Quantifying Risk on the DC Clean Rivers Project

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Schnabel ENGINEERING

Build Better. Together.

Learning Objectives

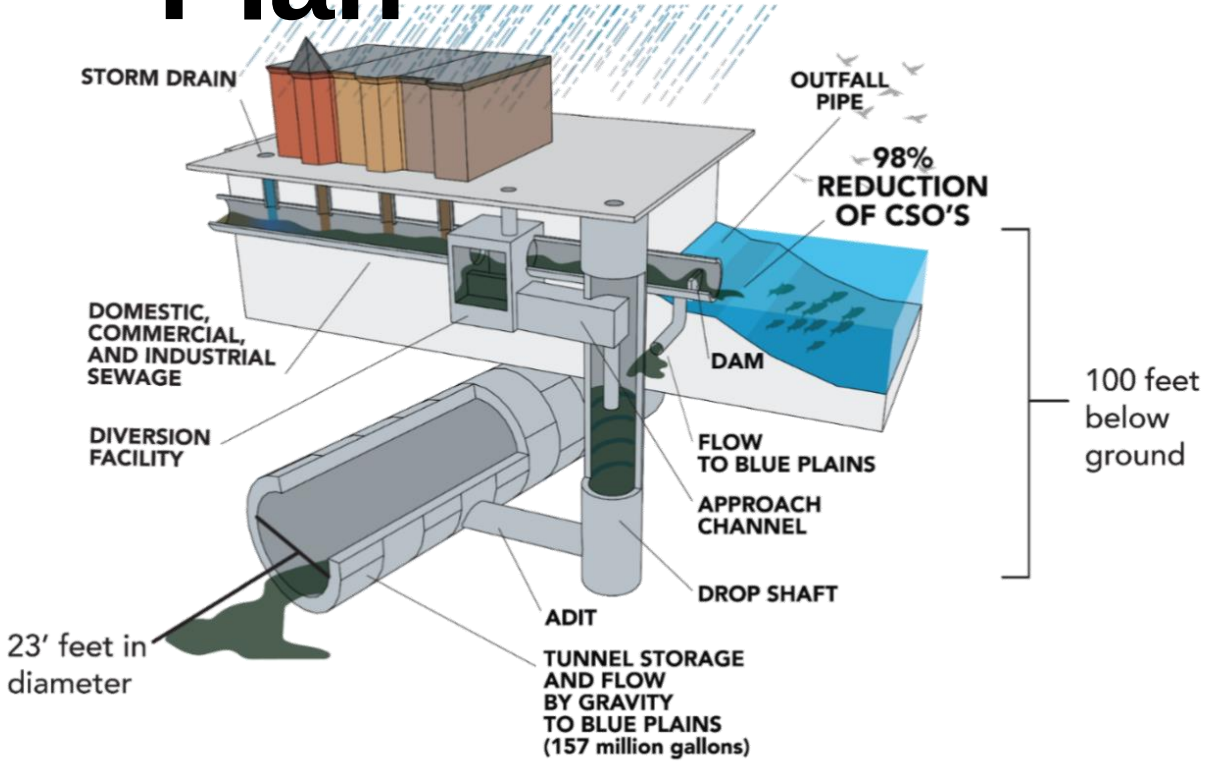
1. An appreciation for the size and complexity of the **DC Clean Rivers Project (DCCRP)**
2. A cursory understanding of **risk management theory and processes**
3. **Quantifying risk** in terms of cost and schedule
4. **Results of the risk management process**

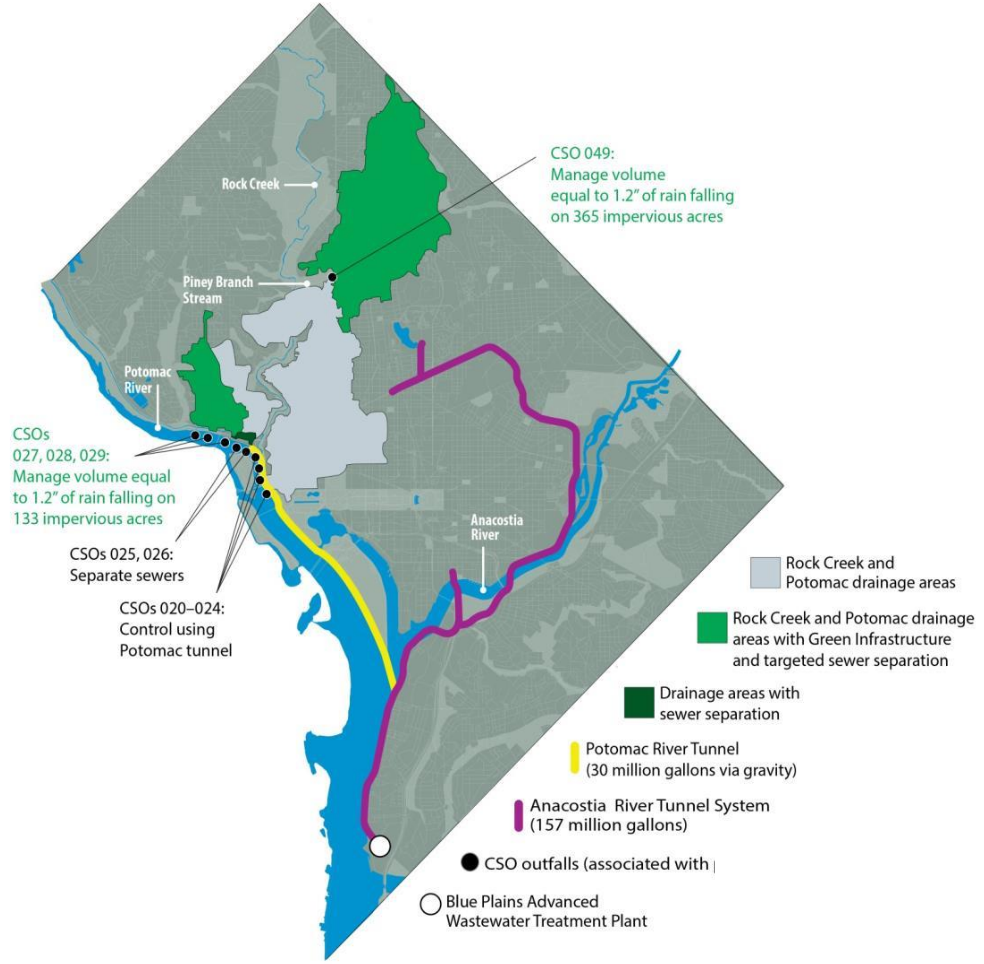
dc water is life

DC Clean Rivers Project (DCCRP)

In 2005, DC Water entered into a consent decree with the **Department of Justice**, the **EPA**, and the **District of Columbia** and embarked on what is currently a 25-year (2005-2030), $2.77 billion program christened the **DC Clean Rivers Project** to reduce CSOs into the Anacostia River, the Potomac River, and Rock Creek by 96% during an average year.

DC Clean Rivers Overview Current Plan





On average, 2.1 billion gallons of untreated sewage and storm water runoff (combined sewage) are discharged to the Anacostia River per year.

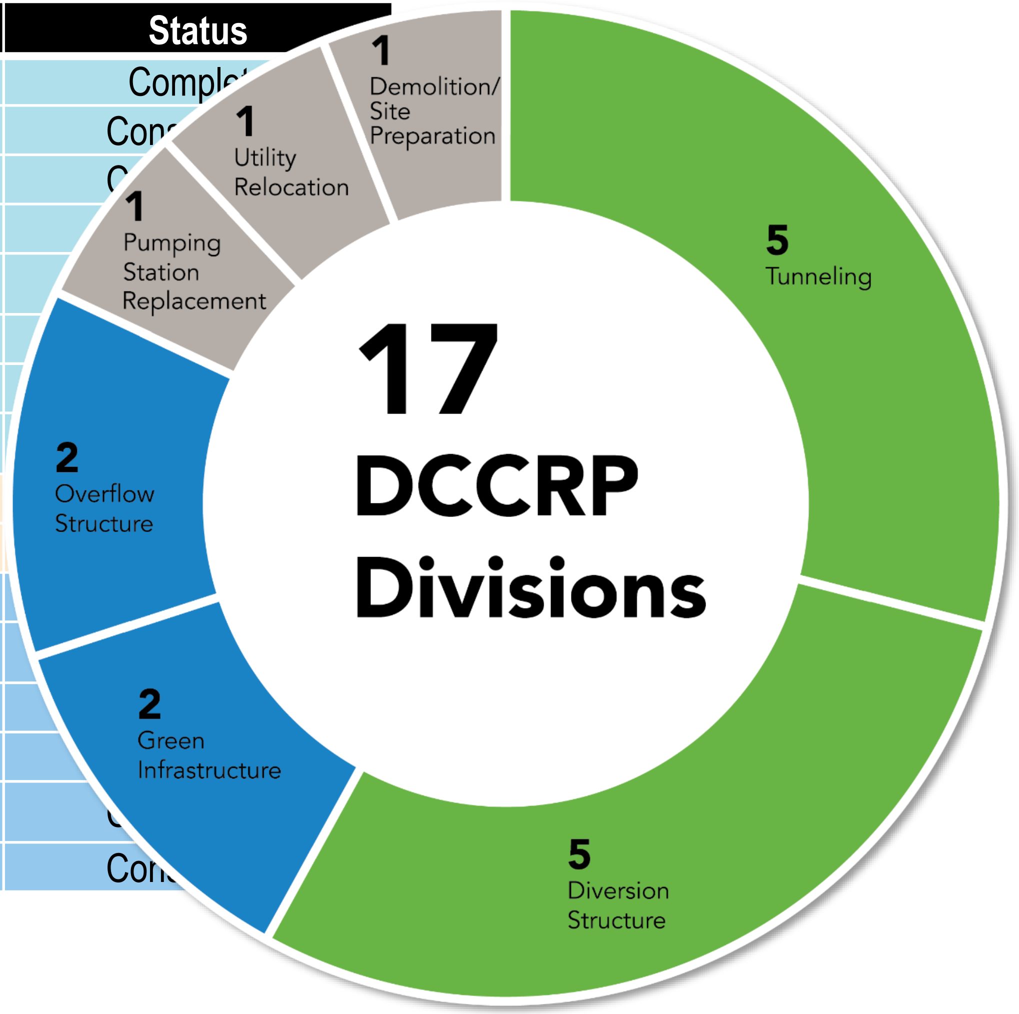
Anacostia River Tunnel System Snapshot

Project	Diameter	Length	Start	Finish
Blue Plains Tunnel	23	24,207	5/2011	12/2015
Anacostia River Tunnel	23	12,484	6/2013	12/2017
Northeast Boundary Tunnel	23	27,000	9/2017	5/2023
First Street Tunnel	20	2,700	10/2013	10/2016

Combined total length of 12.6 miles

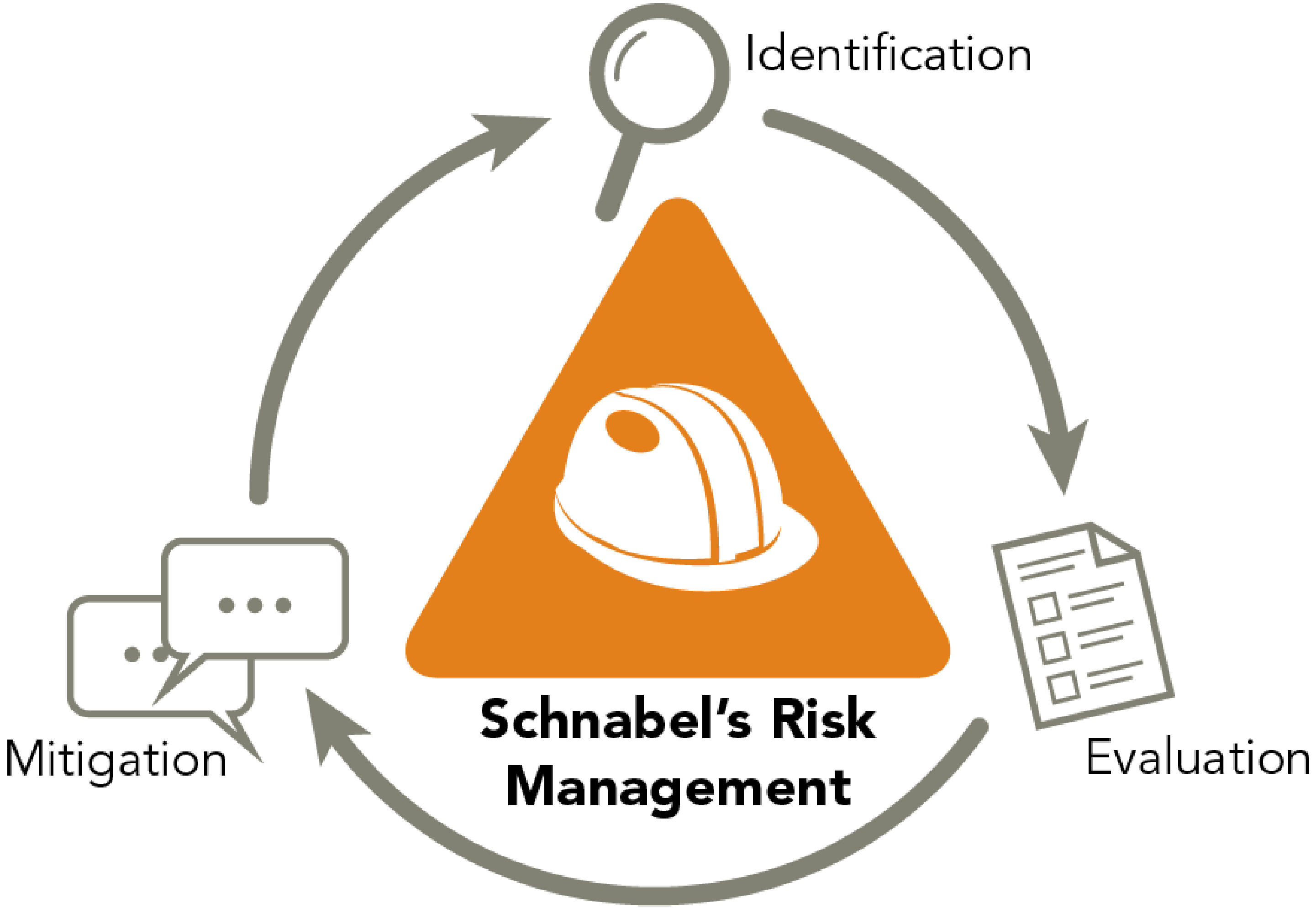
DCCRP Contract Delivery Methods/Status

Delivery	Div	Description	Cost (M)	Status
Design-Build	A	Blue Plains Tunnel	$318.7	Comple
	H	Anacostia River Tunnel	$254	Con
	P	First Street Tunnel	$158	C
	I	Main Pumping Station Diversions	$53	
	D	JBAB Outfall and Diversion Structures	$40	
	J	Northeast Boundary Tunnel	$500-600	
	PR-A	Potomac Area Green Infrastructure	TBD	
	RC-A	Rock Creek Area Green Infrastructure	TBD	
CMAR	B	Tingey Street Diversion Sewer	$16	
	PR-B	CSO 021 Diversion Facilities	$34	
Design-Bid-Build	W	Blue Plains Demolition	$7	
	C	CSO 019 Outfall and Diversion Structures	$28	
	G	CSO 007 Diversion Sewer	$5	
	E	M Street Diversion Sewer	$33	
	Z	Poplar Point Pumping Station Replacement	$53	C
	U	NEBT Utility Relocations	$17	Con



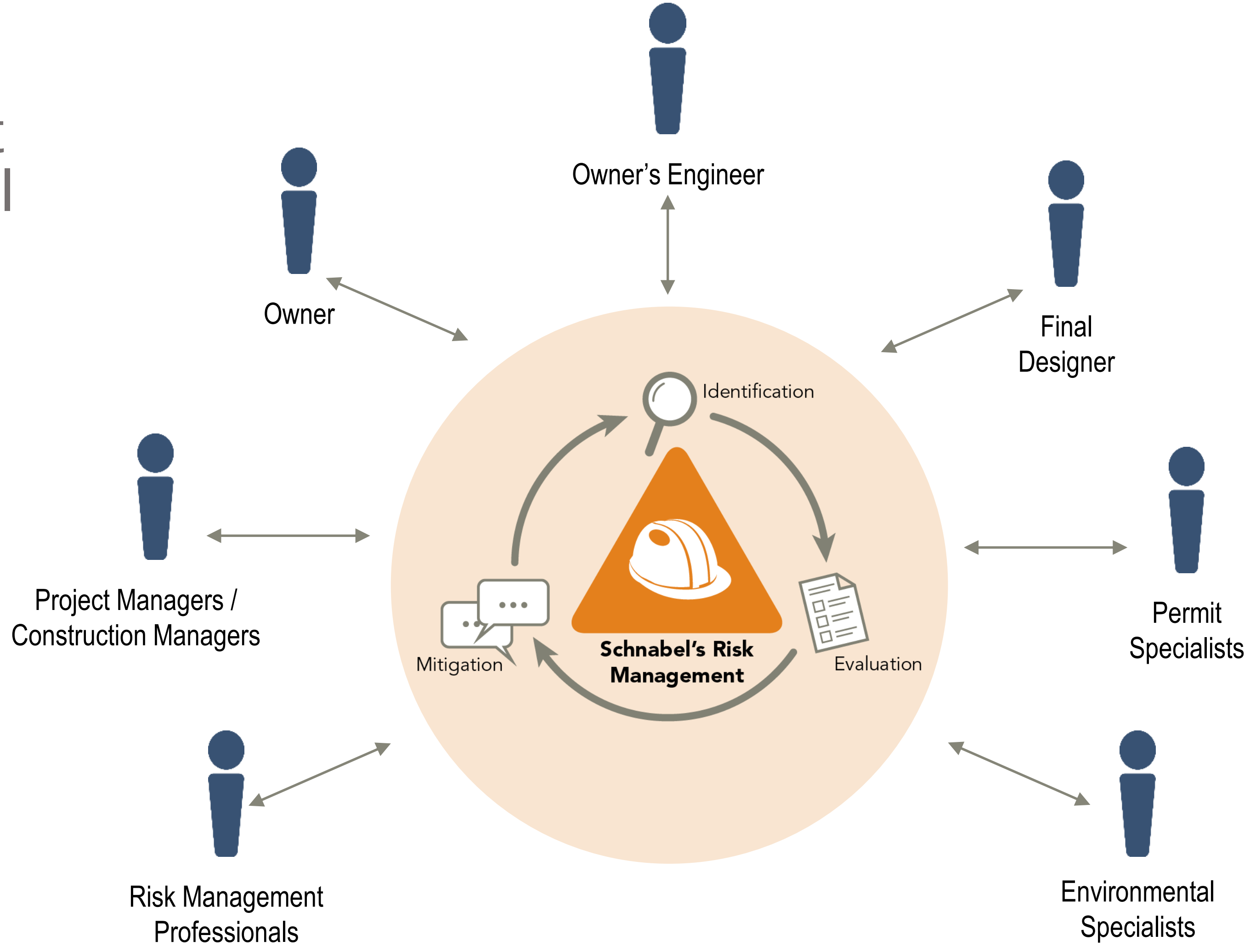
A total of 17 separate Divisions completed or under design/construction.

Introduction to Risk Management



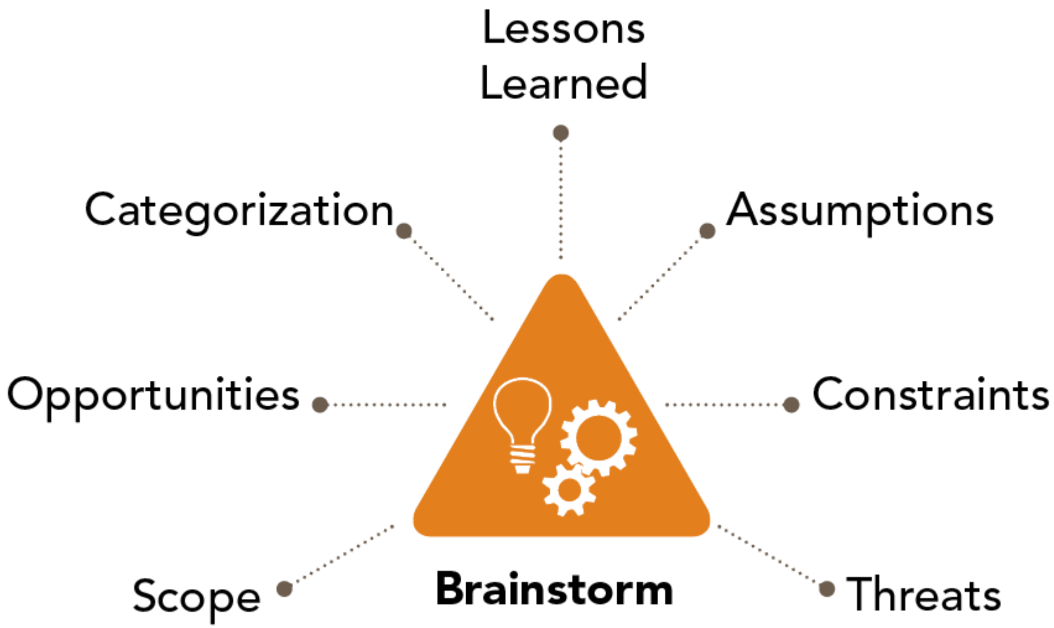
Introduction to Risk Management

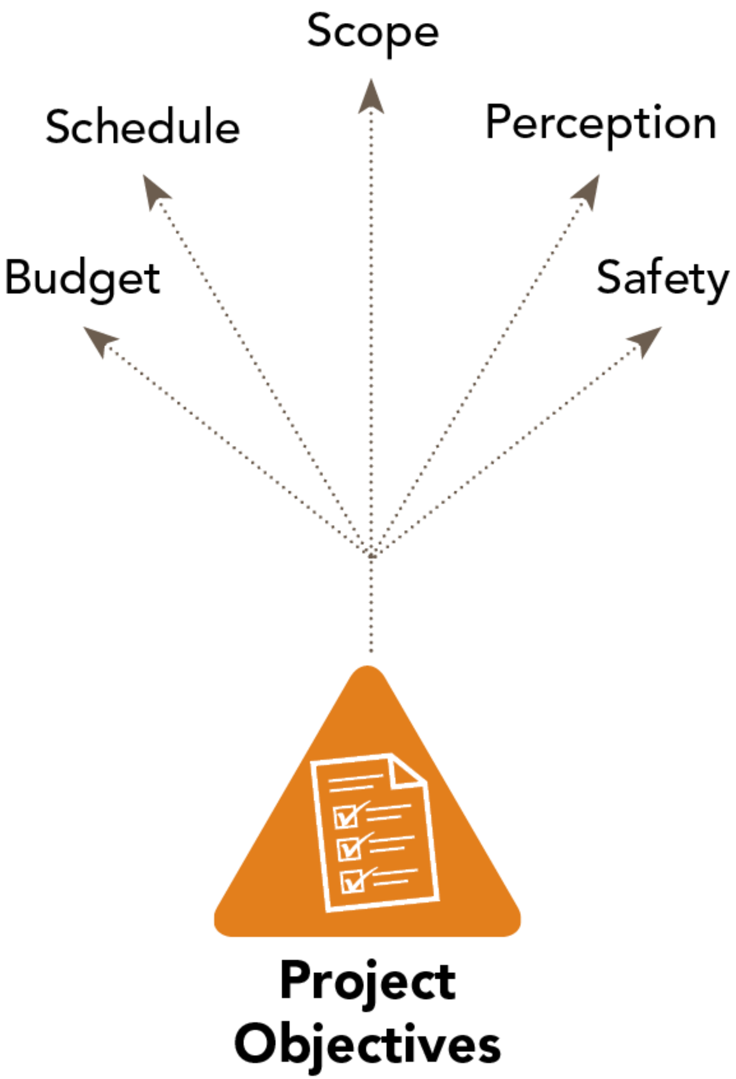
The risk management process utilizes the input and perspectives from all project stakeholders.



Identification

A risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives[1].





[1] Project Management Institute (PMI) - *A Guide to the Project Management Body of Knowledge* (PMBOK Guide)

Identification

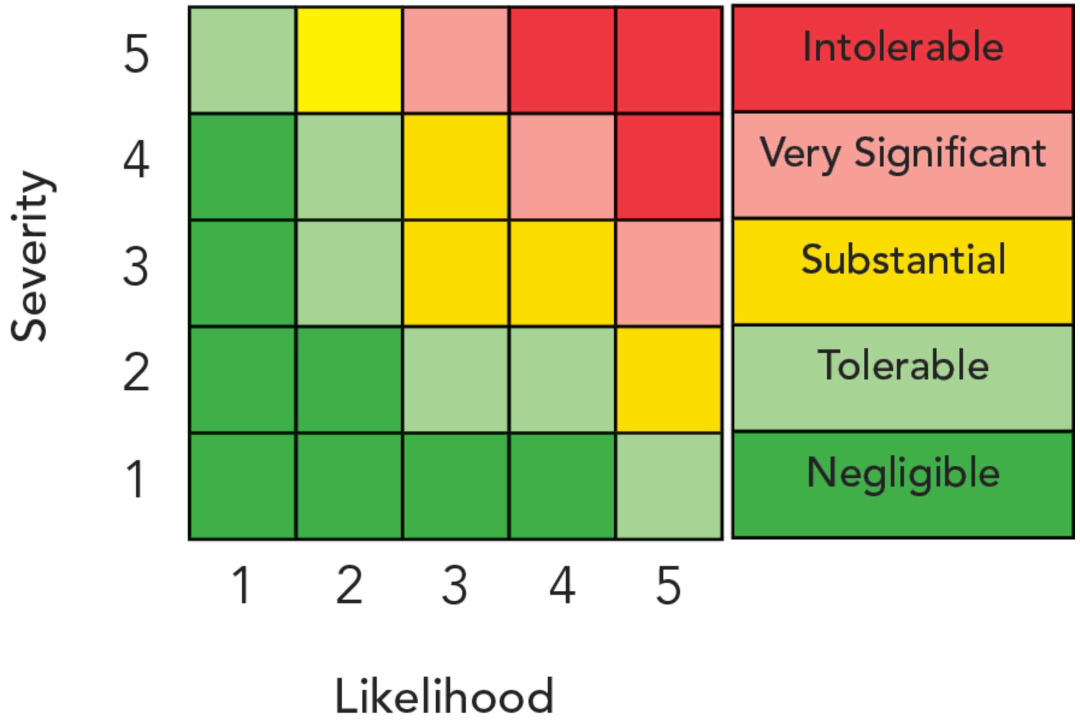
Risk Breakdown Structure

Planning	100	General Planning
	200	ROW & Easements
	300	Permits
	400	Public Relations/Acceptance
	500	Legal Funding
Design	600	Engineering
Procurement	700	Contracting Issues
Construction	800	Material, Equipment & Labor Supply
	900	Environment/Public Impacts
	1000	General Site Conditions
	1100	Construction
	1200	Material Installation
	1300	Safety & Security
Operations	1400	System Operations

Evaluation

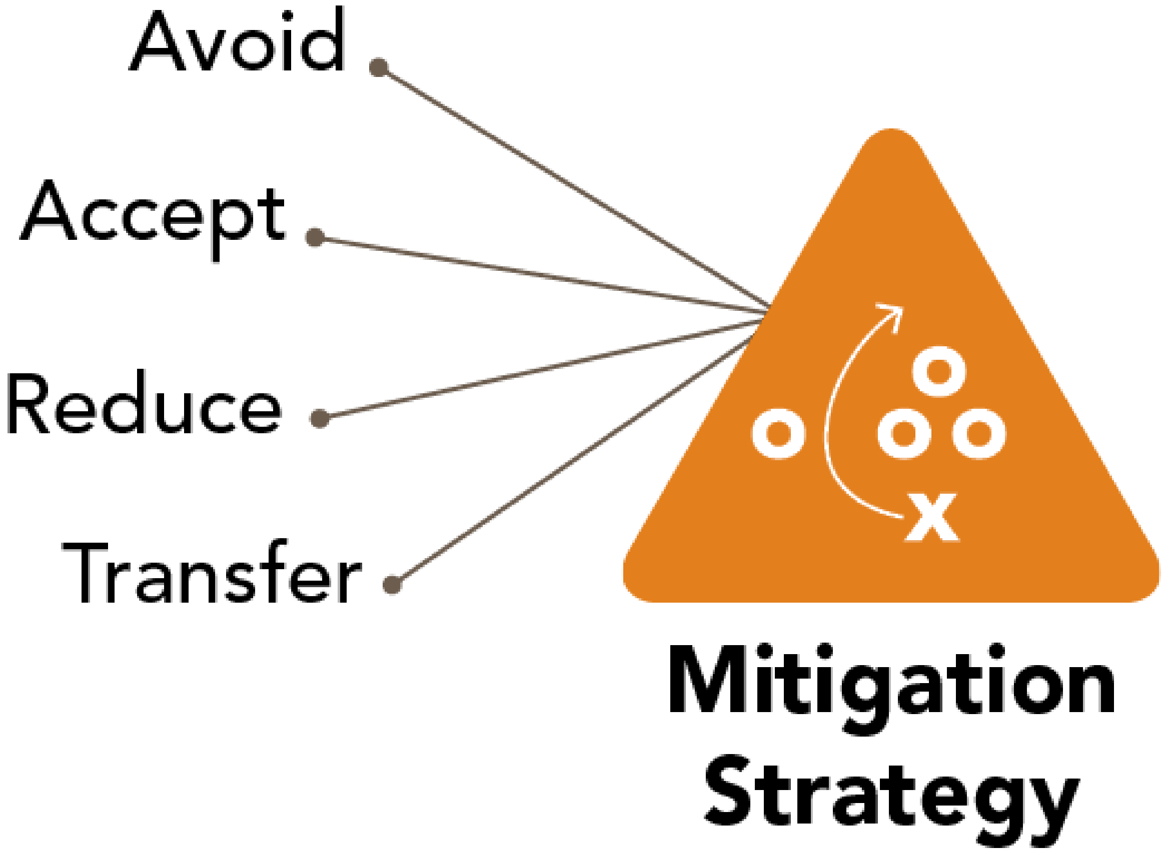
In a collaborative workshop the risks are qualitatively rated by evaluating or assessing and combining each risk's relative likelihood of occurrence and severity of consequence on a scale of 1-5 to determine a risk rating for each risk.

Risk Rating = L x S



Mitigation

Utilizing the risk ratings as a prioritization tool, mitigation actions are developed and assigned to a responsible party or person.



Mitigation: Risk Register

Risk ID	Risk Description	Areas Impacted	Pre-Mitigation Risk Rating: Likelihood of Occurrence (L)	Pre-Mitigation Risk Rating: Severity (S)	Pre-Mitigation Risk Rating: Risk Rating (L x S)	Mitigation Actions	Mitigation Actions Responsibility	Mitigation Actions Status
		S - Schedule C - Cost H - Safety/Health O - Other	1. Very Unlikely 2. Unlikely 3. Possible 4. Likely 5. Very Likely	1. Insignificant 2. Minor 3. Moderate 4. Significant 5. Severe	Intolerable Very Significant Substantial Tolerable Negligible		Owner Designer Contractor Const. Mgr.	Future Ongoing Complete Did not do If necessary
100	**PROJECT PLANNING & DEVELOPMENT - General Planning**							
101	Failure to adequately identify/secure sufficient size staging area(s) for construction.	S - Schedule C - Cost	2	3	6	1. Research necessary size. 2. Sequencing of construction. 3. Identify alternative storage areas.	1. Designer 2. Owner/Designer 3. Owner/Designer	1. Ongoing 2. Future 3. Ongoing
200	**PROJECT PLANN**							
201	Unable to obtain RC							
300	**PROJECT PLANNI**							
301	Difficulty in obtainin permit for dewateri							
302	An unknown permit quality).							
400	**PROJECT PLANNI**							
401	Local public opposit closures/traffic issue construction.							

Risk Rating	Mitigation Actions	Responsibility
8	1. Submit MOT plans to DOT early. 2. 3.	1. Designer 2. 3.
12	1. Research State requirements. 2. Determine theoretical drawn-down levels. 3.	1. Designer 2. Designer 3.
8	1. Research power needs and availability. 2. Develop list of permits. 3. Conduct a permit preapplication meeting.	1. Owner/Designer 2. Designer 3. Designer

Quantitative Cost Analysis

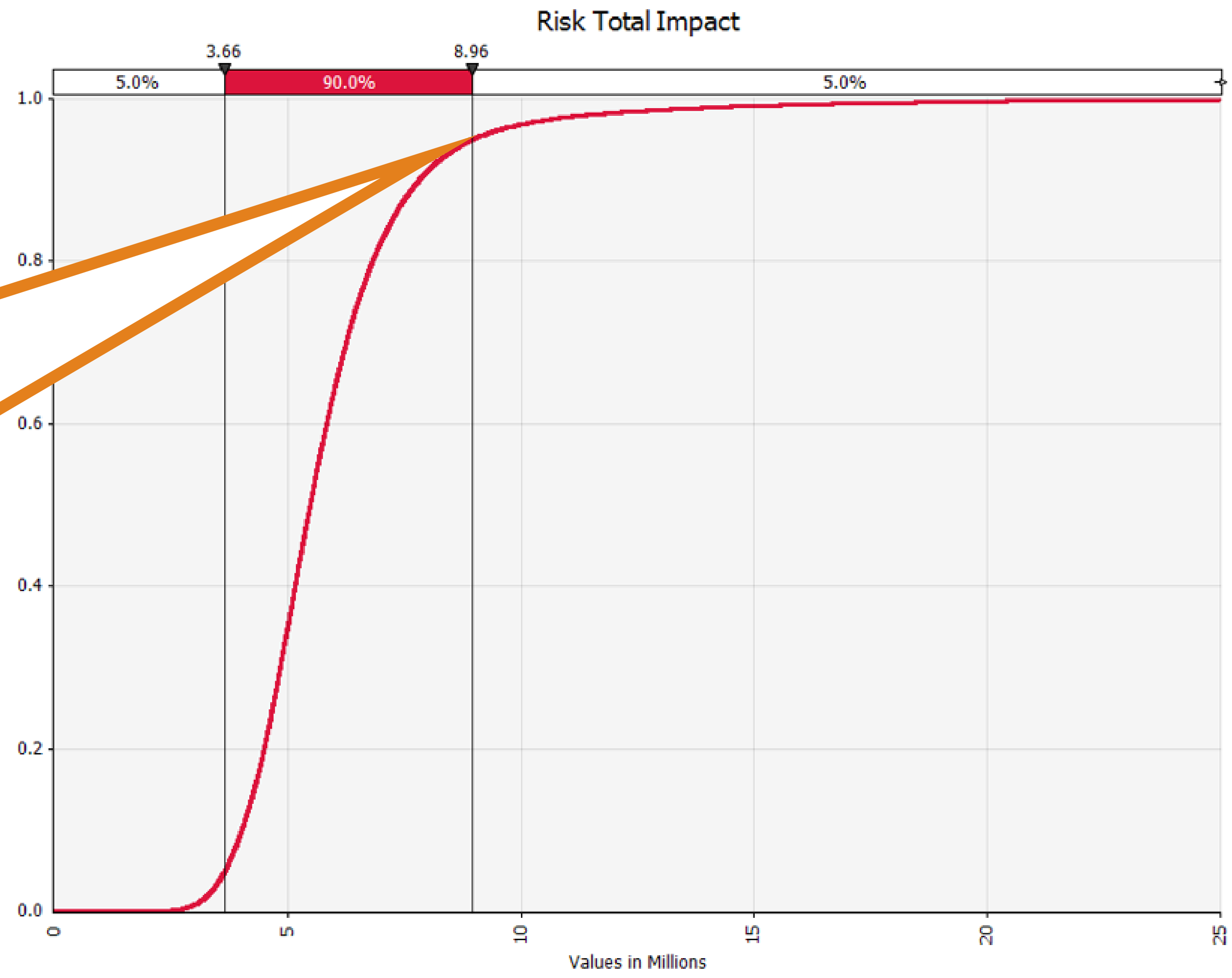
In a collaborative workshop we quantify each cost impact risk by assigning a probability of occurrence and a range of cost consequences in dollars.

Risk ID	Risk Description	Probability of Occurrence %	Owners Share of Risk %	Multiple Occurrence Possible?	Consequence in $ C				
		P	O	Y/N	Min	10%	50%	90%	Max
900	**CONSTRUCTION - Environmental/Public Impacts (permit non-compliance)**								
903	Contaminated groundwater drawn into excavations resulting in extra cost, time and 3rd party claims	**5%**	**100%**	**Y**	$250k	$300k	$500k	$700k	$750k
904	Contractor encounters cultural or archaeological resources (or potentially cultural or archaeological resources) during construction	**90%**	**100%**	**Y**	$25K	$100K	$250K	$300K	$750K
908	Contractor unable to cut off water from excavations due to multiple SOE systems is used	**50%**	**100%**	**Y**	$0k	$50k	$500k	$700k	$2500k
1000	**CONSTRUCTION - General Site Conditions**								
1001b	Construction fails to complete TBM removal in their 90-day window	**50%**	**100%**	**N**	$100k	$200k	$400k	$750k	$1000k

Cost Impacts = P x C x O

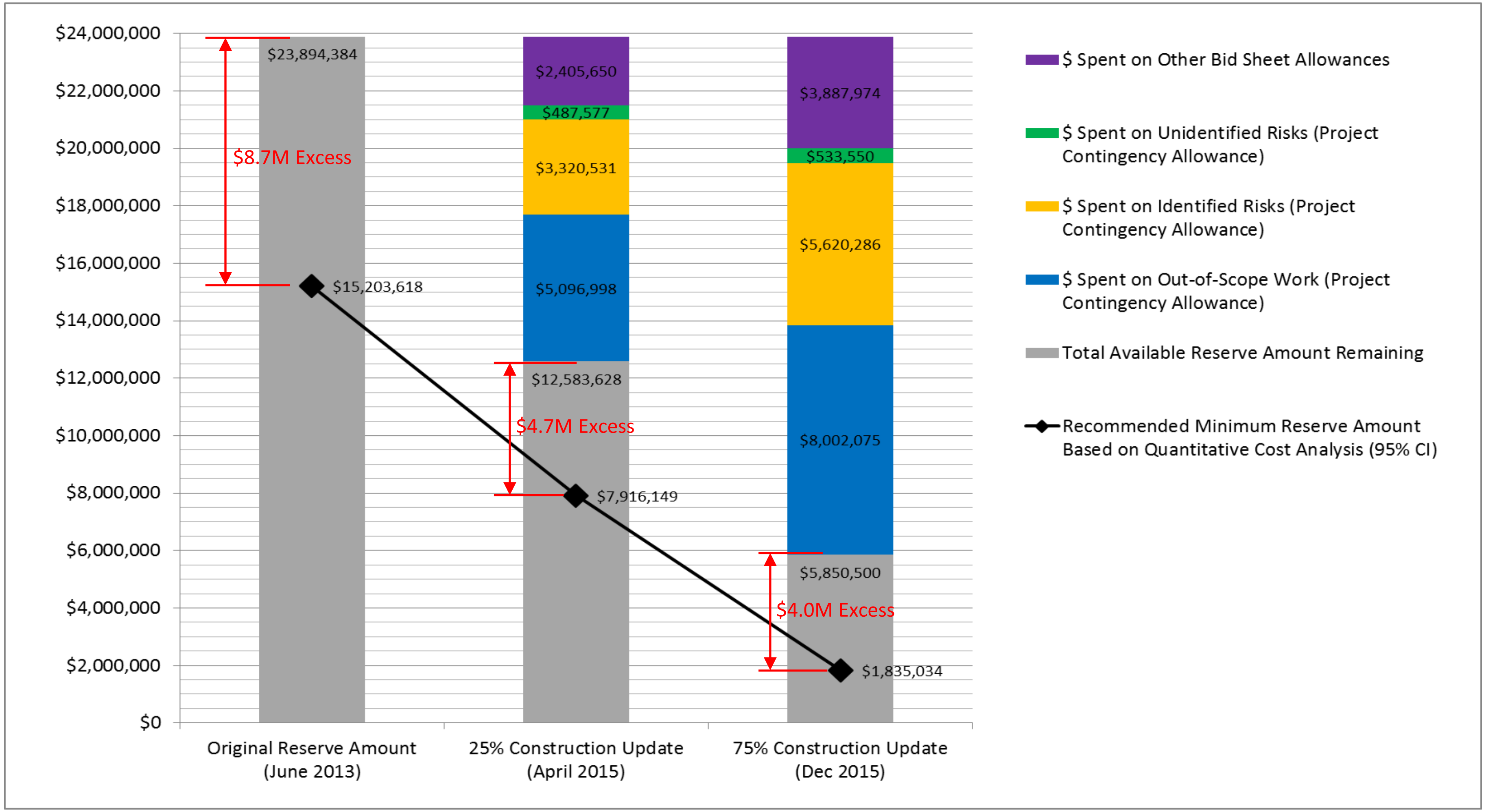
Quantitative Cost Analysis

"We are 95% confident that the total cost impact from risks will be $8.96M or less from today through the duration of this project."



Statistics	Risk Total Impact
Cell	Model Input!N40
Minimum	2,068,530.85
Maximum	44,731,537.01
Mean	5,847,790.91
Mode	5,363,318.61
Median	5,480,507.84
Std Dev	2,047,429.24
Skewness	3.2810
Kurtosis	23.3622
Values	100000
Errors	0
Filtered	0
Left X	3,655,268.23
Left P	5.0%
Right X	8,958,395.72
Right P	95.0%
Dif. X	5,303,127.49
Dif. P	90.0%
1%	3,067,545.79
5%	3,655,268.23
10%	4,016,503.33
15%	4,281,177.80
20%	4,495,389.03
25%	4,674,587.00
30%	4,837,914.75
35%	4,999,721.91
40%	5,156,557.49
45%	5,316,837.94
50%	5,480,507.84
55%	5,648,957.04
60%	5,833,421.40
65%	6,034,870.88
70%	6,253,002.06
75%	6,506,258.14
80%	6,817,282.03
85%	7,222,740.59
90%	7,813,850.38
95%	8,958,395.72
99%	14,243,416.86

Quantitative Cost Analysis



Quantitative Schedule Analysis

- Step 1: Identify Activities
- Step 2: Determine estimated (most likely) Durations.

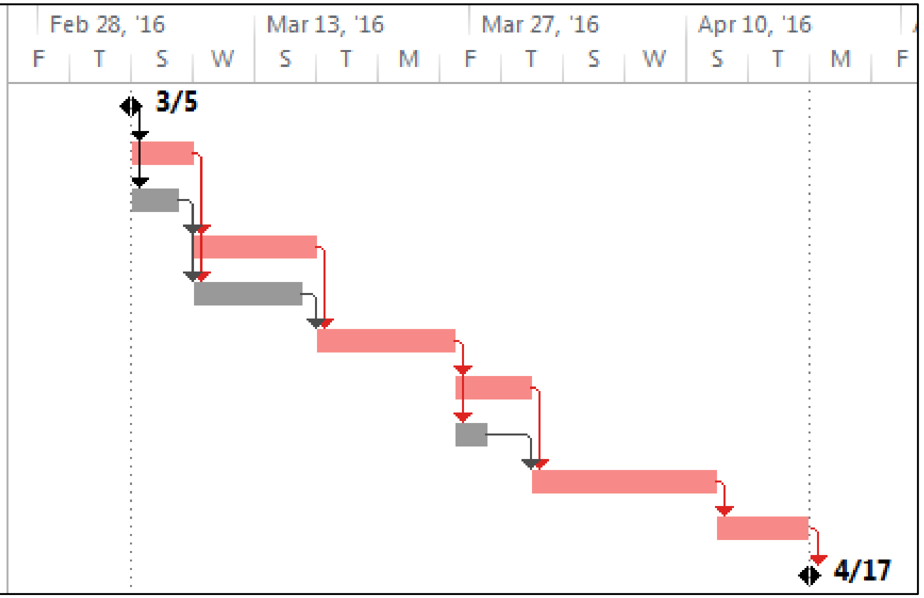
		Task Name	Duration
1		NTP	0 days
2		Site Clearing	4 days
3		Removal of Trees	3 days
4		General Excavation	8 days
5		Grading General Area	7 days
6		Excavation for Trenches	9 days
7		Install Other Utilities	5 days
8		Install Sewer Lines	2 days
9		Concrete Formwork and Rebar	12 days
10		Pouring Concrete	6 days
11		Finish	0 days

Quantitative Schedule Analysis

- Step 3: Assign Dependencies. Relationship between two project activities in which the start or end date of one activity depends on the start or end date of another activity.

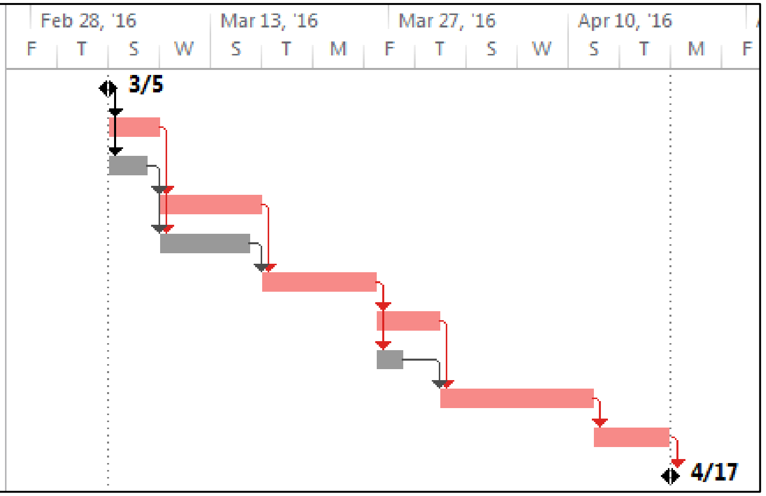
- Step 4: The project schedule software calculates each activity's start date, end date, ***float***, and the ***Critical Path***.

		Task Name	Duration	Start	Finish	Prede
1		NTP	0 days	3/5/16	3/5/16	
2		Site Clearing	4 days	3/5/16	3/8/16	1
3		Removal of Trees	3 days	3/5/16	3/7/16	1
4		General Excavation	8 days	3/9/16	3/16/16	2,3
5		Grading General Area	7 days	3/9/16	3/15/16	2,3
6		Excavation for Trenches	9 days	3/17/16	3/25/16	5,4
7		Install Other Utilities	5 days	3/26/16	3/30/16	6
8		Install Sewer Lines	2 days	3/26/16	3/27/16	6
9		Concrete Formwork and Rebar	12 days	3/31/16	4/11/16	8,7
10		Pouring Concrete	6 days	4/12/16	4/17/16	9
11		Finish	0 days	4/17/16	4/17/16	10



Quantitative Schedule Analysis

	Task Name	Duration	Start	Finish	Prede
1	NTP	0 days	3/5/16	3/5/16	
2	Site Clearing	4 days	3/5/16	3/8/16	1
3	Removal of Trees	3 days	3/5/16	3/7/16	1
4	General Excavation	8 days	3/9/16	3/16/16	2,3
5	Grading General Area	7 days	3/9/16	3/15/16	2,3
6	Excavation for Trenches	9 days	3/17/16	3/25/16	5,4
7	Install Other Utilities	5 days	3/26/16	3/30/16	6
8	Install Sewer Lines	2 days	3/26/16	3/27/16	6
9	Concrete Formwork and Rebar	12 days	3/31/16	4/11/16	8,7
10	Pouring Concrete	6 days	4/12/16	4/17/16	9
11	Finish	0 days	4/17/16	4/17/16	10



- The critical path can be defined as the longest possible path through the "network" of project activities. Or, the path of activities with zero float.
- If activities on this path are delayed then the overall project is guaranteed to be delayed.
- There may be “near” critical paths among all the project activities, so the overall project could be delayed by delaying activities along the “near” critical paths.

Quantitative Schedule Analysis

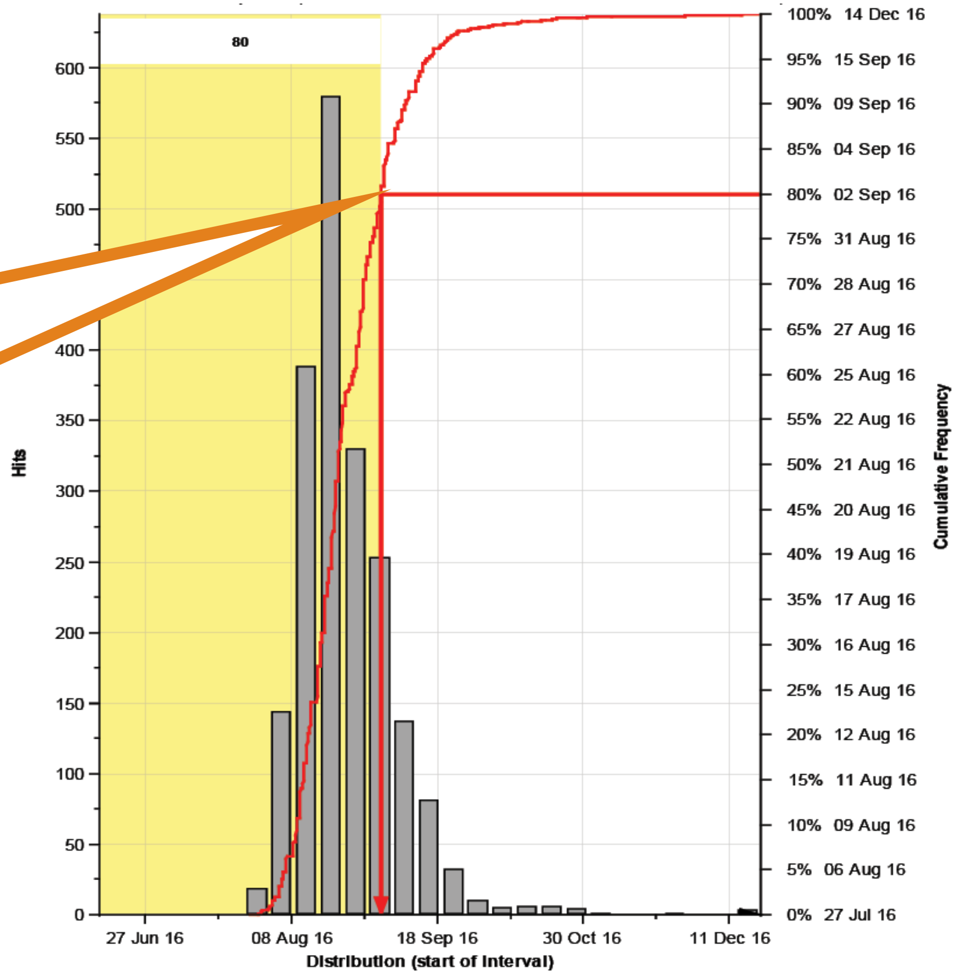
Risk ID	Risk Description	Schedule Activity	Probability of Occurrence %	Consequence in Days		
				Minimum	Most Likely	Maximum
1100						
1103	Tunneling induced settlement of CSX railroad, exceeds allowable limits	**TBM-CON-1120**	**2%**	5	10	20
1107	Existing sewers or utilities are damaged due to age or condition	**CON-VS-1570** **CON-VS-1240**	**20%**	3	5	10

The variability of schedule activities are also assigned >

Activity ID	Activity	Activity Duration		
		Minimum	Most Likely	Maximum
TBM-CON-1120	**TBM mine from Station 0+00 to 12+43**	20	25	35
CON-VS-1570	**Tie-in to existing 36" RCCP water main**	3	5	10

Quantitative Schedule Analysis

> We are 80% confident that, considering the impacts of risks and the estimated variability in selected activity durations, the project will finish on 09-02-16 or earlier.



Quantitative Schedule Analysis

Rank	Description	Deterministic Remaining Duration	Probabilistic P80 Duration	Duration Sensitivity	Criticality Index	Duration Cruciality
1	C-T-23500C-3 - Excavate 659' past the WMATA and 18" Water Sta. 120+95 to Sta. 127+54	10	17	87.97%	53.65%	**47.20%**
2	C-T-23500C-14 - Excavate 100' prior to the WMATA and 18" Water Sta. 111+55 to Sta. 112+55	2	9	91.19%	36.60%	**33.37%**
3	C-T-23500C-4 - Excavate 707.04' to Poplar Point Sta, 127+54 to Sta. 134+61.04	10	14	60.40%	53.65%	**32.40%**
4	C-T-23500C-24 - Excavate 840' under WMATA and 18" Water Sta. 112+55 to Sta. 120+95	12	19	87.89%	36.45%	**32.04%**
5	C-T-23500C-2 - Excavate 1,425' to WMATA Greenline from Sta. 97+30 to Sta. 111+55	20	27	83.93%	36.60%	**30.72%**
6	C-T-23500C-1 - Excavate 3,648.83' from Sta. 60+81.17 under River, 30" and 42" Water to Sta. 97+30	50	59	73.90%	36.60%	**27.05%**
7	C-19-80120-3 - CSO 019 - Excavate NEBTS & Install Struts from (el 15 to el 5)	16	18	11.63%	30.70%	**3.57%**
8	C-19-80125-2 - CSO 019 - Excavate NEBTS & Install Struts from (el 5 to el -5)	14	17	9.05%	30.70%	**2.78%**
9	C-PP-22110-22 - Poplar Point: Backfill and restore around shaft and structure	5	5	6.13%	42.95%	**2.63%**

Results of Risk Management Process for DCCRP

- Risk Aware Culture
- Tools for PM's and CM's
- Informed Budget Decisions
- Allocation of Engineering Resources

Thank You

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