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UPDATE STORMWATER MANAGEMENT (DRAINAGE) STUDY

AT

BGR BANGOR INTERNATIONAL AIRPORT

Draft Final Report

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Section 1 - Executive Summary
The intent of this study is to provide the Bangor International Airport (BGR) with the following:

- Mapping of the airport and the drainage network in Geographical Information System (GIS) database.
- Identification of stormwater conveyance deficiencies and estimated repair costs.
- Current mapping and hydrologic analysis of the airport watersheds.
- An assessment of the current airport detention pond's with respect to the BMP standards.
- Opportunities to improve airport watershed 1.

Section 2 - Introduction

2.1 - Background
The property now known as Bangor International Airport was originally known as Dow Air Force Base which was owned and operated by the U.S. Government. Dow was a 2,000 acre facility whose infrastructure included three (3) triangularly constructed runways with associated taxiways and aprons, support service facilities, and housing. In 1968, the property was purchased by the City of Bangor, the University of Maine, and the Maine Army Guard and the Air National Guard.

While under the present ownership the airport has undergone significant changes to accommodate the growth and aeronautical needs of its users. With this development came modifications and alterations to the original stormwater collection and conveyance system. These changes may not have given enough consideration to the function of the overall system.

In 1991, the airport prepared a Stormwater Management Study which analyzed the airport watershed to determine its effectiveness. The information and recommendations which resulted from the study were helpful in defining and addressing the limitations of the watershed. The study provided the stormwater analysis required for the airport's post-1970 construction activities after-the-fact Site Location of Development Approval (SLODA). The 1991 study also identified the need to enlarge and improve the airport detention pond which was completed in 1992.

It has been nearly 16 years since the 1991 report was published. The development that has occurred at the airport during this time requires the system to again be reviewed and analyzed in an effort to assess its effectiveness and current condition.

In addition, the Maine DEP published the Birch Stream Total Maximum Daily Load (TMDL) Draft Report in August of 2005 which identified the imperviousness of BGR's watershed as being a contributor to the impairment of Birch Stream. The report lists five (5) stressors of concern: propylene glycol, presence of toxic contaminants, high peak flows, elevated water temperatures and elevated nutrients. Implementation recommendations including BMP installation are discussed in general terms within the Maine DEP report. The study also addresses some opportunities to implementing the Maine DEP recommendations.

2.2 – Study Objectives and Deliverables
The objective of this study is to:

- Map the existing airport drainage system
- Observe the existing condition of significant drainage infrastructure (i.e. main drainage conveyances, outlet structures, drainage canals)
- Evaluate the hydrological effectiveness of the airport watershed
- Report findings and recommendations for improvements

Project deliverables include:

- Aerial survey depicting the airport's existing conditions
- Hydrologic analysis of the airport's watershed utilizing HydroCAD® software
- Geographical information system (GIS) electronic file of existing drainage system
- One seat of ArcView® software by ESRI
- Field observation reports of drainage system
- Identification of drainage system deficiencies
- Recommendations for improving the drainage system
- Drainage system plans including; the existing storm drainage system; existing drainage issues; existing watershed; existing impervious areas; existing water quality structure locations; existing deicing fluid collection and watershed improvements plans.

2.3 - Data Assembly
To enable realistic hydrologic evaluations of the complex watershed conditions at BGR, it was necessary to assemble extensive topographic, photographic and physical data for the subject watersheds. Aerial survey was obtained for the project area and two-foot contours were prepared by J.W. Sewall in April 2006. The mapping data was entered into the GIS database and utilized to determine the airport's watersheds, surface drainage features and impervious areas.

The City of Bangor Engineering department's CAD files, the MEANG CAD files, as-built construction documents and tenant SWPPP plans provided the basis for the preliminary drainage system layout. Significant details that could not be determined by photogrammetry or file data were gathered by field observations and GPS ground survey.

Visual inspections of the existing drainage system were performed from the top of structures such as manholes and catch basins, or at the end of outlet pipes. Where investigation required confined space entry, BGR's trained staff entered the confined space and relayed pertinent observations to the field observation team.

The study area consisted of the airport watershed boundary defined in the 1991 Stormwater Management Study. Those limits being defined to the north by the airport security fence beyond Runway 15 and the MEANG complex; to the east by Union Ave; to the south by portions of Maine Avenue & Odlin Road; to the west by the airport fence. The north direction as referred to in the report is aligned with Runway 15.

Section 3 – Existing Conditions of Stormwater Conveyances

3.1 – Summary

The existing drainage system is showing signs of aging. The existing system was constructed 50 to 60 years ago, with exception of the recent (circa 1998-2006) airport terminal apron and heavy duty apron reconstruction projects, and projects within the MEANG facility. Aging in the system manholes and catch basins is evidenced by exposed aggregate, spalls and cracked mortar. Aging in the system drainage pipes is manifested in separation and movement at the pipe joints.

Issues with respect to the existing stormwater conveyances (i.e. pipe, catch basins, swales, etc…) are further described in Section 3.3.

3.2 – Field Inspection

Stormwater conveyance issues were documented during plan-in-hand field investigations in the summer and fall of 2006. The purpose of the field efforts was to document the condition of the existing drainage system, verify pipe sizes and flow directions. Visual inspection of the existing system was performed from the top of the catch basin and manholes as well as the end of the culverts. In certain locations, the airport provided confined space inspection. Deficiencies have been cataloged in the GIS database.

The existing drainage network is provided in the following Figures 3.2.1 to 3.2.26 entitled "Existing Storm Drainage System".

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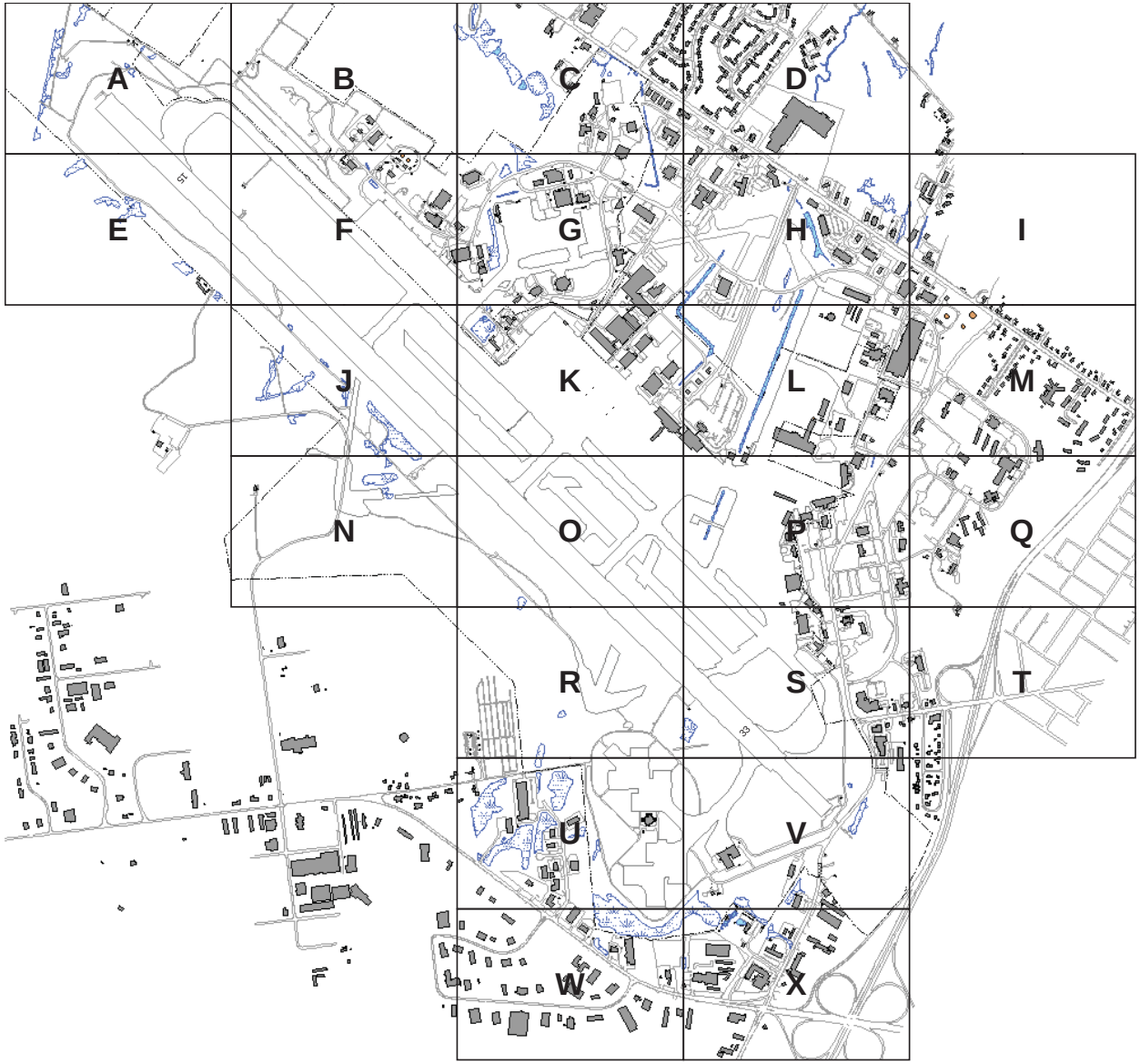
Figures 3.2.1 to 3.2.26 - Existing Storm Drainage System - Key Plan



Legend:

- Buildings
- Fuel Tank
- Runway
- Taxiway
- Roads
- Fence
- Propery Line
- Drainage Flow
- CB
- DMH
- Sewer OWS
- Water OWS
- Storage Tank
- Trench Drain
- Outfall
- Pipes
- Stream
- Marsh
- Water
- SMH
- Sewer
- Impervious Area

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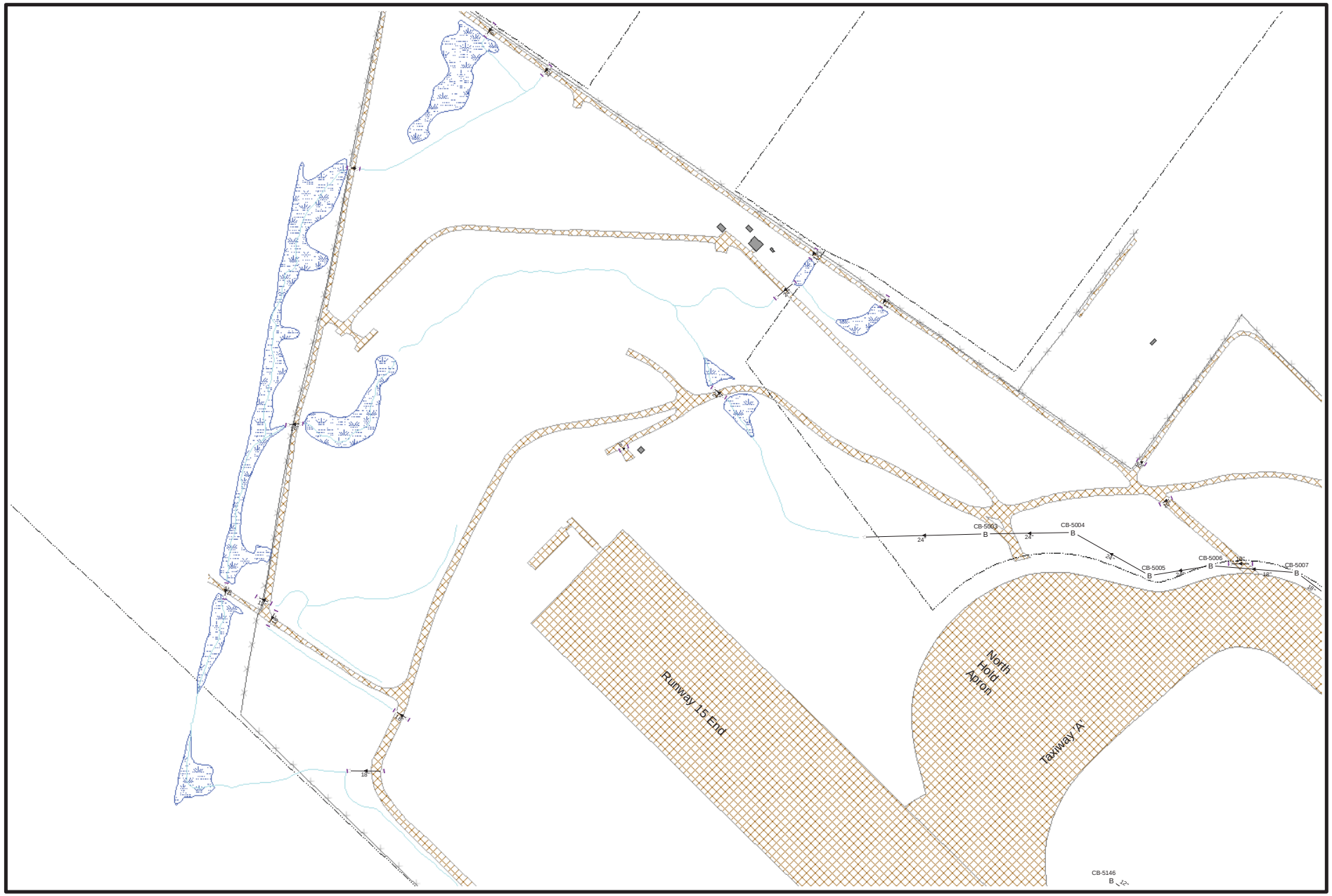

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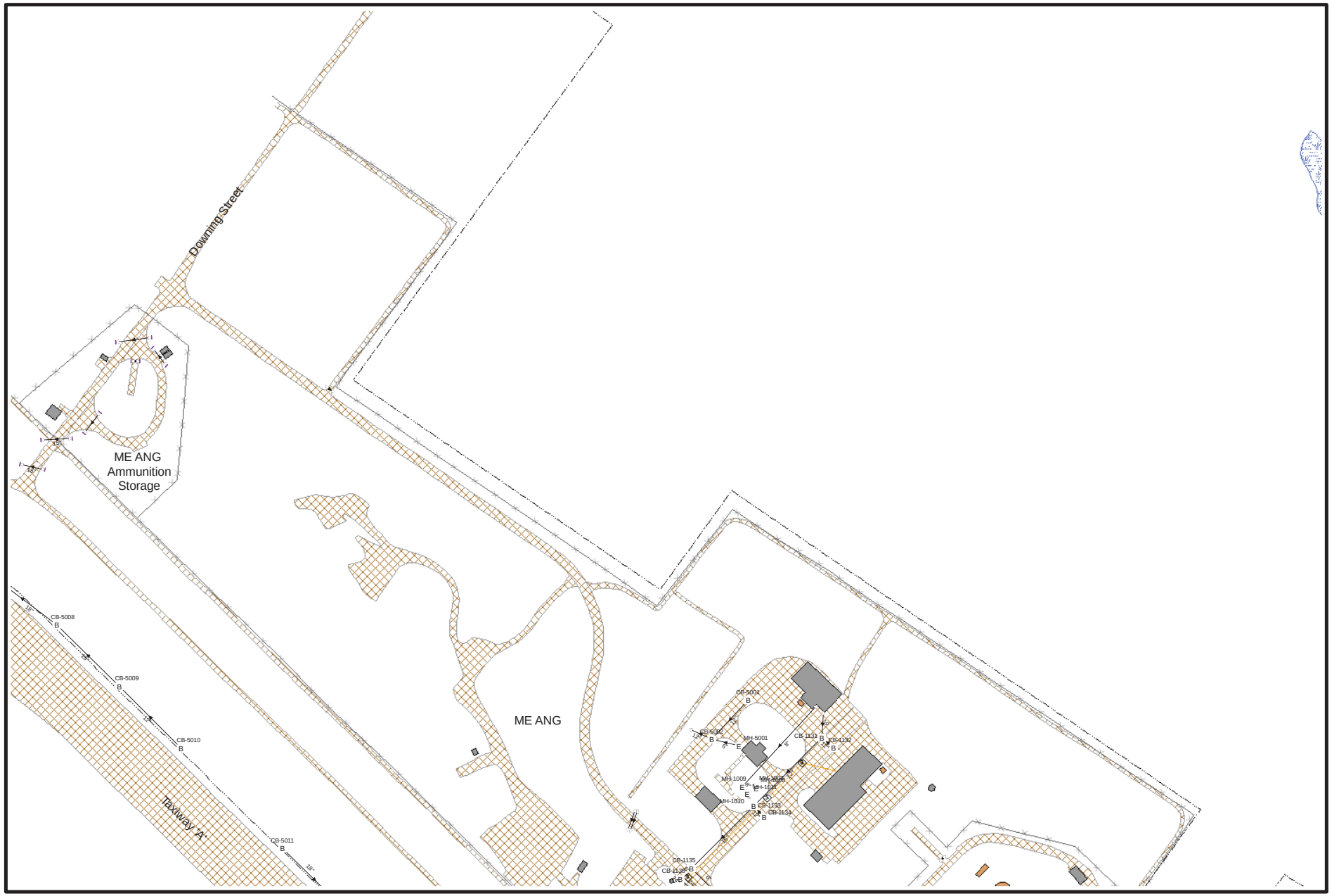

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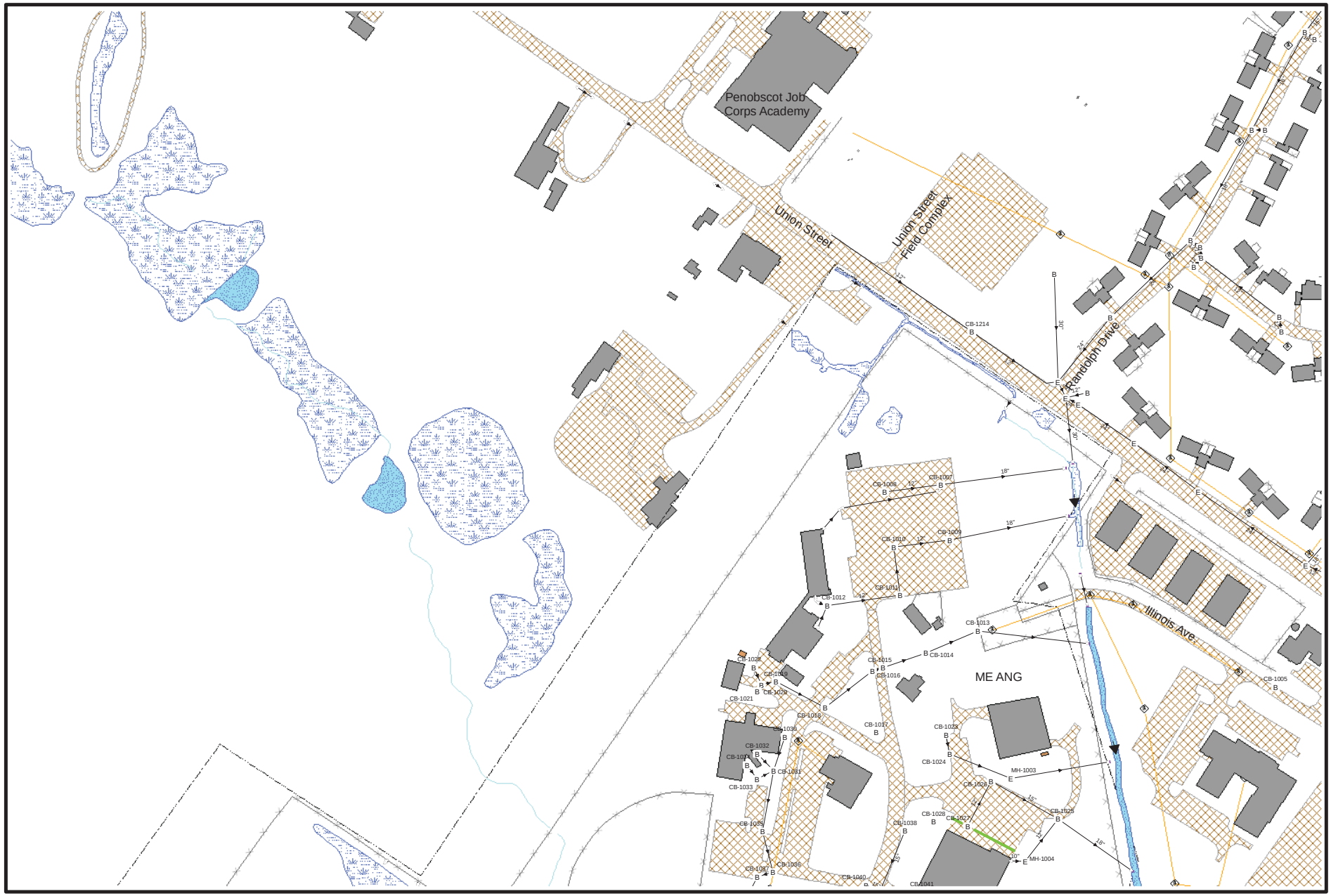

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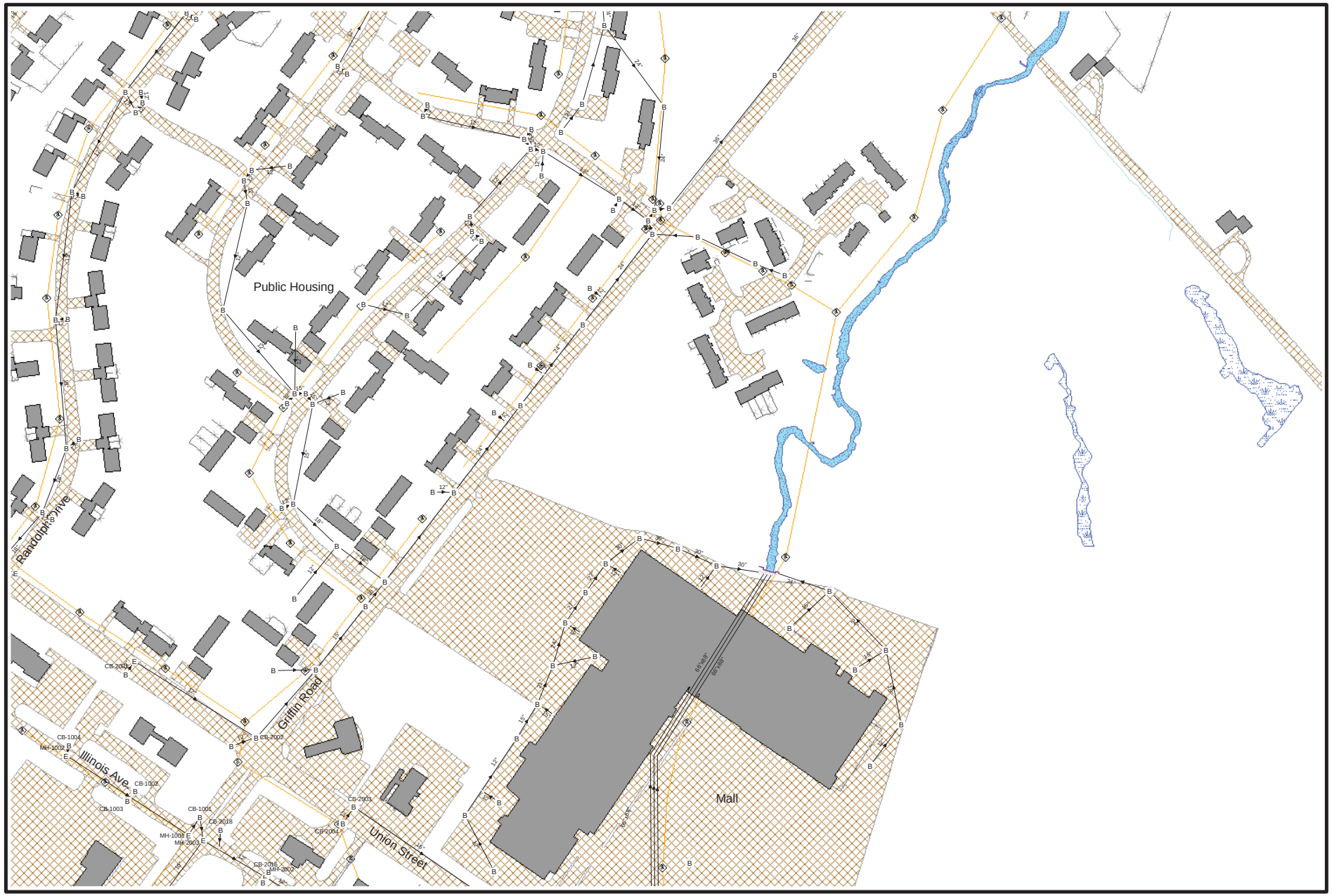

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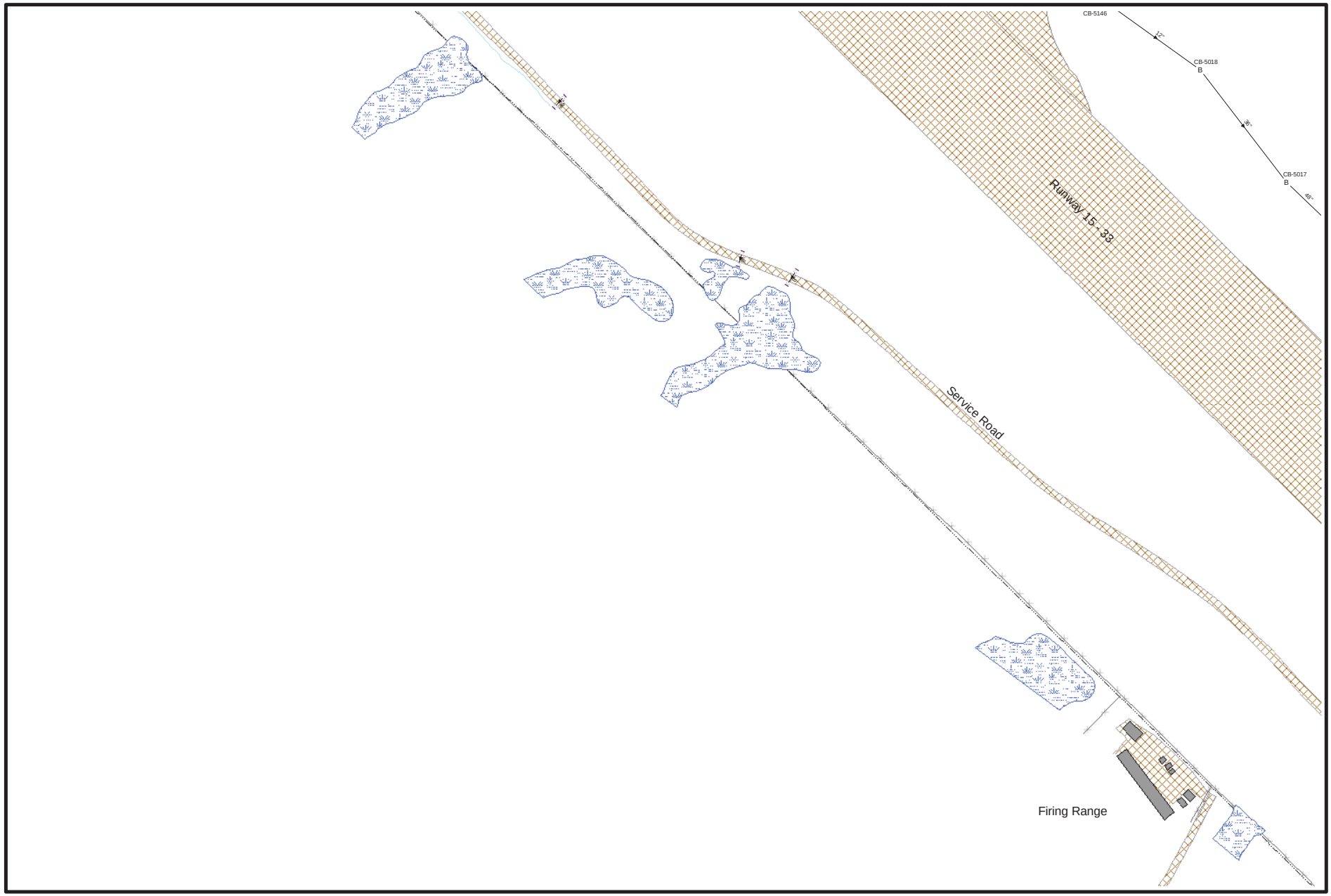

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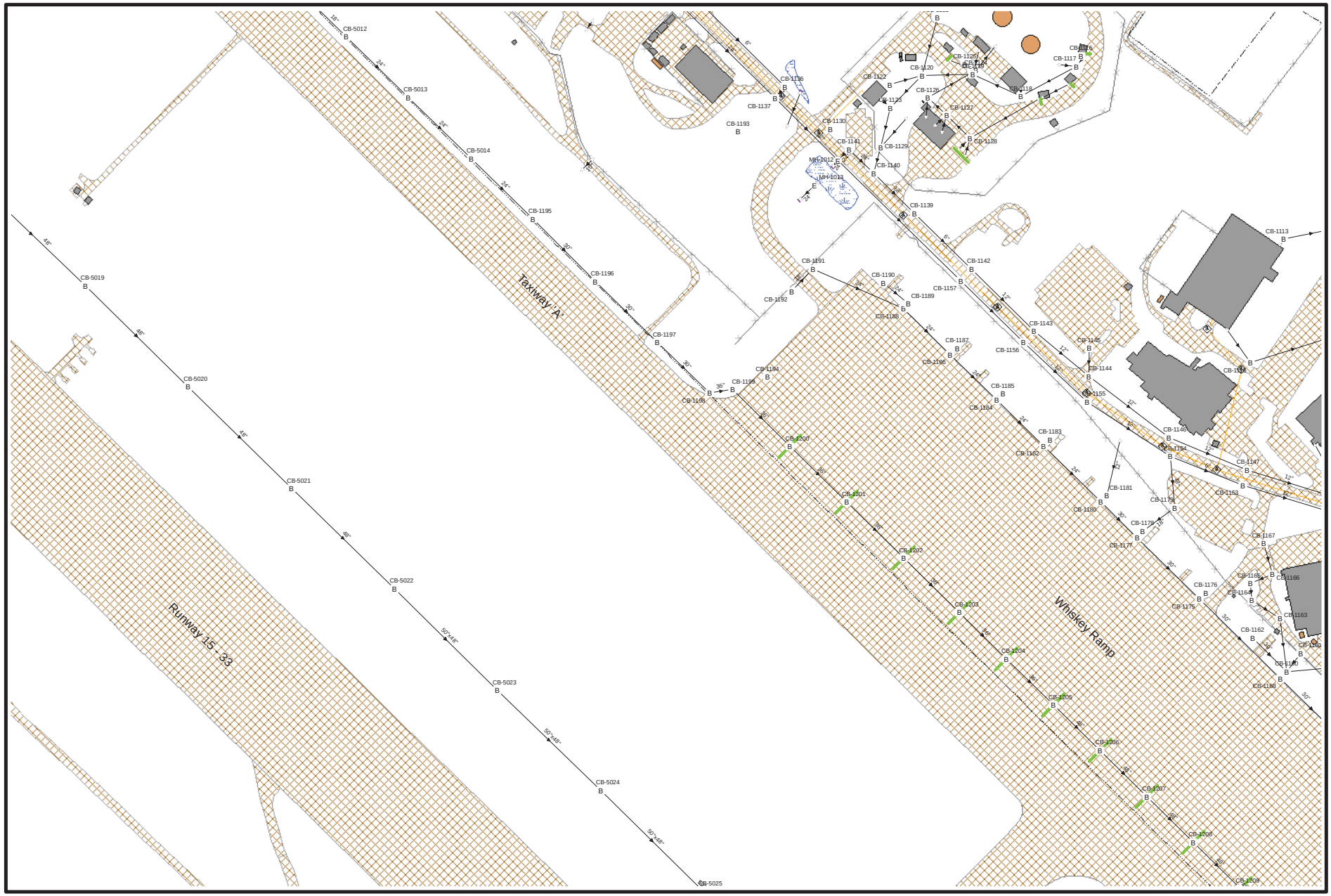

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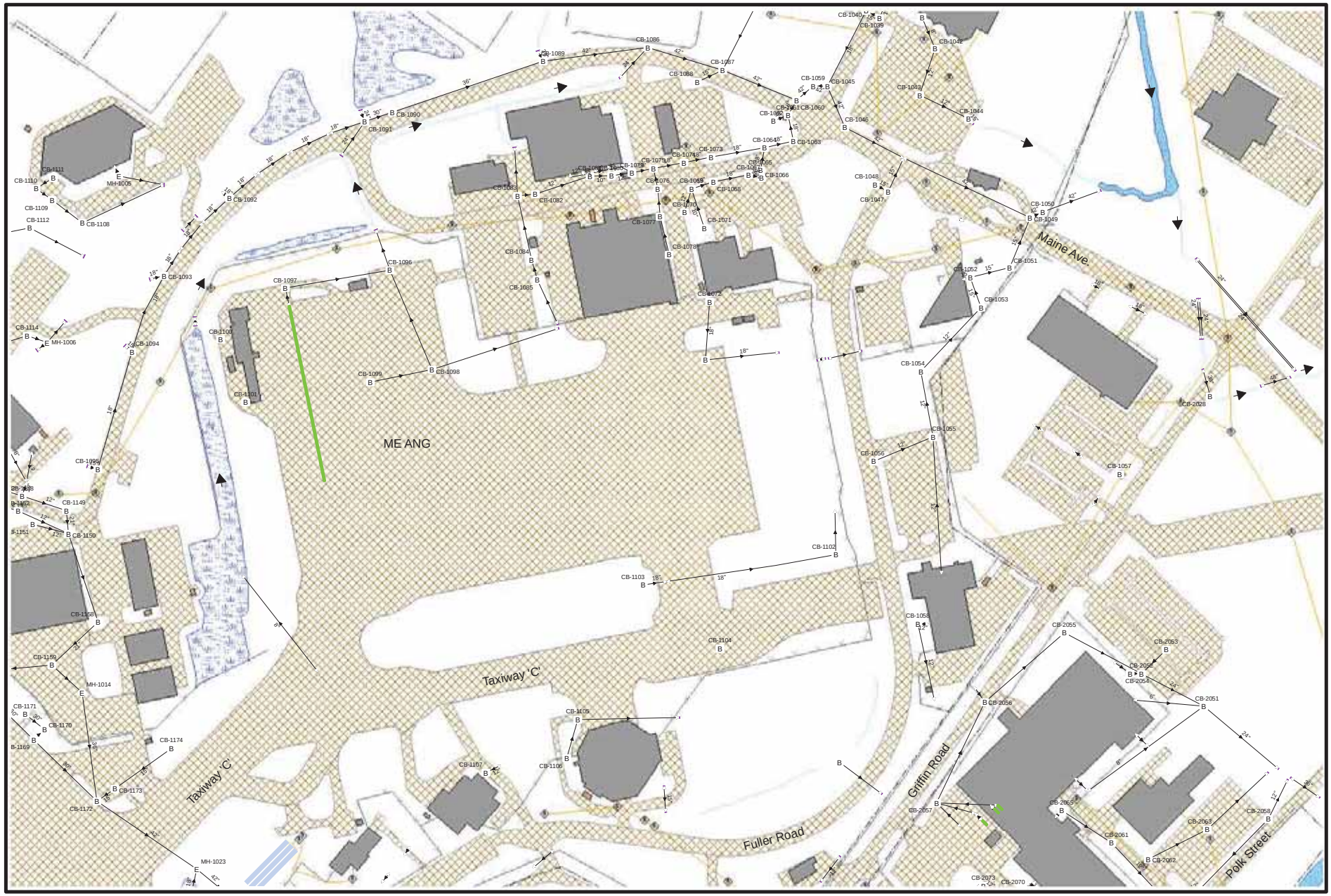

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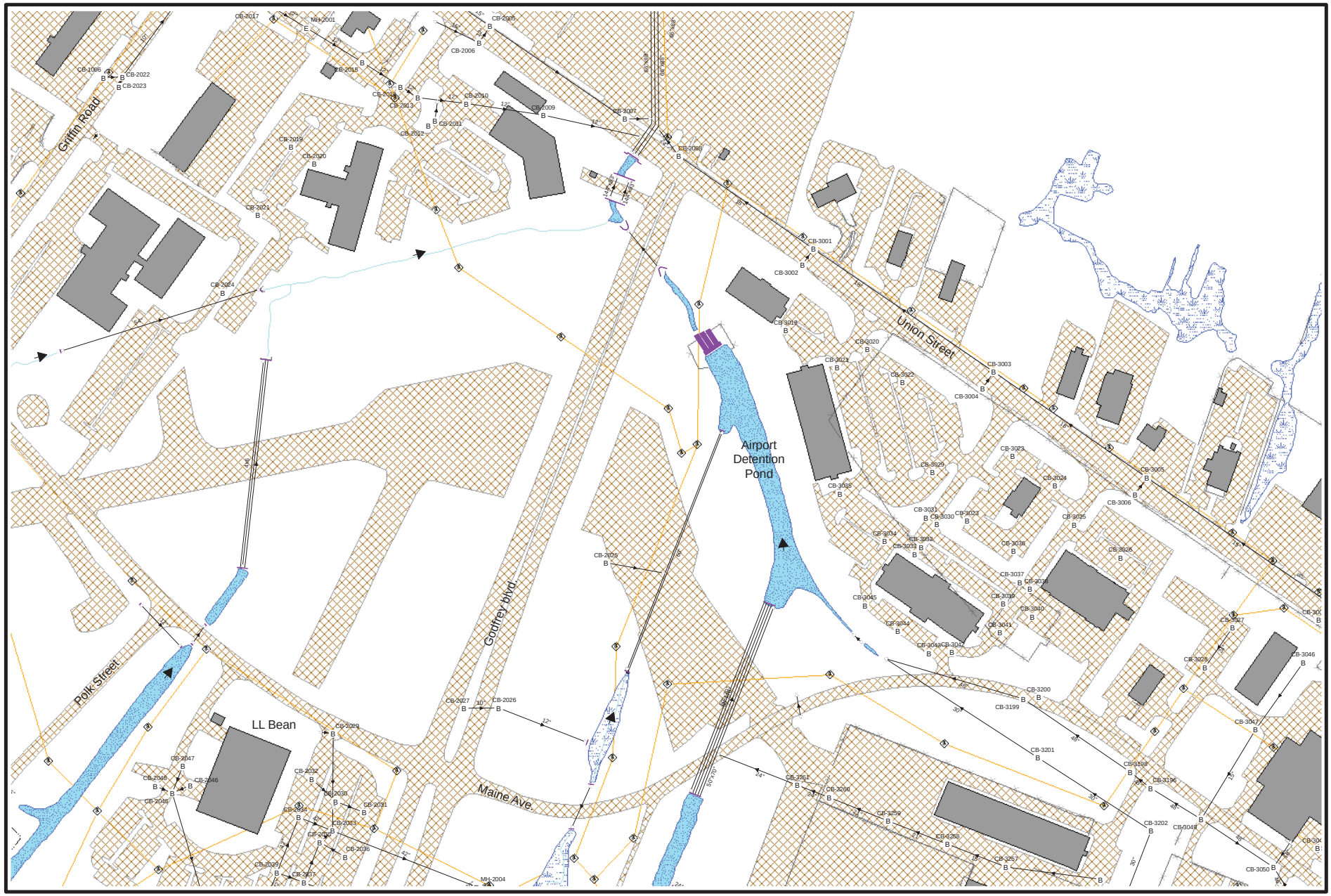

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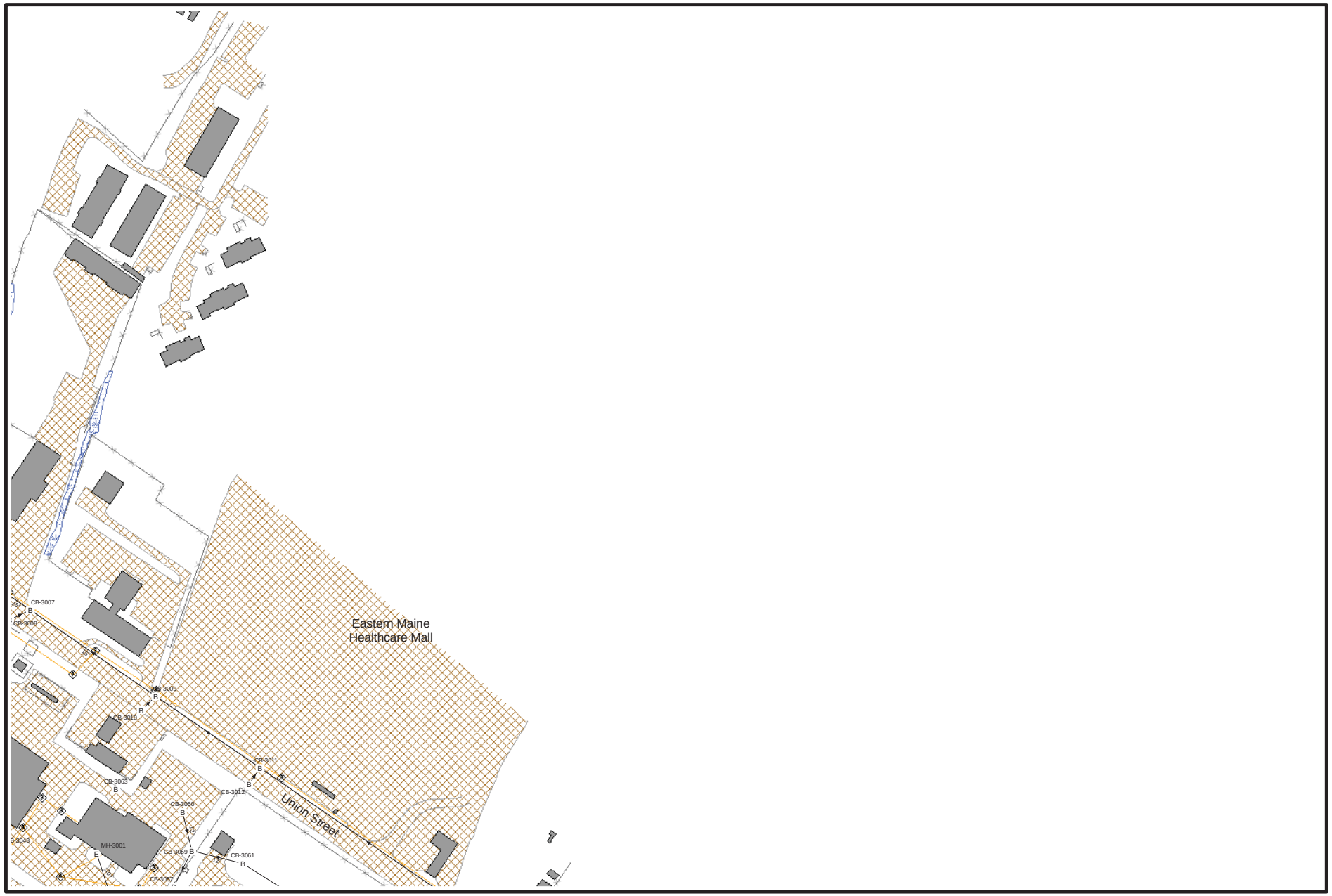

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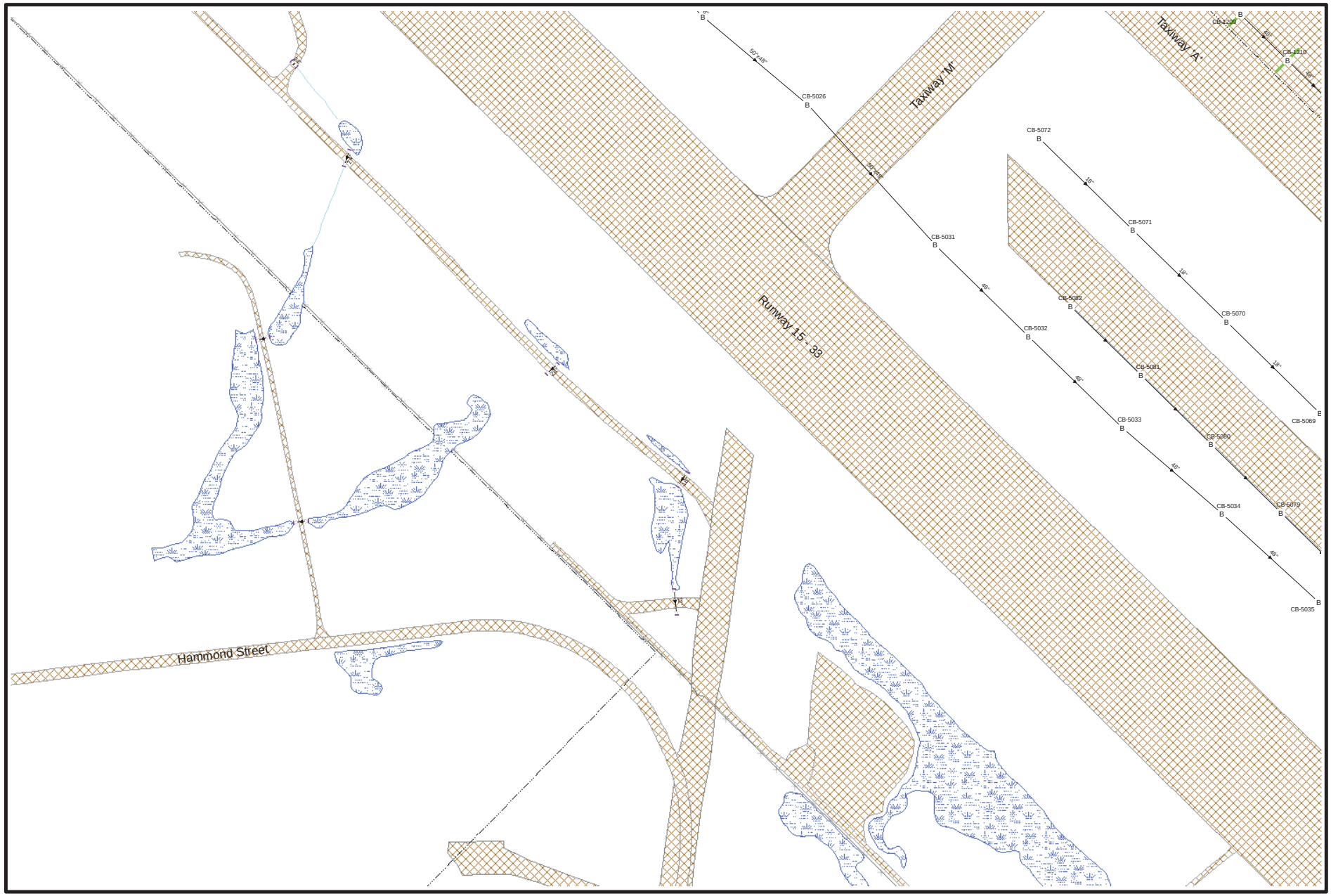

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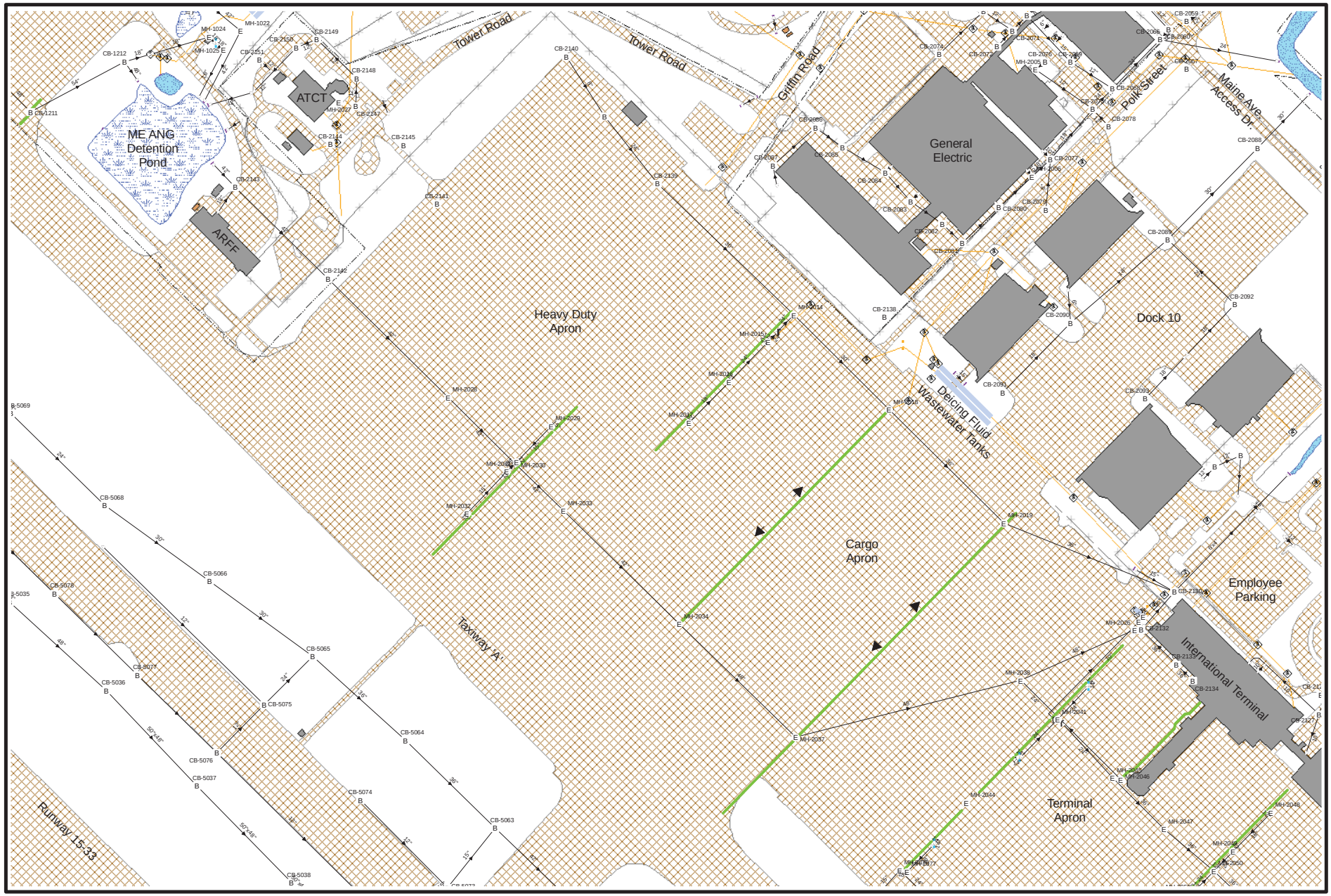

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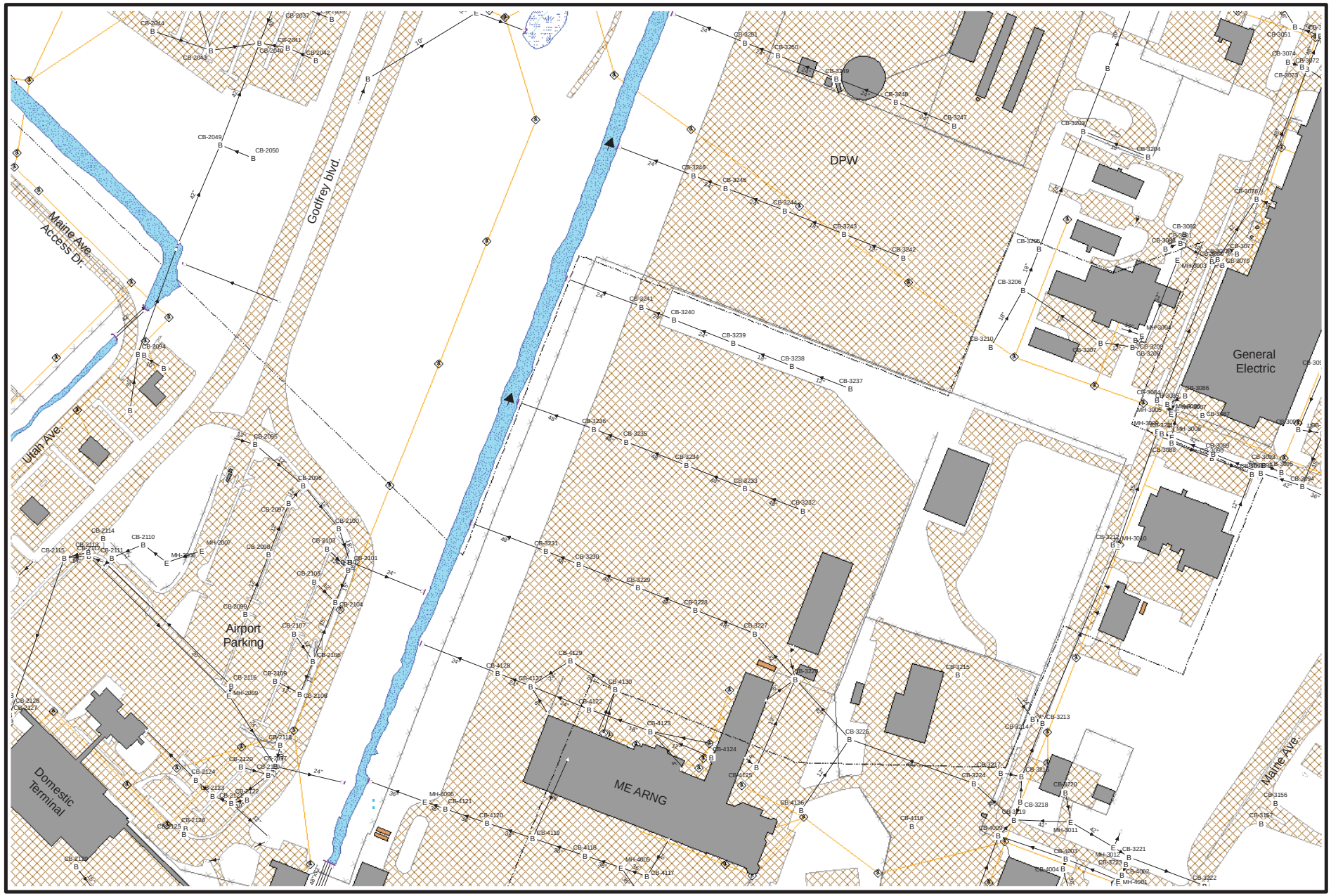

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Index Sheet. L P. 15

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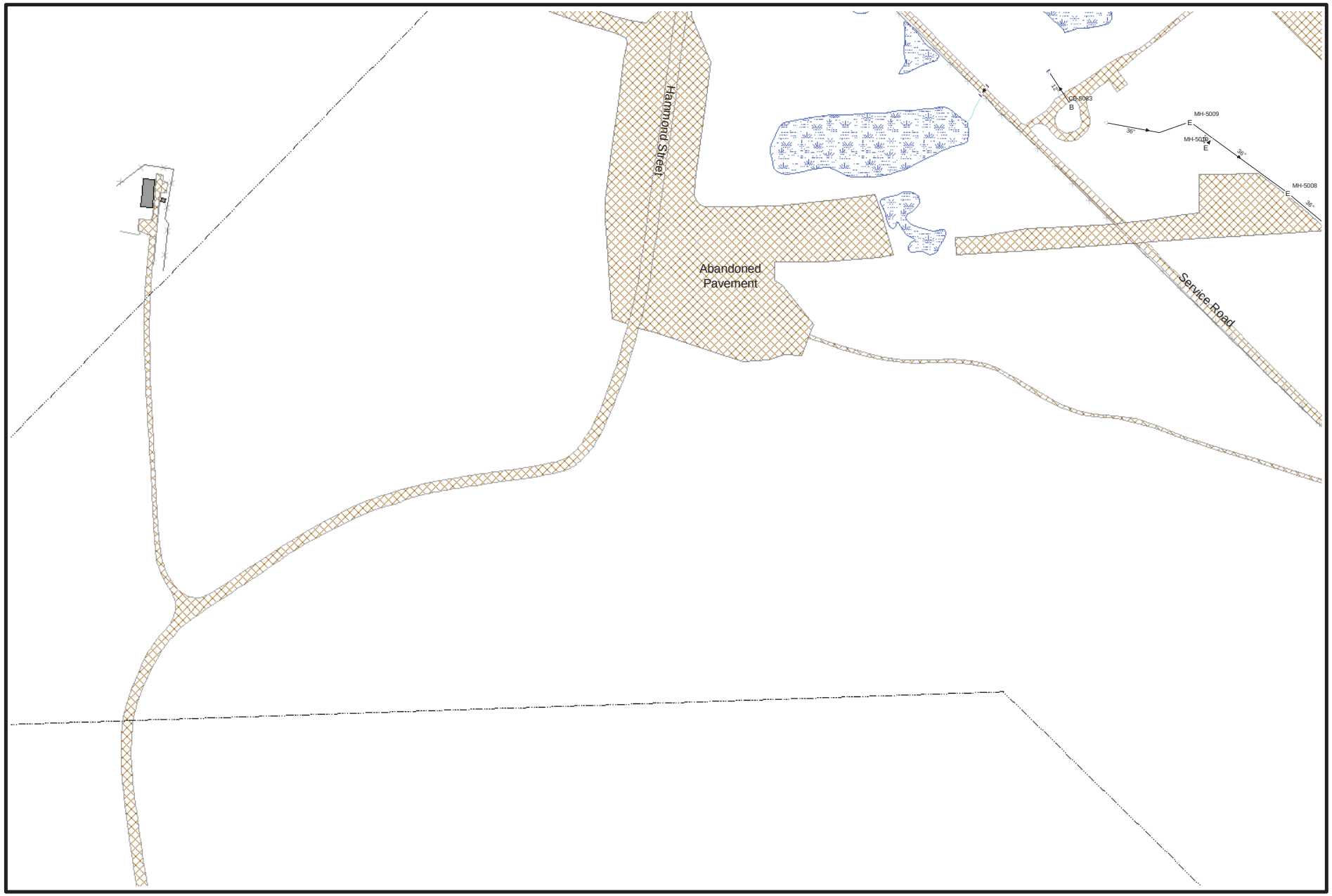

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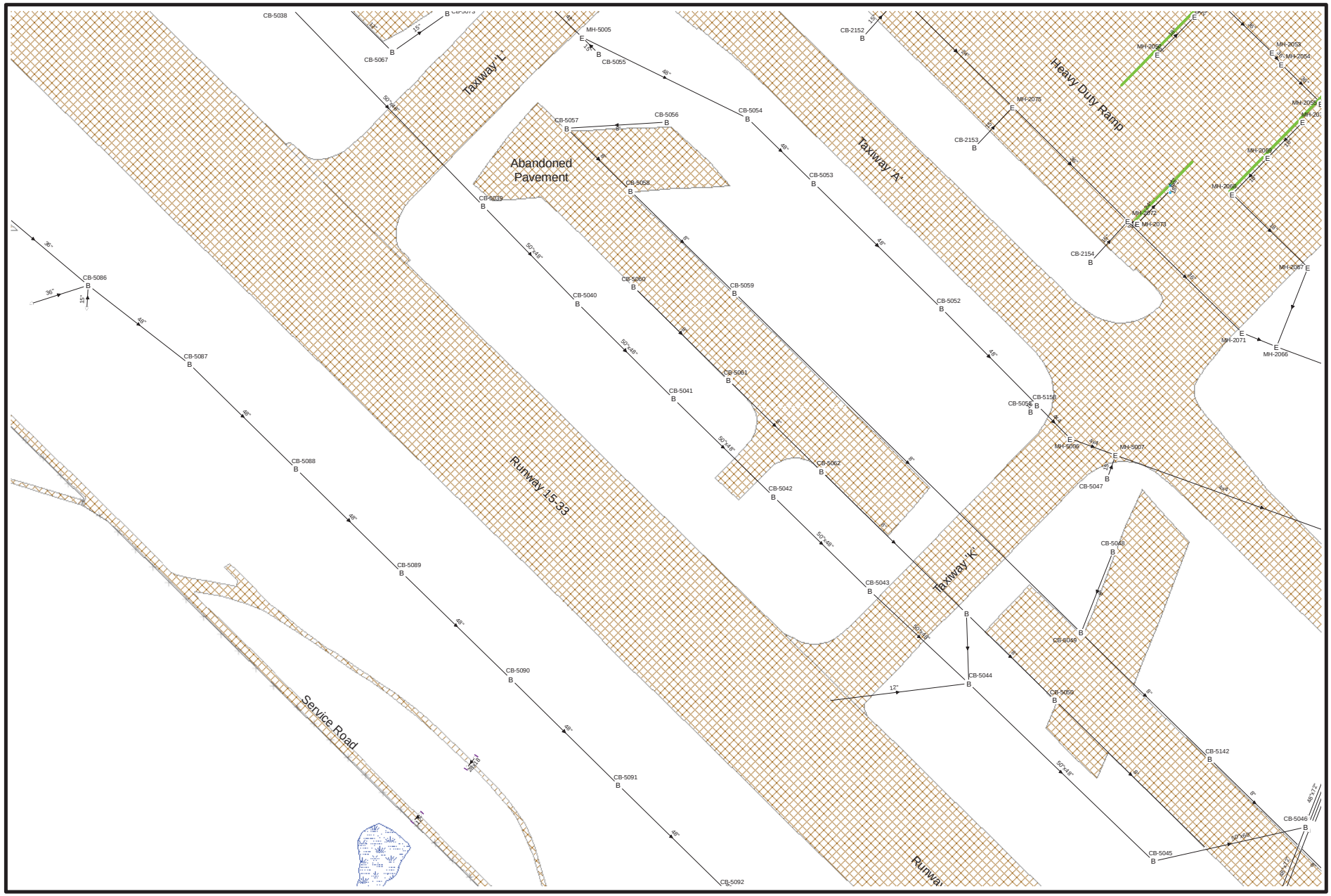

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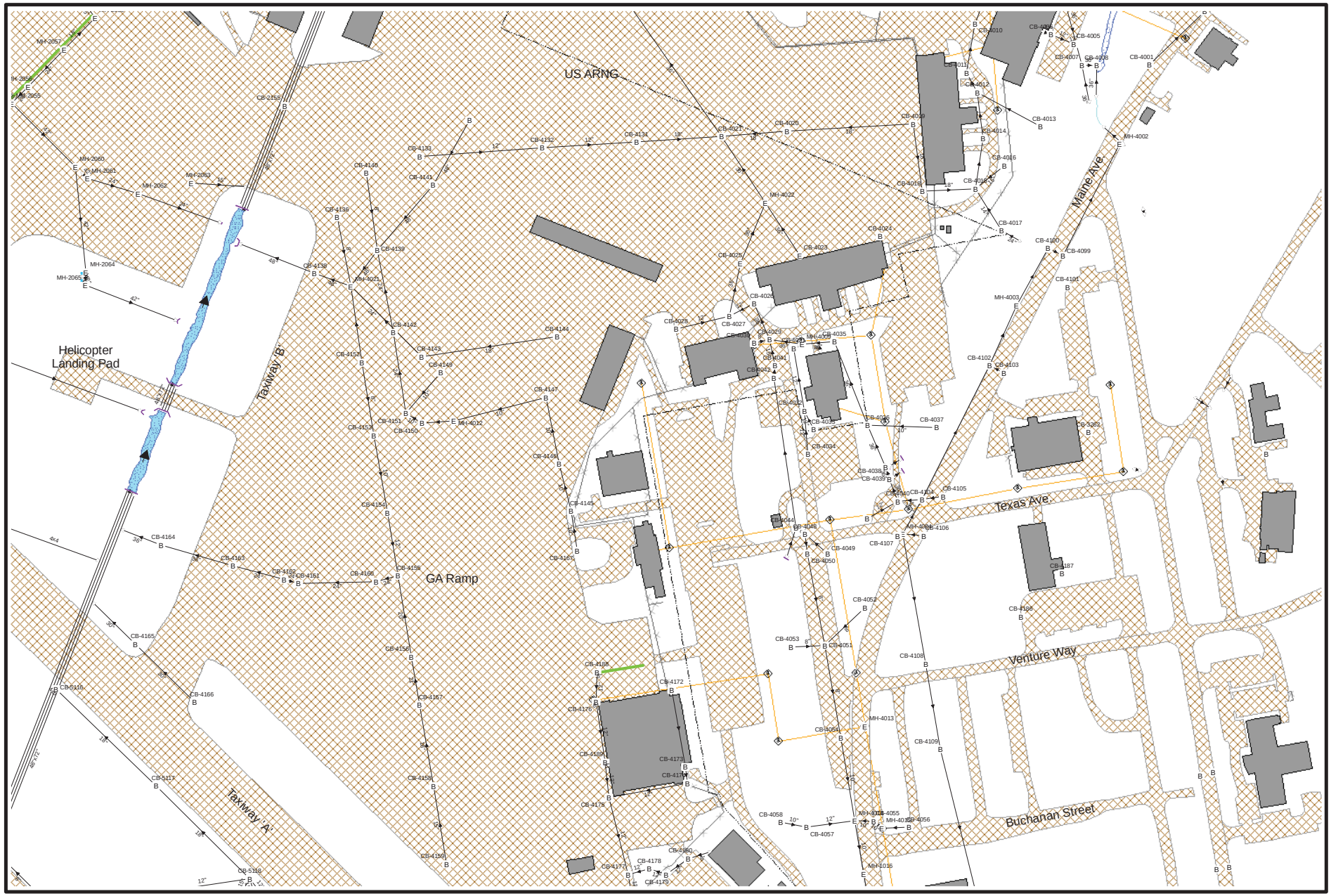

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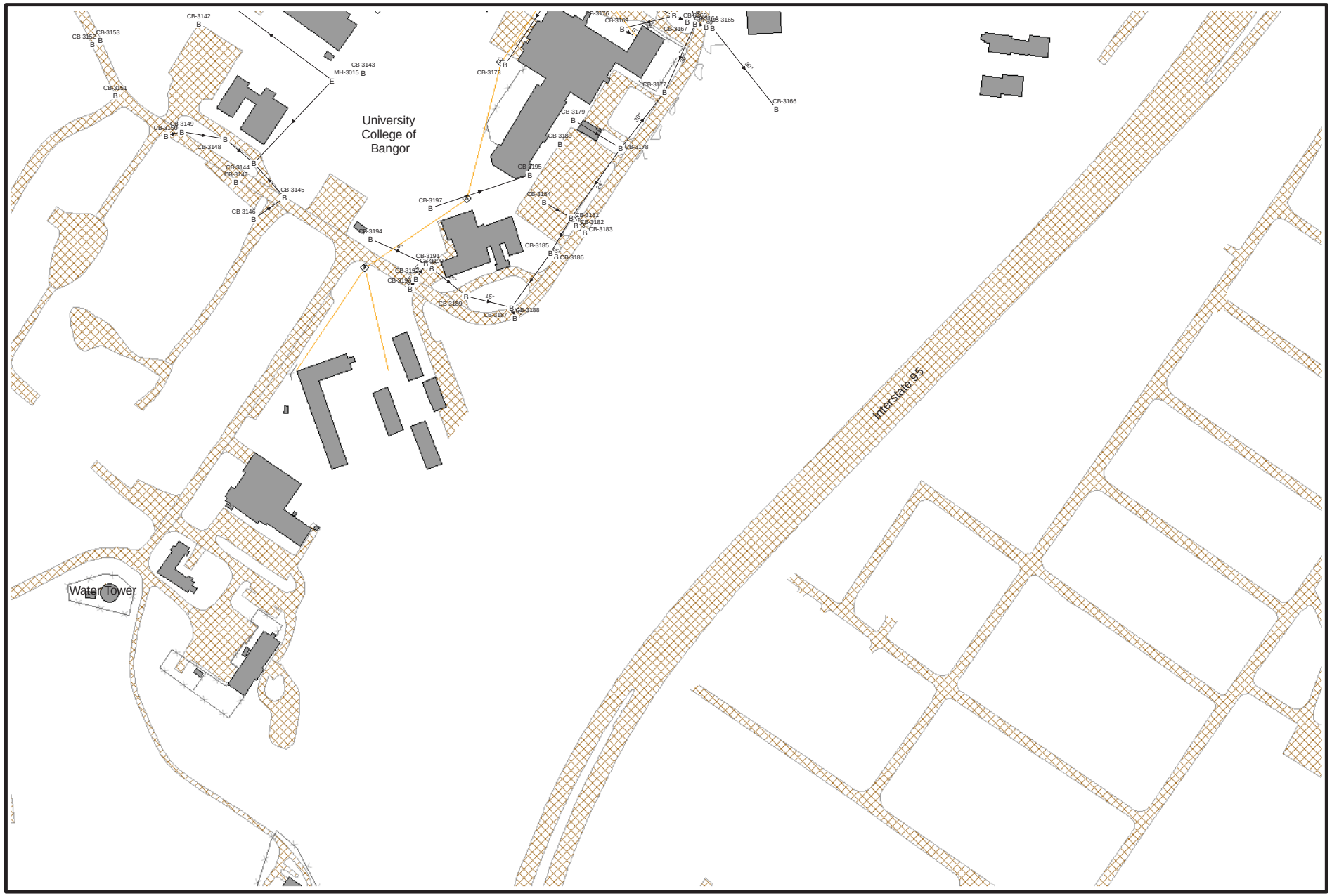

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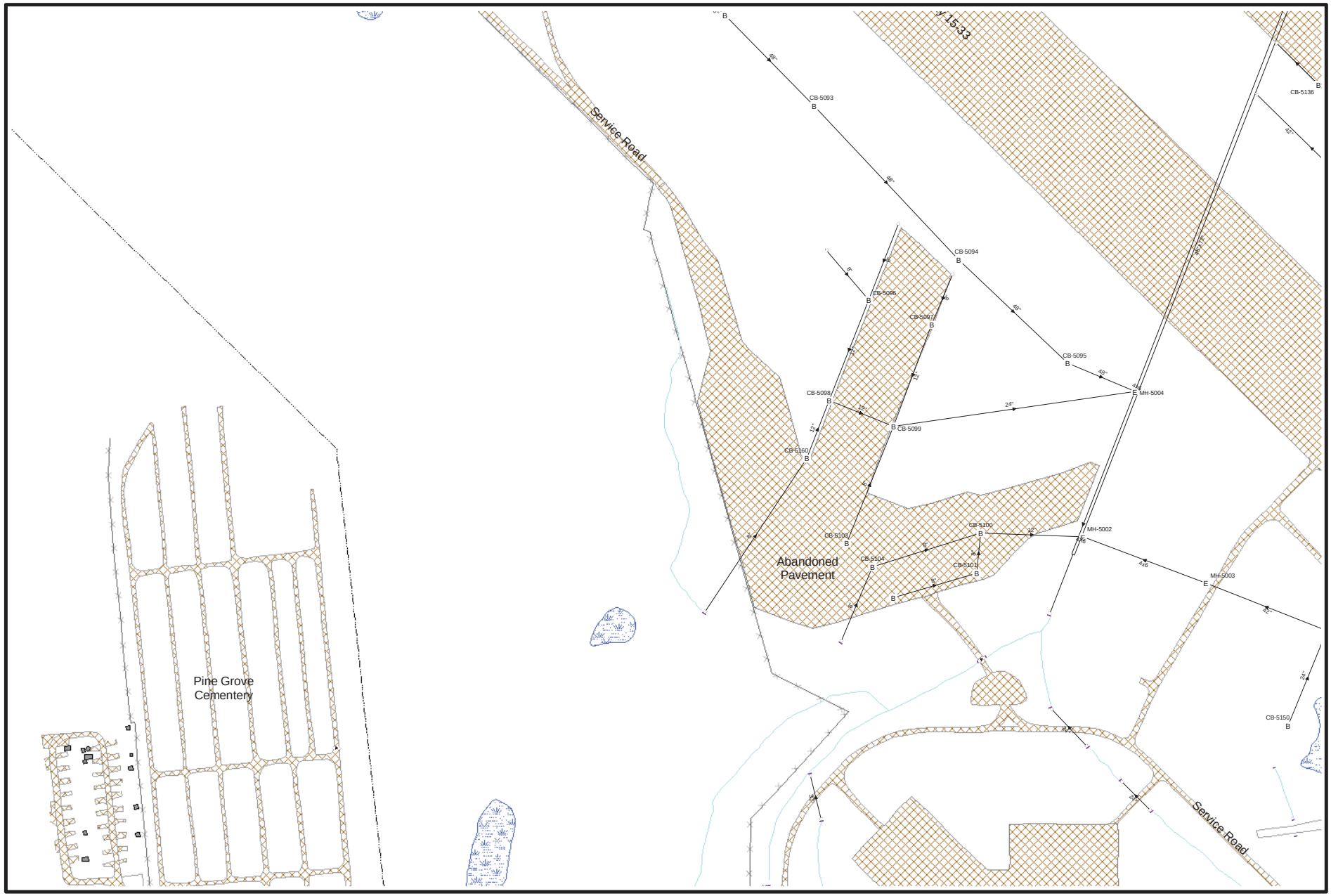

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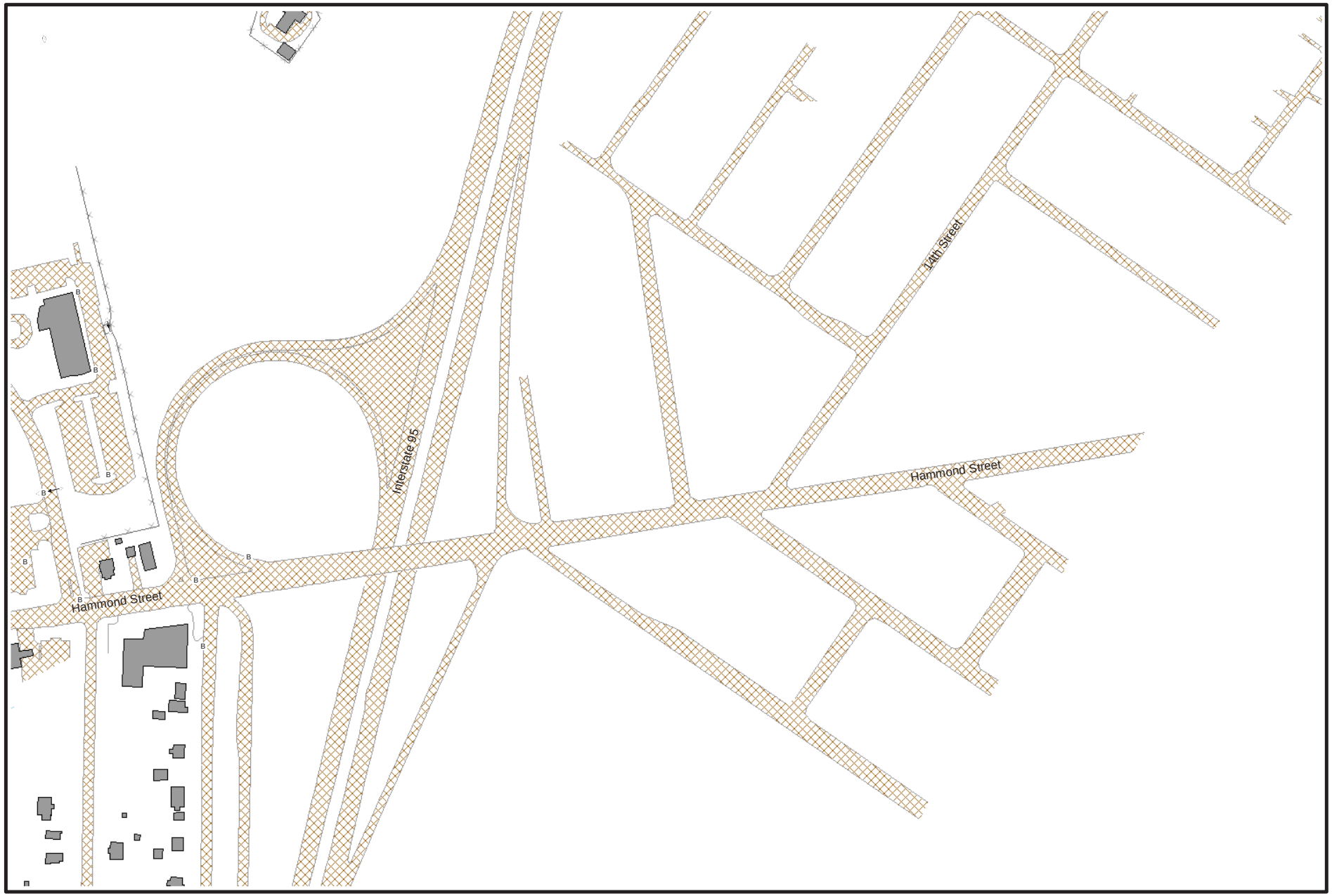

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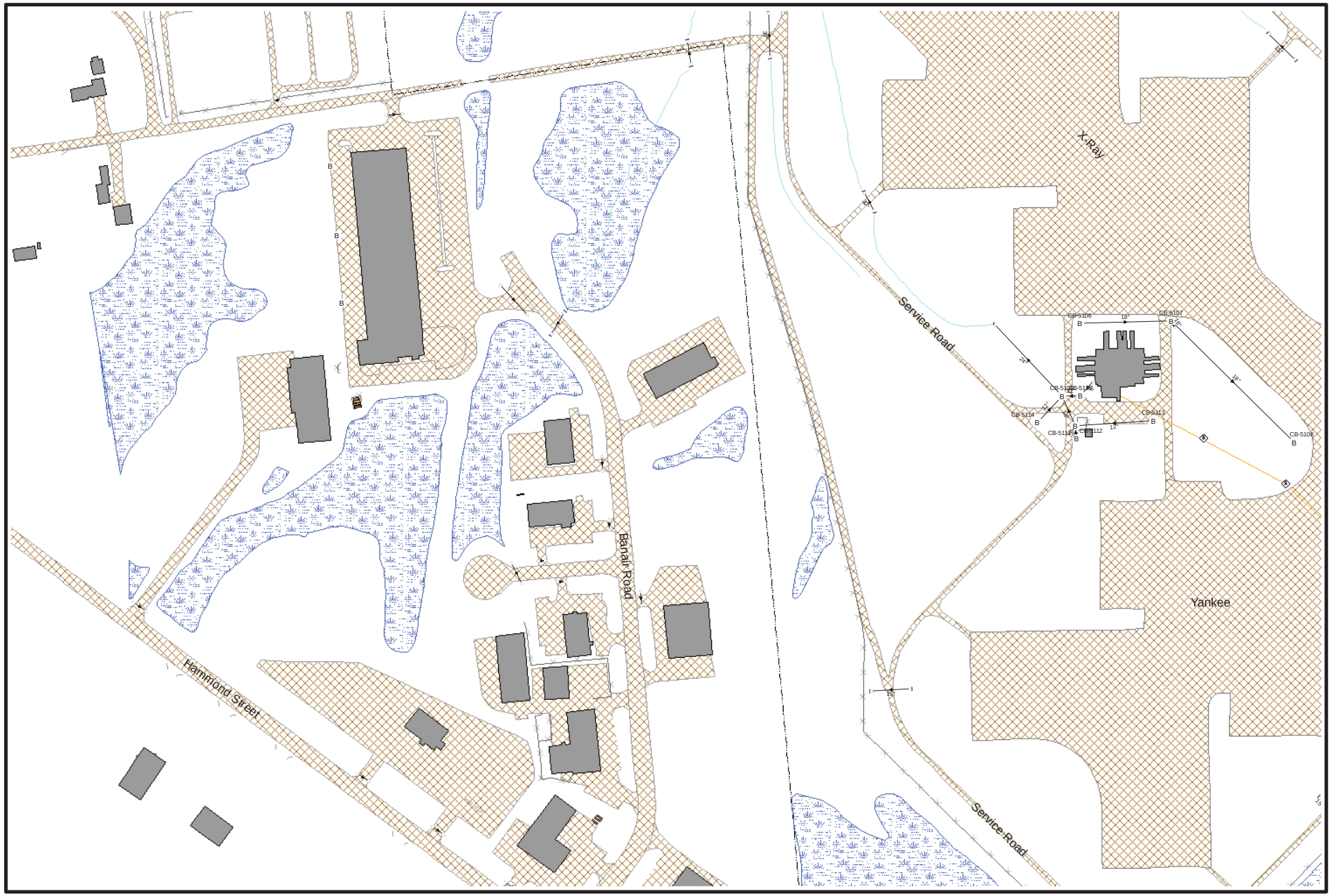

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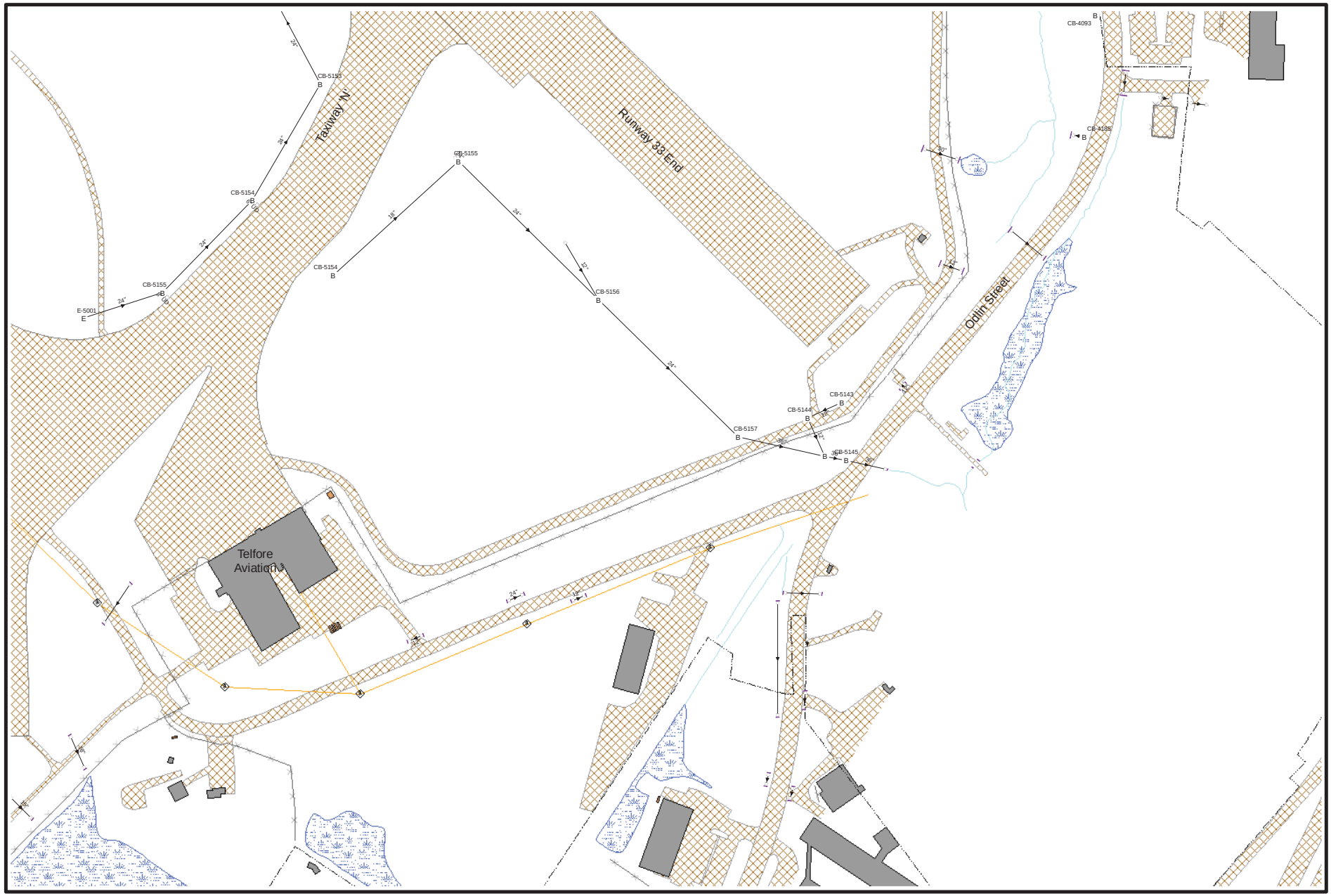

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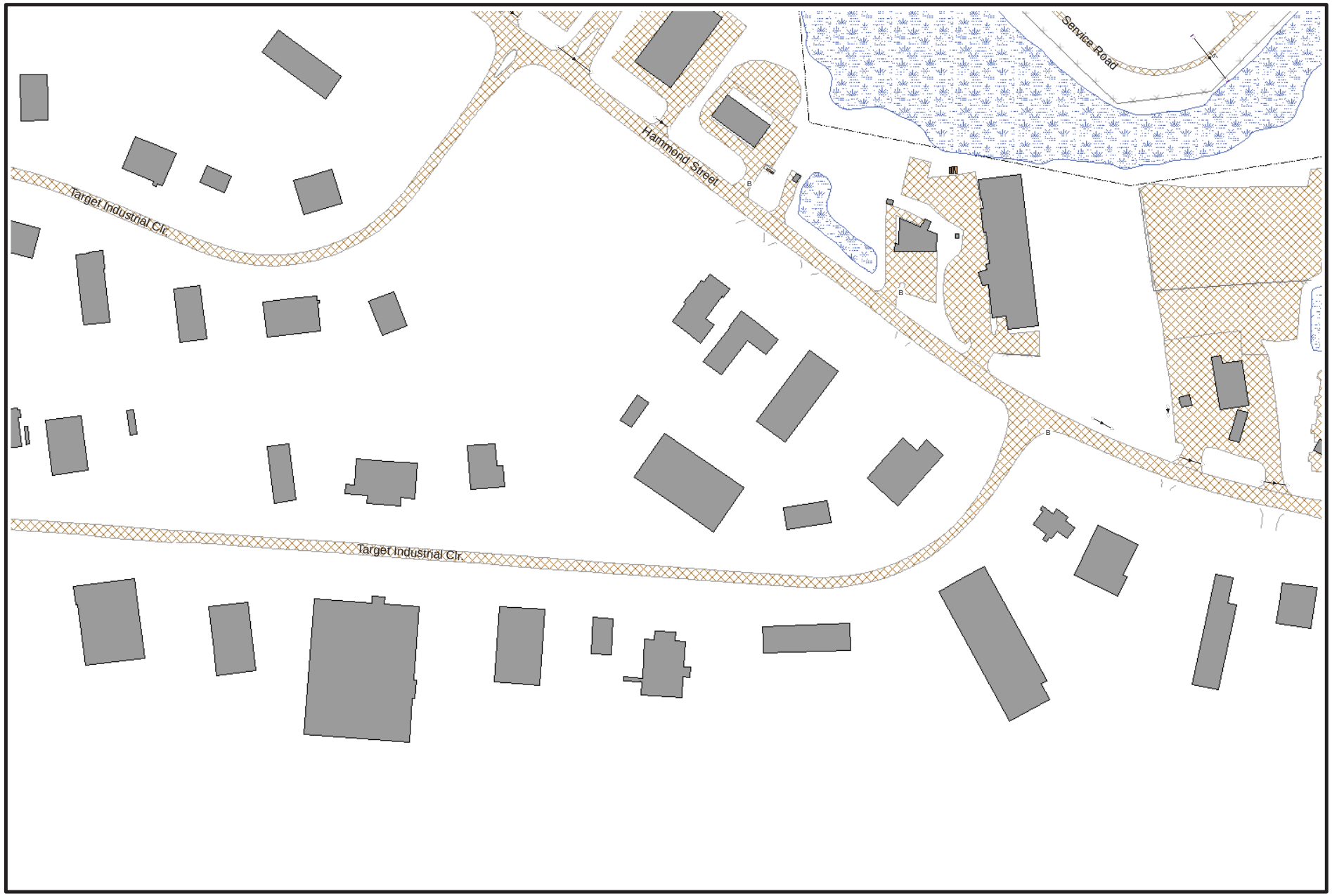

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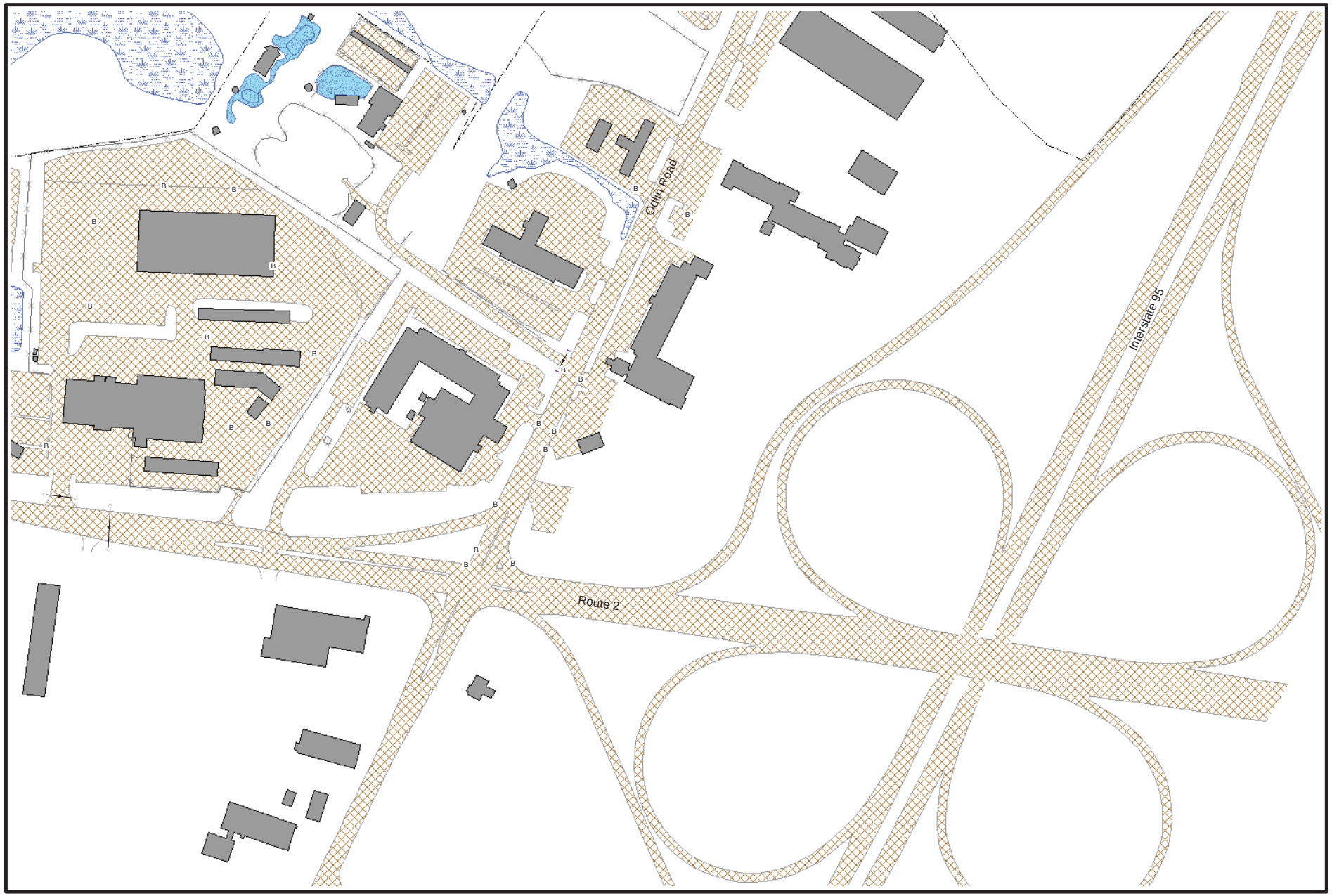

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See Key Plan for Location and Legend

3.3 – Stormwater Conveyance – Existing Issues

Locations that the field inspections identified to have existing drainage conveyance issues and irregularities are discussed in the following sections. The locations of issues are grouped relative to their location to the aircraft operations area. 'Landside' locations are those locations outside the airport security fence. 'Airside' locations include areas within the airport security fence and are considered in the airport operation area (AOA). The landside and airside locations are provided in Figure 3.3 "Existing Drainage Issues Plan" on the following page.

3.3.1 – Landside North

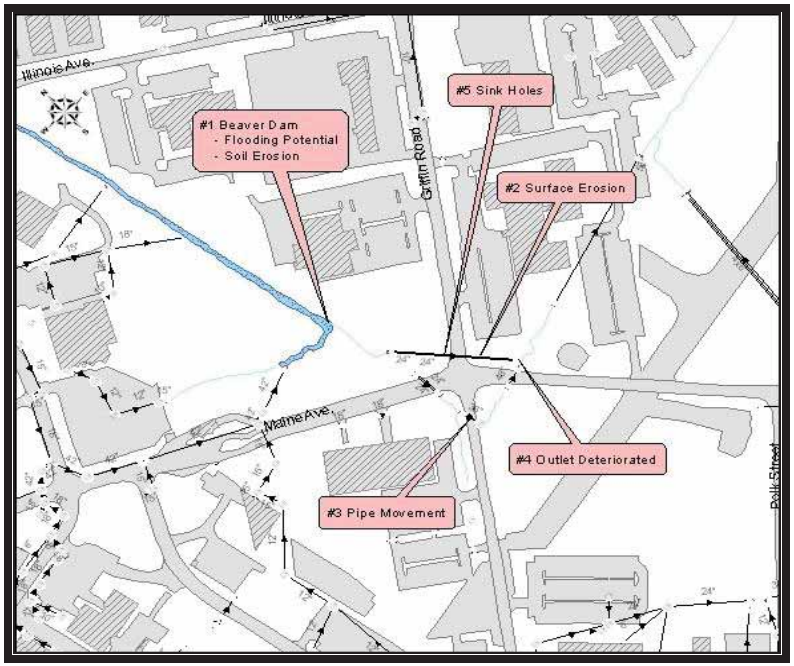


Figure 3.3.1.a "Landside North" (Numbers refer to photographs that follow)

Figure 3.3.1.b - Location #1 - Beaver Dam - (West of Spectacular Events Center)

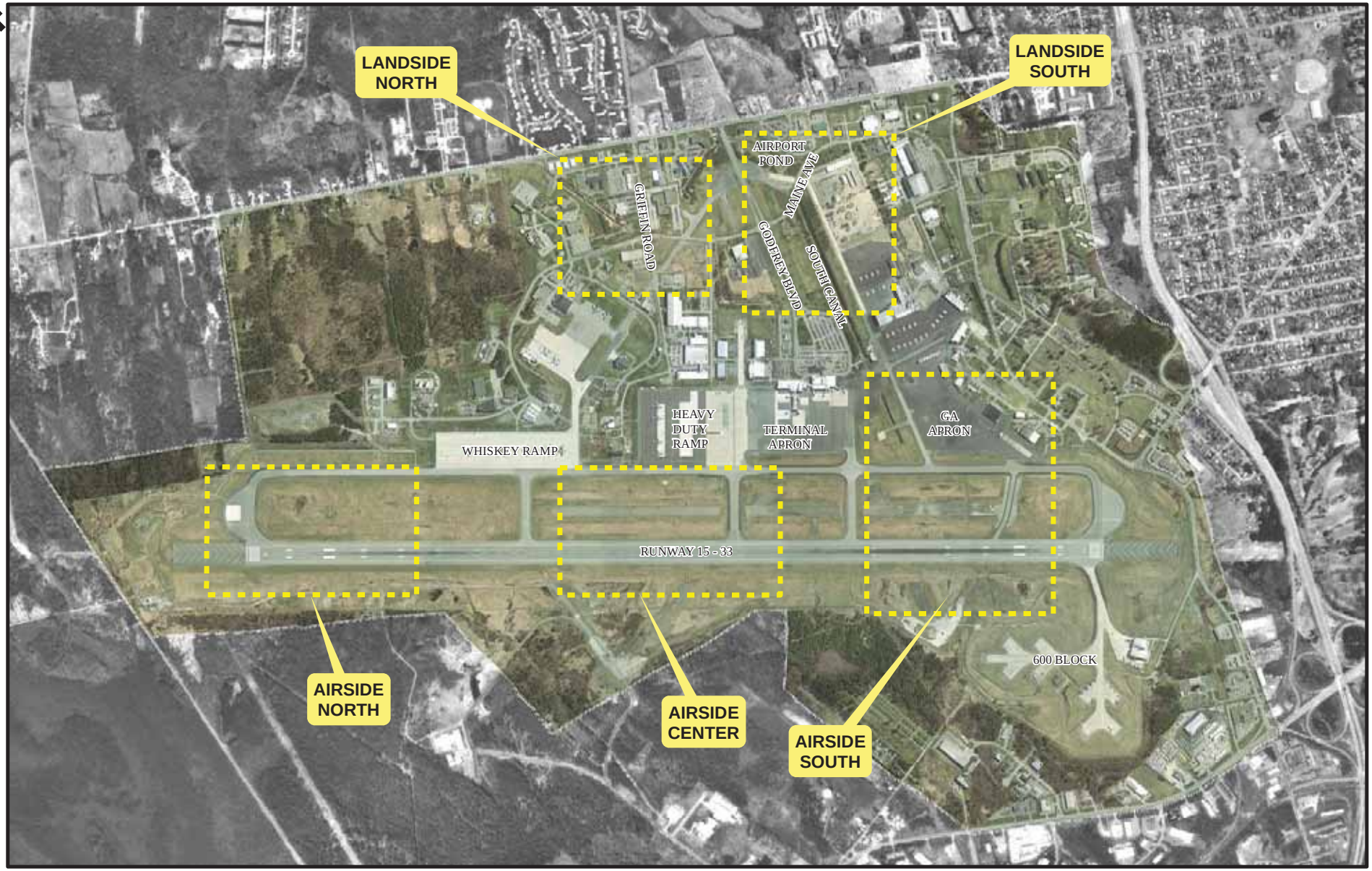
A beaver dam exists north-east of the Maine Avenue – Griffin Road intersection. The beaver dam measures 30' x 10' x 3'deep (approx.) There are 'pros' and 'cons' with respect to Beaver Dam.

Providing a wildlife habitat, attenuation of storm flows, sediment/pollutant settling and retention are some of the 'pros'. The 'cons' include bird wildlife habitat in proximity (0.8 miles) to aircraft activities, increased temperature from slow moving water, lower dissolved oxygen content in heated water, pollutant build- up that is flushed into the downstream conveyance, flooding of upstream properties and stormwater conveyances, flooding of and damage to the Maine Avenue and Griffin Road intersection resulting from a sudden breach of the beaver dam and soil erosion through the existing beaver dam breach.

It is recommended that careful consideration of the pros and cons stated above be factored into the decision to remove the beaver. Removal of a beaver dam as authorized by the game warden does not require a permit as referenced in Maine's Natural Resource Protection Act, Section 480Q, Subsection 21 provided the conditions of Subsection 21 are satisfied.

The cost estimate to remove the existing beaver dam is $5,400 which includes excavation and temporary downstream erosion control measures. A cost estimate is provided in Table 1 at the end of this section.

Figure 3.3 - Existing Drainage Issues Plan



0 600 1,200 2,400 Feet

Details of each area follows this figure

Figure 3.3.1.c - Location #2 - Surface Erosion - (West of Maine Department of Human Services)

Surface erosion west of the Maine Department of Human Service's parking lot measures 10'x 6' x 3' deep (approx). The eroded soil has washed sediment into the downstream stormwater swales and conveyances.

It is recommended that the exposed soils be protected with Maine DOT Item 610.07 'Stone Fill' to prevent additional soil erosion.

The cost estimate to reshape the slope, backfill and install 'Stone Fill' with a geotextile placed below the stone is $4,750. A cost estimate is provided in Table 1 at the end of this section.

Figure 3.3.1.d - Location #3 – Pipe Movement - (36-Inch RCP below Griffin Road)

The 36-Inch RCP, below Griffin Road and south-west of the Maine Avenue and Griffin Road intersection, is showing signs of pipe joint movement. This is occurring over 4 of the 4-foot sections on the north end of the pipe run. The pipe joints appear to be 'dry laid' with no interlocking bell and spigot connection. The pipe movement is outside the road's travel way and no evidence of soil movement from above was identified. Currently the system appears stable.

It is recommended that joint movement be monitored and measured on a recurring 6-month frequency to determine if additional pipe movement is occurring.

Figure 3.3.1.e - Location #4 – Outlet Deterioration - (Twin 24" RCP south of Griffin Road)

Pipe sections of the twin 24-inch RCP outlet south of the Maine Avenue and Griffin Road intersection have moved. The movement is estimated in the last 3 sections of pipe, measuring a total of 24-feet. The soil erosion is occurring above the last 3 sections of pipe on the south end. The soil erosion measures 10-feet x 10-feet x 10-feet deep. Evidence of sedimentation into the downstream stormwater system at the outlet was noted.

It is recommended that a headwall be installed to prevent further pipe movement. This will require removal of the embankment to expose the moved pipe sections, the removal of the shifted pipe, installation of a headwall at the end of the existing stable pipe and installation of erosion protection stone on the re-graded slopes.

The estimated cost to stabilize the outlet as suggest above is $14,380. A cost estimate is provided in Table 1 at the end of this section.

Figure 3.3.1.f - Location #5 – Sink Holes - (Twin 24" RCP below Griffin Road)

In addition to the deteriorated outlet from the twin 24-inch RCP south of Griffin Road, previously mentioned in Figure 3.2.1.f, there is evidence of subsidence over the length of the each of the 2 pipes. The land contour above the two pipes indicates a general depression over the length and width of the pipes. No subsidence above Griffin Road was noted. However, there were 2 sink holes on either side of Griffin Road above the pipe. The sink holes were filled in the Fall of 2006 by the City. The sink holes indicate that soil may be entering the pipe. Sedimentation within the pipes was noted. Sedimentation could be resulting from the upstream conveyances or soil entering the pipe from the dry-laid joints separating.

It is recommended that the two pipes be cleaned and videoed to identify the condition of the pipes.

The estimated cost to clean and video the pipes is $14,500. A cost estimate is provided in Table 1 at the end of this section.

Table 3.3.1 – Landside North Cost Estimates (Refer to Figure 3.3 for general location)

Figure	Finding	Issues	Recommendation	Repair Items	Qty	Unit	Unit $	Estimated $
3.3.1.b	Beaver Dam	Flooding Potential	Consider Removal of 30'x10'x3' deep soil (est.)	Muck Excavation	35	CY	$40	$1,400
		Soil Erosion		Erosion Control	1	LS	$4,000	$4,000
				Subtotal				$5,400
3.3.1.c	Surface Erosion	Sedimentation & Siltation of Drainage	Backfill and Riprap 10'x6'x3' deep (est.) eroded slope	Backfill	10	CY	$20	$200
	(Vicinity of Dept of Human Services)			Riprap	10	CY	$55	$550
				Erosion Control	1	LS	$4,000	$4,000
				Subtotal				$4,750
3.3.1.d	36" Concrete Pipe	Pipe movement	Monitor pipe for further movement	Not applicable				None
	(Below Griffin)	- 4 sections by 4' each		Recommend monitoring				
		- Movement outside travel way						
		- System appears stable						
3.3.1.e	Twin 24" Pipe Outlet	Outlet Deteriorated	Stabilize pipe and provide outlet erosion control	Remove 24" RCP	24	FT	$35	$840
	(South of Griffin Road)	-3 sections by 4' each by 2 pipes		Excavation	15	CY	$20	$300
		-10' by 10' by 10' deep erosion		Headwall	1	LS	$7,000	$7,000
				Backfill	15	CY	$20	$300
				Riprap	20	CY	$55	$1,100
				Erosion Control	1	LS	$4,000	$4,000
				Subtotal				$14,380
3.3.1.f	Sink holes and depressed ground	Soil entering pipe	Remove Soil in Pipes	Water Jet Clean Pipes	16	HR	$250	$4,000
	above Twin 24" Pipe - 340LF each	- Subsidence below Griffin Road potential	Video Inspect Drainage Pipes	Remove soil off-site (Assume Contaminated)	20	Ton	$125	$2,500
	(Below Griffin Road)	- Sedimentation & Siltation of Drainage		Video Pipes	16	HR	$250	$4,000
				Erosion Control	1	LS	$4,000	$4,000
				Subtotal				$14,500

*** Values consider individual projects**.

3.3.2 - Landside South

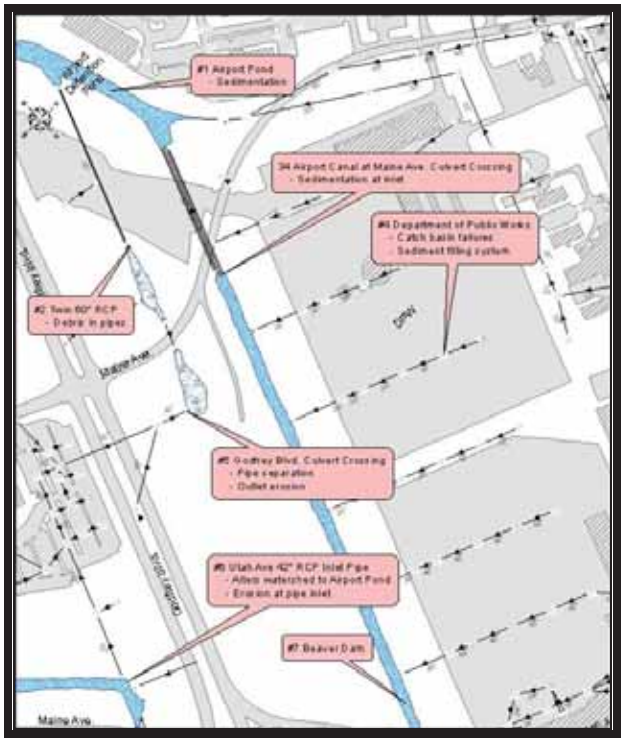


Figure 3.3.2.a "Landside South" (Numbers refer to photograph that follow)

Figure 3.3.2.b - Location #1 – Airport Pond Sedimentation

Deposits of sediments were found in the airport pond. Figure 3.3.2.c on the following page indicates the depth of sedimentation. The pond's storage capacity, as referenced in the 1992 airport pond design report, considers the stormwater capacity of the pond above the permanent pool elevation. The deposits of sediment have not reached an elevation above the permanent pool elevation. Therefore the pond's stormwater storage capacity has not been degraded.

However, the presence of sedimentation at the inlets can result in re-suspension of soil particulate in the water column during high flow events. This could degrade the water quality exiting the airport pond. The sediments also reduce the pond's wet storage capacity and ability to treat stormwater. Chapter 4 of the Maine Department of Environmental Protection (MDEP) Best Management Practices Technical Design Manual recommends dredging when accumulated volume loss is 15 to 20% of the permanent pool, or every 15 to 20 years.

It is recommended that the inlets be monitored for deposits of sedimentation and re-suspension during storm events. Estimated cost to remove the existing sediments is $142,500. A cost estimate is provided in Table 3.3.2 at the end of this section.

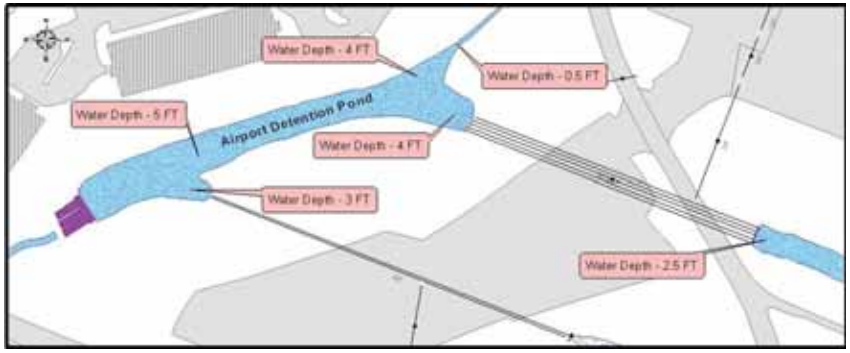


Figure 3.3.2.c – Reference Location #1 - Water depths in Airport Pond

In the above figure, sedimentation is indicated in locations where 5-feet or less, of water depth was measured. Five-feet represent the permanent pool depth considered in the airport detention pond design.

Specifically, 2-feet of sedimentation was found at the twin 60-inch culvert pipes inlet on the west side of the pond and 1-foot of soil deposits were measured at the inlet of the 50-inch by 70-inch box culverts. Toward the center of the pond, elevations of 5-feet were measured. Measurements were made in the Fall of 2006.

Figure 3.3.2.d - Location #2 – Twin 60-inch RCP East of Maine Avenue

Evidence of debris within the inlet of the twin 60-inch RCP's south of Godfrey Boulevard was found. These two pipes parallel Godfrey Boulevard and outlet into the airport detention pond.

It is recommended that the pipe inlet be cleared of existing debris. The inlet debris will continue to fill and reduce the effectiveness of the pipe's ability to convey stormwater. A blockage in the pipes could flood and deteriorate the pipe inlets as well as create a backwater condition in the airport's drainage system. Blocked and or slow moving water also has the tendency to attract wildlife (birds), increase the water temperature which in-turn reduces the oxygen content of the water, and also provides a location for pollutants to concentrate.

There is also debris within the pipes. As the pipe outlets are below the airport pond's wet pool elevation, the pipes remain partially full at all times. To video inspect and/or remove suspected debris within the pipes, would require damming of the inlet and outlet and pumping out the water within the pipes. This is not recommended at this time as these pipes do not appear plugged.

The estimated cost to clear debris from the pipe inlet is $5,000. A cost estimate is provided in Table 2 following this section.

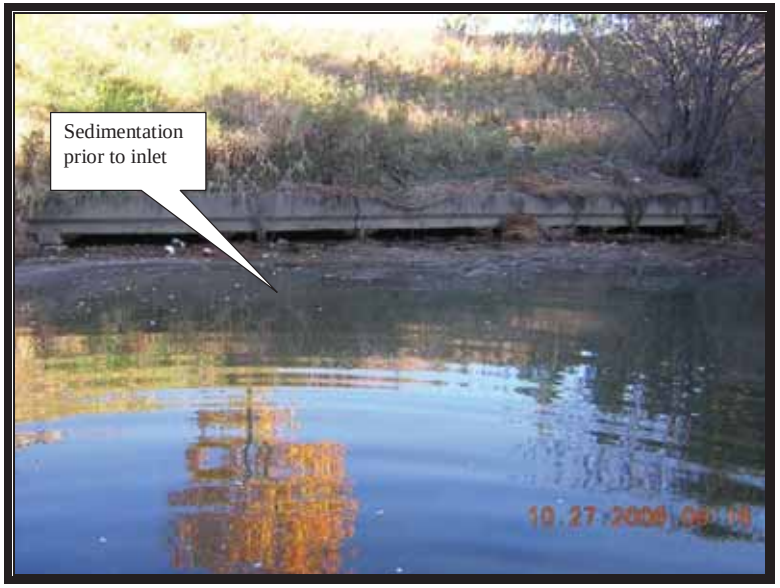


Figure 3.3.2.e - Location #3 – South Airport Canal @ Maine Avenue Crossing

Sediment, two-feet deep, was measured 100-feet south of the 4 cell (50-inch by 70-inch each) box culverts in the Airport's southern drainage canal prior to Maine Avenue. This location is indicated in the Figure 3.3.2.c.

The airport's southern drainage canal, the 4 cell box culverts below Maine Avenue and the airport pond are referenced in the 1992 Airport pond design report. The design report considered the pond's storage capacity as that volume above the pond's permanent pool elevation. The sediment at the inlet is below the detention pond's pool elevation, therefore has not effect on the stormwater detention capacity. However, from a water quality perspective, the accumulation of sediment reduces the wet storage volume and therefore reduces the detention pond's treatment of stormwater. Further, stormwater flows may re-suspend accumulated sediments and degrade the stormwater quality.

As resources allow dredging of sediment from the inlet should be conducted. Estimated cost to remove the current sediments is $85,750. A cost estimate is provided in Table 2 following this section.

Figure 3.3.2.f - Location #4 – Department of Public Works

Sediment filled catch basins were observed within the DPW material storage yard. The two main drainage pipes draining the DPW site are submerged below the water level in the airport canal. Therefore evidence of sediment in the pipes could not be determined at the pipe outlets. The catch basin grate and frames have collapsed in multiple locations in the DPW complex. Erosion control measures were found to be in need of repair and replacement around the existing catch basins. A petroleum smell was noticed in several of the catch basins.

The sediment found in the drainage system appears to be a result of the material storage activities at the site. Controlling the source of sediment run-off from the stockpiles with containment berms and in-line drainage sand/grit/oil separators will reduce the contaminant run-off from the site. Because this site outlet's into the airport canal and airport detention pond, preventing sediment from leaving this site will have a positive effect on the airport's water quality and reduce the costly dredging of sediments from the airport canal, box culverts and airport detention pond.

It is recommended that the catch basins and pipes be cleaned and videoed to determine the existing drainage conditions. At-the-source sediment run-off (i.e. sediment berms) and in-line grit/sand/oil separators are recommend in the site's 2 primary drain lines discharging into the airport's drainage canal. Repair of the damaged catch basin cover's is also recommended.

The estimated cost, not considering stockpile sediment run-off controls, is estimated at $65,250. A cost estimate is provided in Table 2 following this section.

Figure 3.3.2.g - Location #5 – Godfrey Boulevard Culvert Crossing Outlet

The outlet to the 42-inch pipe that discharges south of Godfrey Boulevard is deteriorated. The outlet is located across from the L.L. Bean facility south of Godfrey Boulevard. Outlet deterioration was noted in the 42-inch RCP in the form of pipe separation and outlet erosion. Approximately 28-feet of the end of the drainage pipe has moved.

Erosion at the outlet is noted as flow is directed from the 42-inch pipe at 90-degrees to the drainage channel thereby eroding the far bank. Continued erosion degrades the airport's water quality by suspending sediment in the water and causing downstream sedimentation.

It is recommended that the outlet be stabilized by removing 28-feet of the existing pipe, installing 14-feet of pipe (partial replacement), installing a headwall to provide pipe support at the outlet and installing erosion control stone at the outlet to protect currently exposed side-channel soils.

It is also recommended that the existing pipe run from the deteriorated outlet south of Godfrey to L.L. Bean be cleaned and videoed as the existing separation at the outlet may have occurred elsewhere within the pipe run.

The estimated cost for the recommended actions above is $15,100. A cost estimate is provided in Table 3.3.2 following this section.

Figure 3.3.2.h - Location #6 – Utah Avenue 42-Inch Inlet Pipe

A 42-inch RCP in the airport's center drainage canal near the rental cars on Utah Avenue has been exposed. Drainage from the airport's aircraft parking aprons and the MEANG Whiskey apron currently flows to this 42-inch pipe. The 42-inch pipe was part of the Dow AFB in-field drainage system. Remains of a brick drainage structure were found next to the pipe's inlet. It appears that stormwater has eroded and collapsed the brick structure and exposed the 42-inch pipe. The 42-inch pipe is lower than the canal's bottom and therefore has acted to drain the southern half of the canal.

Review of the 1991 drainage report indicates that the center drainage canal was intended to drain the parking aprons to the north-east through the center drainage canal and not into the exposed 42-inch pipe. In its current condition, the exposed 42-inch pipe has "short circuited" the intended flow and now conveys the parking apron's drainage-runoff to the Airport detention pond. Hydrologic modeling of the airport detention pond indicates that the current flow condition exceeds the Airport pond's flood storage and detention capacity as referenced in 1992 pond design. Section 4.6.1 discusses the Airport pond's current capacity.

It is recommended that the existing "short circuited" condition be removed. This will bring the Airport detention pond to within its original design capacity. Section 5.3 provides options for restoring the airport pond to its design condition.

A headwall and stabilized embankment should be installed if flow through the existing 42-inch pipe is to continue. The cost estimate to stabilize the existing inlet condition is $12,250. A cost estimate is provided in Table 3.3.2 following this section.

Figure 3.3.2.i - Location #7 – Beaver Dam Airport Southern Canal

A 40-foot by 10-foot by 4-foot deep beaver dam is currently within the airport's southern drainage canal. The beaver dam is breached and is currently not retaining stormwater. However, the breach has exposed soil faces which will continue to erode and add sediment to downstream conveyances.

It is recommended that the beaver dam be removed. Removal of a beaver dam as authorized by the game warden does not require a permit as referenced in the Maine Natural Resource Protection Act, Section 480Q, Subsection 21 provided the conditions of Subsection 21 are satisfied.

The estimated cost to remove the beaver dam is $6,400. A cost estimate is provided in Table 3.3.2 following this section.

Table 3.3.2 – Landside South Cost Estimates (Refer to Figure 3.3 for general location)

*** Values consider individual projects.**

Figure	Finding	Issues	Recommendation	Repair Items	Qty	Unit	Unit $	Estimated $
3.3.2.b	Sedimentation in Airport Pond	Pond effectiveness reduced	Pond Dredging to Remove Sedimentation	Muck Excavation (Est. CY)	500	CY	$40	$20,000
		Offsite sedimentation		Remove Soil Offsite (Assume Contaminated)	900	Ton	$125	$112,500
				Erosion Control	1	LS	$10,000	$10,000
				Subtotal				$142,500
3.3.2.d	Inlet to Twin 60" RCP	Debris at inlet to pipes	Remove debris at pipe inlets	Debris Removal (Labor)	40	HR	$100	$4,000
	(East of ME Avenue)			Erosion Control	1	LS	$1,000	$1,000
				Subtotal				$5,000
3.3.2.e	Debris at inlet to Airport Canal Culvert	Canal/Pond Effectiveness	Remove Debris and Sediments	Muck Excavation (Est. CY)	300	CY	$40	$12,000
	(South Canal at ME Avenue)	Downstream Sedimentation		Remove Soil Offsite (Assume Contaminated)	550	Ton	$125	$68,750
				Erosion Control	1	LS	$5,000	$5,000
				Subtotal				$85,750
3.3.2.f	DPW	Catch Basin Failures	Repair Catch Basins	Repair Catchbasin	6	EA	$500	$3,000
		Sediment entering drainage system	Install oil-water-grit separators	Install Grit Separators	2	EA	$20,000	$40,000
			Remove Debris in Pipes	Water Jet Clean Pipes	16	HR	$250	$4,000
			Video Inspect Drainage Pipes	Remove Soil Off Site (Assume Contaminated)	100	Ton	$125	$12,500
				Clean CB's	15	EA	$250	$3,750
				Video Pipes	8	HR	$250	$2,000
				Subtotal				$65,250
3.3.2.g	Godfrey Boulevard Culvert Crossing	Pipe separation	Remove and replace pipes	Remove 42" Pipe	28	LF	$35	$980
		Erosion at outlet	Install Outlet Erosion Control	Replace 42" Pipe	14	LF	$90	$1,260
				Install 42" Flared End Section	1	EA	$5,000	$5,000
				Riprap (15' x20'x 2' est)	25	CY	$55	$1,375
				Excavation (15' x20'x 2' est)	25	CY	$20	$500
				Erosion Control	1	LS	$4,000	$4,000
				Clean Existing Pipe	4	HR	$250	$1,000
				Video Existing Line to LL Bean	4	HR	$250	$1,000
				Subtotal				$15,115
3.3.2.h	Utah Ave - Inlet Erosion	Inlet erosion	Temporary stabilization of current inlet	Remove 42" Pipe (from Rental Car too)	40	LF	$20	$800
		Alteration to Airport Pond Watershed		Replace 42" Pipe	20	LF	$90	$1,800
			Further study required to determine possible	New Manhole	1	EA	$8,000	$8,000
			flood protection berm along Utah Avenue.	Riprap (30' x 25' x 1' est)	30	CY	$55	$1,650
				Subtotal				$12,250
3.3.2.i	Beaver Dam in Canal	Pond/Canal Effectiveness	Remove Beaver Dam	Muck Excavation (40' x 10' x 4')	60	CY	$40	$2,400
				Erosion Control	1	LS	$4,000	$4,000
				Subtotal				$6,400

3.3.3 - Airside

Site observations noted sediment in certain in-field catch basins. In certain pipe locations, sink holes were found above the pipes. The apparent reason for the sink holes is from the sediment entering the drainage system. The existing system (Dow AFB 1940's and 1950's) was most likely constructed with 'dry laid' joints which over time may have shifted and are allowing sediment to enter the drainage system. Airfield maintenance continues to fill the sink holes as they become safety concerns to mowing and airfield operations. Weathering concrete within certain catch basins was noted as evidenced by exposed aggregate and reinforcing in the face of catch basin concrete.

In addition to the safety concern sink holes create, sediment entering the system results in sedimentation of downstream conveyances thereby reducing their effectiveness as well as stormwater pollution. In certain location, the pipes appear to be blocked and stormwater has found a path around these blockages through the soil adjacent to the pipes.

It is recommended that the certain portions of the existing system be further analyzed. Table 3.3.3 indicates pipe lengths where sediment entering the system or a pipe blockage was noted. This will require cleaning of the sediment filled catch basins and pipes followed by a video inspection. The cost estimate to conduct cleaning and videoing is estimated at $180,000 for the airside locations. Figure 3.3.3 on the following page indicates the pipes requiring cleaning and videoing on both the landside and airside.

STRUCTURE			
FROM	TO	LENGTH (FT)	LOCATION
CB-5146	CB-5018	251	South of North Hold Apron
CB-5018	CB-5017	324	South of North Hold Apron
CB-5017	CB-5019	324	South of North Hold Apron
CB-5019	CB-5020	330	South of North Hold Apron
CB-5020	CB-5021	332	South of North Hold Apron
CB-5021	CB-5022	329	South of North Hold Apron
CB-5026	CB-5031	434	South of Taxiway 'M', East of Runway
CB-5031	CB-5032	299	South of Taxiway 'M', East of Runway
CB-5032	CB-5033	300	South of Taxiway 'M', East of Runway
CB-5033	CB-5034	301	South of Taxiway 'M', East of Runway
CB-5038	CB-5039	631	South of Taxiway 'L', East of Runway
CB-5039	CB-5040	309	South of Taxiway 'L', East of Runway
CB-5040	CB-5041	310	South of Taxiway 'L', East of Runway
CB-5137	CB-5138	292	South of Taxiway 'J'
CB-5131	CB-5132	300	North of Taxiway 'J'
CB-5132	CB-5159	377	North of Taxiway 'J'
CB-5159	BOX CULVERT	171	North of Taxiway 'J'
CB-5121	CB-5118	331	North of Taxiway 'J'
CB-5070	CB-5069	300	South of Taxiway 'M', West of Taxiway A
CB-5069	CB-5068	300	South of Taxiway 'M', West of Taxiway A
CB-5068	CB-5066	297	South of Taxiway 'M', West of Taxiway A
CB-5066	CB-5065	293	South of Taxiway 'M', West of Taxiway A
CB-5065	CB-5064	286	South of Taxiway 'M', West of Taxiway A
TOTAL		7,422	

Table 3.3.3 – Airside Drainage Issue Pipes – Clean and video

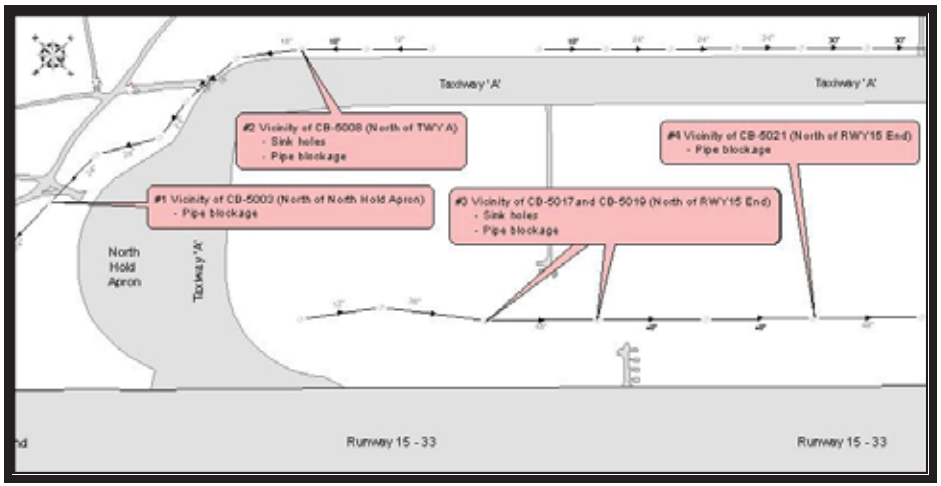


Figure 3.3.3.a "Airside North" (Numbers refer to photographs that follow)

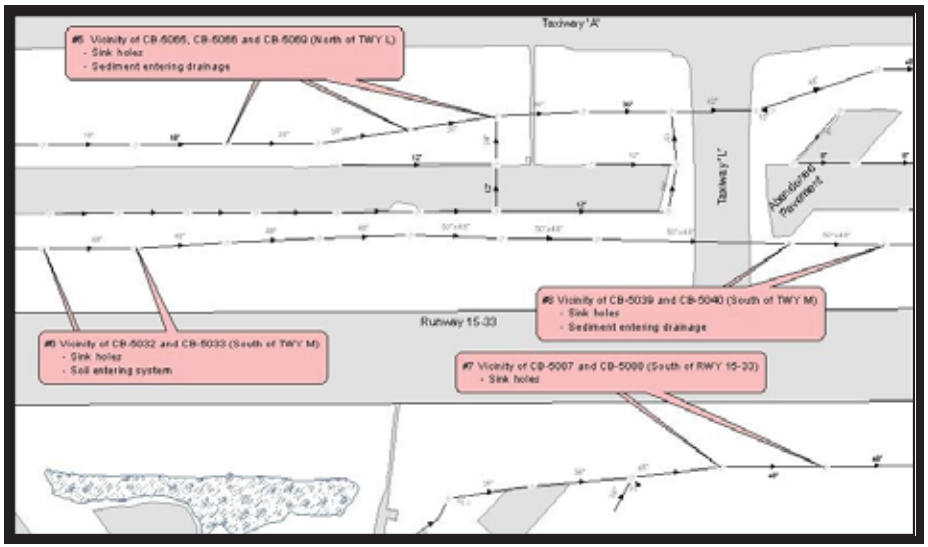


Figure 3.3.3.b "Airside Center" (Numbers refer to photographs that follow)

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Figure 3.3.3 - Airport Drainage Pipes Requiring Cleaning or Videoing

Legend

SD Pipe Issues

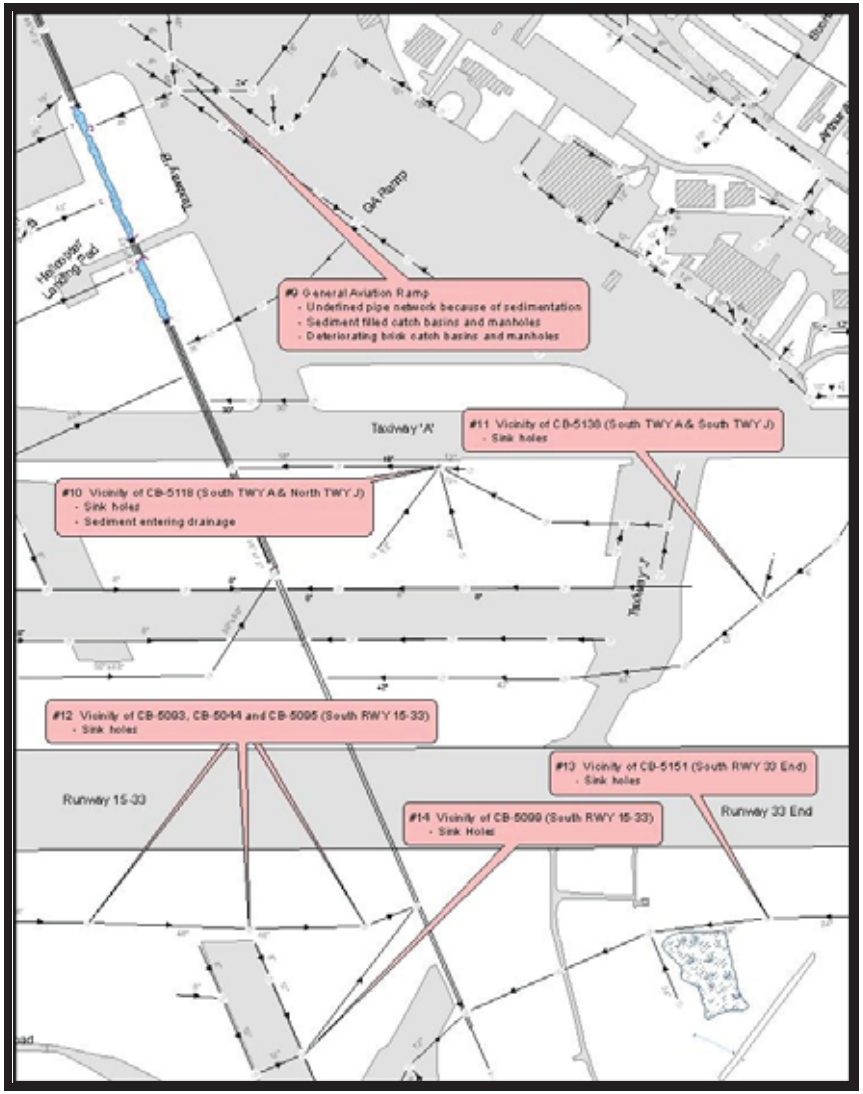


Figure 3.3.3.c "Airside South" (Numbers refer to photographs that follow)

Figure 3.3.3.d - Location #2 – At CB 5008 (North of Taxiway A)

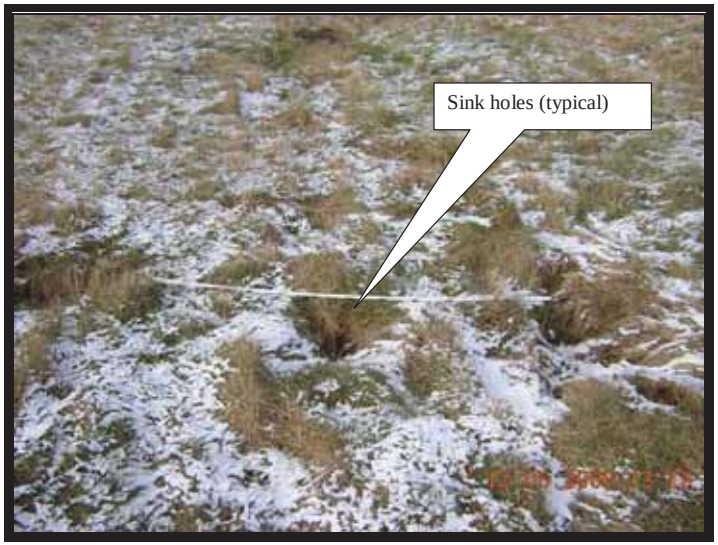


Figure 3.3.3.e - Location #3 – At CB 5017 (North of Runway 15 End)

Figure 3.3.3.f - Location #6 – At CB 5032 (South of Taxiway M)

Figure 3.3.3.g - Location #7 – At CB 5087 (West of Runway 15-33)

Figure 3.3.3.h - Location #9 – General Aviation Ramp (Sediment Filled Structure)

The drainage pipe network of the General Aviation Ramp is not well defined. The majority of the existing catch basins contain sediment above the inlet and outlet pipes. As a result, efforts to follow, locate and map the drainage layout in this area were not successful.

In addition many the existing structures are constructed of brick (as shown in the above photo) and are exhibiting signs of deterioration. Deterioration in the form of broken bricks, spalling, loose mortar and loss of mortar was noted.

A partial removal and abandonment of the existing system is recommended as part of the future General Aviation Ramp reconstruction project. The addition of oil-water-grit separator is also recommended to protect the airport's southern drainage canal from the ramps fueling and aircraft activities.

The estimated cost to remove and abandon a portion of the drainage system, install new drainage and oil-grit-sand separator is estimated at $1.1 million. This cost estimate is provided in the following Table 3.3.4.

Table 3.3.4 – Airside Cost Estimates (Refer to Figure 3.3 for general location)

*** Values consider individual projects.**

Location	Finding	Issues	Recommendation	Repair Items	Qty	Unit	Unit $	Estimated $
Airfield	Pipe blockages	Obstructed conveyance	Remove Debris in Pipes	Water Jet Clean Pipes	300	HR	$250	$75,000
	Sink holes	Sedimentation of drainage system	Video Inspect Drainage Pipes	Remove Soil from Pipe Off Site	1000	Ton	$65	$65,000
	Sediment in airfield drainage		Total Length = 7,400 LF (Est.)	Video Pipes	150	HR	$250	$37,500
			@ 200 LF/Day for cleaning; @ 400 LF/Day for video	Subtotal				$180,400
GA Apron	Sediment Filled Catch basins	Undefined Drainage Layout	Remove/abandon portion of drainage	Remove/Abandon Drainage	1500	LF	$30	$45,000
	Deteriorated Drainage Structures	Sediment filled, non-functioning drainage	Install New Drainage	Install New Trench Drain	2000	LF	$400	$800,000
			Install New Oil-Water-Grit Separators	Install New Drainage Pipe (24")	1500		$50	$75,000
				Install New Drainage Manholes (6' Dia.)	14		$6,000	$84,000
				Install New Oil-Water-Grit Separators	3		$30,000	$90,000
				Subtotal				$1,094,000

Section 4 - Existing Conditions - Watersheds

4.1 - Introduction
The existing watershed areas are similar to the areas defined in the 1991. However, characteristics of certain watersheds have changed with the addition of impervious areas by new development since the 1991 report. Additional watershed areas not considered in the design the airport detention pond have been found.

This site has been separated into three different watersheds totaling approximately 2064 acres. For the purpose of comparison with the 1991 drainage study report, similar watershed labels and subareas are used. These boundaries are depicted on the attached Figure 4.1.1-"Existing Watershed Areas Plan".

Watershed 1 contains approximately 1700 acres and discharges into Birch Stream northeast of the site. This large watershed was split into eleven smaller subareas. The result is subareas: 1-A, 1-B, 1-C, 1-D1, 1-D2, 1-E, 1-F, 1-G, 1-H, 1-I, 1-J. Note that subarea 1-D has been divided and subarea 1-J, not included in the 1991 report, has been added.

Watershed 2 is comprised of approximately 200 acres on the southeastern portion of the site and discharges into an unnamed stream south of Odlin Road. Watershed 2 has been divided into three subareas: 2-A, 2-B, 2-C.

Watershed 3 consists of approximately 149 acres on the north and northwesterly side of the site. The boundaries of watershed 3 coincide with the airport fence line for the purposes of this report. However, this watershed is part of a larger watershed that discharges to Hermon Bog.

4.2 - Methodology
HydroCAD® was the program selected for modeling this hydraulic system. The main theme in this analysis is to be as comparable as possible to the methods used in the 1991 report. HydroCAD® uses the Soil Conservation Service TR-20 runoff method rather than the TR-55 method used in the 1991 report. Even though the two methods have their differences, the SCS TR-20 method will be a more accurate representation of the system.

The current DEP regulations require that storm drain systems and detention structures be designed to control the two, ten, and twenty-five year storm events. This design criteria also coincides with the data from the 1991 report and design information provided.

Watershed boundaries were created and compared to those of the 1991 report to identify changes and other differences.

For the purpose of this report the northern direction will be aligned with Runway 15.

4.3 - Assumptions
The following information describes a few assumptions that were made to model the stormwater runoff of the site:

- For the purpose of calculating the time of concentrations, all pipes are assumed to have a one percent slope.
- The detention pond and southern airport canal south of Godfrey Boulevard are considered as one.
- All areas where soils have been disturbed due to development after the publishing of soil maps were considered part of hydraulic soil factor group C.

4.4 - Soils
The U.S. Department of Agriculture Soil Conservation Service's soil survey of Penobscot County was used for soil information. Since the publishing of this soil survey in 1963, a great deal of the soil has been disturbed due to development. As a result the soil is assumed to be a hydrologic soil group category "C" for average runoff conditions.

4.5 - Precipitation
Volume III of the Stormwater Management for Maine from the Maine Department of Environmental Protection requires a Type III storm for the Bangor area, and ultimately resulted in the selection of the twenty-four hour, Type III distribution used in this analysis. The southern Penobscot rainfall data for the 2, 10, and 25 year storm were chosen for the purpose of comparison with the 1991 report and other design information.

The following table displays the 2, 10, and 25 year 24 hour rain events:

Rain Event	Rainfall
2 Year	2.7 inches
10 Year	4.1 inches
25 Year	4.8 inches

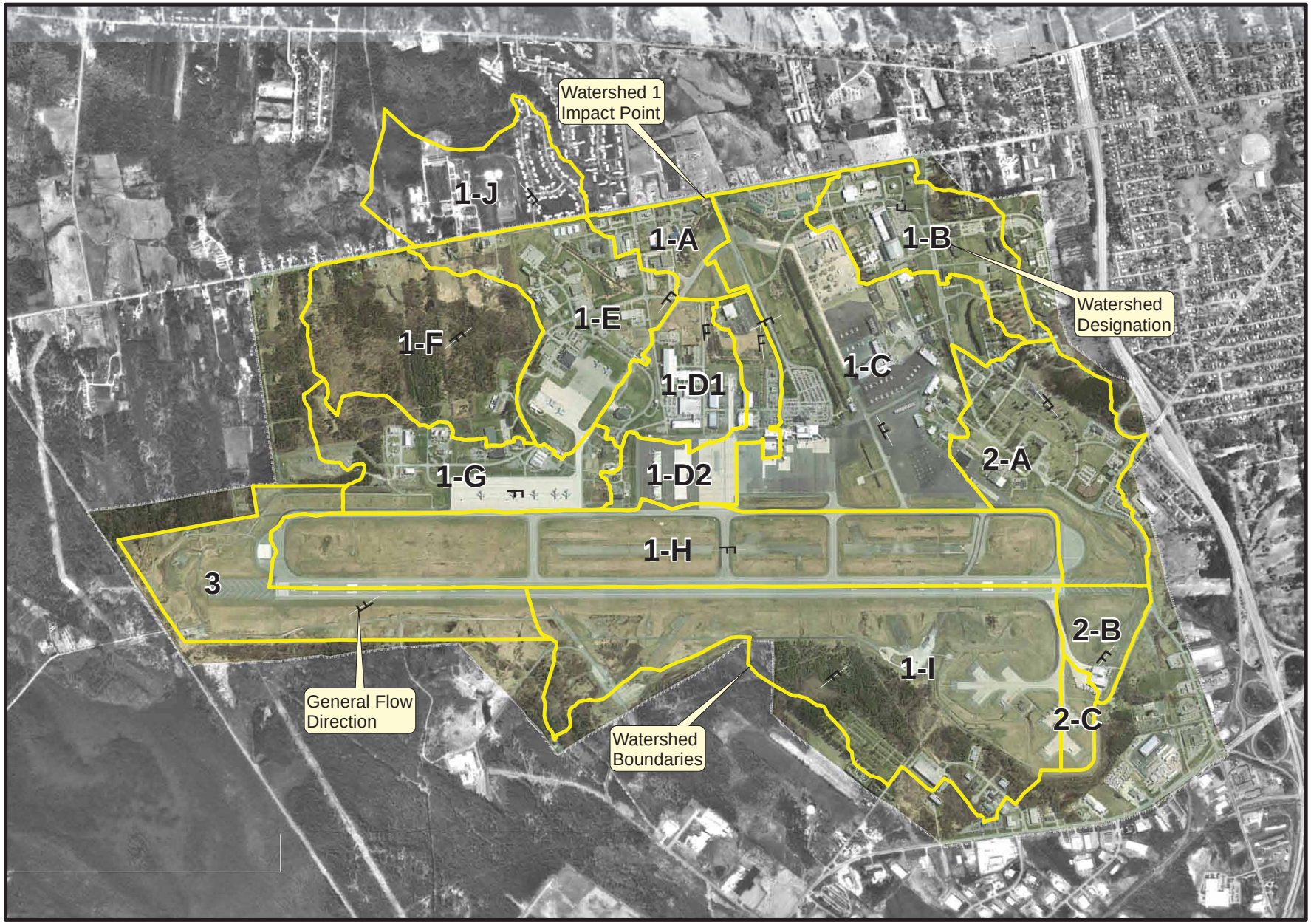
4.6 - Watershed Analysis

4.6.1 - Watershed 1 Analysis
The impact point where all stormwater from watershed 1 leaves the site is located at the 3-cell box culvert below Union Street. Current conditions show that the total stormwater runoff from this watershed is as follows:

Rain Event	Peak Flow
2 Year	568 cfs
10 Year	1123 cfs
25 Year	1655 cfs

Subarea 1-A
Consisting of 41.2 ± acres, subarea 1-A is located near the intersection of Union Street and Godfrey Boulevard. The subarea boundary is similar to that of the 1991 report, with a distinct difference along

Figure 4.1.1 - Existing Watershed Areas Plan



Godfrey Boulevard due to the discovery of a catch basin. This area contains commercial establishments, and paved surfaces that were once part of the Dow Air Force Base flight line.

Rain Event	Peak Flow
2 Year	59 cfs
10 Year	113 cfs
25 Year	140 cfs

Subarea 1-B

This subarea contains 93.6 ± acres and is located in the southeast part of the site. The boundary of this subarea is comparable to the 1991 report with the exception of the retention pond. The current analysis of this watershed removed the retention pond from this subarea compared to the 1991 report. The retention pond is found in subarea 1-C.

Development in this area contains commercial enterprises, abandoned buildings, a portion of Bangor community college (BCC), and large paved areas that were once part of the Dow Air Force Base flight line.

Rain Event	Peak Flow
2 Year	48 cfs
10 Year	95 cfs
25 Year	120 cfs

Subarea 1-C

The 296 ± acres of this subarea is, in general, adjacent to Godfrey Boulevard on the southern side and extends to Taxiway A. In comparison to the 1991 report this subarea boundary has two major differences at the eastern and southwestern boundaries. The northern part of the subarea now includes the retention pond while the southeastern portion now includes an area of the Army National Guard.

This subarea consists of a substantial impervious area from the Army National Guard complex, the Hilton hotel, airport parking, the domestic airport terminal, and the terminal aircraft aprons.

Rain Event	Peak Flow
2 Year	294 cfs
10 Year	529 cfs
25 Year	648 cfs

Subarea 1-D1

Subarea 1-D, as described in the 1991 report, has been broken into two smaller subareas, 1-D1 and 1-D2, due to physical changes within the subarea. Those physical changes consist of stormwater from the drainage ditch entering the storm drain system through an exposed pipe in subarea 1-D2 near Utah Avenue. As well as the apparent buildup of sediment in a portion of the center drainage canal which has created a drainage divide, thus creating subarea 1-D1 and 1-D2.

Encompassing 70.1 ± acres, subarea 1-D1 is centrally located within the site. The buildings, airport hangars, aircraft aprons, and part of the Air National Guard Base all contribute to the impervious area of this subarea.

Rain Event	Peak Flow
2 Year	42 cfs
10 Year	78 cfs
25 Year	97 cfs

Subarea 1-D2

This subarea consists of 67.6 ± acres and is located on the southerly side of subarea 1-D1. As previously described, the runoff for this subarea has been redirected through an exposed pipe in the drainage ditch adjacent to Utah Avenue.

The impervious area of this subarea is comprised largely of the apron along Taxiway A, the terminal building, L.L. Bean call center, rental car facilities, and parking areas.

Rain Event	Peak Flow
2 Year	115 cfs
10 Year	195 cfs
25 Year	235 cfs

Subarea 1-E

Containing 134.9 ± acres this subarea is adjacent to Union Street and extends westerly toward Taxiway A. The boundary described in this subarea is generally the same as the 1991 report, except for the northwesterly portion of the area. This small piece of land discharges into the storm drain system adding to subarea 1-F.

The southern portion of this area is composed largely of Maine Air National Guard property, while the northern portion is only lightly developed with privately owned residences.

Rain Event	Peak Flow
2 Year	90 cfs
10 Year	176 cfs
25 Year	220 cfs

Subarea 1-F

This subarea is found at the northern end of the site and consists of 160.0 ± acres. The large majority of this land is undeveloped with few privately owned residences along Union Street and some other structures at the southernmost part of the subarea. Very little has changed with the majority of this subarea since the 1991 report, except for the small boundary change at the southerly end also mentioned in subarea 1-E.

Rain Event	Peak Flow
2 Year	32 cfs
10 Year	84 cfs
25 Year	113 cfs

Subarea 1-G
The 117.5 ± acres of this subarea is slightly larger than the 1991 report due to some development and other physical changes within the area. Additions to the subarea include a retention pond at the southernmost end and the construction of the Maine Air National Guard Whiskey Ramp and support buildings.

Rain Event	Peak Flow
2 Year	40 cfs
10 Year	78 cfs
25 Year	98 cfs

Subarea 1-H
This subarea consists of 289.0 ± acres and has a similar boundary to the 1991 report. Impervious areas include the western side of Taxiway A, the eastern side of Runway 15-33 with connecting taxiways, and the abandoned portions of Dow Air Force Base that remain between Taxiway A and Runway 15-33.

Rain Event	Peak Flow
2 Year	179 cfs
10 Year	356 cfs
25 Year	449 cfs

Subarea 1-I
Located in the southernmost portion of the site, this subarea consists of 349.7 ± acres and encompasses the northern portion of Taxiway N and the parking aprons utilized by Telford Aviation, a portion of the western side of Runway 15-33, and Banair Industrial Park.

The boundary of this subarea is generally the same as reported in the 1991 report. The time of concentration flow path has significantly changed, but when compared with the 1991 flow path the time of concentrations are very similar.

Rain Event	Peak Flow
2 Year	103 cfs
10 Year	227 cfs
25 Year	293 cfs

Subarea 1-J
The 97.3 ± acres of this subarea was not previously considered as part of the watershed in the 1991 report, but analyzing the watershed reveals that the runoff from this land must travel through the Bangor International Airport property before reaching Birch Stream.

Being located on the northern side of Union Street, this land becomes the northernmost subarea of the watershed. The impervious areas within this subarea consist of some school buildings, parking lots, and a residential development.

Rain Event	Peak Flow
2 Year	21 cfs
10 Year	47 cfs
25 Year	61 cfs

Airport Detention Pond in Subarea 1-C
The airport detention pond was designed to retain the 2, 10, and 25 year storm events from the runoff of watershed subareas 1-B, 1-C, 1-H, and 1-I, but current conditions include the additional subareas 1-D2 and 1-G. See Figure 4.1.2 – "Airport Pond Design Watersheds". As a result of subareas 1-D2 and 1-G discharging into the pond, the 25 year rain indicates that stormwater is discharging over the spillway. The original design for this pond doesn't allow the 25 year rain event to discharge over the spillway, but rather it was intended to control the release of the water and discharge it through the outlet structure. Section 5.3 discusses alternatives with respect to routing watersheds 1D2 and 1G away from the airport pond.

Detention Pond HydroCAD® Analysis – Flow through the Airport Pond's Primary Spillway Comparison

Rain Event	2007 Conditions	1992 Design	Difference
2 Year	413 cfs	311 cfs	102 cfs
10 Year	802 cfs	761 cfs	41 cfs
25 Year	1118 cfs*	960 cfs	158 cfs

* 65 cfs over the secondary spillway

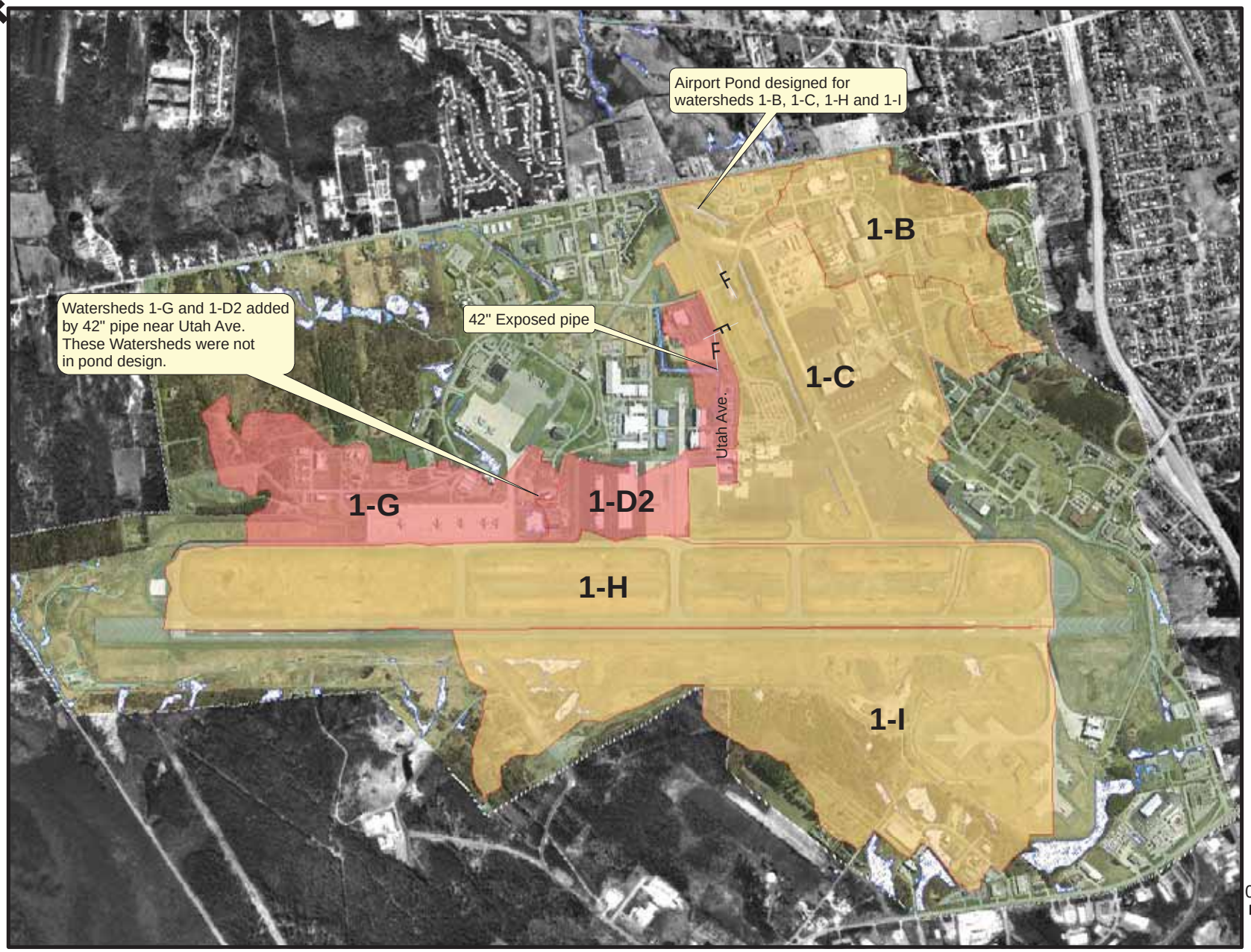
The increased difference on the 2-year event is attributed to the rainfall depth of 2.7-inches which is greater than the 1991 reports 2-year event. Also the time of concentration for the 2-year event was found to be shorter than the 1991 report for certain watersheds.

4.6.2 - Watershed 2 Analysis
The impact point on this watershed is just south of Runway 15-33 where runoff discharges into an unnamed stream south of Odlin Road. Current conditions show that the total stormwater runoff from this watershed is as follows:

Rain Event	Peak Flow
2 Year	65 cfs
10 Year	131 cfs
25 Year	167 cfs

Subarea 2-A
This subarea contains 146.9 ± acres and has a similar location to watershed 2 as defined in the 1991 report. In comparison to the 1991 report, the boundary for this subarea does not include the Army National Guard area. This change was also reflected on watershed subarea 1-C.

Figure 4.1.2 - Airport Pond Design Watersheds



Legend

- Stream
- Marsh
- Water

0 600 1,200 2,400 Feet

Presently, the development in this area consists of a portion of Bangor Community College, private enterprises, and aviation related uses.

Rain Event	Peak Flow
2 Year	54 cfs
10 Year	110 cfs
25 Year	140 cfs

Subarea 2-B

The 35.1 ± acres of this subarea was previously not considered a part of watershed 2.
Located on the western side of subarea 2-A, this portion of land is west of runway 15-33 and south of the 600 block. Development within this area consists of a portion of the runway, the taxiway leading to the 600 block and Telford Aviation.

Rain Event	Peak Flow
2 Year	23 cfs
10 Year	49 cfs
25 Year	62 cfs

Subarea 2-C

Located at the southwestern part of the site, this subarea consists of 16.2 ± acres and encompasses the southern part of the 600 Block up to the Telford Aviation building. The runoff from this land accumulates in a low area south of this subarea and discharges to an unnamed stream south of Odlin Road.

Rain Event	Peak Flow
2 Year	12 cfs
10 Year	23 cfs
25 Year	28 cfs

4.6.3 - Watershed 3 Analysis

This watershed is located at the northern end of Runway 15-33 and was not included in the 1991 report. Being part of a much larger watershed that discharges to Hermon Bog, the boundaries have been drawn at the airport fence line for the purpose of this report. The impact point was then determined to be a stream flowing through a low lying area to the north of Runway 15-33.

This portion of land that contributes to the larger watershed consists of 148.6 ± acres. Development on this land consists of some roads, a portion of the taxiway and runway.

Rain Event	Peak Flow
2 Year	65 cfs
10 Year	146 cfs
25 Year	190 cfs

TABLE 4.6.1 – Watershed Hydrologic Data

Watershed	Subarea	Area (Ac)	RCN	Tc (min)
1	A	41.2	85	8.1
1	B	93.6	83	60.9
1	C	296.5	88	31.1
1	D1	70.1	86	69.4
1	D2	67.6	91	12.2
1	E	134.9	84	47.1
1	F	160.0	73	97.2
1	G	117.5	84	134.4
1	H	289.0	83	48.7
1	I	349.7	79	104.7
1	J	97.3	78	150.2
2	A	146.9	82	101.8
2	B	35.1	80	30.7
2	C	16.2	86	47.9
3	-	148.6	78	51.8

RCN = Runoff Curve Number (Reference HydroCAD®)
Tc = Time of Concentration (Reference HydroCAD®)

4.7 - Existing Watershed Water Quality Protection Systems

4.7.1 - Aircraft De-Icing Fluid Collection and Disposal Systems

Aircraft operations require the use of the propylene glycol based deicing fluid when weather conditions warrant. The airport and the MEANG constructed deicing fluid collection and disposal systems between 2003 and 2005. Each system collects deicing fluid contaminated stormwater run-off in under ground concrete storage tanks. Stored stormwater is then discharged at a controlled rate to the City of Bangor Waste Water Treatment Plant. Figure 4.7.1 “Existing Deicing Fluid Collection Plan” depicts the existing deicing application areas, storage tank location and receiving sewer.

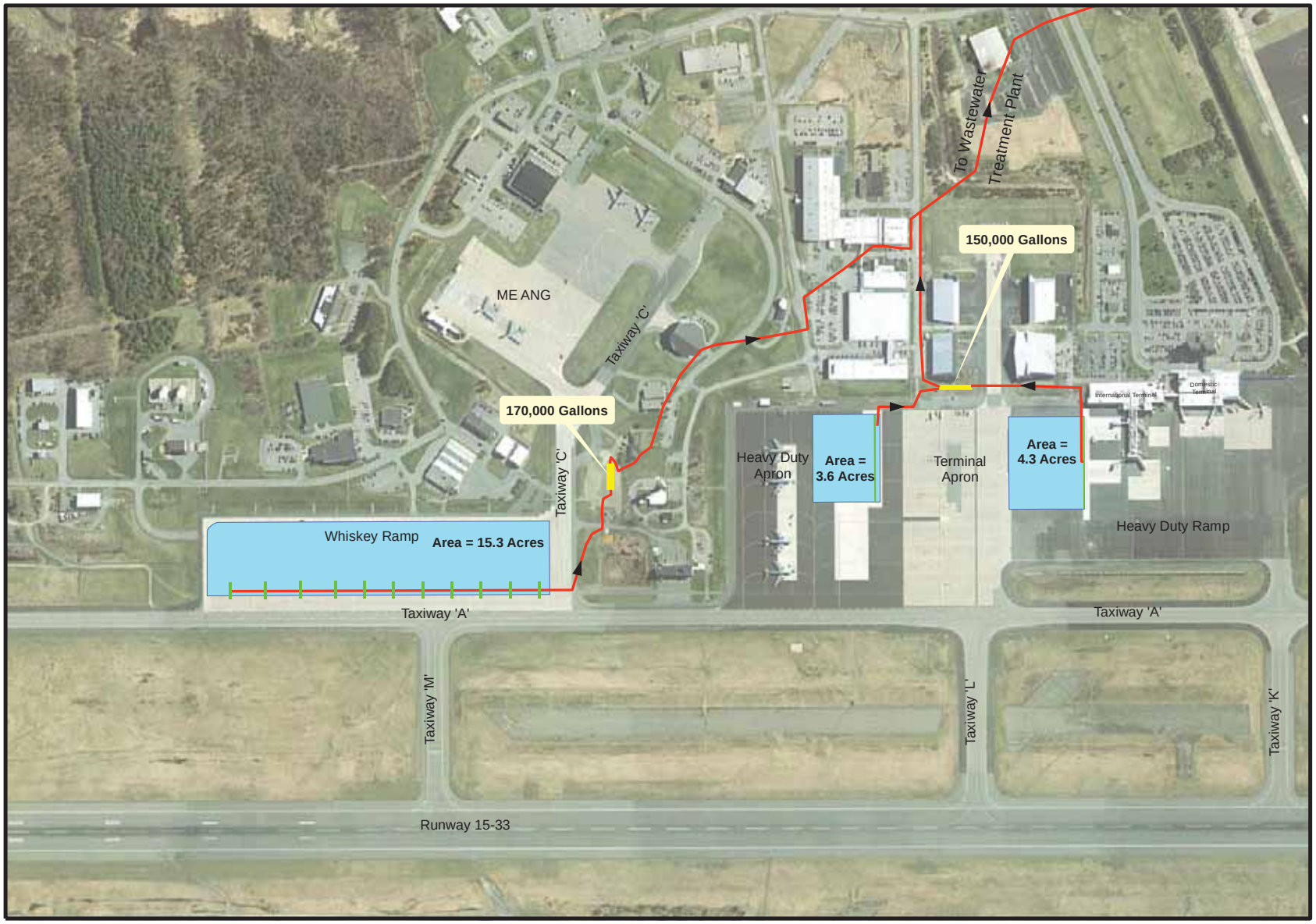
4.7.2 - Existing Water Quality Treatment Structures

Currently the airport has eight stormwater quality treatment units. The water quality treatment units target pollutant removal. Targeted pollutants may include sediment, suspended solids, free oil and grease, fuel and debris.

Five units handle stormwater runoff from the airport’s terminal aprons. One unit treats the MEANG Whiskey Ramp. A unit each is installed at the airport’s tank farm and at the airport’s fuel station. Figure 4.7.2 “Existing Stormwater Quality Structures” attached provides the location of these units.

The stormwater treatment units above are specific to the protection of stormwater run-off. In-line units prior to discharge to the sewer system from floor drains and the airport’s deicing fluid storage tanks are not included as they relate to the sewer system and not stormwater.

Figure 4.7.1 - Existing Deicing Fluid Collection Plan



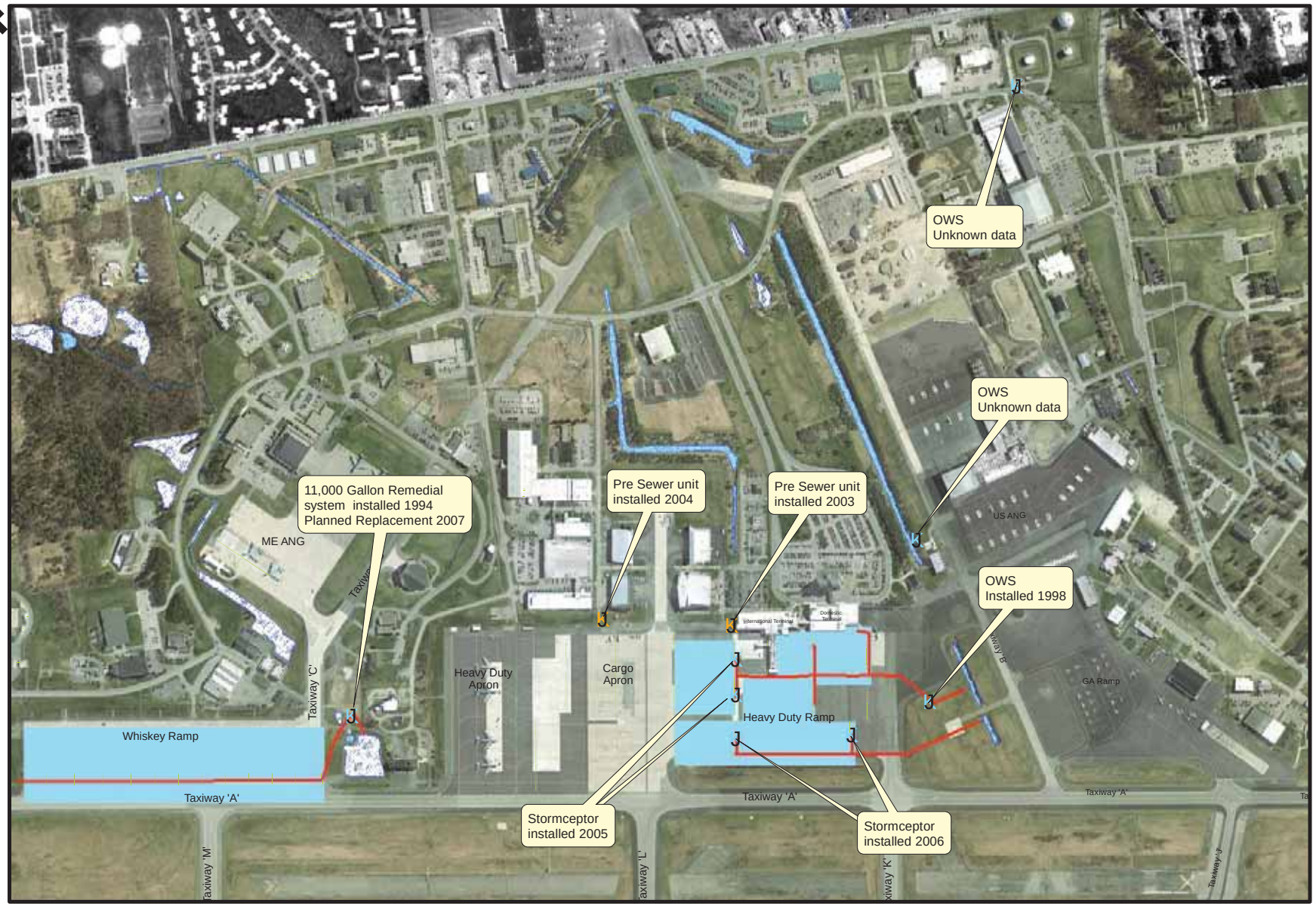
Legend:

- Sewer
- Storage Tanks
- Trench Drain
- Deicing Area

Note:
When not deicing, storm water flows to storm drainage system

0 250 500 1,000 Feet

Figure 4.7.2 - Existing Stormwater Quality Structures



Legend:

OWS

- Sewer Unit
- Stormwater Unit
- Trench Drain
- Stream
- Water
- Marsh
- Pipes
- Treatment Area

0 250 500 1,000 Feet

Section 5 - Watershed Improvement Opportunities

5.1 - Birch Stream Watershed

The Maine DEP prepared the Birch Stream Total Maximum Daily Load (TMDL) Draft Report in August of 2005. The report describes the degradation to the water quality in the Birch Stream. The airport's watershed number 1 contributes stormwater to the Birch Stream along with other development along Union Street.

The TMDL report recommendation is to implement BMP's strategically in a phased program, monitor water quality, compare results to water quality standards and continue BMP implementation. The reports long term strategy is to disconnect or remove impervious surfaces within the watershed.

In addition the City of Bangor and the Maine DEP has developed the Birch Stream Watershed Compensation Fee Utilization Plan (CFUP). The objective of the CFUP is to design natural treatment systems to effectively treat stormwater within the Birch Stream watershed.

Opportunities for improving the stormwater quality from the Airport's watershed 1 are discussed in the following sections.

5.2 - Airport Detention Pond

5.2.1 Peak Flow Control

The MEDEP BMP Technical Manual Chapter 3 provides the guidance for "Peak flow Control/Detention Basins". The objective of this BMP is to have the pond's principal spillway control the flow from the 24-hour storms of the 2, 10, and 25 year frequencies such that post development flows do not exceed pre-development flows. The 1992 airport detention design report considered the year 1970 as the pre-development condition. Anticipated future "build-out" along Godfrey boulevard and Union Street were considered as the post-development condition in the 1991 report.

The stormwater model indicates that the pond is under-sized for the current flow conditions. The 1992 design report considered drainage from watersheds 1B, 1C, 1H and 1I. An exposed pipe at the Utah Street drainage ditch has intercepted flows from watersheds 1D2 and 1G and conveyed the drainage from these areas to the Airport pond. Removal of the watersheds 1D2 and 1G corrects the problem as can be seen in the table that follows. The table considers the impact point at the Union Street box culverts.

Peak Flows at Watershed 1 Impact Point -Union Street Box Culvert (CFS) (See Figure 4.4.1 for Location)

Rain Event	2007 Existing Conditions [1]	2007 Proposed Correction [2]	1992 Post Development[3]	1970 Pre-Development[3]
2 Year	568	542	510	513
10 Year	1123	1109	1077	1189
25 Year	1596	1400	1363	1493

Notes:
[1] Existing conditions considers watersheds 1B, 1C, 1D2, 1G, 1H and 1I.
[2] Proposed conditions consider watersheds 1B, 1C, 1H and 1I similar to the 1992 design.
[3] Reference 1992 airport pond design report.

Removal of watershed's 1D2 and 1G bring the flow to within 3% of the post-development design values and less than the 1970 pre-development target flows. Option's for disconnecting 1D2 and 1G from the airport pond are discussed in Section 5.3.

5.2.1 - Wet Pond BMP Function

The MEDEP BMP Technical Design Manual Chapter 4 provides guidance on the design of "Wet Ponds". To meet the "wet pond" BMP criteria the permanent pool volume must hold a volume equal to 1.5-inches of the subcatchment's impervious area plus 0.6-inches of the subcatchment's non-impervious developed area.

Considering watersheds 1B, 1C, 1D2, 1G, 1H and 1I, the permanent pool volume calculates to 4.2 million cubic feet of permanent pool water volume. The current pond and southern drainage canal, considering 4-feet average depth of water, provides approximately 0.4 million cubic feet of water.

The existing pond provides only 11% of the MEDEP permanent pool criteria. Therefore the existing airport pond is not adequately sized to remove sediments and pollutants associated with stormwater.

When only watersheds 1B, 1C, 1H and 1I are directed to the airport pond, the permanent pool water volume required is 3.5 million cubic feet. The current pond and southern drainage canal provides 0.4 million cubic feet of water, which is only 12% of MEDEP permanent pool criteria.

To expand the airport pond to meet the BMP criteria would be prohibitive based on land availability. An alternative course of action may be to remove the wet pond and reconstruct the current pond area as a surface detention basin. The basin would be generally dry with a principal spillway to manage the 2, 10 and 25 year storm. An emergency spillway would handle the 25-year and greater storms. The basin floor could consist of a porous gravel bed with under drain pipes to allow stormwater to be treated prior to off-site discharge. An organic top layer could be planted with suitable vegetation such as meadow plantings and grasses specifically suited for stormwater basins. This undertaking should be coordinated with the CFUP objective of developing natural treatment systems (i.e. engineered wetlands) on the airport. A secondary benefit of removing the wet pond condition would be to remove the wildlife bird attraction of the current wet pond and southern drainage canal.

5.3 - Modify the Center Drainage Canal

The goal of modifying the center drainage canal would be to direct stormwater away from the airport pond. The 1991 drainage report depicts flow from the aircraft parking aprons flowing through the 'z' shaped center drainage canal to the northeast with no connection to the Airport Pond. A second goal would be to protect Godfrey Boulevard and Utah Avenue from flooding during the 100-year storm event.

As previously mentioned in Section 3.3, there is an exposed 42-inch RCP near the end of the Utah Avenue. The existing condition has diverted flow from the watersheds 1G (MEANG Whiskey Ramp) and 1D2 (Heavy Duty Ramp) to the Airport pond. The additional flows have degraded the airport pond's flood control performance. Diversion of watersheds 1G and 1D2 would restore the airport pond's flood control performance to the pond's design.

The existing canal grades vary and are inconsistent with positive drainage. The existing center drainage canal elevations are indicated on Figure 5.3.1 entitled "Watershed Improvement Opportunity – Existing

Conditions Center Drainage Canal". Hydrologic modeling indicates that under the existing flow conditions Godfrey Boulevard and Utah Avenue could occur during the 100-year storm (1% chance in a year) event.

Four options were considered to achieve the above goals. These options are depicted in Figures 5.3.2 and 5.3.3 "Watershed Improvement Opportunity – Center Drainage Canal Options". Each option maintains Watershed 1 flows less than the 1970 pre-development targeted peak flows.

5.3.1 - Option 1
Option 1 considers closing the exposed 42-inch pipe and maintaining the existing canal grading. During a 100-year storm event, the hydrologic modeling results in a headwater elevation of 149-feet MSL in the center canal. This elevation would flood Godfrey Boulevard and Utah Avenue which are at elevation 148-feet MSL. Therefore a form of flood protection (i.e. a flood berm) with elevation of 151-feet MSL to provide 2-feet of free board would be required along the south side of the center drainage canal. Elevation 152-feet is approximately 5-feet higher than the existing ground. The cost estimate for Option 1 is $120,000.

Option 1 would result in the stormwater ponding within the center drainage canal. This would be advantageous to the development of wetlands, but the attraction of birds may be a disadvantage to the aviation activities. Therefore alternative options were considered.

5.3.2 - Option 2
Option 2 considers closing the exposed 42-inch pipe and re-grades the canal to 0% grade at elevation 145.5. The re-grading would start from the twin 42-inch RCP (elevation 143.7) below the recently constructed airport access drive (STA 5+00) and continue to approximately 1,650 linear feet to the Maine Avenue culvert (STA 21+50). This modification resulted in a 100-year flood elevation of 148-feet MSL in the center drainage canal. The flood berm could be reduced under this option by 1-foot to elevation 150-feet. The cost estimate for Option 2 is $230,000.

With this option approximately 2-feet of stormwater would remain in the canal under this condition. Because of the attraction of birds to the anticipated ponded water, a third option was considered.

5.3.3 - Option 3
Option 3 considers closing the exposed 42-inch pipe and re-grades the drainage canal to establish a positive slope of 0.1%. The re-grading would start from the twin 42-inch RCP (elevation 143.7) below the recently constructed airport access drive (STA 5+00) and continue to approximately 2,500 linear feet to the drainage canal south of Maine Department of Human Services. Culverts below Maine Avenue (STA 21+50) and the old Dow AFB pavement (STA 23+50) would be lowered 4 and 2-feet, respectively. This resulted in a 100-year flood elevation of 146-feet MSL in the center drainage canal. The flood berm could be eliminated as the flood elevation is calculated approximately 2-feet lower than Godfrey Boulevard and Utah Avenue. The cost estimate for Option 3 is $1.1 Million.

5.3.4 - Option 4
Option 4 bypasses flow from the Airport Pond by installing new culvert pipes to redirect flow from the twin 60-inch RCP north of the pond to below the Airport Pond's spillway south of Godfrey Boulevard. This allows the existing flow conditions of the center drainage canal to remain. This resulted in a 100-year flood elevation of 148-feet MSL in the center drainage canal which is equal the Godfrey Boulevard and Utah Avenue elevations. A flood berm with elevation 150-feet MSL would be required for this option. The cost estimate for Option 4 is $375,000.

5.4 - Best Management Practices (BMP) and Low Impact Development (LID) Techniques
The stormwater effects can be lessened and water quality improved by implementing BMP and LID techniques. The Airport watershed was reviewed for possible implementation of the BMP and LID techniques with the purposes of exploring alternatives to improving the stormwater quality contributing to Birch Stream. These BMP and LID techniques are referenced from the MDEP Stormwater Management Manual.

5.4.1 - At-Source Water Quality Treatment Units
Prevention of stormwater contamination from reaching the airport drainage system will improve the water quality leaving the airport. Figure 5.4.1 "Watershed Improvement Opportunity – Additional Stormwater Quality Structures" notes possible locations of treatment units.

Ten locations were selected based on untreated pavement areas where activities may warrant protection of the drainage system. Mapping of the airport drainage network indicates that there are locations where upstream activities are non-airport related or controlled (examples are Union Street and DPW). Stormwater from these uncontrolled locations ultimately combines with the airport drainage. The addition of these treatment units would help to capture pollutants (i.e. oil, grease, sediment) prior to entering the airport drainage system.

Construction costs to install water quality treatment units vary depending on the area to be treated. Units for smaller areas, up to 4 acres, should be budgeted at $30,000 installed. Units for larger areas, up to 30 acres, should be budgeted at $200,000 installed.

5.4.2 - Reduce and Disconnect Impervious Areas
The MDEP TMDL report states that the negative effects of water quality can be reduced by disconnecting impervious surfaces from the stream so that runoff does not reach a water body untreated or converting impervious surfaces to pervious surfaces.

The TMDL report identified the Birch Stream watershed as having an impervious cover of 33%. Through the use of GIS, the pavement and roof top impervious areas of Airport Watershed 1, which contributes to the Birch Stream watershed, were added to calculate an impervious area of 37%.

An opportunity to convert unused, abandoned or not required pavements from an impervious to pervious area was considered for Watershed 1. Figure 5.4.2 "Watershed Improvement Opportunities – Pavement Removal Plan" indicates the potential areas of pavement removal. A modest 3.5% of impervious reduction could be achieved by converting the pavements indicated to pervious (i.e. grass or porous gravel) areas.

Diversion of run-off from parking lot pavements to a suitable treatment BMP was considered for Watershed 1. Smaller intensity storms are treated through infiltration or evaporation prior to discharge to the storm drainage. L.L. Bean's effectively implemented similar measures for their parking lot pavements. Figure 5.4.3 "Watershed Improvement Opportunities – Parking Lot Drainage to BMP" notes an approximate 0.6% reduction in impervious area for Watershed 1. A case by case consideration of each parking lot was not

considered, therefore the above value assumes a 1 in 5 (20%) success of diverting existing roof drainage to a dry well.

Management of roof top run-off to on-site BMP features is discussed in the MDEP Stormwater Management Manual. Smaller intensity storms are effectively treated on the site. BMP's such as drywells, vegetated buffers and infiltration/evaporation swales would be considered. Figure 5.4.4 "Watershed Improvement Opportunities – Roof Drainage" notes an approximate 1% reduction in impervious area for Watershed 1. A case by case consideration of each roof top was not considered. Therefore the above value assumes a 1 in 5 (20%) success of diverting existing roof drainage to a BMP.

In addition to the modest values calculated from the above alternatives, larger intensity storms would continue to discharge from the airport. To effectively disconnect the imperviousness of Watershed 1, opportunities that provide a combination of stormwater treatment and hydrologic compatibility to pre-airport stormwater flow conditions should be considered.

5.5 - Engineered Wetlands

The goal of engineered wetlands would be to provide stormwater quality treatment as well as attenuate stormwater flows to the pre-airport development hydrologic conditions. Any wetland would have to consider the attraction of wildlife (i.e. birds) in proximity to the airport.

Sub-surface flow engineered wetlands consist of a porous gravel bed, overlain by mulch and appropriate wetland grasses could preclude the attraction of bird types that are hazardous to aviation. The minimization of the deeper standing water within the wetland would discourage the larger, more hazardous to aviation bird types such as Canada Geese. Insulation and aeration could be added to specific portions of the wetlands to treat glycol contaminated stormwater runoff from the aircraft deicing activities.

Conceptually, the engineered wetlands consist of treatment cells, tiered in elevation. Vegetation within each cell would add in the uptake of pollutants, slow stormwater and provide cooling. Stormwater flow control outlet structures would be designed to control the flow through the engineered wetland.

Opportunity exists on the north and south side of Godfrey Boulevard to construct these wetlands. With respect to attraction of wildlife, these locations are also furthest from aviation activities and outside the runway approach and departure paths. Figure 5.5.1 "Watershed Improvement Opportunities – Engineered Wetlands" indicates these locations in concept. At each of these locations, topography provides for the relief required to provide for gravity flow through tiered treatment cells. Additional land to enlarge the cells outside the existing drainage footprint is also available. The southern wetland would remove the existing airport pond which is currently undersized as a BMP "wet pond" (See Section 4.6.1 –"Airport Detention Pond in Subarea 1C.")

Planning calculations based the MDEP "BMPs Technical Design Manual" Section 7.1.3 Underdrained Soil Filters indicates that the areas in Figure 5.5.1 are less than the required wetland treatment area. Wetland Treatment areas are based on impervious and nonimpervious areas as well as other factors indicate upwards of 100 acres of wetlands would be required for watershed number 1 by the above method. Available area either side of Godfrey Boulevard between Maine Avenue and Union Street is approximately 20 acres.

The indicated wetland areas would remove potential development parcels. Additionally, utility relocations, historical preservation, soil conditions, seasonal ground water elevation and endangered species would have to be investigated for the indicated areas.

It is noted that the application of the BMP criteria from section 7.1.3 may not be suitable for the size and the imperviousness of the watershed being considered. The wetland areas indicated (in Figure 5.5.1) would provide partial treatment and additional treatment areas would have to be identified upstream of the indicated locations.

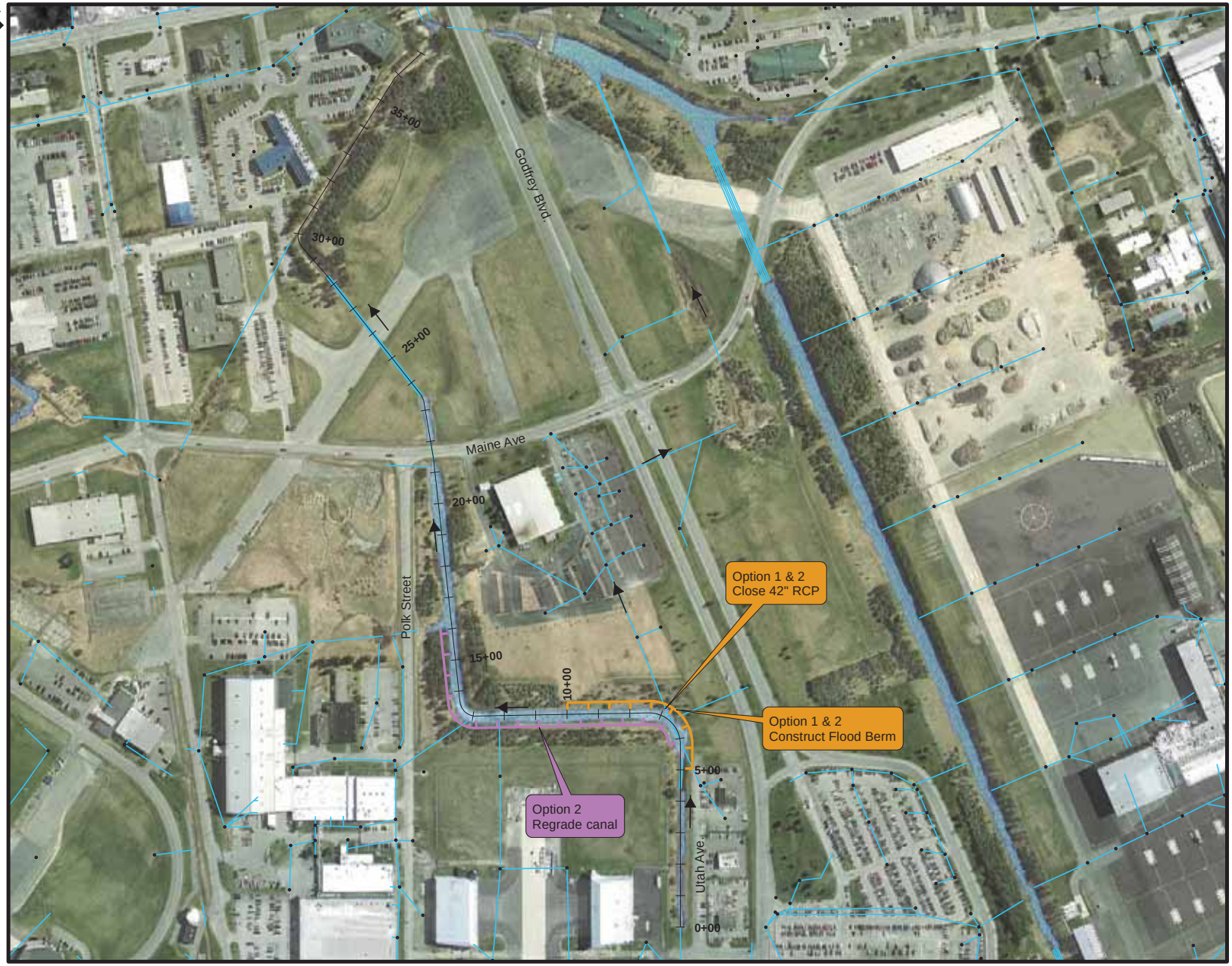
Figure 5.3.1 - Watershed Improvement Opportunity - Existing Conditions Center Drainage Canal

Legend

- CB
- SD Pipes
- Flow

0 250 500 1,000 Feet

Figure 5.3.2 - Watershed Improvement Opportunity - Center Drainage Canal Flow Options 1 & 2



Legend

- CB
- SD Pipes
- Water

0 250 500 Feet

Figure 5.3.3 - Watershed Improvement Opportunity - Center Drainage Canal Flow Options 3 & 4

Legend

- CB
- SD Pipes
- Water

0 250 500 Feet

Figure 5.4.1 - Watershed Improvement Opportunity - Additional Stormwater Quality Structures

Legend:

- Trench Drain
- Pipes
- Stream
- River
- Marsh

Oil-Water Separators

- Proposed
- Ex. Sewer
- Ex. StormWater

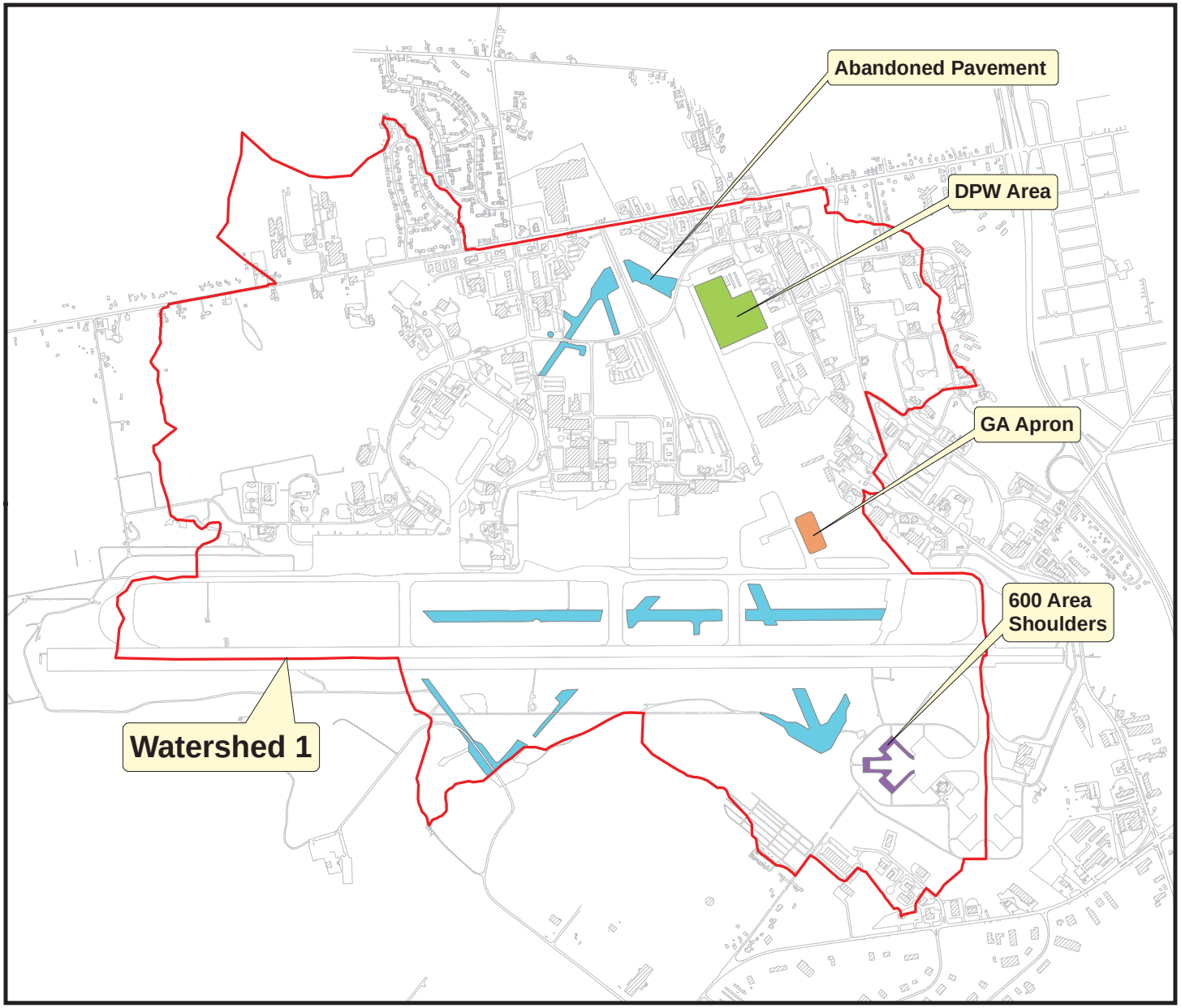
Treatment Area

- Existing
- Proposed

0 250 500 1,000 Feet

Figure 5.4.2 - Watershed Improvement Opportunity - Pavement Removal Opportunities Plan

5



Watershed #1
Total Area = 1717.46 Acres
Impervious Area = 635.41 Acres
Impervious Area Percentage = 36.99%

Remove Abandoned Pavement
Area = 43.82 Acres
Impervious Area Percentage = 2.55%

Remove DPW Pavement
Area = 11.57 Acres
Impervious Area Percentage = 0.67%

Remove GA Apron Pavement
Area = 2.99 Acres
Impervious Area Percentage = 0.17%

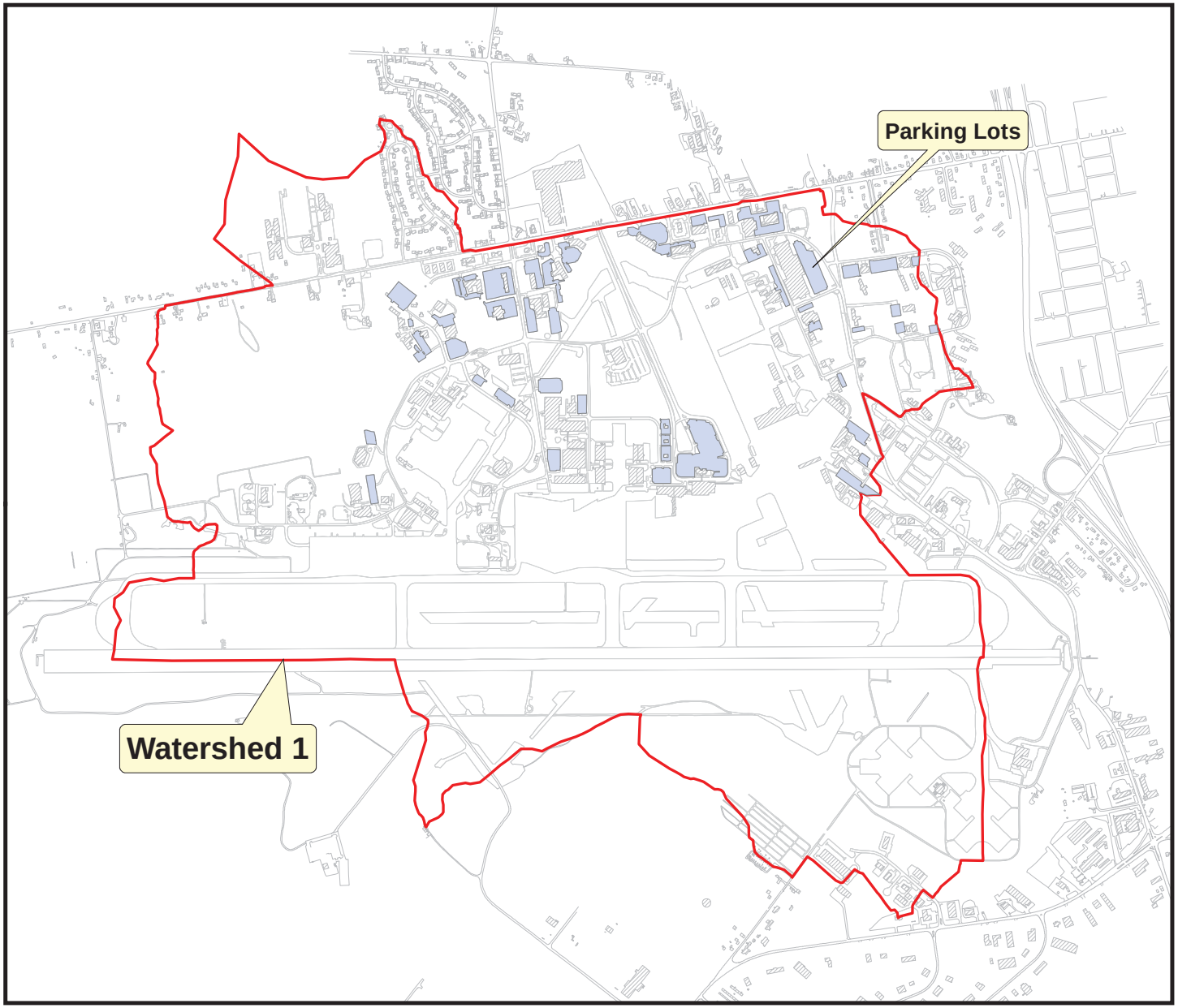
Remove 600 Area Pavement
Area = 2.73 Acres
Impervious Area Percentage = 0.16%

==========

Total Revised Imp. Area = 574.30 Acres
Total Revised Imp. Area Percentage = 33.44%

0 600 1,200 2,400 Feet

Figure 5.4.3 - Watershed Improvement Opportunity - Parking Lot Drainage to Infiltration BMP

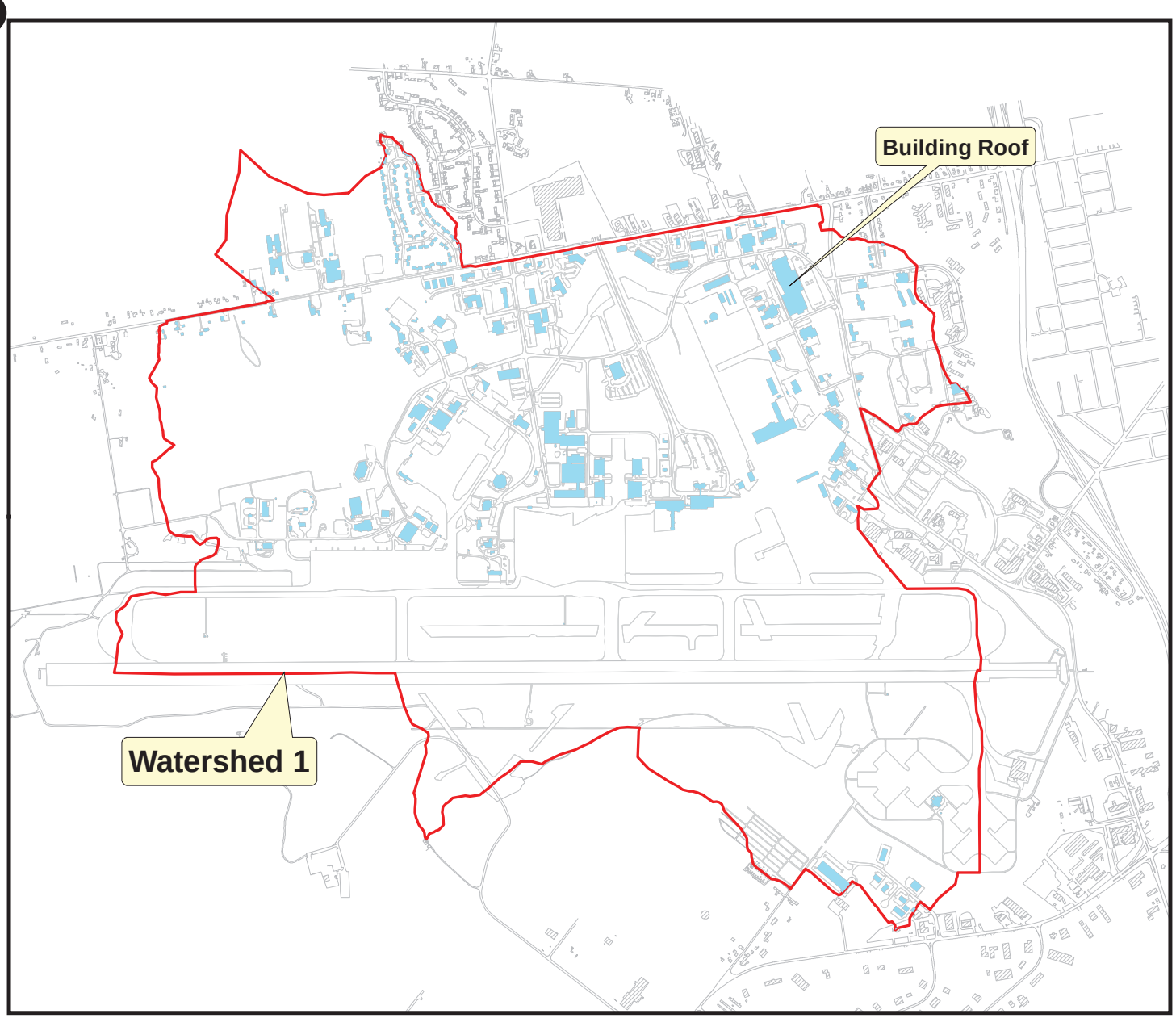


Watershed #1
Total Area = 1717.46 Acres
Impervious Area = 635.41 Acres
Impervious Area Percentage = 36.99%

Total Parking Lots Area = 50.77 Acres
20 % Parking Lots Area = 10.15 Acres
20 % Impervious Area Percentage = 0.59%
==========
Total Revised Imp. Area = 625.26 Acres
Total Revised Imp. Area Percentage = 36.40%

0 600 1,200 2,400
Feet

Figure 5.4.4 - Watershed Improvement Opportunity - Roof Drain to Infiltration BMP



Watershed #1
Total Area = 1717.46 Acres
Impervious Area = 635.41 Acres
Impervious Area Percentage = 36.99%

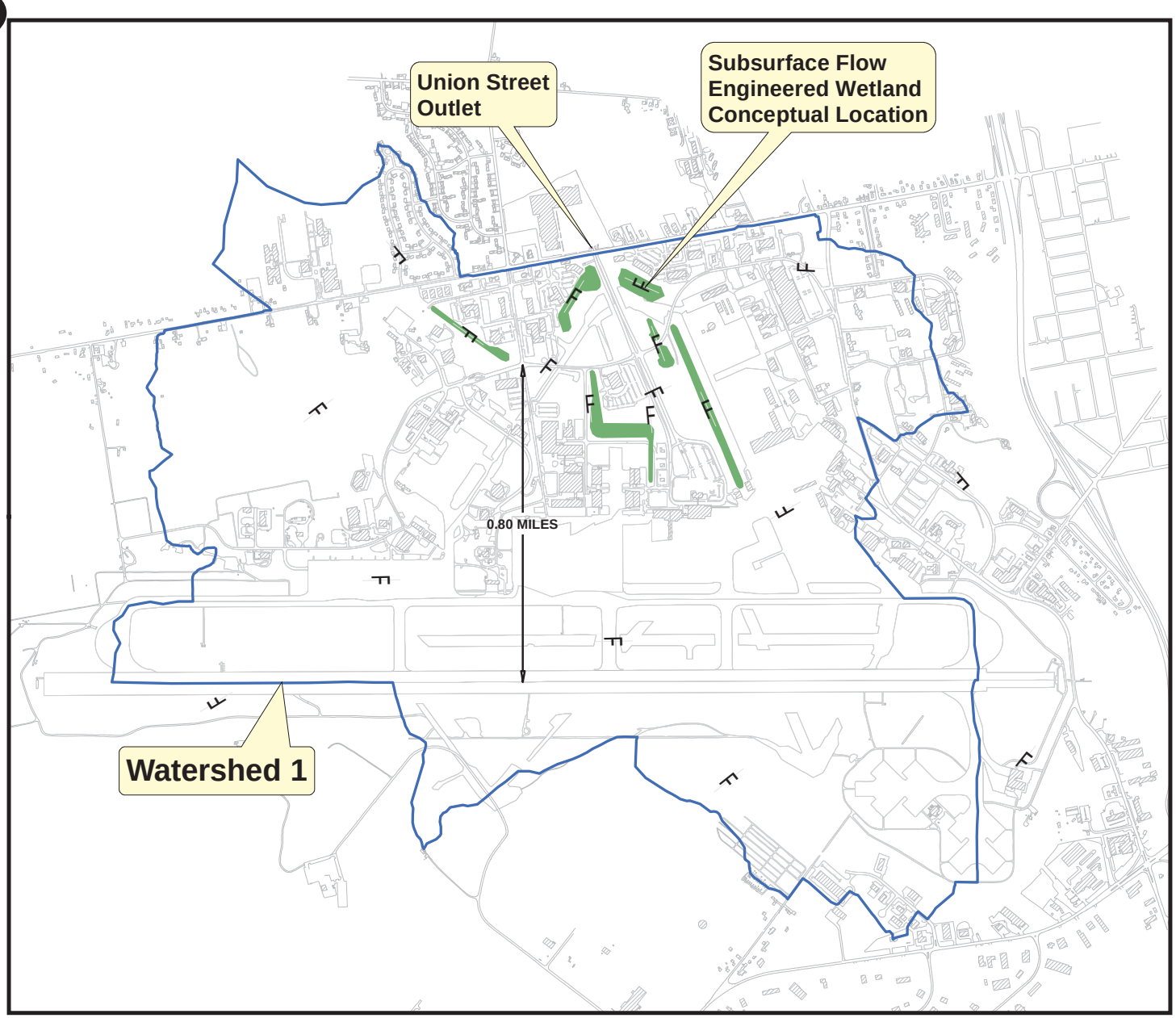
Total Roof Area = 68.81 Acres
20% Roof Area = 13.76 Acres
20 % Impervious Area Percentage = 0.80%

==========

Total Revised Imp. Area = 621.65 Acres
Total Revised Imp. Area Percentage = 36.19%

0 600 1,200 2,400 Feet

Figure 5.5.1 - Watershed Improvement Opportunity - Engineered Wetlands



Legend

Watershed Flow

Engineered Wetlands

NOTE:
Indicated locations are in concept only.
Locations replace or expand existing water bodies.

0 600 1,200 2,400 Feet

Section 6 - Recommendations

Recommendations are categorized based on a near and long term basis. It is recommended that all long term recommendations be coordinated with the city and MDEP recommendations set forth in the CFUP.

Near term activities should be addressed in the next 2 to 5 years. Near term activities address existing problems that may worsen over time. The following are the recommended near term activities.

- Clean and video pipes where suspected infiltration of sediment is occurring. Figure 3.3.3 highlights these locations.
- Restore deteriorated pipe outlets near Griffin Road (Figure 3.3.1.e) and Godfrey Boulevard (Figure 3.3.2.g) to prevent further drain pipe movement.
- Repair surface erosion at Maine Department of Human Services (Figure 3.3.1.c) to prevent additional scour and to prevent a source of sediment loading to the downstream conveyances.
- Repair catch basins and install water quality units for the DPW parking area (Figure 3.3.2.f) to remove a source of sedimentation to the airport pond.
- Remove beaver dams (Figures 3.3.1.b and 3.3.2.i) to prevent a source of sediment loading to the downstream conveyances and remove potential for flooding Griffin Road-Maine Avenue intersection.
- Install stormwater quality units (Figure 5.4.1) to protect airport's water quality from off-site uncontrolled activities. Note DPW area covered above.
- Decide on a course of action with respect to restoring design flows to the airport pond (Section 5.2 and 5.3)

Long term activities would be those activities that would help to restore the hydrologic nature of the airport watershed to its pre-development condition as well as maximize pollutant removal of the stormwater prior to off-site discharge. The following are the recommended long term activities.

- Modify flow through the center drainage canal (Section 5.3) to restore the airport pond to its flood attenuation capacity and provide treatment to stormwater run-off from the airport's heavy duty and MEANG parking aprons.
- Modify existing airport pond from its undersized wet pond condition to a dry basin (Section 5.2) with opportunity for treatment with subsurface flow engineered wetlands (Section 5.5).

Section 7 - References

1. City of Bangor Engineering Department, Bangor International Airport - Sanitary Sewer and Storm Drain System Maps, January 2006.
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3. Edwards and Kelcey Drainage System Field Notes, June, July and October 2006.
4. FGS/CMT Inc., Stormwater Pollution Prevention Plan Bangor International Airport, November 2004.
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7. James W. Sewall Company, Planimetric and Photogrammetric Mapping of Bangor International Airport, April 2006.
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9. Maine Department of Environmental Protection, Site Location of Development, Findings of Fact and Order, Bangor International Airport, #L-2976-18-B-N (Approval), December 18, 1991.
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12. Maine Department of Environmental Protection, Multi-Sector General Permit, Maine Pollutant Discharge Elimination System Stormwater Discharge Associated with Industrial Activity, October 11, 2005.
13. OEST Associates, Inc., Stormwater Management Study, Bangor International Airport, August 15, 1991.
14. Summit Environmental Consultants, Inc., MEARNG BIA Training Facility, Stormwater Pollution Prevention Plan, May 15, 2006.
15. Woodward & Curran, Inc. Airport Retention Pond Design Report, May 29, 1992.
16. Woodward & Curran, Inc. Airport Retention Pond Construction Drawings, May 1992.