Hamilton County MSD Monitor

Cost Certainty Analysis of SI Alternative

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Metro WBE Associates Inc.

plante moran CRESA
REAL ESTATE CONSULTANTS

Hatch Mott MacDonald

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1. Introduction

The Board of County Commissioners (BoCC) has stated that in implementing the Final WWIP [1], compliance with the Consent Decree and applicable law, improvement of water quality particularly near homes and parks, financial solvency of MSD, protection of the MSD ratepayer's ability to pay for services, ongoing MSD financial transparency, and cost-saving innovation are key Board priorities. The BoCC indicated that projects managed by MSD, to the greatest extent practicable within the limits of applicable law, should be planned, designed and constructed in all circumstances "on or under budget". The term "budget" in this case refers to the projected costs listed in the Final WWIP [2].

Thus cost certainty is an extremely important aspect of all projects and strategy brought forth by MSD to meet the objectives of the Final WWIP. MSD has recently requested that the County explain "cost certainty". This report articulates the Hamilton County Monitor's (Monitor) analysis of cost certainty issues related to the SI alternative as presented by MSD to the BoCC in Spring 2012 and made public by MSD in mid-2012 [3].

While there are numerous programmatic elements that translate to cost (schedule compliance, water quality, etc.) we have focused on two principle concerns: Costing Methodology and the CSO Volume Reduction Estimate. The purpose of this document is to serve as the means through which the County provides direction to MSD on how its current proposals may be supplemented or enhanced to provide for greater confidence in their level of cost certainty related to these two areas. Our primary concerns relate to:

1. **Costing Methodology:**
   a. A departure from industry standard practice occurred. The contingency methodology lacks the application of a project risk assessment process that recognizes unique risks for each project and assigns a contingency commensurate with such a risk assessment.
   b. An analysis of the overall confidence level of the stated cost of the program (v. projects) has not been performed.
   c. Significant costs were not included in the current cost estimate.
   d. Inconsistencies were noted within and between projects related to the inclusion of costs for amenities not mandated by the Final WWIP.
   e. Some estimates were based on assumptions inconsistent with industry standards.

2. **CSO Volume Reduction Estimate:**
   a. The SI Alternative is relying on estimates and modeling supported by little to no direct local data.
   b. The limited data that has been relied on to prove performance does not appear to directly support the current effectiveness assumption used by the SI Alternative.
   c. No potential shortfall replacement costs have been provided based on a sensitivity analysis to provide for instances of the program not being as effective as assumed.

d. Reduced effectiveness rapidly increases the cost per gallon uncertainty of the SI Alternative.

This report is structured in five components. This Executive Summary defines the purpose and structure of the report and gives an overview of the findings. The second section of the report contains the substantive text related to the Monitor's analysis and two resulting areas of concern related to certainty of cost. The review criteria for each area of concern are explained and the findings presented in detail based on the review criteria. **The third section articulates potential options for addressing the mitigation or avoidance of cost uncertainty.** The fourth section contains brief descriptions of other potential areas of cost uncertainty concerns. Lastly, attachments referenced within the document are included. At the end of each section are the footnotes related references within that section.

Footnotes:

[1] Final WWIP means the WWIP, November 2009, as prepared by USEPA.

[2] Board of County Commissioners resolution, July 18, 2012

[3] Lower Mill Creek Partial Remedy – Alternatives Evaluation Preliminary Findings Report http://projectgroundwork.org/projects/lowermillcreek/community.htm

2. A. Costing Methodology

REVIEW CRITERIA

In order to have confidence in the SI Alternative cost/budget estimates there must be a rational and consistent application of industry best practices for determining and accounting for the uncertainties inherent in the individual projects, and the program (collection of projects).

To identify uncertainties related to project and program costs the SI Alternative was evaluated against the following parameters associated with appropriate cost/budget development:

1. Budget Development
    a. Project level risk analysis
    b. Program level confidence analysis
2. Completeness
3. Consistency of cost accumulation across projects within the program
4. Certainty of Estimates

Other review criteria included MSD's adherence to their own internal cost accumulation policies and accuracy of cost accumulation. No significant concerns were noted related to these items.

FINDINGS

Several issues were noted related to the review criteria which add to the level of cost uncertainty associated with the SI Alternative. **The County's most significant issues with cost uncertainty relate to project level risk analysis and program level confidence analysis.**

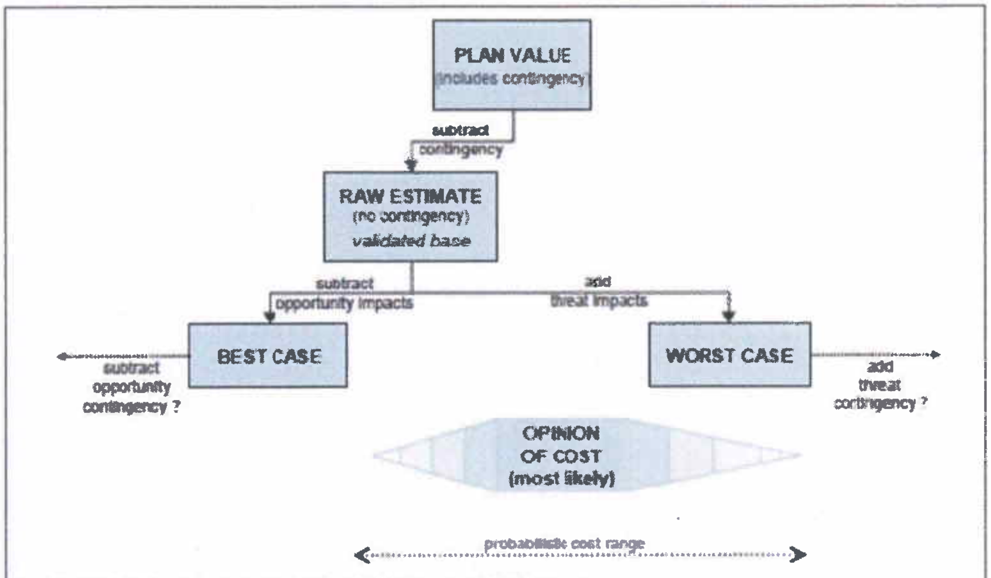
BUDGET DEVELOPMENT

Project Level Risk Analysis

The cost estimate preparation for the individual projects of the SI Alternative program followed costing protocols as represented by MSD to the Monitor on February 23, 2012. The protocols were developed by a committee of both MSD staff and consultants trained in industry cost estimating practices.

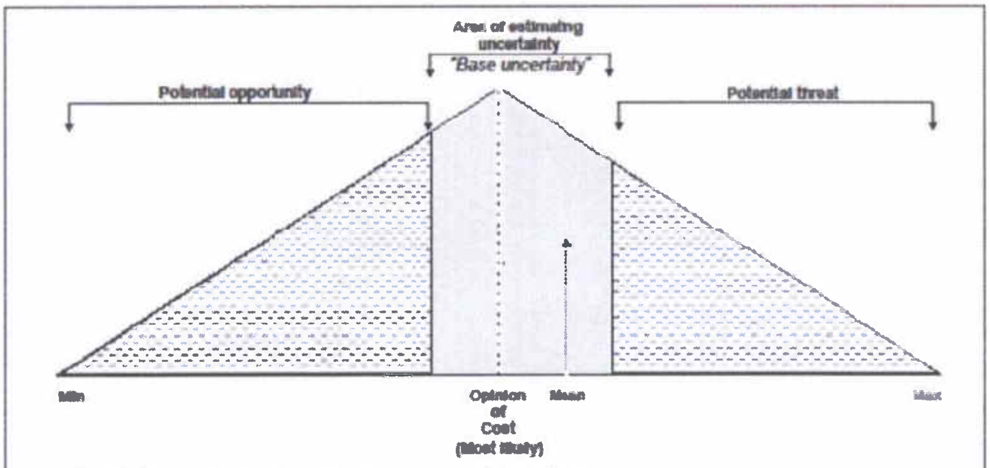
However **an important departure from industry standard practice was the lack of a project risk assessment process** whereby time and cost related risks to each project were identified, evaluated and valued. This project risk assessment process typically results in a reasoned, justifiable contingency value to be applied to each project based on its unique characteristics [1]. MSD's protocols do not include this approach. The SI alternative project budgets simply include a 10% contingency value added to the total construction cost of each project. This policy introduces a significant lack of confidence in the aggregate of project cost estimates that make up the SI Alternative total cost estimate. Industry practices recognize the variability associated with a project cost estimate (see Figures 4-2 and 4-3 below) and there are techniques available to develop a reasonable range of costs for a given project.

2. A. Costing Methodology



Credit: David Hillson, Effective Opportunity Management for Projects

Creating a probabilistic estimate
Figure 4-2



Credit: David Hillson, Effective Opportunity Management for Projects

Regions of an estimate
Figure 4-3

2. A. Costing Methodology

Each project is unique, and has its own set of potential opportunities and risks associated completing the project within its estimated cost. Therefore a risk assessment process should be used on each project to identify the risks, evaluate them as to probability of occurrence and the impact to the project cost if it does occur. Under this approach major cost drivers are identified and management strategies prepared. Based on this analysis, a contingency value would then be recommended. Decision makers could then determine whether the contingency value provides a satisfactory confidence level or whether a different amount should be approved.

Typically the larger the project, the more uncertainty regarding its cost estimate. Described below in the Program Estimate section are more sophisticated risk assessment methods. These should be considered for larger projects as well. For example, the U.S. Army Corps of engineers requires that a sensitivity and risk analysis using the Monte Carlo simulation method be used on every civil works project that has a total project cost estimate of $40 M or more, and strongly recommends these techniques be used on smaller projects that are considered to have significant risk factors. [15]

Program Level Confidence Analysis

In addition to the uncertainty introduced by the project estimate process described above, there is a range of costs that represents the confidence level surrounding the reported SI Alternative total program cost of $317 M. The greatest program risk is if the various projects of the SI Alternative do not perform as predicted related to reducing CSO overflow. **An analysis on the overall confidence level of the stated cost has not been performed.** The individual projects are assumed by the SI Alternative to perform as designed.

The risk factors that should be considered for each project (see chart below), should also be considered for the program as a whole. **Consideration should be made of the potential of the projects not performing as designed or assumed. This would include the concern expressed in the next section of this report related to the certainty of the CSO Volume Reduction Estimate.** Property acquisition delays, local construction industry shortfalls in capacity to support the schedule of projects or regulatory issue delays are other examples of risks to be considered. A risk analysis should be performed for the entire SI Alternative collection of projects in order to determine the significant risks to successful plan completion and the possible cost and schedule impacts that can develop. The potential cost of these risks should be evaluated and presented to decision makers for consideration. Ultimately, a program contingency must be identified so that sound decisions can be made, and the potential program cost can be appropriately planned.

2. A. Costing Methodology

- **Real Estate**
  - Property Acquisition
  - Relocation
  - Condemn
  - Eminent Domain
- **Public Utilities**
  - Analysis and Coordination
  - Agreements
  - Relocation
- **Financial**
- **Politics**
  - Internal/External
- **Environmental**
  - Environmental Impact Studies
- **Historical Significance**
  - Protected Lands
  - Archaeological
  - Structures
- **Contract phasing and packaging**
  - Scope of Work
  - Bid Process/Labor
  - Integrating Construction Packages
- **Community impacts and public perception**
- **Public hearing**
  - Marketing/Communication
  - Safety and Security
- **Material, Equipment and Construction Techniques**

Federal Transit Agency Project Management Handbook, 2009

There are two components of capital program budget development that have not been demonstrated in the MSD cost estimates: Sensitivity Analysis and Risk Analysis. The absence of these considerations results in cost uncertainty.

Quoting from the Federal Office of Management and Budget Guidance for Government Auditors[10]:

"For management to make good decisions, the program estimate must reflect the degree of uncertainty, so that a level of confidence can be given about the estimate. Quantitative risk and uncertainty analysis provide a way to assess the variability in the point estimate. Using this type of analysis, a cost estimator can model such effects as schedule slipping, missions changing, and proposed solutions not meeting user needs, allowing for a known range of potential costs. Having a range of costs around a point estimate is more useful to decision makers, because it conveys the level of confidence in achieving the most likely cost and also informs them on cost, schedule and technical risks."

Sensitivity Analysis

Cost estimating, especially during the planning and early design phases of a project, is inherently imprecise since there may be many unknown or less than fully vetted project elements. In the absence of facts, assumptions must be made to support the cost estimate. In recognition of this, a sensitivity analysis should be performed on the estimate in order to gain an appreciation for those project cost elements that have the highest probability for inaccuracy, and thus can ultimately impact the accuracy of the project cost estimate.

*"Perform the sensitivity analysis: Once the estimate is developed, **decision makers want and need to know how sensitive the total cost estimate is to changes in the data input**. Therefore, a sensitivity analyses is performed to identify the major cost drivers for the estimate. Sensitivity analyses determine how the different ranges of estimates effect the estimates. Cost drivers are those variables that when changed in value, create the greatest changes in cost. Generally many initial assumptions made in the early phases of a*

project's definition will, in later phases, be found to be inaccurate." [10]

Risk Analysis

The Federal Office of Management and Budget (OMB) Capital Programming Guide [9] requires risk analysis as a primary component of a capital project decision template. The OMB cites as the basis for their program budget approach the three basic texts noted in the footnotes [11, 12, 13]:

"Risk management should be central to the planning, budgeting, and acquisition process. Failure to analyze and manage the inherent risk in all capital asset acquisitions may contribute to cost overruns, schedule shortfalls, and acquisitions that fail to perform as expected. For each major capital project (investment), a risk analysis that includes how risks will be isolated, minimized, monitored, and controlled may help prevent these problems."

The OMB requires that an evaluation of each project/program risk be conducted in order to gain an appreciation for the potential cost and schedule impacts of each risk, and how that risk will be managed. ***The result of the risk analysis is an additional cost value that is added to the project cost estimate creating a "Risk-adjusted Program Cost" and a "Risk-adjusted Schedule"***.

"Risk analysis is the process of examining each identified risk issue or process to refine the description of the risk, isolate the cause, and determine the effects. The cost of a risk event occurring can be quantified by determining its expected value (probability X impact). These costs must be included in cost estimates."

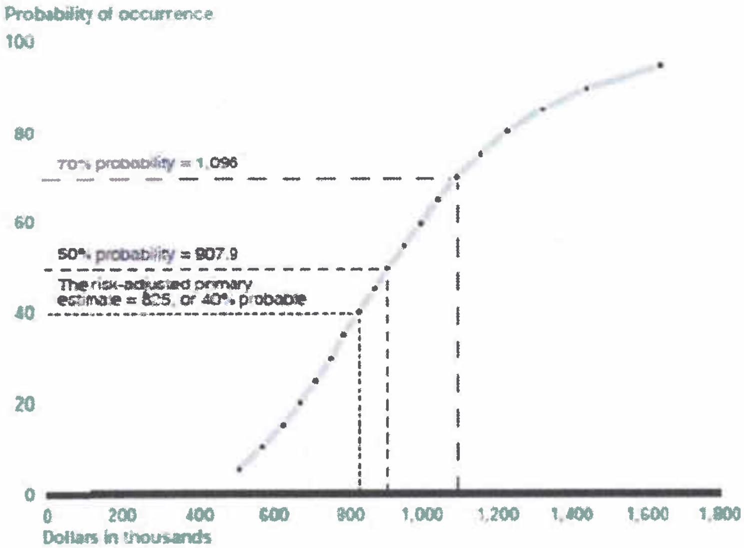
Contingency Reserve

Recognizing the imprecise nature of a program estimate in its preliminary design phase, a contingency reserve is often added to a program budget. Federal guidelines indicate the following:

"Develop Contingency Reserve: Based on the confidence level, a contingency allowance is used to cover the items of cost which are not known exactly at the time of the estimate."

Simulation models are typically used to develop the confidence intervals around a program cost estimate. Using the results from the Risk and Sensitivity Analyses, the simulation develops probabilistic values for cost and schedule impacts due to the risks that are the primary cost and schedule drivers. Using the results of this process, decision makers can determine how much cost risk is acceptable. See an example of a cost probability curve below, Figure 16. [2]

Figure 16: A Cumulative Probability Distribution, or S Curve



Source: GAO and NASA.

"Uncertainty analysis using a Monte Carlo simulation communicates to stakeholders how likely a program is to finish at the estimated cost and schedule, how much cost contingency reserve is needed to provide the desired degree of certainty that the estimate will be adequate, and the likely risks so that proactive responses can be developed." [2]

It can be argued that the 10 percent project contingency applied by MSD is too little given the phase of project development. The use of Sensitivity and Risk Analysis methods for determining cost variability would provide the County with a more accurate representation of likely project costs. And it can also be argued that in the aggregate (at the SI Alternative program level), there may be risks associated with completing all of the SI Alternative projects that should be analyzed, and may warrant a Program Contingency Reserve. Examples of these risks might be design or construction industry capacity to support the program, unanticipated labor cost increases, property acquisition issues or public utility coordination difficulties.

COMPLETENESS

The following observations were made related to potentially incomplete cost budgets within the SI Alternative:

1. In SI Alternative drawings, traffic patterns along Westwood Avenue and Queen City Avenue are modified. These costs to **modify traffic patterns** are estimated to be between $23 to $29 M. These **costs are not included** in the total cost.
2. The SI Alternative Life Cycle cost analysis performed applied a life expectancy of 25 years for all projects and calculated the present worth cost using a single fixed interest rate. **Ranges for 50 year, 75 year, and 100 year life expectances were not included**

to capture the different types of projects with extended life expectancies [3]. This sensitivity analysis also assumed a fixed interest rate instead of evaluating a range of interest rates. An analysis evaluating a range of life expectancies and interest rates would provide a more comprehensive understanding of the life cycle costs.

3. Schedule and constructability of the SI Alternative has not been presented to demonstrate how the multitude of projects that make up the SI Alternative are interrelated. Many projects may need to be constructed simultaneously which may impact traffic, construction access, and staging. These factors are not defined and could increase construction costs.

4. Because long-term responsibilities for new storm sewers is not clarified related to O&M costs and stormwater regulatory costs this will impact future financial responsibility for water quality issues and raise cost uncertainties.

5. The SI Alternative proposes 18 new stormwater detention basins of various sizes. 15 of the 18 have been estimated to be exempt from Dam classification. Therefore, 3 Dams are not exempt and one is currently estimated to be a Class 1 dam. Ohio DNR Class 1 dams are the highest risk classification [8]. With Ohio DNR Class 1 dams, the dam itself needs to be more rigorously constructed to safeguard against breaching and the detention of storm flows to larger storm events provided in order to meet permit requirements. The SI Alternative modifications to the design of this detention basin are currently under consideration. The **capital costs to address these design and permitting requirements are not included** in the cost estimate.

   In addition, the estimated ongoing annual costs to inspect, report and maintain Ohio DNR classified dams are not identified in the detailed cost estimates provided.

CONSISTENCY

6. The Lick Run SI project includes surface features not mandated by the Final WWIP, and referred to as amenities. A detailed description of aesthetic amenities in the Lick Run SI is identified in Attachment 1. Some of these amenities are not required to increase CSO abatement or address stormwater water quality. Approximately $15.8 M of amenities are included in the Lick Run base construction costs [4]. Other nonessential aesthetic costs outside of Lick Run include a park near the West Fork Channel listed at a total cost of $1.48 M [5].

   There are a number of aesthetic items also shown in SI Alternative drawings that are not currently included in the SI Alternative total cost, such as various plazas, civic spaces, gardens, and lighting. This assumes funding will come from sources outside of MSD rates and bond proceeds. However, currently there are no definitive arrangements.

   The County has indicated a desire to better understand these amenities and to determine which should be included in the costs [14].

ESTIMATES

7. Estimated costs for impacts to existing Utilities (gas, electric, telephone, cable and water) accounts for a range from 6.5% to 9% of the base SI construction cost estimate before contingencies are added to the estimate. The estimates are itemized in detail for the utilities, but the estimates do not include utility relocation costs calculated by the local utility. The Utilities are more familiar with the detail of the required work to relocate and their estimates often differ significantly with initial engineering estimates. The SI Alternative projects consist of significant linear construction in urban areas. The conflict between the existing Utilities and proposed construction will be extensive. The Utility owners' costs input on estimated relocation and repair costs are critical to increase the confidence in the estimated base construction cost.

8. The Lick Run project is located in a tight urban setting where very high traffic flows during peak hours are expected to occur. Based on this dynamic, use of a 3% factor for Maintenance of Traffic (MOT) appears to be an appropriate factor to be applied to this project [6]. MSD's detailed estimated cost for the Lick Run Valley Conveyance System project includes approximately 1.4% of the estimated construction cost. A 3% factor for would essentially increase the current SI Alternative MOT budget by about $1.2 M.

9. Design contingencies factors are outlined in the SI Alternative report. For comparative purposes, the values reported generally comply with ODOT's ranges, but typically fall within the lower end of the range. The project stage multipliers appear low when compared with ODOT's estimating procedure, see Attachment 2. It appears the project multipliers used for project stages "Preliminary Design" and "30% Design" are at least 5% low [7].

10. Annual O&M costs for each of the SI Alternative projects were outlined in detail defining the assumptions made to obtain the present worth life-cycle costs. The annual O&M costs account for about 2% of the total overall capital investment over the 25 year life cycle analyzed. Little third party data exists to compare with the SI Alternative estimated O&M costs.

Footnotes:

[1] For example, Washington State Department of Transportation Project Risk Management Guidance, July 2010, pg. 2.

[2] GAO Cost Estimating and Assessment Guide, Best Practices for Developing and Managing Capital Program Costs

[3] Per EPA website "Fundamentals of Asset Management, Step 3. Determine Residual Life – A Hands-On Approach.

[4] CSO 5 Cost Summary from Engineer with a 20% contingency added.

[5] Per MSD Project Construction Cost Estimate for the West Fork Sustainable Watershed Alternatives Analysis

[6] The factor is discussed on ODOT's "Procedure for Budget Estimating (July 2011)" Incidental Costs tab.

[7] The Design Contingency component in outlined on the "PDP Design Risk & Graph" tab of ODOT's "Procedure for Budget Estimating (July 2011)" spreadsheet.

[8] Per the Ohio Administrative Code (OAC) 1501 12-13-01

[9] Capital Programming Guide; V 2.0
Supplement to Office of Management and Budget circular A–11, part 7:
Planning, budgeting, and acquisition of capital assets June 2006, page 85 and 78

[10] GAO Cost Estimating Guide for Government Auditors (Draft—2005), page 91

[11] A Guide to the Project Management Body of Knowledge, Third Edition, Project Management Institute

[12] Project Management: A Systems Approach to Planning, Scheduling and Controlling, 9th Edition, Harole Kerzner

[13] Risk Management: Concepts and Guidance, Second Edition, Carl L. Pritchard

[14] Board of County Commissioners resolution, July 18, 2012

[15] U.S. Army Corps of Engineers Engineer Techncial Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works

2. B. CSO Volume Reduction Estimate

REVIEW CRITERIA

Certainty relating to stormwater separation effectiveness is crucial to defining the performance of the program and determining the related project and program cost. It is also critical to achieving the Final WWIP CSO volume reduction requirements. In terms of defining "certainty" the County has indicated its desire to reduce the potential shortfalls in CSO required reductions that could occur as a result of the projects not being as effective at removing stormwater flow from the system as predicted by the SI Alternative. This is crucial in order to avoid additional projects and cost to achieve the Final WWIP requirements.

To conduct a review of these considerations we applied the principles set forth in the Water Environment Federation's (WEF) Manual of Practice FD-17, Prevention and Control of Sewer System Overflows[1], WEF Manual of Practice FD-6, Existing Sewer Evaluation & Rehabilitation[2], and the WaPUG Code of Practice for the Hydraulic Modeling of Sewer Systems (WaPUG Standards)[3].

FINDINGS

The Monitor has reviewed the information provided in the SI Alternative report along with supporting documentation provided by MSD that provides the estimated resultant CSO volume reduction from the proposed stormwater separation. In addition we conducted discussions with MSD staff to understand their approach and thought processes. **Addressing the dichotomy between predicted effectiveness and what the collected data demonstrates is the County's single most significant issue related to volume reduction certainty.**

Our review found:

1. The SI Alternative is relying on estimates and modeling with **little to no direct local data to predict the effectiveness of CSO volume reduction from storm sewer separation**. In the absence of strong confirming local data, **CSO volume reduction being over predicted is a significant uncertainty to be considered.**

   No direct measurement of CSO volume reduction based on stormwater gallons removed from the combined sewer system (CSS) was performed. The approximate 33 green infrastructure demonstration projects completed to-date were not designed to provide measured data to confirm the effectiveness of storm sewer separation.[4]

   WEF's Manual of Practice FD-6 confirms "Overflows need to be monitored to establish the total system flow if meaningful flow data are to be obtained. Otherwise, the whole program could be rendered ineffective because of incomplete data."[5]

   Empirical data from local "demonstration projects" could have provided accurate stormwater percent capture and CSO volume reduction assumptions and decreased the uncertainty of improper sizing of projects. Such data was not collected or not made available to the Monitor.

2. MSD's Modeling Consultant recommended flow monitoring of a combined sewer separation project to confirm CSO volume reduction effectiveness to be used for planning projects in the future.[6] **MSD did not perform flow monitoring of a combined sewer separation project.** The approach that would provide the most certainty related to the amount of stormwater that will be removed from the CSS and the resulting CSO volume reduction is to perform direct measurements of representative combined sewer separation projects within the watersheds.

   In May 2012 MSD provided the Monitor flow meter data [8] from four locations where existing storm sewers and sanitary sewers were monitored for approximately one year. This data was obtained in basins where the original designs included separate storm and sanitary piping.[9] This data was not obtained from sewersheds which were originally designed as combined sewer areas that had been separated as is proposed with the SI Alternative.[9]

   After a review of this data, **MSD's modeling consultant found the data not representative of sewer separation in a combined sewer area.** The consultant's recommendation was to perform flow monitoring prior to construction and after construction in an area scheduled for stormwater separation.[6] The data could then be analyzed to more accurately measure the effectiveness of a storm water separation project and used for planning projects in the future.[6]

3. To provide a second independent analysis the Monitor analyzed the flowmeter data described in Item 2 above. The Monitor found that even if the flowmeter data was to be considered representative of sewer separation, the **data does not support the SI Alternative's stormwater volume removal assumptions.**

   The ARCADIS Report (Table 4-17) assumes that on average across the six subbasins 75% of the stormwater that enters the CSO system will be removed by the proposed storm sewer separation.[7] In contrast the data showed an average capture of stormwater in the storm sewers of between 23% - 41%. **Based on this limited data, the analysis showed that the SI Alternative is likely overestimating the percent capture.**

   In Lick Run, 87% of the stormwater to be separated is assumed to be captured by the storm sewer system.[7] The 87% assumption includes the capture of local streams that will be diverted to the new storm sewers which the SI Alternative indicates justifies in-part the higher percent capture in the Lick Run basin.

4. **The SI Alternative's analyses do not appear to fully account for the effects of Rainfall Derived Inflow and Infiltration (I/I) continuing to enter the combined sewers after separation.**[6] The effect of not accounting for this I/I volume would be expected to be a lower than estimated CSO volume reduction from the storm sewer separation projects.

   The effectiveness of storm sewer separation in reducing CSO volumes is dependent on how well stormwater is removed from the former combined (now sanitary) pipe and diverted into the new storm sewer pipe. During rain events that cause CSOs, the combined sewers and interceptors are surcharged which prevents a portion of the stormwater volume (typically referred to as I/I) from entering the combined sewers. After the rain event ends and the sewers are no longer surcharged, this I/I then makes its way into the combined sewers. If a portion of the stormwater volume is removed by the storm sewer separation, the existing sewer system can more readily and quickly accept the latent Infiltration/Inflow sources, previously hydraulically excluded from entering the combined sewers resulting in increased flows in the CSS and more CSO volume than estimated. **The effect of this I/I volume continuing to enter the CSO system is not analyzed by the SI Alternative when calculating CSO volume reduction from the storm sewer separation.**

5. The table below is a sensitivity analysis to determine the total reduction of CSO volume over or under the Final WWIP requirement at varying levels of accuracy of the current effectiveness assumption. This analysis is an approximation and assumptions would have to be run through MSD's model to verify the results. Benefits of existing real time controls (RTC's) are included.

   Cost uncertainty results from the need to make up any shortfalls in volume reduction encountered under the potential scenarios included in the table below. **The SI Alternative does not provide potential shortfall replacement costs related to a sensitivity analysis.**

Sensitivity Analysis for SI Alternative			
SI Effectiveness Assumption	Total Annual CSO volume reduction SI + RTC's* (MG)	Total Reduction Over (Under) Target (MG)	
		2 BG	1.8 BG
Base SI Alternative	2,024	24	224
15% Reduced Effectiveness	1,832	(168)	32
25% Reduced Effectiveness	1,704	(296)	(96)
50% Reduced Effectiveness	1,384	(617)	(417)
75% Reduced Effectiveness	1,063	(937)	(737)

   For clarity, the SI Alternative's assumption of separation effectiveness exceeded that demonstrated by monitored data by 34-52%. **Addressing this dichotomy between predicted effectiveness and what the collected data demonstrates is the County's single most significant issue related to volume reduction certainty.**

6. In addition, a second cost uncertainty related to the above table is the cost per gallon increase at reduced levels of effectiveness. The $317 M cost of the SI Alternative excludes the cost of the RTC's [10, 11]. In the table below, utilizing the data from the above table and separating out only the cost and the CSO reduced volume directly attributable to the SI component (and excluding the CSO reduction and cost directly attributable to the RTCs already in place) it is clear that **reduced effectiveness rapidly increases cost per gallon uncertainty**.

2. B. CSO Volume Reduction Estimate

Sensitivity Analysis for SI Alternative			
SI Effectiveness Assumption	Total Annual CSO volume reduction attributed to SI components only (MG)	SI Component Cost	SI Alternative Cost per Gallon
Base SI Alternative	1,281	$317,000,000	$0.25
15% Reduced Effectiveness	1,089	$317,000,000	$0.29
25% Reduced Effectiveness	961	$317,000,000	$0.33
50% Reduced Effectiveness	641	$317,000,000	$0.49
75% Reduced Effectiveness	320	$317,000,000	$0.99

Footnotes:

[1] Water Environment Federation's (WEF) Manual of Practice FD-17, Prevention and Control of Sewer System Overflows, 2011

[2] WEF Manual of Practice FD-6 Existing Sewer Evaluation & Rehabilitation, 1994

[3] Wastewater Planning Users Group Code Of Practice For The Hydraulic Modeling Of Sewer Systems, November 2002

[4] Enabled Impact Program Interim Report, MSD, December 2011

[5] WEF Manual of Practice FD-6 Existing Sewer Evaluation & Rehabilitation, 1994, pg 105

[6] Separate Sewer Modeling in Lick Run and Bloody Run,XCG Consultants, April 16, 2012, pg 11

[7] Sustainability Projects Technical Memorandum – Lower Mill Creek Partial Remedy Study Prepared by Malcolm Pirnie/Arcadis, August 9, 2012, Table 4-17, pg 72

[8] Copy of Question SI-8 Response.xlsx, MSD, May 22, 2012

[9] Separate Sewer Modeling in Lick Run and Bloody Run, XCG Consultants, April 16, 2012, pg 1

[10] Lower Mill Creek Partial Remedy – Alternatives Evaluation Preliminary Findings Report http://projectgroundwork.org/projects/lowermillcreek/community.htm pages 43 and 45

[11] MSD presentation, LMC Study Progress Update for USEPA, Ohio EPA and ORSANCO, July 26, 2012, slide 35

3. Options for Addressing Cost Uncertainty

Approaches need to be considered to mitigate the uncertainties noted in sections 1 and 2. As an initial matter, a detailed risk analysis, following reputable industry standards for public capital projects of the contemplated cost, should be conducted. Final decision-making by the County will fully utilize that analysis. In its absence, decision-makers would need to use alternative methods to account for a range of potential risks.

Approaches to address cost uncertainty include but may not be limited to:

Costing Methodology

A. Mitigating uncertainties considered significant through:
   a. Including project and program contingency allowances calculated in accordance with industry acceptable standards that reflect project level risk analysis and program level confidence analysis.
   b. Inclusion of all known costs for consideration.
   c. Eliminating cost accumulation inconsistencies between components of the program.
   d. Ensuring that assumptions used in determining costs are consistent with industry standards.
   e. Calculation and inclusion of an acceptable level of potential shortfall replacement costs.

B. Undertaking of value engineering (VE) to alter cost while still achieving goals. This would include a full evaluation of existing project specific VE exercises performed to date.

CSO Volume Reduction Estimate

Inclusion or submittal of more cost certain alternatives or revision of current SI Alternative to achieve a greater level of cost certainty:

A. Alternatives could include submittal of a new suite of projects which provide a greater margin of volume capture certainty while remaining within BoCC cost parameters.

B. Alternatives could contain components of the previously submitted SI Alternative with new components that mitigate or minimize the effects of existing cost uncertainty causing attributes. For example, alternatives could include enhanced storage/conveyance within the scope of the previously submitted SI Alternative to provide a greater margin of volume capture certainty. This would allow for an acceptable level of margin of error in the current SI component effectiveness assumption.

4. Other Items to Consider Related to Uncertainty of Costs

Other considerations also exist that could contribute to varying degrees of uncertainty as it relates to the final cost of the LMCPR project. These considerations were not explored in this report but are included for consideration:

1. Flooding: the SI Alternative has not determined the potential for new flooding routes and areas affected by heavy storms. In addition, the effects that the new peak flows from the proposed storm sewers will have on the Mill Creek and its tributaries has not been evaluated. It has yet to be demonstrated that these considerations will not result in additional cost uncertainty.

2. Water Quality: the SI Alternative creates 2.9 BG of new stormwater discharges in order to reduce CSO volume by 2.0 BG. This results in 21% more untreated discharge volume as compared to existing conditions [1]. It has yet to be demonstrated that these new discharges will not result in additional cost uncertainty.

3. Future Potential Stormwater Quality Regulations – According to the USEPA's website, EPA intends to propose a rule to strengthen the national stormwater program by June 10, 2013 and complete a final action by December 10, 2014. It is difficult to ascertain at this point if this future action will, as it relates to the new, segregated stormwater discharges, result in additional cost uncertainty [2].

Footnotes:

[1] LMCPR Alternatives Evaluation Preliminary Findings Report and supporting documentation, MSD, April 2, 2012, Table 7-5, pg 41

[2] http://cfpub.epa.gov/npdes/stormwater/rulemaking.cfm

Essential vs. Non-essential Amenity Costs
Moving from West to East along the lower corridor (starting at where Westwood Ave merges with Queen City Ave and moving East to Mill Creek). The items are grouped by those essential and not essential for CSO volume reduction and WQ benefit.

A. Essential for CSO volume reduction and WQ Benefit included in Lick Run Base Project Cost

a. Wetland forebay
b. Bioswales and rain gardens
c. Daylighting feature – where the stream goes from pipe to the start of the urban waterway
d. Urban waterway itself – conveys flows in an open stream during small rain events. Large rain events are conveyed by the underground concrete box culvert located beneath the urban waterway.
e. Pond and wetland – This is located just upstream of the waterway outfall to the Mill Creek.
f. Urban waterway outfall feature to the Mill Creek – proposed to be located downstream of Lick Run CSO 005 outfall and upstream of the Western Hills Viaduct

B. Non-essential for WWIP CSO volume reduction and/or Consent Decree WQ standards, but included in Lick Run Base Project Cost

a. Boardwalks and railings around the wetland forebay
b. Interpretive Signage
c. Irrigation
d. Trailhead Parking – including porous pavement, brick pavers, trees, lighting, and landscape plantings
e. Urban waterway features
    1. Terraced stone walls
    2. Feature lighting
    3. Signage
    4. Landscape plantings
    5. Islands
    6. Ledge rock, natural stone and boulders
f. Trees for making wooded areas
g. Benches, trash receptacles, bike racks
h. 8-feet wide concrete walkway along length of corridor
i. Pedestrian lighting along the concrete walkway
j. Pedestrian bridges & railings
k. Multi-purpose trail and trail lighting
l. Crosswalks – brick pavers
m. Decorative railing
n. Specialized pavements – brick pavers
o. Public gardens
p. Promenade concrete walk including, (in addition to items J – P above) Railings
    1. Pedestrian Lighting

2. Trees and tree grates
3. Benches, trash receptacles, bike racks

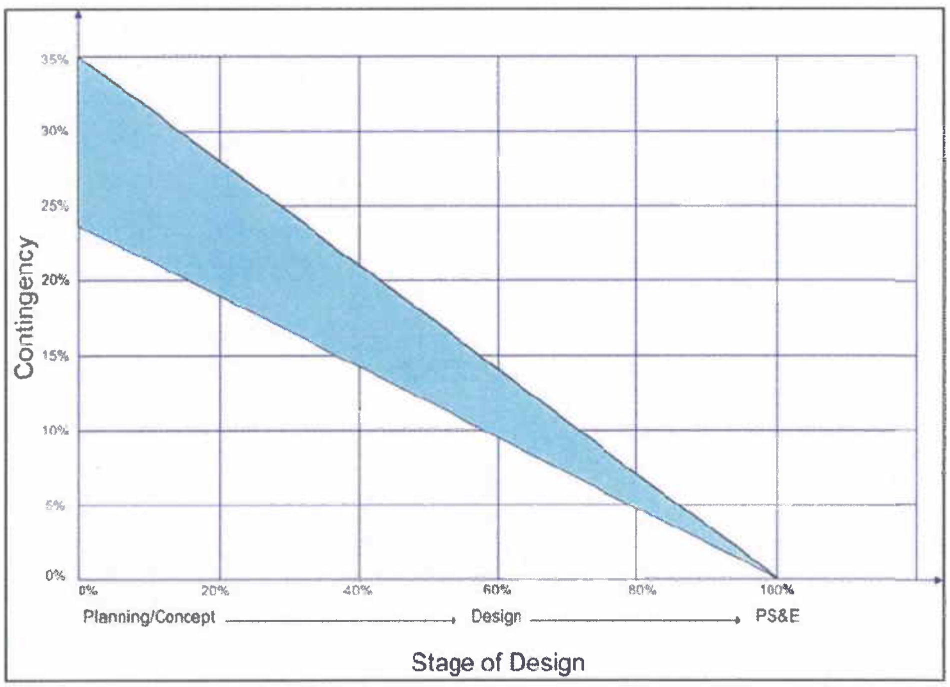
q. Drinking fountains (11)
r. Playground (1)
s. Steps and open space turf
t. Picnic Grove
    1. Trees
    2. Picnic Tables
    3. Trash receptacles
u. Recreational Field
    1. Baseball field
    2. Half a football field
v. Confluence Wildlands (just downstream of Pond/Wetland)
    1. Reforestation
    2. Meadow plantings
w. Shelter (1)
x. Relocated existing playground and basketball courts

C. Non-essential for WWIP CSO volume reduction and/or Consent Decree WQ standards, but NOT included in Lick Run Base Project Cost but Included in Lick Run Artist Drawings used by MSD

a. Gardens
b. Gateway Feature – items to enhance the daylighting feature above
    1. Architectural walls
    2. Feature lighting
    3. Signage
    4. Landscape plantings
    5. Public art
c. Street lighting along Queen City Ave and cross streets
d. Green streets – bioswales, street trees, street lighting
e. Plaza – including public art and trees
f. Western Hills Gateway Plaza
g. Western Hills Gateway Plaza Fountain
h. South Fairmount Civic Space
    1. Concrete walk
    2. Lawn areas
    3. Meadow
    4. Garden
    5. Trees
    6. Brick pavers
    7. Public art features
    8. Bike racks
    9. Trash receptacle

Table 4-1: Design Contingencies (from the LMCPR Alternatives Evaluation Preliminary Findings Report)

Project Stage	Multiplier
Conceptual Planning	35
Facilities Planning	25
Preliminary Design	20
30% Design	15
60% Design	10
90% Design	5



From ODOT's "Procedure for Budget Estimating (July 11)"