town staff should be trained upon hiring and regularly thereafter on how to properly complete the various components in the asset management program, including culvert inventory data collection, inspections, workflow, and record management.

6.4.4 Data Collection and Tracking

The Town should continue to improve its GIS management practices. A consistent workflow and record management process is recommended for culvert and drainage system management. The current data collection forms can be used for new assets located or installed and adapted for future re-inspections as needed. Since the Town does not have internal GIS staff an outside consultant fee was carried in the Five-Year Action Plan in Section 8.

6.4.5 Public Outreach and Education

As culvert replacements and other system improvements are completed, the Town could consider a public education campaign outlining the work and how it improves both water quality and drainage performance. Additionally, when replacements are completed in watersheds of water quality-limited waterbodies or those subject to TMDLs, the Town can complete targeted public education to help meet Small MS4 General Permit education requirements.

6.4.6 Public Works Staff and Equipment

The Town will need to evaluate the necessity of hiring additional staff and purchasing additional vehicles and equipment to implement and oversee the recommendations described in Section 6. In the future, a dedicated "stormwater crew" may improve workflow and tracking of drainage-related expenditures. Organizationally, a stormwater division within the DPW may be beneficial to manage all aspects of the Stormwater Management Program, including the recommendations in this report.

Section 7 Cost Impacts to Implement Asset Management Plan

The previous sections demonstrated the Town's initiative and desire to proactively manage their stormwater system assets. However, the greatest challenge associated with implementation of any asset management program is a municipality's ability to allocate funds to pay for the improvements identified in both priority and secondary list of assets. The following section presents the state of Ayer's stormwater funding with options for other potential funding mechanisms.

7.1 Status of Ayer's Stormwater Utility Fund

In 2010, the Town embarked on creating a Stormwater Enterprise Fund. This began with convening a Stormwater Committee to begin public meetings and outreach and as part of this process, the Town with VHB completed a Stormwater Program Study in May 2010 where it estimated that the Town was spending about $123,000 a year and it was conservatively projected to need to increase to an average annual budget of $312,000. Note that this budget was intended to meet the minimal requirements of the 2003 Small MS4 General Permit, which as since been reissued. The budget carried for capital projects was about $100,000 as a placeholder. Then in May 2011, Town Meeting approved a Stormwater Utility / Enterprise Fund and subsequently a mechanism for funding was created and presented to the Board of Selectmen in 2015. The Select Board voted to not implement the Stormwater Fee and to instead continue funding stormwater through the general fund. Then Town Meeting voted to eliminate the Stormwater Utility / Enterprise Fund.

Recently, a new Select Board was elected in Ayer and the DPW presented the current status of the Ayer's Stormwater budget. The Board indicated that the implementation of Stormwater Utility should be reviewed. This resulted in an additional $25,000 of capital funding allocated to revisit the stormwater utility. As of the date of this report, the stormwater utility has yet to be reinstated, but based on the Five-Year Action Plan present in Section 8 the Town will need to budget much more than the annual $312,000 anticipated in the 2010 Stormwater Program Study. It is recommended that the previous stormwater utility rates are brought up to current conditions and the previous rate structure and rate base will need to be adjusted to account for planned improvements and ongoing stormwater management. A capital improvements plan (CIP) presented in Table 8-1 accounts for recommendations and costs outlined in Section 8 to occur within the next 5 years. This should be added to the annual revenue needs along with labor, Small MS4 Compliance, street sweeping, catch basin cleaning, and other program costs.

7.2 Potential Alternative Funding Sources

Funding options available to the Town of Ayer to facilitate infrastructure replacement include Chapter 90 funds. In addition, MassDOT Small Bridge Program and potentially DER Culvert Replacement, MVP Action Grants, and MassWorks Infrastructure Program, are available. While Department of Public Works Staff are familiar with all these programs, additional information is included below for public information.

7.2.1 MassDOT MassDOT Small Bridge Program Funding

This program provides reimbursable assistance to cities and towns over a 5-year span. The program was updated and extended in FY2022. Each municipality may receive up to $100,000 for design services and $500,000 for construction per year to aid in the replacement and preservation of Town-owned bridges. Costs over $500,000 will be borne by the Town.

This program provides for state reimbursement to municipalities of up to 100% of the total design and construction cost of eligible projects. MassDOT and selected municipalities enter into an agreement to reimburse funds for approved projects.

Additional information is available online at: https://www.mass.gov/municipal-small-bridge-program

7.2.2 DER Culvert Replacement Municipal Assistance Grant Program

The Division of Ecological Restoration's (DER's) Culvert Replacement Municipal Assistance Grant Program is for Massachusetts municipalities interested in replacing an undersized, perched, and/or degraded culvert located in an **area of high ecological value**. The purpose of this funding is to encourage municipalities to replace culverts with better designed crossings that meet improved structural and environmental design standards and flood resiliency criteria. Only projects that intend to meet the goals of the Massachusetts Stream Crossing Standards will be considered for funding. This is a very competitive program and awards may range from $25,000 to $200,000 depending on the project phase and work proposed.

Additional information is available online at:
https://www.mass.gov/how-to/culvert-replacement-municipal-assistance-grant-program

7.2.3 MVP Action Grant Program

The Municipal Vulnerability Preparedness (MVP) grant program provides support for cities and towns in Massachusetts to begin the process of planning for climate change resiliency and implementing priority projects. The state awards communities with funding to complete vulnerability assessments and develop action-oriented resiliency plans. Communities who complete the MVP program become certified as an MVP community and are eligible for MVP Action grant funding and other opportunities.

Additional information is available online at: https://www.mass.gov/municipal-vulnerability-preparedness-mvp-program

7.2.4 MassWorks Infrastructure Program

The MassWorks Infrastructure Program is a competitive grant program that provides funds to municipalities for public infrastructure projects that support and accelerate housing production, spur private development, and create jobs throughout the Commonwealth. Program investments are targeted to projects that require the infrastructure improvements or expansion to support and/or facilitate new growth or address road safety issues.

Examples of past projects that submitted successful construction proposals include various housing developments and repairs of municipally owned bridges. Additional information is

available online at: https://www.mass.gov/service-details/massworks-infrastructure-program

Section 8 Five-Year Action Plan

Table 8-1 presents the Capital Improvement Plan for Ayer's drainage system. This Plan presents capital improvements along with associated budgets based on the work completed as previously described in this report. In addition, the Plan includes programmatic recommendations and associated budgets identified in Section 6 (i.e., inspection and maintenance programs, training, etc.) as well as areas for further investigation and targeted maintenance and repairs. Recommendations may be for one-time costs or annual costs. Capital and programmatic recommendations were evaluated against the goals of this Program and a five-year plan was developed with consideration for desired level of service, local priorities, and available funding. This does not include funding for other on-going stormwater program and capital projects including MS4 outside services, stormwater collaborative fees, stormwater BMP retrofits and dam repairs.

This Action Plan provides the Town with the ability to rank expenditures, plan for and normalize expenditures over the planning period, and minimize operating and maintenance costs.

Detailed information about the 5 high criticality culverts and one top ranked medium culvert, is included in Appendix F with applicable photographs. A detailed Opinion of Probable Construction Costs for these projects is provided in Appendix G.

TABLE 8-1
Proposed Stormwater Action Plan

			Opinion of Probable Cost				
Asset ID and Address	**Summary of Work**	**Criticality Score**	**FY24**	**FY25**	**FY26**	**FY27**	**FY28**
Drainage System Improvement Projects[1]							
P-1096-Willow Road	culvert replacement	High				$ 120,000	$ 853,000
P-1539- Willow Road	culvert replacement	High	$ 130,000	$ 1,170,000			
P-550- Oak Ridge Drive	culvert replacement	High	$ 130,000		$1,138,000		
Potential 11- Spectacle Road	culvert replacement	High		$ 130,000		$ 1,241,000	
P-711 - Madigan Lane	culvert replacement	High			$ 120,000		$ 764,000
P-New1 - Willow Road	culvert replacement	Medium				$ 130,000	
Complete Maintenance and Repair[2]							
DS-1367 and DS-159	Catch basin and manhole cleaning and further investigation	High	In-house				
Various	Pipe Replacement	High/Medium	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000
Various	Pipe Cleaning/CCTV	Medium		$ 30,000	$ 30,000	$ 30,000	$ 30,000
		Subtotal	**$ 460,000**	**$1,530,000**	**$1,488,000**	**$1,721,000**	**$1,847,000**
Further Investigation/Study							
Prices listed below assume only one mobilization is required to CCTV all pipes that year.							
P-590, P-151, P-972, P-224, P-150, P-147, P-1223, P-4, P-17, P-970, P-1226, P-335, P-334, P-1489, P-199	Mobilization, Cleaning and CCTV	High	$ 30,000				
Programmatic Improvements							
Ongoing Maintenance			$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000
Inspection Program			$ 8,000	$ 8,000	$ 8,000	$ 8,000	$ 8,000
GIS Data Maintenance			$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Annual Updated PoF, Criticality, and Recommendations			$ 10,000	$ 10,000	$ 10,000	$ 5,000	$ 5,000
		Total	**$ 780,992**	**$1,628,000**	**$1,558,992**	**$1,764,000**	**$1,890,000**

1. See attached OPCCs (Opinion of Probable Construction Cost) for each project.
2. See Project Summaries in Appendix F for OPCCs (Opinion of Probable Construction Cost) of PLA drainage pipes in need of replacement.

Color Key:	
$	= CCTV Cost
$	= Design and Permitting
$	= Construction Cost

8.1 Estimated Replacement Cost Methodology

Opinions of Probable Construction Cost (OPCC's) were developed for each of the high priority ranked culverts. It should be noted that these OPCCs were developed using the limited information available, with no detailed design having been performed.

The OPCCs presented as part of this report propose replacement of each culvert with a precast concrete box culvert, sized to meet Massachusetts Stream Crossing Standards (MSCS). One criteria of the Massachusetts Stream Crossing Standards requires proposed spans to measure 1.2 times the bankfull width of the stream. It is important to highlight that the bankfull widths measured as part of these culvert assessments were not measured by a wetland scientist and therefore, actual bankfull widths may vary. Furthermore, Massachusetts Department of Transportation (MassDOT) defines a bridge as any structure whose span measures 10 feet or greater. Designs for proposed vehicular bridges in the Commonwealth of Massachusetts are subject to MassDOT review and approval per Massachusetts General Law (MGL) Chapter 85. It should be noted that design requirements under MGL Chapter 85 are far more extensive than those of culverts and therefore are more costly to design and construct.

Culverts P-1539, P-550, Potential-11, and P-New1 have been estimated with 9.9-foot spans. P-1539 and Potential-11 have a pond immediately upstream of the crossing. It is possible that MSCS guidelines for bankfull width may be waived due to upstream limitations. This would need to be justified by additional permitting and review, but the resulting culvert design and construction costs could be assumed to be lower. Similarly, P-550 has a dam and spillway upstream. Finally, the bankfull width of P-New1 was measured to be approximately 7 feet and therefore is predicted to remain a culvert under MSCS, in which a span length of 9.9-foot would be satisfactory.

Due to the limitations highlighted above in addition to a highly volatile economic climate, a 40% Project Contingency and a 20% Materials and Bidding contingency have been included in these OPCCs. Upon further assessment and design of each culvert, these contingencies may be lowered to better reflect the advanced design and bidding climate at the time.

8.1.1 Contractor vs. In-House Staff

If Town staff were to complete the design, permitting, and replacement, these costs could be significantly reduced. If culverts were replaced in-kind instead of improving existing conditions (e.g., installing/replacing guardrails, meeting stream crossing standards), the Town could realize some cost savings.

8.1.2 Considerations for Permitting

In April 2020, the Navigable Waters Protection Rule[7] went into effect. This rule revises the definition of "Waters of the United States" under the Clean Water Act. This rule specifies that under Section 404, culverts themselves will be non-jurisdictional, but upstream and downstream still are. For example, if a cofferdam is proposed to be used for dewatering, a Pre-Construction Notification (PCN) would be required from the US Army Corps of

[7] https://www.epa.gov/nwpr/final-rule-navigable-waters-protection-rule

Engineers. The PCN requires an assessment and demonstration of compliance with their Stream Crossing Standards.

While trenchless technologies are not typically regulated under a Section 401 Water Quality Certification, the local Conservation Commission and MassDEP region may have additional requirements or restrictions related to these rehabilitation solutions. The Town should determine what would be required to gain approval of trenchless rehabilitation prior to committing to a project.

Projects involving activities other than in-kind replacement or basic maintenance that result in the installation of a different size structure may require Chapter 91 licensing, if the stream is considered a jurisdictional waterway under Chapter 91 of the Massachusetts Public Waterfront Act and implementing regulations at 310 CMR 9.00. Waterways, including all submerged lands lying below the high water mark of any non-tidal river or stream on which public funds have been expended for stream clearance, channel improvement, or any form of flood control or prevention work, either upstream or downstream within the river basin, except for any portion of any such river or stream which is not normally navigable during any season, by any vessel including canoe, kayak, raft, or rowboat are jurisdictional.

Furthermore, any culvert improvements that do not constitute in-kind replacement or routine maintenance that result in a substantial change or enlargement are anticipated to require review as a Notice of Intent under the Massachusetts Wetlands Protection Act and implementing regulations (310 CMR 10.00) as well as the local bylaw for work in jurisdictional wetland resource areas (e.g., Land Under Waterbodies and Waterways, Inland Bank, Bordering Vegetated Wetland, Riverfront Area, and Bordering Land Subject to Flooding).

8.2 Permitting for Drainage Replacements

Culvert replacement or repair projects may require permits under the following regulatory programs. Permitting needs will depend on site-specific conditions, the selected design, and impact areas.

- **Wetlands Protection Act Notice of Intent/Order of Conditions –** Culvert improvements are assumed to involve work within jurisdictional resource areas regulated by the Massachusetts Wetlands Protection Act (WPA; *M.G.L. c. 131*, § *40*) and implementing regulations (310 CMR 10.00). It is assumed that a Notice of Intent (NOI) filing would be required with the Ayer Conservation Commission and MassDEP.
- **Massachusetts Environmental Policy Act (MEPA) –** Depending on the project, review thresholds set forth by MEPA (defined under 301 CMR 11.03) may be exceeded and the preparation and submittal of an Environmental Notification Form (ENF) could be required. MEPA review involves submission of an ENF to the Office of Energy and Environmental Affairs (EEA), public notice requirements, a site visit, and response to comments resulting from the public comment period.
- **Massachusetts Endangered Species Act (MESA) Review –** Depending on the culvert location, *Priority Habitats of Rare Species* or *Estimated Habitats of Rare Wildlife* may be present. If present, the project may be subject to a MESA Project Review. Rare Species Information Request would likely also need to be submitted the Massachusetts Natural Heritage and Endangered Species Program (NHESP) to verify the species identified within the project area to guide project design and best management practice development.
- **Chapter 91 Waterways License –** Projects involving activities other than in-kind replacement or basic maintenance that result in the installation of a different size structure may require Chapter 91 licensing, if the stream is considered a jurisdictional waterway under Chapter 91 of the Massachusetts Public Waterfront Act and implementing regulations at 310 CMR 9.00. Waterways, including all submerged lands lying below the high water mark of any non-tidal river or stream on which public funds have been expended for stream clearance, channel improvement, or any form of flood control or prevention work, either upstream or downstream within the river basin, except for any portion of any such river or stream which is not normally navigable during any season, by any vessel including canoe, kayak, raft, or rowboat are jurisdictional.
- **Section 401 Water Quality Certification –** A Section 401 Water Quality Certification (WQC) may be required for culvert replacements if any project results in either in a loss of 5,000 square feet cumulatively of Bordering or Isolated Vegetated Wetlands and Land Under Water, the amount of any proposed dredging is greater than 100 cubic yards, or if any of the other thresholds listed in 314 CMR 9.04 are met. If impact areas do not exceed these thresholds, the WPA Order of Conditions will serve as the 401 WQC.
- **Section 404 Army Corps Pre-Construction Notification –** Culvert replacement projects will involve work within Wetlands and Waters of the United States regulated under Section 404 of the Clean Water Act. The Corps' General Permits (GP) for Massachusetts cover specific activities within the limits of Corps' jurisdiction as stated in each of the activity General Permits. The total temporary and permanent impact area is used to determine if a project is eligible for Self-

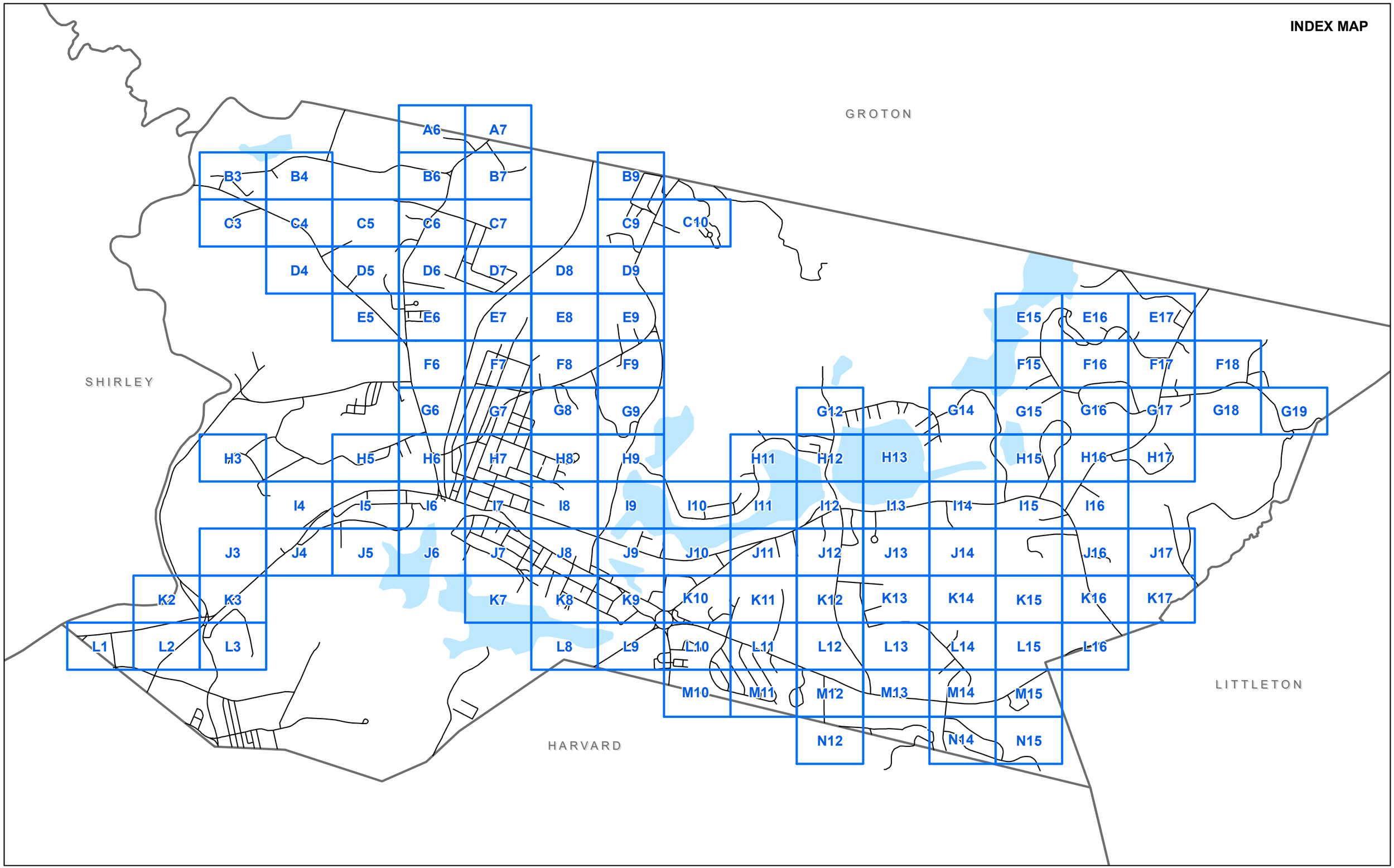
Verification, Pre-Construction Notification, or Individual Permit coverage. It is assumed that most, if not all, of the projects would require a permit application to submitted to the Corps.

In addition to environmental factors, the MA General Permit requires notification of the State Historic Preservation Officer (SHPO), Tribal Historic Preservation Officers (THPOs), and the Massachusetts Board of Underwater Archaeological Resources (MABUAR) per Section 106 of the National Historic Preservation Act, which could take place as part of the MHC PNF submittal discussed below.

- **Massachusetts Historic Commission –** Any new construction projects or renovations to existing structures that require funding, licenses, or permits from any state or federal governmental agencies must be reviewed by the State Historic Preservation Officers, including MHC, MABUAR, and pertinent THPOs for impacts to historic and archaeological properties in accordance with Section 106 of the National Historic Preservation Act of 1966 and 950 CMR 71. The purpose of this review is to ensure that projects minimize or mitigate adverse effects to properties listed in the National and/or State Register of Historic Places. It is assumed that a Project Notification Form (PNF) will need to be completed and submitted to relevant parties for all replacement projects. Should review under the MEPA be required, a copy of the MEPA ENF can be provided to these agencies to initiate historical review and will preclude the need to file a PNF.
- **MassDOT State Highway Access Permit –** Any work that is to take place within State Highways, including detours and traffic signage, require a State Highway Access Permit. The State Highway Access Permit will determine the level of traffic management and control required, changes needed on the alignment, the level of pavement restoration required, the types of bonds and insurances required, and revisions to the design for work in the State Highway.

Appendix A

INDEX MAP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STORMWATER

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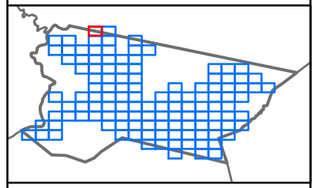
LOCUS MAP



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AMANDREY WAY
GROTON SCHOOL ROAD
DOUGLAS DRIVE

P-1
P-2
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STORMWATER

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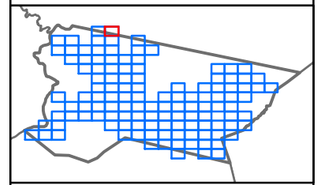

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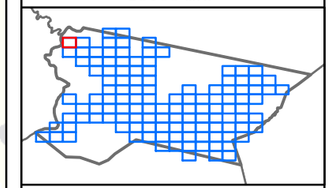

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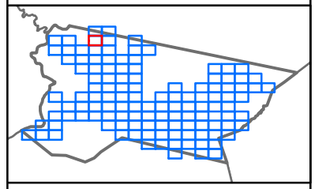

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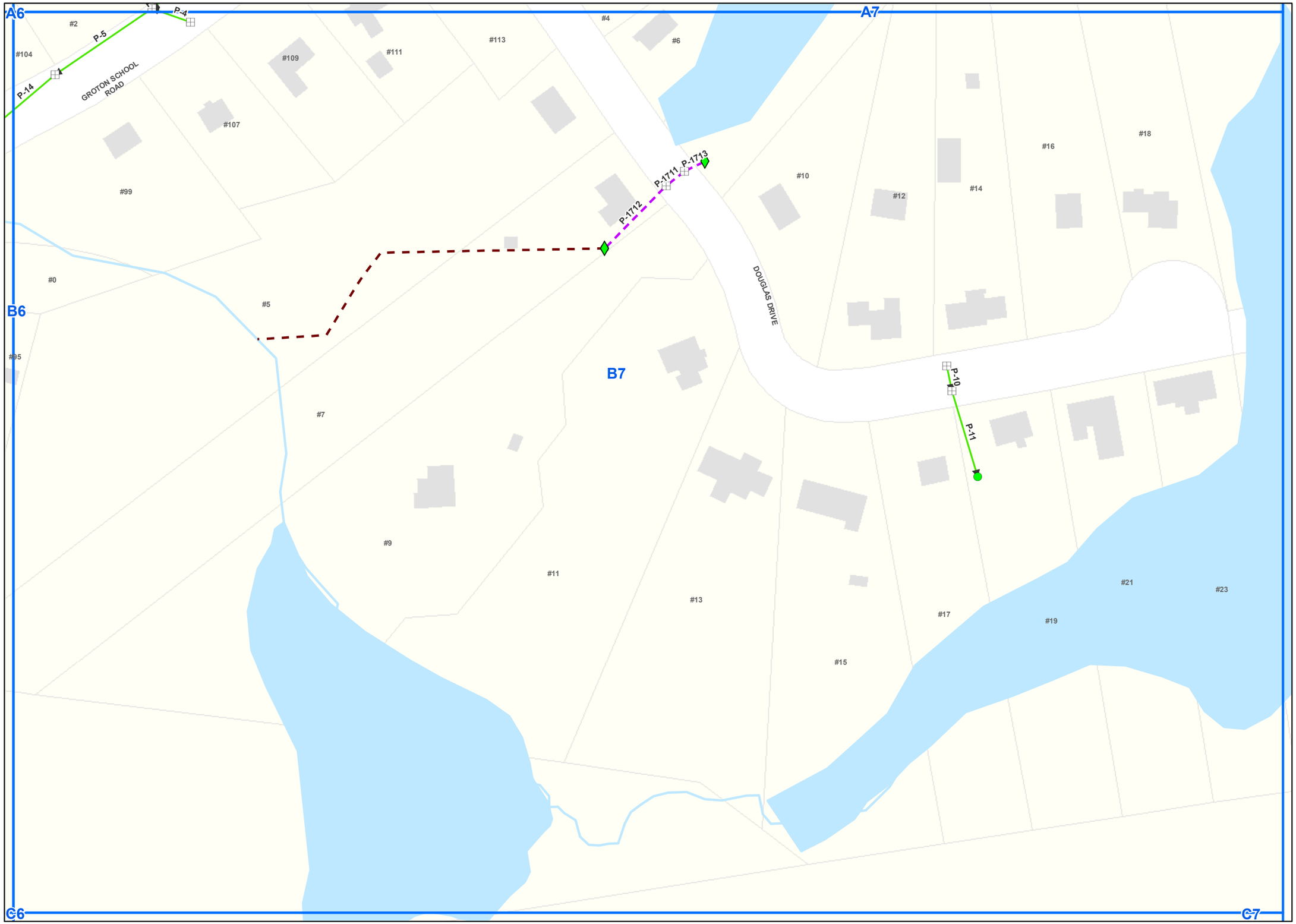

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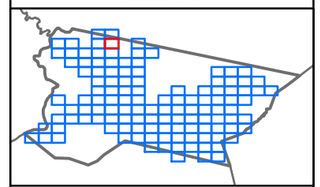

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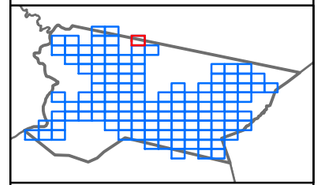

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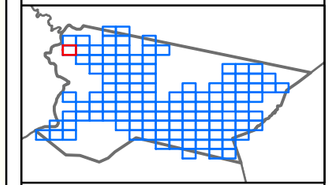

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FITCHBURG ROAD

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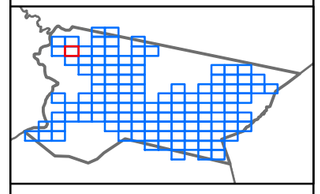

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OAKHURST ROAD

STORMWATER

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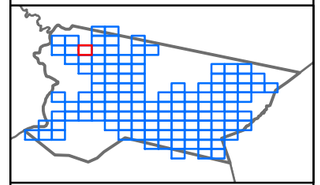
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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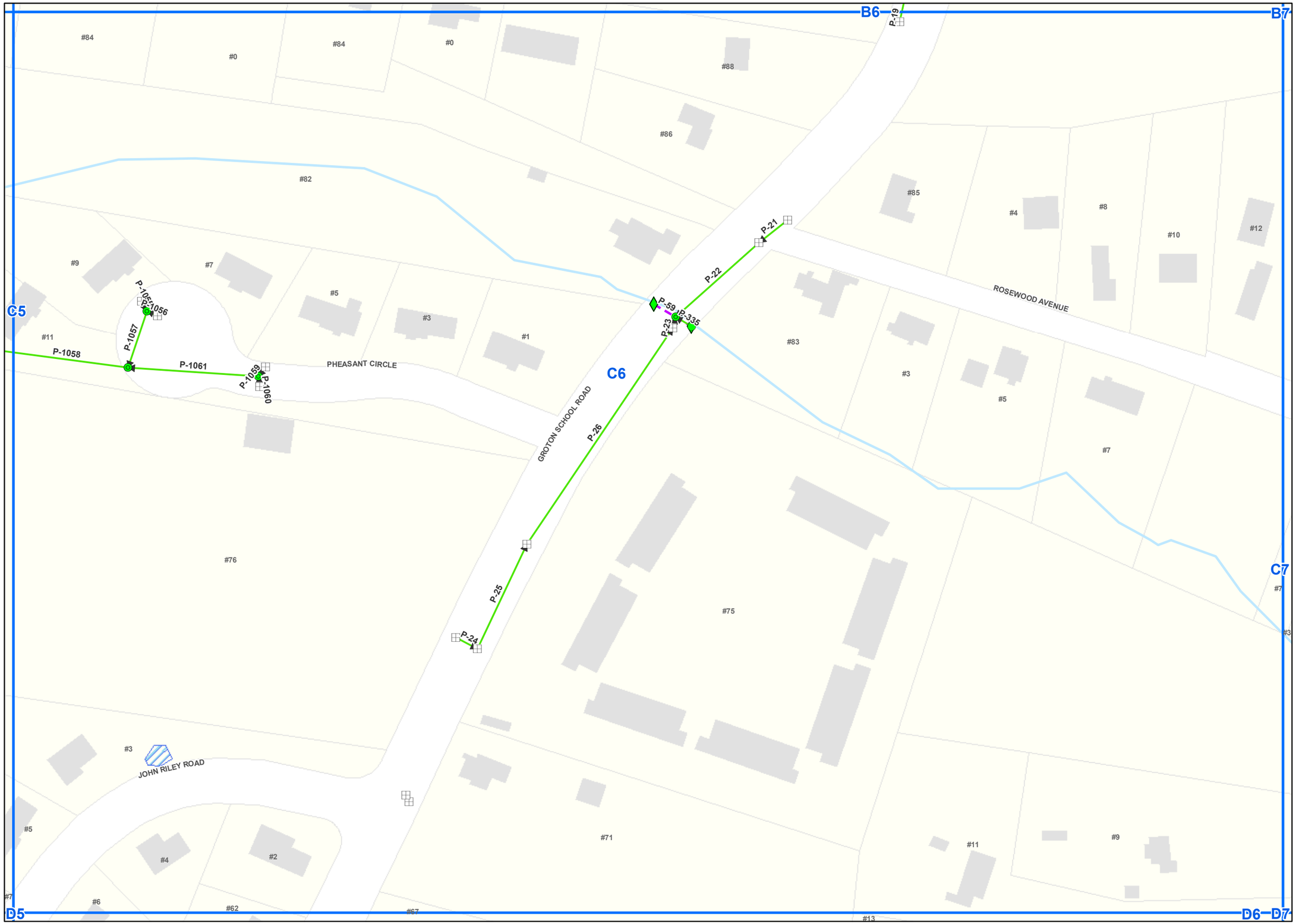
Ayer, Massachusetts

October 2021

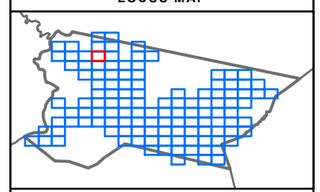
Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
- Stormwater- Detention Area
- Stormwater- Manhole
- Stormwater- Outfall
- Stormwater- Vortex
- Private Stormwater- Catch Basin
- Private Stormwater- Culvert
- Private Stormwater- Detention Area
- Private Stormwater- Manhole
- Private Stormwater- Outfall
- Private Stormwater- Trap
- Private Stormwater- Vortex
- Ditch
- Swale
- Abandoned Drain
- Culvert
- Private Drain
- Drain Line
- Town Owned Rain Gardens
- DetentionBasins

LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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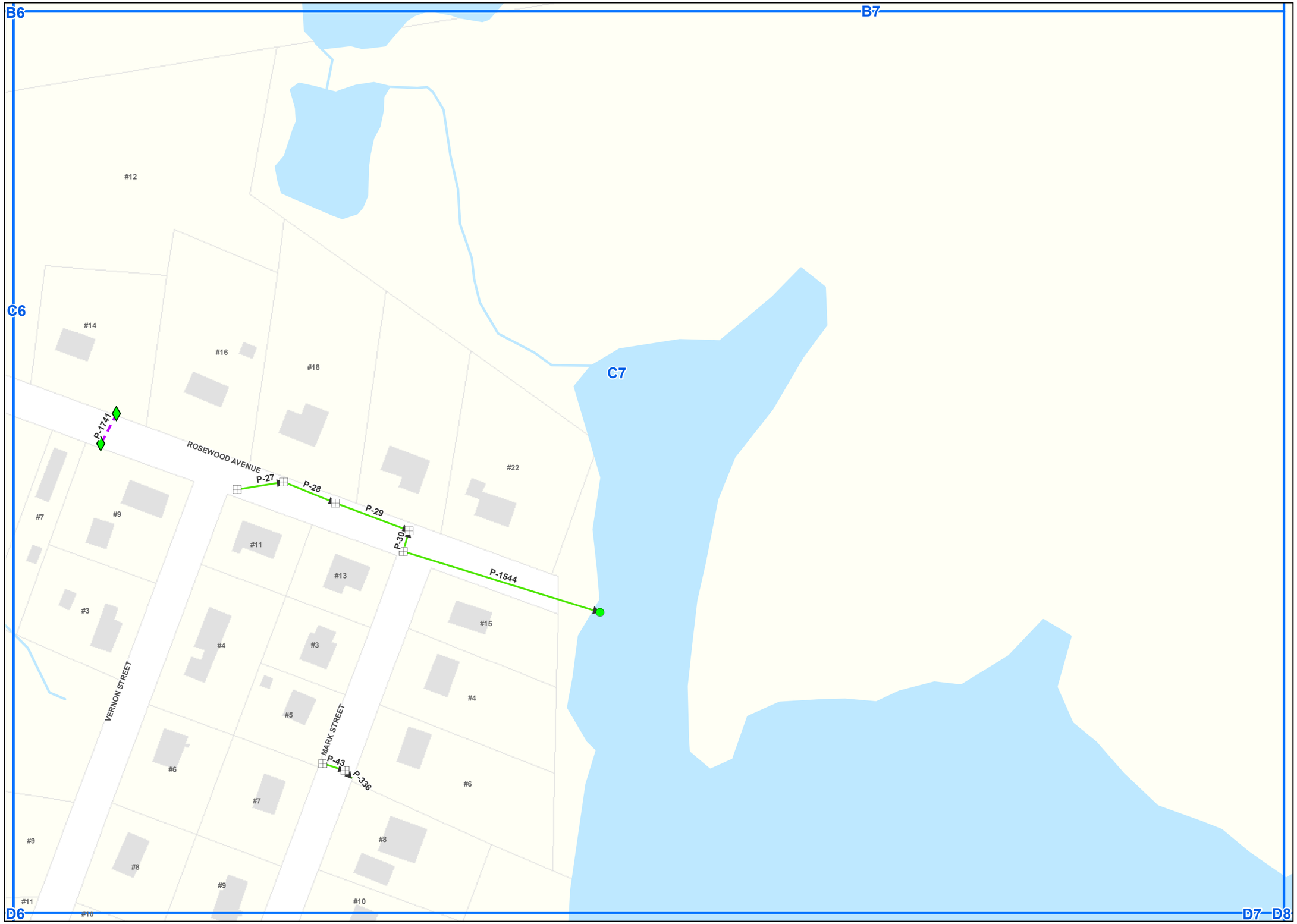
Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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LOCUS MAP

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

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Tighe&Bond

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D9

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P-1162

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P-1167

P-1164

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P-359

P-361

P-358

P-357

P-356

P-355

P-354

P-362

P-363

P-364

MADIGAN LANE

OLD GROTON ROAD

#200

#400

#199

#191

#7

#13

#9

#5

#188

#15

#3

#189

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STORMWATER

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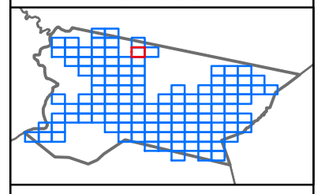
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

- Private BMP
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- Town Owned Rain Gardens
- DetentionBasins

LOCUS MAP

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Tighe&Bond

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C4

C5

D4

D5

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#81

OAKHURST ROAD

#77

FITCHBURG ROAD

#69

#60

STORMWATER

- Private BMP
- Stormwater- Catch Basin
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- Private Drain
- Drain Line
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- DetentionBasins

LOCUS MAP

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

- Private BMP
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- Stormwater- Detention Area
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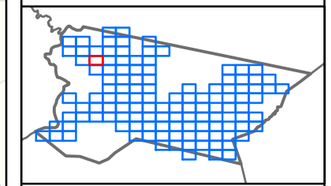
- Ditch
- Swale
- Abandoned Drain
- Culvert
- Private Drain
- Drain Line
- Town Owned Rain Gardens
- DetentionBasins

LOCUS MAP



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NOTES

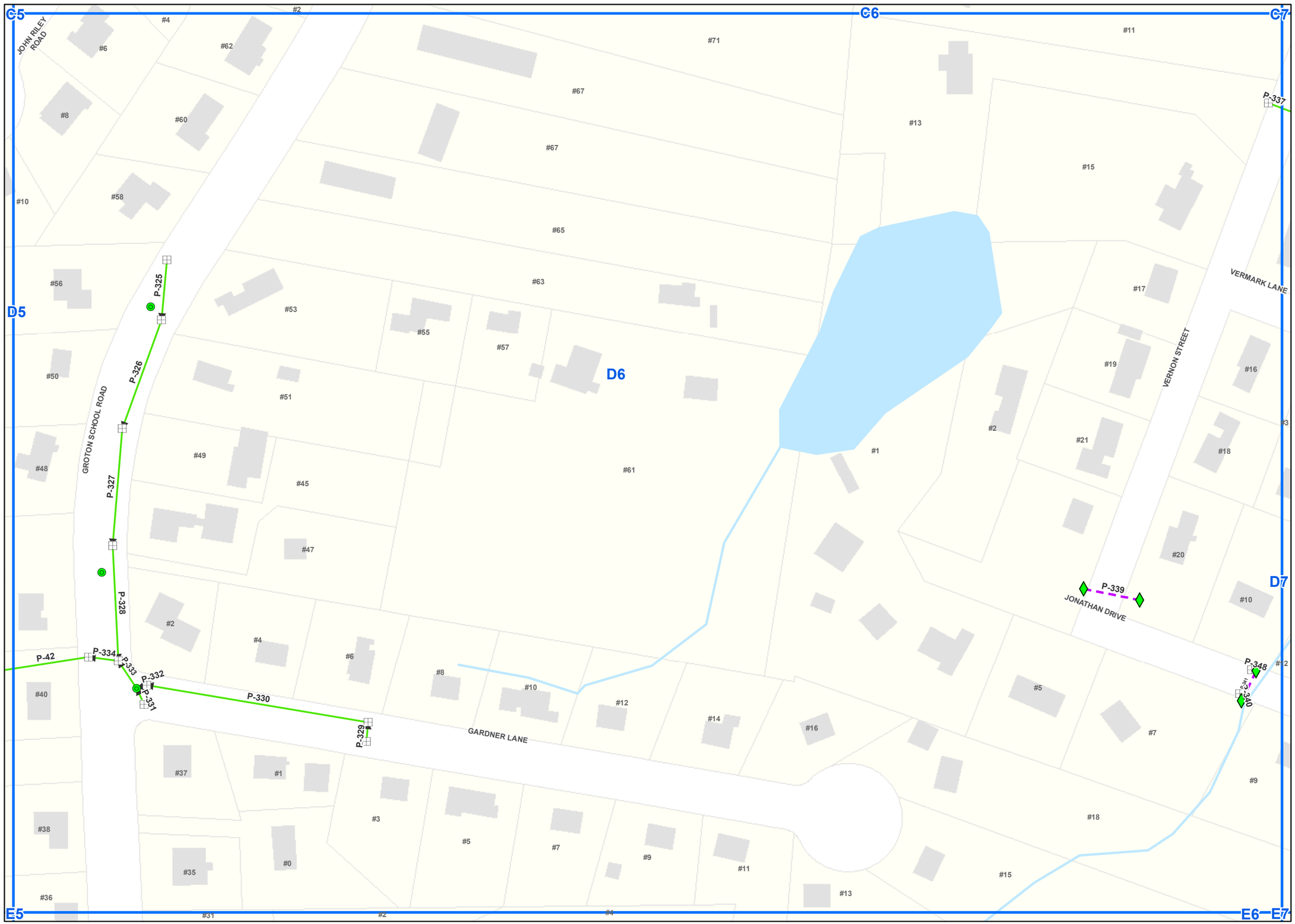
1. Data provided by the Town of Ayer and MassGIS

Page # D5

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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- Culvert
- Private Drain
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- DetentionBasins

LOCUS MAP

N W E S

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Feet

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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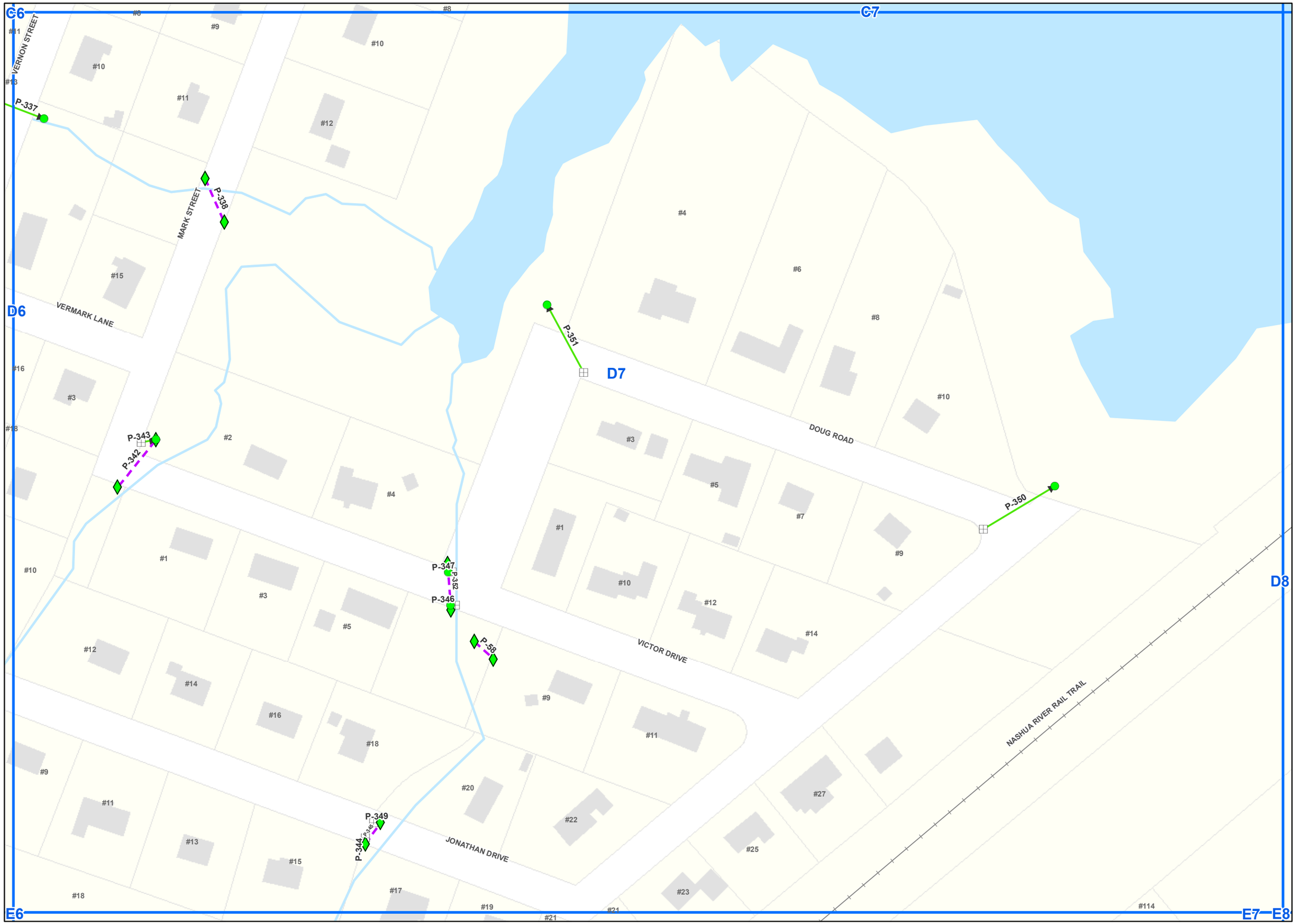
Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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- Culvert
- Private Drain
- Drain Line
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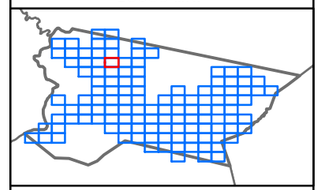
LOCUS MAP



N W E S

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Tighe&Bond

C7

C9

D7

D8

D9

E7

E8

E9

NASHUA RIVER RAIL TRAIL

P-1674

P-1673

P-1675

P-1676

STORMWATER

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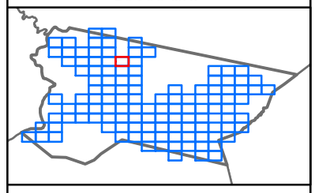
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

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- DetentionBasins

LOCUS MAP

N W E S

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Feet

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

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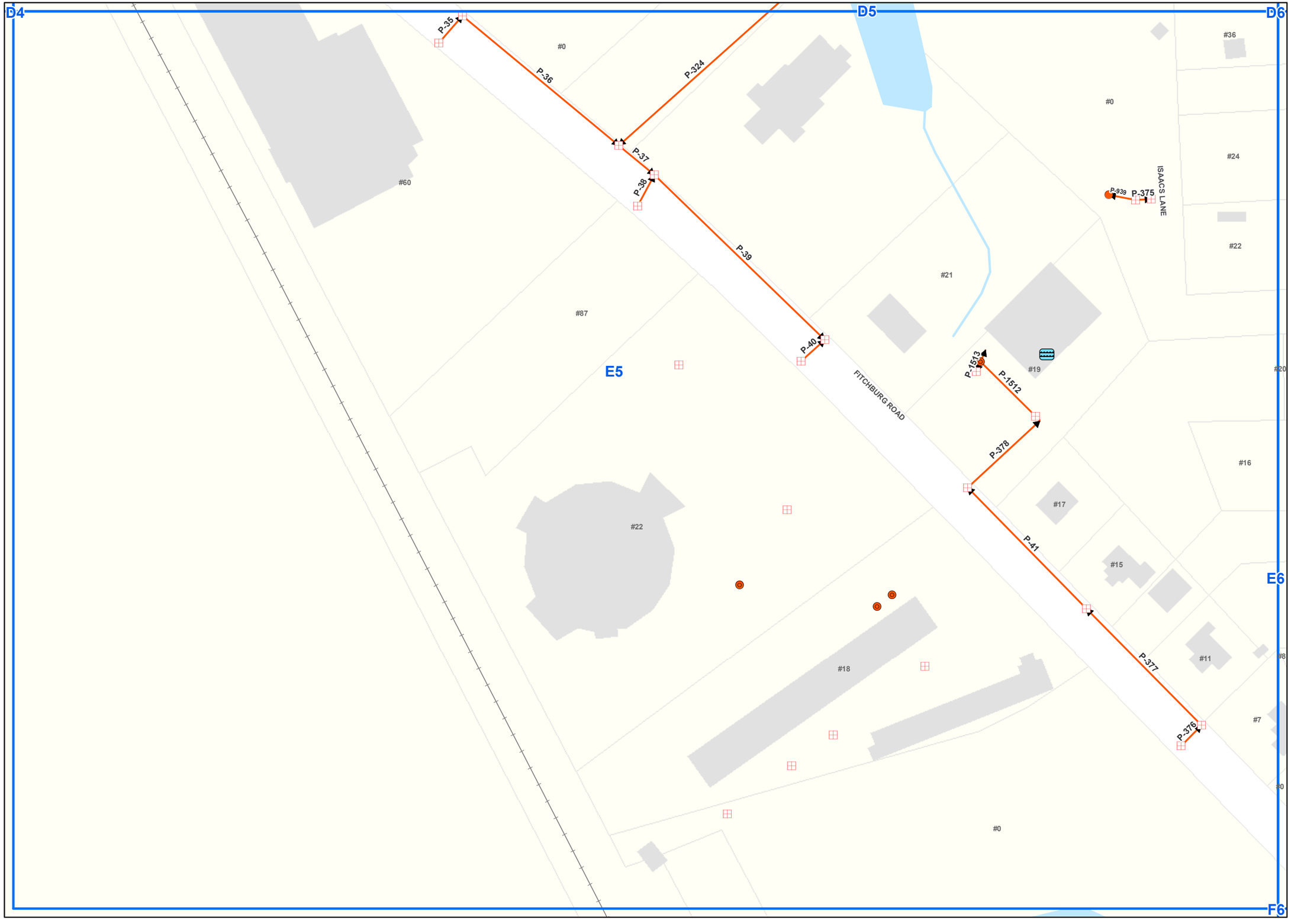
Tighe&Bond



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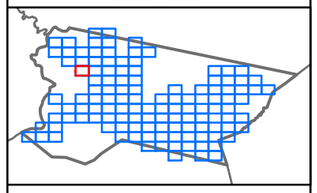
LOCUS MAP



N W E S

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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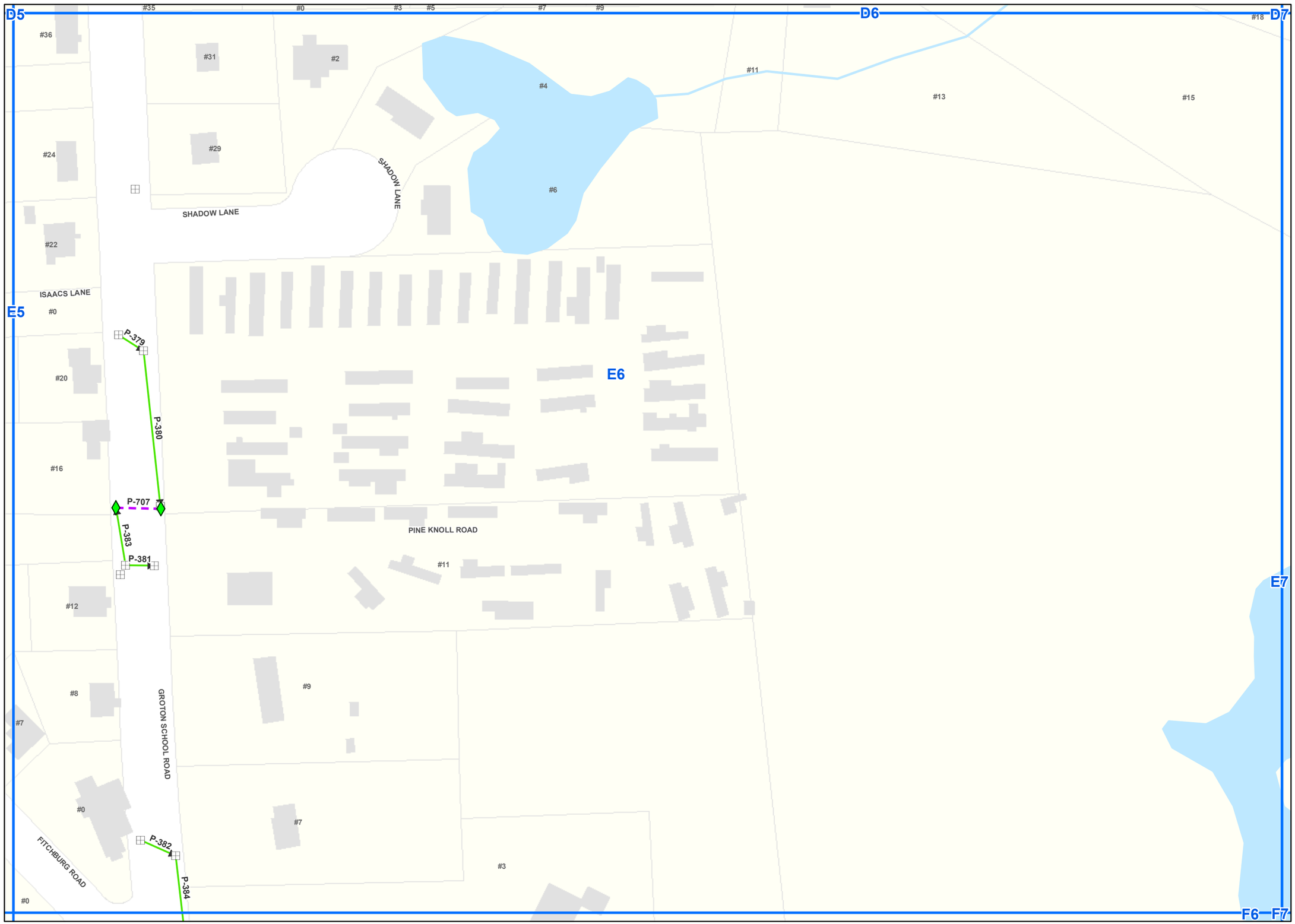
Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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- Abandoned Drain
- Culvert
- Private Drain
- Drain Line
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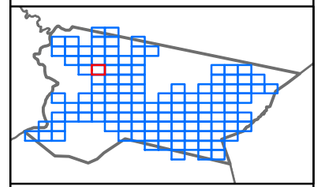
- DetentionBasins

LOCUS MAP



N W E S

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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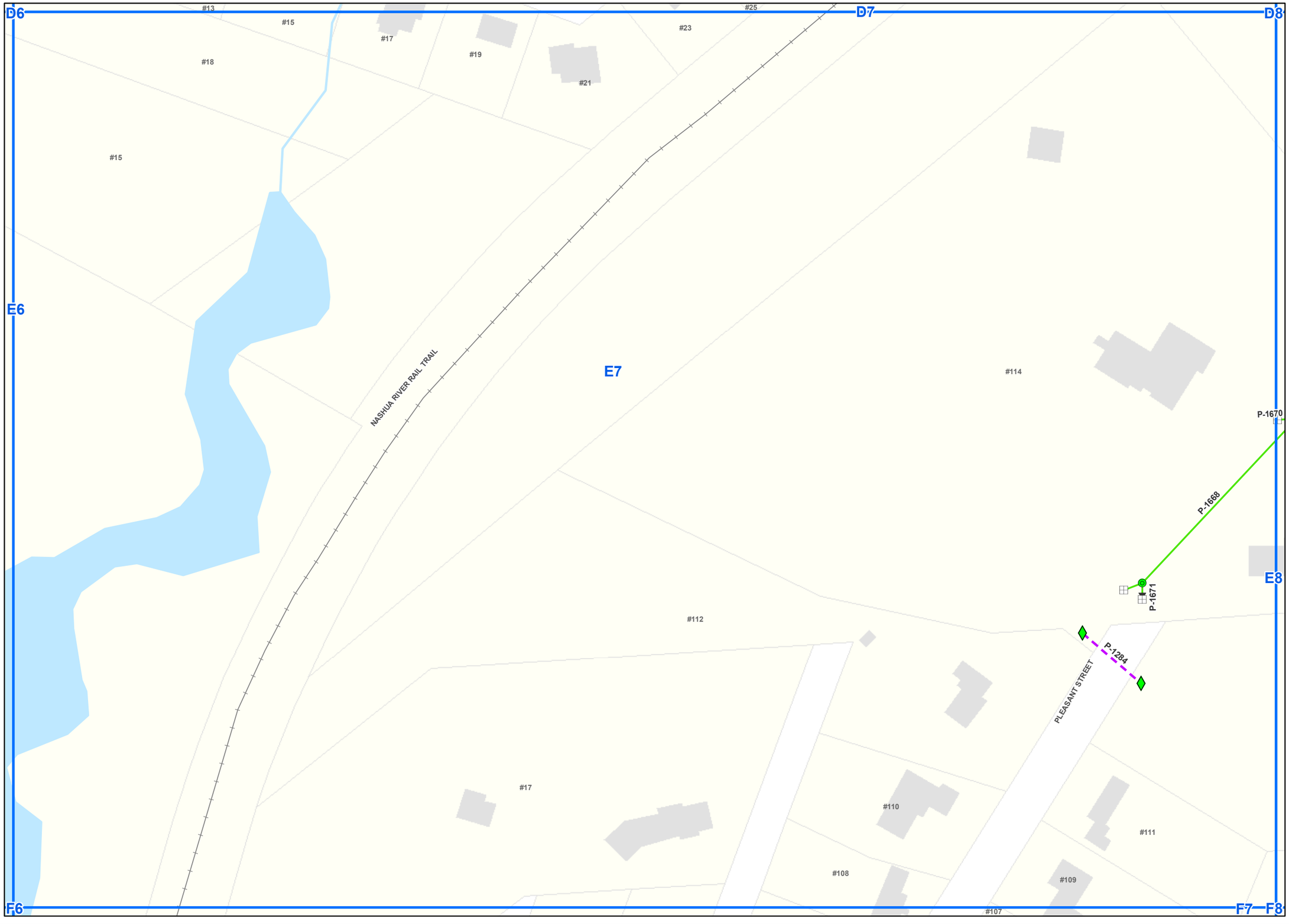
Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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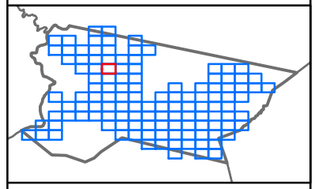
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

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Tighe&Bond

D7 D8 D9

E7 E8 E9

F7 F8 F9

P-1673 P-1674 P-1675 P-1669 P-1670 P-1668 P-1672

#114

STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
- Stormwater- Detention Area
- Stormwater- Manhole
- Stormwater- Outfall
- Stormwater- Vortex
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- Private Drain
- Drain Line
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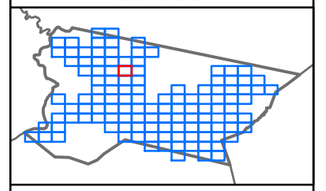
- DetentionBasins

LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

- Private BMP
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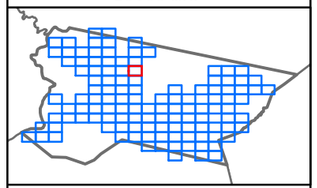
LOCUS MAP



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NOTES

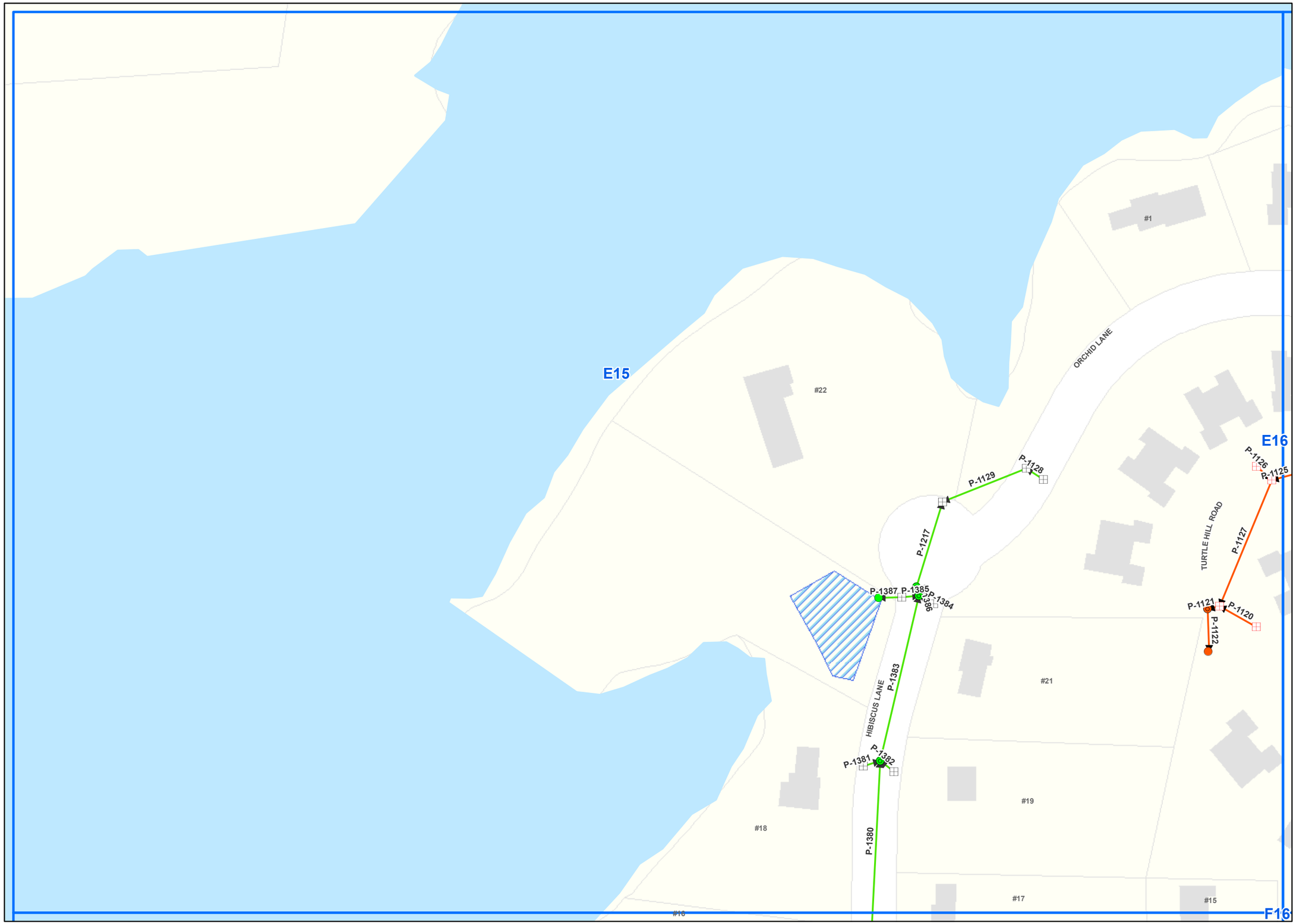
1. Data provided by the Town of Ayer and MassGIS

Page # E9

Ayer, Massachusetts

October 2021

Tighe&Bond



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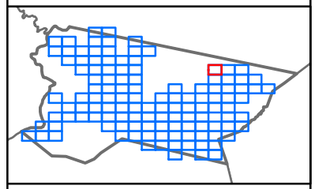
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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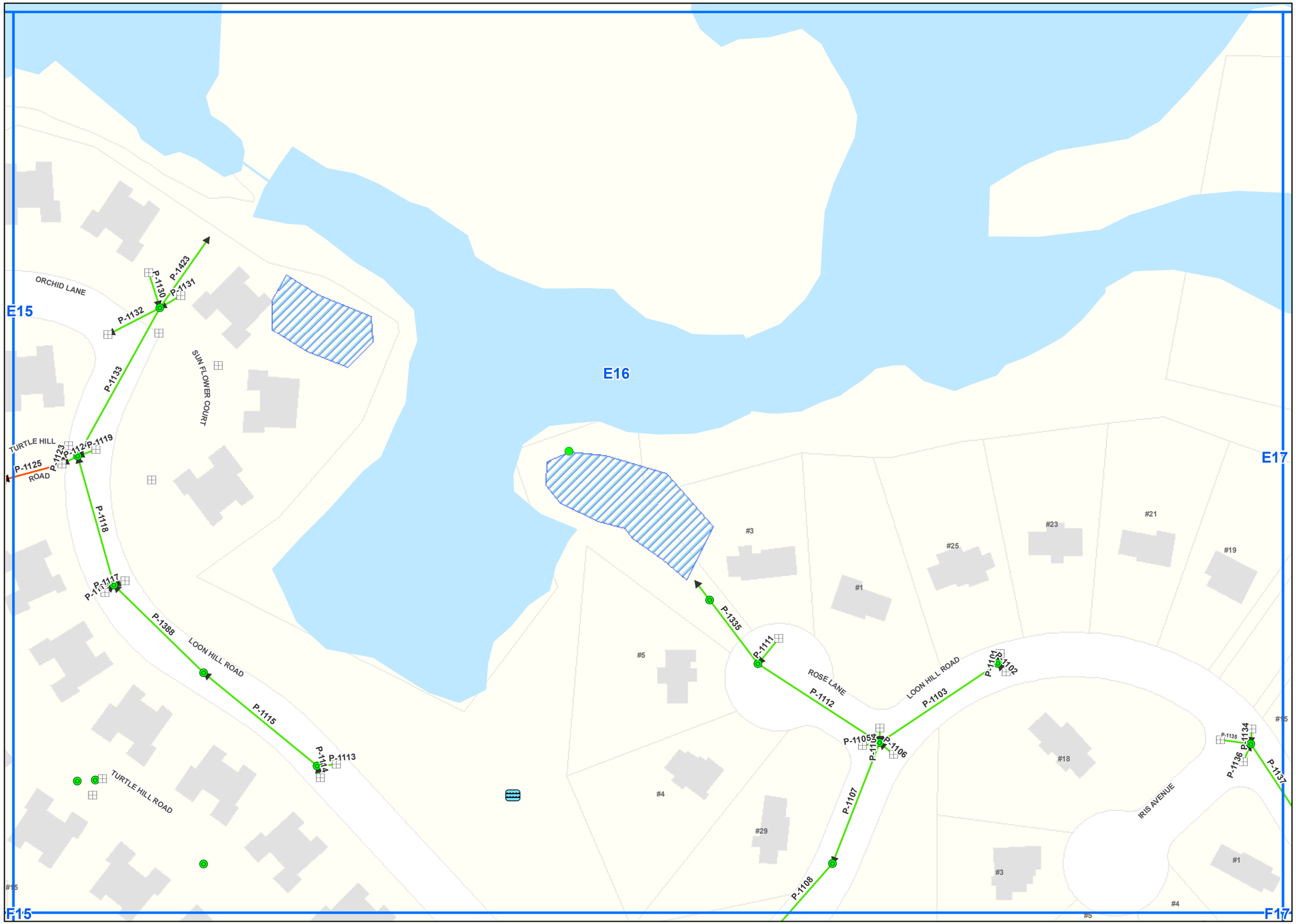
Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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- Stormwater- Catch Basin
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- Drain Line
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- DetentionBasins

LOCUS MAP

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

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Tighe&Bond

STORMWATER

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- Culvert
- Private Drain
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- DetentionBasins

LOCUS MAP

N W E S

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Feet

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

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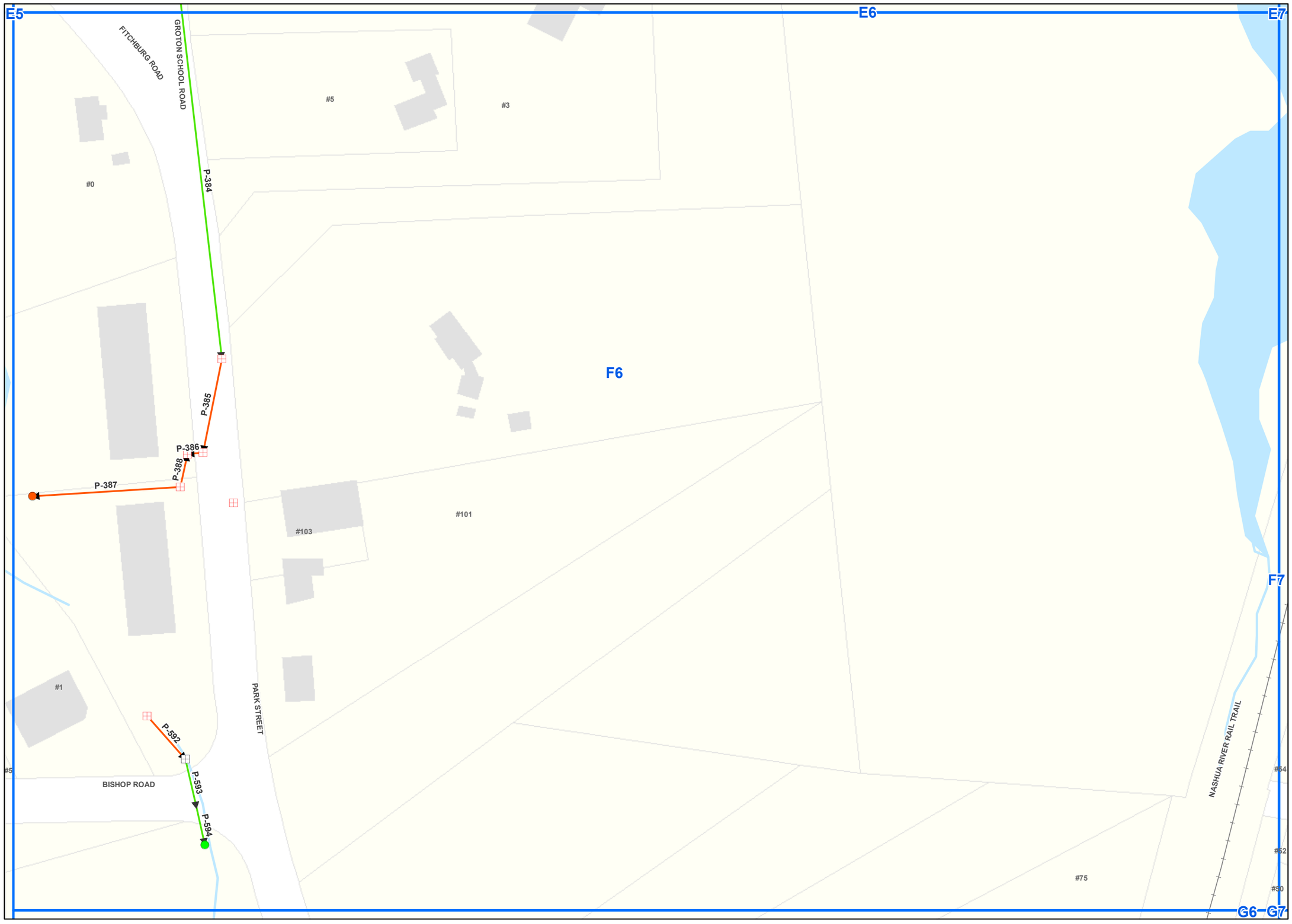
Tighe&Bond



STORMWATER

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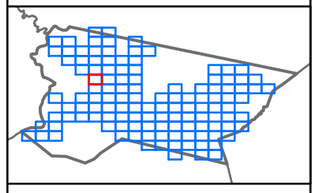
LOCUS MAP



N W E S

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Feet

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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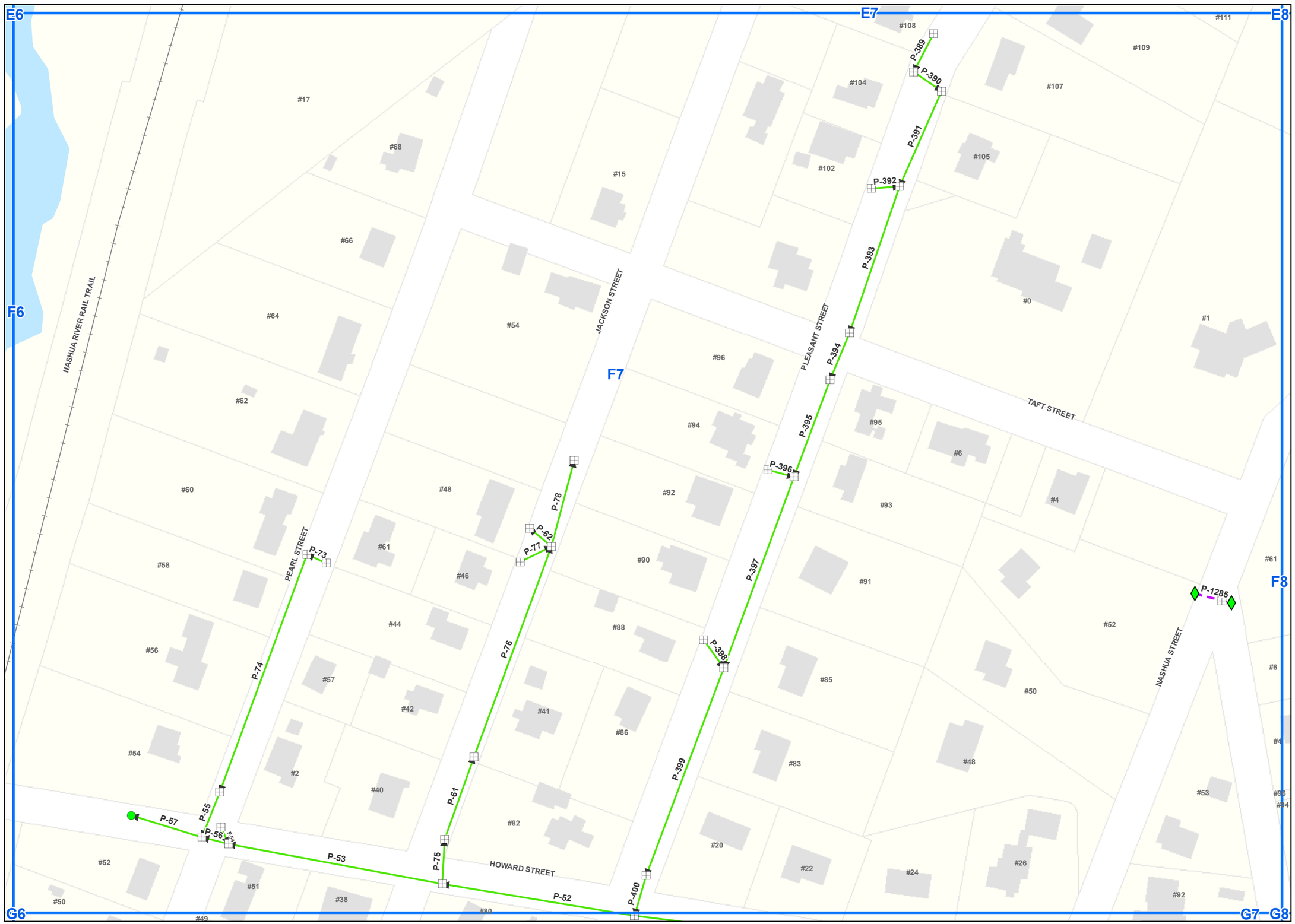
Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
- Stormwater- Detention Area
- Stormwater- Manhole
- Stormwater- Outfall
- Stormwater- Vortex
- Private Stormwater- Catch Basin
- Private Stormwater- Culvert
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- Private Stormwater- Manhole
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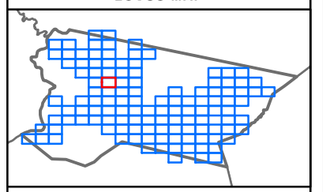
- Private Stormwater- Trap
- Private Stormwater- Vortex
- Ditch
- Swale
- Abandoned Drain
- Culvert
- Private Drain
- Drain Line
- Town Owned Rain Gardens
- DetentionBasins

LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

E7 E8 E9

F7 F8 F9

G7 G8–G9

P-1667 P-1666 P-1215 P-1555 P-1289 P-1556 P-1214 P-1558 P-1290 P-1641 P-1642 P-1684 P-1328 P-1640 P-1207 P-1208 P-1212 P-1213 P-1449

NASHUA STREET MOUNTAIN AVENUE WASHINGTON STREET NORWOOD AVENUE NORWOOD AVENUE

#1 #65 #61 #100 #5 #6 #4 #102 #112 #110 #106 #116 #122 #128 #134 #132 #0 #96 #94 #98 #103

STORMWATER

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LOCUS MAP

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NOTES

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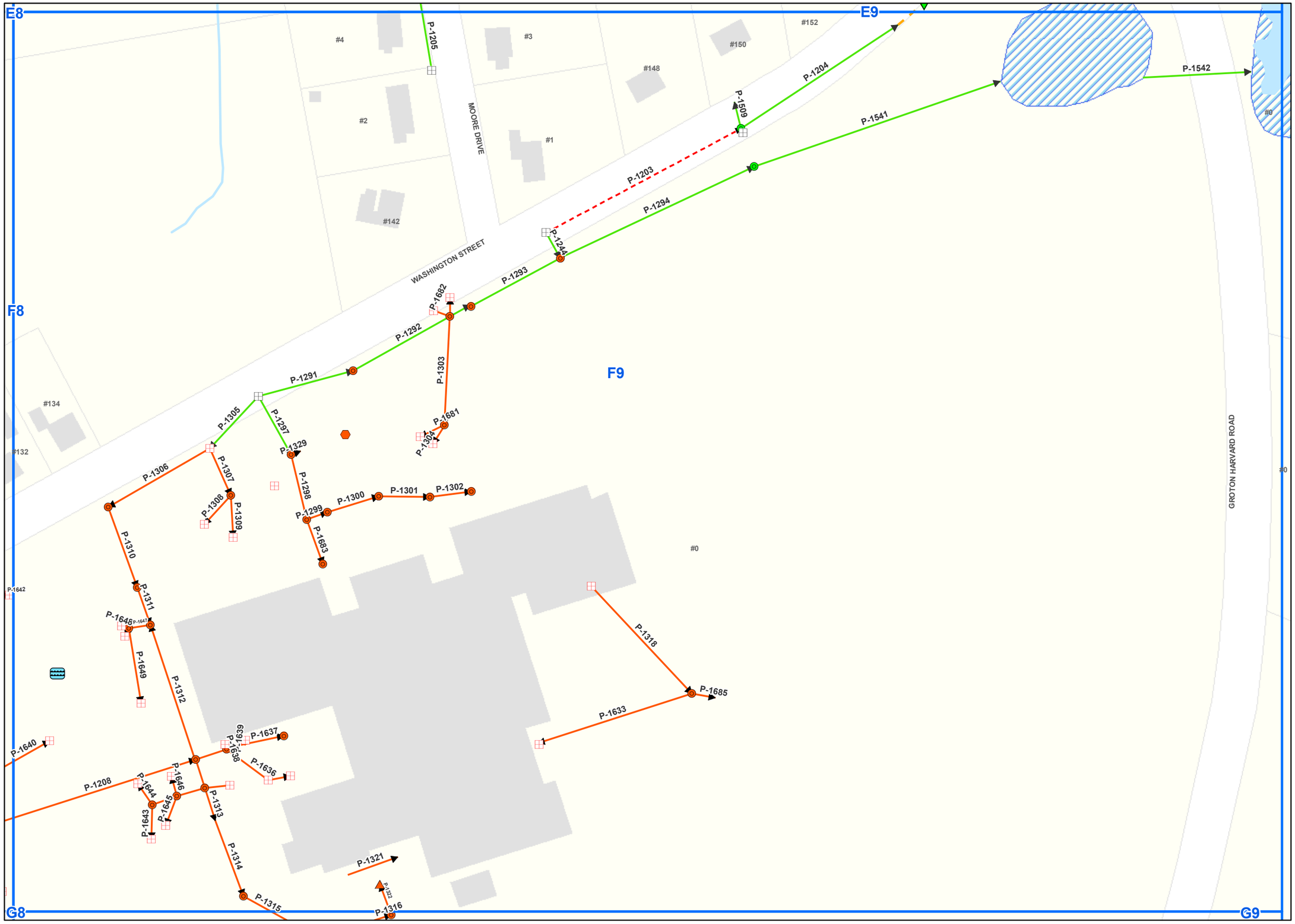
Ayer, Massachusetts

October 2021

Tighe&Bond



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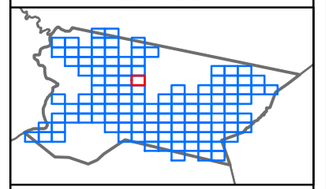

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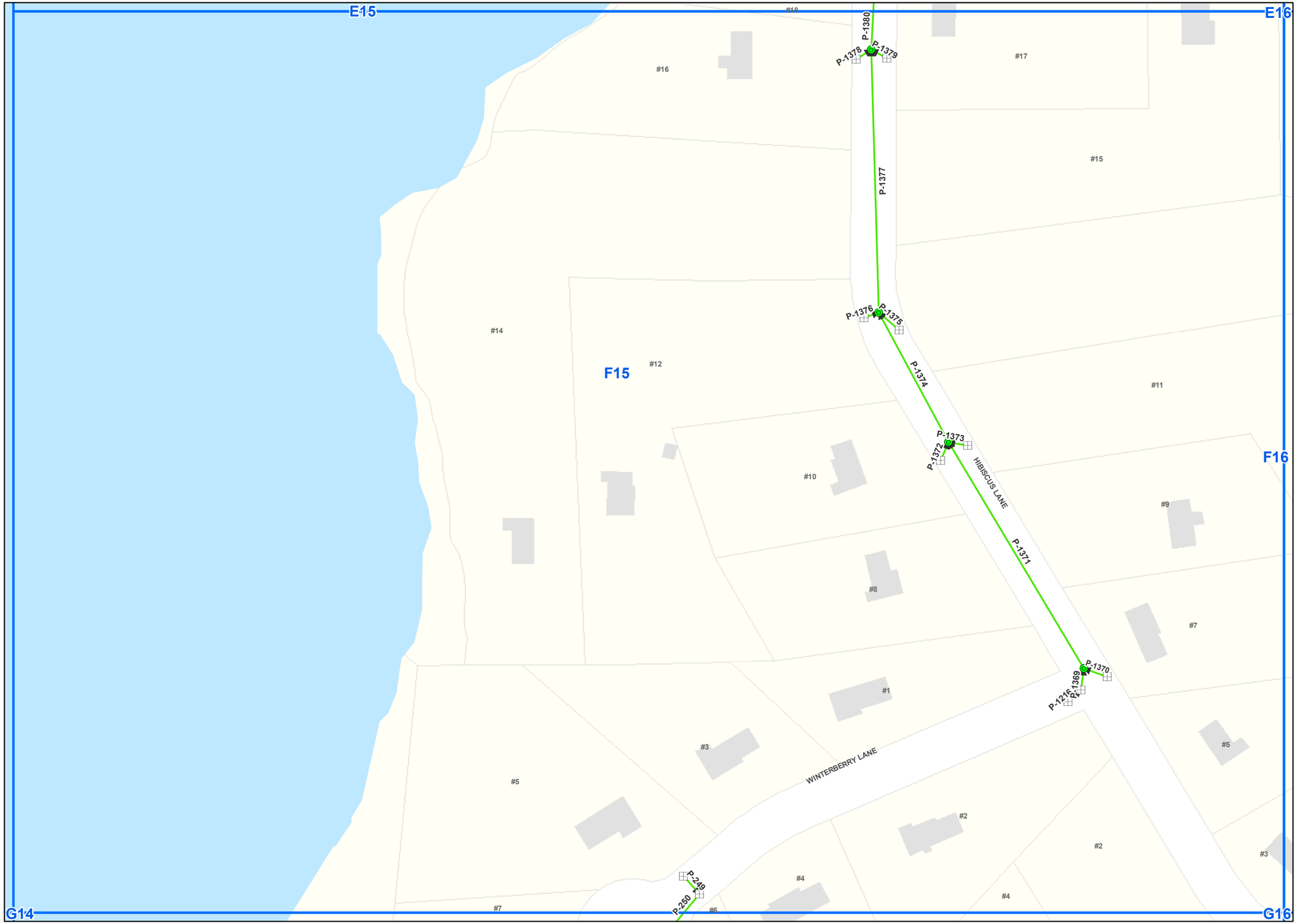
Ayer, Massachusetts

October 2021

Tighe&Bond



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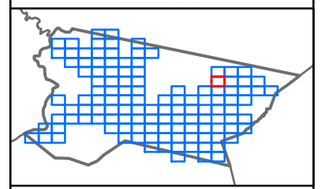
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

E15 E16 E17

F15 F16 F17

G15 G17

TURTLE HILL ROAD

LOON HILL ROAD

MULBERRY CIRCLE

P-1108 P-1109 P-1110 P-552 P-553 P-554 P-555 P-556 P-557 P-558

#1 #3 #4 #5 #11 #15 #7 #9 #29 #27 #25 #23 #21 #19 #17 #13 #24 #22 #18 #16 #12 #28

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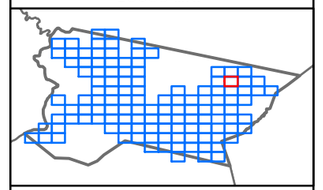
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

E16

E17

F16

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F18

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P-1144

P-1145

P-1146

P-1147

P-1148

P-1149

P-1150

P-1151

P-1152

LOON HILL ROAD

WESTFORD ROAD

BRYAN WAY

MULBERRY CIRCLE

P-552

P-551

P-824

#0

#1

#1

#3

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#66

#62

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STORMWATER

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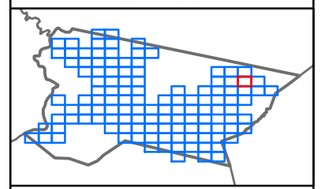

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NOTES

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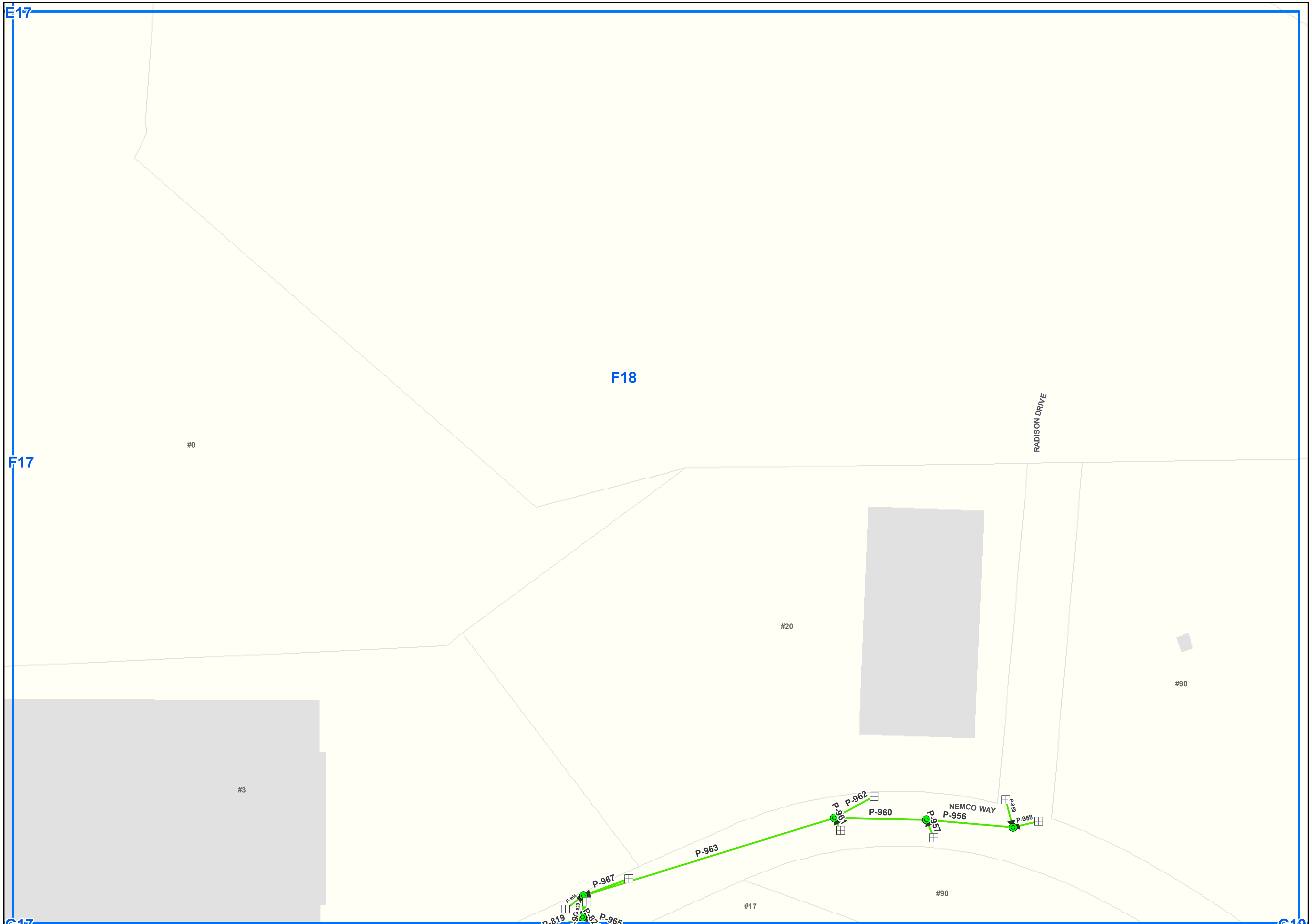
Page # F17

Ayer, Massachusetts

October 2021

Tighe&Bond



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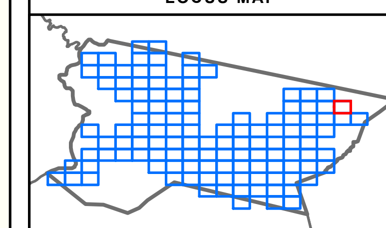

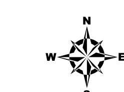

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

F6

F7

G6

G7

H5

H6–H7

PARK STREET

NASHUA RIVER RAIL TRAIL

PEARL STREET

BROOK STREET

#0

#3

#34

#35

#38

#39

#42

#44

#46

#47

#49

#50

#52

#54

#60

#63

#72

#75

P-460

P-461

P-462

P-463

P-465

P-466

P-467

P-468

P-469

P-595

P-596

P-597

P-598

P-599

P-600

P-601

P-602

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P-604

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P-1182

P-1183

STORMWATER

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LOCUS MAP

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Feet

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

F6 F7 F8 G6 G7 G8 H6 H7 H8

HOWARD STREET
PEARL STREET
WASHINGTON STREET
JACKSON STREET
PLEASANT STREET
GROTON STREET
NASHUA STREET
SUMMIT AVENUE
COOLIDGE ROAD
WACHUSETT AVENUE
LINCOLN STREET

P-400 P-52 P-51 P-1296 P-1295 P-478 P-479 P-480 P-481 P-482 P-401 P-402 P-403 P-404 P-405 P-483 P-484 P-485 P-497 P-129 P-130 P-131 P-132 P-133 P-134 P-460 P-458 P-459 P-454 P-455 P-456 P-457 P-1436 P-1437 P-1438 P-1439 P-1441 P-1442 P-1443 P-1444 P-1435 P-1433 P-1440 P-1431 P-1432 P-406 P-407 P-486 P-488

STORMWATER

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LOCUS MAP

N W E S

0 50 100
Feet

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NOTES

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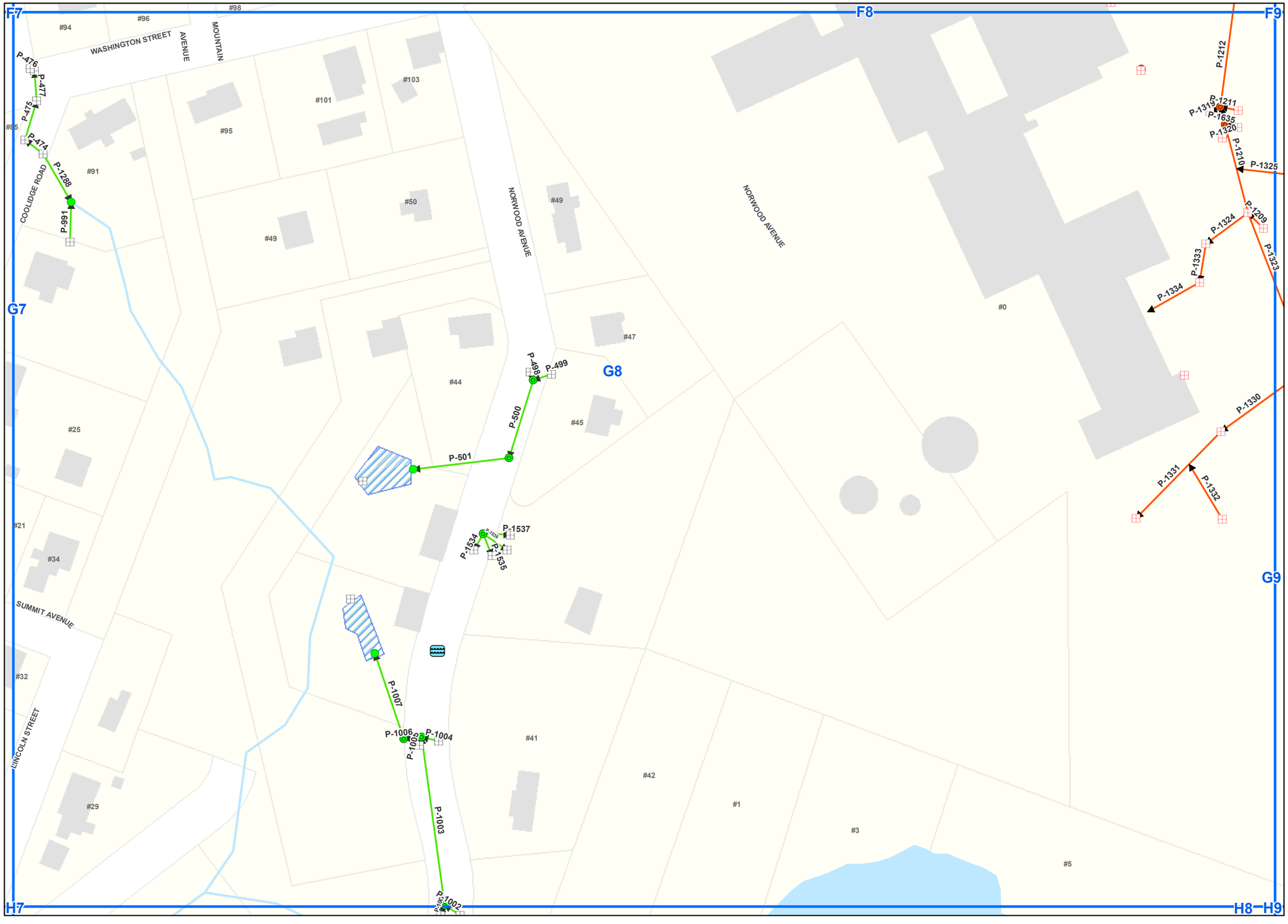
Page # G7

Ayer, Massachusetts

October 2021

Tighe&Bond



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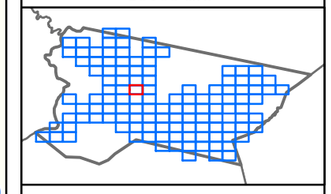
LOCUS MAP



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NOTES

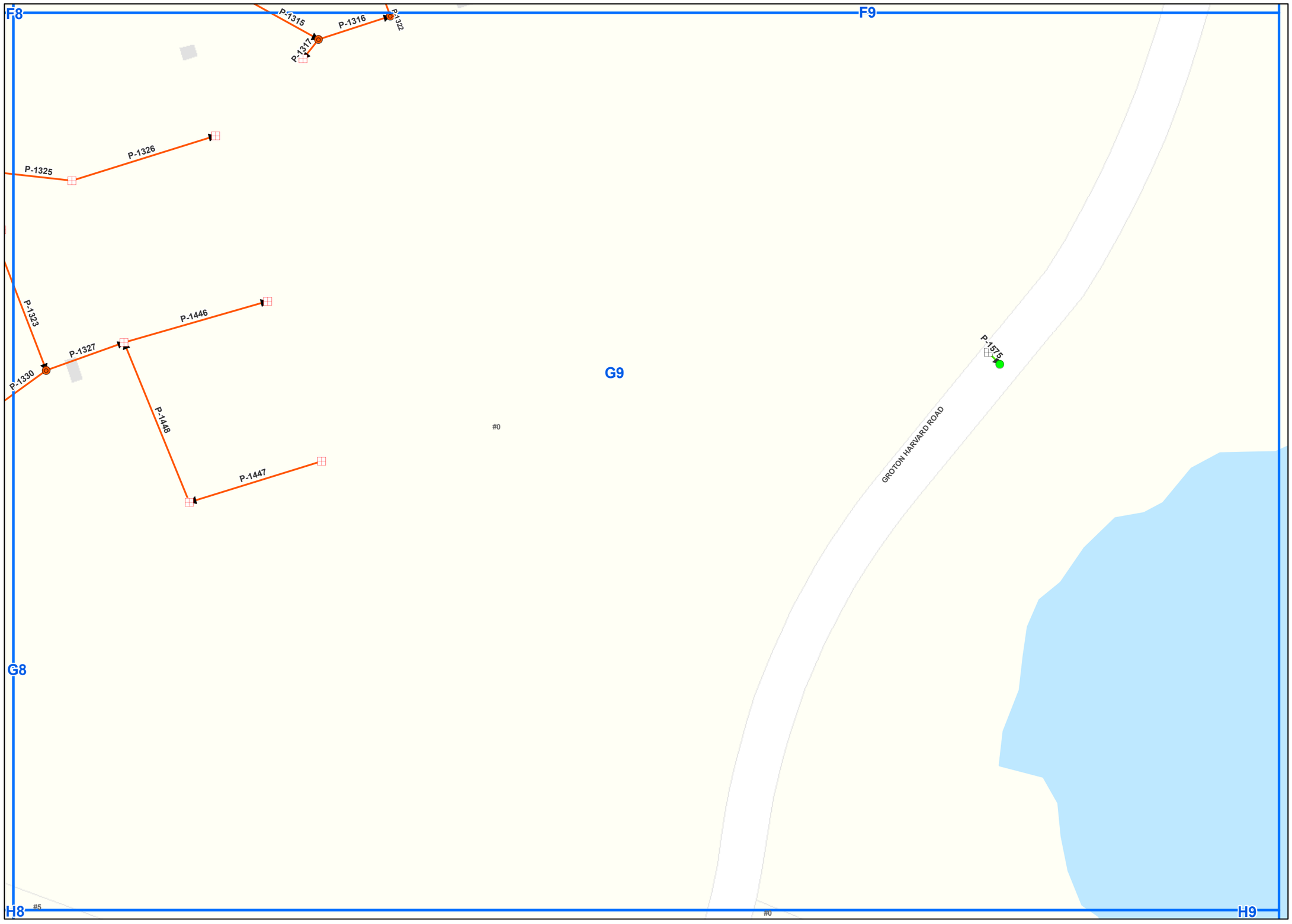
1. Data provided by the Town of Ayer and MassGIS

Page # **G8**

Ayer, Massachusetts

October 2021

Tighe&Bond



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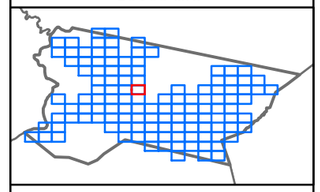
LOCUS MAP



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NOTES

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Ayer, Massachusetts

October 2021

Tighe&Bond

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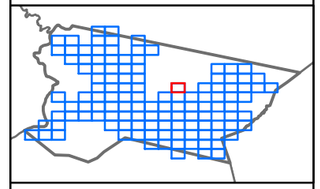

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NOTES

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Ayer, Massachusetts

October 2021

Tighe&Bond

F15

G14

G15

H13

H15

LINDLEY DRIVE

STANDISH AVENUE

WRIGHT ROAD

WACHUSETT AVENUE EAST

MOUNTAIN VIEW ROAD

#1

#2

#3

#42

#44

#46

#51

#53

#55

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#130

STORMWATER

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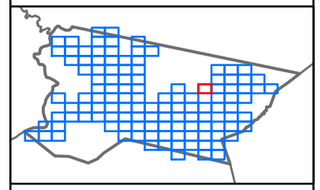

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NOTES

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Ayer, Massachusetts

October 2021

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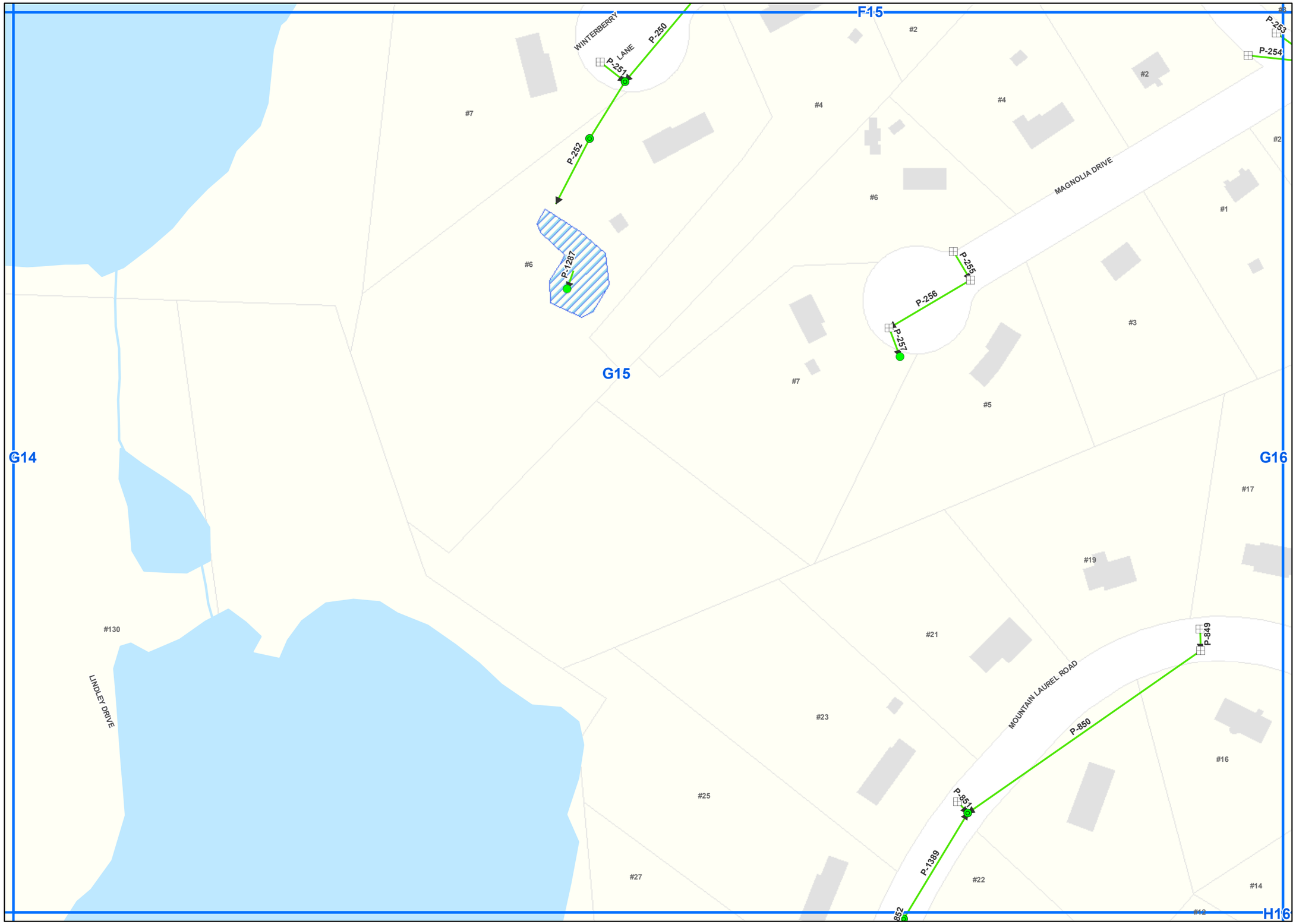

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LOCUS MAP

N W E S

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Page # **G15**

Ayer, Massachusetts

October 2021

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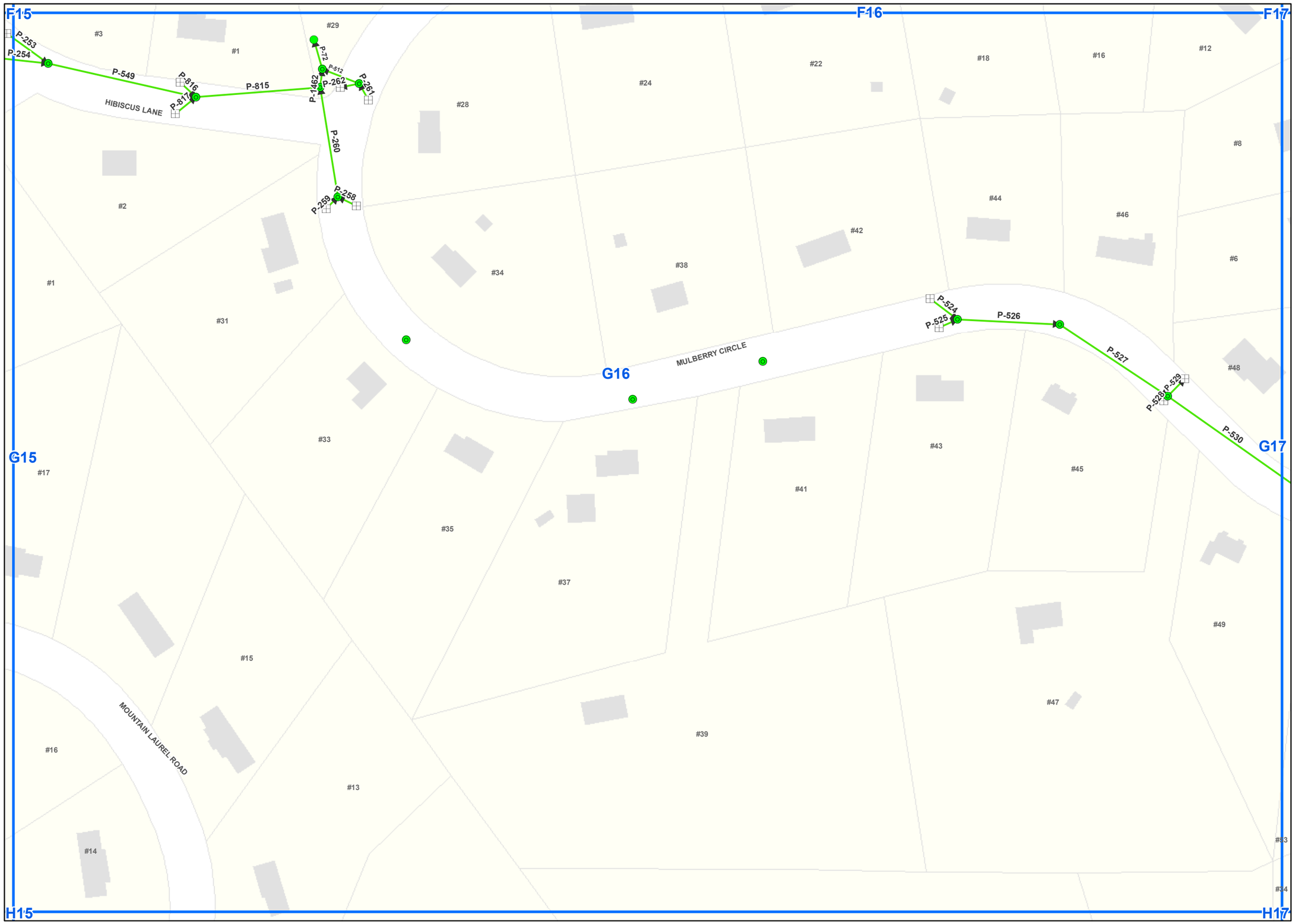

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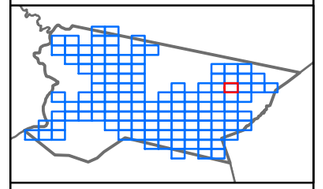

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NOTES

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Page # **G16**

Ayer, Massachusetts

October 2021

Tighe&Bond

F16 F17 F18

G16 G17 G18

H16 H17

MULBERRY CIRCLE

WESTFORD ROAD

BRYAN WAY

NEMCO WAY

P-551 P-538 P-539 P-540 P-534 P-535 P-533 P-530 P-531 P-532 P-537 P-536 P-541 P-542 P-543 P-544 P-545 P-546 P-71 P-547 P-548 P-70 P-523 P-522 P-521 P-520 P-1520 P-1522 P-1523 P-921 P-1519 P-1518 P-1517 P-1524 P-1525 P-1526 P-1527 P-1528 P-1531 P-1529 P-1530 P-825 P-824 P-823 P-946 P-945 P-947 P-944 P-561

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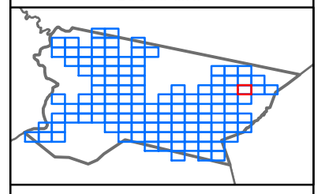

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Page # **G17**

Ayer, Massachusetts

October 2021

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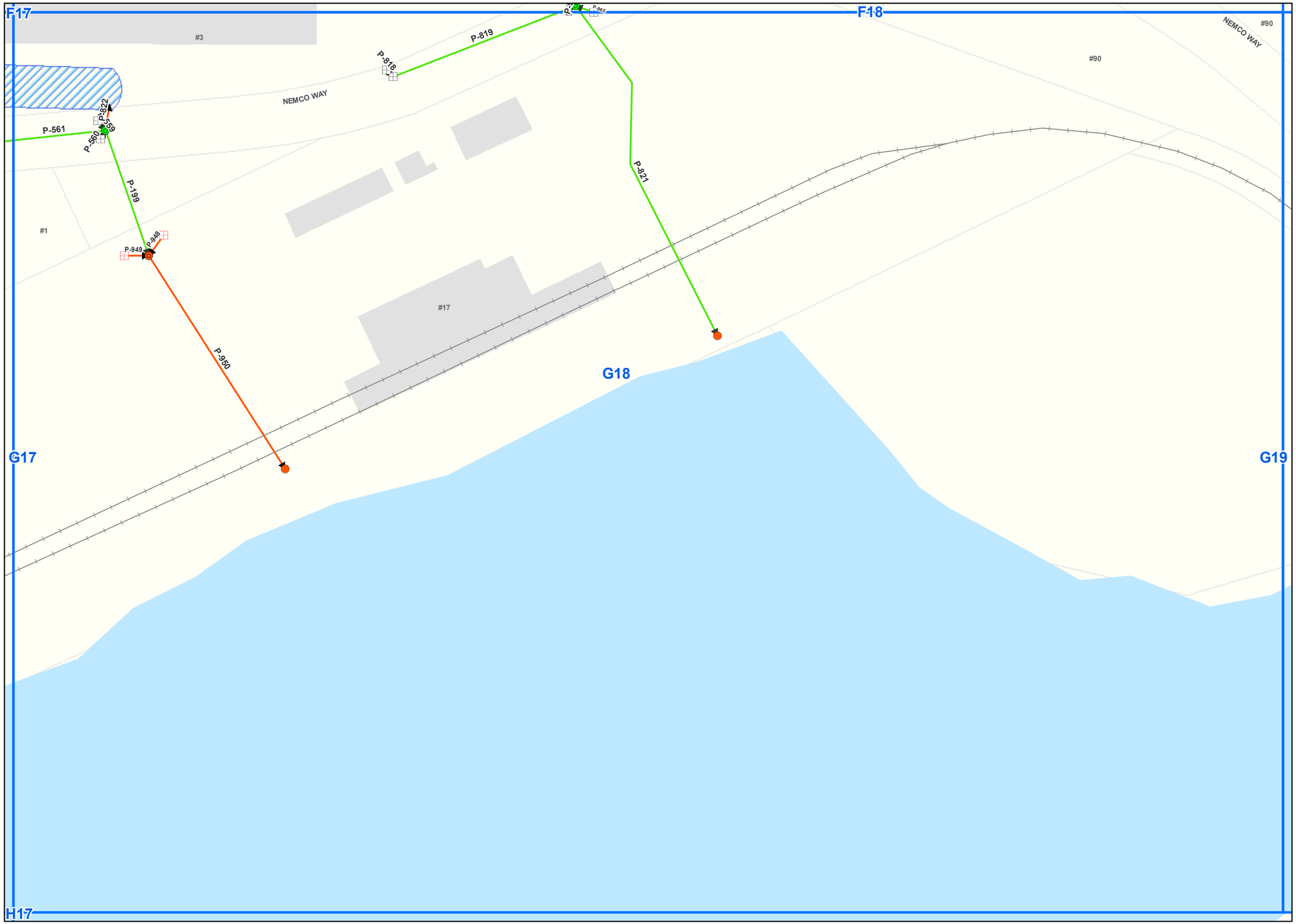

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- Stormwater- Vortex
- Private Stormwater- Catch Basin
- Private Stormwater- Culvert
- Private Stormwater- Detention Area
- Private Stormwater- Manhole
- Private Stormwater- Outfall
- Private Stormwater- Trap
- Private Stormwater- Vortex
- Ditch
- Swale
- Abandoned Drain
- Culvert
- Private Drain
- Drain Line
- Town Owned Rain Gardens
- DetentionBasins

LOCUS MAP

N W E S

0 50 100
Feet

1:1,200

NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

F18

G18

G19

P-954

P-953

P-955

P-951

P-952

NEMCO WAY

#90

#3

#3

WAGON ROAD

SPECTACLE ROAD

LITTLETON

STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
- Stormwater- Detention Area
- Stormwater- Manhole
- Stormwater- Outfall
- Stormwater- Vortex
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LOCUS MAP

N W E S

0 50 100

Feet

1:1,200

NOTES

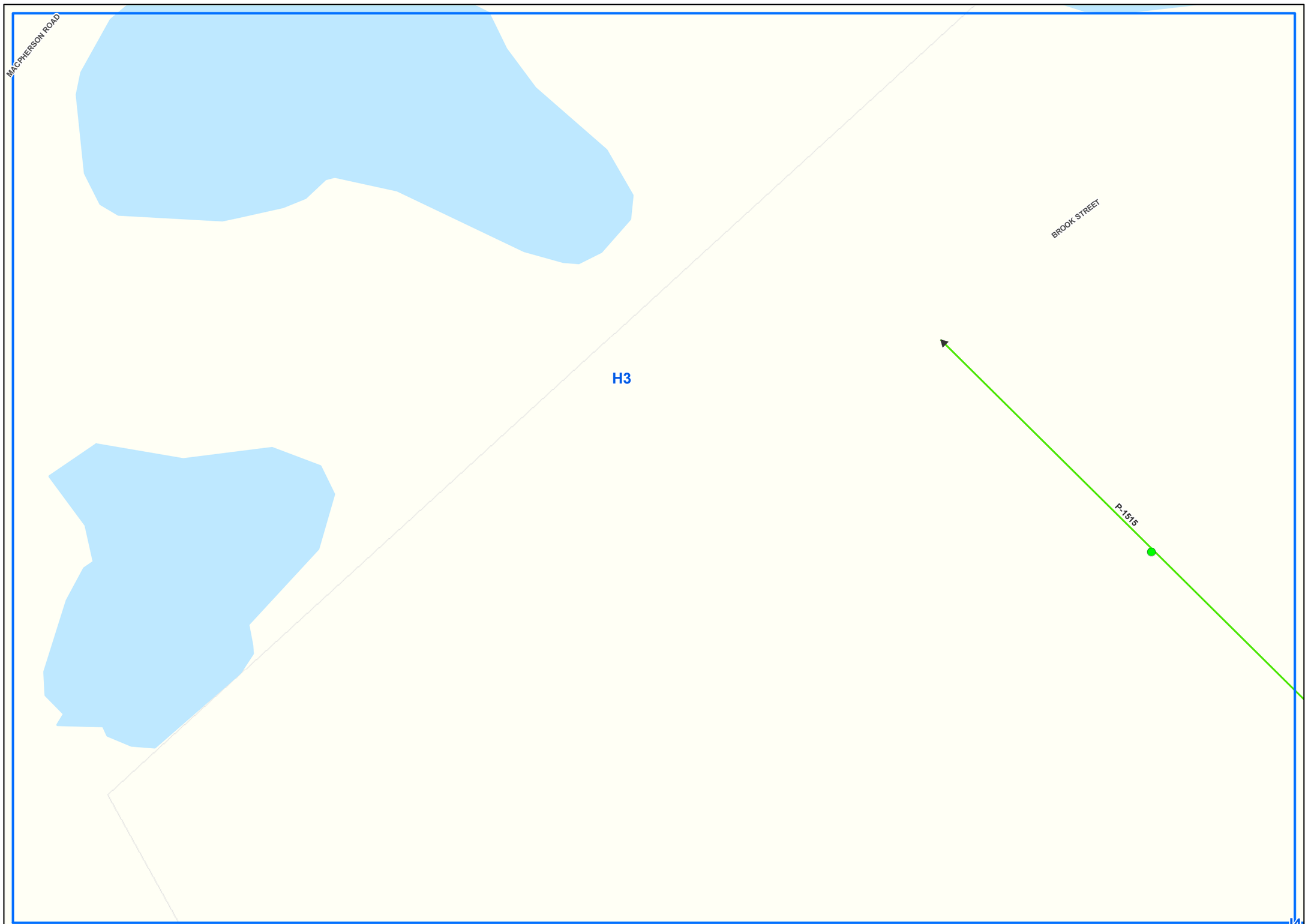
1. Data provided by the Town of Ayer and MassGIS

Page # G19

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
- Stormwater- Detention Area
- Stormwater- Manhole
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LOCUS MAP

N W E S

0 50 100
Feet

1:1,200

NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # **H3**

Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
- Stormwater- Detention Area
- Stormwater- Manhole
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- Stormwater- Vortex
- Private Stormwater- Catch Basin
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- Swale
- Abandoned Drain
- Culvert
- Private Drain
- Drain Line
- Town Owned Rain Gardens
- DetentionBasins

LOCUS MAP

N W E S

0 50 100
Feet

1:1,200

NOTES

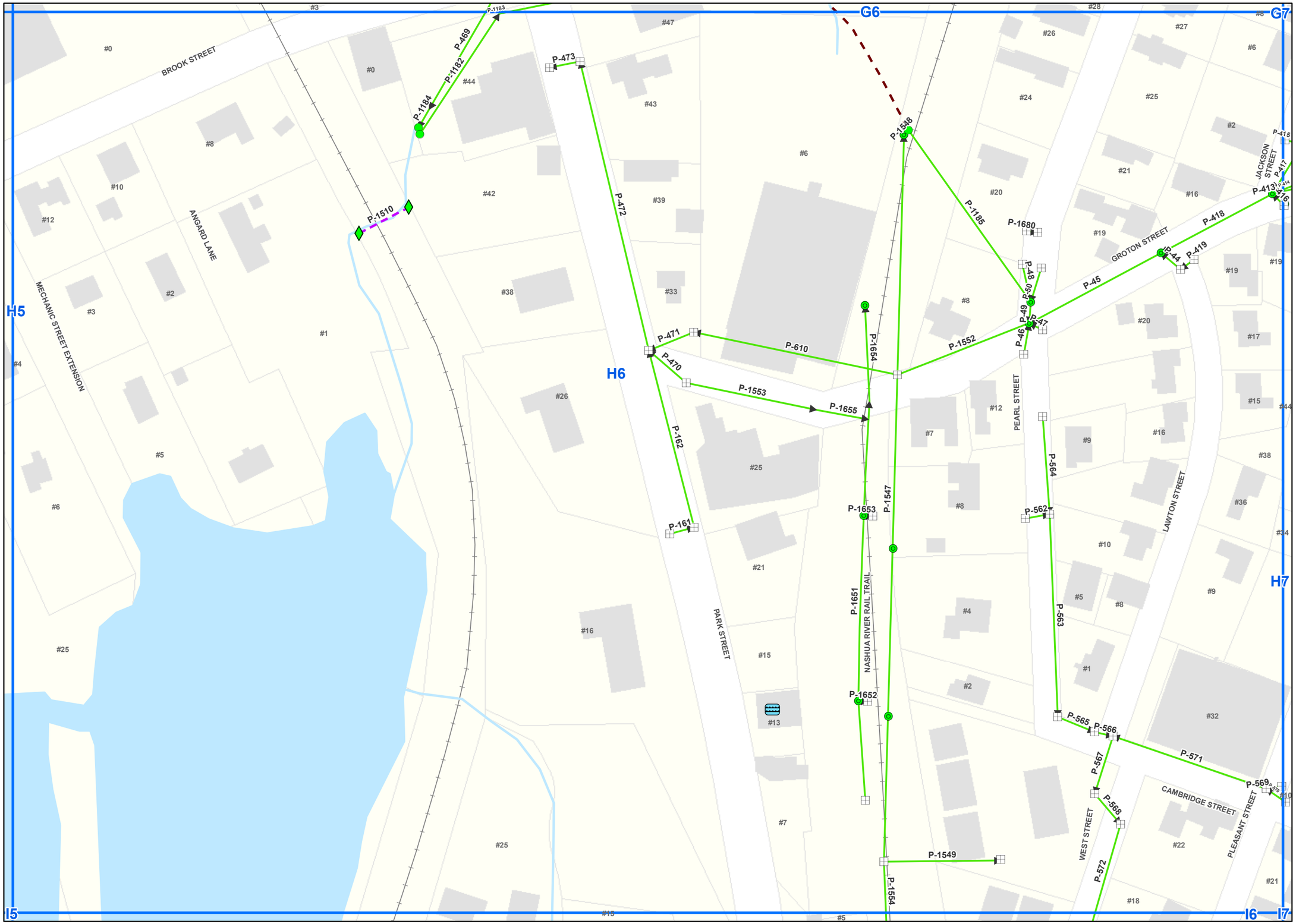
1. Data provided by the Town of Ayer and MassGIS

Page # H5

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
- Stormwater- Detention Area
- Stormwater- Manhole
- Stormwater- Outfall
- Stormwater- Vortex
- Private Stormwater- Catch Basin
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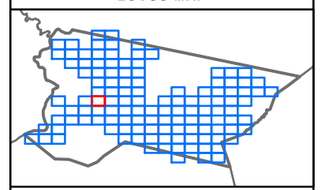
- Private Stormwater- Vortex
- Ditch
- Swale
- Abandoned Drain
- Culvert
- Private Drain
- Drain Line
- Town Owned Rain Gardens
- DetentionBasins

LOCUS MAP



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Feet

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NOTES

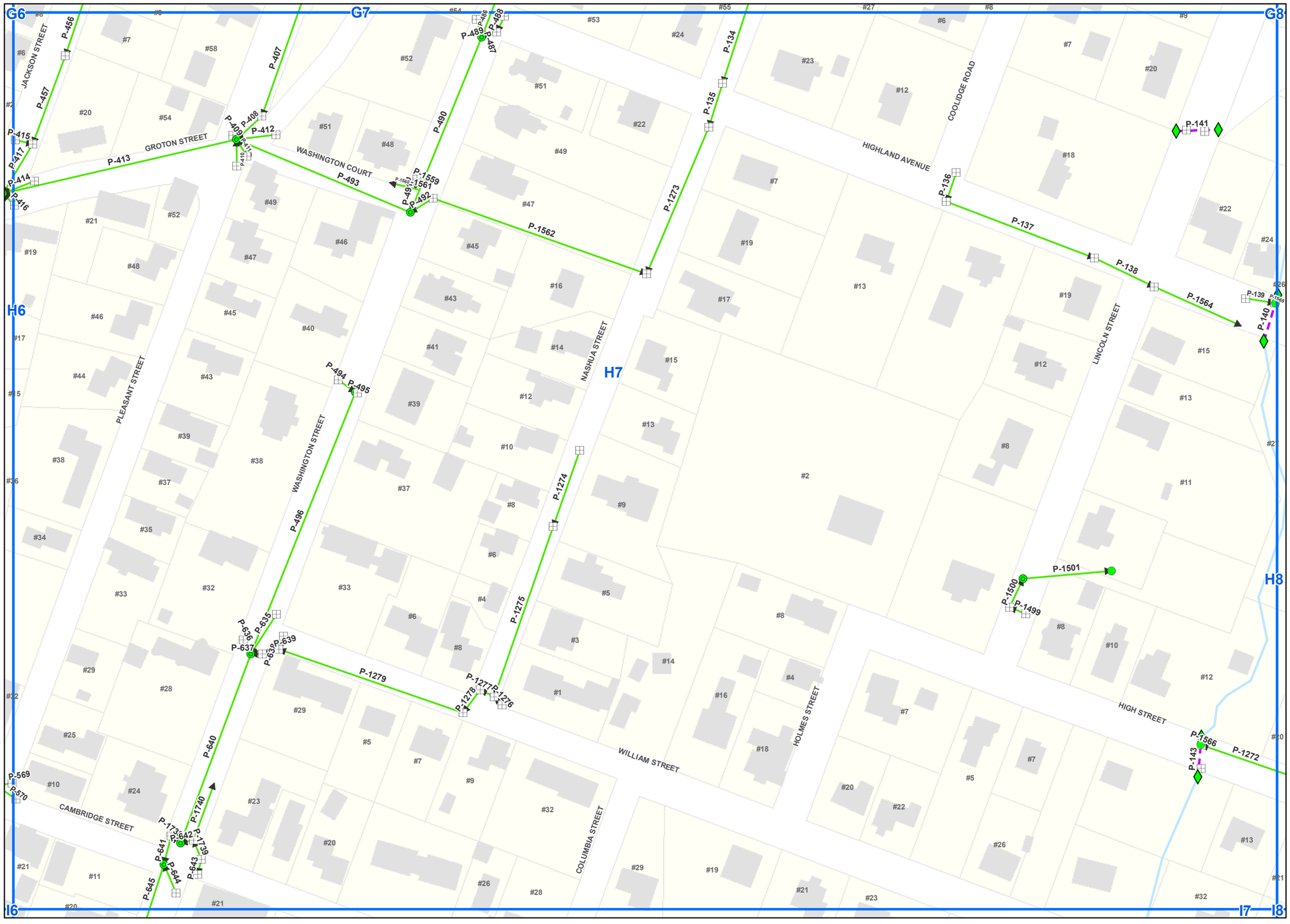
1. Data provided by the Town of Ayer and MassGIS

Page # H6

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
- Stormwater- Detention Area
- Stormwater- Manhole
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- Swale
- Abandoned Drain
- Culvert
- Private Drain
- Drain Line
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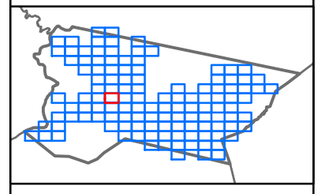
- DetentionBasins

LOCUS MAP



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Feet

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NOTES

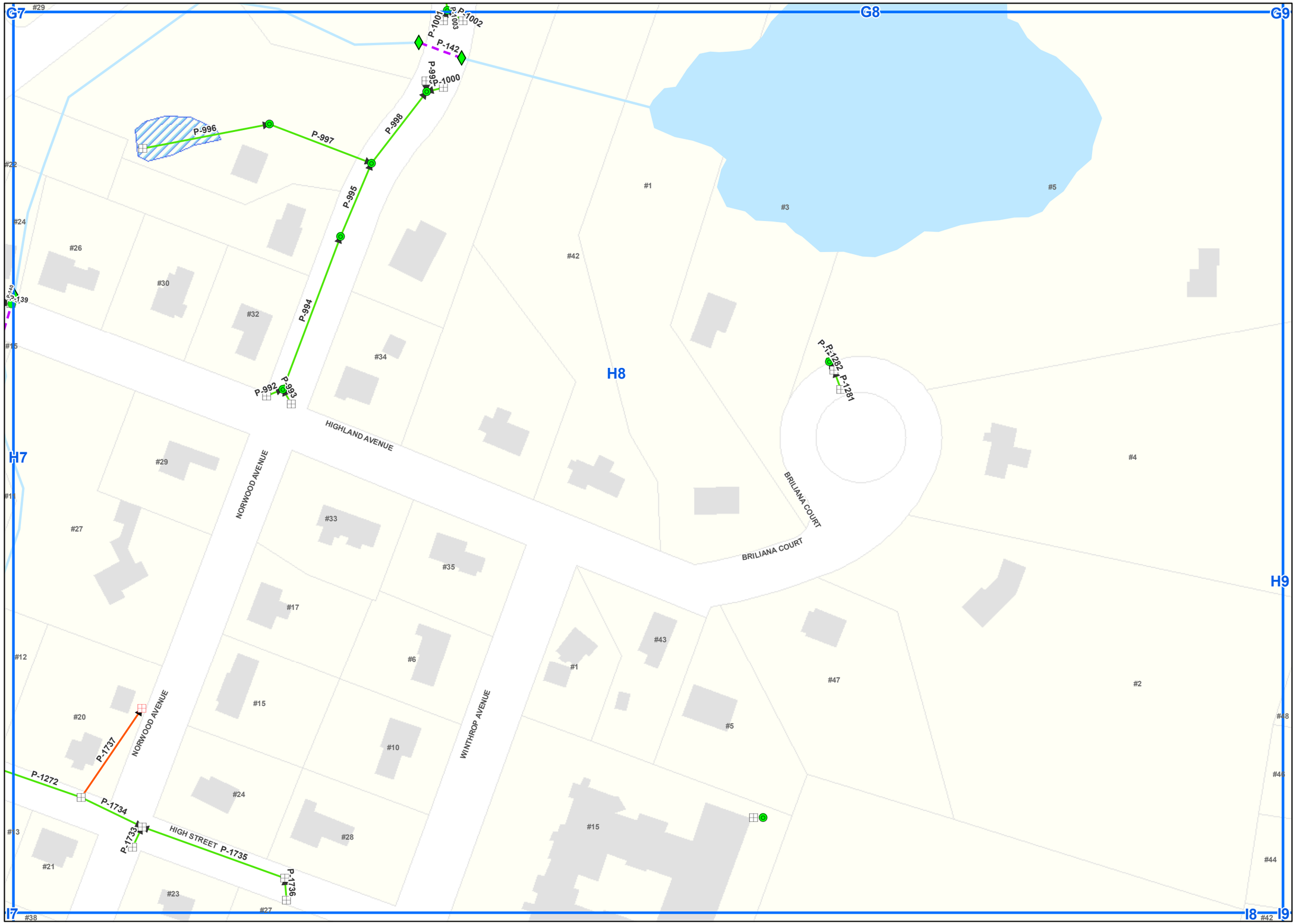
1. Data provided by the Town of Ayer and MassGIS

Page # H7

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
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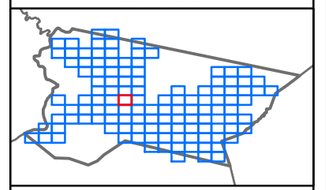
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # H8

Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

- Private BMP
- Stormwater- Catch Basin
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- Culvert
- Private Drain
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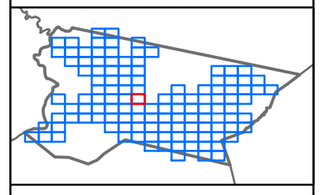
LOCUS MAP



N W E S

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Feet

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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # **H9**

Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

- Private BMP
- Stormwater- Catch Basin
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- Ditch
- Swale
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- Culvert
- Private Drain
- Drain Line
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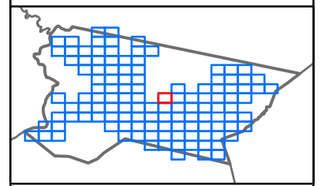
- DetentionBasins

LOCUS MAP



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Feet

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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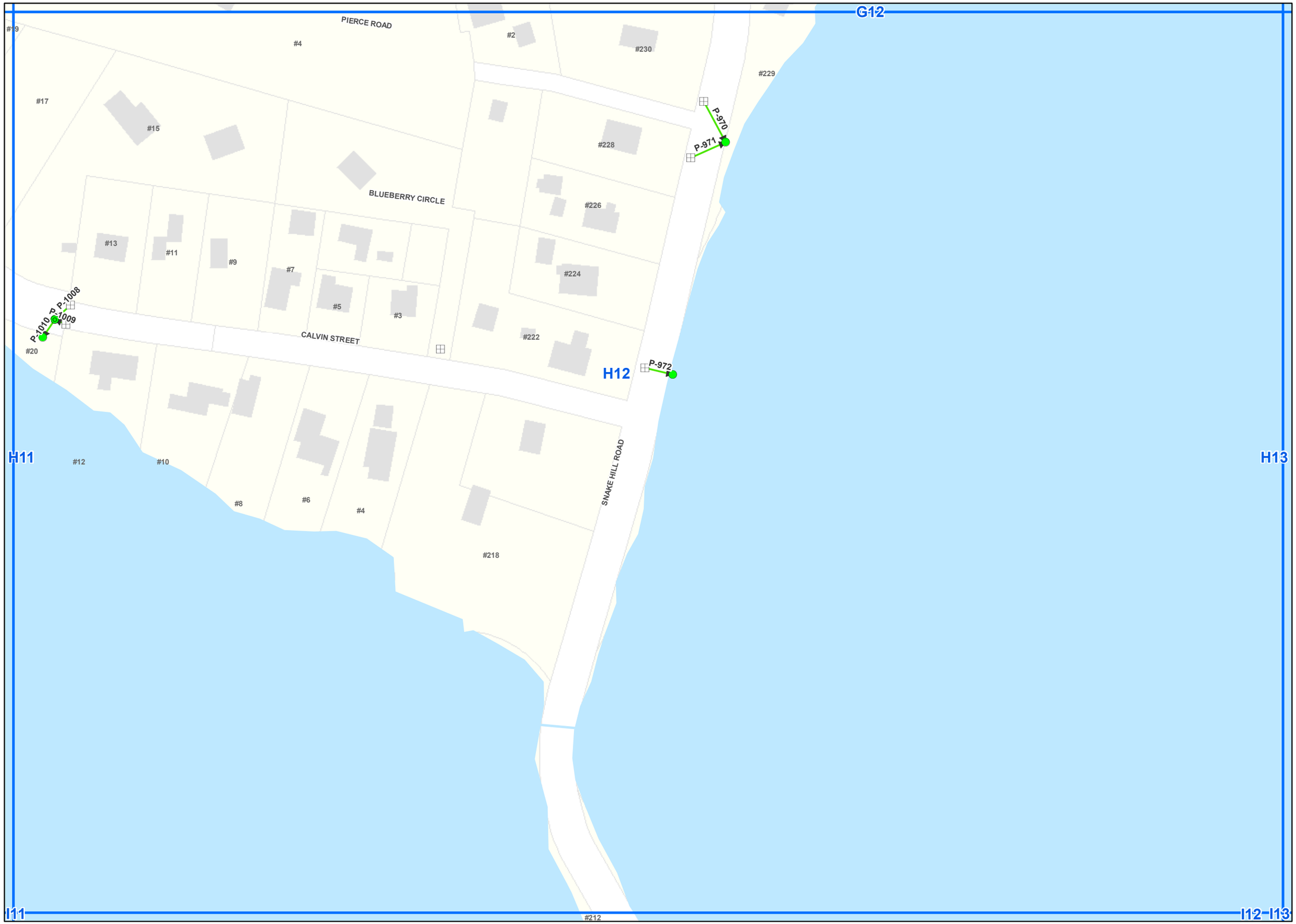
Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
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- DetentionBasins

LOCUS MAP

N W E S

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Feet

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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # **H12**

Ayer, Massachusetts

October 2021

Tighe&Bond

G12

G14

H12

H13

I12

I13–I14

WACHUSETT AVENUE EAST

MOUNTAIN VIEW AVENUE

P-1283

#1

#5

#6

#7

#57

STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
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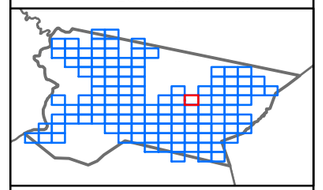
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # H13

Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

- Private BMP
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- Drain Line
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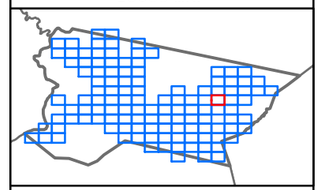
LOCUS MAP



N
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Feet

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NOTES

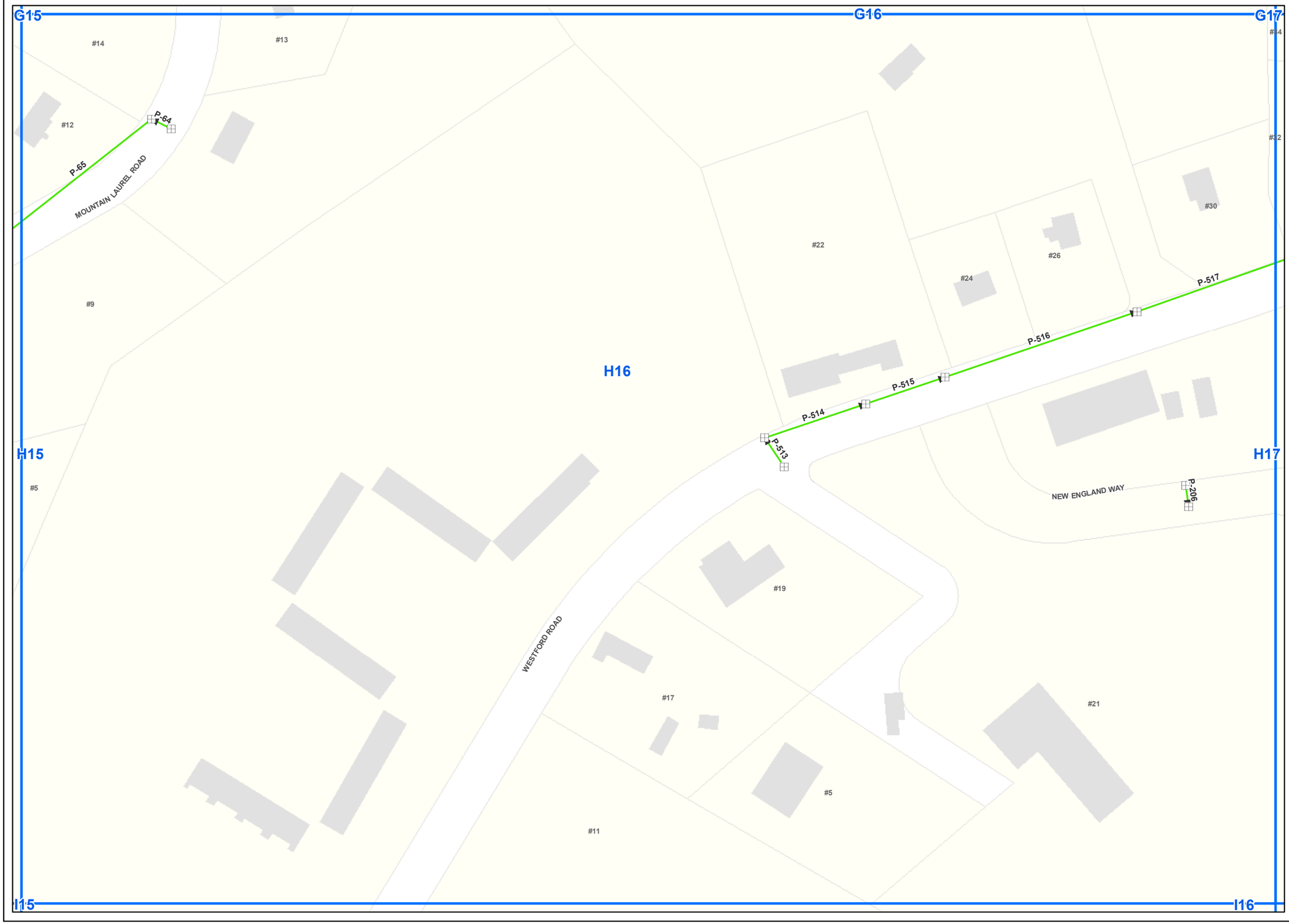
1. Data provided by the Town of Ayer and MassGIS

Page # **H15**

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
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- Private Drain
- Drain Line
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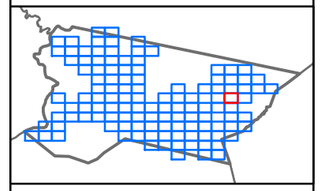
LOCUS MAP



N
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Feet

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NOTES

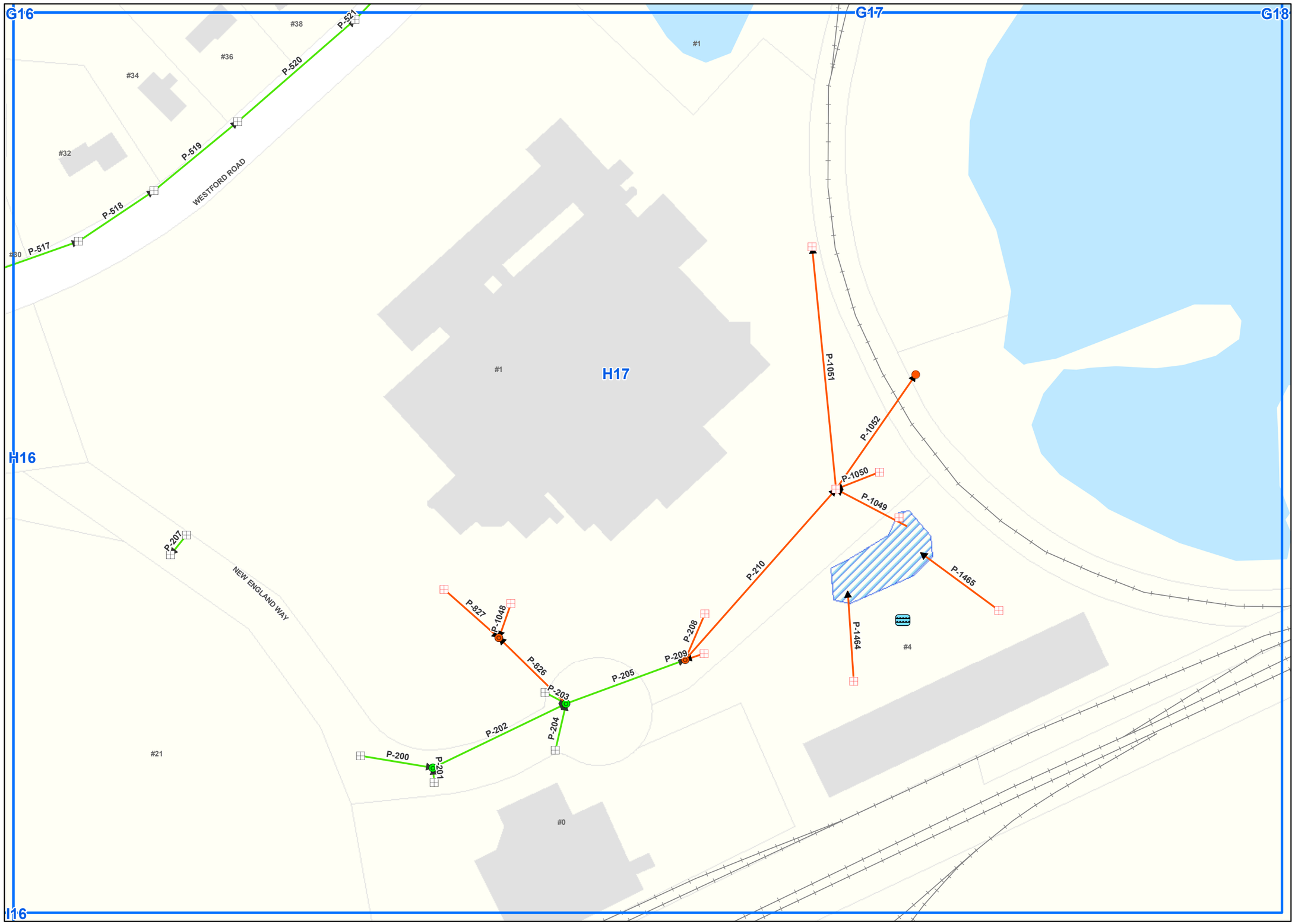
1. Data provided by the Town of Ayer and MassGIS

Page # **H16**

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
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- DetentionBasins

LOCUS MAP

N W E S

0 50 100

Feet

1:1,200

NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # H17

Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

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- DetentionBasins

LOCUS MAP

N W E S

0 50 100
Feet

1:1,200

NOTES

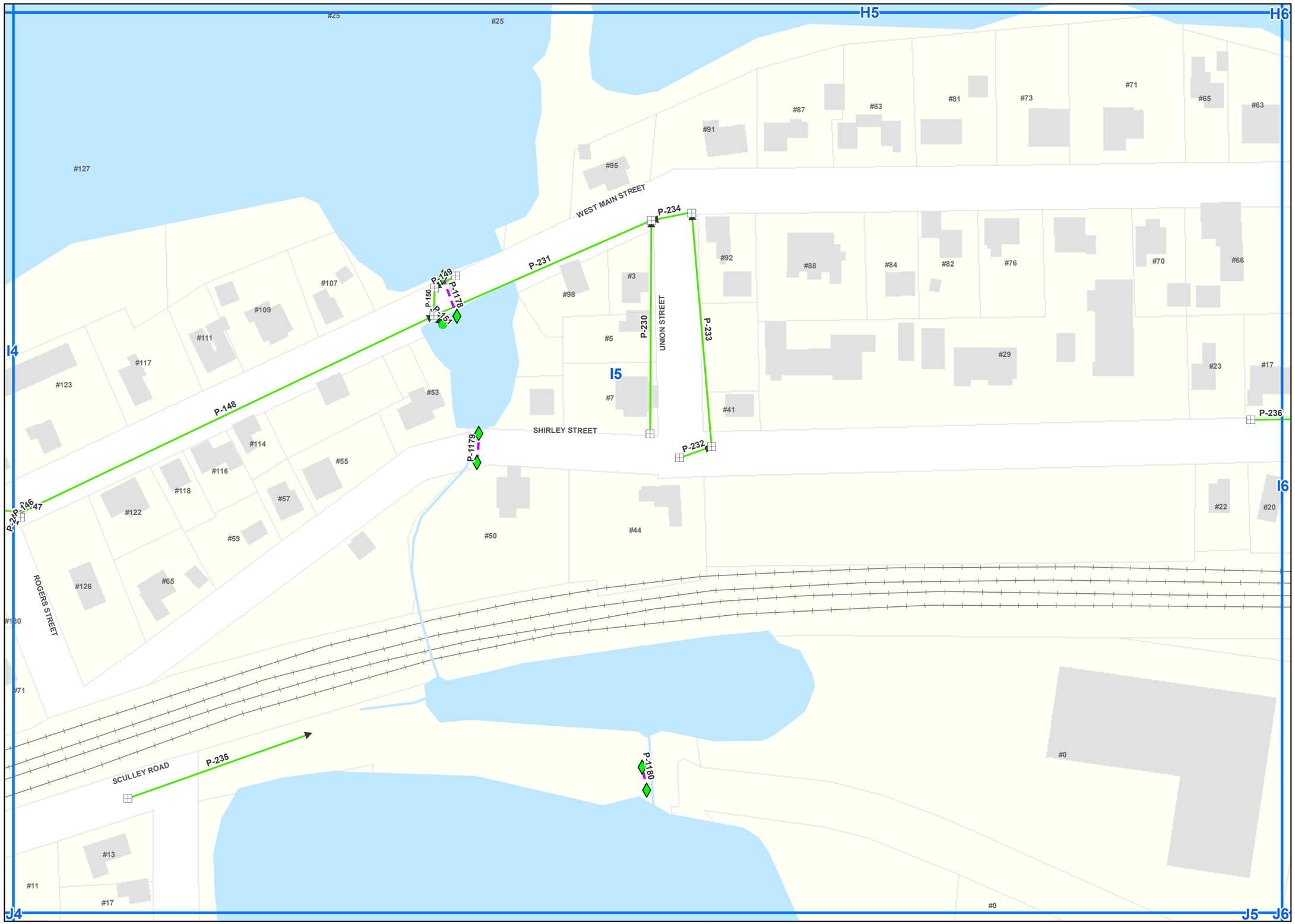
1. Data provided by the Town of Ayer and MassGIS

Page # I4

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
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- Abandoned Drain
- Culvert
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- Drain Line
- Town Owned Rain Gardens
- DetentionBasins

LOCUS MAP

N W E S

0 50 100
Feet

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NOTES

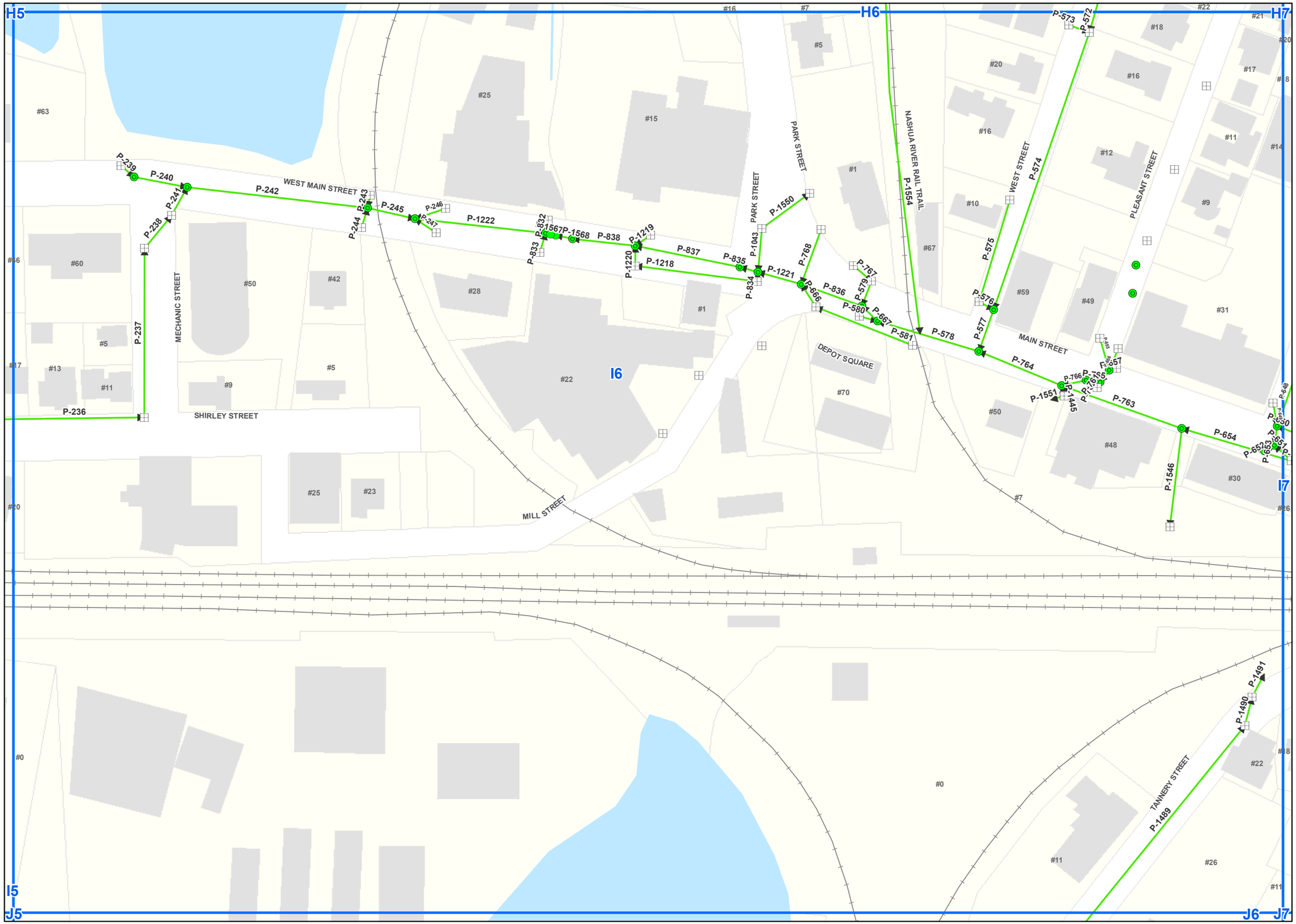
1. Data provided by the Town of Ayer and MassGIS

Page # I5

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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- Stormwater- Catch Basin
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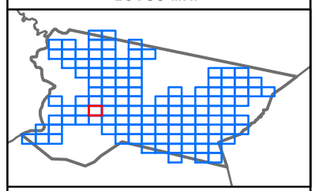
- DetentionBasins

LOCUS MAP



N W E S

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Feet

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NOTES

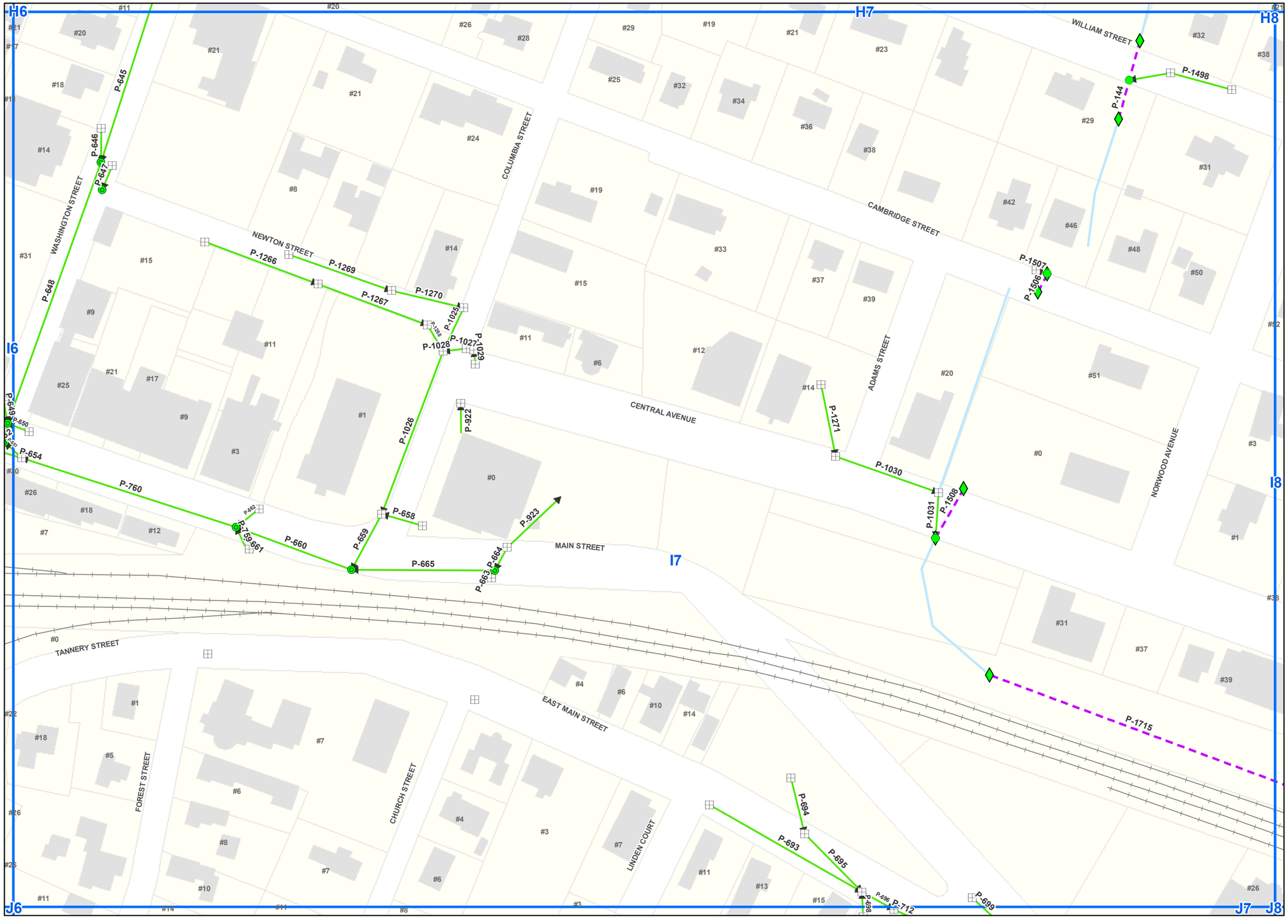
1. Data provided by the Town of Ayer and MassGIS

Page # I6

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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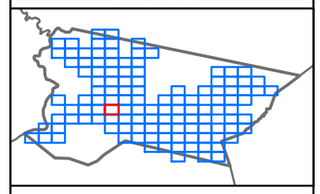
LOCUS MAP



N W E S

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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # I7

Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

- Private BMP
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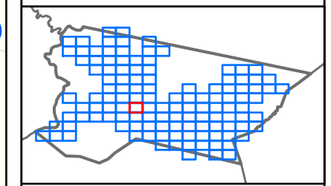
LOCUS MAP



N W E S

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NOTES

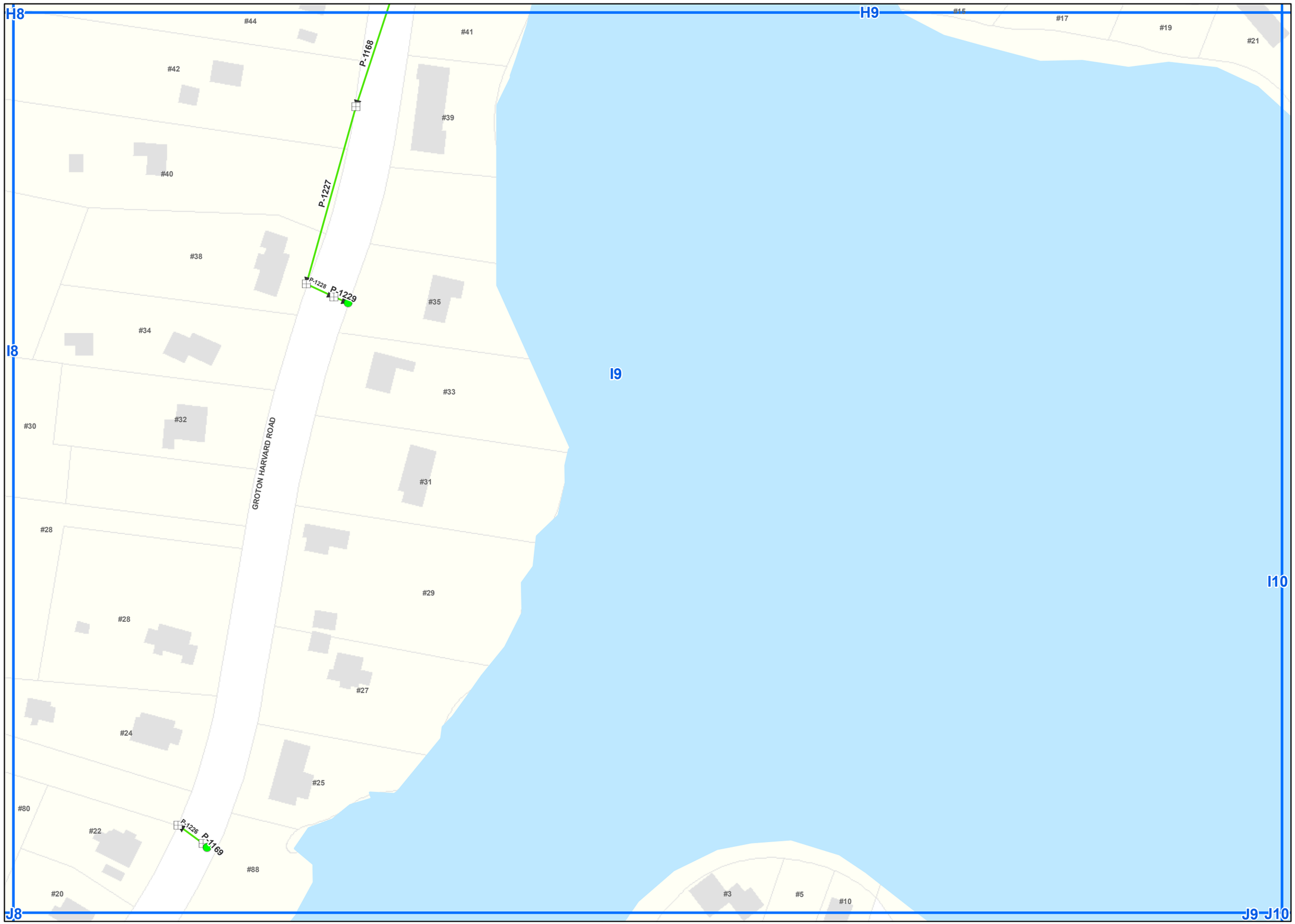
1. Data provided by the Town of Ayer and MassGIS

Page # I8

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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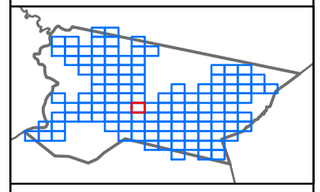
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # I9

Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

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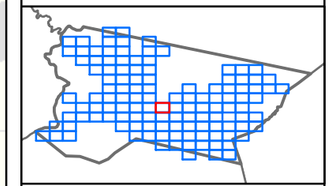
- DetentionBasins

LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # **I10**

Ayer, Massachusetts

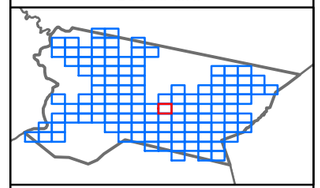
October 2021

Tighe&Bond

STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
- Stormwater- Detention Area
- Stormwater- Manhole
- Stormwater- Outfall
- Stormwater- Vortex
- Private Stormwater- Catch Basin
- Private Stormwater- Culvert
- Private Stormwater- Detention Area
- Private Stormwater- Manhole
- Private Stormwater- Outfall
- Private Stormwater- Trap
- Private Stormwater- Vortex
- Ditch
- Swale
- Abandoned Drain
- Culvert
- Private Drain
- Drain Line
- Town Owned Rain Gardens
- DetentionBasins

LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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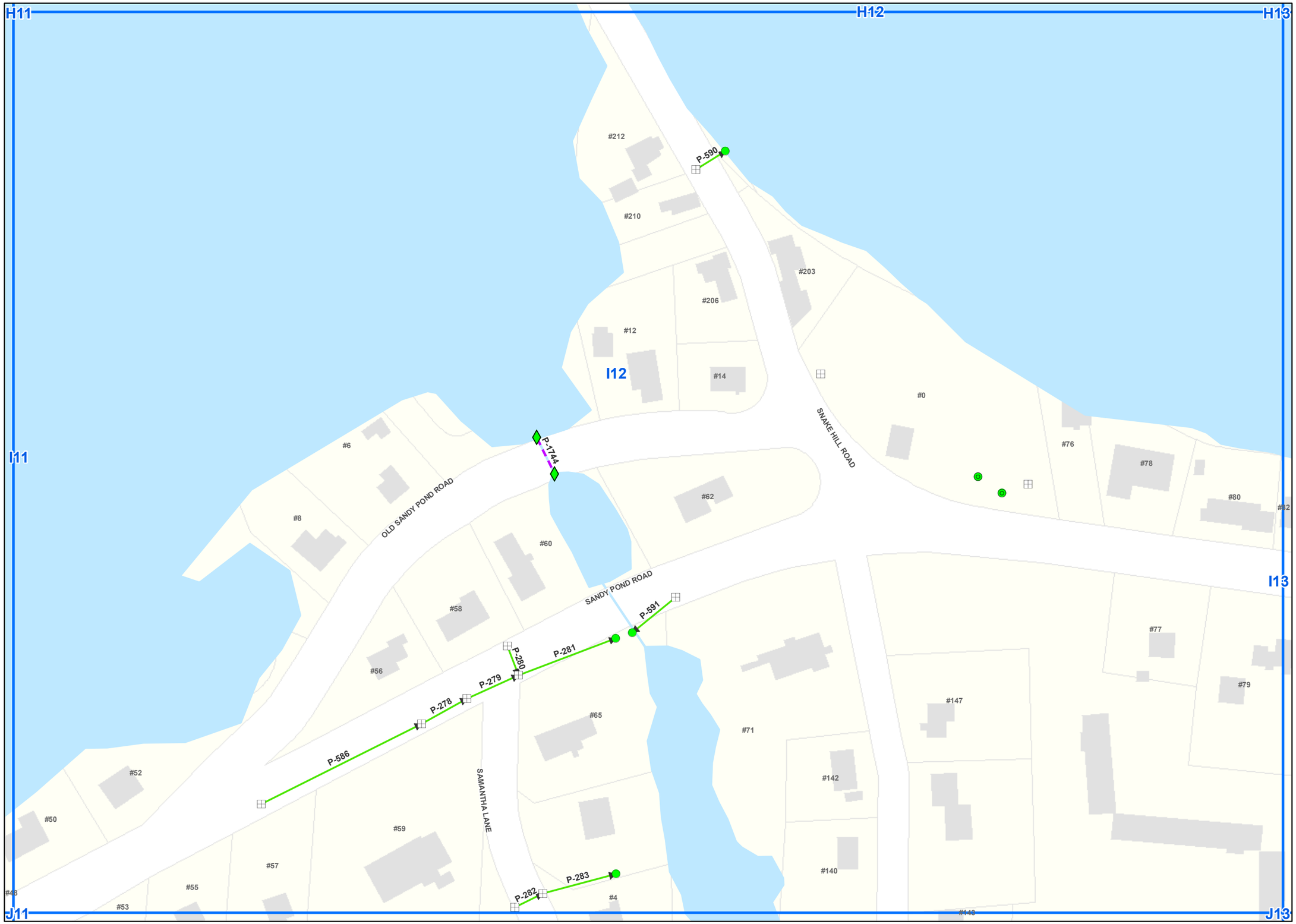
Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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- Stormwater- Catch Basin
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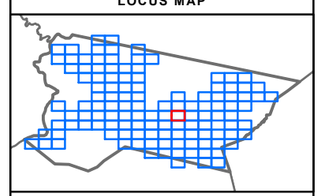
LOCUS MAP



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NOTES

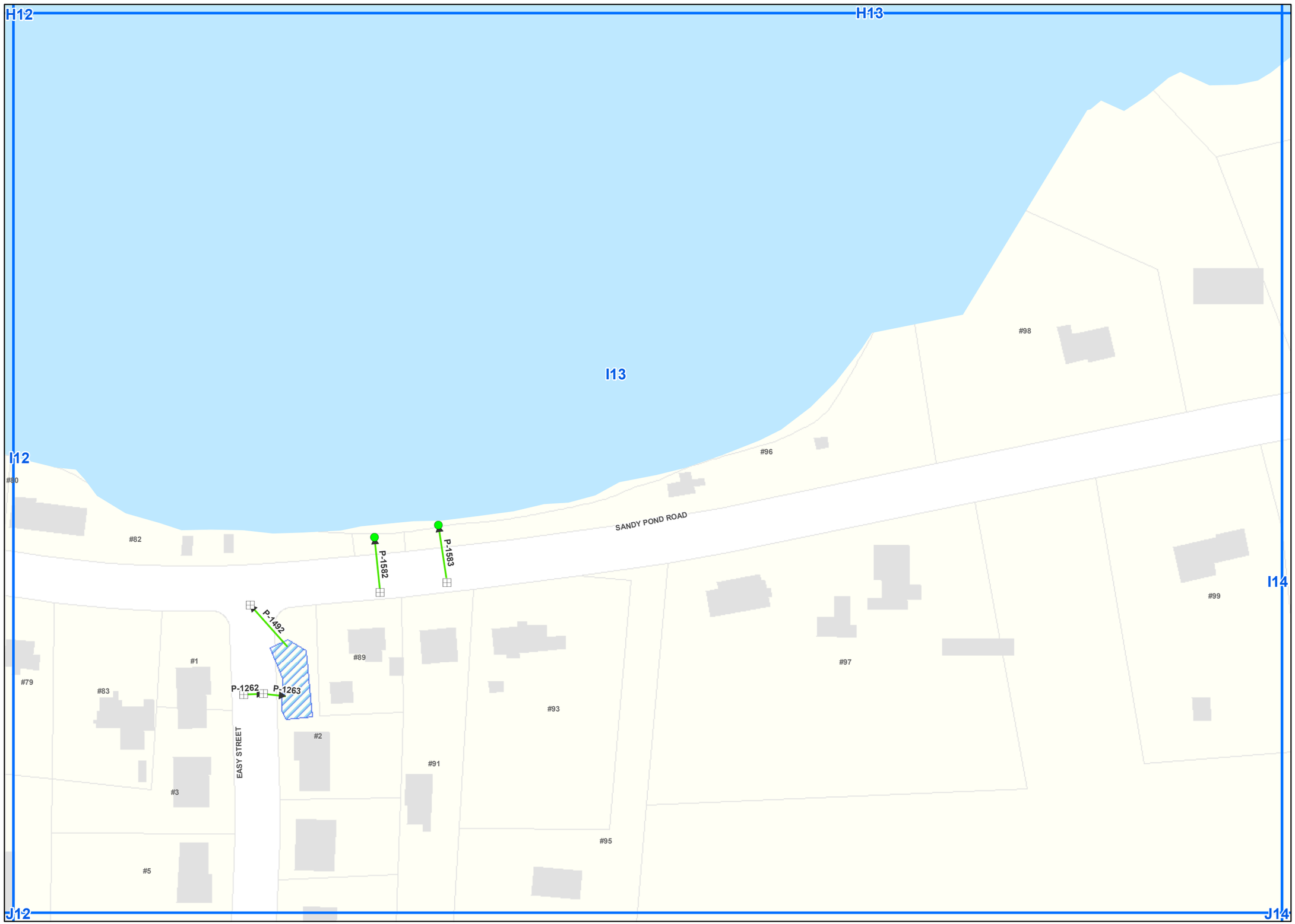
1. Data provided by the Town of Ayer and MassGIS

Page # I12

Ayer, Massachusetts

October 2021

Tighe&Bond



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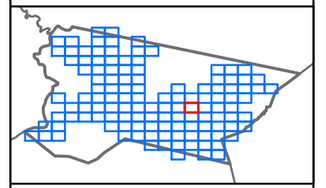
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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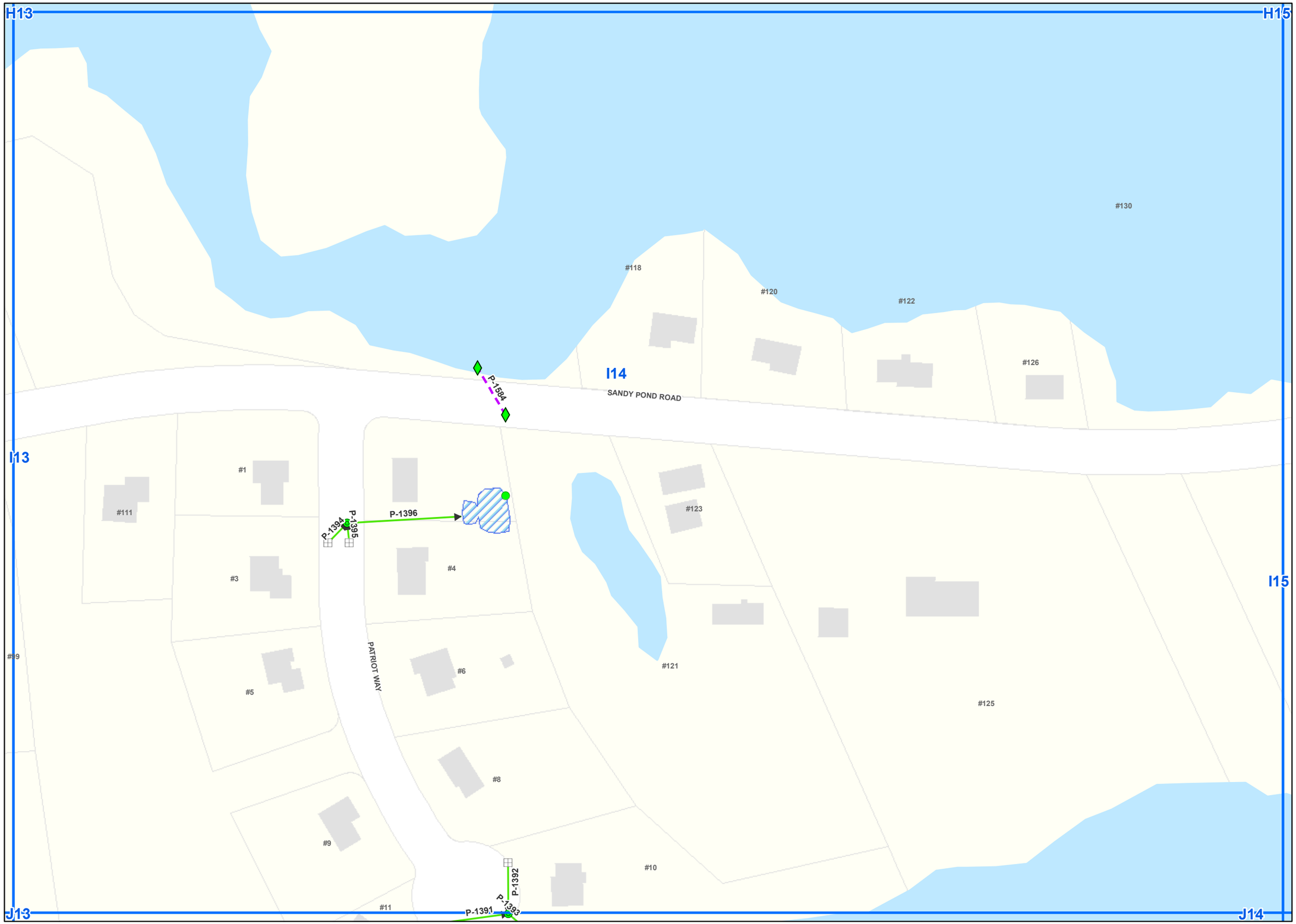
Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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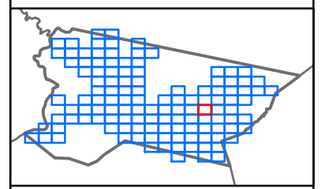
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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October 2021

Tighe&Bond

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- Culvert
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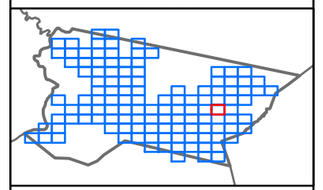
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

H15 H16 H17

I15 I16 J17

WESTFORD ROAD

SANDY POND ROAD

PATRICIA DRIVE

WILLOW ROAD

P-107 P-1587 P-113 P-114 P-115 P-110 P-116 P-117

#0 #3 #4 #5 #11 #11 #21 #157

STORMWATER

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LOCUS MAP

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

J4

J3

#201

#193

#203

WEST MAIN STREET

#196

K2

K3

STORMWATER

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LOCUS MAP

N W E S

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Feet

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NOTES

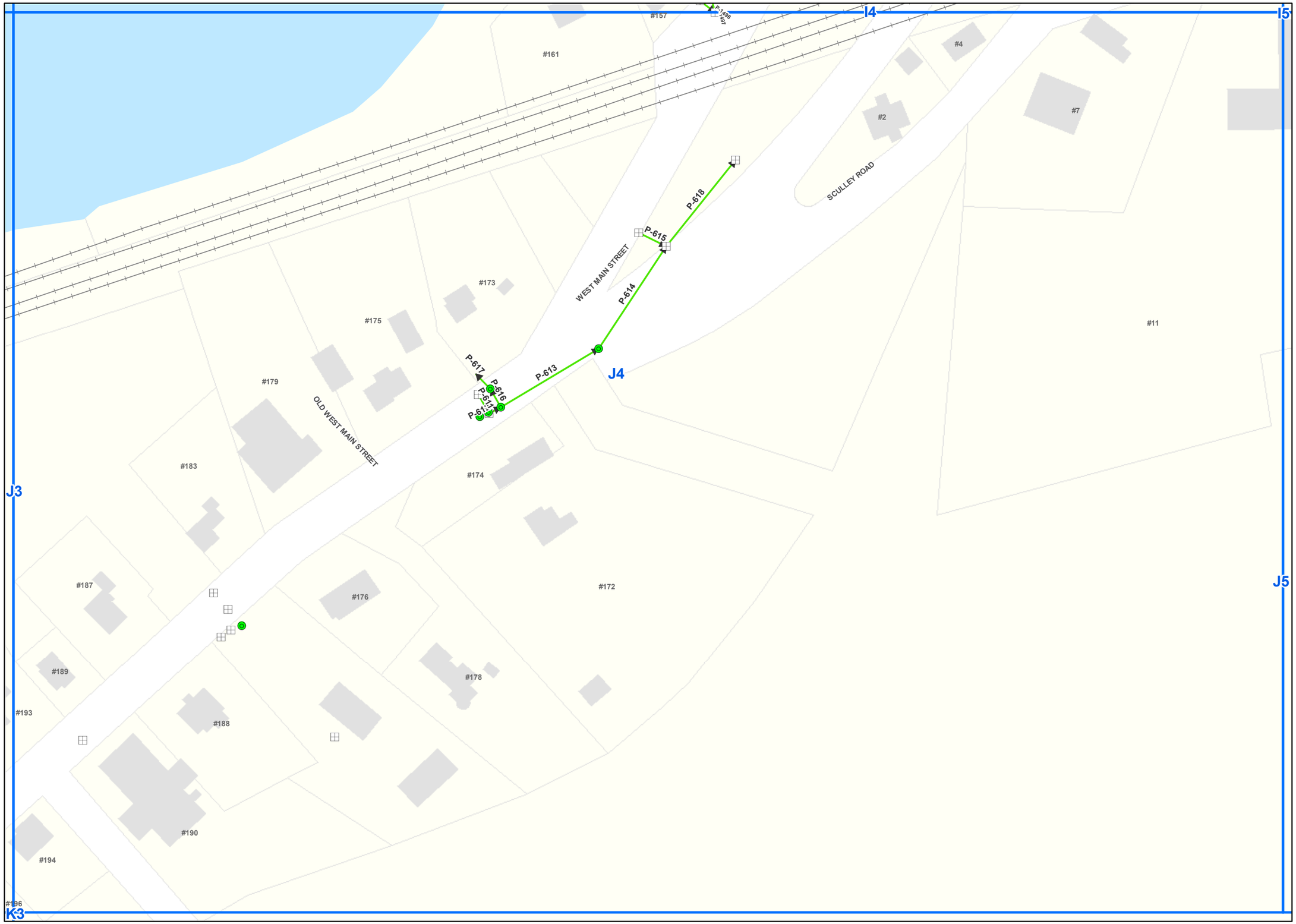
1. Data provided by the Town of Ayer and MassGIS

Page # J3

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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LOCUS MAP

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NOTES

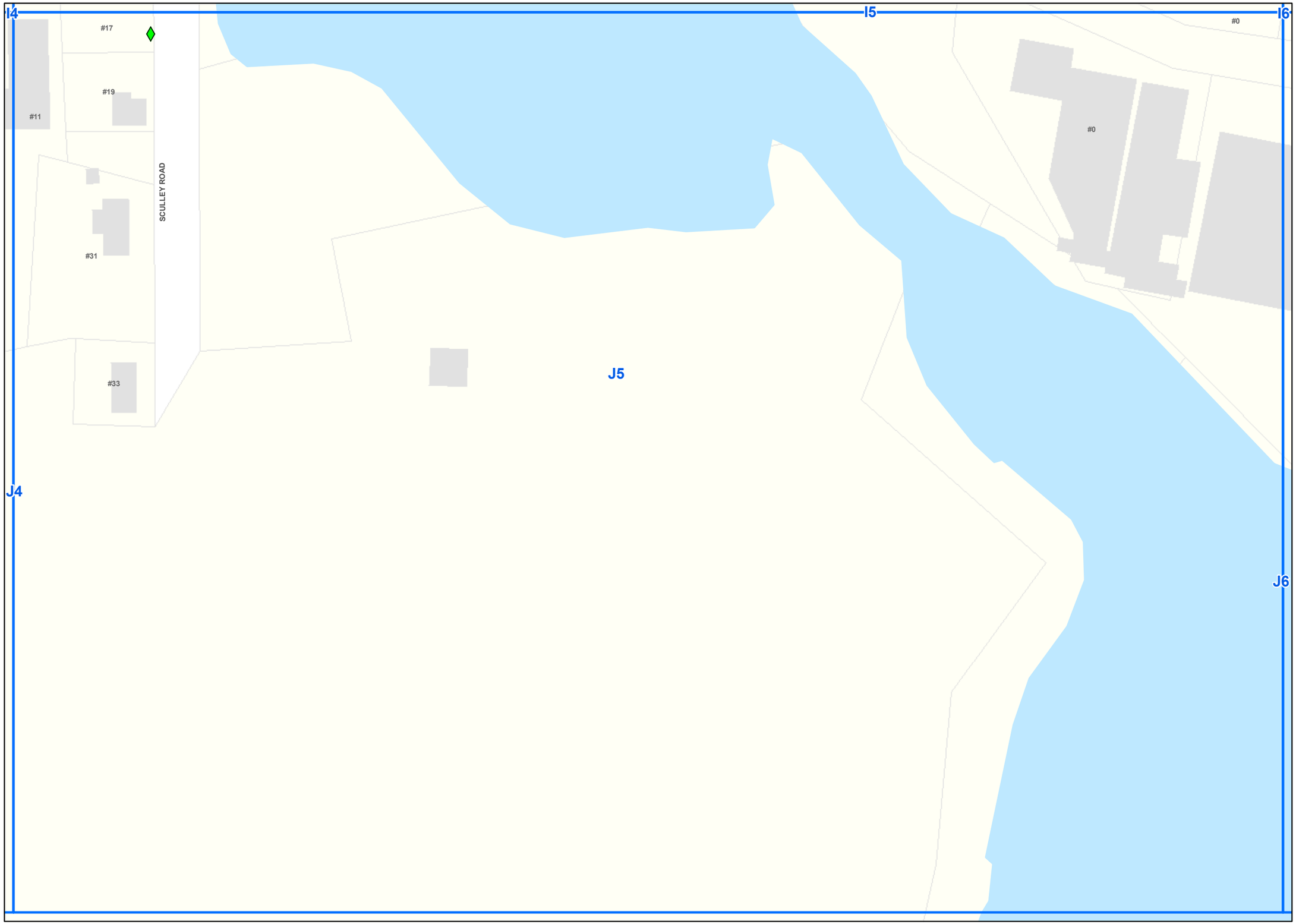
1. Data provided by the Town of Ayer and MassGIS

Page # J4

Ayer, Massachusetts

October 2021

Tighe&Bond



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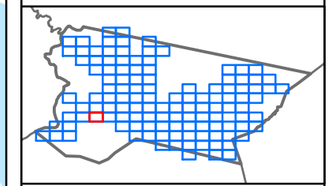
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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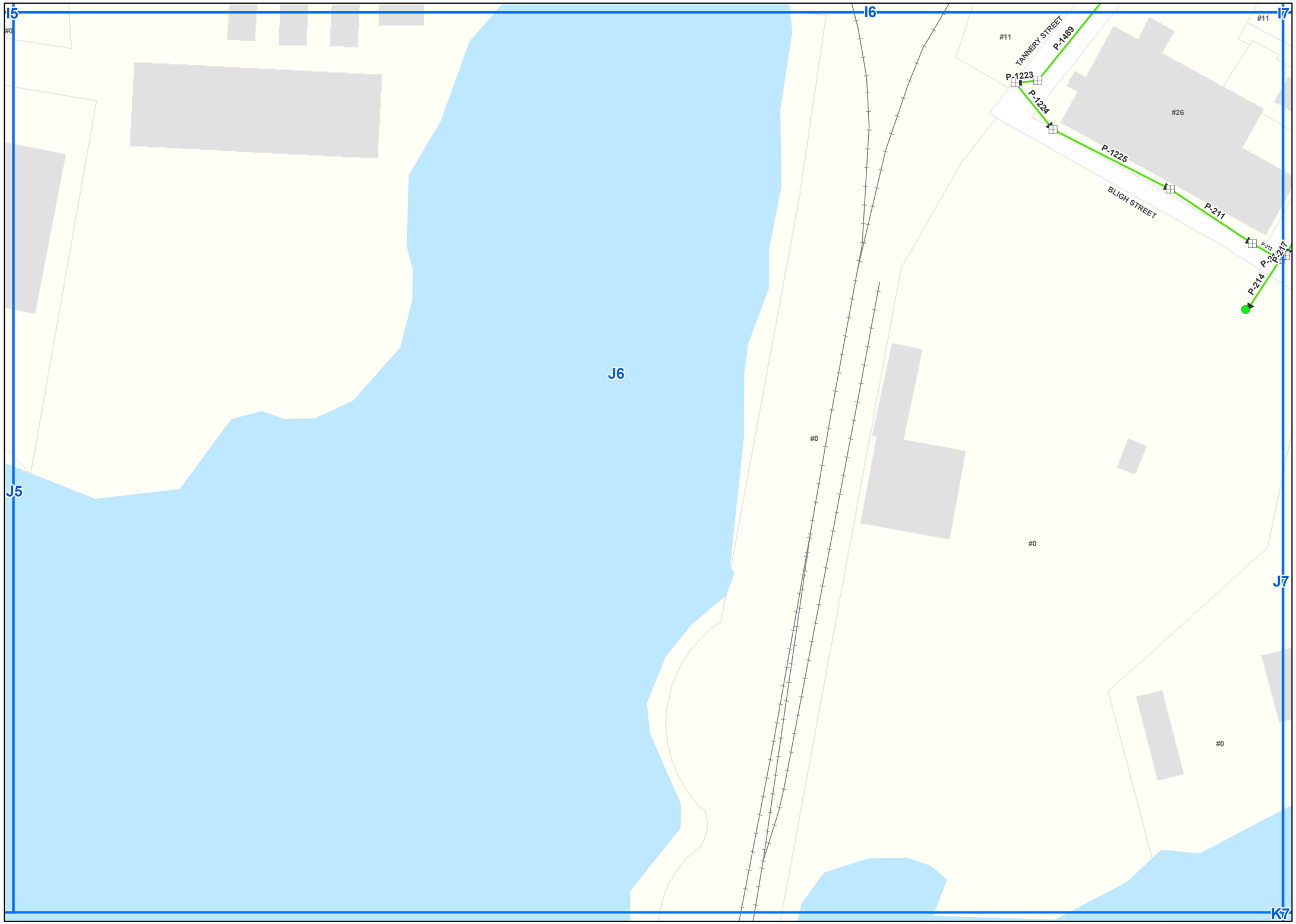
Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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LOCUS MAP

N W E S

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NOTES

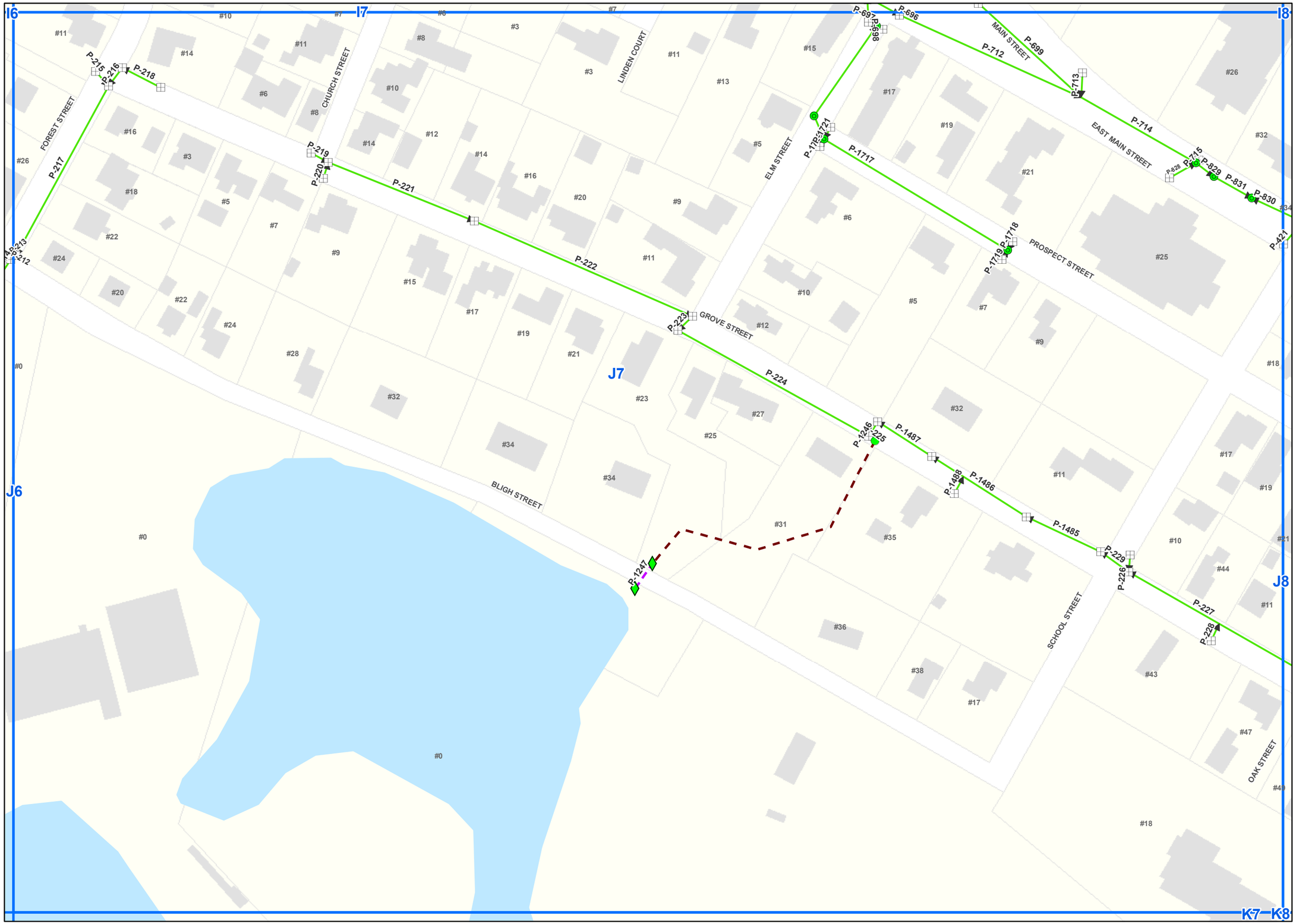
1. Data provided by the Town of Ayer and MassGIS

Page # **J6**

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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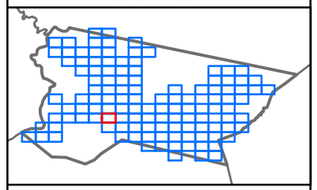
LOCUS MAP



N W E S

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

I7 I8 I9

J7 J8 J9

K7 K8 K9

CENTRAL AVENUE

EAST MAIN STREET

POND STREET

OAK STREET

SCHOOL STREET

PROSPECT STREET

GROVE STREET

FLETCHER STREET

WHITCOMB AVENUE

MAPLE STREET

PAGE STREET

GROTON HARVARD ROAD

P-1715 P-1574 P-422 P-830 P-421 P-420 P-431 P-1721 P-1726 P-430 P-429 P-1724 P-1722 P-1723 P-1728 P-436 P-435 P-437 P-1570 P-439 P-438 P-434 P-440 P-441 P-432 P-433 P-277 P-227 P-276 P-271 P-272 P-273 P-274 P-275 P-1480 P-1482 P-442 P-444 P-443 P-716 P-717 P-718 P-452 P-451 P-1714

#26 #32 #34 #38 #40 #43 #44 #46 #54 #56 #64 #0 #62 #80 #20 #83 #25 #18 #37 #39 #17 #19 #21 #8 #49 #53 #6 #10 #11 #14 #52 #57 #59 #63 #65 #67 #71 #73 #76 #78 #30 #79 #81 #84 #86 #1 #3 #16 #20 #22 #26 #47 #5 #7 #13

STORMWATER

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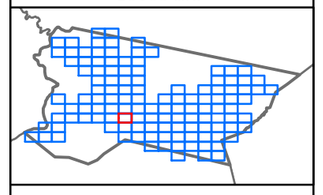
LOCUS MAP



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NOTES

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Ayer, Massachusetts

October 2021

Tighe&Bond

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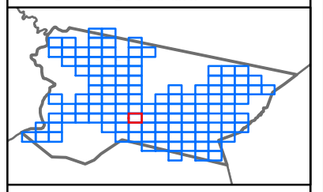
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

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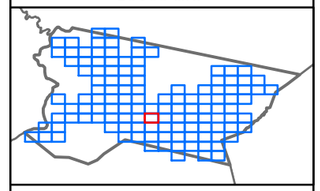
LOCUS MAP



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NOTES

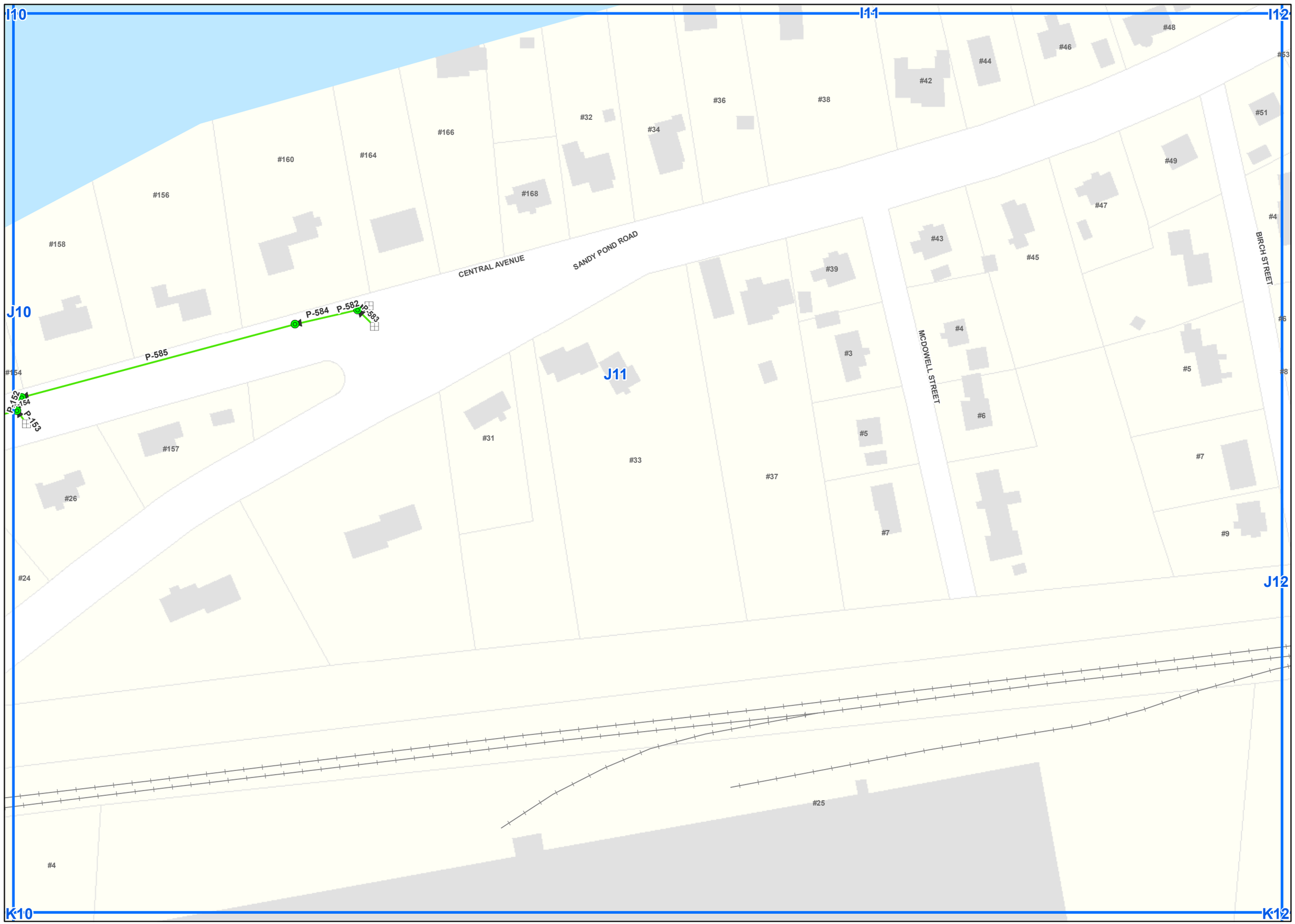
1. Data provided by the Town of Ayer and MassGIS

Page # J10

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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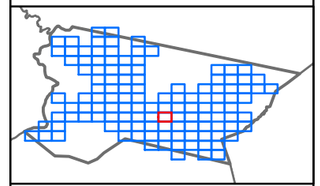
LOCUS MAP



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NOTES

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Ayer, Massachusetts

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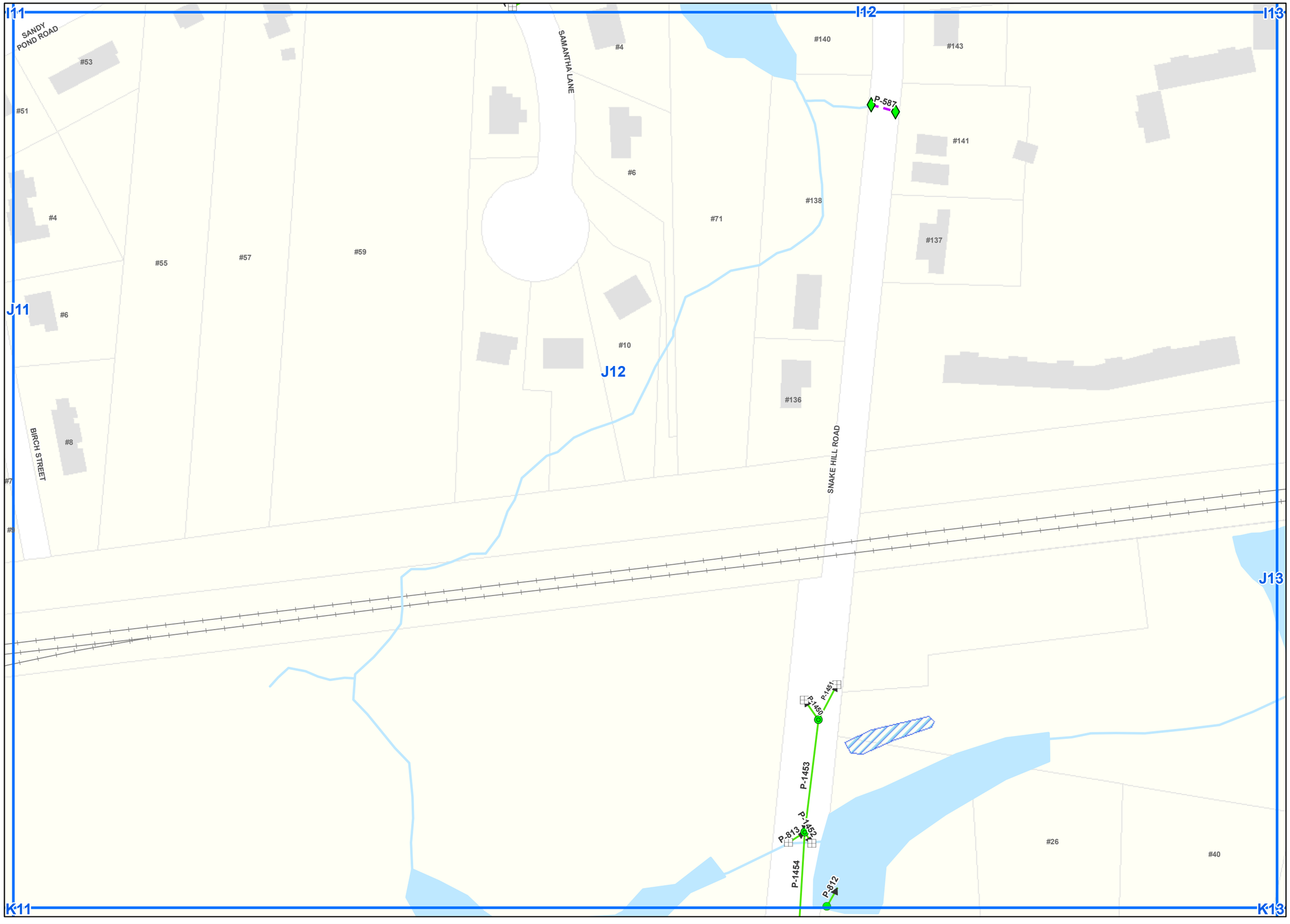

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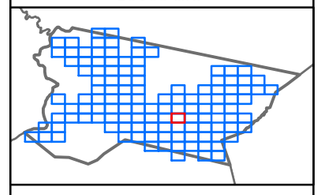
LOCUS MAP



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NOTES

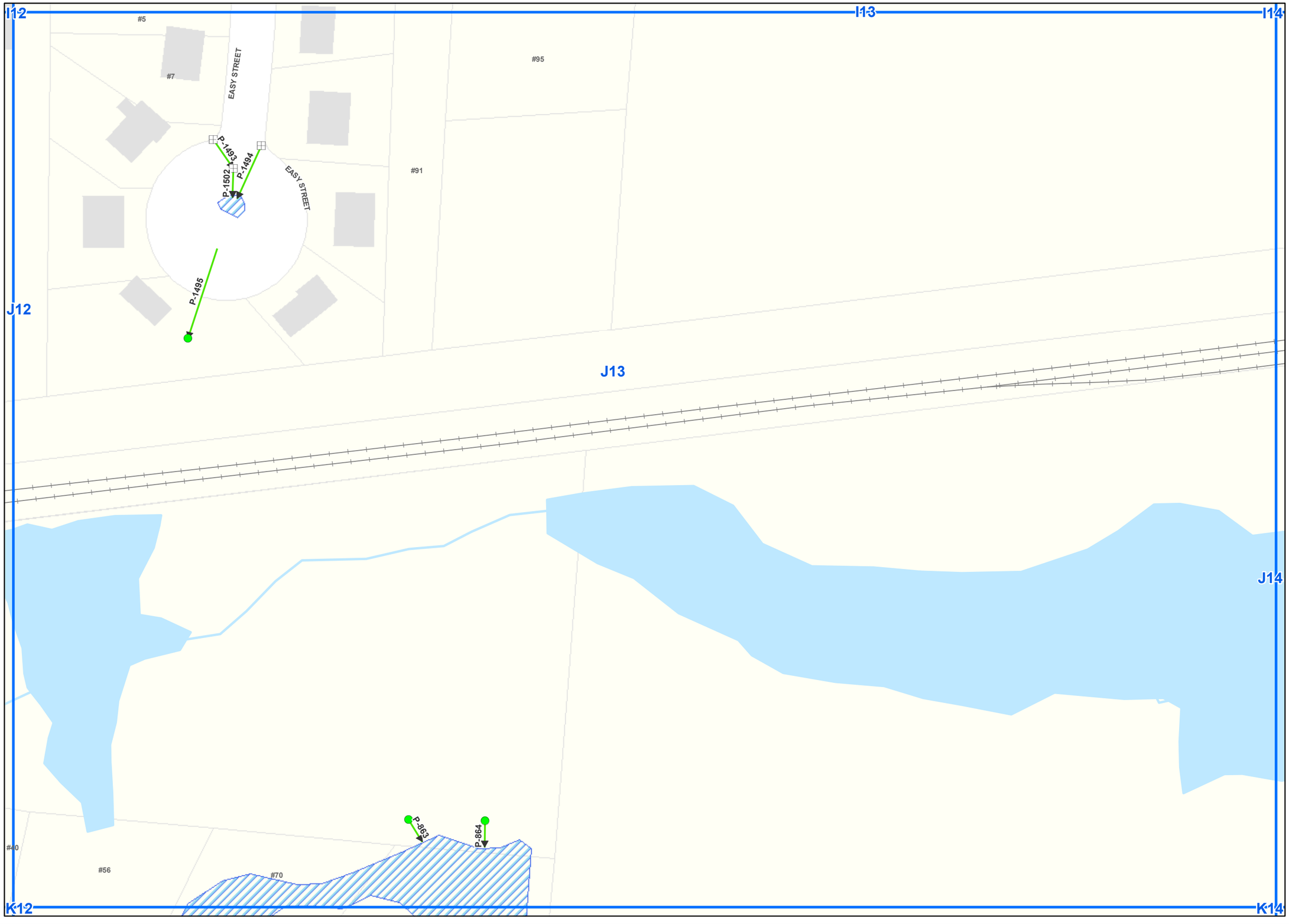
1. Data provided by the Town of Ayer and MassGIS

Page # **J12**

Ayer, Massachusetts

October 2021

Tighe&Bond



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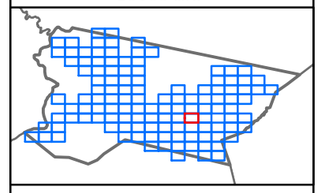
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

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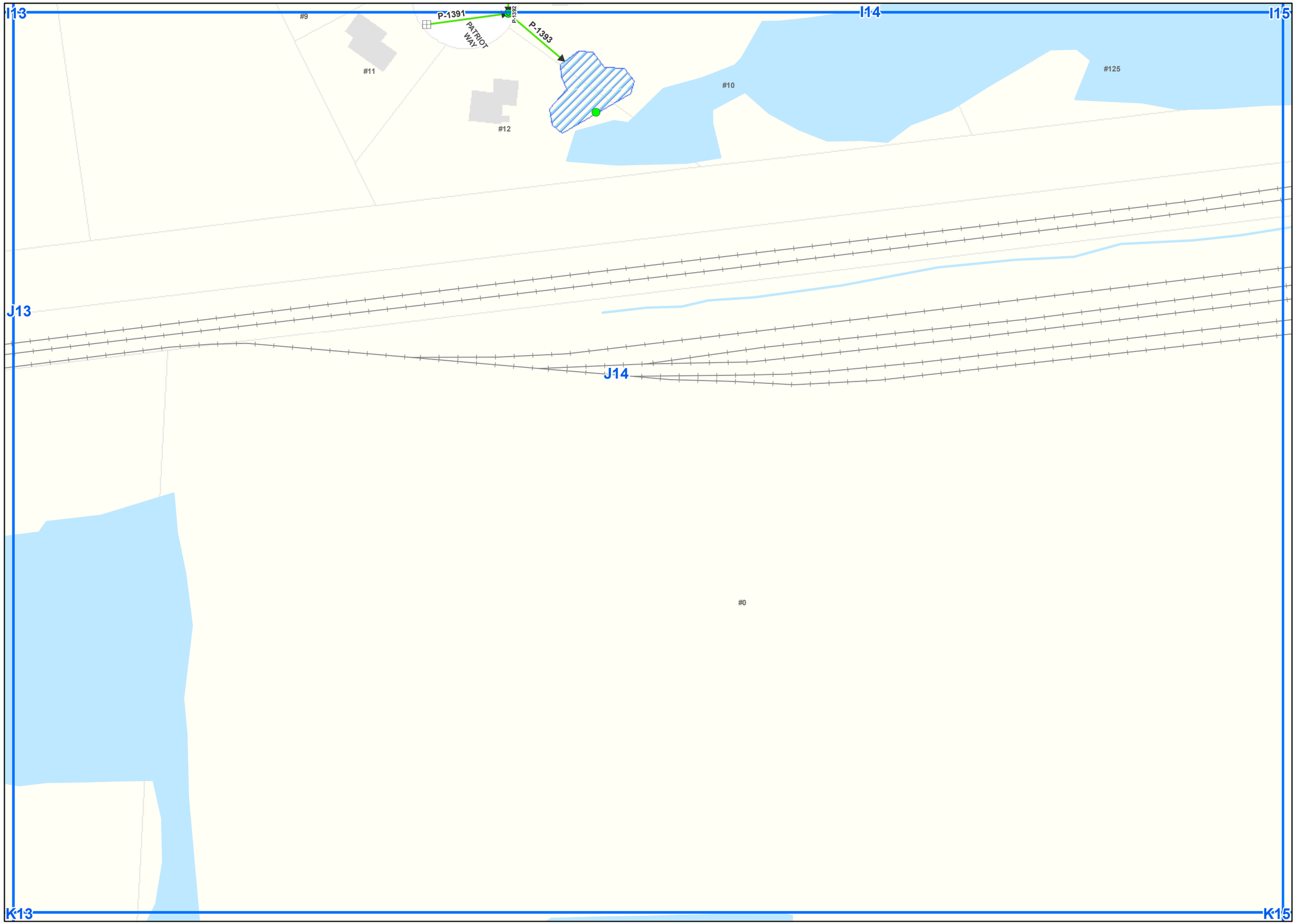
Tighe&Bond



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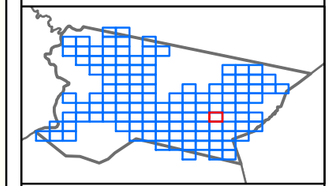
LOCUS MAP



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NOTES

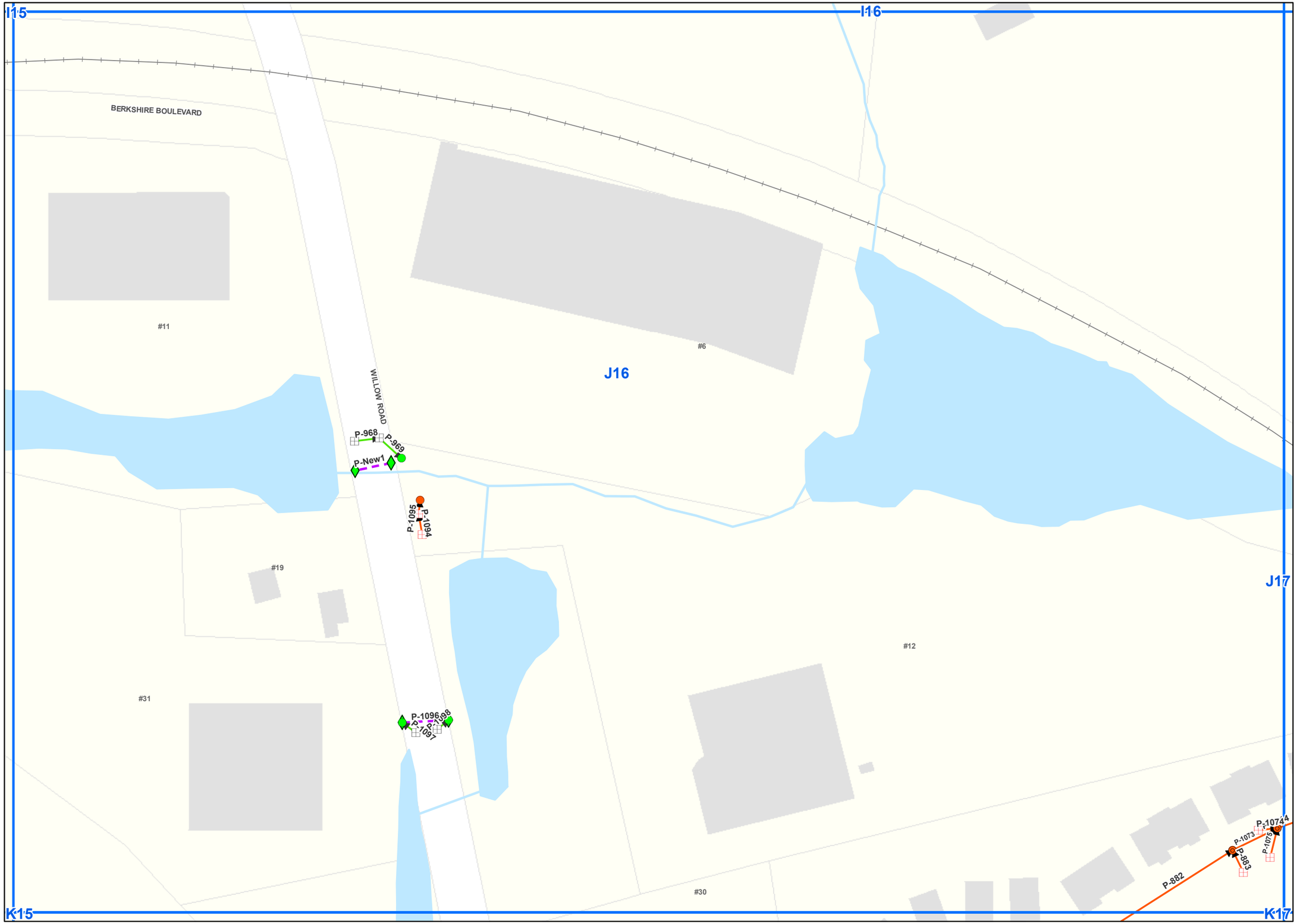
1. Data provided by the Town of Ayer and MassGIS

Page # **J14**

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
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- Stormwater- Outfall
- Stormwater- Vortex
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- Culvert
- Private Drain
- Drain Line
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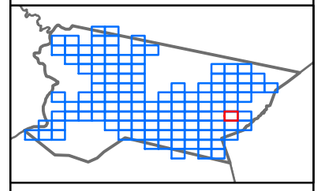
- DetentionBasins

LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

I16

J16

J17

K16

K17

SPECTACLE ROAD

SANDAS POINT ROAD

#6

#12

P-1414

P-1415

P-1416

P-1428

P-1427

P-1417

STORMWATER

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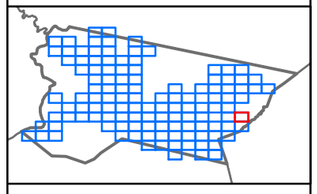
LOCUS MAP



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NOTES

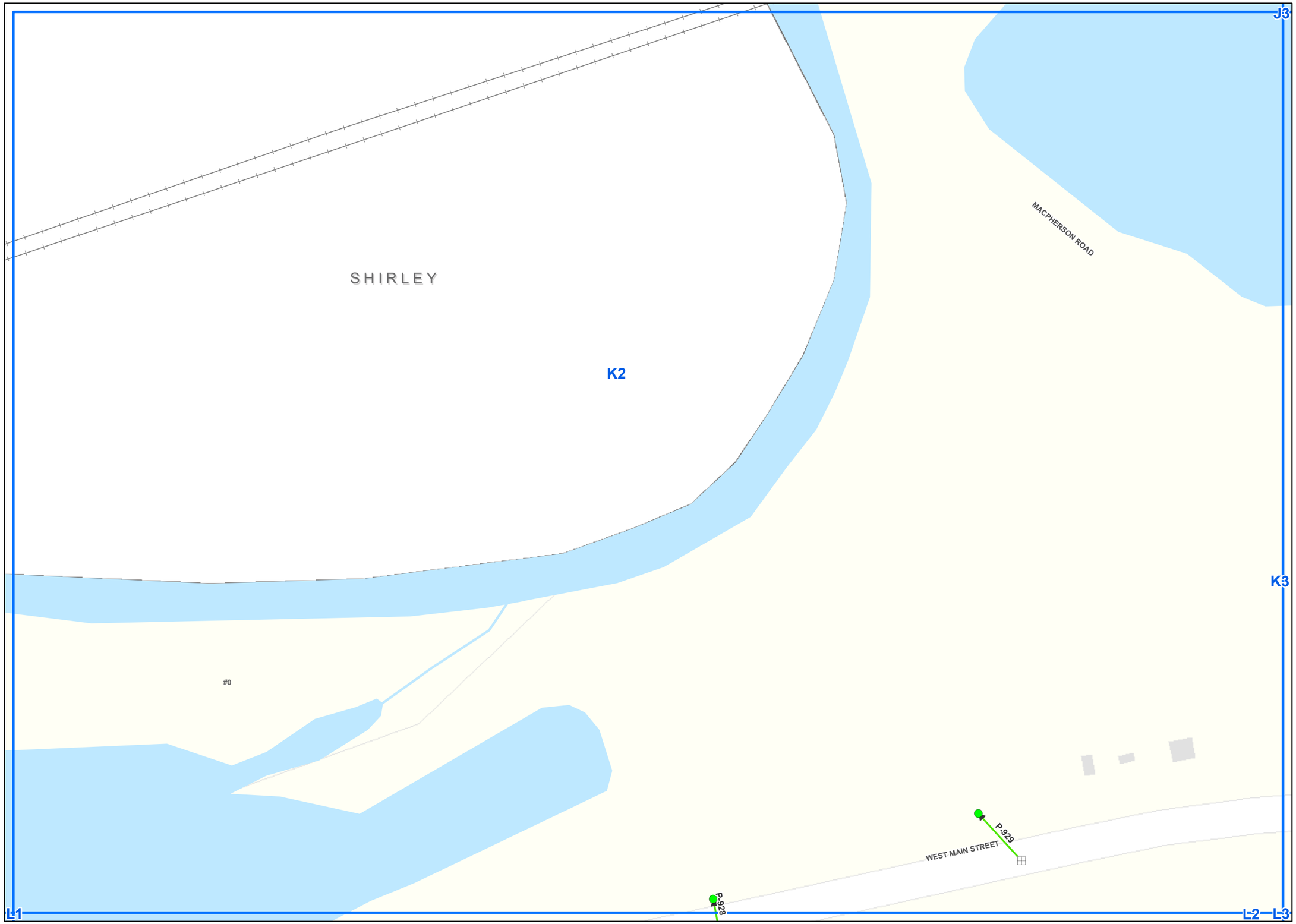
1. Data provided by the Town of Ayer and MassGIS

Page # J17

Ayer, Massachusetts

October 2021

Tighe&Bond



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LOCUS MAP

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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # **K2**

Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

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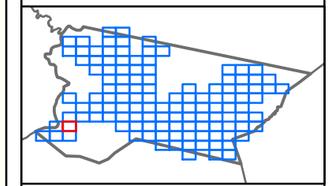
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # **K3**

Ayer, Massachusetts

October 2021

Tighe&Bond

J6 J7 J8

K7 K8

L8

#0 #0 #0

#18

SCHOOL STREET

P-1743

P-1545

STORMWATER

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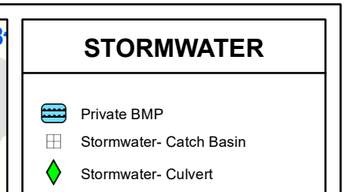
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # K7

Ayer, Massachusetts

October 2021

Tighe&Bond

J7 J8 J9 K7 K8 K9 L8 L9

POND STREET
SCHOOL STREET
WHITCOMB AVENUE
MAPLE STREET
LINDEN STREET
FLETCHER STREET
EAST MAIN STREET
PINE STREET
THIRD STREET
FOURTH STREET
SHELLY LANE

P-631 P-632 P-633 P-634 P-884 P-885
P-1482 P-1480 P-1484 P-1483 P-724 P-723 P-722 P-721 P-720 P-719 P-451
P-1479 P-726 P-725 P-727 P-728 P-729
P-730 P-731 P-733 P-1478 P-736 P-737 P-738 P-739 P-740 P-1472
P-732 P-734 P-735
P-1476 P-1477 P-1473

STORMWATER

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LOCUS MAP

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NOTES

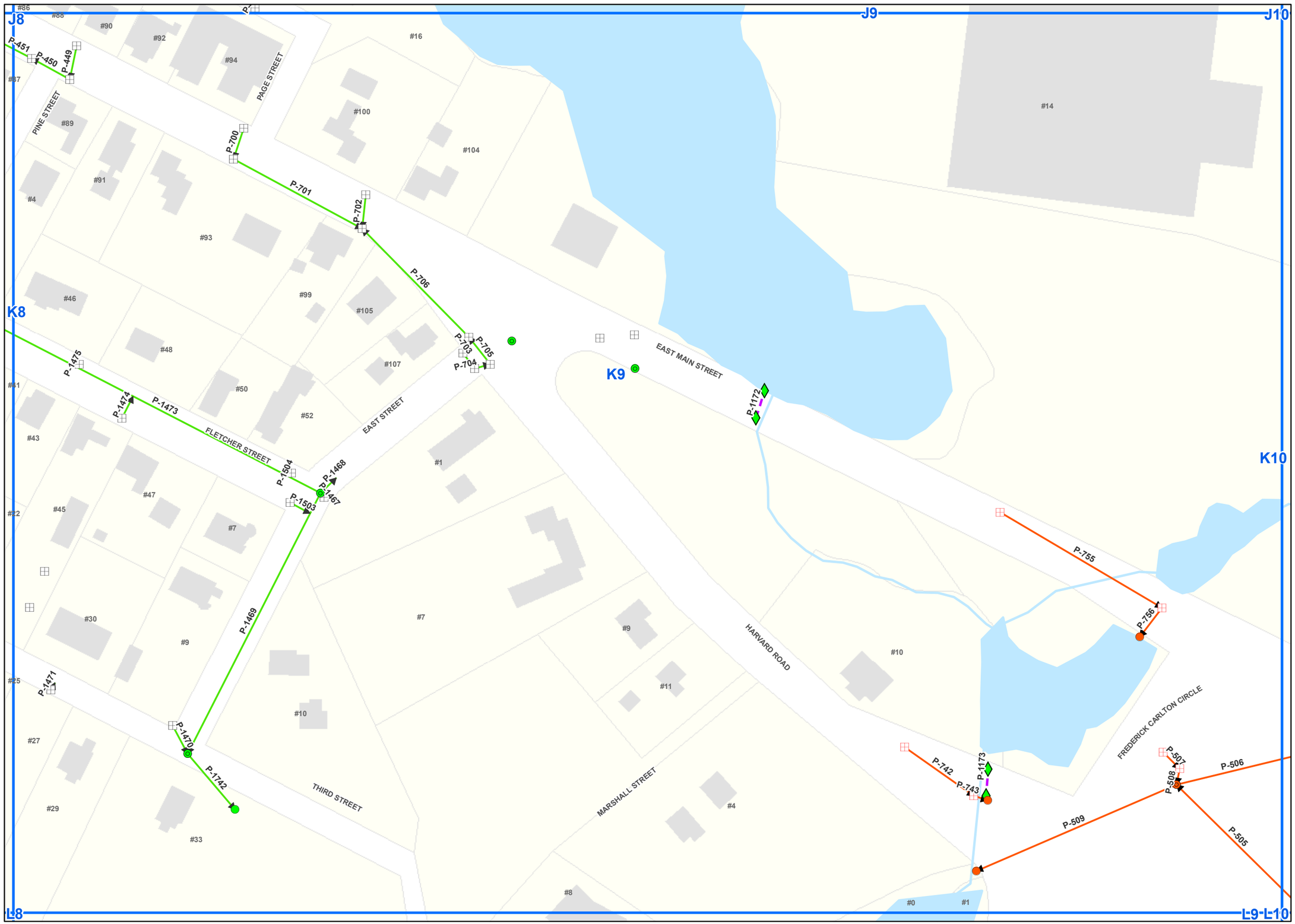
1. Data provided by the Town of Ayer and MassGIS

Page # K8

Ayer, Massachusetts

October 2021

Tighe&Bond



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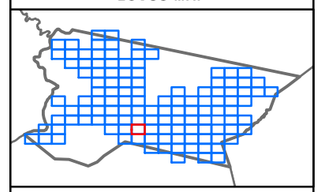
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # K9

Ayer, Massachusetts

October 2021

Tighe&Bond

J9 J10 J11

K9 K10 K11

L9 L11

SANDY POND ROAD

FREDERICK CARLTON CIRCLE

LITTLETON ROAD

DAYBROOK DRIVE

OLD TOWNE ROAD

COPELAND DRIVE

P-1175 P-629 P-627 P-628 P-630 P-621 P-622 P-623 P-624 P-625 P-626 P-506 P-511 P-510 P-505 P-504

#0 #2 #4 #5 #10 #11 #13 #14 #15 #17 #19 #26 #30

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LOCUS MAP

N W E S

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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # K10

Ayer, Massachusetts

October 2021

Tighe&Bond

J10 J11 J12

K10 K11 K12

L10 L12

#4

#25

#10

P-1176

P-589

P-1054

P-1053

COPELAND DRIVE

OLD TOWNE ROAD

COFFMAN WAY

STORMWATER

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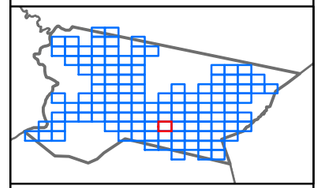
LOCUS MAP



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NOTES

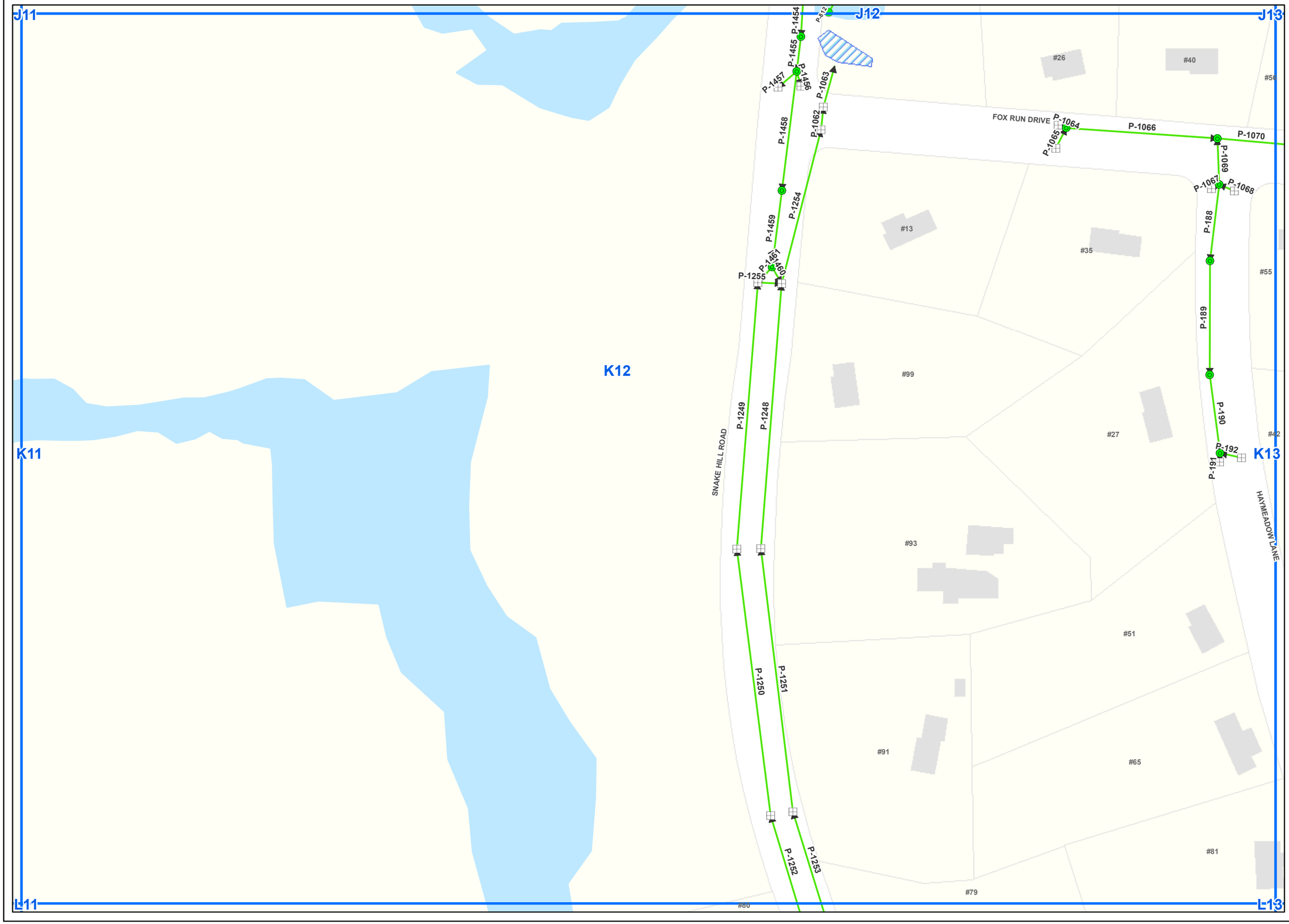
1. Data provided by the Town of Ayer and MassGIS

Page # K11

Ayer, Massachusetts

October 2021

Tighe&Bond



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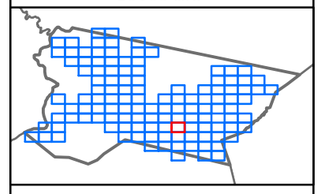

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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # **K12**

Ayer, Massachusetts

October 2021

Tighe&Bond

J12 J13 J14

K12 K13 K14

L12 L14

FOX RUN DRIVE

QUAIL RUN

HAYMEADOW LANE

OLD FARM WAY

#40 #56 #70 #97 #55 #71 #42 #20 #36 #35 #15 #54 #68 #84 #98 #65 #38 #16 #112 #81 #95 #126

P-865 P-814 P-187 P-186 P-1070 P-1071 P-1072 P-185 P-866 P-867 P-868 P-1186 P-198 P-119 P-197 P-194 P-193 P-118 P-1189 P-1191 P-1192 P-1193 P-1194 P-1196 P-1197 P-1198 P-619 P-870 P-121

STORMWATER

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LOCUS MAP

N W E S

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NOTES

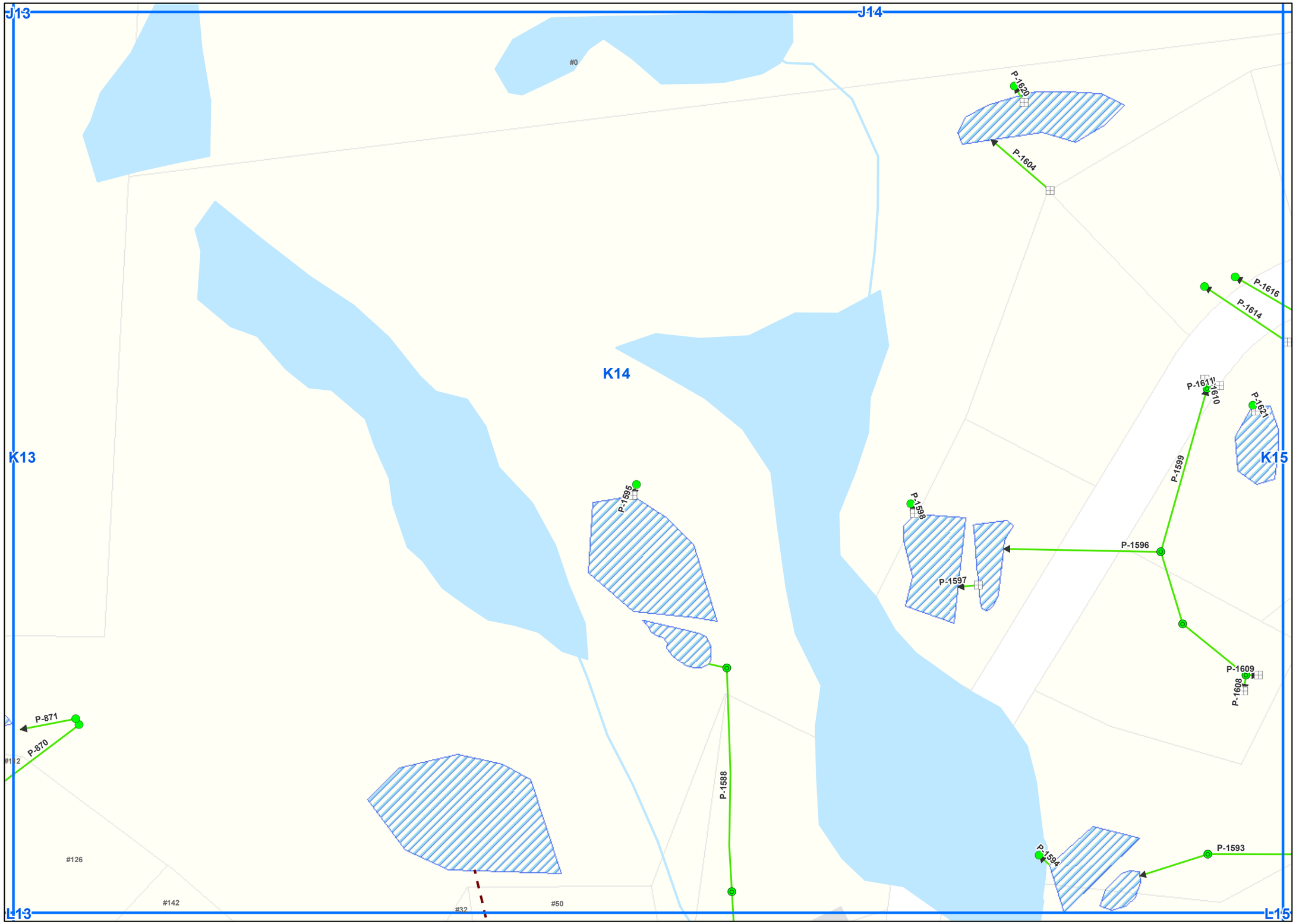
1. Data provided by the Town of Ayer and MassGIS

Page # K13

Ayer, Massachusetts

October 2021

Tighe&Bond



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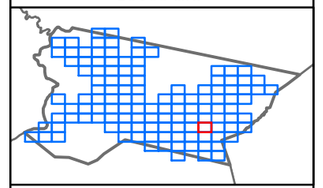
LOCUS MAP



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NOTES

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Ayer, Massachusetts

October 2021

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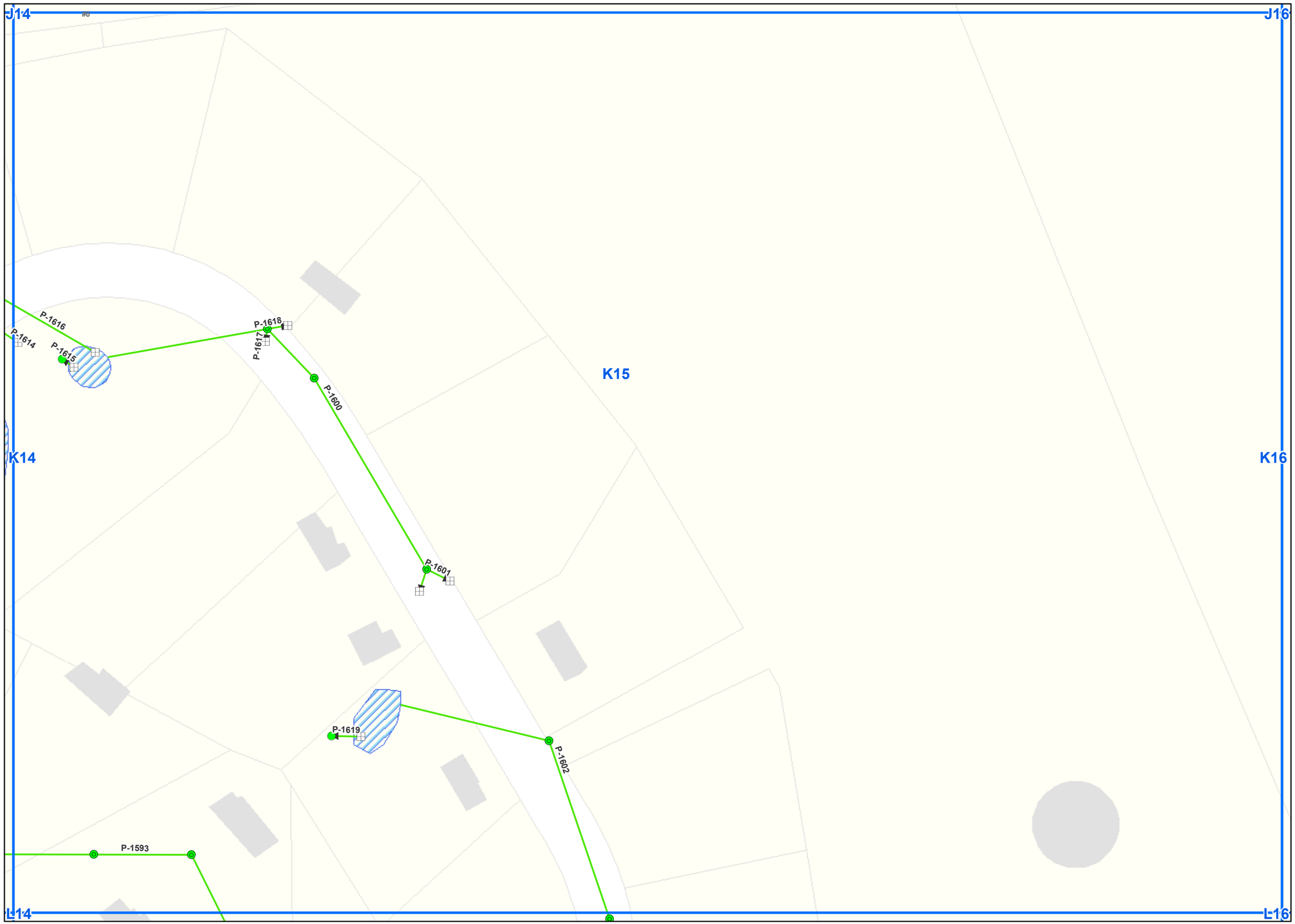

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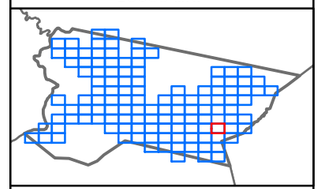

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NOTES

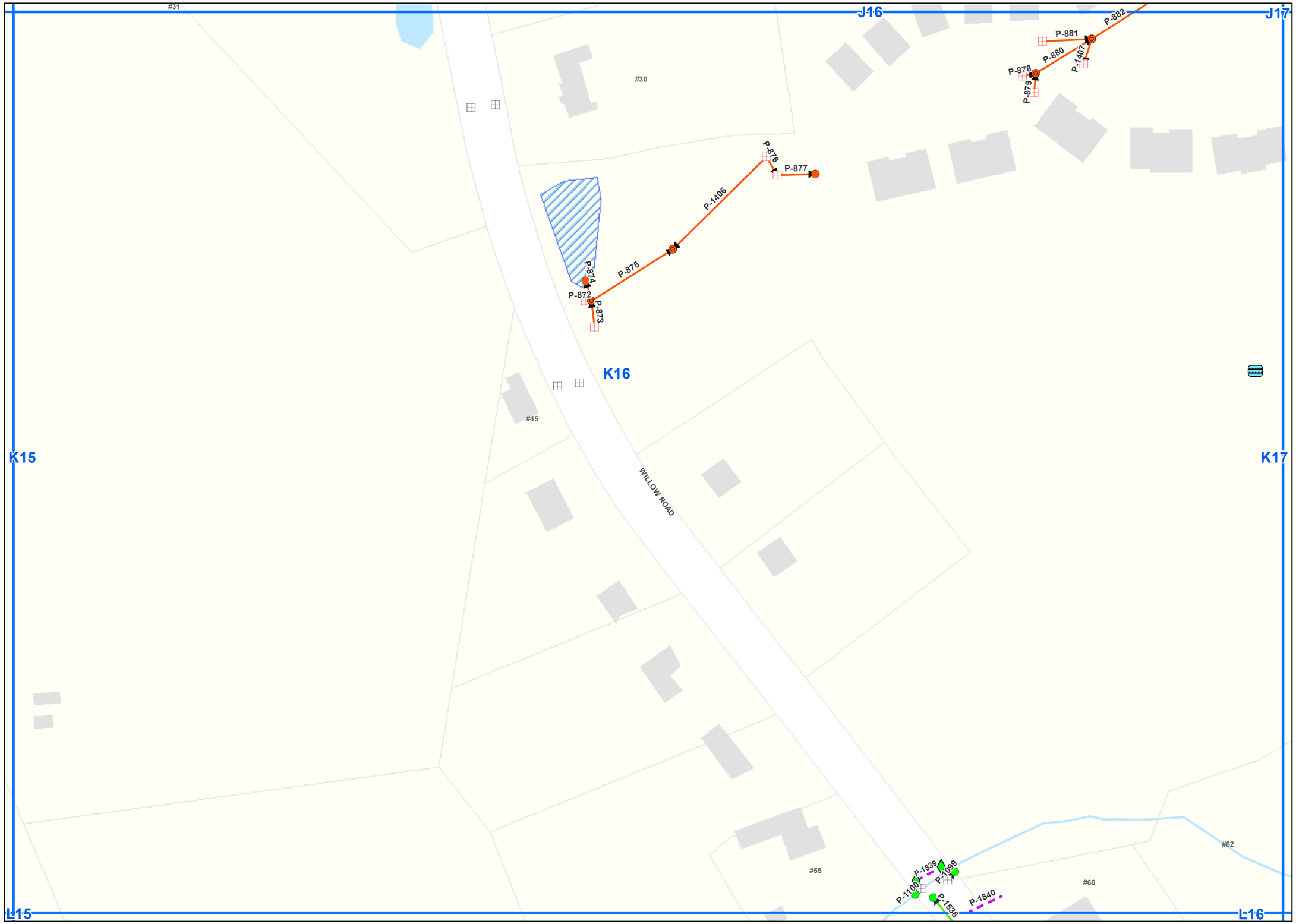
1. Data provided by the Town of Ayer and MassGIS

Page # **K15**

Ayer, Massachusetts

October 2021

Tighe&Bond



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LOCUS MAP

N W E S

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NOTES

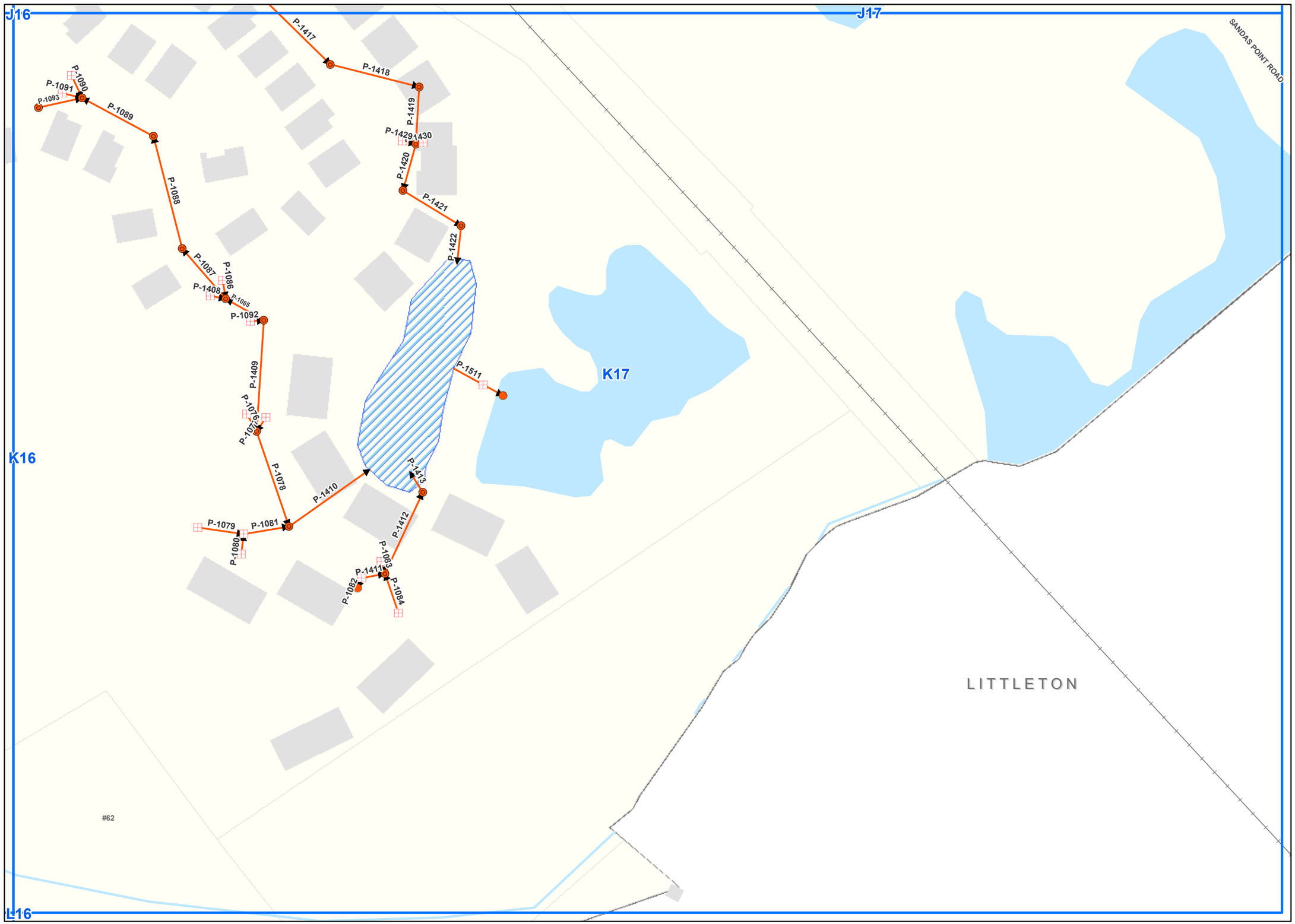
1. Data provided by the Town of Ayer and MassGIS

Page # **K16**

Ayer, Massachusetts

October 2021

Tighe&Bond



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LOCUS MAP

N W E S

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Feet

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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # **K17**

Ayer, Massachusetts

October 2021

Tighe&Bond

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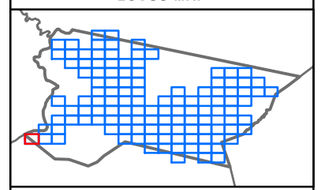
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # L1

Ayer, Massachusetts

October 2021

Tighe&Bond

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LOCUS MAP

N W E S

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Feet

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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # L2

Ayer, Massachusetts

October 2021

Tighe&Bond

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LOCUS MAP

N W E S

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Feet

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NOTES

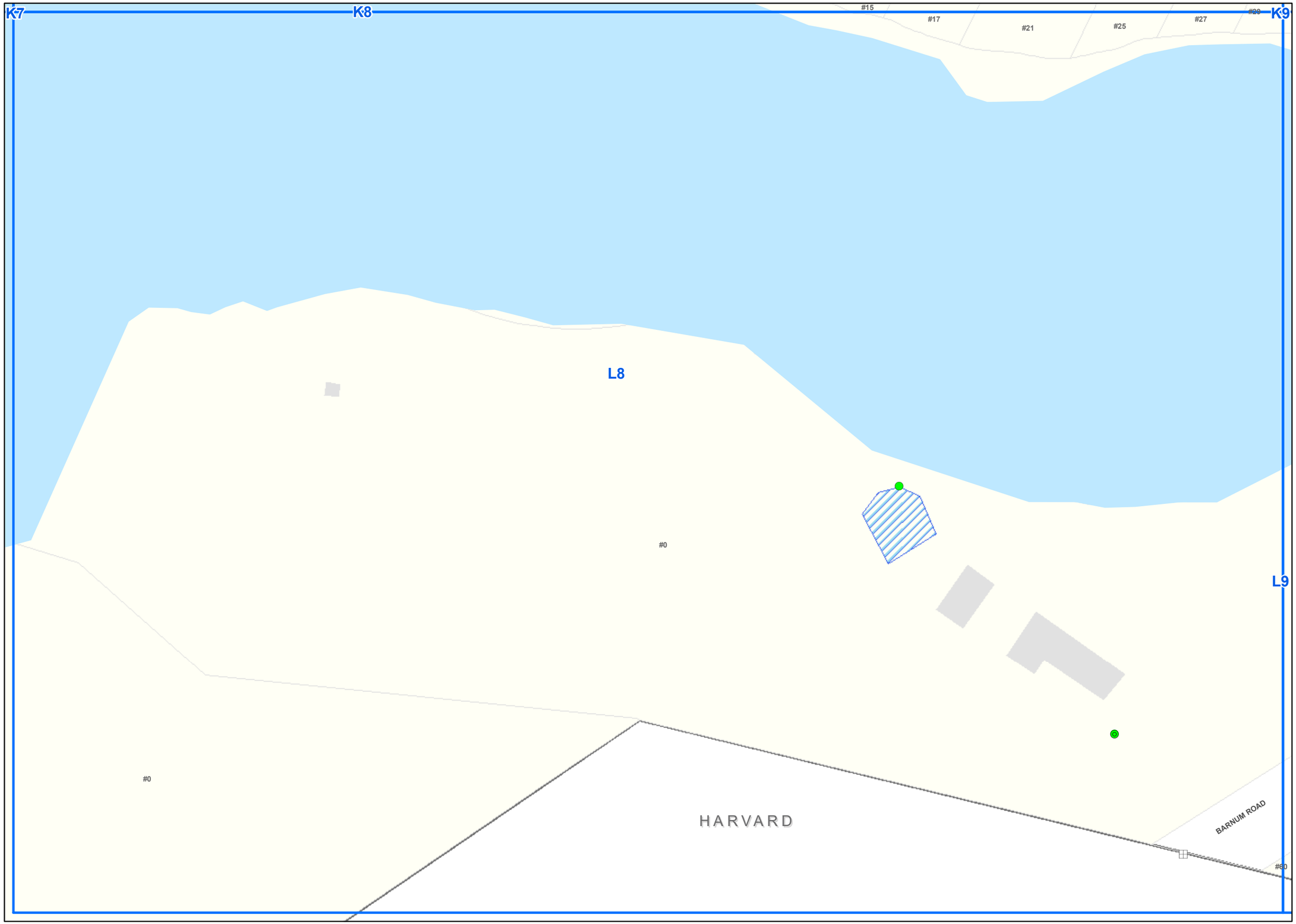
1. Data provided by the Town of Ayer and MassGIS

Page # **L3**

Ayer, Massachusetts

October 2021

Tighe&Bond



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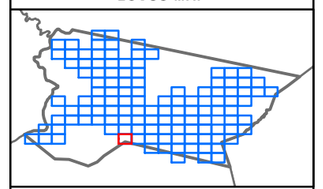
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # L8

Ayer, Massachusetts

October 2021

Tighe&Bond

STORMWATER

- Private BMP
- Stormwater- Catch Basin
- Stormwater- Culvert
- Stormwater- Detention Area
- Stormwater- Manhole
- Stormwater- Outfall
- Stormwater- Vortex
- Private Stormwater- Catch Basin
- Private Stormwater- Culvert
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- Private Stormwater- Manhole
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- Private Stormwater- Trap
- Private Stormwater- Vortex
- Ditch
- Swale
- Abandoned Drain
- Culvert
- Private Drain
- Drain Line
- Town Owned Rain Gardens
- DetentionBasins

LOCUS MAP

N W E S

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NOTES

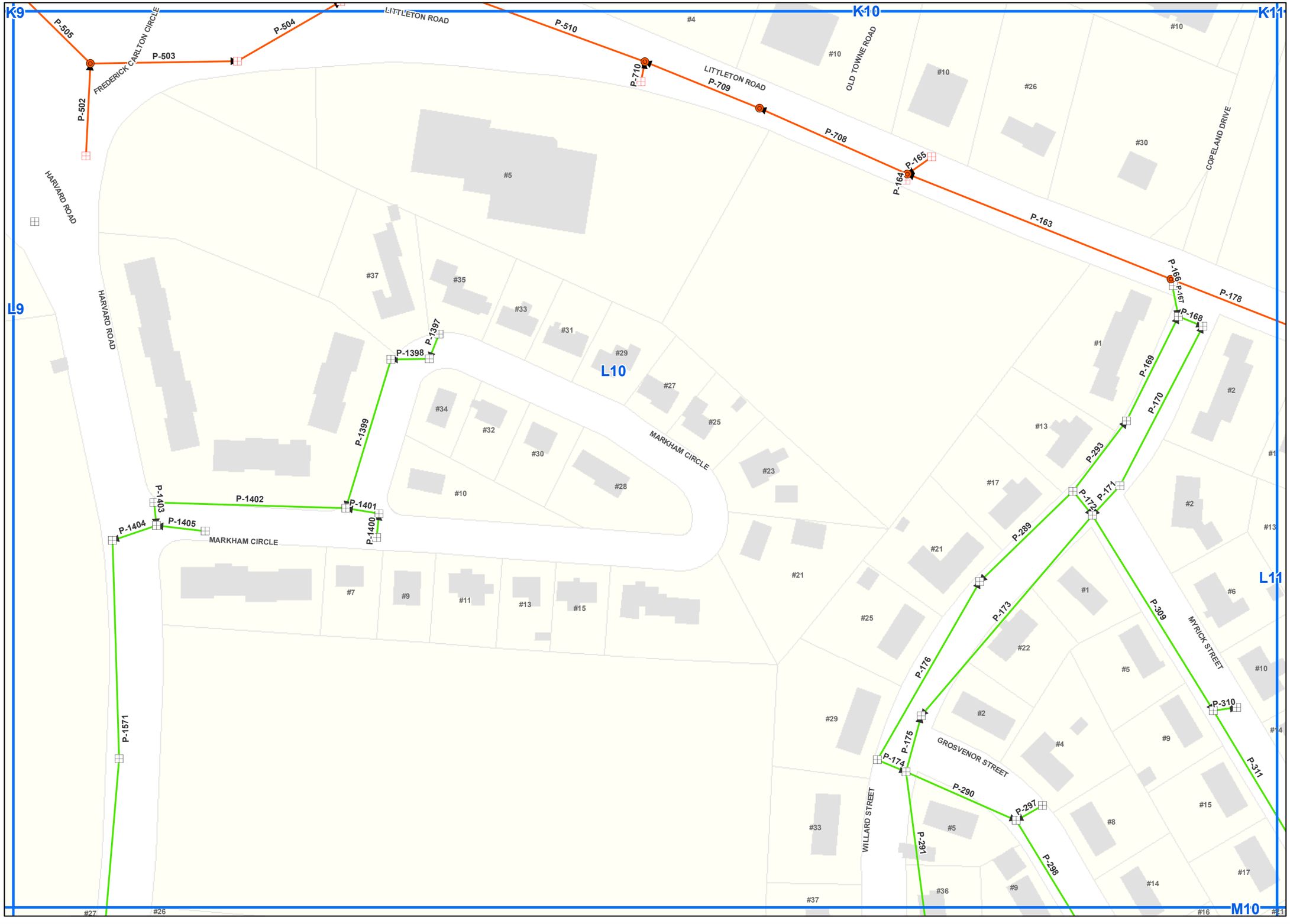
1. Data provided by the Town of Ayer and MassGIS

Page # L9

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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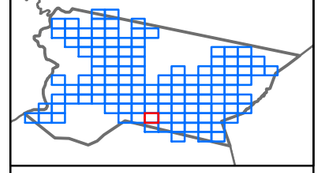
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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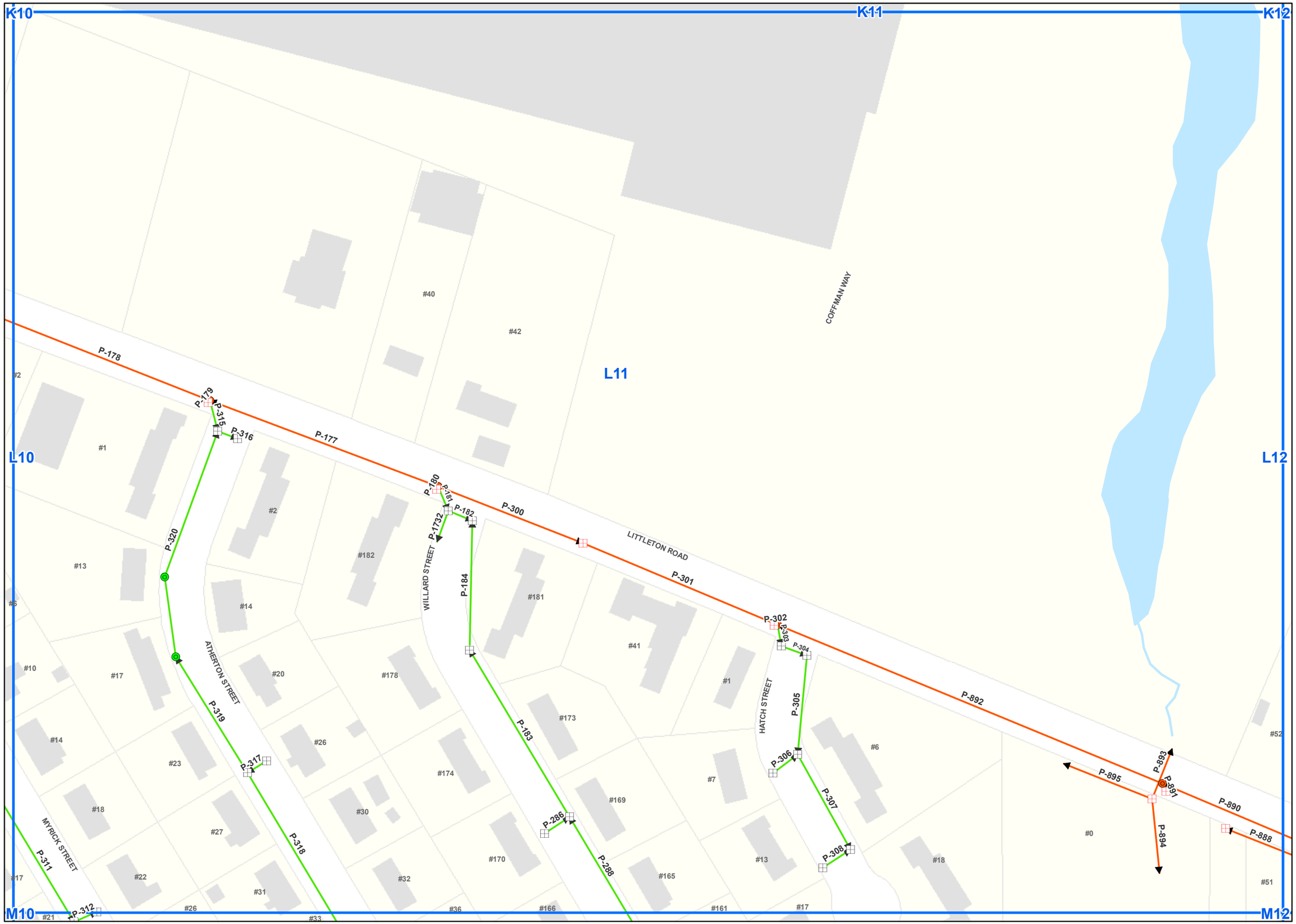
Ayer, Massachusetts

October 2021

Tighe&Bond



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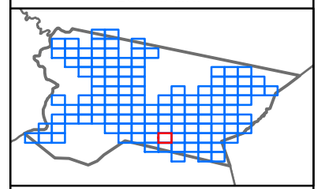
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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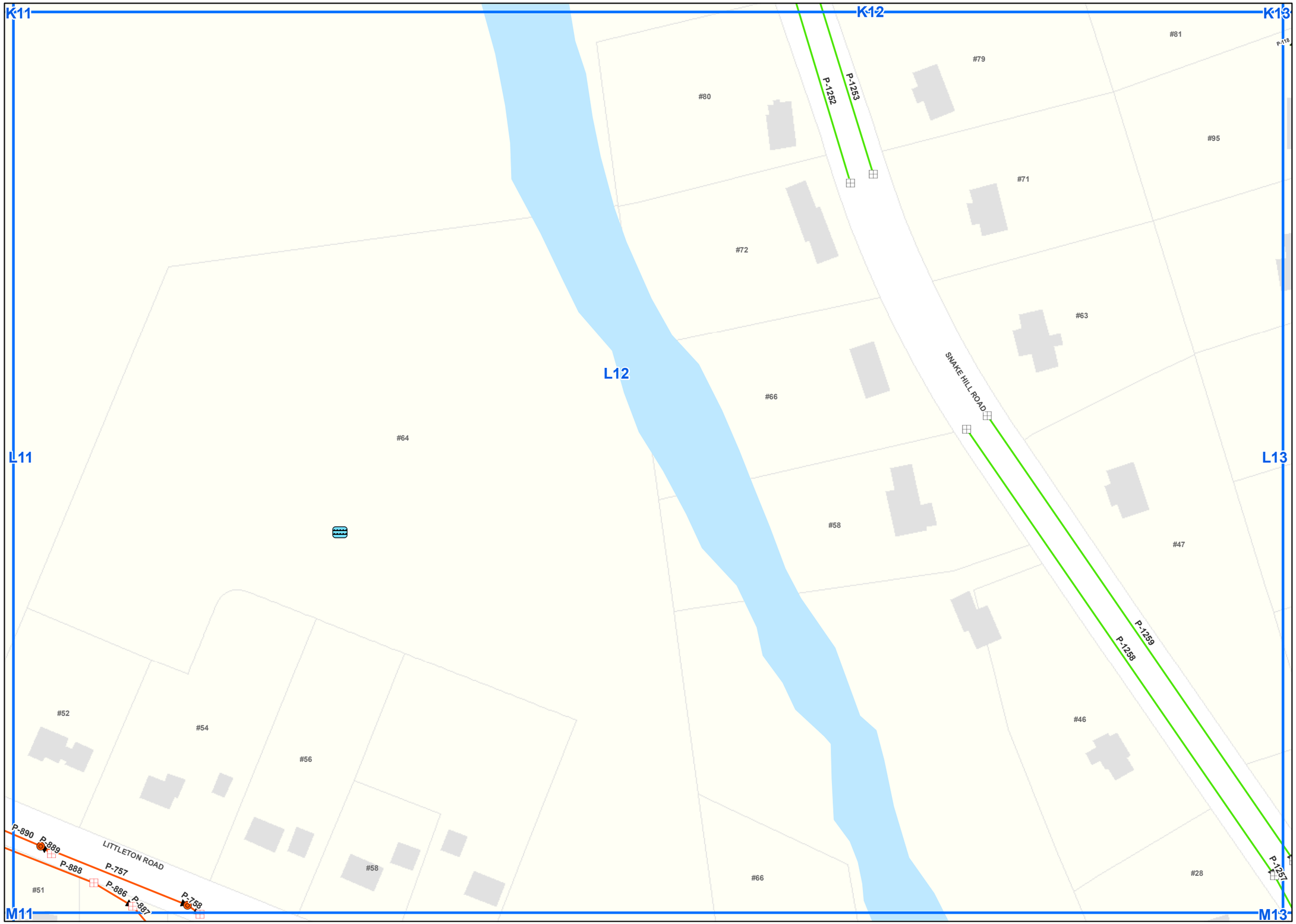
Ayer, Massachusetts

October 2021

Tighe&Bond



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LOCUS MAP

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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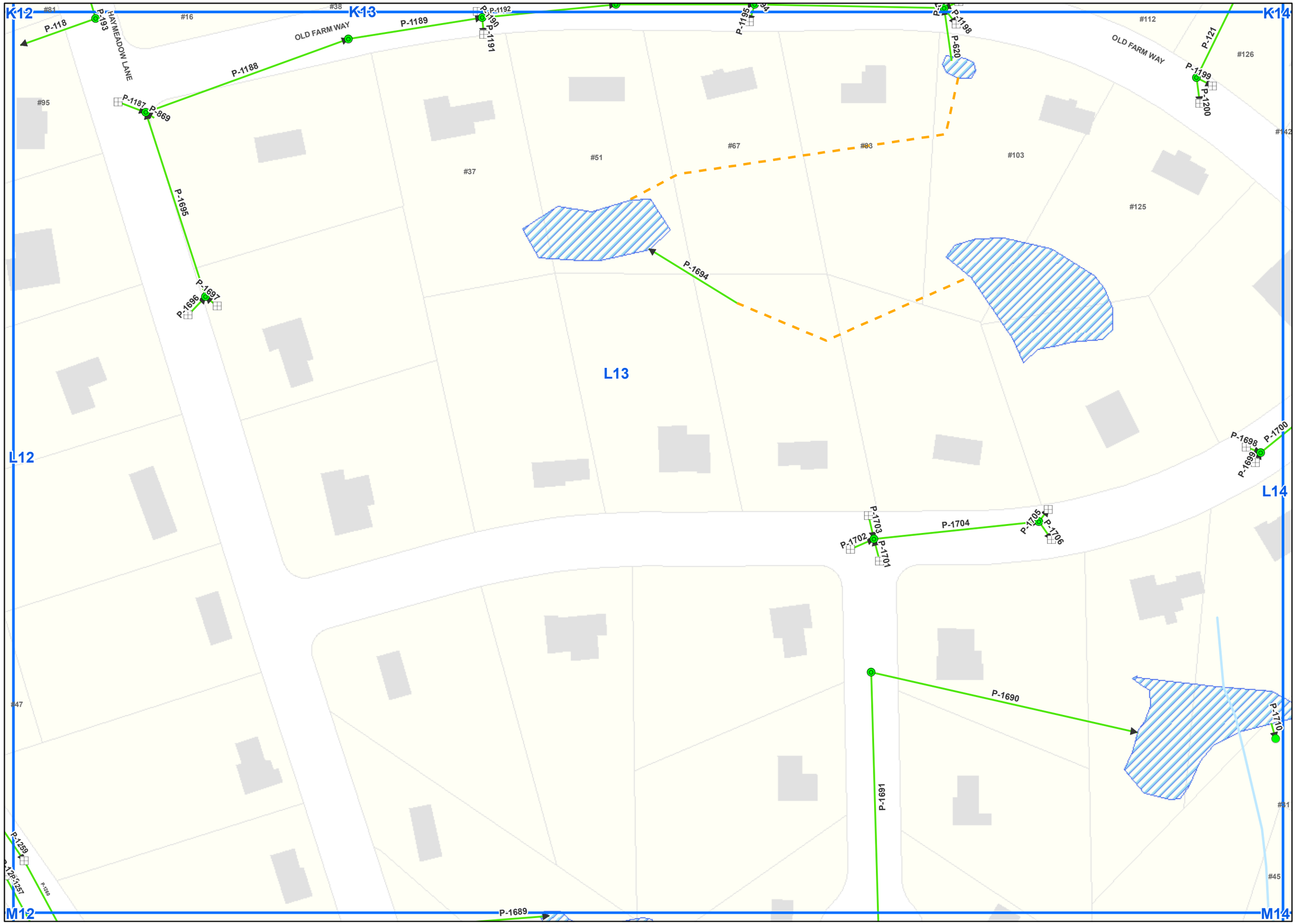
Ayer, Massachusetts

October 2021

Tighe&Bond



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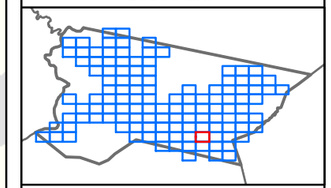
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

K13 K14 K15

L13 L14 L15

M13 M15

#126 #142 #50 #32 #14 #33 #15 #214 #187 #31 #45 #34

DEER RUN PARTRIDGE RUN OLD FARM WAY HICKORY WAY

P-1588 P-1605 P-1589 P-1607 P-1609 P-1612 P-1590 P-1623 P-1622 P-1613

P-811 P-940 P-941 P-942 P-943 P-668

P-676 P-677 P-675 P-1700 P-674 P-671 P-673 P-670 P-672 P-669 P-120

P-808 P-804 P-805 P-806 P-807

P-127 P-678 P-126 P-124 P-125

P-680 P-681 P-682 P-683 P-679

P-1710

STORMWATER

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LOCUS MAP

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NOTES

1. Data provided by the Town of Ayer and MassGIS

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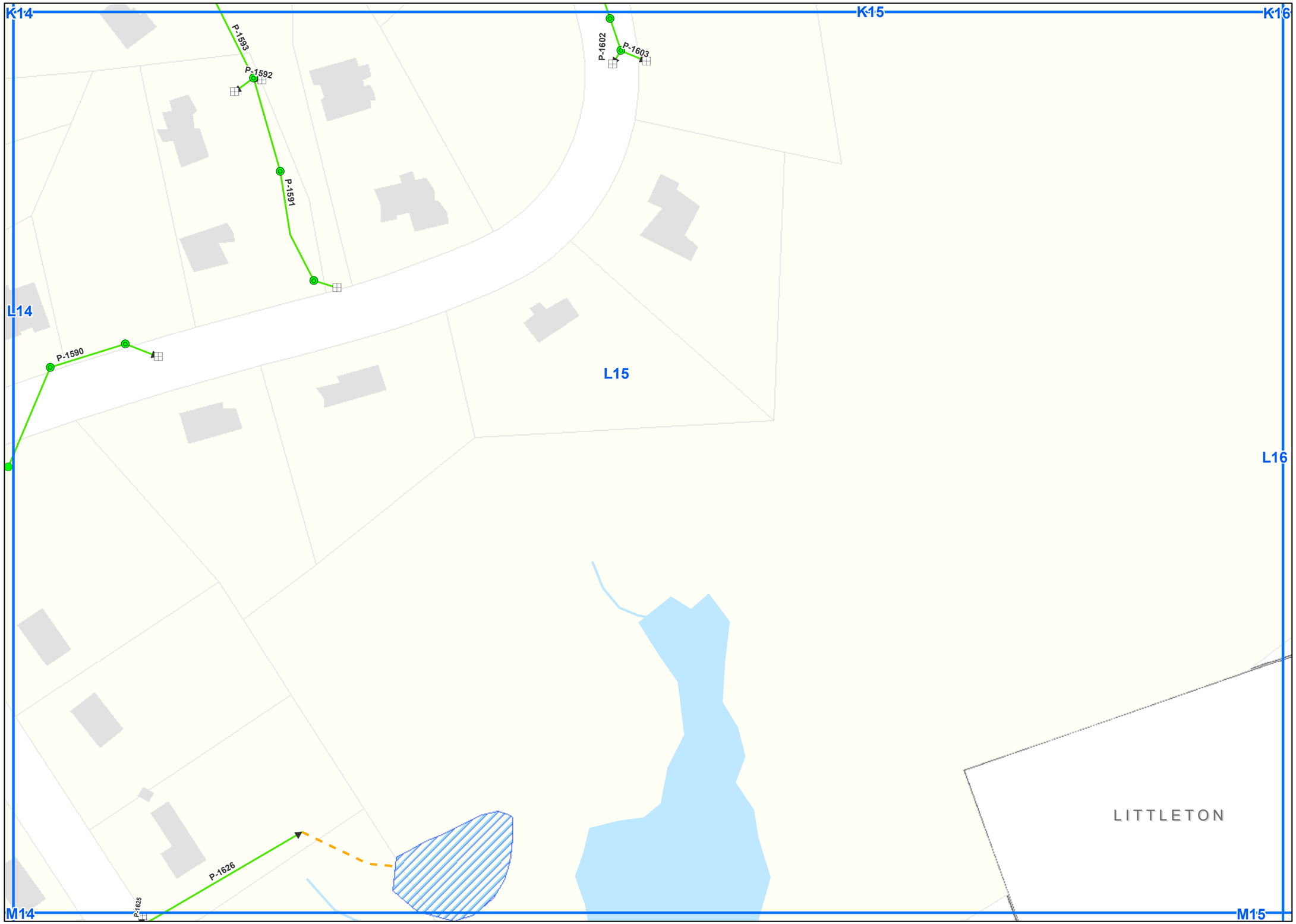
Ayer, Massachusetts

October 2021

Tighe&Bond



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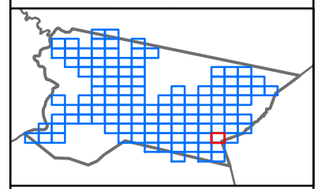
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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Ayer, Massachusetts

October 2021

Tighe&Bond

K15

K16

K17

L15

L16

M15

#55

#60

#62

#62

#64

#59

#192

#190

P-1538

WILLOW ROAD

LITTLETON ROAD

LITTLETON

STORMWATER

- Private BMP
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LOCUS MAP

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NOTES

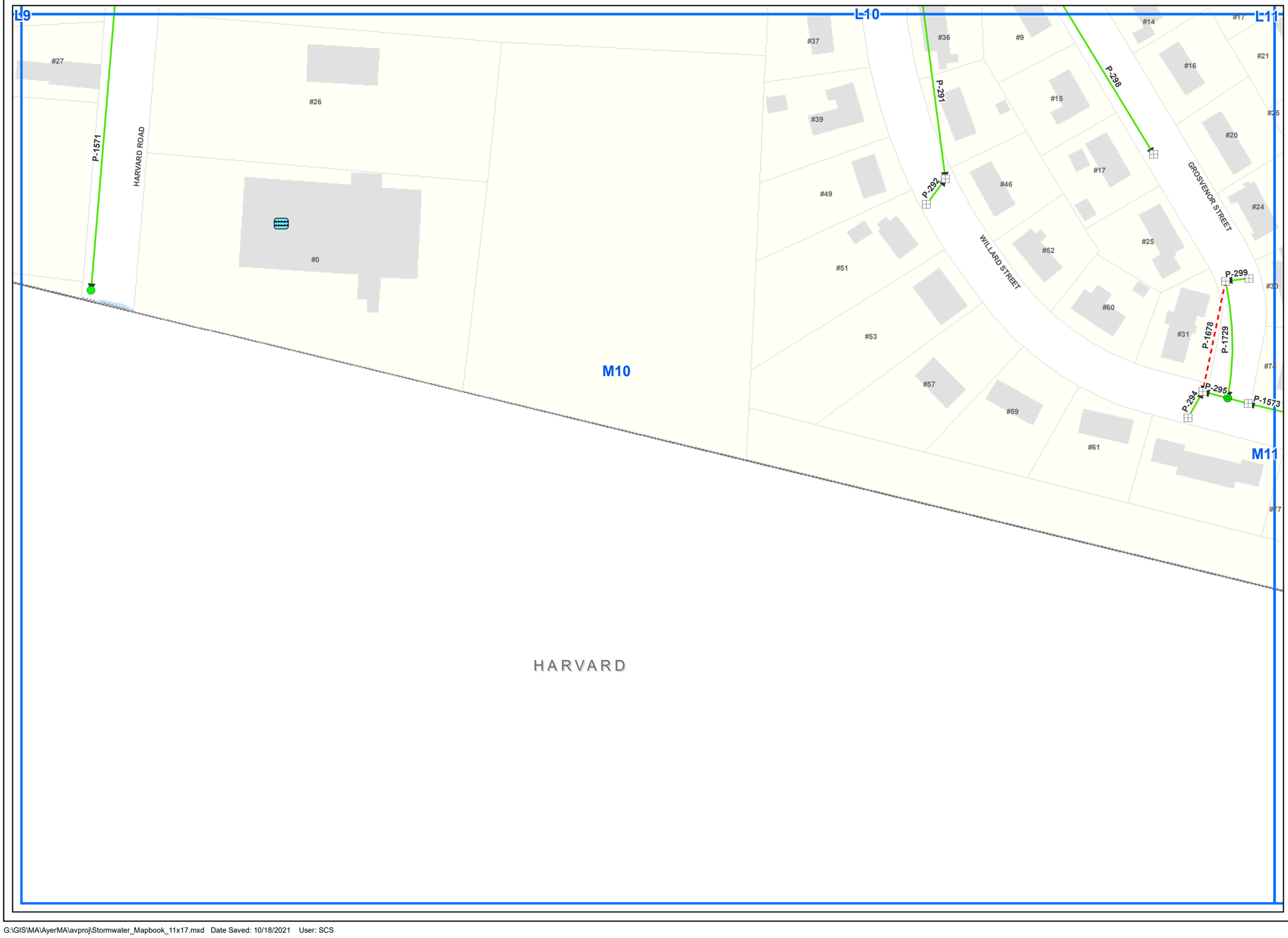
1. Data provided by the Town of Ayer and MassGIS

Page # L16

Ayer, Massachusetts

October 2021

Tighe&Bond



STORMWATER

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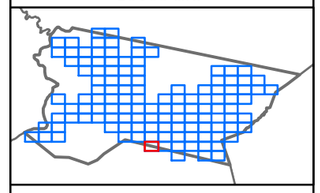
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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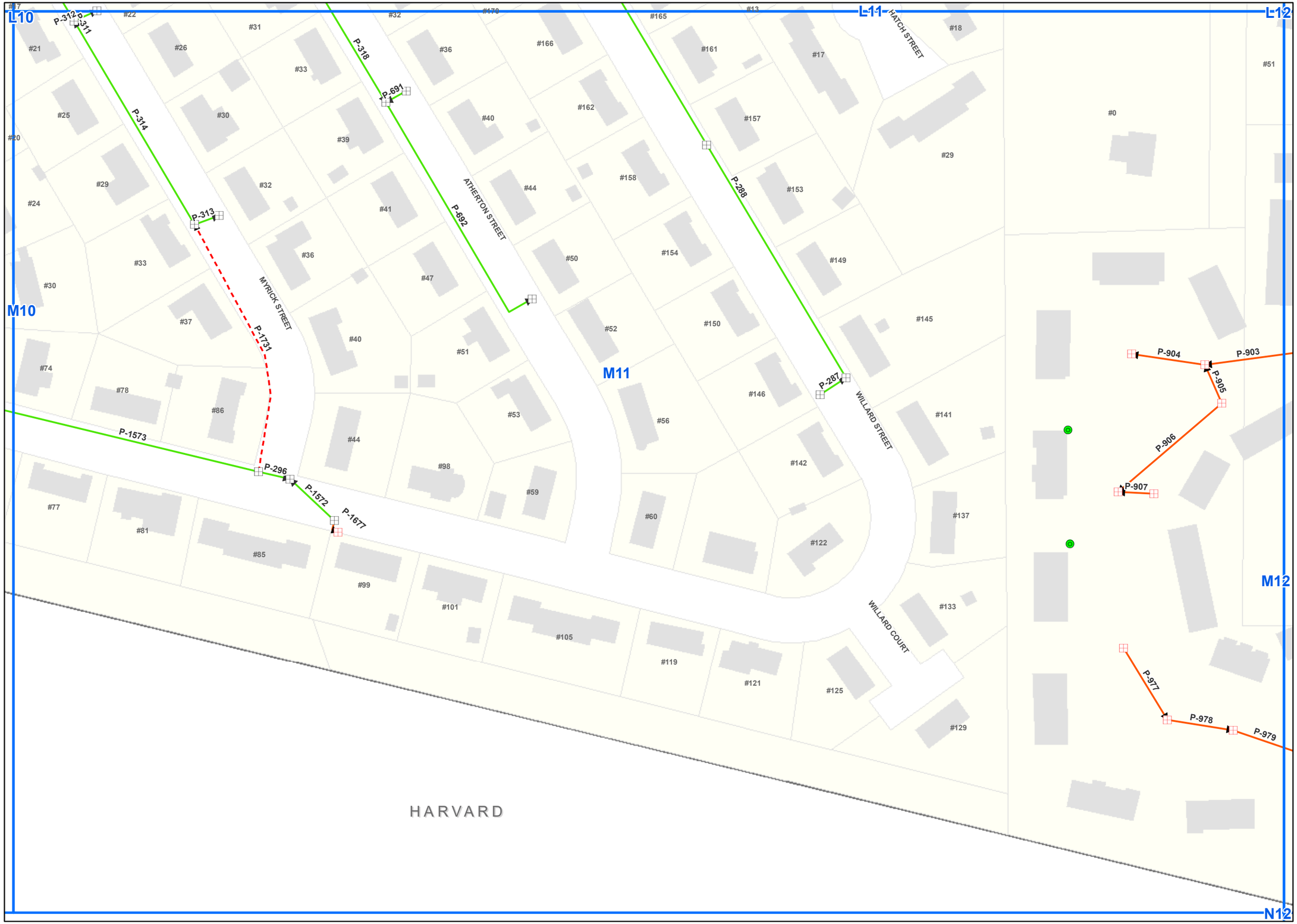
Ayer, Massachusetts

October 2021

Tighe&Bond



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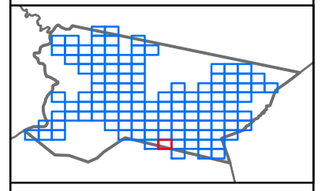
LOCUS MAP



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NOTES

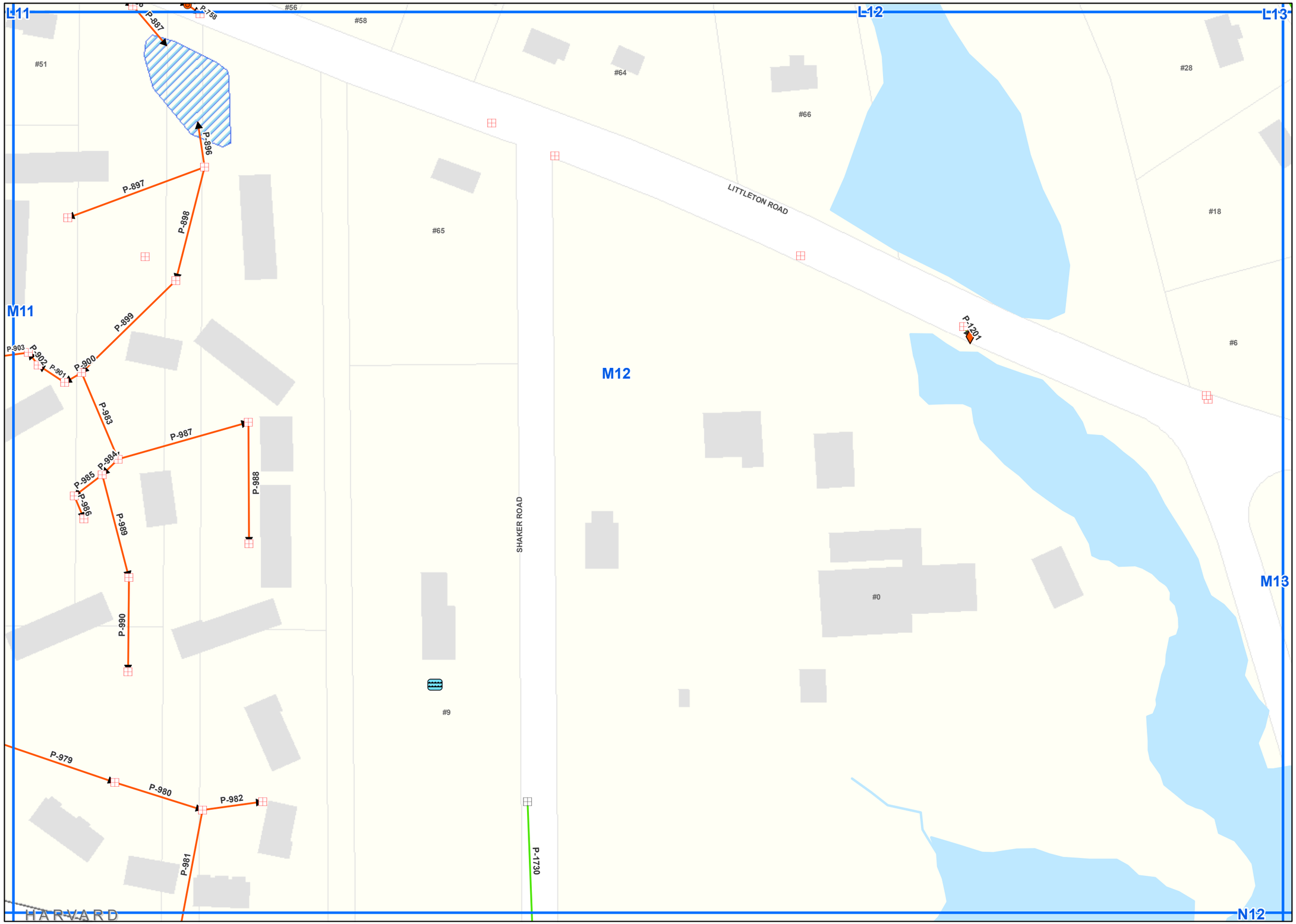
1. Data provided by the Town of Ayer and MassGIS

Page # **M11**

Ayer, Massachusetts

October 2021

Tighe&Bond



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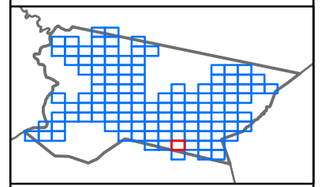
LOCUS MAP



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NOTES

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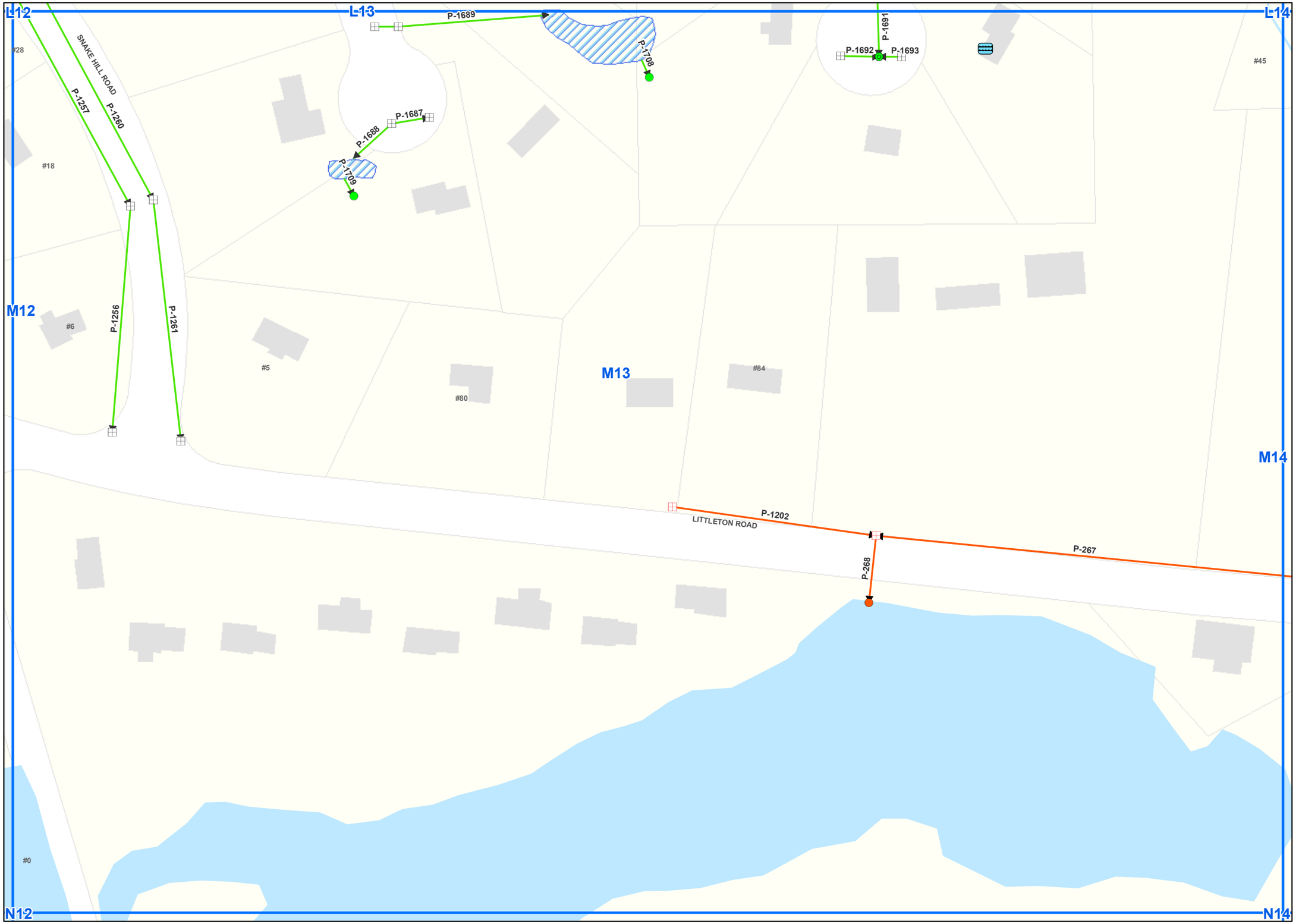
Page # **M12**

Ayer, Massachusetts

October 2021

Tighe&Bond



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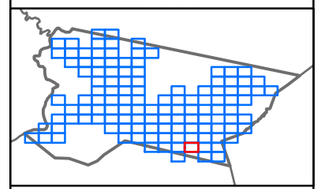
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

Page # **M13**

Ayer, Massachusetts

October 2021

Tighe&Bond

L13 L14 L15 M13 M14 M15 N15

PARTRIDGE RUN
HICKORY WAY
OLD FARM WAY
BENNETTS CROSSING
LITTLETON ROAD

#0 #2 #4 #6 #8 #31 #45 #34 #8 #117

P-122 P-123 P-1707 P-797 P-798 P-799 P-800 P-265 P-1390 P-263 P-267 P-285 P-803 P-2841 P-801 P-802 P-266 P-128 P-687 P-688 P-689 P-690 P-686 P-684 P-685 P-809 P-810 P-269 P-771 P-772 P-773 P-774

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LOCUS MAP

N W E S

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Feet

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NOTES

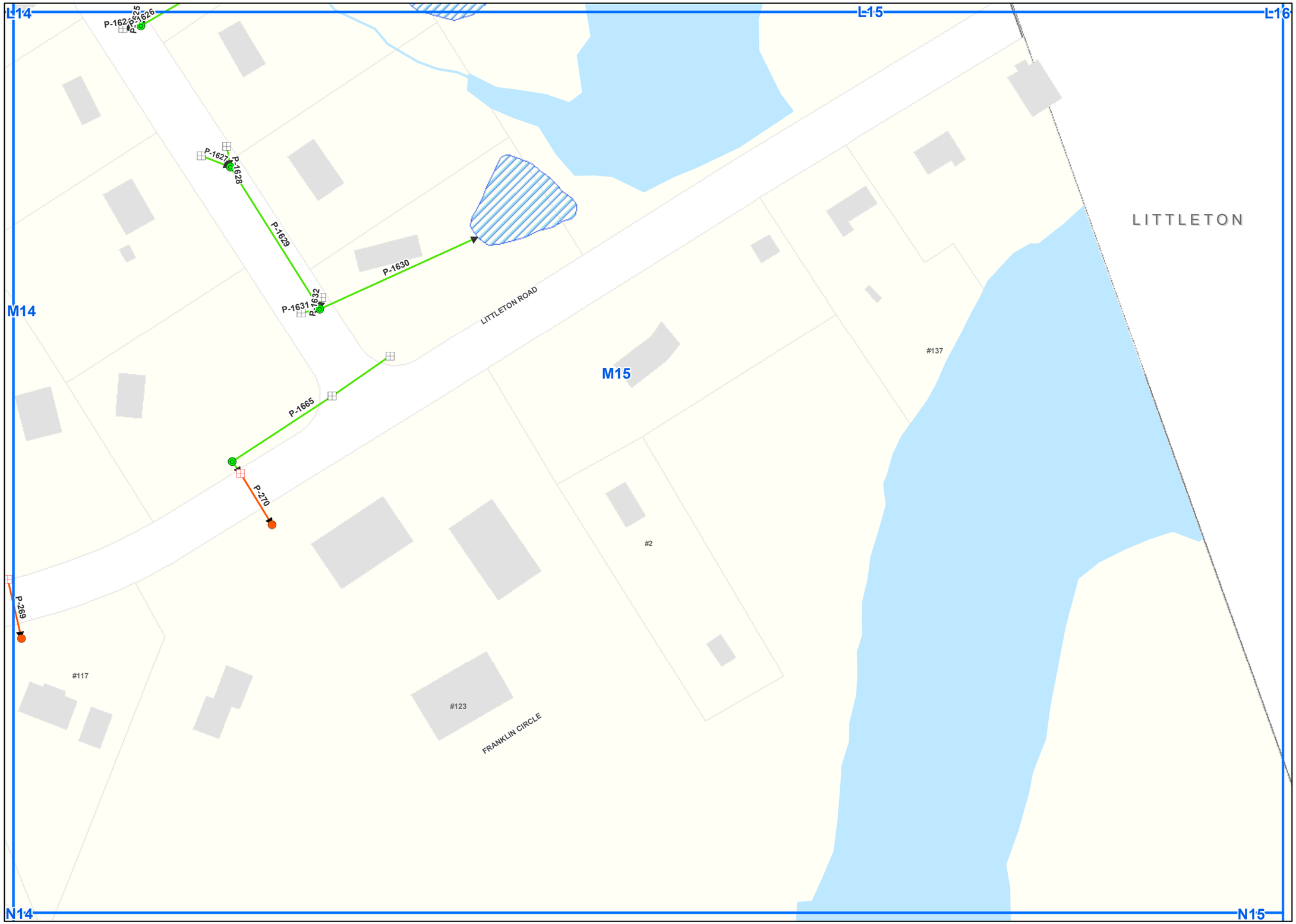
1. Data provided by the Town of Ayer and MassGIS

Page # **M14**

Ayer, Massachusetts

October 2021

Tighe&Bond



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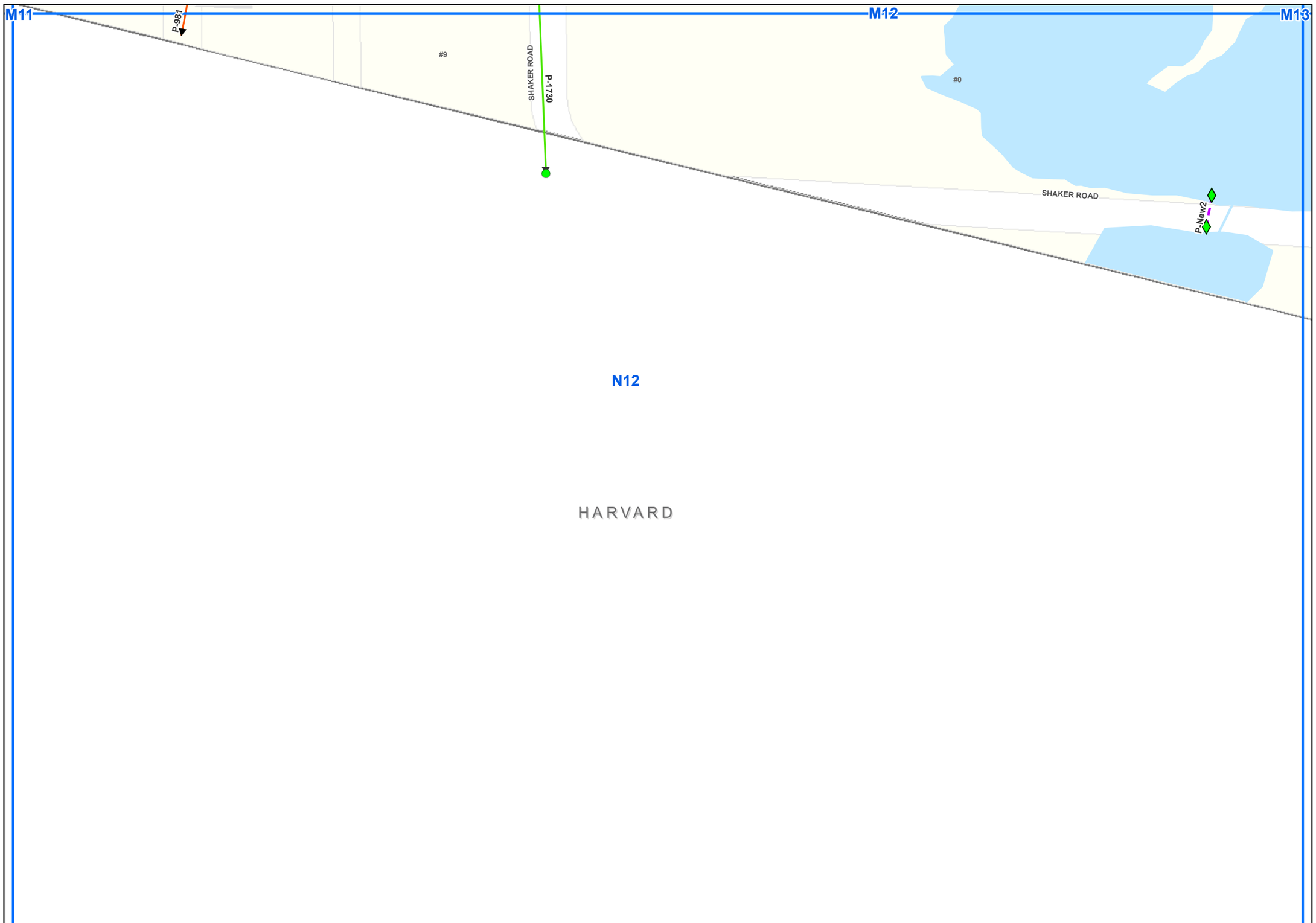

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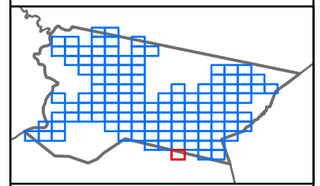
LOCUS MAP



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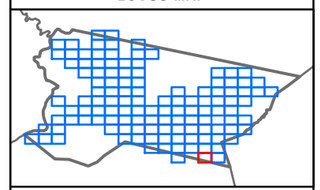

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October 2021

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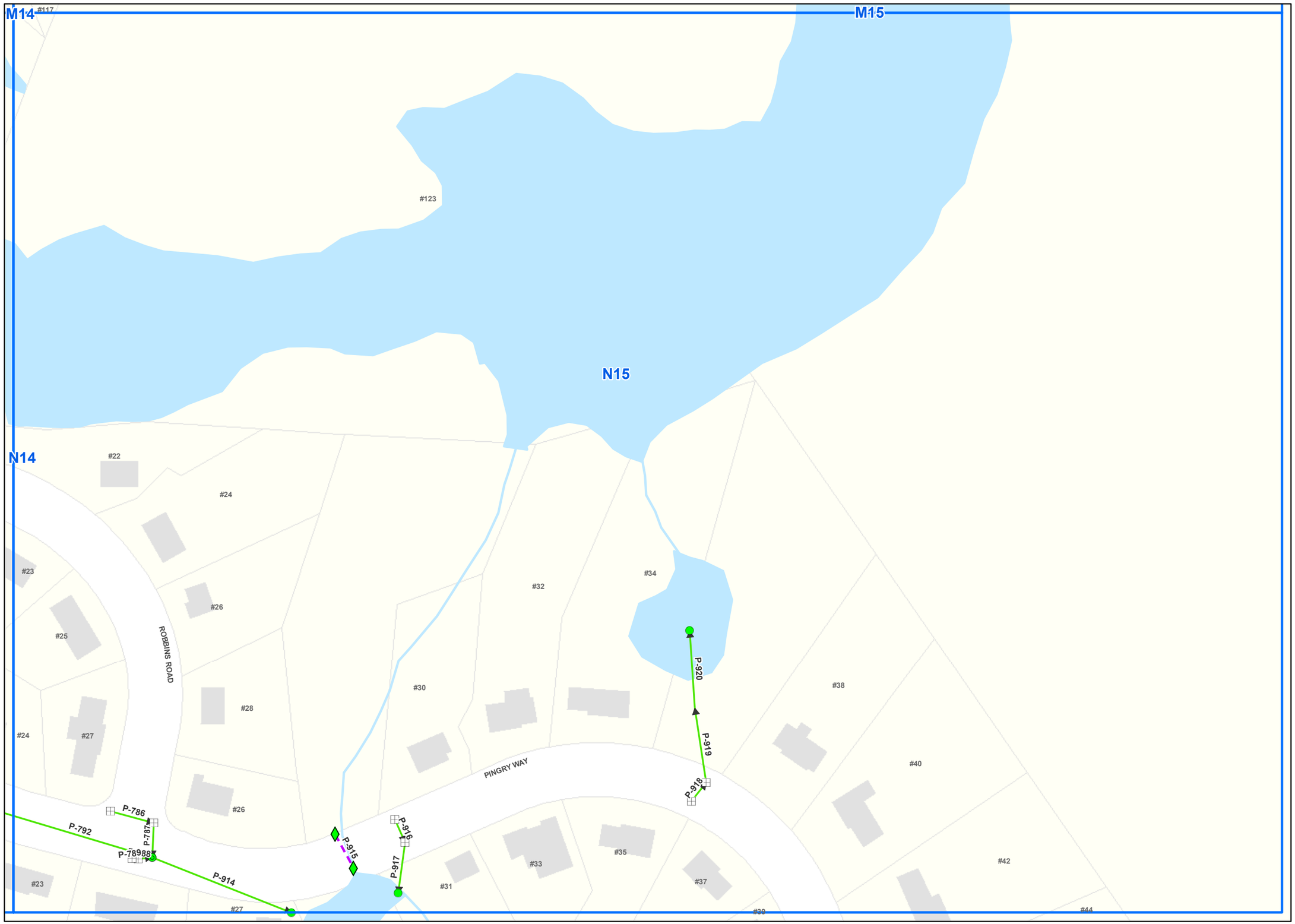

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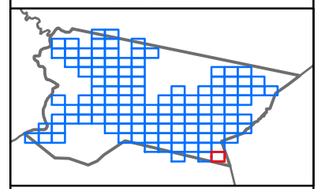
LOCUS MAP



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NOTES

1. Data provided by the Town of Ayer and MassGIS

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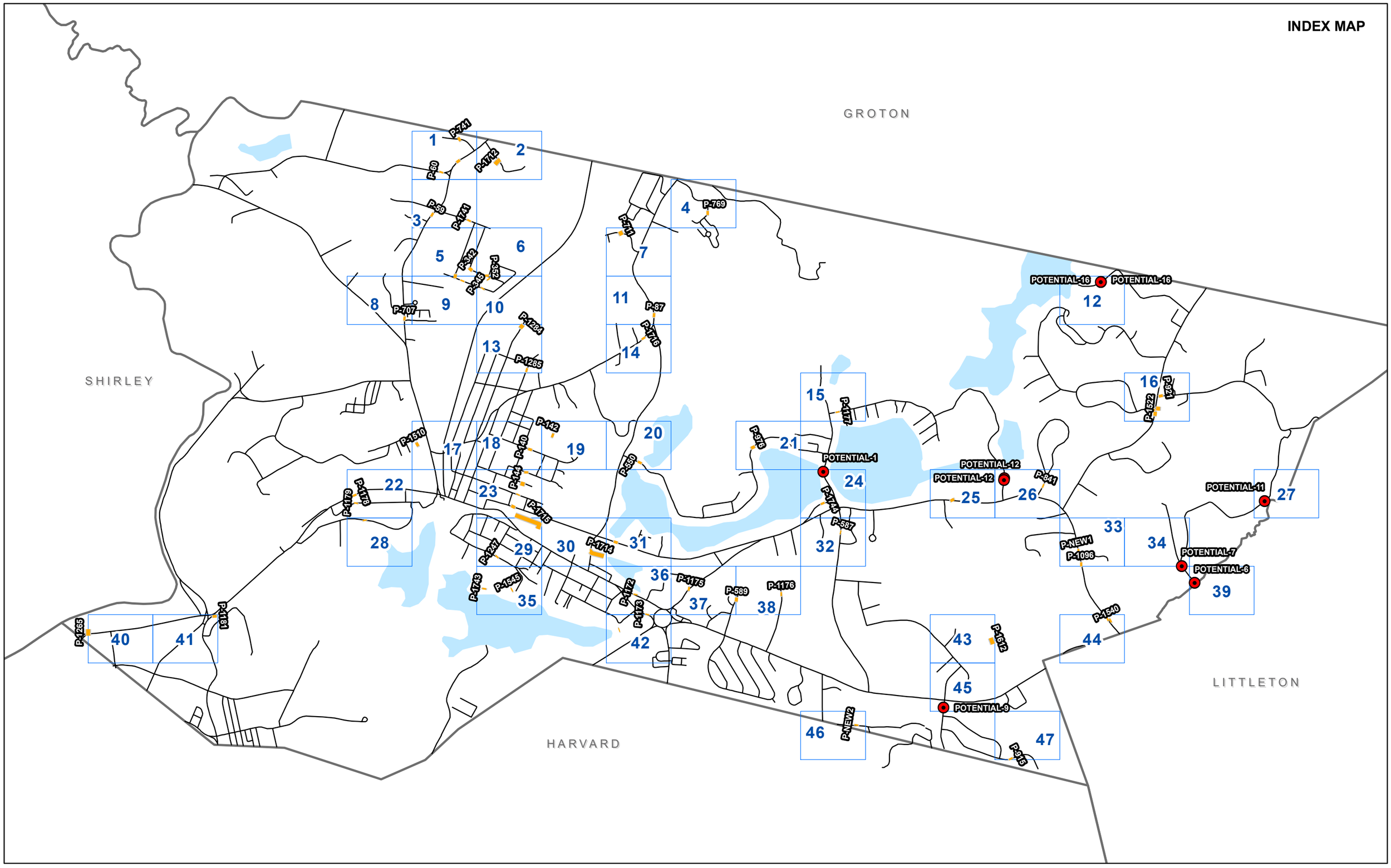
Ayer, Massachusetts

October 2021

Tighe&Bond

INDEX MAP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HARVARD
LITTLETON
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P-1177
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P-921
P-841
P-NEW1
P-1096
P-1540
P-4612
P-NEW2
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POTENTIAL-16
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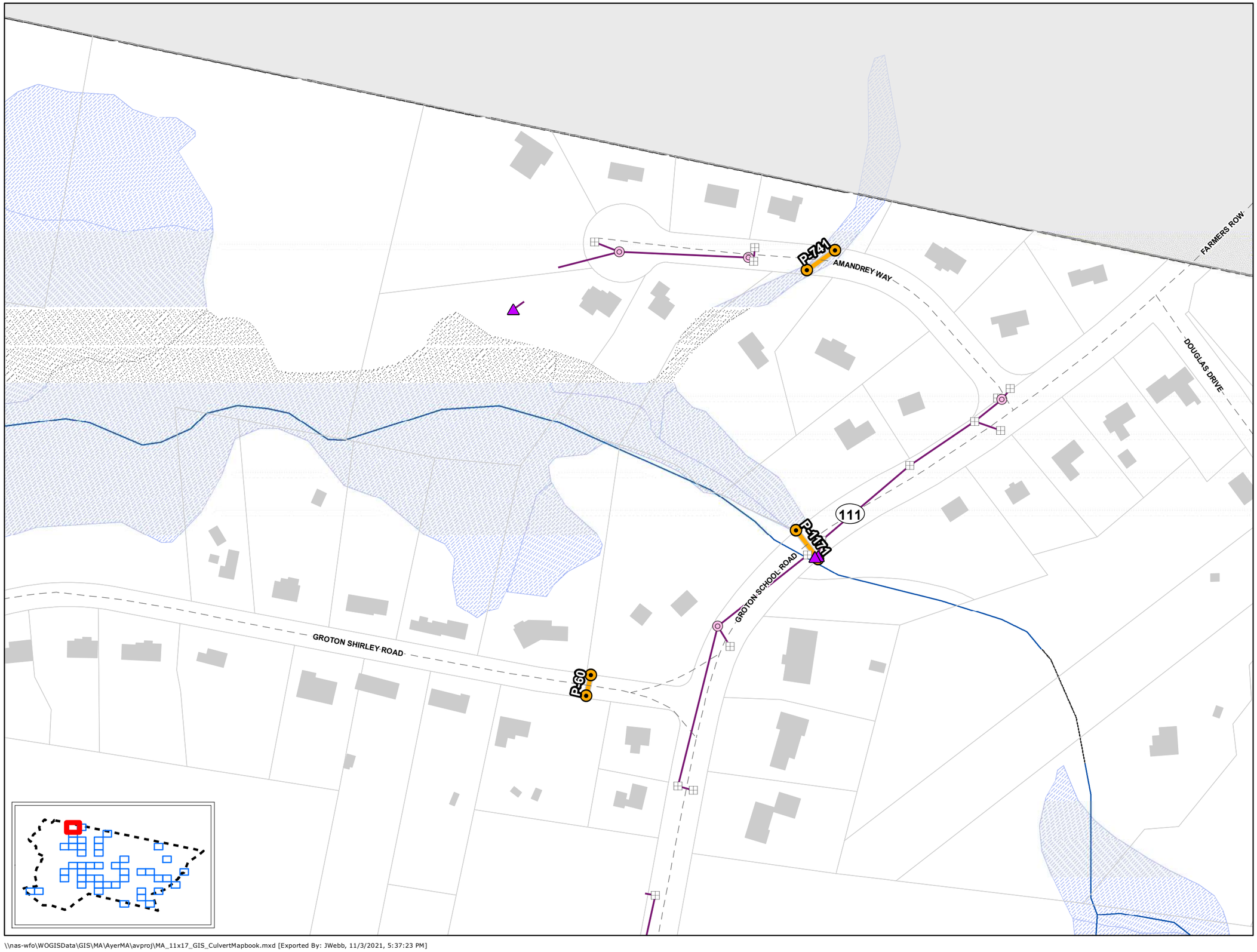

CULVERT INVENTORY

LEGEND

MassDOT Bridges

- DOT
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- MassDEP Not Interpreted Wetlands
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Feet

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1. Data source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, MassIT) Executive Office of Environmental Affairs. Data valid as of November 2021.

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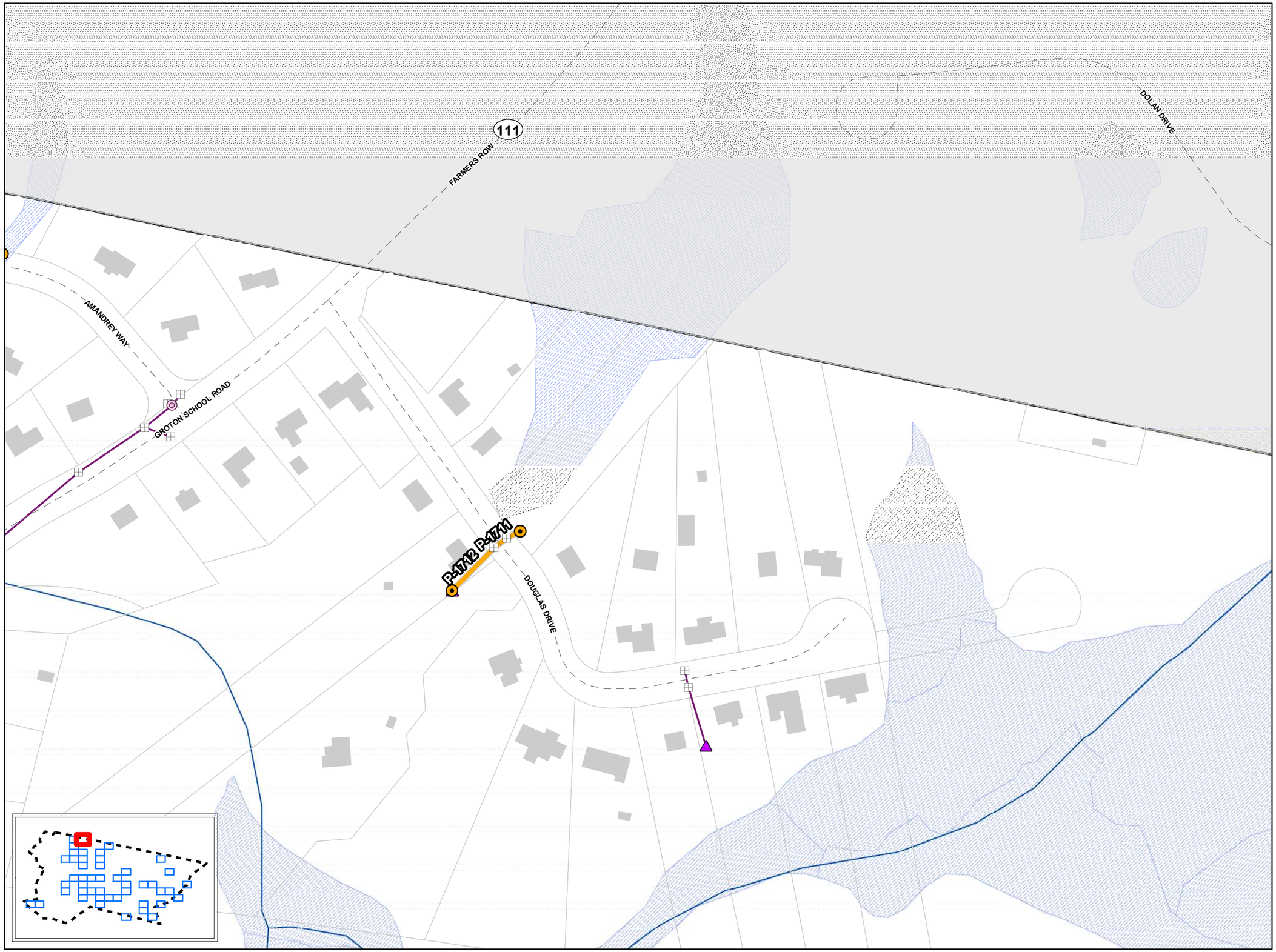
CULVERT INVENTORY



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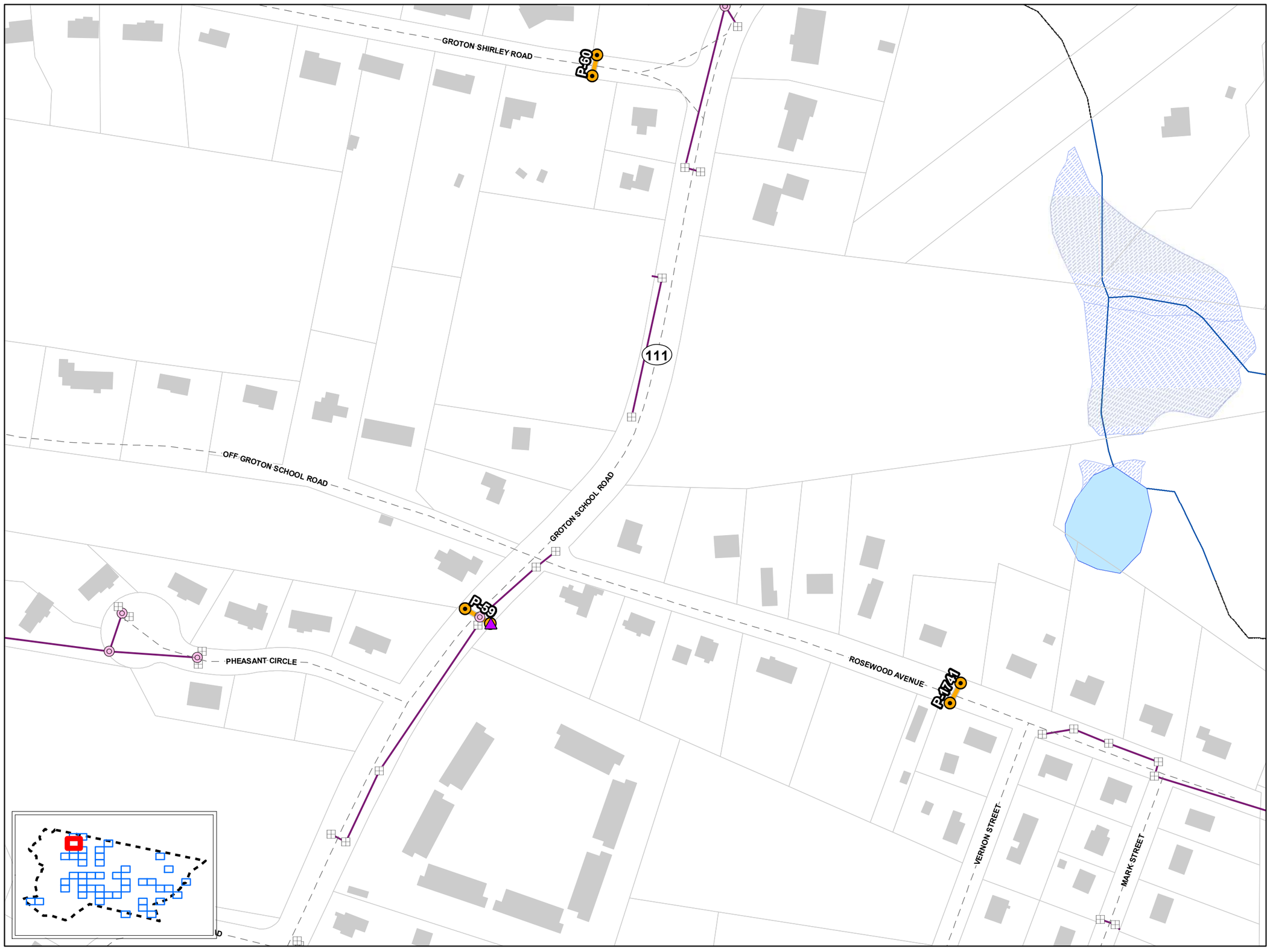

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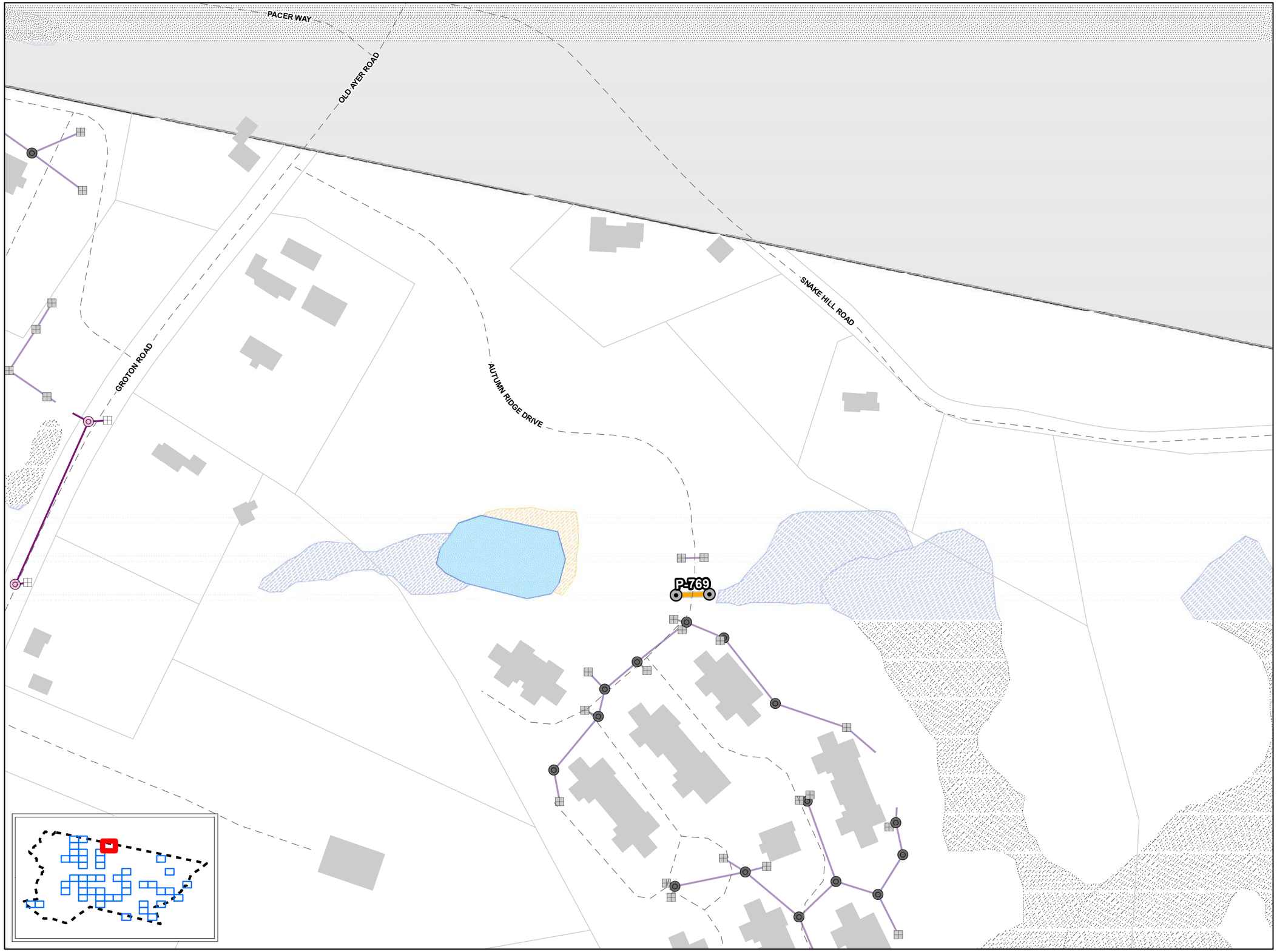

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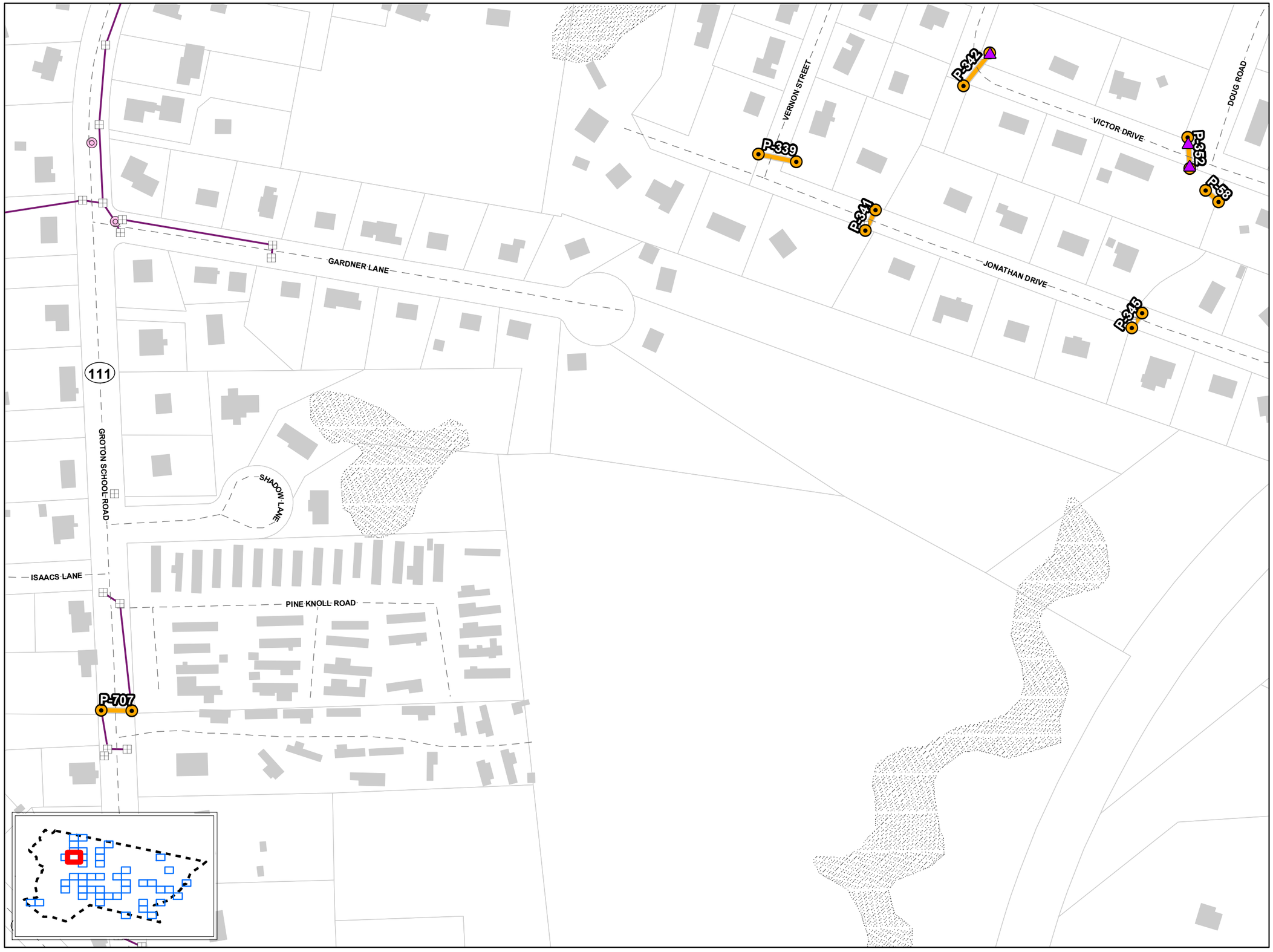

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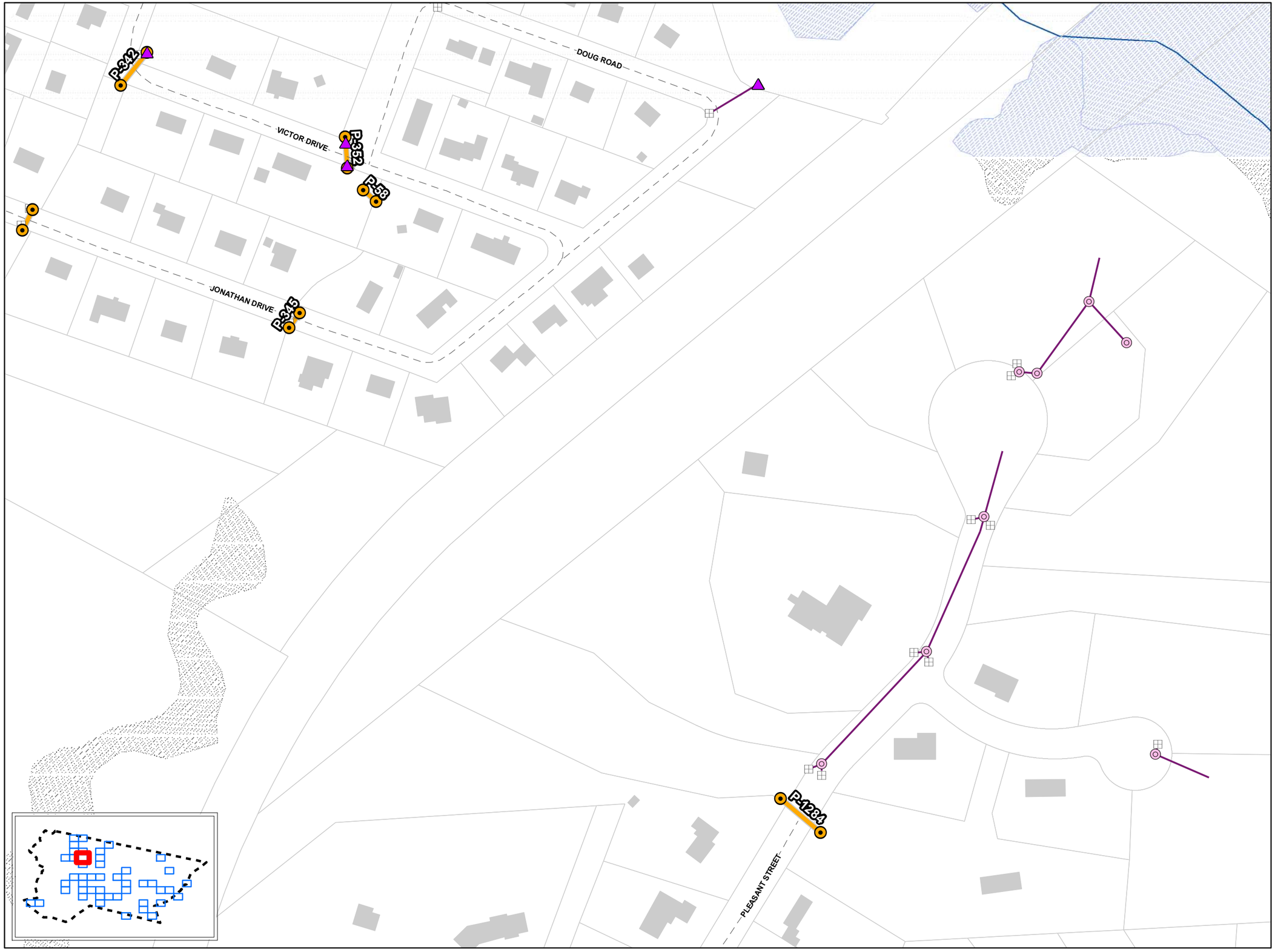

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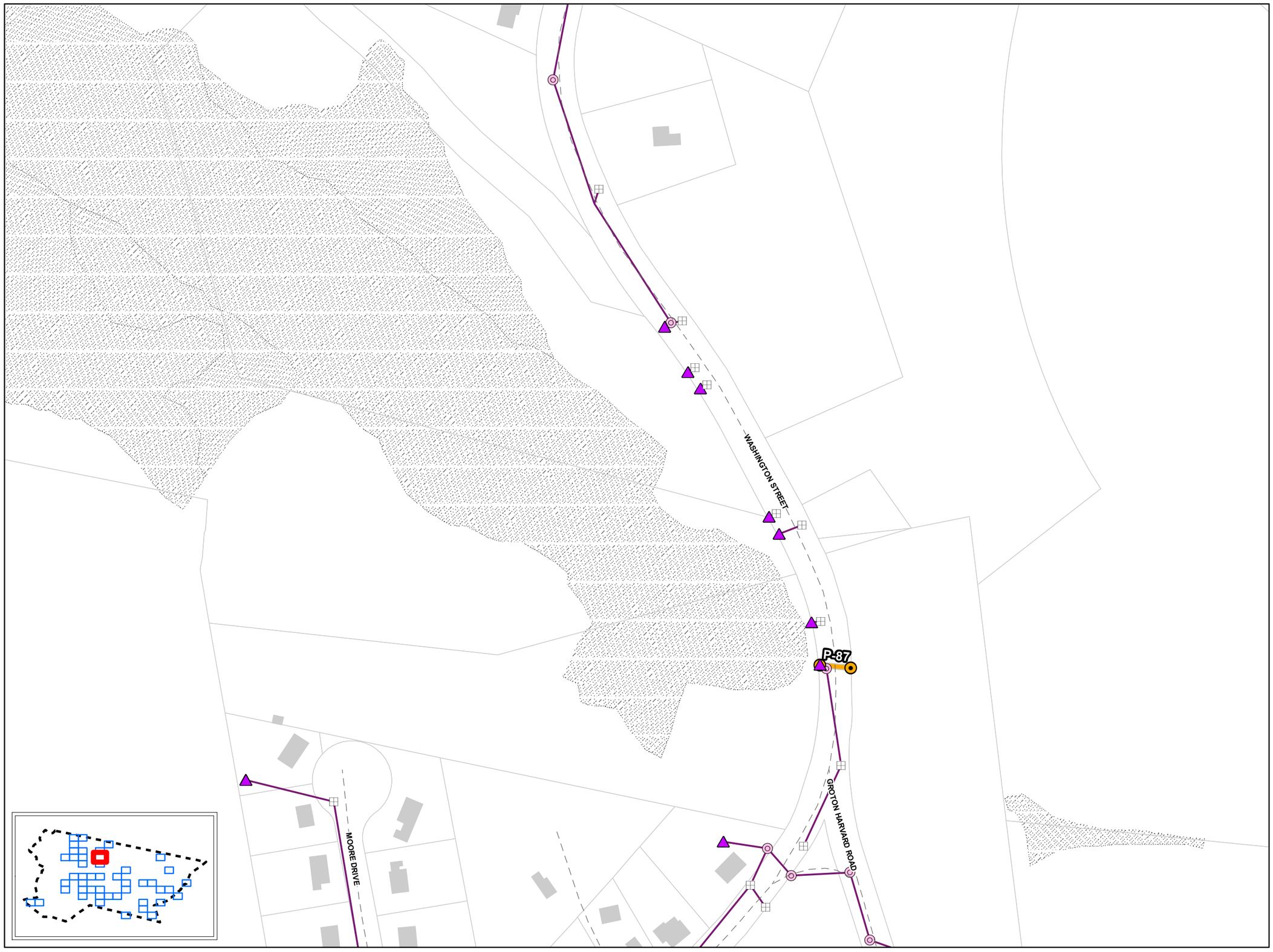

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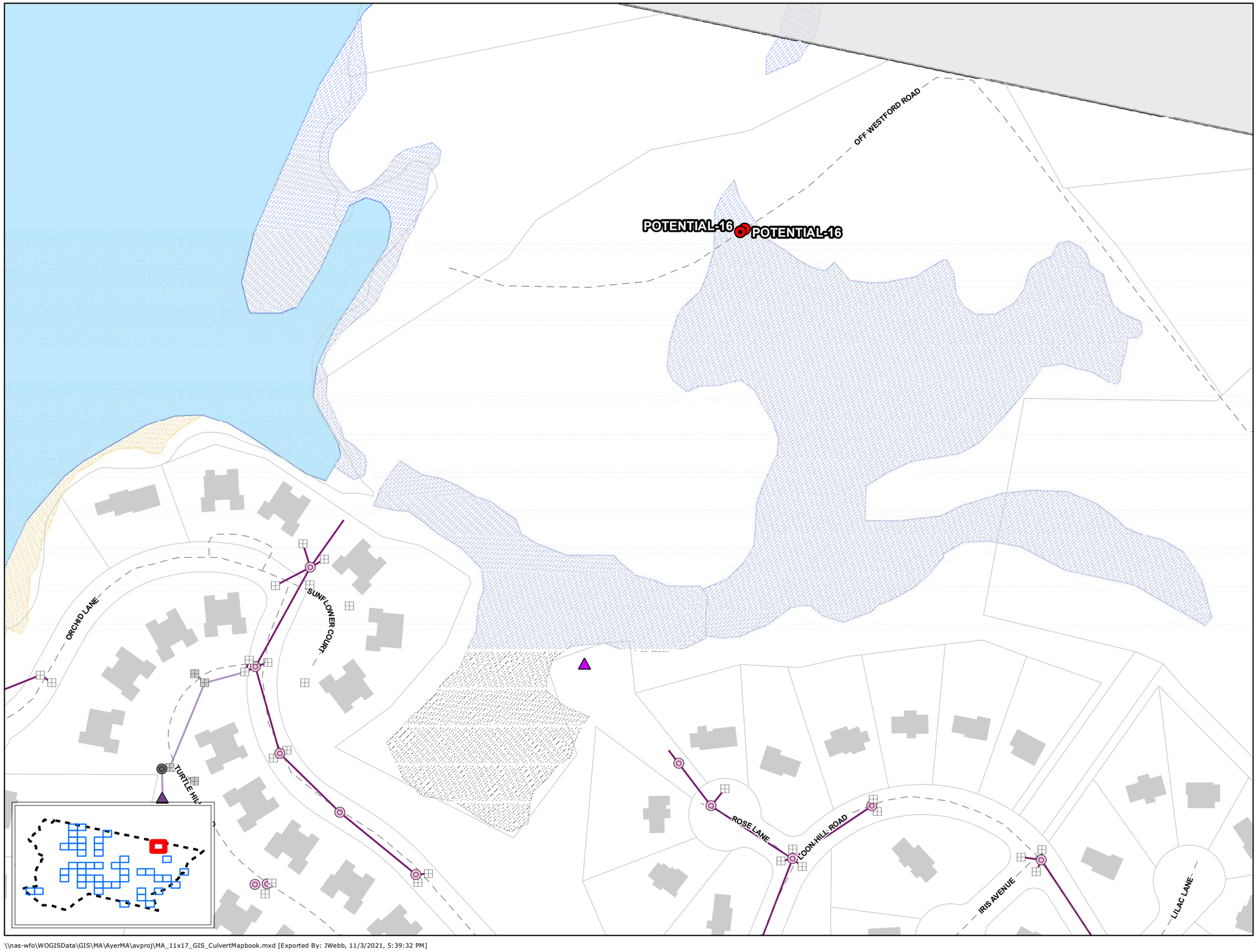

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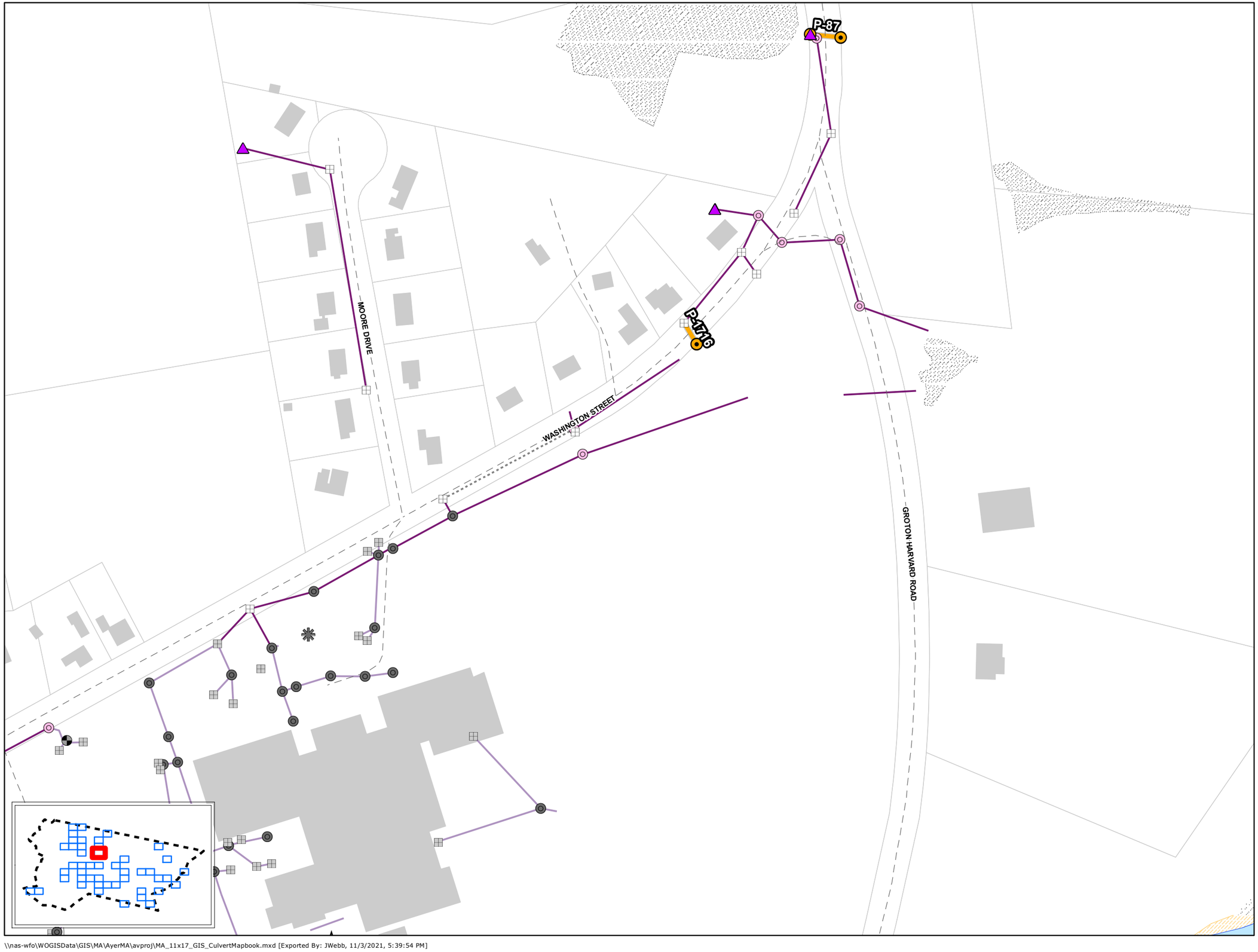

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Feet

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SUMMIT AVENUE

LINCOLN STREET

NORWOOD AVENUE NORTH

P-142

P-141

P-140

HIGHLAND AVENUE

BRILAINIA COURT

WINTHROP AVENUE

HIGH STREET

GROTON HARVARD ROAD

CULVERT INVENTORY

LEGEND

MassDOT Bridges

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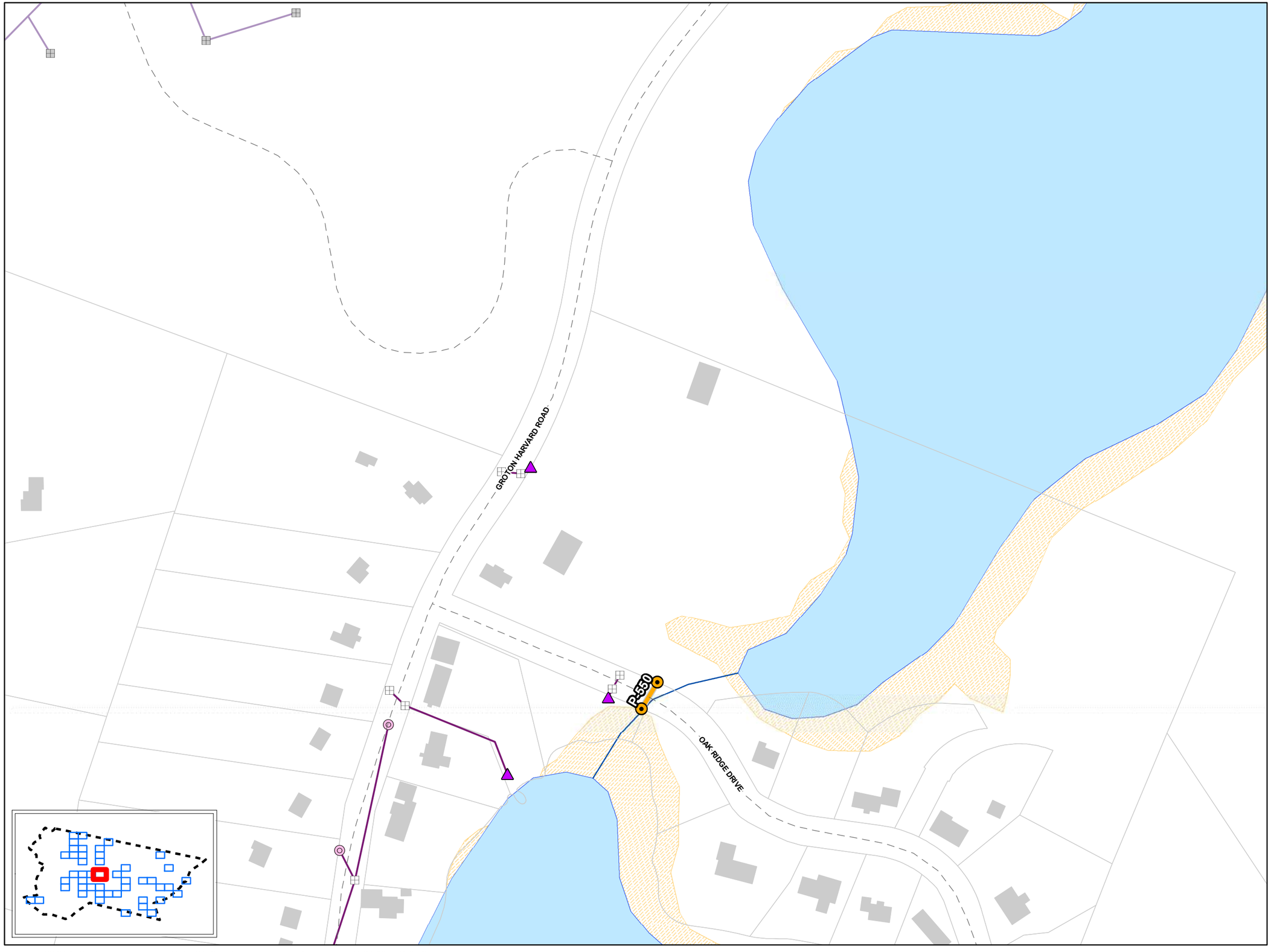

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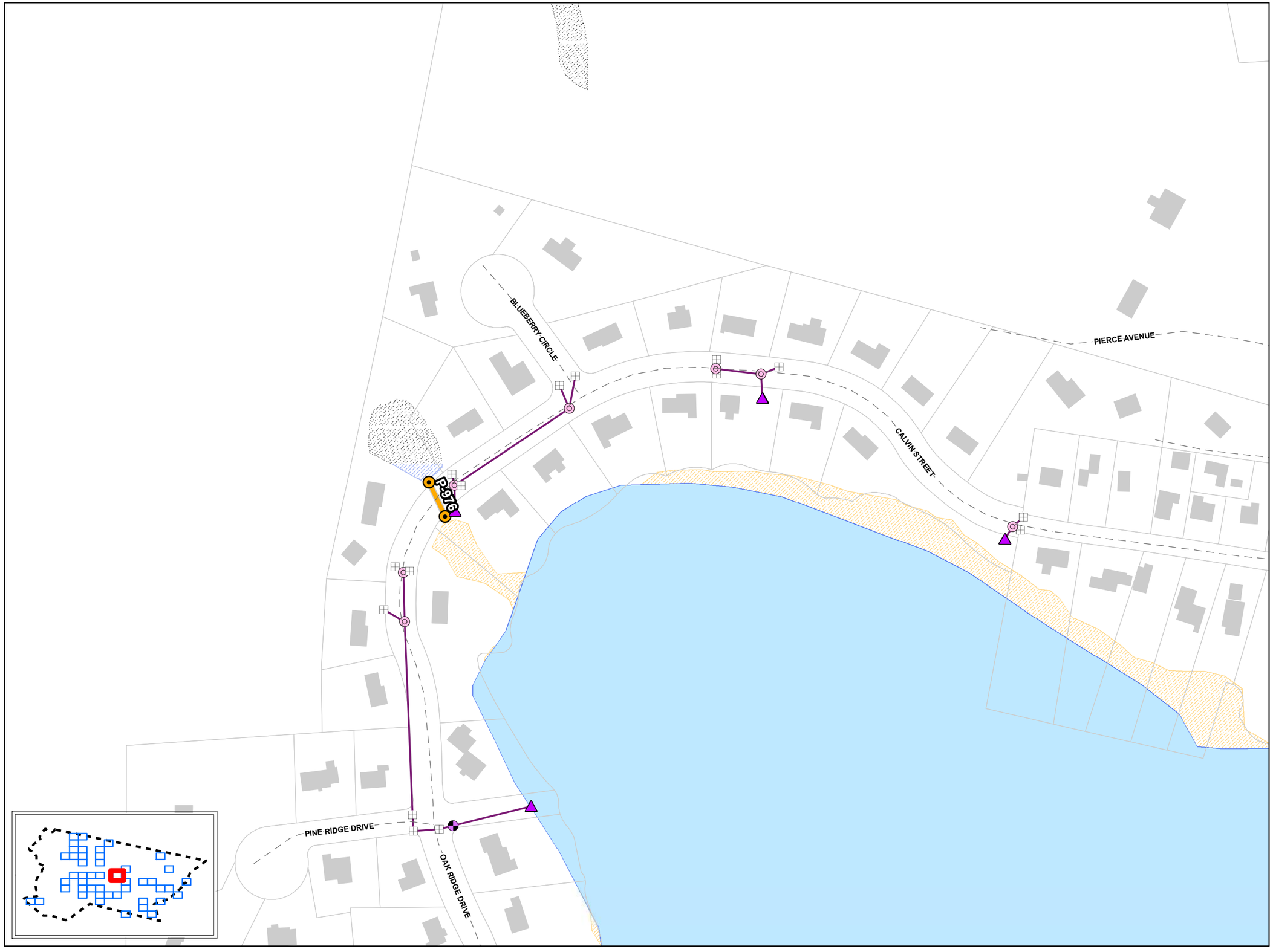

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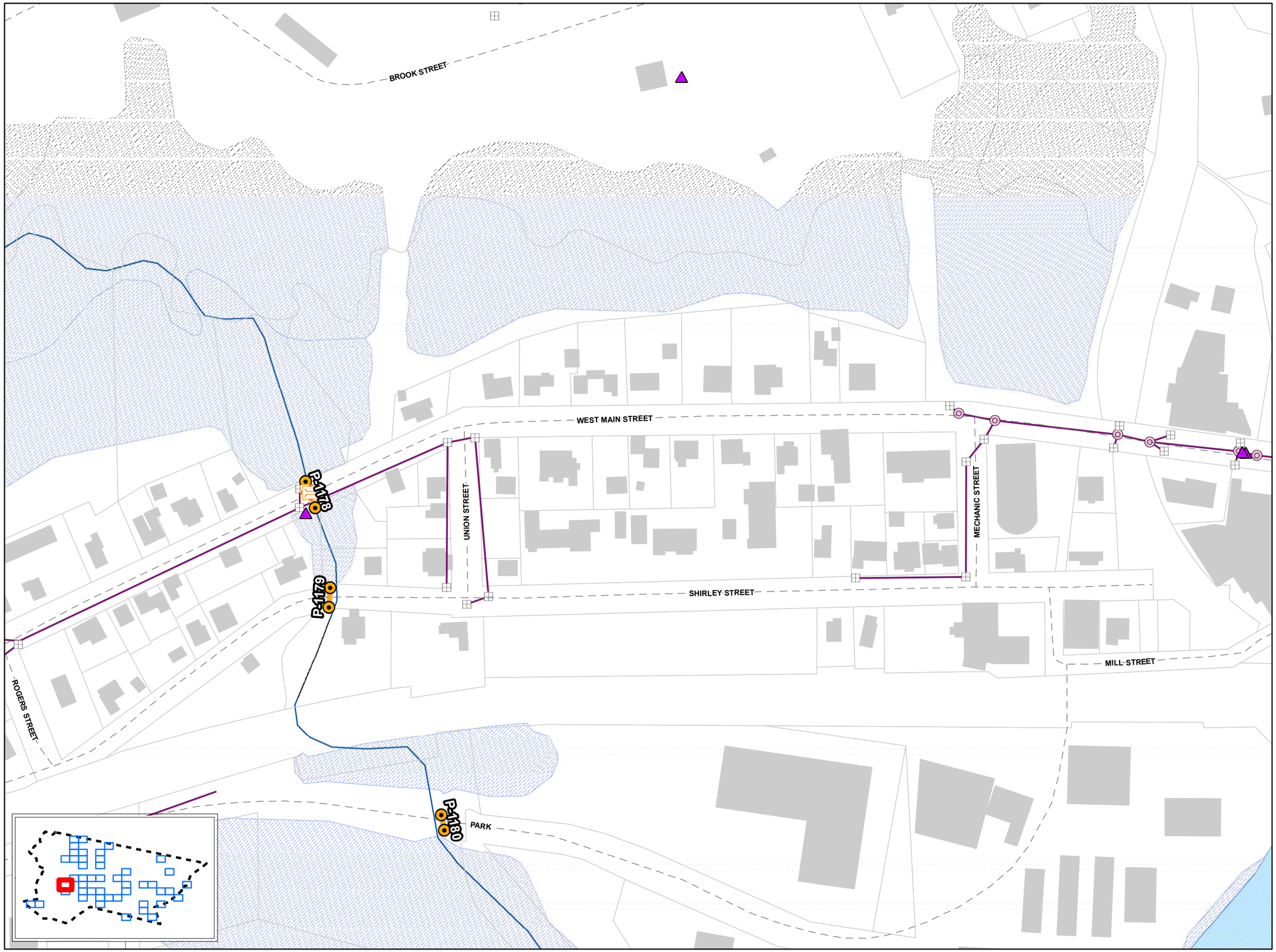

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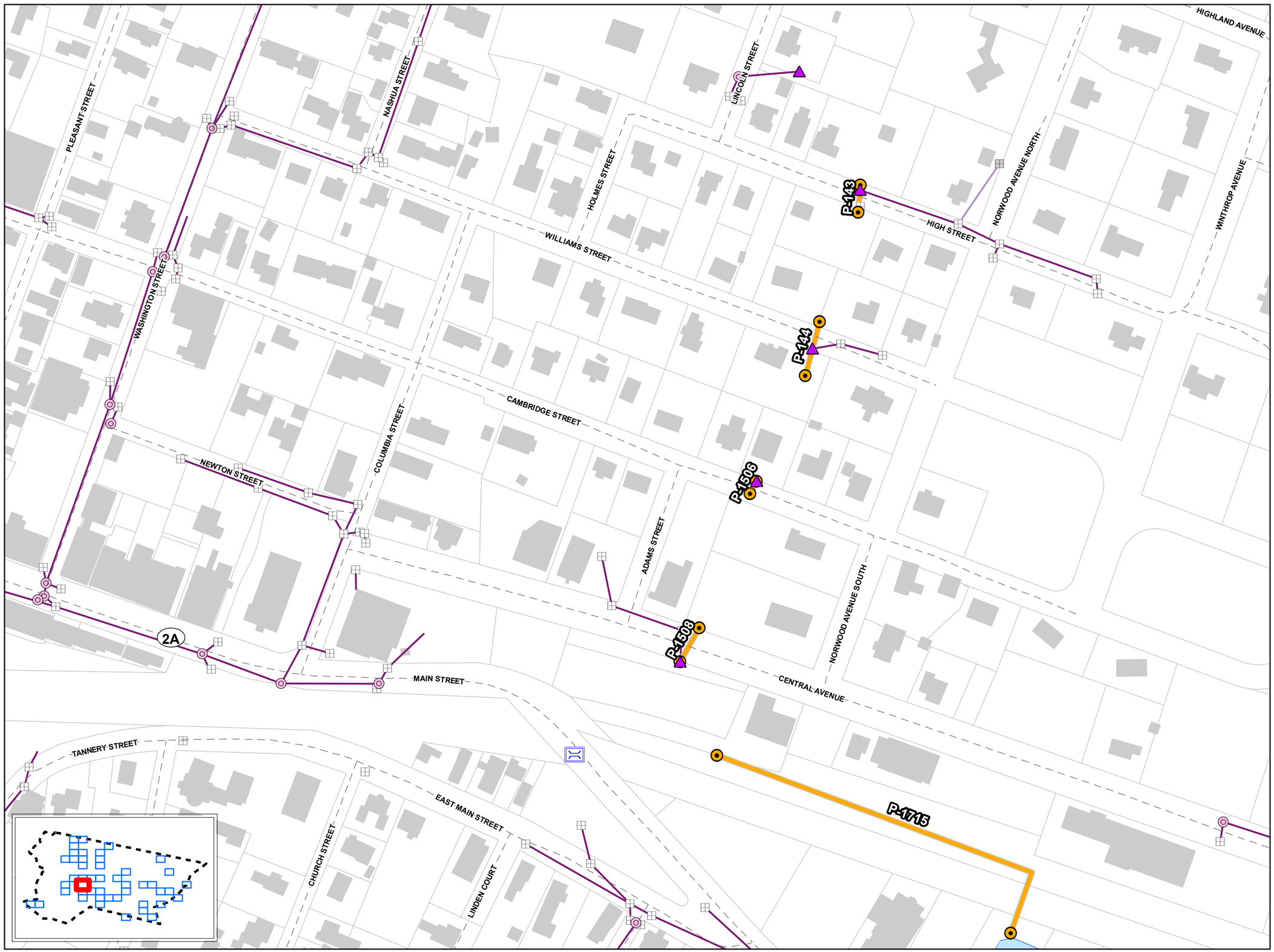

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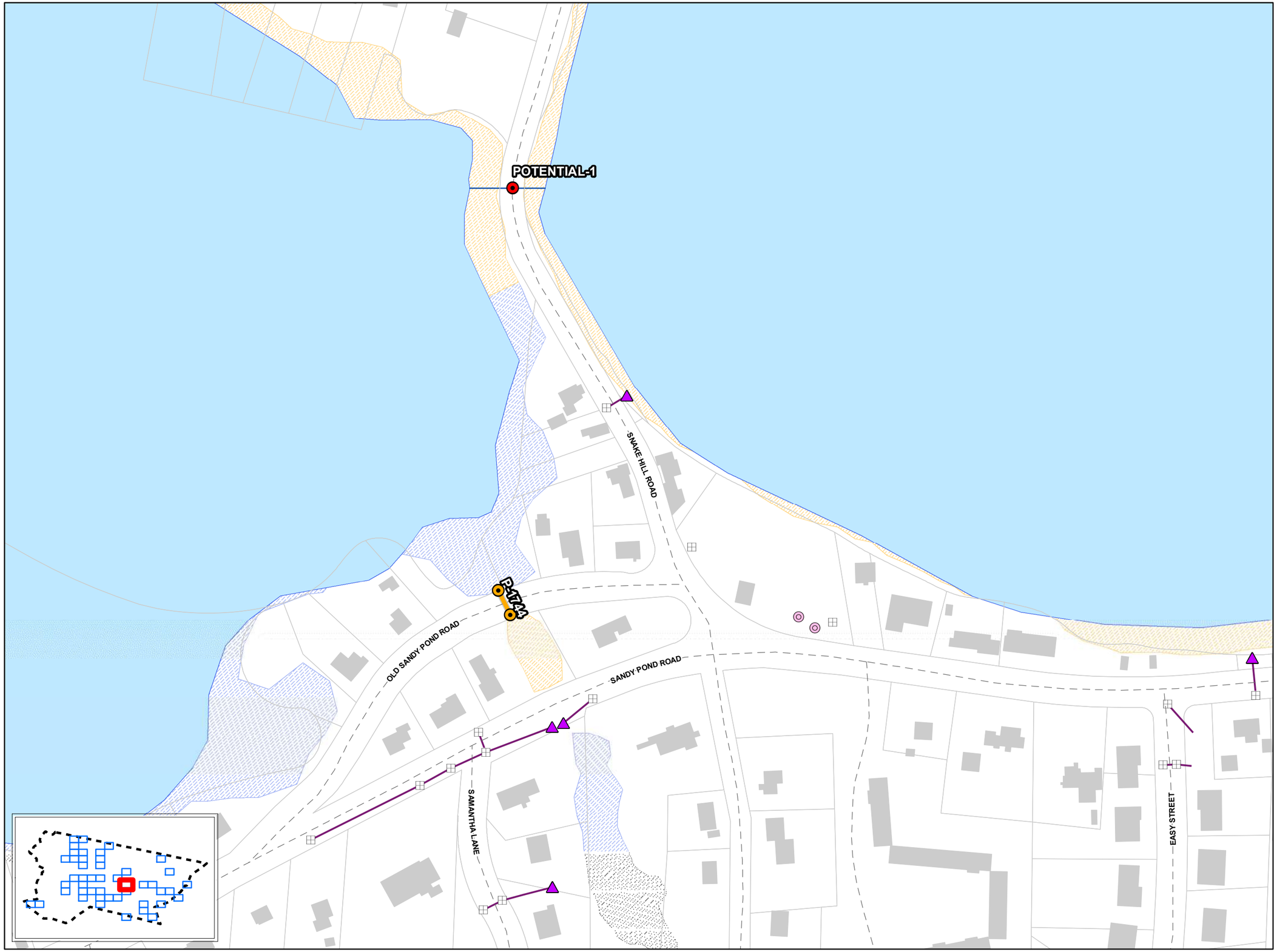

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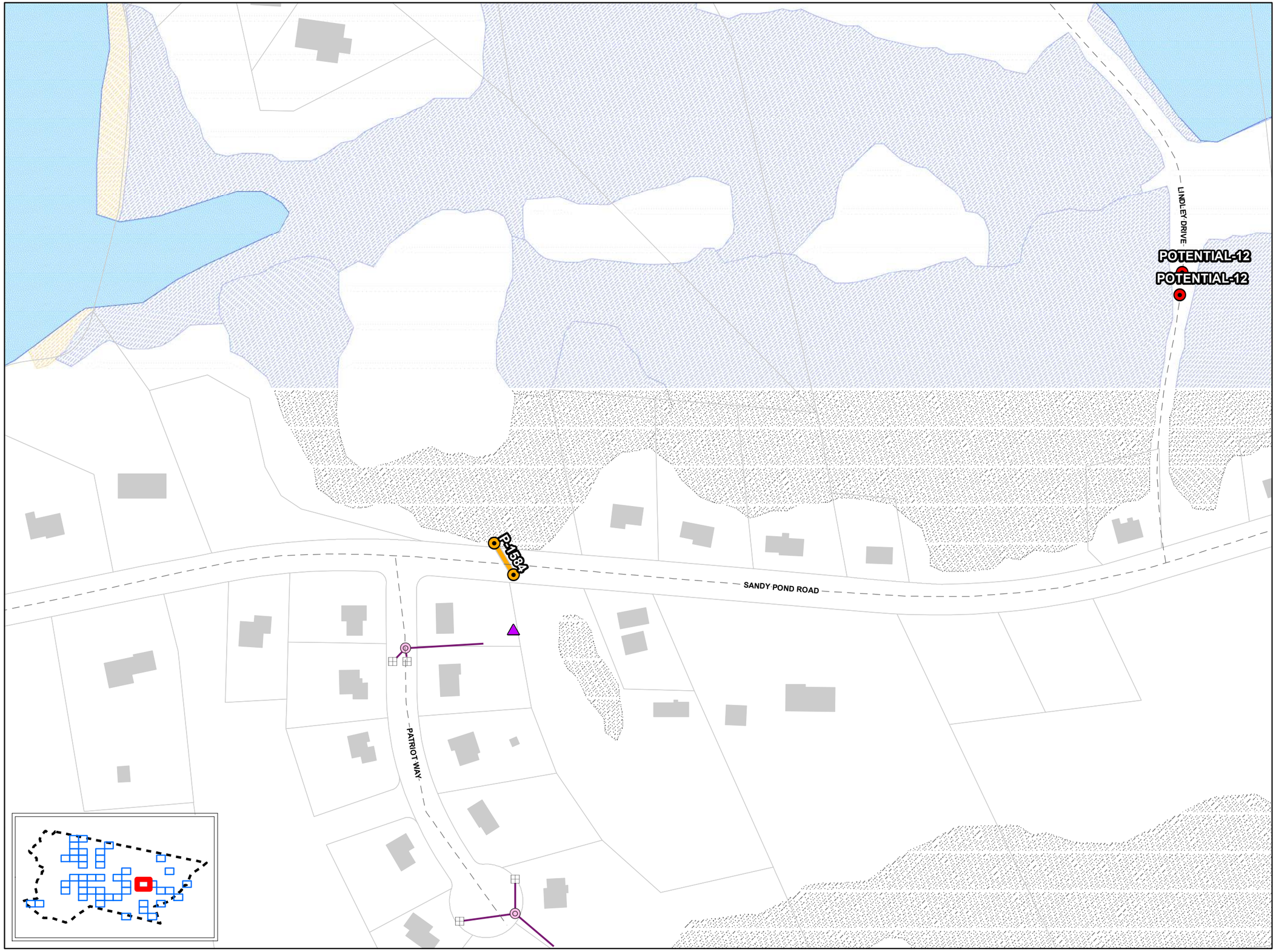

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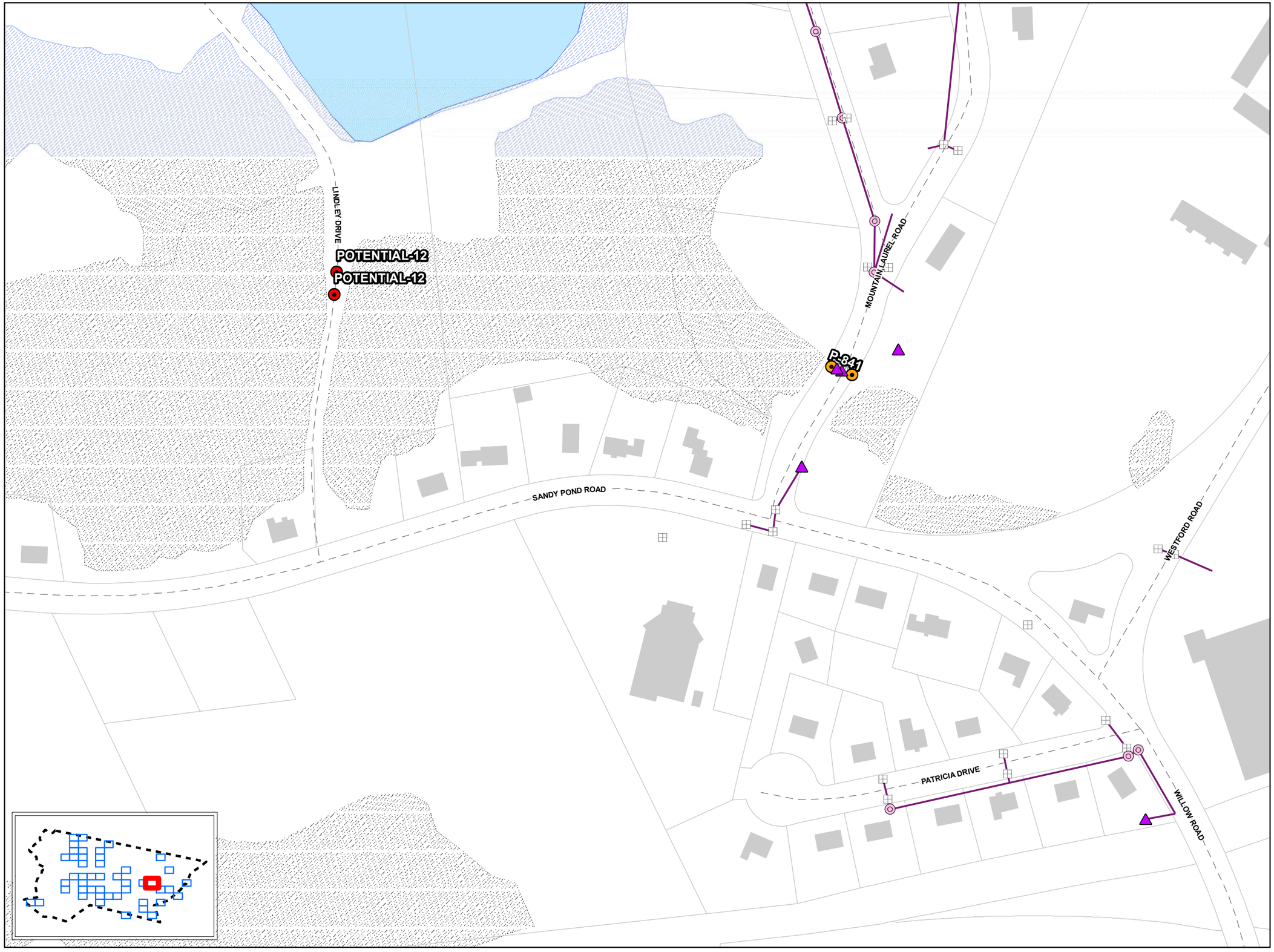

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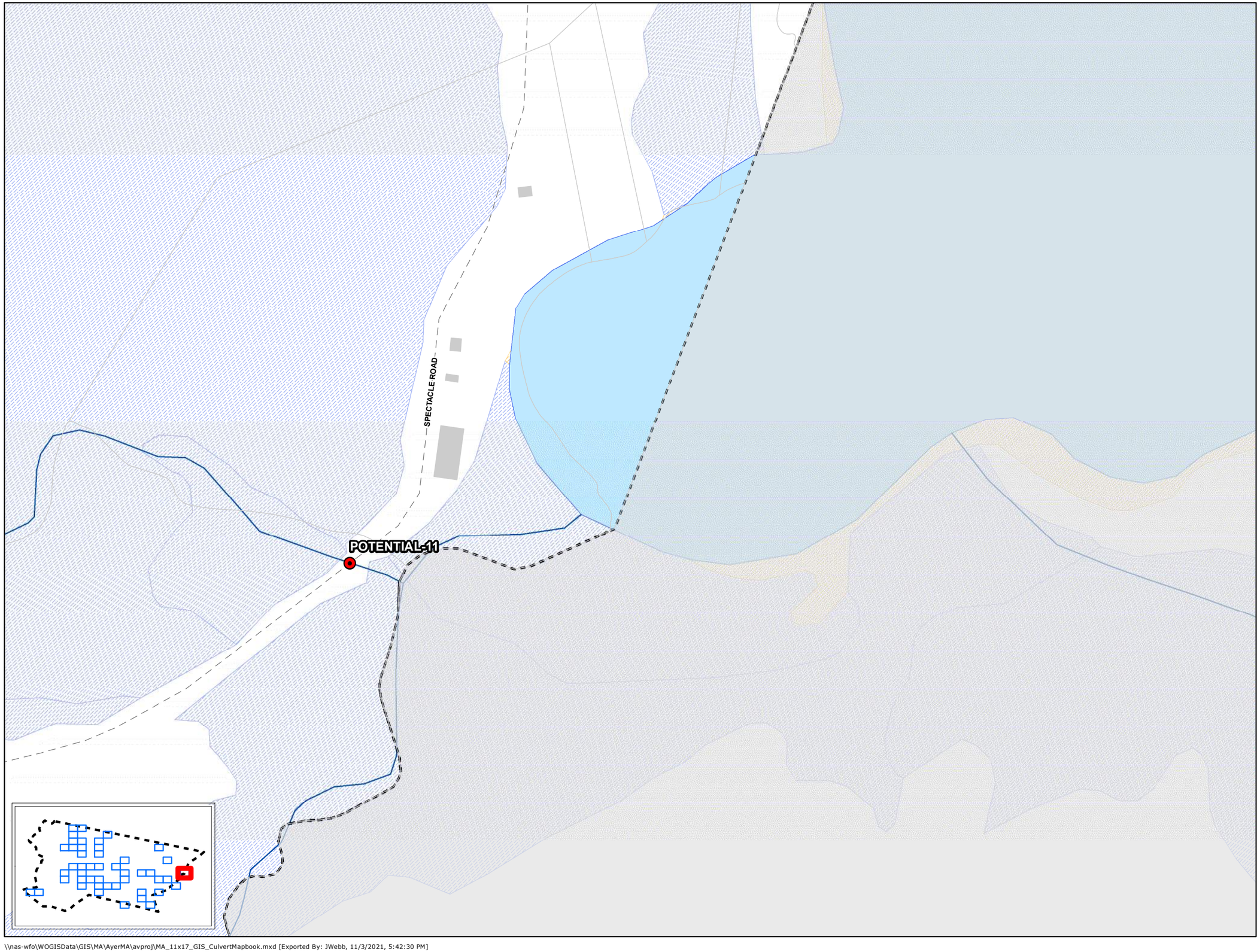

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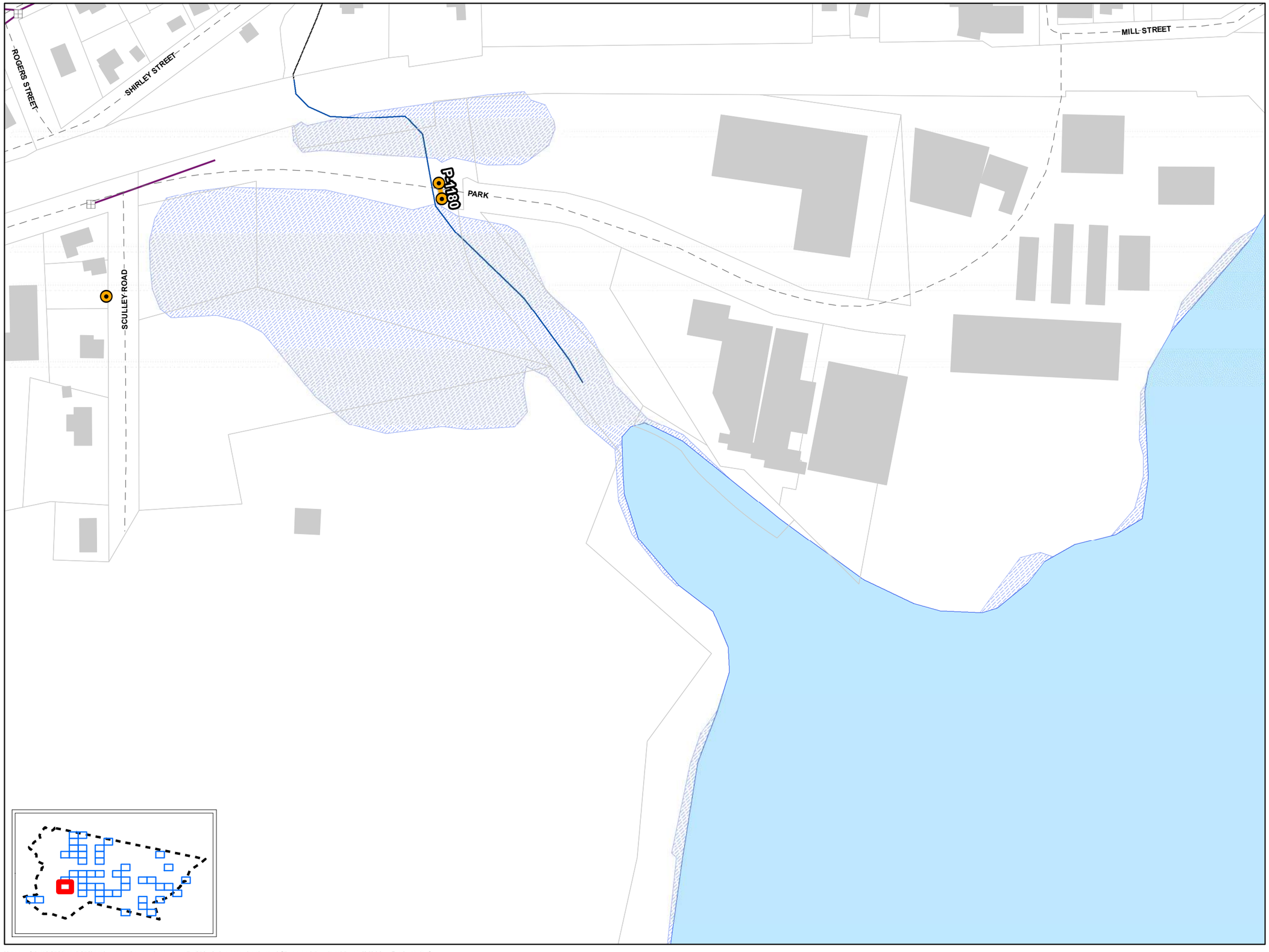

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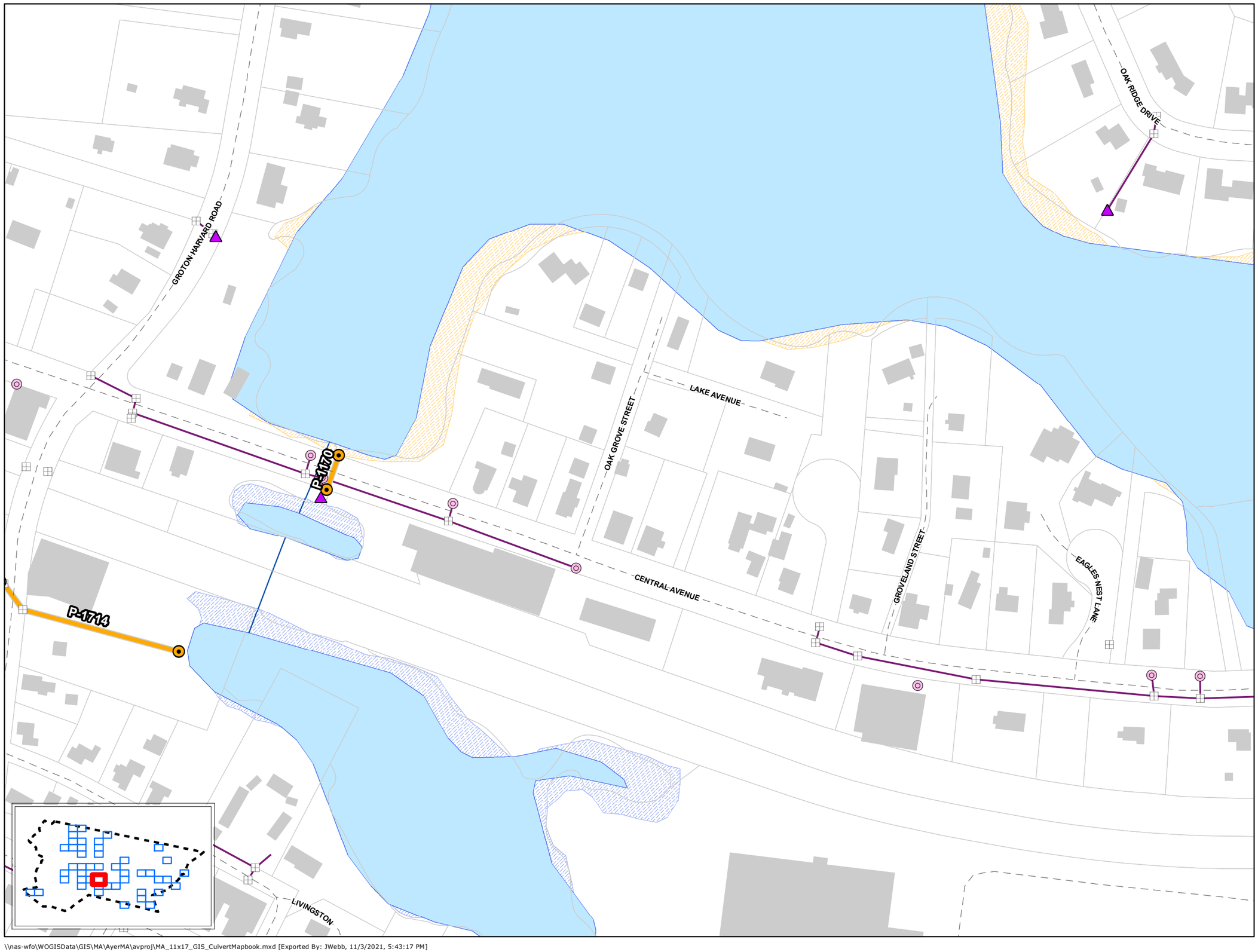

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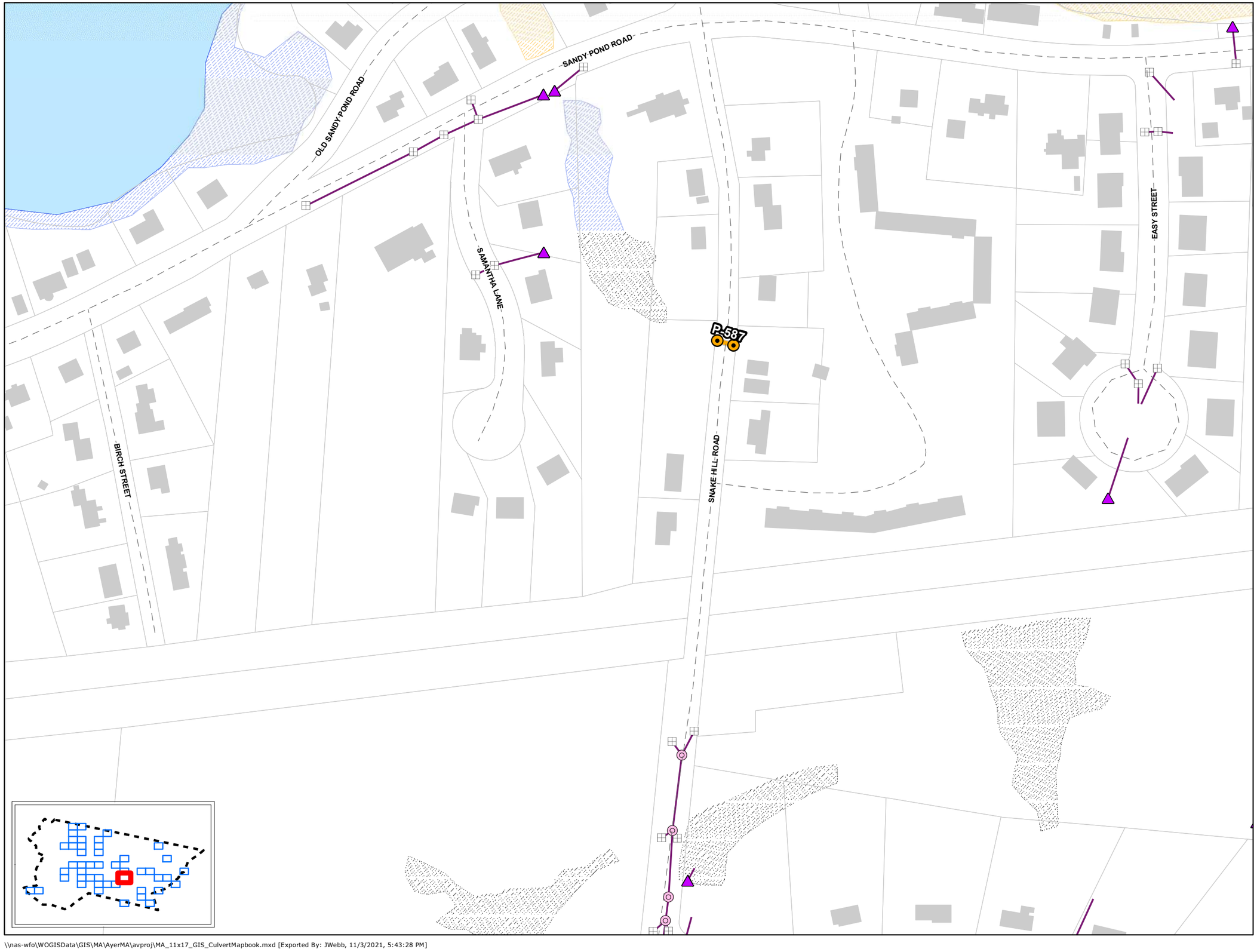

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PATRICIA DRIVE

BERKSHIRE BOULEVARD

WILLOW ROAD

LONGVIEW CIRCLE

BAYBERRY LANE

P-NEW1

P-1096

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N

0 70 140

Feet

1:1,800

1. Data source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, MassIT) Executive Office of Environmental Affairs. Data valid as of November 2021.

POTENTIAL-7

CIRCLE

RAYBERRY LANE

November 2021

Tighe&Bond

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CULVERT INVENTORY

LEGEND

MassDOT Bridges

- DOT
- Municipal
- Potential Culvert Location
- Culverts
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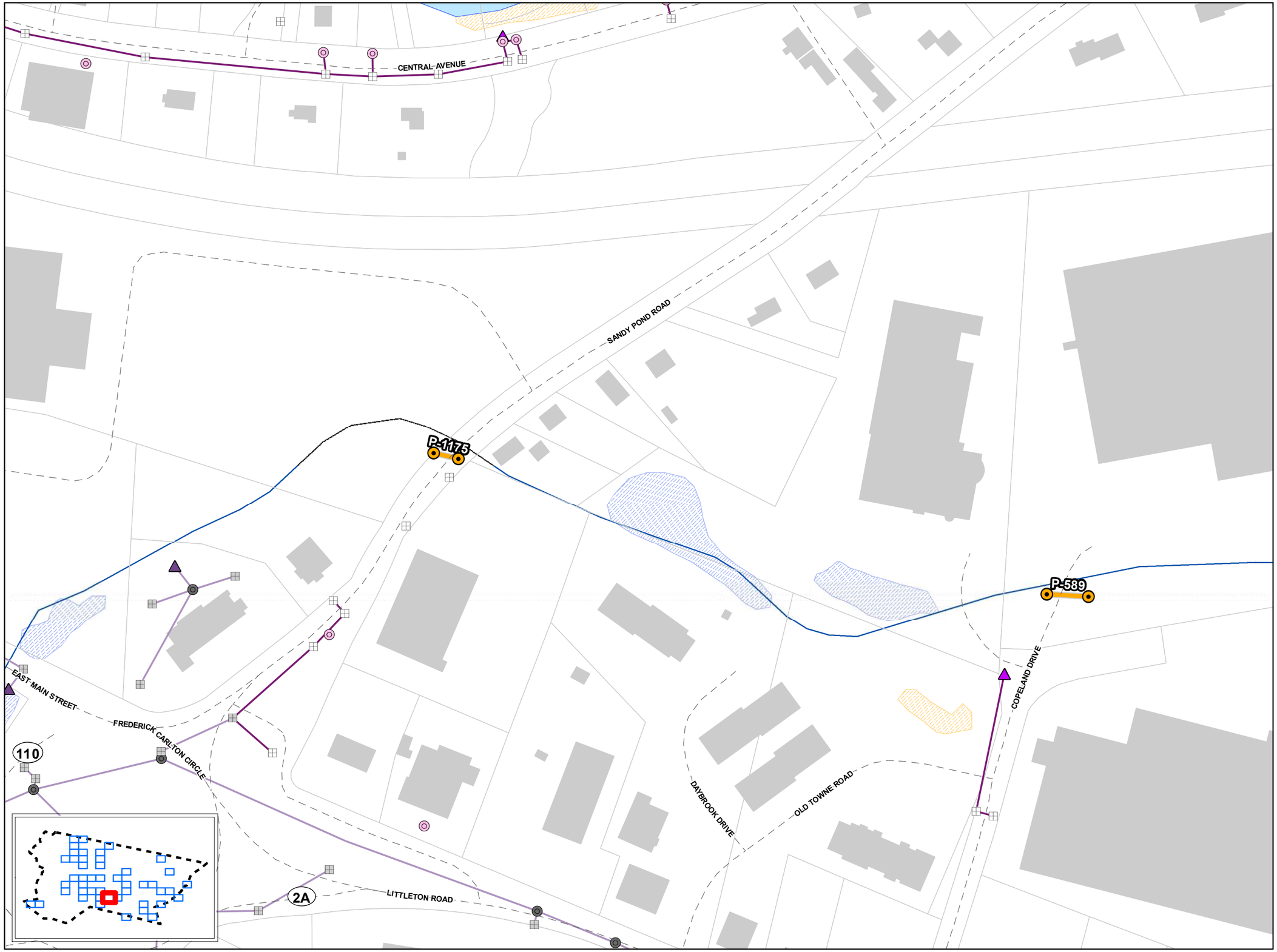

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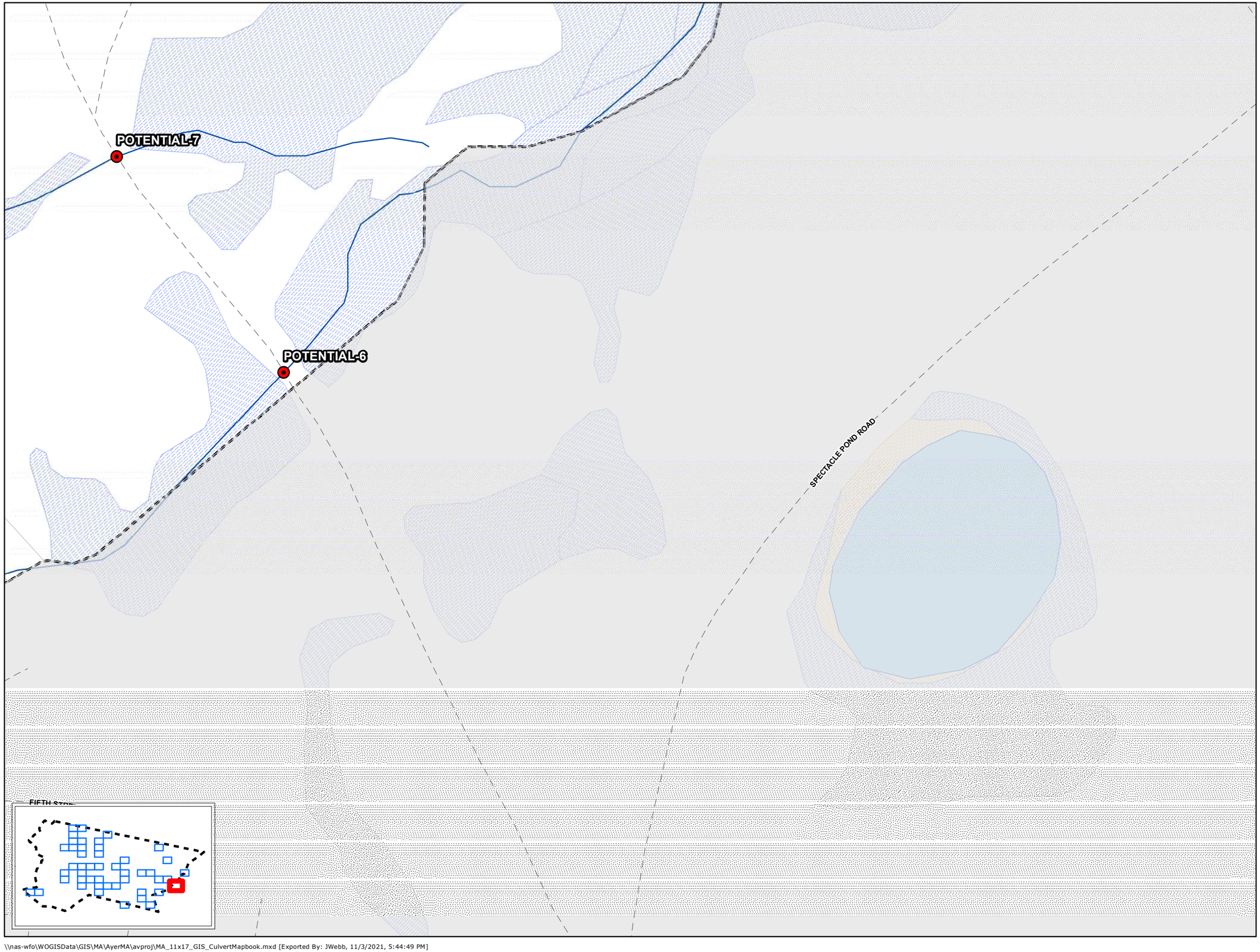

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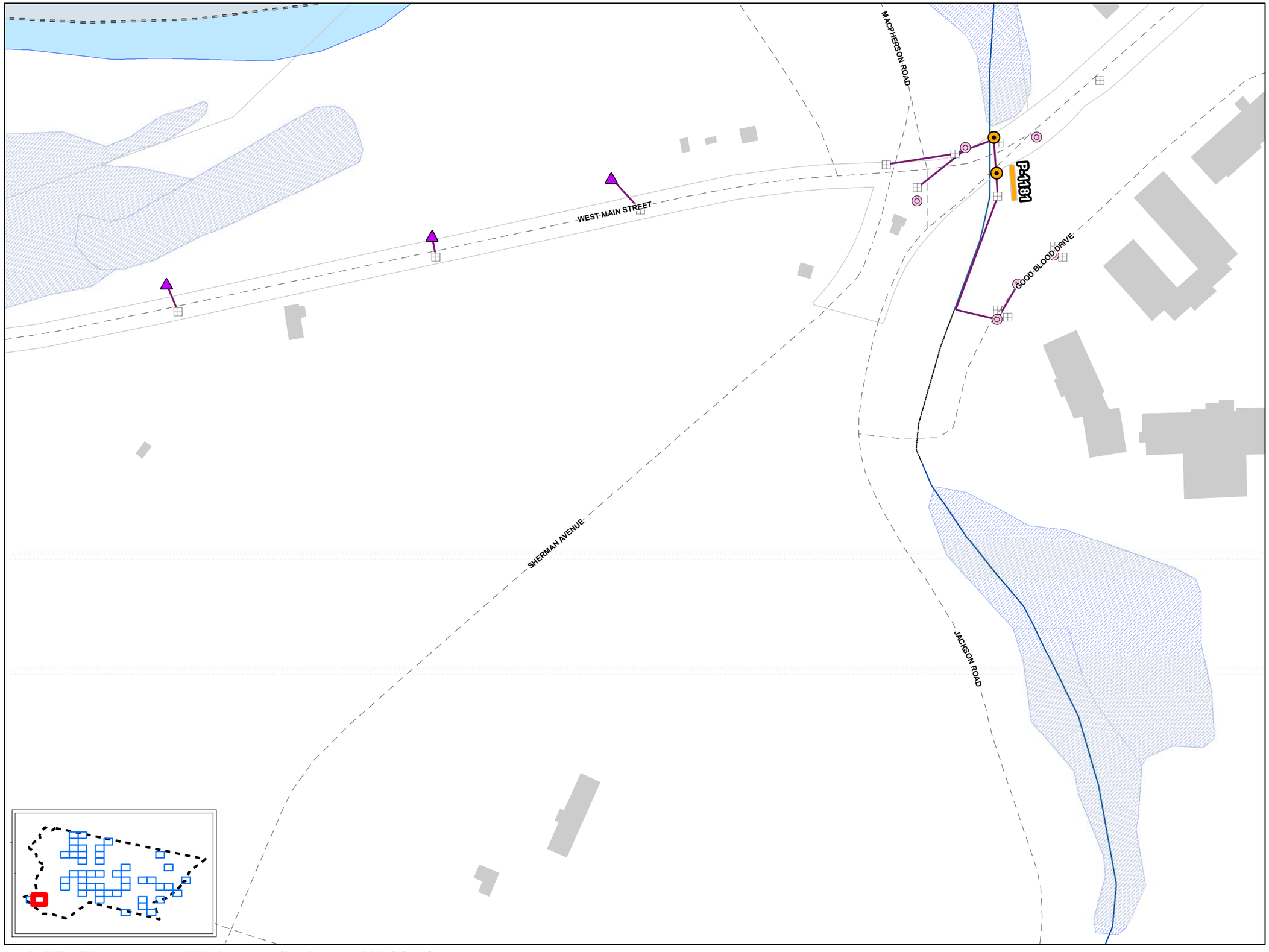

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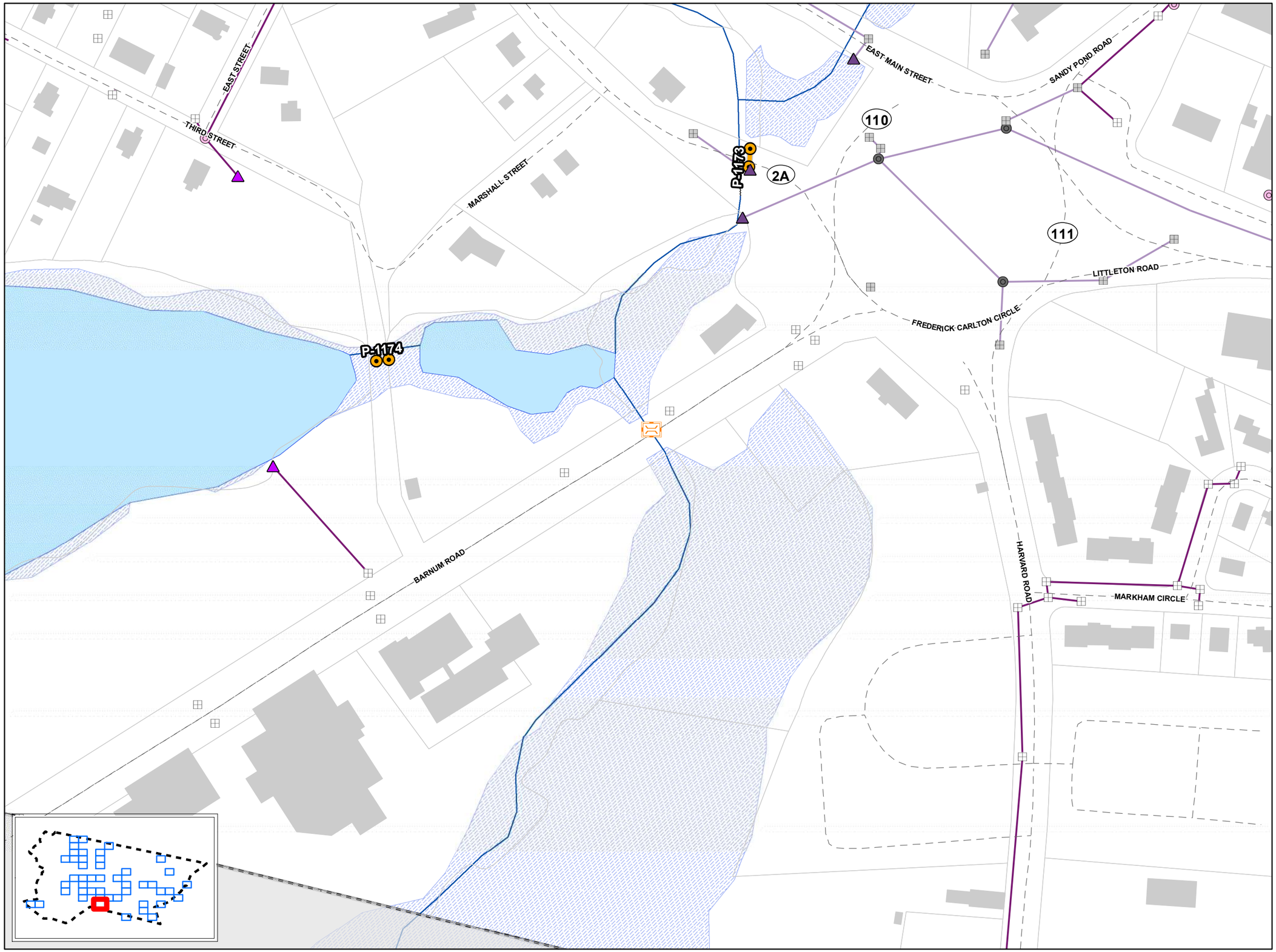

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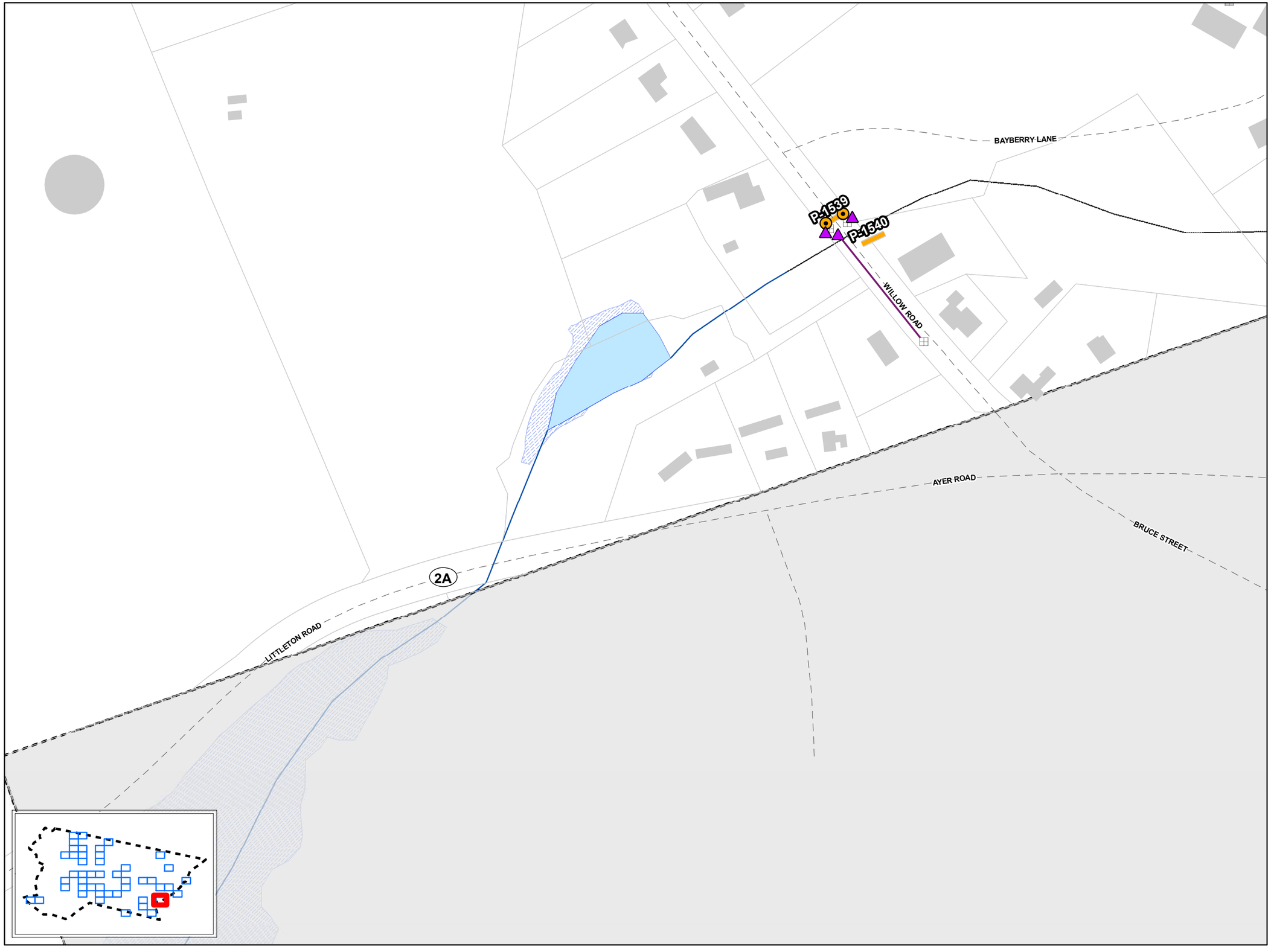

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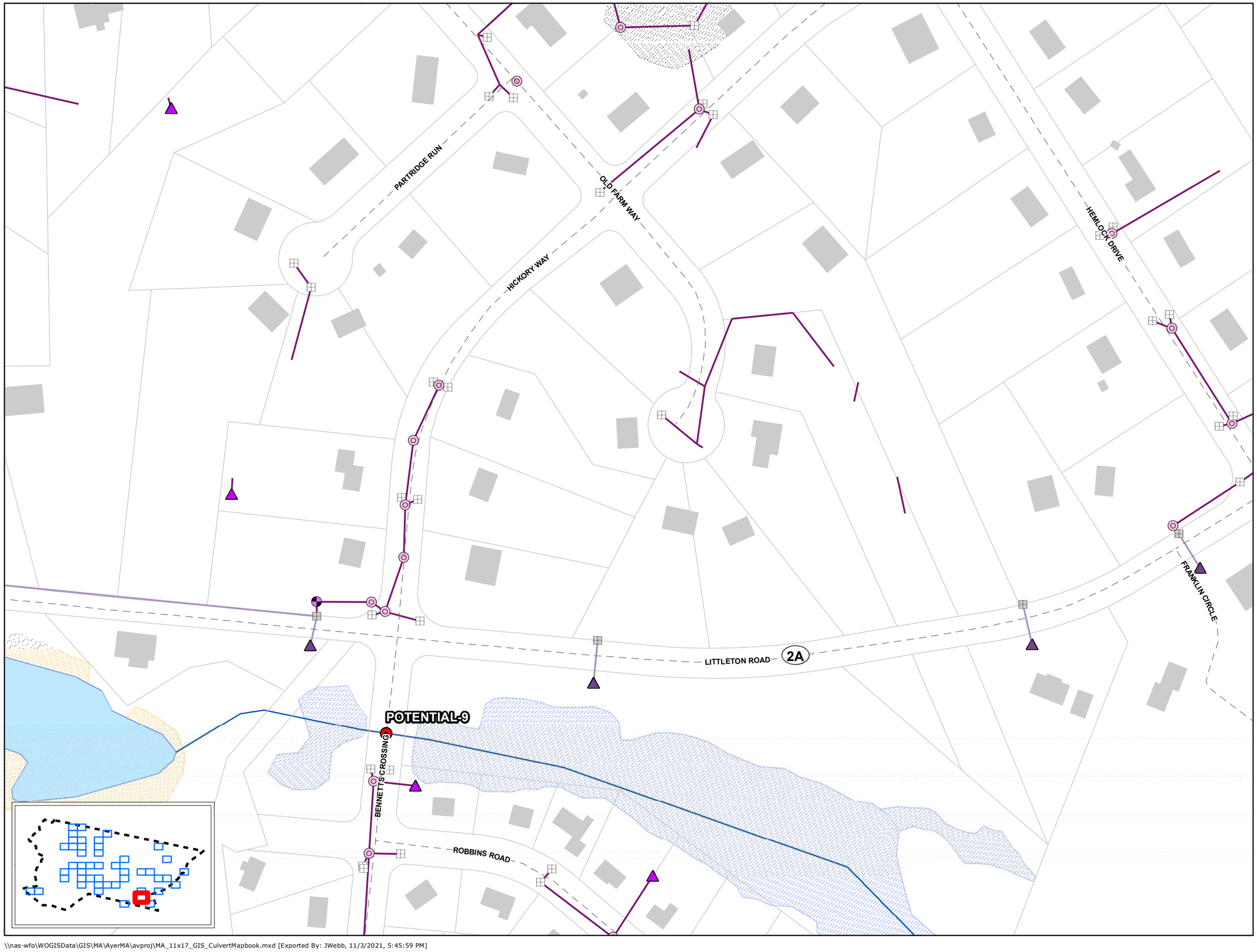

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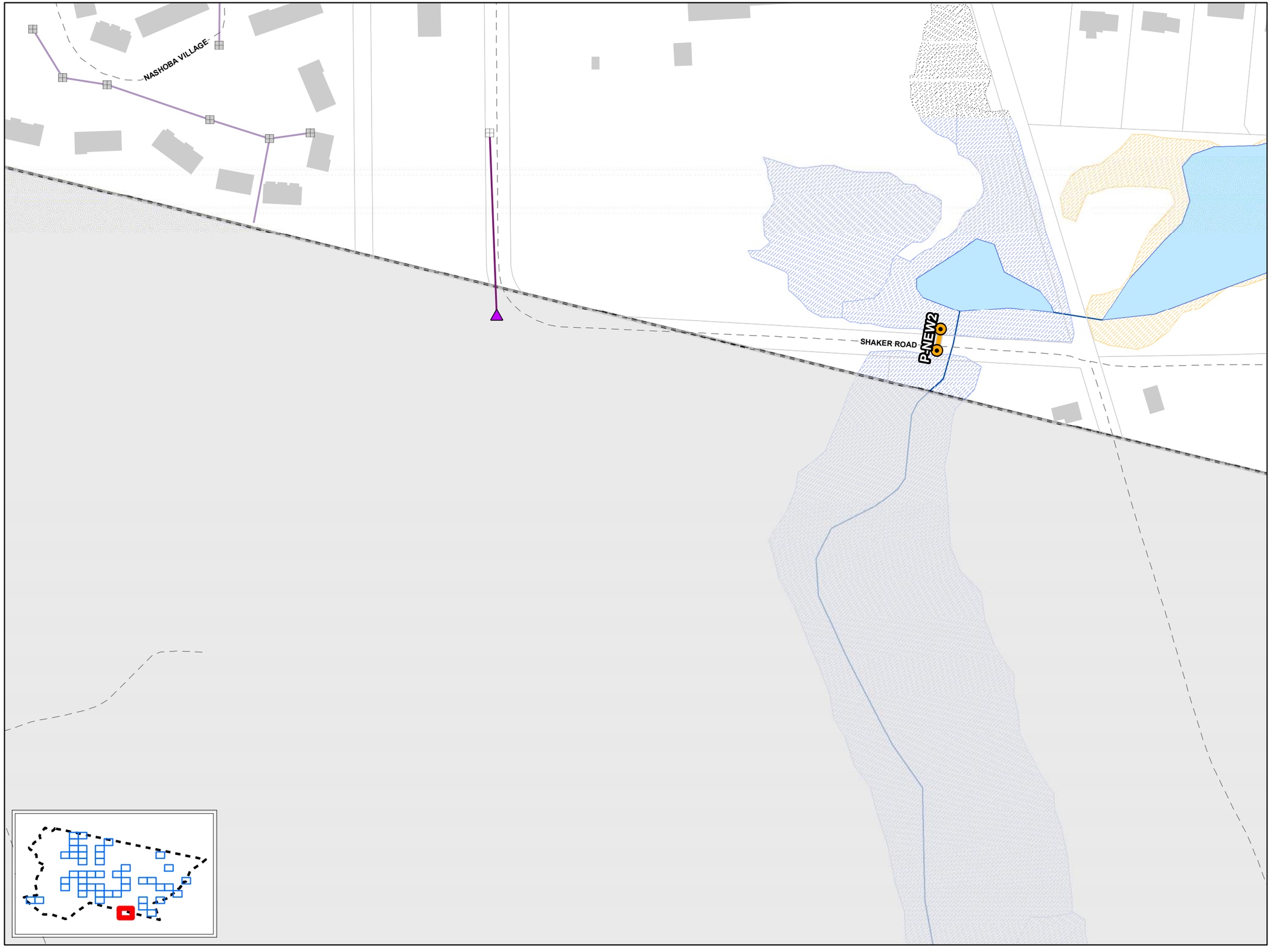

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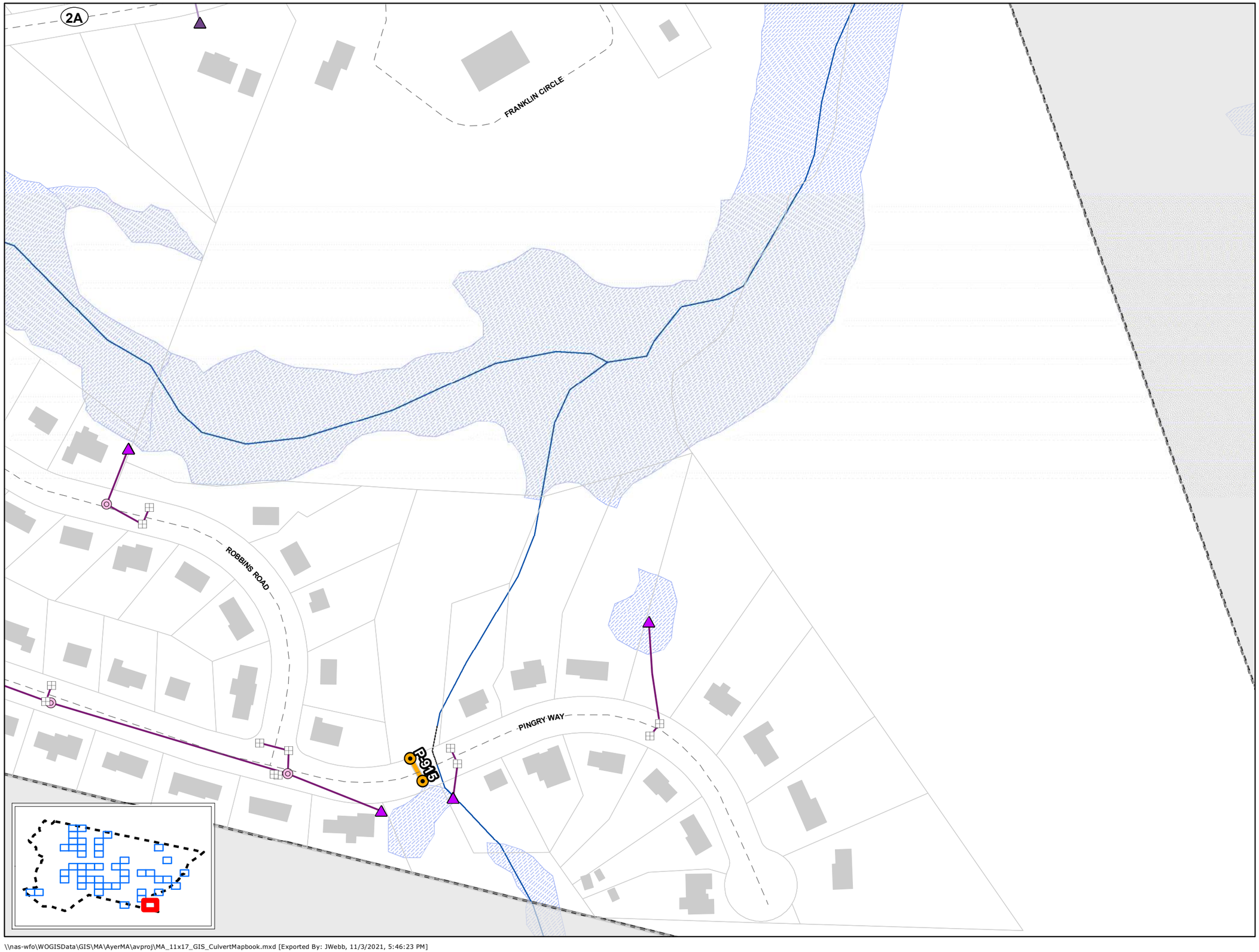

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Appendix B

Natalie

Drainage Structure Inspection Report

Structure ID

TB ID

Date

9/21/2022

08:39 AM

Weather

- Sunny
- Party Cloudy
- Cloudy
- Rain
- Snow
- Other

Street

Inspector

Photo(s)*

Take up to 4 photos

Natalie

Select image file

Structure Video ID

Structure Type

- Manhole
- Catch Basin
- Inlet
- Outfall
- Culvert

General Structure Observation

General Structure Observation

- Excellent
- Good
- Fair
- Poor
- Immediate Attention
- Unknown

Structure Issue

Natalie

Structure Condition*

- Excellent
- Good
- Fair
- Poor
- Immediate Attention
- Unknown

Maintenance Needs

- Flushing
- Cleaning
- Repairs
- Replacement
- Cover/Frame work

Sump

- Yes
- No

Illicit Connection/Odor Issue

- Sewage Odor
- Rancid/Sour Odor
- Petroleum/Gas Odor
- Sulfide/Sulphur Odor
- Laundry Discharge
- Pet Waste Bags
- Yard Waste
- Garbage

Natalie

- [ ] Other

Illicit Connection/Odor Issue Comments

General Structure Comments

Internal Structure Observation

Cover/Grate Material

- ( ) Cast Iron
- ( ) Plastic
- ( ) Other

Cover/Grate Condition

- ( ) Excellent
- ( ) Good
- ( ) Fair
- ( ) Poor
- ( ) Immediate Attention
- ( ) Unknown

Cover/Grade Comments

Natalie

- [ ] Cast Iron
- [ ] Plastic
- [ ] Other

Frame Condition

- [ ] Excellent
- [ ] Good
- [ ] Fair
- [ ] Poor
- [ ] Immediate Attention
- [ ] Unknown

Frame Comments

Corbel Material

- [ ] Concrete
- [ ] Brick
- [ ] Block
- [ ] Precast
- [ ] None
- [ ] Other

Corbel Condition

- [ ] Excellent
- [ ] Good
- [ ] Fair
- [ ] Poor

Natalie

Immediate Attention

Corbel Comments

Steps Material

Metal

Plastic

None

Other

Steps Condition

Excellent

Good

Fair

Poor

Steps Comments

Wall Material*

Concrete

Brick

Block

Precast

Soil

No Wall

Unknown

Other

Natalie

Wall Condition

- Excellent
- Good
- Fair
- Poor

Wall Comments

Floor Material

- Concrete
- Brick
- Block
- Other

Floor Condition

- Excellent
- Good
- Fair
- Poor

Floor Comments

Invert Material

- Concrete
- Brick
- Block
- None

Natalie

Invert Condition

- Excellent
- Good
- Fair
- Poor
- Immediate Attention

Invert Comments

Structure Sketch

Reset

Natalie

Pipe Information (1)

1

Pipe Number

Pipe Video ID

Pipe Video

Select file

Pipe Size*

-Please Select-

Pipe Material*

-Please Select-

Pipe Condition*

- Excellent
- Good
- Fair
- Poor
- Unknown
- Immediate Attention

Natalie

Pipe Issues

- [ ] Cracked
- [ ] Broken
- [ ] Caving In
- [ ] Collapse
- [ ] Root Intrusion

Pipe Sediment Percentage*

- ○ 0-5%
- ○ 6-40%
- ○ >40%

Pipe Maintenance Needs

- [ ] Flushing
- [ ] Cleaning

Natalie

Pipe Comments

Submit

NOTE: This field form contains smart fields. Therefore, some questions in the survey form below have been answered in order to display further fields.

Jamie

My Survey

Ayer

Culvert Inventory Form

Overall

Date Observed

4/20/2022

Time

02:42 PM

Culvert ID*

Number of Barrels

Assessed by*

Eric Ohanian

Town

Jamie

Road name

Crossing*

- (●) Is Present
- ( ) Does Not Exist

Temp (F):

Current Weather

- ( ) Clear
- ( ) Cloudy
- ( ) Rain
- ( ) Sleet
- ( ) Fog
- ( ) Snow

Jamie

- [ ] High Wind

Roadway

Road Type

- [ ] Paved
- [ ] Unpaved - Gravel
- [ ] Other

Roadway Condition*

-Please Select-

Guardrail Present

- [x] Yes
- [ ] No

Guardrail Side

- [ ] One Side
- [ ] Both Sides

Guardrail Condition

- [ ] Satisfactory

Jamie

- [ ] Unknown
- [ ] Poor
- [ ] Critical/Failing
- [ ] NA

Pavement Width

(Feet)

Pavement Width

(Inch)

0 Reset 11

Pavement Width

(Inch)

Culvert Length

(Feet)

Jamie

Culvert Length

(Inch)

0 Reset 11

Culvert Length

(Inch)

123

Crossing Alignment to Roadway

- Road-Aligned
- Skewed (<45)
- Skewed (>45)
- Unknown

Crossing Alignment to Stream

- Stream-Aligned
- Skewed (<45)
- Skewed (>45)

Jamie

Unknown

Roadway Photos

Take up to 5 photos

Select image file

Roadway Sketch

Reset

Other Roadway Observations

e.g. curbing needs repair, etc,

Jamie

255

Upstream

Approximate Bankfull Width
(Feet)

123

Approximate Bankfull Width
(Inch)

0 Reset 11

123

Approximate Bankfull Width
(Inch)

123

Upstream Photos
Take up to 5 photos

Select image file

Upstream Sketch

Jamie

Reset

Upstream Observations

255

Crossing Inlet

Inlet Located

- (•) Located
- ( ) Cannot Locate

If unable to Inspect Inlet, Please select Reason:

- [ ] Poison Ivy

Jamie

- [ ] Debris
- [ ] Heavy Brush
- [ ] Sediment obstruction
- [ ] High water
- [ ] Partial Collapse
- [ ] Full Collapse
- [ ] Other

Crossing Type - Inlet

- [ ] Bridge (Span of 10' or more)
- [ ] Culvert (Span less than 10')
- [ ] Multiple Culverts
- [ ] Unknown

Number of Culverts - Inlet

123

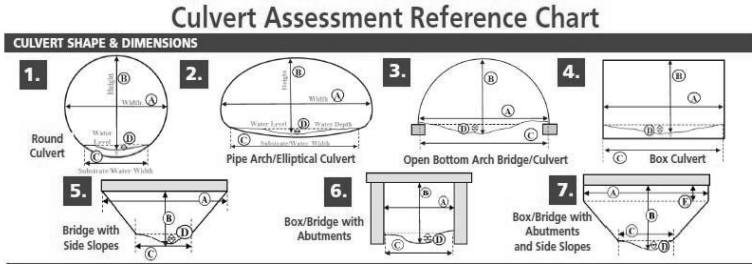
Jamie

Shape - Inlet

Consult Quick Guide)

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7

Shape Inlet Reference



Crossing Dimension A:

(Feet)

Jamie

Crossing Dimension A:

(Inch)

0 Reset 11

Crossing Dimension B:

(Feet)

Crossing Dimension B:

(Inch)

0 Reset 11

Crossing Dimension C:

(Feet)

May not apply to all crossings – consult Quick Guide

Crossing Dimension C:

(Inch)

0 Reset 11

Crossing Dimension D:

Jamie

May not apply to all crossings – consult Quick Guide

Crossing Dimension D:

(Inch)

0 Reset 11

Crossing Dimension E:

(Feet)

May not apply to all crossings – consult Quick Guide

Crossing Dimension E:

(Inch)

0 Reset 11

Bend Mid-Crossing

Yes No

Road Fill Height Ft (Top of Crossing to Road Surface)

(Feet)

Jamie

(Inch)

0 Reset 11

Road Fill Height

Inlet Embankment Slope

- None
- Graded Slope (steeper than 2:1)
- Graded Slope (less than 2:1)
- Retaining Wall
- Other

Inlet Type

- Projecting
- Headwall
- Wingwalls
- Headwall & Wingwalls
- Mitered to Slope
- None

Jamie

- Other

Tree Present by Upstream Headwall/Wingwall

- Yes
- No

Armoring Inlet Condition

- Satisfactory
- Fair
- Unknown
- Poor
- Critical/Failing
- NA

Crossing Material - Inlet

-Please Select-

Inlet Obstruction(s)

Jamie

- [x] Yes
- [ ] No

Inlet Obstruction Type

Check all that apply

- [ ] Trash
- [ ] Wood
- [ ] Sediment
- [ ] Screen/Grate
- [ ] Other

Obstruction Serverity

- [ ] Low
- [ ] Medium
- [ ] High

Material Present in Crossing?

Jamie

- [ ] Yes
- [ ] No
- [ ] Unknown

Inlet Elevation

-Please Select-

Invert Deterioration*

- [ ] Low
- [ ] Medium
- [ ] High
- [ ] None
- [ ] Unknown

Joints and Seams*

- [ ] Satisfactory
- [ ] Fair
- [ ] Poor
- [ ] Critical/Failing
- [ ] Unknown

Jamie

Severity of Cracking*

- ○ Low
- ○ Medium
- ○ High
- ○ None
- ○ Unknown

Apron Condition*

- ○ Satisfactory
- ○ Fair
- ○ Poor
- ○ Critical/Failing
- ○ Unknown
- ○ N/A

This is a required question

Jamie

Scour?*

- ◉ Yes
- ○ No
- ○ Unknown

Scour Damage

- ○ Low
- ○ Medium
- ○ High
- ○ Unknown

Scour Location

- ○ Culvert
- ○ Footer
- ○ Wingwalls
- ○ Other

Jamie

Cross-section Deformation*

- ○ Low
- ○ Medium
- ○ High
- ○ None
- ○ Unknown

Footing Condition*

-Please Select-

Crossing Inlet Overall Comments

Crossing Inlet Photos

Take up to 5 photos

Select image file

Crossing Inlet Sketch

Jamie

Reset

Crossing Outlet

Crossing Outlet Located

- ◉ Located
- ○ Cannot Locate

If unable to Inspect Outlet, Please select reason:

- ☐ Poison Ivy
- ☐ Debris
- ☐ Heavy Brush

- [ ] Sediment obstruction
- [ ] High water
- [ ] Partial Collapse
- [ ] Full Collapse
- [ ] Other

Crossing Type - Outlet

- [ ] Bridge (Span of 10' or more)
- [ ] Culvert (Span less than 10')
- [ ] Multiple Culverts
- [ ] Unknown

Number of Culverts - Outlet

123

Shape - Outlet

Consult Quick Guide)

- [ ] 1

Jamie

- [ ] 2
- [ ] 3
- [ ] 4
- [ ] 5
- [ ] 6
- [ ] 7

Outlet Dimension A:

(Feet)

123

Outlet Dimension A:

(Inch)

0 Reset 11

123

Outlet Dimension B:

(Feet)

123

Jamie

(Inch)

0 Reset 11

Outlet Dimension C:

(Feet)

Outlet Dimension C:

(Inch)

0 Reset 11

Outlet Dimension D:

(Feet)

Outlet Dimension D:

(Inch)

0 Reset 11

Outlet Dimension E:

(Feet)

Jamie

Outlet Dimension E:

(Inch)

0 Reset 11

Road Fill Height Ft (Top of Crossing to Road Surface)

(Feet)

Road Fill Height

(Inch)

0 Reset 11

Road Fill Height

(Inch)

Downstream Embankment Slope

- None
- Graded Slope (steeper than 2:1)
- Graded Slope (less than 2:1)

- ○ Retaining Wall
- ○ Other

Retaining Wall Material:

- ☐ Stone/Rock Blocks
- ☐ Loose Stone/Rock
- ☐ Concrete
- ☐ Brick
- ☐ Other

Condition of Down Embankment*

-Please Select-

Outlet Type

- ☐ Projecting
- ☐ Headwall
- ☐ Wingwalls
- ☐ Headwall & Wingwalls
- ☐ Mitered to Slope
- ☐ None

Jamie

Headwall Material

- ☐ Stone
- ☐ Concrete
- ☐ Metal
- ☐ Other

Wingwall Material

- ☐ Stone
- ☐ Concrete
- ☐ Metal
- ☐ Other

Condition of Headwall Outlet

-Please Select-

Condition of Wingwall Outlet

Jamie

Unknown

Tree Present by Downstream Headwall/Wingwall

- ○ Yes
- ○ No

Armoring*

- ○ Satisfactory
- ○ Fair
- ○ Poor
- ○ Critical/Failing
- ○ Unknown
- ○ N/A

Crossing Material - Outlet

-Please Select-

Outlet Obstruction(s)

yes

Jamie

- ◉ Yes
- ○ No

Outlet Obstruction Type

Check all that apply

- ☐ Trash
- ☐ Wood
- ☐ Sediment
- ☐ Screen/Grate
- ☐ Other

Obstruction Serverity

- ○ Low
- ○ Medium
- ○ High

Material Present in Crossing?

- Yes
- No
- Unknown

Outlet Elevation

-Please Select-

Invert Deterioration

- Low
- Medium
- High
- None
- Unknown

Joints and Seams

- Satisfactory
- Fair
- Poor
- Critical/Failing

Jamie

- Unknown

Severity of Cracking

- Low
- Medium
- High
- None
- Unknown

Apron Condition

- Satisfactory
- Fair
- Poor
- Critical/Failing
- Unknown
- N/A

Jamie

Embankment Piping:

- ○ Low
- ○ Medium
- ○ High
- ○ None
- ○ Unknown

Scour?

- ○ Yes
- ○ No
- ○ Unknown

Cross-section Deformation

- ○ Low
- ○ Medium
- ○ High

Jamie

- ○ None
- ○ Unknown

Footing Outlet Condition

-Please Select-

Crossing Outlet Overall Comments

Crossing Outlet Photos

Take up to 5 photos

Select image file

Crossing Outlet Sketch

Jamie

Reset

Downstream

Downstream

The following questions pertain the the downstream side of the culvert.

Downstream Channel Bankfull Width

(Feet)

123

Downstream Channel Bankfull Width

(Inch)

0 Reset 11

123

Downstream Channel Bankfull Width

(Inch)

123

Downstream Embankment Photo

Take up to 5 photos

Select image file

Jamie

Downstream Embankment Sketch

Reset

Downstream Notes

255

Operation and Maintenance Concerns

Illicit Discharged Observed

Yes

Jamie

- [ ] No

Illicit Discharged Location

- [ ] Nearby Outfall Upstream
- [ ] Nearby Outfall Downstream
- [ ] Observed at Inlet
- [ ] Observed at Outlet

Operation and Maintenance Concerns

- [ ] Suds/Foam/Laundry Discharge
- [ ] Garbage
- [ ] Needs Maintenace
- [ ] Sewage
- [ ] Oil or Fuel
- [ ] Pet Waste
- [ ] Paint

Jamie

- [ ] Excessive Trash
- [ ] Yard Waste or Bulk Dumping
- [ ] Other

Beaver Dam near crossing

- [x] Yes
- [ ] No

Beaver Dam Location

- [ ] Near Inlet
- [ ] Near Outlet

Beaver Dam Distance from Crossing

123

O&M Concern Photo

Select file

Jamie

Reset

Additional O&M Notes

Assessment Status

Survey Complete

- Complete
- Incomplete

Additional Photos

Take up to 5 photos

Select image file

Jamie

Additional Photo Description

255

Comments

255

GIS_ID

Do not modify

Submit

Appendix C

STORMWATER ASSETS ASSESSED

LEGEND

Structures Assessed

Structures Assessed

Culverts Assessed

Culverts Assessed

Pipes Assessed

Pipes Assessed

LOCUS MAP

0 1,050 2,100 Feet

1:12,500

NOTES

1. Based on MassGIS Color Orthophotography (2019)

Ayer Stormwater Asset Management

Ayer, Massachusetts

August 2022

Tighe&Bond

G:\GIS\MA\AyerMA\avproj\StormwaterAssetsAssessed_MA_22x34.mxd

Value of Ayer's Drainage Assets

Asset Type	Quantity [1]	Unit	Replacement Cost [2]		Total Cost	Assumptions
Catch Basin	1,082	EA	$ 4,500	/EA	$ 4,869,000	
Drain Manhole	373	EA	$ 4,900	/EA	$ 1,827,700	
Outfall	143	EA	$ 1,750	/EA	$ 250,250	Assumes concrete flared end, all same size, assumes no concrete headwall
Treatment Unit	21	EA	$ 15,000	/EA	$ 315,000	
Culvert [3]	84	EA	$ 535,000	/EA	$ 44,940,000	Assume 6' precast concrete box culvert
Drain Collector Pipes (inches)						
4	112	LF	$ 100	/LF	$ 11,203	Assumes replace with 6", HDPE
6	1,875	LF	$ 100	/LF	$ 187,464	Assumes replace with 6", HDPE
8	619	LF	$ 105	/LF	$ 64,996	Assumes replace with 8", HDPE
10	1,082	LF	$ 110	/LF	$ 119,046	Assumes replace with 12", HDPE
12	32,678	LF	$ 140	/LF	$ 4,574,863	Assumes replace with 12", HDPE
15	22,356	LF	$ 140	/LF	$ 3,129,803	Assumes replace with 18", HDPE
18	4,603	LF	$ 140	/LF	$ 644,456	Assumes replace with 18", HDPE
24	3,608	LF	$ 150	/LF	$ 541,243	Assumes replace with 24", HDPE
30	1,039	LF	$ 150	/LF	$ 155,902	Assumes replace with 30", HDPE
36	840	LF	$ 175	/LF	$ 147,085	Assumes replace with 36", HDPE
48	21	LF	$ 225	/LF	$ 4,655	Assumes replace with 48" concrete
60	300	LF	$ 300	/LF	$ 90,104	Assumes replace with 60" concrete
Unknown	46,056	LF	$ 150	/LF	$ 6,908,353	Assumes replace with 12", HDPE
Subtotal Drain Pipes	*115,189*	*LF*			*$ 16,579,172*	
			Total Value of Drainage Assets		**$ 68,781,122**	
			Round up and 30% Contingency		**$ 90,000,000**	

1. Quantities are based on the Town's GIS mapping as of the date of this report.
2. Drainage pipe replacement costs include materials and installation. Culvert replacement costs based on 6' precast box culvert OPCC provided in Appendix G
3. The quantity of culverts is subject to change based on confirmation of ownership from the Town.

Disclaimer:

The above figures are estimated replacement costs for various drainage related infrastructure. These figures were prepared in an effort to estimate the approximate value of these assets and should not be used for capital planning purposes. Tighe & Bond has no control over the cost or availability of labor, equipment or materials, market conditions, or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the cost of work will not vary from this estimate.

Culverts with Operation and Maintenance Concerns

Culvert ID	Road name	Material Present in Crossing?/ Substrate depth (Inlet)	Tree Present by Downstream Headwall/Wingwall	Material Present in Crossing? (Outlet)	Operation and Maintenance Concerns	Beaver Dam near crossing	Inlet Obstruction(s)	Outlet Obstruction(s)
P-59	Groton School Road	Yes	No	Yes			No	Yes
P-1741	Roasewood Ave	Unknown		Unknown			No	Yes
P-338	Mark Street	No	No	Yes			No	No
P-342	Victor Drive	Yes	No	No			No	No
P-58	Víctor Drive	Yes	Yes	Yes			No	No
P-345	Jonathan Road	Yes	Yes	Yes			No	No
P-341	Jonathan Road	Yes	No				No	No
P-339	Vernon Street	Yes	No	Unknown			No	Yes
P-1285	Nashua Street	Unknown	No	Yes			Yes	No
P-142	Norwood Avenue	Yes	No	No			No	No
P-140	Highland Avenue	No	Yes	No			No	No
P-141	Lincoln Street	No	Yes	Yes			No	No
P-1510	RAILROAD	No	No				Yes	
P-1265	Wear Main Street	No	Yes	No			No	No
P-1247	Bligh Street	Yes	No	Unknown			No	No
P-143	High Street	No	Yes	Yes			No	Yes
P-144	Williams Street	No	Yes	Yes			No	Yes
P-1506	Cambridge Street	Yes	No	Yes			Yes	No
P-1508	Central Avenue	No	No	Yes			Yes	No
P-1715	RAILROAD	Yes	No				Yes	
P-1173	Harvard Street	Yes					Yes	Unknown
P-1174	N/A		No	Yes			No	Yes
P-1716	Washington Street	Yes					No	Unknown
P-87	Washington Street	Yes	No	Yes			Yes	No
P-711	Madigan Lane	No	No	No			No	Yes
P-976	Calvin St	No	No	No	YardWaste		Yes	Yes
P-550	Oak Ridge Drive	No	Yes	No			No	No
P-1177	Wright Rd	No	No				Yes	
P-1744	Old Sandy Pond Road	No	No	No			Yes	Yes
P-1743	N/A	Yes	No	Yes			Yes	No
P-1170	Central Street	Yes	Yes	Yes			Yes	No
P-1175	Sandy Pond Road	Yes	No	No			No	Yes
P-1176	N/A	No	Yes				No	
P-587	Snake Hill Road	No	No	Yes			Yes	No
Potential-12	Lindley Drive		No	Yes			Unknown	No
P-841	Mountain Laurel Road	No	No	No			No	Yes
P-71	Mulberry Circle	Yes	No	No			No	No
P-921	Nemco way	Yes	No	Yes			No	No
P-589	Copeland Drive	Unknown	Yes	No			No	No
Potential -11	Spectacle Road	Yes	No	Unknown			No	No
Potential-7	Bennet's Brook Lane		No	Yes	YardWaste		Unknown	No
Potential-6	Bonnet's Brook Road	No	Yes	No			Yes	Yes
P-1539	Willow road	No	Yes	No			No	No
P-1096	Willow road	Yes	Yes	Yes			No	No
P-New1	Willow Road	No	Yes	No			Yes	No
Potential-16	N/A walking trail		No	Yes			Unknown	No
P-915	Pingry Way	No	Yes	Yes			Yes	No
Potential-9	Bennetts Crossing	No	Yes	No		Yes	Yes	Yes

Drainage Structures with Operation and Maintenance Concerns

Structure ID	Criticality	Location	Structure Type	Notes
DS-1158	Low	Groton School Road	CatchBasin	Cleaning, submerged pipes
DS-1304	Low	Pearl Steet	CatchBasin	Cleaning, Lots of water and sediment. Could not confirm P-74 existence
DS-1135	Low	Jackson Street	CatchBasin	Cleaning, water
DS-846	Low	Washington Street	CatchBasin	Full with water
DS-3	Low	Faulkner Street	CatchBasin	Flushing
DS-1542	Low	Forest Street	CatchBasin	Flushing,Cleaning, Filled with water. Cannot inspect pipes
DS-1391	Medium	Pearl Street	CatchBasin	Repairs
DS-1424	Medium	Columbia Street	CatchBasin	Cleaning
DS-1552	Low	Markham Circle	CatchBasin	Cleaning
DS-27	Low	Willard Street	CatchBasin	Cleaning
DS-36	Low	Grosvenor Street	CatchBasin	Cover_Frame
DS-401	Medium	Myrick Street	CatchBasin	Cleaning,Flushing, full of water
DS-1251	Medium	Atherton Street	CatchBasin	Cover_Frame
DS-232	Low	Atherton Street	CatchBasin	Cleaning
DS-1094	Medium	Pleasant Street	CatchBasin	Cleaning,Flushing
DS-676	Low	Pleasant Street	CatchBasin	Flushing, Discharge coming from roof drain or sump pump at 95 Pleasant Street
DS-635	Medium	Pleasant Street	CatchBasin	Flushing,Cleaning
DS-633	Low	Pleasant Street	CatchBasin	Cleaning
DS-1307	Medium	Pleasant Street	CatchBasin	Cleaning,Flushing, Rancid_Sour,Garbage
DS-186	Medium	Groton Harvard Road	CatchBasin	Flushing, Sump pump discharging significant flow
DS-1278	Medium	Oak Ridge Drive	CatchBasin	Repairs
DS-902	Medium	Snake Hill Road	CatchBasin	Flushing,Cleaning
DS-903	Medium	Snake Hill Road	CatchBasin	Flushing,Cleaning
DS-1367	High	Snake Hill Road	CatchBasin	Cleaning,Cover_Frame
DS-71	Medium	Snake Hill Road	CatchBasin	Cleaning
DS-263	Low	Samantha Lane	CatchBasin	Flushing
DS-954	Medium	Willard Street	CatchBasin	Flushing,Cleaning
DS-2115	Medium	Willard Street	CatchBasin	Cleaning,Flushing, Garbage
DS-31	Medium	Willard Street	CatchBasin	Flushing,Cleaning
DS-32	Medium	Willard Street	CatchBasin	Flushing,Cleaning,Repairs
DS-239	Medium	Hatch Street	CatchBasin	Flushing,Cleaning, Water flowing out of catch basin
DS-238	Medium	Hatch Street	CatchBasin	Flushing,Cleaning, Filled to the cover with water
DS-237	Medium	Hatch Street	CatchBasin	Cleaning,Flushing, Filled to cover with water
DS-194	Medium	Sandy Pond Road	CatchBasin	Cleaning,Flushing
DS-445	Low	Sandy Pond Road	CatchBasin	Repairs
DS-803	Medium	Willow Road	CatchBasin	Repairs
DS-817	Low	Willow Road	CatchBasin	Petroleum_Gas_Odor
DS-804	Low	Willow Road	CatchBasin	Rancid_Sour
DS-1509	Medium	West Main Street	CatchBasin	Repairs, Invert is collapsing
DS-1046	Low	West Main Street	CatchBasin	Repairs
DS-740	Medium	West Main Street	CatchBasin	Repairs,Flushing,Cleaning, Sides caved in. Full of water and sediment.
DS-741	Medium	West Main Sreet	CatchBasin	Repairs,Flushing, Full of sediment and water
DS-1036	Medium	West Main Street	CatchBasin	Repairs, collapsing wall
DS-956	Medium	West Main Street	CatchBasin	Repairs, Walls collapsing. Full of sediment
DS-174	Low	Groton Harvard Road	CatchBasin	Repairs
DS-715	Medium	Highland Ave	CatchBasin	Repairs
DS-671	Medium	Jackson Street	CatchBasin	Flushing
DS-1140	Medium		CatchBasin	Repairs
DS-1133	Low	Pearl Street	CatchBasin	Cleaning
DS-1099	Low	Jackson Street	CatchBasin	Flushing
DS1099B	Low	Jackson Street	CatchBasin	Flushing
DS-1137	Medium	Jackson Street	CatchBasin	Flushing
DS-1313	Low	Bishop Road	CatchBasin	Flushing, Pipe submerged if it exists
DS-528	Low	Nashua Street	CatchBasin	Flushing, high water level
DS-1041	Low	Williams Street	CatchBasin	Cleaning
DS-309	Medium	Cambridge Street	CatchBasin	Flushing,Cleaning
DS-1501	Low	Amandrey Way	Manhole	Cleaning, rocks on floor
DS-1157	Low	Groton School. Street	Manhole	Cleaning
DS-1811	Low	Norwood Avenue	Manhole	Cleaning
DS-702	Low	Norwood Avenue	Manhole	Cleaning
DS-1764	High	East Street	Manhole	Cleaning, full of sediment
DS-1230	Low	Fletcher Street	Manhole	Cleaning
DS-1190	Low	Washington Street	Manhole	Cleaning
DS-1189	Low	Washington Street	Manhole	Cleaning
DS-1191	Low	Washington Street	Manhole	Cleaning
DS-640	Low	New England Way	Manhole	Cleaning
DS-1385	Low	Nemco Way	Manhole	Cleaning, sediment
DS-1509B	Low	West MainStreet	Manhole	Cleaning
DS-2103	Low	Elm Street	Manhole	Concrete piece in structure
DS-209	Low	Grove Street	CatchBasin	Cleaning
DS-2121	Low	Washington Street	Manhole	Cleaning
DS-481	Low	Hibiscus Lane	CatchBasin	Frame is loose

Drainage Pipes with Maintenance Needs

Pipe ID	Location	Condition	Notes
P-17	Groton School Road	fair	Root_Intrusion
P-334	Groton School Road	good	Root_Intrusion
P-1289	Washington Street	fair	Root_Intrusion
P-1555	Washington Street	good	Root_Intrusion
P-130	Nashua Street	poor	Cracked,Root_Intrusion
P-497	Nashua Street	poor	Root_Intrusion
P-131	Nashua Street	fair	Root_Intrusion
P-132	Nashua Street	poor	Root_Intrusion
P-134	Nashua Street	good	Root_Intrusion
P-417	Groton Street	immediate	Broken
P-1431	Pleasant Street	immediate	Collapse
P-1490	Faulkner Street	poor	Cracked
P-215	Forest Street	poor	Root_Intrusion
P-216	Forest Street	poor	Root_Intrusion
P-219	Grove Street	poor	Broken
P-220	Grove Street	fair	Root_Intrusion
P-226	Grove Street	poor	Cracked
P-1484	Maple Streets	poor	Root_Intrusion
P-565	Pearl Street	poor	Cracked,Broken
P-572	West Street	poor	Caving_In
P-1025	Columbia Street	poor	Cracked
P-1026	Columbia Street	poor	Cracked
P-1029	Columbia Street	immediate	Cracked,Broken,Caving_In,Collapse
P-405	Pleasant Street	poor	Cracked
P-402	Pleasant Street	poor	Root_Intrusion
P-403	Pleasant Street	fair	Root_Intrusion
P-173	Willard Street	poor	Caving_In
P-289	Willard Street	fair	Root_Intrusion
P-291	Willard Street	fair	Root_Intrusion
P-315	Atherton Street	poor	Cracked
P-316	Atherton Street	poor	Cracked
P-319	Atherton Street	fair	Root_Intrusion
P-725	Maple Street	poor	Root_Intrusion
P-726	Maple Street	poor	Cracked,Root_Intrusion
P-1470	East Street	poor	Root_Intrusion
P-1471	East Street	poor	Root_Intrusion
P-721	Fletcher Street	fair	Root_Intrusion
P-273	Fletcher Street	fair	Root_Intrusion
P-274	Fletcher Street	poor	Cracked,Root_Intrusion
P-395	Pleasant Street	poor	Cracked
P-396	Pleasant Street	poor	Broken
P-398	Pleasant Street	poor	Caving_In
P-400B	Pleasant Street	poor	Cracked
P-485	Washington Street	immediate	Caving_In
P-489	Washington Street	immediate	Broken
P-1233	Groton Harvard Road	poor	Root_Intrusion
P-93	Oak Ridge Drive	poor	Caving_In
P-89	Pine Ridge Drive	fair	Root_Intrusion
P-88	Pine Ridge Drive	poor	Root_Intrusion
P-1047	Oak Ridge Drive	fair	Cracked
P-104	Oak Ridge Drive	fair	Cracked
P-105	Oak Ridge Drive	poor	Broken
P-1008	Oak Ridge Drive	good	Root_Intrusion
P-1009	Oak Ridge Drive	good	Root_Intrusion

Drainage Pipes with Maintenance Needs

Pipe ID	Location	Condition	Notes
P-1010	Oak Ridge Drive	good	Root_Intrusion
P-970	Snake Hill Road	fair	Root_Intrusion
P-282	Samantha Lane	fair	Root_Intrusion
P-283	Samantha Lane	fair	Root_Intrusion
P-181	Willard Street	poor	Collapse
P-1732	Willard Street	poor	Root_Intrusion
P-305	Hatch Street	immediate	Collapse
P-306	Hatch Street	poor	Root_Intrusion,Broken
P-307	Hatch Street	immediate	Collapse
P-310	Myrick Street	poor	Caving_In
P-311	Myrick Street	fair	Root_Intrusion
P-168	Willard Street west	poor	Broken
P-199	Nemco Way	fair	Root_Intrusion
P-1100	Willow Road	fair	Root_Intrusion
P-1538	Willow Road	immediate	Cracked,Broken,Caving_In
P-1538B	Willow Road	immediate	Broken,Caving_In
P-1486	Grove Street	fair	Root_Intrusion
P-1226	Groton Harvard Road	fair	Root_Intrusion
P-136	Highland Avenue	immediate	Cracked,Broken,Caving_In
P-415	Jackson Street	immediate	Collapse,Cracked
P-454	Jackson Street	poor	Cracked
P-455	Jackson Street	poor	Cracked
P-78C	Jackson Street	poor	Cracked
P-76B	Jackson Street	fair	Root_Intrusion
P-61	Jackson Street	poor	Root_Intrusion
P-135	Nashua Street	good	Root_Intrusion
P-1277	Nashua Street	fair	Root_Intrusion,Cracked
P-638	Williams Street	poor	Broken
P-639	Williams Street	fair	Cracked
P-646	Washington Street	poor	Root_Intrusion
P-1738	Washington Street	poor	Root_Intrusion
P-635	Washington Street	good	Root_Intrusion
P-636	Washington Street	fair	Root_Intrusion
P-1240	Western Drive	immediate	Caving_In
P-137	Highland Avenue	fair	Root_Intrusion
P-1469	East Street	poor	Root_Intrusion
P-149	West Main Street	immediate	Collapse,Broken
P-174	Willard Street	immediate	Caving_In,Collapse
P-182	Willard Street	immediate	Caving_In,Broken
P-290	Willard Street	poor	Root_Intrusion,Caving_In
P-840	Sandy Pond Road	poor	Collapse,Cracked
P-90	Pine Ridge Drive	poor	Caving_In,Root_Intrusion

Appendix D

PoF Summary Structures

Structure Component	Excellent	Good	Fair	Poor	Immediate	Unknown
Structure Condition	24%	47%	17%	9%	2%	1%
Cover/Grate Condition	31%	63%	3%	1%	0%	1%
Frame Condition	21%	62%	13%	1%	0%	2%
Corbel Condition	32%	43%	16%	4%	0%	4%
Wall Condition	30%	45%	15%	7%	0%	3%
Floor Condition	5%	10%	1%	0%	0%	85%
Invert Condition	11%	39%	27%	20%	0%	2%
Structure Component	**No**			**Yes**		
Maintenance Needs	67%			33%		

PoF Summary Culverts

Culvert Component	Satisfactory	Fair	Poor	Critical/Failing	Unknown	N/A
Roadway Condition	18%	33%	34%	8%	0%	7%
Guardrail Condition	7%	11%	16%	11%	2%	52%
Inlet Conditions						
Condition of Embankment	10%	46%	31%	3%	5%	5%
Condition of Wingwall	3%	18%	11%	5%	8%	54%
Apron Condition	3%	5%	2%	2%	7%	82%
Outlet Conditions						
Condition of Embankment	8%	39%	39%	5%	8%	0%
Condition of Wingwall	3%	13%	13%	0%	16%	54%
Apron Condition	0%	8%	2%	2%	18%	70%

Culvert Component	None	Low	Medium	High	Unknown	N/A
Inlet Conditions						
Obstruction Severity	67%	15%	8%	5%	5%	0%
Culvert Deterioration	25%	21%	20%	13%	21%	0%
Scour Damage	67%	13%	3%	2%	15%	0%
Cross-section Deformation	54%	11%	8%	8%	18%	0%
Culvert Component	**No**		**Yes**		**Unknown**	
Tree Present Inlet	59%		34%		7%	
Outlet Conditions						
Obstruction Severity	66%	11%	5%	5%	13%	0%
Culvert Deterioration	21%	18%	10%	15%	36%	0%
Scour Damage	61%	3%	7%	5%	25%	0%
Cross-section Deformation	51%	3%	13%	7%	26%	0%
Culvert Component	**No**		**Yes**		**Unknown**	
Tree Present Outlet	62%		28%		10%	

PoF Summary Drainage Pipes

Structure Component	Excellent	Good	Fair	Poor	Immediate	Unknown
Pipe Condition	40%	21%	15%	16%	5%	2%
Structure Component	**0%-5% full**		**6%-40% full**		**>40% full**	
Pipe Sediment	55%		33%		12%	
Structure Component	**No**			**Yes**		
Maintenance Needs	69%			32%		

Appendix E

Culvert PLA

TB_ID	PoF Scores	CoF Score	Criticality	Criticality	PLA and SLA	Action
P-1539	0.59	0.61	0.36	High	PLA	Replace
P-550	0.56	0.65	0.36	High	PLA	Replace
P-711	0.61	0.52	0.31	High	PLA	Replace
Potential -11	0.56	0.55	0.31	High	PLA	Replace
P-1096	0.54	0.55	0.29	High	PLA	Replace

Culvert SLA

TB_ID	PoF Scores	CoF Score	Criticality	Criticality	PLA and SLA	Action
P-New1	0.50	0.63	0.31	Medium	SLA	Replace
P-59	0.40	0.65	0.26	Medium	SLA	Aggressive Monitoring
P-1179	0.57	0.45	0.26	Medium	SLA	Aggressive Maintenance
P-1741	0.43	0.58	0.25	Medium	SLA	Aggressive Monitoring
Potential-9	0.31	0.71	0.22	Medium	SLA	Aggressive Monitoring
P-144	0.53	0.39	0.20	Medium	SLA	Aggressive Maintenance
Potential-7	0.40	0.52	0.20	Medium	SLA	Aggressive Monitoring
P-New2	0.35	0.58	0.20	Medium	SLA	Aggressive Monitoring
P-1177	0.36	0.56	0.20	Medium	SLA	Aggressive Monitoring
P-1170	0.39	0.52	0.20	Medium	SLA	Aggressive Monitoring
P-1520	0.25	0.77	0.19	Medium	SLA	Aggressive Monitoring
P-915	0.30	0.63	0.19	Medium	SLA	Aggressive Monitoring
Potential-16	0.34	0.53	0.18	Medium	SLA	Aggressive Monitoring
P-589	0.31	0.58	0.18	Medium	SLA	Aggressive Monitoring
P-1175	0.35	0.50	0.18	Medium	SLA	Aggressive Monitoring
Potential-6	0.31	0.53	0.17	Medium	SLA	Aggressive Monitoring
P-741	0.32	0.52	0.17	Medium	SLA	Aggressive Monitoring
P-1743	0.60	0.27	0.16	Medium	SLA	Aggressive Maintenance
P-1174	0.55	0.29	0.16	Medium	SLA	Aggressive Maintenance
P-841	0.23	0.65	0.15	Medium	SLA	Aggressive Monitoring
Potential -1	0.20	0.68	0.13	Medium	SLA	Aggressive Monitoring
P-1612	0.20	0.61	0.12	Medium	SLA	Aggressive Monitoring
P-87	0.18	0.66	0.12	Medium	SLA	Aggressive Monitoring
P-976	0.16	0.63	0.10	Medium	SLA	Aggressive Monitoring
P-1584	0.16	0.56	0.09	Medium	SLA	Aggressive Monitoring
P-921	0.14	0.58	0.08	Medium	SLA	Aggressive Monitoring

Drainage Pipe PLA

TB_ID	PoF	CoF	Criticality	Criticality	PLA and SLA	Comments
P-590	**0.89**	**0.55**	0.49	**High**	PLA	Full of sediment. Can see outlet
P-151	**0.89**	**0.52**	0.47	**High**	PLA	Completely filled with sediment
P-972	**0.83**	**0.57**	0.48	**High**	PLA	Full of sediment. Cannot inspect.
P-224	**0.83**	**0.55**	0.46	**High**	PLA	Completely full of sediment
P-150	**0.78**	**0.57**	0.44	**High**	PLA	Fully buried
P-93	**0.78**	**0.55**	0.43	**High**	PLA	Initial CMP section is caving in. Remainder RCP section is excellent.
P-147	**0.78**	**0.52**	0.41	**High**	PLA	Full of sediment
P-1223	**0.78**	**0.50**	0.39	**High**	PLA	Noticeable spalling
P-840	**0.72**	**0.52**	0.38	**High**	PLA	Cracks at 9. Apparent collapsed or sagging section at end of video
P-4	**0.67**	**0.62**	0.41	**High**	PLA	Corroded and sediment obstructing flow
P-17	**0.67**	**0.62**	0.41	**High**	PLA	Corrosion. Roots. Debris
P-970	**0.67**	**0.50**	0.33	**High**	PLA	Roots and sediment
P-1226	**0.67**	**0.50**	0.33	**High**	PLA	Roots and sediment. Small offset joints
P-1490	**0.61**	**0.50**	0.31	**High**	PLA	Portions appear cracked and exposed soil
P-335	**0.56**	**0.62**	0.34	**High**	PLA	Culvert
P-334	**0.56**	**0.62**	0.34	**High**	PLA	Sediment
P-1489	**0.56**	**0.50**	0.28	**High**	PLA	Corrosion. Object in pipe
P-1404	**0.50**	**0.67**	0.33	**High**	PLA	Corrosion
P-199	**0.50**	**0.52**	0.26	**High**	PLA	Large root at 12

Drainage Pipe PLA

TB_ID	PoF	CoF	Criticality	Criticality	PLA and SLA	Comments
P-590	**0.89**	**0.55**	0.49	**High**	PLA	Full of sediment. Can see outlet
P-151	**0.89**	**0.52**	0.47	**High**	PLA	Completely filled with sediment
P-972	**0.83**	**0.57**	0.48	**High**	PLA	Full of sediment. Cannot inspect.
P-224	**0.83**	**0.55**	0.46	**High**	PLA	Completely full of sediment
P-150	**0.78**	**0.57**	0.44	**High**	PLA	Fully buried
P-93	**0.78**	**0.55**	0.43	**High**	PLA	Initial CMP section is caving in. Remainder RCP section is excellent.
P-147	**0.78**	**0.52**	0.41	**High**	PLA	Full of sediment
P-1223	**0.78**	**0.50**	0.39	**High**	PLA	Noticeable spalling
P-840	**0.72**	**0.52**	0.38	**High**	PLA	Cracks at 9. Apparent collapsed or sagging section at end of video
P-4	**0.67**	**0.62**	0.41	**High**	PLA	Corroded and sediment obstructing flow
P-17	**0.67**	**0.62**	0.41	**High**	PLA	Corrosion. Roots. Debris
P-970	**0.67**	**0.50**	0.33	**High**	PLA	Roots and sediment
P-1226	**0.67**	**0.50**	0.33	**High**	PLA	Roots and sediment. Small offset joints
P-1490	**0.61**	**0.50**	0.31	**High**	PLA	Portions appear cracked and exposed soil
P-335	**0.56**	**0.62**	0.34	**High**	PLA	Culvert
P-334	**0.56**	**0.62**	0.34	**High**	PLA	Sediment
P-1489	**0.56**	**0.50**	0.28	**High**	PLA	Corrosion. Object in pipe
P-1404	**0.50**	**0.67**	0.33	**High**	PLA	Corrosion
P-199	**0.50**	**0.52**	0.26	**High**	PLA	Large root at 12

Drainage Structure PLA

TB_ID	PoF	CoF	Criticality	Criticality	PLA and SLA	Action
DS-1367	0.63	0.67	0.42	High	PLA	Cleaning
DS-1764	0.56	0.67	0.37	High	PLA	Full of Sedmient

Drainage Structure SLA

TB_ID	PoF	CoF	Criticality	Criticality	PLA and SLA	Action
DS-86	0.42	0.67	0.28	Medium	SLA	Aggressive Monitoring
DS-1277	0.35	0.67	0.23	Medium	SLA	Aggressive Monitoring
DS-1064	0.21	0.67	0.14	Medium	SLA	Aggressive Monitoring
DS-2109	0.19	0.67	0.12	Medium	SLA	Aggressive Monitoring
DS-902	0.56	0.42	0.23	Medium	SLA	Aggressive Maintenance
DS-71	0.53	0.42	0.22	Medium	SLA	Aggressive Maintenance
DS-956	0.67	0.17	0.11	Medium	SLA	Aggressive Maintenance
DS-239	0.65	0.17	0.11	Medium	SLA	Aggressive Maintenance
DS-238	0.65	0.17	0.11	Medium	SLA	Aggressive Maintenance
DS-237	0.65	0.17	0.11	Medium	SLA	Aggressive Maintenance
DS-1036	0.65	0.17	0.11	Medium	SLA	Aggressive Maintenance
DS-1391	0.63	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-2115	0.63	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-194	0.63	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-715	0.63	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-635	0.60	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-1307	0.60	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-740	0.60	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-1140	0.60	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-1424	0.58	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-1278	0.58	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-32	0.58	0.17	0.10	Medium	SLA	Aggressive Maintenance
DS-954	0.56	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-31	0.56	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-741	0.56	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-1137	0.56	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-309	0.56	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-10	0.53	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-26	0.53	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-951	0.53	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-1251	0.53	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-1509	0.53	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-401	0.51	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-1094	0.51	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-186	0.51	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-903	0.51	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-803	0.51	0.17	0.09	Medium	SLA	Aggressive Maintenance
DS-671	0.51	0.17	0.09	Medium	SLA	Aggressive Maintenance

Appendix F

Town of Ayer
Town-Wide Drainage Inventory and Assessment
Proposed Capital Improvement Project Summaries

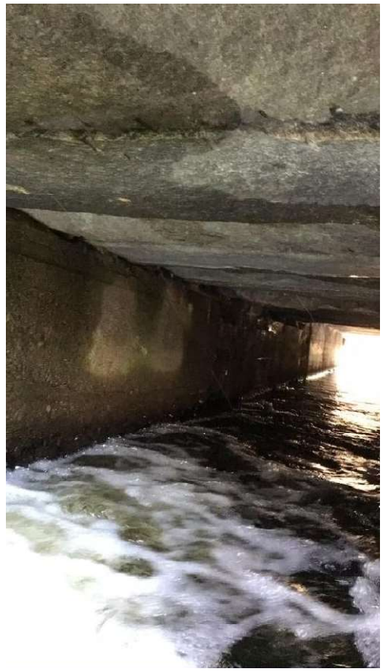
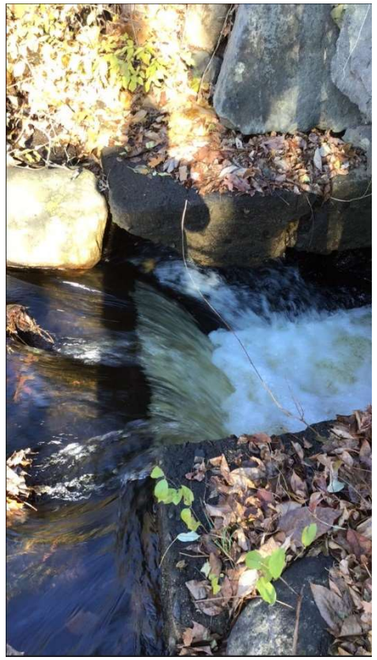
Asset ID	Summary of Statistics	Summary of Inventory Findings and Observations	Probability of Failure (PoF)	Consequence of Failure (CoF)	Recommendations	Criticality Rank	OPC [1]
Culvert ID: P-1096 Willow Road	corrugated metal	- Fair roadway condition - Fair Upstream embankment, poor downstream embankment - Material present in crossing, substrate depth 25% and 75%, tree present - High invert deterioration - High Cross section deformation - Some section loss in pipe at interface of material in culvert pipe	High PoF (0.54)	High CoF (0.55)	• Replacement	High	$973,000

Town of Ayer
Town-Wide Drainage Inventory and Assessment
Proposed Capital Improvement Project Summaries

Asset ID	Summary of Statistics	Summary of Inventory Findings and Observations	Probability of Failure (PoF)	Consequence of Failure (CoF)	Recommendations	Criticality Rank	OPC [1]
P-711 Madigan Lane	corrugated metal	- Poor Roadway condition - High invert deterioration - Critical/failing apron condition - High cross section deformation - 100% section loss deep in pipe - High obstruction severity - Full section loss 2.5', riprap slope failure	High PoF (0.61)	High CoF (0.52)	• Replacement	High	$884,000

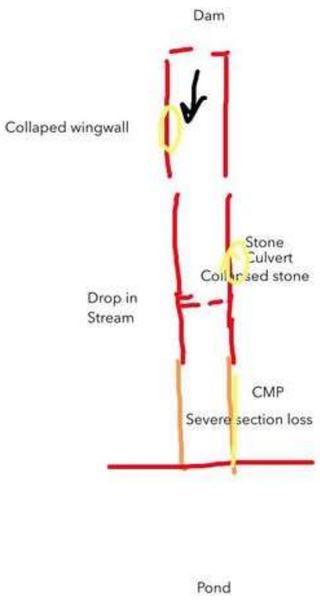
Town of Ayer
Town-Wide Drainage Inventory and Assessment
Proposed Capital Improvement Project Summaries

Asset ID	Summary of Statistics	Summary of Inventory Findings and Observations	Probability of Failure (PoF)	Consequence of Failure (CoF)	Recommendations	Criticality Rank	OPC [1]
P-1539 Willow Road	• Concrete • Scour under both abutments, joints deteriorating in headwall and wingwalls, stone sliding forward, heavy spalling due to deteriorated concrete. Dam at culvert inlet.	- Poor Roadway condition - Guardrail failing/critical - Poor condition of upstream embankment - Poor joints/seams - High invert deterioration - Poor headwall condition - Tree present	High PoF (0.59)	High CoF (0.61)	• Replacement	High	$1,300,000

Town of Ayer
Town-Wide Drainage Inventory and Assessment
Proposed Capital Improvement Project Summaries

Asset ID	Summary of Statistics	Summary of Inventory Findings and Observations	Probability of Failure (PoF)	Consequence of Failure (CoF)	Recommendations	Criticality Rank	OPC [1]
P-550 Oak Ridge Drive	- Collapsed stones from wing walls in stream. - Wing wall about to collapse. - Large joints and gaps between stones in culvert. - Minimal support length for top slab stone	- Poor roadway conditions - Guardrail failing - Wingwall critical/failing	High PoF (0.56)	High CoF (0.65)	• Replacement	High	$1,268,000



Town of Ayer
Town-Wide Drainage Inventory and Assessment
Proposed Capital Improvement Project Summaries

Asset ID	Summary of Statistics	Summary of Inventory Findings and Observations	Probability of Failure (PoF)	Consequence of Failure (CoF)	Recommendations	Criticality Rank	OPC [1]
Potential – 11 Spectacle Road	- Guard rail falling off posts and located on ground or missing - CMP culvert - Identified culvert location but not able to get eyes on culvert. Appears to be set above adjacent streambed elevation but embedded into embankment and fully submerged	- Guardrail critical/failing condition - High invert deterioration - Poor joints and seams - Section loss in pipe. Blockage in middle of culvert - Clogged/ Collapsed/ Submerged	High PoF (0.56)	High CoF (0.55)	• Replacement	High	$1,371,000

Town of Ayer
Town-Wide Drainage Inventory and Assessment
Proposed Capital Improvement Project Summaries

Asset ID	Summary of Statistics	Summary of Inventory Findings and Observations	Probability of Failure (PoF)	Consequence of Failure (CoF)	Recommendations	Criticality Rank	OPC [1]
P-New-1	- Severe section loss and rust - Culvert is deformed		Medium PoF (0.498)	High CoF (0.63)	• Replacement	Medium	$1,279,000



Appendix G

Conceptual- Engineer's Opinion of Probable Cost
P-1539 (9.9' Box Culvert) Culvert Replacement
Town of Ayer, MA

ITEM	DESCRIPTION	QTY	UNITS	UNIT PRICE	AMOUNT
101.	Clearing and Grubbing	0.30	A	$ 47,500.00	$ 14,250.00
116.1	Demolition of Existing Culvert	1	LS	$ 20,000.00	$ 20,000.00
120.	Unclassified Excavation	630	CY	$ 48.00	$ 30,240.00
140.	Bridge Excavation	280	CY	$ 80.00	$ 22,400.00
150.	Ordinary Borrow	100	CY	$ 40.00	$ 4,000.00
151.	Gravel Borrow	140	CY	$ 55.00	$ 7,700.00
151.2	Gravel Borrow for Backfilling Structures and Pipes	280	CY	$ 60.00	$ 16,800.00
156.1	Crushed Stone for Bridge Foundations	40	TON	$ 70.00	$ 2,800.00
170.	Fine Grading and Compacting	380	SY	$ 12.00	$ 4,560.00
415.1	Pavement Milling	70	SY	$ 100.00	$ 7,000.00
440.	Calcium Chloride for Roadway Dust Control	380	LB	$ 0.50	$ 190.00
443.	Water for Roadway Dust Control	0.40	MGL	$ 100.00	$ 40.00
452.	Asphalt Emulsion for Tack Coat	30	GAL	$ 9.00	$ 270.00
453.	HMA Joint Sealant	510	FT	$ 1.50	$ 765.00
460.	Hot Mix Asphalt	130	TON	$ 140.00	$ 18,200.00
482.3	Sawcutting Asphalt Pavement	130	FT	$ 4.00	$ 520.00
509.	Granite Transition Curb	30	FT	$ 60.00	$ 1,800.00
620.12	Guardrail, TL-2 (Single Faced)	100	FT	$ 40.00	$ 4,000.00
627.82	Guardrail Tangent End Treatment, TL-2	2	EA	$ 5,000.00	$ 10,000.00
627.92	Guardrail Flared End Treatmment, TL-2	2	EA	$ 4,600.00	$ 9,200.00
628.22	Transition to Rigid Barrier (Single Faced)	4	EA	$ 5,900.00	$ 23,600.00
748.	Mobilization	1	LS	$ 35,000.00	$ 35,000.00
751.	Loam Borrow	30	CY	$ 65.00	$ 1,950.00
756.	NPDES Stormwater Pollution Prevention Plan	1	LS	$ 6,500.00	$ 6,500.00
765.	Seeding	200	SY	$ 3.00	$ 600.00
767.12	Compost Filter Tubes	100	FT	$ 12.00	$ 1,200.00
833.5	Demountable Reflectorized Delineator - Guard Rail	35	EA	$ 10.00	$ 350.00
833.7	Delineation for Guardrail Termini	4	EA	$ 60.00	$ 240.00
841.3	Sign Support	10	EA	$ 135.00	$ 1,350.00
850.	Traffic Controls for Construction Operations	1	LS	$ 12,000.00	$ 12,000.00
860.04	4" Reflectorized White Line (Painted)	220	FT	$ 2.00	$ 440.00
861.04	4" Reflectorized Yellow Line (Painted)	220	FT	$ 2.00	$ 440.00
983.2	Riffle Substrate	120	CY	$ 80.00	$ 9,600.00
986.	Modified Rockfill	140	CY	$ 105.00	$ 14,700.00
991.1	Control of Water - Structure No. 1	1	LS	$ 20,000.00	$ 20,000.00
995.011	Culvert Structure, Culvert No. 1	1	LS	$ 425,000.00	$ 425,000.00
999.5	Monthly Price Adjustment for HMA Mixtures	1	ALL	$ 500.00	$ 500.00
999.6	Monthly Price Adjustment for Diesel Fuel	1	ALL	$ 500.00	$ 500.00
999.7	Monthly Price Adjustment for Gasoline	1	ALL	$ 500.00	$ 500.00
999.8	Monthly Price Adjustment for Portland Cement in Concrete	1	ALL	$ 1,000.00	$ 1,000.00
999.9	Monthly Price Adjustment for Structural and Reinforcing Steel	1	ALL	$ 500.00	$ 500.00
				Subtotal:	**$ 730,705**
	Construction Contingency		40%		$ 292,282
	Material and Bidding Contingency		20%		$ 146,141
	Design and Permitting				$ 130,000
				Total	**$ 1,299,128**
				Use	**1,300,000**

This is an engineer's Opinion of probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of the Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

Conceptual- Engineer's Opinion of Probable Cost
P-550 (9.9' Box Culvert) Culvert Replacement
Town of Ayer, MA

ITEM	DESCRIPTION	QTY	UNITS	UNIT PRICE	AMOUNT
101.	Clearing and Grubbing	0.30	A	$ 47,500.00	$ 14,250.00
116.1	Demolition of Existing Culvert	1	LS	$ 20,000.00	$ 20,000.00
120.	Unclassified Excavation	470	CY	$ 48.00	$ 22,560.00
140.	Bridge Excavation	260	CY	$ 80.00	$ 20,800.00
150.	Ordinary Borrow	100	CY	$ 40.00	$ 4,000.00
151.	Gravel Borrow	110	CY	$ 55.00	$ 6,050.00
151.2	Gravel Borrow for Backfilling Structures and Pipes	260	CY	$ 60.00	$ 15,600.00
156.1	Crushed Stone for Bridge Foundations	40	TON	$ 70.00	$ 2,800.00
170.	Fine Grading and Compacting	290	SY	$ 12.00	$ 3,480.00
415.1	Pavement Milling	60	SY	$ 100.00	$ 6,000.00
440.	Calcium Chloride for Roadway Dust Control	290	LB	$ 0.50	$ 145.00
443.	Water for Roadway Dust Control	0.30	MGL	$ 100.00	$ 30.00
452.	Asphalt Emulsion for Tack Coat	20	GAL	$ 9.00	$ 180.00
453.	HMA Joint Sealant	490	FT	$ 1.50	$ 735.00
460.	Hot Mix Asphalt	100	TON	$ 140.00	$ 14,000.00
482.3	Sawcutting Asphalt Pavement	100	FT	$ 4.00	$ 400.00
509.	Granite Transition Curb	30	FT	$ 60.00	$ 1,800.00
620.12	Guardrail, TL-2 (Single Faced)	100	FT	$ 40.00	$ 4,000.00
627.82	Guardrail Tangent End Treatment, TL-2	2	EA	$ 5,000.00	$ 10,000.00
627.92	Guardrail Flared End Treatmment, TL-2	2	EA	$ 4,600.00	$ 9,200.00
628.22	Transition to Rigid Barrier (Single Faced)	4	EA	$ 5,900.00	$ 23,600.00
748.	Mobilization	1	LS	$ 34,000.00	$ 34,000.00
751.	Loam Borrow	30	CY	$ 65.00	$ 1,950.00
756.	NPDES Stormwater Pollution Prevention Plan	1	LS	$ 6,500.00	$ 6,500.00
765.	Seeding	200	SY	$ 3.00	$ 600.00
767.12	Compost Filter Tubes	100	FT	$ 12.00	$ 1,200.00
833.5	Demountable Reflectorized Delineator - Guard Rail	35	EA	$ 10.00	$ 350.00
833.7	Delineation for Guardrail Termini	4	EA	$ 60.00	$ 240.00
841.3	Sign Support	10	EA	$ 135.00	$ 1,350.00
850.	Traffic Controls for Construction Operations	1	LS	$ 12,000.00	$ 12,000.00
860.04	4" Reflectorized White Line (Painted)	220	FT	$ 2.00	$ 440.00
861.04	4" Reflectorized Yellow Line (Painted)	220	FT	$ 2.00	$ 440.00
983.2	Riffle Substrate	120	CY	$ 80.00	$ 9,600.00
986.	Modified Rockfill	140	CY	$ 105.00	$ 14,700.00
991.1	Control of Water - Structure No. 1	1	LS	$ 20,000.00	$ 20,000.00
995.011	Culvert Structure, Culvert No. 1	1	LS	$ 425,000.00	$ 425,000.00
999.5	Monthly Price Adjustment for HMA Mixtures	1	ALL	$ 500.00	$ 500.00
999.6	Monthly Price Adjustment for Diesel Fuel	1	ALL	$ 500.00	$ 500.00
999.7	Monthly Price Adjustment for Gasoline	1	ALL	$ 500.00	$ 500.00
999.8	Monthly Price Adjustment for Portland Cement in Concrete	1	ALL	$ 1,000.00	$ 1,000.00
999.9	Monthly Price Adjustment for Structural and Reinforcing Steel	1	ALL	$ 500.00	$ 500.00
				Subtotal:	**$ 711,000**
		Construction Contingency	40%		$ 284,400
	$ 1,138,000	Material and Bidding Contingency	20%		$ 142,200
		Design and Permitting			$ 130,000
				Total	**$ 1,267,600**
				Use	**1,268,000**

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Conceptual- Engineer's Opinion of Probable Cost
P-711 (5' Box Culvert) Culvert Replacement
Town of Ayer, MA

ITEM	DESCRIPTION	QTY	UNITS	UNIT PRICE	AMOUNT
101.	Clearing and Grubbing	0.30	A	$ 47,500.00	$ 14,250.00
116.1	Demolition of Existing Culvert	1	LS	$ 20,000.00	$ 20,000.00
120.	Unclassified Excavation	400	CY	$ 48.00	$ 19,200.00
140.	Bridge Excavation	150	CY	$ 80.00	$ 12,000.00
150.	Ordinary Borrow	100	CY	$ 40.00	$ 4,000.00
151.	Gravel Borrow	110	CY	$ 55.00	$ 6,050.00
151.2	Gravel Borrow for Backfilling Structures and Pipes	250	CY	$ 60.00	$ 15,000.00
156.1	Crushed Stone for Bridge Foundations	40	TON	$ 70.00	$ 2,800.00
170.	Fine Grading and Compacting	300	SY	$ 12.00	$ 3,600.00
415.1	Pavement Milling	60	SY	$ 100.00	$ 6,000.00
440.	Calcium Chloride for Roadway Dust Control	300	LB	$ 0.50	$ 150.00
443.	Water for Roadway Dust Control	0.30	MGL	$ 100.00	$ 30.00
452.	Asphalt Emulsion for Tack Coat	30	GAL	$ 9.00	$ 270.00
453.	HMA Joint Sealant	490	FT	$ 1.50	$ 735.00
460.	Hot Mix Asphalt	100	TON	$ 140.00	$ 14,000.00
482.3	Sawcutting Asphalt Pavement	100	FT	$ 4.00	$ 400.00
509.	Granite Transition Curb	30	FT	$ 60.00	$ 1,800.00
620.12	Guardrail, TL-2 (Single Faced)	100	FT	$ 40.00	$ 4,000.00
627.82	Guardrail Tangent End Treatment, TL-2	2	EA	$ 5,000.00	$ 10,000.00
627.92	Guardrail Flared End Treatmment, TL-2	2	EA	$ 4,600.00	$ 9,200.00
628.22	Transition to Rigid Barrier (Single Faced)	4	EA	$ 5,900.00	$ 23,600.00
748.	Mobilization	1	LS	$ 23,000.00	$ 23,000.00
751.	Loam Borrow	30	CY	$ 65.00	$ 1,950.00
756.	NPDES Stormwater Pollution Prevention Plan	1	LS	$ 6,500.00	$ 6,500.00
765.	Seeding	200	SY	$ 3.00	$ 600.00
767.12	Compost Filter Tubes	100	FT	$ 12.00	$ 1,200.00
833.5	Demountable Reflectorized Delineator - Guard Rail	35	EA	$ 10.00	$ 350.00
833.7	Delineation for Guardrail Termini	4	EA	$ 60.00	$ 240.00
841.3	Sign Support	10	EA	$ 135.00	$ 1,350.00
850.	Traffic Controls for Construction Operations	1	LS	$ 12,000.00	$ 12,000.00
860.04	4" Reflectorized White Line (Painted)	220	FT	$ 2.00	$ 440.00
861.04	4" Reflectorized Yellow Line (Painted)	220	FT	$ 2.00	$ 440.00
983.2	Riffle Substrate	120	CY	$ 80.00	$ 9,600.00
986.	Modified Rockfill	140	CY	$ 105.00	$ 14,700.00
991.1	Control of Water - Structure No. 1	1	LS	$ 20,000.00	$ 20,000.00
995.011	Culvert Structure, Culvert No. 1	1	LS	$ 215,000.00	$ 215,000.00
999.5	Monthly Price Adjustment for HMA Mixtures	1	ALL	$ 500.00	$ 500.00
999.6	Monthly Price Adjustment for Diesel Fuel	1	ALL	$ 500.00	$ 500.00
999.7	Monthly Price Adjustment for Gasoline	1	ALL	$ 500.00	$ 500.00
999.8	Monthly Price Adjustment for Portland Cement in Concrete	1	ALL	$ 1,000.00	$ 1,000.00
999.9	Monthly Price Adjustment for Structural and Reinforcing Steel	1	ALL	$ 500.00	$ 500.00
				Subtotal:	**$ 477,455**
	Construction Contingency		40%		$ 190,982
	Material and Bidding Contingency		20%		$ 95,491
	Design and Permitting				$ 120,000
				Total	**$ 883,928**
				Use	**884,000**

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Conceptual- Engineer's Opinion of Probable Cost
P-New1 (9.9' Box Culvert) Culvert Replacement
Town of Ayer, MA

ITEM	DESCRIPTION	QTY	UNITS	UNIT PRICE	AMOUNT
101.	Clearing and Grubbing	0.30	A	$ 47,500.00	$ 14,250.00
116.1	Demolition of Existing Culvert	1	LS	$ 20,000.00	$ 20,000.00
120.	Unclassified Excavation	620	CY	$ 48.00	$ 29,760.00
140.	Bridge Excavation	190	CY	$ 80.00	$ 15,200.00
150.	Ordinary Borrow	100	CY	$ 40.00	$ 4,000.00
151.	Gravel Borrow	140	CY	$ 55.00	$ 7,700.00
151.2	Gravel Borrow for Backfilling Structures and Pipes	200	CY	$ 60.00	$ 12,000.00
156.1	Crushed Stone for Bridge Foundations	40	TON	$ 70.00	$ 2,800.00
170.	Fine Grading and Compacting	370	SY	$ 12.00	$ 4,440.00
415.1	Pavement Milling	70	SY	$ 100.00	$ 7,000.00
440.	Calcium Chloride for Roadway Dust Control	370	LB	$ 0.50	$ 185.00
443.	Water for Roadway Dust Control	0.40	MGL	$ 100.00	$ 40.00
452.	Asphalt Emulsion for Tack Coat	30	GAL	$ 9.00	$ 270.00
453.	HMA Joint Sealant	500	FT	$ 1.50	$ 750.00
460.	Hot Mix Asphalt	130	TON	$ 140.00	$ 18,200.00
482.3	Sawcutting Asphalt Pavement	120	FT	$ 4.00	$ 480.00
509.	Granite Transition Curb	30	FT	$ 60.00	$ 1,800.00
620.12	Guardrail, TL-2 (Single Faced)	100	FT	$ 40.00	$ 4,000.00
627.82	Guardrail Tangent End Treatment, TL-2	2	EA	$ 5,000.00	$ 10,000.00
627.92	Guardrail Flared End Treatmment, TL-2	2	EA	$ 4,600.00	$ 9,200.00
628.22	Transition to Rigid Barrier (Single Faced)	4	EA	$ 5,900.00	$ 23,600.00
748.	Mobilization	1	LS	$ 35,000.00	$ 35,000.00
751.	Loam Borrow	30	CY	$ 65.00	$ 1,950.00
756.	NPDES Stormwater Pollution Prevention Plan	1	LS	$ 6,500.00	$ 6,500.00
765.	Seeding	200	SY	$ 3.00	$ 600.00
767.12	Compost Filter Tubes	100	FT	$ 12.00	$ 1,200.00
833.5	Demountable Reflectorized Delineator - Guard Rail	35	EA	$ 10.00	$ 350.00
833.7	Delineation for Guardrail Termini	4	EA	$ 60.00	$ 240.00
841.3	Sign Support	10	EA	$ 135.00	$ 1,350.00
850.	Traffic Controls for Construction Operations	1	LS	$ 12,000.00	$ 12,000.00
860.04	4" Reflectorized White Line (Painted)	220	FT	$ 2.00	$ 440.00
861.04	4" Reflectorized Yellow Line (Painted)	220	FT	$ 2.00	$ 440.00
983.2	Riffle Substrate	120	CY	$ 80.00	$ 9,600.00
986.	Modified Rockfill	140	CY	$ 105.00	$ 14,700.00
991.1	Control of Water - Structure No. 1	1	LS	$ 20,000.00	$ 20,000.00
995.011	Culvert Structure, Culvert No. 1	1	LS	$ 425,000.00	$ 425,000.00
999.5	Monthly Price Adjustment for HMA Mixtures	1	ALL	$ 500.00	$ 500.00
999.6	Monthly Price Adjustment for Diesel Fuel	1	ALL	$ 500.00	$ 500.00
999.7	Monthly Price Adjustment for Gasoline	1	ALL	$ 500.00	$ 500.00
999.8	Monthly Price Adjustment for Portland Cement in Concrete	1	ALL	$ 1,000.00	$ 1,000.00
999.9	Monthly Price Adjustment for Structural and Reinforcing Steel	1	ALL	$ 500.00	$ 500.00
				Subtotal:	**$ 718,045**
	Construction Contingency		40%		$ 287,218
	Material and Bidding Contingency		20%		$ 143,609
	Design and Permitting				$ 130,000
				Total	**$ 1,278,872**
				Use	**1,279,000**

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Conceptual- Engineer's Opinion of Probable Cost
P-1096 (6' Box Culvert) Culvert Replacement
Town of Ayer, MA

ITEM	DESCRIPTION	QTY	UNITS	UNIT PRICE	AMOUNT
101.	Clearing and Grubbing	0.30	A	$ 47,500.00	$ 14,250.00
116.1	Demolition of Existing Culvert	1	LS	$ 20,000.00	$ 20,000.00
120.	Unclassified Excavation	500	CY	$ 48.00	$ 24,000.00
140.	Bridge Excavation	140	CY	$ 80.00	$ 11,200.00
150.	Ordinary Borrow	100	CY	$ 40.00	$ 4,000.00
151.	Gravel Borrow	140	CY	$ 55.00	$ 7,700.00
151.2	Gravel Borrow for Backfilling Structures and Pipes	170	CY	$ 60.00	$ 10,200.00
156.1	Crushed Stone for Bridge Foundations	40	TON	$ 70.00	$ 2,800.00
170.	Fine Grading and Compacting	380	SY	$ 12.00	$ 4,560.00
415.1	Pavement Milling	70	SY	$ 100.00	$ 7,000.00
440.	Calcium Chloride for Roadway Dust Control	380	LB	$ 0.50	$ 190.00
443.	Water for Roadway Dust Control	0.40	MGL	$ 100.00	$ 40.00
452.	Asphalt Emulsion for Tack Coat	30	GAL	$ 9.00	$ 270.00
453.	HMA Joint Sealant	510	FT	$ 1.50	$ 765.00
460.	Hot Mix Asphalt	130	TON	$ 140.00	$ 18,200.00
482.3	Sawcutting Asphalt Pavement	130	FT	$ 4.00	$ 520.00
509.	Granite Transition Curb	30	FT	$ 60.00	$ 1,800.00
620.12	Guardrail, TL-2 (Single Faced)	100	FT	$ 40.00	$ 4,000.00
627.82	Guardrail Tangent End Treatment, TL-2	2	EA	$ 5,000.00	$ 10,000.00
627.92	Guardrail Flared End Treatmment, TL-2	2	EA	$ 4,600.00	$ 9,200.00
628.22	Transition to Rigid Barrier (Single Faced)	4	EA	$ 5,900.00	$ 23,600.00
748.	Mobilization	1	LS	$ 26,000.00	$ 26,000.00
751.	Loam Borrow	30	CY	$ 65.00	$ 1,950.00
756.	NPDES Stormwater Pollution Prevention Plan	1	LS	$ 6,500.00	$ 6,500.00
765.	Seeding	200	SY	$ 3.00	$ 600.00
767.12	Compost Filter Tubes	100	FT	$ 12.00	$ 1,200.00
833.5	Demountable Reflectorized Delineator - Guard Rail	35	EA	$ 10.00	$ 350.00
833.7	Delineation for Guardrail Termini	4	EA	$ 60.00	$ 240.00
841.3	Sign Support	10	EA	$ 135.00	$ 1,350.00
850.	Traffic Controls for Construction Operations	1	LS	$ 12,000.00	$ 12,000.00
860.04	4" Reflectorized White Line (Painted)	220	FT	$ 2.00	$ 440.00
861.04	4" Reflectorized Yellow Line (Painted)	330	FT	$ 2.00	$ 660.00
983.2	Riffle Substrate	120	CY	$ 80.00	$ 9,600.00
986.	Modified Rockfill	140	CY	$ 105.00	$ 14,700.00
991.1	Control of Water - Structure No. 1	1	LS	$ 20,000.00	$ 20,000.00
995.011	Culvert Structure, Culvert No. 1	1	LS	$ 260,000.00	$ 260,000.00
999.5	Monthly Price Adjustment for HMA Mixtures	1	ALL	$ 500.00	$ 500.00
999.6	Monthly Price Adjustment for Diesel Fuel	1	ALL	$ 500.00	$ 500.00
999.7	Monthly Price Adjustment for Gasoline	1	ALL	$ 500.00	$ 500.00
999.8	Monthly Price Adjustment for Portland Cement in Concrete	1	ALL	$ 1,000.00	$ 1,000.00
999.9	Monthly Price Adjustment for Structural and Reinforcing Steel	1	ALL	$ 500.00	$ 500.00
				Subtotal:	**$ 532,885**
	Construction Contingency		40%		$ 213,154
	Material and Bidding Contingency		20%		$ 106,577
	Design and Permitting				$ 120,000
				Total	**$ 972,616**
				Use	**973,000**

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Conceptual- Engineer's Opinion of Probable Cost Pot-11
(9.9' Box Culvert) Culvert Replacement
Town of Ayer, MA

ITEM	DESCRIPTION	QTY	UNITS	UNIT PRICE	AMOUNT
101.	Clearing and Grubbing	0.30	A	$ 47,500.00	$ 14,250.00
116.1	Demolition of Existing Culvert	1	LS	$ 20,000.00	$ 20,000.00
120.	Unclassified Excavation	80	CY	$ 48.00	$ 3,840.00
140.	Bridge Excavation	150	CY	$ 80.00	$ 12,000.00
150.	Ordinary Borrow	100	CY	$ 40.00	$ 4,000.00
151.	Gravel Borrow	60	CY	$ 55.00	$ 3,300.00
151.2	Gravel Borrow for Backfilling Structures and Pipes	230	CY	$ 60.00	$ 13,800.00
156.1	Crushed Stone for Bridge Foundations	40	TON	$ 70.00	$ 2,800.00
170.	Fine Grading and Compacting	160	SY	$ 12.00	$ 1,920.00
440.	Calcium Chloride for Roadway Dust Control	160	LB	$ 0.50	$ 80.00
443.	Water for Roadway Dust Control	0.20	MGL	$ 100.00	$ 20.00
452.	Asphalt Emulsion for Tack Coat	20	GAL	$ 9.00	$ 180.00
509.	Granite Transition Curb	30	FT	$ 60.00	$ 1,800.00
620.12	Guardrail, TL-2 (Single Faced)	100	FT	$ 40.00	$ 4,000.00
627.82	Guardrail Tangent End Treatment, TL-2	2	EA	$ 5,000.00	$ 10,000.00
627.92	Guardrail Flared End Treatmment, TL-2	2	EA	$ 4,600.00	$ 9,200.00
628.22	Transition to Rigid Barrier (Single Faced)	4	EA	$ 5,900.00	$ 23,600.00
740.	Engineer's Field Office and Equipment (Type A)	6	MONTH	$ 3,500.00	$ 21,000.00
748.	Mobilization	1	LS	$ 33,000.00	$ 33,000.00
751.	Loam Borrow	30	CY	$ 65.00	$ 1,950.00
756.	NPDES Stormwater Pollution Prevention Plan	1	LS	$ 6,500.00	$ 6,500.00
765.	Seeding	200	SY	$ 3.00	$ 600.00
767.12	Compost Filter Tubes	100	FT	$ 12.00	$ 1,200.00
833.5	Demountable Reflectorized Delineator - Guard Rail	35	EA	$ 10.00	$ 350.00
833.7	Delineation for Guardrail Termini	4	EA	$ 60.00	$ 240.00
841.3	Sign Support	10	EA	$ 135.00	$ 1,350.00
850.	Traffic Controls for Construction Operations	1	LS	$ 12,000.00	$ 12,000.00
983.2	Riffle Substrate	120	CY	$ 80.00	$ 9,600.00
986.	Modified Rockfill	140	CY	$ 105.00	$ 14,700.00
991.1	Control of Water - Structure No. 1	1	LS	$ 20,000.00	$ 20,000.00
995.011	Culvert Structure, Culvert No. 1	1	LS	$ 425,000.00	$ 425,000.00
999.5	Monthly Price Adjustment for HMA Mixtures	1	ALL	$ 500.00	$ 500.00
999.6	Monthly Price Adjustment for Diesel Fuel	1	ALL	$ 500.00	$ 500.00
999.7	Monthly Price Adjustment for Gasoline	1	ALL	$ 500.00	$ 500.00
999.8	Monthly Price Adjustment for Portland Cement in Concrete	1	ALL	$ 1,000.00	$ 1,000.00
999.9	Monthly Price Adjustment for Structural and Reinforcing Steel	1	ALL	$ 500.00	$ 500.00
	Utility Allowance	1	LS	$ 100,000.00	$ 100,000.00
				Subtotal:	**$ 775,280**
	Construction Contingency		40%		$ 310,112
	Material and Bidding Contingency		20%		$ 155,056
	Design and Permitting				$ 130,000
				Total	**$ 1,370,448**
				Use	**1,371,000**

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