AIRPORT MASTER PLAN

CHAPTER 9 - STORMWATER PLANNING

FEBRUARY 2023 - FINAL DRAFT

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9 STORMWATER PLANNING

9.1 EXECUTIVE SUMMARY

This Stormwater Planning report is part of an update of the 20-year Airport Layout Plan (ALP) for St. Louis Lambert International Airport (Airport).

The scope for this project consisted of collection and analysis of existing data for the Airport drainage system; summarization of federal, state, and local regulatory requirements and Airport policies regarding stormwater drainage for existing facilities and future development; evaluation of the existing drainage system by developing a hydraulic model of the Airport's major drainage systems and problem areas; and evaluation of proposed alternatives identified in the ALP from a stormwater perspective.

9.1.1 DATA COLLECTION

Data in the form of as-built drawings, Geographic Information System (GIS) databases, stormwater system models, reports and stakeholder meetings were obtained from a wide range of sources to provide a comprehensive picture of the Airport stormwater system. Some of the key data sources are listed below:

- As-Built drawings from the Airport and the St. Louis Metropolitan Sewer District (MSD)
- GIS facilities databases from the Airport and MSD
- Preliminary regulatory floodplain models developed for the Missouri State Emergency Management Agency (SEMA)
- Report of Special Sewer Investigations performed for MSD and the Airport
- Known stormwater problem areas per Airport staff and Subject Matter Experts

9.1.2 REQUIREMENTS AND POLICIES

St. Louis Lambert International Airport falls within the jurisdiction of several regulatory bodies at the national, state and local level that are concerned with both water quality and hydraulic aspects of stormwater.

The water quality requirements for stormwater are laid out in the National Pollutant Discharge Elimination System (NPDES) permit issued by the Missouri Department of Natural Resources (MDNR) on January 1, 2022. The NPDES permit sets water quality requirements for two outfalls for Coldwater Creek and Cowmire Creek. The area within the fence at the Airport is tributary to a MDNR permitted outfall, so MDNR requirements govern and supersede MSD water quality requirements. MSD requirements of stormwater quantity management shall be evaluated for all Airport projects submitted to MSD for review and approval. MSD water quantity requirements consist of two categories: Channel Protection Storage Volume and Flood Protection Volume requirements. These requirements are described in more detail in Section 4.3.2.

Hydraulic requirements for all parts of the airport stormwater system are specified in FAA advisory circulars and the MSD Rules and Regulations document. Floodplain requirements are specified by both the Federal Emergency Management Agency (FEMA) and MSD.

Other impacts of stormwater such as impacts on airport safety and wildlife are regulated by the FAA, the United States Army Corps of Engineers (USACE) and the Missouri Department of Transportation (MoDOT).

9.1.3 EXISTING CONDITION MODELS

Planning-level models were developed for the Airport stormwater system. The system draining to Coldwater Creek was developed in PCSWMM and the system draining to Cowmire Creek was developed in XPSWMM. Both models were analyzed with a range of 3-hour design storms listed in **Table 9.1-1**. The Maline Creek system was not modeled as discussed in Section 9.5.1. The 3-hour duration was identified as the critical storm duration based on a critical rainfall duration analysis performed for the FEMA Flood Insurance Rate Map (FIRM) update.

Table 9.1-1: List of Design Storms run for the Coldwater Creek and Cowmire Creek Airport Models

DESIGN STORM EVENTS	ASSOCIATED REGULATORY AGENCIES	REQUIREMENTS
5-year 3-hour	FAA	The Airport stormwater system should be able to convey the design storm event with no encroachment of runoff on taxiways and runways for the 5-year storm.
10-year 3-hour	FAA	The center 50 percent of Airport runways and taxiways serving these runways should be free from ponding for the 10-year storm.
15-year 3-hour (CAPACITY)	MSD	MSD storm sewer design requires that sewers be able to convey the 15-year peak discharge rate. For this analysis, the Coldwater Creek Airport Model was run without upstream Coldwater Creek inflow to analyze the capacity of sewers without the influence of Coldwater Creek.
50-year 3-hour	FAA	Check event to identify flooding risks to airport operation.
100-year 3-hour	FAA	Check event to identify flooding risks to airport operation.
	MSD	Peak discharge rates for MSD stormwater detention design are based on 100-year peak flows.
	FEMA	New developments must not impact the FEMA floodplain which is based on the 100-year event.

Sources: U.S. Department of Transportation Federal Aviation Administration Advisory Circular 150/5320-5D / MSD Rules And Regulations and Engineering Design Requirements for Sanitary Sewer and Stormwater Drainage Facilities February 1, 2018

Model results indicate that the airport stormwater system does not meet FAA requirements for the 5-year and 10-year design storms as it shows ponding on the runways and taxiways along the main Coldwater Creek culverts. The majority of ponding for these design storms is due to flow in the Coldwater Creek channel. Model results for the 15-year design storm capacity analysis show several reaches that do not have sufficient capacity to convey design flow. Lastly, model results for the 50-year and 100-year design storms identify stormwater critical features for large events.

The current Coldwater Creek and Cowmire Creek models are for planning purposes only. More accurate models can be developed for design purposes using flow monitoring data at key locations and survey at locations with insufficient data.

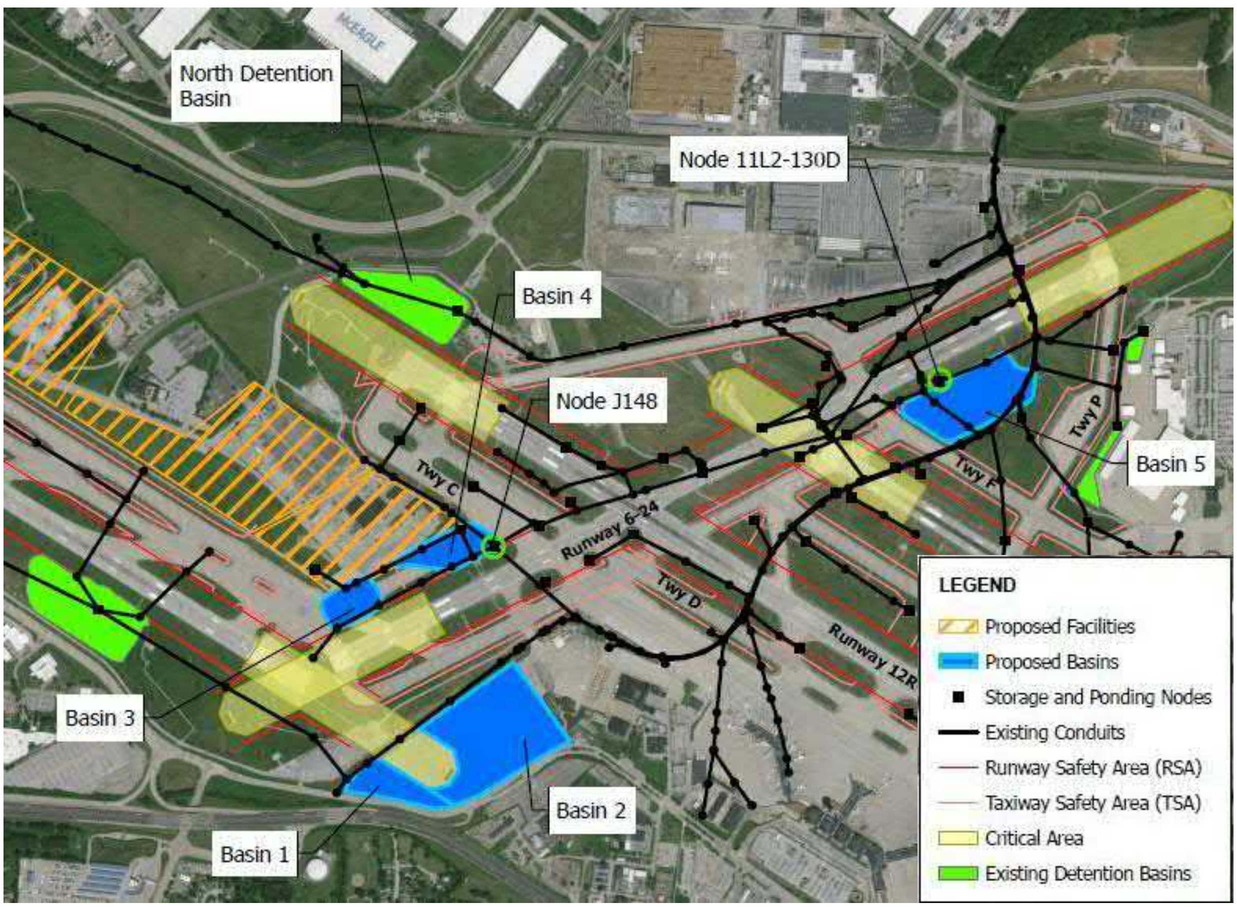
9.1.4 ANALYSIS OF ALTERNATIVES

While some storm sewers on the Airport property were found to have insufficient capacity to convey the MSD 15-year peak design flow, the insufficiency in capacity did not result in any ponding on taxiways and runways when the effects of Coldwater Creek flooding were removed. No upgrades of existing local sewers are included in the recommended alternatives since the root cause of flooding is from Coldwater Creek flooding and local sewer upgrades were ineffective in preventing flooding of taxiways and runways.

Since ponding on Airport property is caused due to high water levels in Coldwater Creek during a large rain event and upgrading local storm sewers would have minimal benefit to ponding on the airfield; potential solutions to reduce water levels were explored. Five basins were identified within airport property. Basins 1 through 5 are recommended as flood storage basins to store flood water from Coldwater Creek to alleviate ponding on the airport taxiways and runways to meet FAA requirements for the 5-year and 10-year storm events.

The preferred stormwater solution consists of use of excess storage capacity in the North Detention Basin to satisfy MSD detention requirements for ALP development and construction of Basins 1 through 5, identified in Section 9.6.3, and depicted on **Figure 9.1-1**.

Figure 9.1-1: Storage and Detention Basin Alternatives



Source: M3 Engineering, 2021.

Based on this high-level stormwater analysis, Basins 1 through 5 all need to be constructed to bring the forecasted Coldwater Creek flooding within the tolerance levels of FAA stormwater guidelines for the 5-year and 10-year storm events.

9.2 INTRODUCTION

9.2.1 PROJECT BACKGROUND

This Stormwater Planning report is part of an update of the 20-year Airport Layout Plan (ALP) for St. Louis Lambert International Airport. The ALP is a Federal Aviation Administration (FAA) guided process to reflect the region's current facility requirements for an efficiently operating airport. Stormwater planning is an important aspect of the ALP as the airport is situated over an enclosed portion of Coldwater Creek. Any proposed projects in the ALP have the potential to impact local runoff rates and stormwater ponding which can present safety concerns. Furthermore, Coldwater Creek has been known to cause flooding events that disrupt airport operation. Evaluating these considerations at the planning stage will enable the airport to anticipate stormwater requirements and costs during the design phases. The Airport stormwater infrastructure consists of open channels, enclosed piping, diversion structures, pump stations, and detention and storage facilities. These components are constructed and maintained by both public and private entities. The main objectives of this stormwater planning effort are:

- To provide a holistic view of the existing Airport stormwater system.
- To identify capacity issues with a focus on stormwater critical features.
- To identify regulatory requirements pertaining to Airport stormwater management for future Airport modifications.
- To advise on stormwater costs for development alternatives in the ALP.

9.2.2 AIRPORT HISTORY

The St. Louis Lambert International Airport began operating as a municipal airport in August 1928. Subsequently, the first passenger terminal was opened in 1933 and a major airport expansion was completed in 1956. In 1947, prior to this major expansion, the open channel Coldwater Creek that passed through the Airport property was enclosed within a double 15-ft 4-in x10-ft arch culvert. Tributaries to Coldwater Creek were also enclosed with large diameter horseshoe sewers and boxes. These sewers drain the central and eastern parts of the present Airport. Most of the sewers built in 1947 are still in operation today. This base stormwater system has been expanded over the years as the Airport extended the airfield, added new concourses to existing Terminal 1 and built the East Terminal (Terminal 2).

The last major Airport development was the W1W Airport expansion program which included the construction of a new 9000-foot parallel runway on the West side of the Airport, new taxiways and a tunnel for Lindbergh Boulevard under the new runway. The new runway became operational in 2006. The W1W expansion involved the construction of the North and South detention basins, both of which drain to the Coldwater Creek Culvert passing under the airfield. The W1W project also involved the construction of a tunnel and detention basin on the northwest side of the Airport to drain flow from the West side of the airfield to Cowmire Creek.

The last comprehensive stormwater model and analysis for the Airport stormwater system was completed in 2001 for design of the W1W Airport expansion. This current Stormwater Planning report will serve as a useful resource as the Airport plans for significant changes in the future and as aging stormwater infrastructure requires rehabilitation or replacement.

9.2.3 PROJECT SCOPE

The scope for this project is divided into four parts:

1. Collection and analysis of existing data for the Airport drainage system.
2. Summarization of federal, state, and local regulatory requirements and Airport policies regarding stormwater drainage for existing facilities and future development.
3. Evaluation of the existing drainage system using existing data to develop a hydraulic model of the Airport's major drainage systems and problem areas.
4. Evaluation, from a stormwater perspective, of proposed alternatives identified in the ALP.

Stormwater planning for this project will provide flooding and capacity analysis of the existing stormwater systems with a focus on stormwater critical features. Stormwater critical features can create safety issues for operation of the Airport such as stormwater ponding on runways, taxiways, and aprons, or flooding of airport buildings. Recommendations for stormwater improvements will also be provided to mitigate the risk of flooding at stormwater critical features in the Airport.

This stormwater planning effort is limited to analyzing stormwater hydraulic aspects of the storm sewers, culverts, and channels that provide drainage of the Airport property. Examining stormwater quality aspects is beyond the scope of this chapter.

9.3 DATA COLLECTION

Data in the form of as-built drawings, Geographic Information System (GIS) databases, stormwater system models, reports and stakeholder meetings were obtained from a wide range of sources to provide a comprehensive picture of the Airport stormwater system. Some of the key data sources are listed below:

- As-Built drawings from the Airport and the St. Louis Metropolitan Sewer District (MSD)
- GIS facilities databases from the Airport and MSD
- Land Use Maps from the Airport
- 2018 Impervious area shapefiles from MSD
- Preliminary regulatory floodplain models developed for the Missouri SEMA for update of Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs)
- The Airport Stormwater Pollution Prevention Plan
- Report of Special Sewer Investigations performed for MSD and the Airport

The above data sources were used to assemble a Stormwater System Map, depicted in **Figure 9.3-1**.

9.3.1 CLIMATIC AND PRECIPITATION CONDITIONS

The St. Louis region experiences four distinct seasons throughout the year – Winter, Spring, Summer and Fall. Although all months are likely to experience rainfall, the Spring season from April to June is the wettest of all the seasons and experiences the most extreme rainfall events. The risk of flooding in these months is compounded as the water table tends to be highest during these months. Freezing precipitation events occur during the Winter months from November to March necessitating Airport deicing activities. The runoff generated from these activities is collected by the Airport Glycol Collection System (GCS) during this season. See Section 3.4.4 for a description of the GCS.

The State of Missouri is reportedly experiencing climate change. An analysis performed by the EPA in 2016 stated the following:

> *"Changing the climate is likely to increase the frequency of floods in Missouri. Over the last half century, average annual precipitation in most of the Midwest has increased by 5 to 10 percent. But rainfall during the four wettest days of the year has increased about 35 percent, and the amount of water flowing in most streams during the worst flood of the year has increased by more than 20 percent. During the next century, spring rainfall and average precipitation are likely to increase, and severe rainstorms are likely to intensify. Each of these factors will tend to further increase the risk of flooding."*[1]

The Airport is at particular risk of experiencing the adverse impacts of climate change because of its proximity to Coldwater Creek which flows as an open channel upstream and downstream of the Airport. Flows associated with previous 100-yr and 500-yr flooding events may occur with a higher frequency under future climate conditions. New Flood Hazard Zones, identified by the FEMA, show widespread flooding of critical Airport infrastructure for the 100-yr and 500-yr events. See Section 4.3.3 for a discussion about these zones.

9.3.2 LAND USE AND SOIL CONDITIONS

Several aviation related entities lease land on the Airport property. These include commercial airlines, cargo companies and defense agencies. Many of these tenants are responsible for maintaining runoff quality and quantity generated on their property and may be subject to different rules and regulations from those applicable to the Airport.

Within airport property, the area tributary to Coldwater Creek is approximately 48% impervious and the area tributary to Cowmire Creek is approximately 21% impervious. A majority of undeveloped land lies in the western half of the Airport property. Upstream of the airport, the Coldwater Creek watershed is mostly developed and is unlikely to experience significant increases in flow due to changes in land use.

[1] EPA 430-F-16-027, What Climate Change Means for Missouri, August 2016

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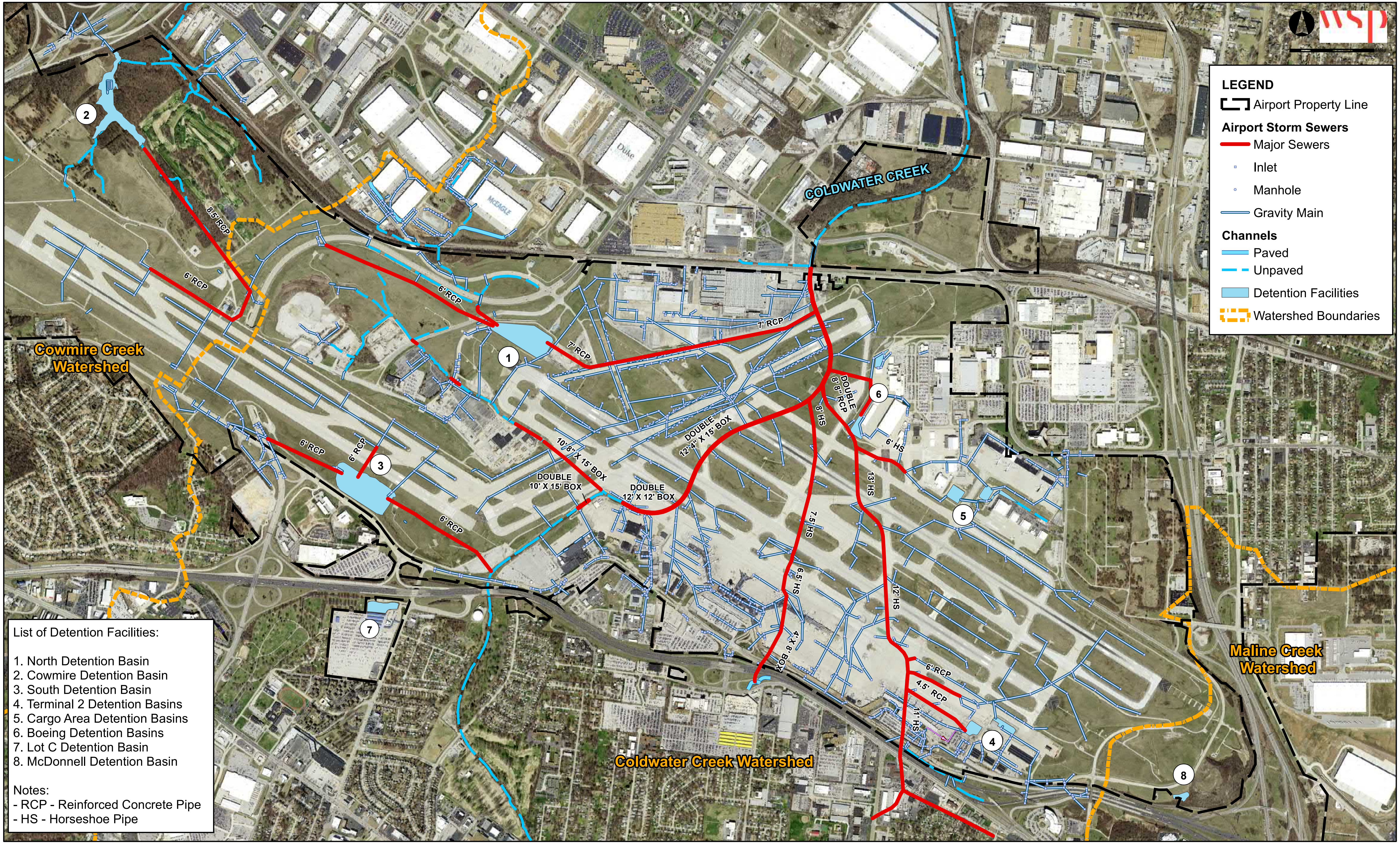
Figure 9.3-1
Stormwater Data Collection
Existing Airport Stormwater System Map



SOURCE: M3 Engineering, 2021.

More than 80% of the soil in these areas is either Urban Land or an Urban Land – Harvester Complex per the Web Soil Survey of the Natural Resources Conservation Service (NRCS). These soils are a mixture of Silt, Loam and Clay. They are moderately well drained and produce high runoff values. An NRCS soil report for the Airport area is attached in Appendix A.

9.3.3 KNOWN FLOODING ISSUES

Through discussions with Subject Matter Experts and Airport staff, the following areas prone to flooding on Airport property were identified:

- The Airport is susceptible to disruptive flooding if a failure occurs on the main Coldwater Creek double arch sewer or any of its tributary horseshoe sewers. For example, in 2018, when a double 187-in CMP pipe near Charlie Pad at the upstream end of the double arch Coldwater Creek sewer collapsed, flow backed up into upstream culverts and flooded the intersection of 12R-30L and 6-24, rendering both runways unusable.
- **Figure 9.3-2** and **Figure 9.3-3** for images of the collapsed pipe and resultant flooding.

Figure 9.3-2: Images of collapsed 187-in CMP pipe in 2018

Source: CMT, 2018.

Figure 9.3-3: Image of flooding due to collapsed 187-inch CMP pipe

Source: CMT, 2018.

- Parts of the Airport property are at increased risk of flooding during extreme events due to the Airport's proximity to open channel creeks. Maline Creek, which runs through the Springdale Parking Lot South of I-70 and East of I-170, floods the parking lot frequently and has undercut the parking lot over time.
- The airfield is also extremely flat. Any low-lying areas with insufficient drainage capacity will create pools of water during a rain event. Pools form regularly in the islands between Taxiways D and C, and between Taxiway D and Runway 12R-30L during rainfall events. The Airport has contracted with a Subject Matter Expert to design a solution to this issue. A "depression analysis" was performed for the Airport property using 2018 LIDAR data to identify low-lying areas susceptible to ponding. The results of this analysis are presented in **Figure 9.3-4**.
- The area between the West end of the Terminal 1 Parking Garage and the Climate Control Building experiences occasional flooding due to the narrowing of a 24-inch sewer into an 18-inch siphon pipe that flows under a utility tunnel near the Climate Control Building. This issue has been resolved in the short term by redirecting flow overland to another part of the stormwater system.
- Ponding North of Taxiway F and West of Runway 6-24.
- Ponding between Taxiway C and Taxiway D and East of Taxiway Q.
- Ponding West of Taxiway V, near Runway 12R-30L.
- Ponding between Runway 12R-30L and Taxiway V, North of the Midfield Service Road.
- Ponding between the North Service Road and Taxiway P.
- Ponding West of the Papa Pad.
- Ponding on Taxiway R between Taxiway C and Taxiway D.

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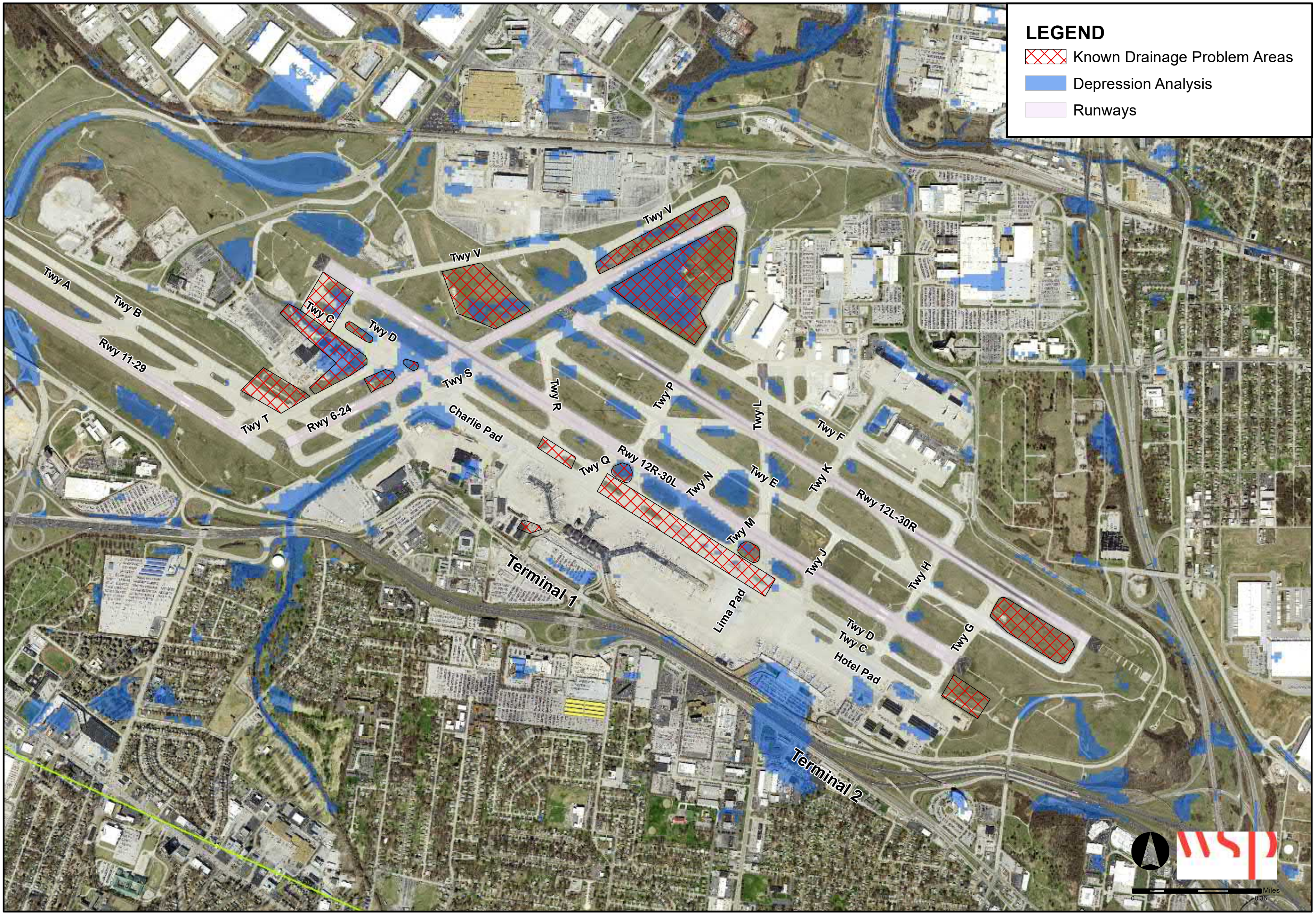
Figure 9.3-4
Map of Known Flooding Issues and Depression Analysis



SOURCE: M3 Engineering, 2021.

- Ponding in the grass area Northeast of the Intersection of Taxiway G and Taxiway E.
- Ponding Southeast of the intersection between Taxiway T and Taxiway C.
- Ponding in the island between Taxiways C, D, and T off of Runway 6-24.
- Ponding in the island between Taxiways C, D, U and V. Ponding East of the East Service Road entrance near the intersection of Taxiway C and Taxiway G.
- Ponding in the area West of the intersection of Taxiway B and Taxiway T. The ponding is most likely due to hydrostatic pressure reaching the surface from under the pavement.
- The Airfield Maintenance Building is subject to flooding due to groundwater and hydrostatic pressure issues as it is in a low-lying area.

These areas are also highlighted in Figure 9.3-4.

9.3.4 EXISTING STORMWATER COLLECTION SYSTEM OVERVIEW

In general, stormwater runoff generated from the airfield is first collected in underdrains and inlets constructed along the edges of runways, taxiways, aprons and islands and conveyed to three streams - Coldwater Creek, Cowmire Creek and Maline Creek. The majority of the runoff from the eastern and central portions of the Airport is conveyed to Coldwater Creek while some flow from the western portion of the Airport is conveyed to Cowmire Creek and an even smaller portion on the easternmost side of the Airport flows to Maline Creek. Coldwater Creek and Cowmire Creek eventually drain into the Missouri River, while Maline Creek drains to the Mississippi River. The watershed boundaries for these creeks are shown in Figure 9.3-1. The watersheds for Coldwater Creek, Cowmire Creek and Maline Creek are discussed in the subsequent sections.

COLDWATER CREEK

Coldwater Creek begins as open channel flow at the South end of the Airport. It then passes briefly under Taxiway Sierra 1 near the former Missouri Air National Guard Complex (MoANG) through two 10-ft high by 15-ft wide concrete culverts and becomes open channel flow once again before transitioning into a newly constructed dual 12-ft high x 12-ft wide rectangular box culvert. The concrete culverts passing under Taxiway Sierra 1, shown in **Figure 9.3-5**, were found to be in good to excellent condition. The new dual rectangular box culvert was constructed in 2019 to replace a Corrugated Metal Pipe (CMP) section of the Coldwater Creek conveyance sewers that rusted through the CMP and resulted in a collapse of this section of culvert.

The new culvert connects into a larger double box culvert that flows under the airfield from South to North. The larger double culvert consists of two concrete arch boxes, each box being 12-ft 4-in high and 15-ft wide. The two box culverts are interconnected by regularly spaced rectangular openings in their common center wall. The creek finally daylights at the North end of the Airport near Banshee Road, as shown in Figure 9.3-1. This is also the location of Outfall #006, which is regulated by an NPDES permit (see Section 9.4.3). There are several major sewers that collect and convey runoff from the airfield to the Coldwater Creek double arch culvert:

- A 6-ft Reinforced Concrete Pipe (RCP) connects the South Detention basin to the Creek at the South end of the Airport.

Figure 9.3-5: Condition of Existing Double Box Culverts under Taxiway Sierra 1

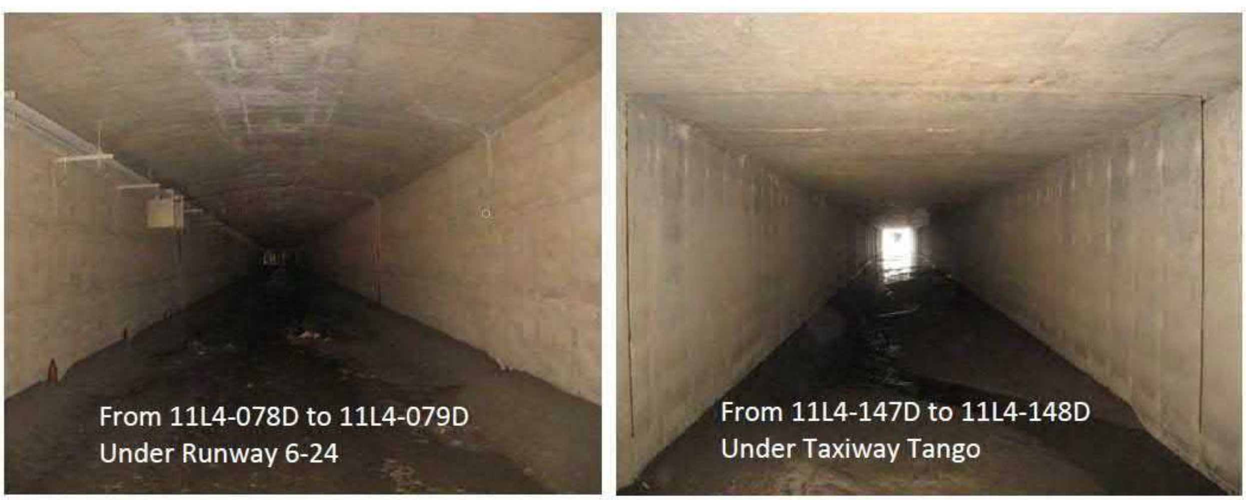
Culverts Under Taxiway Sierra 1
Lambert-St. Louis International

Source: Lambert-St. Louis International Report of Special Sewer Investigations 2009 Through 2010 prepared for MSD

- A 10-ft 8-in high x 15-ft wide concrete culvert passes under Runway 6-24 and Taxiway Sierra and connects into the open channel section of Coldwater Creek near the former Missouri Air National Guard Complex. The culvert under Runway 6-24 shown in **Figure 9.3-6** was found to be in excellent condition per *the Lambert-St. Louis International Report of Special Sewer Investigations 2009 Through 2010*, prepared for MSD.

Figure 9.3-6: Condition of Existing Culvert under Taxiway Tango and Runway 6-24

Culverts Under Taxiway Tango and Runway 6-24
Lambert-St. Louis International



Looking downstream in this 180"w by 128"h concrete box under Runway 6-24. Total length is 837 l.f.

Looking upstream in this 144"w by 97"h concrete box under Taxiway Tango. Total length is 468 l.f.

Source: St. Louis Lambert International Airport, Report of Special Sewer Investigations 2009 through 2010 prepared for MSD

- A rectangular box culvert collects runoff from the East side of Terminal 1 as well as parts of the central airfield and connects into the Coldwater Creek Culvert just North of Taxiway F. The rectangular box varies in size and shape from a 4-ft high x 8-ft wide box near Terminal 1 to an 8-ft horseshoe sewer at the connection into Coldwater Creek.
- A horseshoe pipe of variable size collects flow from most of the eastern taxiways, runways and aprons as well as all flow from Terminal 2. The horseshoe pipe transitions from an 11-ft wide horseshoe pipe at the upstream end to 13-ft wide horseshoe pipe closer to the connection into the Coldwater Creek culvert. The 13-ft horseshoe pipe splits into two 104-in RCP sewers before connecting into the Coldwater Creek culvert.
- Part of the flow from Terminal 2 is first conveyed to the Terminal 2 detention basin and then released into the horseshoe culvert via a 4.5-ft RCP sewer.
- Flow East of Taxiway H is conveyed into the main horseshoe sewer via a 6-ft RCP sewer.
- Runoff from the North of the airfield on the eastern side is conveyed through a 6-ft Horseshoe pipe to the main 13-ft horseshoe near the intersection of Taxiway F and Taxiway F 7. This area consists of the air cargo property, general aviation apron and Boeing property.
- A 7-ft RCP connects the North Detention basin to the creek just North of Taxiway V.

The main Coldwater Creek culvert and the horseshoe sewer lines contributing to it were constructed in 1947 during a major expansion of the Airport. Although these sewers are more than 70 years old, an investigation of special sewers on Airport property carried out by a Subject Matter Expert for MSD from 2009 to 2010 found that these culverts were in fair to excellent condition. However, the report noted localized deterioration for some of the side connections into these main sewers.

COWMIRE CREEK

The western portion of Runway 11-29, associated taxiways, and Lindbergh Tunnel drain to Cowmire Creek through an 8.5-ft RCP tunnel North of the runway on the Northwest side of the Airport property. The tunnel drains into the Cowmire Creek detention basin from which runoff is released into a tributary of Cowmire Creek. The tunnel and detention basin became functional in 2006 along with the opening of Runway 11-29.

MALINE CREEK

A tributary to Maline Creek drains a small part of the Airport property on the East side and passes through the Springdale Parking Lot located Southeast of the main Airport property. During intense rainfall events, the creek rises and floods the parking lot. A map of the parking lot is shown in **Figure 9.3-7**.

GLYCOL COLLECTION SYSTEM (GCS)

In the winter season, airlines apply glycol-based deicing and anti-icing agents on their aircraft near the concourse and on designated deicing pads. Deicing is performed according to the Airport's Winter Deicing Season Protocols which are updated annually. Glycol runoff during rain events is managed using the Airport's GCS.

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Figure 9.3-7
Map of Springdale Parking Lot

SOURCE: M3 Engineering, 2021.

Stormwater runoff from the glycol capture areas is collected and routed through a dedicated forcemain to a 1.7-million-gallon storage tank located East of the Airport that regulates discharge into the sanitary sewer system. A map of the GCS is shown in **Figure 9.3-8**. This GCS is closed during the Spring and Summer months so that all runoff flows to the existing stormwater system. However, during the winter months, the GCS is opened so that runoff from the aprons and deicing pads is conveyed to the storage tank. When large storm events occur during these months, flow from the GCS overflows into the stormwater system once the capacity of the existing GCS has been met. Modifications to the operation and capacity of the GCS are slated to be updated.

STORM SEWER INVESTIGATION

Closed Circuit Television (CCTV) Inspections of the major storm sewers on the airport were performed in 2009 and 2010. The investigation covered 33,808 ft of 10-inch to 16-ft x 12-ft storm sewers. **Figure 9.3-9** shows a map of the storm sewer investigation. A summary of the investigations titled "Lambert-St. Louis International Airport Report of Special Sewer Investigations 2009 through 2010" was prepared by ADS Environmental Services and submitted to MSD in December 2014. All CCTV footage and reports for storm manholes and sewers were submitted along with the investigation summary.

In general, the investigation found most of the main trunk sewers to be in good to excellent condition. However, localized problems were identified in some of the sideline connections to the main trunk sewers. A Storm Sewer Inspection Score was developed in 2014 for each of the inspected sewer reaches based on a review of the CCTV inspections and the MSD defect scoring methodology. Four factors were evaluated when determining the total score:

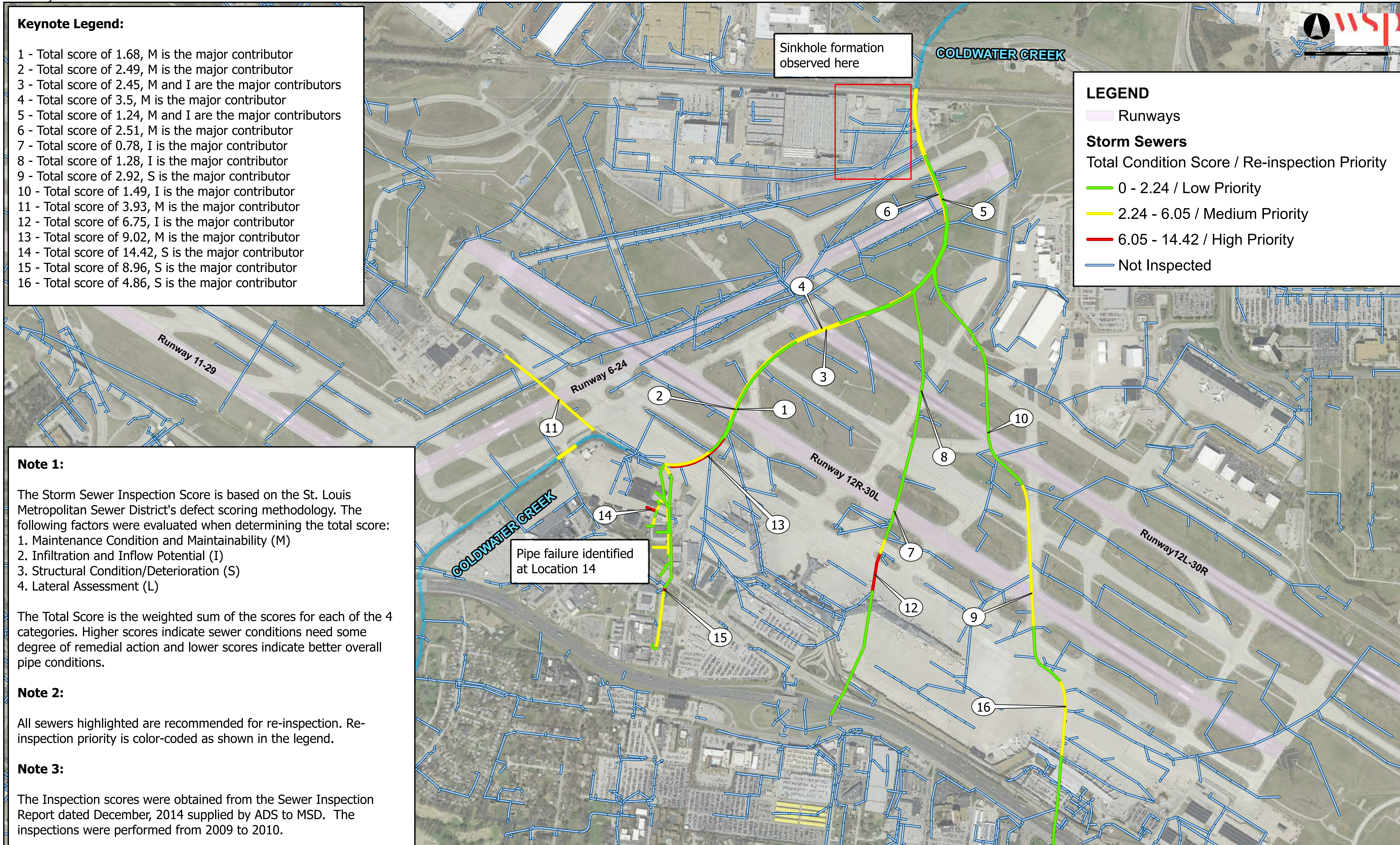
- Maintenance Condition and Maintainability
- Infiltration and Inflow Potential
- Structural Condition/Deterioration
- Lateral Assessment

The Structural Condition/ Deterioration factor is a safety critical factor. A high structural condition/ deterioration score indicates a higher chance of failure that might undermine the ground above it. In Figure 9.3-9, sewers are color coded based on high, medium, and low re-inspection priority. The re-inspection priority classification was set using natural breaks in the Total Condition Score rankings for the inspected sewers. A keynote is provided in Figure 9.3-9 for all inspected sewers with a high re-inspection priority and all sewers at runway crossings to indicate the major contributing factor for the Total Condition Score at that location. It is recommended that all sewers be inspected every 10 years due to the age of the structures.

Figure 9.3-8
Stormwater Data Collection
Map of Glycol Collection System

SOURCE: M3 Engineering, 2021.

Figure 9.3-9
Data Collection
Map of Storm Sewer Investigation



Keynote Legend:

1 - Total score of 1.68, M is the major contributor
2 - Total score of 2.49, M is the major contributor
3 - Total score of 2.45, M and I are the major contributors
4 - Total score of 3.5, M is the major contributor
5 - Total score of 1.24, M and I are the major contributors
6 - Total score of 2.51, M is the major contributor
7 - Total score of 0.78, I is the major contributor
8 - Total score of 1.28, I is the major contributor
9 - Total score of 2.92, S is the major contributor
10 - Total score of 1.49, I is the major contributor
11 - Total score of 3.93, M is the major contributor
12 - Total score of 6.75, I is the major contributor
13 - Total score of 9.02, M is the major contributor
14 - Total score of 14.42, S is the major contributor
15 - Total score of 8.96, S is the major contributor
16 - Total score of 4.86, S is the major contributor

Note 1:

The Storm Sewer Inspection Score is based on the St. Louis Metropolitan Sewer District's defect scoring methodology. The following factors were evaluated when determining the total score:
1. Maintenance Condition and Maintainability (M)
2. Infiltration and Inflow Potential (I)
3. Structural Condition/Deterioration (S)
4. Lateral Assessment (L)

The Total Score is the weighted sum of the scores for each of the 4 categories. Higher scores indicate sewer conditions need some degree of remedial action and lower scores indicate better overall pipe conditions.

Note 2:

All sewers highlighted are recommended for re-inspection. Re-inspection priority is color-coded as shown in the legend.

Note 3:

The Inspection scores were obtained from the Sewer Inspection Report dated December, 2014 supplied by ADS to MSD. The inspections were performed from 2009 to 2010.

SOURCE: M3 Engineering, 2021.

9.4 REQUIREMENTS AND POLICIES

9.4.1 INTRODUCTION

St. Louis Lambert International Airport falls within the jurisdiction of several regulatory bodies at the national, state and local level that are concerned with stormwater. Regulatory documents from these agencies were reviewed to identify relevant regulatory requirements for the Airport. Meetings were conducted with MSD, MODOT, USACE and the Airport to further discuss these requirements. In general, the Airport is obligated to maintain the safety of airport operations, meet water quality and quantity standards and ensure that any new development does not impact the environment adversely. The requirements of these agencies regarding stormwater are discussed in Section 9.4.3. This Section primarily focuses on regulations related to stormwater hydraulics. Regulations related to stormwater quality will be discussed briefly, but water quality impacts due to changes in stormwater runoff quantities was not analyzed in this study.

9.4.2 ENVIRONMENTAL MANAGEMENT SYSTEM

The Airport's environmental policy commits to complying with environmental laws and regulations, preventing pollution, and continually improving environmental performance. The Airport also pledges to develop sustainably and engage all stakeholders in new projects. The Airport developed an Environmental Management System (EMS) in 2012 to serve as a framework to aid in meeting these commitments.

9.4.3 AGENCY REGULATORY REQUIREMENTS

FEDERAL AVIATION ADMINISTRATION (FAA)

The FAA is the regulatory agency within the United States Department of Transportation (USDOT) that is responsible for the safety of civil aviation within the United States. The agency has developed several Advisory Circulars (ACs) that establish guidelines and requirements for all aspects of aviation. Three circulars in particular are relevant to surface drainage and stormwater facilities at the Airport – AC 150/5300-13A[2] addresses Airport Design, AC 150/5320-5D[3] further elaborates on Airport Drainage Design and AC 150/5200-33C[4] addresses hazardous wildlife attractants on or near airports. While the criteria in these circulars do not apply to existing facilities constructed under older standards, if existing facilities are modified, or new facilities are constructed, they must conform to the latest standards.

[2] FAA AC 150/5300-13A *Airport Design*, Change 1, February 26, 2014

[3] FAA AC 150/5320-5D *Airport Drainage Design,* August 15, 2013

[4] FAA AC 150/5200-33C *Hazardous Wildlife Attractants on or near Airports*, February 21, 2020

AC 150/5300-13A – AIRPORT DESIGN

This circular lays out the general objectives for airport drainage design and dictates required gradients and considerations for runways, taxiways, aprons and other areas within the Airport to ensure proper drainage. The main objectives of airport drainage design as stated within the circular are summarized below:

- Provide surface drainage by the rapid removal of stormwater from the airfield.
- Provide an efficient mechanism for collecting airfield flows and conveying design flows to acceptable discharge points.
- Provide levels of stormwater conveyance that protect airfield pavements and embankments from damage during large storm events.
- Provide a safe level of operation for airside and landside ground vehicles.
- Address stormwater quality issues in accordance with individual National Pollution Discharge Elimination system (NPDES) and state and local permit requirements.
- Consider stormwater management needs for future expansion.
- Follow airfield design requirements for safety areas and Object Free Areas (OFAs).

AC 150/5320-5D – AIRPORT DRAINAGE DESIGN

This document discusses the hydraulic requirements for existing and proposed stormwater facilities within the Airport property. The circular provides design guidelines for surface drainage, culverts, channels, storm drains, drainage structures, stormwater control facilities and water quality.

The circular recommends that the Airport stormwater system should be able to convey a 5-year design storm event with no encroachment of runoff on the taxiway and runway pavements, including paved shoulders. Any calculations and provisions for temporary storage and ponding between the runways, taxiways and aprons should only be considered as a safety factor for events beyond the 5-year return period. This temporary storage should not exceed over 4 inches in depth around an inlet. For all other areas within the Airport boundaries, but not on the airfield, a 10-year design storm event should be used at minimum. For the 10-year event, the center 50 percent of runways and the center 50 percent of taxiways serving the runways should be free from ponding.

In addition to the 5 year and 10-year storms, the FAA recommends investigating the consequences of more severe storms to assess the potential for damages and interruptions to operations. These severe events are called check events. The 50-year design storm event should be used to design depressed sections and underpasses where ponded water can only be removed through the storm drainage system and a 100-year event should be used to determine hazards at critical locations where water can pond to appreciable depths. Where significant ponding occurs, the following criteria must be met to ensure the safe passage of vehicles:

- At least one lane is open to traffic during the check storm event.
- At least one lane is free of water during the check storm event.

Due consideration should also be given to maintenance and the handling of debris and snow melt. The drainage facilities should be designed to require minimum maintenance, particularly those serving operational facilities.

AC 150/5200-33C – HAZARDOUS WILDLIFE ATTRACTANTS ON OR NEAR AIRPORTS

This circular discusses requirements and best practices for mitigating and preventing hazards related to wildlife. Poorly drained areas and detention ponds are potential hazards if they encourage wildlife to enter airport approach or departure airspace, or aircraft operations areas. The rules and recommendations laid out in this circular are relevant to St. Louis Lambert International Airport as there are several open detention basins within the Airport premises. In particular, the North Detention Basin near Runway 12R-30L and the South Detention Basin near Runway 11-29 must be properly managed to prevent wildlife hazards. The circular recommends that stormwater detention should not be allowed to pond for more than 48 hours after a storm event. However, if existing facilities do hold water for longer than 48 hours, they should be maintained so that wildlife attracting vegetation does not grow. Physical barriers should also be used around the facility to prevent the access of wildlife to open water. Newly designed basins must be designed to drain completely within 48 hours. St. Louis Lambert International Airport maintains a Wildlife Hazard Management Plan[5] as part of the Airport Certification Manual.

ST. LOUIS METROPOLITAN SEWER DISTRICT (MSD)

MSD has regulatory authority over stormwater hydraulic requirements for St. Louis City and County. MSD's regulatory requirements and policies are published in the document titled "Rules and Regulations and Engineering Design Requirements for Sanitary Sewer and Stormwater Drainage Facilities", February 1, 2018.

The Airport is located within the MSD service boundaries and therefore public stormwater drainage improvements within St. Louis Lambert International Airport may require review by MSD. This includes alteration of any storm drainage channel, site drainage or flood plain within those boundaries. Construction or modification of private sewers on airport property is expected to require MSD review and approval for any private systems that tie into public facilities such as the Coldwater Creek box culvert.

Criteria pertinent to planning for the Airport are presented in Sections 4 and 5 of the MSD Rules and Regulations document. Section 4 provides guidance for the requirements of storm drainage facility design. That includes requirements for construction, hydrologic criteria for the computation of runoff, hydraulic criteria for conveyance of stormwater, minimum standards for open and closed conduits and their appurtenances and stormwater detention basins.

MSD STORMWATER QUANTITY REQUIREMENTS

The requirements of stormwater quantity management shall be evaluated for all projects submitted to the District for review and approval. MSD stormwater quantity requirements for development or redevelopment include the Channel Protection Storage Volume and Flood Protection Volume requirements. Typically, development projects are subject to MSD stormwater quantity compliance if a development or redevelopment project results in a differential runoff rate of 2 cfs or greater for the 15-year, 20-minute event

[5] 139.337 *Wildlife Hazard Management*, Airport Certification Manual, St. Louis Lambert International Airport, April 2020

in a separate sewer area. Since the Airport has prior detention facilities, any additional increase in stormwater runoff rate will require increased detention to satisfy the Channel Protection Storage Volume and Flood Protection Volume.

- The Flood Protection Volume (Qp) regulation requires that the post-developed routed peak flow from the site may not exceed the existing routed peak flow for the 2-year and 100-year, 24-hour events. MSD designates the Coldwater Creek Watershed as a "zero increase" rate watershed. The "Zero increase" rate designation requires the allowable release rate for a 24-hour storm shall have no increase in peak discharge. For development of areas tributary to downstream stormwater problems, an undeveloped existing condition shall be assumed for calculating existing routed peak flow. When analysis shows a development will create an increase in the 2-year or 100-year peak flow rate from a site, additional detention is required. From correspondence with MSD for this ALP, MSD will review the site differential runoff comparison for the Airport property, as a whole, per watershed. MSD correspondence is provided as Appendix B.
- The Channel Protection Volume (Cpv) equates to the 24-hour extended detention of the volume of stormwater generated during the post-developed one-year, 24-hour storm event. Redevelopment of the Airport property is greater than 5 acres, and Coldwater Creek Watershed is a less sensitive "zero increase" rate watershed, but if Qp is required for the site, no exemption is expected and Cpv will also be required.
  - Example 1: The West Deicing Pad is planned for redevelopment west of Runway 6-24 which would result in increased impervious area and runoff discharge to Coldwater Creek and the Foxtrot Taxiway Extension are planned for the same year. A detention storage basin could be provided near the West Deicing Pad to compensate for the increase in runoff for both the West Deicing Pad and the Foxtrot Taxiway Extension by showing an overall net zero or decreased runoff to Coldwater Creek and meet Cpv requirements.
  - Example 2: Airport redevelopment plans include a West Deicing Pad redevelopment planned west of Runway 6-24 which would result in increased impervious area and runoff discharge to Coldwater Creek. Additional plans include a future Foxtrot Taxiway Extension that will not be constructed until 5 to 10 years after West Deicing Pad redevelopment. A detention storage basin could be provided near the West Deicing Pad to compensate for the increase in runoff for both the West Deicing Pad and the future project such as Foxtrot Taxiway Extension by meeting Cpv requirements and showing a negative runoff differential runoff after West Deicing Pad development and a zero increase (or decrease) in runoff differential once both the West Deicing Pad and Foxtrot Taxiway Extension are constructed.
  - Example 3: A potential future Cargo Area development, bounded by McDonnell Boulevard and the existing cargo buildings on the west, Airport Road on the north, the airfield (Taxiway Foxtrot extension) on the south and I-170 on the east is planned on the east end of the Airport. The eastern half of the development is within the Maline Creek Watershed and the western half is within the Coldwater Creek Watershed. In this scenario, the MSD detention requirements, identified above, would need to be met for each watershed, which would typically involve construction of a detention basin in each watershed to provide zero differential runoff and meet Cpv requirements.
  - In some cases, MSD will allow a development to have minor increases in differential runoff rate if these increases will be mitigated with a future planned project. A typical scenario is to have

a series of improvements planned where the small improvements are constructed in a given year with a larger project(s) scheduled for the next year and the detention facility is included in the 2nd year's projects. MSD allows this process on a case-by-case basis and there cannot be an increase in runoff to an existing storm water mitigation facility without determining how the facility would be impacted.

- MSD Flood Protection Volume and Channel Protection Volume requirements are separate from the storage basin alternatives discussed in Section 6. However, given MSD stated the differential runoff for the airport will be managed for the entire airport property, MSD may consider difference in pre-developed and post-developed flow rates in Coldwater Creek as it exits the Airport property resulting from construction of the five proposed storage basins which are discussed in Section 6.3.

As the regional Municipal Separate Storm Sewer System (MS4) permit administrator for the municipal areas surrounding the Airport, the review of best management practices for water quality would typically be under the jurisdiction of MSD. However, the Airport has a separate user permit for three water quality outfalls under the Missouri Department of Natural Resources (MDNR). MDNR water quality outfalls are shown in **Figure 9.4-1**. M3 met with MSD on March 11, 2020 to discuss data collection and regulatory requirements. During this meeting, MSD confirmed that development work within any drainage area tributary to one of these MDNR permitted stormwater outfalls is not under MSD's jurisdiction for MS4 water quality requirements but would be subject to MSD stormwater hydraulic requirements.

FEDERAL EMERGENCY MANAGEMENT ADMINISTRATION (FEMA)

The FEMA prepares Flood Insurance Rate Maps (FIRMs) that identify zones at risk of flooding. In particular, the map identifies a Regulatory Floodway[6] and a Special Flood Hazard Area[7] (SFHA or A Zone) for regulatory purposes. The Regulatory Floodway is a highly restricted zone as any proposal for development in a regulatory floodway must include a "no-rise" certification that shows that the proposed development will not increase flooding. The area that is part of the SFHA but not within the regulatory floodway is called the Floodway Fringe. Development within the Floodway Fringe also requires a floodplain development permit to be submitted to and approved by the appropriate floodplain administrator.

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[6] The Regulatory Floodway is the part of the regulated river or stream that must be kept obstruction free in order to convey the 100-year design storm event at a modelled 100-year flood elevation known as the Base Flood Elevation

[7] The SFHA is also known as the 100-year floodplain. It encompasses a wider area than the regulatory floodway on either side of the stream or river.

[8] As of October 2022 The Missouri SEMA Outreach Floodplain User Portal can be accessed at https://amecei.maps.arcgis.com/apps/webappviewer/index.html?id=2ac0864241b747b4b11302f2c4cc7bc9.

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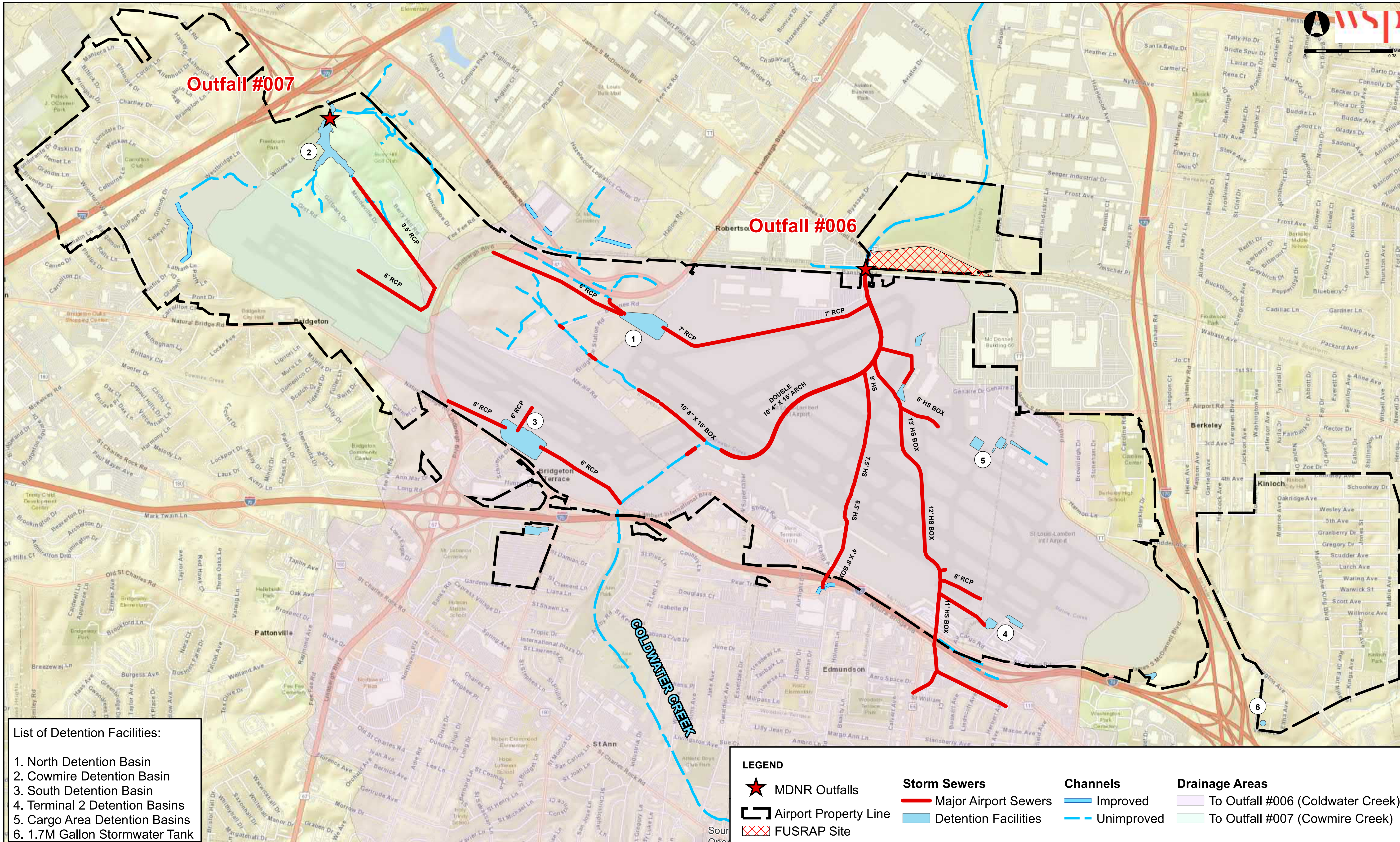
Figure 9.4-1
Stormwater Rules and Regulations
Outfall Locations and Major Sewers Map



SOURCE: M3 Engineering, 2021.

The current effective FEMA FIRM, shown in **Figure 9.4-2**, shows the floodplain of Coldwater Creek upstream (South) of the Airport and downstream (North) of the Airport, but a floodplain is not identified within the boundaries of the Airport. Any development constructed under the current effective FIRM should not require a floodplain development permit. Though a floodplain development permit is not required under the current effective FIRM, it is recommended that development be evaluated to ensure it will not adversely affect flooding on the airfield.

A proposed update to the FIRM for St. Louis City and County establishes a 100-year floodplain within the Airport property but does not show a regulatory floodway for Coldwater Creek. The floodway was not established for Coldwater Creek within the Airport property since overland flooding does not follow the main channel in some areas, which is the box culvert in this case. The preliminary FIRM is shown in **Figure 9.4-3.** The current estimate for the preliminary FIRM to become effective is between July of 2023 and January of 2024. Floodplain development on Airport property will be permitted by the City of St. Louis floodplain administrator.

Once the preliminary FIRM is adopted as the current effective FIRM, any development within the floodplain shown in Figure 9.4-3 will require a floodplain development permit. If development takes place in the AE floodplain zone, an engineer will need to provide a floodplain study to make sure that the development (including past and future development) does not cause more than a one (1) foot rise in the portion of the floodplain without an established FIRM floodway south of Norfolk Southern Railroad near Banshee Road and north of Interstate 70 along Coldwater Creek. Guidelines for preparation of the study are defined in Section 5 of the MSD Rules and Regulations manual. It is also anticipated that an Engineer will need to demonstrate that no rise in the effective published base flood elevations will occur in the floodplain upstream and downstream of the Airport property for development within the floodplain on Airport property.

EXAMPLES OF THE POTENTIAL FLOODPLAIN DEVELOPMENT PERMIT PROCESS

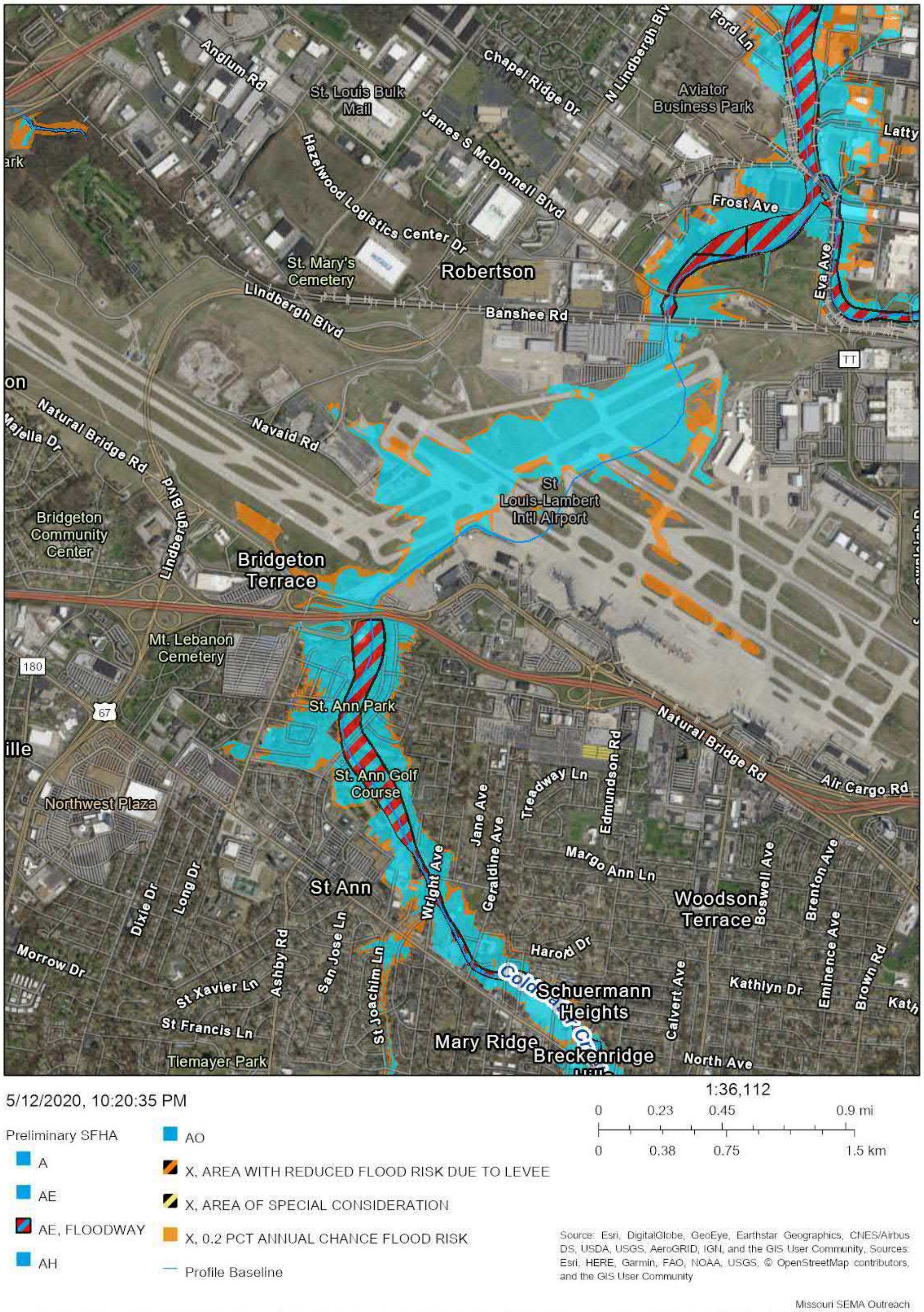
Example 1: No Change in Grade or Flow Characteristics within the Floodplain

If Runway 6-24 is proposed to be reconstructed in some future year to renew the life of the runway, maintaining all existing grades and all existing flow characteristics within the floodplain, this project will require a floodplain development permit since Runway 6-24 is within the mapped floodplain per the FEMA FIRM to be adopted in 2024. The anticipated floodplain development permit process for this scenario would require a no-rise certification be issued by a licensed engineer. A no-rise certification is typically issued based on engineering judgement without computations or hydraulic modeling, given the project will not involve fill or change in grade in the floodplain and will not have any impacts on flow characteristics in the floodplain.

Figure 9.4-2: Current Effective FEMA FIRM

Source: Missouri SEMA Outreach Floodplain User Portal, 2021

Figure 9.4-3 : Preliminary FEMA FIRM



Notes: Zone A= Area inundated by the Base Flood with no Base Flood Elevations determined, Zone AE= Area inundated by the Base Flood with Base Flood Elevations determined, Zone AH= Area inundated by the Base Flood with flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined, Zone AO = Area inundated by the Base Flood with flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined

Source: Missouri SEMA Outreach Floodplain User Portal, 2021

Example 2: Raising Runway 6-24

If Runway 6-24 is proposed to be reconstructed in some future year to renew the life of the runway and raise the elevation of the runway to be above the base flood elevation, this project will require a floodplain development permit since Runway 6-24 is within the mapped floodplain per the FEMA FIRM to be adopted in 2024. The anticipated floodplain development permit process for this scenario would require a no-rise certification be issued by a licensed professional engineer. The no-rise certification for this scenario will require hydraulic analyses, performed according to standard engineering practice, to demonstrate that the cumulative effect of this development, combined with all other existing and anticipated development will not create a rise in base flood elevation of more than 1-foot at any point within the floodplain on airport property that does not have an established floodway and will not result in any rise in the Coldwater Creek system upstream or downstream of Airport property.

UNITED STATES ARMY CORPS OF ENGINEERS (USACE)

The USACE is represented in the region surrounding St. Louis Lambert International Airport by the USACE St. Louis District, which operates in conjunction with the USACE Mississippi Valley Division headquarters. The St. Louis District's functions include maintenance of navigable waterways, flood mitigation levees, and operation of five lakes in addition to its regulatory functions.

Regulatory authority within the domain of the USACE is based upon the following statutes: the Rivers and Harbors Act of 1899 – Sections 8 and 9, the Clean Water Act - Section 404 and the Marine Protection Research and Sanctuaries Act of 1972 - Section 103 as well as portions of other statutes related to these. The USACE promulgates regulations codified within the Code of Federal Regulations, including CFR 33. Under Section 10 of the Rivers and Harbors Act of 1899 (33 USC 403), a permit is required for construction of any structure in or over any navigable water of the United States, or the accomplishment of any other work affecting the course, location, condition, or physical capacity of such waters. Under Section 404 of the Clean Water Act of 1972 (33 USC 1344), a permit is required to excavate in or discharge dredged or fill material into the Waters of the United States.

The regulatory aspect of the St. Louis District most likely to be of significance to the St. Louis Lambert International Airport pertains to Cowmire and Coldwater Creeks. Developments impacting these waterbodies may require a 404 permit. The Corps of Engineers maintains a collection of official permits and application forms. These include:

- Clean Water Act 401 Water Quality Certification
- 2017 Nationwide Permit for Maintenance
- 2017 Nationwide Permit for Outfall Structures
- 2017 Nationwide Permit for Temporary Construction, Access, and Dewatering
- 2017 Nationwide Permit for Stormwater Management Facilities
- 33 CFR 325 404 Permit Application

The nationwide permits are valid only up to limits described within the permit documentation. If a project exceeds these limits, the USACE will initiate an individual permit process along with the relevant agency. Some of the agencies that could be involved in reviewing individual permits include:

- The Missouri Department of Natural Resources
- The State Historic Preservation Officer (SHPO) for cultural hotspots
- The Fish and Wildlife Service for endangered species

FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM (FUSRAP)

Another item of significance to the Airport planning is the presence of residual radioactive material from the Manhattan Project. From 1942 to 1957, uranium was extracted from ore. Material from these processes was stockpiled on land along the North boundary of the Airport. Former historic military manufacturing facilities are a federally permitted Boeing RCRA Hazardous Waste Storage Facility under Corrective Actions, including a restrictive covenant with a soil management agreement that contains a number of enforceable requirements. Shallow, alluvial groundwater in the city owned part of the property is contaminated and the surface water to groundwater pathway requires management in design and construction. The FUSRAP, administered by the USACE, St. Louis District, conducted site characterization activities on these areas. Following that, the USACE issued a Record of Decision which addressed soil contamination for accessible areas (i.e., area that were not beneath buildings or other actively used structures) and groundwater. Remediation removed much of the residual, but some radioactive material still remains in areas that have been inaccessible. This remediation area is highlighted in Figure 9.4-1. Development in areas that have been identified by FUSRAP as having been impacted will require coordination with the FUSRAP representative of the St. Louis District, USACE.

MISSOURI DEPARTMENT OF TRANSPORTATION (MODOT)

The Missouri Department of Transportation is represented in the region surrounding St. Louis Lambert International Airport by the St. Louis District, which operates in conjunction with the central headquarters in Jefferson City and is governed by the Missouri Highways and Transportation Commission. They have regulatory authority over development affecting the safety and operation of the MoDOT roadway system.

The Right-of-Way (ROW) immediately adjacent to the Airport consists of Interstate-70, Interstate I-170, Interstate-270, U.S. Highway 67 (North Lindbergh Boulevard), and State Highway B (Natural Bridge Road). The portion of Natural Bridge Road ROW, west of Cypress Road, has been vacated to the City of Bridgeton. These ROWs include several access ramp and bridge structures, such as the I-70 bridge passing over Coldwater Creek. These major highways are shown in Figure 9.4-1.

Development within MoDOT jurisdiction must conform to their permitting process which is published in the department's Engineering Policy Guide (EPG). The EPG is a dynamic electronic document which exists online and is subject to updates. The MoDOT regulatory requirements and policies pertaining to stormwater are presented primarily in sections 127, 748, 749 and 750 of the EPG.

MoDOT will evaluate projects having an effect upon ROW within its jurisdiction. For developments which affect the hydrologic characteristics of a watershed associated with a MoDOT structure or ROW, the degree of hydrologic impact will first be subjectively evaluated. The EPG stipulates that when the impacts upon the 100-year floodplain and/or regulatory floodway are estimated to be of concern, a detailed analysis shall be performed. Section 127.9.3 of the EPG presents a schematic flow chart for determining whether a floodplain development permit application will be required and if a "No-Rise" Certificate is required to be provided with the permit application.

MISSOURI DEPARTMENT OF NATURAL RESOURCES (MDNR)

MDNR is a state government agency responsible for protecting the state's air, land, water and mineral resources. The department issues NPDES permits to regulate point sources of pollutants in Missouri in accordance with the Missouri Clean Water Law and the Federal Pollution Control Act. The current NPDES permit for the Airport, active from January 1st, 2022 to March 31st, 2026, regulates two outfalls. Outfall #006 on Coldwater Creek at the North end of the Airport and Outfall #007 on Cowmire Creek at the East end of the Airport in the Cowmire Detention Basin. These locations are identified in Figure 9.4-1. The permit sets the water quality concentration benchmarks for various effluent parameters at each of the outfall locations. These permit requirements supersede any MSD water quality requirements in the area covered by the permit.

Per special condition #13 of the NPDES permit, discharge of wastewater or contaminated stormwater to Coldwater Creek or any of tributaries is prohibited unless specifically authorized with the permit. Also note that an anti-degradation analysis may be required if flow to Coldwater Creek is increased.

9.5 EXISTING CONDITION MODELS

9.5.1 INTRODUCTION

The stormwater collection system on airport property conveys flow to Coldwater Creek and Cowmire Creek, and hydraulic models were prepared for each. The Coldwater Creek Airport stormwater model was developed using PCSWMM version 7.2.2785 and the Cowmire Creek Airport stormwater model was developed using XPSWMM version 2018.2.2. The small drainage area from the East end of the Airport to Maline Creek includes overland flow and small drainage channels. Since no flood concerns were reported for this portion of the Maline Creek watershed and no significant projects were anticipated for the area, a Maline Creek model was not developed for this ALP. The models presented in this report are planning-level models which simulate major sewers, detention basins and channels located within the airport premises and simulate overland flow for flooding events.

The main goals of this modelling effort are the following:

- Build an existing model to serve as a base for assessing the impacts of developments proposed by the ALP.
- Analyze the performance of the existing system to identify flooding risks to airport operation.

The Existing Coldwater Creek Airport stormwater model is an expansion of a PCSWMM model developed by the SEMA for the proposed update to the FEMA FIRM mapping of St. Louis County. The Existing Cowmire Creek Airport stormwater model was developed using data from MSD's GIS facilities database.

9.5.2 MODEL COMPONENTS

STORMWATER SYSTEM

COLDWATER CREEK AIRPORT STORMWATER MODEL

The base SEMA Coldwater Creek PCSWMM model was expanded and modified with the help of utility data extracted from CAD, GIS and as-built drawings that were gathered during the data collection phase. See **Figure 9.5-1** for a map of the Coldwater Creek Airport stormwater model. Missing sewer inverts and pipe sizes were interpolated and extrapolated from known upstream and downstream attributes. No additional survey was completed to verify pipe invert elevations or sizes. Manning's n values for various pipe materials were set based on **Table 9.5-1**.

Table 9.5-1: Manning's for Model Pipes

PIPE TYPE	MANNING'S N
Concrete Culverts in Good Condition	0.011
Main Concrete Trunk Sewers	0.012
Other Reinforced Concrete Pipes (RCP)	0.013
Vitrified Clay Pipes (VCP)	0.017

Source: M3 Engineering, 2021.

Entrance and exit losses for all circular pipes less than 8 ft in diameter were set at 0.3 and 0.4, respectively. No entrance and exit losses were assigned to the larger culverts and pipes on the airfield as the magnitude of flow momentum in these sewers makes minor losses negligible. Structure top elevations were all estimated based on recent LiDAR data. Station-Elevation points used to describe the cross section of the Coldwater Creek channel upstream of the Coldwater Creek culvert were imported from the preliminary HEC-RAS model developed for the FEMA FIRM update. Additional points used to describe a tributary channel North of the Airport maintenance building were developed from a Digital Elevation Model (DEM) derived from recent LiDAR data. Storage rating curves were also developed for major retention basins within airport property with the help of ArcGIS software and the DEM.

Overland flow during flooding events was modelled as a series of ponding nodes (storage), overflow channels and overflow weirs. Excess flow that cannot be conveyed by the existing stormwater system ponds in the islands between the taxiways and runways on the airfield. This ponding was modelled using storage rating curves assigned to the closest node that the ponding will drain into. As excess runoff accumulates in the islands, the ponding encroaches onto nearby runways and taxiways. Once the ponded runoff reaches the centerline of the runway or taxiway, it crosses over into the next island as sheet flow. The transfer of flow from one island to the next was modelled as a simplified weir. This improves model stability and allows the system storage to be accurately modelled at each node. The crest of the weir was set to the highest elevation on the runway or taxiway along the sheet flow path and other weir parameters were set so that simulated sheet flow is no more than 0.25 ft deep over any of the runways and taxiways during a model run unless water levels are higher downstream. All non-ponding nodes within the boundary of a modelled ponding area are "sealed".

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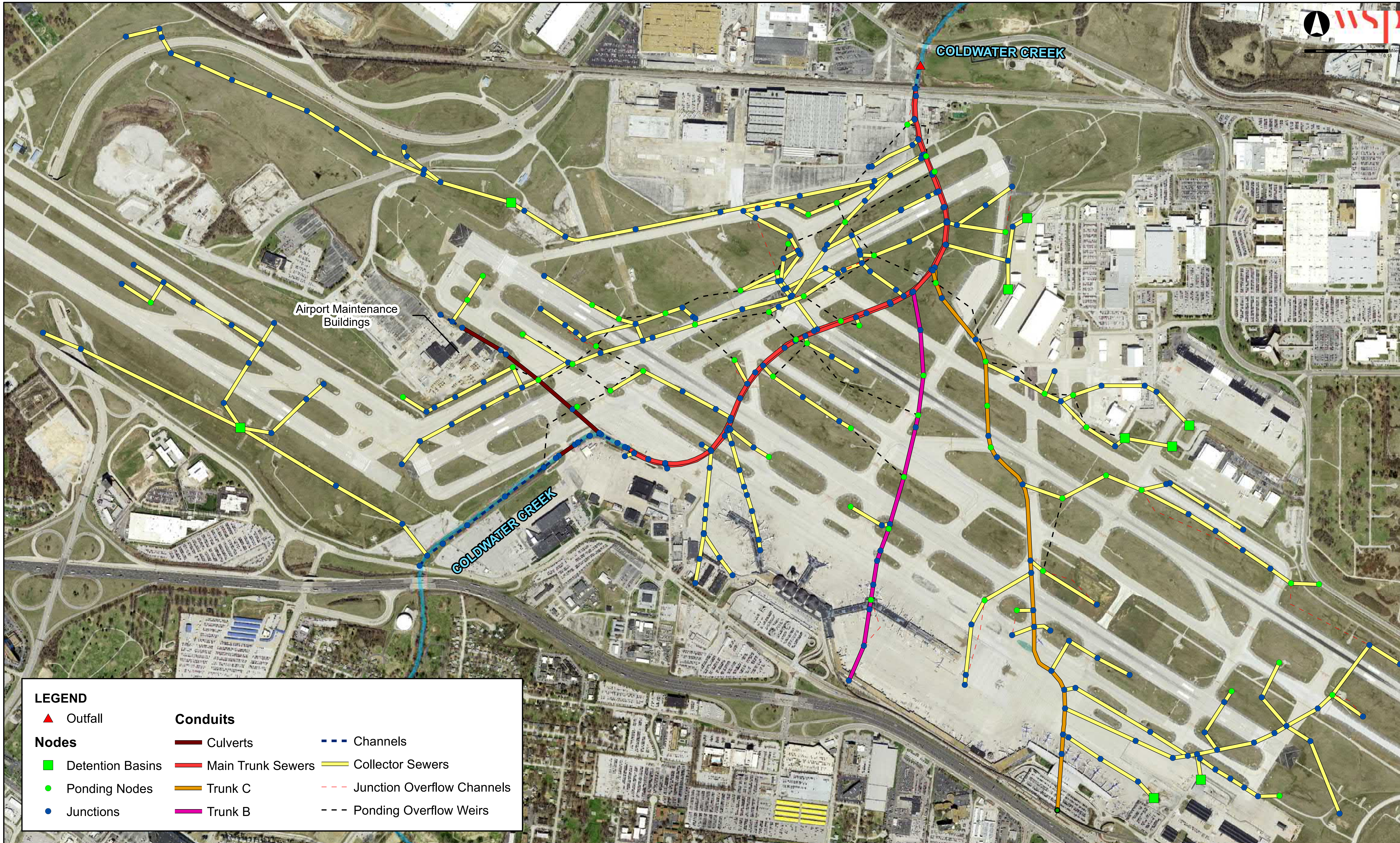
Figure 9.5-1
Coldwater Creek Airport Stormwater Model
Model Overview Map



SOURCE: M3 Engineering, 2021.

This prevents loss of excess flow from the model and forces flow into the modelled ponding nodes. Excess flow from collector sewer nodes with no ponding was routed to downstream nodes in the model using overflow channels along expected overland flow paths.

The resulting Coldwater Creek Airport model consists of the following components:

- 20.77 miles of storm sewer which includes
  - Main Coldwater Creek Trunk sewers
    - 10-ft 4-in x 15-ft double concrete box sewers
    - 12-ft x 12-ft double rectangular box sewers
  - Trunk B
    - 4-ft x 8-ft concrete box sewer
    - 6-ft 6-in to 8-ft horseshoe sewers
  - Trunk C
    - 11-ft to 13-ft concrete horseshoe sewers
    - Two 8.5-ft circular pipes connecting Trunk C to the Main Coldwater Creek Trunk sewers
- 3,354 ft of open channel
- Nine retention basins
- 143 subcatchments
- 1-D (1 Dimensional) simulation of overland flow due to flooding
  - 23 overflow channels
  - 39 ponding overflow weirs

COWMIRE CREEK AIRPORT STORMWATER MODEL

The existing stormwater system for the Cowmire Creek Airport stormwater model was imported from the MSD GIS facilities database. See **Figure 9.5-2** for a map of this model.

Unlike the Coldwater Creek model, all attribute information required for modelling the stormwater system was available within the database. Therefore, no additional data sources were required. Manning's n for the sewers in the Cowmire Creek stormwater system were also set based on Table 9.5-1. A storage rating curve for the Cowmire detention basin was developed with the help of ArcGIS software and the DEM, similar to detention basins in the Coldwater Creek model.

The resulting Cowmire Creek Airport model consists of the following components:

- 2.89 miles of storm sewer which includes
  - 8-ft 6-in Main Trunk Sewers
- The Cowmire Detention Basin
- 30 subcatchments

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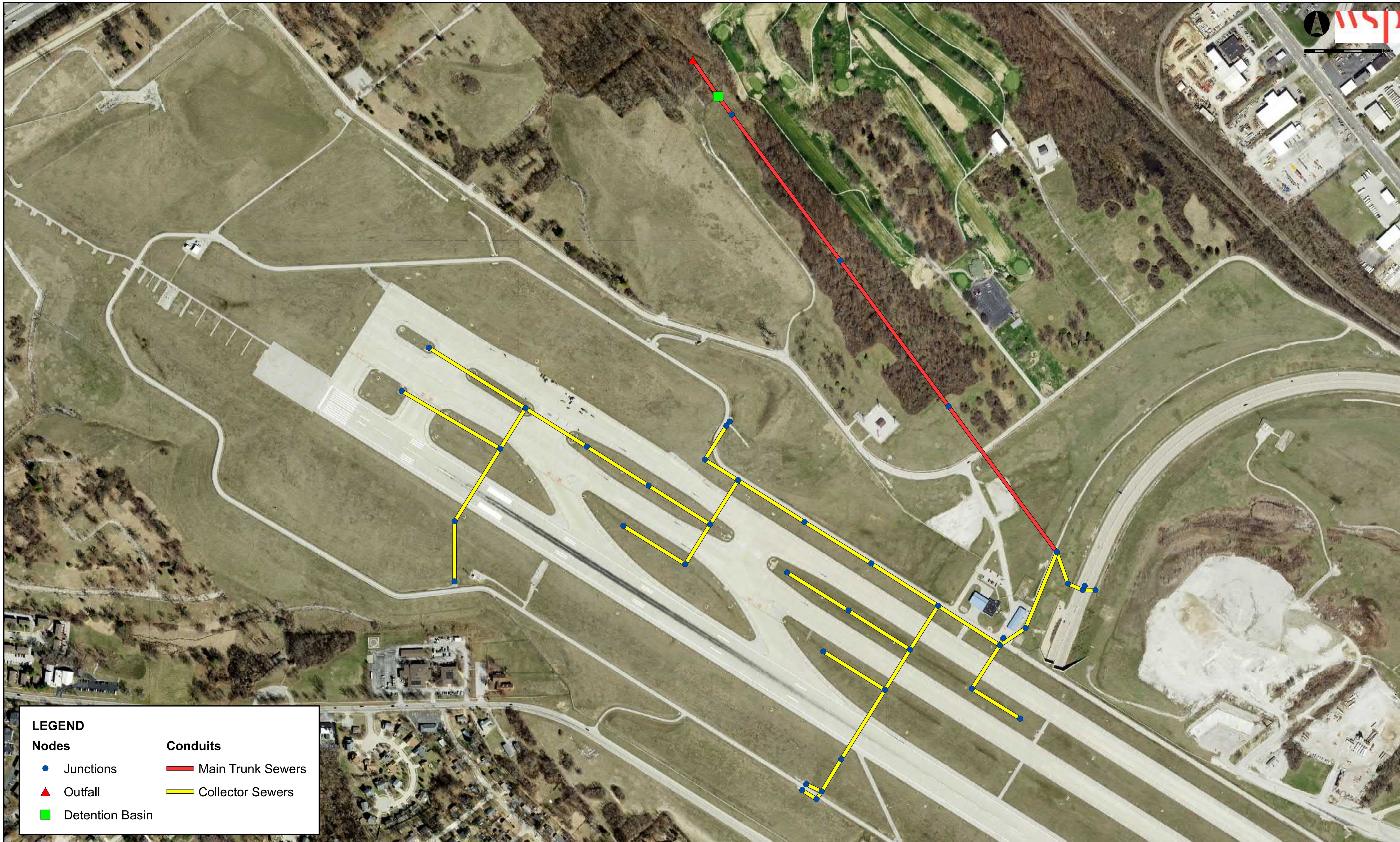
Figure 9.5-2
Cowmire Creek Airport Stormwater Model
Model Overview Map



SOURCE: M3 Engineering, 2021.

SUBCATCHMENTS

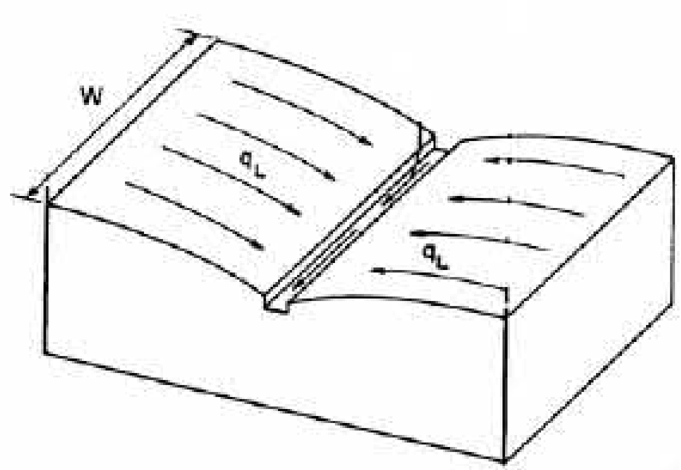
Runoff for the models was generated by delineating subcatchments. Each subcatchment unit requires information about the area, slope, percent impervious, infiltration and width. The subcatchments were delineated based on contour information available for the Airport. Average slopes for each of the subcatchments were calculated using a DEM. The percent of impervious area for each subcatchment was calculated using 2018 impervious data from MSD.

Subcatchment width in SWMM is defined as the length of overland flow. See **Figure 9.5-3** below for a simple representation of a subcatchment and its associated width (W). The subcatchment width was estimated in the following ways based on guidance from the Stormwater Management Model (SWMM) hydrology handbook[8]:

- Most of the airfield behaves like Figure 9.5-3, with the central flow channel representing flow in the island and the edges of the subcatchment representing the highpoints of the runways and taxiways draining to the island. In these cases, subcatchment width is 2W.
- For situations where the main channel is located on the edge of the subcatchment instead of the center, the subcatchment width is W.
- For subcatchments in which the main channel varies from the edge to the center along the subcatchment, a skew factor is incorporated into the width calculation as described in the SWMM Hydrology Handbook.
- Lastly, for more complex shapes, several flow paths were identified and the subcatchment width was averaged.

Infiltration characteristics for all the subcatchments were coded in the FEMA PCSWMM model.

Figure 9.5-3: Idealized Representation of a Subcatchment



Source: Storm Water Management Model Hydrology Reference Manual, Page 68

[8] Section 3.8.4, Pg 67, *Storm Water Management Model Reference Manual, Volume 1 – Hydrology (Revised)*, January 2016

9.5.3 CALIBRATION

Upstream and downstream of the project area, the Coldwater Creek model flows are calibrated to match HEC-HMS flows developed as inputs for the HEC-RAS model used for the FEMA FIRM update. Refer to Section 9.5.4 for a discussion of the upstream calibration. Peak flows at the downstream end of the airport on Coldwater Creek match input flows for the FEMA Coldwater Creek HEC-RAS model. See **Table 9.5-2** for a comparison of downstream flows:

Table 9.5-2: Comparison Between Coldwater Creek HEC-RAS Flows and Coldwater Creek Airport Model Flows at the Downstream End of The Coldwater Creek Airport Model

DESIGN STORM	HEC-RAS FLOWS (CFS)	MODEL FLOWS (CFS)	DIFFERENCE (%)
10-year 12-hour	4630	4878	5.4
50-year 12-hour	8150	7760	-4.8
100-year 12-hour	9750	9670	-0.8

Source: M3 Engineering, 2021.

Within the project area, the subcatchments in the Coldwater Creek and Cowmire Creek Airport models were calibrated to MSD design flow rates for the 15-year 3-hour storm. This approach allows for the model to represent the regulatory design flow conditions for both the floodplain analysis and design flow calculations for individual capacity analysis. Ideally, the model should be calibrated to flow meter data.

9.5.4 MODEL RUNS

DESIGN STORMS

The design rainfall events in the original PCSWMM model used a 12-hour unit hyetograph derived from historic rainfall data. However, a critical rainfall duration analysis, carried out for the FEMA FIRM update, identified the 3-hour storm as the critical rainfall event for the airport location. Accordingly, the 12-hour unit hyetograph was modified to a 3-hour unit hyetograph to simulate the design rainfall events. The rainfall totals for the 3-hour events were obtained from the NOAA Atlas 14 Point Precipitation Frequency Estimates for the St. Louis Lambert International Airport rainfall station.

The rainfall events listed in **Table 9.5-3** were run to analyze various aspects of the stormwater system:

Table 9.5-3 List of Design Storms run for the Coldwater Creek and Cowmire Creek Airport Models

DESIGN STORM EVENTS	ASSOCIATED REGULATORY AGENCIES	REQUIREMENTS
5-year 3-hour	FAA	The Airport stormwater system should be able to convey the design storm event with no encroachment of runoff on taxiways and runways.
10-year 3-hour	FAA	The center 50 percent of Airport runways and taxiways serving these runways should be free from ponding.
15-year 3-hour (CAPACITY)	MSD	MSD storm sewer design requires that sewers be able to convey the 15-year peak discharge rate. For this analysis, the Coldwater Creek Airport Model was run without upstream Coldwater Creek inflow to analyze the capacity of sewers without the influence of Coldwater Creek.
50-year 3-hour	FAA	Check event to identify flooding risks to airport operation.
100-year 3-hour	FAA MSD FEMA	Check event to identify flooding risks to airport operation. Peak discharge rates for MSD stormwater detention design are based on 100-year peak flows. New developments must not impact the FEMA floodplain which is based on the 100-year event.

Source: M3 Engineering, 2021.

BOUNDARY CONDITIONS

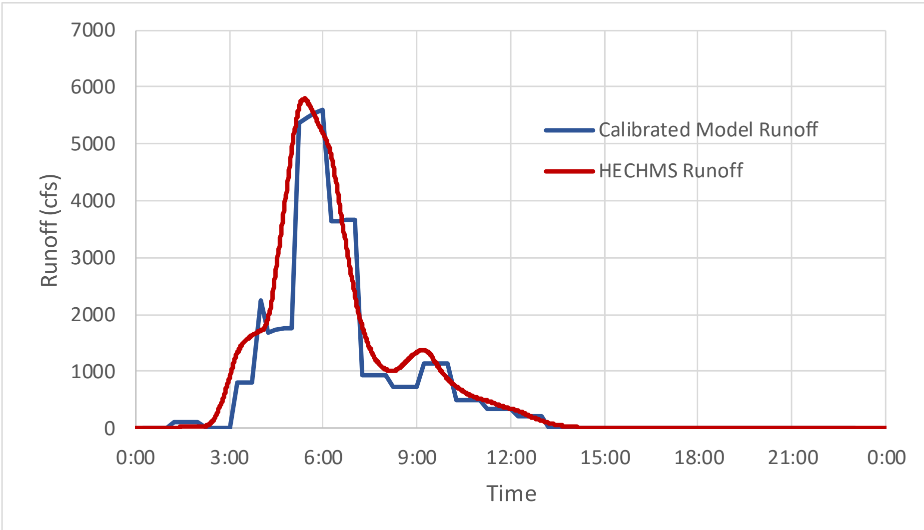
COLDWATER CREEK AIRPORT STORMWATER MODEL

Flow at the upstream end of the model is generated from a dummy subcatchment. The parameters of the dummy subcatchment were calibrated to match incoming flow from the HEC-HMS model which was also used to generate flows for the FEMA Coldwater Creek HEC-RAS model. The calibrated flow matches flow generated for the 50-year 12-hour storm (see **Figure 9.5-4**). However, the dummy subcatchment underestimates flow for the 100-year 12-hour storm and overestimates flow for the 10-year 12-hour storm. The downstream boundary condition is set as a free outfall per the original FEMA PCSWMM model.

COWMIRE CREEK AIRPORT STORMWATER MODEL

The downstream end of the Cowmire Creek Model is modelled as a free outfall.

Figure 9.5-4: Comparison of Calibrated Runoff at the Upstream End of the Coldwater Creek Airport Model and Flow Generated for the FEMA Coldwater Creek HEC-RAS Model for the 50-year 12-hour Storm



Source: M3 Engineering, 2021.

9.5.5 MODEL RESULTS

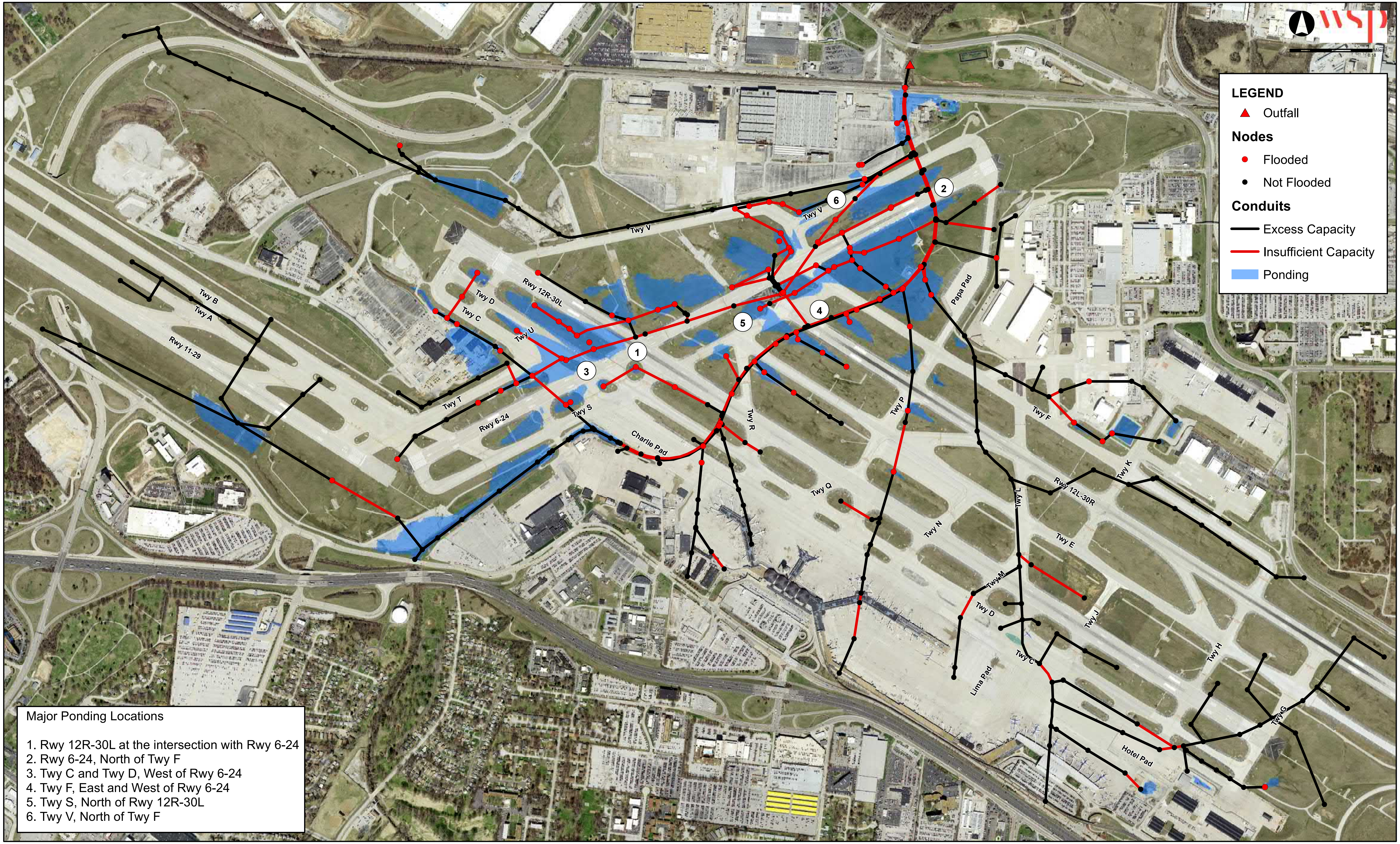
The model results observed match well to the areas where the Airport staff has acknowledged periodic stormwater ponding. The Coldwater Creek Airport model shows widespread ponding for all design storm events. The Cowmire Creek model shows no ponding for any of the storm events.

5-YEAR 3-HOUR EVENT

An analysis of the 5-year storm was run to determine whether the existing stormwater system meets the FAA circular 150/5320-5D requirement that the airport stormwater system should be able to convey a 5-year design storm event with no encroachment of runoff on the taxiway and runways pavements, including paved shoulders. Any calculations and provisions for temporary storage and ponding between the runways, taxiways and aprons should only be considered as a safety factor for events beyond the 5-year return period. This temporary storage should not exceed over 4 inches around an inlet.

The results of the 5-year storm analysis for the Coldwater Creek Airport model are shown in **Figure 9.5-5**.

Figure 9.5-5
Coldwater Creek Airport Stormwater Model
5-yr 3-hr Model Results



SOURCE: M3 Engineering, 2021.

The stormwater system does not meet the recommended FAA guidelines for the 5-year storm event since stormwater ponding is forecast to encroach on the following runways and taxiways:

- Runway 12R-30L at the intersection with Runway 6-24
- Runway 6-24, North of Taxiway F
- Taxiway C and D, West of Runway 6-24
- Taxiway F, East and West of Runway 6-24
- Taxiway S, North of Runway 12R-30L
- Taxiway V, North of Taxiway F

The Cowmire Creek Airport model does not forecast any ponding on the runways and taxiways.

10-YEAR 3-HOUR EVENT

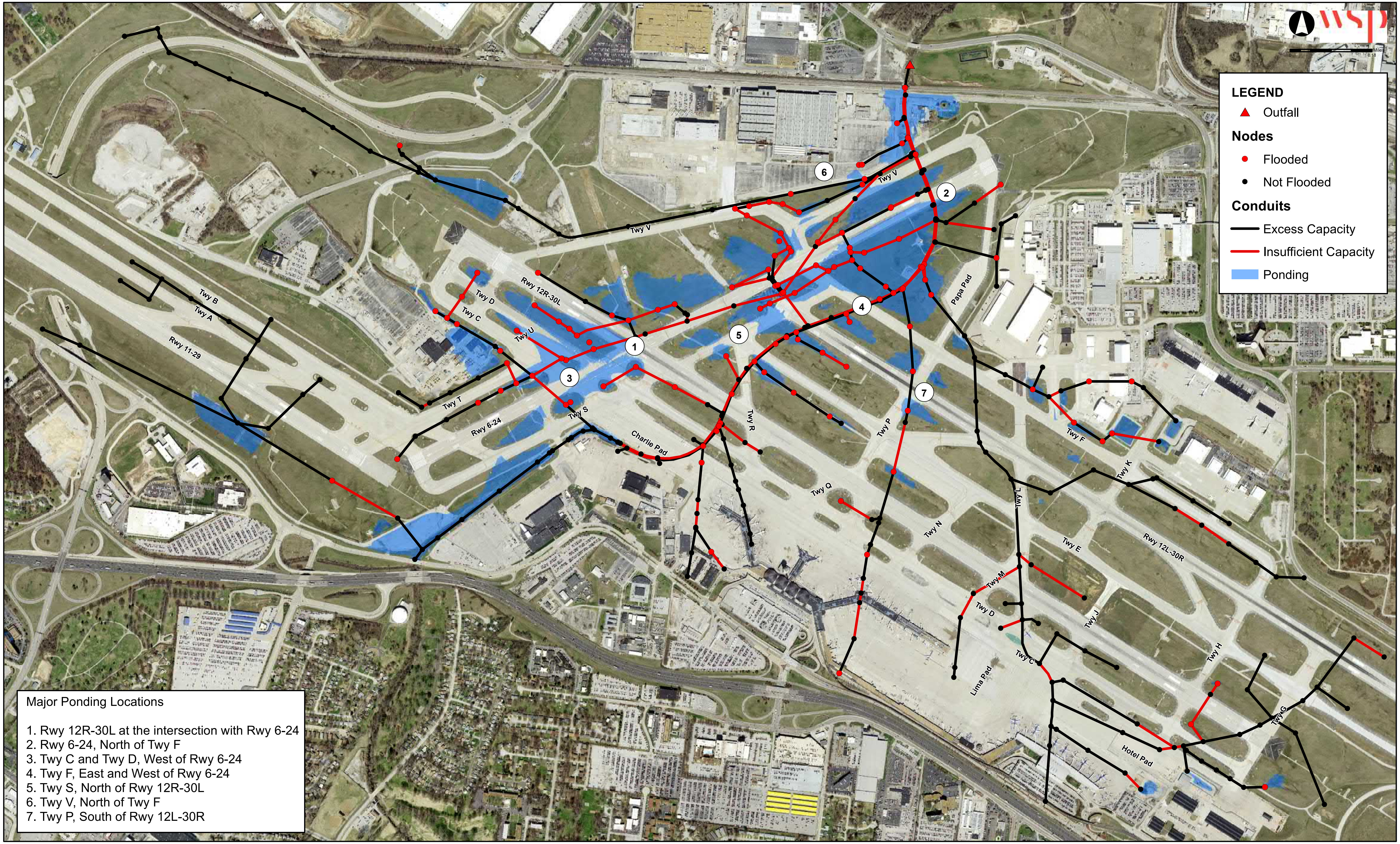
FAA circular 150/5320-5D recommends that the airport stormwater system should be able to convey a 10-year event with the center 50 percent of runways and the center 50 percent of taxiways free from ponding. FAA circular 150/5320-5D also recommends the 10-year design storm event is the minimum event that should be used for storm water analysis of all non-airfield areas within the airport boundaries.

Stormwater ponding is forecast at similar locations to the 5-year event, but the ponding areas are slightly greater in size. The results of the 10-year storm analysis are shown in **Figure 9.5-6**. The stormwater system does not meet the recommended FAA guidelines for the 10-year storm event since the center 50 percent of the following taxiways and runways are not free from ponding:

- Runway 12R-30L at the intersection with Runway 6-24
- Runway 6-24, North of Taxiway F and South of Runway 12R-30L
- Taxiway C and D, West of Runway 6-24
- Taxiway F, East and West of Runway 6-24
- Taxiway S, North of Runway 12R-30L
- Taxiway V, North of Taxiway F
- Taxiway P, South of Runway 12L-30R

The Cowmire Creek Airport model does not forecast any ponding on the runways and taxiways.

Figure 9.5-6
Coldwater Creek Airport Stormwater Model
10-yr 3-hr Model Results



SOURCE: M3 Engineering, 2021.

15-YEAR 3-HOUR EVENT CAPACITY ANALYSIS

An analysis of the 15-year storm was run on local airport sewers as MSD design requirements use the 15-year storm as the standard for storm sewer pipe sizing. For this analysis, the incoming flow from Coldwater Creek, upstream of the airport, was removed to better assess local Airport storm sewer pipe capacity.

As shown in **Figure 9.5-7**, approximately half of the local Airport sewers are at capacity or have insufficient capacity (Capacity Ratio > 1) to convey local drainage for a 15-year, 3-hour storm event. The system surcharges to grade at 69 storm sewer structures.

The sewer capacity analysis provides further confirmation of known ponding areas provided by the Airport staff identified in Section 9.3.3. Specific examples where the sewer model results match staff observed ponding or flooding include:

- Surcharge to grade is forecast at a storm sewer structure adjacent to the climate control building.
- Surcharge to grade is forecast at 10 storm sewer structures in the vicinity of Taxiway F, West of Runway 6-24.
- Surcharge to grade is forecast at 2 storm sewer structures West of the Papa Pad.
- Surcharge to grade is forecast at 13 storm sewer structures in the island between Taxiways C, D, T, and U West of Runway 6-24.
- Surcharge to grade is forecast at 1 storm sewer structure near the East Service Road entrance near the intersection of Taxiway C and Taxiway G.
- Surcharge to grade is forecast at 1 storm sewer structure in the island between Taxiways Q, D, P and Runway 12R-30L.

Other locations with model flooding include:

- Surcharge to grade is forecast at 5 storm sewer structures in the vicinity of Taxiway G.
- Surcharge to grade is forecast at 1 storm sewer structure between the North Service Road and Taxiway P.
- Surcharge to grade is forecast at 8 storm sewer structures North of Taxiway F and West of Taxiway K.

No structures surcharge to grade in the Cowmire Creek Airport model.

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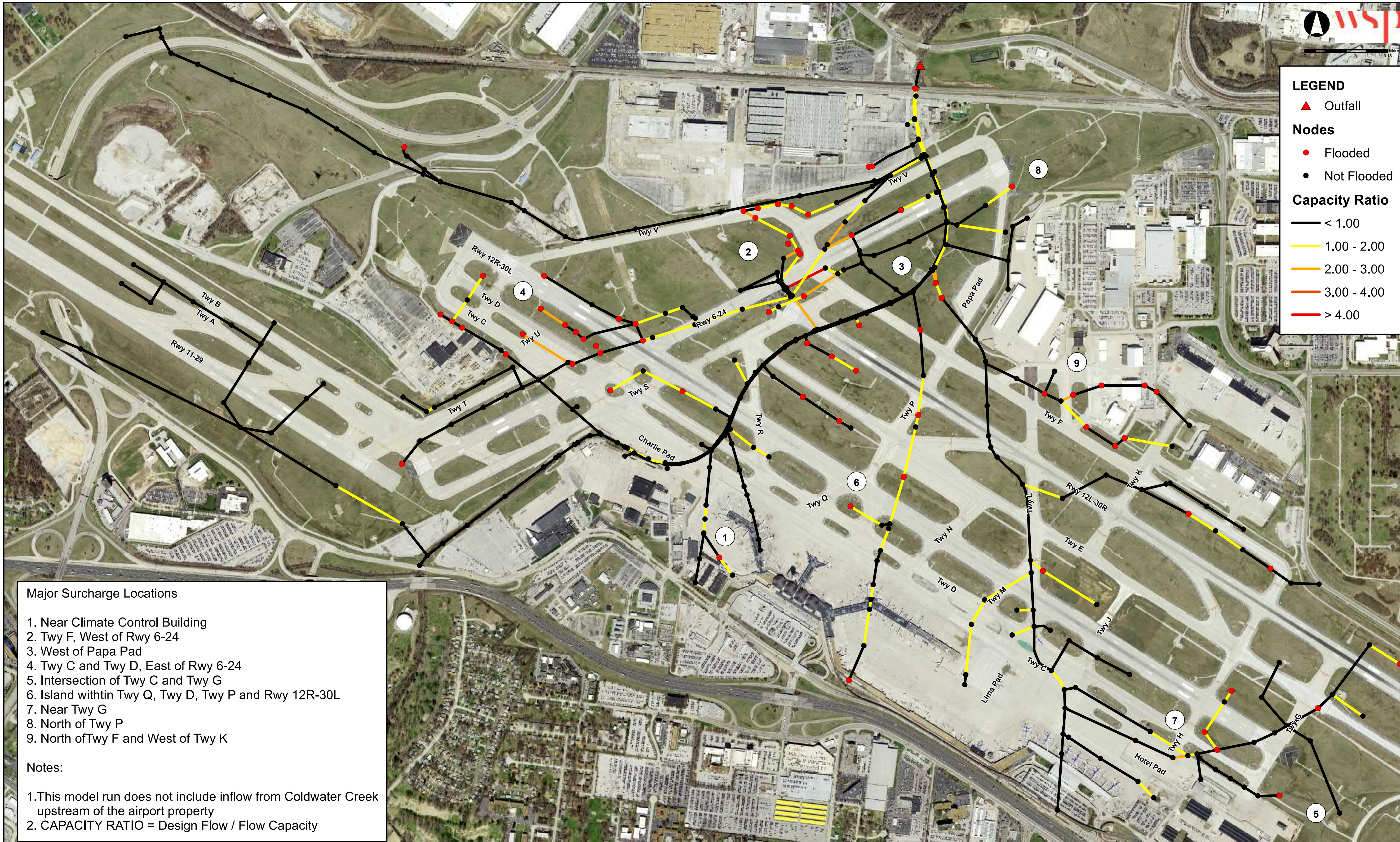
Figure 9.5-7
Coldwater Creek Airport Stormwater Model
15-yr 3-hr Capacity Model Results



Major Surcharge Locations

1. Near Climate Control Building
2. Twy F, West of Rwy 6-24
3. West of Papa Pad
4. Twy C and Twy D, East of Rwy 6-24
5. Intersection of Twy C and Twy G
6. Island withtin Twy Q, Twy D, Twy P and Rwy 12R-30L
7. Near Twy G
8. North of Twy P
9. North ofTwy F and West of Twy K

Notes:

1. This model run does not include inflow from Coldwater Creek upstream of the airport property
2. CAPACITY RATIO = Design Flow / Flow Capacity

SOURCE: M3 Engineering, 2021.

50-YEAR 3-HOUR AND 100-YEAR 3-HOUR EVENTS

The 50-year, 3-hour and 100-year, 3-hour design storms were run to determine what effects major storm events will have on the Airport sewer system, as compared to what is shown in the preliminary FEMA FIRM map of the airport shown in Figure 9.4-3. The forecasted flooding for the 50-year storm event is shown in **Figure 9.5-8** and the 100-year storm flooding is shown in **Figure 9.5-9**. Flooding is forecast in similar areas for both storms with the extent of flooding being greater for the 100-year storm, as expected.

Runways and taxiways completely covered by flooding for these storms are:

- Runway 6-24, between Runway 12R-30L and Taxiway C
- Taxiway C and D, West of Runway 6-24
- Taxiway F, East and West of Runway 6-24
- Taxiway S, North of Runway 12R-30L through Taxiway F
- Taxiway V, North of Taxiway F

These model results match well to the areas where the Airport staff has acknowledged periodic stormwater ponding. The ponding and flooding shown also matches the locations where the preliminary FEMA flood map predicts flooding for the 100-year event but does not reflect the same extent of flooding. This difference occurs because the model used for this project is a 1-D model and the FEMA analysis reflects results from a 2-D model.

The Cowmire Creek Airport Stormwater model does not show any ponding on the airfield for the 50-year and 100-year storm events.

9.5.6 CAUSES OF FLOODING

LOCAL SEWERS

No ponding on taxiways or runways due to insufficient sewer capacity of local sewers was identified in the analysis of either the 5-year or 10-year design storm events. As shown in Figure 9.5-5 and Figure 9.5-6, there are several local sewers that have insufficient capacity to convey the 5-year and 10-year design storms. However, ponding due to local sewer capacity does not reach any taxiways or runways. Ponding shown during the 5-year and 10-year design storm are the result of capacity issues in the Coldwater Creek culverts.

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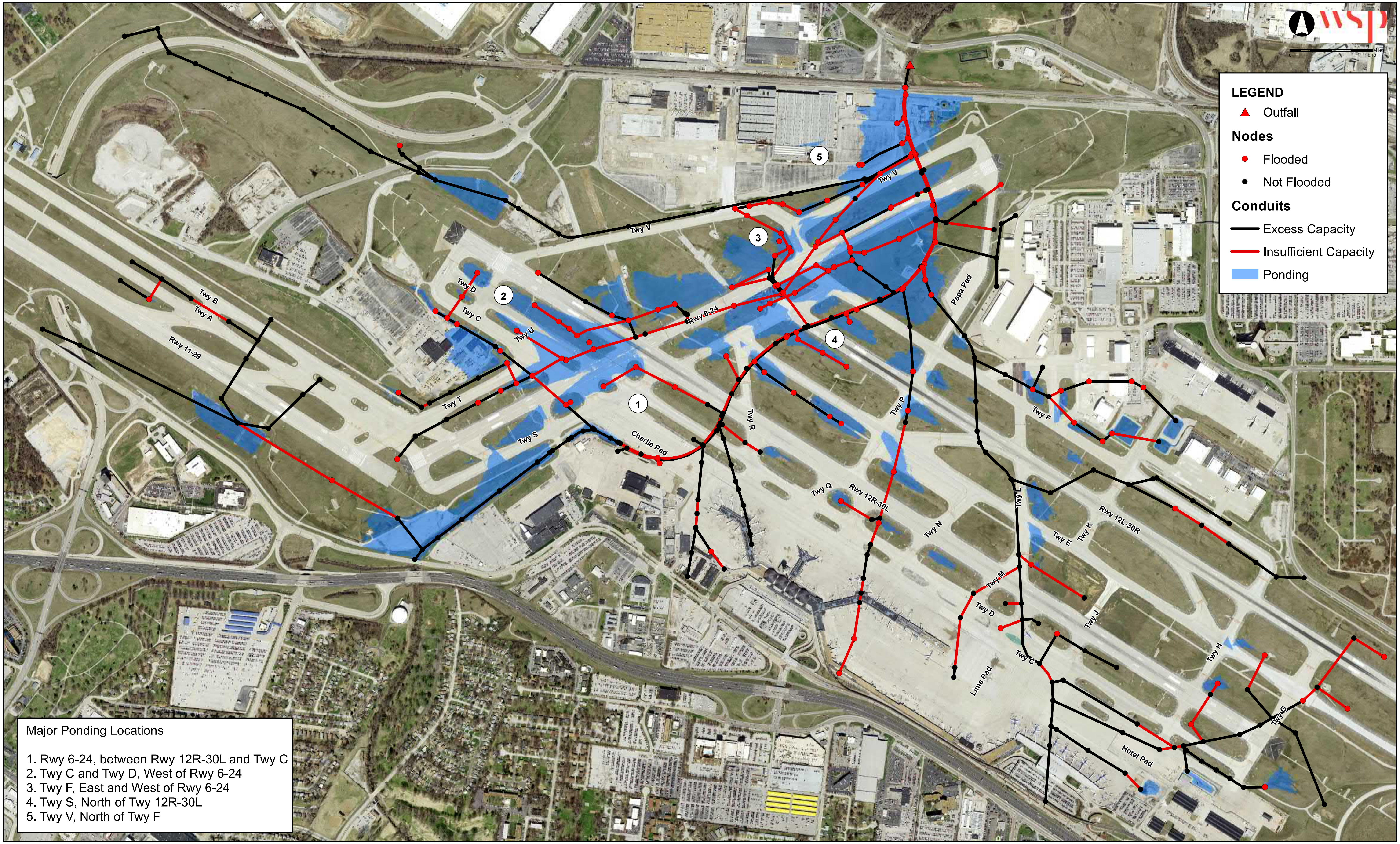
Figure 9.5-8
Coldwater Creek Airport Stormwater Model
50-yr 3-hr Model Results



Major Ponding Locations

1. Rwy 6-24, between Rwy 12R-30L and Twy C
2. Twy C and Twy D, West of Rwy 6-24
3. Twy F, East and West of Rwy 6-24
4. Twy S, North of Twy 12R-30L
5. Twy V, North of Twy F

SOURCE: M3 Engineering, 2021.

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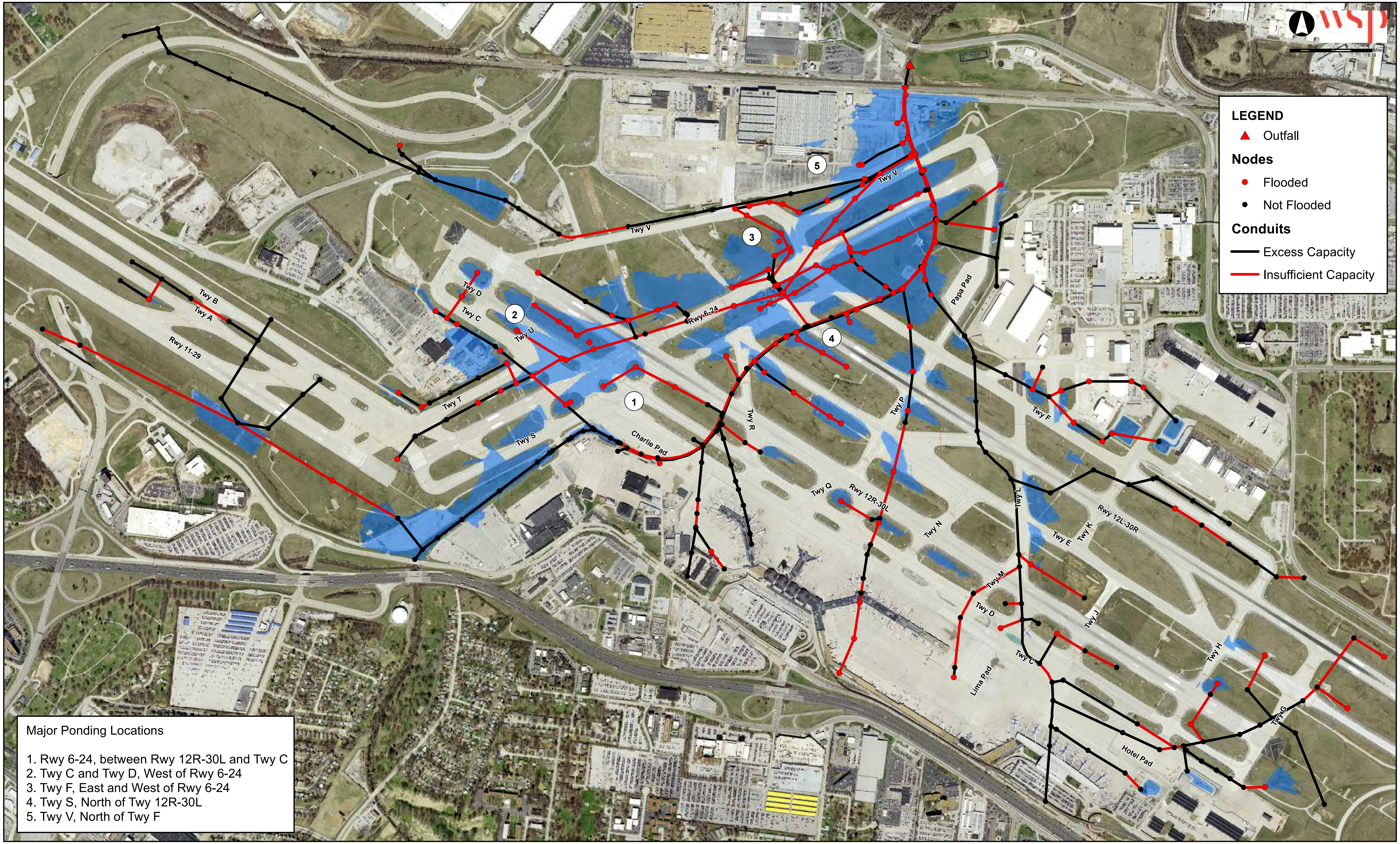
Figure 9.5-9
Coldwater Creek Airport Stormwater Model
100-yr 3-hr Model Results



SOURCE: M3 Engineering, 2021.

IMPACT OF COLDWATER CREEK

The critical overland flow paths over the airfield for excess flow from Coldwater Creek are shown in **Figure 9.5-10** for the 10-year 3-hour storm. The majority of flooding that occurs on the airfield on the West side of Runway 6-24 and South of Runway 12R-30L is due to the water level in Coldwater Creek near Charlie Pad where Coldwater Creek passes through a 10-ft 8-in x 15-ft box culvert under Taxiway S and Runway 6-24. When the water level at this location rises above 518.45 ft, flow from Coldwater Creek backs up into the culvert and ponds at the open culvert junction in the island between Taxiway C, Taxiway T and Runway 6-24 and further upstream to an open junction near the Airport maintenance buildings. When the water elevation rises to 533 ft, excess flow overtops Taxiway C and travels Northeast across Runway 12R 30L, Taxiway F and Taxiway V before rejoining Coldwater Creek North of Banshee Road. Given the finished floor at the Airport maintenance buildings range from 529.79 to 529.87, this ponding of flow up to Taxiway C floods the airport maintenance buildings in the model as they are situated lower than the taxiway. However, the Airport maintenance building storm system is isolated from flooding at Taxiway C with a flap gate (not modelled) and excess flow is pumped from the maintenance building area to the open culvert junction Northeast of the buildings.

Excess flow from the double box culvert that conveys Coldwater Creek under the airfield also tops out at connected inlets and ponds in the islands on either side of Taxiway S, North of Runway 12R-30L. As ponding levels in these islands increase, stormwater will eventually overtop the runways and taxiways adjacent to the islands and flow towards Coldwater Creek North of Banshee Road over Runway 6-24 and Taxiway V.

Both flow paths lead to a 90-ft wide opening under a bridge North of Banshee Road (pictured in Figure 9.5-10), which will control the outflow of overland flow into Coldwater Creek.

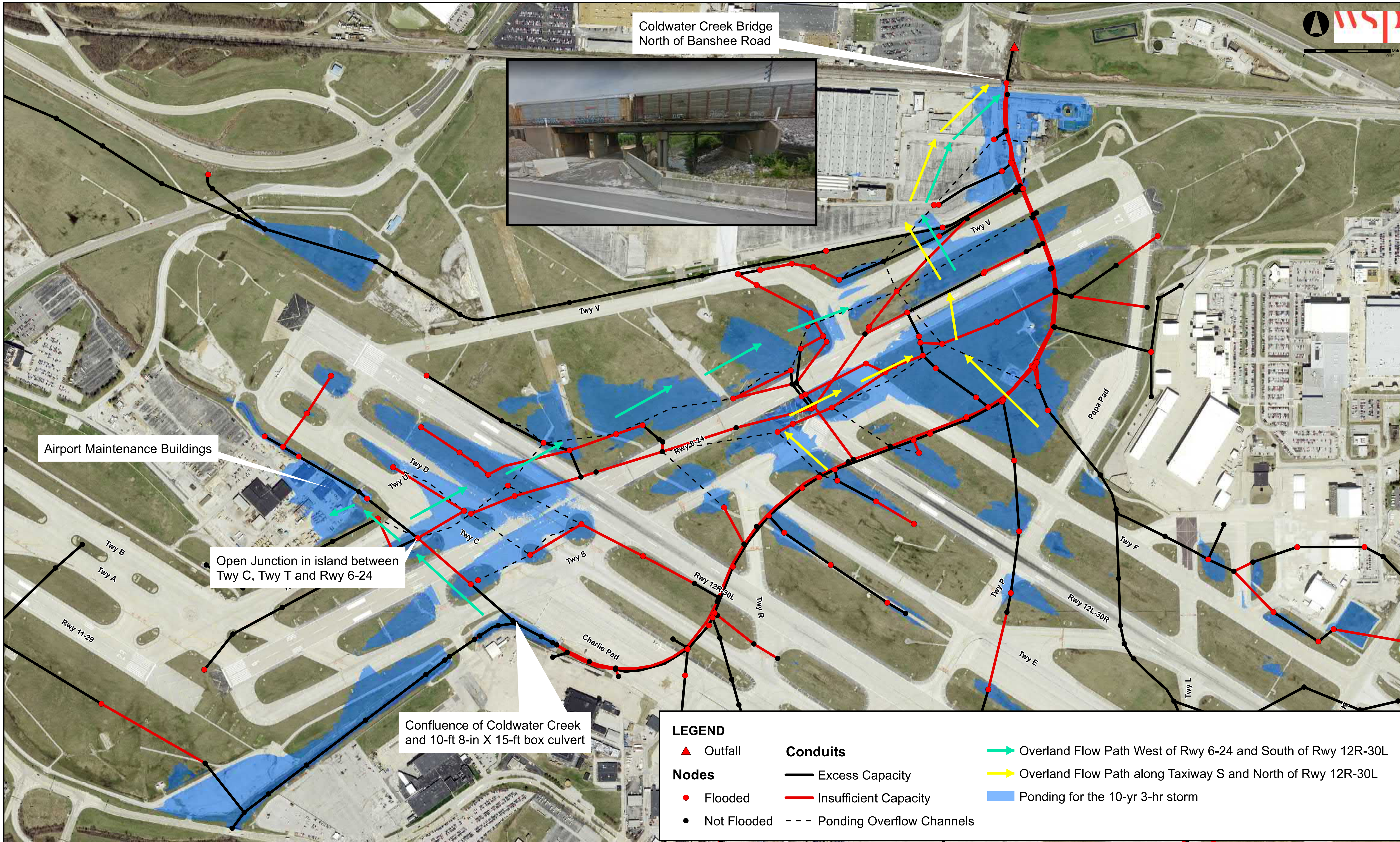
CAPACITY ANALYSIS INTERPRETATION

The results of the capacity analysis for the 15-year 3-hour storm in Section 9.5.3 show that many of the known flooding issues are corroborated by the model. However, the inverts, pipe sizes and pipe locations for some of these locations have been interpolated or estimated due to non-availability of data or conflicting data. Data source types used in the model are highlighted in **Figure 9.5-11**. It is recommended that the following parts of the system be further investigated or surveyed to identify active pipes and inverts.

- Main Coldwater Creek Trunk sewers – 10-ft 4-in x 15-ft double concrete box sewers and side connection inverts.
- Storm sewers to the East and West of Runway 6-24
- Storm sewers on the Missouri Air National Guard Complex

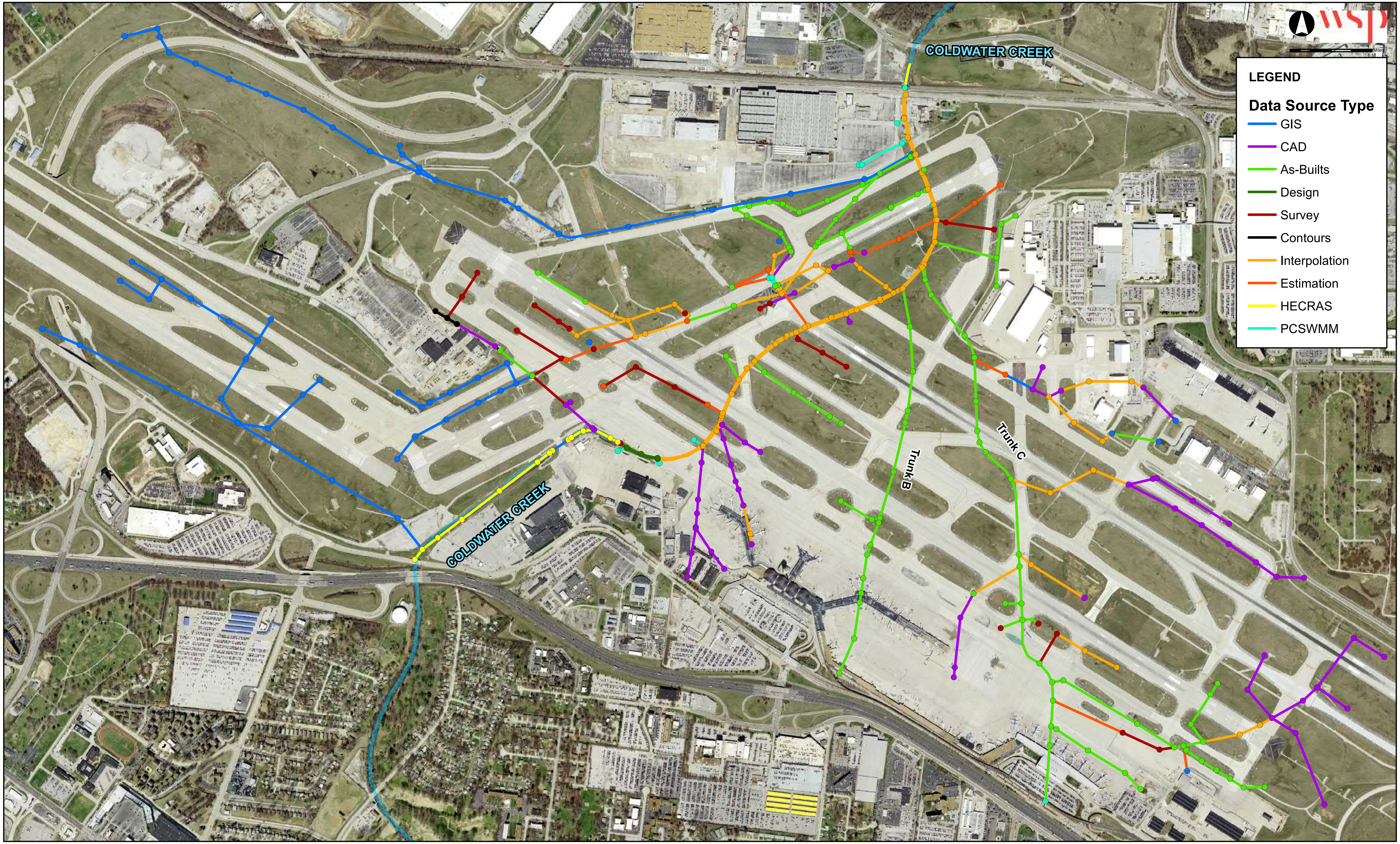
Flow monitoring is also recommended at key locations in the airport stormwater system so that the model can be calibrated to represent system behavior more accurately.

Figure 9.5-10
Coldwater Creek Airport Stormwater Model
Critical Overland Flow Paths for 10-yr 3-hr Storm



SOURCE: M3 Engineering, 2021.

Figure 9.5-11
Coldwater Creek Airport Stormwater Model
Model Data Source Types



SOURCE: M3 Engineering, 2021.

9.6 ANALYSIS OF ALTERNATIVES

9.6.1 INTRODUCTION

This section discusses hydraulic considerations for the proposed developments in the ALP and high-level planning solutions to alleviate ponding on the runways and taxiways for the 5-year and 10-year design events to bring the airport stormwater system in compliance with FAA flooding guidelines. FAA stormwater system guidelines dictate that there must be no ponding on the runways and taxiways for the 5-year event and no ponding on the center 50% of the runways and taxiways for the 10-year event.

The existing stormwater model was first updated with the proposed projects from the ALP. The proposed projects include new site developments and re-location of taxiways. The locations of these projects are shown in **Figure 9.6-1**. These modifications result in changes to impervious area for subcatchments throughout the airport watershed which impact the amount of runoff generated and entering the stormwater system. Some subcatchment boundaries will also change as a result of these projects. Major proposed site developments impacting impervious area include:

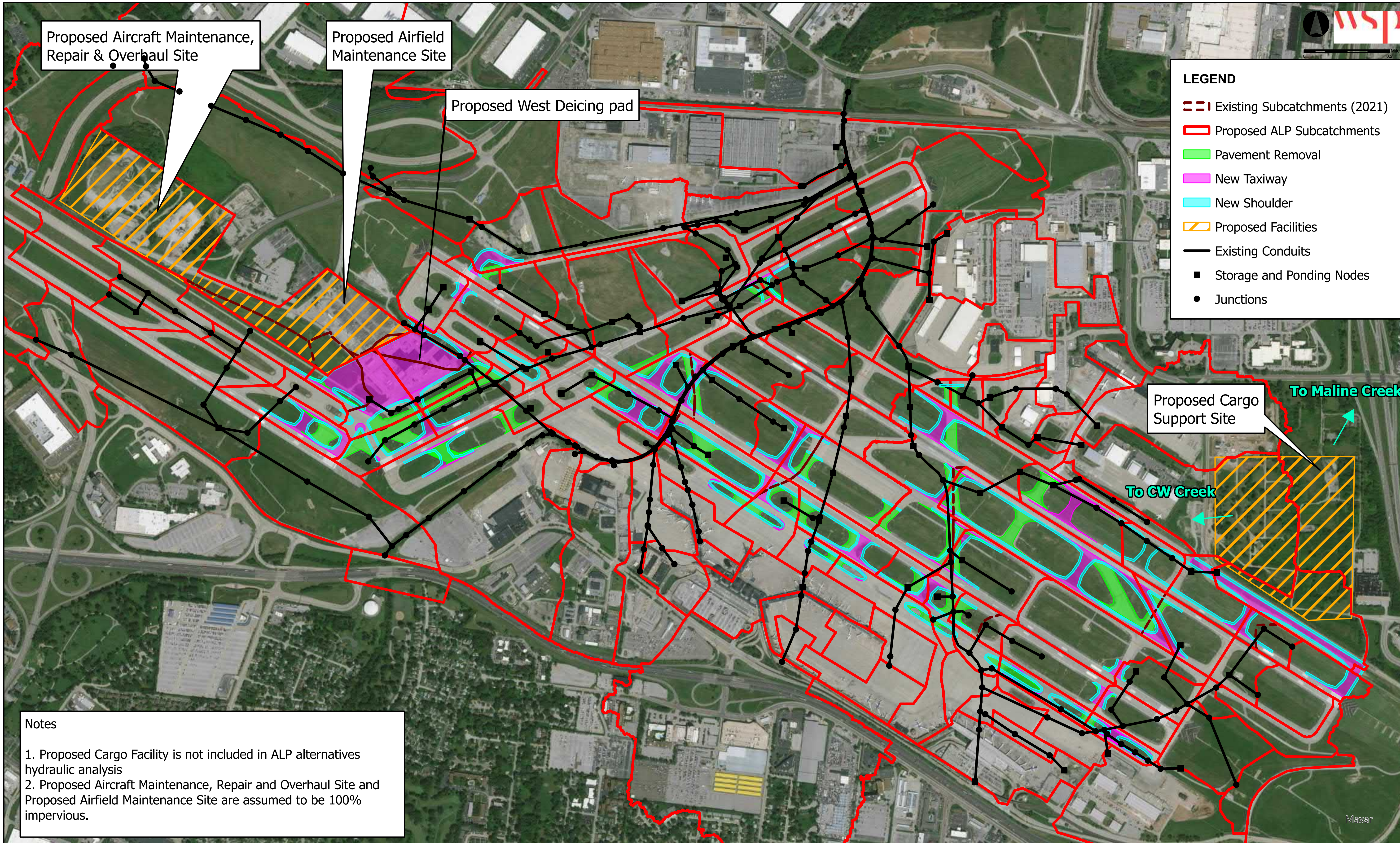
- The Aircraft Maintenance, Repair and Overhaul (MRO) Site
- The Airfield Maintenance Site
- The West Deicing Pad
- Cargo Support Site
- The aircraft MRO site and airfield maintenance site support site will be situated adjacent to each other, North of Runway 11-29 and West of Runway 6-24. With the conservative assumption that these sites will be 100% impervious, it was estimated that 40 acres of impervious area will be added to the watershed. Along with these site development projects, several changes to taxiway alignments are proposed in the ALP. These alignment changes will result in an increase in impervious area of 3 acres.

Two changes were made to the model to account for the proposed projects. First, the subcatchment boundaries were modified to follow the alignments of the new taxiways and development sites. Second, impervious areas were re-calculated for the subcatchments where pavement is to be added or removed. The changes to subcatchment boundaries are shown in Figure 9.6-1 and the changes to impervious area are shown in **Figure 9.6-2**.

The updated model was then run to establish the impacts of the ALP projects. Increases and decreases in runoff were observed in subcatchments that had corresponding increases and decreases in impervious area. However, the changes to impervious area did not have a significant impact on level of flooding observed on the airfield.

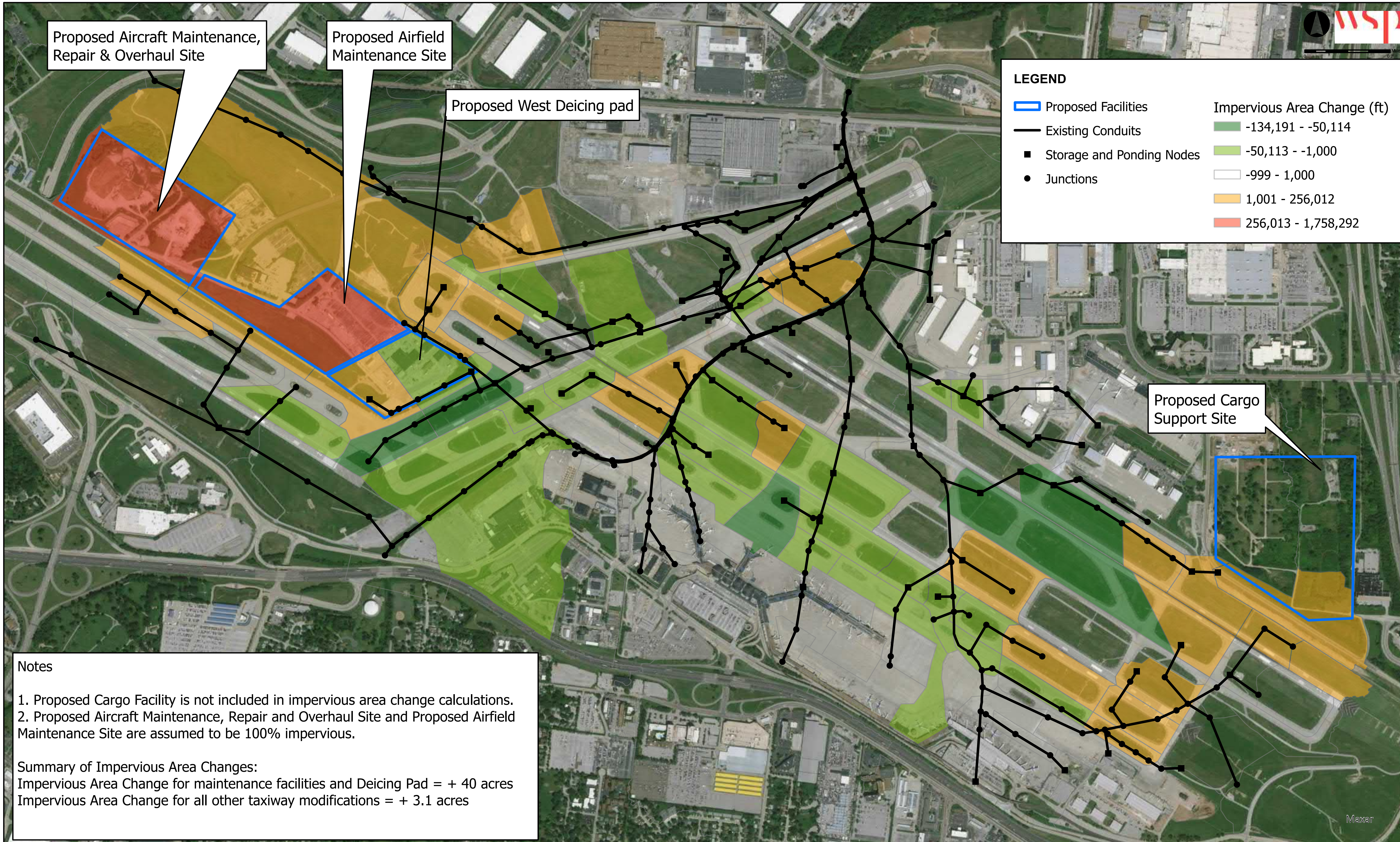
As discussed in detail in Section 9.5.6, the ponding on the runways and taxiways for the 5-year and 10-year design events occurs due to high water levels in Coldwater Creek near Charlie Pad where Coldwater Creek passes through a 10-ft 8-in x 15-ft box culvert under Taxiway S and Runway 6-24. For the 5-year and 10-year design events, the water levels in the Creek are higher than the runways and taxiways, thereby causing ponding over these safety critical features.

Figure 9.6-1
Analysis of Alternatives
Proposed Airport Layout Plan and Subcatchment Modifications



SOURCE: M3 Engineering, 2021.

Figure 9.6-2
Analysis of Alternatives
Impervious Area Changes



Notes

1. Proposed Cargo Facility is not included in impervious area change calculations.
2. Proposed Aircraft Maintenance, Repair and Overhaul Site and Proposed Airfield Maintenance Site are assumed to be 100% impervious.

Summary of Impervious Area Changes:
Impervious Area Change for maintenance facilities and Deicing Pad = + 40 acres
Impervious Area Change for all other taxiway modifications = + 3.1 acres

SOURCE: M3 Engineering, 2021.

9.6.2 SITE DEVELOPMENT DETENTION – NORTH BASIN

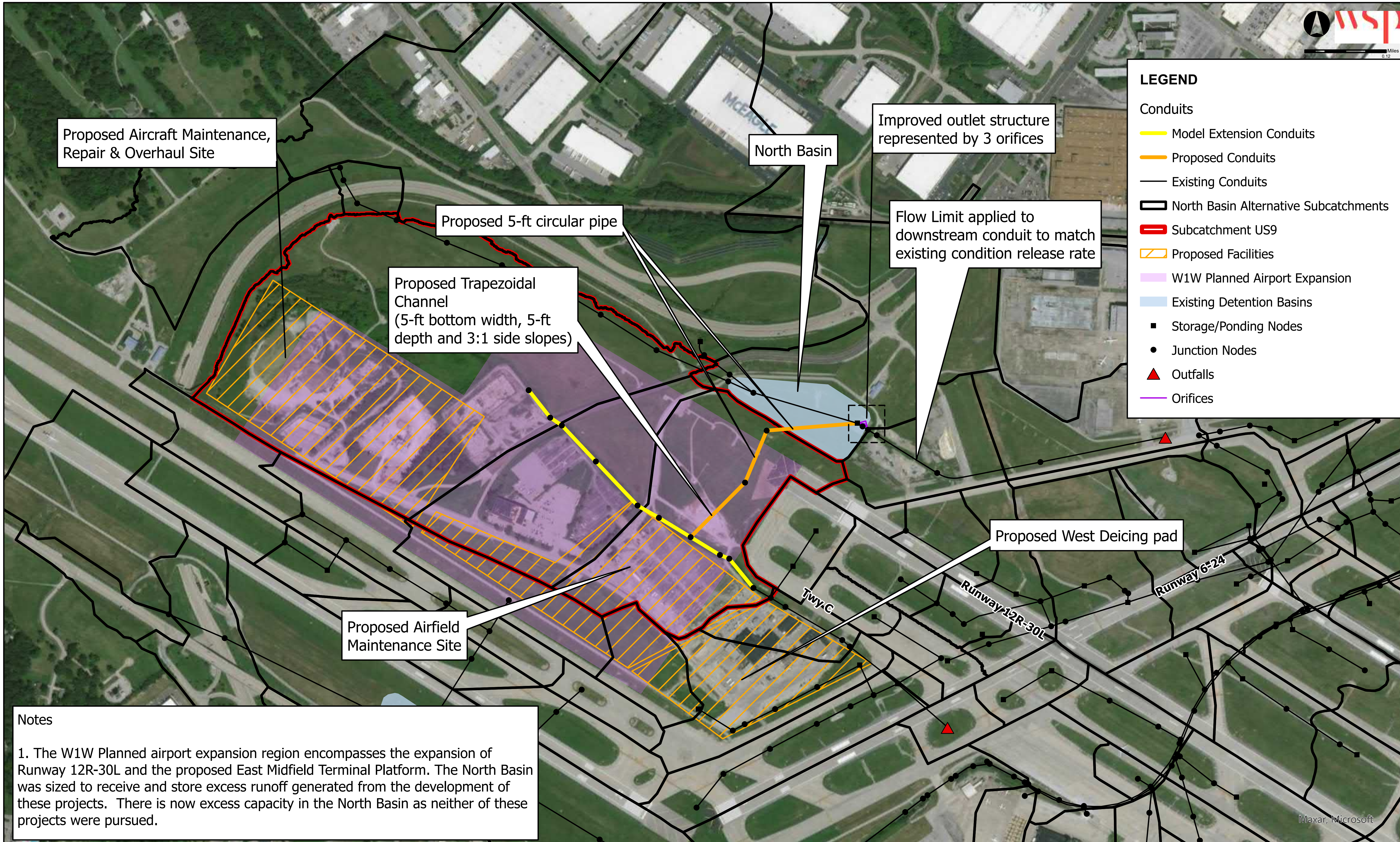
The addition of the Proposed Aircraft MRO site and Proposed Airfield Maintenance Site is expected to increase impervious area by a significant amount, which will likely require detention basin provisions. Impervious area was estimated to increase by approximately 40 acres with the addition of the maintenance buildings and the de-icing pad. The increase in impervious area was determined by using 2018 impervious areas provided by MSD for existing conditions and the assumption that all the area within the proposed site development boundary (Proposed Aircraft MRO site and Proposed Airfield Maintenance Site) will be impervious for future conditions. These assumptions lead to a conservative estimate of increase in impervious area as there may be more existing impervious area than the 2018 impervious area data suggests, and it is unlikely that 100% of the area within the proposed development boundary will be impervious. Actual anticipated increases in impervious area should be studied in detail and incorporated into the model during design.

During the development of the North and South detention basins for the W1W expansion project, the North Basin was sized for a future scenario which involved conveying runoff from the expansion of Runway 12R-30L and the development of the East Midfield Terminal Platform (see **Figure 9.6-3** for an outline of the proposed expansion) to the North Basin. This expansion was never pursued, leaving unused capacity in the North Basin. Therefore, it should be possible to route additional flow from the proposed Aircraft MRO and Airfield Maintenance sites to the North Basin to maintain existing peak flows in Coldwater Creek. The W1W detention basin solution was designed using an XPSWMM model of the Coldwater Creek watershed. While the model could not be sourced during the data collection phase, MSD was able to provide the 60 percent design report which contains the model output text file and maps of the results. The results contained in the W1W report were compared to the existing ALP stormwater models. The ALP generated flows were found to be significantly higher due to differences in subcatchment infiltration modeling. For the purposes of analyzing the usage of the North detention basin for additional flow, parts of the ALP model were modified to replicate the W1W model.

The modifications consisted of the following steps:

- Extending the existing tributary channel to Coldwater Creek location between the proposed airfield maintenance site and Taxiway C
- Dividing the existing model subcatchment US9 (which encompasses the proposed development area) into three separate subcatchments to refine inflows to the extended model
- Modifying the outlet structure representation of the North Basin to include three orifices based on the North Basin design plans
- Changing the infiltration parameters for all subcatchments to match the W1W model infiltration parameters
- Converting two nodes downstream of the North Basin and the Coldwater Tributary into outfalls to analyze 100-year peak flows without the influence of Coldwater Creek

Figure 9.6-3
Analysis of Alternatives
North Basin Alternative



Notes

1. The W1W Planned airport expansion region encompasses the expansion of Runway 12R-30L and the proposed East Midfield Terminal Platform. The North Basin was sized to receive and store excess runoff generated from the development of these projects. There is now excess capacity in the North Basin as neither of these projects were pursued.

SOURCE: M3 Engineering, 2021.

The St. Louis Metropolitan Sewer District (STLMSD) mandates that the post-development peak flow from a site-development may not exceed the existing routed peak flow for the 2-year and 100-year 24-hour events. MSD specifies a rainfall quantity of 7.2" to be used for the 100-year 24-hour rainfall event, which was applied to an SCS Type II design storm curve to generate the design event. All excess flow must be detained on site and released in a controlled manner in order to not exceed the existing peak flows. The modified existing model was run to identify the existing condition peak flow rate. It was found that the existing peak flow rate downstream of the North Basin detention structure was 172.88 cfs.

Then, the modified existing model was updated to a future condition model by making the following changes:

- The impervious percentages for the subcatchments that overlap with site development were increased based on the assumed impervious area increases for the proposed development.
- A diversion channel was created from the Coldwater Creek tributary channel to the North detention basin. The diversion channel consisted of an open trapezoidal channel (5-ft bottom width, 3:1 side slopes and 5-ft depth) and a 60-inch diameter circular pipe for passing under safety zones and into the North Basin.
- For this planning level design, a flow limit of 172.88 cfs was applied to a link downstream of the North Basin. For detailed design, this flow restriction may be achieved my modifying the outlet structure for the basin.

The model was run with the same 100-year 24-hour SCS Type II design rainfall event to analyze the performance of the basin under future conditions with additional flow. The model showed that the North Basin can store the additional runoff generated by the increase in impervious area while maintaining existing runoff rates.

9.6.3 FLOOD CONTROL DETENTION ALTERNATIVES

In order to achieve ponding reductions, five areas were identified for proposed storage basin locations within airport property in order to meet FAA guidelines for the 5-year and 10-year storm events. These basins were identified by taking the following factors into consideration:

- Proximity to Coldwater Creek – Since the majority of the ponding on the airfield is caused by the Coldwater creek channel flowing out of its banks, basins located next to the open channel will be ideal for storing flow from the creek
- Location in the watershed – For this watershed, basins located at the upstream end of the airport will be more effective at reducing flooding
- Safety Critical Zones – Basins can only be built at a safe distance away from runways and taxiways. These distances are specified by the FAA. Areas where surface detention basins cannot be built include the Runway Safety Area (RSA), Taxiway Safety Area (TSA) and Critical Areas. Figure 9.6-3 shows the boundaries for these areas.
- Soil Contamination – The northern parts of the airfield may contain residual radioactive material. In addition, the Boeing RCRA Corrective Action Site and DOD Former Naval Air and Air Force facilities are impacted areas of contamination, including perfluorinated compounds. This contamination makes these parts of the airfield less favorable for basin selection.

- Proximity to site development – Although storage requirements for impervious area can be satisfied in any part of the Coldwater Creek watershed within the airport, the MSD permitting process will be more straightforward when routing increased runoff from the development to a detention basin within or adjacent to the site of the development.
- Large versus small basins – A larger remote detention basin can be favorable to a larger number of smaller basins located close to all tenant and city future development. The challenge with providing one large basin is the additional conveyance from developed areas to the single large basin and finding enough available area in one location and at the proper elevation on the site to provide all required detention needs.
- Dry Detention - All basins were evaluated as dry surface storage basins that do not contain water during dry periods and will fully drain within 24-hours of a storm event to meet FAA requirements to prevent attraction of waterfowl.
- Construction Cost – Underground storage alternatives were considered, but no underground stormwater storage basins were included in the locations proposed in **Figure 9.6-4** since underground storage is more expensive to construct and maintain than surface detention alternatives. The construction cost for underground storage equivalent to the storage volume of Basins 1 through 5 is estimated at $500 million. Underground storage could be a consideration in future development as the Airport expands and surface detention options are no longer available.

The 5 potential basin locations are shown in **Figure 9.6-4** and listed in **Table 9.6-1,** along with a summary of their pros and cons. The North and South detention basins are considered site-development basins that will not significantly reduce ponding on the airport runways and taxiways.

Apart from the basins listed in Table 9.6-1, the following basins were also considered but not pursued further. They are also shown in Figure 9.6-4.

- Basin A (South of Runway 11-29 and Runway 6-24) – This basin is well positioned to reduce ponding on runways and taxiways since it is located at the upstream end of Coldwater Creek within airport property. However, it was not pursued further as it overlapped with safety zones for Runway 6-24.
- Basin B (West of Runway 6-24 and North of Runway 12R-30L) – Favorable because of large amount of unused space and central location. Not pursued further because conveying flow to this location will require construction of large culverts under existing runways which may be cost-prohibitive.
- Basin C (North of Taxiway Victor and South of Banshee Road) – This location may be easily converted into storage. However, since it is located at the downstream end of the Airport, it is unlikely to solve the ponding issues on the runways and taxiways. Furthermore, this area may be susceptible to soil contamination.
- Basin D (East of Runway 6-24 and South of Banshee Road) – Similar to Basin C, this location is not favorable due to its downstream location and potential soil contamination issues.

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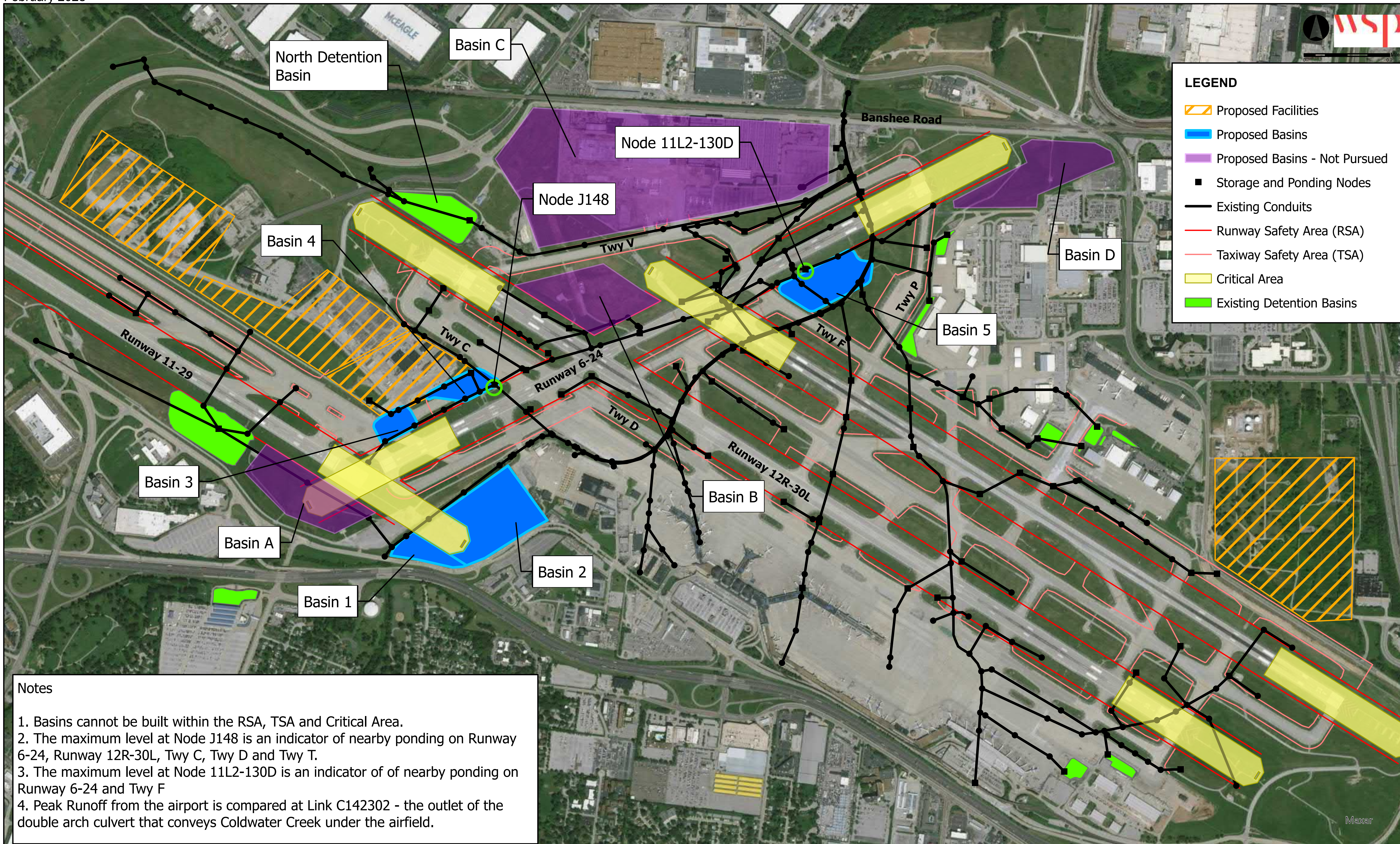
Figure 9.6-4
Analysis of Alternatives
Storage Basin Alternatives



Notes

1. Basins cannot be built within the RSA, TSA and Critical Area.
2. The maximum level at Node J148 is an indicator of nearby ponding on Runway 6-24, Runway 12R-30L, Twy C, Twy D and Twy T.
3. The maximum level at Node 11L2-130D is an indicator of of nearby ponding on Runway 6-24 and Twy F
4. Peak Runoff from the airport is compared at Link C142302 - the outlet of the double arch culvert that conveys Coldwater Creek under the airfield.

SOURCE: M3 Engineering, 2021.

Table 9.6-1: Storage Basin Locations

BASIN NO.	LOCATION	BASIN AREA (AC)	BASIN DEPTH (FT)	BASIN STORAGE (ACRE-FT)	PROS	CONS
1 and 2	Basin 1 – Existing Cellphone Parking Lot Basin 2 – Existing AA Maintenance Facility	22.3	18.0	331.4	• Located at upstream end of Coldwater Creek to maximize flood reduction • Convenient diversion and discharge to and from Coldwater Creek due to proximity to the creek • Will convert existing impervious area to pervious area thereby reducing net impervious area increase	• Dependent on change of existing land use • Not directly connected to site development for detention • Will require re-location of existing MROs and FAA ILS equipment shelter facilities • Size may require expansion of ARFF capability to include water rescue
3 and 4	Between Proposed Deicing facility and Runway 6-24	8.2	Basin3 =11.5 Basin4 =12	Basin3 =33.5 Basin4 =45.9	• Could be designed as detention to mitigate increased runoff rates due to Airport development • Convenient connection for discharge through Coldwater Creek through the nearby culvert junction	• Within the floodplain of the 50-year and 100-year events. Will receive backflow from Coldwater Creek during system-wide flood events • Could receive contamination from de-icing pad runoff
5	Between Rwy 6-24, Twy F and Twy P	11.0	2.8	29.9	• Only re-grading would be needed	• Utility Conflicts • Will Require re-location of DME/ TACAN and re-location of RW24 glide slope equipment

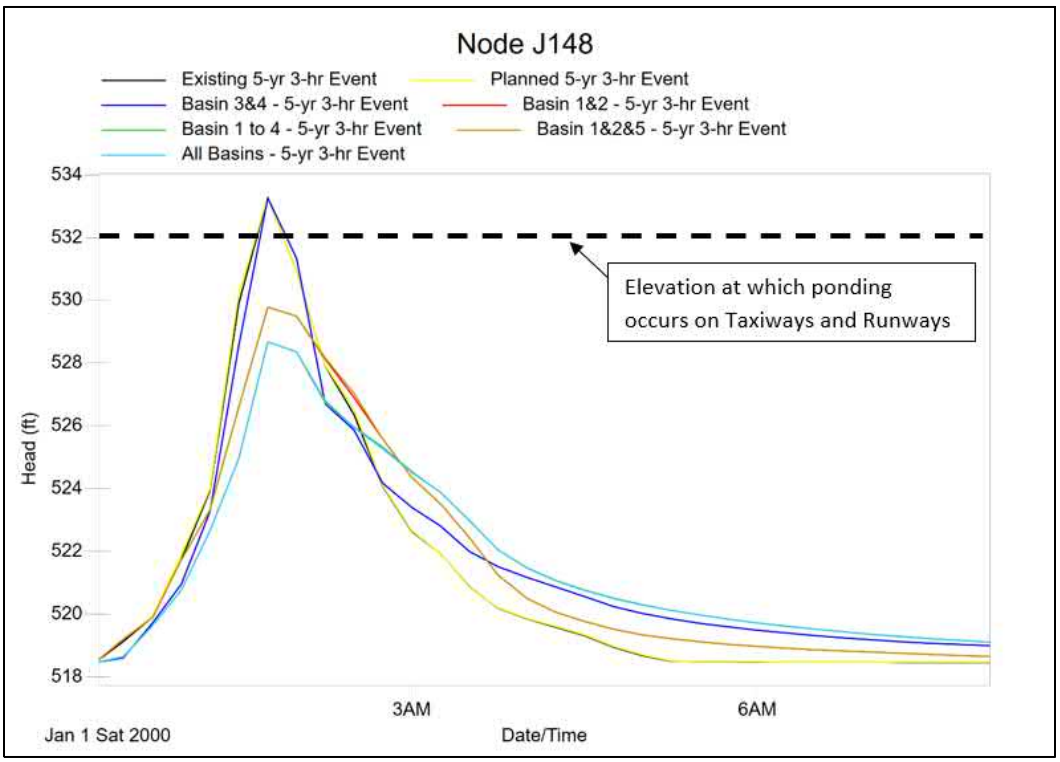
Source: M3 Engineering, 2021.

ANALYSIS OF BASIN ALTERNATIVES

Figure 9.6-5 and **Figure 9.6-6** show comparisons of water elevation at node J148 for the 5-year and 10-year events. These figures show that ponding issues on the airfield for this location may be eliminated with all solutions that contain Basin 1 and 2. The inclusion of Basins 3 and 4 alone will not alleviate ponding on the airfield. **Figure 9.6-7** and **Figure 9.6-8** show comparisons of water elevation at node 11L2-130D for the 5-year and 10-year event. These results show that the inclusion of Basins 1 and 2 eliminate ponding for the 5-year event and the solution with Basins 1, 2 and 5 eliminate ponding for the 10-year event.

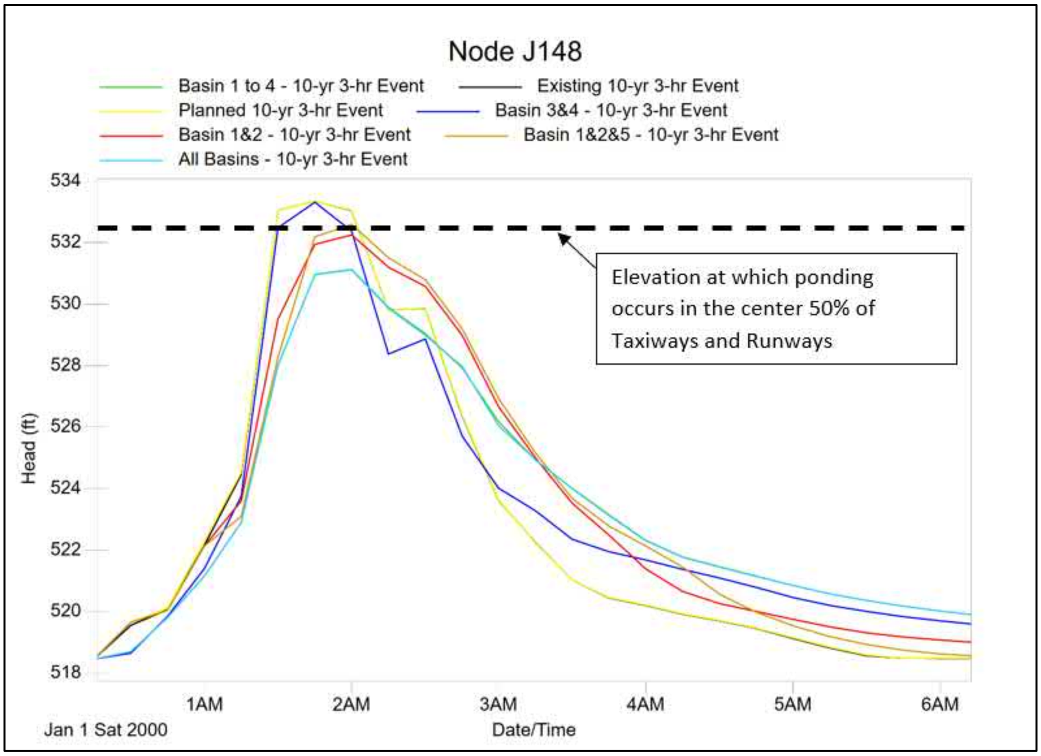
Combinations of the various basin alternatives were modeled with the 5-year and 10-year 3-hour events to analyze the solutions' effectiveness in reducing ponding on the airfield. The ponding from these runs is visualized in **Figure 9.6-9** and **Figure 9.6-10**. The maximum water levels at two nodes in the model were found to be representative of taxiway and runway flooding issues predicted on the airfield. The first is node J148 located at the open culvert junction in the island between Taxiway C, Taxiway T and Runway 6-24. The maximum level at this location is an indicator of nearby ponding on Runway 6-24, Runway 12R-30L, Taxiway C and Taxiway T. The second node 11L2-130D is located East of Runway 6-24, North of Taxiway F and West of Taxiway P. The maximum level at this location is an indicator of nearby ponding on Runway 6-24 and Taxiway F. These locations are shown in Figure 9.6-4.

Figure 9.6-5: Comparison of Head at Node J148 for all basin alternatives for the 5-year event



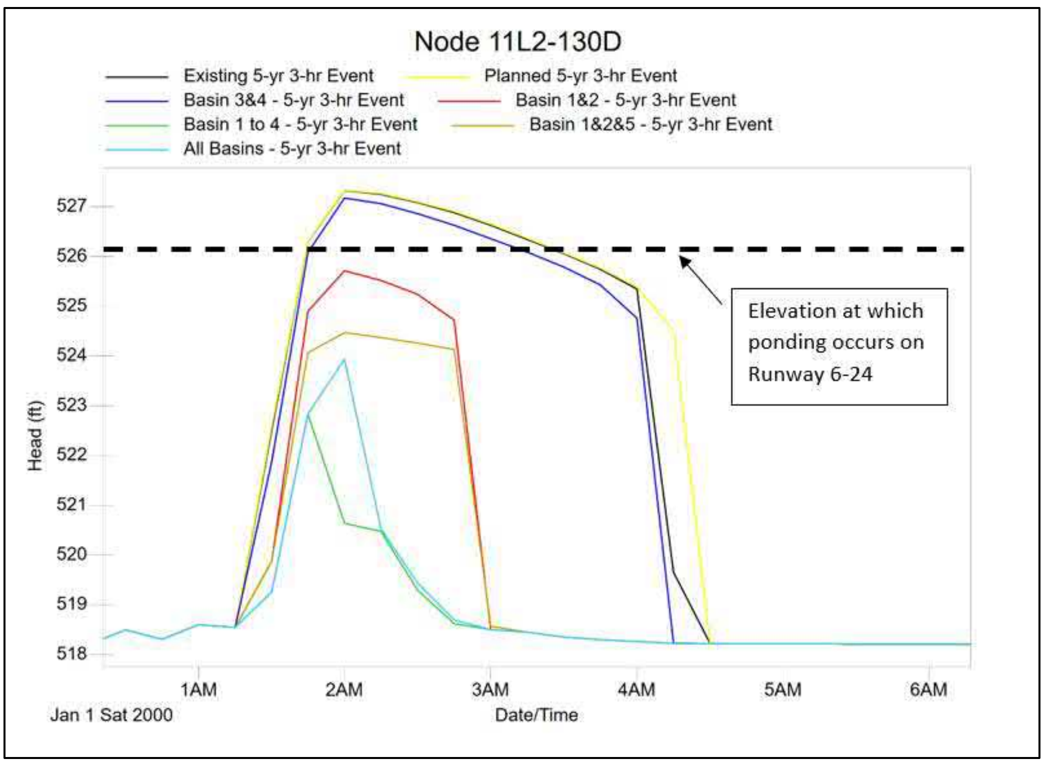
Source: M3 Engineering, 2021.

Figure 9.6-6: Comparison of Head at Node J148 for all basin alternatives for the 10-year event



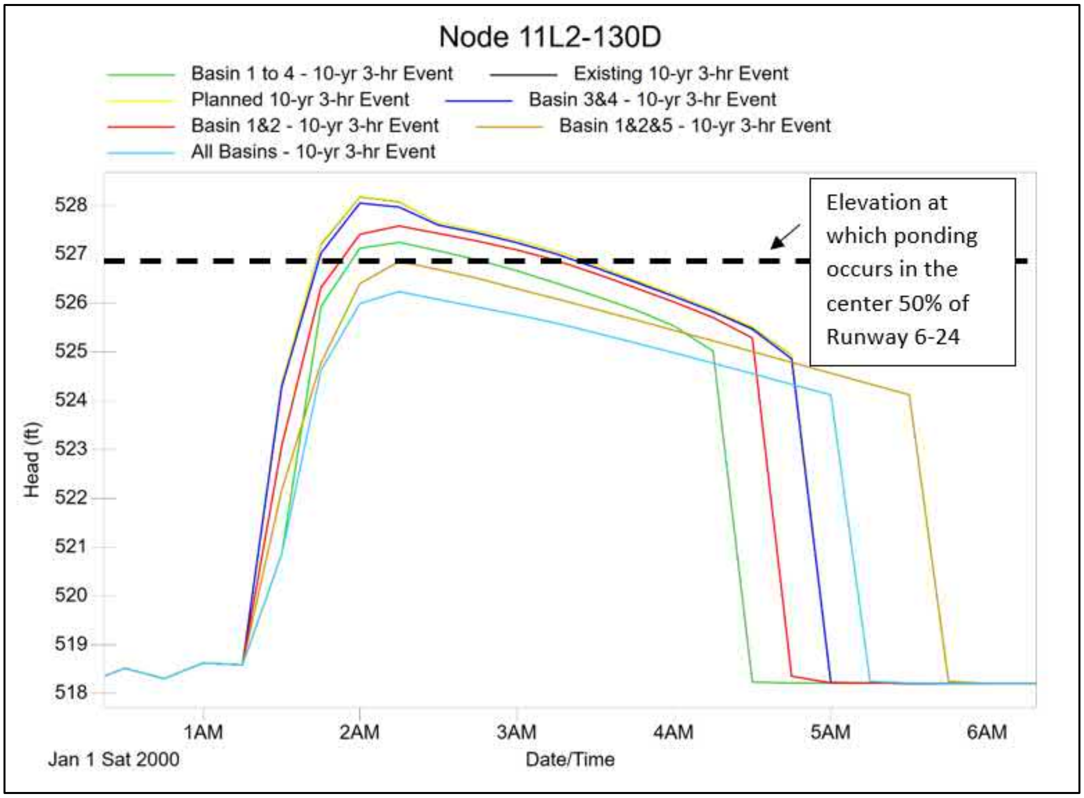
Source: M3 Engineering, 2021.

Figure 9.6-7: Comparison of Head at Node 11L2-130D for all Basin Alternatives for the 5-Year Event



Source: M3 Engineering, 2021.

Figure 9.6-8: Comparison of Head at Node 11L2-130D for all Basin Alternatives for the 10-Year Event



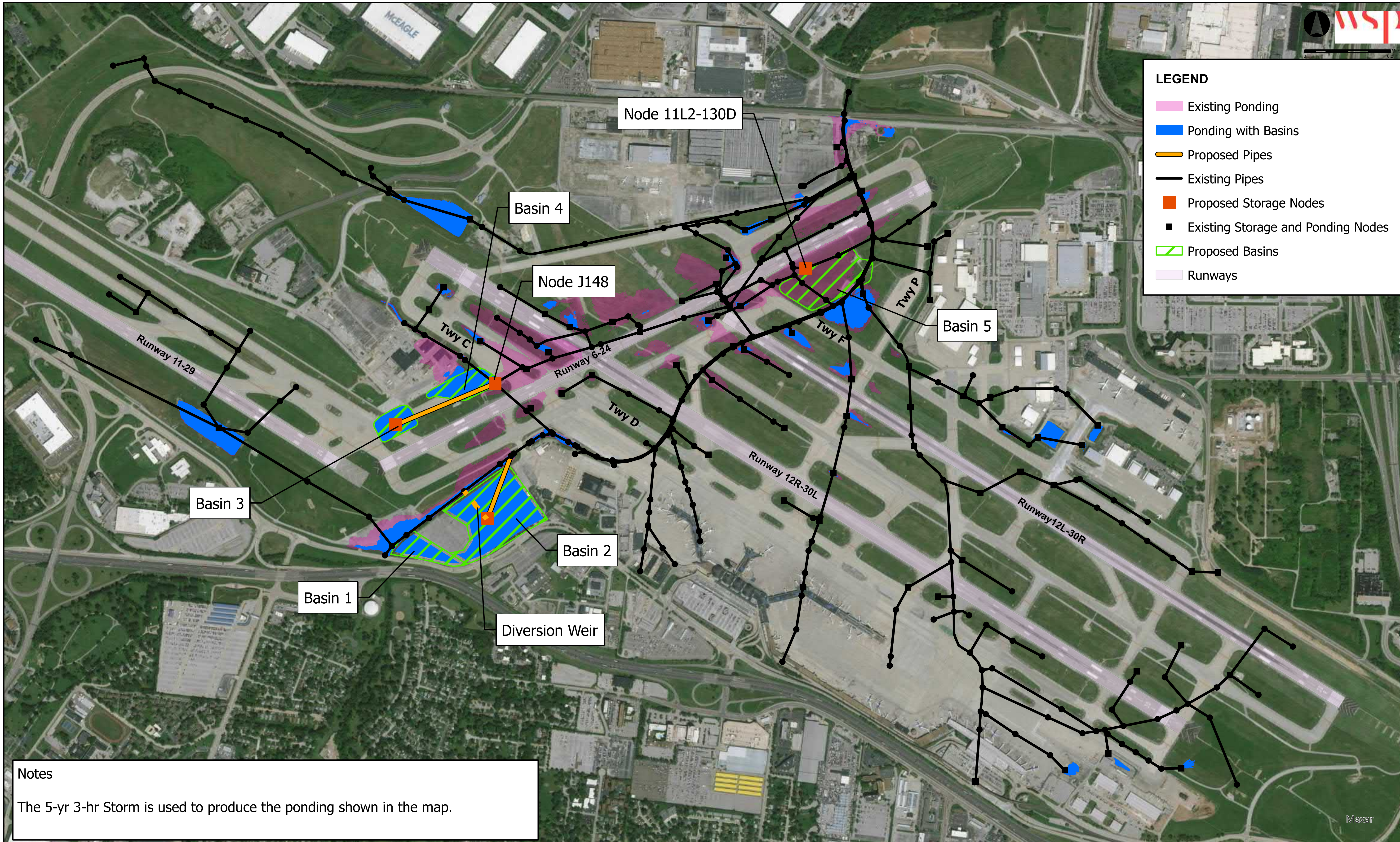
Source: M3 Engineering, 2021.

Per discussions with MSD, it may be possible to account for impervious area increases throughout the airfield with a few large detention basins instead of several individual basins for each development, as long as there is no increase in peak runoff at the downstream end of Coldwater Creek, within airport property. However, the following aspects must be considered before adopting this approach:

- The most effective large detention basin locations to reduce ponding are located close to Coldwater Creek. These locations are often in the takeoff and landing paths of the runways. Therefore, inclusion of these large detention basins may pose significant safety risks which could require costly mitigation strategies such as requiring under-ground detention. Furthermore, diverting flow away from the runways and taxiways when possible (such as the proposed diversion of additional runoff from the airport and airfield maintenance site re-development projects to the North Basin) is favorable as it will reduce the flood risk on the runways and taxiways closer to Coldwater Creek.
- Although airport-wide detention basins may sufficiently control the peak flow at the downstream end of Coldwater Creek within the airport, if the development is located away from the basin, increases in peak runoff may cause capacity issues in the existing sewers that will convey flow to the creek or basin.

If an airport-wide detention basin plan is preferred, a stormwater master plan is recommended which should include more detailed calibration and a 1D-2D hybrid hydraulic modeling approach.

Figure 9.6-9
Analysis of Alternatives
Flood Storage Basin Alternative - 5-yr 3-hr Storm

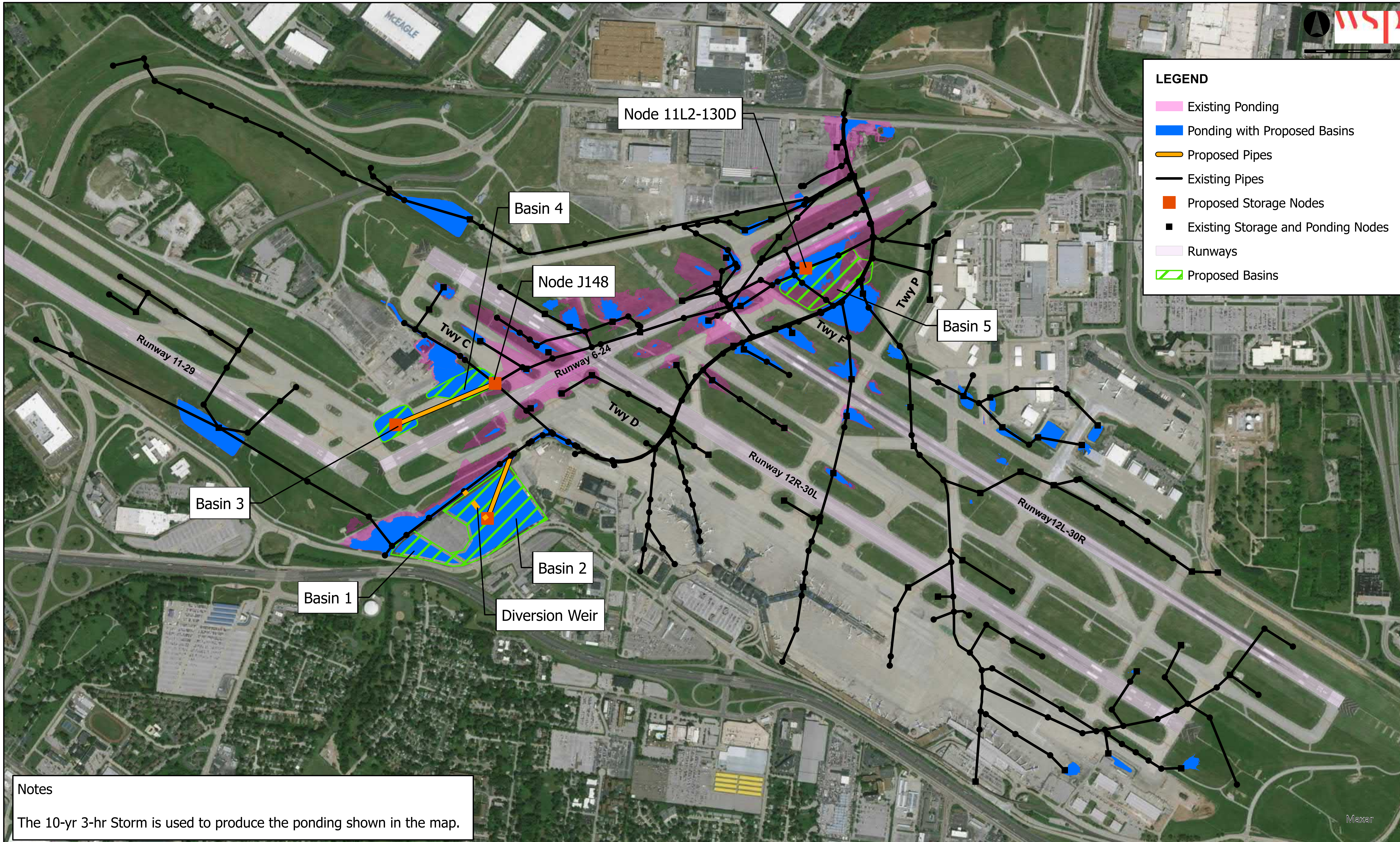


Notes

The 5-yr 3-hr Storm is used to produce the ponding shown in the map.

SOURCE: M3 Engineering, 2021.

Figure 9.6-10
Analysis of Alternatives
Flood Storage Basin Alternative - 10-yr 3-hr Storm



Notes

The 10-yr 3-hr Storm is used to produce the ponding shown in the map.

SOURCE: M3 Engineering, 2021.

9.6.4 INCREASED STORM CONVEYANCE ALTERNATIVES

LOCAL STORM SEWER CONVEYANCE UPGRADES

Sewers that convey drainage from rainfall that falls on the Airport property are considered "Local" storm sewers. As discussed in Section 9.5.6 and shown in Figure 9.5-5 and Figure 9.5-6, there are several local sewers that have insufficient capacity to convey the 5-year and 10-year FAA design storms and the 15-year MSD design storm. However, ponding shown on taxiways and runways during the 5-year and 10-year design storm are the result of capacity issues in the Coldwater Creek culverts and not due to local sewer capacity. For this reason, no local storm sewer conveyance alternatives were developed. Storm sewers that have insufficient capacity to convey the design storms, and are located under Taxiways proposed to be reconstructed, will be evaluated for sewer upsizing. The total costs to construct these local sewer upgrades are included in the Taxiway Alternative costs.

PARALLEL COLDWATER CREEK CULVERT

Another stormwater alternative to reduce ponding on the runways and taxiways is to increase the conveyance of Coldwater Creek under the airfield. The conveyance can be increased by adding a parallel culvert under the airfield to convey excess flow from Coldwater Creek or increasing the size of the existing dual arch culvert. This solution only partially alleviated ponding on the runways and taxiways for the 10-year event given that flow through the new culverts would still be restricted by high water levels in Coldwater Creek. Furthermore, the construction limits of the project would extend over a significant portion of the airport property. This conveyance solution will likely increase the peak flow and water surface elevation in Coldwater Creek downstream of the airport. Any improvements to the Coldwater Creek culverts will need to show a "no-rise" condition in Coldwater Creek base flood elevation both upstream and downstream of the Airport. A construction cost estimate was not developed for the increased conveyance alternative since ponding was not alleviated to meet the FAA criteria. Specifically, the alternative brought ponding conditions for the 5-year storm into compliance in all areas except Runway 6-24. Additionally, the alternative provided no improvement to ponding conditions for the 10-year event.

RAISING RUNWAYS

A third alternative is to increase the elevations of the runways and taxiways to bring them out of the ponded areas for the 5-year and 10-year design events. A construction cost estimate was not developed for this alternative since this solution is not viable solely based on a stormwater improvement basis. This alternative could be implemented if the runways are planned to be replaced as part of an airport runway improvement project and may still be constrained by other runway design and function limitations.

9.6.5 PREFERRED SOLUTION

The preferred stormwater solution consists of construction of Basins 1 through 5 identified in Section 9.6.3. Based on this high-level stormwater analysis, Basins 1 through 5 all need to be constructed to bring the forecasted Coldwater Creek flooding into compliance with the FAA requirements for the 5-year and 10-year storm events.

If it is not feasible for all five basins to be constructed, it is recommended that Basins 3 and 4 be constructed to meet the MSD detention requirements for the increase in impervious area and associated runoff from the ALP.

COST ESTIMATES

High-level construction costs were developed to provide a rough order of magnitude (ROM) of costs to design and construct Storage Basins 1 through 5. The ROM costs provided in **Table 9.6-2** are based primarily on EPA guidance for dry detention basins costs per unit volume. Additional basin features were added as ancillary costs using RS Means and MSD pay items. The ROM costs for Site Detention Basin (North Basin) is provided in **Table 9.6-3.** The construction cost items and ROM cost worksheets for these total ROM costs are provided in Appendix C. A 25% design contingency factor is included in these costs.

Table 9.6-2: ROM Flood Storage Cost Summary

BASIN NO.	ROM COST
1 and 2	$162,000,000
3	$ 4,000,000
4	$ 5,000,000
5	$ 7,000,000
TOTAL ROM	$178,000,000

Source: M3 Engineering, 2021.

Table 9.6-3: ROM Detention Basin Cost Summary

BASIN NO.	ROM COST
North Detention	$ 2,000,000
TOTAL ROM	$2,000,000

Source: M3 Engineering, 2021.

9.6.6 LIMITATIONS OF ALTERNATIVES ANALYSIS

The model used for analysis has several limitations that must be taken into consideration before continuing into detailed design for both the site development alternative as well as the flood control detention basin alternative.

Recommended model updates for both Site Development North Basin alternative and the Flood Control Detention Basins alternatives include:

- Surveying parts of the system where existing pipe locations and inverts are unknown. Refer to section 5.6.3 for additional survey recommendations.
- Perform flow monitoring at the upstream end of Coldwater Creek within airport property in conjunction with the existing flow monitoring at the downstream end of the airport to calibrate storm flow generated by the airfield.

- During design, it is recommended that detailed inlet hydraulics be added to the model in order to more accurately determine the amount of runoff that will enter the below grade stormwater conduit system.

Recommended model updates for the Site Development North Basin Alternative

- During analysis of the Site Development North Basin Alternative, it was found that there were significant differences between the XPSWMM model used for design of the W1W stormwater facilities and the ALP stormwater model. It is recommended that the differences between W1W stormwater model and the ALP stormwater model be reconciled during the design phase of the project.
- The impervious area increases calculated for the airfield and aircraft maintenance site re-development were conservatively estimated. It is recommended that the impervious area increases be calculated in more detail during design.

Recommended model updates for the Flood Control Detention Basin Alternative

- The existing 1D model of the Coldwater Creek stormwater system Solutions for flood control would benefit from a more detailed 1D-2D hybrid hydraulic model analysis prior to flood control detention basin design. A 1D-2D hybrid model will provide a more accurate representation of the movement of overland flow as well as the extent of ponding over the runways and taxiways
- Evaluate performance of the basins under a range of probable rainfall events. It is unlikely that a high intensity event on the airfield will also occur at the same intensity across the entire Coldwater Creek watershed tributary to the Coldwater Creek culvert that passes under the airfield. Therefore, a coincident frequency analysis is recommended to identify rainfall events that are likely to occur over the upstream Coldwater Creek watershed and on airport property for a given return-period.
- Refine the detention outlet structures for Basins 3 and 4 to maximize the effectiveness of the detention storage volume while meeting the FAA's 48-hour maximum time to drain the basin.
- Consider groundwater levels when determining the depths of the detention basins.