
Chapter 2

Direction and Process for Regional I/I Control Program

This chapter summarizes the background, goals, policies, and process for developing a regional infiltration/inflow (I/I) control program. It also provides an overview of I/I control program work completed to date. More detailed information on completed work, including supporting and background documents, is presented in the appendices.

2.1 Regional Wastewater Services Plan Direction: Goals and Policies

In 1999, King County adopted the Regional Wastewater Services Plan (RWSP) under Ordinance 13680. RWSP policies establish the framework and process for a regional I/I control program, as described below.

I/IP-1: King County is committed to controlling I/I within its regional conveyance system and shall rehabilitate portions of its regional conveyance system to reduce I/I whenever the cost of rehabilitation is less than the costs of conveying and treating that flow or when rehabilitation provides significant environmental benefits to water quantity, water quality, stream flows, wetlands, or habitat for species listed under the Endangered Species Act (ESA).

I/IP-2: King County shall work with component agencies to reduce I/I in local conveyance systems by the following:

1. By July 1, 2001, the King County Executive shall propose for County Council review and approval an initial list of pilot rehabilitation projects dealing with the most serious and readily identified I/I problem areas in local sewer systems.
2. By July 1, 2002, the King County Executive shall propose an additional list of pilot projects. The pilot rehabilitation projects shall be used to demonstrate the effectiveness of I/I controls in local sewer systems tributary to the regional system.
3. By December 31, 2002, the County, in coordination with component agencies, shall develop model local conveyance system design standards, including inspection and enforcement standards, for use by component agencies to reduce I/I within their systems.
4. By December 31, 2003 (now March 2005), the King County Executive shall submit to the County Council a report defining I/I levels in each of the local sewer systems, based on assessments of those systems, and identifying options and the associated cost of removing I/I

and preventing future increases. The options should be informed by the results of the pilot rehabilitation projects described in I/IP-2.1. The report shall present an analysis of options on cost-effectiveness and environmental costs and benefits, including, but not limited to those related to water quality, groundwater interception, stream flows and wetlands, and habitat of species listed under the ESA.

The report shall include information on public opinion, obtained through surveys and other appropriate methods, on the role of individual property owners in implementing solutions to reducing I/I, voluntary and mandatory property owner actions, willingness to pay for reducing I/I, and acceptable community options for reducing I/I.

5. No later than December 31, 2004 (now 2005¹), utilizing the report described in I/IP-2.3, the King County Executive shall recommend target levels for I/I reduction in local collection systems and propose long-term measures to meet the targets. These measures shall include, but not be limited to, establishing new local conveyance system design standards, implementing an enforcement program, developing an incentive-based cost-sharing program, and establishing a surcharge program. The overall goal for peak I/I reduction in the service area should be 30 percent from the 20-year level identified in the report.

The County shall pay 100 percent of the cost of the assessments and pilot projects.

I/IP-3: King County shall consider an I/I surcharge, no later than June 30, 2005 (now June 30, 2006²), on component agencies that do not meet the adopted target levels for I/I reduction in local collection systems. The I/I surcharge should be specifically designed to ensure the component agencies' compliance with the adopted target levels. King County shall pursue changes to component agency contracts if necessary or implement other strategies in order to levy an I/I surcharge.

2.2 Process for Regional I/I Control Program Development

The County and local agencies collaborated in developing the approach to a regional I/I control program. The County's collaborative approach included: (1) conducting nine workshops with the 34 local agencies that discharge sewage to the regional sewer system, and (2) conducting over seventy-five work sessions with the Metropolitan Water Pollution Abatement Advisory Committee (MWPAAC) and one of its subcommittees, the Engineering and Planning (E&P) Subcommittee. This approach was and continues to be used to collaboratively develop an I/I control program.

¹ Because of lack of rainfall during the flow monitoring winter season of 2000–2001 and a corresponding lack of flow events, monitoring was continued during the 2001–2002 winter season. This additional monitoring delayed a regional I/I control program from the original RWSP schedule.

² Because of the 1-year delay that resulted from conducting flow monitoring in 2001–2002, the date for considering a surcharge was adjusted by a year in order to provide adequate time for the County Council to take action on the overall I/I program recommendation and then consider a surcharge.

As mentioned above, the County conducted nine County local agency workshops beginning in 2000 and continuing through 2003. The purpose of these workshops, which were attended by both policy makers and technical staff, was to review and reach agreement on key aspects of a regional I/I control program. The workshop topics are listed in Table 2-1.

Table 2-1. King County–Local Agency Workshop Topics

| No. | Workshop Topic |
|------------|---|
| 1 | Introduction, approach, and work plan for a regional I/I control program |
| 2 | Pilot project selection process and criteria; pilot project reimbursement and funding |
| 3 | Introduction to technical concepts |
| 4 | Financial concepts; alternatives for cost sharing |
| 5 | Modeling I/I flows |
| 6 | Design standards and rehabilitation techniques; contract management and language; private property I/I issues |
| 7 | Metropolitan Water Pollution Abatement Advisory Committee (MWPAAC) RWSP Subcommittee; ³ design standards, procedures, and policies |
| 8 | Pilot project selection |
| 9 | Pilot projects update, including sewer system evaluation survey (SSES) results; schedules |

The County also collaborated with MWPAAC and the E&P Subcommittee to develop and recommend several specific regional I/I control program elements. These elements include the following:

- Design standards, policies, and procedures for I/I reduction projects
- Policies and intergovernmental agreements (IGAs) to guide I/I projects
- Criteria for benefits and costs of I/I projects
- Assumptions to model capital facility needs and identify I/I reduction projects
- Assumptions for cost-effectiveness analysis of I/I removal projects
- Issues related to I/I reduction on private property
- Issues related to financing I/I removal

In 2004, the E&P Subcommittee continued to work toward reaching consensus on a large number of complex issues related to the options presented in this report. The E&P

³ Early in the process, MWPAAC’s subcommittee was called the RWSP Subcommittee. This group was expanded to include other local agency representatives interested in I/I, and in 2003, the name was changed to the Engineering and Planning Subcommittee (E&P Subcommittee).

Subcommittee's consensus decisions guided the County and consultant team in developing this report and, along with input from the program workshops, allowed local agencies to shape the parameters of a regional I/I control program.

2.3 Work Completed to Date

This section provides an overview of the work completed to date. The information in this section draws from a number of documents, most of which are included as appendices. The documents contain detailed background information related to the completed flow monitoring, hydraulic modeling, regional sewer system assessment, and pilot rehabilitation projects; the development of draft regional standards, procedures, guidelines, and policies for I/I reduction projects; and the development of procedures for evaluating cost-effectiveness. These completed efforts established the framework, the technical information, and the tools that were used to develop this report. They will also be used to complete the cost-effectiveness analysis needed to identify specific I/I reduction projects, and to develop a regional I/I control program.

2.3.1 Flow Monitoring

In response to the RWSP directive (Policy I/IP-2.3) to assess I/I levels in existing local agency sewer systems, the County monitored wastewater flows throughout the service area during the 2000–2001 and 2001–2002 wet weather seasons. New hydrologic and hydraulic modeling software was obtained and used to identify the location and magnitude of I/I in each system. (For more detailed information on flow monitoring, see *Appendix B1*.)

For modeling purposes, 150 flow meters were used to divide the regional wastewater service area into 147 model basins.⁴ These meters identified flow contributions from each model basin. The service area was further subdivided by the installation of an additional 650 flow meters in approximately 800 mini basins.⁵ The mini-basin flows were used to identify levels of I/I and to assist in selecting appropriate locations for I/I removal projects.

Flow meters were installed during the rainy season of 2000–2001 to gauge flow levels from each local agency system. However, that winter brought an unseasonably low number of storms, resulting in insufficient wet-weather flow data. As a result, the flow meters were reinstalled during the wet weather season of 2001–2002. Several rainfall events during this season produced useful flow measurements that could be used to show I/I amounts.

Results of the 2001–2002 monitoring effort provided important geographic information about where the highest levels of I/I were in the region as well as an indication of how I/I enters the regional system. The geographic results show wide variation in I/I flow rates and volumes during storm events across the collection and conveyance system. I/I flow rates in the various mini basins range from a low of less than 1,100 gallons per acre per day (gpad) to a high of over

⁴ Model basins were comprised of approximately 1,000 acres and 100,000 feet of pipe. The large-scale model basins were used to evaluate I/I flow rates throughout the regional service area.

⁵ Mini basins were comprised of approximately 150 acres and 22,000 feet of pipe. Further subdividing the model basins into mini basins allowed I/I sources to be more accurately located, and identified areas more economically feasible to rehabilitate.

65,000 gpad. The monitoring data also yields information about how I/I is getting into local agency collection systems and then into the regional conveyance system based on how quickly I/I flows rise and fall in a particular mini basin during and after storm events.

Rapid inflow of water that corresponds closely with a peak rainfall event comes mostly from private property, typically from the following sources:

- Downspout connections to the sanitary sewer system
- Cracked side-sewer pipes
- Foundation drains
- Sump pumps

Although not typical, rapid inflow sources can also occur from public portions of the system, including storm drain connections to the sanitary sewer and leaky manholes.

Slow infiltration of water into the collection system is another source of I/I. Slow infiltration typically comes from groundwater and results in higher I/I flows remaining in the system for several days after the conclusion of a storm event. Slow infiltration typically finds its way into the system via leaky manholes, sewer mains owned by the local agencies or the County, and laterals that can either be privately owned or owned by a local sewer agency, depending on the rules in place in the 34 separate agencies.

Once sufficient large storm flow monitoring data were collected, the results were compiled and used to calibrate the hydrologic and hydraulic flow models for each basin. This calibration process used measured rainfall, measured flow data, and basin-specific pipe and service area information. The calibrated basin models were used to simulate I/I flows that could occur in the regional system using a 60-year rainfall record. The results of this 60-year simulation were used to estimate the 20-year peak I/I flow from each model basin. This peak I/I flow was measured in gallons per acre per day and served as an indicator for the performance of each local agency's system.

Please see Chapter 3 of the *Regional Needs Assessment Report* for more detailed information on I/I flows in the existing system.

2.3.2 Regional System Modeling

The County developed a computerized regional flow hydraulic model for analyzing sewer flow data and for determining cost-effectiveness of I/I reduction projects. The model was calibrated to flow data collected during flow monitoring (described above). The model is being used to estimate the timing of conveyance upgrade projects based on projected 20-year recurrence interval projected peak flow rates. In order to make these projections, the model includes historical rainfall data, historical flow data, sewer growth projections, and population and employment projections. Forecasted probable I/I reduction rates were then applied to identify potential cost-effective I/I reduction projects that could reduce or eliminate the need for a particular conveyance system improvement capital project. I/I removal effectiveness information gathered from the I/I pilot projects (see *Appendix B3*) was used to forecast the probable I/I

reduction that could be realized from a particular I/I local system repair or replacement project. The model results, in addition to information in this report, will be used to develop a regional I/I control program.

2.3.3 Standards, Procedures, Guidelines, and Policies

In response to the RWSP directive to recommend new local conveyance system design standards (I/IP-2.2), the County and local agencies (via the E&P Subcommittee) collaboratively developed draft conveyance system design standards, procedures, guidelines, and policies during 2002. In 2004, the County and E&P Subcommittee revised the standards, procedures, guidelines, and policies to reflect lessons learned from the pilot projects.

The draft standards, procedures, guidelines, and policies include a wide range of program details that address physical components of the collection system as well as policy issues. They comprise a mix of standards, procedures, guidelines, and policies for the County and local agencies. Some of the subjects covered are as follows:

- Storm drainage connections to the sanitary sewer
- Smoke and dye testing for sewer system evaluation survey (SSES) investigations
- Pipeline and manhole leak inspections
- Allowable connections to side sewers
- Public funding for all phases of I/I mitigation work
- County and local agency roles in public education programs
- Methods of gaining access agreements to do work on private property.
- I/I program funding
- Public education

A summary of these draft standards, procedures, guidelines, and policies is presented in *Appendix A3*. The complete *Standards, Procedures, and Policies Final Draft* is included in *Appendix B2*.

The draft *Standards, Procedures, and Policies* are intended to guide the engineering and construction of future sewer system infrastructure to achieve long-term I/I control, and to limit system degradation and I/I increases over time. They remain a draft document because further revisions and refinement are anticipated as additional experience with I/I reduction projects is gained. Questions also remain between the County and local agencies regarding whether some items should be employed as guidelines or as standards. This subject is discussed in more detail later in Chapter 4.

2.3.4 Pilot Projects

The County and local agencies reached consensus in April 2002 on the selection of 10 local agency collection system rehabilitation and replacement pilot projects “to demonstrate the effectiveness of I/I controls in the local sewer systems tributary to the regional system” (RWSP policy I/IP-2.1). Pilot project selection was a collaborative effort with MWPAAC, and useful information was gathered during the process. The County was the sole source of funding for most of these pilot projects. In two cases, both the County and host local agencies provided funding.

The local agencies established criteria for selecting the pilot projects at a program workshop. These criteria are described in detail in the *Pilot Project Report* (see *Appendix B3*).

The local agencies and County selected 10 pilot projects among 12 total local agencies. (One manhole rehabilitation project was proposed by three local agencies.) The selected pilot projects are presented in Table 2-2 by local agency service area and by the type of pilot project. The location of the pilot projects are displayed in Figure 2-1.

The pilot projects were completed in late 2003 and early 2004, followed by post-rehabilitation flow monitoring and modeling. The results were compared to the 2001–2002 monitoring and modeling findings to assess the effectiveness of various I/I reduction technologies and approaches. The pilot projects produced valuable information about the use of different technologies and administrative methods to reduce I/I. A brief summary of key findings is included here. Detailed information is available in the *Pilot Project Report* (*Appendix B3*).

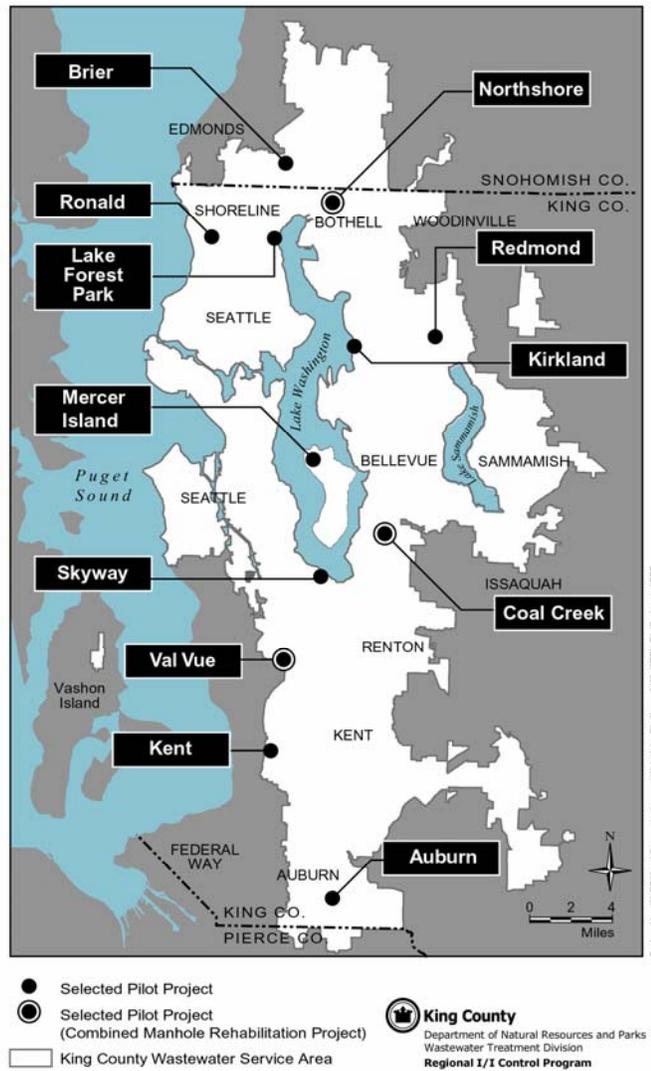


Figure 2-1. Pilot Project Location Map

Table 2-2. Pilot Projects

| Local Agency Service Area | Type of Pilot Project |
|-------------------------------|--|
| Auburn | Rehabilitate public manholes, sewer mains, and laterals; and private side sewers |
| Brier | Rehabilitate public manholes and sewer mains |
| Coal Creek/Northshore/Val Vue | Rehabilitate public manholes |
| Kent | Rehabilitate private laterals and side sewers |
| Kirkland | Rehabilitate public manholes, sewer mains, and laterals |
| Lake Forest Park | Rehabilitate public manholes and sewer mains |
| Mercer Island | Rehabilitate public sewer mains |
| Redmond | Rehabilitate public manholes, sewer mains, and laterals |
| Ronald | Rehabilitate private side sewers and some public laterals |
| Skyway | Rehabilitate and replace public manholes, sewer mains, and laterals; and private side sewers |

Note: "Public" means owned by a local agency, and "private" means owned by property owners.

Key findings from the pilot projects are as follows:

- I/I reduction and control are achievable in areas where the source(s) of I/I can be identified and targeted by focusing repairs on the appropriate system components.
- Achieving significant I/I reduction is contingent on targeting large areas with high volumes of I/I for rehabilitation. In other words, measurable reductions in I/I can be expected only in those areas of the region with higher levels of I/I.
- Pipe bursting and cured-in-place pipe technologies are reliable for reducing I/I. Several other technologies were tested, but were relatively expensive or ineffective. This latter finding may be partially due to site conditions and not the technology alone. As an example, projects that focused on manhole and sewer main rehabilitation would not result in significant I/I reductions if the sources of I/I were primarily from private property.
- Based on lessons learned through the pilot projects, it is believed that where I/I originates on private property, significant reduction can be achieved.
- Coordination and communication between local agencies, contractors, and any other municipalities are essential.

The percent of I/I reduction and the percent of pilot basin improved for each pilot project are listed in Table 2-3. It is important to note that several pilot projects found "no measurable reduction." These projects were more focused on rehabilitation techniques and costs and therefore were not a real measure of percent of I/I reduction in all cases. For example, one pipe-bursting project that had been implemented in a residential area was also implemented in a high-density commercial area that happened to have small amounts of I/I. This was done to test for cost differences between residential and commercial areas. (See the *Pilot Project Report, Appendix B3* for more detail.)

Table 2-3. I/I Reduction Percentages for Pilot Projects

| Pilot Basin | % I/I Reduction Achieved | % of Basin Improved |
|--|---------------------------------|----------------------------|
| Auburn A | No measurable reduction | 11% |
| Auburn B | No measurable reduction | 19% |
| Brier | 54% | 23% |
| Coal Creek/Northshore/Val Vue (Manhole Project) | | |
| Coal Creek | No measurable reduction | 52% |
| Northshore | 23% | 64% |
| Val Vue | No measurable reduction | 45% |
| Kent | 78% | 100% |
| Kirkland | 28% | 25% |
| Lake Forest Park | 69% | 35% |
| Mercer Island | 37% | 70% |
| Redmond | No measurable reduction | 38% |
| Ronald | 74% | 72% |
| Skyway | 87% | 100% |

It should be noted that no conclusions could be made regarding the cost-effectiveness of any of the I/I pilot projects. The purposes of the pilot projects were to see if I/I sources could be pinpointed and to test the applicability of rehabilitation technologies in field conditions. The pilot projects were not of a sufficient scale to identify whether any capital costs for conveyance systems or any costs for treatment could be reduced.

2.3.5 Regional I/I Control Program Assumptions

In spring 2004, the County and local agencies (via the E&P Subcommittee) used the results of the pilot projects and the experience of each local agency in working in their respective service areas to define specific regional I/I control program planning assumptions. The planning assumptions are meant to provide guidance for the modeling and cost-effectiveness analysis that will be used to compare specific I/I projects to related downstream conveyance system improvements. The planning assumptions include factors such as design flow criteria, population growth rates, water conservation, system degradation, septic conversion rates, new system I/I allowance, and unit costs and reduction effectiveness of different rehabilitation technologies. Other factors defined included the assumed discount rate, inflation rate, and O&M factors. Use of these assumptions should provide the greatest chance of identifying I/I projects that would be cost-effective if constructed and should also reduce the risk of identifying I/I projects that would not yield measurable I/I reductions if constructed.

The planning assumptions will be used in a model designed to assess future facility needs including sizing and scheduling. The assumptions and model form the basis of the I/I reduction cost-effectiveness analysis. Goals for development of the planning assumptions were that they be

reasonable and realistic to avoid either under- or over-building and to meet the Growth Management Act requirement that the County regional conveyance system have the ability to convey wastewater flows from each local agency when those flows occur. It is anticipated that the County and local agencies will update and modify these initial planning assumptions over time as they gain experience and collect more information from future larger scale I/I rehabilitation projects. See *Appendix A4* for a detailed explanation of the planning assumptions.

2.3.6 Regional Needs Assessment Report

The *Regional Needs Assessment Report* provides a baseline description of the County's existing sewer system and outlines the conveyance improvements that would be necessary to convey 20-year peak flows. The report summarizes the monitoring, hydrologic, and hydraulic modeling that was completed to determine areas and volumes of I/I and to determine the resulting flows in the County's existing regional conveyance system. The following major elements are included in the *Regional Needs Assessment Report*:

- A description of the regional service area, the local agencies sending flow to the system, and the County's existing regional conveyance and treatment system.
- A summary of how the model was used to model system flows and capacity.
- A description of the I/I project rainfall and flow monitoring program that was used to collect data for input into the model.
- A discussion of the different types of fast-response and slow-response I/I components that make up total wet-weather 20-year design flows used to determine needed conveyance capacity.
- An explanation of how the rainfall and flow data were used to calibrate the model to determine flow volumes, including I/I, from wastewater service (mini and model) basins in the local agencies that contribute to the County's regional conveyance system.
- A description of how 20-year design flows, including I/I, were determined and then routed through the County's regional conveyance system to compare design flows with existing pipe hydraulic capacities.
- A listing of the characteristics and budgetary costs of County regional conveyance system improvement projects that would be needed to convey modeled 20-year design flows (without I/I reduction) in areas where the existing facilities are inadequate.

The *Regional Needs Assessment Report* and the I/I program (once approved by the County Council) are the framework for updating and modifying the recommended conveyance system improvements included in the RWSP.

2.4 Cost-effectiveness and Environmental Benefits

Policy I/IP-1 of the adopted RWSP directs the County to rehabilitate portions of the regional conveyance system to reduce I/I when the cost of I/I improvements is less than the cost of new conveyance and treatment facilities or when significant environmental benefits can be achieved.

2.4.1 Cost-effectiveness Analysis

To determine which I/I reduction projects are cost-effective, a computer model is being used to analyze capital facility and I/I reduction information. The analysis provides a means of estimating the *costs of I/I reduction projects compared with the capital and operating costs of conveying and treating peak wastewater flows that include I/I*. See Chapter 6 for more detail.

A benefit-to-cost ratio will be calculated to determine cost-effectiveness for each I/I reduction project and to provide a ranking of the project compared to other I/I reduction projects. The benefit-to-cost ratio is based on the net present values (NPV)⁶ of the costs and benefits for each project. The following formula shows how the benefit-to-cost ratio will be calculated for each I/I reduction project.

| | | | | |
|--|---|--|---|--|
| NPV <i>(planned capital cost reductions, delays, & eliminations)</i> | + | NPV <i>(operating cost delays, reductions, & eliminations)</i> | / | NPV <i>(I/I project costs)</i> |
|--|---|--|---|--|

This formula may be used in several ways. I/I project cost-effectiveness measures can be applied region-wide or on a project-specific basis. If applied region-wide, I/I projects that are less than or equal to the capital costs of conveyance system improvements *in their entirety* would be recommended. If applied on a project-specific basis, *only I/I projects* estimated to be less than or equal to the capital costs of capital conveyance system improvements would be recommended. The project-specific basis would result in the lowest *combined costs* for I/I projects and conveyance system improvements. See Chapter 4 for more detail.

2.4.2 Environmental Assessment

King County’s Water and Land Resources Division (WLRD) conducted an assessment of the potential environmental benefits and/or impacts that may result from implementing a regional I/I

⁶ Net present value is the amount that future sums of money are worth today after accounting for inflation and a specified rate of return.

program. WLRD's complete assessment is in *Appendix A5A*. The following text summarizes their findings.

The assessment considered the separate elements of I/I: stormwater inflow, stormwater infiltration, and base infiltration. Stormwater inflow responds most immediately to rainfall events. Its most common method of entry into the sanitary sewer system is via direct connections of downspouts and other stormwater collection features into sanitary sewer pipes. Stormwater infiltration responds to rainfall events over varying periods, ranging from immediately to delays of several hours. Common sources of stormwater infiltration are areas where cracked sewer service lines intersect intermittent subsurface flows of seasonally high groundwater. Base infiltration is the portion of the non-wastewater flow in sanitary sewer pipes that remains constant through time. Because base infiltration tends to come from deeper groundwater sources, it is difficult to quantify and is typically reported as an estimated volume.

The focus of an I/I program is to reduce flows during the wet season (stormwater inflow and infiltration). Stream flows and groundwater levels are typically high during the wet season. Where stormwater inflow and infiltration can be reintroduced into the landscape in a safely dispersed or infiltrated manner, environmental benefits may be achieved. However, the potential for erosion and localized flooding also exists. The type and scale of impacts depends highly on the volume of water reintroduced into the environment and the physical condition of the area that would receive the water. Therefore, it may be appropriate to perform a hydrologic assessment for each proposed I/I rehabilitation project that includes a downstream analysis and estimate of I/I volumes to be reintroduced into the local landscape and drainage system.