CONTROLLING *the* SOURCE

A Roadmap For Working Together on Impactful Source Control

July 2020

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We have made every effort to address their comments in this edition of Controlling the Source and we are committed to making further improvements in future editions.

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Acronyms

3RWW	3 Rivers Wet Weather
3WG	3 Rivers Wet Weather Working Group
ACHD	Allegheny County Health Department
ACO	Administrative Consent Order
ALCOSAN	Allegheny County Sanitary Authority
BG	Billion Gallons
CC	Chartiers Creek
CCTV	Closed Circuit Television
CD	Consent Decree
COAs	Consent Orders and Agreements
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CtS	Controlling the Source
CWP	Clean Water Plan (also referred to as the Wet Weather Plan)
DSI[R]	Direct Stream Inflow [Removal]
DWF	Dry Weather Flow
EJ	Environmental Justice
FIS	Flow Isolation Studies
GIS	Geographic Information System
GPIMD	Gallons per inch-mile per day
GROW	Green Revitalization of Our Waterways
GSI	Green Stormwater Infrastructure
GWI	Groundwater Infiltration
H&H	Hydrology & Hydraulic
I/I	Infiltration/Inflow
ICWP	Interim Clean Water Plan (also referred to as the Interim Measures Wet Weather Plan)
IG/IR	Infiltration Gusher/Infiltration Runner
LOGR	Lower Ohio River/Girty's Run
MG[D]	Million gallons [per day]
MG/yr	Million gallons per year
Modified CD	Modified Consent Decree

MR	Main Rivers
MSRS	Municipal Source Reduction Study
NCA	Non-contributing Area
ORE	Overflow Reduction Efficiency
PADEP	Pennsylvania Department of Environmental Protection
PennDOT	Pennsylvania Department of Transportation
POC	Point(s) of Connection
PWSA	Pittsburgh Water and Sewer Authority
RI	Regionalization
ROW	Right-of-way
SMR	Saw Mill Run
SO	System Optimization
SRS	Source Reduction Study
SS	Sewer Separation
SSO	Sanitary Sewer Overflow
SSS	Sanitary Sewer System
TC	Turtle Creek/Thompson Run
UA	Upper Allegheny/Pine Creek
UM	Upper Monongahela
U.S. EPA	United States Environmental Protection Agency
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 Objectives

For more than twenty years, the Allegheny County Sanitary Authority (ALCOSAN) has taken a lead in advocating for source control and supporting implementation of source control projects in coordination with its customer municipalities. ALCOSAN has been committed to reducing the amount of stormwater and groundwater entering the collection system for several reasons including the following:

- Reducing the volume and frequency of overflows and improving water quality.
- Maintaining or restoring the available conveyance and treatment capacity in the system, and therefore asset performance and resilience.
- Eliminating or reducing the need for other types of new sewer infrastructure.
- Reducing the operations and maintenance, energy and chemical demands for conveying and treating wastewater.

In May 2020, ALCOSAN's Modified Consent Decree (Modified CD) [1] with the United States Environmental Protection Agency (U.S. EPA), the Pennsylvania Department of Environmental Protection (PADEP), and the Allegheny County Health Department (ACHD) was entered by the U.S. District Court of the Western District of Pennsylvania. ALCOSAN has adopted its updated Clean Water Plan (CWP)[2] to meet the requirements of the Modified CD.

The ultimate objective of the Modified CD and CWP is to improve and protect the water quality of the region's streams and rivers by reducing the volume of sewer overflows by approximately seven (7) billion gallons (BG) per year. The first phase of the CWP involves the implementation of the Interim Clean Water Plan (ICWP) by Dec. 31, 2036.

Through the Modified CD and CWP, ALCOSAN is continuing its commitment to taking a proactive approach to source control as part of its overall approach to eliminate Sanitary Sewer Overflows (SSOs) and reduce Combined Sewer Overflows (CSOs).

Since the original Consent Decree (CD) was signed in 2008, ALCOSAN and our customer municipalities and authorities have completed substantial work throughout the service area to understand the scope and challenges of preventing extraneous source flow from entering the regional collection system. This work is summarized in Section 2 and Section 3.

Building on these efforts, ALCOSAN has undertaken an engineering analysis to develop a consistent framework for evaluating source control throughout the ALCOSAN service area.

Controlling the Source (CtS) is intended as a resource for ALCOSAN, our customer municipalities and other regional partners to aid in:

- Identifying and implementing impactful source control projects, i.e., increasing the common understanding of where municipalities can be most effective in reducing overflow per dollar spent on source control.

[1] The United States District Court for the Western District of Pennsylvania, Modified Consent Decree, Case 2:07-cv-00737-NR, Document 33-1, Filed 05/14/20.

[2] ALCOSAN, Clean Water Plan, Sept. 2019. Available at https://www.alcosan.org/our-plan/plan-documents.

- Maintaining open communication and fostering collaboration with local customer municipalities and stakeholders on source control projects.
- Leveraging planned work and local investments to extend the reach of ALCOSAN's Green Revitalization of our Waterways (GROW) Program.
- Outlining strategies for implementing regional source control programs.
- Describing and quantifying the impact source controls can have on inflows and overflows under different regional conveyance and treatment system conditions.

1.2 Terminology

Traditional methods to reduce extraneous flow from entering combined or sanitary sewer systems have involved direct stream inflow removal (DSIR), sewer separation (SS) and infiltration and inflow (I/I) reduction. More recently, a fourth method has been gaining significant momentum – green stormwater infrastructure (GSI).

GSI is defined in the 2019 Water Infrastructure Improvement Act as "the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters."

In the Modified CD, green infrastructure measures are defined as "the range of stormwater control measures that use plant systems, soil systems, permeable pavement, or stormwater management, harvest and reuse, or piping to store, infiltrate, evapotranspire, or reuse stormwater and reduce flows to the collection system. Green infrastructure measures may include, but shall not be limited to, restoration of natural hydrology, extended detention wetland areas, green roofs, cisterns, and direct stream removal." Unlike the 2019 Water Infrastructure Improvement Act definition, the Modified CD definition specifically includes direct stream removal.

1 Aspinwall Commercial Alley (GSI project)

2 City of Pittsburgh Sheraden Park Stream Channel (DSIR project)

For the purpose of this document, the following four categories of source control projects were considered: DSIR (considered separately from GSI consistent with the 2019 Water Infrastructure Improvement Act), GSI, SS, and I/I reduction.

Projects in each of these categories can help reduce the volume and/or rate of inflow into the regional collection system and, consequently, the overflow volume.

In terms of reducing inflows and overflows, DSIR, SS and GSI would typically be used in the combined sewer area whereas I/I reduction could apply to the entire service area.

GSI and some DSIR projects are typically more visible after the construction period (as illustrated in the photographs 1 and 2) and can provide added benefits such as water quality improvements and local community benefits.

However, I/I reduction (as illustrated in the photograph 3) and SS are also important methods as part of sound asset management and can provide added benefits such as basement flooding reduction.

3 Cured in-place pipe rehabilitation (I/I reduction project)

1.3 Relationship to ALCOSAN's Organizational Mission

ALCOSAN is one of the western Pennsylvania region's premier environmental and public health organizations, treating wastewater for 83 Allegheny County communities, including the City of Pittsburgh.

The Authority enhances the region's quality of life and safety by working to protect drinking water, rivers and streams; helping to make the Pittsburgh region a great place to live, work and play.

ALCOSAN was created in 1946 under the Pennsylvania Municipal Authorities Act and began treating wastewater in 1959.

The Authority is governed by a seven-member Board of Directors – three appointed by the Mayor of the City of Pittsburgh, three appointed by the Allegheny County Chief Executive and one joint appointment. The Executive Director reports to the Board.

As a nonprofit agency, ALCOSAN is funded by user fees with capital funds raised through the sale of sewer revenue bonds. There are approximately 320,000 residential, commercial and industrial accounts representing a service population of approximately 836,600 (according to the 2010 census).

An environmentally focused and progressive organization, ALCOSAN recently completed a $400 million capital improvement program which addressed odor control, wet weather treatment capacity, solids handling and wet weather planning.

ALCOSAN is now embarking on one of the largest public works projects in the region's history with implementation of the estimated $2 billion (2010 dollars) ICWP.

As noted earlier in this section, ALCOSAN is committed to integrate proactive source control as part of this major undertaking. This commitment is articulated in the Modified CD and the CWP and summarized in Section 1.6 and Section 2, respectively.

ALCOSAN'S historical mission is to provide cost effective, customer oriented and environmentally conscious wastewater treatment that protects public health and enhances the use of our natural resources.

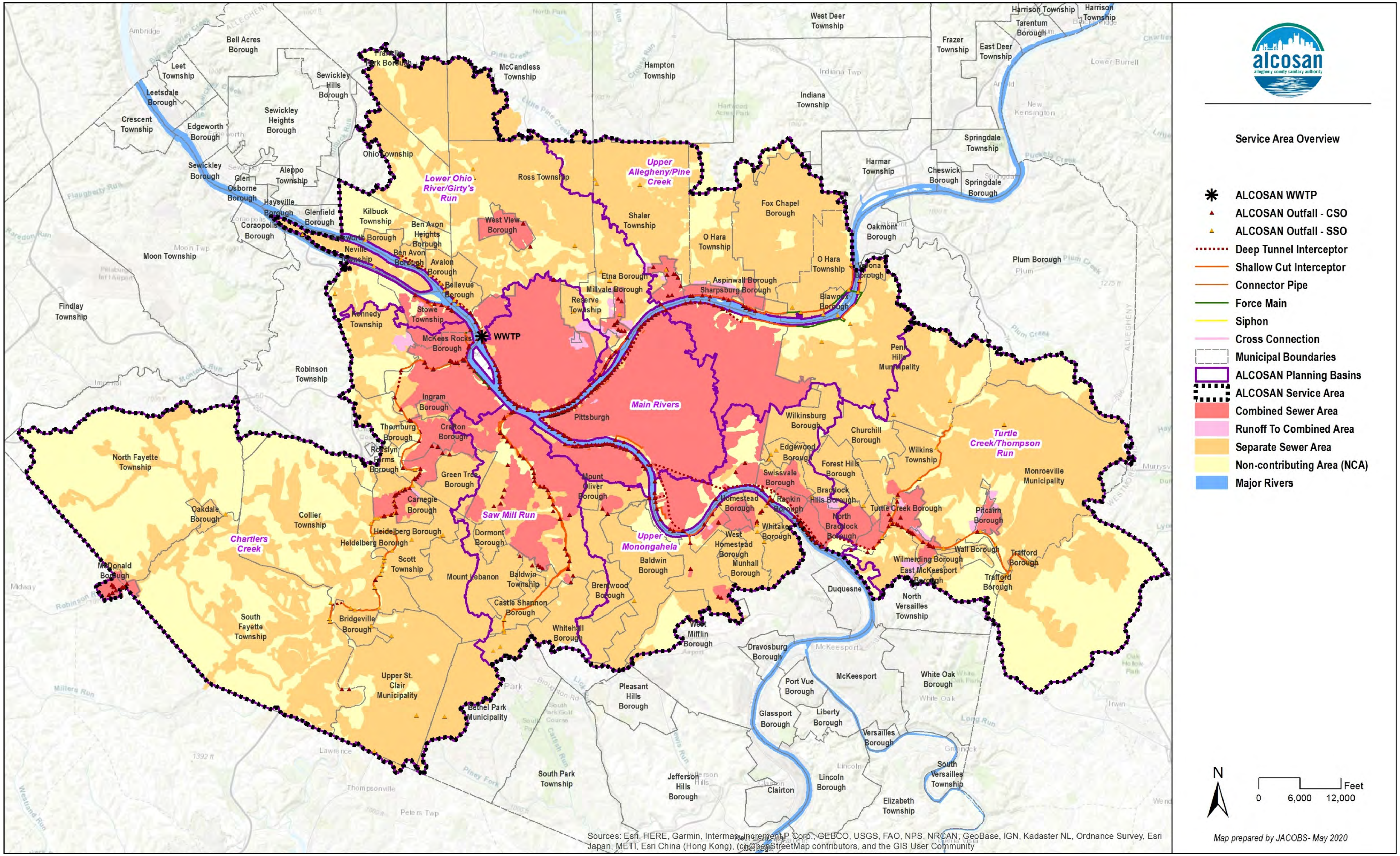
1.4 ALCOSAN Service Area

The ALCOSAN Service Area shown in **Figure 1-1** spans approximately 310 square miles. Located along the Ohio River on Pittsburgh's Northside, ALCOSAN's 59-acre wastewater water treatment plant (WWTP) is one of the largest wastewater treatment facilities in the Ohio River Valley, currently processing up to 250 million gallons per day (MGD) of wastewater.

Figure 1-1 also illustrates:

- The approximate current delineation of the combined sewer system (CSS) vs. separate sewer system (SSS) areas – As noted in Section 1.2, different source control strategies apply to CSS area vs. SSS area, which is an important factor for the source control framework development. The delineation shown on Figure 1-1 was developed during the preparation of the CWP.
- The delineation of the seven ALCOSAN Planning Basins –These planning basins align with major waterways in the service area including Chartiers Creek, Saw Mill Run, Girty's Run, Pine Creek, Turtle Creek, Thompson Run, and the Three Rivers (Allegheny, Monongahela, and Ohio). These planning basins were developed and utilized during the preparation of the CWP.

Figure 1-1. ALCOSAN Service Area Overview



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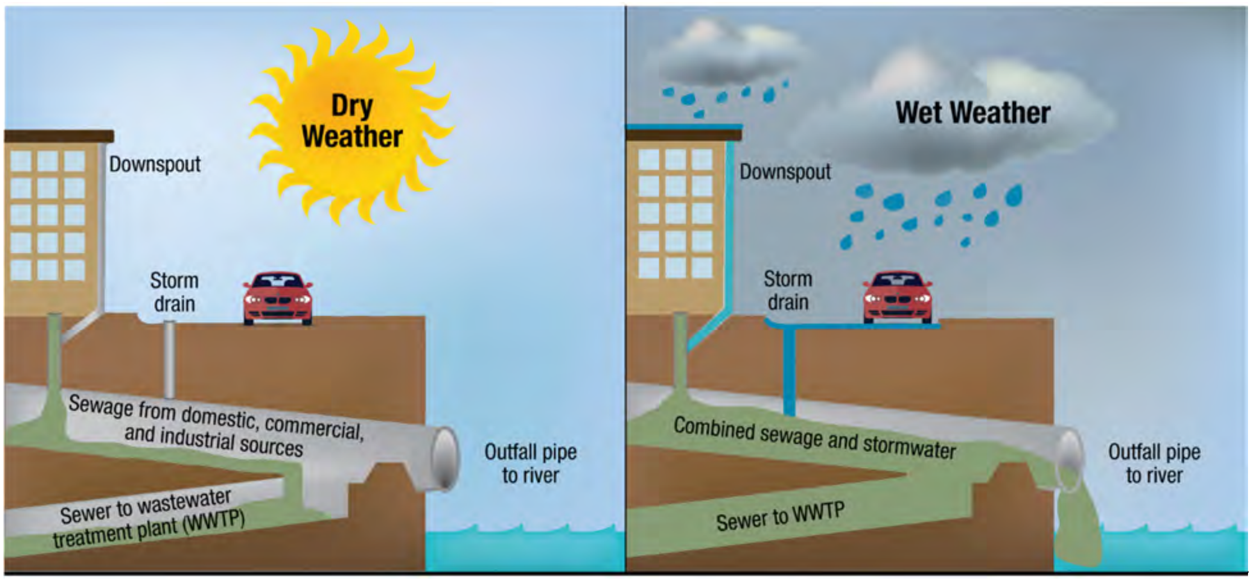
1.5 Regulatory Context

1.5.1 The SSO and CSO Problem Being Addressed

During wet weather events, excess flow causes SSOs and CSOs. CSOs occur when stormwater and sanitary sewage are carried in a single pipe. Combined flow overloads the sewer system and overflows untreated into rivers and streams as illustrated in **Figure 1-2**. SSOs occur when a sewer designed to carry sewage only becomes overloaded. This can cause untreated sewage to overflow from manholes or back up into basements. SSOs typically occur due to infiltration and inflow of excessive flow into sewer lines during and after heavy rainfall due to leaky pipes, inappropriate sewer connections, or equipment failures.

Figure 1-2. CSO Illustration



CSOs occur when stormwater and sanitary sewage, carried in a single pipe, overload the sewer system and flow untreated into rivers and streams (Image Source: Jacobs)

Both SSOs and CSOs usually carry a variety of pollutants, including debris, chemicals, bacteria and animal waste. Controlling overflows is a priority for ALCOSAN, as detailed in the CWP and Modified CD, and its customer municipalities.

1.5.2 Modified Consent Decree

ALCOSAN first entered a CD in 2008 and submitted the required Wet Weather Plan to address overflows in 2013. Public and municipal customer feedback was given to make the plan more affordable and flexible enough to take advantage of advances in the field of green stormwater management. To accommodate this desired flexibility and an extended schedule, the agencies required that ALCOSAN work with customer municipalities towards transferring some of the intermunicipal sewers to ALCOSAN's responsibility and incorporate source control through adaptive management.

On Sept. 19, 2019, a Modified CD was filed with the U.S. District Court for the Western District of Pennsylvania. The Modified CD was entered by the Court in May 2020.

The Modified CD is an agreement between ALCOSAN and the U.S. EPA, PADEP, and ACHD for ALCOSAN to achieve compliance with the Clean Water Act during periods of wet weather. It sets timelines and goals for

ALCOSAN to reduce sewer overflows into the region's rivers and streams. ALCOSAN has adopted its CWP to meet those requirements.

Key items in the Modified CD specifically related to source control are summarized below:

- Paragraph 66.c – ALCOSAN must make a good faith effort to assume responsibility for at least 200 miles of customer municipality sewers by Jan. 2020 (Regionalization).
- Paragraph 66.b.ii – ALCOSAN must make a good faith effort to enter into a legally binding Municipal Source Reduction Agreement with each customer municipality and authority by Jan. 2025. The agreement will include flow targets and a long-term plan that identifies activities and a schedule to achieve the flow targets.
- Appendix Z, Paragraph 1.b, 1.c and 1.d – In 2020, ALCOSAN must request certain information from the customer municipalities for Preliminary Planning and development of the Preliminary Basis of Design Report for the regional tunnel system and wet weather pump station. The information includes all flow monitoring data collected since 2010, all available mapping updates, any source reduction studies, and any other relevant flow reduction information.
- Appendix Z, Paragraph 1.f – In 2021-2025, ALCOSAN must request from the customer municipalities any newly collected flow monitoring data or mapping changes regarding municipal source reduction measures.
- Appendix Z, Paragraph 1.f – In 2020-2025, ALCOSAN must submit an annual analysis of whether flow reduction efforts are "reducing the volume or rate of flow to the conveyance and treatment system."
- Paragraph 67.b – At any time, ALCOSAN may propose, for agency review and approval, revisions to control measures that achieve "equivalent to, or better than," system-wide performance. Alternate control measures may include green infrastructure subject to Municipal Source Reduction Agreements.

The CWP, aligned with the Modified CD, will increase investment in the system by $2 billion (in 2010 dollars) through 2036, including reducing excess flow into the system through source control strategies, using grey infrastructure for the storage and conveyance of excess flow during wet weather events, and significantly increasing the wet weather capacity of the treatment plant.

While the Modified CD is specifically for ALCOSAN, sewage overflows are a regional issue and customer municipalities, residents, and businesses can all play a significant role in addressing the problem by controlling the source of inflow before it even reaches the regional collection system.

1.5.3 Customer Municipalities Consent Orders

Given that municipalities play a primary role in implementing source control, controlling flow at the source is also expected to be a priority in the new Consent Orders and Agreements (COAs) and Administrative Consent Orders (ACOs) for combined sewer and separate sanitary sewer municipalities, respectively. As of May 2020, these COAs and ACOs are being drafted by PADEP and ACHD.

1.6 Key Players in Source Control

The complexities of the municipal sewage jurisdictional structure and the regional collection system require many entities to work together if significant inflow reduction is to be achieved through source control. The primary roles of the key players in source control are summarized below to provide the context for the CtS development and implementation.

1.6.1 ALCOSAN

As more fully described in Section 10 of the CWP, ALCOSAN has been supporting source control projects in the region for more than 20 years through its DSIR program, past regionalization initiatives, public and municipal outreach efforts, and other programs – including the more recent GROW program.

ALCOSAN must, however, rely heavily on regional partners for the actual implementation of source control projects because ALCOSAN does not own significant property or assets on which to implement its own source control projects. The transfer of intermunicipal sewers to ALCOSAN will provide ALCOSAN with some increased ability to implement such projects.

Furthermore, as a regional conveyance and treatment authority, ALCOSAN has no direct ability to mandate or implement source control projects on other public or private properties and recognizes that regional partners will face tradeoffs when seeking to cost-effectively address sewer overflows, flood risk reduction, and other stormwater management objectives.

As such, ALCOSAN's primary role includes the following:

- Playing a leading and programmatic role consistent with its historical practices with the added responsibilities identified in the Modified CD (see Section 1.5.2). The historical practices include providing financial and technical support to customer municipalities. It also includes facilitating the use of source controls through its partnerships with municipalities, property owners, economic development agencies and the non-profit community (see Section 1.6.2 and 1.6.3).
- Defining and implementing its own cost-effective source control projects, including the following:
  - Defining and implementing a cost-effective rehabilitation program for regionalized assets in addition to its existing assets.
  - Evaluating how to best incorporate source control elements in its future assets to be constructed as part of the ICWP.

This framework, developed as part of ALCOSAN's programmatic role, is intended to help ALCOSAN and its customer municipalities to inform their own source control programs tailored to their challenges, opportunities and financial resources.

1.6.2 Customer Municipalities

Implementing source control and achieving significant flow reduction is closely tied to municipal collection system characteristics, property ownership and land development practices.

Given their responsibilities for collection systems and land management practices, the customer municipalities are best situated to implement source control measures at the local level and the related land development codes and ordinances that influence source control.

Studies[3], which provided the basis for the finalization of the CWP, have determined that source controls will be most effective when strategically paired with critical treatment and conveyance capacity upgrades. These upgrades are necessary to meet water quality improvement requirements, even with intensive flow reduction.

For this reason, ALCOSAN is encouraging municipalities to continue coordinating with the Authority to develop and implement their own source control programs as well as to work towards the Municipal Source Reduction Agreements identified in the Modified CD. ALCOSAN is also encouraging municipalities to continue utilizing the Authority's technical and financial support. The framework presented here can help municipalities to identify

[3] Including ALCOSAN, Starting at the Source, 2015

the most effective projects from an overflow reduction standpoint. Local partners will need to consider other benefits such as flood risk reduction, community development, access to green space, etc. separately.

This framework is intended as a technical tool to support this coordination and to allow the municipalities to implement the most effective source controls and better leverage ALCOSAN's financial support.

1.6.3 Others (e.g., Development Community, Policy Makers, Regulators, Foundations, Research Organizations)

The key to identifying the best mix of source controls that cost-effectively reduce overflows is through continued coordination and partnering not only with customer municipalities but also with regional agencies. These would include the U.S. EPA, PADEP, Allegheny County, ACHD, the Pennsylvania Department of Transportation (PennDOT), the U.S. Army Corps of Engineers, and other clean water partners such as developers and those in the development community, foundations, and policy makers.

These partnerships can serve as the pathway (from a funding, institutional or permitting standpoint) to bringing some of the identified opportunities to life, maximizing water quality and other benefits to the region.

This framework is intended to serve as a pathway for engagement with these parties.

1.7 CtS Development Process

The original version of the document was developed by ALCOSAN and its Green Stormwater Infrastructure-Source Control Program Management team led by Jacobs based on planning and engineering work conducted from 2017 through early 2020.

Preliminary elements of the framework, including GSI Concept Plans, were shared with some of the municipalities and other stakeholders. The plans were shared through a series of meetings to discuss potential source control projects, and more than 100 site visits were conducted to assess project feasibility.

Preliminary elements of the framework were also shared during its development with a wider audience through regional events such as the 3 Rivers Wet Weather (3RWW) Sewer Conference and at a Green Infrastructure Network meeting in 2019.

Informal feedback was received from ALCOSAN, our customer municipalities and other regional partners over this period and was incorporated in the final version of the document.

ALCOSAN requested and obtained formal review comments from a range of external reviewers (including select municipalities and local organizations as well as third parties/experts in the field of source control). Every effort was made to address these comments in this First Edition, and we are committed to making further improvements in future editions.

1.8 Organization

This document is organized as follows:

- Section 1 – Introduction (this section), which presents the CtS objectives; documents key source control terminology; provides brief background on the ALCOSAN service area, relationship of source control to ALCOSAN's mission and source control regulatory context; and describes the key players for implementing source control as well as the document development process and anticipated revisions and updates.
- Section 2 – Background on Source Control-Related Efforts, which provides specific background on relevant ALCOSAN initiatives, including the CWP and other capital programs with which source control initiatives will interact, as well as background on relevant municipal initiatives and initiatives by others related to source control.

- Section 3 – Generic Opportunity Identification and Prioritization Process, which details the generic approach proposed as part of this framework; summarizes existing conditions particularly relevant to the various source control strategies; details the overflow reduction efficiencies (OREs) development process and presents the OREs to be used as part of the source control-specific process; and summarizes the existing and previously identified projects that were considered in this version of the framework.
- Section 4 – GSI-Specific Process, which documents how the generic process was adapted to the GSI opportunities evaluation; describes the methodology associated with each step; and presents the key intermediate results.
- Section 5 – DSIR-Specific Process, which documents how the generic process was adapted to the DSIR opportunities evaluation; describes the methodology associated with each step; and presents the key intermediate results. It also documents the status of the process implementation.
- Section 6 – I/I Reduction-Specific Process, which documents how the generic process was adapted to the I/I reduction opportunities evaluation; describes the methodology associated with each step; and documents the status of the process implementation.
- Section 7 – SS-Specific Process, which documents how the generic process was adapted to the SS opportunities evaluation; describes the methodology associated with each step; and documents the status of the process implementation.
- Section 8 – Identified and Prioritized Opportunities, which documents the main results associated with process implementation to date. The results are organized by source control category. The results include list of project opportunities, associated concept plans, planning-level cost estimates and prioritization results.
- Section 9 – Web Map, which provides an overview of how to find and access the Web Map that has been created to accompany the framework and facilitate consultation of information.
- Section 10 – Conclusions, which presents the key conclusions and recommendations associated with the established framework.

The CtS also contains a series of appendices including supporting information and key technical memoranda prepared to support the development and implementation of the framework.

1.9 Updates

ALCOSAN intends this document to be a living document that is updated to incorporate feedback, new information, and results of on-going work, particularly in the 2020-2025 timeframe.

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2 Background on Source Control-Related Efforts

2.1 ALCOSAN

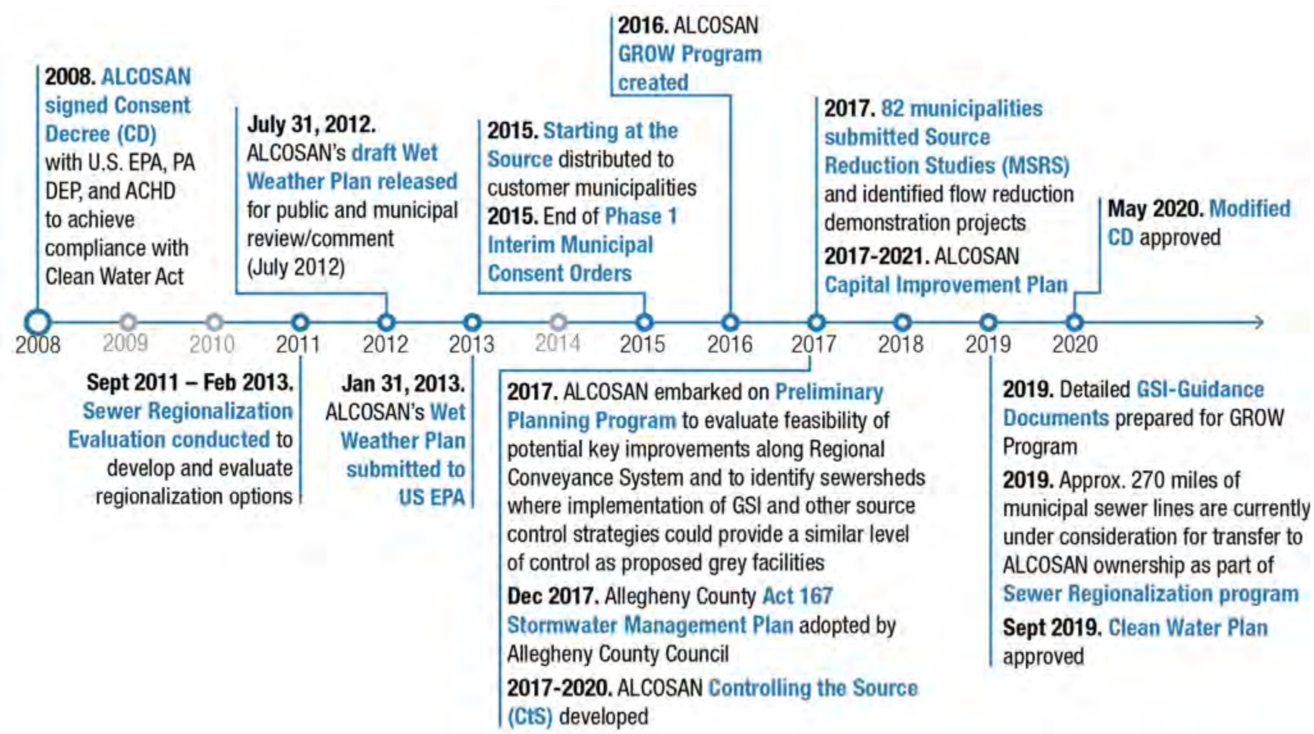
This section provides specific background on relevant ALCOSAN programs and initiatives related to source control and the proposed framework presented in this document.

2.1.1 Recent Program and Initiatives Timeline

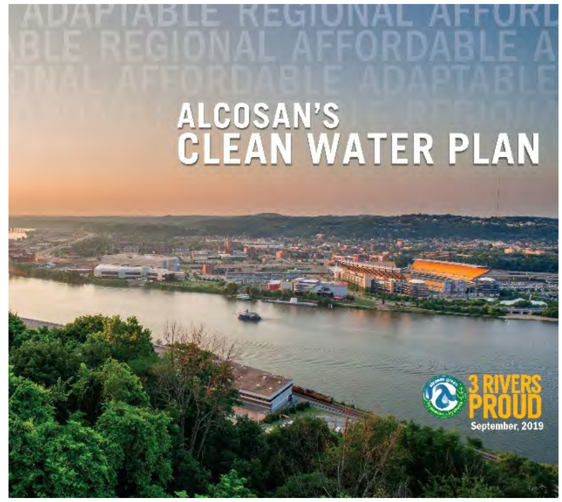
Since the first CD in 2008, ALCOSAN has undertaken several programs to move the region forward in meeting water quality standards and promoting source control as illustrated in **Figure 2-1**. ALCOSAN programs and initiatives most relevant to source control and this framework are described in the following sub-sections.

In addition to ALCOSAN's efforts, many customer municipalities and non-profit organizations/third-party stakeholders have undertaken their own source control initiatives in recent years – some of which, such as the Municipal Source Reduction Studies (MSRS), are also represented in the timeline below. These initiatives are described separately in Section 2.2 and Section 2.3.

Figure 2-1. Recent Source Control-Related Programs and Initiatives Timeline



2.1.2 Clean Water Plan



The implementation of ALCOSAN's long-term plan is intended to reduce the overflows of diluted, untreated wastewater into the region's rivers and improve the water quality of our local waterways. The CWP is designed to be affordable, flexible enough to adapt to evolving technology and regional in scale. The CWP currently includes: expanding the capacity of the WWTP; constructing 18 miles of tunnel to convey the flow to increased-capacity WWTP; making efforts to assume ownership and maintenance of at least 200 miles of multi-municipal sewers; preventing stormwater, some surface streams, and groundwater from entering the sewer system through green stormwater infrastructure and other source control methods; and upgrading conveyance systems and grey infrastructure.

As described in Section 10 and Section 11 of the CWP, ALCOSAN and the regulatory agencies negotiated "a Modified CD that embraces the use of GSI and other source control strategies and recognizes the financial infeasibility of implementing all CD requirements by 2026" as originally envisioned. Through these discussions, the regulatory agencies required a compliance strategy to proceed with the design and construction of an Interim Measures Wet Weather Plan, also referred to as ICWP. The agencies required a strategy "that provides opportunities to integrate GSI and other source reduction practices, while prioritizing the regionalization of multi-municipal trunk sewers and key grey infrastructure projects, where cost-effective."

Since specific flow reduction commitments require on-going coordination with customer municipalities, the Modified CD is "premised on a phased and adaptive implementation framework that supports early implementation of GSI projects, demonstration of effectiveness, and the substitution or reduction of grey infrastructure where GSI and other source control strategies can be shown to cost-effectively provide equivalent [system-wide] performance[4]. Accordingly, the Modified CD includes several adaptive management milestones where new information can be used to propose modifications to ICWP projects and implementation schedules."

Furthermore, the ICWP was divided into three phases:

- Phase 1 elements focus on flow reduction, flow optimization, regionalization, existing infrastructure inspection and rehabilitation, WWTP expansion, and preliminary planning.
- Phase 2 elements include projects that might be influenced by Phase 1 projects and are dependent on the completion of preliminary planning to proceed, including expanding total wet weather treatment capacity from 250 MGD to 600 MGD and construction of the Ohio River tunnel segment.
- Phase 3 projects represent adaptive projects that may be influenced and modified based on the outcome of Phase 1 and Phase 2 evaluations and demonstration projects.

The ICWP currently includes approximately $1.6 billion (in 2010 dollars) in projects associated primarily with the WWTP expansion and construction of the tunnel and associated facilities.

[4] For the ICWP, ALCOSAN and the agencies have established the following performance criteria for evaluating whether potential revisions achieve the same or better system-wide typical year performance: 1. Reduction of untreated ALCOSAN CSO volume to 2,700 MG/yr in a typical year; 2. Control a specific list of ALCOSAN CSOs near Sensitive Areas to zero overflows in a typical year, with the exception of one overflow in a typical year at A-67 (CWP, 2019)

The ICWP also includes $12 million for Preliminary Planning and a commitment to invest up to $200 million in "Regional Flow Optimization Strategy," which includes the following three (3) elements:

- GROW Program.
- Inspection and Rehabilitation of Existing Infrastructure.
- Regionalization and Rehabilitation of Multi-municipal Trunk Sewers.

In the short-term, the elements most relevant to source control in the ICWP are those listed under Regional Flow Optimization Strategy (GROW, Inspection and Rehabilitation of Existing Infrastructure, Regionalization) as well as Preliminary Planning. For this reason, the main objectives and status of these activities are further described below and their relevance to the framework developed in this document is discussed.

2.1.3 GROW Program

2.1.3.1 Program Overview

The ALCOSAN Board of Directors created the Green Revitalization of Our Waterways (GROW) program in a system-wide effort to reduce excess stormwater from entering the collection system. The GROW program is now an essential part of the CWP.

Under the program, any municipality or municipal sewer authority within the ALCOSAN service area is eligible to submit a source control project for grant funding consideration.

Since 2016, the GROW program has provided over $30 million in grant funding towards 105 projects that will reduce sewer overflow by an estimated 142 million gallons.

Table 2-1 provides a summary of these GROW projects as of Jan. 13, 2020, i.e., Cycles 1 through 4.

Figure 2-2 shows the locations of these projects and the location of additional project ideas identified by municipalities during GROW municipal workshops in 2017, 2018, and 2019.

Table 2-1. GROW Projects Summary

	Cycle 1 Awards (#)	Cycle 2 Awards (#)	Cycle 3 Awards (#)	Cycle 4 Awards (#)	TOTAL	Cumulative GROW Grant Amount ($)
GSI	11	12	1	4	28	$10,970,483
DSIR	2	1	-	-	3	$1,039,785
I/I	9	8	11	22	50	$8,582,754
SS	6	7	5	2	20	$7,346,718
SO	-	-	-	1	1	$801,500
TOTAL	28	28	17	29	102	$28,741,240

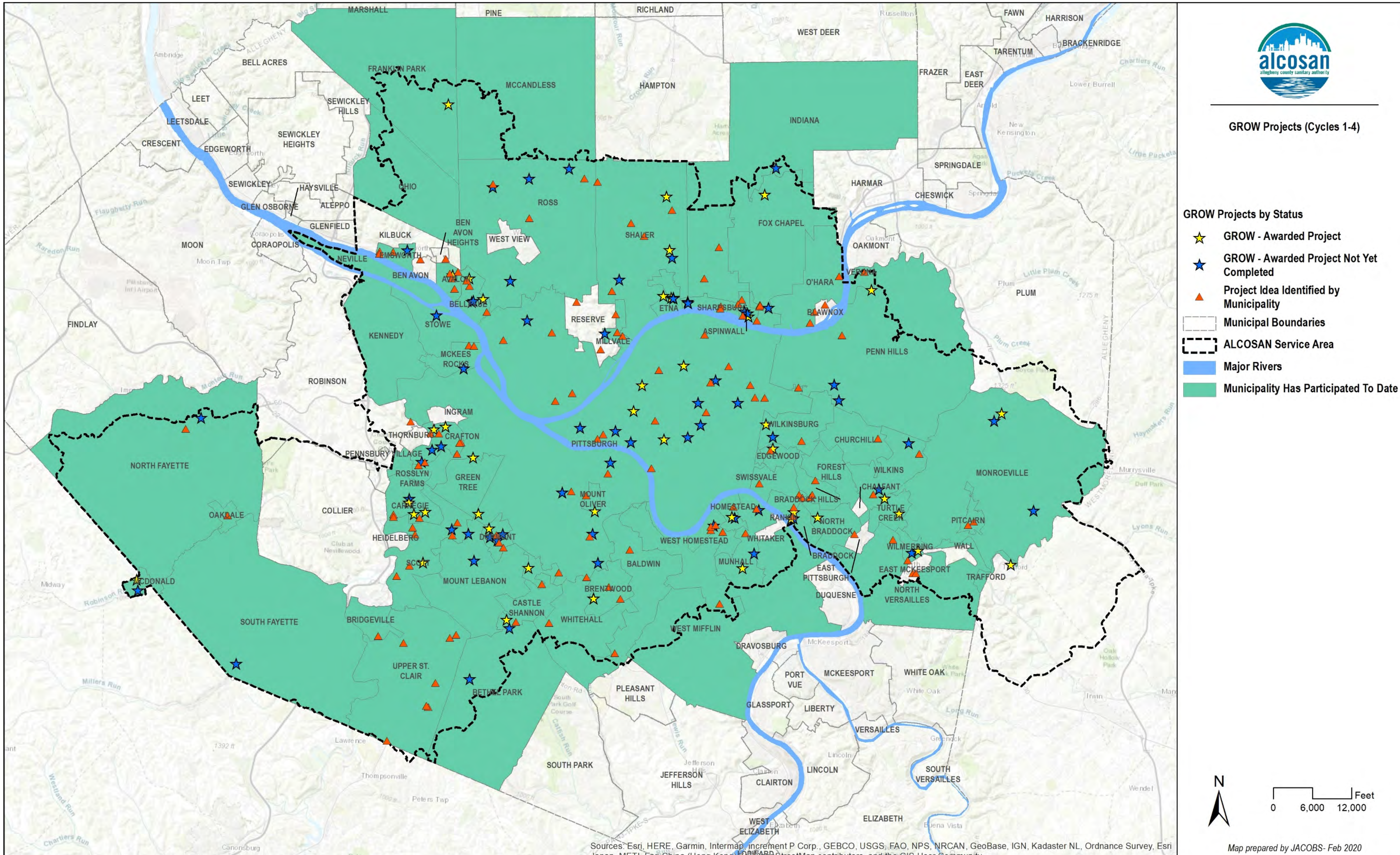
In addition to financial support, ALCOSAN provides technical support to customer municipalities on an as-needed basis and/or through the development of technical documents (see section 2.1.4.2). The as-needed support includes design and flow monitoring support.

Additional information about the GROW Program is available on ALCOSAN's website at https://www.alcosan.org/our-plan/grow-program as well as under the dedicated Municipal Log-In on ALCOSAN's website main page.

The website currently includes information on when and where to apply for financial support, specific information on grant recipients and projects, as well as the GSI Guidance Document discussed in the subsequent section of this document.

Information on the general website and under the Municipal Log-In will be updated as regularly as possible and should constitute the municipalities' and other stakeholders' preferred way of accessing most recent information about the GROW Program.

Figure 2-2. GROW Project Locations



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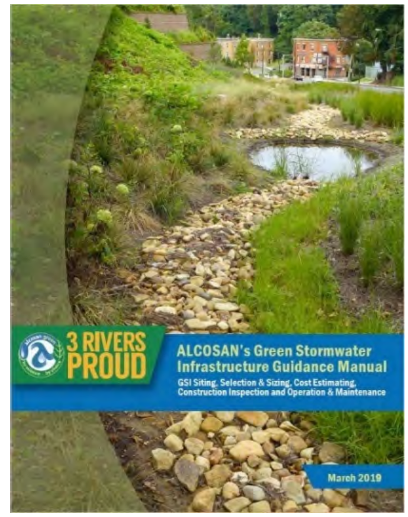
2.1.3.2 Technical Guidance Documents

Two key technical guidance documents relevant to the framework presented in this document were recently developed by ALCOSAN.

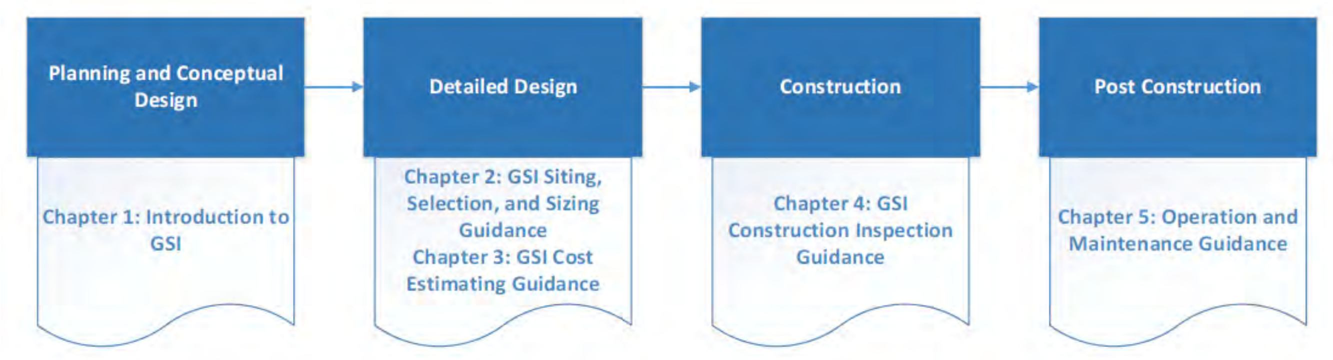


GSI Guidance Manual – In 2019, ALCOSAN developed and distributed a detailed GSI-focused guidance document to its customer municipalities.

The guidance document provides guidelines to facilitate successful implementation of GSI designs, from initial planning stages to post-construction maintenance.

The document is structured as described below to provide guidance from planning and conceptual design through operation and maintenance.

- **Chapter 1 Introduction to GSI** introduces GSI facility types and their components.
- **Chapter 2 GSI Siting, Selection and Sizing Guidance** provides key factors to consider when siting, selecting and sizing the most efficient GSI practices.
- **Chapter 3 GSI Cost Estimating Guidance** provides guidance, requirements and resources for developing clear and accurate cost estimates for GSI projects and discusses eligible and ineligible costs under the GROW program.
- **Chapter 4 GSI Construction Inspection Guidance** provides information to help facilitate successful construction inspections for all phases of GSI construction.
- **Chapter 5 Operations and Maintenance Guidance** provides information on general best practices for GSI operations and maintenance tasks throughout the lifespan of a GSI facility.



The GSI Guidance Manual is now available to the general public on ALCOSAN's website at https://www.alcosan.org/our-plan/grow-program.

Monitoring Guide – In May 2019, ALCOSAN finalized a Monitoring Guide covering a range of source control projects including GSI.

Both in-sewer and in-GSI monitoring protocols are discussed and monitoring summary forms are provided for various project/monitoring types.

The monitoring guide is available to the public through ALCOSAN's website.

2.1.3.3 Relevance of the Proposed Framework to the GROW Program

This framework aims at identifying cost-effective and impactful source control projects that the GROW program could support. The framework supports leveraging planned work and public and private investments to extend the reach of the GROW program. The GROW program is currently based on existing conditions but is anticipated to evolve as the CWP is implemented.

2.1.4 Inspection and Rehabilitation of Existing Infrastructure

As described in Section 11.2.1.6 of the CWP, ALCOSAN will be considering the feasibility of integrating GSI or other SC strategies whenever working on inspection and rehabilitation of its existing assets. For example, GSI was installed at the ALCOSAN Customer Service and Training building when it was constructed, and portions of the shallow-cut regional interceptor lines were rehabbed to address structural and I/I issues.

These opportunities have been considered and implemented by ALCOSAN as part of standard practices. In the future, they could be considered as part of this framework to identify specific upcoming opportunities.

2.1.5 Regionalization and Rehabilitation of Multi-municipal Trunk Sewers

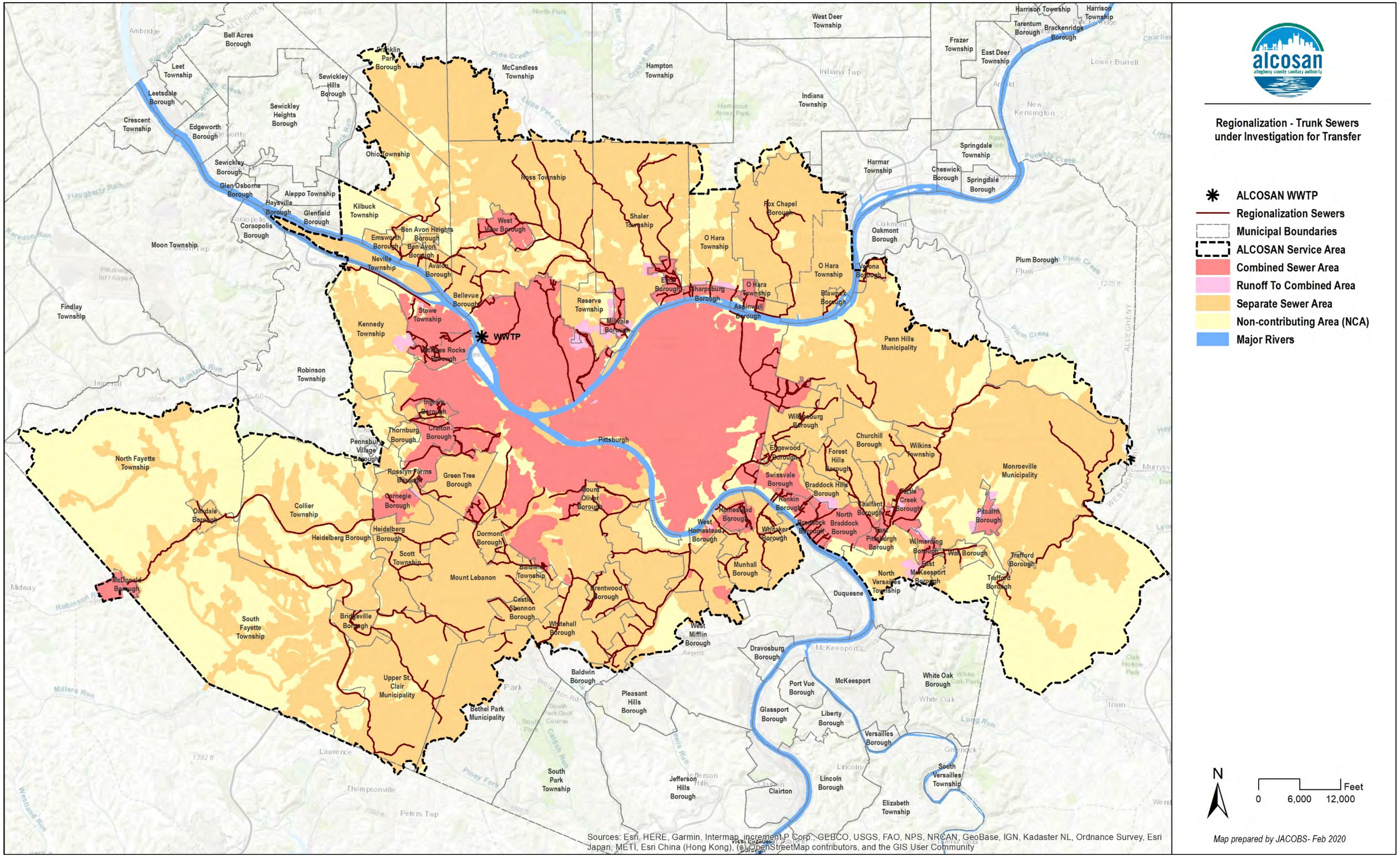
Regionalization is an important component of the CWP and will more than double ALCOSAN's sewer system ownership and maintenance responsibilities in the region. Regionalization involves the voluntary transfer of some of the largest municipal sewers and sewer facilities in the service area over to ALCOSAN. This reduces the financial burden on municipalities and allows ALCOSAN to more directly manage and reduce excess flows into the system. This will be accomplished by ALCOSAN assuming ownership and maintenance of at least 200 miles of large, multi-municipal trunk sewers and associated facilities. In comparison, the current ALCOSAN system encompasses 90 miles. ALCOSAN has conducted closed-circuit television (CCTV) inspections of these sewers, determined what repairs and improvements are necessary, and is now in the process of working with the municipalities to transfer ownership and make the necessary repairs.

Figure 2-3 illustrates the location of the approximately 270 miles of trunk sewers under consideration for transfer.

ALCOSAN anticipates that regionalization will support flow reduction initiatives, including the prioritization of sewer rehabilitation projects to reduce I/I along transferred trunk sewers.

Initial potential flow reduction opportunities to reduce I/I along transferred trunk sewers and/or immediately upstream were considered in the framework under Section 6 to the extent that time and available information allowed and will be subject to future updates.

Figure 2-3. Regionalization – Trunk Sewers under Investigation for Transfer



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2.1.6 Preliminary Planning

The Preliminary Planning component of the CWP advises ALCOSAN on the size, location and route of new conveyance tunnels, drop shafts, regulators, and shallow conveyance sewers that will be constructed (as part of Phase 2 and Phase 3 of the ICWP). It will also integrate data from our treatment plant expansion and GROW program to determine the need and best uses of the proposed facilities. The Preliminary Planning process will culminate in the issuance of a Basis of Design Report.

The Basis of Design Report is anticipated to be completed by Oct. 2020 consistent with the Modified CD requirements.

The Modified CD includes a requirement that, beginning in 2020, ALCOSAN submit an annual analysis of whether flow reduction efforts are reducing the volume or rate of flow to the conveyance and treatment system. Per this requirement, the inflow reduction benefits associated with source control projects flows implemented since the last model update will be evaluated.

In the case of the opportunities identified in this document, their consideration would be contingent upon implementation, the Municipal Source Reduction Agreements (see Section 1.5.2) or separate enforcement orders with PADEP or ACHD.

For this reason, the immediate relevance of the proposed framework to Preliminary Planning/Basis of Design has been focused on identifying sewersheds where implementation of GSI and other source control methods could provide a similar level of control as proposed grey facilities. These sewersheds are associated with the points of connection (POCs) to be controlled in the ICWP. This analysis will be described in the Basis of Design report.

Conversely, the Preliminary Planning/Basis of Design is relevant to the framework in that it affects the OREs presented in Section 3. This point of interaction is handled by calculating the OREs under different system conditions as discussed further in Section 3.

2.1.7 Other Source Control-related Initiatives

Other ALCOSAN source control-related initiatives specifically identified in section 11.2.1 of the CWP, and relevant to the framework, include the following:

- Support municipalities as needed in developing their own municipal flow reduction plans (section 11.2.1.2 of the CWP).
- Support municipalities as needed in developing model ordinances and other initiatives – to be coordinated with requirements in the municipal orders and with Phase 2 of the Act 167 Countywide Stormwater Management Plan (Final, May 2018) being implemented by Allegheny County (section 11.2.1.3 of the CWP).
- Continue flow monitoring activities in support of the flow isolation program, baseline flow monitoring and analysis and other needs (section 11.2.1.4 of the CWP).

As noted in Section 1, this framework is intended to be a tool to support some of these initiatives, including the development of municipal flow reduction plans. Conversely, information provided by other of these initiatives, including the flow monitoring activities, was used to develop and apply the proposed framework.

2.2 Customer Municipalities

This section provides an overview of key recent source control-related programs and initiatives that have been undertaken by customer municipalities in the ALCOSAN service area. It also summarizes the key outcomes or status to date. More details on these programs and initiatives are provided in **Appendix A-1 through A-4**.

Municipalities in urbanized areas that own and operate their own Municipal Separate Storm Sewer System (MS4) are required to obtain a permit to transport and discharge stormwater runoff into local water bodies. The federal MS4 program requires permittees to develop and implement a Stormwater Management Plan (SWMP) that must include pollution prevention measures, treatment or removal techniques, monitoring, use of legal authority, and other appropriate measures including capital improvement projects to control the quantity and quality of stormwater discharges. Since CtS is a framework for controlling the source of inflow to the regional sewer system (and not to municipal separate storm sewers), specific MS4-related efforts are not included in this section.

2.2.1 Allegheny County Act 167 County-wide Stormwater Management Plan

Overview: The Allegheny County (County) Act 167 Stormwater Management Plan was adopted by Allegheny County Council on Dec. 6, 2017. Enacted by the PADEP, Act 167 is a statewide policy which requires that counties put a plan in place to address the problems caused by stormwater runoff. These plans must address both stormwater quantity and quality.

It is the responsibility of the individual municipalities located within the County to adopt or amend an ordinance based on the Model Stormwater Management Ordinance provided in the Act 167 Plan to provide a consistent minimum threshold for the management of stormwater throughout the County.

Key outcomes: The new stormwater management ordinance requirements have the potential to reduce stormwater flows as development and redevelopment occurs in the county.

2.2.2 Municipal Source Reduction Studies

Overview: To comply with their PADEP Phase 1 COAs and ACOs, municipalities in separate sewersheds had to conduct required activities such as developing flow targets, identifying and completing demonstration projects, and preparing MSRS that describe how the municipality plans to address wet weather concerns.

Flow targets for separate sewers are being evaluated in a collaborative process between ALCOSAN and the 3 Rivers Wet Weather Working Group (3WG) Source Flow Reduction and Flow Target Subcommittee. These flow targets were considered in the development of the I/I Reduction Project Identification process (see Section 6).

Each municipality/authority was also required to implement one flow reduction demonstration project. The project could include enacting an ordinance addressing private laterals (separate systems) or expanding the use of Low Impact Development (GSI) in development projects (combined systems). The studies were also required to quantify the effectiveness of the demonstration project, to the extent feasible, i.e., the anticipated flow reduction benefit of the identified projects and strategies.

Each municipality was also required to identify areas which may benefit from GSI, I/I reduction, lateral inspection/repair (separate systems) and DSIR as well as additional flow reduction projects and strategies. They were also required to report the anticipated flow reduction benefit of the identified projects and strategies.

Key outcomes: An internal review by ALCOSAN of the MSRS that were submitted in Dec. 2017 concluded the following:

- A total of 69 demonstration projects were identified (63 completed, five underway, one yet to be selected), as of Apr. 2018.

- 20 municipalities/authorities indicated their demonstration project was an existing, amended or new ordinance enacted to address testing/repair of private sewer laterals at the time of sale or transfer of property. Nine of these ordinances were new with one more expected to be enacted in the near future[5].
- The demonstration projects were estimated to remove 1.7 BG of flow from the sewer system on an annual basis based on information provided by the Municipalities for the individual projects. These numbers do not directly translate to overflow reduction.
- In total, there were 278 other opportunities identified by 54 municipalities/authorities. There were 28 municipalities/ authorities that did not identify any potential source reduction opportunities in their reports.
- Flow reduction was estimated for some individual opportunities, but there was generally insufficient information to estimate the total flow reduction for all opportunities.

2.2.3 Pittsburgh Water and Sewer Authority (PWSA)

2.2.3.1 City of Pittsburgh Stormwater Management Requirements

Overview: The City of Pittsburgh recently updated its stormwater management regulations for new development and redevelopment projects within the City (Mar. 2019, Ord. No. 12-2019) as part of the release of the Allegheny County Act 167 Plan.

Title Thirteen of the Pittsburgh Zoning Code contains the stormwater management requirements, which includes stormwater rate and volume requirements for projects over a certain area of disturbance, and promotes the use of GSI and low impact development practices.

For development and re-development projects that are regulated by this code, including disturbances greater than or equal to 10,000 square feet (SF), or the addition of 5,000 SF of impervious area, stormwater runoff from impervious areas on the site must be controlled on-site. Publicly funded development and redevelopment projects disturbing 500 SF or more of impervious area are also required to follow the stormwater ordinance. The onsite stormwater management techniques and facilities must be properly sized, in priority of order, to infiltrate, evapotranspire, and/or harvest for reuse, without allowing any off-site discharge, and by using GSI and low-impact development practices to the maximum extent technically feasible, the precipitation from all rainfall events less than or equal to the 95th percentile rainfall event (currently 1.5 inches).

If conditions exist that prevent the implementation of water quality and/or quantity control practices on site, upon written request by the applicant, the Planning Department may at its sole discretion accept off-site stormwater management practices, retrofitting, stream restorations, or other practices that provide water quality and/or quantity control equal or greater than onsite practices for the volume which the applicant has demonstrated to be infeasible to manage and treat on site.

The City Planning Department has developed a procedure for a fee-in-lieu alternative compliance, outlining the technical requirements for allowing alternative compliance and a management framework to oversee the process. A fee paid in lieu of constructing a stormwater facility on a project site will be deposited in the City of Pittsburgh Stormwater Trust Fund. The Department of City Planning will utilize these funds for the construction of stormwater management projects designed to serve the immediate or future needs of the city to reduce stormwater flooding and/or erosion, and to enhance water quality in ravines and watercourses.

Key outcomes: The new stormwater management ordinance requirements have the potential to reduce stormwater flows as development and redevelopment occurs in the City.

[5] According to their website consulted in Jan. 2020, Blawnox has not codified their ordinance.

2.2.3.2 PWSA's Citywide Green First Plan

Overview: The 2016 draft Citywide Green First Plan outlines how Pittsburgh and PWSA intend to use innovative, cost-effective GSI approaches to manage stormwater. The draft plan examines the existing stormwater conditions that will guide where GSI could be installed to achieve cost-effective and beneficial results to the residents of Pittsburgh. Creating the plan required extensive sewershed and hydrologic analysis, community and stakeholder outreach, and consideration of future development projects within the City.

The assessment focused on 30 priority sewersheds (nearly 14,000 acres) within the PWSA system. Results show that managing 1,835 acres with GSI coupled with wet weather WWTP capacity increases could achieve 85% capture of CSO volume in these sewersheds. See **Appendix A-3** for more details.

Status: GSI projects implemented to date in progress as part of the plan implementation can be consulted on the PWSA website at https://www.pgh2o.com/projects-maintenance/green-stormwater-projects.

2.2.4 Additional Capital Improvement and Comprehensive Plans

Many of the municipalities in the ALCOSAN service area have their own comprehensive and capital improvement plans that lay out overarching priorities for redevelopment and investment and identify specific projects and areas where improvements are being focused. In addition, agencies such as PennDOT or the Port Authority of Allegheny County (Port Authority) have comprehensive plans that may impact the ALCOSAN service area and have synergies with potential source control strategies.

These individual plans should be referenced when evaluating where to strategically locate source control projects, as many of the recommendations in this framework can complement existing municipal initiatives related to development, infrastructure improvements and environmental protection.

2.3 Others

Below is a summary of concurrent source control-related efforts and initiatives by other entities in the ALCOSAN service area. The Pittsburgh region is rich with active organizations who directly or indirectly support work with ALCOSAN's partners, seeking similar source control solutions. This section is not meant to be an exhaustive documentation of every group, and as such, major entities are included here, and more detail is provided in **Appendix A**.

2.3.1 3 Rivers Wet Weather

3RWW is a nonprofit environmental organization created in 1998 to support 83 Allegheny County municipalities, including the City of Pittsburgh, in addressing the region's wet weather overflow problem. Founded jointly by the ACHD and ALCOSAN, 3RWW is funded by federal, state and local resources, including local foundations. 3RWW seeks to earn municipal trust by building relationships with municipal officials, regulatory agencies, legislators and other regional leaders.

With the cooperation and involvement of communities throughout the ALCOSAN service area, 3RWW is committed to laying the foundation for sewer system consolidation—the key to long-term system sustainability and improved water quality for generations to come.

To promote the most cost-effective, long-term, sustainable solutions, 3RWW does the following:

- Develops technical guidance and resources to assist municipalities with regulatory compliance.
- Convenes forums to encourage a consensus-based approach for feasible and affordable wet weather planning.
- Organizes an annual conference.
- Educates the public.
- Advocates for inter-municipal partnerships aimed to consolidate the fragmented municipal sewer collection system.

2.3.1.1 3RWW Municipal Demonstration Projects

From 1998-2000, 3RWW granted municipalities funding to complete source reduction projects in their municipalities that demonstrated and benchmarked new and cost-effective techniques for manhole rehabilitation, sewer replacement, I/I reduction, pipe bursting, etc. A list of these projects can be found in **Appendix A-5**.

2.3.1.2 3RWW Consolidation Grants

In early 2011, 3RWW awarded grants to Allegheny County municipalities to consider options for consolidating municipal sewer systems in order to save residents millions of dollars and improve water quality. A total of $495,000 was awarded for six projects that included 43 municipalities and authorities. These participants explored options for consolidation that would be the most cost-effective, long-term strategy for the maintenance and operation of the public sewer system. Consolidation could include contract operation and maintenance to asset transfer. The six consolidation studies are described in further detail in **Appendix A-5**.

2.3.2 Watershed Organizations

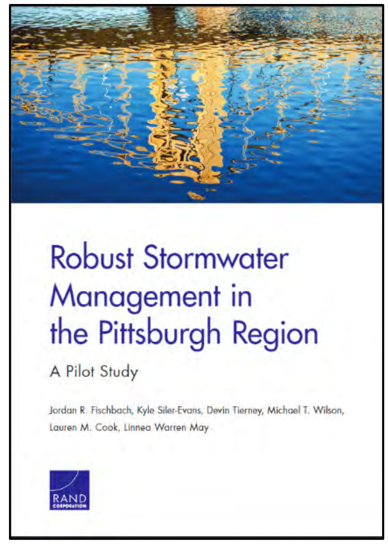
Table 2-2 below lists the primary active watershed organizations and groups within the ALCOSAN Service Area, states their mission and identifies main document(s) relevant to this framework.

Table 2-2. Primary Watershed Organizations and Groups within the ALCOSAN Service Area

Watershed/ Subwatershed	Watershed Organization/Group	Mission/Purpose
Allegheny River	Allegheny Watershed Alliance	Organization within the County Conservation District, dedicated to the support and development of all rivers, creeks and watershed groups in the County by leveraging technology, building capacity and creating spaces for partnerships.
Nine Mile Run	Nine Mile Run Watershed Association	Nine Mile Run Watershed Association restores and protects its watershed ecosystem in Pittsburgh's East End, while working regionally to support and implement resilient solutions for a healthy urban environment. They support residents' efforts to implement innovative solutions to stormwater problems, provide citizen training for urban ecological stewardship and act as an information clearinghouse about key watershed issues. Additional information is provided in **Appendix A-6**.
Saw Mill Run	Watersheds of South Pittsburgh	In partnership with Economic Development South, the mission of this group is to inspire communities in the Saw Mill Run and Streets Run Watersheds by providing environmental leadership, engaging

Watershed/ Subwatershed	Watershed Organization/Group	Mission/Purpose
		citizens in direct action, and partnering on key issues that affect the well-being of the watershed. The Saw Mill Run Integrated Watershed Management Plan is being developed. Additional information is provided in **Appendix A-7**.
Chartiers Creek	Chartiers Creek Watershed Association	The Chartiers Creek Watershed Association is a group of volunteers who work to ensure the high environmental quality of the upper portion of Chartiers Creek in Washington County. The purpose of the Chartiers Creek Watershed Association is to enhance, protect and develop the ecosystem of the watershed. The association studies the natural resources of the watershed, developing programs to maintain and improve the water resources of the watershed, promoting local interest in natural resource conservation, involving local support to correct conditions that cause problems for the watershed, and identifying federal, state, and local programs (financial, technical, and scientific) that would benefit the watershed.
Chartiers Creek	Lower Chartiers Watershed Association	The Lower Chartiers Watershed Association, founded in 2018, promotes the conservation of the Chartiers Creek Watershed in Allegheny County. The group plans litter cleanups, citizen science water monitoring, abandoned mine drainage research, plantings of native trees and plants, and removal of invasive species. The overall goal is to encourage local community members to participate as volunteers in stewardship and to work towards developing an expanded vision of the watershed.
Turtle Creek	Turtle Creek Watershed Organization	Purpose is to promote the conservation of the natural resources of the Turtle Creek Watershed, to conduct educational and scientific investigations and research related to natural resources conservation within and bordering the Turtle Creek Watershed and to improve financial, technical and other assistance from federal, state and local sources to implement the watershed's protection and development.
Girty's Run	Girty's Run Watershed Association	Dedicated to promoting a just and healthy watershed system through advocacy, education, and conservation
Pine Creek	Pine Creek Watershed Coalition	A Coalition of environmental organizations, sportsmen's groups, municipalities, and volunteers was formed to improve the water quality of the Pine Creek Watershed.
	Pine Creek Preservation Association	Preserving the natural and rural character of Pine Creek Valley by facilitating various preservation measures through direct intercession or interaction with planning, regulating or governing agencies and other conservation organizations.
	North Area Environmental Council	Founded in 1969, the group engages in ecological restoration projects, land conservation, education, advocacy, and scientific research, and works collaboratively with 14 municipal partners to keep the Pine Creek watershed clean.

2.3.3 RAND Corporation



In 2017, the RAND Corporation, with the support and input of many local entities, conducted a study of the ongoing challenge of stormwater management in the Pittsburgh region.

The key findings of “Robust Stormwater Management in the Pittsburgh Region” were:

- Recent sewer overflow volumes are up to 15% higher than previously estimated for the 2003 typical year[6] and future rainfall, population, and land-use changes could further increase overflow volumes.
- Expanding wastewater treatment plant capacity or cleaning deep interceptors (if feasible) could represent low-regret, near-term options.
- Large-scale investments in source reduction, or combining source reduction with treatment expansion and/or interceptor cleaning, could help reduce sewer overflow, but with a wide range of uncertainty regarding cost-effectiveness and relative strategy performance.
- None of the combined GSI strategies fully eliminates sewer overflows in current or plausible future conditions.
- GSI strategies, evaluated in isolation, yield poor cost-effectiveness for overflow reduction under commonly used rainfall, capital cost, and GSI performance assumptions.
- Source reduction strategies are more cost-effective in higher rainfall scenarios and could provide a hedging strategy against future climate change.

The study presented several recommendations for how the Pittsburgh region should move forward with stormwater management planning, including the recognition that source reduction could help reliably reduce overflows, but additional research is needed to fully define a long-term, adaptive stormwater and wastewater management strategy. More details can be found in **Appendix A-8**.

2.4 Conclusions

As described, ALCOSAN has undertaken several programs to move the region forward in meeting water quality standards and promoting source control. In addition to ALCOSAN’s efforts, many customer municipalities, non-profit organizations, and third-party stakeholders have undertaken their own GSI and source control initiatives in recent years. Proven interagency collaboration is the best path forward.

In this context, the CtS would provide a common tool to allow all stakeholders to consistently evaluate and prioritize their own source control projects while accounting for regional water benefits and impact.

In addition, future updates of CtS will allow all stakeholders to consider the impact of the implementation on other elements of the ICWP on that prioritization.

[6] “Results from the Recent Historical climate scenario show that the overflow challenge may have already grown in the past decade, with sewer overflows increasing from approximately 9.5 B gal./year in a 2003 Typical Year simulation to a ten-year average of 11 Bgal./year for 2004 to 2013 when holding other system characteristics constant. In part, these increases could be because of an increase in the average annual rainfall, but likely also reflect differences in storm patterns and intensity when comparing the recent ten-year period with the 2003 Typical Year” (RAND, 2017).

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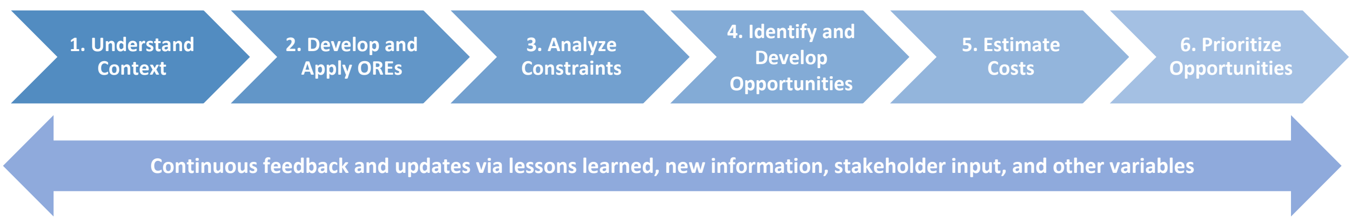
3 Generic Opportunity Identification and Prioritization Process

As noted in Section 1, the primary objective of this CtS is to develop a consistent, science-based step-by-step planning-level framework to aid in identifying cost-effective, impactful potential source control projects (or opportunities).

The framework that was developed to meet this objective considers factors such as physical constraints, overflow reduction and OREs, and costs through the six-element generic source control opportunity identification and prioritization process represented in **Figure 3-1**. Feedback and updates via lessons learned, input from stakeholders, etc. can be considered. Through this process and cooperation, the opportunities identified in this document can be refined and adaptated and additional opportunities can be identified.

Figure 3-1. Generic Opportunity Identification and Prioritization Process



The six elements of this generic process consist of the following:

1. Understand Context: The first element in the process is to understand existing conditions for natural and built systems, such as watershed/sewershed boundaries, land use and existing sewer infrastructure systems. Existing studies and planned/expected conditions should also be considered when relevant (e.g., planned capital improvements and applicable rainfall assumptions).
2. Develop and Apply OREs: To identify optimal, cost-effective locations for impactful source control project implementation, the areas where significant overflow reduction can be achieved must be known. The second element in the process is therefore to develop and apply OREs, i.e., reduction in overflow volume per unit reduction in inflow – to identify where the impact of reduction in inflow on overflow is the highest. These values were calculated across the combined and separate sewer system based on individual subbasin modeling and Step 1 information (such as impervious area).
3. Analyze Constraints: The third element in the process is to analyze constraints based on Step 1 information that may affect potential project definition and/or implementation. For example, in the case of I/I reduction opportunities, these could involve existing hydraulic deficiencies that would influence the type of corrective action recommended. For GSI, constraints could include natural characteristics such as shallow bedrock, steep slopes or poor soils.
4. Identify and Develop Opportunities: The fourth element in the process involves considering existing/ previously identified projects, identifying opportunity areas, and developing specific source control potential projects/opportunities through various approaches depending on source control type. For example, for GSI opportunities, identifying opportunity areas would involve analyzing parcel ownership and land use in the CSS (from Step 1) with relatively low constraints (from Step 3) situated in high ORE subcatchments (from Step 2) and defining a corresponding potential project.

   The intent of the identification step is to supplement and/or complement opportunities identified by municipalities or any other stakeholders, including private property owners.

5. Estimate Costs: The fifth element in the process is to develop preliminary cost estimates. In the case of GSI opportunities, for example, a specific costing methodology was developed that considers integrated costs versus standalone project costs while also considering OREs and constraints as major determinants of cost-effectiveness in terms of overflow reduction.

6. Prioritize Opportunities: The sixth and final element in the process is to prioritize opportunities based on impact and cost-effectiveness.

   The identified opportunities are intended to be further evaluated in coordination with municipalities and would typically be implemented by the municipalities with potential partial funding and technical support from ALCOSAN.

The detailed process (including specific steps and methodology) associated with each of the elements listed above must be adapted to the source control category.

This section only details the following three (3) key steps, which are common to each source control-specific process:

- Understanding context.
- Developing OREs.
- Considering existing/previously identified projects.

Each step and associated methodology and/or outcomes/results are presented below.

The specific processes and associated key intermediate outcomes are detailed in Section 4 for GSI, Section 5 for DSIR, Section 6 for I/I reduction, and Section 7 for SS. The results for all categories are presented in Section 8.

3.1 Understanding Context

The first step in the process is to understand the context for natural and built systems. This information is then used to develop the opportunities and constraints analyses for the different source control categories.

Georeferenced data available for the entire service area was used as the primary initial data source for this framework – in part to allow it to be as broad as possible.

Over 20 geographic information system (GIS) layers were used to support the CtS including parcels, depth to bedrock, sewer infrastructure, transportation infrastructure such as railroads, and wetland inventory. All available layers are referenced in **Appendix B-1** along with a short description and source.

Key information relative to watershed boundaries, geology and soils, land use/land use cover, customer municipalities and sewer infrastructure is summarized below.

3.1.1 Watershed Boundaries

The ALCOSAN Service Area spans three main watersheds – the Allegheny River watershed, the Monongahela River watershed and the Ohio River watershed – as shown in **Figure 3-2**. As described in Section 1.4, the service area was divided into seven planning basins to develop the CWP. To maintain consistency with the CWP and the basin-level H&H models, information in this and subsequent sections was organized by planning basin whenever practical.

Table 3-1 provides statistics on the area of each watershed spanned by the ALCOSAN Service Area.

Table 3-2 lists the watersheds and sub-watersheds associated with each of the ALCOSAN Planning Basins.

Table 3-3 presents drainage characteristics of the larger streams within the ALCOSAN Service Area.

Figure 3-2. Watershed Boundaries in the ALCOSAN Service Area

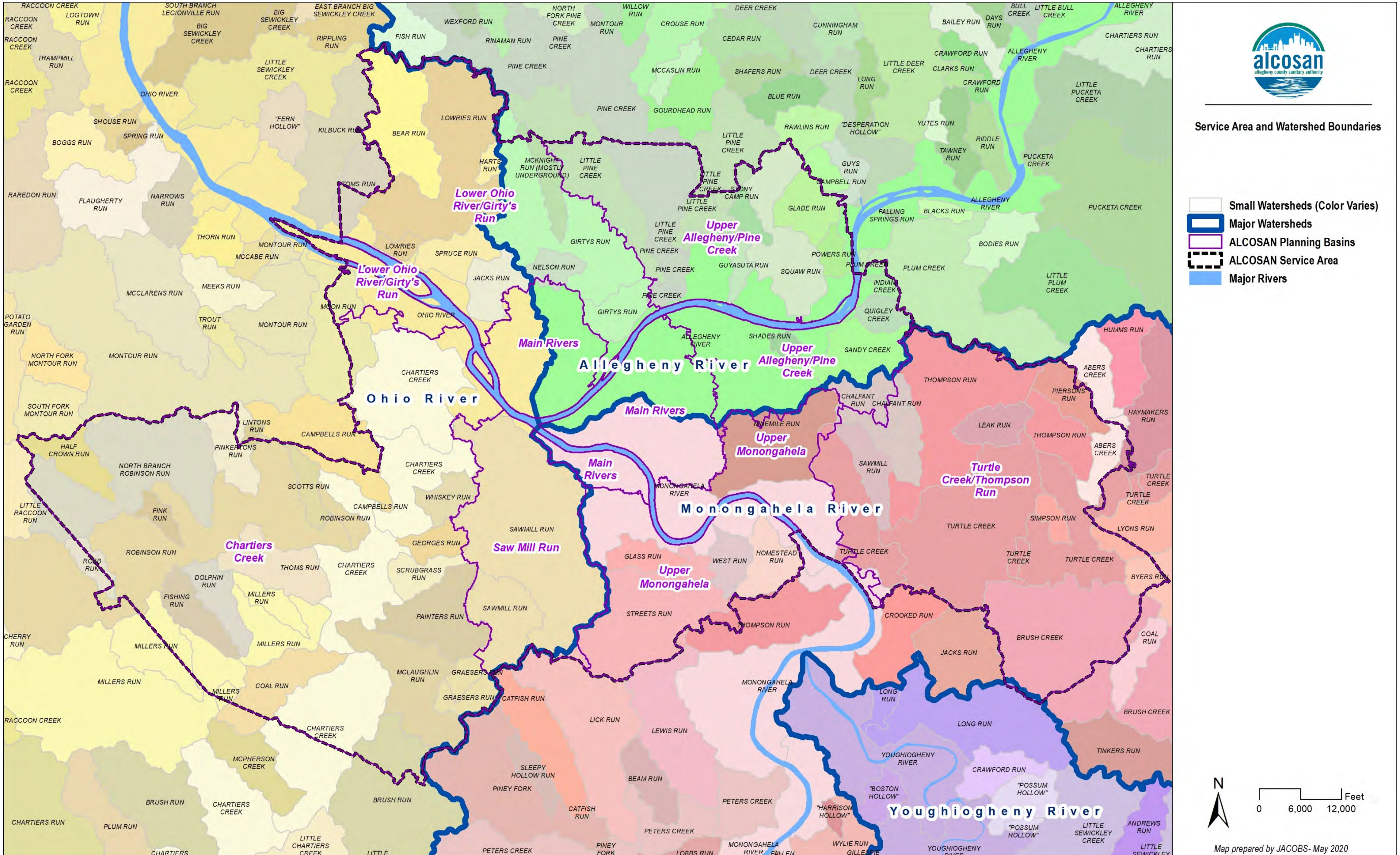


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Table 3-1. Major Watersheds within the ALCOSAN Service Area

Watersheds	Size (sq. mi.)	Portion within ALCOSAN Service Area (sq. mi.)	Portion of Watershed within ALCOSAN Service Area (%)
Allegheny River Watershed	11,580	67	0.6
Monongahela River Watershed	7,340	96	1.4
Ohio River Watershed	189,422	146	0.1

Data sources: ALCOSAN Wet Weather Plan, ALCOSAN Service Area and Sewershed GIS layers

Table 3-2. Primary Watersheds and Sub-watersheds Within Each Planning Basin

Planning Basin	Watershed	Sub-Watershed
Chartiers Creek (CC)	Ohio River Watershed	• Portions of Chartiers Creek • Campbells Run • Robinson Run • Painters Run • McLaughlin Run • Thoms Run • Millers Run • Coal Run • Unnamed tributaries to Chartiers Creek
Lower Ohio/Girty's Run (LOGR)	Allegheny River Watershed/Ohio River Watershed	• Girty's Run • Lowries Run • Spruce Run • Toms Run • Unnamed tributaries to the Ohio River
Main Rivers (MR)	Allegheny River Watershed/ Monongahela River Watershed	• Unnamed tributaries to the Allegheny River • Unnamed tributaries to the Monongahela River
Saw Mill Run (SMR)	Ohio River Watershed	• Saw Mill Run
Turtle Creek/ Thompson Run (TC)	Monongahela River Watershed	• Portions of Turtle Creek • Thompson Run • Portions of Brush Creek • Portions of Abers Creek
Upper Allegheny/Pine Creek (UA)	Allegheny River Watershed	• Powers Run • Squaw Run • Guyasuta Run • Pine Creek • Indian Creek • Quigley Creek • Sandy Creek • Shades Run • Portions of Plum Creek • Unnamed tributaries to the Allegheny River

Planning Basin	Watershed	Sub-Watershed
Upper Monongahela (UM)	Monongahela River Watershed	• Streets Run • Glass Run • West Run • Homestead Run • Nine Mile Run • Unnamed tributaries to the Monongahela River

Data sources: ALCOSAN Wet Weather Plan, PADEP eMapPA, ALCOSAN Service Area and Sewershed GIS layers

Table 3-3. Drainage Characteristics for the Large Streams in the ALCOSAN Service Area

Stream	Length of Stream in Service Area (ft)	Average Annual Flow (cfs) (USGS)	USGS Flow Gage Location	Total Drainage Area (sq. mi.)	Percentage in ALCOSAN Service Area (%)	Percentage in CSS (%)	Percentage in SSS (%)	Percentage unsewered directly draining (%)
CC	117,600	292.0	Carnegie	257	36.5	8	43	49
SMR	43,100	19.3	Duquesne Heights	18	100	26	67	7
TC	61,700	180.4	Wilmerding	147	39	5	58	37
Allegheny River	58,700	20,260	Natrona	11,580	0.6	21	56	23
Monongahela River	52,300	8,766	Elizabeth	7,340	1.4	12	48	40
Ohio River	41,700	34,256	Sewickley	189,400	<0.1	16	56	28

3.1.2 Geology and Soils

Subsurface geology characteristics can significantly impact permeability and the feasibility and cost of earth-moving activities associated with source control projects such as GSI.

Depending on the geologic formations underlying an area, that area may be characterized by steep slopes, shallow depths to the water table and/or bedrock, or prone to landslides. Additionally, large swaths of Allegheny County have been mined for coal. Most of the mines are located underneath the southern and eastern parts of Allegheny County, although there are several areas in the City of Pittsburgh that are mapped as underground mining areas. Abandoned mine areas are considered a relative constraint for GSI due to water quality issues and potential for recharged mine water discharging to surface streams, and have been classified as such in the GSI constraints analysis (see Section 4). "Landslide prone" areas were intentionally omitted from the constraints analysis (Section 4) as they primarily impact infiltration systems not all GSI.

The Pennsylvania Stormwater Best Management Practices Manual (PADEP, 2006)[7] includes useful guidelines on stormwater management related to shallow bedrock/water table, steep slopes, limestone areas, and hotspots.

Soil properties are also an important consideration when selecting locations for potential GSI and source control projects. Taking a closer look at soil characteristics provides ALCOSAN and its municipalities a geospatially

[7] PADEP, Pennsylvania Stormwater Best Management Practices Manual, Dec 2006

informed estimate of areas where GSI and source control potential may be limited and/or costlier based on the likelihood of limited infiltration, reduced performance, and excavation/construction challenges.

For example, GSI facilities promote infiltration of stormwater into the ground to prevent or minimize the amount of stormwater runoff that enters the sewer system, contributing to overflows and/or requiring treatment at the WWTP. Characteristics that promote infiltration include higher soil permeability, low water table and low clay content. Conversely, soils that are in saturated zones or areas with seasonally high-water tables will restrict infiltration. Steep slopes are also not good locations for GSI facilities due to constructability and performance concerns and the fact that saturated soils may increase the likelihood of landslides. The Pennsylvania Stormwater BMP Manual recommends that GSI facilities are designed with separation from bedrock.

Allegheny County is dominated by 10 major soil types. They are divided into two groups: 1) areas dominantly unaltered by urban development and strip mines and 2) areas dominantly altered by urban development and strip mines.[8] Many of these soils have characteristics that are subject to factors that can affect earth-moving activities, such as erosion, seasonal high-water table, hydric soils, landslide, and slow percolation. Much of the ALCOSAN service area, especially the combined sewer area, is likely to have urban soil conditions that may impact the type, performance, or configuration of GSI measures. Site-specific investigations and geotechnical soil testing can provide further details and help identify historic cut and/or fill, soil compaction, building debris, contamination, pH, lack of plant nutrients and other issues.

Further information on geology and soils is provided in **Appendix C-1**.

3.1.3 Land Use/Land Cover

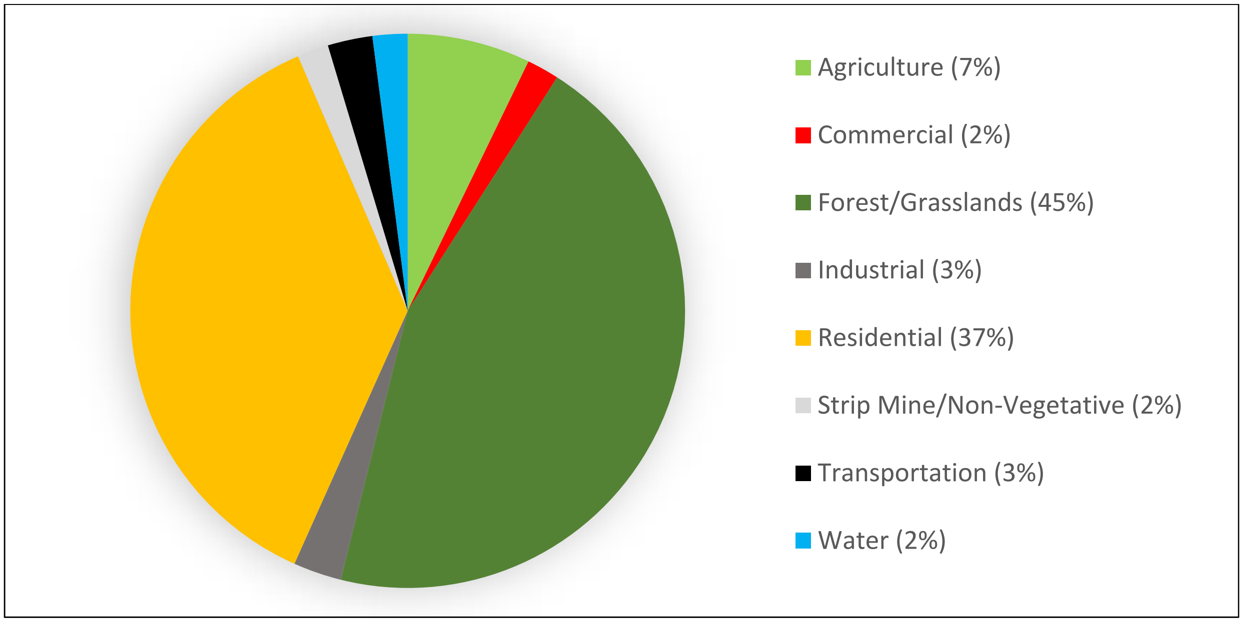
Land use/land cover plays an important role in the identification of source control opportunities and when evaluating the feasibility of source control implementation, particularly GSI.

Land use and property ownership (public versus private) characteristics are considered when evaluating areas for potential project implementation. For example, industrial and manufacturing land uses will typically provide less opportunity for GSI. On the other hand, park and recreation land uses are excellent opportunities for GSI projects, particularly when these properties are publicly-owned. Land use plays a role in both the CtS Constraints and Opportunity Analyses, which are described in the following sections.

A significant portion of the ALCOSAN service area is undeveloped land with forests and grasslands composing 45% of the total land cover (**Figure 3-3**). Residential land uses account for over one-third of the area. The remainder of the service area consists of agriculture (7%), commercial (2%), industrial (3%), strip mine/non-vegetative (2%), transportation (3%), and water (2%). Most of the commercial areas are located within the City of Pittsburgh, where the three rivers converge. The majority of heavy industrial activities occur along the rivers.

[8] Soil Survey of Allegheny County and the Pennsylvania Department of Environmental Protection Erosion and Sediment Pollution Control Program Manual

Figure 3-3. Land Cover within the ALCOSAN Service Area



Data source: Allegheny County Open GIS, Oct. 2015

3.1.4 Customer Municipalities

ALCOSAN provides service to 83 municipalities, including the City of Pittsburgh. The sewage collection systems that are primarily owned, operated, and maintained by these communities, consisting of nearly 4,000 miles of pipes, flow into the wastewater treatment plant owned by ALCOSAN. ALCOSAN's complex mix of large and small customer municipalities have service populations ranging from less than 100 residents to more than 300,000. Municipal median household incomes (2012 estimates) range from less than $18,000 to more than $220,000. This hydraulically and institutionally complex wastewater collection, conveyance, and treatment system requires intensive coordination amongst the various stakeholders, including ALCOSAN's customer municipalities, regional interest groups, and the general public.

The municipal collection systems from the communities/authorities listed transport sewage to the ALCOSAN WWTP located on Preble Avenue in the Woods Run area of Pittsburgh.

Municipalities

Aspinwall Borough
Avalon Borough
Baldwin Borough*
Baldwin Township
Bellevue Borough
Ben Avon Borough
Ben Avon Heights Borough
Bethel Park Borough*
Blawnox Borough
Braddock Borough
Braddock Hills Borough
Brentwood Borough
Bridgeville Borough
Carnegie Borough
Castle Shannon Borough
Chalfant Borough
Churchill Borough
City of Pittsburgh
Collier Township*
Crafton Borough
Dormont Borough
East McKeesport Borough*
East Pittsburgh Borough
Edgewood Borough
Etna Borough
Emsworth Borough
Forest Hills Borough
Fox Chapel Borough*
Franklin Park Borough*
Green Tree Borough
Heidelberg Borough
Homestead Borough
Indiana Township*
Ingram Borough
Kennedy Township
Kilbuck Township
McCandless Township*
McDonald Borough
McKees Rocks Borough
Millvale Borough
Monroeville Borough
Mt. Lebanon
Mt. Oliver Borough
Munhall Borough
Neville Township
North Braddock Borough
North Fayette Township*
North Huntingdon Township*
North Versailles Township
O'Hara Township
Oakdale Borough
Ohio Township*
Penn Hills Township*
Penn Township (Westmoreland)*
Peters Township (Washington)*
Pitcairn Borough
Pleasant Hills Borough*
Plum Borough*
Rankin Borough
Reserve Township
Robinson Township*
Ross Township
Rosslyn Farms Borough
Scott Township
Shaler Township
Sharpsburg Borough
South Fayette Township
Stowe Township
Swissvale Borough
Thornburg Borough
Trafford Borough
Turtle Creek Borough
Upper St. Clair Township
Verona Borough*
Wall Borough
West Homestead Borough
West Mifflin Borough*
West View Borough
Whitaker Borough
Whitehall Borough
Wilkins Township
Wilkinsburg Borough
Wilmerding Borough

Municipal Sewer Authorities

Bethel Park Municipal Authority

Collier Township Municipal Authority

Girty's Run Joint Sewer Authority

McCandless Township Sanitary Authority

Monroeville Municipal Authority

Munhall Sanitary Sewer Municipal Authority

Municipal Authority of the Township of South Fayette

North Versailles Township Municipal Authority

Ohio Township Sanitary Authority

Penn Township Sewerage Authority

Pittsburgh Water and Sewer Authority

Robinson Authority of the Township of Robinson

Western Westmoreland Municipal Authority*

West Mifflin Municipal Sewer Authority

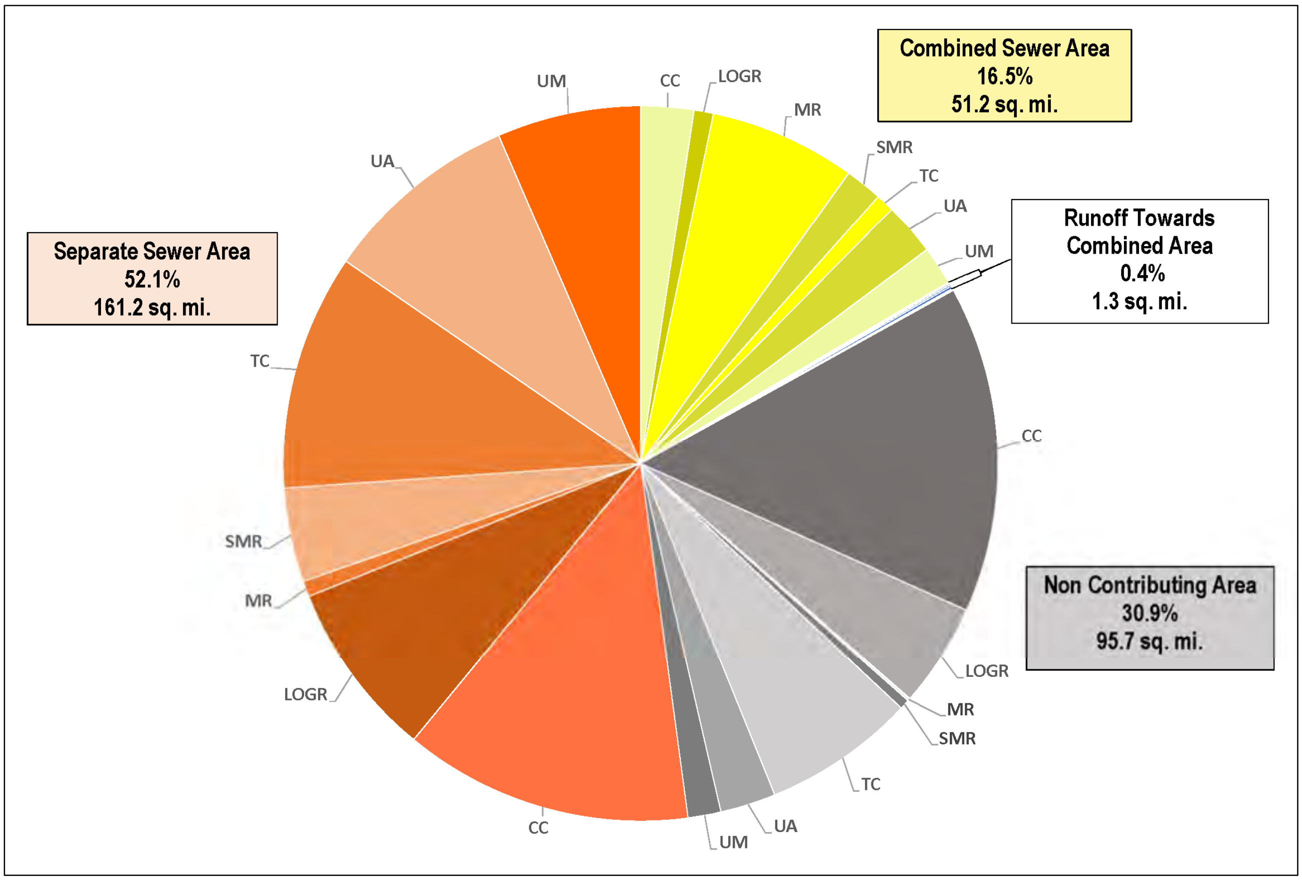
*Communities not served in their entireties

3.1.5 Sewer Infrastructure Systems

3.1.5.1 Overview

Roughly 17% of the area is served by CSSs (where wastewater and stormwater runoff are conveyed through a single sewer pipe system), 52% of the ALCOSAN service area is served by separate sanitary sewer systems (where wastewater and stormwater are conveyed through two distinct piping systems), and 31% are non-contributing areas that are either undeveloped or served by individual on-lot systems (**Figure 3-4**). A small portion of the service area (under 0.5%) is contributing runoff towards the combined area, but does not have combined sewers, for example hillsides sloping towards combined sewer areas that contribute runoff to combined sewer inlets.

Figure 3-4. Sewer System Types within the ALCOSAN Service Area



Data source: ALCOSAN subcatchment GIS data

ALCOSAN owns, operates, and maintains over 88.5 miles of interceptor sewers, force main sewers, and other types of sewers that convey wastewater from the customer municipalities to ALCOSAN's 250 MGD wastewater treatment plant that is located on Preble Avenue in the Woods Run area of Pittsburgh. There are over 300 regulator structures along the ALCOSAN interceptor system that are owned and/or operated by ALCOSAN. These regulator structures direct all dry weather flow to the ALCOSAN system and divert excess flows to the receiving waters during wet weather conditions. The ALCOSAN system also includes six pumping stations and two ejector stations.

There are over 4,000 miles of wastewater collection sewers that are owned, operated, and maintained by the customer municipalities or by their designated municipal authorities. There are nearly 200 municipal regulator structures located along these municipal sewers.

Figure 3-5 illustrates both the planning basins and the existing point of connections (POCs) between the local system and ALCOSAN system.

Table 3-4 describes some of the unique characteristics of each of the seven planning basins as they relate to source controls.

Table 3-4. Sewer Infrastructure Characteristics by Planning Basin in the ALCOSAN Service Area

Planning Basin	Land Area	Population (According to 2010 Census)	% of Total Combined Sewer System	% of Total Separate Sewer System
CC	93.7 sq. mi.	154,566	14.5%	25.1%
LOGR	42.1 sq. mi.	92,061	5.2%	15.3%
MR	23.4 sq. mi.	164,070	40.1%	1.4%
SMR	19.7 sq. mi.	106,722	10.1%	8.2%
TC	57.2 sq. mi.	89,370	5.0%	20.4%
UA	42.6 sq. mi.	112,957	14.4%	17.1%
UM	30.3 sq. mi.	116,809	10.6%	12.5%
TOTALS	**309 sq. mi.**	**836,555**	**100%**	**100%**

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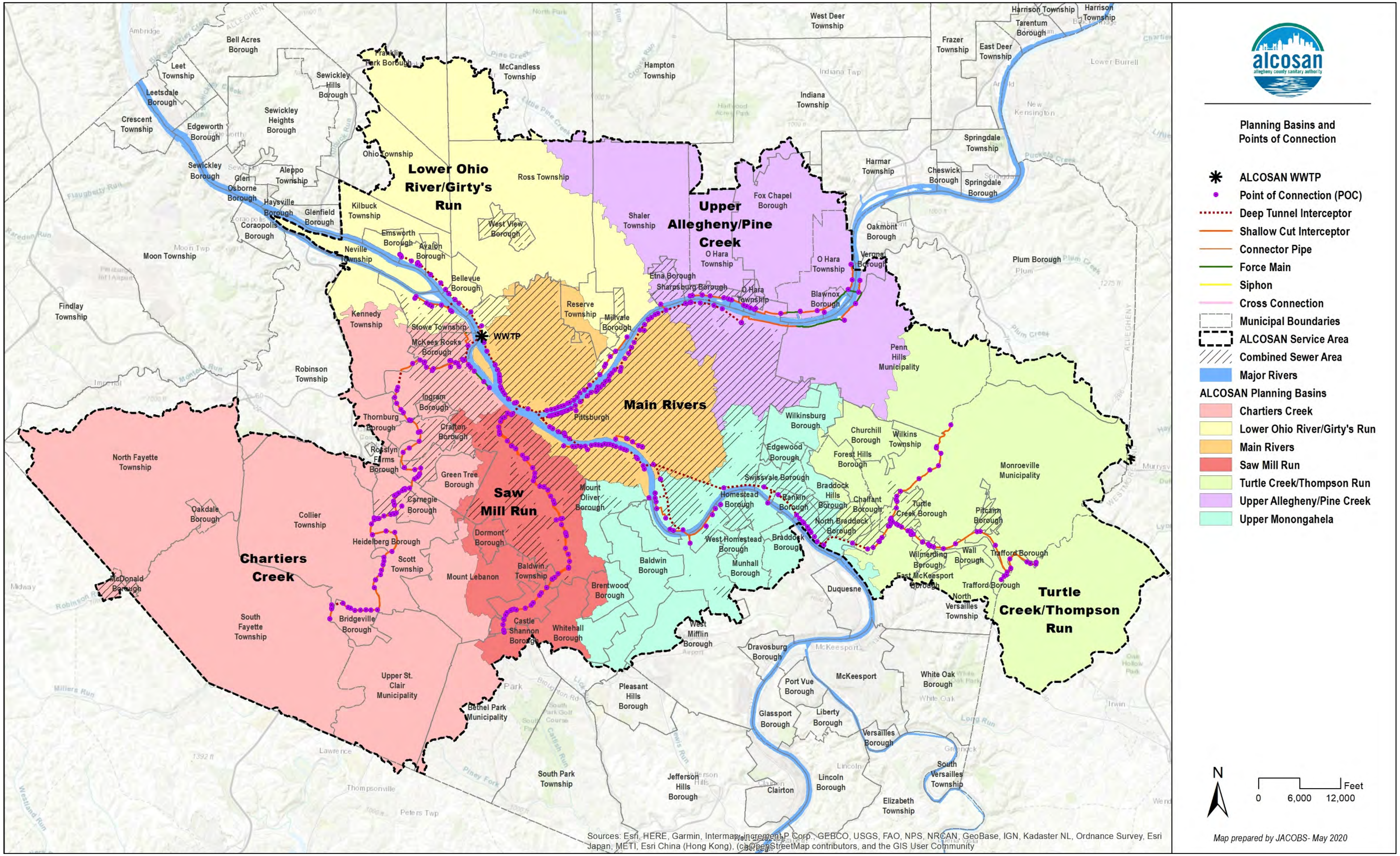
Figure 3-5. Planning Basins and Points of Connection



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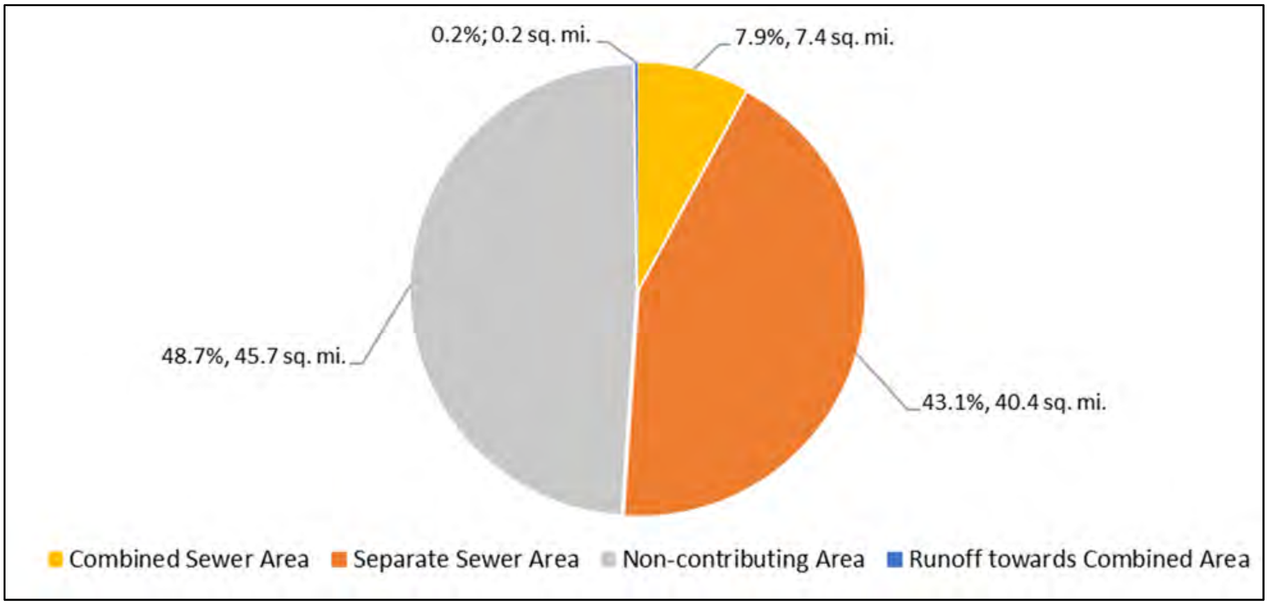
3.1.5.2 Chartiers Creek

The Chartiers Creek (CC) planning basin covers 93.7 square miles in the southwest portion of the ALCOSAN service area. There are 24 municipalities that are located completely or partially within the CC basin. Wastewater flows generated within the basin are conveyed to the ALCOSAN WWTP via a deep tunnel interceptor that begins at the Chartiers/Ohio Junction drop-shaft structure and extends under the Ohio River.

Approximately 8% of CC basin is served by CSSs, 43% is served by separate sanitary sewer systems, 0.2% contributes runoff toward combined areas, and 49% is non-contributing area that is either undeveloped or served by individual on-lot septic systems (**Figure 3-6**).

Figure 3-6. Drainage Area by Type in Chartiers Creek Basin



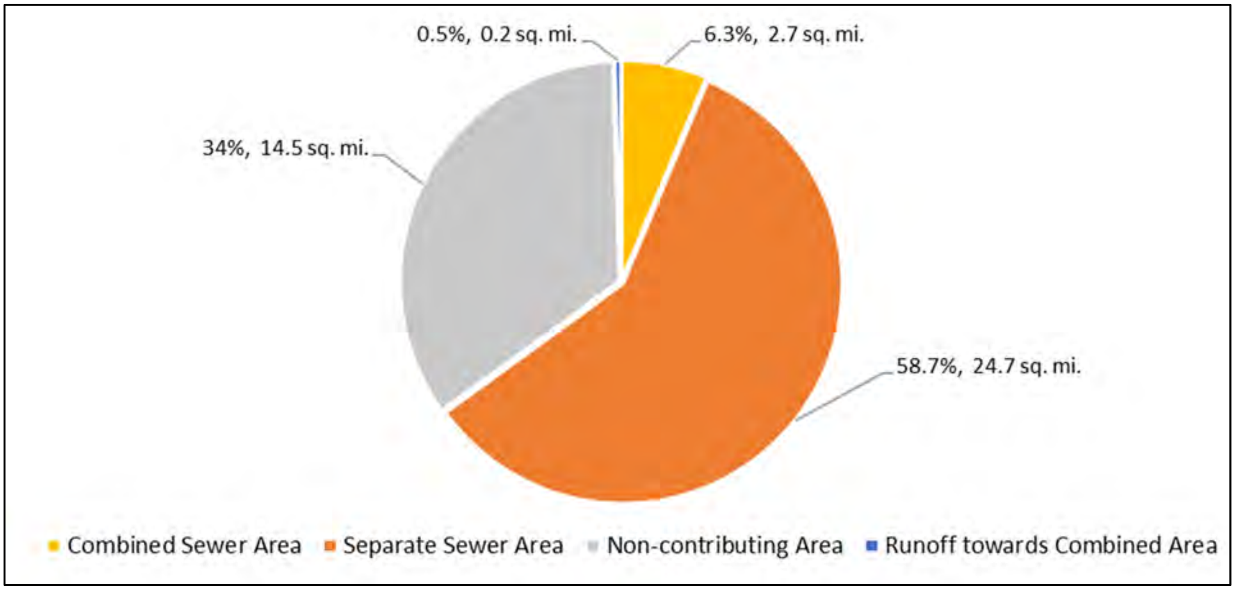
Data source: ALCOSAN subcatchment GIS data

3.1.5.3 Lower Ohio River/Girty's Run

The Lower Ohio River/Girty's Run (LOGR) planning basin covers 42.1 square miles of the ALCOSAN service area. There are 20 municipalities that are located completely or partially within the LOGR basin. Wastewater flows generated within the basin are conveyed to the ALCOSAN WWTP via deep tunnel interceptors that extend along the Ohio and Allegheny Rivers.

Approximately 6% of LOGR basin is served by CSSs, 59% is served by separate sanitary sewer systems, 0.5% contributes runoff toward combined areas, and 34% is non-contributing area that is either undeveloped or served by individual on-lot septic systems (**Figure 3-7**).

Figure 3-7. Drainage Area by Type in Lower Ohio River/Girty's Run Basin



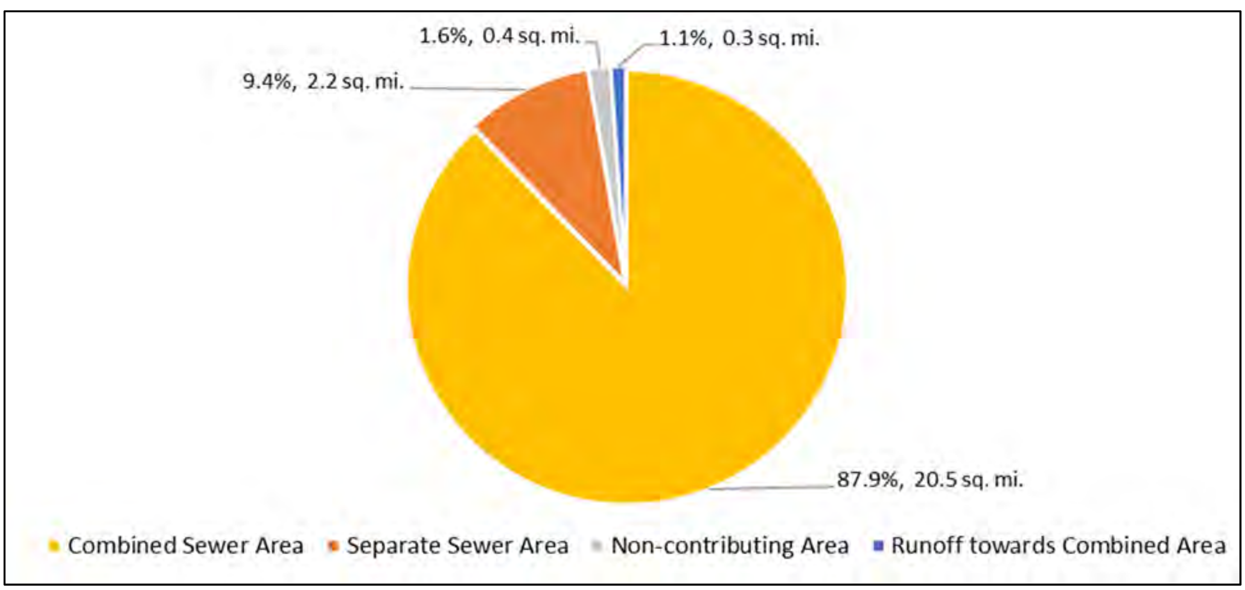
Data source: ALCOSAN subcatchment GIS data

3.1.5.4 Main Rivers

The Main Rivers (MR) planning basin covers 23.4 square miles centrally located in the ALCOSAN service area. The basin serves portions of the City of Pittsburgh, Reserve Township and Ross Township. Wastewater flows generated within the basin are conveyed to the ALCOSAN WWTP via deep tunnel interceptors that extend along the Allegheny, Monongahela and Ohio Rivers.

Approximately 88% of MR basin is served by CSSs, 9% is served by separate sanitary sewer systems, 1% contributes runoff toward combined areas, and 2% is non-contributing area that is either undeveloped or served by individual on-lot septic systems (**Figure 3-8**).

Figure 3-8. Drainage Area by Type in Main Rivers Basin



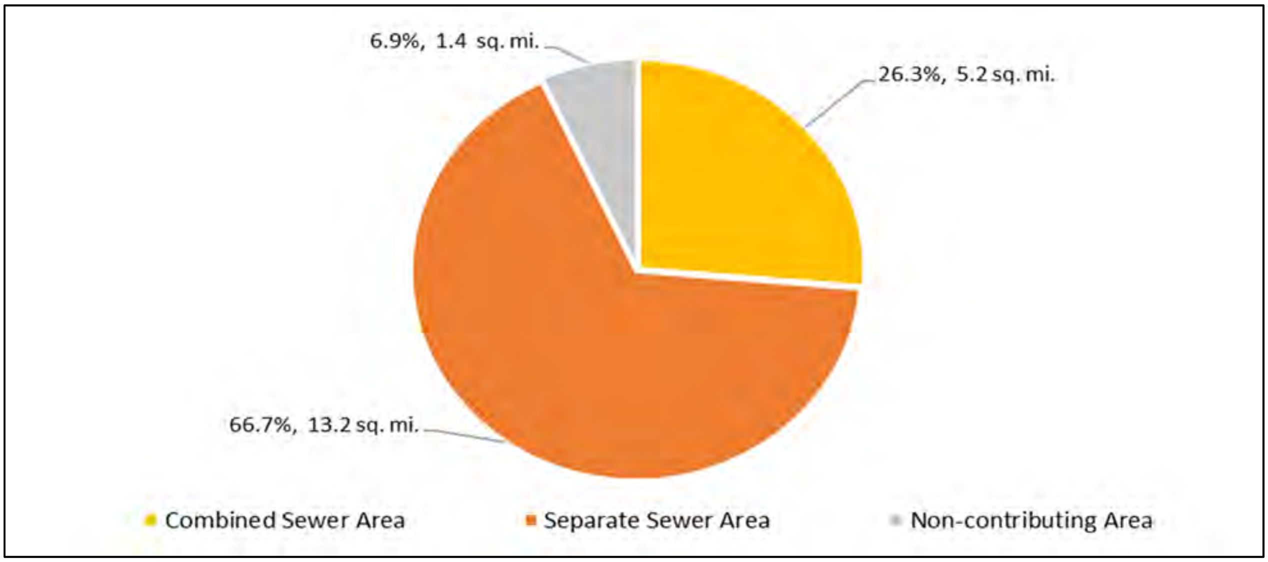
Data source: ALCOSAN subcatchment GIS data

3.1.5.5 Saw Mill Run

The Saw Mill Run (SMR) planning basin covers 19.7 square miles in the south-central portion of the ALCOSAN service area. There are 12 municipalities that are located completely or partially within the SMR basin. Wastewater flows generated within the basin are conveyed to the ALCOSAN WWTP via a deep tunnel interceptor that extends along the Ohio River.

Approximately 26% of SMR basin is served by CSSs, 67% is served by separate sanitary sewer systems, and 7% is non-contributing area that is either undeveloped or served by individual on--lot septic systems (**Figure 3-9**).

Figure 3-9. Drainage Area by Type in Saw Mill Run Basin



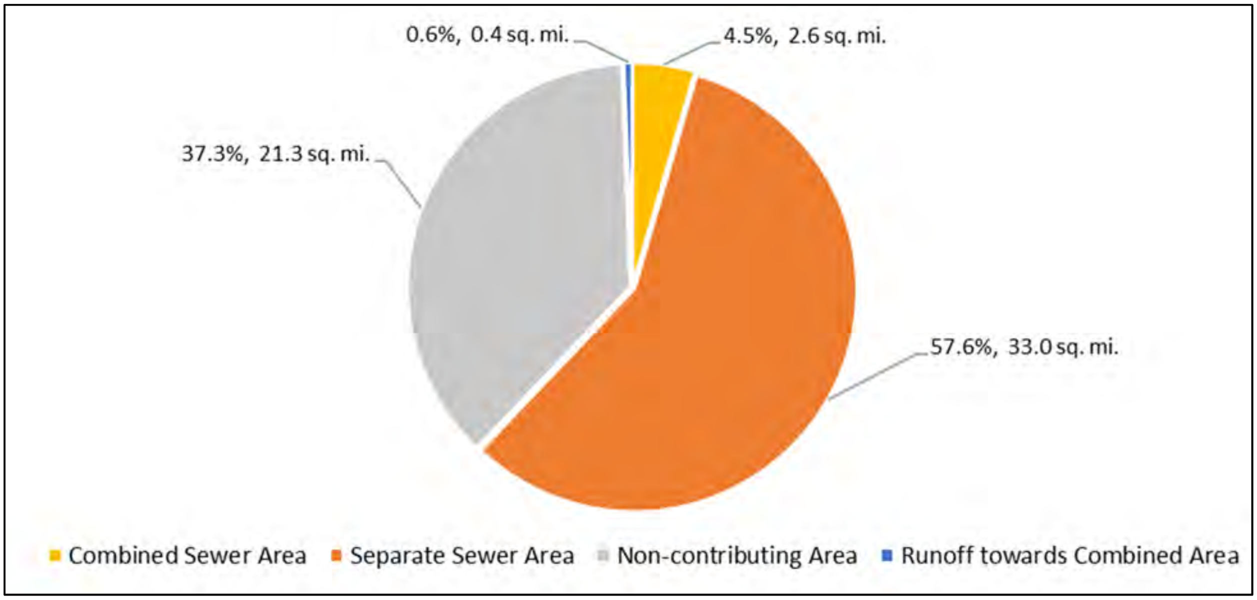
Data source: ALCOSAN subcatchment GIS data

3.1.5.6 Turtle Creek/Thompson Run

The Turtle Creek/Thompson Run (TC) planning basin covers 57.2 square miles in the eastern part of the ALCOSAN service area. There are 20 municipalities that are located completely or partially within the TC basin. Wastewater flows generated within the basin are conveyed to the ALCOSAN WWTP via deep tunnel interceptors that extend along the Monongahela and Ohio Rivers.

Approximately 5% of TC basin is served by CSSs, 58% is served by separate sanitary sewer systems, 0.6% contributes runoff toward combined areas, and 37% is non-contributing area that is either undeveloped or served by individual on-lot septic systems (**Figure 3-10**).

Figure 3-10. Drainage Area by Type in Turtle Creek/Thompson Run Basin



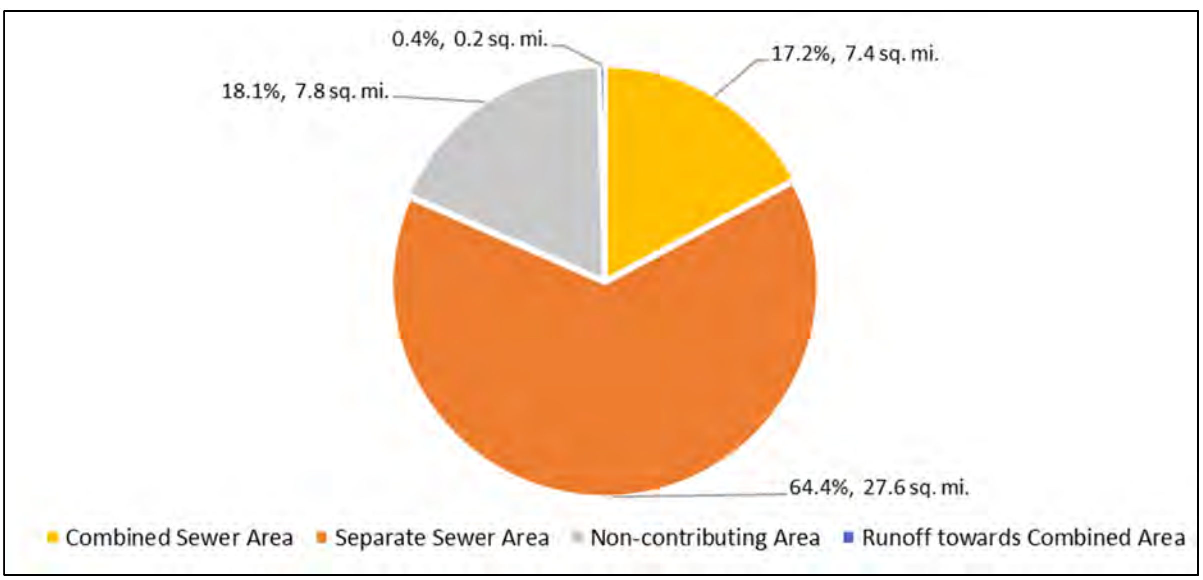
Data source: ALCOSAN subcatchment GIS data

3.1.5.7 Upper Allegheny/Pine Creek

The Upper Allegheny/Pine Creek (UA) planning basin covers 42.6 square miles in the northeast portion of the ALCOSAN service area. There are 15 municipalities that are located completely or partially within the UA basin. Wastewater flows generated within the basin are conveyed to the ALCOSAN WWTP via deep tunnel interceptors that extend along the Allegheny and Ohio Rivers.

Approximately 17% of UA basin is served by CSSs, 64% is served by separate sanitary sewer systems, 0.4% contributes runoff toward combined areas, and 18% is non-contributing area that is either undeveloped or served by individual on-lot septic systems (**Figure 3-11**).

Figure 3-11. Drainage Area by Type in Upper Allegheny/Pine Creek Basin



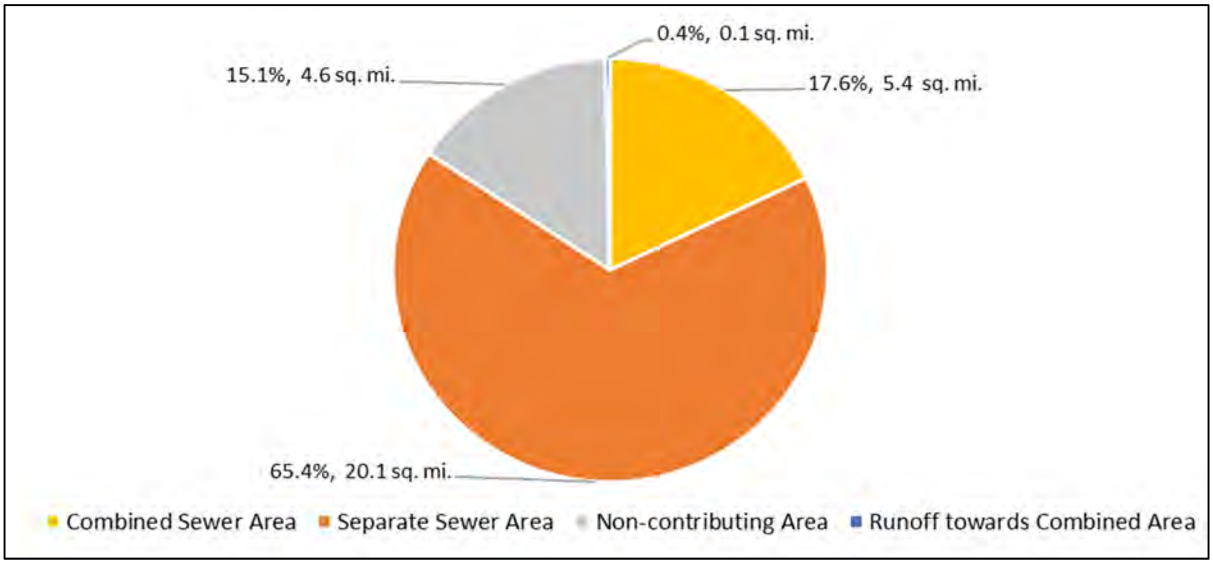
Data source: ALCOSAN subcatchment GIS data

3.1.5.8 Upper Monongahela

The Upper Monongahela (UM) planning basin covers 30.3 square miles of the ALCOSAN service area. There are 21 municipalities that are located completely or partially within the UM basin. Wastewater flows generated within the basin are conveyed to the ALCOSAN WWTP via deep tunnel interceptors that extend along the Monongahela and Ohio Rivers.

Approximately 18% of UM basin is served by CSSs, 65% is served by separate sanitary sewer systems, 0.4% contributes runoff toward combined areas, and 15% is non-contributing area that is either undeveloped or served by individual on-lot septic systems (**Figure 3-12**).

Figure 3-12. Drainage Area by Type in Upper Monongahela Basin



Data source: ALCOSAN subcatchment GIS data

3.2 Developing Overflow Reduction Efficiencies

This section summarizes the ORE modeling concept, baseline conditions and model used, the modeling strategy associated with different source control categories, and the resulting values to be used in the identification and prioritization process. OREs were estimated for GSI, separate sanitary sewer inflow and infiltration (I/I) reduction, and direct stream inflow removal (DSIR), using distinct modeling approaches as needed based upon the type of source control.

A detailed technical memorandum on the development of OREs is available in **Appendix C-2**.

3.2.1 ORE Modeling

The objective of ORE modeling is to estimate the effectiveness of source controls to reduce sewer overflow volumes, across a range of geographies and implementation levels: the higher the ORE, the more effective a given project is likely to be. It should be noted that OREs reflect the efficiency of a potential project and must be considered along with the scale of the project in terms of total inflow capture and overflow reduction.

The ORE value (reduction in overflow volume per unit reduction in inflow) provides ALCOSAN, municipalities, and planning teams a hydraulically-informed estimate of overflow impacts of different projects, so that effort and attention can be focused in those areas with the greatest potential overflow impacts.

The ORE estimate is an early-stage planning tool. As projects and evaluations progress, more detailed modeling will typically be required.

The ORE for an area is calculated according to the following equation, where the overflow reduced is the total reduction at all outfalls in the model resulting from the modeled source control in that area:

$$Overflow\ Reduction\ Efficiency = \frac{Overflow\ Reduced}{Inflow\ Reduced}$$

For example, if a certain scenario resulted in 4,000 gallons of annual inflow reduction and 2,800 gallons of annual overflow reduction, the ORE for that scenario would be 0.7 or 70% (2,800 divided by 4,000):

$$Overflow\ Reduction\ Efficiency = \frac{2{,}800\ gal.\ Overflow\ Reduced}{4{,}000\ gal.\ Inflow\ Reduced} = 0.7 = 70\%$$

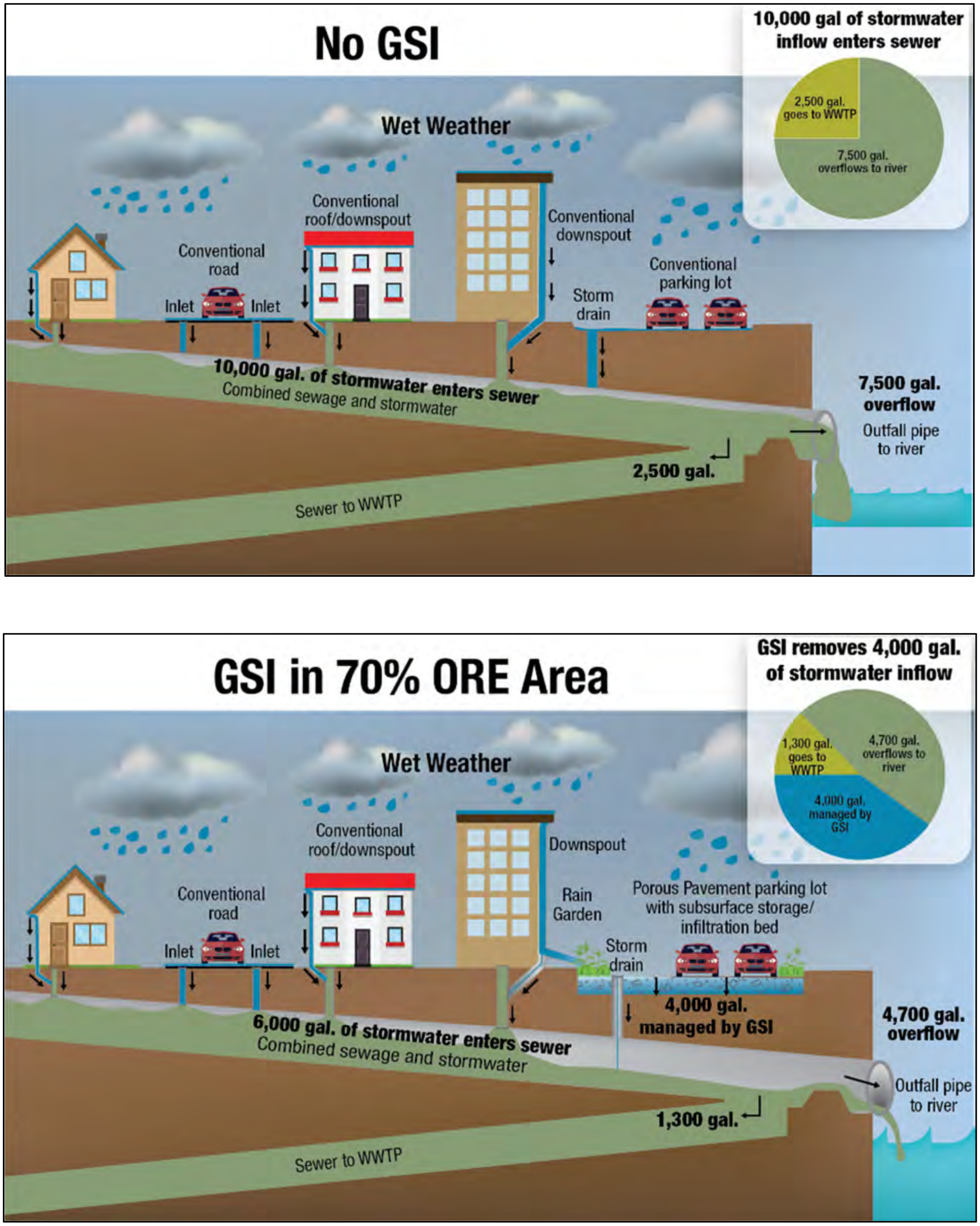
This example 70% ORE scenario is illustrated in **Figure 3-13.** Hypothetical GSI reduces 4,000 gallons of inflow from entering the combined sewer and consequently the amount of overflow discharged into the river decreases from 7,500 gallons to 4,700 gallons (a total of a 2,800-gallon overflow reduction).

The GSI in this example scenario also reduces flow to the treatment plant by 1,200 gallons (the portion of the inflow reduction that does not correspond to overflow reduction as it was already conveyed to the plant).

As described in **Appendix C-2**, some modeled areas (subcatchments in the combined system and sewersheds in the separate sanitary system) were grouped into “geographic units” for the ORE analysis to develop a single ORE estimate per geographic unit for a specific implementation level.

Grouping areas reduces the number of modeling simulations required and results in larger inflow and overflow reductions, so that the resulting ORE is a better estimate of anticipated overflow reduction benefits, and less influenced by minor numerical differences between model simulations. The inflow reduction threshold for grouping is determined through modeling tests to see when inflows are significant enough to result in relatively stable OREs.

Figure 3-13. ORE Concept Illustration



The two graphics compare the overflow situation without GSI with the same overflow situation with GSI implemented in a 70% GSI ORE area, assuming volume removal (not detention). The GSI features are shown for illustrative purposes; actual GSI types should be selected based on specific, local conditions (see GSI Guidance Manual). (Image Source: Jacobs)

3.2.2 Baseline Condition and Model

ALCOSAN developed and implemented a comprehensive hydrologic and hydraulic (H&H) modeling program as a predictive tool for characterizing the collection system under the following conditions:

- **Existing Conditions** – considering existing flows and existing infrastructure and treatment plant conditions as of approximately 2009.
- **Future Baseline Conditions** – considering future baseline flows predicted for the year 2046 and existing infrastructure with planned municipal improvements.
- Various overflow control scenarios evaluated during the development of the CWP – including a specific **Selected Plan Conditions** model considering future baseline flows and the proposed infrastructure and treatment plant capacity consistent with the updated CWP.

All models are run assuming typical year rainfall over a 12-month period. The typical year defined in Chapter 4 of the CWP was used to ensure consistency of CtS with the CWP and the Modified CD. It corresponds to calendar year 2003. Model assumptions are further detailed in the CWP.

The model simulations indicate that under existing conditions with typical year rainfall over a 12-month period the ALCOSAN system captures and treats approximately 77 BG of wastewater flow. Approximately 9 BG (12%) are discharged from the roughly 345 ALCOSAN and municipal combined sewer outfalls scattered throughout the service area and approximately 0.7 BG (0.9%) of wastewater is discharged from 97 ALCOSAN and municipal sanitary sewer outfalls.

Since the ORE estimate is a distillation of inflow reduction impacts in the context of local sewer and system hydraulics, the ORE estimates may vary significantly depending on the modeled baseline condition. For instance, if a storage tank were included in a future alternative condition, it would typically be sized to manage a significant percentage of overflows in its tributary area; therefore, OREs developed without the tank in place would be unrepresentative of the impacts with the tank in place.

The ORE evaluation simulations presented in this document were completed with the Existing Conditions basin models including a treatment plant capacity of 250 MGD.

ALCOSAN is currently evaluating OREs under the Selected Plan Conditions and is also planning on evaluating other interim controls or improvements of the CWP.

These interim controls or improvements (e.g., plant expansion, conveyance and select regulator modifications) will significantly reduce overflows in many locations. Overflow benefits and associated OREs for source controls are therefore anticipated to significantly decrease in sewersheds where these controls or improvements are located. The prioritization of opportunities will also be affected: while source control will still have benefits and make grey infrastructure more effective and resilient in those areas, interim conditions OREs will allow for a focus on areas where controls or improvements are not implemented as part of the ICWP. The results associated with these evaluations will be presented in subsequent updates to this document.

3.2.3 GSI ORE Modeling for the Combined Sewer System

Within the CSS, modeling focused on estimating the impacts of GSI implementation on overflow reduction.

Two implementation levels were considered: 25% and 50% of the total subcatchment impervious area managed by GSI. These two levels of management were modeled by reducing the impervious area by the applicable percentage (and therefore increasing the pervious area to maintain the same total drainage area). This approach assumes that impervious areas managed by GSI elements (which are not modeled explicitly) react in a similar way to pervious areas in the same subcatchment (with the applicable soil and runoff parameters for that subcatchment). Since the impervious area is converted to pervious area, runoff may still be produced for converted impervious area, i.e., the approach does not assume that 100% of the typical year runoff is managed by the hypothetical GSI.

Since the primary intent of the ORE analysis is to estimate the reduction in overflow volume per unit reduction in inflow, these implementation levels are not meant to indicate feasible levels of implementation in specific sewersheds. Instead, they are primarily intended to evaluate whether the efficiencies change significantly at different implementation levels. That is, it might be expected that OREs would decrease as implementation levels increase and there is less overflow volume to reduce. In fact, the OREs based on 50% impervious area managed were lower on average than the ORE based on 25% managed, although typically the difference was not very significant (approximately 5%). In addition, the impervious area changes needed to be significant enough to overcome numerical instabilities in the model. For example, early evaluations with a 10% level of implementation appeared to be less reliable and were therefore not continued.

Based on model results, the ORE with 50% of impervious area managed by GSI was considered more reliable and conservative, and was therefore recommended for use regardless of implementation level. **Figure 3-14** shows the GSI OREs within the CSS at 50% of Impervious Area Managed by GSI under Existing Conditions as an example.

More details and examples of subcatchment parameter changes are included in **Appendix C-2**.

As stated in section 3.2.1, the ORE estimate is an early-stage planning tool and should be refined as needed. For example, more detailed future evaluations in high-benefit areas may represent GSI more explicitly, so that actual performance is constrained by available storage and infiltration capacity. The impact of detention and slow release (as opposed to infiltration and volume removal) can also be evaluated.

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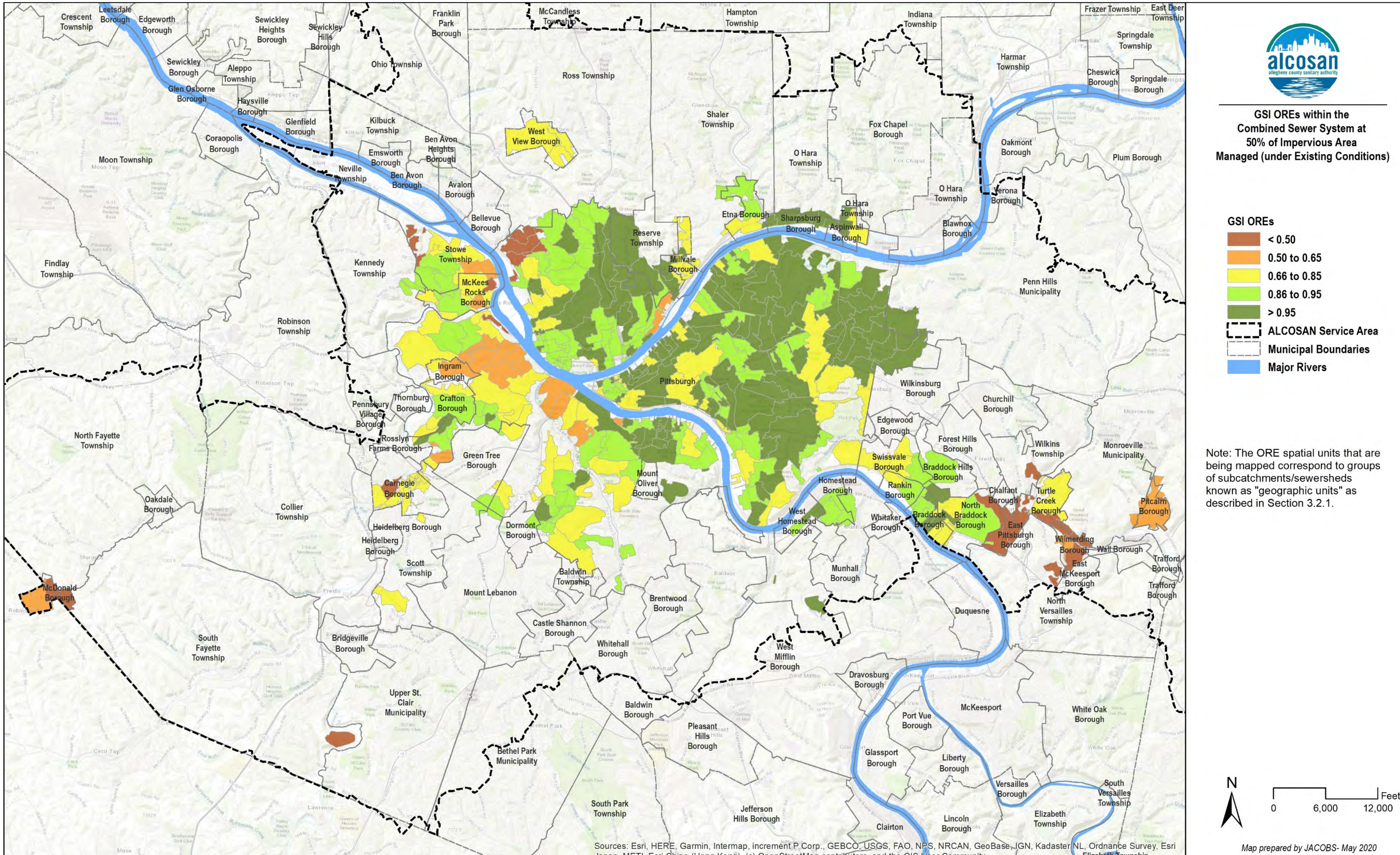
Figure 3-14. GSI OREs within the Combined Sewer System at 50% of Impervious Area Managed (Under Existing Conditions)



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3.2.4 I/I Reduction ORE Modeling for the Separate Sanitary System

Within ALCOSAN's separate sanitary system, modeling focused on predicting the impacts of rainfall-derived inflow and infiltration (I/I) reduction on OREs.

The impact of I/I reduction is simulated by reducing the R values from the RTK unit hydrographs in the sanitary system. RTK unit hydrographs (with R, T and K defined by parameters in bullets below) are used to represent the response of a sewershed to rainfall through a series of up to three triangular unit hydrographs (fast, medium, and slow response), characterized by the following parameters:

- R: the fraction of rainfall volume that enters the sewer system; equal to the volume under the hydrograph.
- T: the time from the onset of rainfall to the peak of the unit hydrograph.
- K: the ratio of time to recession of the unit hydrograph to the time to peak.

The amount of I/I volume depends not only on the R values, but also the sewershed area. Thus, a basin with a high R value and low sewershed area could have less I/I volume than a basin with a low R value and high sewershed area.

As mentioned under Section 3.2.1, separate sanitary sewersheds were grouped into geographic units. For each evaluation, R_{fast}, R_{medium}, and R_{slow} values within a geographic unit were reduced by 30%.

The 30% reduction was considered an approximate lower limit for R values on a sewershed scale after aggressive I/I reduction is implemented and is consistent with past ALCOSAN I/I reduction modeling approaches.

Figure 3-15 shows the I/I Reduction OREs within the service area at 30% reduction under Existing Conditions.

As an alternative approach to evaluate I/I reduction projects that would primarily reduce groundwater infiltration (GWI) rather than rainfall-derived I/I as discussed previously, GWI OREs were also developed for select sewersheds. The modeling focused on predicting the relative impact of GWI reduction on overflows.

Daily GWI was assumed to be represented by the minimum daily flow in ALCOSAN's calibrated inflows file. This GWI was then reduced by 30%, one metershed (the area contributing to an individual flow meter) at a time, to determine the associated overflow reduction at the downstream POC. This overflow reduction was divided by the applicable GWI reduction (inflow reduction) to calculate the GWI ORE.

Figure 3-16 shows the GWI Reduction OREs at 30% reduction under Existing Conditions in sample sewersheds. This process is continuing in other sewersheds and will be documented in future updates of this CtS. The analysis in Section 6 is currently based on the GWI Reduction OREs given the focus on sewer lining to reduce GWI.

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Figure 3-15. I/I Reduction OREs Within the Sanitary Sewer System (Under Existing Conditions)

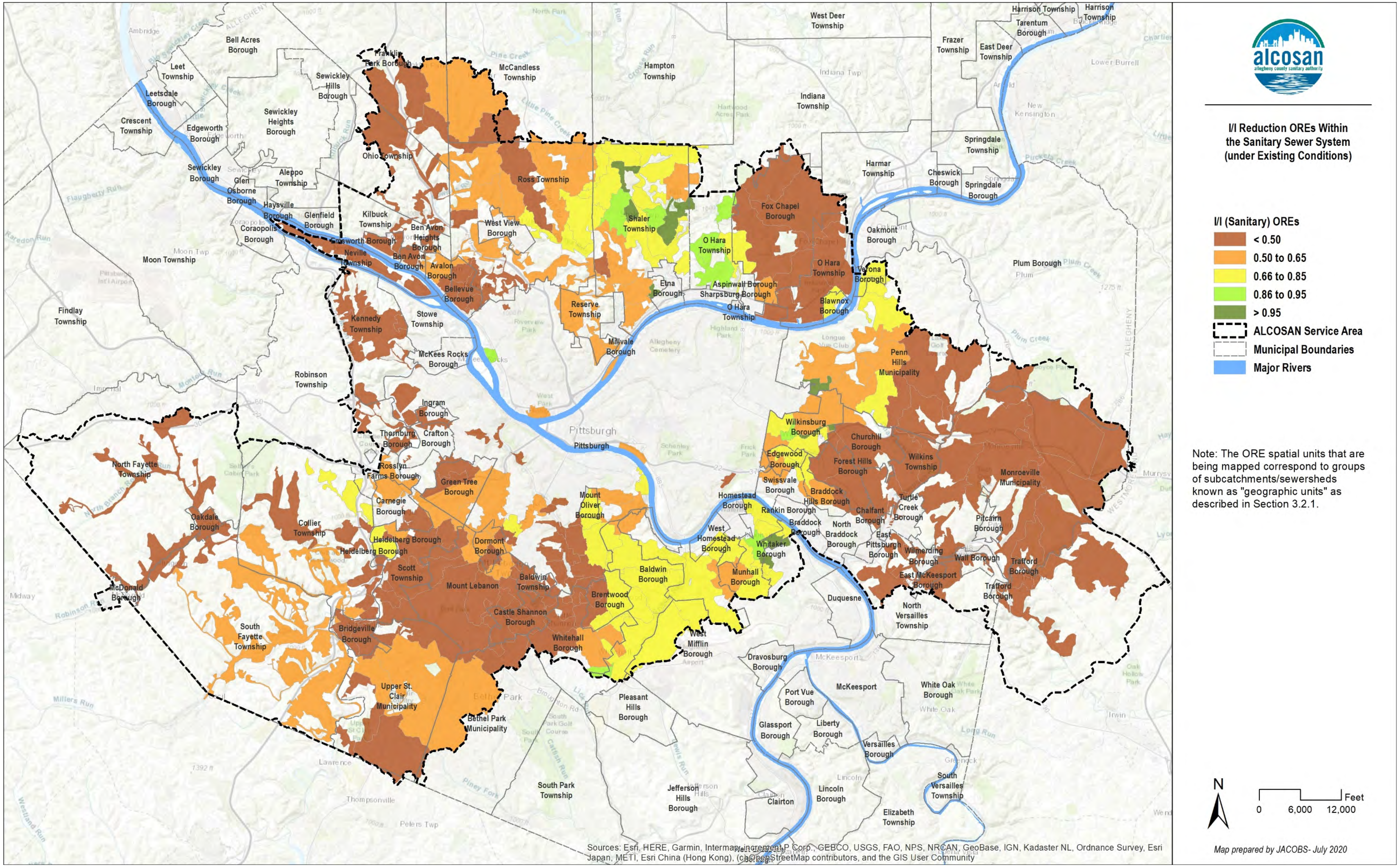
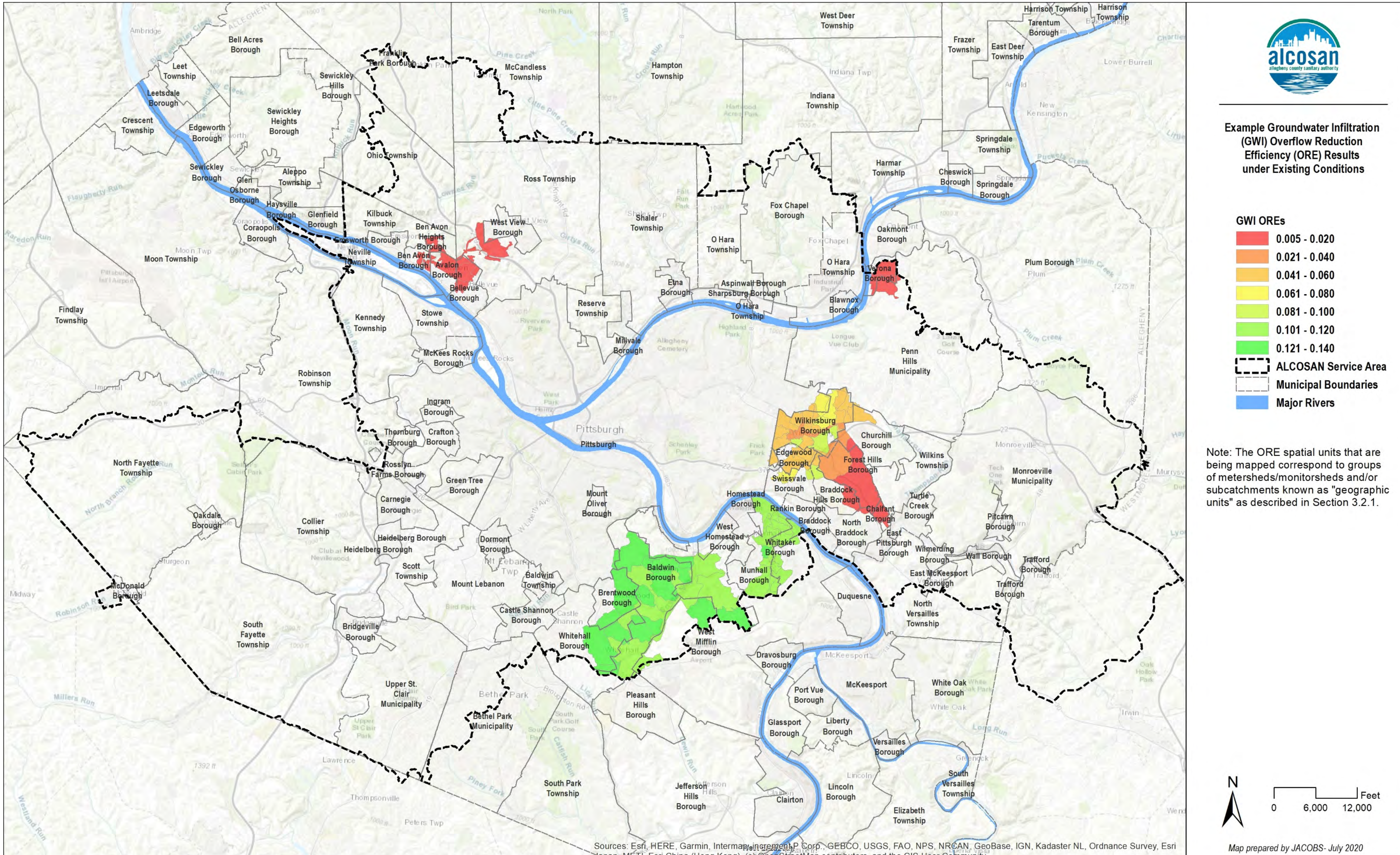


Figure 3-16. GWI Reduction OREs in Sample Watersheds Within the Sanitary Sewer System Area (Under Existing Conditions)



3.2.5 DSIR ORE Modeling for Discreet Locations

The impact of DSIR was estimated for DSI locations that were previously identified and not yet removed.

For DSIR OREs, the geographic unit is defined according to the tributary area to the DSI location. The impact of DSIR is simulated with the following model adjustments:

- Reducing subcatchment area associated with the DSI tributary area. Based on aerial inspection, areas tributary to DSIs tend to consist mostly of pervious cover. Therefore, the DSI tributary area was removed from the model by first reducing subcatchment pervious area. Then, if necessary, any remaining DSI tributary area was reduced from the subcatchment impervious area.
- Reducing the stream baseflow from the relevant node by modifying the dry weather flows represented in ALCOSAN's Existing Conditions external inflow file. For ORE modeling purposes, it was assumed that the stream baseflow associated with the DSI tributary area was equal to the GWI.

Figure 3-17 shows the DSIR OREs for discreet locations included in the modeling, under Existing Conditions. These discreet locations correspond to the previously-identified DSIs that currently discharge into the CSS (see Section 5).

Since a significant portion of the estimated inflow reduction associated with DSIRs is related to stream baseflow (which often contributes flow during periods when overflows are not occurring), DSIRs may have lower ORE values than other source control measures such as GSI. Although OREs may be lower, significant overflow reductions can still be achieved since the inflow reductions for DSIRs can be substantial. In addition, DSIRs have other benefits not quantified by OREs or overflow reduction, such as reduction of sediment and debris to the regional collection system and reduced pumping and treatment costs at the treatment plant.

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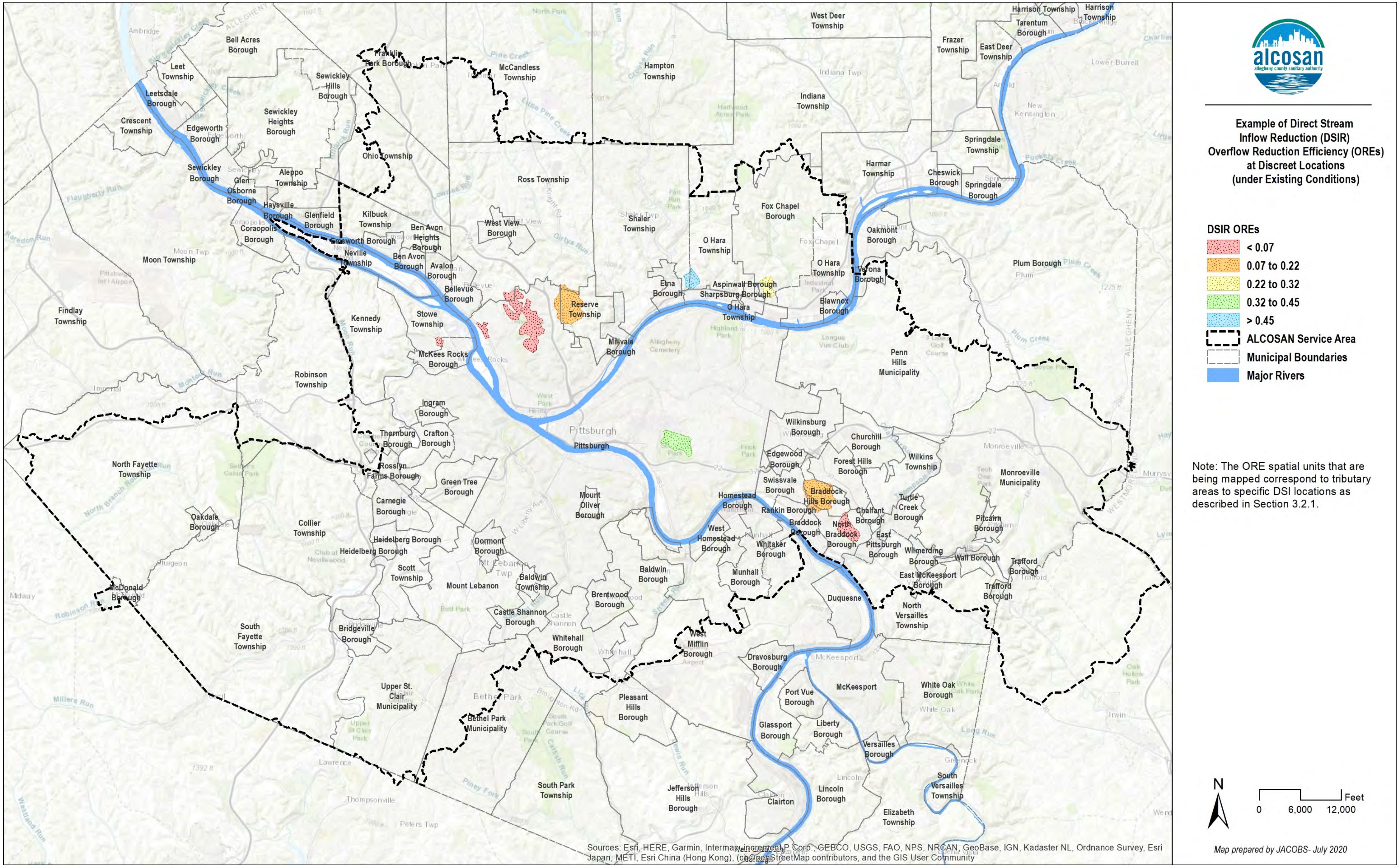
Figure 3-17. DSIR OREs for Discreet Locations (Under Existing Conditions)



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3.2.6 Important Considerations

These ORE estimates help to identify areas where reducing system inflow contributes the most to overflow reduction. ORE data can be combined with additional information (for instance, opportunities and constraints data) to identify areas where source control projects would not only likely be feasible, but also have the highest potential to cost-effectively reduce overflows.

ORE estimates are a planning tool that help to identify areas where reducing system inflow contributes to the greatest overflow reduction.

Significant variation in OREs was identified under Existing Conditions, underscoring the importance of source control project location within the hydraulic context of the sewer network.

Several factors contribute to ORE variation, including the following:

- The amount of existing overflow volume associated with the area.
- The number of active outfalls associated with the area.
- Outfall density, i.e., a higher density of outfalls may contribute to more indirect overflow reduction.
- Network hydraulics, i.e., the impact of flow routing and hydraulic limitations, which connect the impact of decreased inflow with the timing of downstream overflows.

Several trends stood out from the ORE analysis using the existing conditions model:

- GSI ORE estimates were generally higher than I/I reduction ORE estimates which are in turn higher than GWI OREs (within a basin).
- Much of the overflow reduction is seen outside of the immediate downstream overflow. The percentage of overflow reduction occurring immediately downstream of a geographic unit averaged 67% across the system, ranging from 1% to 100%.
- Average OREs varied considerably between planning basins, ranging from 0.43 in TC to 0.96 in MR and UA (for 50% GSI implementation).
- The variation of ORE estimates is considerable within basins. Even in the TC planning basin, which has the lowest average OREs, OREs as high as 0.86 were identified (for 50% GSI implementation). Conversely, in UA, which has the highest average OREs, OREs as low as 0.73 were identified (for 50% GSI implementation).

As stated earlier, the ORE estimate is an early-stage planning tool to help identify priority areas and focus attention on locations with the greatest potential for overflow reduction. As source control projects are identified and developed, projects can be evaluated more directly with greater levels of detail. For example, project-level details and GSI type (e.g., bioretention, porous pavement, infiltration trench) may cause variation in overflow reduction impacts in the same geographic unit (with the same ORE), due to differences in the timing of how they store, infiltrate, and/or discharge flow back to the combined system.

ORE estimates are affected by the infrastructure included in the baseline conditions simulation. For instance, if a storage tank were built to reduce upstream overflows, OREs in the affected tributary areas would likely be significantly reduced. As ALCOSAN's CWP is refined, it will be necessary to evaluate overflow reductions under alternative baseline conditions to identify the most beneficial areas for source controls with planned infrastructure improvements in place. This work has been initiated and will be documented in future updates of this CtS.

3.3 Considering Existing/Previously Identified Projects

When identifying potential source control opportunities, it is important to take existing and previously identified projects into account so that efforts are not duplicated and so that the CtS project identification process (looking at overflow reduction efficiencies, constraints and opportunities) can be used to reinforce already identified project ideas and preliminarily evaluate their viability.

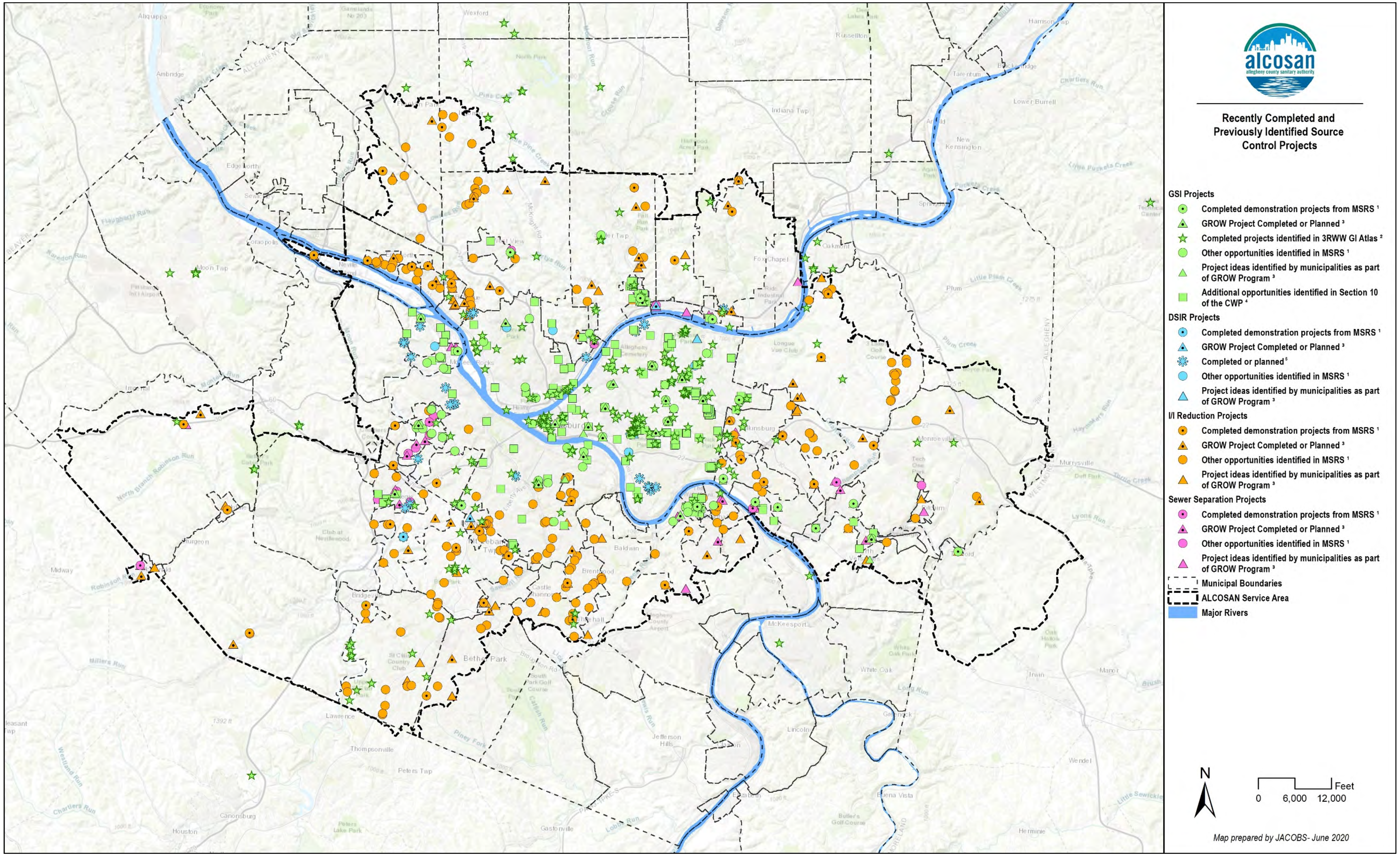
The following projects from these sources were considered:

- ALCOSAN GROW Projects – Awarded Projects (completed or planned) and potential ideas associated with all source control categories.
- ALCOSAN DSIR Projects – constructed projects and potential projects.
- 3RWW GI Atlas – tracking list of constructed GSI projects (provided in Jan. 2018).
- MSRS Demonstration Projects and Potential Projects.
- Starting at the Source – GSI opportunities identified in Starting at the Source, also referred to as the MSRS (Section 10 of the CWP).

Some of the existing projects and identified opportunities from the different databases overlap as the databases have not been integrated.

Figure 3-18 illustrates the general location of recently completed or previously identified opportunities through these various programs and initiatives based on these databases. Additional existing projects and/or previously identified opportunities that were identified through other databases and/or based on ALCOSAN knowledge are also documented in the following sub-sections but are not represented on the map.

Figure 3-18. Existing and Previously Identified Source Control Opportunities in the ALCOSAN Service Area



Data sources: [1] MSRS database; [2] 3RWW GI Atlas database; [3] ALCOSAN GROW project database (Cycles 1 through 4 and ideas from municipal workshops; some overlaps with Demonstration Projects from MSRS database); [4] Starting at the Source potential GSI project database (subset of GSI opportunities mentioned in Section 10 of CWP); [5] ALCOSAN DSIR database.

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3.3.1 GSI Projects

As defined in Section 1, GSI is a range of stormwater control measures that reduce wet weather flows to the sewer system. GSI types include plant systems, soil systems and permeable pavement. The mechanisms of water management include harvesting for reuse, piping to storage, infiltration, and evapotranspiration.

There are numerous GSI projects and identified GSI opportunities within the ALCOSAN service area.

The location of the following examples is shown below in Figure 3-18:

- 13 completed MSRS demonstration projects.
- 28 GSI projects that have been completed or planned as part the GROW Program.
- 48 potential project opportunities identified in MSRS.
- 23 potential GSI project ideas that have been identified as part of the GROW Program workshop with municipalities.
- 307 GSI projects that have been identified in the 3RWW database, many of which are completed.
- 178 GSI opportunities that have been identified in “Starting at the Source”.
  - “Starting at the Source” is a general description of GSI initiatives, plans and projects in the ALCOSAN service area which is included in Section 10.2 of the CWP. Additional opportunities were identified as part of two different analyses conducted in 2015 and documented in Section 10.4 of the CWP. All GSI identified opportunities, excluding the 14,000 locations identified that did not involve specific projects, were compiled in a single database referred to as “Starting at the Source”.

Concept plans associated with these GSI opportunities were generally not available; for this reason, identified opportunities were only considered in the framework when they fell within an opportunity area identified as part of the GSI-specific process (see Section 4).

Additional opportunities are identified in the City of Pittsburgh Citywide Green First Plan, in the SMR Integrated Watershed Management Plan (currently being developed) and other documents listed in Section 2. However, these opportunities are not currently tracked in the databases considered for this framework and were not integrated into the identification process at this time. They would need to be considered in future updates as discussed in Section 10.

3.3.2 DSIR Projects

A DSI is defined as a surface watercourse that discharges into a CSS. DSIR involves redirecting these streams away from the CSS.

The location of the following examples is shown in Figure 3-18:

- 16 completed or planned projects identified in ALCOSAN DSI GIS layer.
- One completed MSRS demonstration projects.
- Three potential project opportunities identified in MSRS.
- Three projects that have been completed or planned as part the GROW Program.
- Three project ideas that have been identified as part of the GROW Program workshop with municipalities.

Existing DSIR Projects financially supported by ALCOSAN are listed in **Table 3-5**.

Table 3-5. Existing DSIR Projects Financially Supported by ALCOSAN

Project	Diversion Structure	Municipalities	Estimated Inflow Removed (MG/year)	Total Project Cost ($)[1]
Jacks Run	O-25A	Ross; Bellevue; Pittsburgh (PWSA)	200-250	$8,522,737
Sheraden Park	C-07	Pittsburgh (PWSA)	40-65	$6,504,437
Pine Hollow	C-09	Stowe; Kennedy; McKees Rocks	100-150	$5,583,000
Ravine Street	A-69	Sharpsburg	70-100	$3,293,478
Carnegie Park	C-40	Carnegie	80-90	$1,340,000
Freid & Reineman	A-66	Reserve	90-125	$924,321
Orr Street	O-03	Stowe	120-140	$684,300
		TOTALS	**700-920**	**~$27,000,000**

[1] No reference year provided. Data source: ALCOSAN, 2019

These projects are shown in Figure 3-18 as part of the 16 completed or planned projects identified in the ALCOSAN DSI GIS layer. As of Feb. 2020, all projects have been completed except for the Ravine Street Project. ALCOSAN has financially supported all projects, investing approximately 40% of the total project cost. In general, municipalities have invested 20% of the total cost while third parties (such as the U.S. Army Corps of Engineers and PennDOT) have covered the remaining 40%. Through these projects, ALCOSAN has determined that DSIR projects can have a significant impact on reducing sewer overflows, minimizing inflow of sediment and debris to the regional conveyance system and can be a cost-efficient source control management strategy.

ALCOSAN has identified several additional DSIs currently discharging to the CSS as summarized in **Table 3-6** and represented in Figure 3-18. These additional DSIs could represent additional DSIR opportunities. In fact, municipalities are currently working on addressing several of these DSIs.

Table 3-6. ALCOSAN-Identified DSIs Currently Discharging to Municipal Combined Sewer Systems

DSI Name	Planning Basin	Tributary Area (acre)	Annual GWI (Baseflow) Volume (MG)[1]
Ella Street	CC	25	774
Spring Garden	MR	390	91
Panther Hollow	MR	216	18
Woods Run Valley	MR	503	305
Delafield Avenue	UA	95	140
Sharpsburg	UA	96	98
Tassey Hollow	UM	356	142

DSI Name	Planning Basin	Tributary Area (acre)	Annual GWI (Baseflow) Volume (MG)[1]
Verner Avenue	LOGR	42	20
Dooker Hollow	TC	162	250
	TOTALS	**1885**	**1838**

Source: ALCOSAN Inflow Point and Inflow Area GIS data

[1] Annual GWI volume based on the daily minimum dry weather flow of each day during a "dry" 2003 typical year simulation. For ORE modeling purposes, it was assumed that the stream baseflow associated with the DSI tributary area was equal to the GWI.

3.3.3 I/I Reduction Projects

I/I reduction addresses the stormwater entering the sanitary sewer (inflow) due to unauthorized system connections, stormwater cross-connections, manhole leaks or other issues. It also addresses the groundwater entering the sanitary sewer system through pipe cracks, connection leaks or other issues (infiltration).

There are numerous I/I reduction projects and identified opportunities for I/I reduction projects within the ALCOSAN service area.

Figure 3-18 shows the location of the following examples:

- 40 completed MSRS demonstration projects.
- 50 I/I reduction projects that have been completed or are planned as part the GROW Program.
- 53 I/I reduction project ideas that have been identified as part of the GROW Program workshop with municipalities.
- 176 potential MSRS project opportunities.

In addition, ALCOSAN is currently using the extensive information from the Regionalization program (including CCTV data and analysis) to help identify potential I/I reduction projects. Areas where significant defects (especially defects related to excessive infiltration) were found on Regionalization sewers are being evaluated in conjunction with the results of flow isolation studies (FIS), overflow reduction efficiencies, and other pertinent data to highlight sub-basins with a high potential for inflow and subsequent overflow reductions (see Section 6).

3.3.4 SS Projects

SS is the practice of separating the combined, single pipe system into separate sewers for sanitary and storm water flows. SS can also be combined with GSI or DSIR to achieve larger source reductions and/or water quality benefits.

SS projects typically fall within one of the following two categories:

- Converting the combined sewer to a sanitary sewer (referred to as a converted sanitary sewer) – which would typically involve constructing a new separate storm sewer but could also include bulkheading or disabling gates or other regulating devices and disconnecting stormwater drainage structures, sump pumps and roof drains.
- Converting the combined sewer to a storm sewer (referred to as converted storm sewer) – which would typically involve disconnecting existing sanitary connections and constructing new sanitary sewer lines and laterals while the storm, roof and footer drains as well as catch basins would remain connected to the converted storm sewer.

As noted in Section 10 of the CWP, ALCOSAN has historically given more emphasis to converted sanitary sewer opportunities, whether complete or partial.

Partial conversion (also referred to as inflow reduction) would look at removing only a portion of the stormwater flow from a combined sewer area where it is most cost-effective. An example cited in Section 10 of the CWP would be “to redirect existing road drainage (catch basins), yard drains and roof leaders (for those homes where this can be done in a safe and responsible manner) from the existing combined sewer to a newly constructed storm sewer system, but connections from the existing foundation drains and some residual roof leader connections would remain connected to the existing combined sewer system.”

Although large-scale SS was previously evaluated and screened out in the WWP, opportunities for local SS projects within the ALCOSAN service area exist and some projects have already been completed or are planned as follows:

- As shown in **Table 2-1** and illustrated in Figure 3-18, 20 SS projects were awarded funds in Cycles 1 through 4 of the GROW Program with a total estimated overflow reduction value of 61 million gallons per year (MG/yr).
- In addition, some areas within the combined service area have been separated. For example:
  - Significant portions of the TC planning basin were identified and verified as separate and are no longer considered part of the CSS.
  - In CC, portions of the combined sewer areas in Carnegie Borough (POCs C-37 and C-38), South Fayette Township (POC C-54-16), and McDonald Borough (POC C-45B-04) have been separated or are in the process of being separated. However, these areas are still not considered fully separated.
  - In MR, portions of the combined area in the vicinity of POCs O-43 and O-40 were separated as part of redevelopment and transportation projects (e.g., the stadiums and routes I-279 and 65). POC A-63, near Herrs Island, has been separated as has POC M-33 near Hazelwood in Pittsburgh, at the site of a former steel mill.

As far as other previously identified opportunities are concerned, it can be noted that:

- Seven potential project opportunities were identified in the MSRS (see Figure 3-18). In addition, as highlighted in Section 10 of the CWP, separation alternatives did not appear to be considered in some studies.
- 18 ideas were identified as part of the GROW workshops with municipalities.

The following potential SS ideas have been identified more recently by ALCOSAN and others:

- As part of the Preliminary Planning work, the following ideas have been brought up – some of which could eliminate the need to control CSO discharges by other means at these locations:
  - **O-39:** SS completed by a proposed development in the area could potentially eliminate the need for the O-39 outfall.
  - **O-43**: potential opportunities for additional SS in this sewershed (a significant portion has already been separated).
  - **A-47:** potential for partial separation of the A-47 sewershed considering a proposed development.
  - **A-56:** past development resulted in the separation of most of the area and field investigation of the buildings and catch basins in and along River Avenue from Goodrich Street to Voeghtly Street are recommended.

- Downstream portion of A-42: PWSA and USACE are currently designing Phase 1 of the Negley Run Section 219 Environmental Infrastructure project which includes installation of a new detention basin, outlet storm drain pipe, and a new dedicated storm outfall to the Allegheny River. The intent of the project is to eventually provide stormwater treatment, GSI, CSO separation, and flood reduction to the Washington Boulevard/Negley Run corridor.
- Portions of Pittsburgh's Strip District as part of large redevelopment projects and PWSA work.
- Several ALCOSAN outfall structures have been found to exhibit no or low flows during dry system conditions suggesting that they could represent potential for conversion to a "converted storm sewer." **Table 3-7** provides a list of these structures by main streams.

Table 3-7. ALCOSAN CSO Structures with No- or Low-flows during Dry System Conditions

Main Streams	CSO Structures
Allegheny River	A-18Z; A-36; A-38; A-40; A-59Z; A-77
Chartiers Creek	C-36; C-37; C-39; C-43; C-44
Monongahela River	M-08; M-20; M-27; M-31Z; M-38; M-39; M-56
Ohio River	O-02; O-08; O-30; O-35; O-37; O-41

Source: ALCOSAN, 2018. Notes on POCs found to exhibit no or low flows but were not included in the table: M-32 is classified in ALCOSAN GIS as non-contributing; there are no O-09 and O-10 sheds in the ALCOSAN GIS. C-36 is mapped as separated in ALCOSAN GIS.

Generally speaking, and as highlighted in the Section 10 of the CWP, "Without […] the detailed records and local understanding of each unique municipal system, it is not possible to identify site-specific opportunities and costs for complete sewer separation or inflow reduction. […] A few general observations can be made as to where complete sewer separation or inflow reduction may be able to remove storm water from the system, at a lower cost than the municipal and ALCOSAN improvements in the Selected Plan. […] sewer separation is likely to be most viable for:

- Small, localized pockets of combined area;
- Areas where a significant portion of a combined sewer area has already been separated due to redevelopment projects and the requirement to provide separate storm and sanitary sewers for those projects;
- Outfalls where complete elimination is desired such as in sensitive areas;
- Areas where special municipal interest/objectives outweigh the cost and disruption of this approach;
- Areas within municipalities that have implemented some successful separation in the past or have made eventual separation a long-term objective; or
- Areas where municipalities have good records and knowledge of their system and past plumbing practices, and therefore have a good handle on sewer separation approaches and associated costs."

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4 GSI-Specific Process

This section documents the study area for which the specific GIS opportunity identification and prioritization process was developed and to which it was applied as part of this CtS, and the process itself. It also details the methodology associated with each step and key intermediate results. The main results associated with the implementation of the process are documented in Section 8.

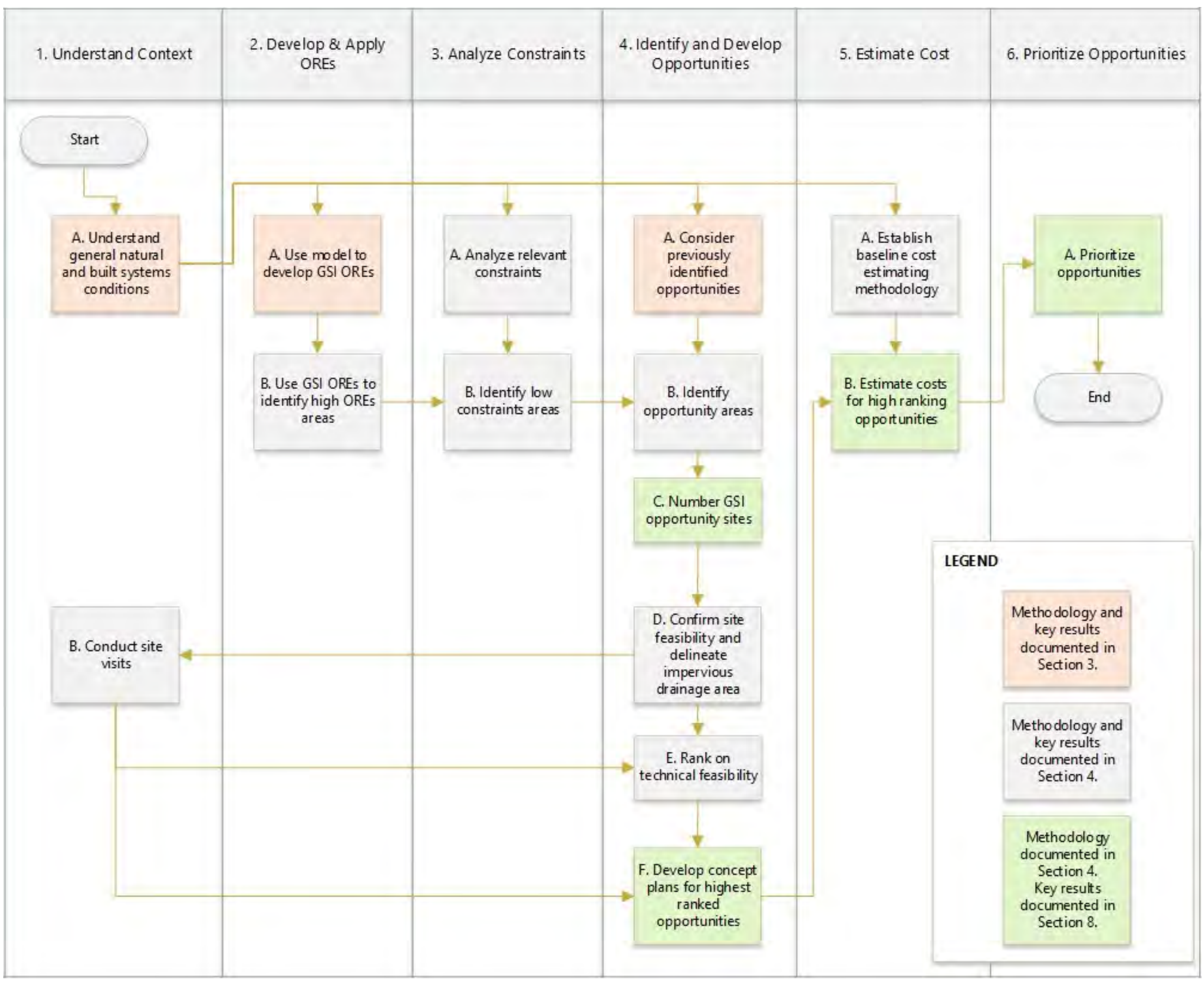
4.1 Study Area

Detailed information associated with many previously identified GSI opportunities noted in Section 3 was not available at the time the CtS work was initiated. As such, the GSI process was developed to identify opportunity sites throughout the CSS area and develop concept plans for highest ranked opportunities.

4.2 Process

Figure 4-1 represents the specific process for GSI opportunity identification and prioritization, adapted from the generic process presented in Section 3.

Figure 4-1. GSI -specific Opportunities Identification and Prioritization Process



The process initiated with a GIS-based desktop analysis. The analysis aimed to identify public properties in the CSS area with relatively low constraints and situated in higher ORE subcatchments where GSI concepts could be implemented to manage a sizable impervious drainage area. “Absolute” constraints (such as very steep slopes, wetlands, railroads) and “relative constraints” (such as hydrologic soil group, utilities, moderate to steep slope) were considered. Identified opportunity areas were then analyzed further in terms of site feasibility and to delineate impervious drainage area; site visits were conducted to further inform the technical feasibility; and conceptual plans and costs were developed for highest ranked opportunities.

4.3 Methodology and Intermediate Results

The methodology and key outcomes associated with the steps in orange in Figure 4-1 are documented in Section 3 as part of the generic process description.

The methodology associated with all the other steps in Figure 4-1 are presented below. Key intermediate results associated with the steps shown in grey in Figure 4-1 are also presented below. When results cannot be practically presented for the entire study area, results are presented for a select area (Rankin and Braddock Borough). Supporting documentation is provided in **Appendix C** and its sub-appendices.

The main results (associated with the steps shown in green in Figure 4-1) are presented in Section 8.

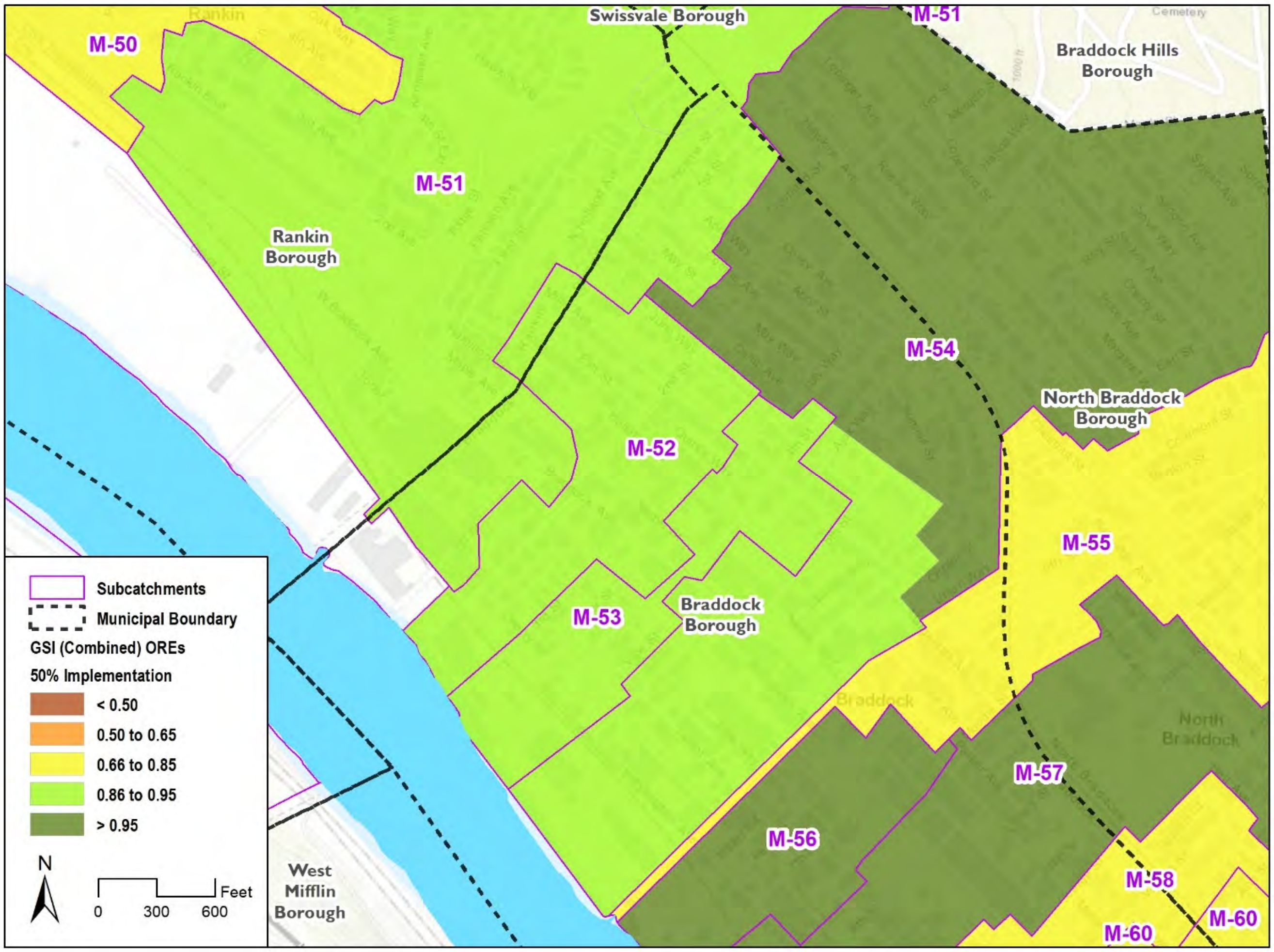
4.3.1 Step 2B: Identify High ORE Areas

Methodology: The GSI OREs under Existing Conditions described in Section 3.3 were analyzed throughout the ALCOSAN service area to help identify where GSI projects can be most effective. For example, a project in an area with an ORE of 0.98 has double the potential to reduce overflow volumes if GSI is implemented versus the same project in an area with a lower ORE of 0.49.

Areas with the lowest OREs (GSI ORE < 0.65) were screened out through a GIS analysis. OREs reflect the efficiency of a potential project and must be considered along with the scale of the project in terms of total inflow capture and overflow reduction and other factors, therefore the ORE cutoff can be adjusted as needed in the future.

Results: **Figure 4-2** provides an example of GSI OREs in a select area (Rankin and Braddock Borough). Based on GSI OREs, no subset of the select area was screened out by the analysis.

Figure 4-2. GSI OREs in the Select Area (Rankin and Braddock Borough) under Existing Conditions



4.3.2 Step 3A: Analyze Relevant Constraints

The methodology and results associated with the constraint analysis are summarized below. The complete "GSI Constraint Analysis Technical Memorandum" is provided in **Appendix C-3**.

Methodology: The constraint analysis focused on identifying relevant physical and environmental constraints that might affect GSI project definition and implementation. Relevant constraints depend on the source control categories. For example, GSI projects are heavily influenced by factors such as soils and geology, land use, slope, or floodplains while DSIR and SS projects are more often impacted by physical barriers (e.g., utility conflicts, railroads, and highways) that prevent a disconnection to a waterbody.

The GSI constraints analysis provides a geospatially informed estimate of areas where GSI potential may be limited and/or costlier based on mapped physical and environmental constraints.

For the purposes of this planning-level analysis, some constraints were considered absolute constraints, representing conditions that typically preclude GSI implementation altogether (e.g., very steep slopes). Absolute constraints are listed in **Table 4-1**. For purposes of GSI opportunities identification, areas with absolute constraints were screened out without exception; the absolute constraints were therefore not scored.

Other constraints, defined as "relative constraints," do not necessarily preclude GSI implementation but may impact the effectiveness, cost, and/or limit the project types possible. For example, shallow depth to bedrock may limit infiltration and limit GI effectiveness. Relative constraints considered in the process are described in **Table 4-2**.

Table 4-1. GSI Constraints Analysis – Absolute Constraint Data

Absolute Constraints	Buffer Included	Notes
Wetlands	10 feet	Regulatory protection[1]
Streams	20 feet from line feature	Regulatory protection[1]
Floodway	None	Regulatory protection and preservation of GSI[1]
Very Shallow Bedrock (less than 1.1 feet)	None	Feasibility, difficulty of construction, performance[1]
Railroads	15 feet from line feature	No GSI on active railroads
Surface water (from Soil and Land Use)	None	Feasibility and possible regulatory protection
Very steep slopes (greater than 25%)	None	Construction difficult / regulatory protection[1]
Superfund or fuel/storage tank parcels	None	Environmental issues / hotspots[1]

[1] The PA Stormwater BMP Manual includes infiltration guidelines related to wetlands and streams buffers, bedrock separation, steep slopes, and hotspots.

Table 4-2. GSI Constraints Analysis – Relative Constraint Data and Scoring Used

Relative Constraints	Constraint Score	Notes / Description of Constraint
Utilities, i.e., sewers including 3-foot buffer	3.5	May limit infiltration and/or increase cost
Slopes (Moderate to Steep)	1 to 5	Lower efficiency and possible regulatory protection at higher slopes[1]
5 to 9.99%	1	
10 to 14.99%	3	
15 to 24.99%	5	
Hydrologic soil group (B/D, C, D, Urban)	0.5 to 2	May limit infiltration and/or reduce performance[1]
B/D	1.5	
C	0.5	
C/D	1.5	
D	2	
Urban	1	
Shallow depth to bedrock	0.5 to 3	May limit infiltration and/or increase cost[1]
1.1 to 2.6 ft	3	
2.6 to 5.0 ft	1	
5.0 to 5.7 ft	0.5	

Relative Constraints	Constraint Score	Notes / Description of Constraint
Shallow depth to water table	2 to 5	May limit infiltration and/or increase cost[1]
Less than 0.49 ft	5	
0.5 to 1.35 ft	4	
1.36 to 1.9 ft	3	
1.91 to 2.26 ft	2.5	
2.27 to 2.59 ft	2	
FEMA 100-year Floodplains (Zones A and AE)	2.5	May reduce performance and/or increase cost[1]
Forest Cover	2.5	Preservation of forest encouraged; tree removal/replacement costs[1]
Brownfields / Abandoned Mines	3	Potential environmental/stability issues[1]
Streets/Roadway	1.5	May have limited space, utility conflicts and/or increased costs
Cemeteries	3	Limited space/opportunity

[1] The PA Stormwater BMP Manual includes infiltration guidelines related to bedrock/water table separation, HSG D soils, compacted fill, limiting excavation, steep slopes, floodplains, hotspots, and preservation of forest.

Relative constraints were scored based on an overall scale of zero to five (with a higher number indicating a higher relative level of constraint) according to the relative degree of constraint for that feature based on professional experience.

Through a GIS overlay process, areas with multiple relative constraints received a total score for all overlapping relative constraints polygons by summing all individual scores into a Total Score value. For example, a brownfield (with a relative constraint score of 3) located in an area with depth to bedrock between 1.1 and 2.6 feet (with a relative constraint score of 3) would have a Total Score of 6.

Relative constraints were categorized into:

- Areas with a relatively high level of relative constraints (total constraint score of 7 or higher).
- Areas with medium high level of relative constraints (scores 4.5 to 6.5).
- Areas with medium level of relative constraints (score 2.5 to 4).
- Areas with low level of relative constraints (score 2 or less).

Areas with a high constraint score are considered less suitable for GSI implementation and low scoring areas (low constraints) are considered more suitable for GSI.

When an absolute constraint overlapped a relative constraint, the absolute constraint governed as illustrated in **Figure 4-3**. Building footprints with a 10-foot buffer, which were originally included as a relative constraint due to the limited options and associated costs for GSI in or on buildings, were treated separately as an overlay in the final step in the analysis.

Figure 4-3. Example Showing the Overlay of GSI Constraint Layers and the Resultant Scores in a Portion of the Squirrel Hill Neighborhood of Pittsburgh

Results: Figure 4-4 provides a summary of overall constraints for ALCOSAN CSS service area. **Table 4-3** provides a summary of overall constraint score for the CSS service area. **Figure 4-5** shows the overall constraints for ALCOSAN CSS service area.

Approximately 14% of the ALCOSAN CSS service area is characterized as having “absolute constraints” and therefore is not deemed suitable for typical GSI implementation due to the prevalence of significantly constraining features such as wetlands, very steep slopes, and railroads.

Buildings (with a 10-foot buffer) cover an additional 27% of the total study area and are typically considered a very limiting constraint unless redevelopment is planned that may remove or relocate an existing building.

Twenty percent of the ALCOSAN CSS service area is categorized as having a low (3%) or medium (17%) level of constraints. These areas could be targeted for GSI implementation.

Figure 4-4. GSI Overall Constraint Score in ALCOSAN CSS Service Area

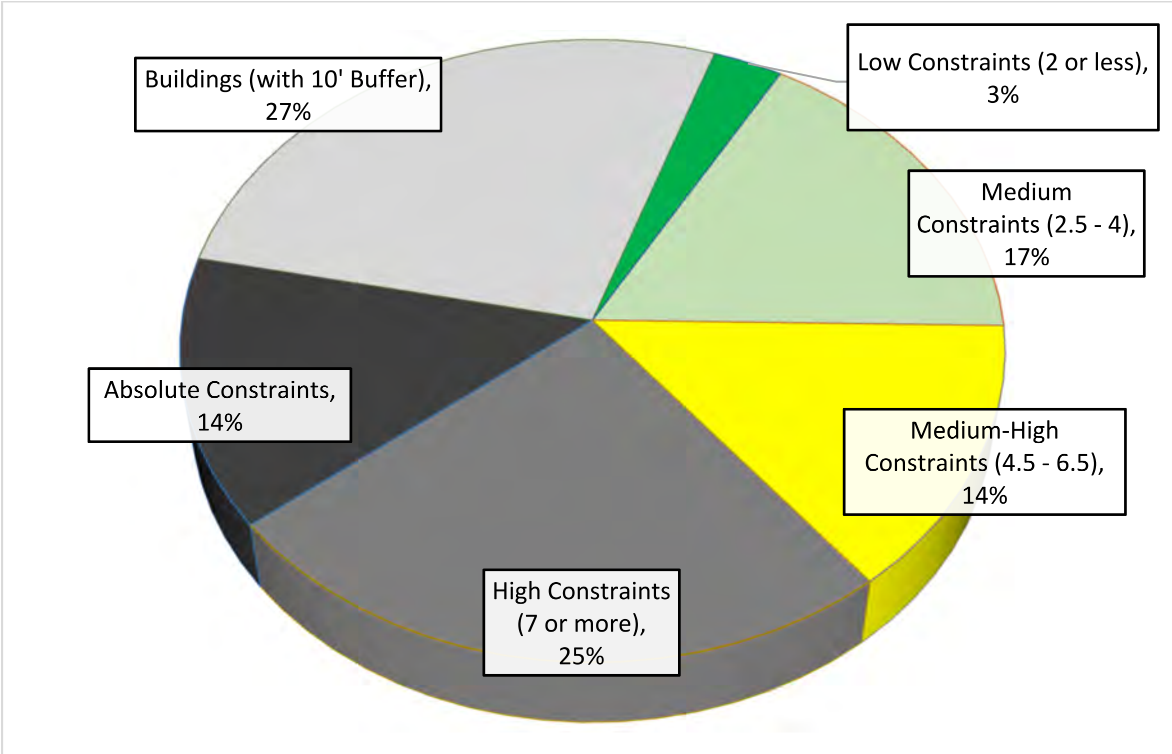


Table 4-3. GSI Overall Constraint Score by Planning Basin

Constraint Score	Percent per Planning Basin							% Total Study Area
	CC	LOGR	MR	SMR	TC	UA	UM	
Low (constraint score 2 or less)	6%	6%	3%	1%	7%	1%	3%	**3%**
Medium (constraint score 2.5 - 4)	22%	15%	17%	6%	11%	23%	19%	**17%**
Medium-High (constraint score 4.5 - 6.5)	14%	15%	14%	19%	12%	14%	15%	**14%**
High (constraint score 7 or more)	16%	22%	26%	28%	28%	25%	26%	**25%**
Absolute (wetlands, very steep slopes, etc.)	15%	16%	13%	19%	21%	10%	11%	**14%**
Buildings with 10' Buffer	27%	27%	27%	28%	22%	28%	26%	**27%**

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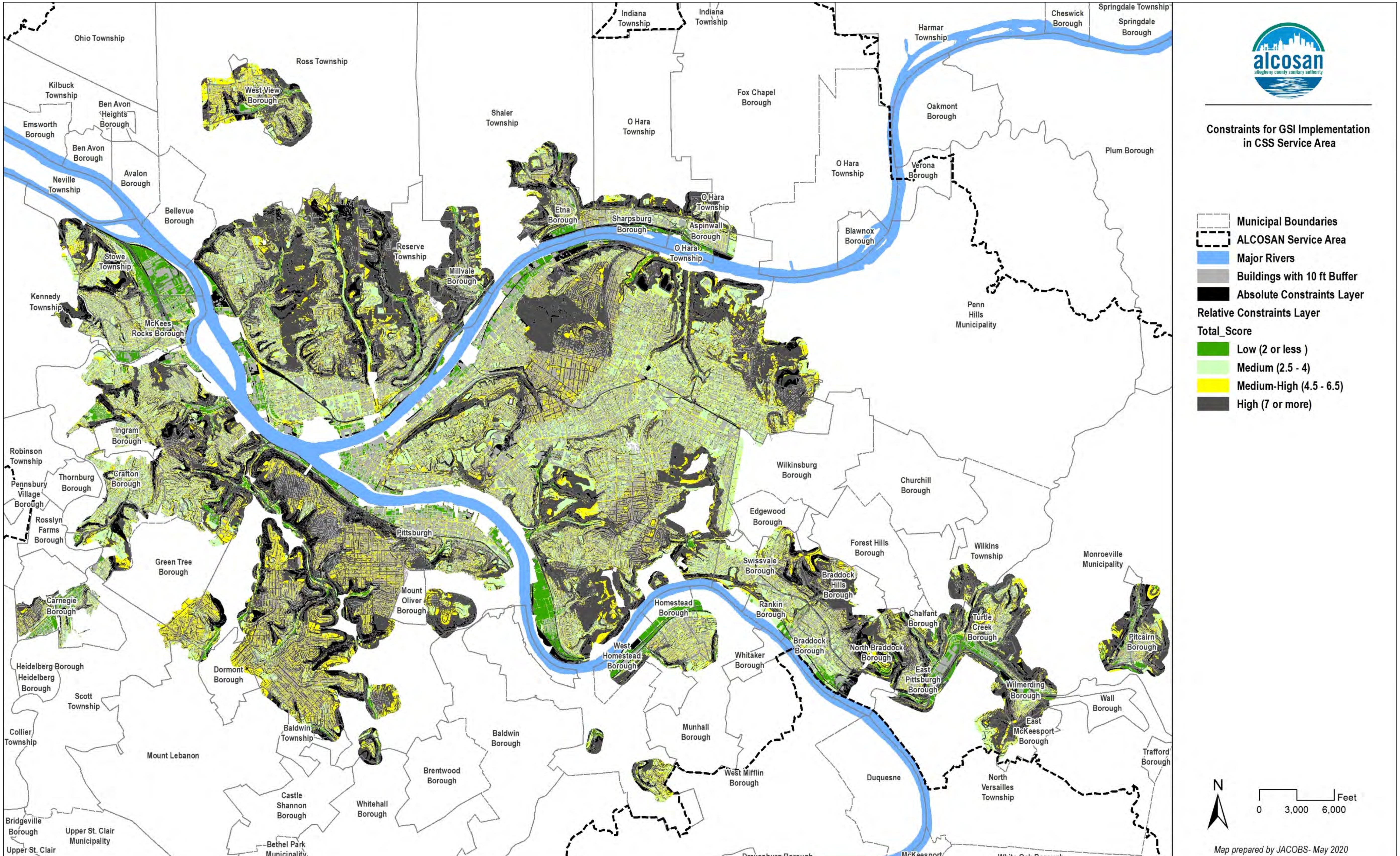
Figure 4-5. Constraints for GSI Implementation in ALCOSAN CSS Service Area



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The remainder of the CSS area has varying levels of relative constraints, with the median relative constraint score for the overall CSS area being 6.

This constraint information can be used in conjunction with results from the ORE modeling analysis and the opportunity analysis to develop potential GSI projects in minimally constrained and high opportunity areas to maximize the potential overflow reduction benefit and cost efficiency of projects. The results of the Constraints Analysis can also be used to inform feasible implementation levels of GSI and cost estimates of GSI implementation to evaluate potential changes to the CWP.

4.3.3 Step 3B: Identify Low Constraint Areas

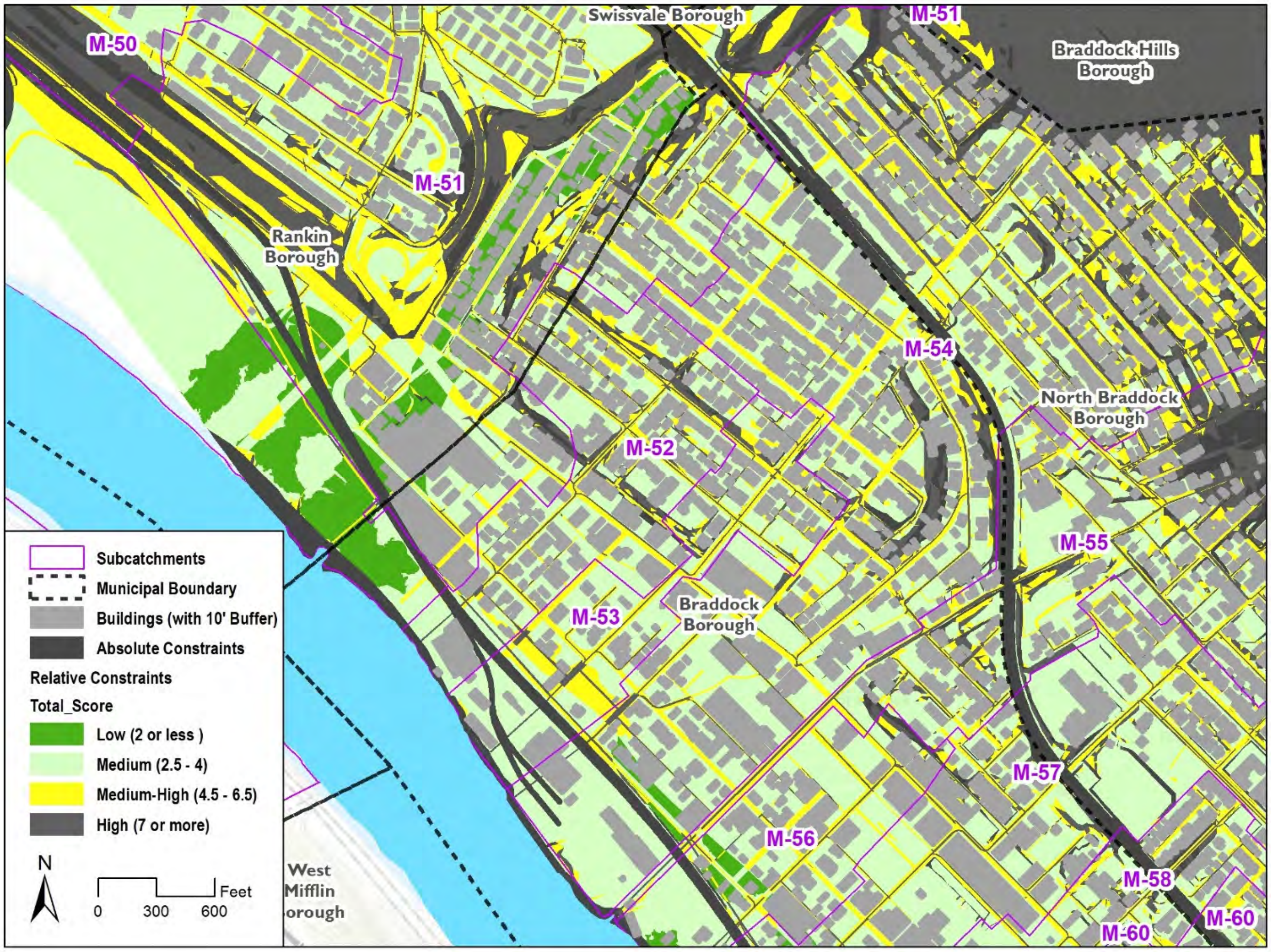
Methodology: Areas with high level of relative constraints (total constraint score of 7 or higher) were generally screened out and the GSI project identification focused on the following areas.

- Areas with medium high level of relative constraints (scores 4.5 to 6.5)
- Areas with medium level of relative constraints (score 2.5 to 4), and
- Areas with low level of relative constraints (score 2 or less).

Since green roofs typically are not cost-effective in terms of overflow reduction as they are relatively expensive per unit area and typically only manage direct rainfall (unlike a rain garden that manages 10 to 20 or more times its own area), buildings and their 10-ft buffers were also considered a high level of relative constraints, i.e., generally screened out, with the understanding that buildings are sometimes demolished or retrofitted with a green roof. Exceptions were made on a case-by-case basis if an otherwise strong potential project from a potential capture and/or other benefits standpoint was identified in a High Constraint area.

Results: Figure 4-6 illustrates identified constraints in the select area. In this case, all the areas showing a relative constraint score of 7 or more were screened out.

Figure 4-6. Identified GSI Constraints in the Select Area

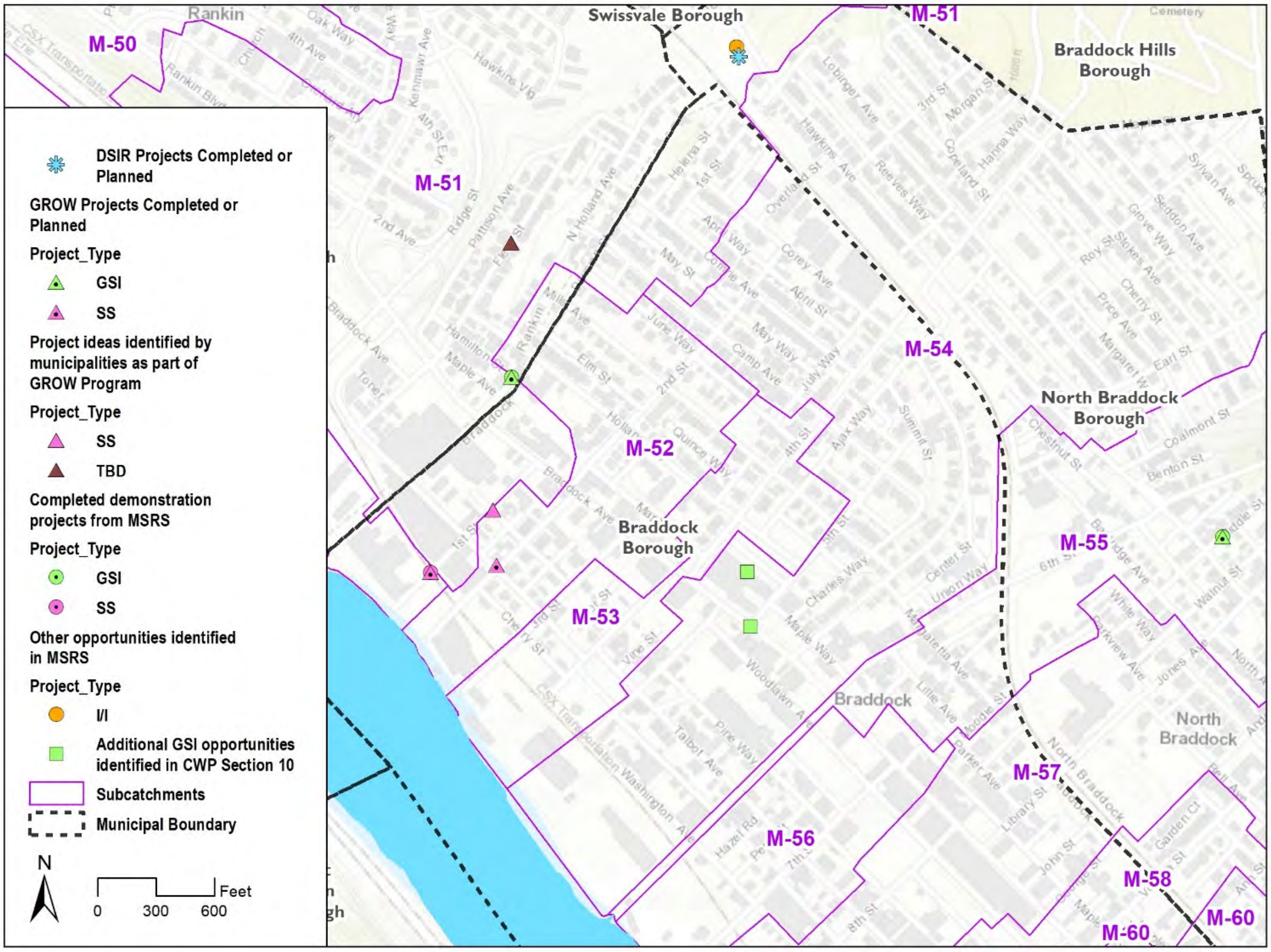


4.3.4 Step 4A: Considering Existing/Previously Identified Projects

Methodology: The projects identified in Section 3.3 were considered on a case by case basis. If there were constructed projects already identified at a particular site, opportunities for additional and/or complementary GSI was considered. For example, if only a green roof exists, the rest of the site could still have potential for GSI to manage the ground-level runoff. For this reason, that area should still be considered in the analysis.

Figure 4-7 illustrates the existing/previously identified projects in the select area.

Figure 4-7. Existing/Previously Identified GSI Projects in the Select Area



4.3.5 Step 4B: Identify Opportunity Areas

The identification of opportunity areas involved three (3) sub-steps: analyzing parcel ownership to define opportunity categories, analyzing impervious area by opportunity category, and grouping the ownership/opportunity categories into several generic potential GSI strategy or program types.

A detailed description of these sub-steps and results for each planning basin area is provided in the "GSI Opportunity Analysis Technical Memorandum" included in **Appendix C-4**. A summary is provided below.

4.3.5.1 Parcel ownership analysis

Methodology: Opportunity areas for GSI primarily focused on CSS areas within public ownership, such as right-of-way (ROW), parks, schools, and municipal-owned parcels. This is because areas within public ownership are where ALCOSAN customer municipalities could implement GSI on their own or are most likely to be successful in collaborating with other public property owners (e.g., school districts and redevelopment authorities). In addition, many parcels within public ownership are larger in size which may allow for GSI of a slightly larger scale (i.e., 10,000 sf or greater) that tend to be able to manage more considerable adjacent drainage areas and therefore can be more impactful, cost-effective projects.

However, parcels in private ownership were also included in the opportunity analysis for the purposes of conducting a comprehensive characterization of the total land area. Implementation of GSI on private property could provide significant benefits at no or reduced cost to the public and should be considered as appropriate when considering feasible implementation levels, conducting sewershed-specific evaluations, etc.

The opportunity analysis heavily relied upon Allegheny County parcel boundary spatial data and associated parcel assessment data, provided Dec. 2017. The assessment data contains important attribute information (i.e. Owner Name, Owner Description, Class Description, and Land Use Code Description) that was reviewed to provide an efficient means to determine the relevant opportunity parcels within the study area. All ownership and land use class/codes should be field-verified as potential projects are developed.

The parcel and assessment data were initially analyzed by the Property Owner field to identify all parcels that were not privately-owned parcels. The data was also summarized and sorted using the Class Description attribute to generate a high-level assessment of the distribution of general land uses for the parcels in the study area. In reviewing the distribution of parcels based on the Class Description, initial opportunity categories were developed.

Next, an iterative process was performed that included a more detailed investigation of the land use code descriptions as they related to both class descriptions and ownership to further refine and finalize the opportunity categories. This process included the following:

1) **Summarizing the number and total area of parcels by Owner and by Land Use Code** to assess the range of owners and land use types in the study area and help determine the most appropriate opportunity category for different owners and land use types.
2) **Assessing parcel ownership** as a determining factor for assigning an opportunity category in some instances (e.g., anything owned by the City of Pittsburgh was classified as “City” regardless of class description and land use description).
3) **Evaluating specific combinations of Class Descriptions and Land Use Code Descriptions** (e.g., a “Residential” Class Description may have a “Vacant” Land Use Code Description and would therefore be categorized as “Vacant”).

Results: Ten opportunity (or ownership) categories were developed. **Table 4-4** provides a summary of the number and area of opportunity categories for the ALCOSAN CSS area.

Figure 4-8 and **Figure 4-9** show a portion of the CC basin with **Figure 4-8** showing publicly-owned parcels in color and privately-owned parcels in grey and **Figure 4-9** showing the reverse with privately-owned parcels in color and publicly-owned parcels in grey. This area of the Chartiers planning basin shows an example of an area with a high percentage of privately-owned parcels (both private residential and private non-residential). Therefore, to achieve high levels of GSI implementation in an area such as this with relatively limited publicly-owned parcels, private participation would be necessary. In general, without joint private and public participation, high implementation levels are difficult to achieve. Private participation could be driven by local regulations (e.g., stormwater ordinances), incentives (e.g., grants, rebates, and stormwater fee credits), education and outreach, recognition programs (e.g., awards and sustainability or green certifications), etc. Because of this institutional complexity, the focus of the rest of the CtS is public-owned property.

Table 4-4. Number and Area of Opportunity Parcels in the ALCOSAN CSS Service Area

Opportunity Category	Description	Number of Parcels	Total Area (Ac)
Public Ownership			
Right-Of-Way	The non-parceled common area that typically includes roads, sidewalks and some adjacent land area. This includes both Municipal ROW and PennDOT ROW.	N/A	8,021
Vacant	The vacant category refers to all properties with a land use description of Vacant Land. Note that this does not necessarily represent urban vacant/abandoned lots but includes some larger undeveloped parcels or those without buildings present	25,350	3,057
Park	Any parcel with a land use description as public park or parcels that were identified as parks in the separate Allegheny County Parks polygon layer which was merged into the master parcel layer.	319	1,942
City	Parcels owned by the City of Pittsburgh and its related agencies, regardless of the land use designation.	8,935	1,357
Authority	Parcels owned by the Housing Authority, Urban Redevelopment Authority, Water Authority, Flood Control Authority, etc.	2,106	844
Non-municipal	Non-municipal government entities like Federal, State, or County properties including ALCOSAN and the Port Authority. Fire Department/EMS and the US Postal Service were also included in this category.	1,059	684
School	Any public-school parcel with an ownership category or land use description of “Board of Education”.	365	402
Municipal	Parcels owned by a municipal form of government. This was spot checked and verified by reviewing the Property Owner name.	648	254
Private Ownership			
Private Non-residential	Privately owned, non-residential parcels that do not fit into any of the other categories	40,500	8,947
Private Residential	Privately owned residential parcels	100,357	10,081
Not Assessed	Some parcels were missing information and had no assessment information for use in this analysis. These areas were not included in any of the opportunity categories.	370	80
TOTALS		**180,009**	**35,668**

Figure 4-8. Parcel Ownership Analysis Highlighting Publicly-Owned Parcels and Right-of-Way in a Portion of the Chartiers Creek Basin

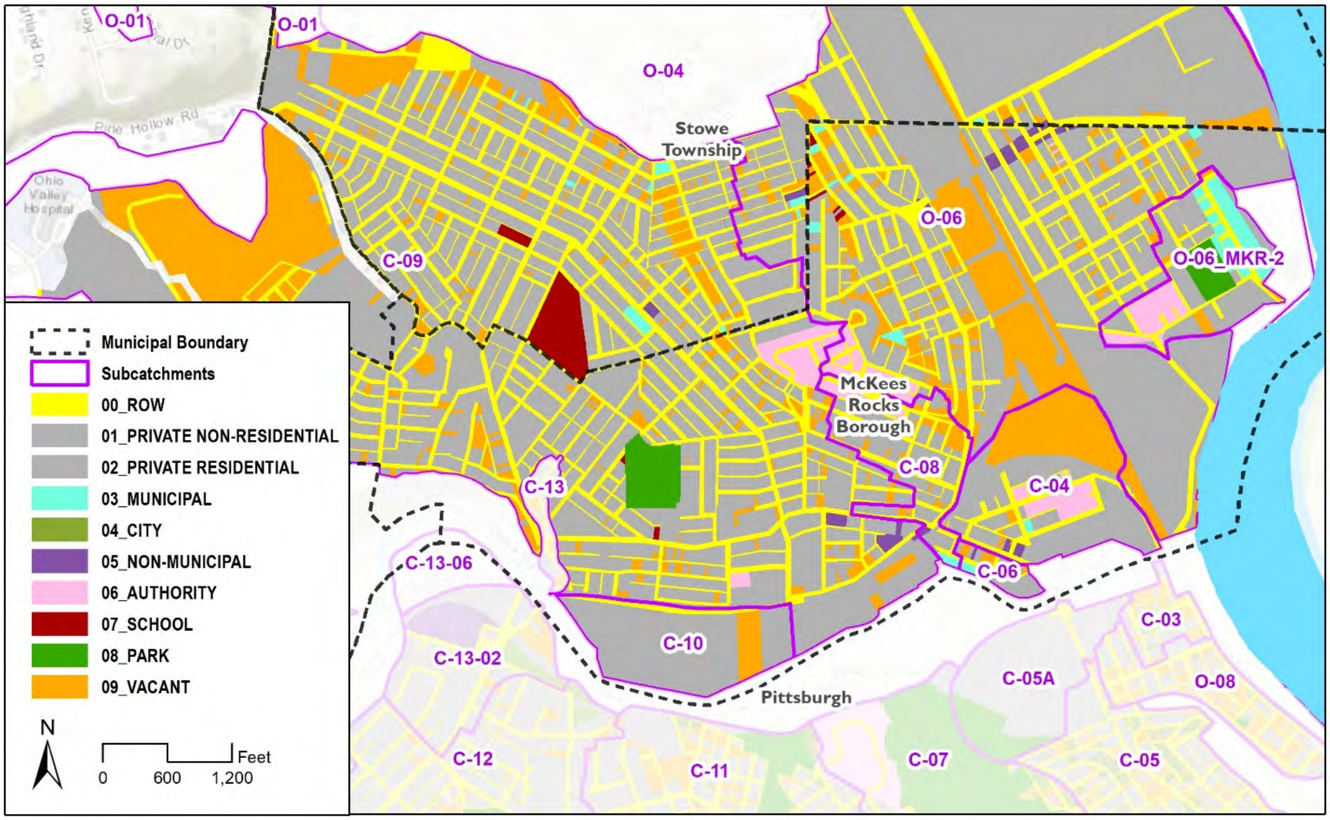
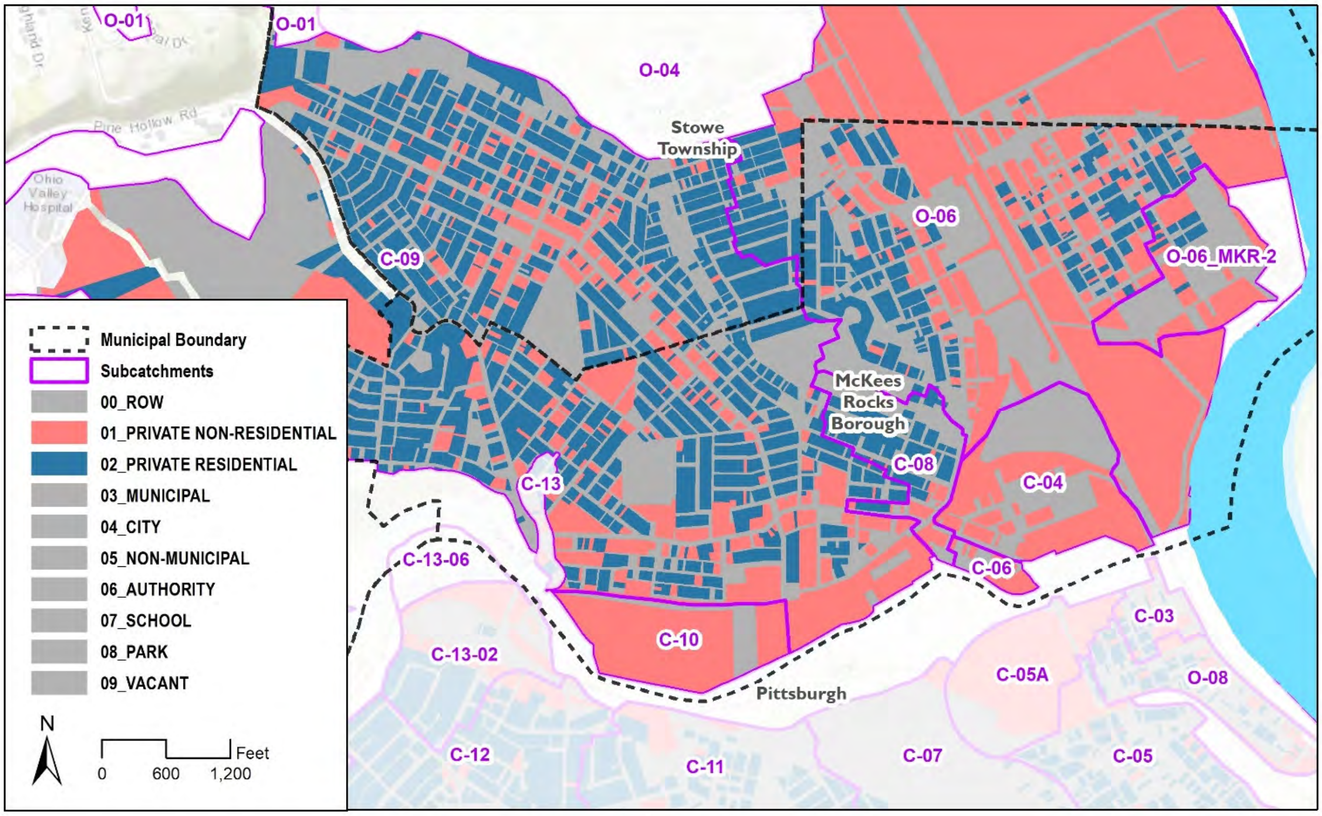


Figure 4-9. Parcel Ownership Analysis Highlighting Privately-Owned Parcels in a Portion of the Chartiers Creek Basin



4.3.5.2 Impervious Area Analysis for Opportunity Categories

Methodology: Impervious surfaces are typically paved surfaces that allow little or no stormwater infiltration into the ground. In combined sewer areas, the amount of impervious area is most directly linked to excess stormwater runoff and CSOs. GSI can manage runoff from impervious areas, mitigating that runoff before it enters the CSS. Therefore, when looking for opportunities to implement GSI, it is important to identify opportunity parcels that are strategically located next to sizable impervious areas, so that the stormwater runoff can be directed from the adjacent contributing impervious drainage areas into the opportunity parcel to be managed.

In addition, some opportunity parcels have the potential to capture impervious contributing areas beyond those captured on-site or from nearby adjacent right-of-way areas and therefore may also realize cost efficiencies. The contributing drainage area should generally only consider right-of-way impervious area, parking lot impervious area, and other major publicly-owned impervious areas. For the initial evaluation, rooftops and driveways were typically not included. To focus on the most potentially impactful sites, a minimum DA of approximately one acre was targeted.

The categorized parcel layer was intersected with impervious area data and summarized to determine the overall impervious area distribution within each opportunity category. **Results: Table 4-5** below summarizes the percent impervious, the total impervious area, and the average parcel size in each opportunity category. Overall, the right-of-way (ROW) opportunity category contains the most impervious area, followed by the private non-residential and non-municipal opportunity categories.

Table 4-5. Impervious Area for Opportunity Categories in the ALCOSAN CSS Service Area

Opportunity Category	Number of Parcels	Total Area (Ac)	Total Impervious Area (Ac)	% Impervious	Average Parcel Size (Ac)
Public Ownership					
Right-Of-Way	N/A	8,021	4,225	53%	N/A
Vacant	25,350	3,057	283	9%	0.12
Park	319	1,942	169	9%	6.09
City	8,935	1,357	113	8%	0.15
Authority	2,106	844	178	21%	0.40
Non-municipal	1,059	684	255	37%	0.65
School	365	402	115	28%	1.10
Municipal	648	254	34	14%	0.39
Private Ownership					
Private Residential	100,357	10,081	2,369	23%	0.10
Private Non-residential	40,500	8,947	3,642	41%	0.22
Not Assessed	370	80	21	26%	0.22
TOTALS	**180,009**	**35,668**	**11,403**	**32%**	**0.20**

4.3.5.3 Opportunity Categories and Corresponding GSI Strategies

Methodology: The ownership/opportunity categories were grouped into several generic potential GSI strategy or program types. This was done to enable an estimate of benefits and costs as part of subsequent analyses. For example, right-of-way was assigned a green streets GSI strategy. More information on these categories/site types can be found in ALCOSAN's Mar. 2019 GSI Guidance Manual.

Results: Table 4-6 provides a summary of the ownership/opportunity categories and corresponding potential GSI strategy. The strategy is not intended to be a comprehensive list, but rather examples of GSI project types that have been successfully implemented at comparable properties.

Table 4-6. Ownership Categories and Corresponding GSI Strategy/Program Types

Ownership Category	GSI Strategy/Program Type
Public Ownership	
Right-Of-Way	Green Streets
Vacant	Vacant Lot Greening
Park	Green Parks
City	Green Facilities
Authority	Green Facilities

Ownership Category	GSI Strategy/Program Type
Non-municipal	Green Facilities
School	Green Schools
Municipal	Green Facilities
Private Ownership	
Private Residential	Rain Gardens/Downspout Disconnection[1]
Private Non-residential	Redevelopment/Retrofits (via code compliance or voluntary actions)

[1] Downspout disconnection opportunities should be sited in conjunction with careful consideration of downstream effects

4.3.6 Step 4C: Number GSI Opportunity Sites

Methodology: GSI opportunities sites identified through the process described above were systematically numbered. The numbering system indicates the planning basin and opportunity number (e.g., Site UM-16).

Results: Results are presented in Section 8.

4.3.7 Step 4D: Confirming Site Feasibility and Delineating Impervious Drainage Areas

Methodology: A desktop site analysis to further investigate the site, assess the potential contributing drainage area, and initially evaluate the feasibility for potential GSI implementation.

The desktop analysis involves looking more closely at aerial site imagery, sewer and infrastructure data, topography, surface flow, and other available data layers. The following items were considered when evaluating potential project feasibility at a potential site:

- Confirmation of site ownership.
- Assessment of site characteristics/factors that might affect potential source control project implementation, i.e. Is construction/redevelopment in progress? Does recent aerial/streetview imagery reveal additional site-specific constraints to avoid?
- Confirmation of available unconstrained space for source controls on site. For example, subsurface GSI projects (such as infiltration trenches/ beds) can be sited underneath existing site features such as parking lots, sports fields, play courts, and open lawn areas. Surface GSI features (such as bioretention areas or bioswales or vegetated curb extensions) typically require open lawn areas or portions of unconstrained right-of-way.

Impacts to existing site programming and use were considered. For example, if a playground has a highly-used basketball court and play structure, those should be preserved when siting potential GSI (although as noted above, GSI could easily be incorporated with an existing basketball court). An open lawn may be a prime opportunity to site a bioretention area (rain garden) but not if that open lawn is used regularly for festivals or sporting events. In a parking lot, care should be taken to minimize the loss of parking spaces. GSI projects should complement existing site uses and not negatively affect available space for site uses.

The next step was to delineate the potential impervious drainage area that a potential source control project could manage. In combined sewer areas, the impervious area is most directly linked to overflows and is therefore directly linked to potential project sizing and cost estimating. The contributing drainage area generally considered the right-of-way impervious area, the parking lot impervious area, and other major publicly-owned impervious areas. Privately-owned impervious areas such as building rooftops and driveways were typically not included initially to be conservative but could be accounted for later as appropriate.

The concept of loading ratios quantifies the amount of contributing impervious drainage area that is flowing towards a particular GSI project, i.e., how much runoff a specific BMP can manage during a storm event. A general rule of thumb is that proposed GSI locations (BMPs) would ideally be able to manage a loading ratio of between 10:1 – 15:1 of contributing impervious drainage area.

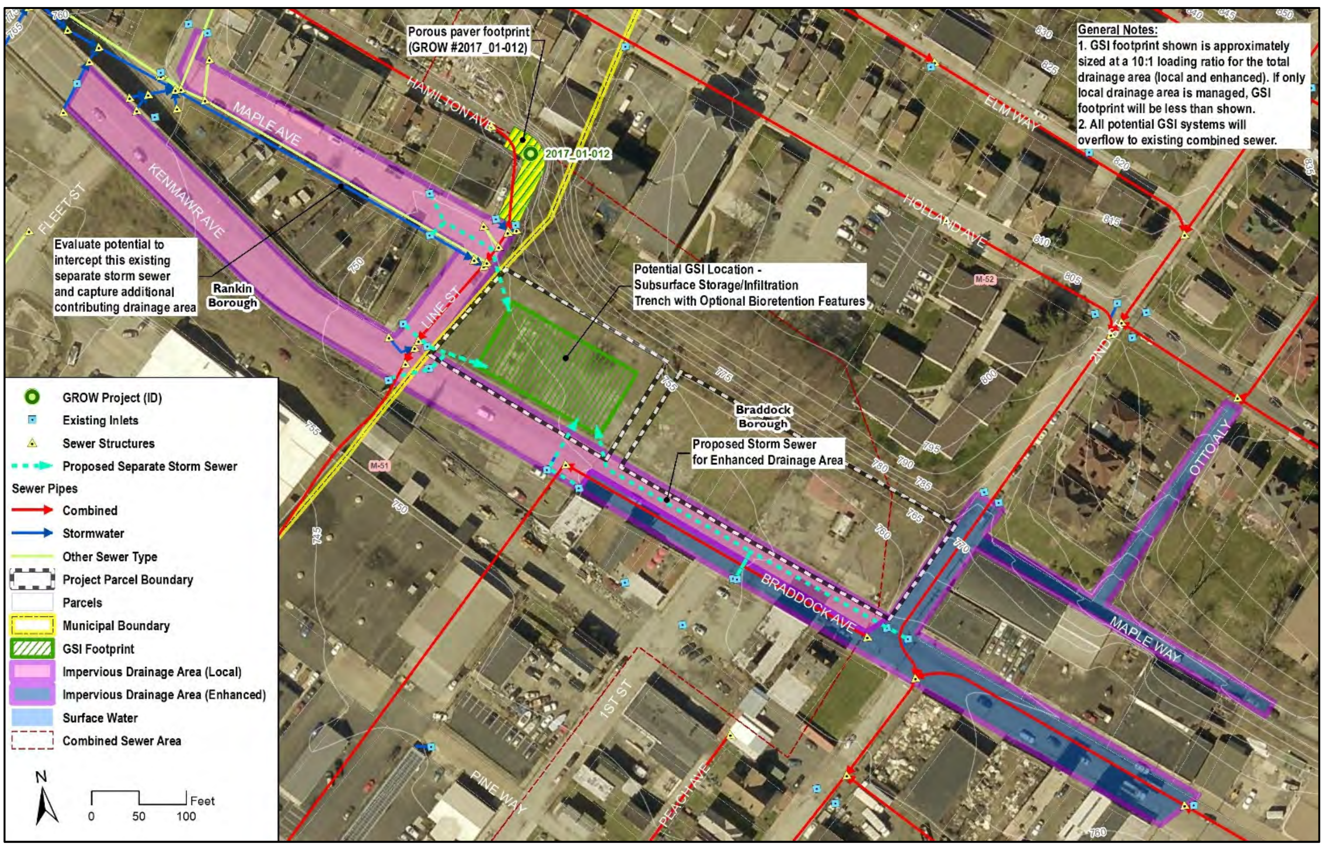
This means that the surface area (square feet or acres) of proposed BMPs should be 1/10th – 1/15th the size of the potential contributing impervious drainage area (square feet or acres) flowing to that particular BMP.

To focus on the most potentially impactful and cost-effective projects, a minimum potential contributing impervious drainage area of approximately one acre was targeted.

Finally, many projects have the potential for enhanced drainage area capture opportunities, where a site can manage multiple blocks of upgradient runoff by installing (or diverting) separate storm sewers and disconnecting those blocks from the current combined sewer infrastructure. As described in the following cost methodology section, these projects may prove to be more cost-effective while managing larger areas of contributing impervious area.

Results: Figure 4-10 shows the delineated drainage area for one of the projects identified in the area of focus in this example, i.e., Site UM-36.

Figure 4-10. Drainage Area Delineation and Initial GSI Footprint Location for Site UM-36



4.3.8 Step 1B: Conduct Field Visits to Supplement Understanding of Existing Conditions

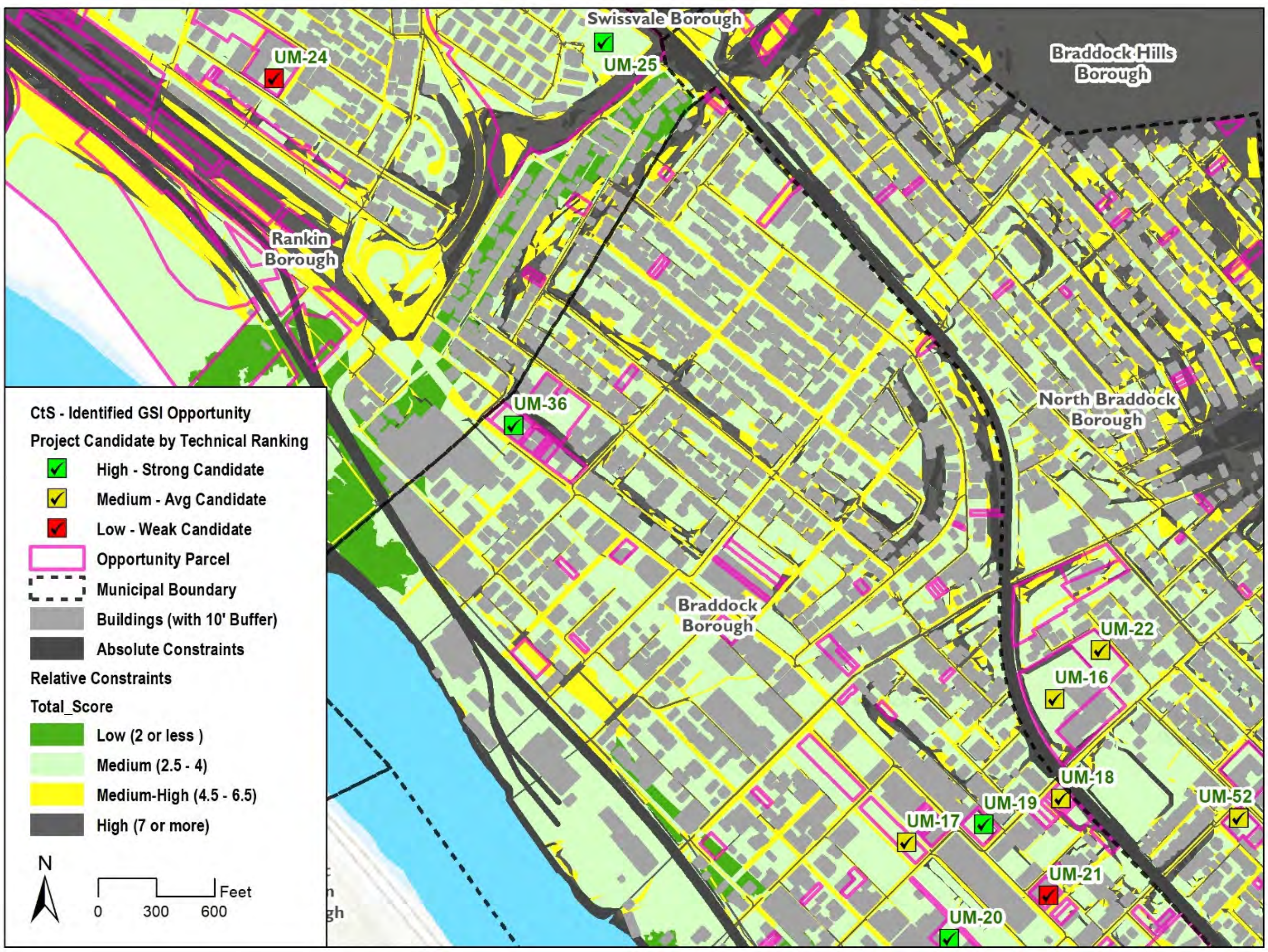
Methodology: Many of the potential GSI project locations were visited in the field so that an in-person site evaluation could be performed to confirm project feasibility and document existing conditions that might not be apparent in the desktop assessment. The specific purpose of the fieldwork was to further assess the accuracy and feasibility of the preliminary drainage areas and GSI footprints and to collect site notes and site photographs as necessary. This information was used for preparing more detailed GSI project concept plans under Step 4F.

4.3.9 Step 4E: Rank for Technical Feasibility

Methodology: Using the site visit information, opportunities identified under Step 4C underwent an initial technical feasibility ranking (High, Medium, Low) that considered site-specific factors such as the size of the potential contributing drainage area able to be conveyed to the site, site slope, visibility, available space for GSI, and an initial assessment of a potential project's constructability or ease of implementation.

Results: Figure 4-11 provides an example of the ranking process results in the select area.

Figure 4-11. Identified GSI Opportunities by Technical Rank in the Select Area



4.3.10 Step 4F: Develop Concept Plans for Highest Ranked Opportunities

Methodology: Concept plans were developed for the highest ranked opportunities. The concept plans were developed consistent with ALCOSAN's GSI Guidance Manual presented in Section 2. The concept plans show the potential contributing impervious drainage areas to be managed, GSI footprint(s), and new storm sewers (if additional drainage is proposed to be conveyed to the site) and include brief concept narratives explaining the intentions for the site and the various potential GSI technology options.

When developing and advancing concepts, existing studies and planned/expected conditions should be considered when relevant (e.g., planned capital improvements and applicable rainfall assumptions).

Results: Results are presented in Section 8.

4.3.11 Step 5A: Establish Baseline Planning-level Cost-estimating Methodology

The methodology focused on the development of baseline planning-level capital costs for widespread, publicly-implemented GSI. This section presents a summary of the key findings and conclusions of the "GSI Planning-level Cost Estimating Technical Memorandum" provided in **Appendix C-5**.

4.3.11.1 Basis for Construction Costs

The basis for planning-level construction costs builds off previous work by ALCOSAN and PWSA and considers information from other regional GSI programs (Philadelphia, Lancaster, and Onondaga County, New York).

The costs were compared on an impervious acre managed (IA) basis as described in **Appendix C-5**. This is a common metric that can be readily compared from distinct locations (as opposed to cost per gallon of overflow reduction for example which is very dependent on the local collection system).

There is a wide variation in reported GSI costs in the literature but planning-level cost estimates at the larger program level can be developed.

For example, *Starting at the Source* (ALCOSAN, 2015)[9] concluded that "...site specific variations make it difficult to consider GSI costing within the intended planning level accuracy range (+50/-30% of the estimated cost) for any single site. However, GSI cost estimation within the intended planning level accuracy range is suited for planning larger concentrations of GSI technologies over several sites in terms of the dollars per impervious acres managed."

Consistent with PWSA's Citywide Green First Plan and Starting at the Source, it is not recommended to separate out construction costs for the three primary types of GSI (bioretention, porous pavement, and subsurface storage/infiltration) since there is not a lot of data to support different costs and because the specific mix of GSI types for future projects is often not yet determined.

4.3.11.2 Stand-alone GSI

Most published costs are assumed to be largely based on stand-alone GSI projects – those in which GSI is the driver and which consist mostly of GSI and the associated ancillary work.

For the purpose of this framework, a median cost of $309,000 per impervious acre managed (Dec. 2017 cost) from the sources identified in **Appendix C-5** was used as the basis for cost estimates for stand-alone GSI.

> Many projects have the potential for enhanced drainage area capture, where a site can manage multiple blocks of upgradient runoff by installing (or diverting) separate storm sewers and "disconnecting" those blocks from the current combined sewer infrastructure.

[9] ALCOSAN, Starting at the Source, 2015

4.3.11.3 Integrated GSI

Integrated GSI projects are those integrated with other capital projects such as transportation improvements, school renovations, water and sewer rehabilitation, and park restorations. Integrated GSI projects have the potential for significant cost savings.

As a matter of fact, the lower GSI costs presented in **Appendix C-5** associated with Lancaster and Onondaga County may be attributed to higher levels of integration in those programs.

Integrated GSI was assumed to cost 30% less than stand-alone GSI (all else being equal), i.e., a baseline cost of approximately $216,000 per impervious acre managed (Dec. 2017 cost).

4.3.11.4 Beneficial Learning Curve

As with other emerging practices or technologies, there is a potential that the cost of GSI may decrease as implementation ramps up. Cost decreases could result from:

- Refinements to the project selection and design process.
- Reduced material costs through the creation or expansion of local markets and supply chains.
- Increased contractor familiarity and competition.
- Reduction in perceived risks.

While there is a potential for cost reductions over time, larger market forces, reduced availability of the most suitable GSI sites, and other factors may counteract them.

For these reasons and due to a deficiency of available data on this topic, a beneficial learning curve was not assumed at this time.

Actual costs in the region should be tracked over time and planning-level costs adjusted periodically.

GSI costs vary widely and can potentially be reduced by integrating with other needed infrastructure improvements, implementing larger-scale projects, and minimizing constraints.

4.3.11.5 Capital Costs

Applying ALCOSAN's 20% multiplier for engineering and implementation to the baseline construction cost of $309,000 per IA yields a baseline capital cost of $371,000 per IA. This is relatively consistent with the middle of the cost range reported in PWSA's Citywide Green First Plan (adjusted to Dec. 2017).

The baseline planning-level costs (Dec. 2017 costs) for stand-alone and integrated GSI are shown in **Table 4-7**.

Table 4-7. Assumed Baseline Planning-level Public GSI Capital Costs

Type of GSI Implementation	Baseline Construction Cost ($/impervious acre managed) [1]	Baseline Planning-Level Capital Cost ($/impervious acre managed)
Stand-alone (retrofit)	$309,000	$371,000
Integrated (redevelopment)	$216,000	$260,000

[1] Assumes 1 to 1.5 inches of capture from the contributing impervious area, different capture depths may require a cost adjustment

For finer-level analyses, these baseline costs should be adjusted based on localized information such as project size, constraints, and the location and setting of the project. Life-cycle and operations & maintenance costs are also important and are discussed in ALCOSAN's GSI Guidance Document.

4.3.12 Step 5B: Develop Opportunity-specific Planning-level Capital Cost Estimates

Methodology: Planning-level capital costs for the GSI concept plans (developed as detailed in Section 4 and documented in Section 8) were developed using the baseline GSI construction costs established in Section 4.3.11 and an escalation or reduction factor based on site-specific considerations.

The following two situations were considered:

- To account for the cost implications of site-specific physical constraints (steep slopes, high groundwater, etc.), the project's relative constraint score was applied to the baseline construction cost. While the cost implications could vary widely for specific projects throughout the Pittsburgh region, evaluations for several categories of relative constraints resulted in estimated cost increases averaging approximately 6% per unit increase in constraint score. Therefore, a 6% relative constraint score escalation/reduction factor was applied for each unit increase/decrease from the median relative constraint score of 6.

  For example, GSI in an area with a relative constraint score of 4 would be estimated to cost 12% (6% * 2) less than the cost of a median site (for example, $272,000 vs. $309,000/IA). A constraint score of 7 would be estimated to be 6% more than the median site ($328,000 vs. $309,000/IA).

- GSI opportunities that have potential to capture impervious contributing areas beyond those captured on-site or from nearby adjacent right-of-way areas may also realize cost efficiencies. This refers to the potential for enhanced drainage area capture opportunities, where a site can manage multiple blocks of upgradient runoff by installing (or diverting) separate storm sewers and "disconnecting" those blocks from the current combined sewer infrastructure. A comparison of average estimated unit area construction costs between decentralized GSI project bundles and large area stormwater disconnection projects in the City of Philadelphia revealed a potential cost savings of 25% when stormwater disconnections were employed to manage runoff on large public properties. This cost savings was found to be the result of cost efficiencies due to economies of scale. For example, the cost of upsizing a centrally located GSI system to manage a significantly larger (enhanced) drainage area, including installation of separate storm sewers, is typically more cost-effective than installing numerous decentralized GSI systems that manage the same drainage area.

  The cost efficiencies associated with managing enhanced drainage areas was quantified by applying a cost reduction of 25% to the baseline unit area construction cost for the enhanced drainage areas when identified for a GSI concept. It should be noted that the 25% cost reduction was not applied to any local drainage areas identified in the GSI concepts regardless of whether the concept included optional enhanced drainage areas.

Results: Results are presented in Section 8.

4.3.13 Step 6A: Prioritize Opportunities

Methodology: Opportunities identified under Step 4D already focused on high OREs areas and were prioritized based on technical feasibility under Step 4E. The opportunities were therefore not further prioritized at this point. Further prioritization could be conducted based on estimated overflow reduction and cost-effectiveness (e.g., cost per gallon of overflow reduction).

It is anticipated that municipalities will consider additional prioritization criteria above and beyond the criteria considered in the framework such as those listed below prior to implementation decision (although some of these were already considered as part of Step 4E to minimize potential issues):

- Ownership/responsible agency.
- Visibility/frequency of use.

- Constructability.
- Accessibility of site for maintenance.
- Planned capital improvements (roadway improvements, utility replacement/rehabilitation, park renovations, etc.) as it is typically most cost-effective to combine GSI implementation with planned street construction and sewer/utility repair and replacement projects.
- Maintenance capacity.
- Opportunities for future expansion or elaboration of GSI network.
- Opportunities for direct discharge to surface waters.

Results: Results are presented in Section 8.

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5 DSIR-Specific Process

This section documents the study area for which the specific DSIR opportunity identification and prioritization process was developed and to which it was applied as part of this CtS, and the process itself. It also presents the methodology associated with each step. The main results associated with the implementation of the process are documented in Section 8.

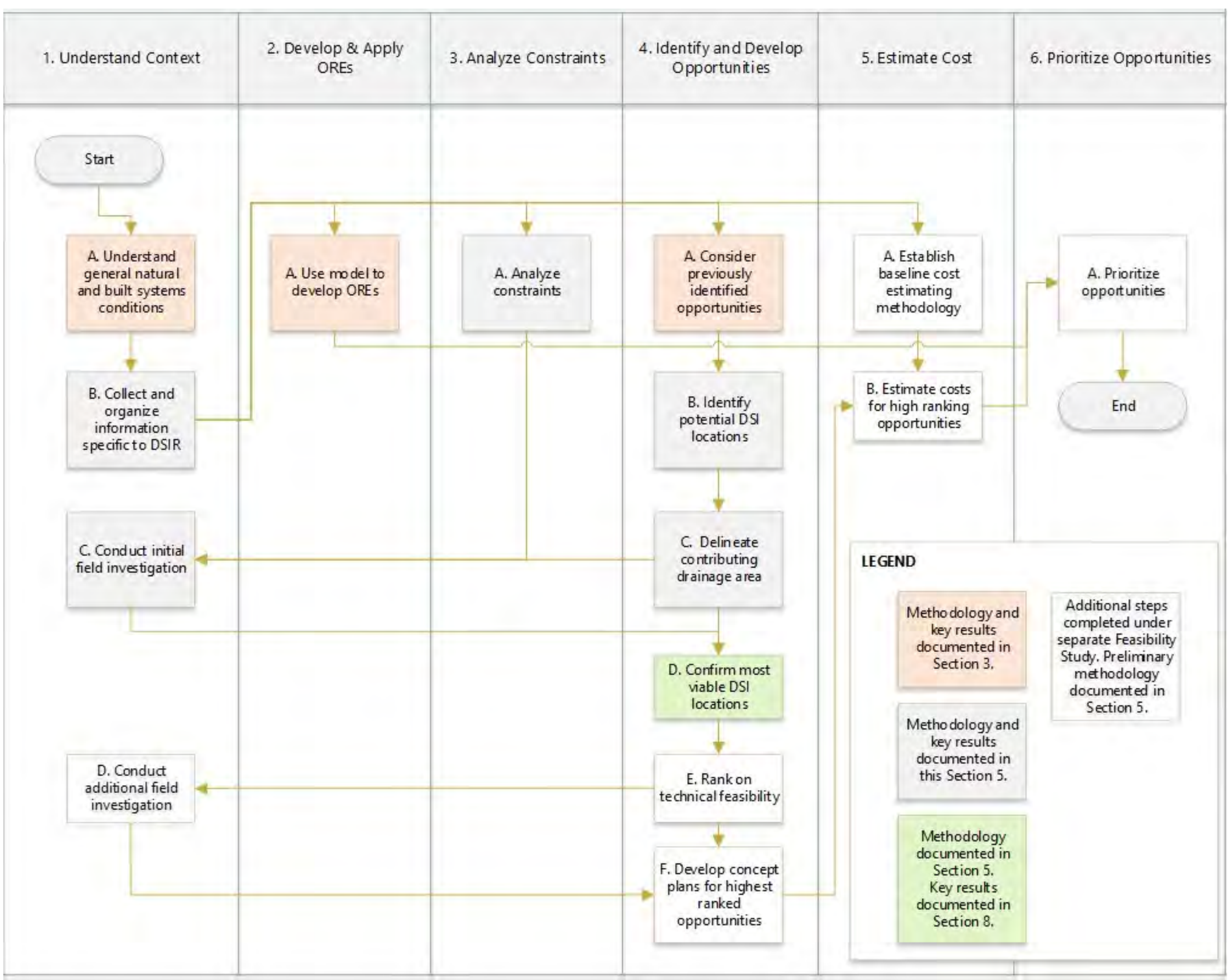
5.1 Study Area

ALCOSAN and municipalities have been working on addressing some of the previously identified DSI locations as described in Section 3. The process was developed for and applied to all sewersheds classified as "combined" or "draining to combined" within the ALCOSAN service area to identify new DSI locations, and to develop DSIR concept plans for highest ranked opportunities.

5.2 Process

Figure 5-1 represents the specific process for DSIR opportunity identification and prioritization, adapted from the generic process presented in Section 3.

Figure 5-1. DSIR-specific Opportunities Identification and Prioritization Process



In general, the process consisted of a GIS-based desktop analysis to identify potential DSI locations followed by a preliminary prioritization process with field evaluations of the most viable potential DSI locations.

The steps shown in the white boxes were then performed under a separate feasibility study for the higher ranking DSI locations identified.

5.3 Methodology

The methodology and key outcomes associated with the steps in orange in Figure 5-1 are documented in Section 3 as part of the generic process description.

The methodology associated with all other steps specific to the DSIR process and completed to date is summarized below. Additional details are provided in the “DSIR Identification Methodology Technical Memorandum” included in **Appendix C-6**.

Once the initial feasibility study is complete, the methodology and results corresponding to the steps shown in white in Figure 5-1 will also be documented.

5.3.1 Step 1B. Collect and Organize Information Specific to DSIR

To supplement the data collected and organized as part of Step 1A, data specific to DSIR was collected. These data specifically include lost (historic) stream paths. Since the region does not have a comprehensive mapping of true historic streams, the USGS historic quad maps were used along with other sources to determine locations where streams existed prior to development.

5.3.2 Step 4B. Identify Potential DSI Locations

Potential DSI locations were identified using ArcGIS geoprocessing tools to generate surface flow drainage lines and to analyze the existing combined, sanitary and storm sewer network relative to natural surface flow and drainage patterns. Aerial and street view imagery (if potential locations were near roads) were also used to review topographical and street level conditions and historical imagery was referenced for additional evidence of any potential inflow location.

Identified potential DSI locations were then numbered. The numbering system indicates the planning basin and assigns a potential location number in sequential order (e.g., CC-04).

In general, most potential DSI locations were found to occur where a sewer pipe or structure may be receiving flow from a natural drainage path (represented by surface flow lines or lost streams) or natural swale (represented by topographic contours).

In addition, potential DSI locations were often found to occur at the edge of wooded or semi-wooded areas, where surface waterways may still flow in an open channel and then drain into a sewer pipe or structure.

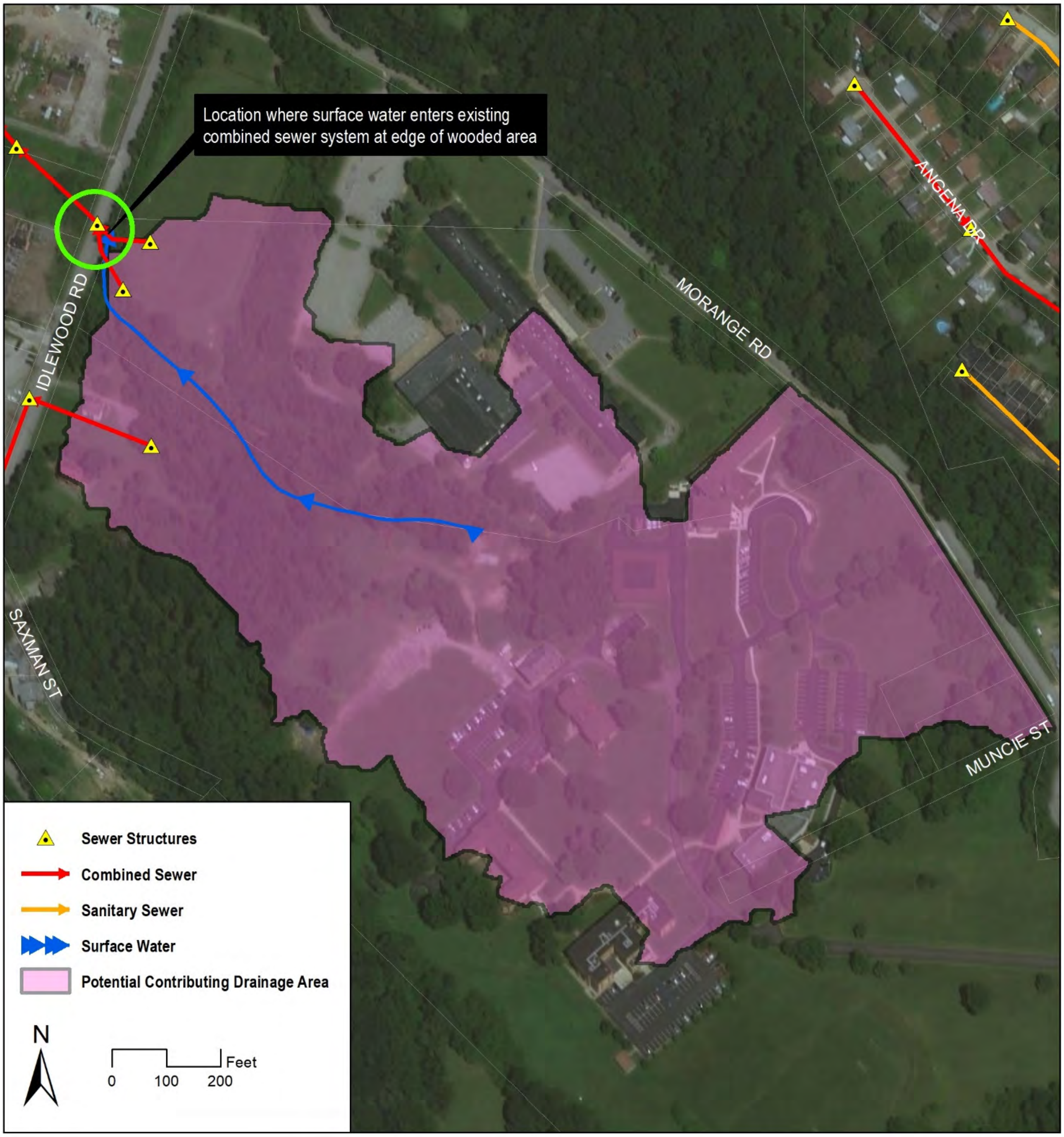
This configuration is illustrated in **Figure 5-2** on the next page.

5.3.3 Step 4C. Delineate Contributing Drainage Areas

Delineating contributing drainage areas associated with each identified potential DSI location is one way of vetting potential stream inflow locations.

It is expected that locations with small corresponding contributing drainage areas (less than approximately 20 acres) may not result in cost-effective projects, so these sites were considered lower priority.

Figure 5-2. Example Potential DSI Location (circled in green)



At this conceptual stage, drainage areas were delineated using a process of ArcGIS geoprocessing tools and manual adjustment to account for the site-specific sewer system drainage network and major roads that impact surface drainage patterns.

5.3.4 Step 3A. Analyze Constraints

A high-level analysis was performed considering constraints such as distance to the nearest receiving water, potential conflicts in the way such as railroads and highways, and other elements to support prioritization of the potential DSI locations for field investigation.

5.3.5 Step 1C: Conduct Initial Field Investigations

The following criteria were considered for prioritizing potential DSI locations for field investigation: size of corresponding contributing drainage area (from Step 4C), proximity to receiving waterbody and other constraints (from Step 3A) as well as evidence from aerial imagery and/or online mapping services that provide 360-degree panoramic ground-level views, and total annual overflow volume in the subcatchment (POC).

Field evaluation of candidate DSI locations used mobile data collection technology to view and update data in real time. The field staff entered relevant attribute data for each potential DSI location and took photographs/videos of the sites as illustrated in **Figure 5-3**. Attribute data included weather conditions (to assess for dry weather flow vs. wet weather flow), field notes, confirmation method (i.e., dye test, CCTV, visual observation) and whether the inflow could be confirmed or if additional verification was required.

Figure 5-3. Example documentation during field investigation of potential DSI Location CC-04

5.3.6 Step 4D: Confirm Most Viable DSI Locations

Using the field data collected under Step 1B, the potential DSI locations identified in the previous steps were screened and DSI locations that could most likely lead to a viable DSIR opportunity were identified.

5.3.7 Step 4E: Rank on Technical Feasibility

As illustrated in Figure 5-1, the most viable DSIR locations, as screened in Step 4D, were then ranked based on technical feasibility. Technical feasibility criteria were established based on drainage area and flow volume reduction potential, distance to nearest receiving waterway and other factors (e.g., access and constructability, potential removal method, and the potential amount of debris and sediment that could be removed).

Results of the planning analysis completed through Step 4E are presented in Section 8.

Fifteen (15) high-ranking locations were selected to be included in a DSIR feasibility study, completed by SKELLY and LOY, Inc. in May 2020. The general steps involved in the feasibility study follow and the results are also summarized in Section 8.

5.3.8 Step 1D: Conduct Additional Field Investigation

Additional field investigations provide supplemental information and help confirm direct stream inflows at select locations where observations from the initial site visit were not conclusive. For example, these additional field visits helped confirm the presence or absence of dry-weather flow. In addition, dry-weather flow measurements were taken to estimate the flow rate and drainage areas were further evaluated in the field. Water samples were collected and analyzed to screen for potential acid mine drainage and other potential water quality issues.

5.3.9 Step 4F: Develop Concept plans for Highest Ranked Opportunities

For selected DSI locations, concept plans were developed to illustrate the site-specific concept and spatial layout of the proposed alternatives. DSIs were evaluated for removal by the following methods:

- New conveyance to direct the inflow to a local receiving water
- Disconnection of the inflow to an existing storm sewer
- GSI alternatives to manage the inflow

Using available information, concepts considered potential utility conflicts, the GSI constraints information described in Section 4, opportunities for open channel conveyance, and the potential need for sediment traps at inflow points and/or energy dissipators at outfalls. Potential opportunities for additional stormwater separation that could remove more flow and improve cost efficiencies were also evaluated. It should be noted that these opportunities need to be considered in conjunction with Municipal Separate Storm Sewer System (MS4) obligations.

5.3.10 Steps 5A and 5B: Establish Baseline Cost-estimating Methodology and Estimate Costs

The ALCOSAN Alternatives Cost Tool (ACT) version 2.1 was used to develop preliminary cost estimates for each of the recommended conveyance alternatives. Conveyance cost estimates include an assumption of depth to rock which can have a significant impact on the cost of pipe trenching and trenchless installations. Costs were developed using rock depths (2 to 4 feet) assumed from U.S. Department of Agriculture soils information. For comparison, costs were also estimated assuming no rock would be encountered. Conveyance costs were developed using both the 10-year and 25-year design storms (other design events could also be evaluated based on site-specific information).

GSI costs were estimated based on the methodology described for GSI in Section 4.

5.3.11 Step 6A: Prioritize Opportunities

The DSIR feasibility study evaluated the potential DSIRs based on estimated cost efficiency and additional information regarding advantages, disadvantages, and additional separation opportunities that could further improve the cost efficiency. Cost efficiencies (e.g., $/gallon/year) are based on the estimated costs from Step 5 and estimates of annual runoff volume and dry weather flow. These results are presented in Section 8.

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6 I/I Reduction-specific Process

This section documents the study area for which the specific I/I reduction opportunity identification and prioritization process was developed and to which it was applied as part of this CtS, and the process itself. It also details the methodology associated with each step. The main results associated with the implementation of the process to date are documented in Section 8.

6.1 Study Area

ALCOSAN has been collecting and analyzing extensive information (including CCTV data) under the Regionalization program described in Section 2. In addition, ALCOSAN is conducting FIS and other field investigations in sewersheds adjacent to the multi-municipal trunk sewers where significant defects and excessive I/I have been observed.

The process was developed for the sewersheds adjacent to the multi-municipal trunk sewers being considered as part of the Regionalization process within the ALCOSAN sanitary sewer service area to take advantage of the information being collected.

To date, the process has been applied to specific sewersheds associated with three POCs within the study area: M-42, M-47 and O-18. Additional POCs are being investigated as relevant data is collected by ALCOSAN and its customer municipalities.

In the future, the process developed for the study area described above could be adapted and applied to broader areas within ALCOSAN sanitary sewer service area.

6.2 Process

Figure 6-1 represents the specific process for I/I reduction opportunity identification and prioritization within the study area, adapted from the generic process presented in Section 3.

In general, the process consists of a GIS-based desktop analysis using data collected and analyzed by ALCOSAN as part of the Regionalization process (including condition assessment data) and targeted field work (FIS, etc.) and analyzed through a prioritization matrix to identify locations where sewer defect repairs can be developed into impactful, cost-efficient I/I reduction projects.

6.3 Methodology

The methodology and key outcomes associated with the steps in orange in Figure 6-1 are documented in Section 3 as part of the generic process description.

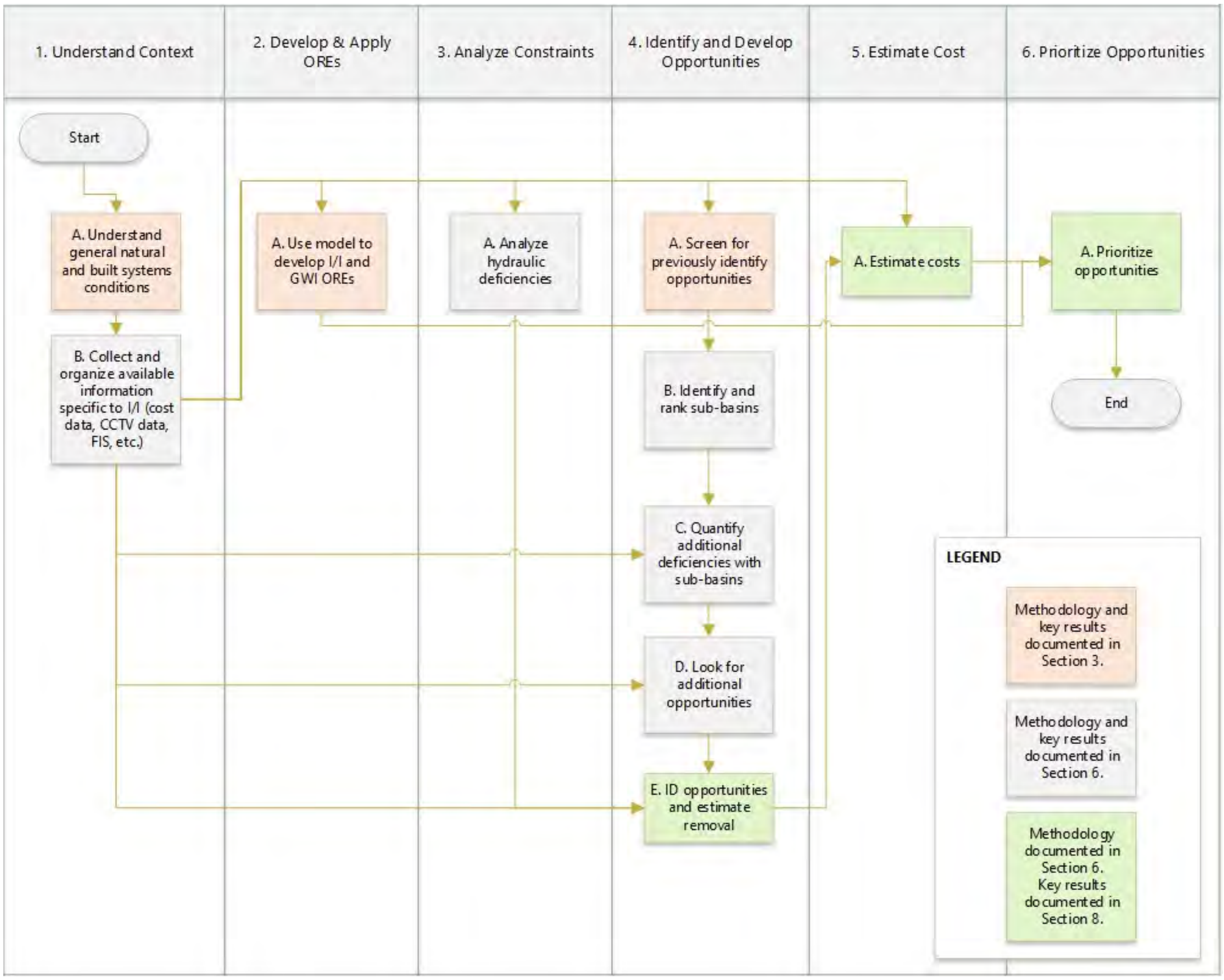
The methodology associated with all other steps specific to the I/I reduction opportunity identification and prioritization process shown in **Figure 6-1** are presented below. The methodology presented herein was adapted from *ALCOSAN. Regionalization Implementation (RI) SA 299, S446 Task 3F: GROW Support Optimization Memo – POC M-47 from AECOM. Sept. 27, 2019*.

6.3.1 Step 1B. Collect and Organize Information Specific to I/I

Data from condition assessment work, FIS, night weir reading micro-sheds and other relevant information available in ALCOSAN InfoNet database such as hydraulic deficiencies is exported to GIS for analysis.

Information on defect repairs and I/I reduction project costs available through ALCOSAN's GROW Program is also collected and organized. It serves as the basis for the cost estimates.

Figure 6-1. I/I Reduction-specific Opportunities Identification and Prioritization Process



6.3.2 Step 4B. Identify and Rank Target Sub-basins Based on Estimated Groundwater Infiltration

Sub-basins within the study area are ranked by measured GWI based on results from the FIS data. Sub-basins are categorized as follows:

- Sub-basins having greater than 4,000 gallons per inch-mile per day (GPIMD) of GWI.
- Sub-basins having less than 4,000 GPIMD of GWI.

This threshold was adopted by ALCOSAN as a slightly more conservative value than the 4,200 GPIMD of GWI recommended by 3RWW as a target for system-wide source reduction in separate sewer areas.

6.3.3 Step 4C. Quantify Additional Deficiencies within Target Sub-basins

GIS analyses are performed to quantify or identify:

- **Percentage of Regionalization (RI):** Compare the percentage of RI and non-RI sewers in each sub-basin. RI pipes are of importance because this is where defects have been identified and condition assessment investigations have collected useful data that is not available for non-RI sewers.

- **DSI:** Identify the sub-basins with DSI. This is useful because removing DSIs has been demonstrated to be an effective means of source reduction (see Section 5).
- **Number of Infiltration Gusher / Number of Infiltration Runner**: Represent the number of infiltration gusher (IG) and infiltration runner (IR) defect observations. Sub-basins with a higher number of these codes are more likely to yield effective source reduction projects through cured-in-place-pipe (CIPP) and makes the location of those projects more easily identified.

6.3.4 Step 3A. Analyze Hydraulic Deficiencies

This step screens for areas of known or modeled capacity issues. Several sources of data from Step 1B are examined to identify these areas and include: Municipal Feasibility Studies (MFS), 3.5xDWF manholes determined by ALCOSAN (i.e., surcharged), diameter reductions, and sewers with persistently high flows observed during CCTV inspections, i.e., defect report recommended bypass pumping. Identifying these areas influences the corrective action recommended. For example, sewers identified in the MFS with a recommended alternative of installing a parallel relief sewer may not be the best candidate for cure-in-place (CIPP) rehabilitation.

6.3.5 Step 4D. Identify Additional Opportunities

This step reviews additional information available in GIS to identify other opportunities to address GWI within the sub-basins. Particularly, it involves reviewing previously identified I/I reduction projects as identified in section 3.3 and reviewing nighttime weir reading in the micro-sheds. Such readings help identify smaller areas within a sub-basin that could be strong candidates for targeted lining, thereby reducing the overall costs compared to lining an entire sub-basin.

6.3.6 Step 4E. Identify Opportunities and Identify Removal

This step involves a more thorough review of the higher ranked sub-basins and identifies specific projects or corrective actions that would result in target volume removal (selected based on the more conservative of either a 30% reduction in inflow, or the reduction needed to achieve 4,000 GPIMD).

6.3.7 Step 5A. Develop Preliminary Cost Estimates

The preliminary costs to perform sewer lining (if feasible considering constraint analysis) and/or implement specific repairs are estimated based on GROW projects and local bids from Step 1B.

6.3.8 Step 6A. Prioritize Opportunities

An estimate of overflow removed is calculated based on the GWI OREs developed as part of Section 3.

Opportunities are then prioritized based on cost, estimated volume removal and overflow reduction, and cost per gallon of overflow reduction.

A projected GROW match can then be calculated (if desired) based on the overflow reduction cost efficiency, with a maximum 85% match currently assigned to overflow reduction cost efficiencies of $0.60 or less.

Additional repairs or source reduction projects may be recommended by ALCOSAN to be combined with high match GROW projects to optimize the use of GROW funds while maximizing benefits and cost savings for the municipalities.

Table 6-1 presents the results of the prioritization process for the sub-basins within POC O-18 that were considered in the FIS.

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Table 6-1. Prioritization Matrix for POC-18

Sub-Basin	% Regionalization	DSI	# Infiltration Gusher	# Infiltration Runner	# Short Term Repairs	# Long Term Repairs Only	Hydraulic Deficiencies	100-Year Flood Plain	Inch-Miles	Overflow Reduction Efficiency [1]	GWI (GPD)	GWI (GPDIM)	30% Reduction in GPD	Flow Target @ 4,200 GPIMD	GPD Over 4,200 GPIMD	Conservative Reduction GPD	Target GPIMD	*Place holder Cost Estimate for Lining of Entire Sub-Basins [2]*	*$/Gallon Inflow Removed/Year*	Total Gallons Removed/Year	Total Gallons Overflow Reduced/Year	Overflow Reduction Cost Efficiency ($/gal/yr)
O-18-BE-M8-2-06	0%	0	0	0	0	0	N	N	1.7	0.012	35,061	20,115	10,518	7,321	27,740	10,518	14,080	*$46,016*	*$0.01*	3,839,179	46,838	$0.98
O-18-BE-M8-2-08	0%	0	0	0	0	0	N	N	1.3	0.012	16,548	12,771	4,964	5,442	11,106	4,964	8,939	*$34,207*	*$0.02*	1,811,970	22,106	$1.55
O-18-BE-M8-2-10	0%	0	0	0	0	0	N	N	1.1	0.012	12,504	11,805	3,751	4,449	8,056	3,751	8,263	*$27,964*	*$0.02*	1,369,240	16,705	$1.67
O-18-BE-M8-2-05	0%	0	0	0	0	0	N	N	5.8	0.012	51,495	8,947	15,448	24,173	27,322	15,448	6,262	*$145,953*	*$0.03*	5,638,702	68,792	$2.12
O-18-BE-M8-2-09	0%	0	0	0	0	0	N	N	0.8	0.012	4,187	5,172	1,256	3,400	787	787	4,200	*$21,374*	*$0.07*	287,235	3,504	$6.10
O-18-BE-M8-2-02	0%	0	0	0	0	0	N	N	0.9	0.012	4,594	4,839	1,378	3,987	607	607	4,200	*$25,064*	*$0.11*	221,429	2,701	$9.28
O-18-BE-M8-2-04	0%	0	0	0	0	0	N	N	0.5	0.012	2,196	4,808	659	1,918	278	278	4,200	*$12,059*	*$0.12*	101,367	1,237	$9.75
O-18-BE-M1-02	0%	0	0	0	0	0	N	N	2.3	0.014	10,394	4,541	3,118	9,614	781	781	4,200	*$60,428*	*$0.21*	284,894	3,846	$15.7
O-18-AV-M3-02	0%	0	0	0	0	0	Y	N	2.6	0.010	9,899	3,767	2,970	11,037	-	-	3,767	-	-	-	-	-
O-18-BE-M8-2-03	21%	0	0	1	1	7	N	N	4.8	0.012	12,818	2,695	3,845	19,976	-	-	2,695	-	-	-	-	-
O-18-BE-M8-2-01	28%	0	0	0	0	7	N	N	6.5	0.012	11,326	1,752	3,398	27,152	-	-	1,752	-	-	-	-	-
O-18-BE-M8-2-07	0%	0	0	0	0	0	N	N	1.3	0.012	1,789	1,421	537	5,288	-	-	1,421	-	-	-	-	-
O-18-AV-M3-03	0%	0	0	0	0	0	N	N	1.0	0.010	1,293	1,261	388	4,306	-	-	1,261	-	-	-	-	-
O-18-BE-M1-03	0%	0	0	0	0	0	N	N	2.6	0.014	2,557	983	767	10,924	-	-	983	-	-	-	-	-
O-18-AV-M3-01	0%	0	0	0	0	0	N	N	0.7	0.010	-	-	-	2,988	-	-	0	-	-		-	-
O-18-BE-M1-01	0%	0	0	0	0	0	N	Y	0.6	0.014	-	-	-	2,643	-	-	0	-	-	-	-	-

[1] GWI OREs (see details in Section 3).

[2] CIPP lining unit costs were not available in the GROW Program costing support database available as of 12/2019. A placeholder unit cost (for sliplining) has been applied. Columns impacted by this assumption are italicized.

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7 Sewer Separation-specific Process

This section documents the study area for which the specific SS opportunities identification and prioritization process was developed and to which it was applied as part of this CtS, and the process itself. It also details the methodology associated with each step. The main results associated with the implementation of the process to date are documented in Section 8.

For the purpose of the identification of prioritization process, two categories of potential SS projects were considered in addition to the traditional converted storm sewer and converted sanitary sewer categories discussed in Section 3.3:

- Storm sewers within the existing CSS that have the potential to be managed locally with GSI.
- Storm sewers currently connected to the CSS within riverfront communities or near receiving waters (i.e., streams) that have the potential to be disconnected from the CSS and rerouted directly to the adjacent receiving water or have the potential to be added onto an existing or planned SS project in proximity.

Storm sewers shown as connecting to the CSS in the H&H model that are likely already disconnected/separated in the field were flagged during the process development and implementation as part of a data management task. These special model conditions do not correspond to physical SS opportunities.

7.1 Study Area

The study area consisted of the specific POCs identified by ALCOSAN within the CSS listed in Section 3.3 as far as the traditional converted storm sewer and converted sanitary sewer categories is concerned and the entire existing CSS area when considering the expanded definition.

In the future, the process developed for this specific study area could be adapted and applied to broader areas within the CSS.

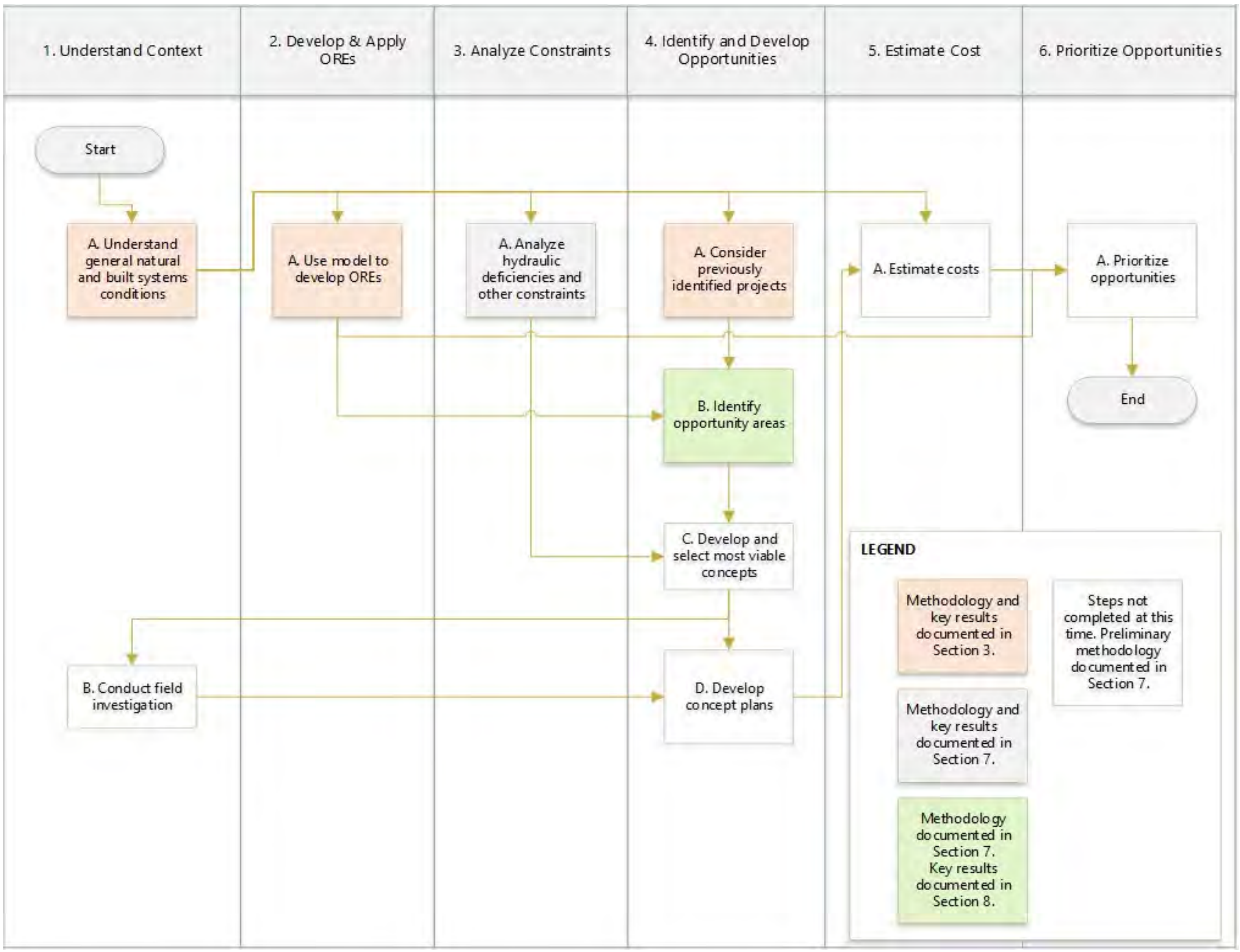
7.2 Process

Figure 7-1 represents the specific process for SS opportunity identification and prioritization within the study area, adapted from the generic process presented in Section 3.

The process completed to date consisted mostly of a GIS-based desktop analysis.

The steps shown in white are currently being performed separately. Results will be presented in future updates of this CtS.

Figure 7-1. SS-specific Opportunities Identification and Prioritization Process



7.3 Detailed Methodology

The methodology associated with the steps in orange in Figure 7-1 are documented in Section 3 as part of the generic process description.

The methodology associated with all other steps specific to the SS process are presented below.

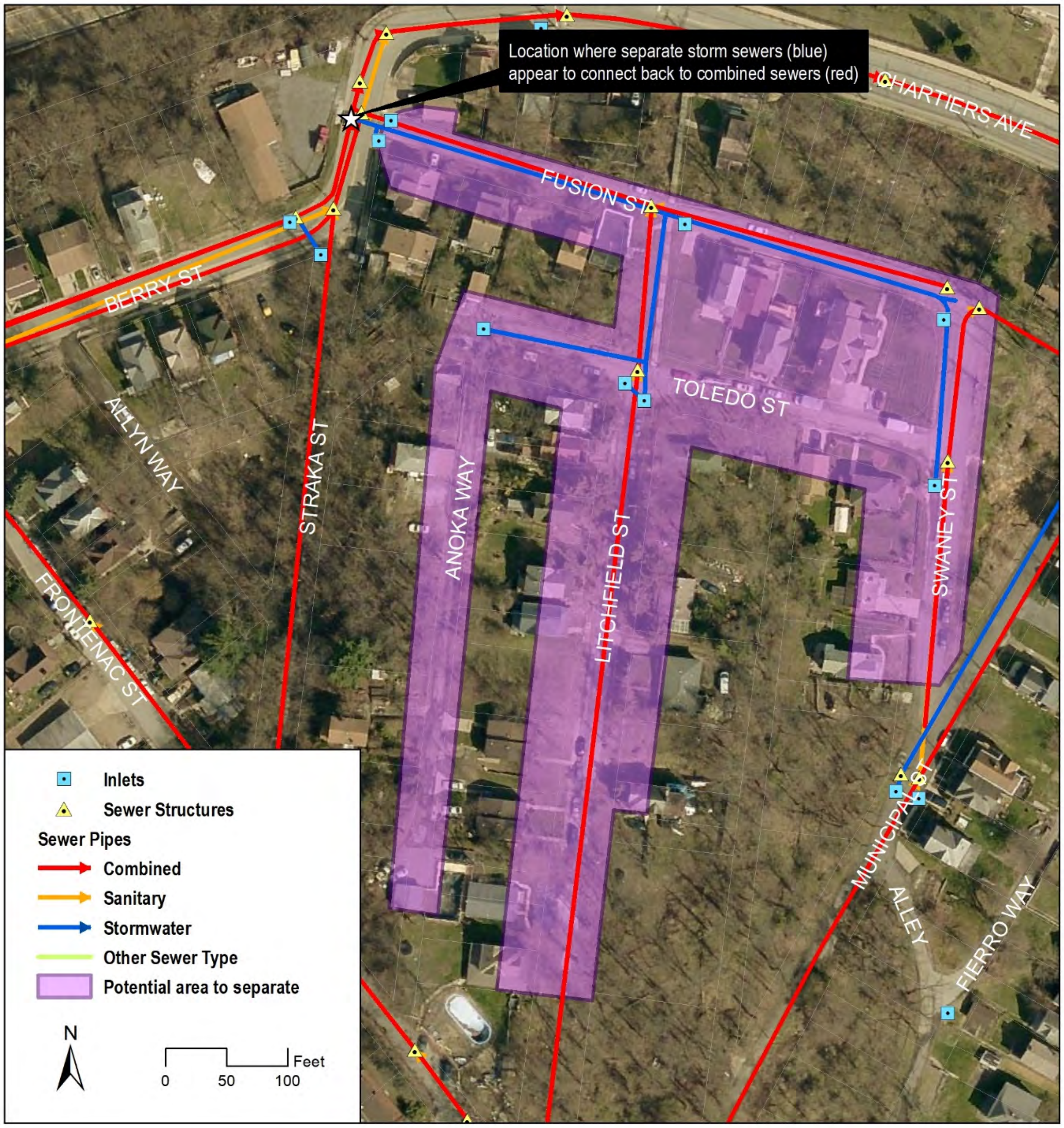
The main results associated with Step 4B are presented in Section 8.

7.3.1 Step 4B. Identify Opportunity Areas

Opportunity areas for the traditional converted storm sewer and converted sanitary sewer categories correspond to the previously identified opportunities identified in Section 3.3. Additional opportunity areas for the additional categories of opportunities described above were identified through a GIS-desktop analysis.

Figure 7-2 shows an example area that was identified as a potential area of separate storm sewer that is currently mapped as discharging into the CSS, with an approximate potential contributing drainage area of 3.7 acres. Areas such as this example should be further field-investigated, and dye tested as needed to confirm existing sewer characteristics and connections and to develop potential concepts to manage the flows locally with GSI.

Figure 7-2. Specific Example of a Potential Sewer Separation Opportunity



SSS and CSS GIS data are generally available and complete; stormwater system GIS data currently available through ALCOSAN are more sporadic and were supplemented with available data from the 3RWW Sewer Atlas or other available sources. As more separate storm sewer systems are mapped and/or more data becomes available, additional potential SS opportunity areas will likely present themselves for evaluation.

7.3.2 Step 4C. Develop and Select Most Viable Concepts and Identify Issues to be Investigated

For each opportunity area identified under Step 4B, potential concepts would be developed, including map(s) showing existing and proposed facilities and key characteristics (size, approximate depth, etc.) and proposed facilities with key characteristics (size, length, etc.). These potential concepts would be developed based on a Desktop evaluation using available GIS data from Step 1A.

For preliminary analysis purposes:

- The amount of stormwater flows to be diverted would be extracted from the existing HH model.
- The sizing of the new sanitary sewers would be based on municipality standard design criteria and/or common pipe sizes.
- A spreadsheet analysis would be used to confirm ability of existing stormwater system to handle diverted stormwater flows resulting from the separation, when applicable.
- The sizing for new storm sewer(s) would be based on standard design criteria and/or common pipe sizes.

Additional assumptions would be defined as needed.

The most viable concept for the specific opportunity area being considered would be selected based on a high-level opportunity and constraint analysis considering existing hydraulic deficiencies, facility needs, and other potential constraints (from Step 3A).

Preliminary cost estimates would then be developed for the most viable concept. The preliminary cost estimates would be developed following the Alternatives Costing Tool (ACT) User Reference Manual Guidelines (ALCOSAN, 2010)[10]. The guidelines and associated ACT tool data would be supplemented with unit cost information to be extracted from the GROW Program SS construction costs database as applicable. The ACT Tool is intended to provide cost estimates consistent with Class 5 or 4 estimates as per AACE International Recommended Practice No. 18R-97. Should GSI opportunities be identified, the cost methodology presented under Section 4 would be used.

The most viable concepts would then be documented for estimated costs, estimated benefits in terms of typical year volume removal and overflow reduction using the OREs, cost-effectiveness (i.e., $ per gallon of CSO overflow removed per year), and significant critical unknowns and/or potential issues such as potential constructability issues or implications on MS4 obligations would be identified.

7.3.3 Step 1C. Conduct Field Investigation

Field investigation to address some of the unknowns identified under Step 4C would be conducted. It might require site visits, utility research, and/or dye testing as needed to confirm existing sewer characteristics and connections. Input from municipalities could also be obtained through this step regarding potential issues and/or to address some of the unknowns.

7.3.4 Step 4E. Develop Concept Plans

Based on information from Step 1C., the selection from Step 4C. would be reviewed and validated. The selected concept would be considered an "identified opportunity" and would be developed at conceptual-planning level.

7.3.5 Step 5A. Estimate Cost

This step would involve refining the preliminary cost estimates developed under Step 4D using the same cost estimating methodology and considering the concept plans from Step 4E. The costs would be refined to a Class 4 estimate as per AACE International Recommended Practice No. 18R-97.

7.3.6 Step 6A. Prioritize Opportunities

The identified opportunities would be prioritized based on costs, estimated benefits in terms of typical year volume removal and overflow reduction using the OREs, as well as cost-effectiveness, i.e., $ per gallon of overflow reduced per year.

[10] ALCOSAN, Alternatives Costing Tool (ACT) User Reference Manual Guidelines, 2010

8 Identified and Prioritized Opportunities

This section presents the primary opportunities (or potential projects) identified and prioritized applying the processes described in Sections 3 through 7. This section is organized by source control category.

As noted in Section 3, these opportunities would generally not be implemented or funded solely by ALCOSAN. The opportunities would need to be further evaluated in coordination with municipalities and other applicable stakeholders. They would typically be implemented by the municipalities, with potential funding and technical support from ALCOSAN.

8.1 GSI Opportunities

Following the process established in Sections 3 and 4, 195 GSI opportunities were identified.

Table 8-1 provides a summary of the number of opportunities by planning basin and by technical ranking.

Table 8-1. Identified GSI Opportunities by Planning Basin

	Project Technical Ranking			
Planning Basin	High - Strong Candidate	Medium - Average Candidate	Low - Weak Candidate	Total
CC	11	7	18	36
LOGR	2	4		6
MR	13	19	23	55
SMR	4	4	10	18
TC		2	5	7
UA	11	13	11	35
UM	7	20	11	38
TOTAL	**48**	**69**	**78**	**195**

Figure 8-1 displays the locations of the opportunities within ALCOSAN CSS service area and the technical ranking associated with each of these opportunities. Figure 8-1 also includes the GSI ORE under Existing Conditions.

The complete list of the GSI opportunities and concept plans for 59 prioritized opportunities are provided in **Appendix D**. The concept plans show the potential contributing impervious drainage areas to be managed, GSI footprint(s), and new storm sewers (if additional drainage is proposed to be conveyed to the site) and include brief concept narratives explaining the intentions for the site and the various potential GSI technology options. An example of such plan for Site UM-36 is provided in **Figure 8-2**.

Summary tables were also included on the concept plans that show the impervious area captured, the estimated construction cost (Dec. 2017 dollars) for both stand-alone GSI and integrated GSI, the relative constraint score of the area where the GSI footprint is proposed, the annual estimated runoff capture, the ORE of the contributing drainage area, the annual estimated CSO reduction, and the estimated cost-efficiency of the project.

Table 8-2 summarizes these metrics for the prioritized GSI project opportunities.

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Figure 8-1. Identified Potential GSI Opportunity Locations. Projects with higher OREs will generally provide more overflow reduction than similar projects with lower OREs.

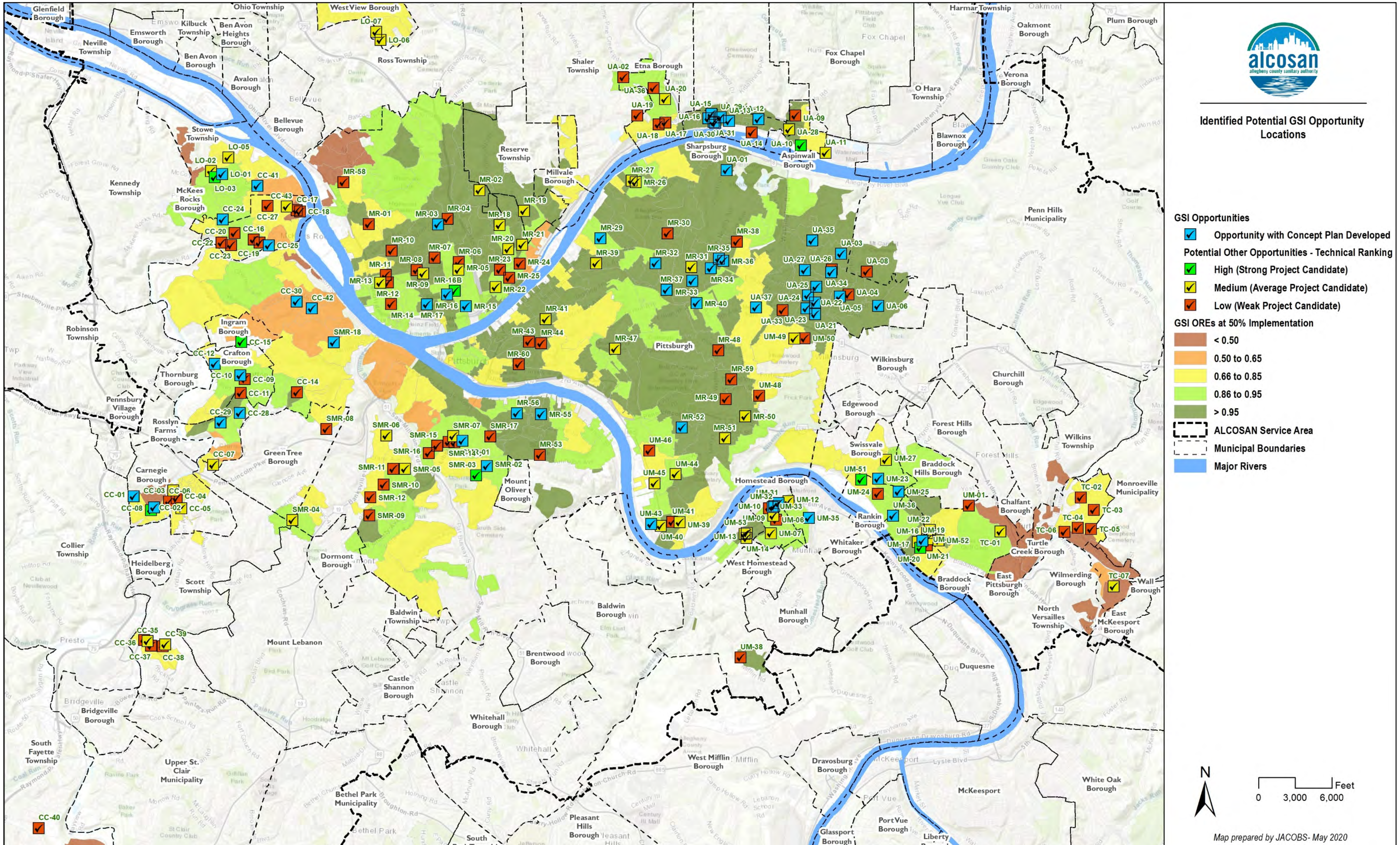
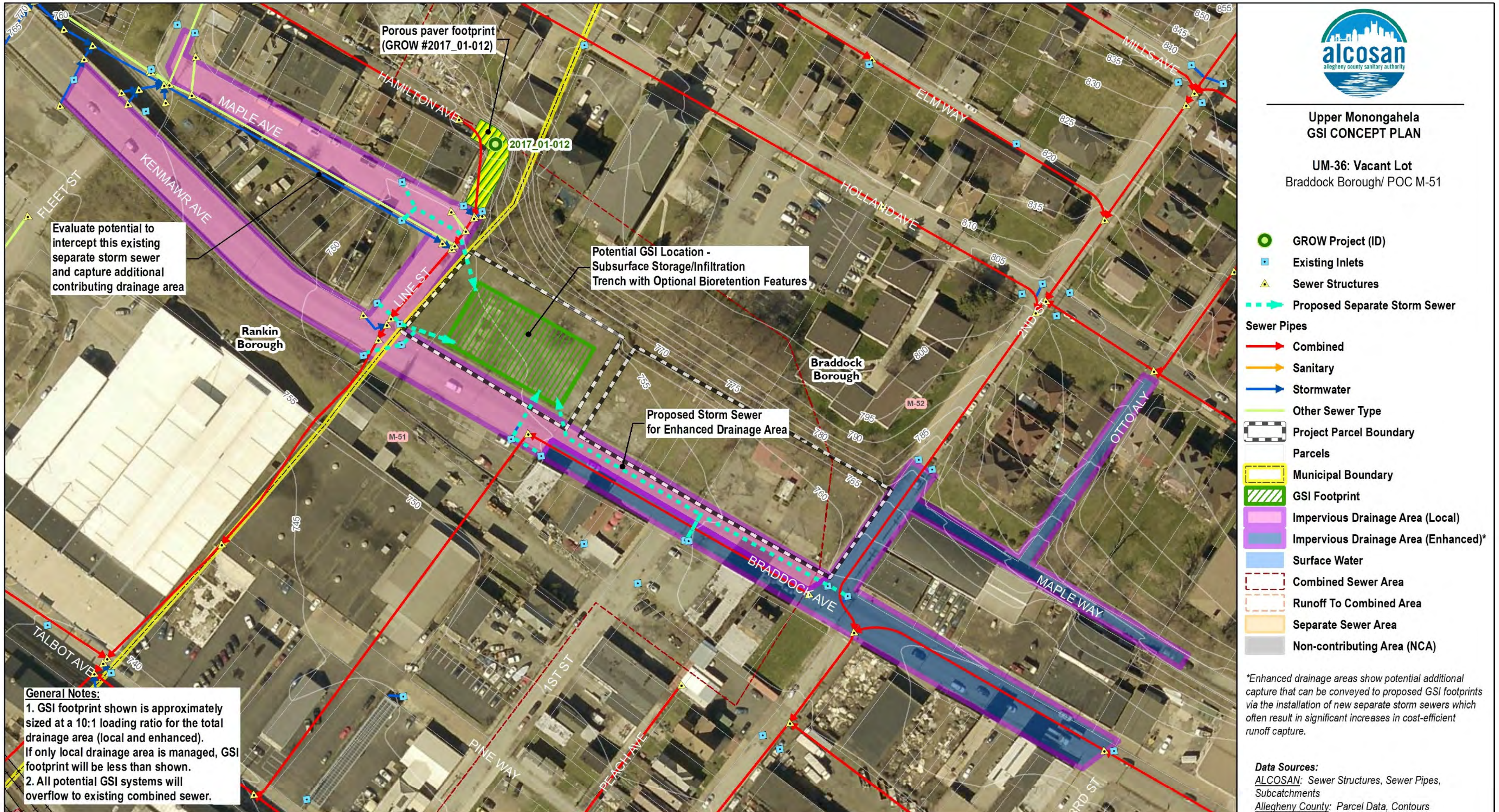


Figure 8-2. GSI Concept Plan for Site UM-36 in Braddock Borough



The currently vacant lot at the corner of Braddock Ave and Line St is a prime opportunity to integrate green stormwater infrastructure (GSI) with any planned redevelopment activities. A subsurface storage/infiltration trench can be located underneath the existing pavement/lawn area and has the potential to manage runoff from Braddock Ave, Kenmawr Ave, Maple Ave, Otto Alley, Hamilton Ave, and Line St. Roadway runoff can be directed to the GSI feature by installing a new storm sewer along Braddock Ave and smaller portions of pipe across Line St or potentially by intercepting the sewer mapped as separate storm along Maple Ave (if feasible). Depending on the potential redevelopment plans for the site, the GSI can be designed to efficiently integrate with site improvements and include optional bioretention features with or without trees or include permeable paving as well.

Project UM-36 (Parcel Owner: Redevelopment Authority of Allegheny County)

	Impervious Area Captured (ac)	*Construction Cost for Stand-alone GSI	*+Construction Cost for Integrated GSI	Relative Constraint Score	Runoff Capture (gal/yr)	Overflow Reduction Efficiency (ORE)	CSO Reduction (gal/yr)	**Cost Efficiency ($/gal/yr overflow reduction)
Local GSI	1.36	$350,000	$240,000		1,120,000		1,040,000	$0.34
Enhanced Drainage Area	0.94	$180,000	$130,000		770,000		720,000	$0.25
Project Totals	2.31	$530,000	$370,000	3.0	1,890,000	93%	1,760,000	$0.30

*Costs are planning-level estimates with an expected accuracy range of -25% to +50%, +Integrating GSI with other planned site improvements is assumed to result in a 30% cost reduction, **Efficiency based on construction cost for stand-alone GSI

Table 8-2. Prioritized GSI Opportunities

Project ID	Project Name[1]	Parcel Owner	Impervious Area Captured (ac)	Construction Cost for Stand-alone GSI[2]	Construction Cost for Integrated GSI[2]	Relative Constraint Score	Runoff Capture (gal/yr)	Overflow Reduction Efficiency (ORE50)	CSO Reduction (gal/yr)	Cost Efficiency ($/gal/yr overflow reduction)[2, 3]
CC-01	Seventh Avenue Park	Carnegie Borough	1.85	$660,000	$460,000	8.5	1,520,000	78%	1,180,000	$0.56
CC-02	Carnegie Station Park n Ride *(Local and Enhanced)*	Port Authority of Allegheny County	5.60	$1,270,000	$890,000	4.0	4,590,000	49%	2,230,000	$0.57
CC-10	Port Authority Park and Ride Crafton	Crafton Volunteer Fire Department	1.14	$320,000	$220,000	4.5	930,000	88%	810,000	$0.40
CC-12	Crafton Park *(Local and Enhanced)*	Crafton Borough	2.79	$570,000	$400,000	3.0	2,290,000	84%	1,920,000	$0.30
CC-24	Sto-Rox HS Community Field *(Local and Enhanced)*	Sto-Rox School District	3.93	$950,000	$670,000	3.0	3,230,000	88%	2,850,000	$0.33
CC-25	Furnace St Parking Lot *(Local and Enhanced)*	McKees Rocks Borough	4.64	$1,080,000	$760,000	3.5	3,810,000	80%	3,050,000	$0.35
CC-28	Oakwood Park *(Local and Enhanced)*	City of Pittsburgh	2.17	$480,000	$340,000	3.0	1,780,000	95%	1,690,000	$0.28
CC-29	Bishop Canevin School *(Local and Enhanced)*	City of Pittsburgh	3.52	$890,000	$ 620,000	3.0	2,890,000	93%	2,690,000	$0.33
CC-30	Port Authority Parking Lot (*Local and Enhanced)*	Port Authority of Allegheny County	5.12	$990,000	$ 690,000	1.0	4,190,000	64%	2,670,000	$0.37
CC-41	School Bus Lot *(Local and Enhanced)*	WL Roenigk LP (Private)	6.74	$1,360,000	$950,000	1.0	5,530,000	62%	3,430,000	$0.40
CC-42	Pittsburgh Classical Academy (*Local and Enhanced)*	School District of Pittsburgh	7.98	$1,650,000	$1,160,000	1.0	6,550,000	64%	4,210,000	$0.39
LO-01	Pleasant Ridge Public Housing	Allegheny County Housing Authority	7.01	$1,970,000	$1,380,000	4.5	5,760,000	90%	5,190,000	$0.38
MR-03	Fowler Playground *(Local and Enhanced)*	City of Pittsburgh	2.54	$530,000	$380,000	3.0	2,090,000	96%	2,000,000	$0.27
MR-15	Allegheny Commons/East Park *(Local and Enhanced)*	City of Pittsburgh	3.00	$670,000	$460,000	3.0	2,470,000	93%	2,290,000	$0.29
MR-16	Allegheny Commons/West Park Ballfield *(Local and Enhanced)*	City of Pittsburgh	4.82	$1,020,000	$710,000	3.0	3,960,000	93%	3,690,000	$0.28
MR-17	Allegheny Commons/West Park *(Local and Enhanced)*	City of Pittsburgh	3.94	$920,000	$650,000	3.0	3,240,000	97%	3,140,000	$0.29
MR-29	Arsenal School *(Local and Enhanced)*	Board of Public Education of the School District of Pittsburgh	3.86	$830,000	$590,000	3.0	3,170,000	93%	2,960,000	$0.28
MR-32	Friendship Park *(Local and Enhanced)*	City of Pittsburgh	4.75	$1,380,000	$970,000	6.0	3,900,000	99%	3,850,000	$0.36
MR-33	Baum Grove Parklet *(Local and Enhanced)*	Friendship Community Group	2.97	$750,000	$530,000	3.0	2,440,000	97%	2,370,000	$0.32
MR-34	Enright Parklet *(Local and Enhanced)*	City of Pittsburgh	5.04	$1,050,000	$730,000	3.0	4,140,000	96%	3,960,000	$0.27
MR-35	Garland Parklet (Local and Enhanced)	City of Pittsburgh	4.17	$1,000,000	$710,000	3.0	3,420,000	96%	3,270,000	$0.31

Project ID	Project Name[1]	Parcel Owner	Impervious Area Captured (ac)	Construction Cost for Stand-alone GSI[2]	Construction Cost for Integrated GSI[2]	Relative Constraint Score	Runoff Capture (gal/yr)	Overflow Reduction Efficiency (ORE50)	CSO Reduction (gal/yr)	Cost Efficiency ($/gal/yr overflow reduction)[2, 3]
MR-36	Urban Redevelopment Authority Lots *(Local and Enhanced)*	Urban Redevelopment Authority of Pittsburgh	5.19	$1,280,000	$890,000	3.0	4,260,000	96%	4,070,000	$0.31
MR-37	Osceola Parklet *(Local and Enhanced)*	City of Pittsburgh	1.65	$510,000	$360,000	6.0	1,360,000	97%	1,320,000	$0.39
MR-40	Liberty School *(Local and Enhanced)*	Board of Public Education of the School District of Pittsburgh	3.03	$690,000	$490,000	3.0	2,490,000	93%	2,320,000	$0.30
MR-52	Magee Playground *(Local and Enhanced)*	City of Pittsburgh	5.23	$1,170,000	$810,000	3.0	4,290,000	99%	4,250,000	$0.28
MR-55	Phillips K-5 School *(Local and Enhanced)*	Board of Education of the School District of Pittsburgh, Pennsylvania	2.25	$570,000	$400,000	3.0	1,850,000	105%	1,940,000	$0.29
MR-56	Armstrong Playground *(Local and Enhanced)*	City of Pittsburgh	3.14	$740,000	$520,000	3.0	2,580,000	96%	2,480,000	$0.30
SMR-01	Warrington Field & Rec Center *(Local and Enhanced)*	City of Pittsburgh	3.95	$1,060,000	$750,000	5.5	3,240,000	87%	2,810,000	$0.38
SMR-02	Knoxville Elementary School *(Local and Enhanced)*	School District of Borough of Knoxville	4.07	$1,140,000	$800,000	5.5	3,340,000	75%	2,490,000	$0.46
SMR-18	Townsend Parklet *(Local and Enhanced)*	City of Pittsburgh	1.22	$290,000	$200,000	3.0	1,000,000	72%	720,000	$0.40
UA-01	Natoli Field *(Local and Enhanced)*	City of Pittsburgh	5.38	$1,110,000	$780,000	3.0	4,420,000	99%	4,370,000	$0.25
UA-03	Chadwick Playground *(Local and Enhanced)*	City of Pittsburgh	2.81	$850,000	$590,000	6.0	2,310,000	97%	2,230,000	$0.38
UA-05	G-Tech Strategies Sunflower Garden *(Local and Enhanced)*	Urban Redevelopment Authority of Pittsburgh	2.74	$620,000	$440,000	3.0	2,250,000	98%	2,200,000	$0.28
UA-06	Crescent Early Childhood Center Parking *(Local and Enhanced)*	School District of Pittsburgh	2.52	$680,000	$480,000	4.0	2,070,000	96%	1,990,000	$0.34
UA-12	Heinz Memorial Field	Sharpsburg Borough	1.06	$270,000	$190,000	3.0	870,000	100%	870,000	$0.31
UA-13	Marion Gerardi Memorial Park	Sharpsburg Borough	1.51	$380,000	$270,000	3.0	1,240,000	101%	1,260,000	$0.30
UA-15	Sharps Terrace	Allegheny County Housing Authority	0.60	$150,000	$110,000	3.0	490,000	109%	540,000	$0.28
UA-16	The Watson Institute	The Watson Institute	1.37	$350,000	$240,000	3.0	1,130,000	109%	1,240,000	$0.28
UA-21	Urban Redev Auth of Pittsburgh *(Local and Enhanced)*	Urban Redevelopment Authority of Pittsburgh	3.23	$780,000	$550,000	3.0	2,650,000	96%	2,530,000	$0.31
UA-22	Homewood Montessori School *(Local and Enhanced)*	Urban Redevelopment Authority of Pittsburgh	3.64	$850,000	$600,000	3.0	2,990,000	97%	2,910,000	$0.29
UA-23	Westinghouse Park *(Local and Enhanced)*	City of Pittsburgh	4.31	$910,000	$640,000	3.0	3,550,000	97%	3,460,000	$0.26
UA-24	Urban Redev Auth of Pittsburgh *(Local and Enhanced)*	Housing Authority City of Pittsburgh	4.39	$1,000,000	$700,000	3.0	3,610,000	97%	3,510,000	$0.28

Project ID	Project Name[1]	Parcel Owner	Impervious Area Captured (ac)	Construction Cost for Stand-alone GSI[2]	Construction Cost for Integrated GSI[2]	Relative Constraint Score	Runoff Capture (gal/yr)	Overflow Reduction Efficiency (ORE50)	CSO Reduction (gal/yr)	Cost Efficiency ($/gal/yr overflow reduction)[2, 3]
UA-25	City Vacant Lot *(Local and Enhanced)*	City of Pittsburgh	1.97	$460,000	$320,000	3.0	1,620,000	97%	1,580,000	$0.29
UA-27	Westinghouse Academy Track & Football Field *(Local and Enhanced)*	Board of Public Education of School District of Pittsburgh	7.20	$1,500,000	$1,050,000	3.0	5,910,000	98%	5,810,000	$0.26
UA-29	Kennedy Park	Sharpsburg Borough	2.51	$640,000	$440,000	3.0	2,060,000	109%	2,250,000	$0.28
UA-30	Municipal Parking Lot	Sharpsburg Borough	0.66	$170,000	$120,000	3.0	540,000	109%	590,000	$0.29
UA-31	Sharpsburg Library & Community Garden	Sharpsburg Borough	0.14	$40,000	$30,000	3.0	120,000	109%	130,000	$0.31
UA-34	Urban Redevelopment Authority Vacant Lot *(Local and Enhanced)*	Urban Redevelopment Authority of Pittsburgh	1.78	$450,000	$320,000	4.0	1,460,000	104%	1,520,000	$0.30
UA-35	Paulson Playground *(Local and Enhanced)*	City of Pittsburgh	2.59	$560,000	$400,000	3.0	2,130,000	97%	2,060,000	$0.27
UA-37	Mellon Park *(Local and Enhanced)*	City of Pittsburgh	5.13	$1,210,000	$850,000	3.0	4,210,000	85%	3,570,000	$0.34
UM-19	Library and Braddock parking lot *(Local and Enhanced)*	Braddock Borough	3.05	$680,000	$480,000	3.0	2,500,000	98%	2,440,000	$0.28
UM-23	Swissvale Park and Ride *(Local and Enhanced)*	Port Authority of Allegheny County	3.79	$950,000	$660,000	4.5	3,110,000	82%	2,560,000	$0.37
UM-25	Hawkins Village	Allegheny County Housing Authority	5.36	$1,360,000	$950,000	3.0	4,400,000	93%	4,090,000	$0.33
UM-31	Parking Lot at McClure and 7th Ave *(Local and Enhanced)*	Homestead Borough Parking Authority	2.81	$630,000	$440,000	3.0	2,310,000	92%	2,130,000	$0.30
UM-32	Parking Lot at NW corner of Ann and 7th *(Local and Enhanced)*	Redevelopment Authority of Allegheny County	2.38	$540,000	$380,000	3.0	1,960,000	92%	1,810,000	$0.30
UM-33	Parking Lot at NE corner of Ann and 7th	Homestead Borough Parking Authority	0.30	$80,000	$50,000	3.0	240,000	92%	220,000	$0.36
UM-35	Munhall Fire Playground *(Local and Enhanced)*	Munhall Borough	3.07	$710,000	$490,000	3.0	2,520,000	88%	2,220,000	$0.32
UM-36	Vacant lot at Kenmawr Ave and Hamilton St *(Local and Enhanced)*	Redevelopment Authority of Allegheny County	2.31	$530,000	$370,000	3.0	1,890,000	93%	1,760,000	$0.30
UM-43	Blair Street Park *(Local and Enhanced)*	City of Pittsburgh	3.01	$530,000	$370,000	1.0	2,470,000	94%	2,310,000	$0.23
	TOTALS - Local and Enhanced (All projects, full implementation)		**198.92**	**$46,780,000**	**$32,800,000**	**3.3**	**163,340,000**	**92%**	**146,010,000**	**$0.32**

[1] Project names with "(Local and Enhanced)" after them show the totals for both the local and enhanced drainage areas (see Figure 8-2 for an example).

[2] Costs are planning-level estimates with an expected accuracy range of -25% to +50% + Integrating GSI with other planned site improvements is assumed to result in a 30% cost reduction. Reference year: 2017.

[3] Efficiency based on construction cost for stand-alone GSI.

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8.2 DSIR Opportunities

Following the process established in Sections 3 and 5, 86 new potential DSI locations were identified during the desktop analysis phase and field investigated.

The investigation resulted in the following:

- 44 new potential DSI locations were confirmed as DSIs.
- Four were noted as needing additional field work for confirmation (due to site obstructions, access issues, or a need for more detailed information).
- 18 were discovered (via dye testing and/or visual observation) to either connect directly to adjacent receiving waters or to flow into existing storm sewers rather than the combined system. Therefore, these sites are not DSIs but may have revealed areas previously shown as combined that are in fact separate. This information could prove to be useful for the model and GIS updates that are underway under a separate effort.
- 20 locations were field investigated and found not to be DSIs (due to no observed dry weather surface flows or no observed specific inflow points).

The 44 new confirmed locations complement the 33 potential DSIR locations previously identified by ALCOSAN (of which 16 were labeled as completed or planned in the ALCOSAN DSI database as detailed in Section 3).

Table 8-3 provides a summary of the DSI locations identified to date by status.

Table 8-3. Identified DSI Locations by Confirmation Status

Status	Count	Approximate Drainage Area (ac)
Previously identified DSI locations	33	3,481
New DSI locations confirmed in field	44	818
Potential DSI locations with additional field verification required	4	121
Total	**81**	**4,420**

Figure 8-3 illustrates the location and status of the total of 81 DSI locations summarized in Table 8-3.

Figure 8-4 provides an example of a previously identified DSI location in Fox Chapel Borough upstream of Aspinwall (Site UA-02). ALCOSAN recently helped secure over $3M in funding from the U.S. Army Corps of Engineers to remove this DSI.[11]

[11] Source: Army Civil Works Program FY 2020 Work Plan – Construction, assessed May 2020 at https://www.usace.army.mil/Portals/2/docs/civilworks/budget/FY%202020%20Work%20Plan%20Construction%20Statement%20of%20Managers%20FINAL.PDF

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Figure 8-3. Identified DSI Locations by Confirmation Status

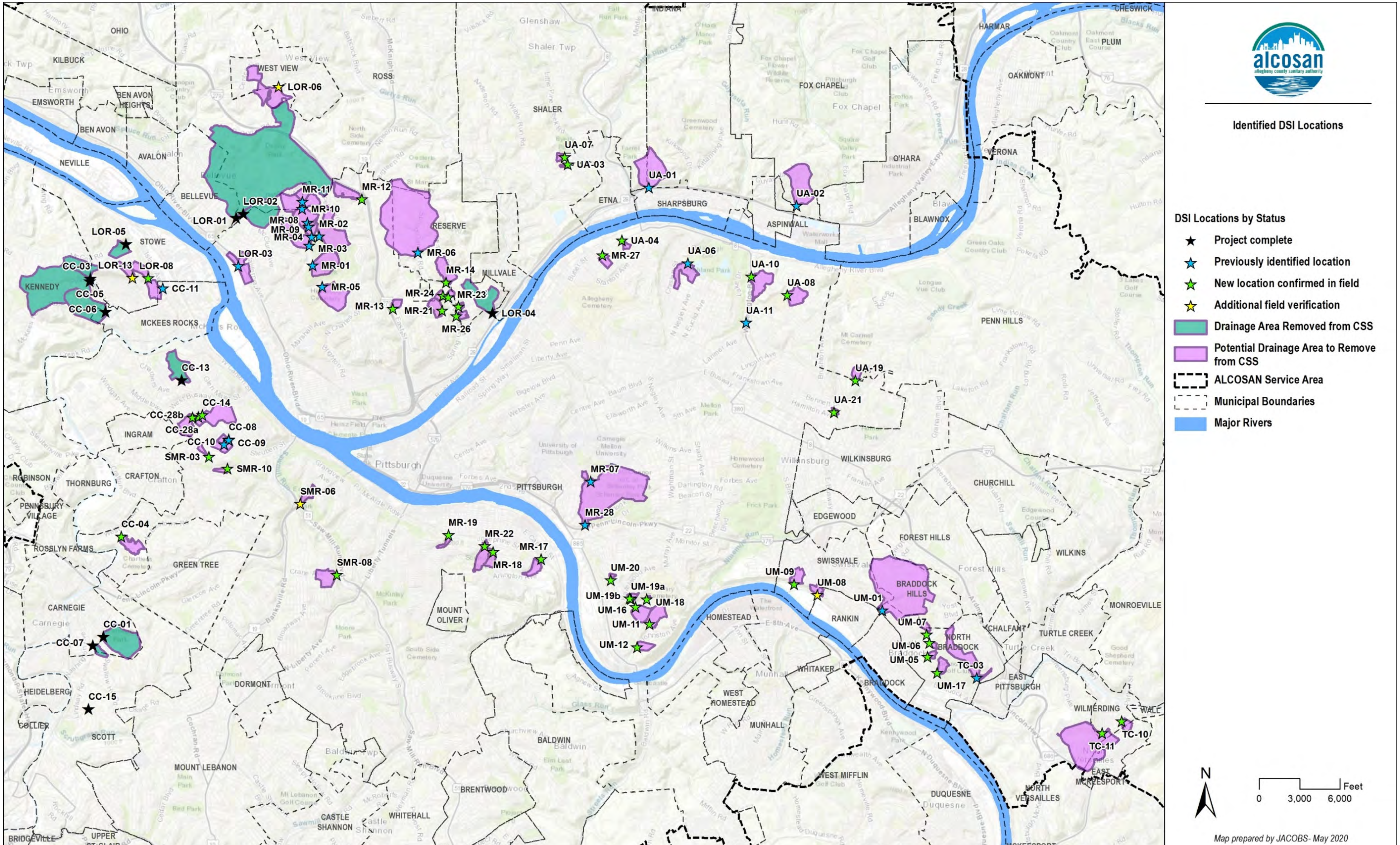

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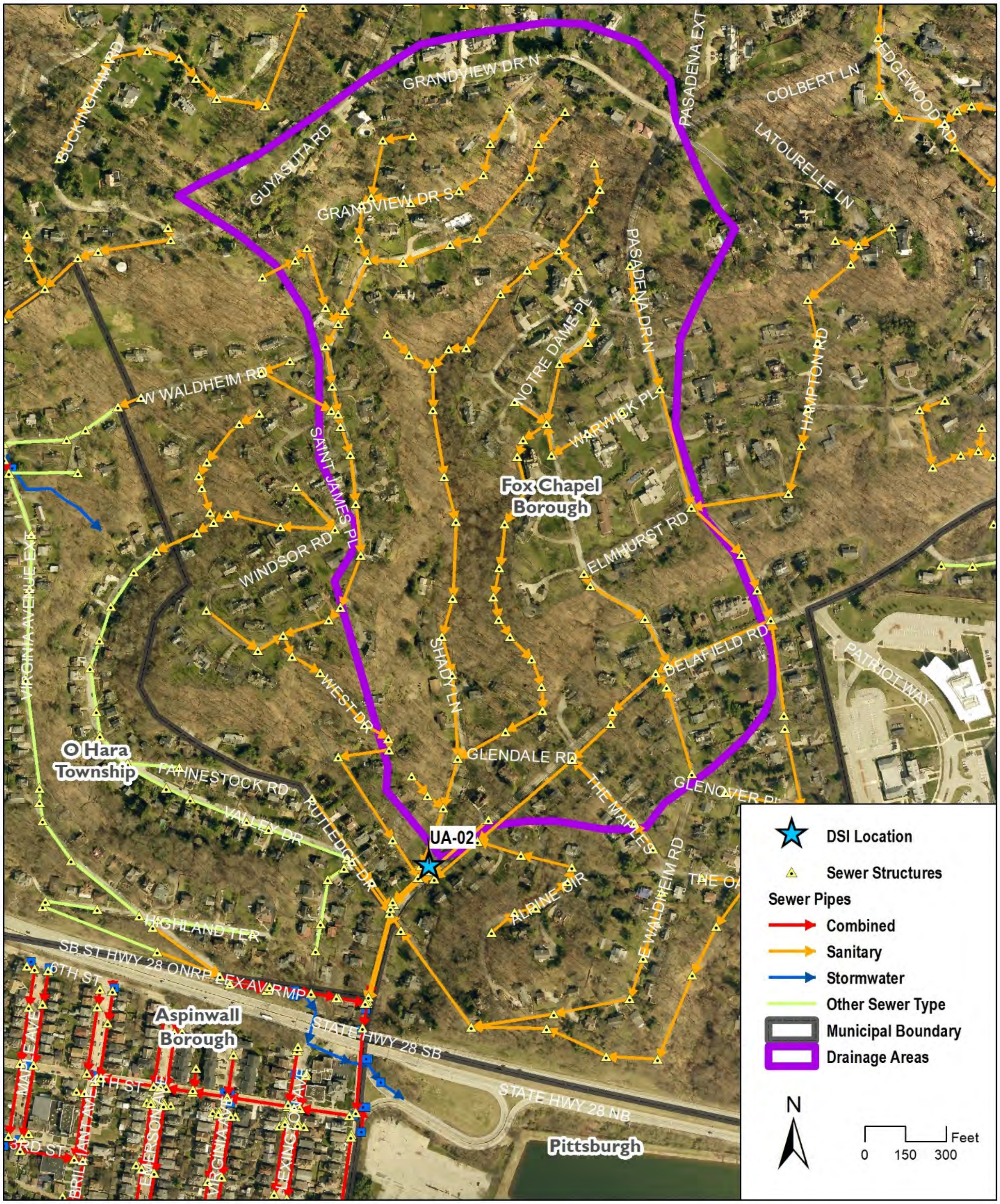
Figure 8-4. Example of Identified DSI Location (Site UA-02)



8.2.1 DSIR Feasibility Study

As described in Section 5, high-ranking new DSI locations were selected to be included in a DSIR feasibility study, completed by SKELLY and LOY, Inc. in May 2020. The overall feasibility recommendations are summarized below and in **Table 8-4** and are shown on **Figure 8-5**.

- Three locations have no DSIR action recommended due to poor water quality and/or a lack of dry weather flow observed during the additional field investigations.
- 11 sites are recommended for further evaluation; 10 of which may be suitable for removal through new conveyance and one of which may be suitable for management using GSI. If the viability is confirmed and the DSIRs are implemented, the study estimates that these projects would manage approximately 39 MG/year of inflow volume. Concept plans are included in **Appendix D-3** and an example of one is included in **Figure 8-6**.
- The potential opportunity for additional stormwater separation based on field reconnaissance and data analysis was noted for the following locations. The general locations of potential additional separation are also noted for each as it relates (upstream, downstream, and/or adjacent) to the actual DSI location:
  - CC-28_14 (upstream, downstream and adjacent)
  - SMR-08 (upstream)
  - UA-04 (downstream and adjacent)
  - UM-18 (upstream and adjacent)
  - UM-19 (upstream)
  - UM-20 (upstream)
- Potential next steps include the development of overflow reduction estimates and the completion of a preliminary design to confirm the viability of pursuing stream inflow removals at these locations.

Table 8-4. Recommended DSIR Alternative for Further Evaluation for Each DSI Location Evaluated

Site ID	Site Name	DSIR Recommendation	Advantage(s)	Disadvantage(s)
CC-04	Idlewood Road	Conveyance to New Outfall	Relatively short pipe run; Relatively high cost efficiency	Private property; Observed Sediment
CC-08	Wilton Way	No Action	No dry weather flow observed	No dry weather flow observed
CC-14	Greenway Drive 1	Conveyance to New Outfall	Opportunity for additional separation; Limited space for GSI	Long pipe run; Private property; Utility conflicts; Railroad
CC-28a	Greenway Drive 2	Conveyance to New Outfall	Opportunity for additional separation; Limited space for GSI	Long pipe run; Private property; Utility conflicts; Railroad
CC-28b	Greenway Drive 3	Conveyance to New Outfall	Opportunity for additional separation; Limited space for GSI	Long pipe run; Utility conflicts; Railroad
MR-27	Shop 'n Save	Conveyance to New Outfall	Opportunity for additional separation; Limited space for GSI	Urban area; Utility conflicts; Private property; Railroad
SMR-08	Crane Avenue	Conveyance to New Outfall	Relatively short pipe run; Highest cost efficiency; Opportunity for additional separation; Limited space for GSI	Railroad underpass
TC-11	Orient Street	No Action	Confirmed Acid Mine Drainage (AMD)	Confirmed AMD
UA-04	Sawyer Street	Conveyance to New Outfall	Relatively short pipe run; Relatively high cost efficiency; Opportunity for additional separation	Utility conflicts; Railroad
UA-21	Haverhill Street	No Action	No dry weather flow observed	No dry weather flow observed
UM-16	Kilbourne Street	Conveyance to New Outfall	Opportunity for additional separation; Limited space for GSI	Long pipe run; Private property; Utility conflicts; Railroad
UM-18	Flowers Avenue	Conveyance to New Outfall	Opportunity for additional separation	Long pipe run; Private property; Utility conflicts; Railroad
UM-19	Giddings Street	Conveyance to New Outfall	Opportunity for additional separation; Limited space for GSI	Potential AMD
UM-20	Gladstone Street	Green Stormwater Infrastructure	Avoids long pipe run; GSI cost efficiency is higher than conveyance cost efficiency	Saturated soils

Source: Adapted from Direct Stream Inflow Removal Feasibility Study Report, SKELLY and LOY, April 2020

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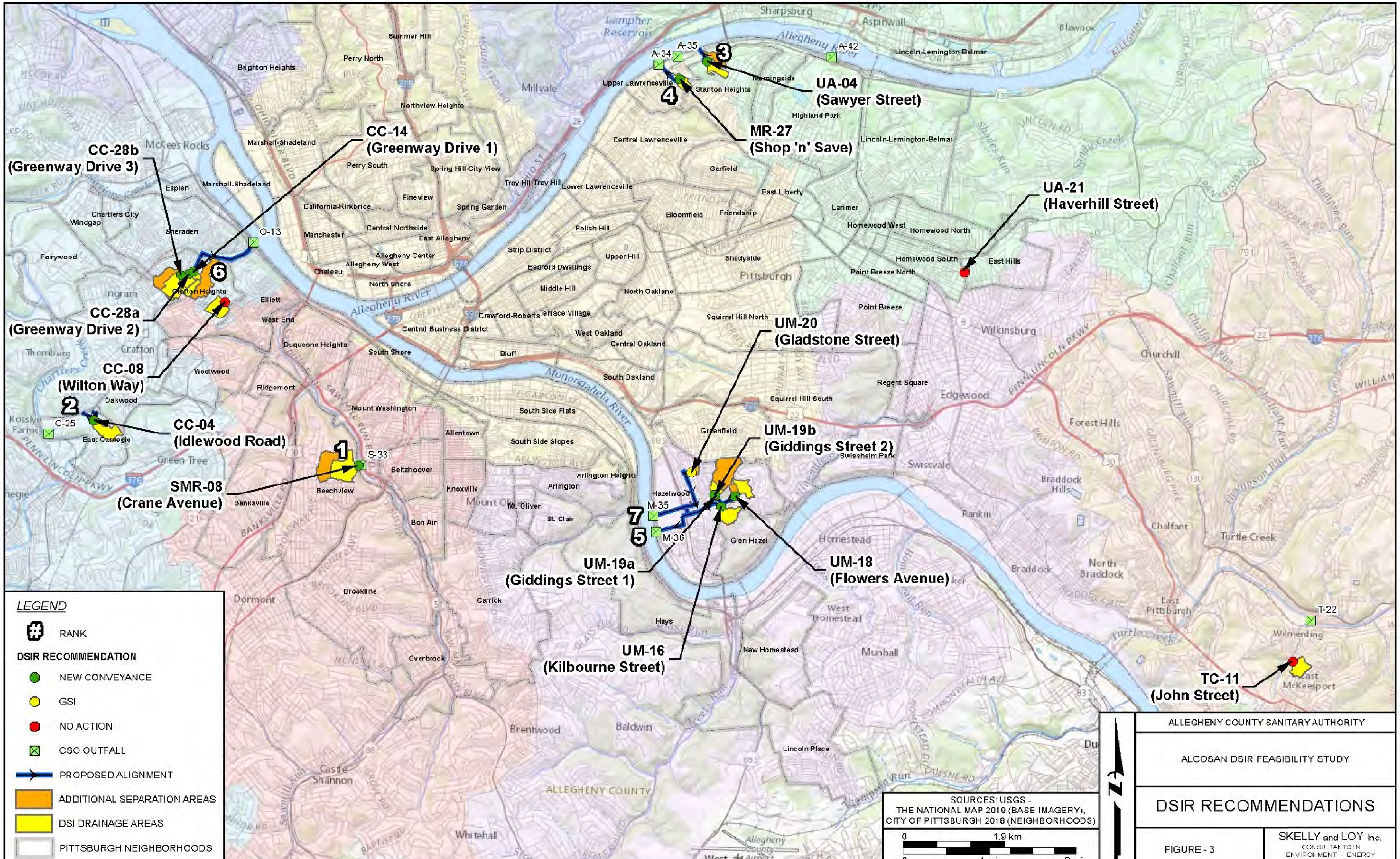
Figure 8-5. DSIR Recommendation Map from DSIR Feasibility Evaluation

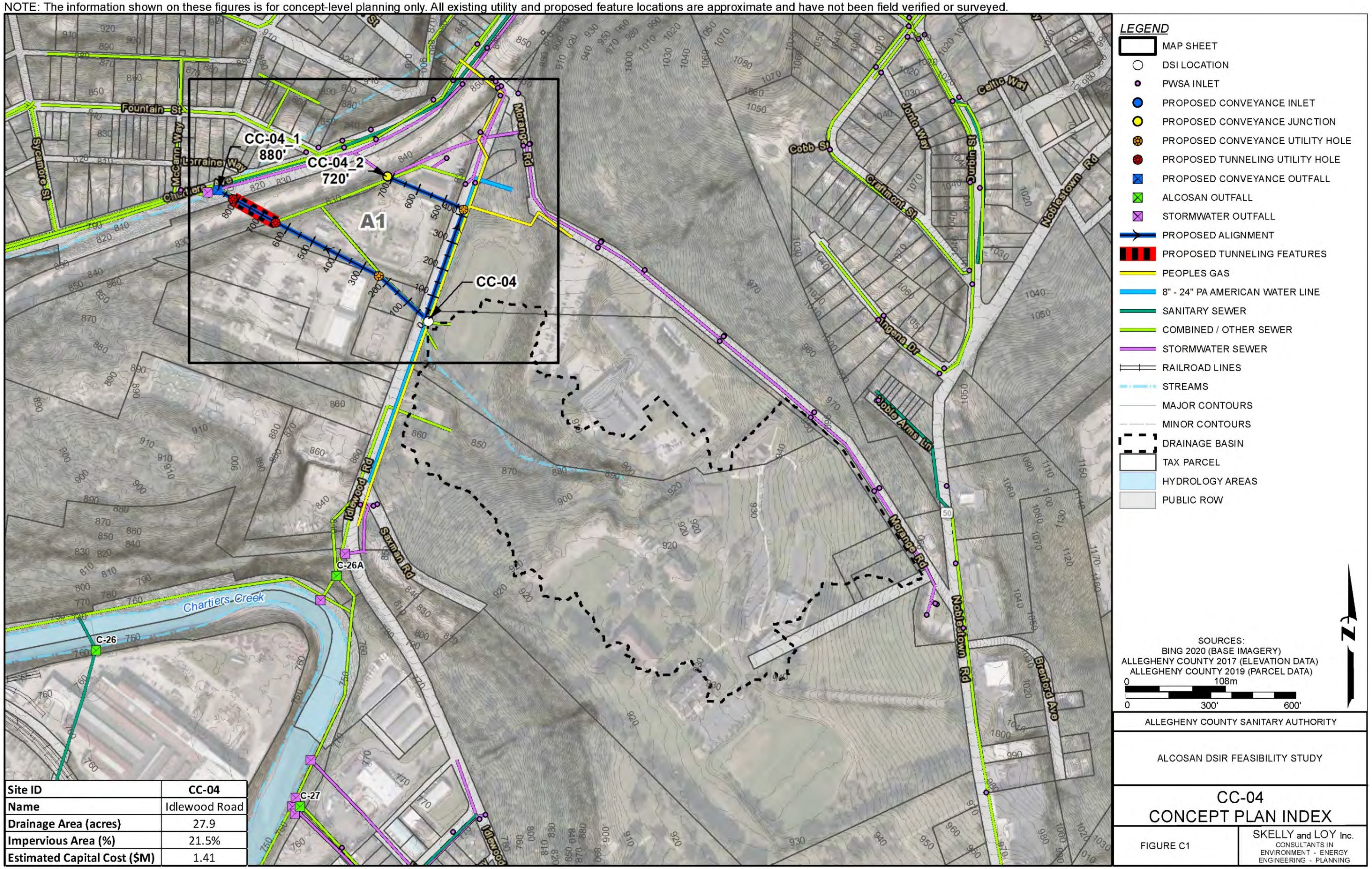


Note: Rank (1 to 7) based on estimated cost efficiency

Source: Direct Stream Inflow Removal Feasibility Study Report, SKELLY and LOY, April 2020

Figure 8-6. DSIR GSI Concept Plan for Site CC-04

NOTE: The information shown on these figures is for concept-level planning only. All existing utility and proposed feature locations are approximate and have not been field verified or surveyed.



Site ID	CC-04
Name	Idlewood Road
Drainage Area (acres)	27.9
Impervious Area (%)	21.5%
Estimated Capital Cost ($M)	1.41

Source: Direct Stream Inflow Removal Feasibility Study Report, SKELLY and LOY, April 2020

8.3 I/I Reduction Opportunities

As noted in Section 6, the I/I reduction process was developed for the sewersheds adjacent to the multi-municipal trunk sewers being considered as part of the Regionalization process within the ALCOSAN sanitary sewer service area.

As of May 2020, the process has been applied to specific sewersheds associated with three POCs within the study area: M-42, M-47 and O-18. Four additional POCs (M-49, A-45, O-21, T-04) are underway. Additional POCs will be investigated as relevant data is collected by ALCOSAN.

I/I reduction opportunities have therefore yet to be fully identified and compiled.

The preliminary results associated with POC O-18 are provided as an example.

Figure 8-7 illustrates the location of the priority sub-basins for I/I reduction that were identified through the process for POC O-18. Priority sub-basins correspond to the sub-basins shown in red and orange. **Table 8-5** presents the I/I reduction opportunities associated with those sub-basins.

The preliminary cost of lining the eight prioritized sub-basins identified in Table 8-5 is estimated to be approximately $375,000 for an inflow reduction of approximately 13 MG/yr and a corresponding overflow reduction of approximately 0.2 MG/yr – which would correspond to an average unit cost of approximately $0.03/gallon of inflow reduction and $2.25/gallon of overflow reduction (with a minimum of $0.98/gallon of overflow reduction associated with sub-basin O-18-BE-M8-2-06).

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Figure 8-7. Priority Sub-Basins for I/I Reduction Associated with POC O-18 (Shown in Red and Orange)

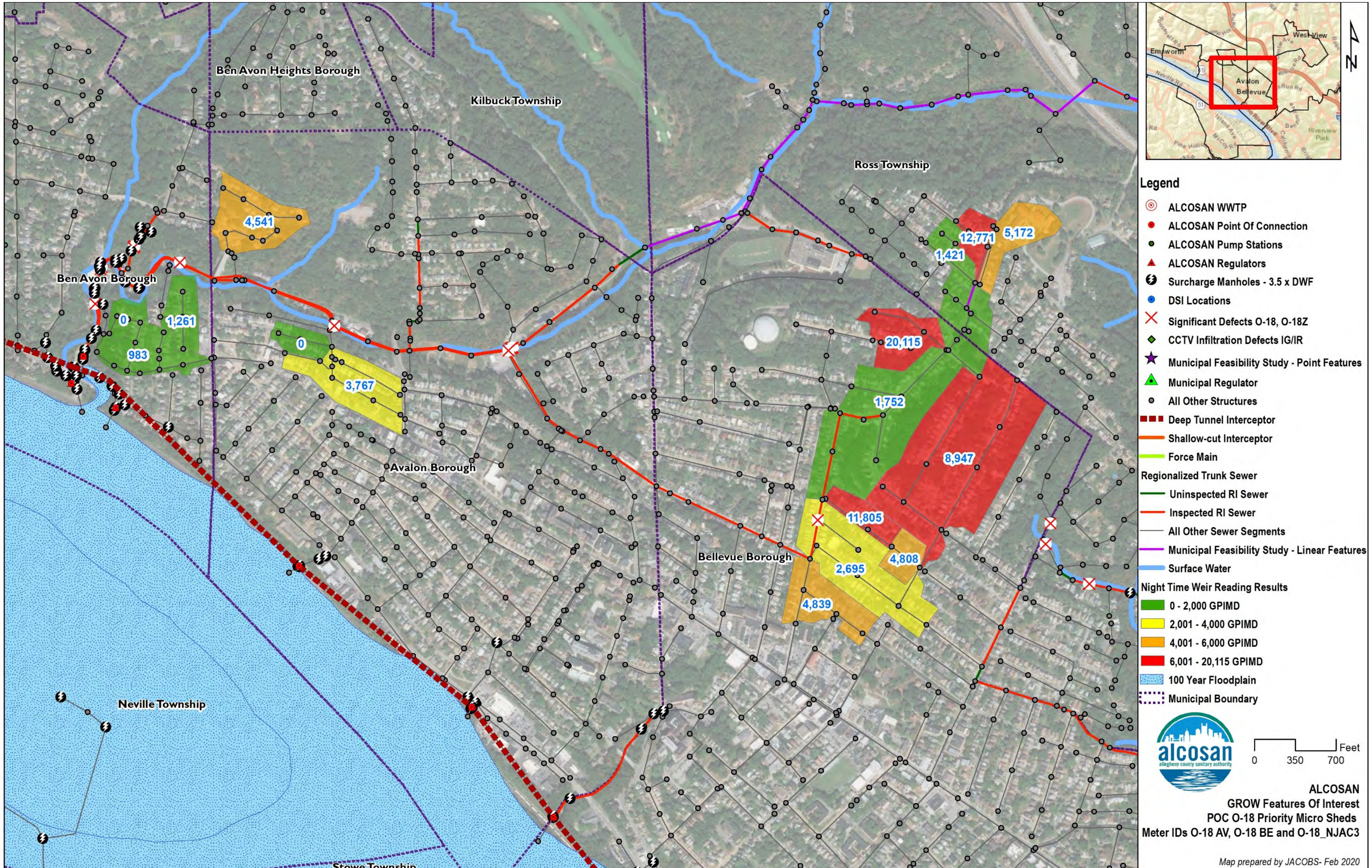

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Table 8-5. Potential I/I Reduction Projects – POC O-18

Sub-Basin	Estimated GWI (GPIMD)	Defect Report Repairs	Recommendations
O-18-BE-M8-2-06	20,115	N/A	Lining
O-18-BE-M8-2-08	12,771	N/A	Lining
O-18-BE-M8-2-10	11,805	N/A	Lining
O-18-BE-M8-2-05	8,947	N/A	Lining
O-18-BE-M8-2-09	5,172	N/A	Lining
O-18-BE-M8-2-02	4,839	N/A	Lining
O-18-BE-M8-2-04	4,808	N/A	Lining
O-18-BE-M1-02	4,541	N/A	Lining
O-18-BE-M8-2-03	2,695	MH0215R01.MH0160C05.1	Although GWI is estimated to be below 4,000 GPIMD it is recommended that the short-term defects be repaired with the work required on above sub-basins.
O-18-BE-M8-2-01	1,752	MH0215R02.MH0215R01.1	

8.4 SS Opportunities

Figure 8-8 shows the opportunity areas identified within the study area based on information available as of Dec. 2019 and through implementation of the first steps of the process described in Section 7.

The opportunity areas include a combination of previously identified opportunities associated with the converted storm sewer or converted sanitary sewer categories and newly identified opportunities falling into the two new categories:

- Storm sewers within the existing CSS that have the potential to be separated and managed locally with GSI.
- Storm sewers within riverfront communities or near receiving waters (i.e. streams) that have the potential to be disconnected from the CSS and rerouted directly to the adjacent receiving water or have the potential to be added onto an existing SS project in proximity.

The total potential contributing drainage area associated with the 100 new potential SS opportunities shown in Figure 8-8 is estimated to be approximately 1,300 acres (380 impervious acres).

As noted in Section 7, the full process – which will allow to develop specific opportunities at conceptual-level and prioritize them for implementation- is currently being refined and implemented; results will be presented in future CtS updates.

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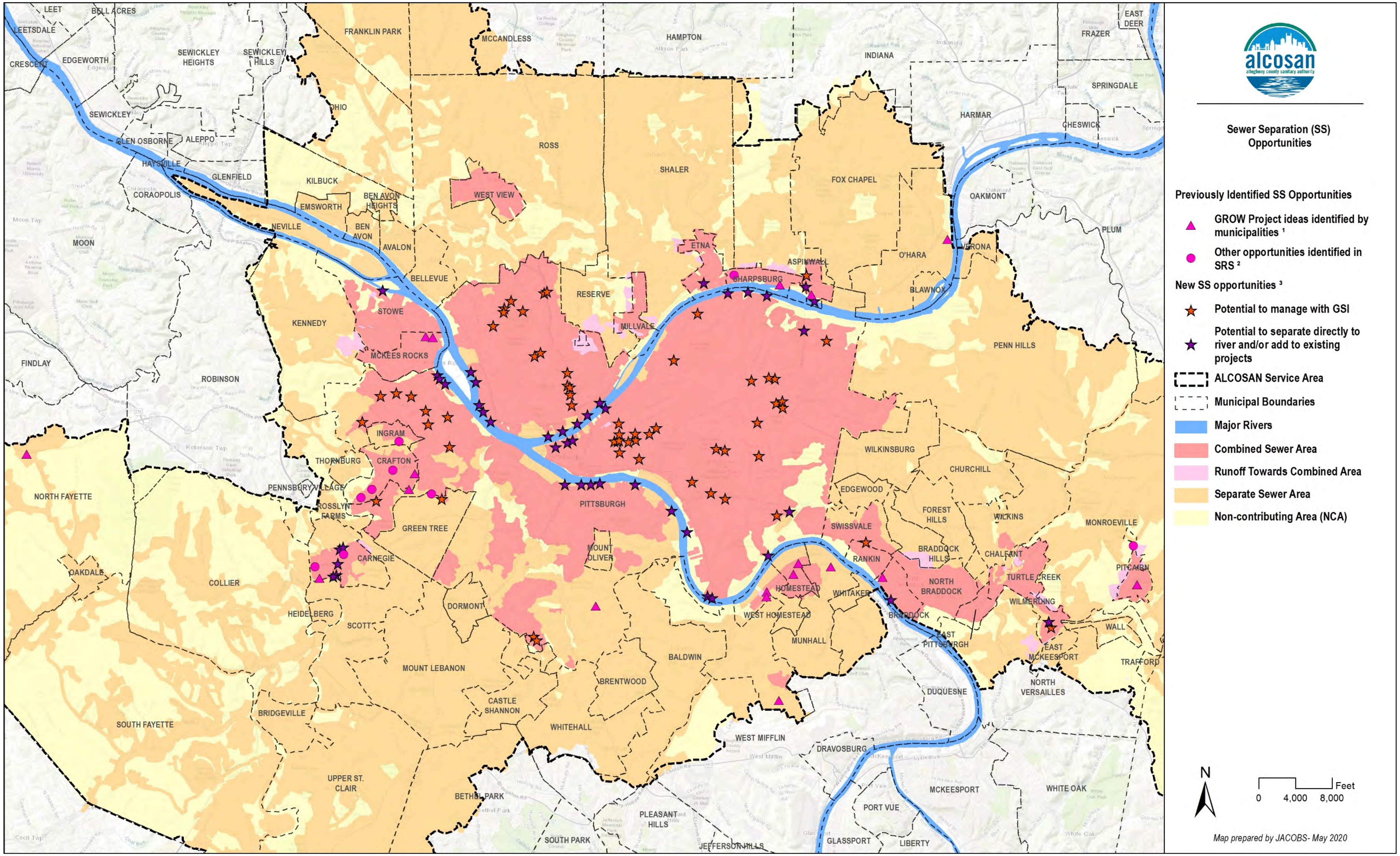
Figure 8-8. Identified Sewer Separation Opportunities Areas by Status



Data Sources: [1] ALCOSAN GROW project database; [2] MSRS database; [3] ALCOSAN SS opportunity database

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9 Web Map

An online interactive Controlling the Source (CtS) Web Map has been created to accompany the methodology for identifying and evaluating GSI and other source control opportunities. The Web Map can be accessed on ALCOSAN's website.

Below is an overview of how to navigate the Web Map and a brief introduction to the different layers of information that the Web Map contains. The instructions shown in **Figure 9-1** through **Figure 9-7** correspond to the major steps associated with the GSI-specific process.

A complete CtS Web Map instruction manual is provided in **Appendix B-2**.

Figure 9-1. How to Navigate the Web Map and Instructions Associated with "Understanding Context"

Controlling the Source (CtS) Web Map - Instructions

Upon opening the CtS Web Map, the map will automatically zoom to the full ALCOSAN service area.

To navigate within the map, either use the mouse to manually zoom in/out and pan or use the address/place search bar at the top to enter a specific address.

The ALCOSAN Service Area and ALCOSAN Planning Basin layers are shown upon opening the map. Use the mouse to click directly on an area to see the associated Planning Basin name. Municipal boundaries and POC Subcatchment data can be accessed by zooming further into the map (the layers will automatically turn on when zooming in further).

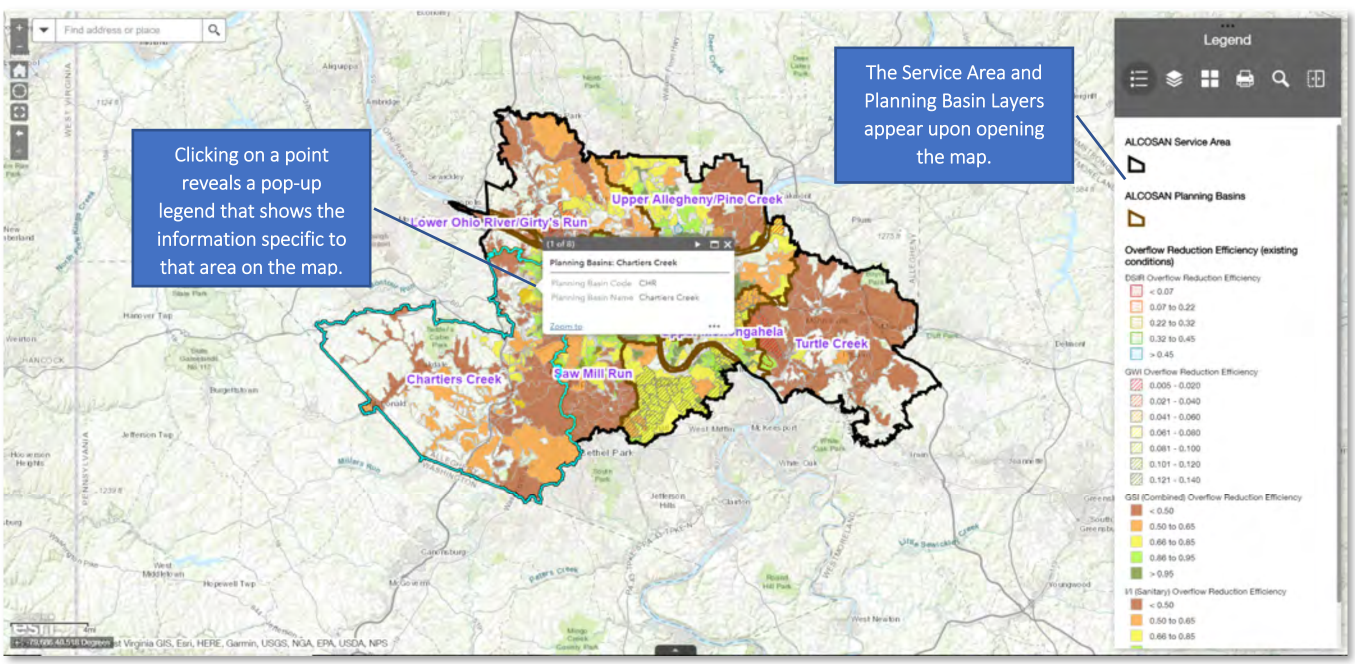


Figure 9-2. Web Map Instructions Associated with "Developing and Applying OREs"

Controlling the Source (CtS) Web Map - Instructions

The **Overflow Reduction Efficiency** (ORE) layers are automatically shown upon opening the map. Use the mouse to click directly on an area to see the associated ORE value, whether it is the GSI, I/I, DSI, or GWI ORE. A legend will pop up displaying the ORE value(s).

As discussed in the report, the **GSI (Combined) Overflow Reduction Efficiency** value is based on reducing impervious area in the hydrology and hydraulic model. These values may not be representative of detention only GSI practices which will have a lower ORE.

For sanitary areas, the **I/I (Sanitary) Overflow Reduction Efficiency** field in the pop-up legend will display the associated I/I ORE.

In select sewersheds, the DSIR and GWI OREs are also available and shown as the **DSIR Overflow Reduction Efficiency** and **GWI Overflow Reduction Efficiency** fields in the pop-up legend.

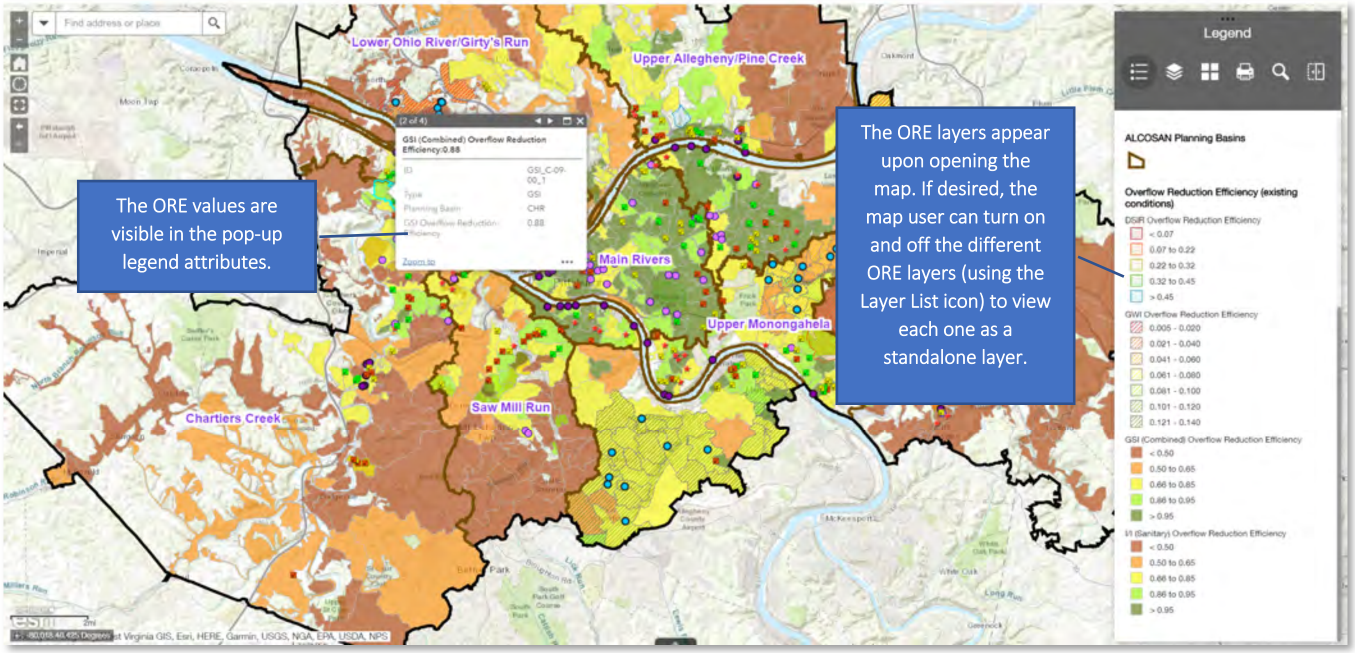


Figure 9-3. Web Map Instructions Associated with "Analyzing Constraints"

Controlling the Source (CtS) Web Map - Instructions

The Constraints layers are set to turn on only when the map is zoomed in to a scale of 1:5,000 or closer. Manually zoom in and pan using the mouse (and +/- buttons) or use the address/place search bar at the top to enter a specific address to search for.

The **Absolute Constraints** are displayed as black polygons. Clicking on this layer will reveal a pop-up legend that shows which factors are contributing to a site being "absolutely constrained", indicated by a "Yes" value.

The total **Relative Constraint** scores are displayed in various colors of green, yellow, and grey. Clicking on this layer will reveal a pop-up legend that shows which factors are contributing to a site being "relatively constrained" and will reveal the Total Relative Constraints score for that location.

Buildings are shown as a medium-grey, with a built-in 10-foot buffer around each building footprint.

Figure 9-4. Web Map Instructions Associated with "Considering Existing/Previously Identified Projects"

Controlling the Source (CtS) Web Map - Instructions

The project point layers are set to turn on only when the map is zoomed in to a scale of approximately 1:100,000 or closer. Manually zoom in and pan using the mouse (and +/- buttons) or use the address/place search bar at the top to enter a specific address to search for.

The Legend shows the different symbols and sources of project information included on the CtS Web Map. Clicking on a specific project point will reveal a pop-up legend that displays more details about the projects (as available).

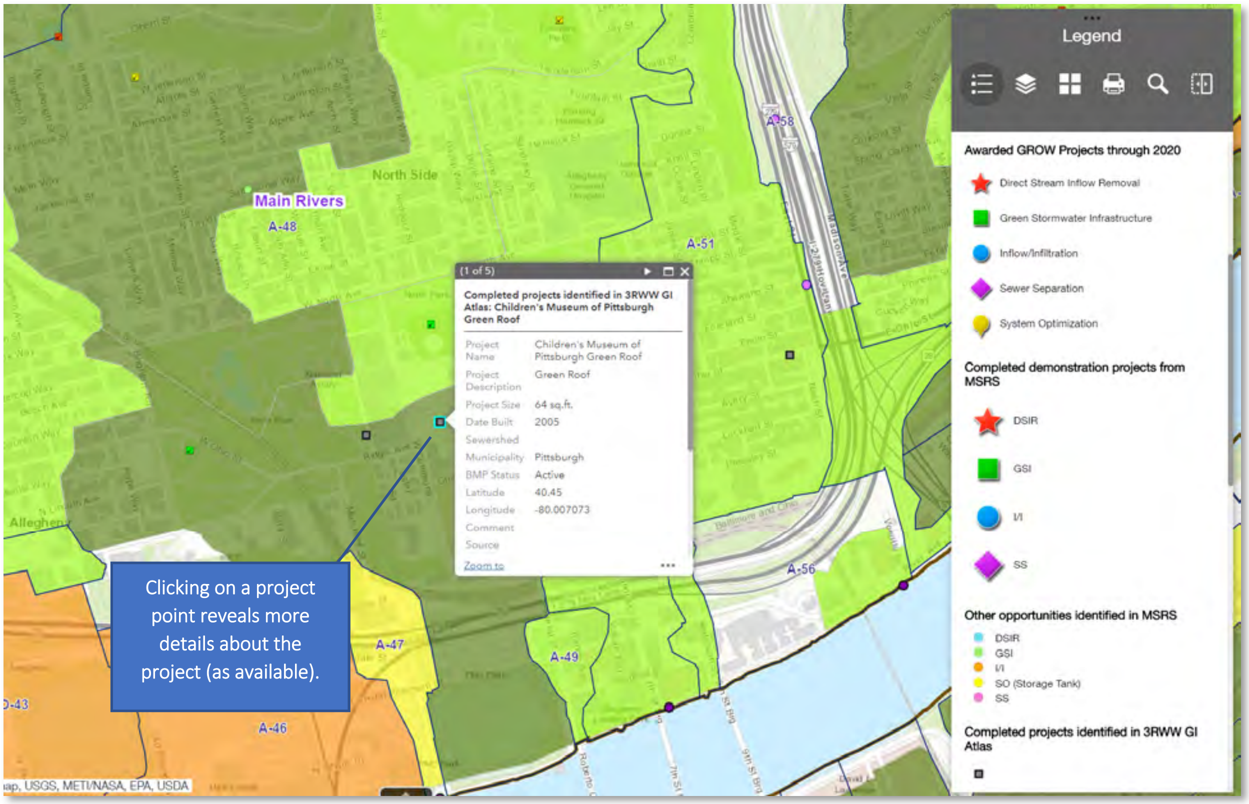
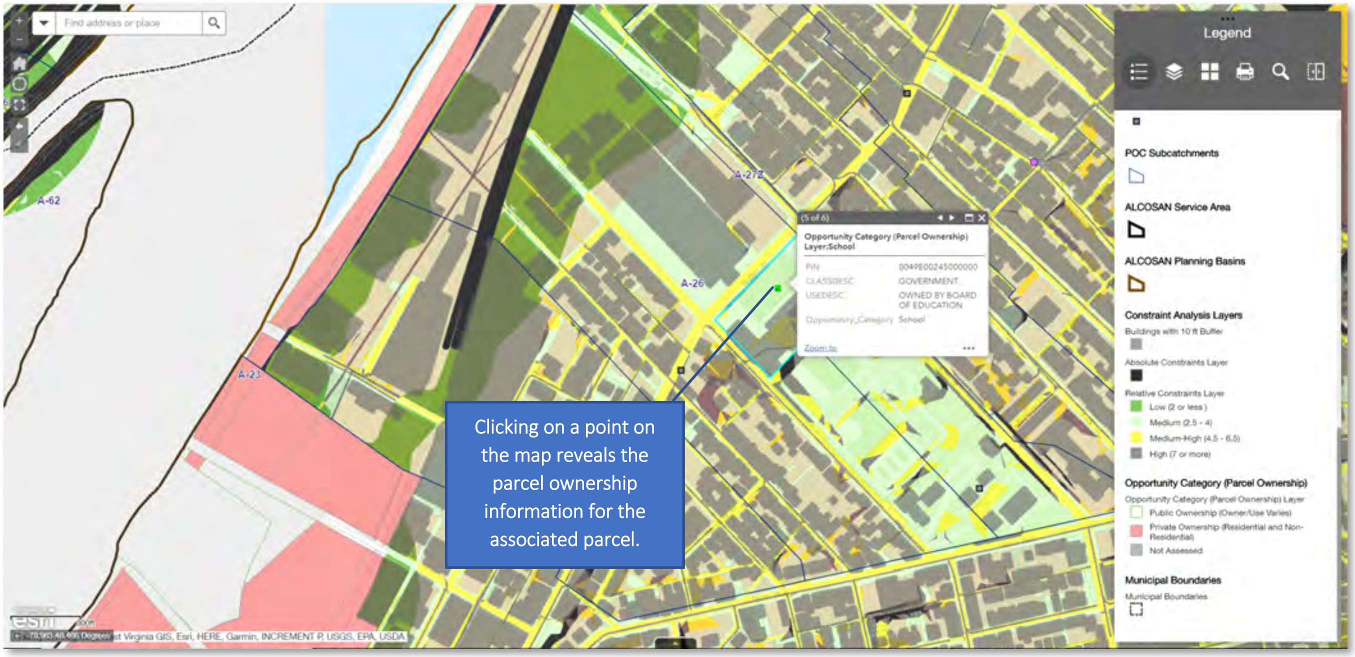


Figure 9-5. Web Map Instructions Associated with "Identifying Opportunity Areas"

Controlling the Source (CtS) Web Map - Instructions

Similar to the Constraints layer, the **Opportunity Category (Parcel Ownership)** layer is set to turn on only when the map is zoomed in to a scale of 1:5,000 or closer. Manually zoom in and pan using the mouse (and +/- buttons) or use the address/place search bar at the top to enter a specific address to search for.

Clicking on a point will reveal a pop-up legend that shows the parcel ownership information for the associated parcel. The **Opportunity Category (Parcel Ownership)** will be shown.


Legend
POC Subcatchments
ALCOSAN Service Area
ALCOSAN Planning Basins
Constraint Analysis Layers
Opportunity Category (Parcel Ownership)
Municipal Boundaries
Opportunity Category (Parcel Ownership) Layer:School
A-62
A-23
A-26
A-27Z
Clicking on a point on the map reveals the parcel ownership information for the associated parcel.

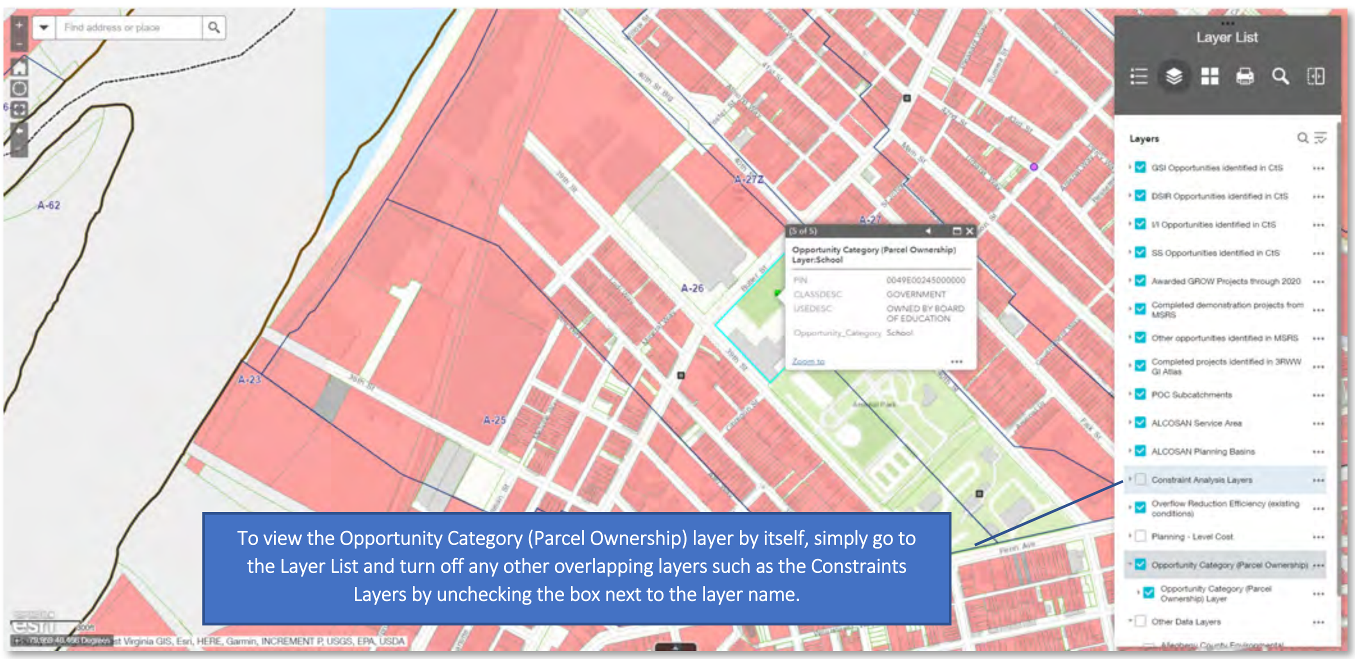

Layer List
Layers
GSI Opportunities identified in CtS
DSIR Opportunities identified in CtS
I/I Opportunities identified in CtS
SS Opportunities identified in CtS
Awarded GROW Projects through 2020
POC Subcatchments
ALCOSAN Service Area
ALCOSAN Planning Basins
Constraint Analysis Layers
Planning - Level Cost
Opportunity Category (Parcel Ownership)
Other Data Layers
Opportunity Category (Parcel Ownership) Layer:School
A-62
A-23
A-25
A-26
A-27Z
To view the Opportunity Category (Parcel Ownership) layer by itself, simply go to the Layer List and turn off any other overlapping layers such as the Constraints Layers by unchecking the box next to the layer name.

Figure 9-6. Web Map Instructions Associated with "Ranking for Technical Feasibility"

Controlling the Source (CtS) Web Map - Instructions

The various **Opportunities identified in CtS** layers are set to turn on only when the map is zoomed in to a scale of approximately 1:170,000 or closer. Manually zoom in and pan using the mouse (and +/- buttons) or use the address/place search bar at the top to enter a specific address to search for.

The **GSI Opportunities identified in CtS** layer shows the nearly 200 potential GSI projects identified using the CtS approach.

Clicking on a specific project point will reveal a pop-up legend that displays more details (as available). The Technical Ranking (High, Medium, Low) is displayed.

Many of the potential GSI projects have accompanying photos and a concept plan attached – if available, this will be listed in the "**Attachments**" section of the pop-up legend. Click on the attachment name (JPG or PDF) to be able to view site photos and concept plans in a separate browser window.

The **DSIR Opportunities identified in CtS, I/I Opportunities identified in CtS,** and **SS Opportunities identified in CtS** show the other potential project types identified using the CtS approach.

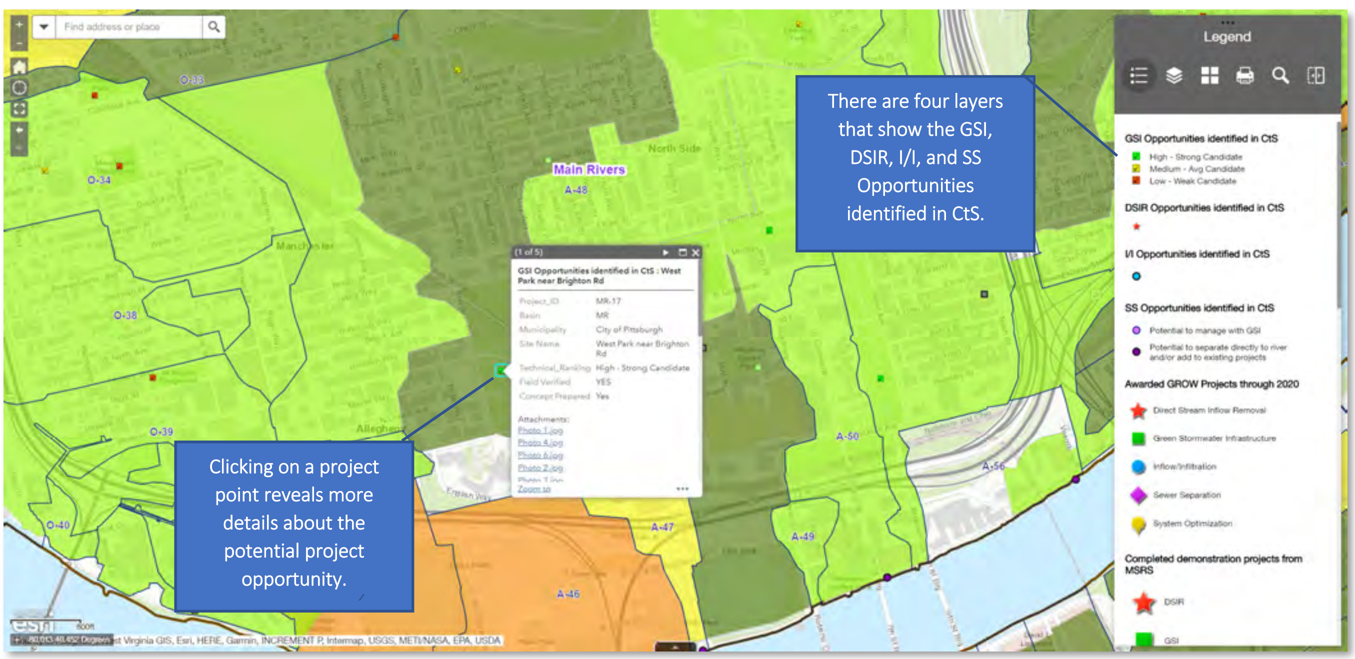


Figure 9-7. Web Map Instructions Associated with "Estimating Costs"

Controlling the Source (CtS) Web Map - Instructions

The **Planning Level Capital Cost Per Acre - For GSI Projects** layer can be accessed by going to the "Layer List" and checking the Planning Level Cost group layer to turn it on. It is visible at the same scale as the Relative Constraints Layer (1:5,000). Once the layer is turned on, clicking on an area will display the pop-up legend.

Click on a point on the map to see the pop-up legend that displays the associated **Planning Level Capital Cost Per Acre** (for potential GSI projects) for that area, which includes the adjustment for the site-specific relative constraints.

10 Conclusions

10.1 Objectives and Outcomes to Date

ALCOSAN undertook an engineering and planning analysis to develop a consistent framework for identifying and evaluating source control opportunities throughout the Authority's service area. The framework is intended to be a resource for ALCOSAN, our customer municipalities and other regional partners to aid in:

- The implementation of cost-effective and impactful source control projects, i.e., increasing the common understanding of where municipalities can be most effective in reducing overflow per dollar spent on source control.
- Maintaining open communication and fostering collaboration with local customer municipalities and stakeholders on source control projects.
- Leveraging planned work and public and private investments to extend the reach of ALCOSAN's GROW Program.
- Outlining strategies for implementing source control projects and programs.
- Describing and quantifying the impact source control can have on inflows and overflows under different Regional Conveyance and Treatment System conditions.

CtS lays out this framework, which was tailored to the four most common source control categories: GSI, DSIR, I/I reduction and SS.

As of May 2020, the development and application of the framework has led to:

- Identifying 195 GSI opportunities and developing 59 GSI concept plans – representing a potential runoff capture of 163 MG/yr and potential overflow reduction of 146 MG/yr under Existing Conditions. The planning-level estimated stand-alone cost of construction associated with the 59 concepts is approximately $47 million (2017 dollars) or $0.32/gal of overflow reduced.
- Identifying 44 new DSI locations and completion of a feasibility study for 15 of these new locations.
- Defining a process to leverage the extensive data collection and analysis work performed by ALCOSAN under the Regionalization program and the results of field investigations in sewersheds near multi-municipal trunk sewers to identify impactful, cost-effective I/I reduction opportunities.
- Identifying 100 SS opportunity areas that are now being evaluated.
- ALCOSAN, municipalities and other stakeholders engaging on specific opportunities identified through the framework and potential next steps.
- Creating a Web Map to facilitate information sharing and collaboration between parties.
- Better understanding opportunities throughout the service area and engaging with municipalities and stakeholders on upcoming GROW funding cycles and associated funding opportunities.
- Furthering the understanding of the potential impact of the identified source control opportunities on ALCOSAN's Regional Collection System and CSO reduction. As shown above as an example, considering only the GSI opportunities identified and developed at the conceptual-level to date, the potential for overflow reduction is estimated at 146 MG/yr.

Significant work is still in progress as detailed in Sections 3 through 8. This work in progress includes:

- The development and applications of OREs under the "Selected Plan Conditions" and other interim controls or improvements of the CWP, as well as discussion of impact on previously identified and prioritized opportunities. Overflow reduction benefits for source controls are anticipated to significantly decrease in sewersheds where these controls or improvements (e.g., plant expansion, conveyance and select regulator modifications) are located. The prioritization of opportunities will also be affected: while source control will still have benefits and make grey infrastructure more effective and resilient in those areas, interim conditions OREs will allow to focus on areas where improvements are not implemented as part of the ICWP. The results associated with the development and applications of these OREs will be presented in subsequent updates to this document.
- An initial DSIR Feasibility Study on 15 identified DSI locations was completed in May 2020 and it recommended further evaluation of 11 locations.
- The application of the I/I reduction-specific process to all the sewersheds being investigated by ALCOSAN to identify impactful and cost-effective I/I reduction opportunities.
- The refinement and application of the SS-specific process to the opportunity areas identified in this framework.

10.2 Planned Updates

As stated in Section 1, ALCOSAN intends this document to be a living document that is updated to incorporate feedback, new information, and results of on-going work, particularly in the 2020-2025 timeframe.

Specific updates envisioned at this time include the incorporation of the results associated with work in progress identified in Section 10.1.

In addition, CtS and supporting documents are anticipated to be updated as needed to account for such elements as:

- Availability of new data/information (e.g., new stormwater system mapping; new identified projects by ALCOSAN and others; H&H model updates; new cost information; additional flow monitoring/FIS data; relevant data collected as part of the Modified CD requirements starting in 2020).
- Continued integration with other ongoing CWP activities, including the need to inform and/or adapt to the decisions that are being made on other relevant elements of Phases 1 and 2 of the ICWP (including Preliminary Planning and Regionalization).
- Potential improvements identified through the framework development and implementation, feedback from municipalities, or other sources.

10.3 Potential Improvement(s) Identified to Date

One of the difficulties pointed out in Section 3.3 of this CtS is the lack of integration of existing information associated with source control opportunities.

In the short-term, one of the potential improvements to the framework would be to develop/maintain an integrated source control project database to track all source control projects performed by ALCOSAN on its own assets and as many significant source control projects in the region as practical including status, actual construction and capital costs, performance, lessons learned, and operations and maintenance needs and costs.

Such a database would facilitate the application of the processes presented in this Framework and future updates, would allow for the tracking of progress on actual implementation of the identified opportunities, would support the continuous integration of opportunities from other databases and improve the pipeline to the Framework process, and would inform the overall performance of the source control program. In addition, it would allow ALCOSAN to organize the data to be requested from the municipalities per the Modified CD requirements.

10.4 Recommendations to Leverage the Framework

To leverage the framework, the following actions are recommended:

10.4.1 For ALCOSAN

- Finalize work in progress and perform planned updates.
- Consistently use the framework to identify and track all source control projects associated with its own assets.
- Work with municipalities to use the framework to identify and evaluate source control projects in their purview and leverage GROW Program funding and/or secure other funding sources (as identified in **Appendix E**) to move forward with implementation.
- Work with other stakeholders to further evaluate and implement source control opportunities from CtS, including by providing regular updates to external constituencies (i.e., foundation community, Allegheny Conference, developers, etc.) related to ALCOSAN's efforts and progress in advancing source control projects.
- Identify more source control opportunities and support municipal efforts to implement projects, including by conducting an annual customer municipality survey and/or host an annual "town hall" / panel discussion to solicit municipal feedback on helpful programs, answer questions related to funding opportunities, and showcase model source control projects and opportunities.

10.4.2 For Municipalities and Municipal Authorities

- Provide feedback on CtS and work with ALCOSAN to further evaluate and implement prioritized opportunities from CtS based on municipal priorities and funding availability.
- Adapt and apply the framework at the local level:
  - Incorporate community-specific data as available (utilities, capital improvement plans, historical information, redevelopment zones, etc.).
  - Identify more source control opportunities, including additional public sites and right-of-way opportunities:
    - *Evaluate ways to integrate source controls with other planned improvements (CIP, sewer/water, transit, schools, redevelopment, etc.) and to use GSI to help address other municipal needs (greening, traffic calming, park improvements, etc.).*
    - *Look for programmatic opportunities to repeat or scale up source controls.*
  - Utilize and promote the GSI and Monitoring Guidance documents presented in Section 2 as applicable.
- Partner with stakeholders such as schools, neighborhood associations, non-profits, park groups, and PennDOT on co-locating source controls and shared programmatic support such as education, outreach, and maintenance.
- Pursue/secure funding for implementing source controls (e.g., GROW and other grants, loans, and stormwater fees).

10.4.3 For all Stakeholders

- Develop partnerships between government entities and foundations, non-profits, trade schools, etc. to provide funding and services such as workforce development and training on GSI maintenance to support implementation of prioritized opportunities.
- Work to better quantify the water quality and overflow reduction benefits of urban forestry/tree canopy efforts in the region using the Stormwater Management Model (SWMM), iTree, or other appropriate tools.
- As new information and tools become available, consider how variable rainfall patterns and climate change might impact this source control framework and broader wet weather management in the region.
- Help improve ordinances, codes and programs to facilitate GSI:
  - Identify and remove remaining code barriers to GSI and further encourage it, building off the 2013 University of Pittsburgh Environmental Law Clinic report "Barriers and Facilitators to Green Infrastructure and Low-Impact Development in Allegheny County, Pennsylvania".
  - Incentivize and/or require source controls on public and private property through ordinances, stormwater fee credits, grants, etc.
  - Conduct education and awareness campaigns with residents, businesses, municipal officials, and developers on stormwater source control options and benefits.
  - Consider how residents and business/property owners can get more directly involved (e.g., downspout disconnections, rain barrels, rain gardens, tree plantings).
  - Consider how residents can provide real time reporting of project performance or problems with installed SC facilities, if such a reporting system were put in place.