Cost Risk Assessment

Port Lands Flood Protection and Enabling Infrastructure

Waterfront Toronto

June 15, 2016

Final Report

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Disclaimer

The risk-based estimating process, Cost Risk Assessment (CRA), is iterative in nature. This process represents a “snapshot in time” for a specific project and characterizes the conditions known at the time of the workshop.

The information contained in this report is the professional opinions of the subject matter experts (SMEs) during the CRA. These opinions were based on the information provided to the SMEs at the time of the workshop.

As the project continues to develop, new information will become available, and this information will need to be evaluated on how it may affect the risks and findings in this report. All costs displayed in the report are based on the best available information at the time of the workshop.

1 Cost Risk Assessment Summary

HDR was retained by the Toronto Waterfront Revitalization Corporation to provide Cost and Schedule Risk Analysis Consultant Services for the Port Lands Flood Protection and Enabling Infrastructure Project (the Project). HDR is a recognized industry leader in cost and schedule risk analysis for major infrastructure projects across North America. The risk analysis process represented in this report is based on industry standards and best practices.

The project comprises the flood protection and naturalization features set out as part of the preferred alternative (Alternative 4WS Amended) in the approved DMNP EA. The project also encompasses the major municipal infrastructure that must be constructed – or in some cases, reconstructed – in conjunction with implementing flood protection, so as to maintain functional transportation and service networks.

The following high level activities were performed as part of the cost and schedule risk assessment:

1) As with all large infrastructure projects, as the project progresses project cost and schedule estimates become more certain. At this stage of the project, the cost estimating consultant (Hanscomb) has provided a Conceptual base cost estimate assuming no changes to project scope.
2) Project support cost estimates were developed by Waterfront Toronto. Both construction and support cost estimates were provided to the HDR risk analysts to serve as the project baseline cost. Amounts for contingency and escalation were removed.
3) In addition to the 10% design allowance and 13% general contractor requirements & fee that were already included in the base costs provided to HDR, a 20% (design and construction) ‘soft cost adder’ was applied to the total project cost estimates and allocated to the appropriate activities. A net HST of 1.76% (13% tax rate, less 11.24% tax credit as provided by Waterfront Toronto) was applied to all costs.
4) A project schedule was developed through a collaborative effort with the project’s engineer consultants, cost consultants, WT and HDR. This schedule served as the baseline and was developed assuming negligible schedule delays due to unforeseen circumstance. In essence, a project timeline was constructed assuming “everything goes as planned”.
5) The baseline cost and schedule were entered into the project’s risk assessment simulation model. While this model is custom built for this specific project, the foundation is common to the risk assessment projects that HDR conducts and is based on industry best practice. The model employs probabilistic simulation techniques to combine the project flowchart, the base costs with uncertainty, the risk register, and other key inputs and assumptions, to produce probability distributions for project cost and schedule outputs.

6) An assessment of the base cost uncertainty was conducted. This focused solely on the inherent uncertainty associated with quantity and unit price estimates based on the current level of design and the estimate classification for each contract within the project.

7) Project specific escalation rates were developed and incorporated into the risk assessment tool to allow the baseline estimates to be expressed in "year of expenditure" costs. The escalation rates utilized in this analysis were obtained from Waterfront Toronto and WT's cost estimating consultant Hanscomb.

8) A two-day risk identification and quantification workshop was conducted on October 6-7, 2015 with wide ranging participation from project stakeholders. During this workshop, all potential risk elements were catalogued within the project's risk register including a consensus view of probability of occurrence and impacts to cost and schedule should the risk occur. The risk register was incorporated into the risk assessment simulation tool. Probabilistic cost and schedule estimates were generated in the absence of risk mitigation.

9) A follow-up workshop was conducted on March 21, 2016 in which key risk elements were revisited and quantified based upon know mitigation strategies.

1.1 Risk Based Results – Project Cost

Figure ES-1 provides a graphical representation of cost-risk results. These risks include base cost uncertainty, the monetary impact of discrete risks as defined in the risk register plus escalation, as well as the monetary impact of schedule delays through extended overhead and additional escalation caused by schedule delays. The *non-escalated* base-cost estimate for this contract has been determined through the estimating process to be $958 million. Assuming no risk or uncertainty on this value and incorporating projected escalation provides an *escalated* base-cost estimate of $1,077 million. Further incorporating risk associated with: (i) the base cost estimate, (ii) specific event risks and (iii) potential schedule delay provides a risk-based estimate of total Project costs. As shown in Figure 1, there is an 80% probability that this cost will lie between $1,075 million ($10^{th}$ percentile) and $1,235 million ($90^{th}$ percentile). At the 70^{th} percentile, the risk-based cost estimate is $1,188 million.

To compare this to a traditional cost estimating approach (in which allowance and/or contingency are set at fixed proportions of the base cost estimate), this outcome suggests the Project should budget a 10.3 percent allowance/contingency over the escalated base cost estimate of $1,077 million (to ensure a level of confidence of 70 percent).

Figure ES-1: Risk-Based Total Project Cost

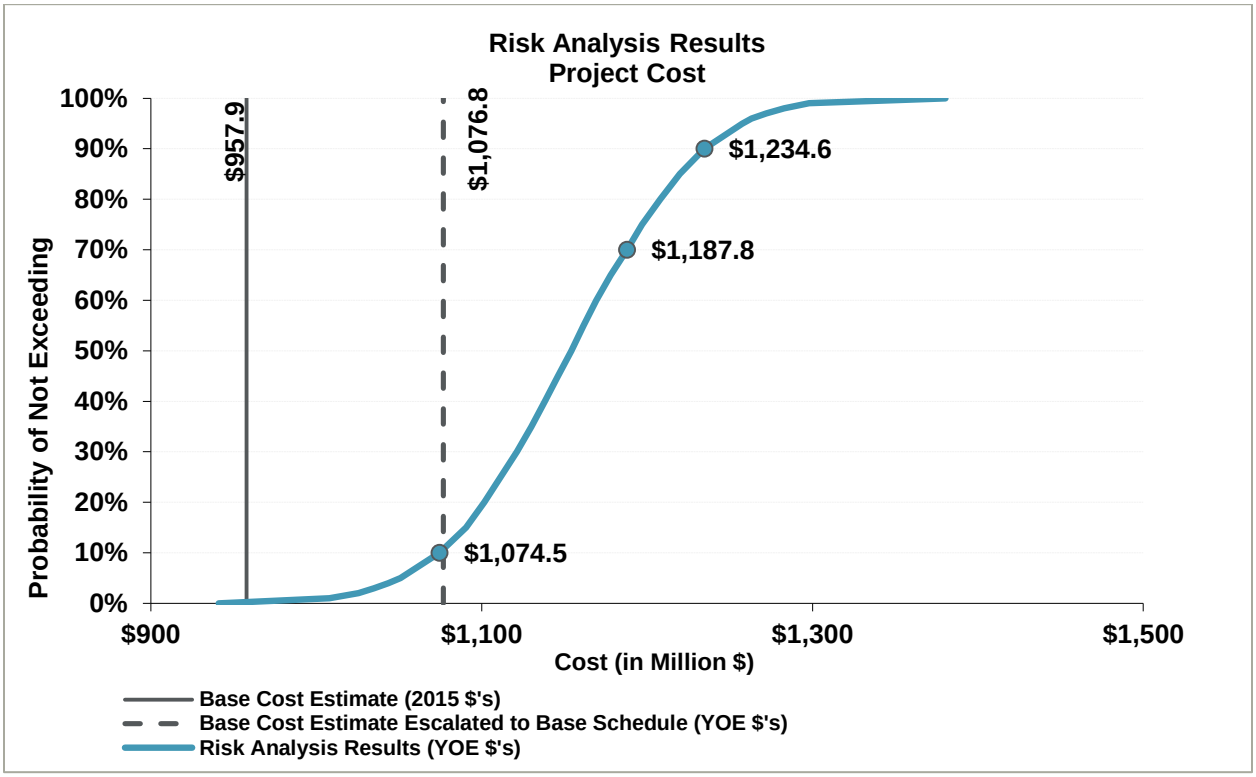


Table ES-1 provides the top five risks that may impact the Project cost and the expected cost impact should each risk element occur.

Table ES-1: Significant Project Cost Risk Elements

Risk ID	Risk Name	Description	Expected Cost Impact ($ million)
ENV 50.02	Contaminated Material	The volume of soil unsuitable for use within the project limits and requiring off-site disposal is greater than anticipated.	$17.06 M
DES 900.04	Risk Aggregate below Threshold	There were 24 risks discussed that fell in the minor risk category.	$9.97 M
CNS 900.01	Differing Site Conditions	Conditions in the field are found to be different than shown in the plans and specifications resulting in construction changes.	$6.85 M
DES 10.03	Stormwater Treatment Facility Design	City insists on a quality system being built upfront resulting in an increase of $15M to the base cost estimate and 12 months to schedule.	$6.47 M
CNS 900.03	Exposed Armour	Additional excavation is required due to exposed armour constructability issues in steeper areas.	$5.40 M

1.2 Risk Base Results - Project Schedule

Figure ES-2 provides a graphical representation of the schedule-risk results for the project which reflects quantitated schedule risks. The 70th percentile completion date is November 2023, which represents a delay of 1.4 months relative to the base schedule completion date.

Figure ES-2: Risk-Based Schedule Completion Date

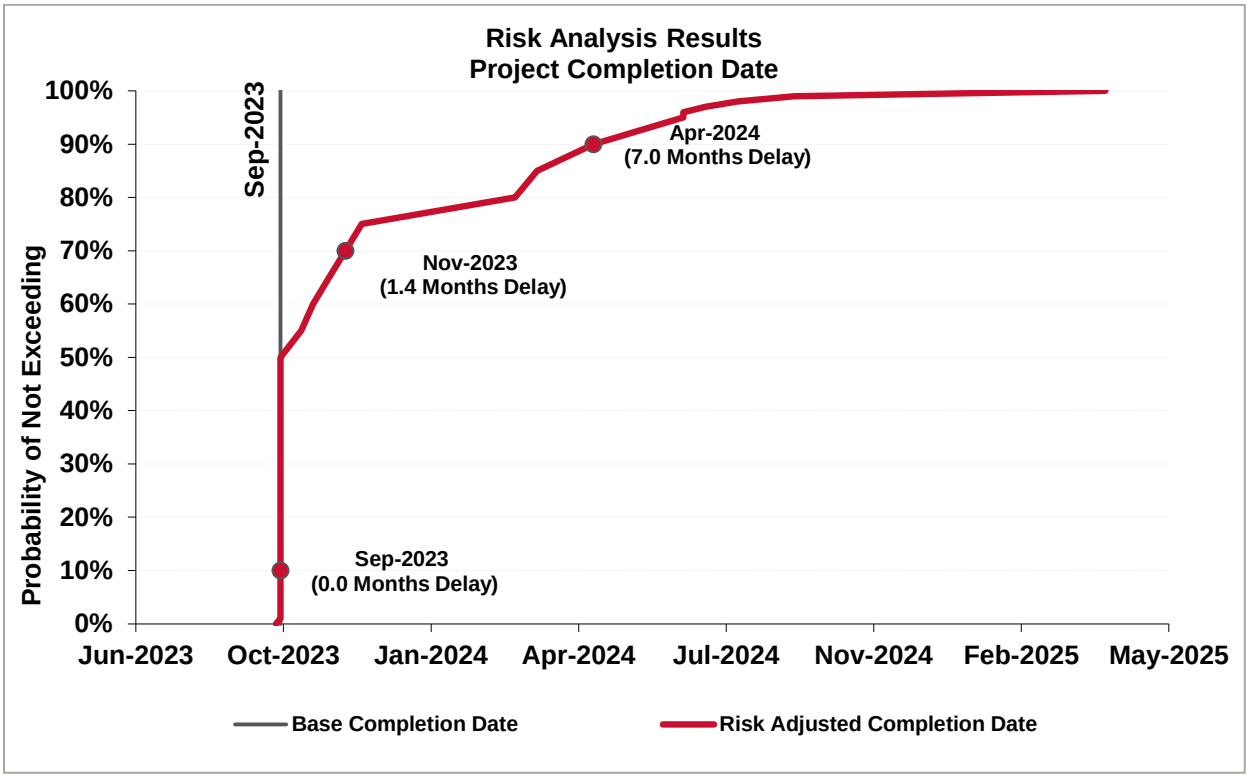


Table ES-2 provides the top five risks that may impact the project schedule and the expected delay should each risk element occur.

Table ES-2: Significant Project Schedule Risk Elements

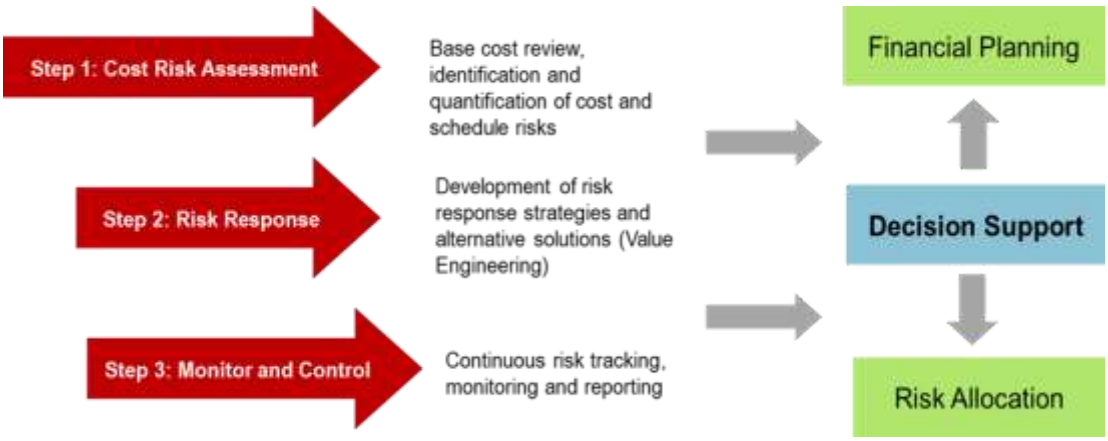
Risk ID	Risk Name	Description	Expected Schedule Impact (months)
ENV 30.01	CBRA Permits Approval Issues	The CBRA permit has a history of experiencing delays of 6 to 12 months for a project of this magnitude (in addition to base 12mo).	3.15 Mo
CNS 70.08	Settlement, Preloading and Surcharging in Grade Change Areas	Orchestrated movement of soil is necessary to accomplish settlement, preloading or surcharging of areas in the Eastern section of the site.	3.00 Mo
DES 10.03	Stormwater Treatment Facility Design	City insists on a quality system being built upfront resulting in an increase of $15M to the base cost estimate and 12 months to schedule.	3.00 Mo
ENV 10.01	Environmental Assessment Compliance and Amendments	Schedule delay due to change in approval requirements pertaining to environmental assessment. Design progression may trigger a minor or major environmental amendment.	1.82 Mo
ENV 80.02	Open Water in Excavation Cannot be Released to Lake Ontario	More pre-treatment than expected is required for water from excavation activities before it can be released to Lake Ontario.	1.13 Mo

2 CRA: The Detailed Process

2.1 Step 1: Cost Risk Assessment

Before the risks can be identified, the base cost estimate and project schedule must be defined. The base cost estimate represents the project cost that can reasonably be expected, if the project materializes as planned, absent of risk or contingency. The base cost estimate is prepared in current year dollars and excludes any escalation.

Figure 1: Risk Management Process



Since estimating is not an exact science, uncertainty is defined for the unit bid prices and quantities that are associated with the estimate. When applied to the project estimate, this uncertainty establishes the range of costs the base cost could fall within.

The schedule is a critical component of any project, with risk considerations that affect cost and public perception of an agency's success in delivering the needed infrastructure. Projects are often driven by political delivery expectations, requiring the project to overcome limiting constraints such as environmental, construction, or social issues. The risk management process requires development of a project schedule to a sufficient level of detail to define the activities and their interdependencies necessary for the delivery of the project or program.

Once the base cost estimate and project schedule have been established, the key project risks are identified and quantified within the framework of a risk assessment workshop. Key members of the project team, project stakeholders, and external subject matter experts, who have a valued perspective on potential project risks, collaborate to identify and quantify the risks.

The likelihood and potential impact of each event risk are quantified during the workshop. This quantification is achieved through a consensus-based approach, facilitated by the Risk Lead. These inputs are taken and evaluated within a probabilistic simulation model to estimate probability distributions for project cost and schedule outcomes.

2.2 Step 2: Risk Response

Risk response is the process of developing strategic options and actions, to enhance opportunities and reduce threats to the project's objectives. During both workshops, the Risk Lead facilitated the identification of the appropriate risk response strategies to address the critical risk factors. Developing these strategies requires coordination between the risk analysis team and the functional specialists on the project team, in order to clearly define the options considered.

The risk analysis team should identify a risk response strategy including the costs and impacts for each identified risk. The goal of the risk response is to reduce the overall impacts of the risk on the project objectives. The typical action in response to a risk falls into one of the following categories:

Threats	**Opportunities**
1. Avoid	1. Exploit
2. Transfer	2. Share
3. Mitigate	3. Enhance
4. Accept	4. Accept

New and innovative approaches inherently carry risk. To quantify these impacts, the response strategies that are identified in Step 2 are input into scenario models as opportunities or threats. They are inputted in terms of their likely impact, in addition to the probability of implementation. This provides a "what-if" scenario of potential project

cost and schedule outcomes if the risk response strategies are successfully implemented.

2.3 Step 3: Monitoring and Control

The final step involves continual tracking, monitoring and control of project risk factors. In order to increase the probability of successfully implementing the risk response strategies identified in Step 2, a risk management plan must be implemented. This plan involves:

- Identifying Risk Owners to take responsibility for key risk factors and associated risk response strategies;
- Identifying the Monitoring Frequency for risk updates and feedback on the effectiveness of ongoing risk response strategies;
- Updates to the risk assessment model and updated results at key project milestones and / or when baseline cost and schedules are updated; and
- Continuous updates to the risk management plan which documents and report the project's risk management progress.

There is a feedback loop needed from this step to put back into the risk analysis modeling. Regular updates to the risk analysis model are conducted to update the estimated range of project cost and schedule outcomes. This also serves to track the effectiveness of risk management efforts. The outcomes from the risk management process can be used for additional project decision support, such as financial planning or risk allocation. A more detailed look at the methodology was provided in a technical report on September 10th, 2015 and is included in **Appendix F** – Cost Risk Analysis Detailed Methodology.

3 Project Review

3.1 Project Description

The Port Lands Flood Protection and Enabling Infrastructure Project (the Project) is a comprehensive strategy for flood protecting the south east district of downtown Toronto – including parts of the Port Lands, South Riverdale, Leslieville and the First Gulf/Unilever development site – that is at risk of flooding under a provincially-defined Regulatory Storm event. As a result, these areas are effectively undevelopable until the flood risk is removed. This project will unlock nearly 356 hectares (880 acres) of these lands for revitalization and facilitate billions of dollars in private investment.

Working together over the past decade, Waterfront Toronto, TRCA and the City of Toronto have developed and refined a solution to protect the Port Lands and adjacent areas from potential loss of life and costly flood damage associated with a major flooding event. The project provides flood protection through the creation of a new, naturalized mouth for the Don River and other flood protection measures. This will effectively provide three outlets for the Don River, which ultimately will be surrounded by new parks, green space and public realm enhancements as development proceeds in the area.

The creation of a new river valley, carved from post-industrial lands, is a unique undertaking with no local or regional precedents. In order to create more certainty on the project's cost estimate, schedule and risks, the project team began a due diligence program in June 2015. A team of professional consultants has been engaged to conduct the due diligence program. The consulting team includes expertise in major project development, geotechnical, civil, environmental, hydraulic and structural engineering, landscape, river and dock wall design, environmental law, project planning, cost estimating, scheduling, risk assessment, P3/AFP screening, economic and real estate impact analysis.

Figure 2: Project Location

3.2 Project Schedule Review

The schedule is a critical component of any major project, with risk considerations that affect project cost. The risk-based cost estimation process requires development of a project schedule to a sufficient level of detail to define the activities and their interdependencies necessary for the project delivery.

The durations of each activity, shown in **Table 1**, were adjusted based on the information available at the time of the analysis.

Table 1: High Level Project Schedule

Line Item	Activity ID	Activity Name	Duration	Start	Finish	Predecessors
1	x1	Community Based Risk Assessment (CBRA) Complete	0 days	4/3/17	4/3/17	
2	x2	Full Funding Confirmation/Availability	0 days	4/3/17	4/3/17	
	WT-CWS	Core Work Scope				
3	01a	[1A] Essroc Quay Work (Cells #1 & #2)	305 days	10/2/17	11/30/18	3
4	14b	[14b] Cherry Street Bridge North (Vehicular + Transit)	305 days	10/2/17	11/30/18	3
5	14c	[14c] Cherry Street Bridge South	521 days	10/2/17	9/30/19	3
6	15b	[15b] Commissioners Street Bridge	544 days	10/2/17	10/31/19	3
7	PE2	**Preliminary Engineering/Procurement (Core Scope)**	**390 days**	**4/3/17**	**9/28/18**	
8	x9	Bulk Excavation, Sorting and Stockpiling	195 days	4/3/17	12/29/17	2
9	x10	Lakefill Cell #3 Design	260 days	4/3/17	3/30/18	2
10	x11	Roads and Municipal Services	390 days	4/3/17	9/28/18	2
11	x12	River/Flood Protection Design	390 days	4/3/17	9/28/18	2
12	x13	Structure Design	390 days	4/3/17	9/28/18	2
13	x14	Hydro One Tower Modifications	260 days	4/3/17	3/30/18	2
-	DES1	Design/Approvals Completion	250 days	10/1/18	9/27/19	8
14	03	**[3] River Valley System**	**913 days**	**1/1/18**	**6/30/21**	
15	x16	**West End River/Floodplain (Phase 1)**	**609 days**	**1/1/18**	**4/30/20**	
16	x17	Staging/General Conditions	43 days	1/1/18	2/28/18	9
17	x18	Excavation (Cut Area C1) (approx. 20% of total cut)	175 days	3/1/18	10/31/18	17
18	x19	Soil Treatment (Cut Area C1)	304 days	3/1/18	4/30/19	18SS
19	x20	Restoration (Cut Area C1)	172 days	9/3/18	4/30/19	18FS-43 days
20	x21	Establishment of Vegetation (Cut Area C1)	262 days	5/1/19	4/30/20	20
21	x22	**River Connection at Polson Slip (Phase 4)**	**283 days**	**6/1/20**	**6/30/21**	
22	x23	Staging/General Conditions	22 days	6/1/20	6/30/20	45
23	x24	Excavation (Cut Area C4c) (approx. 10%)	132 days	7/1/20	12/31/20	23,70,38FF
24	x25	Soil Treatment (Cut Area C4c)	218 days	7/1/20	4/30/21	24SS
25	x26	Restoration (Cut Area C4c)	129 days	1/1/21	6/30/21	24
26	02	**[2] Polson Slip Naturalization (Phase 2)**	**478 days**	**11/1/18**	**8/31/20**	
27	x28	Staging/General Conditions	43 days	11/1/18	12/31/18	18
28	x29	Excavation (Cut Area C2c) (Fisheries Cal.) (approx. 5%)	218 days	1/1/19	10/31/19	28
29	x30	Soil Treatment (Cut Area C2c) (Winter Calendar)	348 days	1/1/19	4/30/20	29SS
30	x31	Restoration (Cut Area C2c)	261 days	9/2/19	8/31/20	29FS-44 days
31	04	**[4] Don Greenway (Spillway and Wetland)**	**782 days**	**11/1/18**	**10/29/21**	
32	x33	**Lower Greenway/Spillway (Phase 2)**	**500 days**	**11/1/18**	**9/30/20**	
33	x34	Staging/General Conditions	22 days	11/1/18	11/30/18	18
34	x35	Excavation (Cut Area C2b) (approx. 10%)	130 days	12/3/18	5/31/19	34
35	x36	Soil Treatment (Cut Area C2b)	216 days	12/3/18	9/30/19	35SS
36	x37	Restoration (Cut Area C2b)	262 days	4/1/19	3/31/20	35FS-45 days
37	x38	Dockwall Removal at Ship Channel	131 days	4/1/20	9/30/20	37
38	x39	**Upper Greenway/Spillway & Central River/Floodplain (Ph. 2&3)**	**522 days**	**11/1/18**	**10/30/20**	
39	x40	Central R/F Staging/General Conditions	43 days	11/1/18	12/31/18	18

Line Item	Activity ID	Activity Name	Duration	Start	Finish	Predecessors
40	x41	Central R/F Excavation (Cut Area C2a) (30% total C2a & C3)	174 days	1/1/19	8/30/19	40
41	x42	Soil Treatment (Cut Area C2a)	261 days	1/1/19	12/31/19	41SS
42	x43	Restoration (Cut Area C2a)	219 days	7/1/19	4/30/20	41FS-45 days
43	x44	Upper G/S Staging/General Conditions	21 days	9/2/19	9/30/19	41,35,29FS-44 days
44	x45	Upper G/S Excavation (Cut Area C3) (30% total C2a & C3)	174 days	10/1/19	5/29/20	44
45	x46	Soil Treatment (Cut Area C3)	262 days	10/1/19	9/30/20	45SS
46	x47	Restoration (Cut Area C3)	153 days	4/1/20	10/30/20	45FS-43 days
47	x48	Dockwall Extension	131 days	4/1/20	9/30/20	47SS
48	x49	**River Connection at Keating Channel (Phase 4)**	**370 days**	**6/1/20**	**10/29/21**	
49	x50	Staging/General Conditions	22 days	6/1/20	6/30/20	45
50	x51	Excavation (Cut Area 4a) (approx. 5%)	218 days	7/1/20	4/30/21	50,24FF+22 days,47FF+130 days
51	x52	Soil Treatment (Cut Area C4a)	305 days	7/1/20	8/31/21	51SS
52	x53	Restoration (Cut Area C4a)	130 days	5/3/21	10/29/21	51
53	01b	[1B] Balance of Essroc Quay Lakefilling (Cell #3)	325 days	9/3/18	11/29/19	10,18SS+132 days
54	10	**[10] Sediment and Debris Management Area**	**435 days**	**9/2/19**	**4/30/21**	
55	x56	Staging/General Conditions	44 days	9/2/19	10/31/19	41,11FS-87 days
56	x57	Excavation (Cut Area C4e) (20%)	173 days	11/1/19	6/30/20	56
57	x58	Soil Treatment (Cut Area C4e)	261 days	11/1/19	10/30/20	57SS
58	x59	Restoration (Cut Area C4e)	261 days	5/1/20	4/30/21	57FS-43 days
59	08	[8] Don Roadway Valley Wall Feature	371 days	5/1/19	9/30/20	12,35SS+107 days,64
60	13	[13] Lake Shore Road Bridge (over Lower Don) Modifications	327 days	10/1/18	12/31/19	13
61	19	[19] Villiers Island Grading	196 days	1/1/20	9/30/20	44SS+87 days
62	11	[11] Flow Control Weirs	348 days	1/1/20	4/30/21	12,13,61
63	18	[18] Hydro One Integration (Tower Foundation Modifications)	175 days	4/2/18	11/30/18	14
64	14a	**[14a] Cherry Street Re-alignment**	**305 days**	**10/1/18**	**11/29/19**	
65	x66	Railway Corridor to Keating Channel	261 days	10/1/18	9/30/19	11
66	x67	Keating Channel to Commissioners Street	260 days	12/3/18	11/29/19	11,18SS+87 days,4,5
67	x68	Commissioners Street to New River Valley	153 days	5/1/19	11/29/19	67SS+107 days,6FF+22 days
68	x69	South of New River Valley/Tie-in to Existing Cherry Street	153 days	5/1/19	11/29/19	67SS+107 days,6FF+22 days
69	x70	New Cherry Street Route Available/Open to Traffic	0 days	11/29/19	11/29/19	5,6,66,67,68,69
70	15a	[15a] Commissioners Street West	283 days	5/1/19	5/29/20	11,67SS+107 days,18
71	05	[5] Site Wide Municipal Infrastructure	784 days	10/1/18	9/30/21	11,66SS,75FF
72	14d	[14d] Old Cherry Street Bridge Demolition	261 days	12/2/19	11/30/20	5,67,66
73	15c	[15c] Commissioners Street East	327 days	6/1/21	8/31/22	11,75
74	07a	[7a] Don Roadway North	369 days	1/1/20	5/31/21	61,7,11,8SS+130 days
75	16	[16] Keating Channel Modifications	260 days	5/3/21	4/29/22	12,73,54,83SS
	WT-PPLS	Park Programming and Landscaping Scope				

Line Item	Activity ID	Activity Name	Duration	Start	Finish	Predecessors
76	PD1	Park Design	610 days	7/2/18	10/30/20	12FS-65 days
77	(17b-20-21)	**[17b/20/21] Park Construction**	**609 days**	**6/1/21**	**9/29/23**	
78	x79	[17b] Promontory Park South	609 days	6/1/21	9/29/23	77,31,26FS-22 days
79	x80	[20] River Park North	609 days	6/1/21	9/29/23	26FS-22 days,43,77
80	x81	[21] River Park South	609 days	6/1/21	9/29/23	77,26FS-22 days,43
	WT-SAWS	Stand Alone Work Scope				
81	12	[12] Eastern Avenue Flood Protection	325 days	1/1/21	3/31/22	12,83FF
82	09	[9] First Gulf/Unilever Flood Protection Landform	239 days	5/3/21	3/31/22	12,51
83	x84	Flood Protection Functionally Complete	0 days	4/29/22	4/29/22	82,83,76,62,60
84	WT-END	Project Complete	0 days	9/29/23	9/29/23	79,80,81,75,72,74

A more detailed project schedule is presented separately in **Appendix E** – Detailed Project Schedule**.**

3.3 Base Cost Estimate Review

3.3.1 Introduction

One of the objectives of a cost risk assessment is to review the base cost estimate using both expert opinion and team consensus. The base cost estimate represents the project cost that can reasonably be expected if the project materializes as planned absent any risk or contingency.

The base cost estimate is unbiased and neutral - it is neither optimistic nor conservative. The base cost includes the known and quantified items and the known but not yet quantified items or miscellaneous item allowances. The base cost estimate does not include any risks (either threats or opportunities), unknown-unknowns or contingencies.

3.3.2 Base Cost Estimate

Waterfront Toronto engaged Hanscomb to provide an Independent Cost Estimate (ICE) to be used as the base cost estimate. The ICE estimate was created using a combination of a "bottom up" or contractor's estimate with allowances for items not yet designed. Any contingency and escalation values were removed from the ICE Estimate prior to risk modeling and an HST cost of 1.76% net of credits added.

Table 2: Project Base Cost Estimates

Activity ID	Activity Name	Pre-tax Base Cost (2016$)	Net HST (1.76%)	Total Base Cost (2016$)
WT-PAWS	**Potential Advance Work Scope**			
PE1	Preliminary Engineering/Procurement (Advance Work)	**$ 8,456,000**	$ 148,826	**$ 8,604,826**
01a	Essroc Quay Advance Work	**$ 15,226,000**	$ 267,978	**$ 15,493,978**
14b	Cherry Street Bridge North (V+T)	**$ 40,743,500**	$ 717,086	**$ 41,460,586**
14c	Cherry Street Bridge South	**$ 30,844,000**	$ 542,854	**$ 31,386,854**
15b	Commissioners Street Bridge	**$ 31,568,400**	$ 555,604	**$ 32,124,004**
WT-CWS	**Core Work Scope**			
PE2	Preliminary Engineering/Procurement (Core Scope)	**$ 33,294,667**	$ 585,986	**$ 33,880,653**
DES1	Design/Approvals Completion	**$ 16,647,333**	$ 292,993	**$ 16,940,326**
03	River Valley System	**$ 169,127,200**	$ 2,976,639	**$ 172,103,839**
02	Polson Slip Naturalization	**$ 44,609,700**	$ 785,131	**$ 45,394,831**
04	Don Greenway (Spillway & Wetland)	**$ 173,685,200**	$ 3,056,860	**$ 176,742,060**
01b	Balance of Essroc Quay Lakefilling, etc.	**$ 29,836,000**	$ 525,114	**$ 30,361,114**
10	Sediment and Debris Management Area	**$ 54,397,300**	$ 957,392	**$ 55,354,692**
08	Don Roadway Valley Wall Feature	**$ 18,952,000**	$ 333,555	**$ 19,285,555**

Activity ID	Activity Name	Pre-tax Base Cost (2016$)	Net HST (1.76%)	Total Base Cost (2016$)
13	Lake Shore Road Bridge Modifications	**$ 13,867,000**	$ 244,059	**$ 14,111,059**
19	Villiers Island Partial Regrading	**$ 19,862,700**	$ 349,584	**$ 20,212,284**
11	Flow Control Weirs	**$ 25,476,000**	$ 448,378	**$ 25,924,378**
18	Hydro One Integration	**$ 8,631,000**	$ 151,906	**$ 8,782,906**
14a	Cherry Street Re-alignment	**$ 15,737,100**	$ 276,973	**$ 16,014,073**
15a	Commissioners Street West	**$ 12,682,000**	$ 223,203	**$ 12,905,203**
05	Site Wide Municipal Infrastructure	**$ 71,151,900**	$ 1,252,273	**$ 72,404,173**
14d	Old Cherry Street Bridge Demolition	**$ 2,754,500**	$ 48,479	**$ 2,802,979**
15c	Commissioners Street East	**$ 4,547,200**	$ 80,031	**$ 4,627,231**
07a	Don Roadway North	**$ 4,603,000**	$ 81,013	**$ 4,684,013**
16	Keating Channel Modifications	**$ 22,821,800**	$ 401,664	**$ 23,223,464**
WT-PPLS	**Park Programming and Landscaping Scope**			
PD1	Park Design/Approvals/Construction Procurement	**$ 4,356,000**	$ 76,666	**$ 4,432,666**
(17b-20-21)	Park Construction	**$ 60,986,400**	$ 1,073,361	**$ 62,059,761**
WT-SAWS	**Stand Alone Work Scope**			
12	Eastern Avenue Flood Protection	**$ 3,090,600**	$ 54,395	**$ 3,144,995**
09	First Gulf/Unilever FPL	**$ 3,360,000**	$ 59,136	**$ 3,419,136**
WT-END	**Project Complete**			
		$ 941,314,500	**$ 16,567,135**	**$ 957,881,635**

3.3.3 Uncertainty

Estimating is not an exact science; a cost estimate is only an approximation of the costs and is made up of many elements that may not be completely or equally defined at the time the estimate is prepared. As a result, there is variability or uncertainty associated with any estimate. When applied to the project estimate, this uncertainty establishes the range that the base cost could fall within. A numerical value of uncertainty is, in essence, an estimate of the error or tolerance within the quantity or unit price of each item within the estimate.

In establishing the uncertainty ranges for each item, consideration was given to factors that might affect quantities or bid prices, such as project location (rural vs. urban), quantities (large or small), items that are difficult to construct or site constraints, methods of payments, timing of advertisement, specialty work, geotechnical and project delivery methods. Uncertainty is typically expressed in terms of a percentage (of the quantity and/or unit cost) lower or higher than the base.

For any given project, the level of uncertainty is directly related to its position in the project life cycle, i.e., the earlier in the project development process, the greater the

uncertainty; conversely, the closer to completion, the less uncertainty. Hanscomb provided an opinion as to the uncertainty in the base cost estimate, and after subsequent discussion and validation, a low value was set at -10% and the high was established at 15% for all activities.

3.3.4 Escalation

Escalation is the measurement of the change in project costs due to inflation, uncertainty in prices and market conditions. As the price of a construction component changes, the overall costs of a construction project typically varies with it. In this analysis, escalation rates are applied across all activities in order to estimate the future project costs under the baseline schedule and any extensions due to schedule delay. A rate of 2.5% was assumed for all future design and construction activity costs based on the rate used by the City of Toronto Finance Group for directly-managed capital projects.

3.3.5 Extended Overhead Costs

Schedule delays extending the construction administration period create extra overhead expenses. Owner extended overhead expenditures during construction as well as contractor extended overhead during construction were calculated and are presented in the table below. The contractor monthly overhead costs during construction were assumed to be 8% of the average monthly base construction costs over the base construction duration based on recent market data.

Table 3 presents the additional project overhead costs (per additional calendar month of project phase extension) for the project construction activities.

Table 3: Extended Overhead Cost Assumptions

	Agency	Contractor	Total Per Month of Delay
All Construction Activities	$1,230,191	$820,127	**$2,050,319**

4 Cost Risk Assessment Results

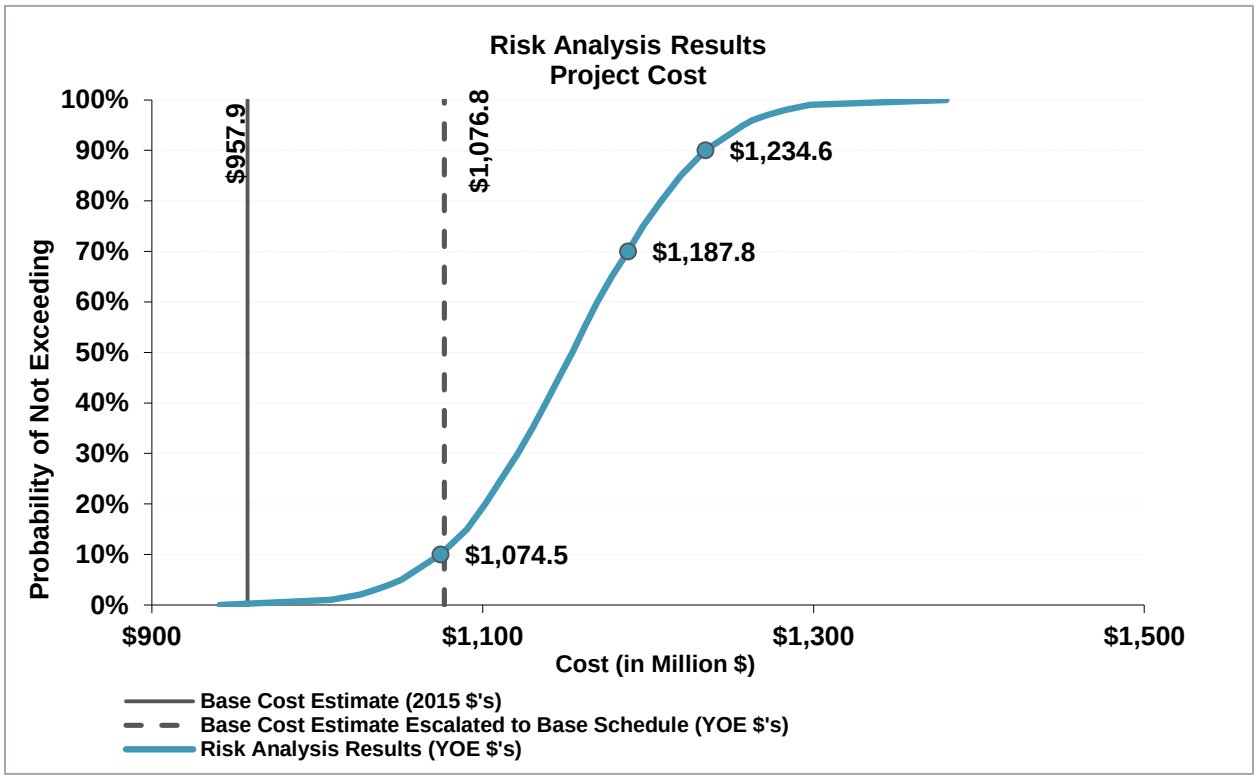
This chapter presents the results of the Cost Risk Assessment for the Port Lands Flood Protection and Enabling Infrastructure project. Early in the project development process, a base cost estimate is established and a risk assessment is conducted to provide the Project Manager the foundation that will be used to measure project delivery performance. This risk-based cost estimate is escalated to the year of expenditure (YOE) and risk response strategies are determined. This information will be used to establish the initial project budget.

These results reflect all the information gathered during the risk workshops and provided by all parties involved based on the "snapshot in time" information. The risk-adjusted total cost results are presented first, followed by the risk-adjusted construction costs, the top cost risks, and then the risk-adjusted schedule results and the top risk factors for schedule.

4.1 Cost Results

Table 4 depicts the total cost risk analysis results in the form of a probability distribution or "S-Curve" graph. The S-curve shows the relationship between cost and the probability of not exceeding that cost. Each graph indicates the best opinion of the cost ranges by the workshop participants at the time of the analysis.

Figure 3: Risk-Based Total Project Costs



The solid **black** vertical line represents the base cost of **$958 million**.

The dashed **black** vertical line represents the base cost of escalated to the base project schedule in year-of-expenditure (YOE) dollars or **$1,077 million**.

The **blue** curve represents the cumulative probability distribution, or "S-curve," for the project costs including risk response and mitigation strategies. This S-curve reveals that prior to risk response, there was a **70 percent** chance of the total costs for this project being less than or equal to a sum of **$1,188 million** based on each year of expenditure (YOE).

Table 4 presents the risk-adjusted project cost summary by project components. It's important to note that the costs of each component are provided at the given level of overall **project** cost probability – not the probability of each individual component. In other words, in the case where the overall project costs $1,188 million (at the 70th percentile), the preliminary engineering and procurement for the core scope is expected to cost $40 million and the design and approvals completion process is expected to cost $19.6 million.

Table 4: Project Costs by Component

	Activity	Base Cost ($M 2016)	Base Cost (YOE $M)	Risk Adjusted Cost ($M)		
				50%	70%	90%
WT-PAWS	**Potential Advance Work Scope**					
PE1	Preliminary Engineering/Procurement (Advance Work)	$8.6	$9.1	$9.5	$9.8	$10.0
01a	Essroc Quay Advance Work	$15.5	$16.7	$17.4	$17.9	$18.6
14b	Cherry Street Bridge North (V+T)	$41.5	$44.6	$46.1	$47.0	$47.5
14c	Cherry Street Bridge South	$31.4	$34.1	$35.2	$35.9	$36.3
15b	Commissioners Street Bridge	$32.1	$34.9	$36.1	$36.8	$37.3
WT-CWS	**Core Work Scope**					
PE2	Preliminary Engineering/Procurement (Core Scope)	$33.9	$36.1	$38.8	$40.0	$41.0
DES1	Design/Approvals Completion	$16.9	$18.6	$19.2	$19.6	$19.9
03	River Valley System	$172.1	$191.7	$215.5	$222.0	$229.2
02	Polson Slip Naturalization	$45.4	$50.6	$52.9	$54.5	$56.3
04	Don Greenway (Spillway & Wetland)	$176.7	$200.2	$223.8	$230.3	$237.0
01b	Balance of Essroc Quay Lakefilling, etc.	$30.4	$33.6	$34.8	$35.8	$37.0
10	Sediment and Debris Management Area	$55.4	$63.0	$64.8	$66.1	$67.0
08	Don Roadway Valley Wall Feature	$19.3	$21.6	$22.3	$22.8	$23.1
13	Lake Shore Road Bridge Modifications	$14.1	$15.7	$16.2	$16.5	$16.8
19	Villiers Island Partial Regrading	$20.2	$22.9	$23.7	$24.1	$24.4
11	Flow Control Weirs	$25.9	$30.5	$31.5	$32.1	$32.5
18	Hydro One Integration	$8.8	$9.5	$9.8	$10.0	$10.1
14a	Cherry Street Re-alignment	$16.0	$17.7	$18.3	$18.7	$19.3

	Activity	Base Cost ($M 2016)	Base Cost (YOE $M)	Risk Adjusted Cost ($M)		
				50%	70%	90%
15a	Commissioners Street West	$12.9	$14.4	$14.9	$15.2	$15.4
05	Site Wide Municipal Infrastructure	$72.4	$82.1	$86.9	$91.1	$109.3
14d	Old Cherry Street Bridge Demolition	$2.8	$3.2	$3.3	$3.3	$3.4
15c	Commissioners Street East	$4.6	$5.6	$5.7	$5.9	$5.9
07a	Don Roadway North	$4.7	$5.4	$5.6	$5.7	$5.8
16	Keating Channel Modifications	$23.2	$28.1	$32.5	$34.9	$36.8
WT-PPLS	**Park Programming and Landscaping Scope**					
PD1	Park Design/Approvals/Construction Procurement	$4.4	$4.9	$5.0	$5.1	$5.3
(17b-20-21)	Park Construction	$62.1	$74.1	$76.6	$78.4	$81.0
WT-SAWS	**Stand Alone Work Scope**					
12	Eastern Avenue Flood Protection	$3.1	$3.7	$3.7	$3.8	$3.9
09	First Gulf/Unilever FPL	$3.4	$4.0	$4.1	$4.3	$4.4
WT-END	**Project Complete**					
		$957.9	**$1,076.8**	**$1,154.2**	**$1,187.8**	**$1,234.6**

The charts below present overall project cash flows by year as well as the cumulative costs in year of expenditure dollars by level of confidence. While overall costs increase at higher levels of confidence, the occurrence of certain opportunity risks that reduce costs and the change in timing of various components can have a material impact on the incremental timing of those costs. This is particularly evident at the 90th percentile where schedule delays result in a shift of costs towards the later years. Similarly, certain schedule opportunities allow expenditures to occur sooner.

Figure 4: Annual Project Cash Flow Estimates

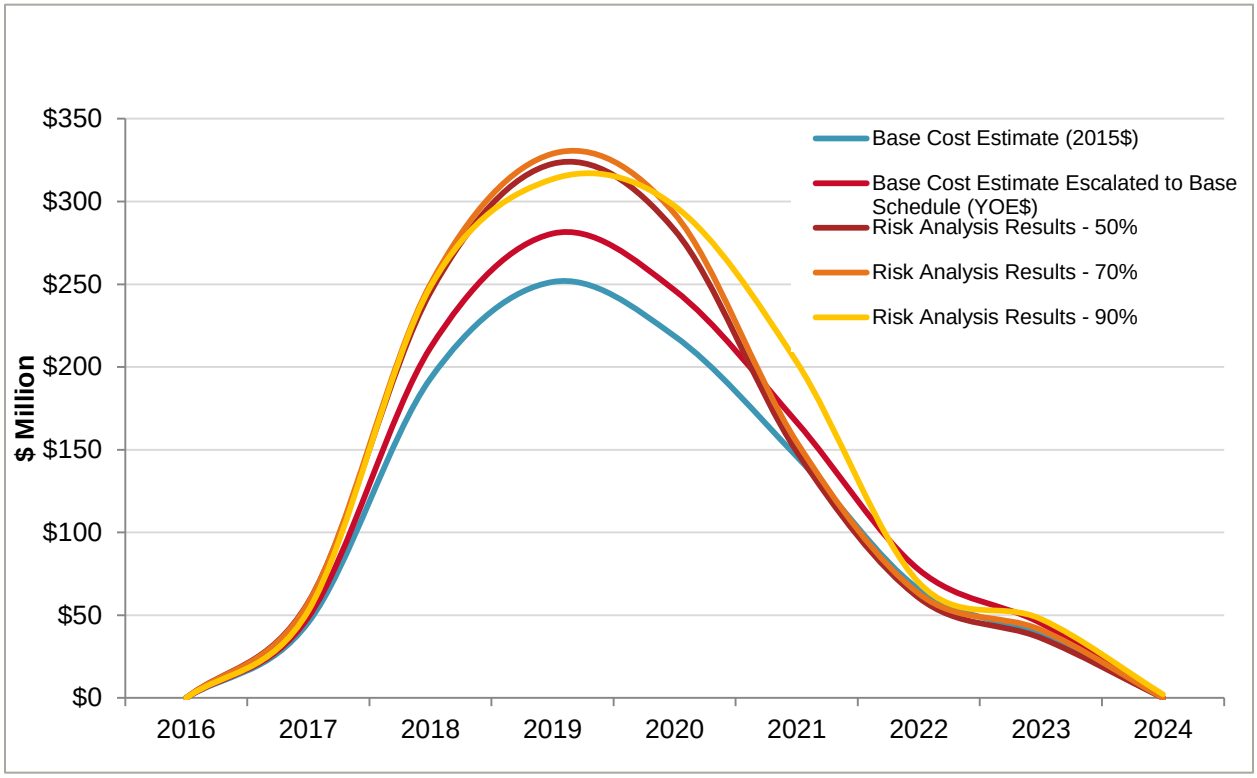


Table 5: Annual Project Cash Flow Estimates

$Millions	2016	2017	2018	2019	2020	2021	2022	2023	Total
Base Cost Estimate (2016$)	$0.0	$45.7	$193.0	$251.4	$218.6	$145.9	$65.6	$37.7	**$957.9**
Base Cost Estimate Escalated to Base Schedule (YOE$)	$0.0	$48.9	$211.6	$280.6	$246.4	$166.6	$77.5	$45.2	**$1,076.8**
Risk Analysis Results - 50%	$0.0	$57.8	$245.2	$322.8	$282.7	$148.9	$60.5	$36.2	**$1,154.2**
Risk Analysis Results - 70%	$0.0	$57.4	$250.0	$328.9	$292.6	$154.7	$63.1	$41.1	**$1,187.8**
Risk Analysis Results - 90%	$0.0	$52.6	$248.5	$313.5	$297.3	$203.0	$69.8	$47.7	**$1,234.6**

Figure 5: Cumulative Project Cash Flow Estimates

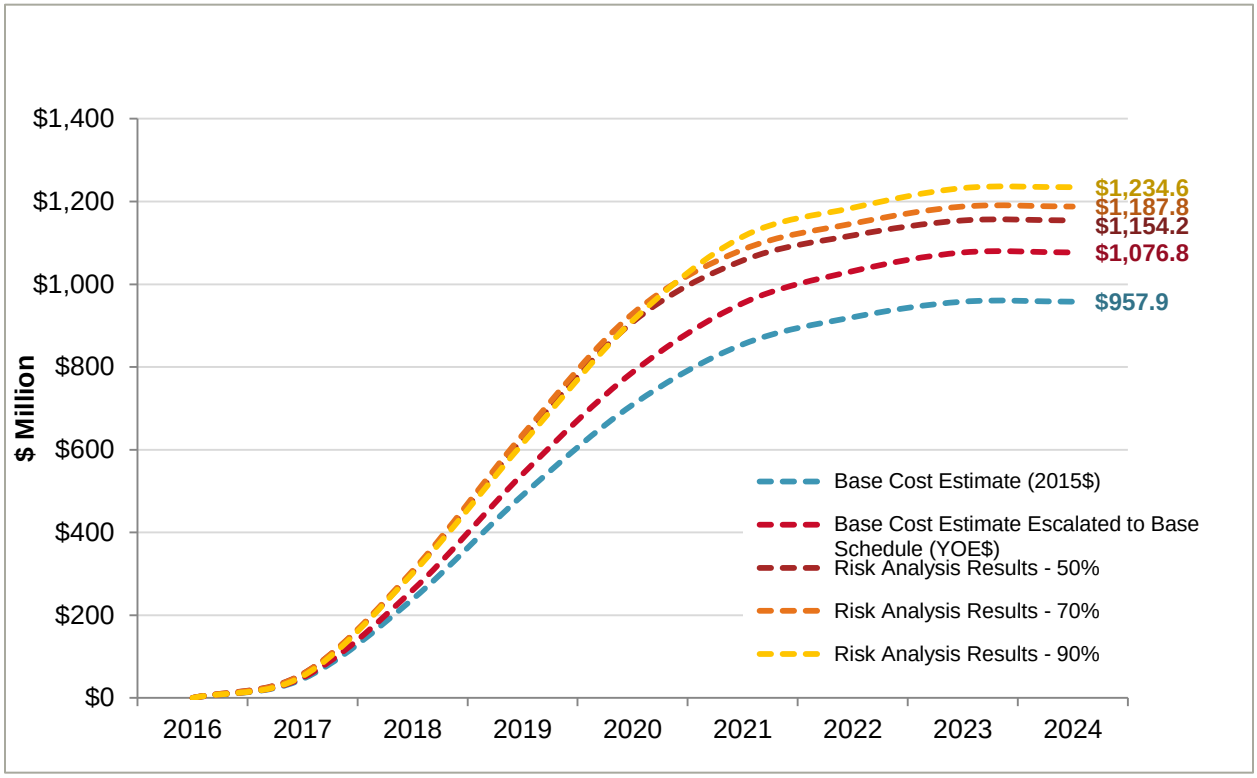
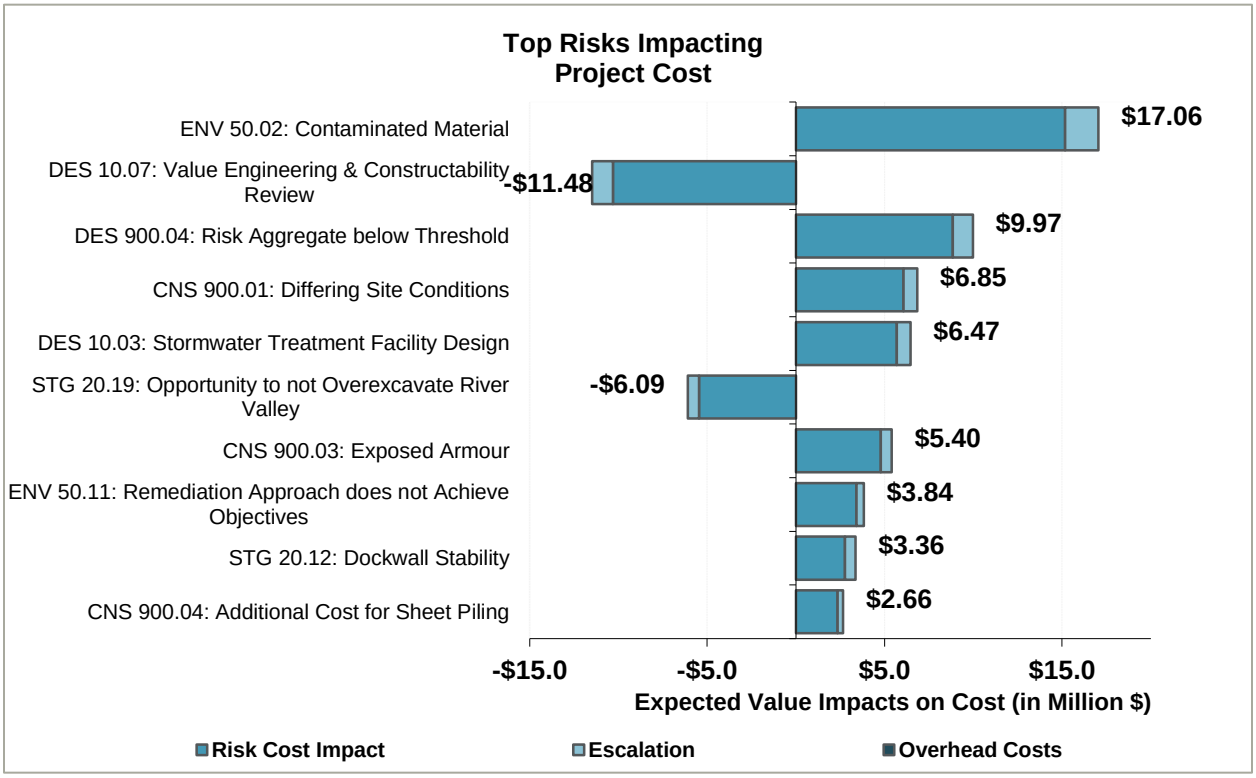


Figure 6 is a diagram showing the top cost risks of the project. This "tornado" chart shows the expected value for each risk. The risks in the tornado chart are ranked in descending order, with the largest risks at the top of the diagram. Risk names are listed along the vertical axis with the expected impact (in million $) of the risk shown along the horizontal axis.

Figure 6: Top Cost Risks



The overall impact of the risk may be comprised of three components: the impact caused by the risk occurring (risk cost impact), impact due to escalation, and extended overhead costs caused by project delay.

The *risk cost impact* is measured as the probability of the risk, times the mean cost impact developed during the CRA Workshop as risk cost ranges recorded within the risk register. *Escalation* impacts are the additional costs borne by a project and attributed to a schedule delay risk. Such costs might stem from the higher costs of construction required as expenditures are pushed further into the future. *Extended Overhead Costs* are increases in project management expenses incurred as a result of a schedule delay risk that extends the duration of phases of a project and requires management oversight.

It is recommended that projects are budgeted at the 70% level of confidence of the post-response results, which is $1,188 million in year of expenditure dollars. The difference between the 70% level of confidence and the base cost in the YOE is $111 million ($1,188 - $1,077). This value represents the risk reserve for the project. The risk reserve is a sum of money usually held by management and not normally intended to be spent. It is used to provide insurance in the case of risk occurrences.

4.2 Schedule Results

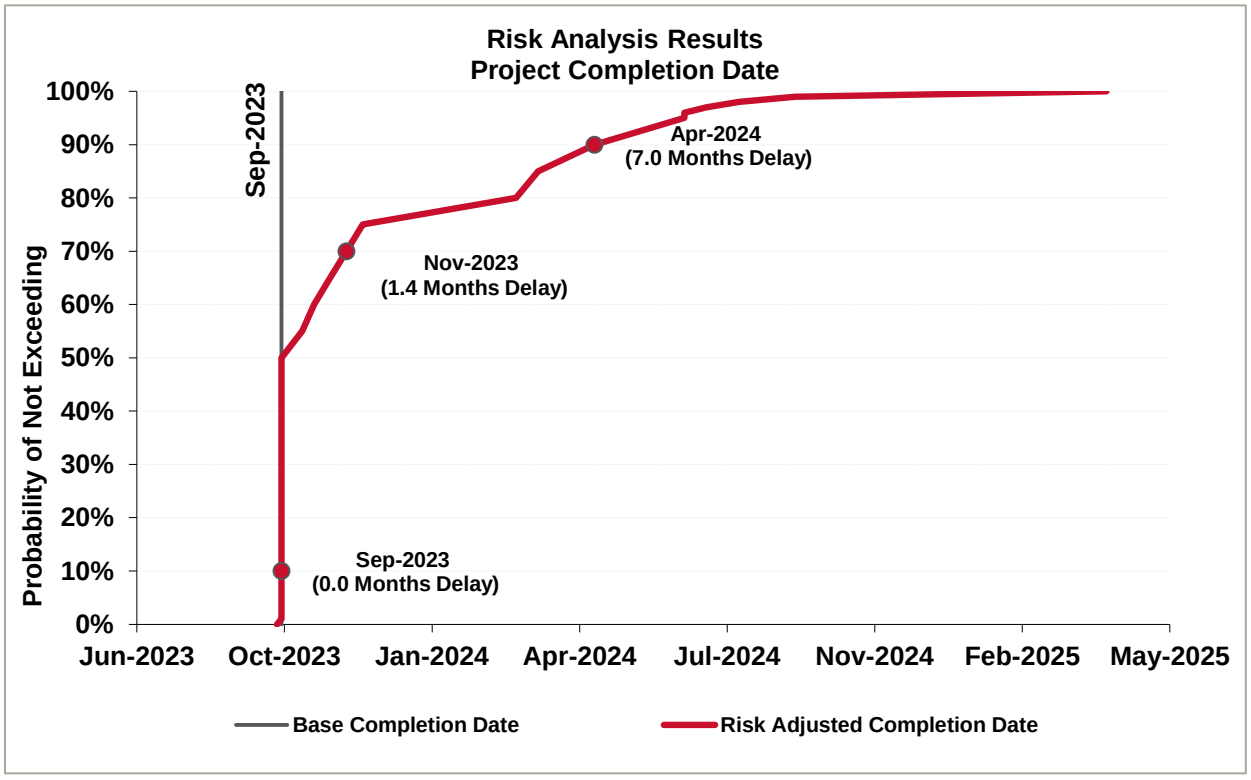
The project base schedule assumes a completion date of September 29, 2023 and represents the best case scenario taking into account all project activities, their interdependencies, and any project 'risks' that are expected to occur. In other words, any

events that are anticipated to occur with absolute certainty are included in the base schedule as the 'status quo'.

Figure 7 shows the risk-adjusted project completion date and indicates that there is a 70 percent probability the project will be completed by mid-November 2023, a delay of 1.4 months. With 90 percent likelihood, the project will not be delayed more than 7 months. The approximately 50% chance of completing the project on time reflects all the initiatives that have gone into optimizing the timing of project activities and mitigating risks that were identified in the first risk workshop and early stages of the study.

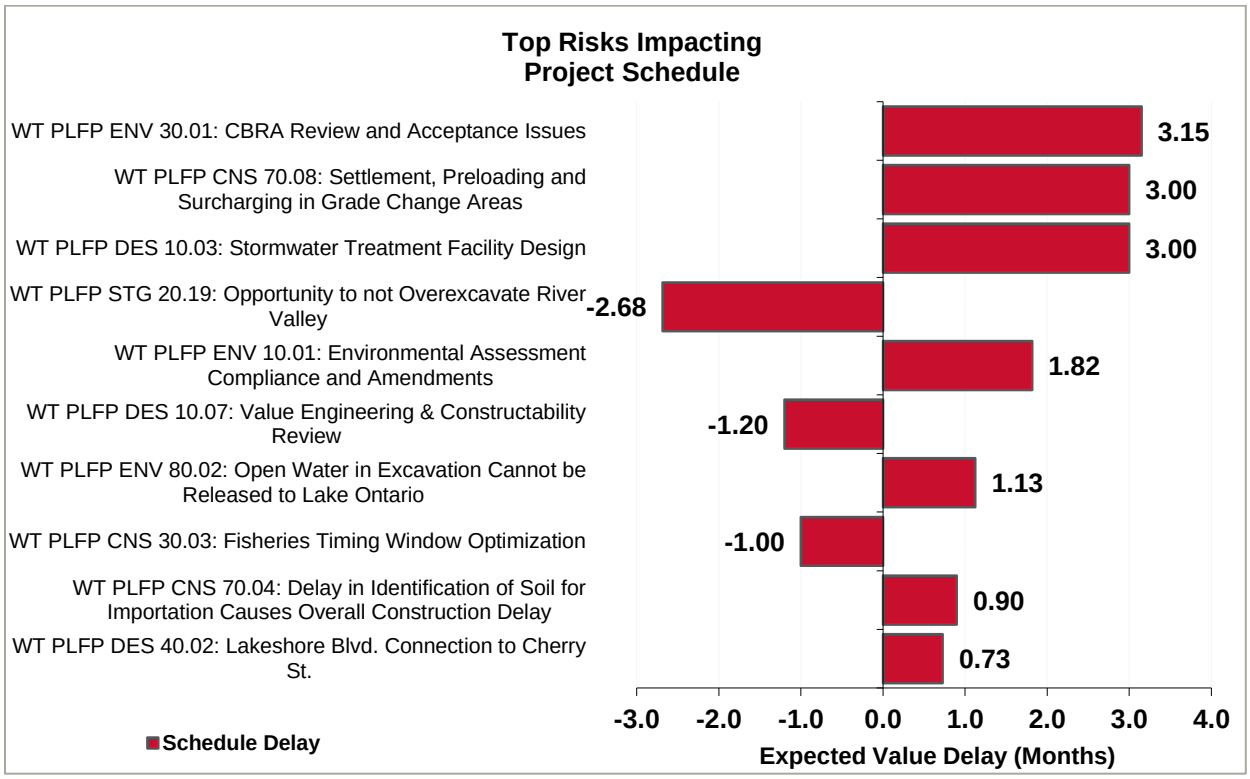
In general, all efforts should be made to deliver the project within the established cost and schedule budget. Project managers and teams must not plan on using the risk reserve from onset of a project. They should avoid or mitigate threats and exploit opportunities. If the avoidance of a risk is not possible, the team should try to minimize the likelihood of occurrence or reduce the impact of threat.

Figure 7: Risk-Based Schedule Completion Date



The top schedule risks for the project are shown in **Figure 8**. For each risk factor, the expected value impacts are added up across all phases and are shown in terms of months of cumulative impact to the overall project schedule. The top 10 risks contain seven threats and three opportunities that impact overall project schedule.

Figure 8: Top Schedule Risks



Appendix B - Risk Identification presents all risks in greater detail and documents risk management strategies as well as risk managers who are responsible for monitoring and mitigating threats and exploiting opportunities as the project progresses.

5 Ongoing Risk Management

The risk register, which serves as the primary tool to document and facilitate risk response planning and is a key output for risk management, has been updated to reflect the most current risk profile. Detailed extracts of the risk register are included in Appendix B of this report. This chapter outlines the approach to risk response planning and the anticipated steps in the ongoing risk management process for the Port Lands Flood Protection and Enabling Infrastructure Project.

5.1 Risk Response Approach

The intent of risk response planning is to identify proactive responses to key project risk factors in the hopes of minimizing project risk and uncertainty, and potentially reducing project cost and schedule overruns.

Risk response takes the form of several strategies, specific to threats or opportunities, which are described further below. Risk response also entails focusing on the event risks that pose the greatest impact to the project. A project may contain a risk register of dozens of quantified event risks; however, typically a bulk of the risk will manifest in only a fraction of the total event risks for a project. One good tool in establishing these criteria

is the Pareto Principle, also known as the 80-20 rule. Usually 80 percent of cost and schedule delays are found in 20 percent of the event risks identified. Concentrating on the top 20 percent provides the project team with a manageable number of risks. But depending on time and budget constraint, the comprehensive risk response plan may entail the project team to actively manage additional risks.

5.2 Risk Response Strategies

Following identification and analysis of project risks, project managers and project teams must take action in response to the identified project risks, focusing on risks of most significance, in order to shift the odds in favor of project success. Typical risk response strategies are given in **Table 6** below.

Table 6: Typical Risk Response Strategies

Threats Risk Factors that Increase Cost or Schedule	Opportunities Risk Factors that Reduce Cost or Schedule
Avoid: Change the project scope to eliminate the impact of a risk.	**Exploit:** To make a proactive decision to take action to show that an opportunity is realized.
Transfer: Move a risk to another party who is more capable at handling the risk (such as the developer or insurance company).	**Share:** Assigning ownership of the opportunity to a third-party who is best able to capture the benefit for the project.
Mitigate: The project team may seek to lessen the impact of a specific risk item, which may involve the consumption of additional time and/or money. Mitigation usually requires positive action and has a cost.	**Enhance:** Take action to increase the probability and/or impact of the opportunity for the benefit of the project; seeking to facilitate or strengthen the cause of the opportunity, and proactively targeting and reinforcing its trigger conditions.
Accept: To take no action when a response may be too costly to be effective or when the risks are uncontrollable and no practical action may be taken to specifically address it. In active acceptance, the project team sets up a contingency reserve fund to account for the residual expected value of the remaining risks.	

5.3 Ongoing Risk Management

The project team works from this initial list of mitigation strategies to manage and contain potential project risks. Risk management is a continual process, therefore these strategies will need to be tracked and updated over time. This feeds directly into Step 3 of the risk management process, as discussed in Chapter 2 of this report. The next steps include:

- Identifying Risk Owners to take responsibility for key risk factors and associated risk response strategies
- Identifying the Monitoring Frequency for risk updates and feedback on the effectiveness of risk response strategies
- Quarterly task lead meetings to review action items and mitigation strategies
- Scheduling annual updates to the risk assessment model and results at key milestones or when base cost and schedules are updated; and
- Continuous updates to risk management plan which document and report progress.

The project risk register contains fields to record this information and can be used to track and monitor risks going forward.

Appendix A: Glossary

Base Cost Estimate – The base cost estimate represents the project cost that can reasonably be expected if the project materializes as planned and there is no occurrence of risk. The base cost estimate is unbiased and neutral - it is neither optimistic nor conservative. The base cost includes the known and quantified items and the known but not yet quantified (miscellaneous item allowance). The base cost estimate does not include any risks, unknown/unknowns or contingencies. NOTE: Base cost estimates are to be prepared in current year dollars and will exclude future cost escalation.

Construction Contingency – A markup applied to the base cost estimate to account for uncertainties in quantities, unit costs, and minor risk events related to quantities, work elements, or other project requirements during construction. For design related contingencies see the definition of **Miscellaneous Item Allowance.**

Construction Engineering (CE) – The total construction management effort (cost) of taking a project from contract execution (through construction) to project completion

Escalation – Changes in the cost or price of specific items or work over a period of time.

Miscellaneous Item Allowance – Sometimes referred to as “minor items” or “design allowance”, miscellaneous item allowance is typically meant to cover a variety of possible events and problems not specifically identified or quantified yet. It is also used to account for a lack of project definition during the preparation of planning and environmental phase base cost estimates. Often percentages are used as individual “placeholders” for items that have not yet been estimated.

Opportunity – A risk event that can save the project time or money

Preliminary Engineering (PE) – The total effort (budget & cost) of taking a project through the Planning, Environmental and Final Design phases along with any design effort needed for construction support. The terms “Design” or “Design Phase” are sometimes used interchangeably with PE.

Total Project Cost – The total project cost includes PE + ROW + Construction + CE + Utility relocations + Agreements.

Project Cost Range – The project cost range is reported as 10^{th} percentile for the low estimate and 90^{th} percentile the high estimate.

Right of Way Cost (ROW) – The cost to acquire the right of way needed for the project. Utility relocation cost is not part of the ROW cost of the project.

Risk – The combination of the probability of an uncertain event and its consequences. A positive consequence presents an opportunity; a negative consequence poses a threat.

Risk-Based Cost Estimation – Involves simple or complex modeling based on inferred and probabilistic relationships among cost, schedule, and events related to the project. Risk elements (opportunities or threats) are defined and applied to the base cost estimate with its uncertainties through modeling to provide a probable range for both project cost and schedule.

Appendix B - Risk Identification

Risk identification involves determining which risks might affect the project and documenting their characteristics. The identification of risk should occur throughout the project development process.

As a project evolves from planning to environmental to design and eventually construction, the risk profile also evolves as project knowledge and understanding grows. Previously identified risks may occur, change or be retired and new risks are identified throughout the life of the project.

Risk identification is an iterative process and should be performed throughout the duration of the project. Early and continual identification of risks is critical to the success of the risk management processes.

Led by the Risk Lead, the CRA Team first brainstormed as many risks as possible that may affect the project objectives and deliverables. The Risk Lead determined the risk thresholds for the project by establishing a minimum dollar amount and time duration considered significant for the project under evaluation and then focused the CRA Team on identifying large significant risks which affect project objectives. These risks should be identified to the maximum extent that is practicable. When a risk is identified is should be:

- Specific – The risk should be identified and described to the level of detail that the project phase will allow. For the planning phase the risks should be less specific than what may be expected during the final design phase.
- Tangible – The risk should be tangible enough that impacts can be measured and assessed. The probability of that risk occurring should be reasonably assessed and the event that triggers the risk should be identifiable.
- Relevant – The risk identified should have impacts to the project baselines and should be able to be triggered or managed during the duration of the project.

Risk identification includes recognizing and understanding risk triggers: warning signs that indicate the probability of a risk occurring is approaching certainty. Risk identification also includes recognizing and understanding how a risk may be impacted or affected by another risk or event.

Risk Count Detail

A unique number is assigned to each risk for tracking purposes. This was done by using an established risk breakdown structure (RBS).

During the October 2015 and March 2016 workshops, 133 risks were discussed, of those 4 were retired, 67 are inactive (of which 21 were individually relatively minor and were included in an aggregate risk category – other inactive risks include those not quantified but on the watch list) and 62 are active quantified risks. **Table 7** illustrates how many risks were identified in each functional area. The overall totals are less than the sum of cost and schedule risks as certain risks have both cost and schedule impacts.

Table 7: Risk Count

Risk Category	Active		Inactive	Retired	Total
	Cost	Schedule			
Environmental & Hydraulics	9	9	16	0	31
Right-of-Way	1	0	3	0	4
Utilities	0	2	2	1	5
Design / PS&E	4	4	8	3	18
Structures & Geotech	9	11	17	0	35
Partnerships and Stakeholders	0	2	2	0	4
Management / Funding			2	0	2
Contracting and Procurement	1	0	3	0	4
Construction	12	5	14	0	30
Total	**36**	**33**			
		62	**67**	**4**	**133**

Active Risks

The active risks that were updated/identified during the October 2015 and subsequent March 2016 CRA Workshops are described on the following pages.

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 30.01
Sub-Project	Port Lands Flood Protection	Status	Active

Flooding During Construction

Risk Trigger		Flowchart Activity	WF-EW-0001.,WF-EW-0002.,WF-EW-0003.,WF-EW-001.,WF-EW-002.,WF-EW-007.,WF-EW-008.,WF-EW-009.,WF-EW-
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
3%					38	33	
Cost ($M)	$1.00	$2.00	$5.00	$0.07	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	1.00 Mo	2.00 Mo	3.00 Mo	0.06	38	33	

The area is prone to flooding, flooding during construction could delay construction activities and require considerable clean up. 1% chance of flooding over the channel wall (1 in 100 year event); higher likelihood of localized flooding from heavy rainfall.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
3%						
Cost ($M)	$1.00	$2.00	$5.00	$0.07	Strategy	3/21/2016
Schedule (Mo)	1.00	2.00	3.00	0.06	Mitigate	

Provide contractor with historical flood events and flood risk network - transfer risk to contractor to manage 100yr event.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Construction PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 30.03
Sub-Project	Port Lands Flood Protection	Status	Active

Fisheries Timing Window Optimization

Risk Trigger		Flowchart Activity	2,3,4,16

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%					39	12	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	-3.00 Mo	-2.00 Mo	-1.00 Mo	-1.00	39	12	

Increased duration due to restrictions for in-water work - investigate opportunities for confined work areas to allow for work to proceed during timing windows. 3-9 months potential reduction over 3 years. Can be optimized as far as workflow and ask for an extension or exception.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	-3.00	-2.00	-1.00	-1.00	Exploit	

Include window and permit condition in contracts.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 70.01
Sub-Project	Port Lands Flood Protection	Status	Active

Excavation for River Channel

Risk Trigger		Flowchart Activity	3,4

Dependency & Correlation	

Pre-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
	20%	70%	10%		19	35	
Cost ($M)	-$12.00	$0.00	$12.00	-$1.20	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	19	35	

Dredging time and unit costs are different than initially anticipated. Dredging unit rate risk (as opposed to volume). Base assumes $50/m3; this includes temporary pads for excavation equipment to prevent sinking. Historical records have had costs as high as $80 and as low as $20-25 but extremely unlikely. 390k m3 impacted.

Post-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
	20%	70%	10%			
Cost ($M)	-$12.00	$0.00	$12.00	-$1.20	Strategy	3/21/2016
Schedule (Mo)				0.00	Exploit	

More detailed geotech testing. Refine cut geometry that minimizes risk. Consider alternative delivery to DBB that could help manage this production risk.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 70.02
Sub-Project	Port Lands Flood Protection	Status	Active

Excavation for River Channel

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					34	35	
Cost ($M)	$0.00	$1.00	$2.00	$0.25	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	34	35	

Obstructions encountered during dredging of the new river channel. Low risk of potential change orders.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.00	$1.00	$2.00	$0.25	Strategy	3/21/2016
Schedule (Mo)				0.00	Accept	

Maintain risk reserve.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Construction PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
1/1/2017	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 70.04
Sub-Project	Port Lands Flood Protection	Status	Active

Delay in Identification of Soil for Importation Causes Overall Construction Delay

Risk Trigger		Flowchart Activity	1,2,9
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	5	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	6.00 Mo	9.00 Mo	12.00 Mo	2.25	39	5	

Importing about 150k m3. Risks are other larger projects in the area competing for imported material. Requirement is table 1 material.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
20%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	3.00	4.50	6.00	0.90	Mitigate	

Soil management strategy - table 1 only required within 30m of water body; optimize use of table 1 material.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 70.08
Sub-Project	Port Lands Flood Protection	Status	Active

Settlement, Preloading and Surcharging in Grade Change Areas

Risk Trigger		Flowchart Activity	1,2,9
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					39	2	
Cost ($M)	$0.00	$0.00	$0.00	$0.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	3.00 Mo	6.00 Mo	9.00 Mo	4.50	39	2	

Applies to Eastern section of the site (Don Roadway). Orchestrated movement of soil is necessary to accomplish settlement, preloading or surcharging of areas. If not complete, then additional time required before antecedent tasks can be completed. Base assumes 6 months for preloading Don Roadway.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%					$1.00	
Cost ($M)	$0.00	$0.00	$0.00	$1.00	Strategy	3/21/2016
Schedule (Mo)	3.00	6.00	9.00	3.00	Mitigate	

Proper design, soil management strategy, construction sequencing.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 70.09
Sub-Project	Port Lands Flood Protection	Status	Active

Significant Quantities of NAPL Encountered during Excavation

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%					32	35	
Cost ($M)	$0.25	$0.50	$1.00	$0.27	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	32	35	

Assumptions in NAPL recovery during excavation invalid and additional cost incurred. Base includes $1M for skimming liquid. Risk that the costs would be double.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.25	$0.50	$1.00	$0.27	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Include bid items to account for risk in contract.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 70.10
Sub-Project	Port Lands Flood Protection	Status	Active

Fill Availability

Risk Trigger		Flowchart Activity	1,2,9
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					14	35	
Cost ($M)	$3.00	$6.00	$12.00	$1.63	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	14	35	

Increased costs from importing more soil than anticipated as result of excavated soil quality not as expected - if more than 150k m3 needed. Mostly Essroc Quay; risk is need additional 200k m3 of import and 200k m3 export. Due to available fill not in alignment with excavation schedule (right soil, right quality, right time); at the high end $60/m3 * 200k m3.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
20%						
Cost ($M)	$3.00	$6.00	$12.00	$1.30	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Detailed construction phasing plan that will provide the fill when needed - coordination of the fill & soil strategy within the soil management plan.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design / Construction PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 70.16
Sub-Project	Port Lands Flood Protection	Status	Active

Opportunity to Receive Fill Tipping Fees

Risk Trigger		Flowchart Activity	9

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
10%					37	35	
Cost ($M)	-$1.50	-$1.00	-$0.50	-$0.10	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	37	35	

Potential to expand the project area and allow for tipping fees in areas of future fill could generate tipping fee revenues.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)	-$1.50	-$1.00	-$0.50	-$0.10	Strategy	3/21/2016
Schedule (Mo)				0.00	Exploit	

Develop soil management plan that includes this opportunity. Advertise to other agencies the available area for receiving fill.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 70.17
Sub-Project	Port Lands Flood Protection	Status	Active

Reduced Rubble Fill Material Cost for Essroc Berm

Risk Trigger		Flowchart Activity	1,2
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
10%					30	35	
Cost ($M)	-$5.80	-$2.50	-$1.00	-$0.28	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	30	35	

Proactively identify sources for material at less than market cost. Can make up to 10% of $5.8M cost as revenue.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)	-$5.80	-$2.50	-$1.00	-$0.28	Strategy	3/21/2016
Schedule (Mo)				0.00	Exploit	

Develop soil management plan that includes this opportunity. Advertise to other agencies the available area for receiving fill.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 70.18
Sub-Project	Port Lands Flood Protection	Status	Active

Reduction in Earthwork Haul Distance

Risk Trigger		Flowchart Activity	1,7a,7b,9,14a,17b

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					24	35	
Cost ($M)	-$5.00	-$3.00	-$1.00	-$0.75	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)				0.00	24	35	

Base assumes 6km round trip, opportunity to reduce haul distance by optimizing stockpile locations.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	-$5.00	-$3.00	-$1.00	-$0.75	Strategy	3/21/2016
Schedule (Mo)				0.00	Exploit	

Detailed soil management plan.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design / Construction PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 70.19
Sub-Project	Port Lands Flood Protection	Status	Active

Settlement in Public Realm

Risk Trigger		Flowchart Activity	17b
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					20	35	
Cost ($M)	$1.00	$1.50	$2.00	$1.13	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	20	35	

Hardscaping in public parks is at risk of damage due to continued settlement. Mitigation measure could be surcharging that would add an additional cost of up to $1M.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$1.00	$1.50	$2.00	$0.38	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Revised schedule moved Parks projects to the end and has mitigated and reduced the probability of risk.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 90.02
Sub-Project	Port Lands Flood Protection	Status	Active

Timely Delivery of Materials

Risk Trigger		Flowchart Activity	8,13,14b,14c,15b

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
5%					39	30	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	3.00 Mo	4.50 Mo	6.00 Mo	0.23	39	30	

Fabricated components don't always meet delivery date resulting in construction delays. Schedule delay impact only.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
5%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	3.00	4.50	6.00	0.23	Transfer	

Put provisions in the contract to meet schedule; transfer risk of long lead time of materials to contractor.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 900.01
Sub-Project	Port Lands Flood Protection	Status	Active

Differing Site Conditions

Risk Trigger		Flowchart Activity	1,2,3,4,5,7a,8,9,10,11,12,13,14a,14b,14c,14d,15a,15b,15c,16,17b,18,19,20,21
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					3	35	
Cost ($M)	$6.00	$8.00	$10.00	$6.00	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	3	35	

Conditions in the field are found to be different than shown in the plans and specifications resulting in construction changes. Assume risk of 1% of construction cost (~$800M).

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$6.00	$8.00	$10.00	$4.00	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Additional geo-environmental delineation has assisted in identifying individual risks that normally incorporated in this risk. Maintain a risk reserve for unknown change orders during construction.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Construction PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 900.03
Sub-Project	Port Lands Flood Protection	Status	Active

Exposed Armour

Risk Trigger		Flowchart Activity	3,4,16
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
90%					8	35	
Cost ($M)	$2.00	$3.50	$5.00	$3.15	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	8	35	

Risk is constructability of the exposed armour with potential requirement for additional excavation. Final slope is designed at 2:1 to 4:1 (range); risk is additional excavation to build the slope and fill it back. Risk is in the 4:1 or steeper, ~30% of area, requiring 4-5 times more armouring material = $552/m2 * 1000 m2.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
90%						
Cost ($M)	$2.00	$3.50	$5.00	$3.15	Strategy	3/21/2016
Schedule (Mo)				0.00	Accept	

Complete detailed design and update base cost accordingly.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CNS 900.04
Sub-Project	Port Lands Flood Protection	Status	Active

Additional Cost for Sheet Piling

Risk Trigger		Flowchart Activity	3,4,16
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
40%					15	35	
Cost ($M)	$2.60	$4.10	$5.10	$1.61	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	15	35	

Sheet pile embedment depth may need to be increased based on further detailed design. Base cost assumes 1.5 times embedment, but could increase to 2 times. Low / most likely / high estimates based on 50/80/100% of sheet piling requiring increased embedment depth.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
40%						
Cost ($M)	$2.60	$4.10	$5.10	$1.61	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Advance design and coordinate geotech information with channel design & revise base costs accordingly.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP CTR 50.01
Sub-Project	Port Lands Flood Protection	Status	Active

Supply and Demand of Materials

Risk Trigger		Flowchart Activity	1,2,3,4,5,7a,8,9,10,11,12,13,14a,14b,14c,14d,15a,15b,15c,16,17b,18,19,20,21
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%					9	35	
Cost ($M)	$2.00	$4.00	$8.00	$2.17	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)				0.00	9	35	

With all the major capital projects underway, there is the risk of escalating costs for raw materials due to competing local demand for resources - i.e. Aggregate. Market conditions risk. Gardiner, TTC Relief Line, Lakeview & Ashbridges Bay project, etc. as well as other projects in Ontario. Risk of low equipment supply (trucks, etc.) and some material. Up to 1% of total project cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$2.00	$4.00	$8.00	$1.08	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Have discussed cash flow with industry to ensure sufficient bidders and materials. Biggest concern is the timing of the bid process - that their bid is not during or within 2 months of another major project.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP DES 10.03
Sub-Project	Port Lands Flood Protection	Status	Active

Stormwater Treatment Facility Design

Risk Trigger		Flowchart Activity	5

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					6	3	
Cost ($M)	$13.00	$15.00	$17.00	$3.75	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	10.00 Mo	12.00 Mo	14.00 Mo	3.00	6	3	

BFF (Stormwater Treatment Facility); Base includes $10M for facility. Risk that City insists on a quality system being built upfront ($15M more). Modified facility would be 12mo in base; quality system would add 12mo.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$13.00	$15.00	$17.00	$3.75	Strategy	3/21/2016
Schedule (Mo)	10.00	12.00	14.00	3.00		

Have discussions with the City about a phased approach.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

MMM to support.

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP DES 10.07
Sub-Project	Port Lands Flood Protection	Status	Active

Value Engineering & Constructability Review

Risk Trigger		Flowchart Activity	1,2,3,4,5,7a,8,9,10,11,12,13,14a,14b,14c,14d,15a,15b,15c,16,17b,18,19,20,21

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
20%					2	9	
Cost ($M)	-$50.00	-$35.00	-$17.50	-$6.92	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	-9.00 Mo	-6.00 Mo	-3.00 Mo	-1.20	2	9	

Opportunity: Creative soil reuse, optimizing the design to reduce the durations, flexible land use and development, combining functions, integrated engineering. Can save 5-10% of project cost; other opportunities are accounting for part of this already. Base duration of construction is 117mo.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
20%						
Cost ($M)	-$50.00	-$35.00	-$17.50	-$6.92	Strategy	3/21/2016
Schedule (Mo)	-9.00	-6.00	-3.00	-1.20	Exploit	

Schedule constructability and value engineering reviews.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP DES 40.02
Sub-Project	Port Lands Flood Protection	Status	Active

Lakeshore Blvd. Connection to Cherry St.

Risk Trigger		Flowchart Activity	14a
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
5%					39	15	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	6.00 Mo	12.00 Mo	24.00 Mo	0.65	39	15	

Changes to the Lakeshore alignment due to the Gardiner and other projects result in additional costs or delays. Unquantified at the moment - no Gardiner project schedule info until year-end. Risk is that the 2 projects are not in alignment for when you need to remove the existing Cherry St. bridge resulting in delays. Update 3/21/2016 revised schedule has moved it up ahead of Gardiner project - reduced risk related Lakeshore re-alignment from 30% to 5%.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
5%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	6.00	12.00	24.00	0.65	Mitigate	

Close coordination between the 2 projects to align construction schedule.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP DES 40.04
Sub-Project	Port Lands Flood Protection	Status	Active

Opp: Avoided Eastern Ave. Grade Separation/Modifications

Risk Trigger		Flowchart Activity	12

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
10%					35	35	
Cost ($M)	-$3.50	-$2.00	-$1.00	-$0.21	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	35	35	

City may construct project resulting in not needing to do the Eastern Ave. project. Opportunity that WT does not have to do as much due to other design modifications.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	-$3.50	-$2.00	-$1.00	-$0.52	Strategy	3/21/2016
Schedule (Mo)				0.00		

New opportunity for a third party developer cost sharing. Increases the likelihood. Continued meetings with developer and Senior personnel at City and Province to define scope and cost sharing concurrent with flood protection.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP DES 60.01
Sub-Project	Port Lands Flood Protection	Status	Active

Design Review Panel Delay

Risk Trigger		Flowchart Activity	DAP1

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
10%					39	29	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	1.00 Mo	3.00 Mo	6.00 Mo	0.32	39	29	

Panel may take longer to approve project design or require changes. Panel only meets once a month - any adjustments can result in an additional month of delay. Each milestone is 30-60-90 delay. Impacts public realm projects.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
0%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	1.00	3.00	6.00	0.00	Avoid	

Keeping panel informed of design as it is progressing will mitigate risk.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP DES 900.02
Sub-Project	Port Lands Flood Protection	Status	Active

Aggressive Design and Approval Schedule

Risk Trigger		Flowchart Activity	DAP1

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
20%					39	16	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	1.00 Mo	3.00 Mo	5.00 Mo	0.60	39	16	

Base assuming 10 months of design for Essroc Cell1,2 (Early work package); 100 day review by DFO - final package due after 60 days, 90 days from final package. Design schedule is compressed to meet constrained funding and constrained completion dates - there is a risk to not be able to meet the schedule. Triggered by availability in funding. Design can finish during review process as long as no changes. Update 3/21/2016

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
20%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	1.00	3.00	5.00	0.60	Mitigate	

DFO review concurrent with design. Advance the design of the habitat.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Director of Environmental		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP DES 900.04
Sub-Project	Port Lands Flood Protection	Status	Active

Risk Aggregate below Threshold

Risk Trigger		Flowchart Activity	1,2,3,4,5,7a,8,9,10,11,12,13,14a,14b,14c,14d,15a,15b,15c,16,17b,18,19,20,21
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%					4	35	
Cost ($M)	$3.00	$10.00	$20.00	$5.25	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	4	35	

Twenty four (24) risks discussed fell below $1M or 1mo delay threshold.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$3.00	$10.00	$20.00	$5.25	Strategy	3/21/2016
Schedule (Mo)				0.00		

Continue to complete the design and update base estimates.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 10.01
Sub-Project	Port Lands Flood Protection	Status	Active

Environmental Assessment Compliance and Amendments

Risk Trigger		Flowchart Activity	PE1,PE2,PDA
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	3.00 Mo	6.00 Mo	12.00 Mo	1.63	39	6	

Schedule delay due to having to change the approvals of the environmental assessment. Design progression may trigger a minor or major environmental amendment. Minor amendment have to consult with MoE, 3-6mo. 6-12mo for major change. Update 3/21/2016 - ability to do some scheduling for construction component, a lot can be concurrent.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	3.00	6.00	12.00	1.63	Mitigate	

Develop a list of red flag action items to share with designers. Integrate overall construction phasing, address any amendments in the later construction packages.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
TRCA Senior Manger		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 30.01
Sub-Project	Port Lands Flood Protection	Status	Active

CBRA Review and Acceptance Issues

Risk Trigger		Flowchart Activity	DAP1

Dependency & Correlation	

Pre-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
	50%	20%	5%		39	1	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	6.00 Mo	9.00 Mo	12.00 Mo	5.40	39	1	

Information submitted for approval, changes in regulations, reviewer delay. Base preparation and approval process is 12mo. The CBRA review process has a history of experiencing delays of 6 to 12 months for a project of this magnitude (in addition to base 12mo).

Post-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
	50%	20%	5%			
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	3.00	6.00	9.00	3.15		

Added consultation with agencies who are reviewing the documents.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Environmental PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 30.06
Sub-Project	Port Lands Flood Protection	Status	Active

Sediment Management Operations Equipment

Risk Trigger		Flowchart Activity	PE2

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%					12	35	
Cost ($M)	$2.50	$3.75	$5.00	$1.88	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	12	35	

Onshore management area approval issues with landscaping, pavement expansion, etc. Sediment and debris management area. Risk of going to the large paved area. Potential risk that new equipment has to be added to capital cost estimate for continued O&M. Equipment consists of 1 self-propelled hydraulic dredge, hydrocyclone system, low headroom tug, and maintenance storage shed.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$2.50	$3.75	$5.00	$1.88	Strategy	3/21/2016
Schedule (Mo)				0.00	Accept	

Consider opportunities of advance acquisition for construction.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 30.07
Sub-Project	Port Lands Flood Protection	Status	Active

Environmental Permits Approval Issues

Risk Trigger		Flowchart Activity	PE2
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
40%					39	28	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	-2.00 Mo	1.00 Mo	3.00 Mo	0.33	39	28	

Environmental compliance approval (ECA) has a history of up to 3 months delay from a base of 12mo.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
40%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	-2.00	1.00	3.00	0.33	Mitigate	

Leverage pilot test approval process with MOECC and contractors and technology with existing ECA.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Environmental PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 40.01
Sub-Project	Port Lands Flood Protection	Status	Active

Archaeological / Cultural Discoveries

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
10%					39	32	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	0.50 Mo	0.75 Mo	1.00 Mo	0.08	39	32	

Presence of First Nations artifacts. Highest risk will be during the excavation of previously undisturbed areas. If a significant artifact is found, can result in partial delay of construction, could require inefficiencies or slower construction.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	0.50	0.75	1.00	0.08	Accept	

Use best management practices for inadvertent discoveries during construction.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Construction PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
9/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 50.02
Sub-Project	Port Lands Flood Protection	Status	Active

Contaminated Material

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
	20%	20%	10%		1	35	
Cost ($M)	$15.00	$22.50	$25.00	$10.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)				0.00	1	35	

The volume of soil unsuitable for use within the project limits and requiring off-site disposal is greater than anticipated. More contaminated soil has to be remediated on site (>300k m3) - more material (other risk was failure of process). Risk of 150k m3 more. Update 3/21/2016 - increased risk; impacts based on risk tolerance.

Post-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
	20%	20%	10%			
Cost ($M)	$15.00	$22.50	$25.00	$10.00	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Do additional soil sampling & testing; testing treatment technologies; contract drafting must be framed to include provisional sum for up to 150k m3.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 50.10
Sub-Project	Port Lands Flood Protection	Status	Active

Groundwater Remediation Determined to be Required

Risk Trigger		Flowchart Activity	3

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
20%					28	35	
Cost ($M)	$1.00	$2.00	$3.00	$0.40	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)				0.00	28	35	

Further analysis of groundwater to surface water interaction shows that upland groundwater treatment or groundwater barrier is required to prevent contamination entering the new river valley. Risk to have to put in a barrier wall such as sheet pile, etc. No impact on schedule, done concurrently.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
20%						
Cost ($M)	$1.00	$2.00	$3.00	$0.40	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Obtain additional environmental information - data gap analysis. Additional site characterization to determine groundwater contamination and include possible barriers if and where required.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Environmental PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 50.11
Sub-Project	Port Lands Flood Protection	Status	Active

Remediation Approach does not Achieve Objectives

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
35%					10	35	
Cost ($M)	$4.00	$6.00	$9.00	$2.16	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)				0.00	10	35	

Soil cannot be remediated to reuse standards and needs to be exported off-site for disposal and soil imported to site to make up difference. Assumed 300k m3 being remediated to a certain standard to be used below barrier. Risk is that some of it is not remediated to a level it needs to be at. Assume 10% does not meet standards ($120/m3, 10-20%) material may not be available when needed and must be imported ($30/m3).

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
35%						
Cost ($M)	$4.00	$6.00	$9.00	$2.16	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Additional soil and treatment technology testing to refine base cost and consider a provisional sum for additional disposal and import.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Environmental PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 50.12
Sub-Project	Port Lands Flood Protection	Status	Active

Performance of Selected Soil Remediation Strategy/Approach

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
30%					25	14	
Cost ($M)	$1.00	$2.00	$5.00	$0.70	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	2.00 Mo	2.50 Mo	3.00 Mo	0.75	25	14	

The flow through rates, costs and effectiveness for producing materials that can be reused may not meet projected conditions, resulting in significant delays and additional costs. Assume production rates are ~750m3/day. Risk is that dredging rate is lower and 10-20% of the dredging goes to remediation. Schedule and cost risk. If process goes into winter, soil processing costs go up dramatically - pinch point is the liquid treatment, polymer, insulating pipes, equipment, etc.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
15%						
Cost ($M)	$1.00	$2.00	$5.00	$0.35	Strategy	3/21/2016
Schedule (Mo)	2.00	2.50	3.00	0.38	Mitigate	

Conduct pilot testing program to evaluate production and treatment rates under varying conditions. Build flexibility into contract; ability to scale the remediation process to meet variable production rates.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Environmental/Construction PMs		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
9/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 50.13
Sub-Project	Port Lands Flood Protection	Status	Active

Hazardous Soil

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
	10%	7%	3%		26	21	
Cost ($M)	$2.00	$3.80	$5.00	$0.62	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	2.00 Mo	2.50 Mo	3.00 Mo	0.47	26	21	

Current studies showed no hazardous material but possible that 0.5% would be hazardous waste requiring offsite disposal at $700-$1000/m3. High end includes upgraded PPE (personal protective equipment) costs.

Post-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
	10%	7%	3%			
Cost ($M)	$2.00	$3.80	$5.00	$0.62	Strategy	3/21/2016
Schedule (Mo)	2.00	2.50	3.00	0.47	Mitigate	

Additional soil sampling & testing will assist in revising the base cost.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Environmental PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 60.01
Sub-Project	Port Lands Flood Protection	Status	Active

Habitat Creation

Risk Trigger		Flowchart Activity	3,4,10,17b
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					22	35	
Cost ($M)	-$6.00	-$4.00	-$2.00	-$1.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)				0.00	22	35	

WT pushed to further advance habitat creation and need to look at costs and benefits of doing that. Opportunity for early wetland establishment will allow WT to plant smaller, more economical plants, improved naturalization. Base has ~$21M in it ($20-25M). Update 3/21/2016 only looking at 20% of project where we can apply this.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	-$6.00	-$4.00	-$2.00	-$1.00	Strategy	3/21/2016
Schedule (Mo)				0.00	Exploit	

Stage construction of wetlands.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 70.01
Sub-Project	Port Lands Flood Protection	Status	Active

Hydraulic Operational Requirements

Risk Trigger		Flowchart Activity	PE1,PE2

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	11	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	3.00 Mo	4.00 Mo	6.00 Mo	1.04	39	11	

Changes to design to meet operational requirements is a potential risk to the design schedule.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
5%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	3.00	4.00	6.00	0.21	Mitigate	

Plan for it. Let an RFP early to finish the modeling early.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
TRCA PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 80.02
Sub-Project	Port Lands Flood Protection	Status	Active

Open Water in Excavation Cannot be Released to Lake Ontario

Risk Trigger		Flowchart Activity	3,4

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					16	10	
Cost ($M)	$5.00	$6.00	$7.00	$1.50	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	3.00 Mo	4.50 Mo	6.00 Mo	1.13	16	10	

Open water in excavation cannot be released to Lake Ontario. Level of contamination too high for water to be released to Lake Ontario and pre-treatment is required. Potential for delays and increased costs. Base includes a skimming operation for any material that emerges in the water during excavation, and some water treatment. Treatment only for water from dewatered operations - but not from excavation. May result in delay by as much as 6 months. Update 3/21/2016 planning for this in base cost/schedule; risk is of being worse than expected.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$5.00	$6.00	$7.00	$1.50	Strategy	3/21/2016
Schedule (Mo)	3.00	4.50	6.00	1.13	Mitigate	

Management of provisional allowances for additional water treatment from excavation; treatment technologies for soil and groundwater; sequencing of construction & remediation.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Environmental PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 80.04
Sub-Project	Port Lands Flood Protection	Status	Active

Nuisance Odours during Construction

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%					27	35	
Cost ($M)	$0.50	$0.75	$1.00	$0.60	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	27	35	

Exposing petroleum hydrocarbons could produce nuisance odours requiring odour suppressants. Dependent on type of contaminants, etc. Typically carried as a provisional cost element. Two main areas that would be impacted.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$0.50	$0.75	$1.00	$0.60	Strategy	3/21/2016
Schedule (Mo)				0.00	Accept	

Have provisional sum item in contract.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Environmental PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ENV 900.01
Sub-Project	Port Lands Flood Protection	Status	Active

Change in Environmental Regulations

Risk Trigger		Flowchart Activity	PE1,PE2

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
20%					39	13	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	2.00 Mo	4.00 Mo	6.00 Mo	0.80	39	13	

Risk that environmental regulation change before approval in a way that negatively impacts the project. Schedule delay and potential minor cost impacts due to different thresholds.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
5%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	2.00	4.00	6.00	0.20		

Monitoring and engagement with government. Plan to incorporate any potential changes into plan.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Environmental PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP PSP 30.02
Sub-Project	Port Lands Flood Protection	Status	Active

TPA Dockwall Operations

Risk Trigger		Flowchart Activity	14b,14c
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
1%					39	33	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	4.00 Mo	6.00 Mo	8.00 Mo	0.06	39	33	

If TPA does not agree to move remaining dockwall operations from Keating channel in time, project would be delayed. Agreement needs to be made in next 2 years. Delay to Cherry St. bridge construction. Update 3/21/2016 - TPA (Ports TO) is on record indicating they're moving their operations.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
1%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	4.00	6.00	8.00	0.06	Mitigate	

Continue to coordinate and verify that TPA is on schedule for the move.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP PSP 30.03
Sub-Project	Port Lands Flood Protection	Status	Active

Public Realm Design Issues

Risk Trigger		Flowchart Activity	DAP1

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
40%					39	8	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	1.00 Mo	3.00 Mo	6.00 Mo	1.27	39	8	

Overlapped approvals of design and tender period before getting the permit assuming the permit would come. If all went wrong, the 2 overlapping periods + tender overlapping period totals 5mo. Overlapping period with City and Agency review.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	1.00	3.00	6.00	0.32	Mitigate	

Permit coordination to develop a schedule with City and Agencies (TPLC, Transportation, Port Authority, Parks, TRCA, etc.). Underlying assumption is to provide funding/resources to the City to expedite the permitting process - should be covered in the ~20% soft costs. Maintain float in schedule for parks permits.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP ROW 50.01
Sub-Project	Port Lands Flood Protection	Status	Active

Added Property Costs

Risk Trigger		Flowchart Activity	ROW1

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%					33	35	
Cost ($M)	$0.10	$0.50	$1.00	$0.26	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	33	35	

Added property cost due to added ROW needs. Cost per acre differs by area.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.10	$0.50	$1.00	$0.26	Strategy	3/21/2016
Schedule (Mo)				0.00	Accept	

Maintain risk reserve for unknown ROW costs.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.02
Sub-Project	Port Lands Flood Protection	Status	Active

Groundwater Level

Risk Trigger		Flowchart Activity	3,4

Dependency & Correlation	

Pre-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
	15%	20%	40%		21	35	
Cost ($M)	-$1.40	$1.00	$2.80	$1.11	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	21	35	

Higher groundwater level - requiring more dredging and less dry conventional excavation. Wet volume of 440k m3 and dry of 771k m3. Risk of 20% more wet material. Opportunity that it is more dry.

Post-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
	15%	20%	40%			
Cost ($M)	-$1.40	$1.00	$2.80	$1.11	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Transfer risk to contractor & include historical lake and groundwater levels into contract.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.05
Sub-Project	Port Lands Flood Protection	Status	Active

Potential Presence of Soft Sediments in the Lakefill Areas

Risk Trigger		Flowchart Activity	1,2,3,4,5

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					30	25	
Cost ($M)	$0.25	$0.35	$0.60	$0.28	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	0.00 Mo	0.50 Mo	1.00 Mo	0.38	30	25	

Presence of soft sediments or thick clay deposits may result in stability issues that require mitigation (e.g. clay removal, structural support, etc.). Risk is that the fill and Essroc Berm needs additional dredging, overexcavation and backfill with select materials.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$0.25	$0.35	$0.60	$0.28	Strategy	3/21/2016
Schedule (Mo)	0.00	0.50	1.00	0.38	Accept	

In-water drilling is expensive & currently not in plan. Have drilled in close proximity of shorelines and extrapolated

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM - Lakefill TRCA		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.09
Sub-Project	Port Lands Flood Protection	Status	Active

Tunnelling Obstructions

Risk Trigger		Flowchart Activity	3

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
10%					36	35	
Cost ($M)	$1.00	$1.50	$2.00	$0.15	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)				0.00	36	35	

Obstructions encountered during microtunnelling. Risk of hitting something while tunnelling.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)	$1.00	$1.50	$2.00	$0.15	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Additional boreholes and alignment transfering information to contract documents and share risk with contractors.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.12
Sub-Project	Port Lands Flood Protection	Status	Active

Dockwall Stability

Risk Trigger		Flowchart Activity	16

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
60%					13	35	
Cost ($M)	$1.00	$3.00	$5.00	$1.80	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	13	35	

The stability of the existing dockwalls poses a potential risk if we have to replace. Dredging in the vicinity of the existing walls will be at or near existing foundations. Keating Channel South wall - 60m high risk, 120m medium risk, 620m low risk. $18.5k/m to replace sheetpile in high risk area.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
60%						
Cost ($M)	$1.00	$3.00	$5.00	$1.80	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Reviewing the dockwall study and will adjust design if required.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.14
Sub-Project	Port Lands Flood Protection	Status	Active

In-situ Soil within the RA/RM Cut is Suitable for Remaining in Place and no Cut Needed.

Risk Trigger		Flowchart Activity	3,4

Dependency & Correlation	

Pre-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
	10%	20%	40%		18	35	
Cost ($M)	-$3.40	-$2.00	-$1.20	-$1.22	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	18	35	

RA/RM (Risk Assessment Risk Management) 265k m3 soil has to be cut and placed back into clean barrier. Potential for 25% to leave in place, uncut - $18/m3 + $15 screening allowance + $20 >> ~$70/m3 savings.

Post-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
	10%	20%	40%			
Cost ($M)	-$3.40	-$2.00	-$1.20	-$1.22	Strategy	3/21/2016
Schedule (Mo)				0.00	Exploit	

Include excavation controls clause in contract defining soil types.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.15
Sub-Project	Port Lands Flood Protection	Status	Active

More Peat and Organic Soil during River Valley Excavation

Risk Trigger		Flowchart Activity	3,4

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
30%					17	35	
Cost ($M)	$1.00	$4.00	$8.50	$1.28	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	17	35	

More peat and organic soils may be encountered during River Valley excavation than predicted and excavation may have to be deeper to overexcavate. North-South segment has a higher potential. Base is overexcavating by 2m, high end of risk assumes additional 2m for 60k m (~50% of the site) - $50/m3 dredge, $50/m3 process, $64/m3 backfill at high end.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
30%						
Cost ($M)	$1.00	$4.00	$8.50	$1.28	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Collecting additional geotech information. Include provisional items for unsuitable soils, excavation, and import in contracts.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.16
Sub-Project	Port Lands Flood Protection	Status	Active

Stockpiling of Soil Inadvertently Changes Flood Risk Profile

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					29	35	
Cost ($M)	$1.00	$1.25	$1.50	$0.31	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	29	35	

Filling or interim stockpiling to construct flood protection may result in interim flood risk to other areas outside the existing inundation zone. Cost risk associated with double-handling stockpiles (additional trucking). Base assumes excavating soil, processed, and temporarily stockpiled before transporting to final destination; risk is soil would be temporarily moved to another temporary location before final destination. Initial modeling for phase 1 and 2 does not show this as impact, modeling for 3 and 4 not yet complete.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
5%						
Cost ($M)	$1.00	$1.25	$1.50	$0.06	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Modeling on proposed construction phasing has suggested that it does not increase flood risk during interim construction.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM - TRCA		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.17
Sub-Project	Port Lands Flood Protection	Status	Active

Polson Quay River Connections

Risk Trigger		Flowchart Activity	3

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
10%					39	31	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)	1.00 Mo	2.00 Mo	3.00 Mo	0.20	39	31	

River connection at Polson Quay is complex and may take up to 3 months more than expected. The bridge may not be in place when we get the sheet pile in place. May not be a risk at this time.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
5%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	1.00	2.00	3.00	0.10	Mitigate	

Planning and phasing of updated shedule.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.18
Sub-Project	Port Lands Flood Protection	Status	Active

Peat / Settlement Issues

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%					22	35	
Cost ($M)	$1.00	$2.00	$3.00	$1.00	Project Rank Cost	Project Rank Schedule	10/5/2015
Schedule (Mo)				0.00	22	35	

Stockpiling soil may cause settlement due to peat and may damage existing utilities. May be some costs to protect in place utilities due to settlement issues. Limited to certain areas with known peat issues.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$1.00	$2.00	$3.00	$0.50	Strategy	3/21/2016
Schedule (Mo)				0.00	Mitigate	

Additional geotech boring locations. Define areas in contract where stockpiling or construction traffic will not be allowed to influence design.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.19
Sub-Project	Port Lands Flood Protection	Status	Active

Opportunity to not Overexcavate River Valley

Risk Trigger		Flowchart Activity	3,4
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
40%					7	4	
Cost ($M)	-$12.50	-$9.00	-$5.50	-$3.60	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	-8.50 Mo	-6.50 Mo	-5.00 Mo	-2.63	7	4	

Assumed overexcavating 2m in base. Opportunity to only have to excavate to 1m below design grade; 380k m3 less excavation. Resulting in 190k m3 (75% area affected), $50 for dredging, $38 for processing, resulting in $12.5M at high end. Related to excavation to construct environmental barrier, does not affect geotech.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
40%						
Cost ($M)	-$12.50	-$9.00	-$5.50	-$3.60	Strategy	3/21/2016
Schedule (Mo)	-8.50	-6.50	-5.00	-2.63	Exploit	

Advance gap analysis and CBRA (Community Based Risk Assessment) and adjust the base cost accordingly.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
WFT Program Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP UTL 10.01
Sub-Project	Port Lands Flood Protection	Status	Active

Utility Conflicts in Design

Risk Trigger		Flowchart Activity	PE1,PE2
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
40%					39	7	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	2.00 Mo	4.00 Mo	6.00 Mo	1.60	39	7	

Revisions to design due to utility conflicts / need for additional crossings. Toronto Hydro is an example of a potential design risk in coordinating project design with their requirements and incorporating into their global package. Delay only to the roads design portion - Cherry, Commissioners.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
20%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	1.00	2.00	3.00	0.40	Mitigate	

Proactively working with utilities & engaged with the City. Looking to identify conflict areas and deal with them in advance. Leave ROW for utilities on side in joint use trench.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP UTL 900.01
Sub-Project	Port Lands Flood Protection	Status	Active

Utility Conflicts during Construction

Risk Trigger		Flowchart Activity	6,7a,8,12,13,14a,14b,14c,14d,15a, 15b,15c
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	20	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	3/21/2016
Schedule (Mo)	1.00 Mo	2.00 Mo	3.00 Mo	0.50	39	20	

Finding of unknown or not previously identified utilities during construction and delays of identified ones being moved. Only on roadway construction. Cost applied as well, but likely minor.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)				$0.00	Strategy	3/21/2016
Schedule (Mo)	1.00	2.00	3.00	0.20	Mitigate	

Identifying and notifying all utilities, mapping them.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design PM		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	3/21/2016
Next Review	**Risk Assignment**
6/1/2016	

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.21
Sub-Project	Port Lands Flood Protection	Status	Active

Soil Treatment Production Rates - West End River/Floodplain (Phase 1) - Cut Area C1

Risk Trigger		Flowchart Activity	x19

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	18	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	6/13/2016
Schedule (Mo)	0.60 Mo	2.20 Mo	3.30 Mo	0.53	39	18	

Production rates of soil treatment are less than expected. Impact assumed to be an additional 5% / 20% / 30% to duration of the activity.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	6/13/2016
Schedule (Mo)	0.60	2.20	3.30	0.53		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.22
Sub-Project	Port Lands Flood Protection	Status	Active

Soil Treatment Production Rates - River Connection at Polson Slip (Phase 4) - Cut Area C4c

Risk Trigger		Flowchart Activity	x25

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	26	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	6/13/2016
Schedule (Mo)	0.40 Mo	1.40 Mo	2.10 Mo	0.34	39	26	

Production rates of soil treatment are less than expected. Impact assumed to be an additional 5% / 20% / 30% to duration of the activity.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	6/13/2016
Schedule (Mo)	0.40	1.40	2.10	0.34		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.23
Sub-Project	Port Lands Flood Protection	Status	Active

Soil Treatment Production Rates - Polson Slip Naturalization (Phase 2) - Cut Area C2c

Risk Trigger		Flowchart Activity	x30

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	18	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	6/13/2016
Schedule (Mo)	0.60 Mo	2.20 Mo	3.30 Mo	0.53	39	18	

Production rates of soil treatment are less than expected. Impact assumed to be an additional 5% / 20% / 30% to duration of the activity.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	6/13/2016
Schedule (Mo)	0.60	2.20	3.30	0.53		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.24
Sub-Project	Port Lands Flood Protection	Status	Active

Soil Treatment Production Rates - Lower Greenway/Spillway (Phase 2) - Cut Area C2b

Risk Trigger		Flowchart Activity	x36

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	26	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	6/13/2016
Schedule (Mo)	0.40 Mo	1.40 Mo	2.10 Mo	0.34	39	26	

Production rates of soil treatment are less than expected. Impact assumed to be an additional 5% / 20% / 30% to duration of the activity.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	6/13/2016
Schedule (Mo)	0.40	1.40	2.10	0.34		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.25
Sub-Project	Port Lands Flood Protection	Status	Active

Soil Treatment Production Rates - Upper Greenway/Spillway & Central River/Floodplain (Ph. 2&3) - Cut Area C2a

Risk Trigger		Flowchart Activity	x42

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	22	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	6/13/2016
Schedule (Mo)	0.50 Mo	1.80 Mo	2.70 Mo	0.43	39	22	

Production rates of soil treatment are less than expected. Impact assumed to be an additional 5% / 20% / 30% to duration of the activity.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	6/13/2016
Schedule (Mo)	0.50	1.80	2.70	0.43		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.26
Sub-Project	Port Lands Flood Protection	Status	Active

Soil Treatment Production Rates - Upper Greenway/Spillway & Central River/Floodplain (Ph. 2&3) - Cut Area C3

Risk Trigger		Flowchart Activity	x46

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	22	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	6/13/2016
Schedule (Mo)	0.50 Mo	1.80 Mo	2.70 Mo	0.43	39	22	

Production rates of soil treatment are less than expected. Impact assumed to be an additional 5% / 20% / 30% to duration of the activity.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	6/13/2016
Schedule (Mo)	0.50	1.80	2.70	0.43		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.27
Sub-Project	Port Lands Flood Protection	Status	Active

Soil Treatment Production Rates - River Connection at Keating Channel (Phase 4) - Cut Area C4a

Risk Trigger		Flowchart Activity	x52

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	17	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	6/13/2016
Schedule (Mo)	0.60 Mo	2.20 Mo	3.40 Mo	0.53	39	17	

Production rates of soil treatment are less than expected. Impact assumed to be an additional 5% / 20% / 30% to duration of the activity.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	6/13/2016
Schedule (Mo)	0.60	2.20	3.40	0.53		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Waterfront Toronto	Risk ID	WT PLFP STG 20.28
Sub-Project	Port Lands Flood Protection	Status	Active

Production rates of soil treatment are less than expected. Impact assumed to be an additional 5% / 20% / 30% to duration of the activity.

Risk Trigger		Flowchart Activity	x58
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%					39	22	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	6/14/2016
Schedule (Mo)	0.50 Mo	1.80 Mo	2.70 Mo	0.43	39	22	

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	6/14/2016
Schedule (Mo)	0.50	1.80	2.70	0.43		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Retired and Inactive Risks

Risk ID	Status	Date Identified	Threat / Opportunity Events	Description
WT PLFP DES 10.01	Retired	10/5/2015	Lakeshore Bridge	Opp: Lakeshore bridge options are being considered related to both replacement and modification. There may be a relocation requirement that comes out of the broader Gardiner planning effort or build as part of Gardiner. The base cost Assumes $28.8M for bridge and rail extension - could be less, shared with Gardiner project. Assumes they do it before WT widens channel. Could remove 6-12 months but Gardiner has longer duration; could incur more time.
WT PLFP UTL 10.03	Retired	3/21/2016	Hydro One Relocations	Base cost is ~$40M; opportunity to save ~$15M if towers left in place and only replace the utility bridge over Lower Don River. Mix of required and discretionary needs with the towers.
WT PLFP CNS 10.01	Inactive	10/5/2015	Maintain Traffic Flows	The requirement to maintain traffic requires additional time during construction. Minor risk, covered in 15% design allowance.
WT PLFP CNS 30.02	Inactive	10/5/2015	Planting Seasons	Can put dirt in but can't necessarily plant (wetlands etc.) that same season. Minor risk, watch list.
WT PLFP CNS 70.03	Inactive	10/5/2015	Bedrock is deeper than expected based on current data	Potential increased costs due to increase in depth of bedrock. Minor risk, may be captured in base cost uncertainty.
WT PLFP CNS 70.05	Inactive	10/5/2015	Assumed earthworks production rates different than anticipated	Covered in other risk
WT PLFP CNS 70.06	Inactive	10/5/2015	Over excavation in the River Valley may not be needed.	Covered
WT PLFP CNS 70.07	Inactive	10/5/2015	Significant haulage of soil around sites with variability in haulage costs	Project haulage costs sensitive to fuel costs. To be covered in global market conditions risk.
WT PLFP CNS 70.11	Inactive	10/5/2015	Fill Availability - Clay	Delays in obtaining suitable soil within the timeline required for construction of landforms. Risk that part (25%) of Valley Wall volume (160k m3) requires import of clay. Minor risk.

Risk ID	Status	Date Identified	Threat / Opportunity Events	Description
WT PLFP CNS 70.12	Inactive	10/5/2015	Fill Availability	The volume of soil geotechnically suitable for use within the project limits is less than anticipated, requiring amendment. Watch list opportunity.
WT PLFP CNS 70.13	Inactive	10/5/2015	Fill Availability	The volume of soil geotechnically suitable for use within the project limits is less than anticipated, requiring supply from outside sources. Covered in other risk.
WT PLFP CNS 70.14	Inactive	10/5/2015	Fill Availability	Increased costs from exporting more soil than anticipated as result of soil quality not as expected. Covered in other risk.
WT PLFP CNS 70.15	Inactive	10/5/2015	Plantings requirements (vitality and die off) cause delay in finalizing earthworks section.	Minor risk.
WT PLFP CNS 90.01	Inactive	10/5/2015	Public Access during Construction	Some site areas may be used as public venues. Access restrictions and temporary public access requirements could impact cost and schedule. Assumed to be part of design allowance.
WT PLFP CNS 900.02	Inactive	10/5/2015	Demolition Delays	Delay in demolishing properties causes other construction delays. Preliminary base cost estimate is ~$30M, 2 months of schedule for demolition. Minor risk, watch list.
WT PLFP CNS 900.05	Inactive	10/5/2015	Presence of methane changes excavation requirements	Covered in other risk
WT PLFP CTR 10.01	Inactive	10/5/2015	Changes in project delivery methods	Revising the assumed project delivery method impacts cost and schedule. Will be covered through VFM.
WT PLFP CTR 40.01	Inactive	10/5/2015	Availability of Resources	Labour strike or lack of competent contractors. Limited number of qualified landscaping contractors in Toronto and lots of landscaping. Watch list.
WT PLFP CTR 900.01	Inactive	10/5/2015	Coordination of Contract activities between parallel Port Lands work, and other major capital projects	To make the required timeframes, many construction sites will need to proceed at the same time, as well as works on the Gardiner, Don River and Central Waterfront Project, TTC relief line, and possibly the Metrolinx expansion. Traffic, raw material supplies, available contractors, and coordination of activities will be necessary with all this activity underway. Watch list - needs to

Risk ID	Status	Date Identified	Threat / Opportunity Events	Description
				be closely coordinated.
WT PLFP DES 10.02	Inactive	10/5/2015	Scope gaps in design	Incomplete design or last minute changes to design by third party. Base includes a 15% design allowance. Allowance need to be made as design progresses for public art, stakeholder requests, etc. Minor risk at this time.
WT PLFP DES 10.04	Inactive	10/5/2015	Cherry St. bridge design	Uncertainty about Cherry St. bridge over Keating Channel design and associated risks. Risk that design competition causes delays due to reconsideration of design and additional procurement. Base includes Cherry St. and Cell 1&2. Base schedule assumes design competition is 3 months before funding approval of overall project - time for competition is built in. Minor aggregate risk.
WT PLFP DES 10.05	Inactive	10/5/2015	Water Treatment Plant needs to be upgraded to treat volume/quality of water	Minor item
WT PLFP DES 10.08	Inactive	10/5/2015	Civilian Facilities	Risk that City will require additional civilian facilities such as restrooms, pavilion structure, etc. that are not included in the base cost. Assumed to be outside of project scope.
WT PLFP DES 40.01	Inactive	10/5/2015	Interconnected element design	Multiple design firms working on interconnected elements may cause conflicts resulting in project delays and increased costs. Base assumes using construction managers as advisors to design. Minor risk
WT PLFP DES 40.03	Inactive	10/5/2015	Opp: Avoided lakeshore Blvd. modifications	Covered in other risk
WT PLFP DES 60.02	Inactive	10/5/2015	CBRA approach for River Valley not accepted by future owners	CBRA approach not accepted and site specific risk assessment approach is required. Cost and schedule impact. Minor risk.
WT PLFP DES 900.03	Inactive	10/5/2015	Opportunity for On-site Nursery	Pre-sourcing material, making sure we have it in place, etc. May be able to partner with the City or TRCA to use their nurseries. This is a potential response for another risk for landscaping unavailability. Watch list item.

Risk ID	Status	Date Identified	Threat / Opportunity Events	Description
WT PLFP ENV 30.02	Inactive	10/5/2015	Regulatory Review	Regulatory agencies may take longer to review than anticipated Covered in other risk
WT PLFP ENV 30.03	Inactive	10/5/2015	Environmental compliance approval	Environmental compliance approval/sign-off may take longer than programmed - assumed 3 iterations of reviews, it may take more than 3
WT PLFP ENV 30.04	Inactive	10/5/2015	DFO Permits	Timing of river filling and delayed completion can result in having to re-negotiate with DFO. Actively working with DFO, not really a risk at this time.
WT PLFP ENV 30.05	Inactive	10/5/2015	Permitting delays	Permit comes with condition, can't give NTP until permit although procurement can happen in advance. Captured under ECA
WT PLFP ENV 50.01	Inactive	10/5/2015	Duplicate	Areas of contaminated soils are found to be unsuitable for reuse within the project limits and require disposal as hazardous waste (i.e. registerable waste under the Ontario Regulation 347 context)
WT PLFP ENV 50.03	Inactive	10/5/2015	Hazardous Material/ Contaminated material	The volume of soil environmentally suitable for use within the project limits is less than anticipated, requiring treatment. Covered in other risk.
WT PLFP ENV 50.04	Inactive	10/5/2015	Hazardous Material/ Contaminated material	The volume of soil environmentally suitable for use within the project limits is less than anticipated, requiring supply from outside sources Covered in other risk.
WT PLFP ENV 50.05	Inactive	10/5/2015	Contaminated Soil and Groundwater	Larger areas of impermeable barriers will be required within the river channel footprint than initially anticipated. Covered in other risk.
WT PLFP ENV 50.06	Inactive	10/5/2015	Hazardous Material/ Contaminated material	Soil and groundwater contamination requires engineered controls or personal protective equipment during construction. Covered in other risk.
WT PLFP ENV 50.07	Inactive	10/5/2015	Hazardous Material/ Contaminated material	Contaminant types and/or concentrations require the use of non-standard materials for the river channel liner. Covered in other risk.
WT PLFP ENV 50.08	Inactive	10/5/2015	Hazardous Material/ Contaminated material	Contaminant types and/or concentrations require the use of non-standard materials for the utilities or the requirement to use utilidors. Covered in other risk.
WT PLFP ENV 50.09	Inactive	10/5/2015	Hazardous Material/ Contaminated material	Groundwater conditions or the occurrence of non-aqueous phase liquids require interim/temporary control (e.g. cut off walls) prior to river channel construction or permanent liner placement. Covered in other risk.

Risk ID	Status	Date Identified	Threat / Opportunity Events	Description
WT PLFP ENV 50.20	Inactive	10/5/2015	Hazardous Material	Areas of contaminated soils are found to be unsuitable for reuse within the project limits and require disposal as hazardous waste (i.e. registerable waste under the Ontario Regulation 347 context)
WT PLFP ENV 70.02	Inactive	10/5/2015	Heavy Rainfall Stormwater Excavation Overflow Treatment	Minor risk, watch list.
WT PLFP ENV 80.01	Inactive	10/5/2015	Methane occurrence	Areas of methane gas occurrence are encountered, delaying site work or requiring engineered controls. Natural peats can generate methane concentrations - current investigation hasn't identified any. Risk is that they exist meaning changes in construction practices. Watch list.
WT PLFP ENV 80.03	Inactive	10/5/2015	Offsite flood impacts during construction	Increased risk to adjacent sites during construction, should a flood occur; currently mitigated by design.
WT PLFP MGT 30.01	Inactive	10/5/2015	Delay of Funding	Delay in funding causes additional costs and project delays. Scenarios will be run based off funding if requested.
WT PLFP MGT 900.01	Inactive	10/5/2015	Soft Costs	Base assumes 20% for environmental monitoring, design, and construction admin & management. Risk of a higher percentage. -10/+15% of base cost range covers the uncertainty.
WT PLFP PSP 20.01	Inactive	10/5/2015	Nuisance odours or volatile cause a stop work order	Covered in other risk.
WT PLFP PSP 30.01	Inactive	10/5/2015	Construction activities impede productivity/commercial viability of existing tenants	Primarily for shipping traffic - mainly one ship with opportunity to work around the shipping schedule. Watch list risk, within design allowance.
WT PLFP ROW 50.02	Inactive	10/5/2015	Un-willing sellers of property	Potential delay and added costs to acquire property from un-willing sellers / pay off leasees. Not a lot of private land. Minor risk.
WT PLFP ROW 900.01	Inactive	10/5/2015	Phasing of Port Lands Works versus Private Development Block Works	This is particularly important with the Villiers Island, and First Gulf sites - how to advance public work undertakings in conjunction with the private development areas without impacting both components. Minor risk.
WT PLFP STG 10.01	Inactive	10/5/2015	Lakeshore bridge replacement	Lakeshore bridges may need replacement instead of extension. Covered in other risk.

Risk ID	Status	Date Identified	Threat / Opportunity Events	Description
WT PLFP STG 10.02	Inactive	10/5/2015	Lakeshore bridge issues	Hydraulic issues on Lakeshore bridge – hydraulic conveyance under the bridge in channel. Currently clearance is tight. Based on current status of Gardiner, assume we're at minimum conveyance clearance.
WT PLFP STG 10.03	Inactive	10/5/2015	Cherry St. bridge design	Interference with existing dockwall structure. Not a risk at this time.
WT PLFP STG 10.04	Inactive	10/5/2015	Lakeshore bridge modification	Existing structure foundations not able to take increased loads (e.g. from grade raise, new bridge structure, etc.). Covered in other risk.
WT PLFP STG 20.01	Inactive	10/5/2015	Soil remediation	Removed soil will be used to generate additional land forms into the harbor. Covered in other risk.
WT PLFP STG 20.03	Inactive	10/5/2015	Settlement Issues - East of Cherry Street to Don Roadway	Preloading, surcharging or other settlement mitigation measures are required prior to future utility/roadway/hard programming construction, increasing costs and/or delaying project schedule. Covered in other risk.
WT PLFP STG 20.04	Inactive	10/5/2015	Settlement Issues - East of Don Roadway	Preloading, surcharging or other settlement mitigation measures are required prior to future utility/roadway/hard programming construction, increasing costs and/or delaying project schedule. Covered in other risk.
WT PLFP STG 20.06	Inactive	10/5/2015	Grade raise around heritage structures	Grade raises around heritage structures resulting in settlement around heritage structures, damaging services to these structures or requiring means to maintain the integrity of existing services. Covered in the base cost estimate, not a risk at this time.
WT PLFP STG 20.07	Inactive	10/5/2015	Excavations around heritage structures	Heritage structures require support during excavations for utilities. Not a risk at this time.
WT PLFP STG 20.08	Inactive	10/5/2015	Obstructions during bridge construction	Obstructions encountered during installations of piles for bridge supports. Piling, not shafts. Covered in other risk & minor risk.
WT PLFP STG 20.10	Inactive	10/5/2015	Pumping Station Construction	Requirements and costs for groundwater management during shaft installation and ongoing operation are greater than anticipated. Minor aggregate risk.
WT PLFP STG 20.11	Inactive	10/5/2015	Tunnelling	Requirements and costs for groundwater management during tunnel installation and ongoing operation are greater than anticipated. Dewatering for shafts. Covered in other risk.

Risk ID	Status	Date Identified	Threat / Opportunity Events	Description
WT PLFP STG 20.13	Inactive	10/5/2015	Bridge or structure foundations	The occurrence of a suspected bedrock valley in the area east of Cherry Street requires deeper structural supporting elements. Minor risk.
WT PLFP STG 20.20	Inactive	10/5/2015	Presence of groundwater	Dewatering/stabilization delays construction schedule. Covered in other risk.
WT PLFP STG 30.01	Inactive	10/5/2015	Changes in structure type	Revisions in structure and foundations type could add cost. Minor risk covered in base cost uncertainty.
WT PLFP STG 50.12	Inactive	10/5/2015	Assumptions made on percentages of soil that can be directly reused prove to be incorrect	Soil cannot be directly reused and will have to be treated/remediated first. Volume of soil to be remediated increases. Covered in other risk.
WT PLFP STG 900.01	Inactive	10/5/2015	Don Roadway Valley Wall Feature	Don Roadway wall feature may not be ready to accept soils and there may not be room for stockpiling. Minor risk, covered in other risk.
WT PLFP UTL 10.02	Inactive	10/5/2015	Utility Conflicts in Design - Hydro One	Hydro One may object/delay relocation of distribution/transmission lines. Currently working with Hydro One on feasibility study. Minor risk at this time.
WT PLFP UTL 900.02	Inactive	10/5/2015	Utilities ROW	May need to work outside WT ROW during utilities installations resulting in additional costs. Potential to need construction easements. Minor risk.
WT PLFP DES 10.06	Retired	10/5/2015	Sediment Management Basin Design Uncertainty	For example, Sediment management technology and management approach to be confirmed in 2016, INCLUDING new water vessels that will fit under the fixed Cherry Street Bridge. Physical hydraulic model to test and refine the numerical model operation of the weir systems. Risk of time to the design schedule. Update 3/21/2016 risk can be retired as can be done concurrently under revised schedule.
WT PLFP DES 900.01	Retired	10/5/2015	Opportunity to Advance Design	Base assumes final design package starting July 1st, opportunity to move it up 3 months. Update 3/21/2016 as schedule has changed to Oct 1; no longer opportunity to advance.

Appendix C – Risk Workshop Agenda

Cost Risk Assessment Workshop Agenda
Waterfront Toronto

October 6-7, 2015
Location: WT Office

Meeting Objectives:

1. Common understanding among participants of the Cost Risk Analysis Process.
2. Describe Project characteristics, schedule, cost, and risk issues.
3. Review project schedule and cost estimate.
4. Develop Risk Response Strategies

Participants: All Workshop Participants be there at 8:00 AM on Day 1 and then return at the designated time in the agenda.

Core Group: Julius Gombos, Veronica Bergs, Simon Karam, Ken Smith, Fred Kramer, Jose Theiler, Serguei Kouznetsov

Tuesday 09/6/2015	***Topic***	***Lead***	***Attending (Alphabetical Order)***
8:00 - 8:15	**Welcome, sign-in, updates, etc. Introductions Agenda Review**	Ken Smith	All
8:15 - 8:45	**Overview of CRA process**	Ken Smith	All
8:45 - 10:00	**Project Briefing** Project Presentation / Base Schedule Review	Project Team	All
10:00 - 10:15	**Break**		
10:15 - 10:45	**Flowchart (Schedule) Finalization & Concurrence**	Ken Smith	All
10:45 - 11:00	**Base Cost Review Discussion** ▪ Top cost items ▪ Cost uncertainty	Ken Smith	All
11:00 - 12:00	**Brainstorm Issues**	Ken Smith	All
12:00 - 1:00	**Lunch**		
1:00 - 3:00	**Design Risk**	Ken Smith	Aisling O'Carroll, Chris Glaisek, Core Group, Edward Ng*, Ghassan Hariri*, Herb Sweeney, Ken Dion, Meggen Janes, Paul Passalent, Pedram MolkAra, Pina Mallozzi, Rehana Rajabali, Shawn Walters, Steven Desrocher, Stu Seabrook, Tim Dekker, Tina Panagoulia*
3:00 - 3:15	**Break**		
3:15 - 5:00	**Permitting and Environmental Risk**	Ken Smith	Amanda Santo*, Brett Howell*, Camilo Martinez, Chris Glaisek, Core Group, David Hatton, David Kusturin,

			Edward Ng*, Ghassan Hariri*, Herb Sweeney, Ken Dion, Lisa Prime, Meg Davis*, Meggen Janes, Paul Passalent, Pina Mallozzi, Shawn Walters, Steve McKenna*, Steven Desrocher
5:00	**Adjourn**		

Wednesday 09/7/2015	***Topic***	***Lead***	***Attending (Alphabetical Order)***
8:00 - 10:00	**Earthworks and Flood Protection Projects**	Ken Smith	Aisling O'Carroll, Camilo Martinez, Core Group, Edward Ng*, George Hicks, Ghassan Hariri*, Herb Sweeney, Ken Dion, Lisa Prime, Mark Preston, Meggen Janes, Paul Passalent, Pedram MolkAra, Pina Mallozzi, Rehana Rajabali, Richard Aqui, Shawn Walters, Stu Seabrook, Terry Lorentz, Tim Dekker, Tina Panagoulia*
10:00 - 10:15	**Break**		
10:15 - 12:00	**Earthworks and Flood Protection Projects**	Ken Smith	Aisling O'Carroll, Camilo Martinez, Core Group, Edward Ng*, George Hicks, Ghassan Hariri*, Herb Sweeney, Ken Dion, Lisa Prime, Mark Preston, Meggen Janes, Paul Passalent, Pedram MolkAra, Pina Mallozzi, Rehana Rajabali, Richard Aqui, Shawn Walters, Stu Seabrook, Terry Lorentz, Tim Dekker, Tina Panagoulia*
12:00 - 1:00	**Lunch (provided)**		
1:00 - 3:00	**Roadwork/Bridge/Utilities Risk**	Ken Smith	Aisling O'Carroll, Amanda Santo*, Core Group, David Kusturin, Edward Ng*, Elsy Aceves*, Ghassan Hariri*, Herb Sweeney, Ken Dion, Pedram MolkAra, Pina Mallozzi, Rehana Rajabali, Richard Aqui, Shawn Walters, Stu Seabrook, Tim Dekker
3:00 - 3:15	**Break**		
3:15 - 4:00	**Public Realm Risk**	Ken Smith	Brett Howell*, Chris Glaisek, Core Group, Edward Ng*, Ghassan Hariri*, Herb Sweeney, Pina Mallozzi, Richard Aqui, Steve McKenna*
4:00 - 4:30	**Management and Stakeholders Risk**	Ken Smith	Amanda Santo*, Brett Howell*, Core Group, David Kusturin, Edward Ng*, Ghassan Hariri*, Herb Sweeney, Ken Dion, Kevin Newson*, Lisa Prime, Meg Davis*, Pina Mallozzi, Richard Aqui, Steve McKenna*, Tina Panagoulia*
4:30 - 5:00	**Funding & Market Conditions Risk**	Ken Smith	Amanda Santo*, Brett Howell*, Core Group, David Kusturin, Edward Ng*, Ghassan Hariri*, Herb Sweeney, Kevin Newson*, Meg Davis*, Richard Aqui, Steve McKenna*
5:00	**Adjourn**		

*** Optional Attendees**

Update Cost Risk Assessment Workshop Agenda
Toronto Waterfront

March 21, 2016

Location: Waterfront Toronto, 20 Bay Street, Suite 1310 – Turquoise Room (North 12)

Meeting Objectives:

1. Common understanding among participants of the Cost Risk Analysis (CRA) Process.
2. Describe Project characteristics, schedule, cost, and risk issues, focusing on what has changed/been confirmed since October 2015 initial risk workshop
3. Review updated project schedule; anticipated changes to cost estimate; key risks and response strategies
4. Clearly identify required "homework" for meeting participants to finalize inputs to HDR's CRA update.

Core Group: WT: Julius Gombos, Veronica Bergs, Camilo Martinez, Lisa A Prime, Pina Mallozzi; **WSP/MMM:** Shawn Walters, Aaron Small; **CH2M:** Paul Passalent, Pedram Molkara; **Hanscomb:** Richard Aqui; **TRCA:** Ken Dion, Don Ford; **City of Toronto:** Steve McKenna

Monday 3/21/2016	***Topic***	***Lead***	***Participants***
9:00 – 9:10	**Welcome, sign-in, updates, etc.** **Introductions Agenda Review**	Ken Smith	All
9:10 - 9:30	**Overview of CRA process**	Ken Smith	All
9:30 – 10:10	**Project Update Briefing** **Business Relocation & Disposition of Existing Buildings** **Accommodation of Transit Facilities** **Project Schedule Presentation/High Level Discussion**	Veronica Bergs/Julius Gombos	All
10:10 – 10:30	**Base Cost Review Discussion** ▪ Key changes from interim estimate ▪ Top cost items ▪ Cost uncertainty	Julius Gombos	All
10:30 – 10:45	**Break**		
10:45 – 11:15	**Roads, Services and Utilities** ▪ Service Protection, Access Maintenance, and Temporary Construction ▪ New Services and Facilities ▪ ROW Easement ▪ HONI Relocations	Ken Smith	Core Group
11:15 – 12:00	**Structures** ▪ New Bridge Design/Construction ▪ Lakeshore Road/Rail Bridge Extensions ▪ Flow Control Weirs ▪ New and Modified Dockwalls	Ken Smith	Core Group

Monday 3/21/2016	*Topic*	*Lead*	*Participants*
12:00 – 12:30	**Environmental and Permitting** ▪ Environmental Documentation ▪ Environmental Permitting (CBRA, AHT, etc.) ▪ Other Required Permits	Ken Smith	Core Group
12:30 – 1:15	**Lunch**		
1:15 – 1:45	**Civil (Earthwork) Design**	Ken Smith	Core Group
1:45 – 3:15	**Construction** ▪ Define risks ▪ Response Strategies	Ken Smith	Core Group
3:15 – 3:30	**Break**		
3:30 – 4:00	**Recap of Top Project Risks and "Homework" Assignments**	Ken Smith	Core Group
4:00 – 4:30	**Contracting Strategy & Market Conditions** ▪ Contracting ▪ Escalation Sensitivity	Ken Smith	WT, Hanscomb, HDR, City
4:30 – 5:00	**Other Business**	Ken Smith	WT, Hanscomb, HDR, City
5:00	**Adjourn**		

Appendix D – Risk Workshop Attendance List

Cost Risk Assessment Workshop
Waterfront Toronto

Sign-in Sheet **Tuesday October 6, 2015**

Name	Company	Time
Aceves, Elsy		
Aqui, Richard	Hanscomb	8:19 on
Davis, Meg	Waterfront Toronto	
Dekker, Tim		
Desrocher, Steven	GOLDER	8:00
Dion, Ken	TRCA	8:00
Glaisek, Chris		
Hariri, Ghassan	EY	8:00
Hatton, David		
Hicks, George		
Howell, Brett		
Janes, Meggen		
Kusturin, David	—	
Lorentz, Terry		
Mallozzi, Pina	waterfront T	
Martinez, Camilo	waterfront T	
McKenna, Steve		
MolkAra, Pedram	CH2M	8:08
Newson, Kevin		
Ng, Edward	EY	800
O'Carroll, Aisling		
Panagoulia, Tina		
Passalent, Paul	CH2M	8:00
Preston, Mark		
Prime, Lisa		
Rajabali, Rehana		
Santo, Amanda	waterfront to	
Seabrook, Stu	Riggs Engineering	7:55
Sweeney, Herb	MVVA	7:50
Walters, Shawn	mmm	8:01
Panday, Dale	Hanscomb	
COYNE, LISA	GOLDER ASSOCIATES.	
Meggen James	CH2M	
[illegible]	mmm	8:01
EMILY MUELLER DE CUNS	MVVA	8:11
Ken Smith	HDR	7:30
Jose Theiler	HDR	7:30
	[illegible]	10
Kouznetsov, Serguei	HDR	7:30
KRAMER, PAUL	HDR	7:30

Cost Risk Assessment Workshop
Sign-in sheet

Sign-in Sheet — Wednesday October 7, 2015

Name	Company	Time
Aceves, Elsy		
Aqui, Richard	HANSCOMB	8:12pm
Davis, Meg		
Dekker, Tim		
Desrocher, Steven		
Dion, Ken	TRCA	8:00 am.
Glaisek, Chris		
Hariri, Ghassan		
Hatton, David		
Hicks, George	CH2M	7:50
Howell, Brett		
Janes, Meggen	CH2M	7:50
Kusturin, David		
Lorentz, Terry	CH2M	7:50
Mallozzi, Pina	WT	8:00 AM
Martinez, Camilo	WT	7:50 AM
McKenna, Steve		
MolkAra, Pedram	CH2M	7:50
Newson, Kevin		
Ng, Edward		
O'Carroll, Aisling		
Panagoulia, Tina		
Passalent, Paul	CH2M	7:50
Preston, Mark		
Prime, Lisa		
Rajabali, Rehana	TRCA	8:00
Santo, Amanda		
Seabrook, Stu	Kriegs Engineering	7:50
Sweeney, Herb	MVVA	7:50
Walters, Shawn		
THEILER, JOSE	HDR	7:50
SMITH KEN	HDR	7:30
Kouznetsov, Serguei	HDR	7:30
KRAMER, FRED	HDR	7:30
FORD, DON	TRCA	8:00 am
DAVID HATTON	TRCA	8:00 am
Mark Preston	TRCA	8:00 am
SIMON KARAM	WT	8:00 AM
COYNE, LISA	GOLDER	8:00 am
JULIUS GOMBOS	WT	8:00
DOUG DIXON	MMM	1:00 - 3:00
EMILY MUELLER DE GEUS	MVVA	8 - 4

CRA – Workshop					HDR	
March			NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE
21						Office / Cell / EMAIL
✓			Ken Smith	HDR	Risk Lead	(360) 570-4415 (360) 451-2527 Ken.I.smith@hdrinc.com
✓			Serguei K.	HDR	Sr. Economist	647-777-4950 416-543-2899 serguei.kountsov@hdrinc.com
✓			Fred Kramer	HDR	Principal Economist	403-404-4022 FRED.KRAMER@HDRINC.COM
✓			Don Ford	TRCA	Remediation	416-661-6600 647-287-1550 dford@trca.on.ca
✓			Aaron Small	MMM	Civil	905 882 1100 647 920 4357 Smalla@mmm.ca
✓			Shawn Walters	mmm	Civil	905 882-1100 647-222-0460 waterssa@mmm.ca
✓			Ken Dion	TRCA	Project Manager	416 661 6600 x1570 416 985 0780 kdion@trca.on.ca
✓			C. MARTINEZ	WT	PROJECT MANAGER	416-303 1445 CMARTINEZ@WATERFRONTORONTO
✓			R. AQUI	HANSCOMB	COST CONSULTANT	416 487 3811 EXT 256 raqui@hanscomb.com
✓			P. PASSALENT	CH2M	ENVIRONMENTAL & EARTHWORKS	416-499-0090 EX 73532 PAUL.PASSALENT@CH2M.COM

			CRA – Workshop		HDR		
March			NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE	
21						Office	Cell
						EMAIL	
			JULIUS GOMBOS	WT	SENIOR PROJECT DIRECTOR -		647.262.2647
						jgombos@waterfrontoronto.ca	
			Steve McKenna	CT	Project Manager	smckenna@toronto.ca	
						416 397 4082	
			LISA PRIME	WT	Director Env. Innovation		416-214-1344
						lprime@waterfrontoronto.ca	

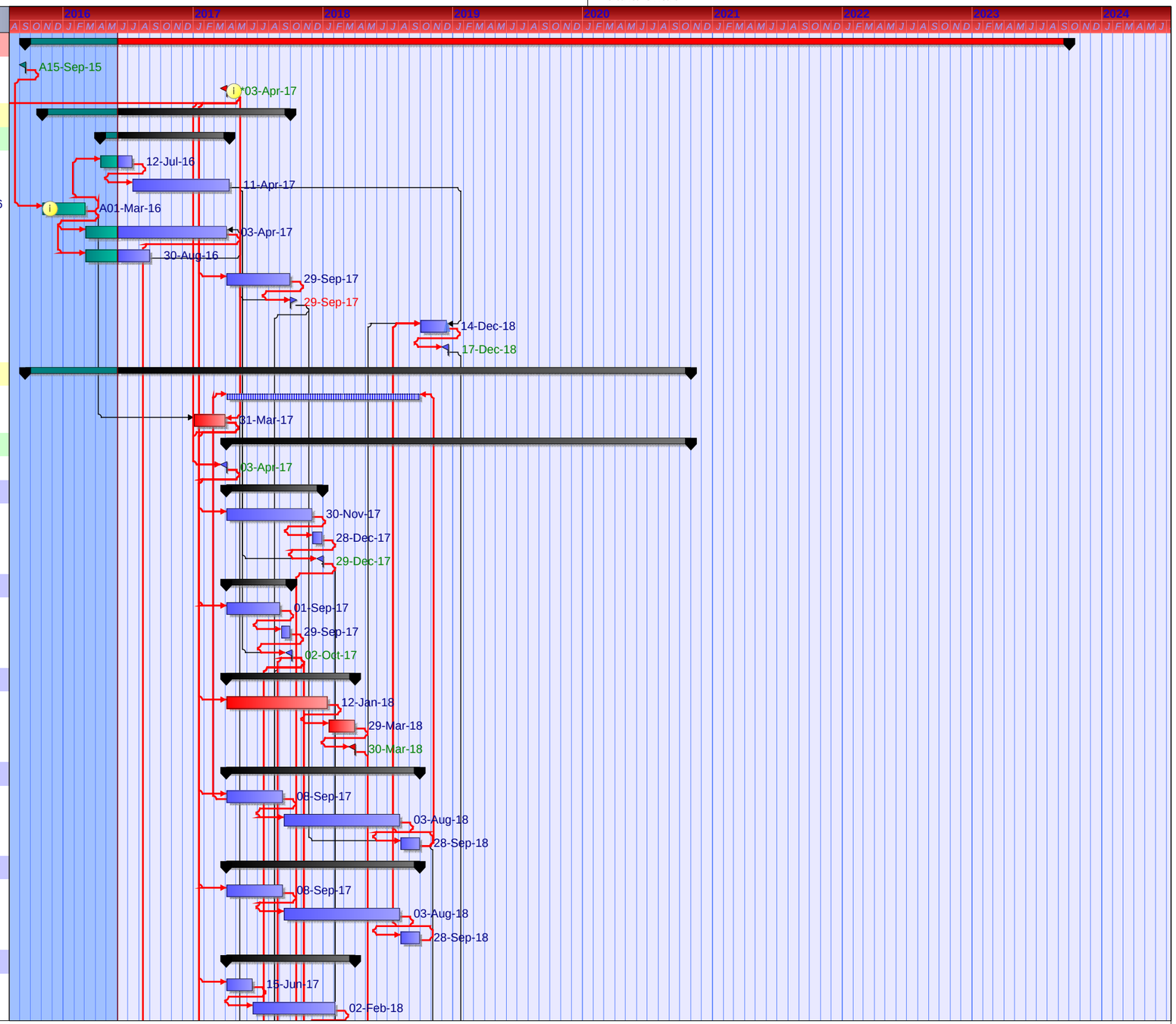
Appendix E – Detailed Project Schedule

WaterfronToronto

Initial Draft 6/10/2016 Update

Gantt Chart

ID	Estimate Source	Description	Remaining Duration	Start	Finish
WF-000		WATERFRONT TORONTO PROJECT	1913	A15-Sep-15	29-Sep-23
WF-100		Project Start	0	A15-Sep-15	
WF-100-01		Funding Availability Due	0	*03-Apr-17	
WF-100-05		Environmental Site Assessment	486	A02-Nov-15	29-Sep-17
WF-100-03		Permitting (Environmental)	225	A13-Apr-16	11-Apr-17
WF-100-35		Prepare Permits package	30	A13-Apr-16	12-Jul-16
WF-100-40		Approval Process by Regulatory agency	195	13-Jul-16	11-Apr-17
WF-100-10		Terms of Reference	0	A02-Nov-15	A01-Mar-16
WF-100-15		CBRA	219	A02-Mar-16	03-Apr-17
WF-100-20		Data Gap Delineation	65	A02-Mar-16	30-Aug-16
WF-100-25		Pilot Soil Testing	130	03-Apr-17	29-Sep-17
WF-100-50		Environmental Site Assessment Sign-off	0		29-Sep-17
WF-170		Procurement	55	01-Oct-18	14-Dec-18
WF-171		NTP	0	17-Dec-18	
WF-PE		Preliminary Engineering	1000	A15-Sep-15	30-Oct-20
WF-PE-120		Permitting	390	03-Apr-17	28-Sep-18
WF-PE-130		Design Procurement	65	02-Jan-17	31-Mar-17
WF-PE-CORE		PE Core Work Scope	935	03-Apr-17	30-Oct-20
WF-PE-CORE-001		Design Begins	0	03-Apr-17	
WF-PE-130-ADV-002		Excavation, Sorting, and Stockpiling	195	03-Apr-17	29-Dec-17
WF-PE-130-ADV-02		Design	174	03-Apr-17	30-Nov-17
WF-PE-130-ADV-020		Approvals and Tendering	20	01-Dec-17	28-Dec-17
WF-PE-130-ADV-025		NTP	0	29-Dec-17	
WF-PE-130-ADV-003		Essroc Quay (Cell 1 & 2) and Bridges	131	03-Apr-17	02-Oct-17
WF-PE-130-ADV-030		Design	110	03-Apr-17	01-Sep-17
WF-PE-130-ADV-040		Approvals and Tendering	20	04-Sep-17	29-Sep-17
WF-PE-130-ADV-045		NTP	0	02-Oct-17	
WF-PE-130-ADV-004		Essroc Quay Cell 3	260	03-Apr-17	30-Mar-18
WF-PE-130-ADV-004-010		Design	205	03-Apr-17	12-Jan-18
WF-PE-130-ADV-004-015		Approvals and Tendering	54	15-Jan-18	29-Mar-18
WF-PE-130-ADV-004-020		NTP	0	30-Mar-18	
WF-PE-140		Road and Municipal Services	390	03-Apr-17	28-Sep-18
WF-PE-141		First Engineering (30% plans) - Submittal	115	03-Apr-17	08-Sep-17
WF-PE-142		Final Design	235	11-Sep-17	03-Aug-18
WF-PE-143		Tender Documents	40	06-Aug-18	28-Sep-18
WF-PE-150		River/Flood Protection Design Package	390	03-Apr-17	28-Sep-18
WF-PE-151		First Engineering (30% plans) - Submittal	115	03-Apr-17	08-Sep-17
WF-PE-152		Final Design	235	11-Sep-17	03-Aug-18
WF-PE-153		Tender Documents	40	06-Aug-18	28-Sep-18
WF-PE-160		HYDRO ONE Design Package	260	03-Apr-17	30-Mar-18
WF-PE-161		First Engineering (30% plans) - Submittal	54	03-Apr-17	15-Jun-17
WF-PE-162		Final Design	166	16-Jun-17	02-Feb-18



Normal Task | Normal, Critical | Normal, Actual | Summary Task | Summary, Critical | Summary, Actual | Start Milestone Task | Start Milestone, Critical | Start Milestone, Actual

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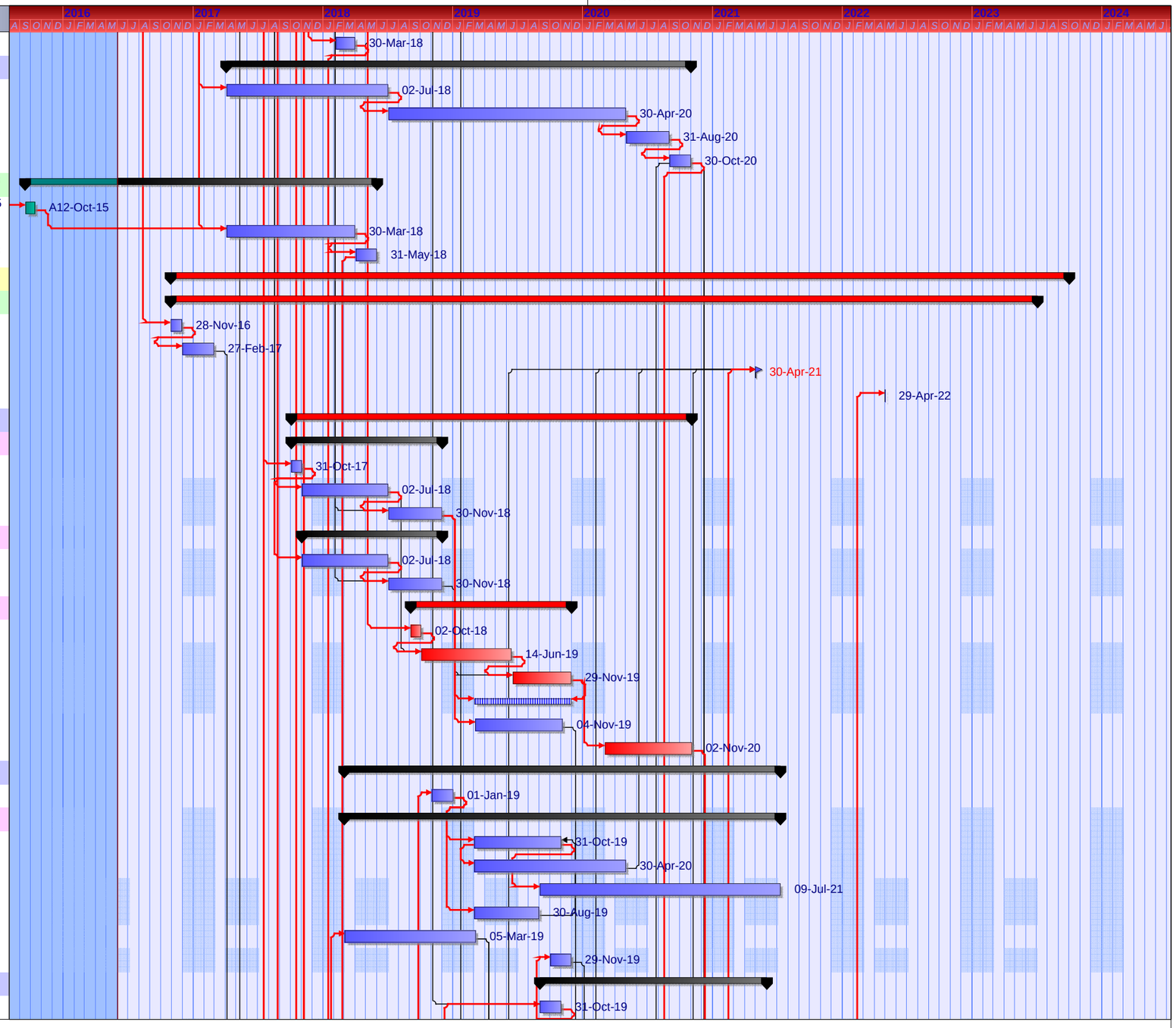
Gantt Chart

ID	Estimate Source	Description	Remaining Duration	Start	Finish
WF-PE-163		Tender Documents	40	05-Feb-18	30-Mar-18
WF-PE-170		Parks Design and Approvals	935	03-Apr-17	30-Oct-20
WF-PE-170-1		First Engineering (30% plans) - Submittal	326	03-Apr-17	02-Jul-18
WF-PE-170-2		Final Design	478	03-Jul-18	30-Apr-20
WF-PE-170-3		Design & Construction Permitting	87	01-May-20	31-Aug-20
WF-PE-170-4		Tender Documents	44	01-Sep-20	30-Oct-20
WF-PE-200		Property Acquisition	304	A15-Sep-15	31-May-18
WF-PE-205		Termination Notice	0	A15-Sep-15	A12-Oct-15
WF-PE-210		Lease Termination	260	03-Apr-17	30-Mar-18
WF-PE-230		Demolition	44	02-Apr-18	31-May-18
WF-PROJ		Construction Projects	1806	28-Oct-16	29-Sep-23
WF-EW		Earthworks and Flood Protection Projects	1742	28-Oct-16	03-Jul-23
WF-EW-0001		Staging/General Conditions	22	28-Oct-16	28-Nov-16
WF-EW-0002		Soil Processing Plant	65	29-Nov-16	27-Feb-17
WF-EW-0003		Soil Treatment Ends	0		30-Apr-21
WF-001-8185		Flood Protection Works Complete	1	29-Apr-22	29-Apr-22
WF-EW-001	1	Essroc Quay Armouring and Lakefill	806	02-Oct-17	02-Nov-20
WF-EW-001-C1	1A	Phase 1A - Cell 1 (Essroc Quay North Side)	305	02-Oct-17	30-Nov-18
WF-EW-001-C1-300		Site Preparation	22	02-Oct-17	31-Oct-17
WF-EW-001-C1-301		Confinement Structure (Sheet Piling and berm)	110	01-Nov-17	02-Jul-18
WF-EW-001-C1-302		Fill	109	03-Jul-18	30-Nov-18
WF-EW-001-C2	1A	Phase 1A - Cell 2 (Essroc/Cousins Quay Internal)	283	01-Nov-17	30-Nov-18
WF-EW-001-C2-311		Confinement Structure (Berm)	110	01-Nov-17	02-Jul-18
WF-EW-001-C2-312		Fill	109	03-Jul-18	30-Nov-18
WF-EW-001-C3	1B	Phase 1B - Cell 3 (Western Shore)	325	03-Sep-18	29-Nov-19
WF-EW-001-C3-320		Site Preparation	22	03-Sep-18	02-Oct-18
WF-EW-001-C3-321		Confinement Structure (Berm)	119	03-Oct-18	14-Jun-19
WF-EW-001-C3-322		Fill	120	17-Jun-19	29-Nov-19
WF-EW-001-C4-100		Essroc Top Fill	196	01-Mar-19	29-Nov-19
WF-EW-001-C4-110		Pre-Load material Cells 1 & 2	176	04-Mar-19	04-Nov-19
WF-EW-001-C4-120		Pre-Load material Cell 3	176	02-Mar-20	02-Nov-20
WF-EW-002	2	Polson Slip North Side Naturalization	877	01-Mar-18	09-Jul-21
WF-EW-002-300		Staging/General Conditions	44	01-Nov-18	01-Jan-19
WF-EW-002-301		Earthwork and Flood Protection Activities	684	01-Mar-18	09-Jul-21
WF-EW-002-302		Excavation Polson Slip	175	01-Mar-19	31-Oct-19
WF-EW-002-303		Soil Treatment	240	01-Mar-19	30-Apr-20
WF-EW-002-304		Restore Polson Slip Site (includes complete works)	222	02-Sep-19	09-Jul-21
WF-EW-002-305		Demolition of wall south side of Cousins Quay	65	01-Mar-19	30-Aug-19
WF-EW-002-306		Fill Above Cousins Quay	200	01-Mar-18	05-Mar-19
WF-EW-002-307		Lafarge Dockwall extension	44	01-Oct-19	29-Nov-19
WF-EW-007	10	Sediment and Debris Management Area	457	02-Sep-19	01-Jun-21
WF-EW-007-301		Staging/General Conditions	44	02-Sep-19	31-Oct-19



Normal Task | Normal, Critical | Normal, Actual | Summary Task | Summary, Critical | Summary, Actual | Finish Milestone Task | Hammock Task | Summary, Start

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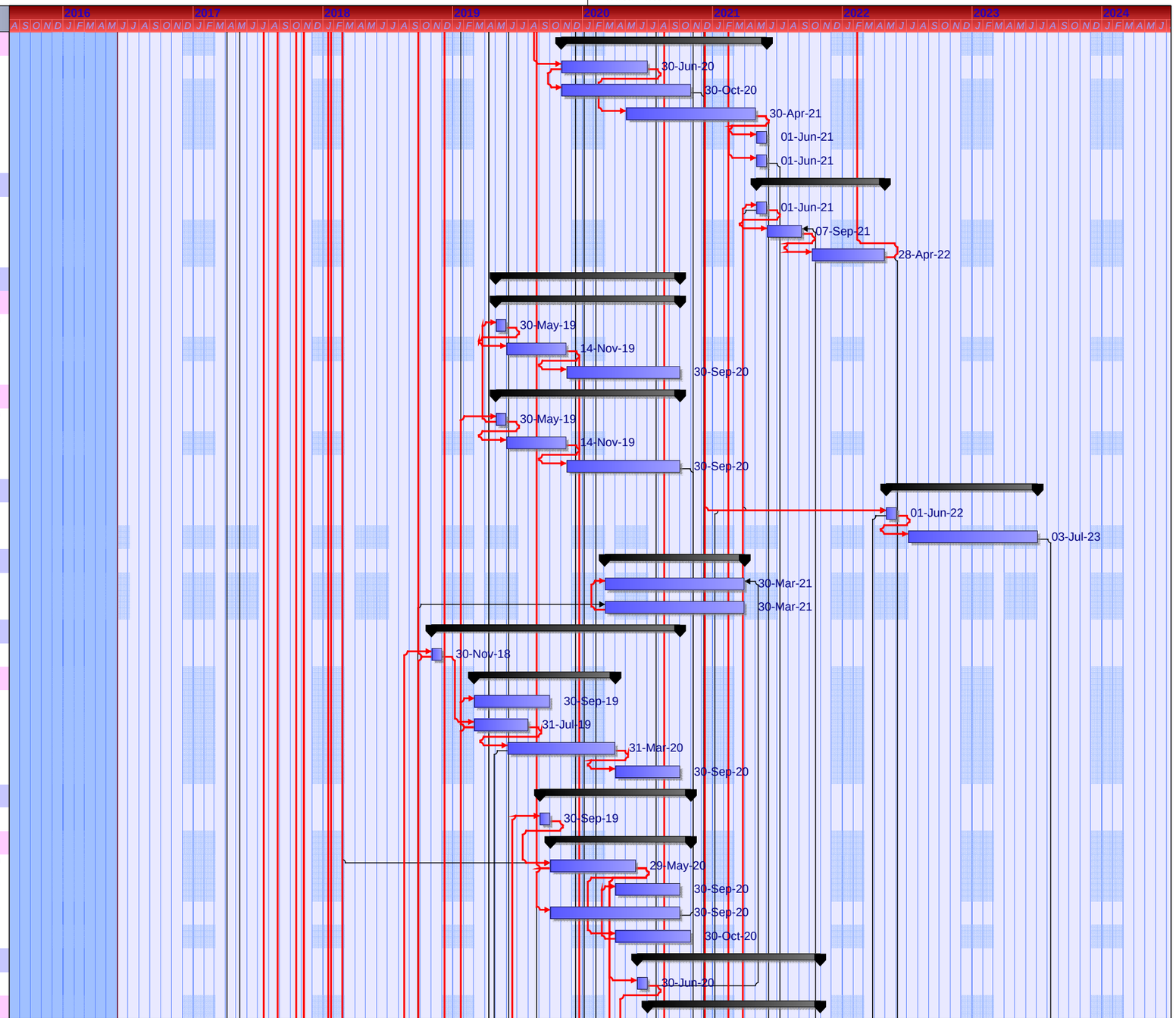
Gantt Chart

ID	Estimate Source	Description	Remaining Duration	Start	Finish
WF-EW-007-302		Earthwork and Flood Protection Activities	284	01-Nov-19	01-Jun-21
WF-EW-007-303		Excavation SDM	173	01-Nov-19	30-Jun-20
WF-EW-007-304		Soil Treatment	196	01-Nov-19	30-Oct-20
WF-EW-007-305		Restoration (C4e)	197	01-May-20	30-Apr-21
WF-EW-007-306		SDM Wetland Construction	22	03-May-21	01-Jun-21
WF-EW-007-307		SDM On-shore Management Area	22	03-May-21	01-Jun-21
WF-EW-008	9	First Gulf Site Flood Protection Landform	259	03-May-21	28-Apr-22
WF-EW-008-300		Staging/General Conditions	22	03-May-21	01-Jun-21
WF-EW-008-301		Flood Protection Land Form (FPL)	70	02-Jun-21	07-Sep-21
WF-EW-008-302		Finishing	83	06-Oct-21	28-Apr-22
WF-EW-009	8	Don Roadway Valley Wall Feature	371	01-May-19	30-Sep-20
WF-EW-009-N-300		North of Commissioner St.	371	01-May-19	30-Sep-20
WF-EW-009-N-301		Staging/General Conditions	22	01-May-19	30-May-19
WF-EW-009-N-302		Construct Wall Feature	120	31-May-19	14-Nov-19
WF-EW-009-N-303		Pre-loading (Don Roadway wall North)	229	15-Nov-19	30-Sep-20
WF-EW-009-S-300		South of Commissioner St.	371	01-May-19	30-Sep-20
WF-EW-009-S-301		Staging/General Conditions	22	01-May-19	30-May-19
WF-EW-009-S-302		Construct Wall Feature	120	31-May-19	14-Nov-19
WF-EW-009-S-303		Pre-loading (Don Roadway wall South)	229	15-Nov-19	30-Sep-20
WF-EW-010	16	Keating Channel Modifications	305	03-May-22	03-Jul-23
WF-EW-010-301		Staging/Laydown Area	22	03-May-22	01-Jun-22
WF-EW-010-302		Channel Modifications	131	04-Jul-22	03-Jul-23
WF-EW-015	11	Flow Control Weirs	282	02-Mar-20	30-Mar-21
WF-EW-015-300		Downstream Weir	151	02-Mar-20	30-Mar-21
WF-EW-015-301		Upstream Weir	151	02-Mar-20	30-Mar-21
WF-EW-3/4A	4	Phase C2a - Lower Greenway/Spillway	500	01-Nov-18	30-Sep-20
WF-EW-3/4A-300		Staging/General Conditions	22	01-Nov-18	30-Nov-18
WF-EW-3/4A-301		Earthwork and Flood Protection Activities	218	01-Mar-19	31-Mar-20
WF-001-8125		Soil Treatment	152	01-Mar-19	30-Sep-19
WF-EW-3/4A-302		Excavation	109	01-Mar-19	31-Jul-19
WF-EW-3/4A-303		Restore Site (includes complete works)	152	03-Jun-19	31-Mar-20
WF-EW-3/4A-304		Shipping Channel Dockwall Removal	131	01-Apr-20	30-Sep-20
WF-EW-3/4B	4	Phase C3 - Upper Greenway/Spillway	305	02-Sep-19	30-Oct-20
WF-EW-3/4B-300		Staging/General Conditions	21	02-Sep-19	30-Sep-19
WF-EW-3/4B-301		Earthwork and Flood Protection Activities	219	01-Oct-19	30-Oct-20
WF-EW-3/4B-302		Excavation	109	01-Oct-19	29-May-20
WF-EW-3/4B-302-10		Northern Spillway Marine Wall	131	01-Apr-20	30-Sep-20
WF-EW-3/4B-303		Soil Treatment	262	01-Oct-19	30-Sep-20
WF-EW-3/4B-304		Restore Site (includes complete works)	153	01-Apr-20	30-Oct-20
WF-EW-3/4C	4	River Connection at Keating Channel	370	01-Jun-20	29-Oct-21
WF-EW-3/4C-300		Staging/General Conditions	22	01-Jun-20	30-Jun-20
WF-EW-3/4C-301		Earthwork and Flood Protection Activities	284	01-Jul-20	29-Oct-21



Normal Task Summary Task Summary, Start Summary, Finish

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Gantt Chart

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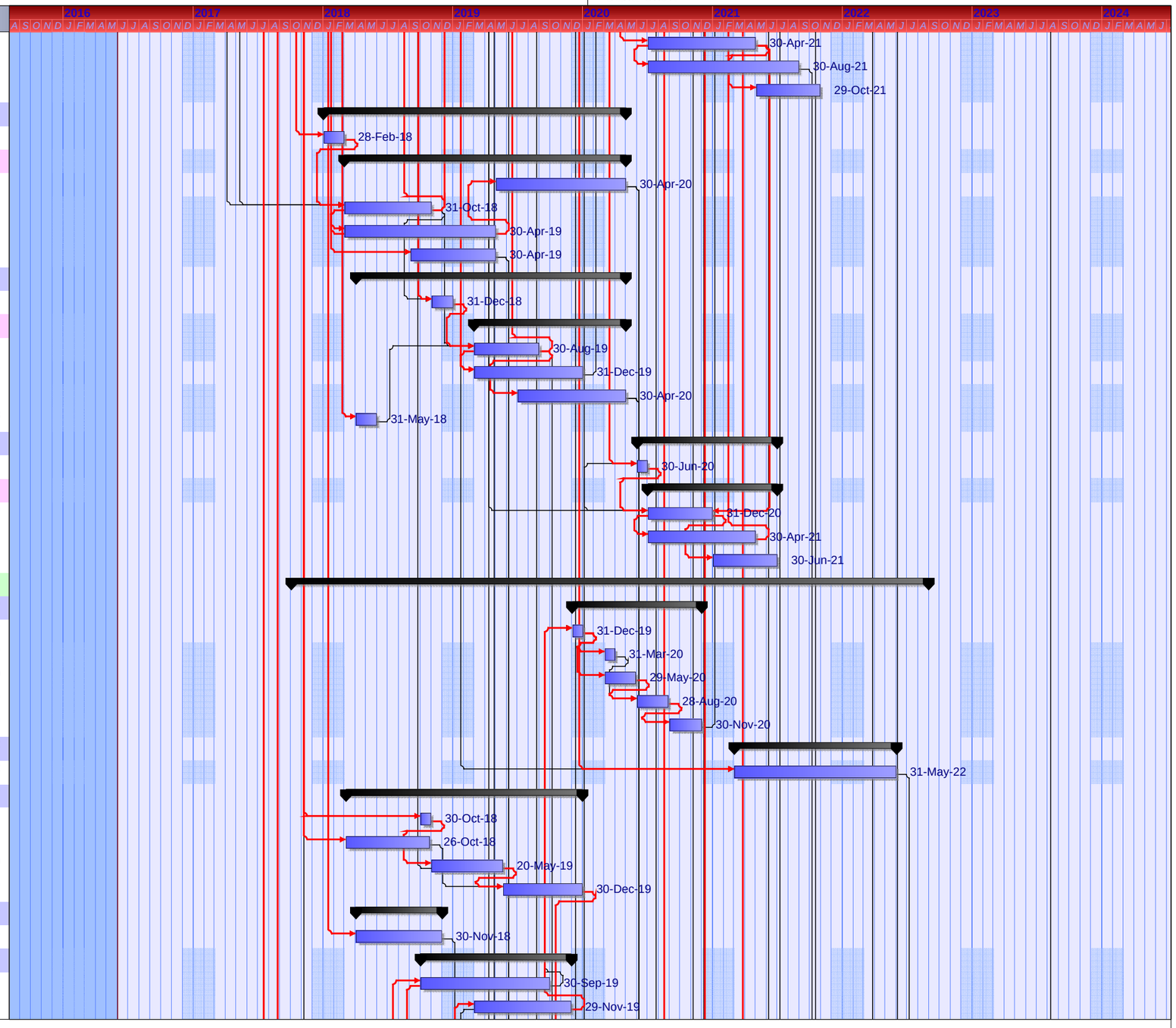
WF-EW-3/4C-302		Excavation	154	01-Jul-20	30-Apr-21
WF-EW-3/4C-303		Soil Treatment	240	01-Jul-20	30-Aug-21
WF-EW-3/4C-304		Restore Site (includes complete works)	130	03-May-21	29-Oct-21
WF-EW-5/6A	3	West End River/Floodplain (Imperial Oil Site)	609	01-Jan-18	30-Apr-20
WF-EW-5/6A-300		Staging/General Conditions	43	01-Jan-18	28-Feb-18
WF-EW-5/6A-301		Earthwork and Flood Protection Activities	437	01-Mar-18	30-Apr-20
WF-001-8115		Establishment of Vegetation	262	01-May-19	30-Apr-20
WF-EW-5/6A-302		Excavation	175	01-Mar-18	31-Oct-18
WF-EW-5/6A-303		Soil Treatment	240	01-Mar-18	30-Apr-19
WF-EW-5/6A-304		Restore Site (West-End - includes complete works)	108	03-Sep-18	30-Apr-19
WF-EW-5/6B	4	Central River/Floodplain	544	02-Apr-18	30-Apr-20
WF-EW-5/6B-300		Staging/General Conditions	43	01-Nov-18	31-Dec-18
WF-EW-5/6B-301		Earthwork and Flood Protection Activities	240	01-Mar-19	30-Apr-20
WF-EW-5/6B-302		Excavation	131	01-Mar-19	30-Aug-19
WF-EW-5/6B-303		Soil Treatment	218	01-Mar-19	31-Dec-19
WF-EW-5/6B-304		Restore Site (Central River - includes complete works)	154	01-Jul-19	30-Apr-20
WF-EW-5/6B-305		Demolition	44	02-Apr-18	31-May-18
WF-EW-5/6C	3	River Connection at Polson Slip	283	01-Jun-20	30-Jun-21
WF-EW-5/6C-300		Staging/General Conditions	22	01-Jun-20	30-Jun-20
WF-EW-5/6C-301		Earthwork and Flood Protection Activities	197	01-Jul-20	30-Jun-21
WF-EW-5/6C-302		Excavation	132	01-Jul-20	31-Dec-20
WF-EW-5/6C-303		Soil Treatment	218	01-Jul-20	30-Apr-21
WF-EW-5/6C-304		Restore Site (West Plug - includes complete works)	129	01-Jan-21	30-Jun-21
WF-RMS		Roads & Municipal Services	1282	02-Oct-17	30-Aug-22
WF-RMS-011	14d	Cherry St. Bridge Demolition & Channel Wall Stabilization	261	02-Dec-19	30-Nov-20
WF-RMS-011-300		Staging	22	02-Dec-19	31-Dec-19
WF-RMS-011-301		Environmental Protection	22	02-Mar-20	31-Mar-20
WF-RMS-011-302		Tie roadway to new alignment	65	02-Mar-20	29-May-20
WF-RMS-011-303		Bridge Superstructure Demolition	65	01-Jun-20	28-Aug-20
WF-RMS-011-304		Bridge Abutment Demolition & Channel Wall Stabilization	66	31-Aug-20	30-Nov-20
WF-RMS-012	12	Eastern Ave. Grade Separation Modifications	326	02-Mar-21	31-May-22
WF-RMS-012-300		Eastern Ave. Work	262	02-Mar-21	31-May-22
WF-RMS-013	13	Lake Shore Road & Rail Bridge Hydraulic Capacity Improv...	476	05-Mar-18	30-Dec-19
WF-RMS-013-300		Staging	22	01-Oct-18	30-Oct-18
WF-RMS-013-301		Steel Fabrication	170	05-Mar-18	26-Oct-18
WF-RMS-013-302		Substructure	144	31-Oct-18	20-May-19
WF-RMS-013-303		Superstructure	160	21-May-19	30-Dec-19
WF-RMS-014	18	Don River Hydro Crossing Removal/Replacement	175	02-Apr-18	30-Nov-18
WF-RMS-014-300		Facilities Modifications	175	02-Apr-18	30-Nov-18
WF-RMS-016	14a	Cherry St. Re-alignment	241	01-Oct-18	29-Nov-19
WF-RMS-016-301		Railway corridor to Keating Channel Segment	197	01-Oct-18	30-Sep-19
WF-RMS-016-302		Keating Channel to Commissioners Segment	196	01-Mar-19	29-Nov-19



Normal Task Summary Task Summary, Start Summary, Finish

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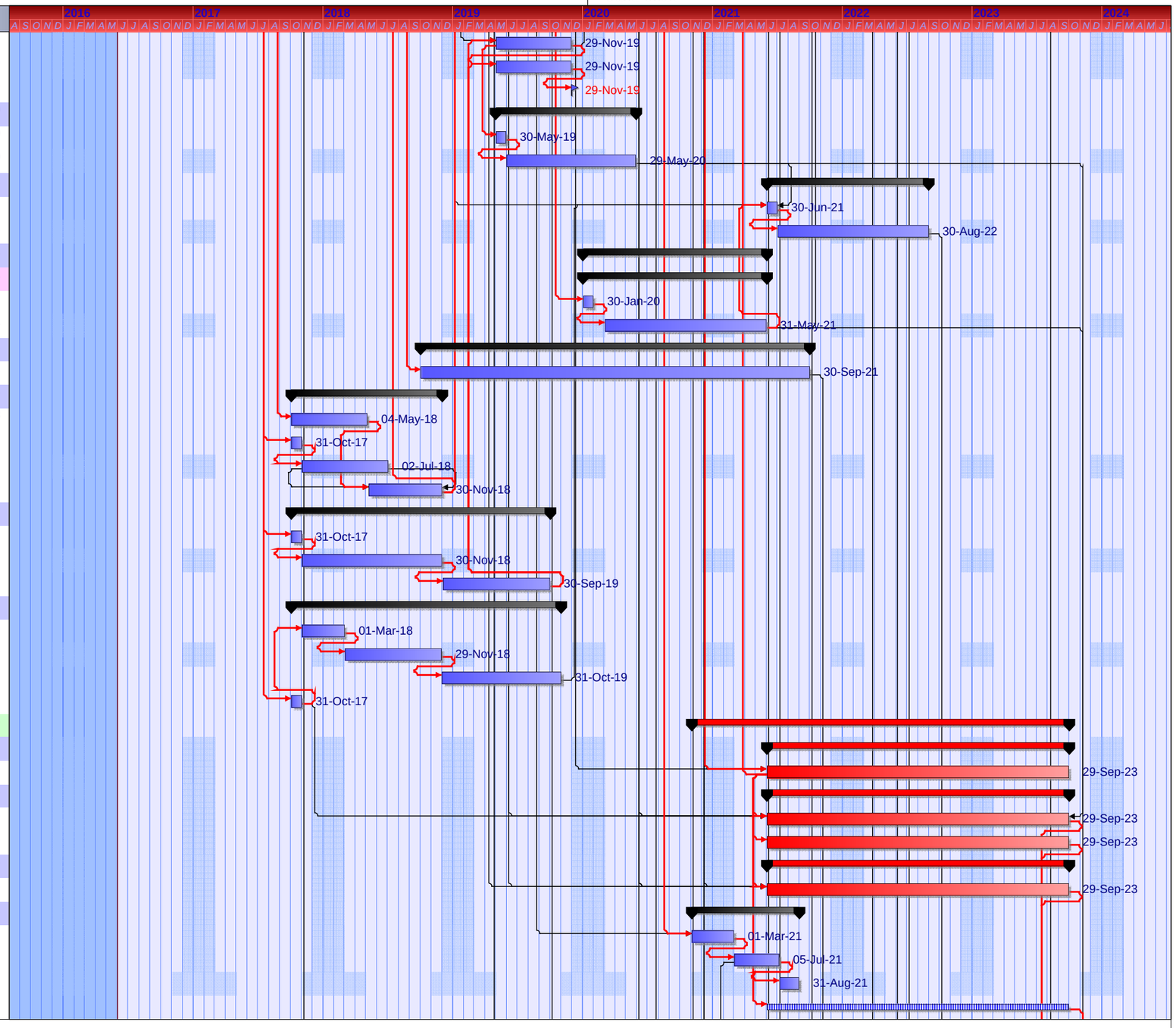
Gantt Chart

ID	Estimate Source	Description	Remaining Duration	Start	Finish
WF-RMS-016-303		Commissioners to River Valley Segment	153	01-May-19	29-Nov-19
WF-RMS-016-304		River Valley to Ship Channel Segment	153	01-May-19	29-Nov-19
WF-RMS-016-305		Open to Traffic	0		29-Nov-19
WF-RMS-017	15a	Commissioners St. Reconstruction (West of Spillway/Don ...	283	01-May-19	29-May-20
WF-RMS-017-300		Staging/laydown area	22	01-May-19	30-May-19
WF-RMS-017-301		Commissioners St (West) Roadway Construction	196	31-May-19	29-May-20
WF-RMS-018	15c	Commissioners St. Reconstruction (East of Don Roadway/...	326	01-Jun-21	30-Aug-22
WF-RMS-018-300		Staging/laydown area (Commisioners West)	22	01-Jun-21	30-Jun-21
WF-RMS-018-301		Commissioners St (East) Roadway Construction	240	01-Jul-21	30-Aug-22
WF-RMS-019	7a	Don Roadway Reconstruction	369	01-Jan-20	31-May-21
WF-RMS-019-310		North of Commissioner St.	369	01-Jan-20	31-May-21
WF-RMS-019-311		Staging/laydown area	22	01-Jan-20	30-Jan-20
WF-RMS-019-312		Roadway Construction	262	02-Mar-20	31-May-21
WF-RMS-021	5	Site Wide Municipal Infrastructure	784	01-Oct-18	30-Sep-21
WF-RMS-021-300		Site wide municipal infrastructure installations	784	01-Oct-18	30-Sep-21
WF-RMS-023	14b	[New] Cherry St. Bridge Over Keating Channel	305	02-Oct-17	30-Nov-18
WF-RMS-023-300		Steel Fabrication	155	02-Oct-17	04-May-18
WF-RMS-023-301		Staging/General Conditions	22	02-Oct-17	31-Oct-17
WF-RMS-023-302		Substructure	110	01-Nov-17	02-Jul-18
WF-RMS-023-303		Superstructure	150	07-May-18	30-Nov-18
WF-RMS-024	14c	Cherry St. Bridge Over New River Valley	521	02-Oct-17	30-Sep-19
WF-RMS-024-300		Staging/General Conditions	22	02-Oct-17	31-Oct-17
WF-RMS-024-301		Substructure	219	01-Nov-17	30-Nov-18
WF-RMS-024-302		Superstructure	216	03-Dec-18	30-Sep-19
WF-RMS-025	15b	Commissioners Street Bridge	544	02-Oct-17	31-Oct-19
WF-RMS-025-300		Temproary Road Construction	87	01-Nov-17	01-Mar-18
WF-RMS-025-301		Substructure	195	02-Mar-18	29-Nov-18
WF-RMS-025-302		Superstructure	240	30-Nov-18	31-Oct-19
WF-RMS-025-303		Commisioners Street Bridge Staging/General Conditions	22	02-Oct-17	31-Oct-17
WF-ZPR		Parks and Development Areas	760	02-Nov-20	29-Sep-23
WF-PR-028	17b	Promontory Park	481	01-Jun-21	29-Sep-23
WF-PR-028-300		Promontory Park South	481	01-Jun-21	29-Sep-23
WF-PR-030	20	River Park North	481	01-Jun-21	29-Sep-23
WF-PR-030-300		River Park North Construction East	481	01-Jun-21	29-Sep-23
WF-PR-030-301		River Park North Construction West	481	01-Jun-21	29-Sep-23
WF-PR-032	21	River Park South	481	01-Jun-21	29-Sep-23
WF-PR-032-300		River Park South Construction	481	01-Jun-21	29-Sep-23
WF-PR-035	19	Villiers Island Re-grading	153	02-Nov-20	31-Aug-21
WF-PR-035-300		Fill Placement	22	02-Nov-20	01-Mar-21
WF-PR-035-301		Fill Compaction	90	02-Mar-21	05-Jul-21
WF-PR-035-303		Planting & Site Improvements	41	06-Jul-21	31-Aug-21
WF-PR-038		On-going Environmental Monitoring	609	01-Jun-21	29-Sep-23



Normal Task | Normal, Critical | Summary Task | Summary, Critical | Finish Milestone Task | Finish Milestone, Critical | Hammock Task | Summary, Start | Summary, Finish

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Gantt Chart

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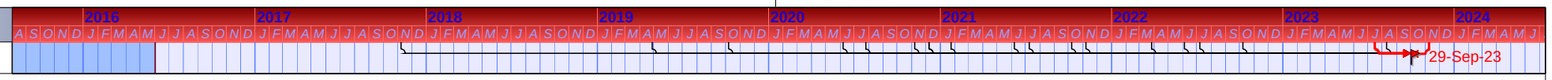


Finish Milestone, Critical

Appendix F – Cost Risk Analysis Detailed Methodology

Waterfront Toronto

Cost Risk Analysis Detailed Methodology

September 10, 2015

Table of contents

1. HDR's approach to Cost Risk Analysis

1.1 Introduction

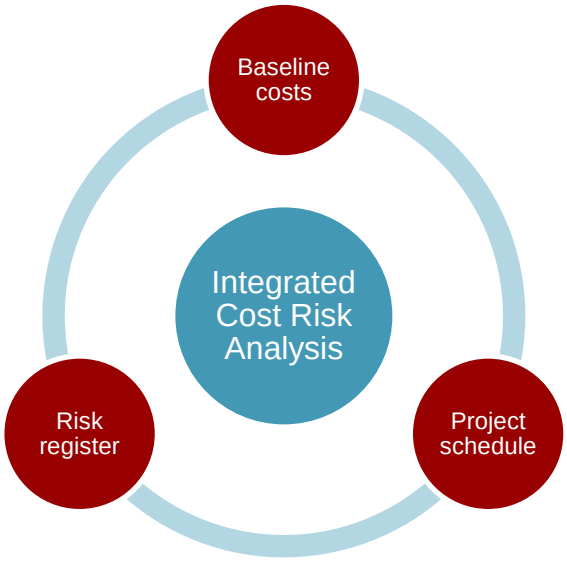
This section of the report briefly describes HDR's approach to Cost Risk Analysis. Following sections of this report provide a more detailed overview of the methodology and HDR's implementation of industry best practices with respect to Monte Carlo simulation and Cost Risk Analysis. HDR has used this Cost Risk Analysis methodology to assess a multitude of different types of capital projects across North America and HDR's assessment of best practices is based on this project experience.

1.2 Primer on HDR's approach to Cost Risk Analysis

HDR's approach to Cost Risk Analysis reflects industry best practices and provides a fully integrated and comprehensive assessment of cost, scope and schedule risks. Cost Risk Analysis is a tool/process used to identify, quantify and control potential cost and schedule risks on complex infrastructure projects. Cost Risk Analysis facilitates:

- A better estimate of project costs and schedule;
- A quantified risk management plan for project planning;
- Better project cost forecasts for budgeting and bonding encouraging pro-activity and early planning;
- Development of mitigation strategies for all anticipated risks or threats; and
- Transparency and integrity throughout the life-cycle of the project.

Figure 1 – Integrated Cost Risk Analysis



Monte Carlo simulation is used to generate a range of possible outcomes and the expenditure profile, project schedule and risk register are fully integrated, which provides a detailed and comprehensive understanding of the risk faced by organizations developing large infrastructure projects with multi-year construction profiles. Fundamentally, CRA requires the following central pieces of information:

- **Baseline costs** outlines the total costs associated with the project on a unit cost basis (e.g., hours of construction labour,

tonnes of rebar, engineering consulting costs etc.). In other words, it provides a bottom-up assessment of the total project costs.[1]

- **Project schedule** shows the key phases of the project and the dependencies between phases over a project timeline. Linking the baseline costs to the project schedule (by specifying when costs are made along the project timeline) generates the **expenditure profile**.

- **Risk register** specifies all the risks that face the project and includes a probability of occurrence and a cost and/or schedule impact if the risk occurs.

HDR's approach to Cost Risk Analysis, which is consistent with industry best practices, explicitly links baseline costs, the project schedule and risk register, which leads to a more accurate, comprehensive and holistic understanding of the risks.

Types of risks considered

HDR's approach to Cost Risk Analysis distinguishes between budget risks, event risk and scope risk. These are defined below:

- **Budget risks:** Risk that budget elements will deviate from estimates (such as deviations in unit prices, deviations in quantities). Theses are often represented by uncertainty ranges around the prices and/or quantities that make up a cost estimate. These ranges can be determined by those with specific knowledge of the project, external experts on cost estimating or generally accepted standards for cost estimating uncertainty.

- **Event risks:** Risk of internal or external events that force the project team to work beyond project scope and schedule (extreme weather, contractor non-performance, regulatory events etc.). These risks are defined by a probability of occurrence, ranging from 0% to 100% likelihood and the probable risk impact, cost and/or schedule, typically represented by a range of potential outcomes.

- **Scope risks:** Risk of significant change to project scope from external pressures (e.g., community pressure for change in alignment or location) or other factors. These types of risks are generally represented in the CRA as separate options or alternatives to the base project scope.

While budget risks generally only apply to cost risks, event risks and scope risks can potentially have a cost impact and/or a schedule impact.

[1] HDR recommends the use of overnight prices to develop the baseline cost estimate. Overnight prices are non-escalated prices and assume that the project can be completed the next day, hence the term "overnight prices". HDR generally models and builds escalation into the construction prices as part of the Cost Risk Analysis.

Escalation

Large scale and multi-year infrastructure projects can face considerable risk in the form of price escalation especially if the project is delayed. HDR has found that many organizations underestimate the impact of escalation and this is generally due to (1) not fully integrating and linking baseline costs, the project and the risk register and (2) use of aggregated escalation factors that do not necessary reflect the unit cost in question (e.g., hourly rate for an electrician or construction worker, price of rebar per tonne) or the geographic region (e.g., using Province-wide escalation factors for Toronto).

Overhead

Organizations developing large scale infrastructure projects typically need to allocate internal resources to manage, monitor and report on the project and for a variety of other purposes. The size and scale of these costs depend on the complexity of the project, procurement method and a variety of other factors. Nevertheless, as project delays occur they result in increased organizational resources and hence costs that should be reflected in a Cost Risk Analysis.

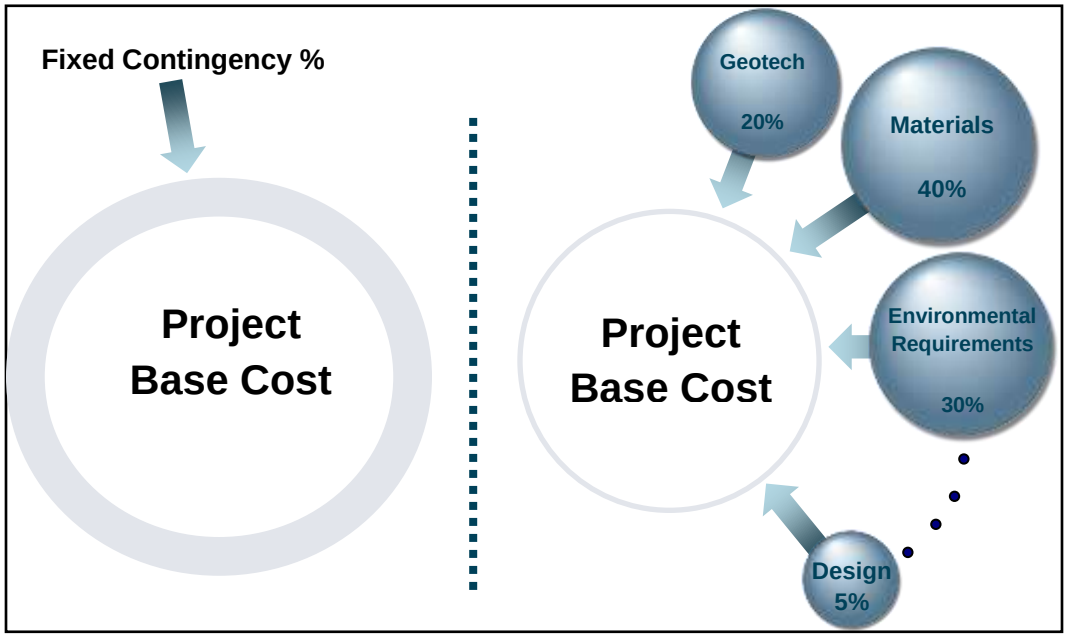
2. Procedures and guidelines

2.1 Introduction

Cost Risk Analysis is a type of risk analysis that focuses on construction project uncertainties, especially those that impact a project's cost and schedule. Cost Risk Analysis is a "bottom-up" analysis of potential impacts to costs and schedule at the activity level. Quantified impacts are added to baseline costs to estimate a new, risk-adjusted final cost distribution.

Cost Risk Analysis is an alterative to traditional cost methods that apply top-down, uniform contingency markups to base costs. Figure 2 illustrates the conceptual departure taken by Cost Risk Analysis as compared to traditional methods. The traditional approach (on the left) indicates that a fixed contingency percentage is often applied to the entire base cost.[2] The contingency is intended to account for all uncertainties and unforeseen events that could increase project cost estimates.

Figure 2 – Conceptual comparison between traditional and risk-based cost estimating



By comparison, a CRA quantifies risks to specific categories of project activities (e.g., geotechnical, material costs, environmental permitting and design, etc.). These risks may have small or large impacts on the project base cost or schedule. Quantified risks are added to the base cost to determine a risk-adjusted or probability-based cost and schedule estimates. These results have been found to more accurately represent final construction costs and schedules, whereas total costs estimated with fixed contingencies are often too low and provide minimal impact to project risks.

The Cost Risk Analysis approach entails six key steps:

[2] In some cases, multiple fixed contingencies are applied to different components, such as property acquisition or construction. The effect of these fixed contingencies is however the same.

1. Development of a flowchart of the project that dictates the baseline key activities and their schedule. Excess activity durations, or "float" is removed from the schedule, as it should represent the ideal case for activity durations.

2. Assessment of the base project costs, which are defined as "expected" costs.

3. Examination of the risk surrounding base costs and the development of ranges, when applied, to cost line items with substantial level of uncertainty.

4. Development of a risk register for the project which is structured to identify individual risks, their likelihood of occurrence, and potential cost and schedule impact to each activity on the schedule.

5. Within a consensus-based process, assess the likelihood of the event risks and their potential impact on project cost and/or schedule by activity, and potentially mitigation strategies for the risks.

6. Evaluate the impact of all quantified risks and mitigation measures using Monte Carlo methods. Monte Carlo methods allow all inputs to be varied simultaneously within their distributions.

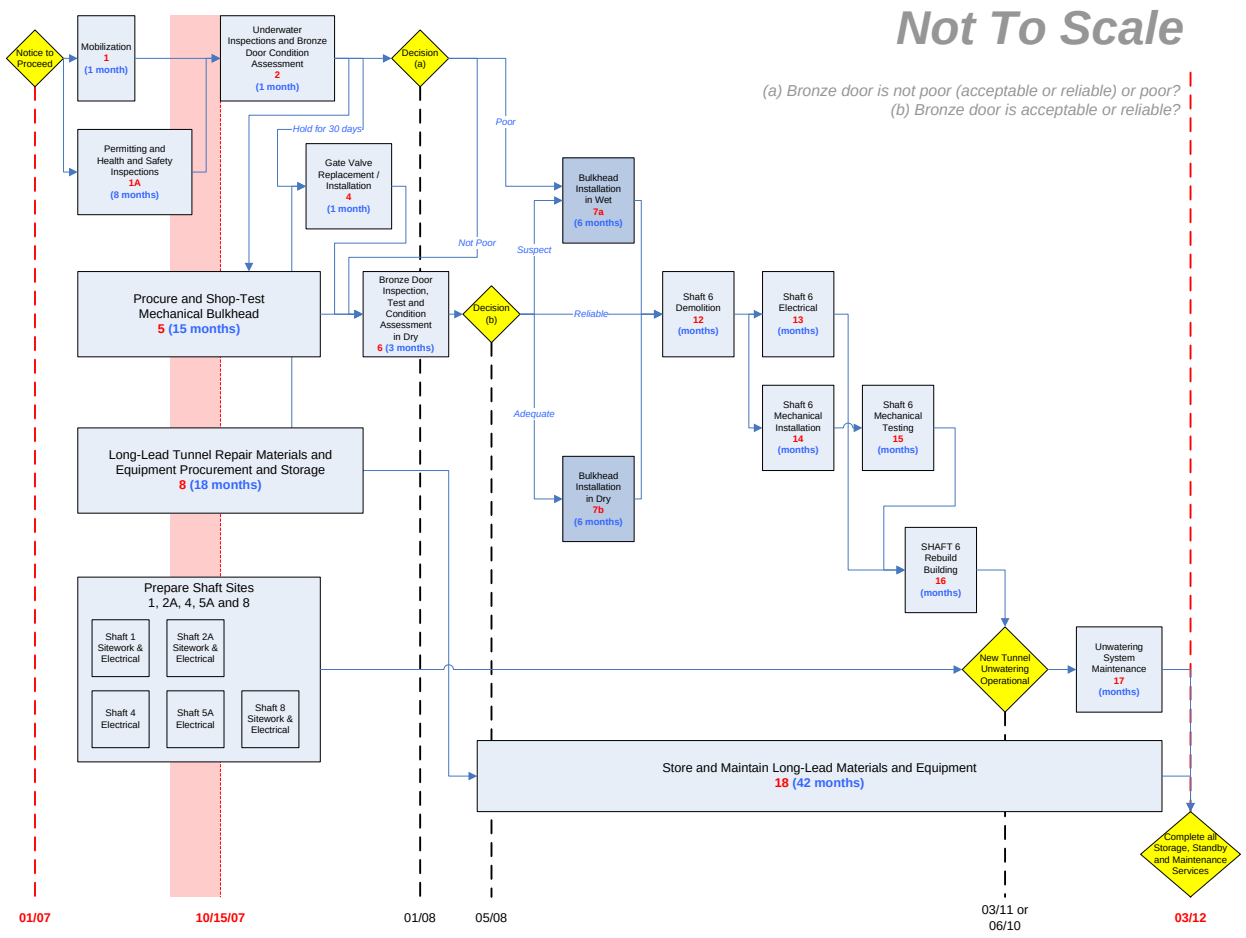
These six steps are discussed in detail below.

2.2 Flowchart development

The flowchart should be a simplified representation of the overall project schedule or Gantt chart. The purpose of the flowchart is to allow specific risks to be assigned to key activities within the project that they may impact. As such, similar activities which may have similar risks are grouped together. This flowchart should illustrate the logical flow of the project, covering preconstruction activities through project completion. All activities should include a title, activity number and duration on the flowchart. Dependencies between activities should be clearly marked on the flowchart. The flowchart does not need to be made to scale, so long as activity durations and dependencies are clearly marked and able to be read from the flowchart. A sample flowchart is provided in Figure 3.

In the event that a formalized project schedule does not yet exist for a specific project, the Cost Risk Analysis team can work with the project team to determine an appropriate flowchart, based on previous projects of a similar nature.

Figure 3 – Sample Schedule Flowchart



2.3 Assessment of base costs

Base costs should be prepared by the project team prior to the Cost Risk Analysis. Within the Cost Risk Analysis framework, the base cost estimates are reviewed and assessed for their reasonability. Through the creation and discussion of the project flowchart schedule in the previous step, it is now important to ensure that costs for all activities are appropriately estimated and included in the base cost estimate.

Based on the project type, best practices and standards for cost estimating should be used in determining the base cost estimates.

2.4 Examination of risk surrounding base costs (Budget Risk)

As noted previously, there are three main types of risks assessed under Cost Risk Analysis: budget risks, event risks and scope risks. Under this step, budget risks are assigned to the base costs. These risks should take the form of ranges around the unit prices and quantities for each line item in the base cost estimate. These ranges should be elicited from the project cost estimators, and should take into account specific knowledge of the project, the project area, and market conditions.

Ranges for the unit prices can be due to several factors including external market conditions, market conditions brought on by the project (scale of project may drive up demand for materials or labor in region), and competition from other regional projects. These ranges in unit prices should account for some of the uncertainty of market conditions.

Variations in quantities can be due to many reasons, including a potential underestimate of project materials, or uncertainty around site conditions, building techniques or structure types. In some cases, quantities may range to zero as a low, if there is uncertainty as to whether or not a certain item is necessary.

Risk ranges should account for both increases and decreases in unit prices and quantities (risks and opportunities). Generally these base cost uncertainties are gathered as ranges, where the initial base cost estimate is treated as the median or "most likely" outcome. The high value of the range is typically entered at the 90th percentile. That is to say the value where there thought to be a 90 percent probability that the actual value will not exceed the high value. Similarly the low value of the range is typically entered at the 10th percentile, which is to say there is only a 10 percent probability that the actual value will fall below this low value. The high and low values for the range on base cost uncertainties therefore generally represent an 80 percent confidence interval around, i.e. there is an 80 percent probability that the actual value will fall within this range.

It is important to ensure that risks identified under this step, the base cost uncertainty, or budget risks, are not quantified again under elsewhere in the analysis. This would result in double counting of a risk, and not accurately measure the level of risk to the project.

Two commonly used resources for budget uncertainty ranges are:

- AACE International Recommended Practice No. 17R-97, COST ESTIMATE CLASSIFICATION SYSTEM, TCM Framework: 7.3 – Cost Estimating and Budgeting[3]

- ASTM Standard Classification for Cost Estimate Classification System1, Designation: E 2516 – 06[4]

Both of these technical documents present generally accepted budget uncertainty ranges, based on the level of project definition, ranging from feasibility study to final bid.

2.5 Development of a risk register

The risk register is the key interface for Cost Risk Analysis. This tool is used to record important information on project risk. It is composed of a list of potential project risks, the probability an individual risk will occur, the activity(s) a risk will impact, and a quantification of the risk's expected cost and/or schedule impact to the project.

The risk register is developed under this step, and then populated in the following step. The basis of the risk register is the list of potential project risks. These risks can be derived from previous projects

[3] This document can be obtained from: http://www.aacei.org

[4] This document can be obtained from: http://www.astm.org/Standards/E2516.htm

of a similar nature, past project experience, and input from the project team based on their specialized knowledge of the project. Risks should be categorized by functional assignments. Examples of functional classifications are Environmental, Right of Way, Construction, and External. The type of project and risks identified will dictate the number and type of functional assignments on the final risk list. Once this list of risks has been created it should be circulated and vetted by the project team and other key stakeholders. At this point, any suggested changes to the risk list should be reflected in the risk list and this should be finalized.

While additional risks can be added in the session, the risk list should be finalized and have a full representation of potential risks prior to the session. This list should be circulated to potential risk workshop participants prior to the next step. A sample of the risk register, populated with a sample risk list is presented in Figure 4.

Figure 4 – Risk register identification

Identification				
Activity Impacted	**Functional Assignment**	**Threat/ Opportunity Events**	**Type of Risk**	**Panelists' Comments**
C2	C3	C4	C5	C6
1, 9-13	Environmental	Unanticipated Hazardous Materials or Contaminated Soils	Cost and Schedule	Very low likelihood in this corridor, impacts environmental into construction, discovery during construction, 5% probability.
7	Design	Change in Final Alignment Geometry before Bid	Cost	If contractor initiates it, this is an opportunity, may change alignment to save money; want to capture opportunity and risk, possibility of reduced cost, changes in scope, basic configuration change, areas for optimization.
8	Right of Way	Utility relocation may not happen in time	Schedule	Depends on how well the master agreement is negotiated, schedule issue, 5 to 10% probability of risk.
9, 10, 11, 12, 13	Competition	Lack of Sufficient Number of Bidders	Cost	Recent project was bid with 2 bidders, still good number of bidders on recent projects; probability of low number of bidders, 10 to 15% cost impacts (of total project cost) if risk occurs.
9, 10, 11, 12, 13	Construction	Interference from other projects	Cost	Potential for conflict with other projects; high probability but low dollar impact.
9, 10, 11, 12, 13	Political	Protest from local property owners cause delay	Cost and Schedule	Cases in court system could take multiple years, 3 years upper end for court case, lower end could slow project by 6 months, year for first litigation, year and 1/2 for EIS, potential for second case, 6 months to 5 years; less than 5% probability of lawsuit, big impact; significant cost impact as well - at least $2M a year.
9, 10, 11, 12, 13	Utility	Working around Aqueduct	Cost	May have to move a section, have to monitor, chance of damaging pipe; 5 to 10 percent

Identification				
Activity Impacted	**Functional Assignment**	**Threat/ Opportunity Events**	**Type of Risk**	**Panelists' Comments**
C2	C3	C4	C5	C6
				chance, 1.5 mile length impacted area; $8M relocation at $1,000 a foot plus structures at either end.

2.6 Consensus based risk workshop

A critically important step in cost risk analysis is the identification and quantification of a risk item within the consensus-based process.

In this step, a workshop is convened which is composed of a panel of experts to quantify risks in the risk register. The panel discusses each risk to the project, determines the probability that a risk could occur, and the impact on project cost and/or schedule if the risk did occur. The impact is quantified by establishing a range of values and probability distribution defining the likelihood of each value. Risks that are identified as insignificant or irrelevant are noted as such with specific reasons, when available. The panel may also be involved in identifying and quantifying mitigation actions for key risks. The duration of the risk workshop is dependent on the nature of the project and the number of risks to be analyzed.

Prior to the workshop, the role of the CRA team is to assist the project team in determining the workshop participants and to circulate the appropriate materials to the participants prior to the workshop. These materials should include the project schedule flowchart, the base cost estimates (with uncertainty if available), and the risk list.

The agenda for the workshop should include an overview of the CRA process to ensure all participants are familiar with the process. The workshop session entails the identification and quantification of risks by the participants. Within the workshop, participants are asked to:

Identify a risk factor;

- Determine a probability of occurrence (i.e., the likelihood of the risk happening);
- Determine the impact of the risk factor on cost and schedule if it occurs, entered as a range; and,
- Identify mitigation strategies for specific risks (if desired).

When this information is elicited from the panelists, it is recorded into the risk register. The identification of mitigation strategies is not necessary; however it can be extremely helpful during the project as a way to deal with significant risks.

Figure 5 is a continuation of Figure 4 which illustrates the quantification of these individual risks with their probability of occurrence, the cost impact (represented as a range) and the schedule impact (represented as a range) are recorded into the risk register based on the panelists' consensus opinion.

Figure 5 – Risk register quantification

Quantitative Analysis								
Prob.	Cost Impact ($)				Schedule Impact (months)			
	Distribution	Median	Low	High	Distribution	Median	Low	High
C7	C8	C9	C10	C11	C15	C16	C17	C18
5%	Trigen	$20,000	$20,000	$20,000	Pert	0.5	0.5	0.5
70%	Trigen	($5,500,000)	($16,000,000)	$5,000,000	Pert			
70%	Trigen	$0	($16,007,019)	$16,007,019	Pert			
15%					Pert	4.5	3	6
35%	Trigen	$20,008,773	$16,007,019	$24,010,528	Pert			
40%	Trigen	$1,000,000	$1,000,000	$1,000,000	Pert			
5%	Trigen	$5,500,000	$1,000,000	$10,000,000	Pert	33	6	60
13%	Trigen	$5,500,000	$1,000,000	$10,000,000	Pert			

Figure 6 is also a continuation of Figure 4 which illustrates the risk mitigation portion of the risk register. While not mandatory, mitigation is highly recommended as it can be extremely useful to the project team during the course of the project. The risk mitigation portion of the risk register allows the CRA team to record the type of mitigation to use, notes on the mitigation strategy, as well as the mitigated cost and schedule impacts, expressed as a range. CRA simulated model runs (under step 6 of the analysis) may be completed if desired to show the impact of risk on cost and schedule when a risk is mitigated.

It is important to record information on risks even when a risk is eliminated, or noted as not relevant, as the risk register serves as a record of the risks that were considered.

Figure 6 – Risk register mitigation

Mitigated Impacts								
Strategy	Response Actions including Advantages and Disadvantages	Prob.	Cost Impact			Schedule Impact		
			Expected	Low	High	Expected	Low	High
C19	C20	C21	C22	C23	C24	C25	C26	C27
Acceptance								
Acceptance	Optimize design as much as possible, set up bid options in RFP							
Mitigation	Put schedule delay on contractor, more design to know that cost will no increase, tighten up estimate,	70.0%	$0	$(8,003,509)	$8,003,509			

Mitigated Impacts								
Strategy	Response Actions including Advantages and Disadvantages	Prob.	Cost Impact			Schedule Impact		
			Expected	Low	High	Expected	Low	High
C19	C20	C21	C22	C23	C24	C25	C26	C27
	30% design estimates from above will reduce the risk							
Mitigation	Well planned agreement, get as many utility companies as possible to work under contractor and get refusals to relocate early							
Mitigation	Market the projects ahead of time, contact construction industry, industry reviews	15.0%						
Mitigation	Identify and acknowledge other projects in SR 92 documents							
Acceptance	Potential for 3rd party legal review							
Avoidance	Design to avoid aqueduct, good communication.							

Additionally, the risk register includes information on the probability distributions employed for each risk. Information on the type of distribution for each risk does not need to be solicited during the workshop. The nature of the risk may determine the type of risk. Additionally the client or panelists may provide input on the type of distribution to use. Impacts for each risk are elicited in ranges to represent an 80 percent confidence interval (e.g., at the lower 10^{th} percentile, median value, and upper 10^{th} percentile). As such, probability distributions can be fitted to this data. Schedule impacts typically follow a Beta distribution, where there is an upward skew to the distribution. Cost impacts on the other hand typically, but not necessarily, follow a more symmetric shaped distribution.

2.7 Evaluation of risks with Monte Carlo modeling techniques

Following the workshop, the inputs gathered from the panelists are analyzed within a cost risk analysis model utilizing Monte Carlo modeling techniques. Software packages providing risk analytic functionality directly into MS Excel have become much more accessible and allow risk analysis to be directly integrated into traditional cost estimating protocols. With risk analysis, ranges or probability

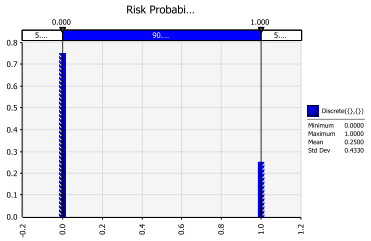
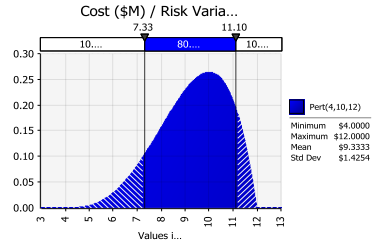
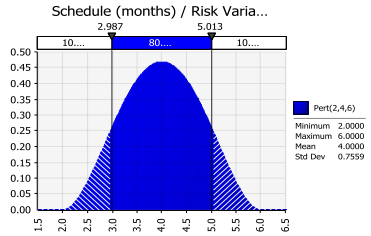
distributions are entered directly into the cost risk model for each of the risk elements and, through the risk simulation functionality, cost outcomes take into account all possible input values allowing them to be presented with certain levels of probability.

Monte Carlo simulation is a technique that utilizes thousands of individual iterations to generate an overall probability distribution for each model output. During each iteration, all input variables (base cost uncertainties, event risks, and escalation factors, etc.) are varied simultaneously, according to their own probability distribution. Within the iteration, each input variable draws a value from its sample distribution range. It is necessary to have a large number of iterations, typically thousands, to get a sample of values that represent the whole distribution.

To further reinforce this concept, the following provides an example of computing the impact of an individual risk. A risk is defined with two distinct components, the likelihood (probability) that the risk occurs and the impact (in terms of cost or schedule) if that specific risk actually occurs. During each iteration of the Monte Carlo simulation, a risk will either occur or not occur, as determined by the likelihood. For example, a risk with 40 percent likelihood will be realized within approximately four of every ten iterations. If this simulation is run for 10,000 iterations, this risk occurs in approximately 4,000 of the iterations. The second major input is the impact of the risk. The impact of the risk is developed by asking, if the risk event occurs, what is the range of the impact? This range of low, middle, and high impacts is used to create a probability distribution of the impacts. In any given iteration of the Monte Carlo simulation, an impact for the risk will occur in the given range of the impact distribution. These impacts can take the form of cost and/ or schedule impacts. An example of an individual risk, including the probability of occurrence and the cost and schedule impact is portrayed in Figure 7. In this example the risk is defined with 40 percent likelihood, a cost impact ranging from $4 to $12 million, and a schedule impact ranging from 2 to 6 months. The likelihood is combined with each of the impacts to produce the probabilistic outcomes for the cost and schedule.

For each iteration of the Monte Carlo simulation, the cost and schedule impact that is selected from the distribution is multiplied by the one or zero that is triggered based on the likelihood of the risk occurring. The inputs from Figure 7 below indicate that in 40 percent of the iterations in the Monte Carlo simulation, the risk will occur. When the probability value is zero, there is no cost or schedule impact. An example of a simple ten iteration Monte Carlo simulation is shown in Table 1. The first column indicates the iteration number. The second column indicates if the risk occurred on a specific iteration: 1 if the risk occurs, 0 if the risk does not occur. The third and fourth columns indicate the cost and schedule impacts of the risk on a specific iteration based on the range of potential impacts; however, the risk may not occur. If the risk does occur on a specific iteration, a cost and schedule impact is shown in the fifth and sixth columns. Because the probability of the risk is 40 percent, on 4 out of the 10 iterations the risk occurred.

Figure 7 – Example of inputs for a cost and schedule risk using Monte Carlo simulation

Risk Definition	Likelihood Risk Occurs	Likelihood Risk Does Not Occur	Value if Risk Occurs	Value if Risk Does Not Occur	Risk Variable	Risk Distribution
Likelihood	40%	60%	1	0	**40%**	
Risk Impact	**Low**	**Most Likely**	**High**		**Risk Variable**	**Risk Distribution**
Cost ($M)	$4.0	$10.0	$12.0		**$9.3**	
Schedule (months)	2.0	4.0	6.0		**4.0**	
Cost Risk					**$3.7**	
Schedule Risk					**1.6**	

The table below provides a simplified example for a single risk. In practice, this process varies all input variables simultaneously, for thousands of iterations, to derive probability distributions for cost and schedule outcomes.

Table 1 – example of the Monte Carlo Output for a Risk

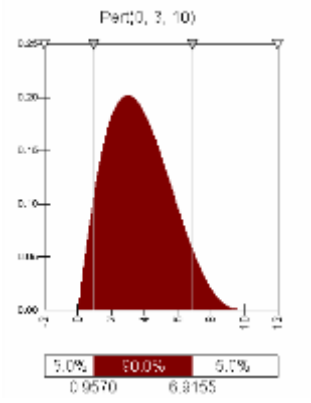
Iteration	Risk Occurs?	Cost Impact if Risk Occurs	Schedule Impact if Risk Occurs	Cost Risk Impact	Schedule Risk Impact
1	0	$8.2	3.4	$0.0	0.0
2	0	$10.3	4.7	$0.0	0.0
3	0	$8.9	3.7	$0.0	0.0
4	0	$11.3	5.4	$0.0	0.0
5	0	$6.9	2.8	$0.0	0.0
6	1	$10.7	4.9	$10.7	4.9
7	0	$10.2	4.4	$0.0	0.0
8	1	$7.9	3.2	$7.9	3.2
9	1	$9.1	3.9	$9.1	3.9
10	1	$9.5	4.1	$9.5	4.1
Summary	**4**	**$9.3**	**4.0**	**$3.7**	**1.6**

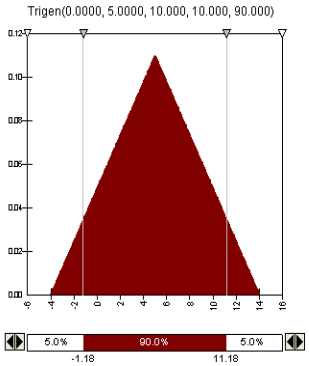
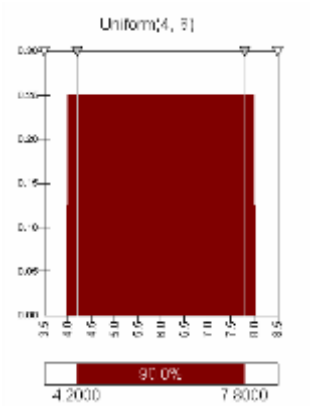
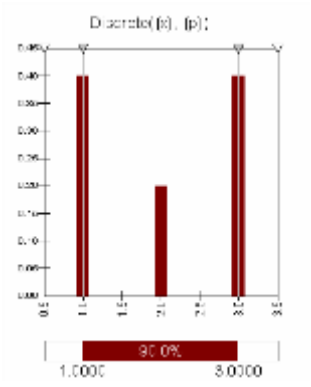
Risk distribution options

Key inputs to the Cost Risk Analysis, such as event risks and budget risks, are generally represented by a distribution of potential outcomes. The selection of the appropriate distribution should be guided by the characteristics of risk. Several distribution types which are commonly used to model risks within the CRA are listed below.

Figure 2 below provides graphical examples of each of these 4 probability distributions.

Figure 2 – Typical Cost Risk Analysis input distributions

Distribution type	Description
	**Pert:** a pert distribution is a special form of the Beta distribution. The Beta distribution allows for a skew to the data, either upward or downward, and therefore can be used to represent risks where for example, the upper extreme is further from the median than the lower extreme. Because of this characteristic, it is often used in modeling schedule risks. The pert distribution uses the median, minimum (or lower percentile, such as 10%), and maximum (or upper percentile, such as 90%) as input parameters.

Distribution type	Description
	**Trigen:** is a triangular based distribution, which uses the median, lower percentile (such as 10%), and upper percentile (such as 90%) as input parameters. Based on these input parameters, a triangular distribution is fitted to the data, and the absolute minimum and maximum are calculated as a function of the distribution. This distribution is often utilized for budget risks, where there is equal probability of an input parameter being lower or higher than the median.
	**Uniform:** is a distribution for risks where the where all values within the range of potential outcomes have the same distribution. For example, a schedule risk where there is an equal probability of a 2 month delay, or a 6 month delay, or any value between these extremes, the uniform distribution should be utilized. The uniform distribution requires the minimum and maximum values as input parameters.
	**Discrete:** is a distribution where each potential outcome is represented by a value and corresponding probability. An example of this is a regulatory risk, where key project decision can only occur when a regulatory group meets, which could be in 6 month increments. For this schedule risk, if a key decision milestone is missed, there could be an 80% probability of a 6 month delay, and a 20% probability a 12 month delay. In this example, there is no possibility for intermediate values between 6 and 12 months. This distribution takes the values and corresponding probabilities as the input parameters, where the sum of the probabilities for each value should equal 100%.

Correlating variables

Once variables have been defined with probability densities and the appropriate risk ranges, one should consider if some variables are correlated. That is, one should assess whether there is a theoretical, intuitive or empirical basis for the movements in two or more risk variables to be related (without a direct causal relationship). This relationship can exist between any variable inputs – risk probabilities, cost estimates, schedule delays, escalation factors, and so on.

When all of the input variables have been identified and defined with ranges and density functions, it is important to then consider which variables may be correlated and to define the degree of

correlation. Not including the appropriate correlations in the risk analysis may result in an underestimation (or overestimation) of the actual risk in the CRA outcomes and may include results from unrealistic scenarios within the simulation.

Structuring dependency among risks

Depending on the nature of the risks identified in the risk register, there is a possibility of direct and certain relationships that exist between risk events which should be coded in the CRA model. For instance, this can apply to risks that could occur simultaneously and thus would not be additive; instead, the maximum value of either risk would be considered for estimating total impacts. Other situations where specifically coded relationships are necessary could include similar risks across different phases of the project that could only occur once (e.g. risk A can occur in phase 1, 2, or 3 with different cost and schedule impacts, but once it occurs it stops being a risk for the remainder of the project.)

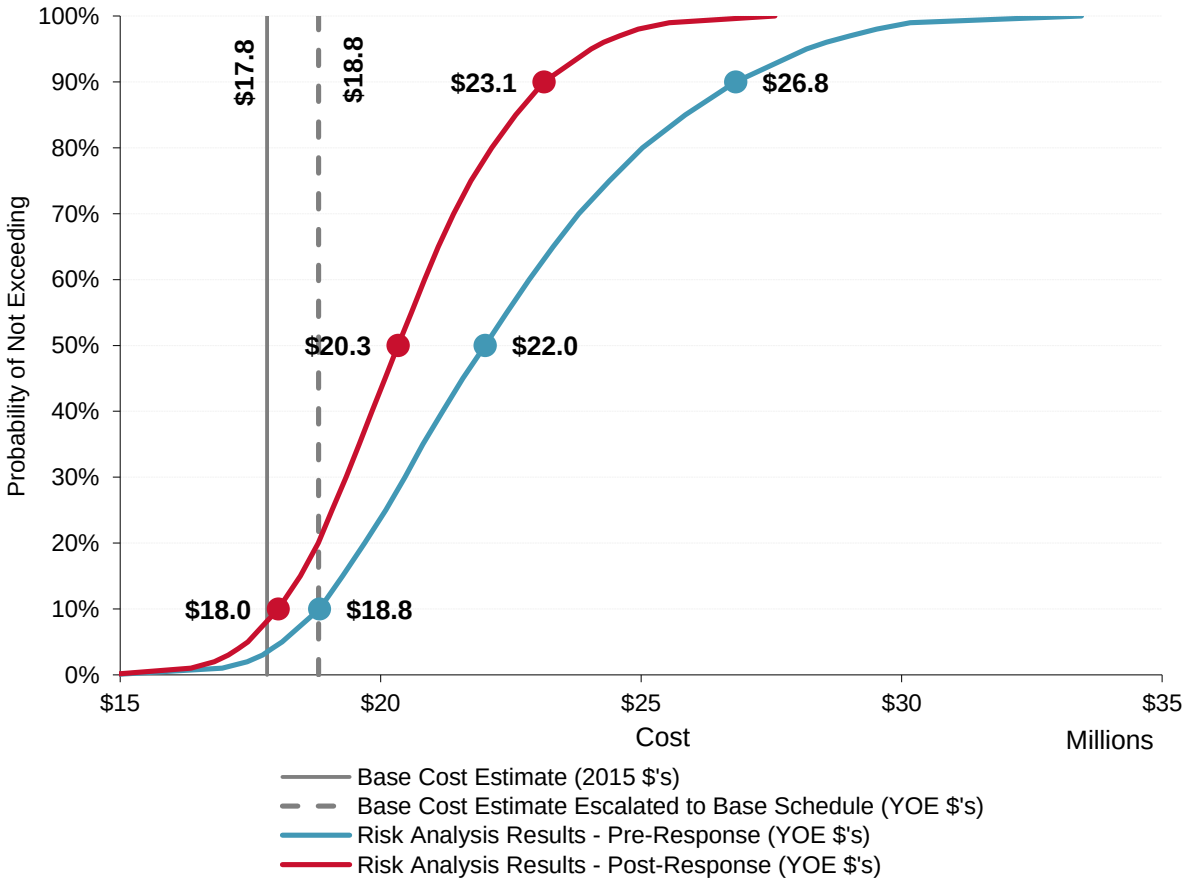
It's important to note that both correlations and risk dependencies further add to the complexity of the CRA model and should be used sparingly to account for critical relationships among variables.

2.8 Typical Cost Risk Analysis results

There are two main types of outputs generally presented as results from the CRA modeling. These are (1) Cumulative Probability Distributions (or S-Curves); and (2) Tornado Diagrams of top risk factors. Note that additional types of outputs may be dictated by a specific project.

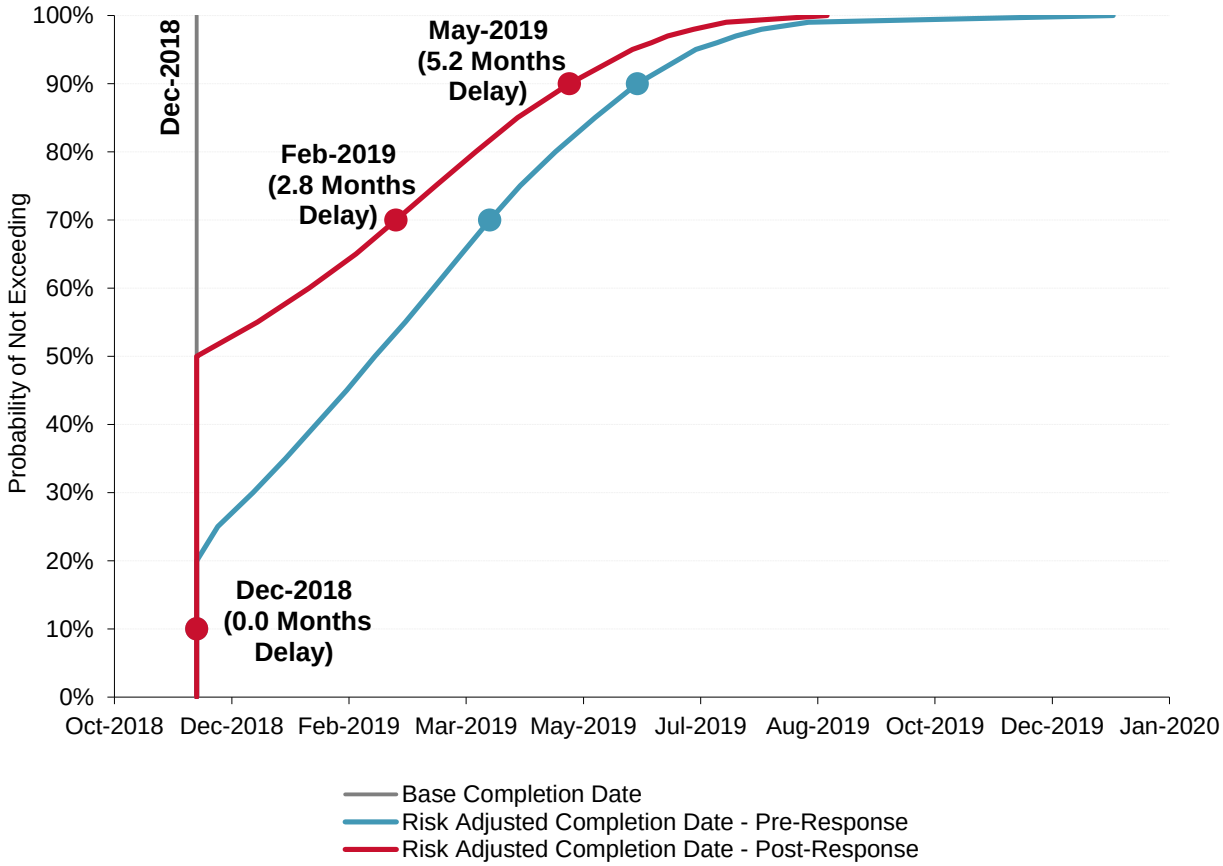
S-Curves are typically generated for total project costs (or subsets of total cost) and overall project schedule (or key milestones and project delay). These cumulative probability distributions represent the specific values (either cost or schedule) and the associated probability of not exceeding such a value. Sample cost S-Curves are presented in Figure 9. This figure shows the S-Curves for total pre-response and post-response project costs, highlighting the median values ($22 M and $20.3 M), and the lower and upper 10th percentiles ($18.8 M and $26.8 M, $18.0 M and $23.1 M, respectively). In interpreting the pre-response chart, for example, there is a 90% probability that total project costs will be less than or equal to $26.8 million. Typically, the S-Curve is presented alongside the base cost estimate for comparison purposes. In this figure, the base costs (both non-escalated and escalated) are presented by the dashed vertical lines. In this example, there is only a 10% probability that the escalated base cost estimate will be realized.

Figure 9 – Sample cost probability distribution



Similar to the cost distribution above, Figure 10 below illustrates a sample schedule probability distribution. In this example, there is a 50% probability that the project will be completed by December 2018, with a 90% confidence that the project will complete between December 2018 and May 2019 (in the post-response case). In this example, the baseline completion date from the project flowchart is represented as a vertical line, with the value of December 2018. As the flowchart is a representation of the optimistic conditions for the project schedule, it is often the case that there is no probability of realizing this date, as shown in the figure.

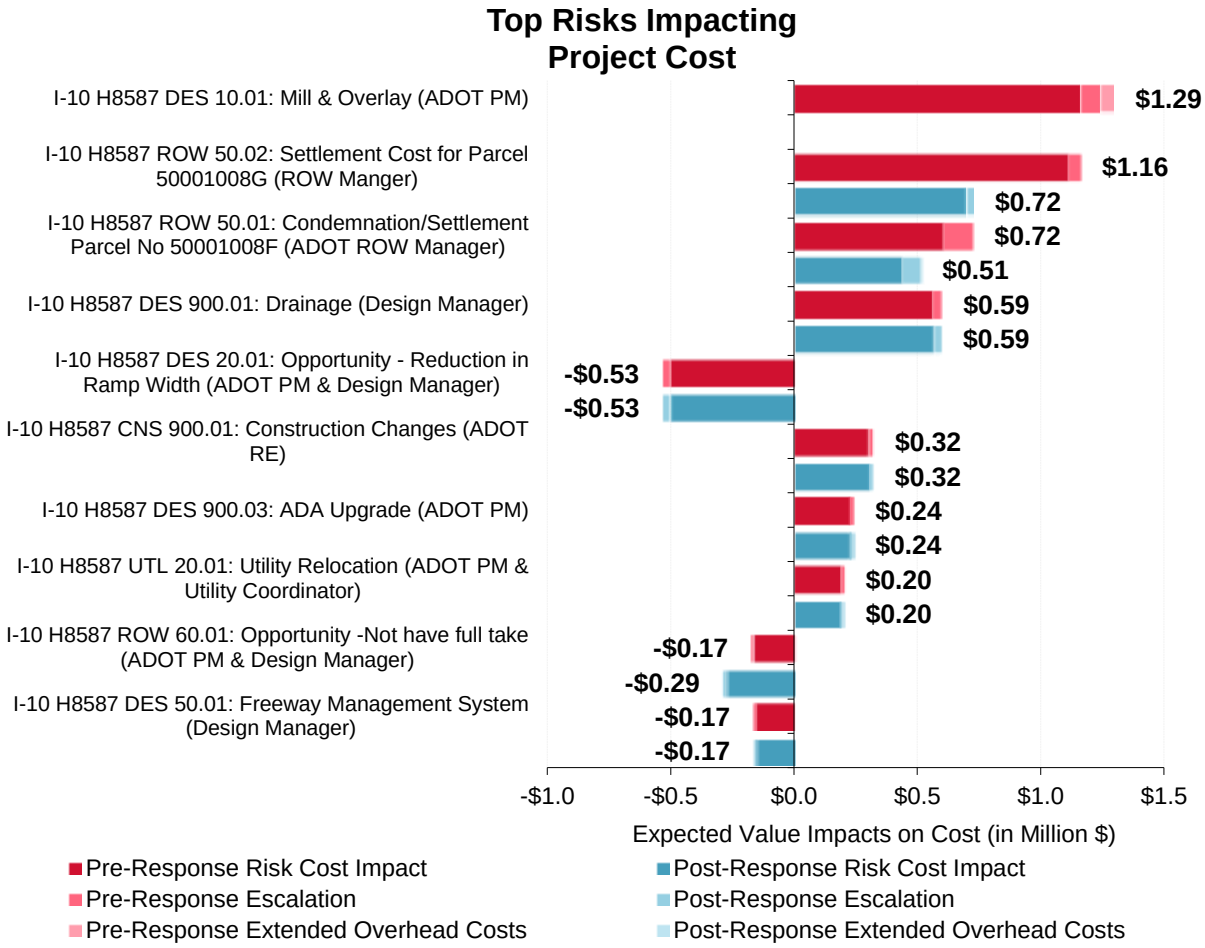
Figure 10 – Sample schedule probability distribution



Tornado diagrams provide a graphical ranking of risk factors, by their expected value. The expected value is calculated as the product of the average risk impact (when a risk is expressed as a range of potential impacts) and the associated probability of occurrence of that risk. On a tornado diagram, risks are typically ranked in descending order based on their overall cost impact to the project. Figure 11 provides an example of a tornado diagram.

In this example, both cost and schedule risks are shown, in terms of a monetary impact to the project. Cost risks are assigned a specific cost impact when quantified within the risk register. Schedule risks, on the other hand, have a monetary impact on total project in terms of project cost escalation and other costs associated with delay, such as overhead or staffing costs. Months of delay can be translated into their associated escalation and delay cost, based on their estimated impact in association with the project flowchart (for instance, a 2-month delay could result in 2 months of cost escalation for the remainder of unpurchased equipment plus 50% of the project overhead cost under the assumption that half the resources would be redirected towards other projects during periods of delay). In this example, the top project risk is Mill & Overlay, which is estimated to cost $1.29 million in terms of its expected value. Tornado diagrams can serve as a key artifact in efforts to manage and minimize project risk.

Figure 11 – Sample tornado diagram



The tornado chart depicts the expected value pre-response and post-response cost for each event risk. The overall cost impact may be comprised of three components: direct event risk cost impact, escalation cost impact, extended overhead costs impact. The risk cost impact is measured as the probability of the risk, times the mean cost impact developed from the SME risk cost ranges recorded within the risk register. Escalation impacts are the additional costs borne by a project and attributed to a schedule delay risk. Such costs might stem from the higher costs of construction required as expenditures are pushed further into the future. Additional support costs or extended overhead costs are the increase in project management expenses incurred as a result of a schedule delay risk that extends the duration of phases of a project and requires management oversight. For the analyst, a tornado chart where one variable totally dominates or is much larger in magnitude than other variables, may indicate a problem in the Cost Risk Analysis model assumptions. For decision makers, the tornado chart will lead to additional questions:

- What percent design is the cost estimate based on?
- Do we need to do a more detailed design?
- Do we need a peer review?
- Can we mitigate any of the cost risks?

- Can we transfer risk to another party?
- Do we need to do a Value Engineering study?

By using risk analytic techniques to display key project outcomes throughout the business case lifecycle improves the effectiveness of decision making in an organization. It leads to more informed decision making by facilitating an understanding of risk and uncertainty; it generates discussion by decision makers on the key drivers of the business case and facilitates specific actions such as additional research and/or risk management processes to try to get a better perspective and better management of the key risk drivers.

2.9 Selecting a confidence level for risk informed budgeting

Probabilistic cost and schedule risk analysis represents a departure from traditional methods of estimating of cost and schedule outcomes, wherein it allows for the incorporation of uncertainty in risk. Employing this process can increase the confidence decision makers have in setting cost and schedule objectives, by providing the full spectrum of potential outcomes. The use of quantitative techniques, such as Monte Carlo simulation, allows for cost and schedule estimates to be represented in the form of a range, or probability distribution. From this range, a specific target, or threshold, can be selected for planning and budgeting purposes. When setting such a threshold, such as the project budget, careful consideration must be made selecting the appropriate confidence level.[5]

An agency that is more risk averse may choose to budget for a project based on the 90th percentile confidence level. That is to say, based on the risk analysis, there is a 90 percent chance the actual project cost will fall below this threshold. This selection should ultimately be based upon an organization's risk tolerance. Selecting too high of a confidence level may result in allocating funds where they are not needed, potentially delaying or eliminating other worthy investments due to a lack of funding. Selecting too low of a confidence level may result in a funding shortfall for the project.

Washington State Department of Transportation (WSDOT), an early pioneer in probabilistic cost and schedule risk analysis for public infrastructure projects, initially budgeted projects at the 90th percentile. Over time, through effective use of risk management and observations of risk informed budgets compared to final project cost, WSDOT has reduced this to the 60th percentile. Federal agencies within the US that employ probabilistic cost and schedule risk analysis have requirements for the confidence level for setting a project's budget. For example, the US Federal Transit Administration budgets projects based on the 80th percentile confidence level. For projects overseen by the US Army Corps of Engineers, Congress and the Assistant Secretary of the Army typically budget at the 80th percentile. For highway projects within the US with federal funding, the Federal Highway Administration requires budgets be set based on the 70th percentile confidence level.

Additionally, different confidence levels may be selected for probabilistic cost and schedule risk analysis. While industry best practice calls for integrated cost and risk analysis, i.e. allowing for

[5] Cost and schedule forecasts are presented as probability distributions. In this context, the confidence level refers the percentage of all possible outcomes that can be expected to not exceed the corresponding cost or schedule threshold.

schedule risks to impact cost through price escalation and additional overhead costs, an organization may be more willing to accept schedule risk than cost risk (or vice versa). In the case of setting a higher confidence level for cost relative to schedule, this indicates an organization is more willing to accept schedule delays relative to cost overruns.

Ultimately the selection of the appropriate confidence level for budgeting must be an organization specific decision, which takes into account the organization's willingness to accept risk. This threshold should be revisited and reviewed as the organization gains experience in budgeting through probabilistic cost and schedule risk analysis. An organization may choose to set a standard confidence level for all projects; however this may need to be revisited on a case by case basis as based on specific project characteristics (e.g. project cost, project risk profile).