Appendix 1 – Basis of Costs

1.1 Cost Development Approach

The following sections outline the approach to develop each key component of the Lifecycle Costs utilized in the Alternatives Analysis.

1.1.1 Opinion of Probable Construction Cost

The Opinion of Probable Construction Cost (OPCC) is comprised of the following three components.

- **Direct Construction Cost** includes the materials, labor, and equipment to build new Combined Sewer Overflow (CSO) control facilities, and to upgrade, expand, or rehabilitate existing facilities. Direct Construction Costs are derived from multiple data sources, including costing algorithms developed from national and regional wet weather control facilities. The costs are adjusted based on location and date with the following factors.
  - Costworks (formerly RS Means) Location Index for Harrisburg, PA of 97.9.
  - Engineering News Record Construction Cost Index for February 2024 of 13,518.
- **Indirect Construction Cost** includes the contractor's overhead, permits, bonds and profit. For construction cost data sources that do not include Indirect Construction Cost, this is estimated as **25%** of the Direct Construction Cost.
- **Construction Contingency** accounts for unknowns in construction requirements or pricing at the planning stage. For example, these unknowns can include site-specific costs for a particular control technology, season-specific costs of traffic management, and construction market conditions during bidding. Values between **25 percent to 50 percent** were multiplied by the sum of Direct Construction Cost and Indirect Construction Cost to calculate the Construction Contingency. Individual values for Construction Contingency are assigned by CSO control technology, with more complex treatment processes being assigned higher contingency values.

The Opinion of Probable Construction Cost is the sum of the Direct Construction Cost, Indirect Construction Cost, and Construction Contingency.

1.1.2 Non-Construction Capital Costs

In addition to the construction cost, the following non-construction capital costs are included.

- **Project Contingency** typically ranges from 5 to 30 percent of the Opinion of Probable Construction Cost depending on the following factors: the level of planning and design completed, the level of difficulty of the project, risks associated with unknown underground site conditions, and the requirements for including contingencies for State Revolving Fund (SRF) or other loan and grant programs. A value of **25 percent** is multiplied by the OPCC to calculate the Project Contingency.
- **Engineering, Administration, and Legal Costs** include permitting, engineering design, construction oversight, resident engineering, administration, program management, legal costs,

professional services for geotechnical investigations and engineering, hazardous materials survey, land and utility surveys, and outreach and communication with public and stakeholders. A value of **25 percent** iss multiplied by the OPCC to estimate these costs.

- **Land Acquisition and Easements/Rights-of-Way Costs** are specific local conditions and land values preclude the use of a standard multiplier for land acquisition, easements, and rights-of-way (ROW). A preliminary identification was made for conveyance routes for new pipelines and sites for control facilities. Estimates of potential new acreage for leasing land easements were developed. Land purchase costs will vary depending on the location, and an value of **$500,000 per acre** is utilized.

1.1.3 Concept Level Capital Cost

The Concept Level Capital Cost is the sum of the Opinion of Probable Construction Cost and all Non-Construction Capital Costs.

1.1.4 Lifecycle Cost

Lifecycle Costs are the total costs of building, operating, maintaining, and rehabilitating/replacing the facilities throughout the selected planning period. In addition to the Concept Level Capital Cost, the lifecycle costs are developed based on present value for the following components as described below.

- A planning period of **20 years** is used for the lifecycle cost analysis.

- A **5% discount rate** is applied over the planning period to calculate the present value. The 2023 Federal water resources discount rate is 2.5%, which is considered the minimum value. Inflation is a risk common to all alternatives, which is not independently calculated for this analysis, but a higher, more conservative discount rate allows for inflation.

- **Annual Operations and Maintenance Costs** are estimated as a percentage of the Opinion of Probable Construction Cost. The percentage varies by CSO control technology ranging from **0.10% to 1% per year** based on the level of staffing and complexity of the treatment process required. The annual Operations and Maintenance Costs are converted to present value for the Lifecycle Cost calculation.

- **Rehabilitation/Replacement Costs** are estimated at **0% to 20%** of the Concept Level Capital Cost (excluding land costs), which provides an allowance for the equipment, primarily electrical/instrumentation/control, expected to require replacement at the end of the 20-yr planning period. This future cost is converted to present value for the Lifecycle Cost calculation.

- **Annual AWTF Treatment Costs** are estimated based on the annual volume of combined sewage that is either directed to the CRW Advanced Wastewater Treatment Facility (AWTF) for treatment or incorporated as a credit for volumes removed from the CRW collection system and no longer requiring treatment at the AWTF. A treatment cost of $0.001124 per gallon is utilized. The annual Treatment Cost (or Credit) is converted to present value for the Lifecycle Cost calculation.

The total Lifecycle Cost for each alternative is the sum of Concept Level Capital Cost, Operations and Maintenance Present Value, Rehabilitation/Replacement Present Value, and AWTF Treatment Cost/Credit.

1.2 Technology-Specific Cost Basis

The following sections outline the specific assumptions, data sets, and cost algorithms utilized to develop the Direct Construction Cost for each CSO control technology (e.g. storage tank) or supplementary element (e.g. diversion structure).

1.2.1 Open Cut Pipe Replacement

The direct construction cost opinion for open cut installation of new gravity sewers or the replacement of existing gravity sewers is based upon the following unit price data.

Open Cut Gravity Sewer in Roadway Cost [$/LF]					
Installation Depth [ft]		6	10	16	22
Sewer Pipe Diameter [in]	12	$291	$473	$835	-
	15	$297	$480	$841	-
	18	$310	$492	$854	-
	21	$322	$505	$866	-
	24	$335	$518	$879	$923
	30	$373	$555	$917	$968
	36	$392	$574	$936	$1,019
	42	$511	$631	$992	$1,103
	48	$596	$681	$1,043	$1,213
	60	$676	$757	$1,109	$1,384
	72	-	$883	$1,235	$1,510
	84	-	$1,034	$1,386	$1,661
	96	-	$1,185	$1,537	$1,812
	108	-	$1,336	$1,688	$1,963
	132	-	-	$2,266	-
	144	-	-	$2,896	-

Depending on the depth and diameter of the pipe, the unit price is multiplied by the total length of the pipe. These unit prices include costs for manholes and roadway reconstruction. The unit prices above are adjusted to Harrisburg, PA in February 2024.

These unit costs are applied for consolidation sewers, interceptor upgrades, and influent/effluent sewers to facilities.

A construction contingency of 25% is utilized for open cut pipe replacement.

The annual operation and maintenance cost for gravity sewers is estimated at 0.1% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 0%.

1.2.2 Pumping Stations

The direct construction cost opinion for wet-well, dry-well pumping stations with standby power is based upon the following equation.

- Y = 0.385002 * X^0.8941 *(Y = construction cost in $ million, X = flow in MGD)*

  (ENRCCI = 8551, Location Index = 100)

This equation is utilized for standalone conveyance pumping stations, as well as pumping stations to support satellite storage and satellite treatment. Pumping station costs were developed based on peak flow for conveyance and treatment facilities, however, dewatering pumping stations for storage tanks were based upon dewatering over a 3-day time period.

A construction contingency of 35% is utilized for pumping stations.

The annual operation and maintenance cost for pumping stations is estimated at 1.0% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 20% of the concept level capital cost (excluding land costs).

1.2.3 Green Stormwater Infrastructure

The direct construction cost opinion for green stormwater infrastructure (GSI) based upon $250,000 per acre of impervious area managed, which already includes a 25% construction contingency. In areas anticipated to have more construction conflicts with GSI implementation, cost multipliers were also applied to determined direct construction cost opinion; however, this only applies to single technology systemwide GSI implementation (not MTAs).

The annual operation and maintenance cost for GSI is estimated at $8,000 per acre of impervious area managed.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 0%.

1.2.4 Storage Tanks

The direct construction cost opinion for below grade storage tanks is based upon the following equations.

- Y = -0.0328 * X^2 + 4.4766 * X + 7.566 Tanks equal to or greater than 1 MG volume
- Y = -0.0328 * X^2 + 4.4766 * X + 3.0 Tanks less than 1 MG volume

  (Y = construction cost in $ million, X = volume in MG) *(ENRCCI = 11281, Location Index = 100)*

A construction contingency of 25% is utilized for storage tanks.

The annual operation and maintenance cost for storage tanks is estimated at 0.25% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 10% of the concept level capital cost (excluding land costs).

1.2.5 Sewer Separation

Sewer separation costs are evaluated two different ways:

1) New Sanitary Sewers (only for 100% sewer separation)
    a) Calculate sanitary sewer costs
    b) Calculate streetscaping costs
    c) Calculate lateral connection costs
    d) Assume supplemental GSI costs (75% impervious acres managed) – this is included to manage the new stormwater overflow volumes
2) New Storm Sewers
    a) Calculate storm sewer costs (match diameter of existing combined sewers)
    b) Calculate streetscaping costs
    c) Calculate lateral connection costs (assume 50% of building have storm laterals)
    d) Calculate inlet reconnection costs
    e) Assume supplemental GSI costs (75% impervious acres managed) – this is included to manage the new stormwater overflow volumes

Unit price data utilized in the sewer separation cost development is presented below:

Sewer Separation Cost Components [ENRCCI: 8551; Location: 115.2]

Component	Unit Cost	Units
New storm sewers	see table for costs as function of diameter	$/ft
New Sanitary Sewers	$1,700,000	$/mile
Lateral from new sewer to property	$6,000	$/lateral
Interior plumbing modifications - Residential	$6,000	$/lateral
Interior plumbing modifications - Non-Residential	$20,000	$/lateral
Concrete Street Base	$6.25	$/sq. ft
Asphalt Paving	$3	$/sq. ft
Concrete Sidewalk	$6.5	$/sq. ft
Concrete Curb	$26	$/ft

Open Cut Sewer Costs [ENRCCI: 10500; Location: 100]

Diameter	Cost/LF
12"	$663
15"	$668
18"	$678
21"	$688
24"	$698
30"	$728
36"	$743
42"	$788
48"	$828
60"	$881
72”	$981
84”	$1,101
96”	$1,221
108”	$1,341
132"	$1,800
144"	$2,300

A construction contingency of 25% is utilized for sewer separation.

The annual operation and maintenance cost for sewers is estimated at 0.1% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 0%.

1.2.6 Tunnel Storage

The direct construction cost opinion for tunnel storage was developed from on a tunnel costing workbook, which takes into account multiple factors including tunnel diameter, tunnel depth, number and types of shafts, dewatering pumping station, ground conditions, and installation methods. The resulting unit costs are presented in the following table:

Diameter (ft)	Cost/LF
3.5	$4,000
5	$5,100
6	$5,700
12	$11,450
14	$11,700

A construction contingency of 25% is utilized for tunnel storage.

The annual operation and maintenance cost for tunnel storage is estimated at 0.25% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 10% of the concept level capital cost (excluding land costs).

1.2.7 Disinfection & Dechlorination

The direct construction cost opinion for chlorine disinfection coupled with dechlorination is based upon the following equation.

- Y = 0.446 * X^0.8941 *(Y = construction cost in $ million, X = peak flow in MGD)*
  (ENRCCI = 8551, Location Index = 100)

The direct construction cost opinion for the chlorine contact tank is based on the following equation.

- Y = 3.48 * X^0.826 *(Y = construction cost in $ million, X = 15-min contact volume in MG)*
  (ENRCCI = 8551, Location Index = 100)

A construction contingency of 25% is utilized for disinfection/dechlorination facilities.

The annual operation and maintenance cost for disinfection/dechlorination facilities is estimated at 0.5% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 20% of the concept level capital cost (excluding land costs).

1.2.8 Screening

The direct construction cost opinion for mechanical screening is based upon the following equation.

- Y = 0.0834 * X^0.843 *(Y = construction cost in $ million, X = peak flow in MGD)*
  (ENRCCI = 8551, Location Index = 100)

A construction contingency of 25% is utilized for screening facilities.

The annual operation and maintenance cost for mechanical screening is estimated at 0.5% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 20% of the concept level capital cost (excluding land costs).

1.2.9 Retention Treatment Basins

The direct construction cost opinion for retention treatment basins (RTBs) is based upon the following equation.

- Y = 9.72 * X^0.826 + 3.2 15-min contact time
- Y = 12.7 * X^0.826 + 3.2 30-min contact time

  (Y = construction cost in $ million, X = 15-min contact time in MG for the peak flow)

  (ENRCCI = 8551, Location Index = 100)

This equation includes screening and disinfection. This excludes the cost of pumping, which is applied separately, when required, to determine the total RTB facility cost. This excludes the cost of dechlorination, which is applied separately to determine the total RTB facility cost.

A construction contingency of 35% is utilized for RTBs.

The annual operation and maintenance cost for RTBs is estimated at 0.7% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 20% of the concept level capital cost (excluding land costs).

1.2.10 High-Rate Clarification

The direct construction cost opinion for high-rate clarification (HRC) is based upon the following equation.

- Y = 0.640 * X^0.708 + 3.2 *(Y = construction cost in $ million, X = peak flow in MGD)*

  (ENRCCI = 8551, Location Index = 100)

This excludes the cost of pumping, which is applied separately, when required, to determine the total HRC facility cost. This excludes the cost of mechanical screening disinfection and dechlorination, which are applied separately to determine the total HRC facility cost.

A construction contingency of 25% is utilized for HRCs.

The annual operation and maintenance cost for HRCs is estimated at 1.0% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 20% of the concept level capital cost (excluding land costs).

1.2.11 High-Rate Filtration

The direct construction cost opinion for high-rate filtration (HRF) is based upon the following equation.

- Y = 0.656500 * X^0.9098 + 5.2 *(Y = construction cost in $ million, X = peak flow in MGD)*

  (ENRCCI = 9550, Location Index = 100)

This excludes the cost of pumping, which is applied separately, when required, to determine the total HRF facility cost. This excludes the cost of mechanical screening and disinfection and dechlorination, which are applied separately to determine the total HRF facility cost.

A construction contingency of 50% is already included in the above equation.

The annual operation and maintenance cost for HRFs is estimated at 0.7% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 20% of the concept level capital cost (excluding land costs).

1.2.12 Diversion Structures

The direct construction cost opinion for diversion structures is based upon the following equation.

- Y = 0.02 * X *(Y = construction cost in $ million, X = peak flow in MGD)*

  (ENRCCI = 8551, Location Index = 100)

A construction contingency of 50% is already included in the above equation.

The annual operation and maintenance cost for diversion structures is estimated at 0.1% of the opinion of probable construction cost.

The rehabilitation/replacement cost at the end of the 20-year lifecycle is estimated to be 0%.