

5. STREAM INFLOW IMPROVEMENTS ANALYSIS

Direct Stream Inflow (DSI) is defined as a surface stream that connects into the combined sewer system. There are several known (and potentially other unknown) DSIs within the PWSA service area. Depending upon the nature of the stream, DSI can take up valuable conveyance capacity in the collection system as well as a portion of the available treatment plant capacity. A perennial stream can contribute flow throughout the year, adding to the base wastewater flow in the collection system. An understanding of the significant amounts of stormwater runoff, including the perennial stream baseflow and other seasonal stream influences, is extremely important for an already capacity deficient collection system. Removing DSI from the collection system can thus restore significant amounts of wastewater conveyance and treatment capacity in dry and wet weather within the system, resulting in reduced combined sewer overflows (CSOs). Stream removal and daylighting projects can also potentially provide significant opportunities for catalyzing new development and redevelopment of surrounding land areas.

As discussed in Section 1 of this report, the current top 10 largest DSI locations were reviewed and identified as listed below. This Section of the report discusses the evaluations performed for each location, options for detaining and/or removing the DSI (stream base flow and stormwater runoff during wet weather conditions) from the sewer system, and opinions of estimated capital cost for the identified stream inflow solutions.

- Spring Garden
- Woods Run (8 locations)
- Panther Hollow Stream and Lake

5.1 Spring Garden Stream Inflow

5.1.1 Site Information and Review of Past Stream Removal Reports

The Spring Garden DSI is located along Spring Garden Avenue just north of Wilson Road in Reserve Township. This DSI location has been evaluated in previous studies as listed below. Each study was reviewed to gather background information on the location for this analysis.

- ALCOSAN Wet Weather Plan Report (2013)
- PWSA Wet Weather Feasibility Study (WWFS) Report (2013)
- 3 Rivers 2nd Nature – Stream Restoration & Daylighting Report (2001)

Data analysis was also conducted, utilizing the following resources:

- PASDA Digital Elevation Models
- Existing PWSA GIS data for storm sewers, combined sewers, and inlets

- 3 Rivers Wet Weather (3RWW) Regional Sewer Mapping Tool
- USGS StreamStats Version 3 Beta
- Historic Mapping: <http://peoplemaps.esri.com/pittsburgh/>
- Previous PWSA Flow Monitoring data in the Spring Garden area (2003-2004 data)
- Field visits

5.1.2 Site Overview

The 3 River's 2nd Nature Report notes that the Spring Garden total watershed area is 2,302 acres, making it the 7th largest watershed in Allegheny County. The upstream half of the Spring Garden sewershed is located in Reserve Township, and the downstream half of the sewershed is located in the City of Pittsburgh's Troy Hill neighborhood. The contributing drainage area for the Spring Garden inflow point covers 334 acres, mostly within Reserve Township.

The stream carries a base flow throughout the year, and also contributes flow from stormwater runoff. The entire stream enters a 72-inch diameter combined sewer system upstream of the City of Pittsburgh, near the intersection of Spring Garden Avenue and Wilson Road in Reserve Township. Ideally, the stream inflow can be captured at this location and "daylighted" or detained. Figure 5-1 highlights the stream inflow point and contributing drainage area. There are 2 SSOs owned by Reserve Township located upstream of the Spring Garden DSI location.

At this inflow point, the stream flows constantly into a 72-inch diameter PWSA-owned combined sewer and contributes to combined sewer overflows (CSOs) through the A-60 outfall at the Allegheny River. During a site visit on a dry weather day, an active, flowing stream base flow was observed. The collection system model indicates the base stream flow entering the sewer system to be approximately 97 million gallons annually. Figure 5-2 shows the entire A-60 combined sewershed, with the stream inflow location identified.

Table 5-1 lists the characteristics of the Spring Garden watershed provided by the USGS StreamStats tool. This tool provides useful information related to land use and the amount of impervious and pervious areas.

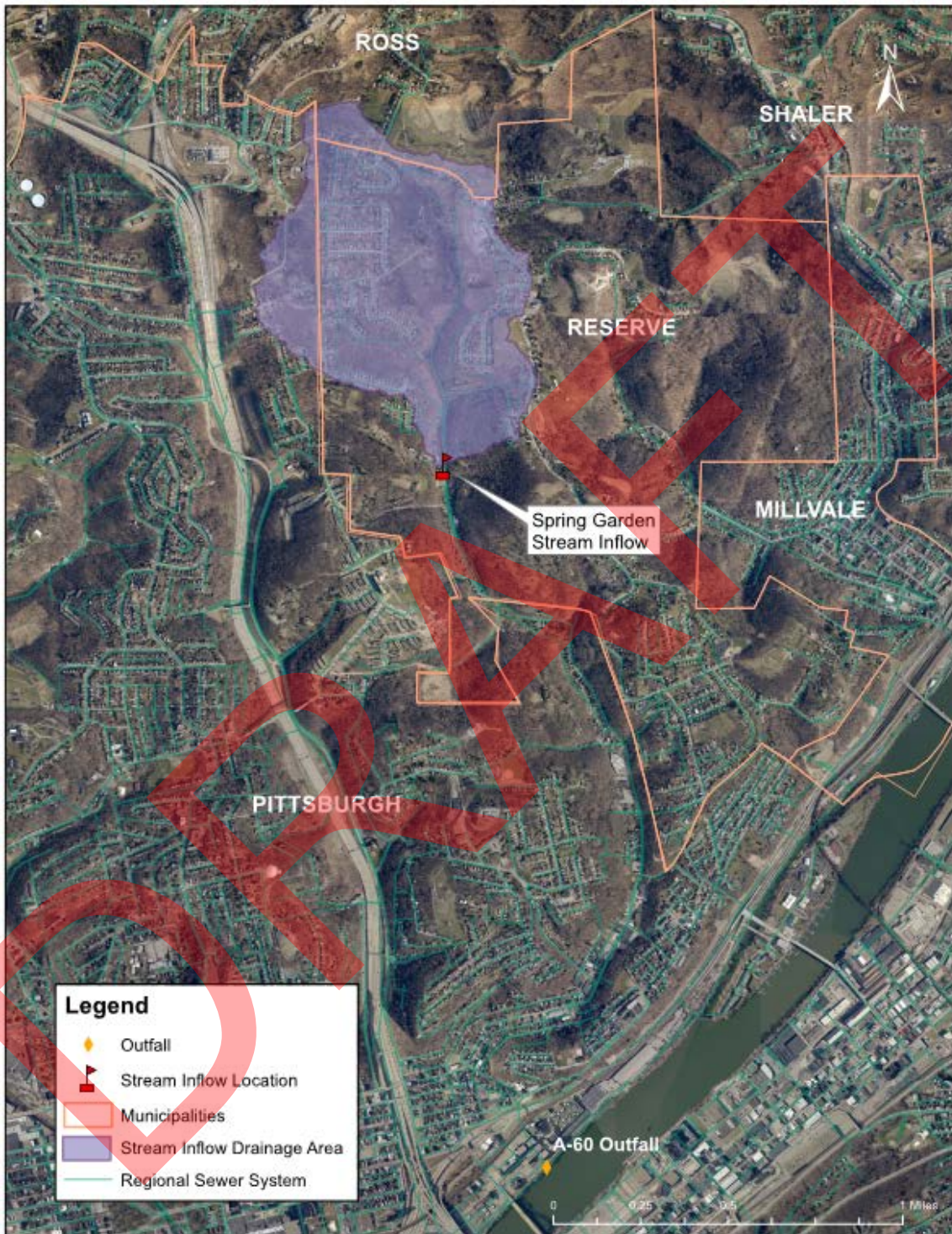


Figure 5-1: Spring Garden Watershed Area and Stream Inflow Point

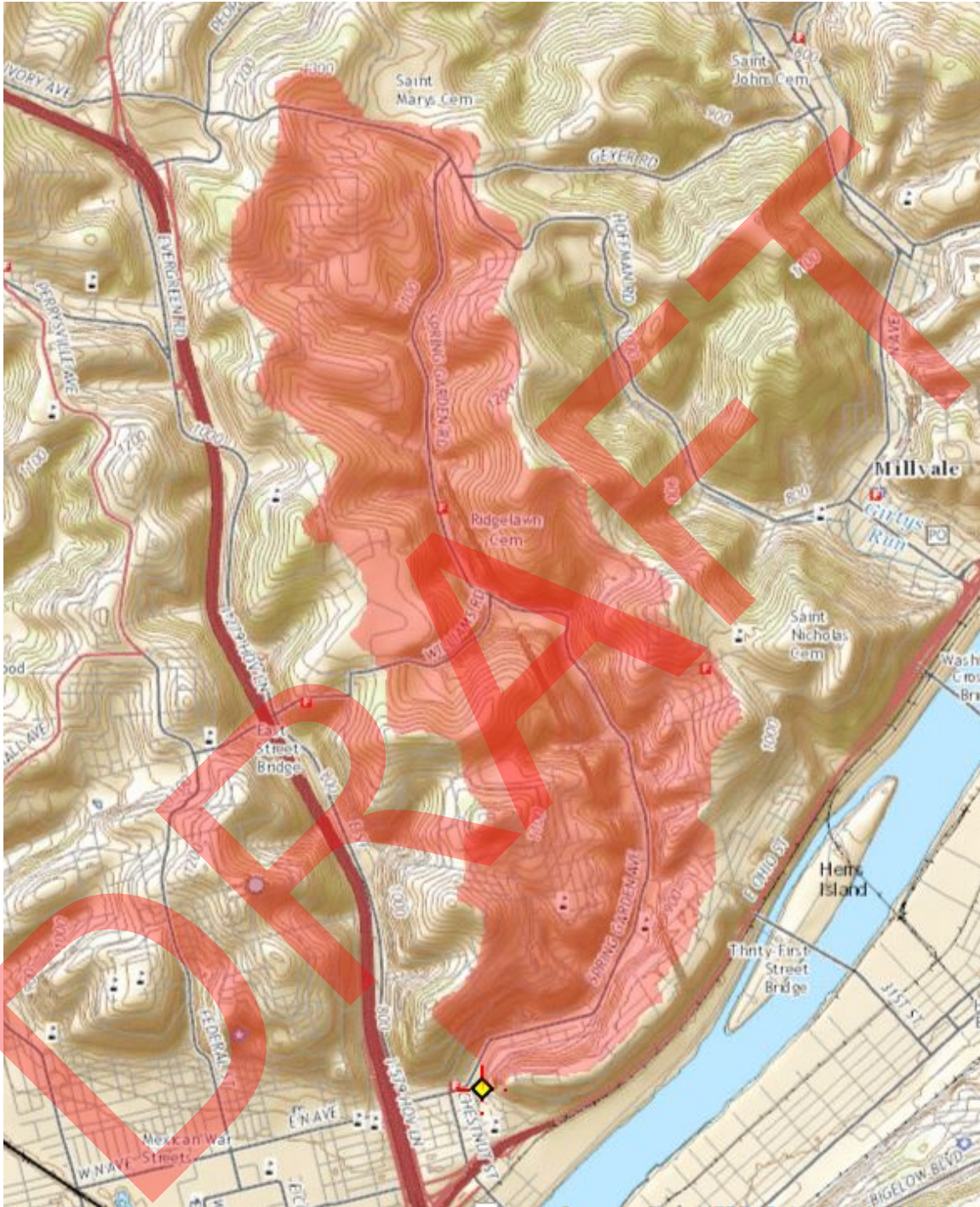


Figure 5-2: Spring Garden Combined Sewershed A-60

**TABLE 5-1
SPRING GARDEN BASIN CHARACTERISTICS USED FOR
THE USGS STREAMSTATS TOOL**

| Label | Value | Units | Definition |
|-----------|--------|---------------|---|
| DRNAREA | 1.78 | square miles | Area that drains to a point on a stream |
| BSLOPD | 11.9 | degrees | Mean basin slope measured in degrees |
| BSLOPDRAW | 12.15 | degrees | Mean basin slope, in degrees, raw value unadjusted for bias |
| FOREST | 4 | percent | Percentage of area covered by forest |
| PRECIP | 37 | inches | Mean Annual Precipitation |
| URBAN | 90 | percent | Percentage of basin with urban development |
| ELEV | 1060.6 | feet | Mean Basin Elevation |
| DRN | 3.6 | dimensionless | Drainage quality (1=well drained to 7=poorly drained) from dataset at http://water.usgs.gov/GIS/metadata/usgswrd/XML/ussoils.xml |
| IMPNLCD01 | 22 | percent | Percentage of impervious area determined from NLCD 2001 impervious dataset |
| LC01DEV | 68 | percent | Percentage of land-use from NLCD 2001 classes 21-24 |
| LC11IMP | 22.7 | percent | Percentage of impervious area determined from NLCD 2011 impervious dataset |
| LC11DEV | 68.4 | percent | Percentage of land-use from NLCD 2011 classes 21-24 |

5.1.3 Stream and Collection System Modeling Approach

The ALCOSAN Main Rivers Basin hydrologic and hydraulic (H&H) model was used to model the inflow point, as well as run simulations to quantify the resulting effects on the existing combined sewer system and combined sewer overflow at the A-60 outfall. The existing ALCOSAN model contains sewer trunk lines throughout the A-60 sewershed, up to and including the stream inflow point.

To update the Main Rivers model to represent the daylighting and detention options covered in section 5.1.4, the existing SWMM model subcatchments currently contributing wet weather flow to the stream inflow point were redirected to a new node. Combined with the stream base flow, this new node represented the flows that would need to be managed in any detention or daylighting solution. A total of 334 acres of the 1,282 acres in the A-60 sewershed was determined to connect to the stream inflow point.

The two SSO outfalls located upstream of the stream inflow point show no activations during the typical year. The SSO outfalls were left as shown, and not directed into modeled detention and daylighting features. The SSOs will need to be closed prior to any work to manage the flows from the Spring Garden Stream. The 2013 Reserve Township long term control plan outlines a plan to capture flow from, and close the outfalls with a larger diameter sanitary sewer line.

5.1.4 Conceptual Daylighting and Storage Options

5.1.4.1 Daylighting Option

Stream daylighting could take two forms. One option would be to remove the stream from the existing combined sewer and restore the natural stream channel down to the Allegheny River. The second option would be to divert the stream flow out of the combined sewer system to a new storm sewer and route the new storm sewer to the Allegheny River. From the Spring Garden stream inflow point located in Reserve Township, the combined sewer runs along Spring Garden Avenue towards the City. The existing street is narrow along the proposed conveyance pathway and homes are situated close to the right-of-way. The inflow point is approximately two miles from the Allegheny River. For these reasons, the first option of restoring the natural stream channel was ruled out. However, the second option of routing the stream to the river using a new storm sewer was evaluated as a potential option.

For the daylighting option, the watershed was modeled with all of the contributing area entering the stream inflow point and being routed downstream to the Allegheny River via a new storm sewer. This includes all base stream flows and wet weather flows. Base stream flows for the Spring Garden watershed include approximately 97 million gallons annually. With no stream flow entering the combined sewer system from Spring Garden, the combined sewer overflow volume at the A-60 outfall would be reduced by approximately 54 million gallons under typical year wet weather conditions.

Full daylighting provides the most overflow reduction. However, due largely to the distance from the inflow point to the Allegheny River, the constraints of the Spring Garden area, and the large wet weather flows, the costs of full daylighting are significantly greater than the costs of the other options. This daylighting cost was previously estimated as part of PWSA's 2013 WWFS to be over \$31 million.

5.1.4.2 Detention & Slow Release Option

Another scenario for managing the stream volume from the Spring Garden watershed is to temporarily detain the peak wet weather stream volumes within a larger best management practice (BMP) facility near the inflow location. Multiple options were evaluated including subsurface storage and surface storage. Subsurface storage options include modular storage, larger concrete cell storage or aggregate storage. Surface storage includes options such as subsurface gravel wetlands, and dry basins. All surface and subsurface options would route the stream base flow through the BMPs, while maintaining the storage volume capacity needed to temporarily detain the peak flows during typical year rain events.

In all subsurface and surface storage BMP options, the peak wet weather flows detained within the BMPs were modeled as a slow release over approximately 72 hours back into the combined sewer system to maximize overflow reduction at the A-60 outfall. The 72 hours was selected based on previous analysis on the time it takes for the deep tunnel interceptors to regain capacity after typical year storm events. This scenario involves routing both the base stream flow and the wet weather flow through the storage structure.

Site visit observations indicate that there appears to be limited area for surface storage near the Spring Garden stream inflow location. There may be opportunities to capture and manage flows on parcels adjacent to the steam inflow point. For the conceptual stage of evaluating this storage option, the assumption was made to evaluate the storage options at adjacent parcels, which serve as the most feasible location for managing flows from a technical standpoint.

An analysis was conducted using a combination surface and subsurface storage option with all stream flows detained and slowly released back to the combined sewer system. The storage BMP was sized to detain all of the base stream flow and wet weather flow for the typical year wet weather events. To manage that volume, the surface and subsurface storage layers would require an equivalent of a 1 acre (43,560 square feet (SF)) footprint assuming a 7-foot depth. This would achieve the required volume to detain an estimated 2,244,000 gallons, as determined to be required by the hydraulic model. To optimize release to the combined sewer system over 72 hours, small diameter underdrain piping was modeled as 6 inches in diameter.

In this scenario, all of the existing 169 million gallons of annual stream volume (baseflow volume and wet weather volume) will still enter the combined sewer system. However, the detention storage helps to significantly reduce the peak flows in the combined sewer system, reducing A-60 CSO volume by approximately 44 million gallons in the typical year.

Facilities associated with this scenario involve the surface and subsurface storage, connections back to the existing combined sewer, and any necessary property purchases to store the water. The approximate cost for this scenario is \$1.8 million.

5.1.4.3 Blend of Detention & Separation Option

A third scenario to manage the Spring Garden inflow was evaluated to include a blend of detention and separation. This would involve detaining the base stream flow and the wet weather flow with surface detention structure and slowly releasing the detained flow into a small diameter storm sewer routed to the Allegheny River. The smaller diameter storm sewer results in a significantly lower cost as compared to the \$31 million full daylighting scenario as indicated in the PWSA WWFS.

For this scenario, the watershed was modeled with the Spring Garden inflow contributing drainage area being routed into surface and subsurface storage before being released into an 8-inch and 12-inch diameter pipe that would drain all the way to the Allegheny River and exit via a new storm sewer outfall.

This option provides the removal of all Spring Garden stream dry and wet weather volume during the typical year from the combined sewer system resulting in an A-60 CSO reduction of approximately 53 million gallons. Rain events larger than the typical year design detention capacity would be diverted into the combined sewer system. This alternative provides nearly the same amount of CSO reduction during the typical year compared with full daylighting, and it removes the stream inflow from the system. The cost of this scenario is approximately \$10.7 million.

5.1.5 CSO Reduction Benefits

The costs and overflow reduction benefits for the above alternatives are summarized in in Table 5-2. The CSO removal quantities are based on managing the stream base flow, and wet weather flow. The model indicates that the stream base flow is approximately 96,884,000 gallons per typical year. The wet weather generated flows entering the stream were shown to be approximately 71,939,000 gallons per typical year.

Table 5-2 shows the overflow volume (MG) at the A-60 CSO outfall for existing conditions and the three alternatives considered. Under current conditions, the typical year A-60 CSO volume is approximately 210 MG. The detain and slow release options reduce the outfall volume to 166 MG or 157 MG remaining in the typical year, respectively, depending if the connection is back into the combined system or small diameter daylighting pipe to the river. The full daylighting option with no storage results in a remaining overflow volume of 156 MG in the typical year.

The combination detention and daylighting alternative provides the greatest cost-benefit for CSO reduction, and may also provide reduced wastewater flows conveyed to treatment and reduction of the grit and sediment entering the existing combined sewer and downstream deep tunnel interceptor system.

**TABLE 5-2
SPRING GARDEN STREAM INFLOW IMPROVEMENT SCENARIOS, TYPICAL YEAR**

| Scenario | Modeled Scenario | Outfall Overflow Volume (MG) A-60 OF -Typical Year | Annual Stream Flow Volume Entering System (MG) | Overflow Volume Reduced (MG) | Planning Level Capital Cost Estimate | System Improvement Description |
|----------|---|--|--|------------------------------|--------------------------------------|---|
| 1 | Existing Conditions- MR Basin Model Run | 210.2 | 168.8 | - | - | Main Rivers basin model run |
| 2 | Detain 2.2 MG & Slow Release into CSS (Routing all Base & Wet Weather Flows Through Storage) | 166.5 | 168.8 | 44 | \$1,831,000 | All flows (base stream flow and wet weather) area routed through the storage, and connected back to the CSS through a 6" orifice. |
| 3 | Detain 2.2 MG & Daylight through smaller diameter Storm Sewer (Base Stream Flow Routed Through Storage) | 157.3 | 0 | 53 | \$10,723,000 | All flows (base stream flow and wet weather) area routed through the storage, and daylighted to the river through a small diameter storm sewer. |
| 4 | Full Daylighting to River | 156.1 | 0 | 54 | \$31,491,000 ¹ | All base stream flows, and wet weather flows are fully removed from the CSS inflow point and daylighted to the river. |

¹ From 2013 WWFS. Sized for 5-year Design Storm.

5.1.5.1 Cost Estimates

The planning level capital cost estimate for the detention and slow release alternative is summarized in Table 5-3. The cost is based on an assumption that a surface detention feature is used and constructed on parcels neighboring the stream inflow point. Unit costs for grading, excavation, and small diameter daylighting pipe were developed from the ALCOSAN costing tool and local bid tabulations. A conservative assumption of 15 feet of depth was made in the excavation quantities. Additional discussion for the development of the costs is included in Section 7 of this report.

| TABLE 5-3 SPRING GARDEN STREAM INFLOW IMPROVEMENT SCENARIO, PLANNING LEVEL CAPITAL COST ESTIMATE; SPRING GARDEN SOLUTION: DETENTION POND & SMALL DIAMETER SEPARATION PIPE TO RIVER; CONTROL LEVEL: 2.2 MG STORAGE | | | | |
|--|-------------------------|--------------------|-------------------|--------------|
| Items of Work | Approximate Quantity | Unit of Measure | Unit Bid Price | Total |
| Land Acquisition | 1 | EA | \$312,500 | \$313,000 |
| Mobilization, Demobilization, and Field Office | 1 | LS | \$268,700 | \$269,000 |
| Field Survey and Engineering | 1 | LS | \$11,240 | \$12,000 |
| Erosion and Sediment Control | 1 | LS | \$11,240 | \$12,000 |
| Grading | 5,856 | SY | \$5 | \$27,000 |
| Engineered Soil Media and Gravel | 3,550 | CY | \$60 | \$213,000 |
| 8" PVC SDR-26 Sewer Pipe, Less than 15' Deep | 500 | LF | \$125 | \$63,000 |
| Excavation 0-15' Deep | 16,000 | CY | \$9 | \$144,000 |
| Vegetation | 30,000 | SF | \$3 | \$90,000 |
| Rock and Obstruction Excavation – All Depths | 500 | CY | \$25 | \$13,000 |
| Outlet Structure | 1 | EA | \$3,000 | \$3,000 |
| Overflow Structure | 1 | EA | \$9,000 | \$9,000 |
| Small Diameter Storm Daylight Pipe 8" – 12" | 10,970 | LF | \$347 | \$3,807,000 |
| Pipe Tunnel Boring Under Rt. 28 | 300 | LF | \$3,211 | \$964,000 |
| Maintenance & Protection of Traffic | 1 | LS | \$17,000 | \$17,000 |
| | | | Subtotal | \$5,956,000 |
| Planning Level Construction Contingency | | | 40% | \$2,383,000 |
| Engineering (Planning, Design, & CA Services) | | | 20% | \$1,192,000 |
| Project Contingency | | | 20% | \$1,192,000 |
| | | | Total | \$10,723,000 |

5.2 Woods Run Stream Inflow

5.2.1 Site Information and Review of Past Stream Removal Reports

The Woods Run DSIs are actually 8 separate locations that route primarily surface drainage from hillsides and nearby roads into the combined sewer system. This DSI location has been evaluated in previous studies as listed below. Each study was reviewed to gather background information for this analysis.

- ALCOSAN Wet Weather Plan Report (2013)
- PWSA Wet Weather Feasibility Study report (2013)
- 3 Rivers 2nd Nature – Stream Restoration & Daylighting Report (2001)

Data analysis was also conducted, utilizing the following resources:

- PASDA Digital Elevation Models
- Existing PWSA GIS data for storm sewers, combined sewers, and inlets
- 3 Rivers Wet Weather (3RWW) Regional Sewer Mapping Tool
- USGS StreamStats Version 3 Beta
- Previous PWSA Flow Monitoring data in the Woods Run area (2003-2004 data)
- Historic Mapping: <http://peoplemaps.esri.com/pittsburgh/>
- Field measured data at site visits in 2015

5.2.2 Site Overview and Field Visit Observations

The Woods Run watershed and sewershed are located in the City's Brighton Heights and Marshall-Shadeland neighborhoods. The 3RWW's 2nd Nature Report notes that the Woods Run Watershed area is 1,280 acres, making it the 14th largest watershed in Allegheny County.

The United States Geological Survey's "StreamStats" tool was used to compare the Woods Run watershed boundary against other gathered information. Figure 5-3 shows the watershed area, which is tributary to the O-27 combined sewershed. Table 5-4 presents the basin characteristics that were obtained from the USGS StreamStats tool.

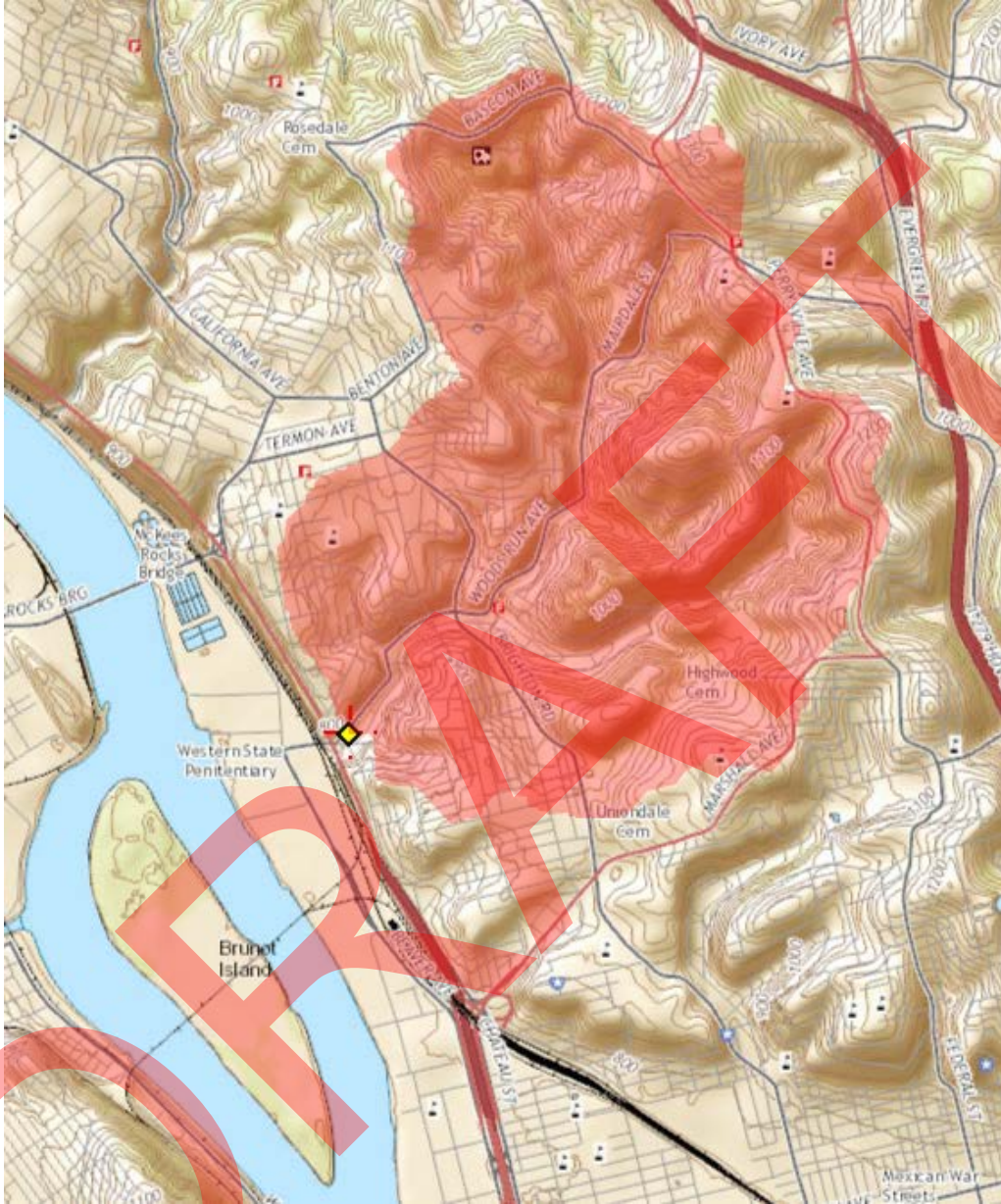


Figure 5-3: Woods Run Watershed

**TABLE 5-4
WOODS RUN BASIN CHARACTERISTICS USED FOR THE STREAMSTATS TOOL**

| Label | Value | Units | Definition |
|-----------|--------|---------------|---|
| DRNAREA | 1.94 | square miles | Area that drains to a point on a stream |
| BSLOPD | 10.9 | degrees | Mean basin slope measured in degrees |
| BSLOPDRAV | 11.14 | degrees | Mean basin slope, in degrees, raw value unadjusted for bias |
| FOREST | 35 | percent | Percentage of area covered by forest |
| PRECIP | 37 | inches | Mean Annual Precipitation |
| URBAN | 62 | percent | Percentage of basin with urban development |
| ELEV | 1004.6 | feet | Mean Basin Elevation |
| DRN | 3.6 | dimensionless | Drainage quality (1=well drained to 7=poorly drained) from dataset at http://water.usgs.gov/GIS/metadata/usgswrd/XML/ussoils.xml |
| IMPNLCD01 | 26 | percent | Percentage of impervious area determined from NLCD 2001 impervious dataset |
| LC01DEV | 75 | percent | Percentage of land-use from NLCD 2001 classes 21-24 |
| LC11IMP | 26.9 | percent | Percentage of impervious area determined from NLCD 2011 impervious dataset |
| LC11DEV | 75.3 | percent | Percentage of land-use from NLCD 2011 classes 21-24 |

Based on a review of the information available, there are 8 documented stream inflow locations with the potential to be captured in a daylighting or detention solution. Given the close proximity of the inflow points and drainage areas, all 8 locations in Woods Run, were evaluated together. Figure 5-4 highlights these inflow points and contributing drainage areas.



Figure 5-4: Documented Stream Inflow Points in the Woods Run O-27 Sewershed

5.2.2.1 Stream Base Flow

Only 1 of the 8 stream inflow points was observed during 2015 field visits to have stream dry weather base flow. Inflow Point 5 in Figure 5-4 shows the location of the stream inflow point where dry weather base flow was observed. The contributing drainage area for this location is approximately 71.9 acres and the inflow point enters into a 36-inch diameter PWSA brick combined sewer. There are two active tributary branches of the stream, meeting directly upstream of the inflow point.

During a site visit on a dry weather day (September 9, 2015), an active flowing stream base flow was observed and measured. At this site visit, both contributing stream branch flows were measured separately using a Marsh-McBirney Model 2000 Flo-Mate portable flowmeter. The measured flow was 5.4 gallons per minute (GPM) from the main stem, and 2.7 GPM from the west tributary. Figure 5-5 shows the two tributaries, along with the direct inflow point to the combined sewer system. Given the fluctuating nature of stream base flows, additional long term flow monitoring is recommended to inform the design of any stream removal improvements. For the purpose of this study, the measured stream base flow was carried forward and used in this analysis.

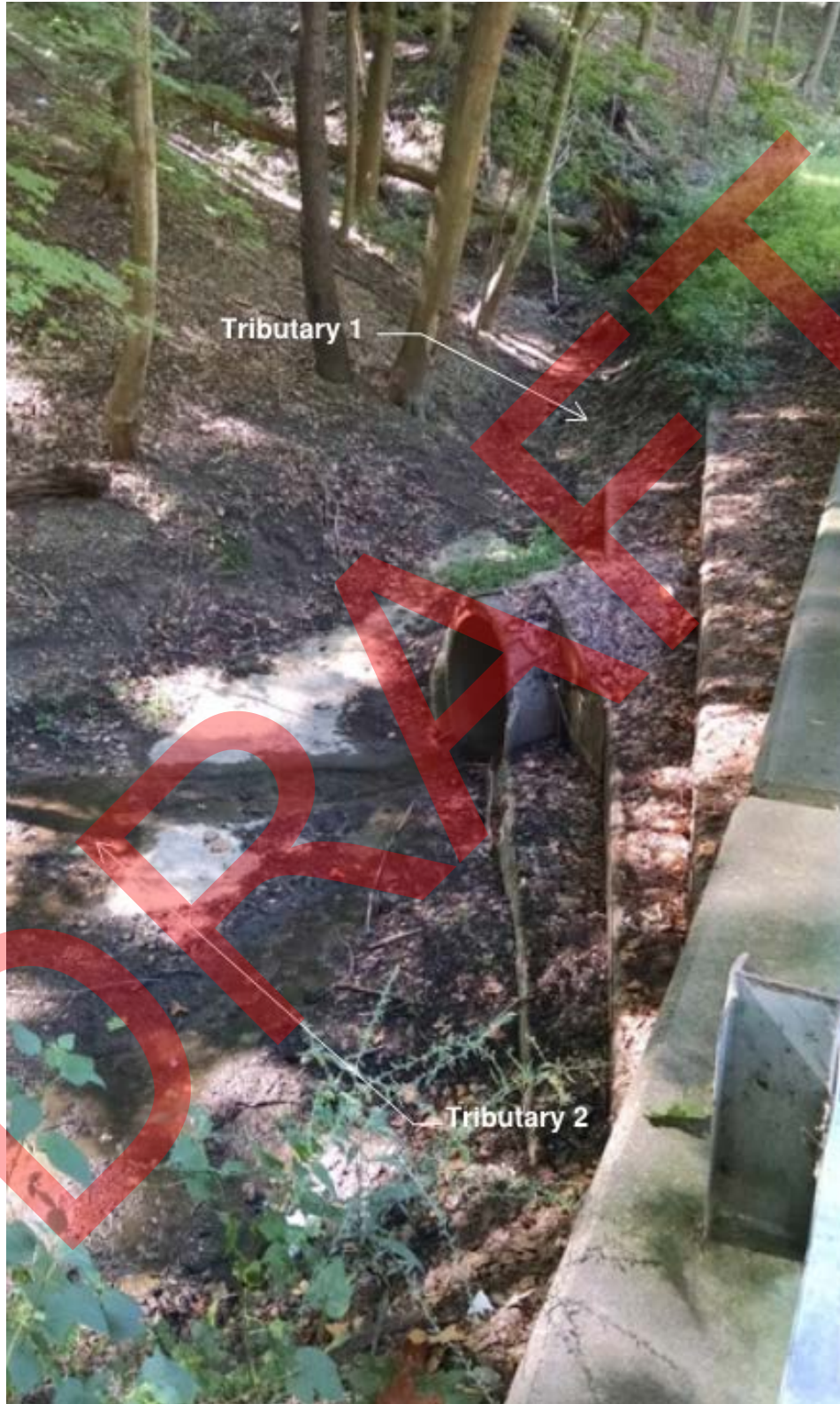


Figure 5-5: Stream Inflow from Two Woods Run Tributaries

5.2.3 Stream and Collection System Modeling Approach

The ALCOSAN Main Rivers Basin hydrologic and hydraulic (H&H) model was used to model the inflow points, as well as run simulations to quantify the resulting effects on the existing combined sewer system and CSO O-27. The existing ALCOSAN model contains sewer trunk lines throughout the O-27 sewershed, up to and including all of the 8 inflow points. The model subcatchments as received were not set up to specifically separate and quantify runoff from the 8 stream inflow points tributary areas. The model represented these stream inflow points grouped together with other combined sewer flows in the sewershed.

To update the Main Rivers model to represent the wet weather flows entering the 8 inflow points, the existing model subcatchments were divided to represent the tributary areas draining to each inflow point. ArcMAP GIS 3D Analyst tool was used to perform contour tracing to identify the areas naturally draining to the inflow points. These areas were compared against the existing SWMM model subcatchments, and overlaid with the PWSA sewer system GIS data to check, confirm, and refine the areas draining to each inflow point. The resulting subcatchments were then included in the SWMM model to represent both the areas continuing to drain to the combined system, and those that would be diverted into a daylighted stream or other detention option. A total of 492 acres of the 1,227 acres in the O-27 sewershed was determined to connect to one of the 8 inflow points.

This analysis considered several stream daylighting alternatives, including partial and full daylighting, and surface detention as described below. Overland runoff, inflow and infiltration (I&I), and base stream flow were quantified in the model and diverted from the combined sewer system in these alternatives.

5.2.4 Conceptual Daylighting Option Location and Conveyance Pathways

With the stream inflows isolated from other sewage flows in the model within the sewershed, a daylighting option was modeled to simulate the multiple stream flow components being diverted into a separate channel. Stream daylighting would restore the natural stream channel, and divert flow out of the combined sewer system. The daylighting would remove from the combined sewer system both the stream base flow during dry weather periods, and the wet weather runoff from the 8 contributing drainage areas upstream of the inflow points.

Currently, the Woods Run inflow points capture stormwater runoff from steeply sloped, undeveloped and wooded terrain. At the 8 stream inflow locations, the stormwater runs off the hillsides and into a ravine where it is captured by an inlet structure and directed into the combined sewer system. Before development of this area, these hillside regions historically drained into a common stream channel. The stream path flowed through the valley along what is now Woods Run Road, and discharged into the Ohio River.

The primary daylighting path investigated was the historic stream channel path running along Woods Run Road taking into account elevation and topography as it follows the natural valleys within the watershed. This alternative presents the challenges of establishing a stream along densely developed roadways with limited width along the ravine. Figure 5-6 shows the preferred daylighting path along Woods Run Avenue and Oakdale Street.

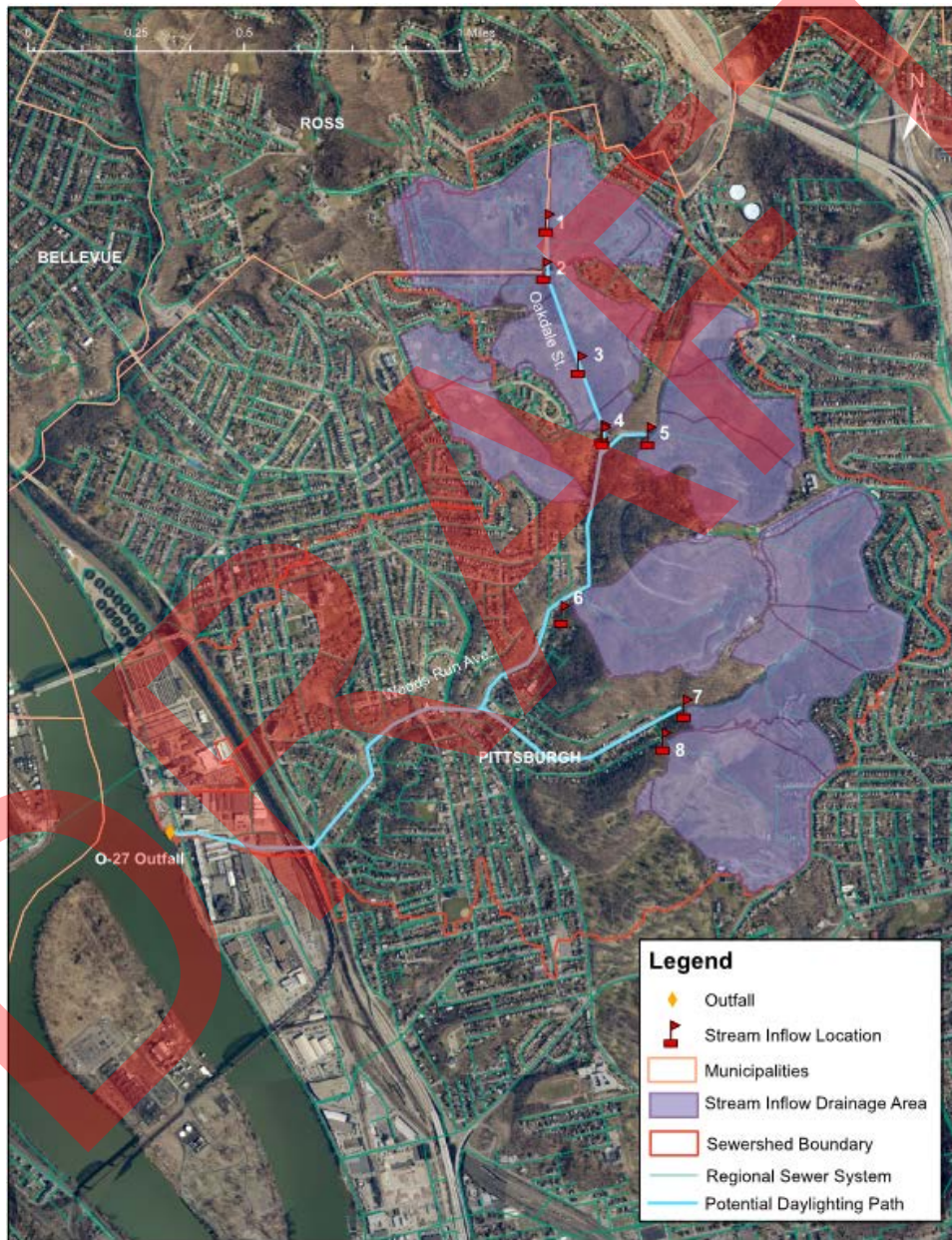


Figure 5-6: Preferred Pathway for Woods Run Stream Daylighting

Figure 5-7 provides an aerial view of a portion of the potential daylighting path, showing the typical level of development and topography within the O-27 sewershed. For a new conveyance pipe, approximately 15,000 feet of storm sewer would be required to capture the 8 inflow points and convey the flow to the Ohio River. This concept as evaluated in PWSA's WWFS required pipe sizes to range from 42 inches in diameter to over 108 inches in diameter to effectively convey both the stream base flow and wet weather peak flows from the 5-year design storm event. With the density and type of development along the potential pathway, construction of a large new storm sewer would be very challenging.



Figure 5-7: Aerial View of a Portion of the Potential Woods Run Stream Daylighting Pathway

5.2.5 Detention Option

With the difficult pathway needed for full stream daylighting, an upstream distributed detention option was evaluated to capture and temporarily detain the stream and wet weather runoff flows. By diverting the base and wet weather flows at the inflow points to detention prior to entering the combined sewer system (CSS), the flows can be managed closer to the source. Each unique inflow location was evaluated for the possible use of constructed surface storage, subsurface storage, or distributed right-of-way BMPs that would help reduce and slow the peak flows into the combined sewer system during rain events. The BMPs would be designed to slowly return the detained wet weather volume over 72 hours back into the combined sewer system to maximize overflow reduction at the O-27 outfall.

The stream inflow modeling was performed by routing all the associated stream inflows through a modeled storage node with a small diameter underdrain. All flows from modeled detention features were connected back into the combined sewer system, and fully drained within 72 hours.

The modeling results, with the Typical Year wet weather events simulated, were used to estimate the storage capacity needed for each inflow location. The detention volumes were optimized to be able to handle all wet weather events in the Typical Year without overflowing. Table 5-5 summarizes the volumes needed for each detention location, and associated stream inflow point to meet the target wet weather control (Typical Year) for this for option.

**TABLE 5-5
REQUIRED STORAGE VOLUME NEEDED FOR THE
WOODS RUN DETENTION OPTION, TYPICAL YEAR**

| Detention Location | Stream Inflow Points Managed | Storage Volume (MG) |
|---------------------------|-------------------------------------|----------------------------|
| A | 1, 2 | 0.16 |
| B | 3, 4 | 0.50 |
| C | 5 | 0.35 |
| D | Separate Storm Sewer Area | 0.10 |
| E | 6 | 0.22 |
| F | 7 | 0.48 |
| G | 8 | 0.28 |
| | Total | 2.10 |

These required storage volumes were used as a basis for selecting the type of detention, as well as the storage detention size required. Each of the 7 locations was evaluated independently to select the best solution for each location. Available space, topography, detention sizing, ability to capture sediment and debris, and the characteristics of the existing sewer systems, such as depth, were taken into account. The 7 detention locations, selected type of detention, and planning level cost estimates are summarized in Appendix D.

Figure 5.8 below illustrates the locations, and stream inflow points captured by each detention location. Detention BMPs are not to scale, and are shown enlarged in this figure for visual purposes.

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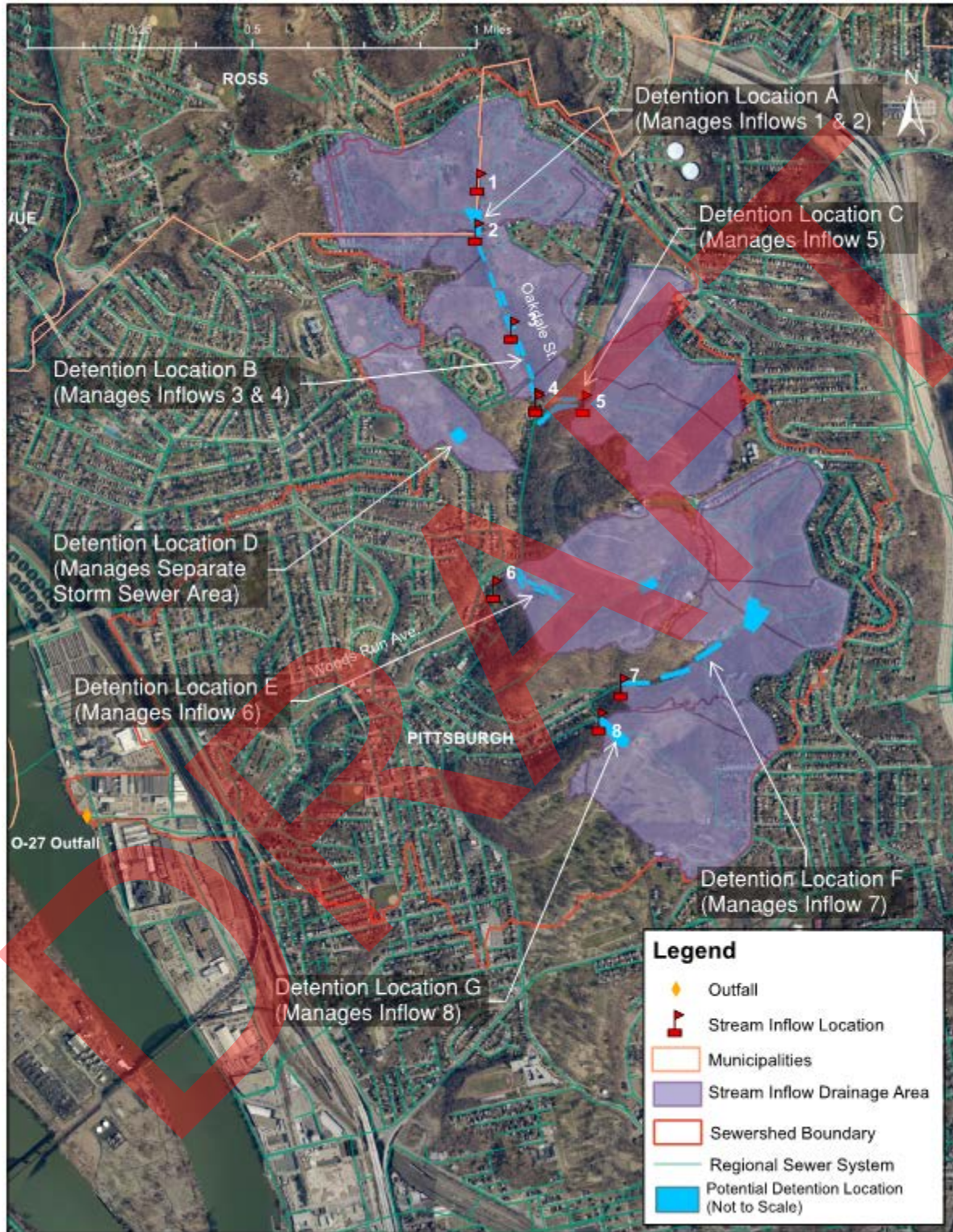


Figure 5-8: Stream Inflow Points Captured by Each Detention Location

A rendering of the potential detention location 3 surface / subsurface is shown in Figure 5-9 for illustrative purposes. The large diameter pipe beneath the street surface represents the existing PWSA 36" combined sewer. The stream base and wet weather flows would be diverted from the 36" sewer and routed to detention location 3, shown on the left side of the image. A pretreatment system would screen grit and other debris prior to entering the subsurface storage facility. All diverted stream flow in this example, and all other Woods Run inflow locations, will connect back into the combined sewer system. In this example, the subsurface detention would have an underdrain connecting to the 36" combined sewer further downstream on Mairdale Ave. This detention feature offers the benefit of pretreating, and managing peak flows from larger storm events prior to entering the sewer system.



Figure 5-9: Rendering for Detention Location 3

5.2.6 CSO Reduction Benefits at the O-27 Outfall

The collection system model was used to simulate the Typical Year and estimate CSO overflow reduction volumes for both the daylighting option and the detention option.

The stream daylighting option resulted in a 22% reduction in CSO volume at outfall O-27 during the typical year. Annual CSO volume was reduced by 16 MG from 73 MG to 57 MG in the Typical Year.

The option managing flow near the inflow points with 7 detention features resulted in a 20% reduction in CSO volume at outfall O-27. Overflow volume was reduced by 15 MG from 73 MG to 58 MG in the Typical Year.

5.2.7 Planning Level Capital Costs

Estimated costs of the inflow detention option for the seven inflow points are listed in Table 5-6. The combination of these improvements result in the removal of approximately 2,832,000 gallons of base stream flow, and an additional 16,900,000 gallons of wet weather flow. The total cost of the seven distributed detention facilities within the Woods Run sewershed is \$10.5 million.

| System Number | Location | Description | Estimated Capital Cost |
|----------------------|--------------------------------------|---|-------------------------------|
| 1 | Northern end of Oakdale Street | Subsurface Storage | \$752,000 |
| 2 | Near Oakdale St. and Mairdale Avenue | Distributed BMPs | \$3,869,000 |
| 3 | Mairdale Avenue and River View Drive | Surface and Subsurface Storage | \$1,057,000 |
| 4 | Benton Field | Surface and Subsurface Storage | \$319,000 |
| 5 | Behind 915 Woods Run Ave Houses | Distributed BMPs and Subsurface storage | \$1,245,000 |
| 6 | Kilbuck Road | Distributed BMPs and Subsurface storage | \$2,343,000 |
| 7 | Smithton Avenue and Henley Street | Subsurface Storage | \$890,000 |
| | | | \$10,475,000 |

5.3 Panther Hollow Stream Inflow Locations

5.3.1 Site Information and Review Past Stream Removal Reports

Reports reviewed for the Panther Hollow stream inflow locations include:

- ALCOSAN Wet Weather Plan Report (2013)
- PWSA Wet Weather Feasibility Study (2013)
- 3 Rivers 2nd Nature – Stream Restoration & Daylighting Report (2001)
- Panther Hollow Conceptual Design Memo by EDC (2009)

Data analysis was conducted, utilizing the following resources:

- PASDA Digital Elevation Models
- Existing PWSA GIS data for storm sewers, combined sewers, and inlets
- 3RWW Regional Sewer Mapping Tool
- USGS StreamStats Version 3 Beta
- Additional Flow Monitoring data provided by ALCOSAN (data from 2013-2015)

5.3.1.1 Background Information

With significant work and study previously completed for the Panther Hollow Lake, this information was reviewed and expanded on throughout this analysis. The Pittsburgh Parks Conservancy has conducted in-depth data gathering and planning on the Panther Hollow Stream and Lake. Conceptual daylighting routes have been investigated by EDC in the “Panther Hollow Conceptual Design Memo”.

This analysis will build off of previous work, while providing further insight into the downstream impacts on CSO that discharges into the Monongahela River at the M-29 point of connection, as a result of detaining or daylighting the Panther Hollow stream base flow and wet weather flows.

5.3.2 Site Overview and Field Visit Observations

The Panther Hollow watershed was first reviewed to determine the boundaries of the wet weather flow contribution to the Panther Hollow Lake. The existing ALCOSAN Main Rivers Basin SWMM model has delineated the boundaries generating wet weather flow, and separated out the upstream residential areas currently serviced by the combined sewer system. The remaining 176-acre area was used in modeling as the area generating wet weather flow to the lake. The Panther Hollow watershed upstream of the lake is illustrated in Figure 5-10.



Figure 5-10: Panther Hollow Watershed Upstream of Panther Hollow Lake

The portion of Schenley Park in the sewershed directly south of the Panther Hollow shed was included in the analysis as an area for potential stormwater runoff capture by a stream daylighting project. This 94-acre area is shaded in Figure 5-11. Together, these two sheds make up the land area contributing stormwater runoff that was evaluated for a potential stream daylighting project. Model simulations were based on managing these two watersheds.



Figure 5-11: Panther Hollow Watershed and Schenley Park Potential Stormwater Capture Area

To better understand the Panther Hollow Lake and base inflow, a site visit was carried out in September 2015 to observe the lake inflow and overflow points. A photo of the lake is provided in Figure 5-12.



Figure 5-12: Panther Hollow Lake

Figure 5-13 shows the diversion structure located at the eastern side of the lake. Base stream flow from the Panther Hollow Stream is either diverted 90 degrees into the lake, or continues through the weir structure into a concrete overflow channel running alongside the lake, and eventually discharges to a PWSA combined sewer.



Figure 5-13: Stream Inflow Diversion Structure at Panther Hollow Lake



Figure 5-14: Overflow Channel Downstream of the Stream Inflow Diversion at Panther Hollow Lake

The concrete overflow channel, shown in Figure 5-14, is one of the two means for both the wet weather flow and the stream base flow to enter the PWSA combined sewer system. The channel flows are not currently measured by a flow meter, nor have they been measured in the past. The currently active ALCOSAN flow monitor is placed on the lake overflow pipe. This pipe conveys overflow discharge from the two overflow weirs shown in Figure 5-15. Lake overflow discharge is conveyed through the overflow pipe to a PWSA combined sewer.



Figure 5-15: Panther Hollow Lake Overflow Weirs Diverting Water to the Lake Overflow Pipe

This layout is summarized in Figure 5-16, showing the two overflow lines, the location of the ALCOSAN flow meter, and the connection to PWSA’s 72-inch diameter combined sewer. As described in the sections below on base stream flow and wet weather flow, the overflow channel diversion causes uncertainties in the monitored flow data because flow that is diverted through the overflow channel is not measured by the meter. A combination of flow meter data and hydrologic and hydraulic (H&H) modeling was used to develop a reliable estimate of flows based on available data.



Figure 5-16: Panther Hollow Stream and Lake Flow Configurations

5.3.2.1 Estimating Base Stream Flow

In order to estimate the base stream flow, an average of monthly 2015 ALCOSAN flow metering data was compared with the stream base flows generated with the SWMM models. The SWMM model indicates a base flow of approximately 14 MG per year from the Panther Hollow Lake sewershed. A review of recent flow monitoring shows a much higher stream base flow. After subtracting out wet weather events from the 2015 flow monitoring data, the average base flow from Panther Hollow Lake throughout the year was approximately 68 MG per year. As shown in Figure 5-16, this data is limited to flows entering the combined system through the overflow weirs in the lake, and does not include base stream flow conveyed through the concrete overflow channel. During a 2015 field site visit, there was a stream base flow observed in the concrete channel. Actual stream base flow may be higher than 68 MG per year, if the concrete channel flows were measured and included in the total.

5.3.3 Stream and Collection System Modeling Approach

5.3.3.1 SWMM Model Updates

The ALCOSAN Main Rivers Basin H&H SWMM model was used to model the two inflow points, as well as run simulations to quantify the resulting effects on the existing combined sewer system and combined sewer overflow at M-29. The existing ALCOSAN model contains sewer trunk lines throughout M-29, up to and including the two inflow points. The model as received was not set up to specifically separate and quantify runoff from the two stream inflow point tributary areas. The model combined these stream inflow points with other combined sewer flows in the sewershed.

To update the Main Rivers model to represent the wet weather flows entering the two inflow points, the existing model subcatchments were divided up as needed to represent the areas draining to each inflow point. The ArcMAP GIS 3D Analyst tool was used to perform contour tracing to identify the areas naturally draining to the inflow points. These areas were compared against the existing SWMM model subcatchments, and overlaid with the PWSA sewer system GIS data to check and refine the areas draining to each inflow point. The resulting subcatchments were then included in the SWMM model to represent both the areas continuing to drain to the combined system, and those that would be diverted into a daylighted stream or other detention option. An area of 270 acres of the 2,378-acre total M-29 area was determined to connect to the two inflow points or the separate storm sewer shed.

5.3.4 Conceptual Daylighting Option Location and Conveyance Pathways

To daylight Panther Hollow Stream, conveyance options were investigated taking into account the existing features between the Lake and the Allegheny River. This includes the recreational aspects of the park including Junction Hollow Trail, and the soccer field. Obstacles within the last 2,200 feet from the river outlet location include railroad tracks, bridges, highways, buildings, parking lots, and the existing topography.

M-29 and Panther Hollow were identified as a key opportunity for the city, that also required more in depth planning given the challenges and multiple stakeholders involved. Section 6 expands on strategic urban planning aspects of the Panther Hollow daylighting location, along with a broader strategic plan for the watershed as a whole.

Potential daylighting solutions and cost estimates are provided in the M-29 portion of Section 6. Figure 5-17 shows an overview of the potential conveyance pathway discussed in Section 6.



Figure 5-17: Panther Hollow Stream Conveyance Pathway

5.3.5 CSO Reduction Benefits

The daylighting options would remove base flow from Panther Hollow Lake, along with wet weather contributions from 270 acres. Typical year modeling results with the daylighting option show a CSO volume reduction of 31,900,000 gallons per year reduction at the M-29 outfall. The existing conditions overflow volume of 423,800,000 gallons per year would be reduced 7.5% to 391,900,000 gallons per year. As noted above, these reductions will likely increase as the SWMM model is updated with more detailed flow monitoring specific to the Panther Hollow Lake area.

In addition to the CSO reduction benefits, approximately 68,000,000 gallons of base stream flow would be removed from the conveyance and treatment system throughout the year. Removal of the stream base flow would also provide a reduction in sediment and grit entering the conveyance system.

5.3.5.1 Costs

Costs associated with the capture and daylighting of the two inflows are estimated to be approximately \$25,000,000 to \$40,000,000. Additional costs for urban planning work in the M-29 sewershed are outlined in detail in Section 6.