Model Behavior: A Framework for Regional, Inter-jurisdictional, and Multi-level Stormwater Planning

Prepared for

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Executive Summary

Model Behavior: A Vision for Interjurisdictional Stormwater Modeling, Planning and Solutions

Water knows no boundaries. Following the path of least resistance, it flows downhill, often crossing many arbitrary lines: municipal borders, infrastructure rights, planning areas, and modeling extents. While water may not respect these border lines, they nevertheless inform our decisions as water resource managers, elected officials, property owners and citizens—so they matter a great deal.

However, local planning often requires coordinating across these same lines. Consider a road that passes through several communities: If it is four lanes and 40-miles per hour in one municipality, but connects to a two-lane, 20-mile-per-hour road in the neighboring community, we can expect traffic snarls, accidents and unhappy drivers. Likewise, significant problems can arise when communities fail to work together on water, sewer, and stormwater planning. Uphill, there may be an affluent community with an ample budget for staff, infrastructure investments and innovative solutions—as well as a lot of impervious surfaces. In heavy rains, the community downhill—which is struggling to afford solutions to today's crises, much less plan for the future—will be overwhelmed by that same water when it floods the streets and people's basements. By collaborating, these two communities will be much more likely to identify cost-effective solutions that address the root causes of their shared stormwater management challenges.

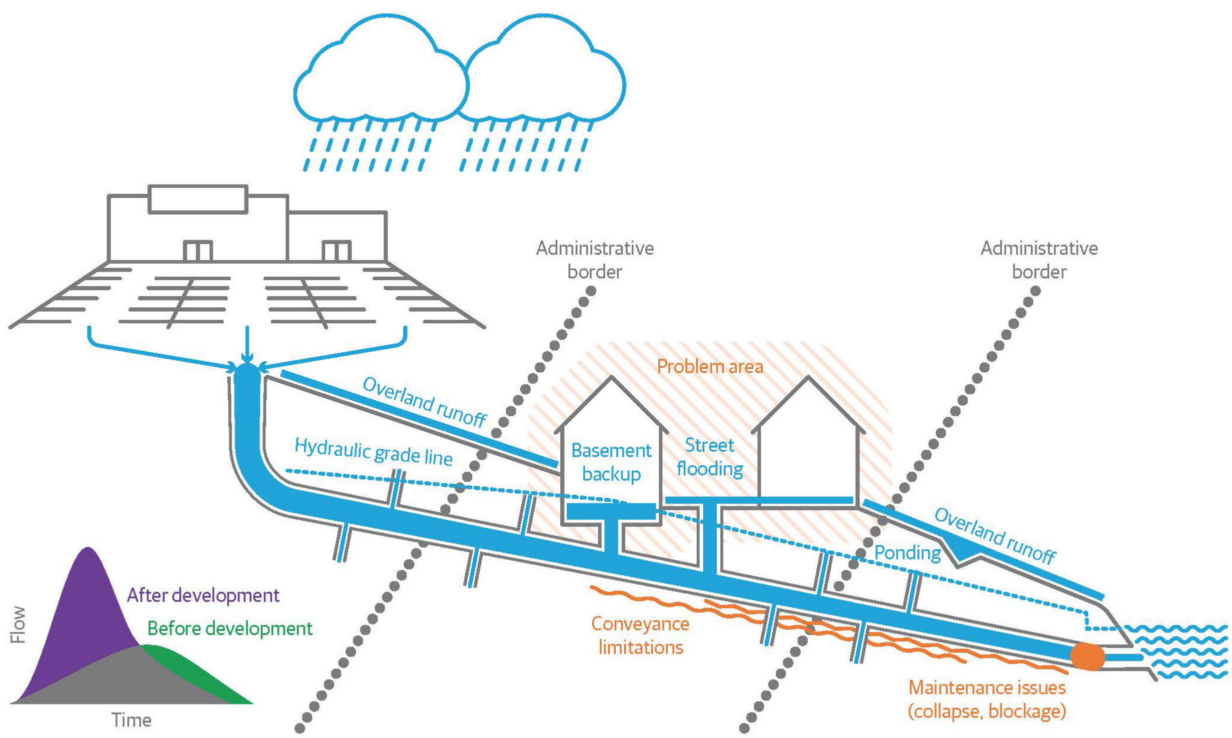

Figure ES-1. Drainage System Schematic

Because stormwater runoff often crosses boundaries, solutions require collaboration.

With heavy rains, and therefore incidents of urban flooding, predicted to increase for our region, we need to continue to get better at solving our stormwater problems. To do so requires current data, robust modeling tools and investments in hard and nature-based infrastructure. The good news is that local communities have made progress in recent years to adopt modern policies, tools, and tactics—such as nature-based infrastructure solutions, water reuse, and property buyouts—but usually, one jurisdiction at a time. What's still lacking are strategic partnerships, systems for sharing information, and the political will to empower collaboration at sewershed and watershed scales, to optimally deploy these new tools, along with our tried-and-true hard infrastructure.

What follows is a *vision* for how to do that. The Metropolitan Planning Council (MPC), working in concert with CH2M, a global engineering leader with experience in the Chicago region, created this vision because we believe that the ability to plan and implement stormwater solutions across boundaries is a vital component of the next wave of innovation in solving flooding and other stormwater-related challenges.

We call this vision the Regional Planning Framework (RPF). It combines new ways to use existing stormwater modeling and planning tools at new scales, plus new protocols and processes for multiple jurisdictions to exchange information, identify shared problems, and make mutually beneficial decisions.

What follows in the white paper developed by CH2M are:

- The basics of how the RPF would function (integrated modeling across borders)
- The benefits of creating it (leads to more efficient investment and policy decisions)
- What would be required to create it (political will, data and funding)
- An examination of why it does not already exist (a new way of thinking about stormwater planning)
- What we need to do next (broker agreement between major players on roles and responsibilities; secure funding)

MPC and CH2M believe the basic principles behind the RPF could work not only in metropolitan Chicago, but in many urbanized areas in the United States and beyond. However, to ground the need for and details of the RPF in real-life examples, we focused on the Calumet sub-region of the Chicago metropolitan area as a case study. By facilitating the Calumet Stormwater Collaborative, MPC and its many partners have invested years in fostering greater coordination and collaboration between the dozens of units of government, private firms and non-government organizations responsible for and active in stormwater management in this area. For its part, CH2M conducts regular stormwater modeling and other planning for three of the largest actors in the Calumet: the Metropolitan Water Reclamation District of Greater Chicago (MWRD), City of Chicago Department of Water Management and the U.S. Army Corps of Engineers (Corps).

The RPF would allow planners—in one part of a sewershed or watershed—to determine with greater certainty both the root cause and optimal solution to a pressing stormwater problem. It also would allow for planners working to solve local stormwater problems to see the regional effect, and vice versa; as well as to compare and visualize tradeoffs between different solutions. A group such as the Illinois Environmental Protection Agency (IEPA) would be able to model the impact of a local stormwater project on the water quality of a whole river system, ultimately making more effective decisions in awarding limited infrastructure loan funding. An entity such as the Cook County Land Bank could readily identify vacant parcels of land in areas needing stormwater detention. And a single community, or someone providing them technical assistance, could identify exactly where and how to prevent a critical street intersection from flooding repeatedly.

Be sure to check out the appendixes, which include valuable new research on the current state of stormwater modeling in the Chicago region and beyond, which will be useful to anyone trying to understand what tools do what, who is using them, and how they might work together better.

This holistic approach relies on systemic access to tools called Hydrologic and Hydraulic models, and the capacity to use them. This can be a significant challenge in itself as many lower-income communities don't have the resources. And yet the communities most in need of stormwater solutions are often least able to provide them for themselves. Much of the premise for the RPF is driven by the desire to improve equity in regional stormwater management. Building the RPF to its full potential likely requires someone else—a philanthropy, another unit of government—to assume the upfront cost of developing the framework, and then an appropriate entity to manage its upkeep and use.

As this white paper demonstrates, there is no *technical* reason the RPF cannot be built (though there are plenty of challenges). We have the ability to create Hydrologic and Hydraulic models where they do not exist, to connect them where they do, to store and make available past modeling results, and even to allow citizen scientists to use aspects of the RPF to develop and propose stormwater solutions. We have the tools, we have the data, and we could readily develop the protocols needed to protect sensitive information.

If technology is not the missing ingredient, what is? A better framework and approach to bridging across traditional borders. In the coming year, MPC, with support from members of the Calumet Stormwater Collaborative, will work to build the political will to create this framework. We will need to join forces with many critical actors to fully realize the benefits of the RPF, including MWRD, Cook County, the Chicago Metropolitan Agency for Planning, South Suburban Mayors and Managers Association, IEPA, the City of Chicago, and other individual municipalities. This vision is the starting point for those discussions.

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Acronyms and Abbreviations

CNT	Center for Neighborhood Technology
CSO	combined sewer overflow
DTM	digital terrain model
GIS	geographic information system
H&H	hydrologic and hydraulic
HEC-HMS	Hydrologic Engineering Centers Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Centers River Analysis System
LiDAR	light detection and ranging
MPC	Metropolitan Planning Council
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
RPF	regional planning framework
SWMM	Storm Water Management Model
TARP	Tunnel and Reservoir Program

SECTION 1

Overview

1.1 Motivation

Stormwater does not adhere to jurisdictional boundaries, and the source of runoff is often spatially dislocated from its impact. Infrastructure and interventions from the local to the regional scale play a part in managing stormwater. Yet at present, **there are limited tools in place to understand the impact of regional infrastructure, or adjacent communities' stormwater practices, on other communities**. This lack of a regional planning framework complicates the understanding of trans-jurisdictional impacts and also makes it difficult to understand how regional collaboration could enhance stormwater solutions. **This study is an effort to define how regional planning tools could foster collaboration and build upon a host of current stormwater activities to maximize the benefits of future stormwater improvements. We envision a framework that combines technical innovation and collaborative processes to help match our collective knowledge to the scale of stormwater problems.**

1.2 Objectives

The overarching objective of this study is to define a framework for considering the benefits and costs of potential stormwater improvements at a range of scales. Achieving that objective, however, requires first building upon a thorough understanding of existing practices and tools. It is helpful to consider the benefits of such a system (and the challenges to its implementation) in an actual geography, not just abstractly. Throughout the report, therefore, we refer to current practices and future opportunities in the Calumet area (defined in Section 2). The following intermediate objectives are also defined:

- Document models and tools used elsewhere in the United States and abroad for stormwater management
- Categorize tools and summarize what specific categories of tools do and do not do
- Document existing geographic information system (GIS) data and tools used for stormwater planning in the Calumet
- Define a range of potential performance metrics for the Calumet

In the end, of course, **the goal is to reduce adverse impacts from excess stormwater—and maximize the beneficial use of this resource**. It is our hope that the information contained in this report, and particularly the vision for a regional planning framework (RPF), contributes to those goals by supporting informed, collaborative decision making.

1.3 Report Organization

Section 2, which presents the RPF, introduces the Calumet study area (referred to as the Calumet), and builds upon existing and past modeling efforts to improve the understanding of local and regional stormwater interactions in the Calumet. Section 2.4 elaborates several components integrated into the RPF, including a mock-up of an interactive mapping application for accessing the RPF (Section 2.4.6). Then, in Section 2.5, different users' vantage points are taken to clarify how the RPF can support stormwater planning. Section 2.6 discusses considerations related to security and data protection for participating agencies. Section 2.7 provides a number of additional concepts that are not fundamental to the RPF, but which may increase its value or applicability in the long run. Section 2.8 considers the feasibility of the RPF from the technical, financial, and institutional perspectives.

Sections 3 and 4 summarize the RPF's technical, conceptual, and informational underpinnings; the sections detail existing models and data, and show how this information can be used to understand tradeoffs between different stormwater improvement options. Section 3, Stormwater Planning Tools and the Regional Planning Framework in the Calumet, begins with an overview of models and a high-level delineation of what is included in different types of models. (This section is supported by a broad and relatively detailed review of stormwater planning and modeling tools included in Appendix A.) Section 3.2 builds upon integration and data sharing activities of the Collaborative, documenting member responses to questionnaires regarding the data and models currently used to support stormwater planning in the Calumet.

Section 4, Measuring Performance towards Goals, focuses on how metrics can be defined and tracked to provide a quantitative, performance-based means of comparing alternative solution effectiveness. Section 4.2 discusses a range of potential metrics that may be applicable in the Calumet. These metrics, to be further developed and agreed to collaboratively in the future, tie back directly to the RPF as a means of comparing benefits and costs for potential solutions (as illustrated in Figure 2-2).

Finally, the appendixes summarize the information gathered and produced in the development of this report. Appendix A summarizes a broad range of stormwater planning tools ranging from models, to costing toolkits, to green infrastructure planning tools. The primary purpose of each tool/model is defined, as well as its principal inputs and outputs of the tool. Appendix A thus provides a good starting place for understanding both the tools available to use and the range of different questions they address. Appendix B provides similar information for web-based stormwater-mapping or -planning apps. Appendix C summarizes the responses of key stakeholders in the Calumet regarding the data sources they use, the data they would like to have, and the models they use to understand current and future system performance.

Regional Modeling Framework for the Calumet

2.1 Collaboration in the Calumet

In 2014, the Metropolitan Planning Council (MPC) convened the Calumet Stormwater Collaborative (the Collaborative), an inclusive, cross-disciplinary network of agencies, communities, stakeholders, and professionals, with the overarching purpose of increasing collaboration to improve stormwater outcomes in the area known as the Calumet (described in Section 2.2). Members of the Collaborative noted a wide array of factors contributing to stormwater management problems, including:

- Deteriorating infrastructure
- Lack of funding to operate and maintain infrastructure
- Increased imperviousness causing more runoff
- Larger storms occurring with greater frequency
- Lack of quantitative data and models to understand the changes needed to improve stormwater management
- Highly variable economic resources across the Calumet to respond to stormwater challenges
- Overlapping and unclear responsibilities across agencies managing stormwater

The Collaborative was founded on the belief that increased coordination, communication, and resource sharing can help address these challenges.

2.2 Geographic Scope and System

The Calumet is the geographic union of the Calumet Water Reclamation Plant sewershed and the areas draining to the Little Calumet and Cal-Sag Waterways. While the RPF is intended as a generalized framework—an underlying conceptual scheme connecting users to a suite of technical and data management tools—that could be applied outside the Calumet as well, we use the Calumet as an example to illustrate specifically many of the concepts of the RPF. In addition the sections on Stormwater Planning Tools (Section 3) and Performance Metrics, while considered in this specific context, may also be applicable elsewhere. Figure 2-1 provides an overview of the Calumet drainage system.

2.3 Vision for Regional Planning Framework

The Calumet is a complex system, weaving highly developed urban and suburban areas with natural areas and drained by a combination of combined and separate systems, local open-channel drainage, larger regional waterways, and the Deep Tunnels of the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC). The regional planning framework outlined in this document is intended to help with understanding the interactions of these systems, and particularly to optimize local community stormwater investment in its regional context. MPC, CH2M, and others have been developing concepts related to the RPF vision for some time, and the Collaborative presented a unique opportunity to explore the RPF further. To be clear, the RPF vision is intended to be an exportable concept that could work and be beneficial in a wide array of geographies; indeed many of the challenges noted in Section

2.1 occur elsewhere, and the interplay between local and regional systems occurs in many metropolitan areas. The RPF is intended to improve stormwater outcomes in watersheds and sewersheds in which multiple government or non-government actors plan, build and operate stormwater infrastructure.

The RPF vision acknowledges that numerous agencies have invested in models and tools for understanding their system(s), and apply these tools to understand existing risks and potential benefits of system improvements. The RPF is not a substitute for such activities; indeed, implementation of the RPF depends upon the integration of existing models of the Calumet drainage system.

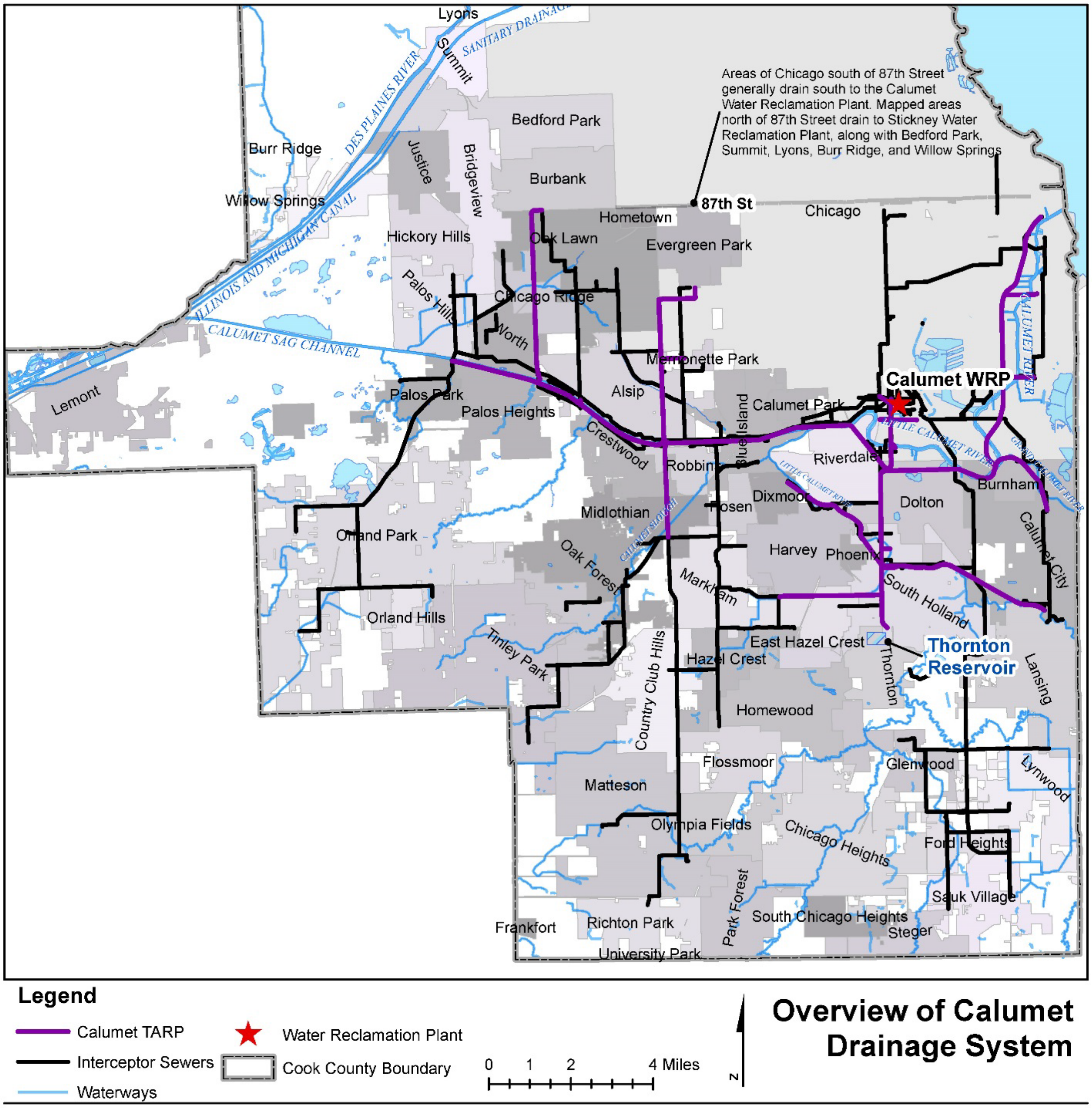

Figure 2-1. Overview of Calumet Drainage System

2.3.1 Goals for Regional Planning Framework

The RPF will be designed to maximize the following goals:

- Extend hydrologic and hydraulic (H&H) modeling coverage to smaller communities
- Facilitate linkage of H&H models across jurisdictions (using the Calumet as an example)
- Enable local planners to make decisions with knowledge of regional constraints and opportunities
- Enable regional planners to prioritize local projects, and to understand aggregate impact of local projects on regional performance
- Visually summarize flood risk and key performance metrics
- Aid understanding of benefits and costs of alternative investment strategies

2.3.2 Concept Diagram

The RPF is a structured approach for simulating the Calumet system in a manner that considers both local and regional contributions to stormwater problems and solutions, and such that analysis can support a range of uses for a wide array of stakeholders. Figure 2-2 provides a visual overview of the RPF, with key components described in the subsequent sections. Section 2.5 presents specific workflows for using and maintaining the RPF. The callout box at right outlines what the RPF is and is not to frame the more detailed information that follows.

What the RPF Is and Is Not…

The RPF is a technical framework which facilitates:

- Data communication between models at different scales or across geographies
- Making best available model data accessible to (authorized) users
- Efficient post-processing of simulations to convert model output into meaningful performance measures
- Compelling visualization of current and future system states in geospatial context

The RFP is not:

- A single master model
- A “wonder-tool” that magically solves hard problems
- A system that tells users what they should be trying to achieve
- A straightforward extension of current modeling practices in the Calumet

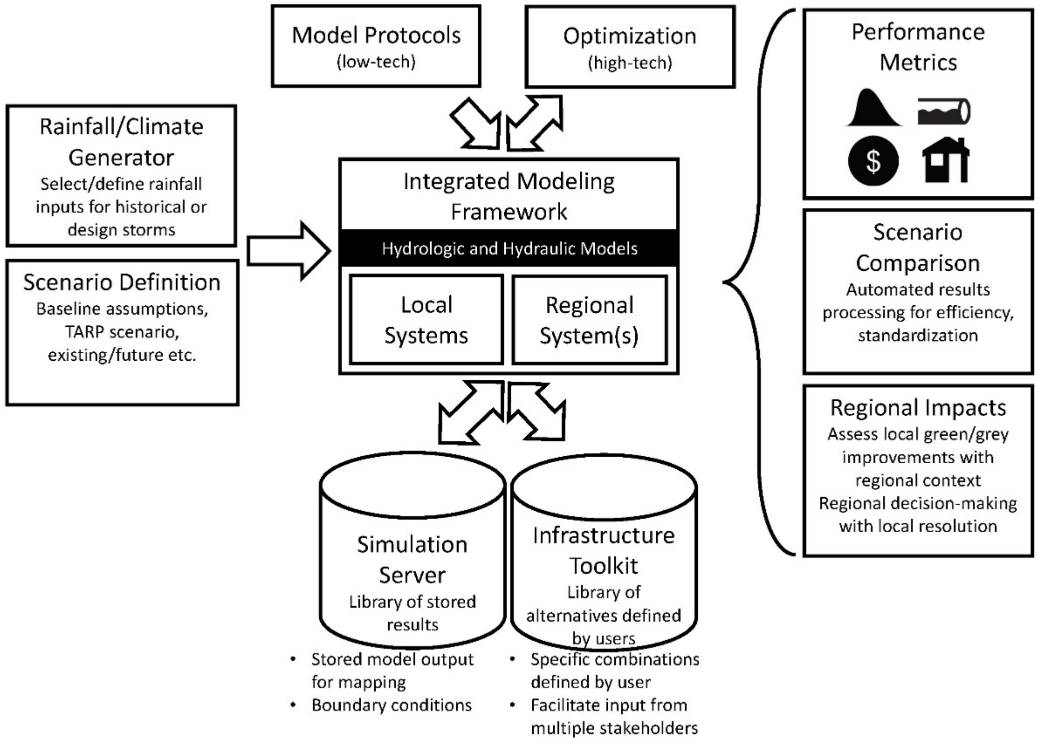

Figure 2-2. Concept for Regional Planning Framework

2.4 Components of Regional Planning Framework

2.4.1 Users

The RPF provides a means for people institutions to make better decisions regarding stormwater management—with a particular emphasis on issues that span jurisdictional boundaries. Each component of the RPF must be developed to meet the needs of a diverse anticipated user base. **Users' stormwater expertise will be critical for applying the RPF to develop, compare, and prioritize stormwater solutions**. User workflows are discussed in greater detail in Section 2.5, with attention to specific roles the RPF will facilitate. The callout box at right provides a high-level overview of how the RPF will benefit users, and the responsibilities of users to contribute to a successful RPF.

Overview of User Responsibilities and Benefits…

Responsibilities:

- Define desired functionality
- Prioritize implementation needs
- Provide input data and models
- Provide clear feedback and suggestions
- Seek opportunities to apply the RPF

Benefits:

- Increased access to best available models for planning
- Leverage the work of others to more efficiently solve problems
- Availability of H&H models in unrepresented areas
- Better representation of local and regional interactions
- Productivity tools for streamlined, efficient workflows
- Develop consistent summary metrics that enables more substantive cross-perspective communication

Distinct from but related to the role of how users and institutions will apply the RPF is the question of how the framework will be governed. How will this toolset be stewarded and sustained, funded, checked and validated, its development activities steered to meet a broad range of user needs? We recognize governance as a vital issue that is critical to the success of the RPF. This document focuses on the overall vision for the RPF, particularly the technical components, that will facilitate regional collaboration, with the intent that, as that vision evolves, in the future a governance model for this framework can be developed.

2.4.2 Hydrologic and Hydraulic Models

H&H models provide fundamental insight into how rainfall is converted to runoff (hydrology) and how excess flows are routed through the sewer network (or overland) to a downstream outlet—a river, the MWRDGC Tunnel and Reservoir Program (TARP) system, or a treatment plant. Combining infrastructure information with physical flow equations, H&H models can be used to estimate flood levels and duration for different storms. H&H models are frequently used to quantify the potential benefits of improvement alternatives on performance metrics like flood risk.

This component would include the creation of H&H models for all communities in the Calumet. By consolidating model construction and maintenance across numerous communities, economies of scale, which provide greater value than what any one community could do independently, can be realized. Communities that cannot afford H&H models or do not at the present time see their value can benefit from the ability to understand system response to rainfalls. H&H models provide the basis for understanding local and system response and interactions.

Differing models, or modeling approaches may be required depending on the questions driving study. As Figure 2-2 illustrates, different questions suggest different modeling approaches, which again may vary based upon the scale of analysis. During the development of the RPF, it is important to keep in mind a range of potential uses for the models, and to make decisions that maximize their applicability for the breadth of potential applications. Table 2-1 summarizes several ways the RPF can leverage H&H models (and their output) to help address specific stormwater challenges.

Table 2-1. Using RPF to Address Specific Stormwater Challenges

Stormwater Challenge	How RPF Helps
Basement backups	Increase H&H modeling coverage in Calumet Understand impacts from adjacent communities or receiving interceptors Assess opportunities for both local and regional actions to reduce/mitigate
Water quality and combined sewer overflows	Quantify overflow volumes to receiving systems, with understanding of both local and regional conveyance limitations and TARP storage potential
Prioritization of green infrastructure location	Quantify system benefits (e.g., reduced flooding, reduced CSO volume) based on individual and aggregate impact Triple-bottom-line cost-benefit analysis
Manage inflow and infiltration	Help manage monitoring data to identify leaky systems Model impact of I&I mitigation measures to prioritize areas where I&I causes the most severe problems
Private- and/or property-scale runoff control	Understand the local and regional system context Help better understand opportunities and limitations of what private interventions can achieve
Overbank flooding	Model output from overbank simulations (HEC-RAS) input into repository for increased accessibility. In its initial phases, the RPF does not target alternative analyses for overbank problems.

2.4.2.1 Modeling Platforms

Numerous H&H modeling software packages are available for modeling subsurface, open-channel, and two-dimensional drainage systems. Types of modeling software differ in their hydraulic solution scheme, interface, usability, integration with GIS, integration capability with other software, ability to store metadata and model elements (for example, the data source for specific model data like a pipe elevation invert), scenario management capabilities, licensing terms, and cost. **An H&H modeling platform review is recommended, which considers the strengths and weaknesses of different simulation software against the needs of the RPF or Calumet system user base, providing a basis for model platform selection (or combination of choices) based on a clearly defined set of needs**. The needs of smaller communities, which may not be able to afford expensive simulation software, will be a key consideration of this review. A potential outcome is that the RPF itself will be designed to be "platform agnostic" so that data can be imported to and exported from a range of simulation software. This will enable users to use or continue to apply the software of their choice, while still benefiting from the RPF.

2.4.3 Modeling Protocols

Modeling protocols are well-defined, standardized approaches for managing data, documenting modeling decisions, and performing model data development to maximize consistency among models developed by different individuals, communities, or firms. Modeling protocols provide the direction for the effective documentation and data management which H&H modeling depends upon. They should be clear and easy to follow, yet also comprehensive and specific. Specific model protocols may include the following:

- **Model development protocols.** These establish consistent norms to be applied across the Calumet and include both data management and documentation requirements as well as technical guidelines and requirements.
  - **Example data management guidelines.** Data-flagging protocol based upon source data used and notation requirements for specific model element attributes.
  - **Technical approach definition.** Recommend data sources to use for hydrologic parameters, for example, representing imperviousness and soil characteristics. Identify loss method for infiltration simulation. Define size limits for inclusion of pipes in hydraulic network. Define runoff routing method.
- **Model maintenance protocols.** Similar to model development protocols but focused on guidelines for events that may trigger a baseline model update.
- **Intermodal communication.** This protocol can be used to define connection points between subsystems that are components of the overall regional modeling framework or to define membership to one or more subsystems that may be modeled independently (with appropriate boundary conditions) or with the system as whole.

Modeling protocols are effective only if they are applied; automated testing scripts, combined with peer review, can be performed to identify variance from established protocols. **The development of modeling protocols is recommended prior to the initiation of H&H model development.**

2.4.4 Simulation Server

The output of H&H models may be of interest to RPF users who do not have time, access, or technical background to run H&H simulations. The simulation server will provide a repository of the well-documented, authoritative simulation data. The simulation server will provide select model output for previously run simulations to end users, or calling applications (for example, authorized third-party or agency applications that consume simulation results) for use.

2.4.4.1 Results Storage

Dynamic models produce large quantities of time-series data for numerous modeled variables (flow, level, Froude number, storage, pollutant concentration, etc.). Depending upon the number of modeled nodes and the duration of the simulation, time-series results data can be very data intensive. In addition, summary results are produced that represent peak, total, or average values for the simulation (peak water level, peak flow, total flow, etc.).

The simulation server will store both time-series results and summary results. Time-series data may not need to be stored for all model elements for all simulated variables. Even with data storage increasingly inexpensive, the potential volume of data may be very large, and in some cases may have limited future use. At least initially, a subset of modeled locations may be defined for storage:

- **Interface locations.** Stored flow, level, and pollutant concentration (if applicable) for all locations that are the interface between different system components. For instance, links where the community system connects to MWRDGC interceptor or drop shafts, or where community systems flow into one another, are interfaces.
- **Discharge locations.** Links or outfall nodes representing overflows to waterways or to treatment plants would store flow (and pollutant concentration if applicable).
- **Representative flood risk locations.** Water level would be stored for nodes throughout the modeled system. Depending on the level of detail of the subsystem model, this could include every modeled node, or more likely, a subset of nodes (such as the modeled drainage node).
- **Key system locations.** The modeler and others may identify other links or nodes of interest. This may include flow or level at problem areas, monitoring locations, pumps or other actively operated controls, or other locations of interest.

The types of locations described above are those most likely to be useful for anticipated “downstream” applications, and by being selective, storage requirements can be reduced by perhaps 20 to 100 times. Summary results, which are much less data intensive, could be extracted for all variables and locations in the model. In both instances, a data loader that extracts data from the model and pushes it into a structured data format would be required.

2.4.4.2 Simulation Definition Protocol

The simulation server will store model results for thousands of scenarios of interest that represent different specific assumptions or storm events for both existing and alternative/future conditions. To be discoverable and unambiguous regarding the conditions represented in each model, a simulation definition protocol will be required to clearly define stored scenarios. Table 2-2, for instance, illustrates the type of fields needed to clearly define a simulation. Some fields[1] would be expected to change frequently between simulations—for instance, different rainfall events—whereas others would generally always be the same except when evaluating alternative baseline conditions (for instance, antecedent moisture conditions or future population assumptions).

[1] “Fields” is used somewhat loosely to refer to type of stored data and should not be interpreted as an actual field on a specific table. A relational database structure will be developed to store information pertaining to a scenario.

Table 2-2. Simulation Definition Protocol Example

	Description
Rainfall	Recurrence Interval (if synthetic design event, that is, not a historical event)
	Duration (if design event)
	Climate change assumptions
	Historical period
Hydrology	Antecedent moisture conditions
	Land-use projection
TARP condition	Existing system
	2016 Thornton online
	2029 McCook Stage 2 Reservoir online
	TARP availability (full, offline)
Temporal	Historical or current (clearly identify year) or future population
	Past, planned, or future infrastructure investments
Alternative	Baseline conditions[a]
	Future land-use (e.g., 2030 development patterns)
	Green infrastructure—implementation level
	Conveyance alternative
	Storage alternative
	Integrated Solution
Boundary systems	Waterway condition
	Waterway alternative (for example, under aquatic nuisance species control)
	Includes regional system or not (subset)

[a] Baseline condition will change with time, and may include local and/or regional projects that are constructed or imminent. Any alternative condition must clearly reference the baseline condition to be used for comparison.

In addition to a scenario, a linked application (for example, a website, reporting program, or third-party tool; see Section 2.7.3 regarding third-party tools) would need to define a model element and a variable, along with a scenario identifier, to request information regarding a specific model element. The simulation server could publish a service which is called by a linked application providing required parameters through a declared interface.

2.4.4.3 Facilitate Cross-system Data Linkage

The RPF will include local H&H models that may be useful for modeling related tasks in community-scale subsystems. While the user will have the ability to simulate the entire regional system, in many instances hydraulic interactions may be limited to a few discrete connections. Boundary conditions, which represent flows and levels of linked systems that are not explicitly modeled, can be used to more realistically represent the regional system, but without the dynamic linkage between the two systems. Boundary conditions can be extracted from “interfacing locations” in the simulation server and set up as boundaries at the outlet of the modeled subsystem. This enables much faster simulation of the system of interest, and results can always be verified against simulation of the entire regional system if needed. As with many applications of the RPF, engineering judgment and system understanding will be required to make good decisions about when local subsystem modeling is appropriate; the simulation server will facilitate this process by providing boundary conditions for requested scenarios which can be integrated into the local model.

2.4.5 Infrastructure Toolkit

The infrastructure planning toolkit will provide a menu of conceptual-level stormwater alternatives, developed by the RPF user base, to improve stormwater problems at a range of spatial scales. The toolkit will provide a means for users to do the following:

- Suggest stormwater improvements
- Discover and consider suggestions made by others
- Quantitatively evaluate the benefits of an alternative against performance metrics
- Compare the benefits and cost tradeoffs of different solutions

2.4.5.1 Technology Options

The interface will enable the definition of primary technologies for system-level (local or regional, as distinguished from site scale) stormwater improvements:

- **Conveyance.** Route flows to an outlet or portion of the system with capacity to accept the flows
- **Storage.** Capture and store stormwater during the peak of a storm, releasing it back into the system when capacity is available
- **Inflow reduction.** Reduce the stress on a system by managing stormwater where it falls, via infiltration and evapotranspiration and distributed storage

Using intuitive, specialized GIS interface controls, the user will be able to define the location, type, and basic characteristics of specific technology options. In a typical instance, a user may have identified baseline conditions impairments, considered existing land-use and performance of existing infrastructure, and then developed one or more alternative components to comprise a potential solution.

2.4.5.2 Refining the Alternative

Assessing the viability of an alternative requires detailed consideration of site constraints, existing system geometry, and engineering best practices. A modeler/engineer will need to review proposed alternatives and develop the geometry details required for modeling, for example:

- **Conveyance.** Confirmation of pipe geometry, invert elevations, pipe slope, and connection details to existing infrastructure
- **Storage.** Tank geometry, invert elevation, dewatering approach, connection details to existing infrastructure
- **Green infrastructure inflow reduction.** Amount of impervious area managed, type of green infrastructure, broad-scale sizing characteristics (for example, depth of stone layer under bioswale or permeable pavement), and under-drain assumptions tying back to the sewer network

The modeler will develop and test several options and define the best working alternative configuration (or multiple potential solutions). These are still conceptual-level alternatives that are not based upon survey, may not consider all potential utility considerations, and are not thoroughly reviewed by an engineer. However, with this degree of information applied in a model, the system impacts of the alternative can be assessed for different storms or conditions of interest.

The modeler will store the alternative component as an alternative configuration file. The detailed alternative configuration will be identified in the RPF and is a prerequisite for simulating the solution through the RPF.

2.4.5.3 Simulating Alternatives

Simulations can be defined using a scenario definition (Section 2.4.4.2), or a family of runs (for example, storms of ranging magnitudes) and an alternative configuration. There are several options for how the simulation is actually performed, with differing complications to implement and benefits to the user. As the RPF is defined, these will be further reviewed and tested to determine the best approach, but the following will be considered:

- **Modeler simulation.** Once defined, the alternative simulation is queued for simulation and a modeler actually creates the simulation, executes it, and runs a data loader to push the results to the simulation server
- **Automated execution.** A simulation is automatically generated using the modeling software's application programming interface and executed on RPF dedicated resources, on the user's machine, or in the cloud

2.4.6 Interactive Mapping Application

The interactive mapping application is a geospatial, interactive map that supports visualizing model output in its geographic context, summarizing existing conditions' performance metrics in an informative and visually compelling manner, and helping users understand and evaluate tradeoffs between different performance objectives. **The mapping application enables the user to ask and answer questions about the system of interest, informed by the best available underlying data and modeling**. It includes at minimum the following components:

- **Authentication.** A mechanism for identifying a user, organization affiliation(s), and level of access to different types of model output by geography
- **Mapping engine.** This displays geographic information in a zoom-able, context-driven environment. Alternative mapping engines, such as ESRI, Google Earth, WebGL, and open source alternatives, will be evaluated for functionality and licensing requirements. Model output and infrastructure features will be pulled from GIS data layers, web services, or the simulation server
- **Scenario selector.** A form or toolbar for selecting a scenario of interest
- **Infrastructure toolkit.** Identifies conveyance, storage, and inflow reduction alternatives, including green stormwater management infrastructure options. These elements are geographically specific and include sizing information. By selecting specific combinations of alternative technologies, the user can select pre-run simulations that include these technologies. If the simulation has not been run previously, it can be identified and queued for later simulation. Some degree of simulation automation may be possible; however, this involves numerous complications. For the first incarnation of the map a manual, discontinuous (for example, the results will not appear immediately) process is envisioned.
- **Visualization options for performance metrics.** Predefined mapping themes will be defined that are linked to specific performance metrics. Users will be able to define one or more theme to display. Of particular interest may be the ability to automatically compare performance metrics (for example, flood risk) under alternative conditions versus a selected baseline condition.

The mapper is the interface for users to interact with the Calumet system, and to explore performance under a range of hypothetical future scenarios. Flood risk, water quality, and environmental benefits will be displayed in their system context, and provide a vehicle for discussion of pros and cons of different intervention strategies, informed by the most current and accurate technical analysis. The mapper will be highly scale sensitive, providing relevant information in a manner that is intelligible to users with a range of technical backgrounds. Figure 2-3 is a mock-up of a potential mapping interface.

The mapping application will help users understand how upstream and downstream systems affect their community (or spatial extent of interest), enabling a more complete understanding of how the regional system provides flooding relief or, potentially, may limit the effectiveness of other interventions. Similarly, the mapping application can help to show visually the aggregate impact of local interventions on regional system performance. The mapping application will thus reflect the goal of the RPF as a whole, aiding in understanding of local system performance by placing it in the regional context. Design and development of the application will focus on highlighting tradeoffs of costs and benefits associated with alternative solution strategies.

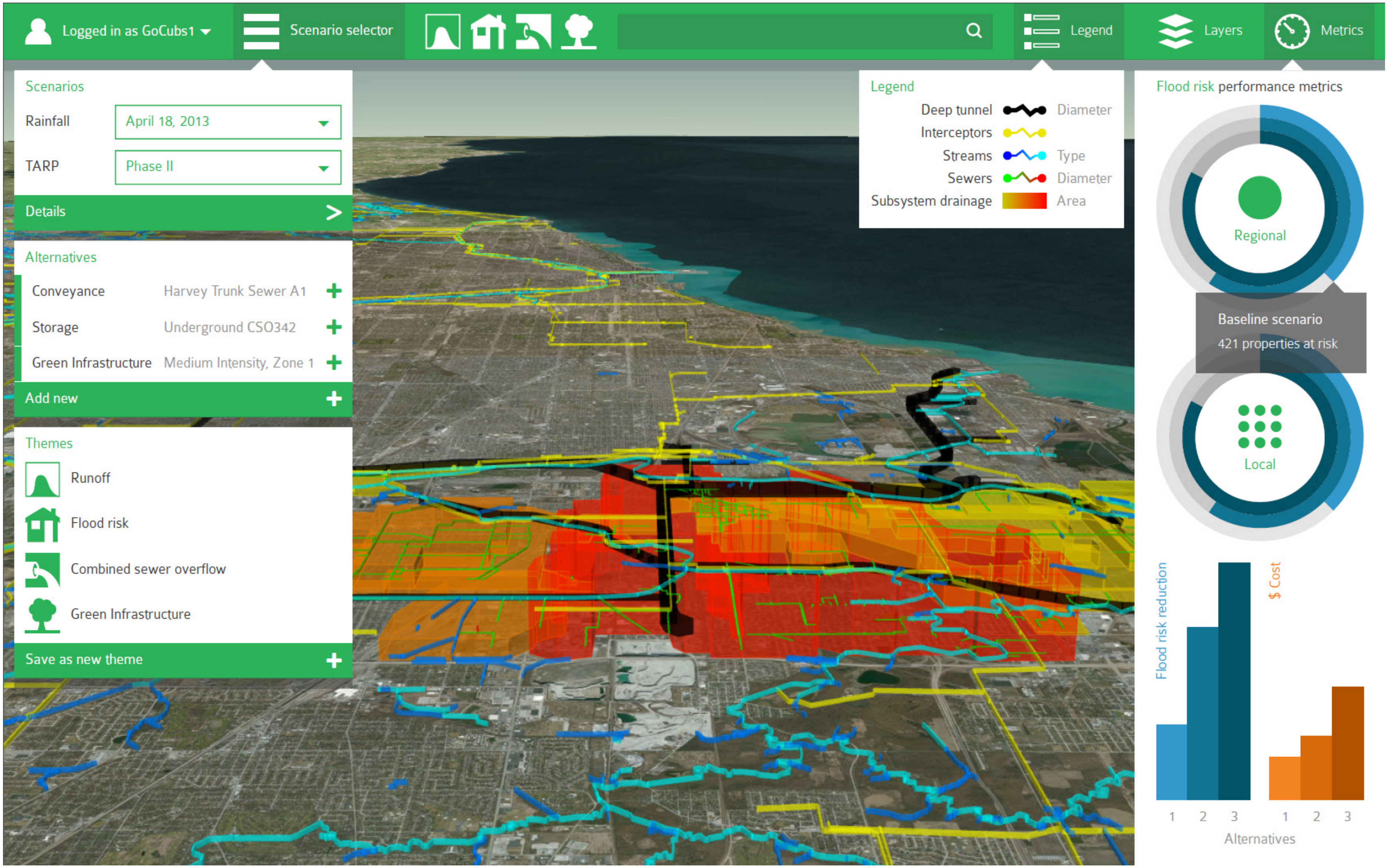

Figure 2-3. Mock-up of Interactive Mapping Application

2.5 Workflows

The RPF will be developed to maximize benefits for a range of users, focusing on the following primary goals (repeated from Section 2.3.1):

- Extend H&H modeling coverage to smaller communities
- Facilitate linkage of H&H models across jurisdictions (using the Calumet as an example)
- Enable local planners to make decisions with knowledge of regional constraints and opportunities
- Enable regional planners to prioritize local projects, and to understand aggregate impact of local projects on regional performance

The diversity of potential users, scales, and uses of the RPF presents a challenge; identifying primary supported-use cases is a means of constraining possible functionality to meet the most immediate application needs. The workflows in this section help with this task by conceptualizing specific ways that different types of users will engage with the RPF either to build the foundational knowledge it is based upon or to make decisions on the basis of outputs from the RPF.

User categories (Section 2.5.1) provide a high-level generalization of the different needs and requirements of key types of user. High-level conceptual workflows that provide a "big picture" view of how the RPF may be employed are then presented. Section 2.5.2 then focuses on specific actions required to develop and load needed information into the RPF. Finally, Section 2.5.3 provides greater detail on potential steps involved in using the RPF to answer more specific questions.

2.5.1 User Categories

A range of users will interact with the RPF. Table 2-3 outlines three types.

Table 2-3. User Categories for Regional Planning Framework

	Engineer/Modeler	**Public Works or Planning Director**	**Decision Maker**
Primary question(s)	How can I use available data and tools to best estimate the impacts of a range of stormwater control measures?	What measures can effectively eliminate repeated flooding complaints and maintenance issues in my community?	Which solution meets one or more stormwater objectives cost effectively? How reliable is the solution?
Benefit from RPF	Quickly identify extant modeling Extract regional system boundary conditions to understand limitations of local improvements Efficiently process model output into meaningful information	Can view range of potential solutions Has means of submitting ideas or concepts for inclusion in simulation Quantify cumulative benefit of solutions (grey and green)	Compare performance criteria for alternatives in geospatial setting Visually review flooding risk information Compare benefits of range of levels of investment Allocate limited funds to most cost-effective projects
Contribution to RPF	High-value model simulations[a] loaded into simulation server library	Local, on-the-ground knowledge Understanding of operational and maintenance challenges	Aid in defining key factors to include in performance scoring

[a] "High-value" in this context means potentially of interest to other users. In general, modelers look at many intermediate solutions, many of which are not of general interest once the number of potential alternatives is reduced.

Others will benefit, even if they do not interact with the RPF directly. For example, members of the public and community organizations are not included in Table 2-3, as they will not have direct access to the RPF, since it is oriented towards planning needs rather than outreach. The public will benefit indirectly from the above cases, and may also provide an important data source regarding the extent and frequency of flooding, opportunities for interventions on private property, or neighborhood/community-scale knowledge regarding project feasibility.

2.5.2 Example High-level Workflows

Figures 2-4 and 2-5 document two example high-level workflows showing specific ways that different users may collaborate, aided by the RPF, to develop, prioritize, and select effective stormwater solutions. In subsequent sections, a more detailed consideration of user workflows is explored.

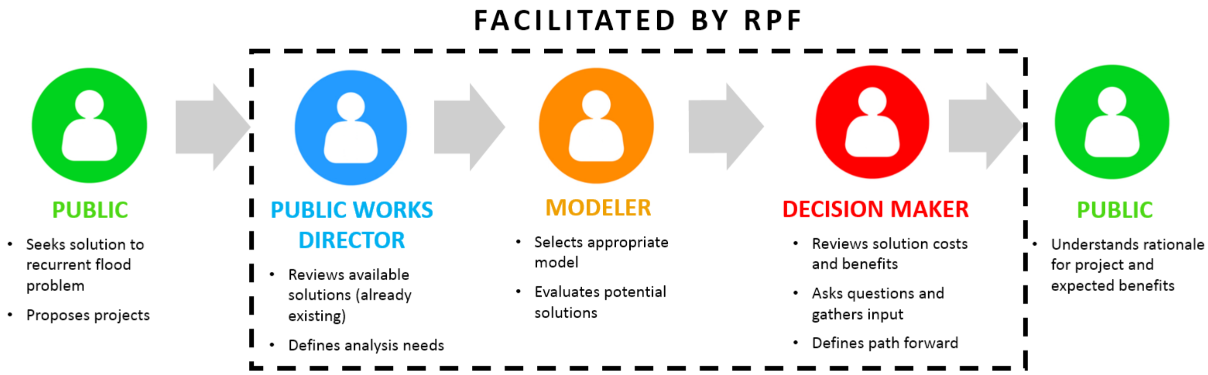

Figure 2-4. Using the RPF to Address Concern from Member of Public

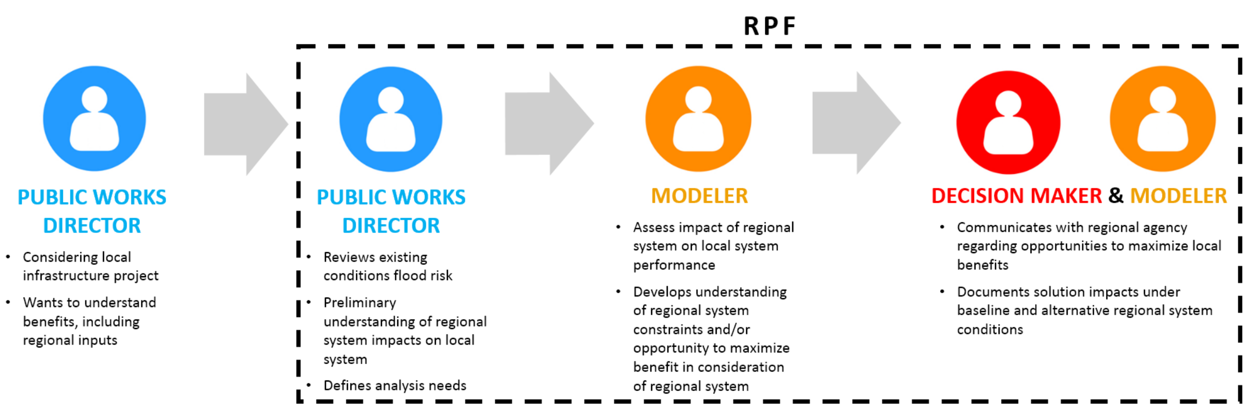

Figure 2-5. Using the RPF to Address Community Technical Concern

2.5.3 Data Development and Maintenance Workflows

The data development and maintenance workflows are required for populating the application with useful data. Where possible, this will be proposed as part of standard agency/owner modeling tasks; the additional effort is to extract model results and load them into the simulation server. It is anticipated that a large number of simulations will be processed to populate the database initially; automation should be used to the extent practicable for this purpose.

2.5.3.1 Baseline Model Data Load for Simulation Server

The RPF will draw upon large quantities of modeling output from baseline conditions H&H models. Table 2-4 outlines key steps involved in loading these data into the RPF.

Table 2-4. Workflow for Loading Baseline Model Data

Step	Label	Description
1	Select scenarios	Identify baseline condition scenarios of interest. This is likely to include a range of design storms and/or historical storms of interest
2	Perform model simulations	Run simulations. Batch processes or automation may be used to increase efficiency
3	Postprocessing	Postprocess model output to quantify selected metrics
4	Documentation	Document metadata about scenarios and notable findings
5	Results validation and review	Combination of peer review and automated scripts to validate results, compare differences to previous simulations, etc.
6	Data load to server	Run data loader to push model results to simulation server
7	Refresh inventory	Update simulation inventory (automatic) to make available for future users

2.5.3.2 Alternative Model Data Load for Simulation Server

A primary use of the RPF is to facilitate the evaluation of alternative conditions H&H models, as described in Table 2-5.

Table 2-5. Workflow for Loading Alternative Conditions Model Data

Step	Label	Description
1	Identify objectives	Discuss with stakeholders target goals for alternative and level of effort expected
2	Develop concepts	Develop conceptual level alternatives
3	Alternative testing	Test potential alternatives and make sizing adjustments using engineering judgment to maximize performance
4	Alternative simulation	Run simulations. Batch processes or automation may be used to increase efficiency
5	Postprocessing	Postprocess model output to quantify selected metrics
6	Documentation	Document metadata about scenarios and notable findings
7	Results validation and review	Combination of peer review and automated scripts to validate results, compare differences to baseline conditions
8	Data load to server	Run data loader to push model results to simulation server
9	Refresh inventory	Update simulation inventory (automatic) to make available for future users

2.5.3.3 Model Data Updated Based on System Improvement

Maintenance of model’s data is essential to keep up with system modifications and improvement. Table 2-6 outlines the key steps involved in ensuring that accurate, up-to-date information is included in the simulation server.

Table 2-6. Workflow for Model Maintenance

Step	Label	Description
1	Trigger update	Identify need for update based upon trigger (for example, date of year, major project complete)
2	Obtain and review data	Coordinate with municipality or agency to obtain updated information
3	Model update	Add or update model updates to represent altered system condition
4	Workflow 2.3.3.1	Run applicable steps in previously defined workflow
5	Deprecate superseded model	Update metadata regarding previous scenario

2.5.4 User Workflows

2.5.4.1 Technical User 1: Simulating Local System Alternatives

Engineers and modelers interested in developing community-scale solutions can apply the RPF to understand alternative conditions local system performance in the regional context, as described in Table 2-7.

Table 2-7. Workflow for Local System Analysis

Step	Label	Description
1	Extract local model	Run script to automatically extract a local system model based upon model element classification/flagging.
2	Boundary condition definition	Retrieve time-series boundary condition information from regional modeling and insert into input model file(s)
3	Inventory and model setup validation	Review local system model to ensure extents and data values are reasonable
4	Baseline simulations	Simulate baseline conditions, to provide point of comparison
5	Alternative evaluation workflow	Complete steps 1–9 of Table 2-5
6	Regional system confirmation	If applicable, confirm alternative condition performance in the whole system model

2.5.4.2 Technical User 2: Assessing Regional System Performance

The RPF will include a suite of value-adding tools that increases the efficiency of data-intensive model postprocessing tasks. Therefore, by applying the RPF, even agencies that already have significant modeling capacities can benefit from services and tools included in the RPF. Table 2-8 summarizes one way such users may choose to engage the RPF.

Table 2-8. Workflow for Regional System Performance Comparison

Step	Label	Description
1	Select and review scenarios	Select two scenarios of interest for comparison. If a scenario has not yet been evaluated, perform the workflow in Section 2.5.2.1 or 2.5.3.2 to produce scenarios
2	Compare regional system scenarios	Run the built-in scenario comparison tool, which leverages the structured data format of the simulation server to compare differences in model output
3	Visualize performance metrics and differences	Apply one or more predefined themes to symbolize differences geospatially
4	Subsequent analysis	Based upon the findings in steps 2 and 3, the user may decide to evaluate additional regional baseline or alternative conditions

2.6 Security, Data Sharing, and Access

The RPF will build upon existing and yet-to-be-developed data and models, some of which are open, others of which are proprietary. **To be a relevant, buy-in from key agencies will be required**. That is, the benefits to agencies of participation in the RPF must outweigh the risks or perceived risks from increased data sharing. Acknowledging that agencies may have different levels of comfort or willingness to share data with impacted stakeholders, or incentives to do so, the RPF must provide means to provide acceptable levels of control of data flow to end-users.

Potential objections to sharing data may include the following:

- **Sensitive information.** Data may include sensitive information that the agency does not wish to disseminate, such as location of critical infrastructure, flood risk, or other information
- **Concern of misapplication.** Data may require specific expertise to be applied properly, and the agency may wish to limit potential misinterpretation of data

Recognizing that agencies may wish to limit control of certain types of data, the RPF acknowledges data security as a key requirement. Following are two approaches to mitigating potential data-sharing concerns:

- **Levels of access.** Users will be assigned membership to specific categories that will have access privileges to specific types of data and models. Some user groups may need access only to high-level, summary performance metrics; others may need access to specific flood risk data, direct model output, or the underlying models themselves.
- **Modeling data server.** Agencies may wish to limit the circulation of models of their system, which may contain sensitive or proprietary information. Of course, some sharing, as already takes place between agencies, is needed to answer agency-specific questions. The simulation server will provide a means for users who do not have access to the actual regional model, or perhaps the expertise or software to apply it, to gain the benefits from the library of archived simulation results. Users (with proper rights) will be able to access time-varying model results, and use as the boundary conditions for their more localized models, thus gaining the benefits of the RPF without the need to access the regional model directly.

Concerns associated with data sharing are real, and the RPF will provide a structured, secure means of managing and accessing sensitive data. Authenticated user accounts belonging to specific group memberships will provide a means of enabling users who need higher levels of access to underlying data or models to obtain it. Of course, the cooperation and support of Collaborative members—particularly those sharing models and proprietary data is critical. Working closely with these groups will be critical to defining a process that benefits users, and the agencies (who may be users as well).

2.7 Building upon the RPF

The preceding workflows and concepts outline core elements of the RPF and center on H&H models (some existing, some proposed for construction) of the drainage infrastructure of the Calumet. There are, of course, many other features which could be integrated into such a modeling framework. The following are briefly described, primarily to identify key underlying concepts that could be incorporated into the RPF once the core concepts are built and proven. Importantly, the RPF provides a basic modeling and data management infrastructure that enables this kind of extensibility of new applications/modules that build upon core RPF functionality. The RPF, in this way, becomes a basic toolkit that users and collaborators can leverage to help answer new questions as they emerge.

2.7.1 Collaborative Modeling

Collaborative modeling is a modeling approach and structured process that emphasizes the importance of participation of a variety of stakeholders in the definition of modeling objectives, as well as informing decisions regarding modeling approach that may affect the usefulness of the model. This does not require modeling expertise of all participants. Rather, it enables stakeholders with a broad range of backgrounds and interests to understand key aspects of how available data is used to construct models, as well as understanding the applicability and limitations of such models. Collaborative modeling is a means for achieving buy-in into a technical framework, thus providing increased acceptance of results produced by the tools.

2.7.2 Crowdsourcing Change

Local residents, community members, and stakeholders have intimate knowledge of local conditions, opportunities, and stormwater problems. An interactive, GIS-based “crowd-sourcing” map (a specific view of the RPF) could provide opportunities to harvest this knowledge in a structured manner to complement the RPF. Specific types of knowledge that could be gained include the following:

- Flood extent and depth information for specific storm events
- Observations regarding high-water marks, road overtopping, or other information
- Identification of potential green infrastructure projects
- Identifications of variation between model prediction and observations
- Notification of maintenance needs or infrastructure impairment or failure which may contribute to flooding

2.7.3 Third-party Tools

Users and institutions may wish to develop customized tools that address either a specific question, or a specific subgeography within the Calumet. The RPF can facilitate this type of “stormwater app” development in several ways:

- Serving the most up to date model output data
- Providing accessible value-adding tools (for example, scenario management, rainfall generators, postprocessing functions)
- Helping to visualize data/output generated by the third-party tool

- Providing an avenue for incorporating data from approved third-party apps, thus making the data accessible to other decision makers

The combination of the RPF along with custom applications (that is, third-party tools) developed by an active, engaged user base would create an integrated stormwater management planning ecosystem; data, expertise, and technical processes are transferred between the RPF and linked applications. The RPF provides a set of modeling and data management protocols that can be leveraged by a more nimble set of custom applications that meshes RPF data with other data sets. An Application Programming Interface (means for an external app to automatically call RPF functions and reference datasets) would be a necessary component of the RPF so that the third-party custom apps can retrieve the needed datasets from the simulation server.

Third-party tools can be developed that help specific audiences engage with specific stormwater management questions. Examples spanning two different spatial scales are described in Table 2-9. While the RPF focuses on how the RPF could help this type of application, RPF users could also benefit from information flow in the opposite direction: that is, What is the aggregate impact of lot-scale or neighborhood-scale interventions on local and regional systems?

Table 2-9. Example Third-party Tools using RPF

Potential Third-party Tool	Tool Objective	Value of RPF
Community Engagement at Neighborhood Scale	Understand impact of neighborhood-scale interventions on reducing adverse stormwater impacts Understand performance and cost tradeoffs between alternatives	Provide best available information regarding local and regional sewer system performance for specific storms
Private Property Retrofits at Site Scale	Identify site-scale stormwater improvements Quantify runoff impacts into sewer system Understand anticipated benefits of site-scale interventions	Provide means of quantifying impact of runoff reduction on system (e.g., overflows, flooding) Help understand constraints to private scale interventions (e.g., system deficiencies which will maintain risk even with site-scale improvement)

2.7.4 Dynamic Systems Analysis

Dynamic systems analysis evaluates quantitative relationships between diverse system elements to understand holistic system performance, as well as how variation in performance or operation of one component of a system affects other elements, or the system as a whole. This can be powerful when considering diverse system elements that either cannot be simulated in a common platform or result in prohibitively complex modeling architecture to assess in complete detail. In general, relationships are simplified in comparison to an H&H model; instead of solving hydraulic equations, dynamic simulation models generally depend upon simplified mathematical relationships, as well as referencing the results of previously simulated H&H model runs and other kinds of model results. For example, stormwater may enter a collection system, be diverted to a wetland pond, provide watershed habitat benefits and reduce flooding potential. A hydraulic model for collection system, a separate stream channel model, water balance for wetlands, and bioenergetics for wetlands fauna might be needed to assess all system elements. These elements may operate on different time scales of concern—flooding is short-term and habitat impacts are long term effects. Creating a common, simplified platform to evaluate alternatives and exchange important dynamic relationships between elements can be beneficial.

A benefit to dynamic simulation is the ability to explore and visualize potential alternatives in real time. Furthermore, the weighting assigned to performance metrics can be modified to reflect different stakeholder priorities, providing a means of understanding the perspectives of the range of stakeholders, and negotiating differences in values in a context that is informed by overall system performance. Depending upon the need for real-time, quantitative demonstration of linkages between system elements, the interactive mapping application may provide a dynamic simulation view to be considered.

2.7.5 Optimization

Optimization is the application of algorithms to drive a solution search to identify robust, cost-effective solutions that meet overall system goals. Because drainage systems are hydraulically linked, combinations of solutions can perform differently than their component parts. Key performance metrics (including cost) are aggregated into an overall objective function (or defined as multiple objectives, if multi-objective algorithms are used). Optimization, similar to dynamic simulation, enables an exploration of how different solutions perform against multiple, sometimes competing objectives.

Optimization has the potential to provide great value to the Collaborative, but depends first on the development of accurate models or planning tools. Furthermore, it requires definition of performance objectives, as well as alternative improvement options to be considered by the algorithm. Therefore, it is recommended as a future improvement to the RPF once core elements are developed. The definition and refinement of performance metrics, defined in Section 4, and the development of H&H models (Section 4.2) will be key inputs to the optimization process.

2.7.6 Costing Toolkit

Cost estimates are critical for comparing and prioritizing alternatives; the benefit-cost ratio is often used for comparison (which of course depends on the metrics used to define benefits). Cost estimation is a complicated endeavor itself; to simplify, we can identify several standard cost components- the capital cost, operations and maintenance cost, and sometimes replacement cost. Land-acquisition costs are often required, as well as mobilization, engineering and design costs, and construction management.

Different levels of detail of cost-estimate exist, and these typically vary based upon how much is known about a potential project. Effort to define an acceptable cost-estimating approach will require collaboration to establish and document at the onset of the RPF development.

2.8 Feasibility

Sections 2.1 through 2.5 outline a framework for integrating regional stormwater planning to enable an increased, systemic understanding of stormwater problems and solutions at a range of scales and across jurisdictional and system boundaries. We propose a toolset to increase the efficiency and power of scenario comparisons, and a mapping viewer to present scale-sensitive modeled flood risk and alternative performance data to users spanning a range of technical expertise. While these seem like useful and beneficial capabilities to add to our collective wet-weather understanding throughout the Calumet, they will prove useful only if this can be feasibly implemented, at a cost that is reasonable in comparison with the toolset's benefits. In this section, the feasibility of the RPF is evaluated.

A good first question to ask when encountering a good-sounding but novel idea is, What comparable systems exist? And if none exist, why not? This question is helpful not because we can never advance beyond previous achievements, but because there are often reasonable explanations for why such an idea has not progressed to implementation before. We ask that question now of the RPF. Before addressing this question directly, we first consider whether technical, financial, or political/institutional resources needed for the RPF are barriers to its completion.

2.8.1 Technical Resources

Technical requirements of the RPF include primarily information technology and hydraulic modeling:

- **Information technology.** The RPF will require the storage and retrieval of large amounts of simulation data. The interactive mapping viewer provides an interface for simulation output, and baseline and alternative performance criteria. While there are numerous challenges to hosting, making accessible, and presenting this information intuitively to a broad user base, this is technically feasible; many websites or applications provide graceful solutions to serving large quantities of data in an easy-to-use manner. The skillset required to construct such a solution is distinct from that of modeling, but widely available.
- **Hydraulic modeling.** Developing standards of information flow and local-model extraction from an overall system model will required advanced understanding of essentially the range of existing and potential uses of H&H models to be supported by the RPF. During the use/application phase, the RPF will not make significant additional modeling demands on the user; indeed, it should aid modeling efforts. However, additional data management effort will be needed to make model data and output discoverable and retrievable by other, future users. The modeling protocols will define the data management approaches to support this functionality. Based upon experience, there is a need for some level of oversight and validation that such protocols are followed; otherwise, priority may be given to alternative modeling tasks.

The technical requirements of the RPF do not appear to be barriers to implementing the RPF. However, both technical components, but particularly the IT component, will need an initial investment to support initial construction of the system (touched upon further in Sections 2.8.2 and 2.8.3).

2.8.2 Financial Resources

Significant investment is required to build the RPF data system, component tools, and interactive mapping viewer. It is beyond the scope of this effort to estimate the cost of the RPF, which depends on details that are not yet defined. For purposes of estimation, it is likely that such an effort is on the order of magnitude of $1 million, as opposed to $100,000 or $10 million. That said, investment in H&H modeling and alternatives analysis in Cook County has surely been nearer $10 million over the last 8–10 years. The cost of developing the RPF is therefore significant but not unreasonable in comparison with the cost of recent and/or ongoing modeling efforts. The RPF is scalable, and specific components could be prioritized based upon desired functionality and near-term planning needs. Opportunities for integrating RPF advancement with other modeling efforts should also be explored. As the technical components of the RPF are further developed, it will be possible to more accurately estimate the cost to develop it.

Once constructed, there would be a cost to maintain the system, and additional fees for modeling studies to comply with the RPF data needs. This cost is not known at this time, and may vary by the type of modeling study, but is estimated at 7–10 percent of the cost of a modeling effort itself (for example, an engineering firm was performing a modeling study costing $100,000, an addition $7,000 to $10,000 to comply with the modeling protocol and participate in the RPF). Once constructed, the RPF will provide substantial opportunity for cost savings, due to both superior project selection and synergies across projects, and increased efficiency for analysis and results communication.

The financial costs of the RPF are significant but not a barrier to implementation. The most significant outlay would be for the initial development of the system. The cost of the RPF is likely to be relatively small in relation to cost of creating the primary information (for example, H&H models).

2.8.3 Institutional Cooperation

Agencies and/or municipalities may have reservations about sharing models, data, or simulation results (see Section 2.6 for a discussion of security and data access concerns). Note that currently, many agencies operating in the Calumet already share models and model data, recognizing the benefits of having these kinds of representations of systems that impact their own. Intergovernmental agreements that govern the sharing and use of shared data already exist. Therefore, it is clear that an institutional basis for the sharing of data between agencies already exists. At present, this sharing occurs more on an ad hoc, as-needed basis. The RPF would facilitate more systematic methods for such sharing to occur between authorized parties.

2.8.4 Miscellaneous Challenges

Table 2-10 outlines several other potential challenges to the implementation of the RPF, and factors that may mitigate each challenge.

Table 2-10. Miscellaneous Challenges to Implementing the RPF

Challenge	Mitigating Factor
RPF risks failure by trying to be too many things to too many people	It is critical that the team developing the RPF clearly delineate a boundary between what tasks the RPF supports and what is done by users of in outside applications
Diverts attention from core analysis tasks	An objective of the RPF is, on the contrary, to provide clear processes and protocols for data management and modeling to enable greater focus on core effort.
Models available will not be sufficient for all modeling needs	This is true; in some cases more-detailed models or alternative methods will be needed. The RPF will not attempt to serve all potential modeling needs. The RPF may provide important boundary conditions for such approaches, and/or processes or data that support such needs.
Models will become outdated	As built and natural systems change, models will become outdated, with or without the RPF. By integrating standardized processes and modeling workflows, updated models can efficiently be reevaluated to update performance criteria.
Timing of model updates across systems may not be aligned	This is a subtle but important issue (and one that exists without the RPF as well). One community or agency may be implementing changes to a system that are dependent upon a system affected by changes being considered by another community, however each project is on a distinct time schedule. The RPF and the Collaborative both provide means of communicating to maximize the opportunity for integrated planning of projects.
Agencies and municipalities may not buy into system	If this is true, there is no mitigating factor. Buy-in of key agencies and representative communities should be established prior to project inception.
Communities may not have money to enact better stormwater solutions	The RPF will strive to provide H&H models in communities where they do not yet exist. This will enable comparison of project benefits and the ability to define the most cost-effective solution- or to eliminate projects that are not beneficial due to downstream, regional system limits.
Modelers may not buy into system	The RPF will strive to provide processes that aid modelers' workflows and work products. The goal of the RPF will be to clearly demonstrate the value of the RPF to more efficiently achieve better modeling outcomes.

2.8.5 Assessment of Feasibility

Having given these matters consideration, we return to the question, Why don't we have such a framework/toolset now? While many factors may contribute, likely two primary factors are the evolution of underlying capacity and the issue of scope of concern:

- **Evolution of underlying capacity.** There has been a significant increase in the availability of H&H models throughout the greater Chicago area over the past 8–10 years. The Chicago combined sewer trunk sewer model and the MWRDGC TARP system model are two examples. Prior to having these system-scale models available, implementing the RPF would have required a very significant base model development effort. The availability of high-quality models means the task is largely to integrate, add detail, or extend existing models. Thus, we have just recently reached a point where the RPF can be achieved with a lower degree of effort by capitalizing on the region's existing models.
- **Scope of concern.** Agencies will generally seek to develop the most cost-effective modeling or analysis approach to address a specific need or anticipated need. However, the agency may not be aware of other potential uses for such a model by other municipalities or agencies. The RPF is generally not the most efficient way to answer specific stormwater questions, but by expanding the scope of concern to include benefits for other potential users or communities, more optimal solutions for the system as a whole may be identified.

These primary factors intersect with a growth in awareness of stormwater challenges and solutions. There is increasing awareness of the costs of stormwater problems and basement backups across the Calumet. At the same time, there is an increased value placed upon the health and quality of our waterways and their ability to support a range of uses. Finally, there is a growing appreciation that, just as the source of stormwater is distributed across impervious surfaces throughout the watershed, solutions may need to involve distributed measures that help manage stormwater while providing community benefits.

In the Calumet, there is a convergence between the underlying technical capacity and increased awareness and concern with stormwater problems. To move beyond 'problem-specific' or 'community/sub-system specific' approaches (addressing the 'scope of concern' challenge), a broader perspective that seeks to maximize both local and regional system understanding, and the interplay between the two, is needed. **The RPF is a proposal to build upon the strong foundations of H&H modeling throughout the Calumet to take a more comprehensive view of the Calumet combined sewer drainage system. This is a feasible effort; no technical, financial, or institutional barriers have been identified. This is not to say the task is straightforward; indeed, the RPF is a departure from "business as usual" and will require innovative thinking and meaningful collaboration from numerous actors to develop, apply, and continue to evolve the RPF**.

Stormwater Planning Tools and the Regional Planning Framework in the Calumet

In this section we consider how the suite of RPF capabilities (outlined in Section 2) could augment existing practices in the Calumet. Since what models are and how they are used are not commonly understood, we begin with a general overview of what models are, how they are used, and what the input/output data for different types of models are. Then, in Section 3.2, we discuss existing practices in the Calumet, covering both GIS data sources and models used by a range of agencies.

Considering the existing state of practices in the Calumet and the availability of baseline models is important for evaluating the potential benefits of the RPF in the future. It is important to recognize that the RPF itself is not a solution, just as much as development of the RPF is not an endpoint. Instead, the RPF is a technical framework that, when combined with an engaged user base and clear, specific objectives, can facilitate more informed, transparent, and ultimately cost-effective decision making for stormwater management. Therefore, this section can be thought of as a first look at how current practices in the Calumet can intersect with planned functionalities of the RPF to provide a better platform for stormwater decision making.

3.1 Modeling Tools Overview

The quantity of stormwater generated and its potential impacts—both positive and negative—depend on a complex interaction between the built and natural environments. Models are tools that help understand how this wet-weather system responds to a range of rainfall events. Figure 3-1 shows key elements of the drainage system in combined-sewered areas of the Collaborative. Other areas of the Collaborative contain dual drainage, or separate systems, one for stormwater drainage to the streams and the other designed to convey sewage to the wastewater treatment facilities.

Decision makers, of course, are not simply interested in understanding the performance of a current, suboptimal condition. Rather, they seek to make informed, science-based decisions about how to maximize benefits and reduce damages associated with stormwater. Models help to explore these alternative conditions. They represent, with higher or lower level of detail, the physical system, as well as the physics of water as it is routed through the drainage system. The usefulness of a model depends on both its accuracy at representing the processes governing runoff production and flow in the system and the ability to modify the infrastructure and/or assumptions of the model to evaluate the performance of hypothetical alternative conditions. As George E. P. Box once stated, “all models are wrong, some models are useful.” While seemingly pessimistic on the surface, this quotation underscores an important point about models: they are simplifications of complex systems; indeed, it is these simplifications which make them useful. The modeler’s task is to understand which models are applicable in different situations, and how and to what extent simplifications affect the model’s applicability in a specific context, and then to apply the model and interpret its output to support stormwater investment decisions.

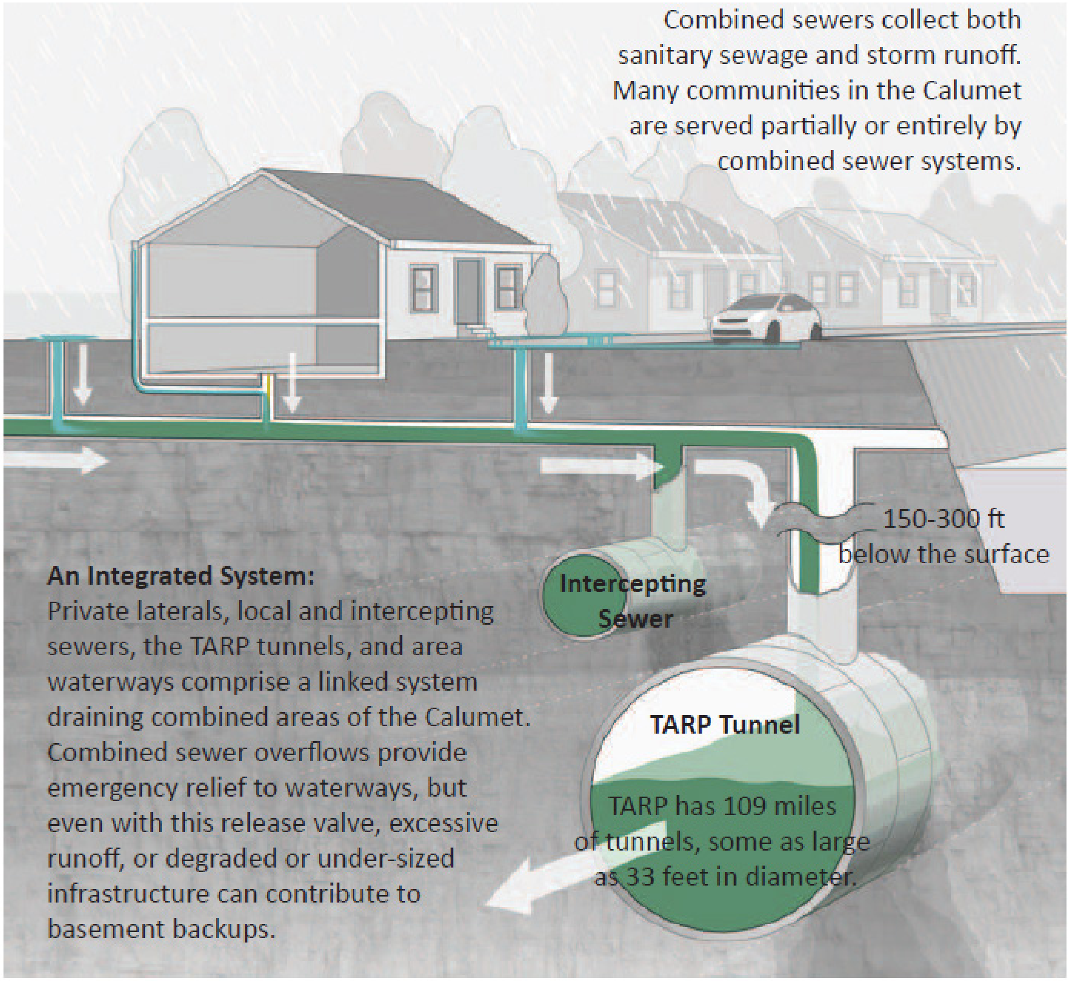

Figure 3-1. Schematic of a Drainage System

Adapted from the Metropolitan Water Reclamation District of Greater Chicago's (MWRDGC's) "Understanding Your Sewer" presentation.

A large number of stormwater models (referred to simply as models throughout this report) and modeling approaches exist. An appropriate modeling approach depends upon the questions which motivate the study of a system. Key considerations include the following:

- **Motivation.** What kinds of questions do you need to answer?
- **Scale (spatial and temporal).** Block, neighborhood, community, watershed? What level of detail in the output is needed to support decision making?
- **Input data requirements.** Are the data needed for the model available? These may include infrastructure (sewers, canals, pumping stations), topography, land use, and many other data
- **System interactions.** What other systems affect the performance of the system in question? How can they be represented to simulate impact on this system?
- **Assumptions.** What assumptions are built into the modeling methodology? Are they applicable?
- **Resources.** What quantity of time and expertise are required to apply the model? What are the long-term needs for maintenance and update of the model?

3.1.1 Stormwater Planning Tool Categories

A wide variety of tools and models exist to help with aspects of stormwater planning; their variety is indicative of the diverse disciplines and activities underlying stormwater management. The breadth of tools can be confusing to those without direct experience using them; for example, what is the difference between a fully dynamic H&H model and a steady state runoff calculator? How does the output from an alternatives analysis based upon H&H modeling differ from desktop calculators that are much easier to apply? This report identifies some distinctions between these approaches. Table 3-1 begins with a high-level definition of different modeling categories.

Table 3-1. General Stormwater Planning Tool Categories

	Model Input Requirement				
Tool Category	**Rainfall**	**Land Surface**	**Sewer Network**	**At-risk Assets**	**Solution**
Generalized project modeling	Y	Y	N	N	Y
Generalized watershed modeling	Y	Y	N	N	N
Hydrologic modeling	Y	Y	N	N	N
Hydraulic modeling		Y	Y	N	N
Hydrologic and hydraulic modeling	Y	Y	Y	N	N
Hydrologic and water quality modeling	Y	Y	N	N	N
Mapping and data visualization	N	Y	Y	N	N
Preliminary design	Y	Y	N	N	Y
Regulatory compliance	N	N	Y	N	Y
Triple bottom line	N	N	N	Y	Y
Costing	N	N	N	N	Y

3.1.1.1 Key Modeling Concepts

The following is an abbreviated list of some terms that frequently arise in the stormwater modeling literature. They are important concepts to keep in mind when evaluating modeling tools:

- **Hydrologic model.** Model representing land-surface runoff response to rainfall (for example, the Environmental Protection Agency's Storm Water Management Model (SWMM) Runoff model)
- **Hydraulic model.** Model representing the physical flow of water through a network of pipes and channels (often referred to as a system)
- **Loss method.** Approach for representing infiltration losses to subsurface (for example, Horton, Green-Ampt, and Curve Number are distinct approaches for representing the rate and quantity of water lost to the subsurface)
- **Open-channel flow.** Flow in streams and rivers (nonpressurized except sometimes at structures).
- **One-dimensional flow.** Flow assumption that all flow momentum is in one direction. Energy losses from two-dimensional effects are generally represented with empirical coefficients. Most models of the Calumet system are one-dimensional models.
- **Routing (hydrologic).** Method for simulating water conveyance that does not represent hydraulics (for example, Muskingum method).
- **Routing (hydraulic).** Hydraulic method for simulating flow through a system based upon numeric approximation of the Saint-Venant equations (physical equations representing open-channel flow).

- **Runoff volume.** Volume of excess rainfall (rainfall that has not infiltrated or been intercepted) that runs off a land surface.
- **Steady flow.** Flow that is not varying in time; some models assume steady-flow conditions (a simplifying assumption that is valid for some types of analysis, but often not for understanding highly dynamic systems).
- **Subsurface flow:** Either flow in subsurface conduits or groundwater flow; contrasted with open-channel flow.
- **Two-dimensional modeling:** Modeling that represents flow in two dimensions; in open-channel systems, this is generally related to flow perpendicular to the primary flow direction, but it can also be used to represent stormwater flow over the land surface.
- **Unsteady flow (dynamic):** Time varying flow, generally simulated by fully dynamic representation of the Saint-Venant equations. Rainfall is highly variable in space and time, resulting in runoff patterns that generally require an unsteady flow model to represent flows through the sewer or waterway system.

3.1.1.2 Stormwater Planning Matrix

A review of frequently used or cited stormwater planning tools was performed. A detailed summary of input requirements, outputs, and capabilities of these tools is provided in Appendix A. This list, while not comprehensive, demonstrates the breadth of stormwater planning tools that exists.

Figure 3-2 provides a high-level summary of what kind of information is needed to address “typical stormwater planning questions.”

3.1.1.3 Web-based Outreach Tools

Web applications have been developed by communities and agencies to engage the public in stormwater planning decisions. The public is a major stakeholder in stormwater planning since most stormwater projects are government-funded and private property is a large contributor to stormwater runoff. The web portals generally attempt to accomplish one or more of the following:

- Educate the public regarding current stormwater initiatives and the benefits of reducing runoff
- Identify the type and extent of green infrastructure projects (public and private)
- Solicit input to support the planning process
- Provide tools to help owners understand how actions on their property can affect stormwater runoff

The purpose, type, data needs, and specific outcomes of several web applications are summarized in Appendix B. While the list of web applications is not exhaustive, the matrix provides examples of how several cities have used web-based outreach tools to engage the public. Most web applications reviewed provide information to the public rather than incorporate the public into the decision-making process.

Informative web applications are usually in the form of interactive maps or data sharing portals. Many cities have interactive maps and free geospatial data on their websites to provide to the public useful information such as road closures, bike trails, and zoning districts. As cities invest in green stormwater infrastructure, new web applications have been developed displaying geospatial data for stormwater planning and future capital improvement projects.

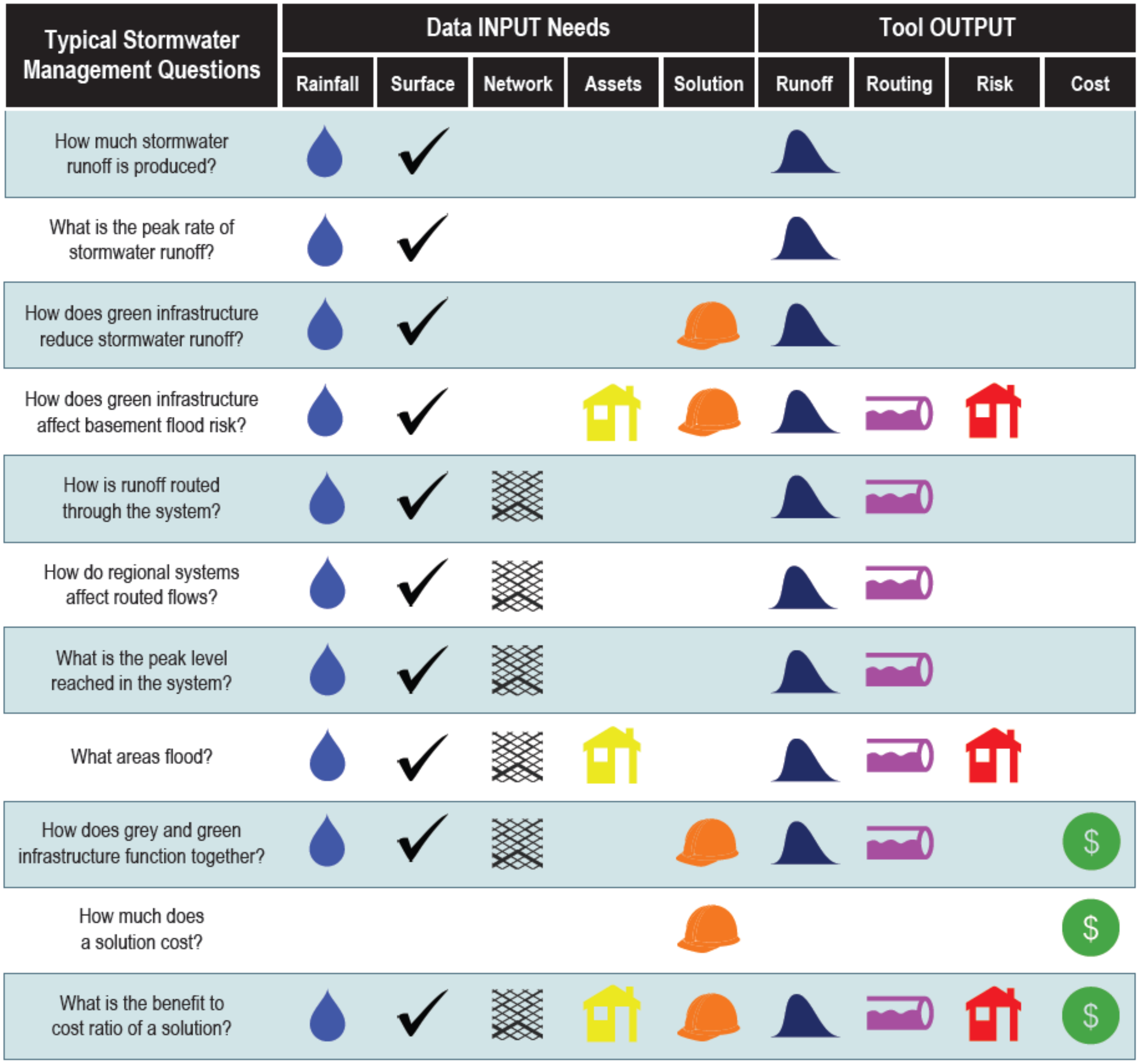

Figure 3-2. General Data Requirements for Typical Stormwater Questions

Decision-making web applications utilize much of the same data the informative web applications do, but apply several assumptions and back-end calculations to provide quick outputs that help users make decisions. GreenUp DC, for example, allowed property owners in Washington, D.C., to test different green infrastructure alternatives at their properties and evaluate the benefits and cost of each (this web application has since been discontinued).

3.2 Existing Practices in the Calumet Area

A wide range of communities and agencies manage stormwater in the Calumet. To better understand the technical basis of stormwater management within and across communities, surveys were distributed to select participants in the Collaborative. While the response is not fully comprehensive, it is representative of the range of datasets and tools being used, and the variability in application of planning tools to meet the different needs of each organization.

3.2.1 Geographic Information System Data

Appendix C aggregates the survey responses related to geographic information system data layers used for stormwater management. Table 3-2 provides an overview of the responses.

Table 3-2. Overview of Existing GIS Use in Calumet

Agency	Topography	Sewer Network	Problem Areas	Planned Projects	Additional Layers
City of Chicago (Water Department)	DTM processed from Cook County Lidar data	Sewer mains, interceptor sewers, siphons, manholes, tumbling basins, drop shafts, collection structures	Basement flooding risk (as predicted by City's trunk sewer model), 311 data	Sewer capital improvement plan, water capital improvement plan	Impervious areas, land use data, road edge, building footprints, soil data, municipal separate storm sewer system areas, trunk sewer model data, waterways, wards
Chicago Metropolitan Agency for Planning (CMAP)	DTM processed from Cook County Lidar data, elevation contours from county GIS department	—	National Flood Hazard layer (Federal Emergency Management Agency floodplains)	—	Impervious areas, regional green infrastructure, watershed boundaries, aerial imagery, soils data, land use data,
Cook County Forest Preserve	Lidar 1-foot topography	—	Regional floodplains	—	Streams, lakes, national wetland inventory, National Resource Conservation Service soils, hydric soils, roads, Forest Preserves of Cook County parking lots, parcels, aerial photos
MWRDGC	—	Waterways, watersheds, deep tunnels, drop shafts, combined sewers	Regional 100-year inundation areas (link to viewer)	Green infrastructure planning	—
City of Chicago (Planning Department)	ESRI GRID file representing average ground Elevations on grid 5 × 5 feet	—	—	—	—
Center for Neighborhood Technology (CNT)	—	—	Flood claims, flood reports	—	Housing stock, flood plains

Note: Data are based upon responses and may not represent an agency or department as a whole.
DTM, digital terrain model.

3.2.2 Modeling and Tools Summary

Appendix C aggregates the survey responses related to models being used by respondents of the survey. Table 3-3 provides an overview of the responses.

Table 3-3. Overview of Existing Model Use in Calumet

Agency	General Summary
City of Chicago (Water Department)	Combined sewer trunk sewer model: accepts rainfall as input and outputs flow rates and peak levels throughout the system. Enables simulation of all or parts of Chicago system under a wide range of assumptions (for example, TARP availability, alternative future conditions, waterway levels)
Chicago Metropolitan Agency for Planning	ArcHydro ArcGIS—used geoprocessing tools to define flow paths based upon lidar topography, and used to evaluate land-use change modifications
Cook County Forest Preserve	HydroCAD—outputs site-scale runoff rates and volumes
MWRDGC	GIS, HEC-RAS, HEC-HMS, MetroFlow Open-channel (HEC-RAS) models used to identify regional flood risk for 2-year through 500-year storms. Used to evaluate hydraulic impacts of stormwater control alternatives. HEC-HMS runoff model used to generate flows based upon Soil Conservation Service curve number MetroFlow—integrated modeling package for simulating inflow to TARP system and TARP system performance
CNT	U.S. Environmental Protection Agency Stormwater Calculator, CNT Economic Benefits of Green Infrastructure Tool, CNT Green Infrastructure Portfolio Standard—use these tools to quantify site runoff/green infrastructure benefits, and determine size/location of stormwater best management practices

HEC-HMS, Hydrologic Engineering Centers Hydrologic Modeling System; HEC-RAS, Hydrologic Engineering Centers River Analysis System.

3.2.3 Leveraging Data and Models through the RPF

The survey of Collaborative participants demonstrates a range of existing capacity and investment in modeling tools in the Calumet (and Greater Chicago). As discussed in Section 2.4.2, H&H models help to understand how a system reacts under a range of conditions, and a critical input to the RPF. A focal point of the RPF is understanding the impact across system boundaries at a range of scales; for instance:

- Regional interceptor facilities' impacts on local and trunk sewer performance
- TARP system impact on interceptors, trunk sewers, and local sewers
- River management scenario impact on sewer system performance
- I&I impacts on downstream sewer performance, regional infrastructure, and overflows
- Land-use-change impacts on sewer performance both within and without community boundaries
- Impact of inflow reduction through green infrastructure both at local and regional scale

The RPF will facilitate information transfer across model/system boundaries (aiding modeler and decision-maker understanding of cross-system impacts). In addition, scenario comparison and processing tools will increase the efficiency of specific model development and post-processing tasks (discussed further in Section 4). The RFP also increases the availability of key model outcomes to decision makers, as well as potential aligned uses through linked custom applications (see Section 2.4.6). As the Collaborative process has shown, there is widespread interest in the Calumet for pursuing shared approaches to the shared problem of excess stormwater. The RPF seeks to provide a technical basis for sharing the best available understanding of system knowledge throughout the various participants and enables a more integrated view of the impact of local and regional interactions.

3.3 Summary: Modeling Tools' Relevance for the Calumet

Agencies, communities, and stormwater managers in the Calumet have built and apply a variety of models[2] to understand how their systems respond to rainfall and how improvements to the systems can increase performance in the future. The past 8 to 10 years has seen significant investment in modeling tools within the Calumet, including modeling of open-channel waterways, combined sewer systems, and the Deep Tunnel system. Furthermore, a significant degree of information sharing and model integration has occurred on an as-needed basis. For example, the City of Chicago model provides input to the MetroFlow model, and waterway models have been used as boundary conditions[3] for sewer models. Regional and subregional planning has occurred on an as-needed basis as determined by different stakeholders and driven by their information needs.

The advances in modeling tools to support planning are not equally available throughout the whole of Calumet. Many communities do not have H&H models of their systems. They are at a disadvantage when evaluating solutions to address their stormwater problems, and may not have the tools to understand the impacts or regional infrastructure on their system. The RPF (described in Section 2) includes the development of H&H models for these communities that represent both local systems and regional infrastructure.

The review of stormwater tools in Section 2.1.1.1 (and summary in Appendix A) demonstrates the variety of models and tools available to provide insight into aspects of the stormwater management challenge. The potential benefits of such tools should be considered in relation to the specific needs within the Calumet.

There are no "magic tools"; in general the level of information output from a model is closely related to the quantity of information—and often the labor resources—input into a tool. The RPF incorporates this perspective by seeking to integrate a toolset that builds upon the significant investment in models to date made by Collaborative members, increasing these component models' utility, and hopefully providing a greater breadth of applicability than their owners may have originally envisioned.

[2] These models generally do not target the Calumet specifically, but all or part of the Calumet is represented within them.

[3] Boundary conditions represent unmodeled components of the system that influence system response. They model inputs based on other simulations, monitoring, or assumptions.

Measuring Performance with the RPF

4.1 Measuring Performance towards Goals

Goals and objectives are critical aspects of defining a desired future state of a system. Inextricably linked with such goals are *performance metrics*—measures of how well a system achieves or progresses towards specific goals. All systems for prioritization involve comparison of metrics. Taking the Collaborative as an example (though we could take almost any system), one can consider the relationship between goals and metrics. The vision of the Collaborative is the following:

> *The Calumet Stormwater Collaborative will be a model of coordinated deployment of knowledge, technology, and financial resources to minimize the negative impacts of precipitation and maximize the positive to make the Calumet region a better place to live, work and recreate.*

The resonance of this vision is attested to by the strong participation from communities and agencies to help define stormwater solutions to achieve it. However, the Vision itself is not quantitative, nor specific enough to enable comparisons between different proposals for how to achieve such a future condition. Performance metrics are the quantitative indicators that enable one to track progress towards fulfillment of this Vision or towards goals that are either implicit or explicit for parts or all of the system. In this section, we begin by reiterating the quantifiable goals established by the Collaborative. Section 4.1.2 then discusses general considerations for the selection (analogous to the general modeling discussion in the previous section). Finally, in Section 4.2, we discuss a range of potential metrics for the Calumet, as well as how the RPF can facilitate the calculation and comparison of these metrics.

4.1.1 Goals for the Calumet System

Through facilitated dialogue, the Collaborative identified the following three fundamental challenges as those that they, collectively, can make an impact on today, and that but for the intervention of the Collaborative, would not get solved:

- Causes and consequences of non-overbank flooding
- Declining performance and sufficiency of grey and green infrastructure over time
- Drain on public and private resources from repeated ineffective and partial interventions

The Collaborative's goals, optimal conditions, action items and measurable outcomes are all geared toward addressing these three challenges, as well as seeding future coordination by building more consistent dialogue between stakeholders.

4.1.2 Evaluating Performance Metrics

Table 4-1 summarizes two key axes of metrics. While many metrics provide value, modeled performance metrics are of particular importance because they allow decision-makers to make investment decisions based upon the anticipated benefits of potential projects.

Table 4-1. Key Metric Categories

Categories	Real World	Predictive Model
Program/preparedness	Reflects the existence of programs, tools, and preparedness efforts related to stormwater management May be quantitative, but does not relate to specific system performance—rather, whether certain conditions are met	Whether models and/or other quantitative tools exist for comparing the effectiveness of solutions
Performance	How the real world system actually performs—generally, based on monitoring data. Cannot be used to assess future performance.	How the modeled system performs under baseline and future conditions

Performance metrics must be selected carefully, because once established they can become planning or management benchmarks that drive investment decisions. When considering performance metrics related to stormwater management, the following should be considered:

- **Clarity.** Can the metric be easily explained and understood?
- **Directness.** Does the metric directly relate to an objective for the system? Are there other factors that may more heavily influence future outcomes than proposed solutions?
- **Responsiveness.** Is the metric sensitive enough to demonstrate progress based on system interventions?
- **Quantifiability.** Can the objective be quantified, and how complicated or time intensive is it to do so?
- **Subjectivity.** How objective is the measure? Subjectivity is not necessarily a negative issue for a metric; however, it must be acknowledged and assumptions should be stated. Indeed, metrics built into decision support tools, which enable alternative valuations of outcomes, provide structured means for assessing subjective measures.
- **Fairness.** Does the metric unfairly favor one group of stakeholders over another?

Generally speaking, performance metrics that represent “ends” rather than “means” better represent actual goals for the system. We are more interested in how much flooding is reduced, or how many stormwater benefits are enhanced, rather than how much money is spent on a program, or even how many acres of green infrastructure are implemented. However, means-based metrics are typically easier to calculate, and also to manage to.

4.1.2.1 Measuring Performance to Level of Service

The stochastic nature of rainfall presents an additional detail for definition of performance metrics, since the specific characteristics of rainfall that a system will experience in the future are not known. Instead, objectives must be defined that identify a target level of service or, similarly, a target level of risk that a system’s capacity is exceeded. For example:

- **Runoff reduction.** One cannot establish a goal of, say, 20 percent reduction in runoff. Runoff is related to numerous factors, including soil conditions and the intensity and timing of unique and unpredictable rainfall events. A meaningful analogous metric might be, “Reduce runoff volume by 20 percent based upon the 2014 monitored rainfall record.”
- **Flood risk reduction.** One cannot establish a goal of eliminating flooding or, say, reducing the number of individuals adversely impacted by flooding by 20 percent. A meaningful analogous metric might be, “Reduce the number of individuals predicted to experience flooding for the 5-year recurrence interval, 2-hour duration storm event.”

The selection of the comparison rainfall event must be closely tied to the objectives for the system and may vary by specific metric.

4.1.2.2 Baseline Conditions

Metrics may be meaningful on their own, or as a difference when compared to a baseline condition. Generally an independent metric (for example, area at 5-year risk of flooding) is useful for assessing the starting point or existing conditions, while a relative metric (decrease in 5-year risk of flooding) is useful for comparing different alternative benefits.

Selecting and documenting a baseline condition is important. The baseline condition represents the system at a given point in time, and may or may not reflect significant past investment towards an objective (for example, past sewer system upgrades that already benefit residents). By comparing a range of alternative conditions to the same baseline, alternative benefits can be directly compared.

4.1.2.3 Scaling Metrics to Cost

Relative improvement performance metrics (i.e. comparisons to the baseline condition) can only be meaningfully compared when scaled to cost. Otherwise, further spending would almost always lead to some additional, though diminishing, benefit.

4.1.2.4 Avoiding Metric Blindness

Numbers are not everything. Metrics are indicators of a specific aspect of the performance of a complex system. The benefits of improved stormwater management, reduced flooding, and increased green space in the community include a host of factors which are not easily quantified. While metrics are an important piece of establishing measurable goals towards a desired future condition, it is important to consider approaches and frameworks for valuing intangible aspects of a resilient, functioning system, even if these factors elude straightforward quantification.

4.2 Potential Performance Metrics

Table 4-2 provides a list of potential metrics that may benefit the Calumet (or a generalized wet-weather system). It is not comprehensive, and there are numerous details related to the calculation of each one. Rather, it is representative of the range of potential metrics, and challenges associated with their definition. Guidance and additional explanation is provided for several of the metrics, following the table. The value of these metrics depends both on how well the performance metrics correspond to system goals and also on how well the planning tools and models used to develop metric inputs (especially for "ends"-based metrics) represent system performance. Thus definition of performance metrics must consider how well the models and/or tools they are based upon represent the actual response of the system.

Table 4-2. Representative Metrics for the Calumet System

Performance Metrics	**Means or Ends**	**Metric Type**[a]	**Clarity**[b]	**Direct**[b]	**Responsiveness**[b]	**Quantifiable**[b]	**Subjectivity**[b]
Sewer inflow volume[c]	Intermediate	Input	4	3	4	5	1
Storage and conveyance capacity restored/added to system	Means	Investment	4	3	5	5	1
Peak wet weather flows at key system locations[c]	Intermediate	Input	5	3	4	5	1

Table 4-2. Representative Metrics for the Calumet System

Performance Metrics	Means or Ends	Metric Type[a]	Clarity[b]	Direct[b]	Responsiveness[b]	Quantifiable[b]	Subjectivity[b]
Basement flooding risk[d]	Ends	Impact	3	5	4	4	2
Basement flooding severity[e]	Ends	Impact	4	5	4	4	2
Economic value of basement flooding damages	Ends	Impact	3	5	4	4	3
CSO risk[d]	Ends	Impact	3	4	4	5	1
CSO volume[c]	Ends	Impact	5	4	4	5	1
CSO activations[c]	Ends	Impact	3	4	4	5	1
Decreased nutrient loading	Ends	Input/impact	3	3	4	4	2
Number of communities with stormwater-inclusive capital improvement plans	Means	Planning	5	3	5	5	2
Number of communities with H&H models	Means	Planning	5	2	4	5	2
Funding deployed for infrastructure	Means	Investment	4	2	2	5	2
Green infrastructure acreage implemented in system	Means	Investment	5	2	2	5	1
Impervious acreage managed by green infrastructure in system	Means	Input	4	3	4	5	2
Ecosystem benefits	Ends	Impact	3	3	3	2	5
Recreational benefits on waterways	Ends	Impact	3	3	3	3	4

CSO, combined sewer overflow.

Value of 1 is low, 5 is high on numeric scoring. In general, high is good, except for subjectivity.

[a] Metric type categorizes what the impact measures. In general, 'Impact' is associated with ends-based goals (what are we trying to achieve), whereas 'Planning' and 'Investment' are categories for specific types of means to achieve those goals.

[b] The numeric scoring is filled in based upon professional judgment; different reviewers may have different scorings – the challenge involved in "scoring" performance metrics is representative of the challenge of converging upon shared understanding of metrics in general.

[c] Flow-based metrics: Flow-based metrics are relevant for a defined rainfall event. Design rainfall events may be useful for basement flooding metrics, whereas longer duration events—such as a year or multiyear period—are more informative for quantifying CSO and inflow benefit (because CSO events occur much more frequently and are responsive to the large number of small rains that occur annually). Defining which storm events to use for different metrics is a critical element of the metric (see Section 4.1.2.1).

[d] Here, "risk" refers to the probability of occurrence, without factoring in the consequence. For example, if the more frequent 6-month storm causes sewer levels to exceed the basement flood risk threshold, an area is at higher risk than if the same occurs for the 25-year event. Some definitions of risk incorporate both probability and consequence (a potential alternative metric).

[e] Severity measures impact, for a given type of storm (for example, for the 5-year, 2-hour storm event). Severity could be aggregated in several ways, including area affected, number of people affected, structures affected, or property value affected.

4.2.1 Role of RPF in Calculating Metrics

The RPF will include tools to facilitate the calculation and comparison of metrics (for example, the "Scenario Comparison" component in Figure 2-2). For "ends"-based metrics, which represent how well the baseline or alternative condition of the system achieves a desired goal, generally the following steps are followed:

1. Create a model representation of the system condition of interest
2. Execute the simulation
3. Extract specific results from locations of interest in the model
4. Calculate the performance metric of interest

The RPF will increase the efficiency of each step, but especially the calculation and comparison of performance metrics of interest. It is time-consuming to extract model results for many locations in a model for a large range of simulations and perform the necessary calculations to develop metrics. Furthermore, minor variations in the calculation approach can lead to inconsistencies between the calculations of different users. The RPF will standardize the methodology and increase the efficiency of calculating performance metrics.

The RPF will improve stormwater related decision making by helping to efficiently provide modelers and decision makers the information needed to understand how well alternatives achieve specific goals and how cost-effectively they do so in comparison to other alternatives. Modelers and decision makers will be able to spend their valuable time on those tasks requiring human judgment and deep system understanding, augmented by the data management, scenario comparison, and visualization capabilities of the RPF.

4.3 Metrics Summary

The process of defining goals, and the metrics to measure progress towards goals, is an important aspect of developing a collaborative, shared vision for improved stormwater management in the Calumet. This process is likely to be an evolutionary one, and iteration will be required. The RPF will facilitate the consistent, efficient calculation of consistent metrics that represent goals for the Calumet (or specific subgeographies of the Calumet). The concepts and examples discussed in this section provide examples for consideration and identify some of the key characteristics needed to make metrics useful. We suggest the metrics be considered a starting point, to be honed, tested, and adapted by the Collaborative moving forward.

SECTION 5

Summary

Smart investment in solutions to improve stormwater outcomes involves making decisions, sometimes challenging decisions, regarding how to deploy limited resources. The regional planning framework is a road map for building upon existing member efforts to develop a toolset that enables communities and agencies to understand local stormwater problems in the context of regional drainage infrastructure, as well as the aggregate impact of local improvements on regional systems. The RPF will provide a structured means to better understand current system challenges and, most importantly, to compare the benefits of a range of interventions in their system. By integrating the best available data and modeling tools with performance metrics that have been developed and refined by the Collaborative as a whole, the RPF will support informed, technically sound decision making that considers the interplay between regional and local factors, and therefore smarter use of limited financial resources.

While the Collaborative provides an opportunity for developing and implementing the RPF, the value of this technical framework is not unique to the Calumet. The RPF outlines a vision for integrating knowledge across local and regional systems, and these kinds of linked systems managed by multiple jurisdictions are prevalent. The RPF therefore has the ability to help improve stormwater solutions in many sewersheds and watersheds that experience their own version of the challenges outlined for the Calumet. This observation suggests a longer-term, “downstream” goal of leveraging the RPF not just to help address local/regional issues in hydraulically linked systems like Calumet- but also as a means of integrating knowledge and technical expertise across geographies (through the development of specific shared modules or components, for instance), where stormwater managers are linked not by a particular hydraulic system, but by a shared interest in technically grounded, collaborative solutions for cost-effective stormwater solutions.

Appendix A
Stormwater Planning Tools Matrix

								Input Data Requirements									Output														
Tool/Model Name	**Primary Purpose**	**Description**	**Scale**	**Developed and Maintained By**	**Licensing / Cost**	**Format**	**Target User**	**Land-Use Data**	**Soil data**	**Topography**	**Open Channel Geometry**	**Sewer Network Geometry**	**Meteorological Information**	**Capital Cost Data**	**BMP Design Details**	**Other**	**Peak Runoff Rate**	**Runoff Volume**	**Time-varying Runoff Hydrograph**	**Hydraulic Routing Method**	**Hydraulic Variables (levels, flows)**	**Pollutant Loading**	**Water Quality**	**Ancillary Benefits**	**Cost**	**Flood Risk**	**Ability to perform alternatives analysis**	**Ability to simulate green infrastructure**	**Level of support available**	**Version and/or Last Update/Published Date**	**URL**
ArcHydro	Mapping and Data Visualization	Visualize and analyze hydrologic data using standardized processes and formatting for water resource modeling and decision-making methods.	Multiple	ESRI	Free (need ArcGIS Spatial Analyst license)	Data model and tool within ArcGIS	Engineer/Specialist	N	N	Y	Y	Y*	N	N	N		N	N	N	N	N	N	N	N	N	N	None	None	User guide, training, and online support	10.2	http://www.esri.com/library/fliers/pdfs/archydro.pdf
Bioretention Design Spreadsheet Model	Preliminary Design	Design and sizing of bioretention based on site parameters and area available for BMP.	Site	NC State Cooperative Extension	Free	Spreadsheet	Engineer/Specialist	Y*	Y*	Y*	N	N	Y*	N	Y		Y	Y	Y	Y	N	N	Y	Y	Y	N	Low	Low	NCSU Professors	Aug-07	http://www.bae.ncsu.edu/stormwater/downloads.htm
Bioretention Hydrologic Performance (HyPer) Model	Preliminary Design	Long-term prediction of hydrology and water quality of a bioretention design.	Site	NC State Cooperative Extension	Free	Spreadsheet	Planning staff	N	Y	Y	N	N	Y*	N	Y		N	Y	N	N	N	Y	Y	N	N	N	Low	Medium	NCSU Professors	Dec-11	http://www.bae.ncsu.edu/stormwater/downloads.htm
Bioretention Thermal Model	Preliminary Design	Assesses temperature, energy and volume reduction of bioretention designs.	Site	NC State Cooperative Extension	Free	Model	Planning Staff	N	Y	N	N	N	Y*	N	Y		N	Y	N	N	N	Y	N	Y	N	N	Low	Medium	On-screen help	Dec-08	http://www.bae.ncsu.edu/stormwater/downloads.htm
BMP and LID Whole Life Cost Models Version 2.0	Costing	Estimates stormwater management whole life costs (capital, operations & maintenance) for a variety of BMP types.	Site	Water Environment Research Foundation (WERF)	WERF Membership	Spreadsheet	Engineer/Specialist	N	N	N	N	N	N	Y	Y		N	N	N	N	N	N	N	N	Y	N	External	None	Extensive documentation	Report SW2R08 - 2009 Spreadsheets associated with SW2R08 - 2009	http://www.werf.org/i/a/Ka/Search/ResearchProfile.aspx?ReportId=SW2R08
BMP-REALCOST (BMP-Rational Estimation of Approximate Likely Costs of Stormwater Treatment)	Costing	Estimates life-cycle cost and BMP performance of structural BMPS.	Site	Colorado State University & Urban Drainage and Flood Control District, Colorado (UDFCD) & Urban Watersheds Research Institute Inc.	Free	Spreadsheet	Planning Staff	Y	Y	Y	N	N	Y	Y	Y		N	Y	N	N	N	Y	Y	N	Y	N	External	Medium	Extensive documentation. Email developers.	August 2013; v.1.21	http://www.udfcd.org/downloads/down_software.htm http://www.udfcd.org/downloads/software/BMP-REALCOST_V1.21.zip
Clean Water Optimization Tool	Generalized Watershed Modeling	Evaluates stormwater pollution reduction strategies to meet nutrient and sediment reduction goals at the lowest cost.	Community	Center for Watershed Protection	Free	Spreadsheet	Planning Staff	Y	N	N	N	N	N	Y	Y		N	N	N	N	N	Y	Y	N	Y	N	None	Medium	Email developers	Alpha (beta not available yet). June 2014.	http://www.cwp.org/august2014-1
Delaware Urban Runoff Management Model (DURMM)	Preliminary Design	Assists in BMP design by accounting for disconnection of impervious area as well as the "run-on" process to derive both the volume and rate of run-off.	Site	Delaware Department of Natural Resources & Environmental Control	Free	Spreadsheet	Engineer/Specialist	Y	Y	N	Y	N	Y*	N	Y		Y	Y	N	Y	N	Y	N	N	N	N	Low	Medium	Users Manual	v1.0, January 2004	http://www.dnrec.delaware.gov/swc/Drainage/Documents/Sediment%20and%20Stormwater%20Program/DURMM/DURMM_UsersManual_01-04.pdf
EnviroAtlas	Mapping and Data Visualization	Collection of interactive tools and resources that allows users to explore the many benefits of ecosystem services.	Multiple	USEPA, USGS, and NRCS	Free	Web map; interactive web tool; Report	Public	N	N	N	N	N	N	N	N		N	N	N	N	N	N	Y	Y	N	N	None	None	Limited	-	http://enviroatlas.epa.gov/enviroatlas/atlas.html
EPA National Stormwater Calculator (SWC)	Generalized Project Modeling	Estimates the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States (including Puerto Rico).	Site	EPA	Free	Desktop Application	Planning Staff	Y*	Y*	Y*	N	N	Y*	N	Y	Climate Change scenarios if desired.	N	Y	N	N	N	N	N	N	N	N	Low	Medium	User guide & email listserve	v1.1 (User's Guide revised Jan 2014)	http://www2.epa.gov/water-research/national-stormwater-calculator
Flood Resilience Checklist	Regulatory Compliance	60 item checklist for to evaluate level of flood resiliency.	Community	USEPA	Free	Checklist	Planning Staff	Y	N	Y	N	N	N	N	N	Existing policy and regulatory environment	N	N	N	N	N	N	N	N	N	Y	None	None	Example project using checklist (Vermont)	Jul-14	http://www.epa.gov/smartgrowth/pdf/Flood-Resilience-Checklist.pdf
Green Infrastructure Valuation Toolkit	Regulatory Compliance	Estimates the qualitative and quantitative benefits of existing green assets and proposed green infrastructure.	Community	Green Infrastructure North West	Free	Spreadsheet	Planning Staff	Y	Y	N	N	N	Y	Y	Y	Demographics, land value, energy use, recreation usage statistics	N	Y	N	N	N	N	N	Y	Y	Y	External	High	Extensive documentation. Email developers	-	http://www.greeninfrastructurenw.co.uk/html/index.php?page=projects&GreenInfrastructureValuationToolkit=true
Green LTCP-EZ	Regulatory Compliance	Provides a framework for organizing and completing a Long Term Control Plan (LTCP) that builds on existing controls (grey and green) to assist in the elimination or control CSOs in accordance with Clean Water Act.	Community	EPA	Free	Template	Planning Staff	Y*	N	N	Y*	Y	N	Y	N	Information on CSO outfalls/structures/volume, average dry weather WWTP flow, CSS area, financial capability analysis, quality conditions of waterbodies receiving CSO discharge	Y	Y	N	N	N	N	N	Y	Y	N	Low	Low	Coordination between small communities and regulatory authority required	Apr-11	http://www.epa.gov/npdes/pubs/final_green_ltcpez_instructionswithpoecacomments.pdf
Green Roof Hydrologic Simulation Model	Preliminary Design	Simulate green room performance for specific rainfall events.	Site	NC State Cooperative Extension (from Penn State)	Free	Spreadsheet	Engineer/Specialist	N	Y	N	N	N	Y	N	Y		Y	Y	Y	N	Y	N	N	N	N	N	None	Medium	Penn State - no contact information provided	-	http://www.bae.ncsu.edu/stormwater/downloads.htm
Green Values National Stormwater Management Calculator	Triple bottom line	Compares performance, costs, and benefits of LID to conventional stormwater practice.	Site	Center for Neighborhood Technology	Free	Online Tool	Planning Staff	Y	Y	N	N	N	N	N	Y		N	Y	N	N	N	N	N	Y	Y	N	Low		Pop-up help screens	-	*National Stormwater Management Calculator: http://greenvalues.cnt.org/national/calculator.php *Chicago Ordinance Calculator: http://greenvalues.cnt.org/chicago/calculator.php
GSI Calculator	Preliminary Design	Provides standard method for LID sizing and estimates benefitted area.	Site	Washington Stormwater Center	Free	Desktop Application	Planning Staff	Y	Y	N	N	N	Y*	N	Y	Infiltration rate	N	N	N	N	N	N	N	Y	N	N	External	Medium	User manual, online contact	v1	http://www.wastormwatercenter.org/gsicalc/
Hydrologic Modeling System (HEC-HMS)	Hydrologic Modeling	Simulates the complete hydrologic processes of dendritic watershed systems.	Watershed	USACE	Free	Model	Engineer/Specialist	Y*	Y*	N	Y*	N	Y	N	N	Numerous hydrologic methods	Y	Y	Y	Y	Y	N	Y	N	N	N	Medium	Medium	User guide, user forums, 3rd party companies	v4.0; August 2013	http://www.hec.usace.army.mil/software/hec-hms/
Hydrological Simulation Program - Fortran (HSPF)	Hydrologic and Water Quality Modeling	Continuous simulation of hydrology and water quality in natural and man-made water systems.	Watershed	USGS	Free	Model	Engineer/Specialist	Y	Y	Y	Y	N	Y	N	N	Optional pollutant information	Y	Y	Y	Y	Y	Y	Y	N	N	N	External	Medium	USGS provided nominal support, experienced users provide more	12.2	

Tool/Model Name	Primary Purpose	Description	Scale	Developed and Maintained By	Licensing / Cost	Format	Target User	Input Data Requirements: Land-Use Data	Soil data	Topography	Open Channel Geometry	Sewer Network Geometry	Meteorological Information	Capital Cost Data	BMP Design Details	Other	Output: Peak Runoff Rate	Runoff Volume	Time-varying Runoff Hydrograph	Hydraulic Routing Method	Hydraulic Variables (levels, flows)	Pollutant Loading	Water Quality	Ancillary Benefits	Cost	Flood Risk	Ability to perform alternatives analysis	Ability to simulate green infrastructure	Level of support available	Version and/or Last Update/Published Date	URL
ISIS	Hydraulic Modeling	1D-2D coupled hydraulic model with built-in mapping tool and interface.	Multiple	CH2M HILL	Free version available; "Unlimited" version available for a fee	Model	Engineer/Specialist	Y	Y*	Y	Y	N	Y	Y	N		Y	Y	Y	Y	Y	N	N	N	Y	Y	Medium	Medium	Customer support by email; user forum; robust users guide.	v3.7.0.93; August, 2014	http://www.isisuser.com/
I-Tree	Preliminary Design	Urban forestry analysis and benefits assessment.	Urban watershed	USDA Forest Service	Free	Model	Planning Staff	Y*	Y*	Y*	N	N	Y*	N	N		Y	Y	N	N	N	Y	Y	Y	Y	N	Low	Medium	User manual, support page, help panel within tool, training material (webinars), user forum and support via email/phone	N/A	http://www.itreetools.org/index.php
LID Quicksheet	Preliminary Design	Evaluates various green infrastructure features to reduce detention requirements.	Site	Milwaukee Metropolitan Sewerage District	$25 CD	Spreadsheet	Planning Staff	Y	Y*	Y*	N	N	N	N	Y		Y	Y	Y	N	N	N	N	N	N	N	Low	Low	Users Manual	v1.2, May 2005	
Long-Term Hydrologic Impact Assessment Model (L-THIA) Low Impact Development	Generalized Watershed Modeling	Evaluates the impact of land use change, LID practices and non-point source pollution measures on water quantity and quality.	Watershed	Local Government Environmental Assistance Network	Free	Spreadsheet or Online Tool	Planning Staff	Y	Y*	Y*	N	N	N	N	N		N	Y	Y	N	N	Y	N	N	N	N	Medium	Medium	Tutorials and manual	2011; 6 state versions	https://engineering.purdue.edu/mapserve/LTHIA7/
MIKE FLOOD	Hydrologic and Hydraulic Modeling	Utilizes a wide selection of 1D and 2D flood simulation engine enabling any flood problem to be modeled.	Multiple	DHI	Varies based on modules used	Model	Engineer/Specialist	Y	Y	Y	Y	Y	Y	N	N		Y	Y	Y	Y	Y	Y	Y	N	N	Y	Medium	High	Full customer support (with paid license); robust users guide		http://www.mikebydhi.com/
Model for Urban Stormwater Improvement Conceptualization (MUSIC)	Hydrologic Modeling	Evaluates a wide range of treatment devices to find best way to capture and reuse stormwater runoff, remove its contaminants, and reduce the frequency of runoff.	Community	eWater	21-day Free Trial, $2,992 per year for Single Computer License	Model	Engineer/Specialist	Y	N	N	N	N	Y	N	Y	Time-series data (flow, pollutants, water quality), water quality objectives	Y	Y	Y	Y	Y	Y	Y	N	Y	N	External	Medium	Paid support and maintenance ($495 per license), Training courses available	v6	http://www.ewater.com.au/products/music/music-overview/
Permeable Pavement Hydrologic Design Model	Preliminary Design	Compares impermeable and permeable pavement performance.	Site	NC State Cooperative Extension	Free	Spreadsheet	Planning staff	N	Y	Y	N	N	Y*	N	Y		Y	Y	Y	N	N	N	N	N	N	N	Low	High	NCSU Professors	Aug-08	http://www.bae.ncsu.edu/stormwater/downloads.htm
Program for Predicting, Polluting Particle Passage through Pits, Puddles, and Ponds	Hydrologic and Water Quality Modeling	Predicts the generation and transport of stormwater runoff pollutants.	Urban watershed	William Walker	Free	Spreadsheet	Engineer/Specialist	Y*	Y*	Y*	N	N	Y	N	Y		Y	Y	Y	N	N	Y	Y*	N	N	N	External	Medium	Google Groups User Forum; email developer; fee-based tech support program	v.3.4; October 2007	http://wwwalker.net/p8/
Rainwater Harvesting Design Model	Preliminary Design	Evaluates rainwater harvesting performance.	Site	NC State Cooperative Extension	Free	Model (*.exe)	Planning Staff	N	Y	N	N	N	Y	Y*	Y		N	Y	N	N	N	Y	Y*	N	Y	N	None	High	NCSU Professors	7/1/2014, Version 3	http://www.bae.ncsu.edu/stormwater/downloads.htm
RECARGA	Preliminary Design	Evaluating the performance of bioretention facilities, raingarden facilities, and infiltration basins. Results can be used to size facilities to meet specific performance objectives.	Site	University of Wisconsin - Madison - CEE Dept.	Free	Model	Engineer/Specialist	Y*	Y*	Y*	N	N	Y*	N	Y	Evaporation conditions	Y	Y	Y	N	N	N	N	N	N	N	High	High	User manual	v.2.3; 2004	http://dnr.wi.gov/topic/stormwater/standards/recarga.html
River Analysis System (HEC-RAS)	Hydraulic Modeling	One of the most commonly used stream/river hydraulic models in the USA. Performs 1D steady flow, unsteady flow, sediment transport/mobile bed computations, and water temperature modeling.	Watershed	USACE	Free	Model	Engineer/Specialist	N	N	Y	Y	N	N	N	N	Detailed hydraulic structure geometry	N	N	Y	Y	Y	N	Y	N	N	Y	Medium	None	User guide, user forums, 3rd party companies	v4.1; January 2010	http://www.hec.usace.army.mil/software/hec-ras/
SimCLIM	Generalized Project Modeling	Climate change planning and analysis tool. Reports changes in sea level, precipitation, temperature, wind and other parameters between present and 2100. Results are derived from standard IPCC models.	Multiple	CLIMsystems	$6000/company; $1000/government; $600/education	Model	Engineer/Specialist	N	N	N	N	N	Y	N	N	Climate Change scenarios	N	N	N	N	N	N	N	N	N	N	High	None	User guide, email developers, user forum	-	http://www.climsystems.com/simclim/
Site Evaluation Tool (SET)	Preliminary Design	Stormwater BMP evaluation tool, required for surface water pollution loading rate analysis. Evaluates the overall effectiveness of combined site development design features and BMPs.	Site	Tetra Tech for Pulaski County, Arkansas	Free	Spreadsheet	Public	Y	N	Y*	N	N	N	N	Y		N	Y	N	N	N	Y	N	N	N	N	External	Low	User guide	June 2010; spreadsheet v.1c; document v.14	http://pulaskicounty.net/pdf/PulaskiCountySETV1c.xls http://pulaskicounty.net/pdf/SETUserGuidanceV14.pdf
Source Loading and Management Model (WinSLAMM)	Hydrologic and Water Quality Modeling	The only urban stormwater Quality Model that evaluates runoff volume and pollution loading for each source area within each land use for each rainfall event.	Multiple	PV&Associates	$375+85	Model	Engineer/Specialist	Y	Y	Y	N	N	Y	N	N	BMP category	N	N	N	N	N	Y	Y*	N	N	N	External	Medium	Training workshops, reference documents, email	v10.1.1 May 2014	http://www.winslamm.com/
SSOAP (Sanitary Sewer Overflow Analysis and Planning)	Hydrologic and Hydraulic Modeling	Statistical analysis used for the quantification of rainfall-derived infiltration and inflow (RDII) and help capacity analysis and condition assessment of sanitary sewer systems	Sewershed	USEPA	Free	Model	Planning Staff	N	N	N	N	N	Y	N	N	Flow monitoring data	N	N	N	N	N	N	N	N	N	N	None	None	Email contact	v2.0.0 August 2013	http://www2.epa.gov/water-research/sanitary-sewer-overflow-analysis-and-planning-ssoap-toolbox
Stormwater Treatment Objective - Relative Measure (STORM) Calculator	Generalized Project Modeling	Assess whether best practice water quality objectives have been achieved for your site.	Site	Melbourne Water	Free	Website	Planning Staff	Y*	N	N	N	N	Y*	N	Y		N	N	N	N	N	N	Y	N	N	N	None	Low	How-to guides	-	http://www.storm.melbournewater.com.au/
Surface Water Treatment Selection Tool	Mapping and Data Visualization	Explore the choices for surface water treatment features according to catchment area and receptor.	Site	Hydro International	Free	Website	Public	Y*	N	N	N	N	N	N	N		N	N	N	N	N	Y	Y	Y	N	N	None	None	Hotline & Email	-	http://stormtraintool.hydro-int.com/
SWMM	Hydrologic and Hydraulic Modeling	Provides a flexible interface to model urban hydrology and conveyance system hydraulics for single event or continuous simulation. Note: SWMM used to represent several 1-D subsurface models including Infoworks CS, PC-SWMM, and Mike Urban.	Multiple	EPA	Free	Model	Engineer/Specialist	Y	Y	Y	Y	Y	Y	N	N	Optional pollutant and LID information	Y	Y	Y	Y	Y	Y	Y	N	N	Y	External	High	Extensive user group interaction, some developer support	v5.1	http://water.epa.gov/scitech/datait/models/basins/bsnsdocs.cfm#hspf
System for Urban Stormwater Treatment and Analysis Integration Model (SUSTAIN)	Hydrologic Modeling	Develop, evaluate, and select optimal BMP combinations at various watershed scales based on flow and water quality performance and cost.	Multiple	EPA & TetraTech	Free	ArcGIS platform (require version 9.3, does not support later version)	Engineer/Specialist	Y	Y	Y	Y*	N	Y	Y	Y	Landownership shapefile, Road shapefile, Groundwater table depth shapefile	Y	Y	Y	Y	Y	Y	Y	N	Y	N	High	High	Contact form on website	Version 1.2, July 2014	http://www2.epa.gov/water-research/system-urban-stormwater-treatment-and-analysis-integration-sustain

								Input Data Requirements									Output														
Tool/Model Name	**Primary Purpose**	**Description**	**Scale**	**Developed and Maintained By**	**Licensing / Cost**	**Format**	**Target User**	**Land-Use Data**	**Soil data**	**Topography**	**Open Channel Geometry**	**Sewer Network Geometry**	**Meteorological Information**	**Capital Cost Data**	**BMP Design Details**	**Other**	**Peak Runoff Rate**	**Runoff Volume**	**Time-varying Runoff Hydrograph**	**Hydraulic Routing Method**	**Hydraulic Variables (levels, flows)**	**Pollutant Loading**	**Water Quality**	**Ancillary Benefits**	**Cost**	**Flood Risk**	**Ability to perform alternatives analysis**	**Ability to simulate green infrastructure**	**Level of support available**	**Version and/or Last Update/Published Date**	**URL**
U.S. Green Infrastructure Portal	Mapping and Data Visualization	Visualize the reports of green infrastructure activities across the nation.	Site	University of Nebraska-Lincoln	Free	Website and Mobile App	Public	N	N	N	N	N	N	N	Y		N	N	N	N	N	N	N	N	N	N	None	None	Email developers	-	http://zyfbta.wix.com/us-gi-reporter#
UK Sustainable Drainage Guidance & Tools (SuDs)	Hydrologic Modeling	Evaluates and sizes available stormwater BMPs for a specific site development.	Site	HR Wallingford	Free	Website and Spreadsheet	Public	Y	Y*	Y	N	N	Y	N	Y	Contaminated soils	Y	Y	N	N	N	Y	Y	Y	Y	N	Low	High	Training classes, technical reports and customer support	-	http://www.uksuds.com/
Watershed Treatment Model	Generalized Watershed Modeling	Estimates the benefits of a wide range of management practices.	Urban watershed	Center for Watershed Protection	Free	Spreadsheet	Planning Staff	Y	Y	N	N	N	Y	N	Y	Info on possible pollution sources: # of CSOs/yr, # of illicit connections, # of livestock, road sanding, non-point.	N	Y	N	N	N	Y	N	N	N	N	External	Low	Extensive documentation. Email developers	June, 2013	http://www.cwp.org/online-watershed-library/cat_view/65-tools/91-watershed-treatment-model
WERF Performance and Whole-Life Costs of BMPs and Sustainable Urban Drainage Systems (SUDS)	Preliminary Design	Evaluates and develops guidance on the performance of BMPs and SUDs, long-term maintenance needs and the impact of maintenance activities on performance.	Site	Water Environment Research Foundation (WERF)	Free to WERF members	PDF report (2005)	Planning Staff	N	N	N	N	N	Y	Y	Y		N	N	N	N	N	Y	Y	N	Y	N	External	Medium	Extensive documentation.	Report 01-CTS-21Ta - 2005	http://www.waterrf.org/Pages/Projects.aspx?PID=2880 http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=01-CTS-21-TA
WEST	Hydrologic and Water Quality Modeling	Dynamic modelling and simulation of collection systems, wastewater treatment plants (WWTP) and rivers in a single model. Prime purpose is to look at the water quality impacts of wet weather inputs. Can be used to test effect of CSO improvements and SuDS etc.	City wide	DHI	c. $8000	Model	Engineer/Specialist	N	N	N	N	Y*	N	N	N	Inputs for physical and biochemical processes used in WWTP, includes parameter estimation	Y	Y	Y	Y	Y	Y	Y	N	Y	N	High	Medium	Training & support from DHI	upgrade in 2014	http://www.mikebydhi.com/products/west
WinTR-55	Hydrologic and Hydraulic Modeling	Develops runoff hydrographs for both urban and agricultural areas and at selected points along the stream system.	Small watershed	Natural Resources Conservation Service	Free	Model	Engineer/Specialist	Y	Y	Y	Y	N	Y	N	N		Y	Y	Y	N	N	N	N	N	N	N	Medium	Low	Extensive documentation. Email developers	January 2009	http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?cid=stelprdb1042901

Note: Y* refers to input or outputs not explicitly used by the tool but still considered

Acronyms

BMP Best Management Practice
CSO Combined Sewer Overflow
LID Low Impact Development
SUDS Sustainable Urban Develop

Appendix B
Stormwater Web Application Matrix

Stormwater Web Application Matrix

Name	Location	Owner	Type	Description	Primary Purpose	Intended Audience	Data: Planning	Data: BMP	Data: Other	Specific Outcome	Link
Green Stormwater Infrastructure Project Map	Philadelphia, PA	Philadelphia Water Department (PWD)	Interactive map	Educate public on the green projects PWD is designing or has completed.	Public Outreach and Data Sharing	Public	*Land Use & Zoning *Watershed boundaries *Transportation	*Site Details *Type	—	Open access to City's GIS data	http://www.phillywatersheds.org/BigGreenMap
Philadelphia Combined Sewer Overflow Public Notification System (CSOCast)			Interactive map	Provide CSO notification based on flow monitoring, rainfall gauge network and combined sewer SWMM model.	Public Outreach	Public	*Combined Sewer infrastructure (outfalls and gauges)	—	*Flow monitoring *Rainfall data *SWMM model outputs	CSO public notification	http://www.phillywatersheds.org/what_were_doing/documents_and_data/live_data/csocast
GreenUp DC	Washington, DC	District of Columbia Department of the Environment	Decision-making tool	Aid property owners to design, plan, and install green projects on their properties. You can lower your bills and protect the environment by saving energy and reducing stormwater runoff.	Public Outreach and Green Infrastructure Planning	Property owners	*Land Use *Soils	*Site details *BMP Type *Benefit and Cost	*Existing Utility Rates	Incentivize property owners to install BMPs and track stormwater program status	Discontinued
Stormwater Infrastructure and Capital Planning Maps	Bozeman, MT	City of Bozeman, MT	Interactive map, data sharing portal	Provide information on existing and future infrastructure	Data Sharing	Public, Planners, Engineers	*Land Use & Zoning *Existing Stormwater Infrastructure *Capital Improvement Projects *Political Boundaries *Topography *Transportation	—	—	Open access to City's GIS data	http://www.bozeman.net/Departments-%281%29/Public-Works/GIS/Interactive-GIS
Natural Connections	Chicago area (14 counties in WI, IL and IN)	Center for Neighborhood Technology & Openlands	Interactive map, data sharing portal	Provide better information about green infrastructure (natural resource and sustability GIS data)	Data Sharing	Planners	*Land Use *Soils *Watershed Boundaries *Waterbodies and Wetlands	*GI Vision *GI Inventory	—	Create customized maps related to GI	http://www.greenmapping.org/about.php

Appendix C
GIS and Model Survey Responses

The Calumet Stormwater Collaborative Data & Modeling Work Group is collecting data about the use of GIS, models, and to tools in an effort to foster regional collaboration to solve stormwater problems in northeastern Illinois.
Please complete parts 1-4 of the questionnaire below by filling in responses to listed questions and by providing details regarding specific GIS layers and models/tools being used. Hover cursor over red triangles for additional instructions. Note, carriage returns can be entered by pressing Alt+Enter. Fields can be resized based on the contents by double clicking in the field.

PART 1

Organization Information

Question	Response
Organization Name	Chicago Department of Water Management
Completed By	ACE
Date	9/25/2014
Contact Information	

PART 2

GIS Layer Inventory

Question	Response
Please summarize how your organization uses GIS to support stormwater planning and management.	CDWM keeps a detailed inventory of its combined sewer system in GIS, some small areas of the city are serviced by stormwater pipes. GIS of sewer systems are used to assist with planning and modeling. Flooding complaints are kept in GIS to allow for review of problem areas. Information on characteristics of land is used (impervious, landuse, soils, elevation).
What additional GIS data would be helpful to have for stormwater planning? How might this data be used?	More detailed landuse, imperviousness, soils information could be used for more detailed planning
Does your organization use any spatial data standards? If so, please describe which one(s).	Yes, sewer data was digitized from sewer atlas sheets according to a set of standards. This data was intended to have a certain level of spatial accuracy (eg. Pipe locations are generally represented on the correct side of a street) but not exact
Do you use scripts (e.g. python, VB, etc.) for geospatial processing or operations? If so, please describe their purpose.	Yes, consultants using CDWM GIS data use scrips to process data such as 311, landuse/impervious, building counts, basement information, new project benefitting areas.
How do you think data sharing between members of the Calumet Stormwater Collaborative could improve your organization's ability to use GIS to support stormwater planning?	
Additional comments?	

Please list GIS layers and corresponding details in the space below. While many GIS layers are likely used, please list those most relevant to stormwater management.

Name of Data Layer	Contents	Use	Feature Type	Data Source	Date / Timestamp	Update Frequency	Spatial Extent	Available to Share (Yes, No, Maybe)	Additional Notes
SewerFeatures.gdb	Combined sewer network features: pipes, manholes, collection structures, with inverts, diameters, ground elevations attributes	Used in project planning and model creation		CDWM	2014	~3 times a year?	City of Chicago		
Impervious	Polygons of impervious areas (streets, parking lots, buildings, etc.)	Used during model creation for subcatchment runoff parameters	Polygon	CDWM					
MS4 areas.gdb	MS4 drainage areas and outfalls. Area, source, waterway, status						City of Chicago		
Subareas.shp	Combined sewer system model subcatchments	Used to help define drainage areas, areas impacted by new projects	Polygon	CDWM			City of Chicago		
COC_311.mdb	Address, date, description of 311 call reports of water in basement and water in street	Used to evaluate flooding problem areas	Point	CDWM	6/25/2014		City of Chicago		
LU01_v12.shp	Landuse information		Polygon	CDWM					
Road_Edge..shp	Boundaries of city streets		Polygon	CDWM			City of Chicago	Yes	
DTM	Digital terrain model raster	Surface elevation and flow paths							
Aerial Imagery									
Soils.shp			Polygon	USGS?				Yes	

PART 3

Model/Tool Inventory

Question	Response
What models/tools does your organization use to support stormwater planning?	InfoWorks CS Chicago Trunk Sewer Model - combined sewer system model
Are you considering applying other models/tools in the future? If so, please describe.	
What are key questions you are trying to answer by applying models/tools?	Flooding locations and impact, improvements to system, impacts of new projects
Do you account for climate change in current analysis approaches? Do you believe it is important to do so?	
How do you think the Calumet Stormwater Collaborative could improve your organization's ability to use models/tools to support stormwater planning?	
Additional comments?	

Please list models/tools used to support stormwater planning below.

Model/Tool Name	Key Question	Required Inputs	Model/Tool Output	Model/Tool Platform	User Base	Calibration	Maintenance and Updates	Agency Coordination	Additional Notes
IW CS CTSM	Basement flooding, CSOs, CIP planning	Land use data, rainfall	Flows, levels, flood risk,	InfoWorks CS	Internal use only	Yes -	Yes, yearly maintenance and updates to reflect changes to the system		

PART 4

Additional Notes/Comments

Please provide any additional notes or comments.

The Calumet Stormwater Collaborative Data & Modeling Work Group is collecting data about the use of GIS, models, and to tools in an effort to foster regional collaboration to solve stormwater problems in northeastern Illinois.
Please complete parts 1-4 of the questionnaire below by filling in responses to listed questions and by providing details regarding specific GIS layers and models/tools being used. Hover cursor over red triangles for additional instructions. Note, carriage returns can be entered by pressing Alt+Enter. Fields can be resized based on the contents by double clicking in the field.

PART 1

Organization Information

Question	Response
Organization Name	Chicago Metropolitan Agency for Planning
Completed By	Jason Navota
Date	22-Aug-14
Contact Information	312.386.8750

PART 2

GIS Layer Inventory

Question	Response
Please summarize how your organization uses GIS to support stormwater planning and management.	CMAP uses GIS mapping to understand existing conditions for communities, to map areas with stormwater challenges, and to identify potential areas where solutions to these challenges could be implemented. We also use GIS for watershed planning work, with similar application, as well as for estimating pollutant loading by land use. We have the capacity to use ArcHydro, and are working on applications of this for additional stormwater planning uses.
What additional GIS data would be helpful to have for stormwater planning? How might this data be used?	Flowpath modeling; FEMA Repetitive/Severe Repetitive Loss Properties; Historical stream mapping (Georeferenced USGS quad or other); Depth of Groundwater; any way to integrate H+H results into a GIS format to use for planning-level analysis and solutions; flood problem areas and type (e.g., overbank or sewer capacity issues); municipal storm drainage system including ditches, swales, storm sewers, catch basins, detention basins, etc. (this information is often only avaiable in paper atlases, scattered among development plans filed away in variuos places, or even nonexistent in any form) including detention basin ownership and management information. Many basins are on private property, with a homeowners association responsible for maintenance. Municipal governments may rarely be responsible for maintenance or condition assessment/repair of detention basins. Thus, there appears to be a disconnect between the role that stormwater detention basins play in the regulatated community's stormwater management plans and the highly decentralized nature of ownership and/or maintenance responsibilities. Impacts include little or no incentive on either party's part for retrofits that might be appropriate from a water quality improvement perspective. A homeowners assocation may not have the means or the inclination to pay much attention to their basins until such a time as a problem occurs.
Does your organization use any spatial data standards? If so, please describe which one(s).	
Do you use scripts (e.g. python, VB, etc.) for geospatial processing or operations? If so, please describe their purpose.	Python is used for GIS data manipulation/automation. ArcGIS ModelBuilder and Python are used to create custom geoprocessing tools.
How do you think data sharing between members of the Calumet Stormwater Collaborative could improve your organization's ability to use GIS to support stormwater planning?	Use of consistent, shared data sets would help ensure that assumptions are common across agencies and users
Additional comments?	

Please list GIS layers and corresponding details in the space below. While many GIS layers are likely used, please list those most relevant to stormwater management.

Name of Data Layer	Contents	Use	Feature Type	Data Source	Date / Timestamp	Update Frequency	Spatial Extent	Available to Share (Yes, No, Maybe)	Additional Notes
Land Use Inventory	Detailed land use types	Various	Polygon	Various	2005	3-5 years	CMAP Region	Yes	2001 inventory also available, with 2010 version slated for a 2014 release.
LiDAR Digital Terrain Model (DTM)	LiDAR-derived elevation values	Various, including watershed delineation	Raster	Cook County/CMAP	2009	Infrequent	CMAP Region	No	LiDAR point data was processed to create regional LiDAR DTM. Permission needed from Cook County before sharing.
National Flood Hazard Layer	FEMA Floodplains	Various	Polygon	FEMA	Various	Infrequent	CMAP Region, excluding Will/ DuPage	Yes	Data can be ordered from FEMA's Map Service Center.
NLCD Impervious Surface Area	Percent Developed Impervious	Various	Raster	MRLC	2011	5-years	CMAP Region	Yes	Data can be downloaded from MRLC website. 2001 and 2006 also available.
Green Infrastructure Vision	Regional green infrastructure (ecological network and protected lands)	Various	Polygon	Chicago Wilderness	2011-2012	Infrequent	CMAP Region	Yes	
NHD-Plus	National Hydrography Dataset	Various, including watershed delineation	Polyline, Polygon	US EPA	Various	Infrequent	CMAP Region	Yes	Data can be downloaded from Horizen Systems website.
Elevation Contours	1 and 2-ft elevation contours	Various	Polyline	County GIS depts	Various	Infrequent	CMAP Region	No	Permission needed from counties before sharing.
4-Band Aerial Imagery	R,G,B, and NIR bands	Various	GeoTiff	Consortium coordinated by Cook County	2012	Annually	CMAP Region	No	Permission needed from counties before sharing.
SSURGO Soils data	Soil type and characteristics.	Various	Polygon	USDA NRCS	Various	Infrequent	CMAP Region	Yes	A large portion of Cook County is unmapped by SSURGO.

PART 3

Model/Tool Inventory

Question	Response
What models/tools does your organization use to support stormwater planning?	ArcHydro; ArcGIS
Are you considering applying other models/tools in the future? If so, please describe.	Flowpath modeling
What are key questions you are trying to answer by applying models/tools?	Areas where land use changes or modifications (e.g., green infrastructure installations) can help address stormwater issues; locations for BMPs (for watershed plans)
Do you account for climate change in current analysis approaches? Do you believe it is important to do so?	Not to a significant degree. Yes.

How do you think the Calumet Stormwater Collaborative could improve your organization's ability to use models/tools to support stormwater planning?	Better informed local governments (including CMAP) on how to identify and address stormwater challenges would help to de-mystify the stormwater challenge for local officials attempting to deal with problems. CMAP would like to be better equipped to assist local governments with this challenge, particularly communities without the capacity to address challenges on their own, either with staff or contracting with engineering firms.
Additional comments?	

Please list models/tools used to support stormwater planning below.

Model/Tool Name	Key Question	Required Inputs	Model/Tool Output	Model/Tool Platform	User Base	Calibration	Maintenance and Updates	Agency Coordination	Additional Notes

PART 4

Additional Notes/Comments

Please provide any additional notes or comments.

- Topography (LiDAR),
- Floodplains (FEMA DFirm)
- FEMA Repetitive/Severe Repetitive Loss Properties
- Historical stream mapping (Georeferenced USGS quad or other)
- Depth of Groundwater
- Soils (SSUGO)

The Calumet Stormwater Collaborative Data & Modeling Work Group is collecting data about the use of GIS, models, and to tools in an effort to foster regional collaboration to solve stormwater problems in northeastern Illinois.
Please complete parts 1-4 of the questionnaire below by filling in responses to listed questions and by providing details regarding specific GIS layers and models/tools being used. Hover cursor over red triangles for additional instructions. Note, carriage returns can be entered by pressing Alt+Enter. Fields can be resized based on the contents by double clicking in the field.

PART 1

Organization Information

Question	Response
Organization Name	Forest Preserves of Cook County
Completed By	Eric Otto
Date	7/30/2014
Contact Information	eric.otto@cookcountyil.gov

PART 2

GIS Layer Inventory

Question	Response
Please summarize how your organization uses GIS to support stormwater planning and management.	I use LIDAR 1-foot topography, stream / lakes / wetlands, soils, regulatory floodplain / floodway, and other GIS data layers to understand the hyrdrology and hydraulics of existing drainage system, and design proposed stormwater management infrastructure.
What additional GIS data would be helpful to have for stormwater planning? How might this data be used?	There are many, many locations where municipalities or other agencies discharge stormwater to FPCC property via underground storm sewers. The locations, sizes, tributary areas, land uses, and other H&H-type data associated with these outfalls would be very helpful. With this data, FPCC could better understand how to mitigate the impacts of urban stormwater discharges to its natural areas.
Does your organization use any spatial data standards? If so, please describe which one(s).	Probably. I asked this question to FPCC GIS Manager, but no response to date.
Do you use scripts (e.g. python, VB, etc.) for geospatial processing or operations? If so, please describe their purpose.	Same as above.
How do you think data sharing between members of the Calumet Stormwater Collaborative could improve your organization's ability to use GIS to support stormwater planning?	
Additional comments?	

Please list GIS layers and corresponding details in the space below. While many GIS layers are likely used, please list those most relevant to stormwater management.

Name of Data Layer	Contents	Use	Feature Type	Data Source	Date / Timestamp	Update Frequency	Spatial Extent	Available to Share (Yes, No, Maybe)	Additional Notes
LIDAR 1-foot topo									
Stream lines									
Lake polygons									
National Wetland Inv.									
NRCS soils									
Hydric soils									
Reg. floodplain, f-way									
Roads									
FPCC parking lots									
Parcel lines									
Aerial photos									

PART 3

Model/Tool Inventory

Question	Response
What models/tools does your organization use to support stormwater planning?	I use HydroCAD for site-scale stormwater modeling.
Are you considering applying other models/tools in the future? If so, please describe.	For watershed-scale modeling, I would probably try to use MWRD's models developed as part of the Detailed Watershed Plans. Although, continuous simulation modeling could give a better understanding of surface-water and ground-water interactions, and stream baseflows.
What are key questions you are trying to answer by applying models/tools?	With site-scale stormwater modeling, I am trying to understand runoff rates and volumes.
Do you account for climate change in current analysis approaches? Do you believe it is important to do so?	Currently, I don't consider climate change in any analyses. Climate change is probably something to consider as it relates to stream baseflows.
How do you think the Calumet Stormwater Collaborative could improve your organization's ability to use models/tools to support stormwater planning?	
Additional comments?	

Please list models/tools used to support stormwater planning below.

Model/Tool Name	Key Question	Required Inputs	Model/Tool Output	Model/Tool Platform	User Base	Calibration	Maintenance and Updates	Agency Coordination	Additional Notes
HydroCAD									

PART 4

Additional Notes/Comments

Please provide any additional notes or comments.

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Please complete parts 1-4 of the questionnaire below by filling in responses to listed questions and by providing details regarding specific GIS layers and models/tools being used. Hover cursor over red triangles for additional instructions. Note, carriage returns can be entered by pressing Alt+Enter. Fields can be resized based on the contents by double clicking in the field.

PART 1

Organization Information

Question	Response
Organization Name	MWRD
Completed By	John Watson
Date	8/4/2014 to 8/15/2014
Contact Information	John.Watson@mwrd.org

KEY: **Alex initial** **Rachel edits (QC)** **John checks (QA)** Storino requests modeling group additions

PART 2

GIS Layer Inventory

Question	Response
Please summarize how your organization uses GIS to support stormwater planning and management.	exhibits for board letters & public meetings, IDing property, existing infrastructure info, 1' county topo comes in handy all the time, sometimes we give our model s to consultants, who extract the info and import into H&H models, tracking permits
What additional GIS data would be helpful to have for stormwater planning? How might this data be used?	Shades of imperviousness (or at least better impervious/pervious)
Does your organization use any spatial data standards? If so, please describe which one(s).	no official data standards to my knowledge. Most however are in the following XY coordinate system: NAD_1983_StatePlane_Illinois_East_FIPS_1201_Feet; Projection: Transverse_Mercator
Do you use scripts (e.g. python, VB, etc.) for geospatial processing or operations? If so, please describe their purpose.	Visual Basic, some python. Searches in GIS, I use VB for just about everything…
How do you think data sharing between members of the Calumet Stormwater Collaborative could improve your organization's ability to use GIS to support stormwater planning?	improved model updatedness at the minimum, at the most, more precise and effiecient models that accurately model reality
Additional comments?	see bottom

Please list GIS layers and corresponding details in the space below. While many GIS layers are likely used, please list those most relevant to stormwater management.

Name of Data Layer	Contents	Use	Feature Type	Data Source	Date / Timestamp	Update Frequency	Spatial Extent	Available to Share (Yes, No, Maybe)	Additional Notes
SWTR.SWTR_Waterways	Thalwegs of regional waterways	multiple	Polyline	EGISDW_GISVIEWER	12/31/2010	Unknown	Cook County?	Yes	No
SWTR.SWTR_Waterways_fema	Thalwegs of regional waterways	multiple	Polyline	EGISDW_GISVIEWER	2/28/2011	Unknown	Cook County?	Yes	No
SWTR.SWTR_XSCutlines_100	Cross-sectional Cutlines	multiple	Polyline	EGISDW_GISVIEWER	12/31/2010	Unknown	Cook County?	Yes	No
SWTR.SWTR_Inundation100	Watershed	multiple	Polygon	EGISDW_GISVIEWER	12/31/2010	Unknown	Cook County?	Yes	No
SWTR.SWTR_XSModeled_fema	Cross-sectional Cutlines	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
SWTR.SWTR_XSModeledAnno_fema	Elevations	multiple	Polygon	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
SWTR.SWTR_XSRoundedAnno_fema	Elevations	multiple	Polygon	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
SWTR.SWTR_XSRounded_fema	Cross-sectional Cutlines	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
GIS.SWTR_100YrFloodcc_fema	Flood Locations	multiple	Polygon	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
GIS.SWTR_SMPWatersheds	Green Infrustructure Planning	multiple	Polygon	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_DeepTunnelInterfaceLoc_PT	Deep Tunnel Interface Locations	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_DropShaftLocation_PT	Deep Tunnel Shaft Locations	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
INTS_LS_CONNECTION_PT	Connection Point	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
LCLS_CATCH_BASIN_PT	Water Catch Basin	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_ConnStrcLoc_PT	Deep Tunnel Connection Structure Location	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_InterfaceLocation_PT	Deep Tunnel Interface Locations	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_PumpStation_PT	Deep Tunnel Pump Station	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_Junction_PT	Deep Tunnel Junction	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_StructureLocation_PT	Deep Tunnel Structure Location	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_SluiceGateLocation_PT	Deep Tunnel Sluice Gate Location	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_GateLocation_PT	Deep Tunnel Gate Location	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_ControllingStrcLoc_PT	Deep Tunnel Control Structure Location	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_ShaftLocation_PT	Deep Tunnel Shaft Locations	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_OutfallLocation_PT	Deep Tunnel Outfall Locations	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_GENERIC_NODE_PT	Deep Tunnel Generic NODE	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_WeirLocation_PT	Deep Tunnel Weir Location	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_DeepStructure_LN	Deep Tunnel Structure Location	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_ConnectingTunnel_LN	Deep Tunnel Connecting Tunnel	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_OtherStructure_LN	Deep Tunnel Structure Location	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_DeepTunnel_LN	Deep Tunnel Layout	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_NearSurfaceStructure_LN	Deep Tunnel Near Surface Structure	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP Graphical Representation Polygon	Deep Tunnel and Reservior Program	multiple	Polygon	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
TARP_Reservoir_PN	Deep Tunnel Reservior Location	multiple	Polygon	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
Retaining Wall	Water Retaining Wall	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
Tunnel Tarp	Deep Tunnel and Reservior Program	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
MUPPS.SEWR_COMB_ANNO	Combined Sewer	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
MUPPS.SSWR_ANNO	Storm Water	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No
MUPPS.STRM_ANNO	Storm Water	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No

MUPPS.Misc_Anno_SEWERS	Misc. Combined Sewer	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Storm Manhole	Stormwater Manhole	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Storm Curb Inlet	Stormwater Inlet	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Combined Sewer Manhole	Combined Sewer	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Storm Catch Basin	Stormwater Catch Basin	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Storm Inlet	Stormwater Inlet Access	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Storm Vault	Stormwater Vault	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Storm Vent	Stormwater Vent Access	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Combined Sewer Leader	Combined Sewer	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Combined Sewer Pipe	Combined Sewer	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Abandoned Storm Pipe	Stormwater Inlet	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Storm Leader	Stormwater Leader	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Storm Pipe	Stormwater Pipe	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Storm Tile	Stormwater Tile	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Tunnel	Tunnel Combined	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
LCLS_MANHOLE_PT	Local Sewers Manhole Inspection Point	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
INTS_OUTFALL_PT	Interceptor Outfall Point	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
INTS_STRUTURE_PT	Interceptor Struture Location	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
INTS_GENTERIC_NODE_PT	Interceptor Generic NODE	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Miscellaneous Lines in Water	Water Lines	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
LCLS_END_SECTION_PT	Local Sewers End Section	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
INTS_PUMP_STATION_PT	Interceptor Pump Station	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
INTS_GATE_PT	Interceptor Gate Housing	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
INTS_PIPE_LN	Interceptor Pipe	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
LCLS_PIPE_LN	Local Sewers Pipe	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
LCLS_SWER_DISTRICT_PN	Local Sewers District	multiple	Polygon	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Wastewater Lagoon	Wastewater Lagoon Location	multiple	Polygon	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Abandoned Sewer Pipe	Sewer Pipe	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
MUPPS.WWTR_ANNO	Wastewater	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Sewage Manhole	Sewage Manhole Inspection	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Sewage Valve	Sewage Valve	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Wastewater Manhole	Wastewater Manhole	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Wastewater Structure	Wastewater Structure	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Wastewater Valve	Wastewater Structure	multiple	Point	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Sewage Leader	Sewage Leader	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Sewage Pipe	Sewage Pipe	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Wastewater Leader	Wastewater Leader	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		
Wastewater Pipe	Wastewater Pipe	multiple	Polyline	EGISDW_GISVIEWER	Unknow/Time Disabled	Unknown	Cook County?	Yes	No		

PART 3

Model/Tool Inventory

Question	Response
What models/tools does your organization use to support stormwater planning?	GIS tools (clip), HEC-RAS, HEC-HMS
Are you considering applying other models/tools in the future? If so, please describe.	Database system that connects permits with spatial data
What are key questions you are trying to answer by applying models/tools?	Which areas are at risk for flooding? Conducting cost-benefit ratio analyses based on flood areas for further use in MWRD property acquistion project.
Do you account for climate change in current analysis approaches? Do you believe it is important to do so?	Yes, because it is evident that 25, 50, 100, etc yr flood events happen much more frequently than their names suggest. This must be considered in flood damages mitigation.
How do you think the Calumet Stormwater Collaborative could improve your organization's ability to use models/tools to support stormwater planning?	coordination b/w agencies leading to better performance and cost-effeniency throughouth, with the overall end goal to mitigate flooding in Cook County!
Additional comments?	see bottom

Please list models/tools used to support stormwater planning below.

Model/Tool Name	Key Question	Required Inputs	Model/Tool Output	Model/Tool Platform	User Base	Calibration	Maintenance and Updates	Agency Coordination	Additional Notes
MetroFlow	What is the outcome when all the models are run together?	IUHM, InfoWorks, ICAP, Interceptor SWMM, TARP SWMM, and ITM	CSO numbers, overall system behaviour	MetroFlow	MWRD, others?	unknown	unknown	unknown	difficult to change to test upgrades to system, GI
IUHM	create usable model from sparse dataset (estimate missing data (diameters, inverts) using Horton's stream ordering, etc)	as much infrastructure data as possible (inverts, diameters, connections, etc), design storm or typical year (1984?), etc	outflow hydrographs to TARP and interceptors	IUHM, based on infoworks, SWMM, and ArcGIS/ArcInfo	U of I students (and hardly anyone else)	unknown	when funding allows	unknown	typically difficult to modify / support without another contract (at least that's what we're told), likely due to the combined pseudo-consultant/research institutuion relationship with CH and need to support students on RA's, ect.

InfoWorks	(Column C-Row 114) What is distribution of flow between TARP dropshaft and combined sewer overflow location? What is volume, duration and frequency of CSO's caused by Hydraulics of TARP tunnels and dropshafts? Basement backups	(Column D-Row 114)inflow hydrographs from IUHM and city model. hydralic information, slope, diameter, length, roughness. Invert elevation, diameter of junctions. Description of TARP	(Column E-Row 114) water Depth, head, inflow in nodes,flow, velocity, volume, overflow volume, as time varied data. Hydrographs at	(Column F-Row 114) IUHM, GIS	(Column G-Row 114) MWRD	(Column KLM-Row 114) Limited gate control structures . Cannot explicitly model sluice gates of roller gates.	?	?	?
ICAP	(Column C-Row 115) what is the conveyance capacity of the TARP system and the impact of different pump out rates and reservoir conditions?	(Column D-Row 115) runoff hydrographs form IUHM, Lumped SWMM model of from SWMM interceptor	(Column E-Row 115) Depth, flow, volume, CSO duration, Text summaries, tabular	(Column F-Row 115) ICAP, IUHM, SWMM	(Column G-Row 115) MWRD	(Column KLM-Row 115) just operates under steady-state assumptions	?	?	?
Interceptor SWMM	Interceptor performance, CSOs, urban flooding	rainfall, land area, infrastructure data (inverts, diameters, connections, etc)	hydrographs, CSOs?	SWMM	MWRD	unknown	unknown	unknown	unknown
TARP SWMM	Interceptor performance, CSOs, urban flooding	interceptor, connection hydrographs	hydrographs, CSOs?	SWMM	MWRD	unknown	unknown	unknown	unknown
ITM	(Column C-Row 118) How the system response under pressurized, free surface and mixed condition?	(Column D-Row 118)inflow hydrographs from IUHM, Lumped SWMM model or interceptor model. hydralic information, slope, diameter, length, roughness. Invert elevation, diameter of junctions. Operation rules and hydralice characteristics of control structures, pumps, gates. stage-storage relations for storage units. Initial conditions describing flow rates, stages, and control settings for entire system.	(Column E-Row 118) water Depth, head, inflow in nodes,flow, velocity, volume, overflow volume, as time varied data. Hydrographs at dropshafts as input data necessary for ITM and ICAP. Text summaries, tabular reports, visual graphs.	(Column F-Row 118) IUHM, GIS, SWMM	(Column G-Row 118) MWRD	(Column KLM-Row 118) All models need time to run but ITM requires more.	?	?	?

PART 4

Additional Notes/Comments

Please provide any additional notes or comments.

(summarize internal and UIUC emails in a PR-appropriate way)

The Calumet Stormwater Collaborative Data & Modeling Work Group is collecting data about the use of GIS, models, and to tools in an effort to foster regional collaboration to solve stormwater problems in northeastern Illinois.
Please complete parts 1-4 of the questionnaire below by filling in responses to listed questions and by providing details regarding specific GIS layers and models/tools being used. Hover cursor over red triangles for additional instructions. Note, carriage returns can be entered by pressing Alt+Enter. Fields can be resized based on the contents by double clicking in the field.

PART 1

Organization Information

Question	Response
Organization Name	Chicago Department of Planning and Development
Completed By	Michael Berkshire
Date	8/13/2014
Contact Information	michael.berkshire@cityofchicago.org - 312-744-0363

PART 2

GIS Layer Inventory

Question	Response
Please summarize how your organization uses GIS to support stormwater planning and management.	several data sets/layers have been used to identify areas where green infrastructure could have a positive impact: stormwater modeled pipe size, 5-year street and basement flooding risk areas, stormwater flowpath analysis, city-owned lots
What additional GIS data would be helpful to have for stormwater planning? How might this data be used?	GIS data used to create DWM's "Chicago Combined Sewer Model: Basement Flood Risk Map"
Does your organization use any spatial data standards? If so, please describe which one(s).	
Do you use scripts (e.g. python, VB, etc.) for geospatial processing or operations? If so, please describe their purpose.	
How do you think data sharing between members of the Calumet Stormwater Collaborative could improve your organization's ability to use GIS to support stormwater planning?	
Additional comments?	

Please list GIS layers and corresponding details in the space below. While many GIS layers are likely used, please list those most relevant to stormwater management.

Name of Data Layer	Contents	Use	Feature Type	Data Source	Date / Timestamp	Update Frequency	Spatial Extent	Available to Share (Yes, No, Maybe)	Additional Notes
	ESRI GRID file representing average ground surface elevations on a 5-foot by 5-foot grid spaces (Digital Terrain Model - DTM)								

PART 3

Model/Tool Inventory

Question	Response
What models/tools does your organization use to support stormwater planning?	
Are you considering applying other models/tools in the future? If so, please describe.	a city-wide permeability baseline data
What are key questions you are trying to answer by applying models/tools?	where are the most cost effective areas to construct green infrastructure or add permeability
Do you account for climate change in current analysis approaches? Do you believe it is important to do so?	yes
How do you think the Calumet Stormwater Collaborative could improve your organization's ability to use models/tools to support stormwater planning?	
Additional comments?	

Please list models/tools used to support stormwater planning below.

Model/Tool Name	Key Question	Required Inputs	Model/Tool Output	Model/Tool Platform	User Base	Calibration	Maintenance and Updates	Agency Coordination	Additional Notes

PART 4

Additional Notes/Comments

Please provide any additional notes or comments.

The Calumet Stormwater Collaborative Data & Modeling Work Group is collecting data about the use of GIS, models, and to tools in an effort to foster regional collaboration to solve stormwater problems in northeastern Illinois.
Please complete parts 1-4 of the questionnaire below by filling in responses to listed questions and by providing details regarding specific GIS layers and models/tools being used. Hover cursor over red triangles for additional instructions. Note, carriage returns can be entered by pressing Alt+Enter. Fields can be resized based on the contents by double clicking in the field.

PART 1

Organization Information

Question	Response
Organization Name	Center for Negihborhood Technology
Completed By	Ryan Wilson
Date	9/29/2014
Contact Information	rwilson@cnt.org

PART 2

GIS Layer Inventory

Question	Response
Please summarize how your organization uses GIS to support stormwater planning and management.	We use ArsGIS and QGIS to collect and correlate quanititative data (flood claims, flood reports) to housing stock, flood plains, public infrasructure.
What additional GIS data would be helpful to have for stormwater planning? How might this data be used?	1) High Risk Areas (from H&H models or other) would be helpful in correlating reported damage/impact to projected risk. 2)Residentassessment, complaints records and property surveys of flooding would be helpful to target outreach/community engagment. 3)Planned & on-going Capital Improvements (Stormwater) could be used to target outreach. 4) SSMMA/Chicago Wilderness mapping would be useful to identify gi opportunites (5) flood damage payout data
Does your organization use any spatial data standards? If so, please describe which one(s).	
Do you use scripts (e.g. python, VB, etc.) for geospatial processing or operations? If so, please describe their purpose.	
How do you think data sharing between members of the Calumet Stormwater Collaborative could improve your organization's ability to use GIS to support stormwater planning?	Yes. The data collection of CMAP and SSMMA seem like good examples of how data-sharing could occur. For more sensitive data, I could imagine some sort of non-disclosure or MOU to allow use of information for planning.
Additional comments?	

Please list GIS layers and corresponding details in the space below. While many GIS layers are likely used, please list those most relevant to stormwater management.

Name of Data Layer	Contents	Use	Feature Type	Data Source	Date / Timestamp	Update Frequency	Spatial Extent	Available to Share (Yes, No, Maybe)	Additional Notes

PART 3

Model/Tool Inventory

Question	Response
What models/tools does your organization use to support stormwater planning?	US EPA Stormwater Calculator V1.1/CNT Economic Benefits of Green Infrastructure Tool/CNT Green Infrastructure Portfolio Standard
Are you considering applying other models/tools in the future? If so, please describe.	Yes. We are planning to implement new models/tools, as yet undefined, to help with planning and implementation of Rain Ready and Wetrofit projects. This will include a sensor based flood alert ystem that we're at the early stages of developing. We also plan to use the Chicago Wilderness/SSMMA GI maps, the City of Chicago LIDAR maps, and community mapping/residential surveys.
What are key questions you are trying to answer by applying models/tools?	1) Which areas are experiencing greatest impact by excess stormwater and flooding. (2) What upgrades to properties can help homeowners/businesses get their property RainReady, what cost, with what benefits
Do you account for climate change in current analysis approaches? Do you believe it is important to do so?	There is some function to account for climate change in EPA's tool. It is important to do so.
How do you think the Calumet Stormwater Collaborative could improve your organization's ability to use models/tools to support stormwater planning?	Yes.
Additional comments?	Rain Ready Community is a program that will require good community-based mapping of flooding/water quality/supply risks and opportunities. We would rather work with others and draw on their expertise than try and do it alone.

Please list models/tools used to support stormwater planning below.

Model/Tool Name	Key Question	Required Inputs	Model/Tool Output	Model/Tool Platform	User Base	Calibration	Maintenance and Updates	Agency Coordination	Additional Notes
EPA Storrmwater Calculator	1) Site Runoff 2) GI Benefits	1) Location 2) BMP sizing							

PART 4

Additional Notes/Comments

Please provide any additional notes or comments.