

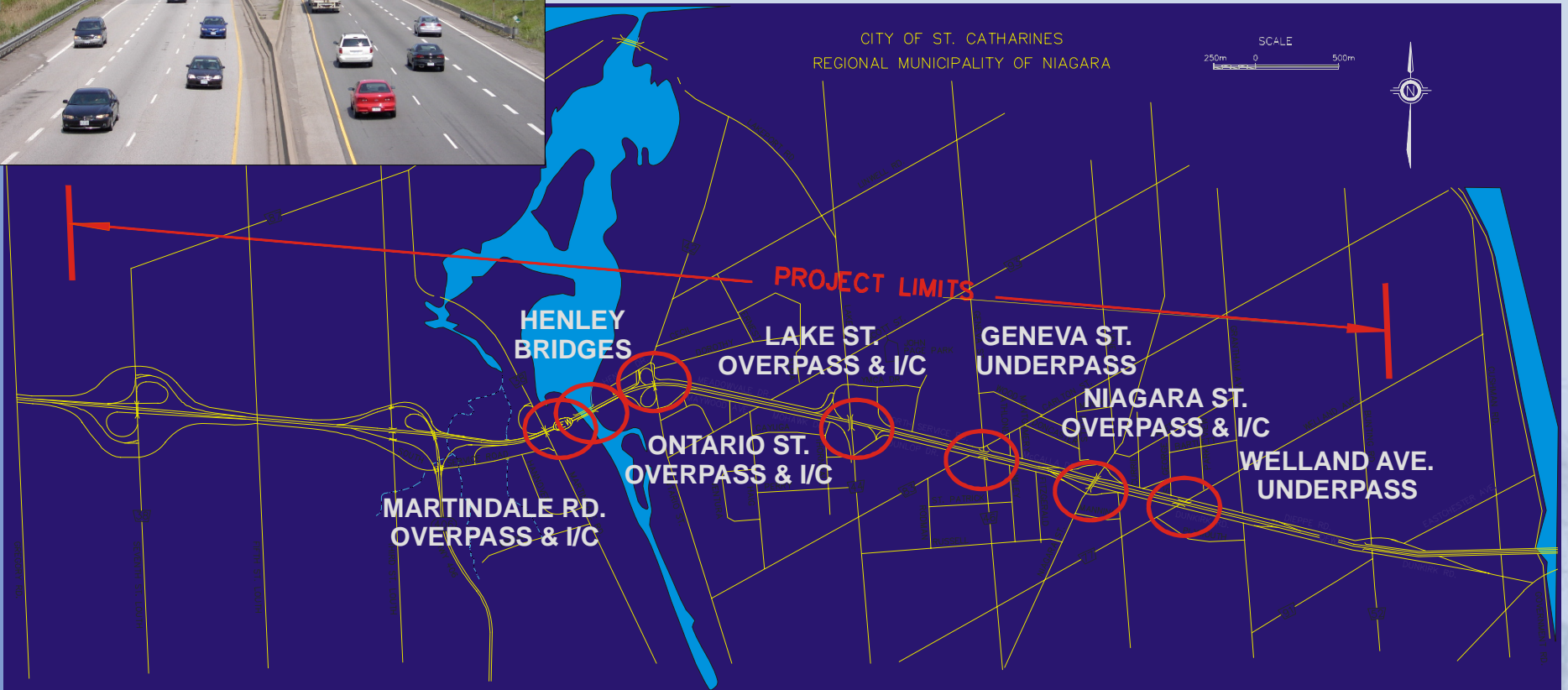


QEW Risk-Based Cost & Schedule Analysis – Lessons Learned

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Major Project Elements

- Highway widened to three lanes per direction
- New 8.5 m wide median, 3 m wide paved right-side shoulders for main-line lanes, 2.5 m wide paved right-side shoulders for ramp lanes
- Concrete barriers on both sides of the roadway
- Noise walls adjacent to residential areas (5 km of walls)
- New storm drainage & management system
- High-mast lighting
- Retaining walls

Major Project Elements

- Widening of the QEW 3rd Street overpass
- Martindale Road bridge replacement with 2-lane structure
- Symmetrical widening of Henley Bridges (separate contract)
- Rehab. of Ontario Street bridge, interchange improvements
- Lake Street bridge replacement (4 lane, 2-stage) interchange improvements
- QEW Geneva Street replacement
- Rehab. of QEW Niagara Street overpass (including ramp)
- Widening of QEW Welland Avenue overpass

Status at Time of Analysis

- Preliminary design studies and environmental planning for widening of the QEW through St. Catharines were begun in 1994
- Bids closed for Henley Bridges widening contract on 2nd day of workshop – design fully completed (\$16M)
- Preliminary design updated & completed with preliminary cost estimates of \$70M for Year 2000 \$ used as basis for funding/cost-sharing agreements
- Detailed design contract for remaining widening project awarded prior to workshop – detailed design nearing 30% complete

Analysis

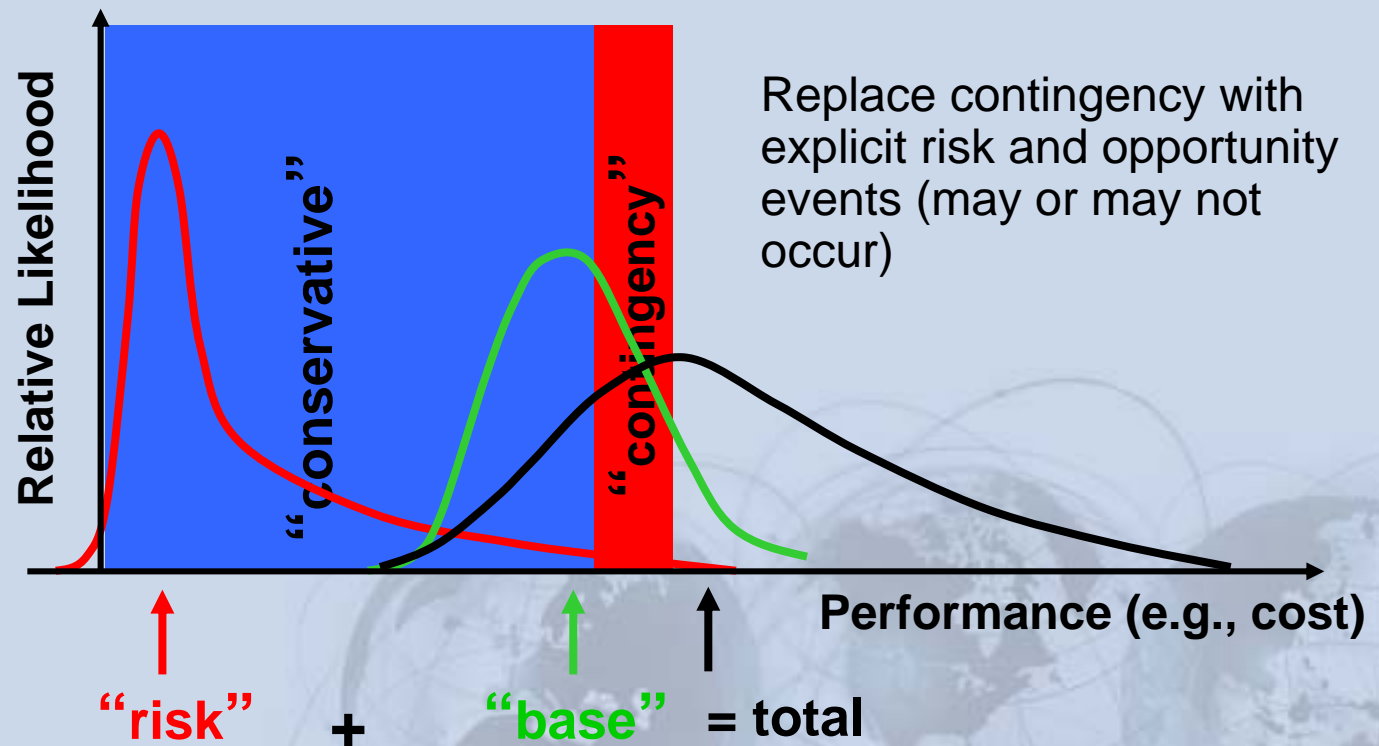
- Completed Risk-Based Cost & Schedule Analysis
- Initial Plan
 - Construction cost estimate only
 - Target date for tender (bid) advertisement – Summer 2006
- Re-examined and validated “base” cost & schedule
 - took out bias and contingencies
 - added other costs such as properties, design, inflation, risks

Workshop Participants

- Risk Analysis Team
- Designer:
 - Project Manager
 - Senior Highway Eng.
- Contractor Specialist
- Construction Admin. Specialist
- MTO Project Staff
 - Project Manager
- MTO Other Staff
 - Traffic
 - Construction
 - Utilities
 - Legal/Property
 - Environmental

Replacement of Estimate+Contingency

$$Total \approx "Base" + "Risk"$$



Quantify “risk” and uncertainty in “base” to determine uncertainties in total

Assumptions

- Construction includes bridges, ramps, and related localized roadway work (service and mainline).
- Environmental permits included in Environmental Process and Update with Addendum activities.
- Partial funding by federal government.
- Single construction contract
- Parallel construction strategy (bridges at same time as road)

Assumptions

- Some utility relocation work is included in individual construction activities.
- Utility relocations are assumed to not require additional property.
- If award before Nov. 15th, construction activities may begin. If award between Nov. 15th and Apr. 1st, construction will not begin until following Apr. 1st.

Assumptions

- Cannot close adjacent on- and off-ramps;
- Roadway must be returned to “normal conditions” (i.e., lanes and capacity) for the winter shutdown period (4.5 months).
- Lake St. I/C constructed in 2 stages: 1) demolition ½ existing, construction 1st half; 2) demolition last ½ existing, construction of the second half (e.g., southbound) of the new bridge.

Assumptions

- 2nd ½ Lake Street I/C can't start in same season as *start* of 1st ½ , but may start in same season of 1st ½ finish.
- Construction on Lake I/C 1st ½, or Lake 2nd ½ and Ontario St. can't begin June 15th to maximize likelihood of completion before winter “normal conditions” requirement.

Assumptions

- Two funding scenarios were evaluated:
 - Unconstrained – funding is available when needed
 - Funding delayed by one year

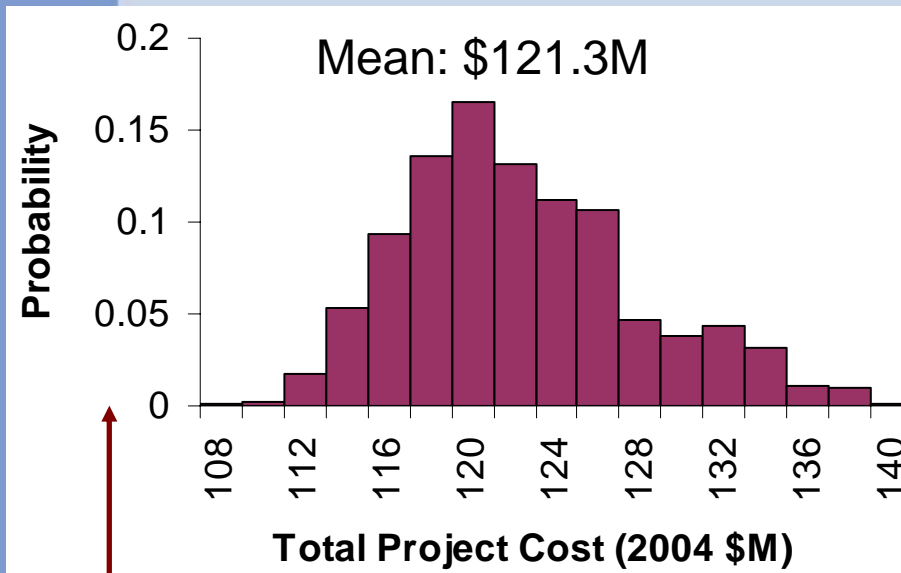
- Cost escalation was estimated to be an average of 3.5% based on past MTO data and project-level decision for first MTO risk-based cost and schedule analysis
 - Average over preceding 10 yrs \approx 3%
 - Average over preceding 15 yrs \approx 2.5%

Risk Register

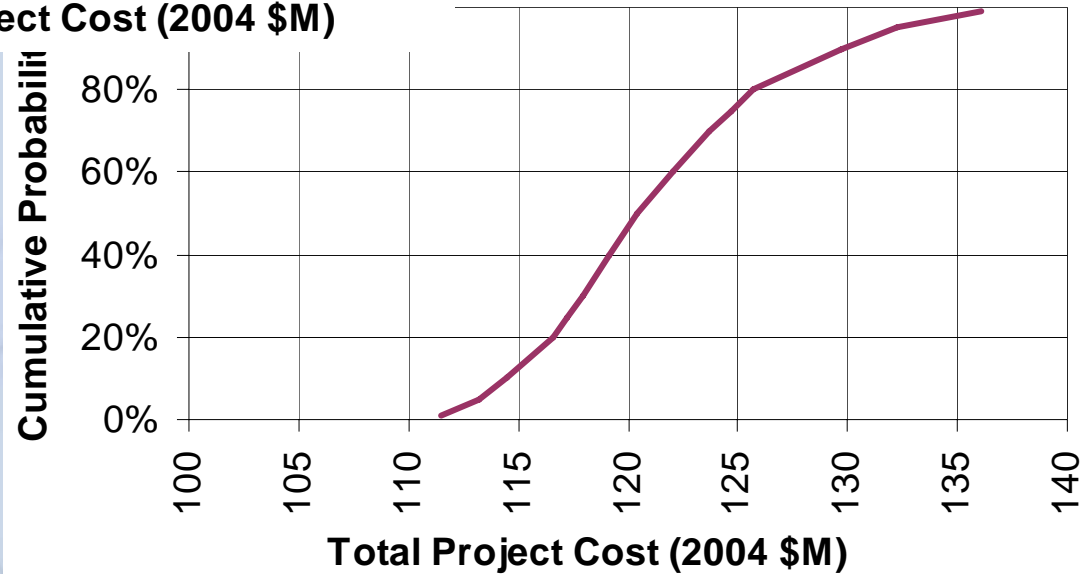
Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (current \$M)	Duration Change (months)
C17	<p>Design errors and/or omissions discovered during construction.</p> <p>It is assumed that the owner/designer/contractor effort during design will be done at a high level of effectiveness (rather than the lower level of effectiveness that can happen under adverse situations). The errors are likely to be smaller rather than major. The risk is defined as the net cost after insurance or other compensation.</p>	Allocate among 19, 20, 21, 27	<p>A. 30%</p> <p>B. 60%</p> <p>C. 10%</p>	<p>A. 0 (base)</p> <p>B. 1</p> <p>C. 4</p>	<p>A. 0</p> <p>B. 1</p> <p>C. 7.5 (one season)</p> <p>Duration change is perfectly correlated to cost change</p>
C18	<p>Contractor change proposals related to design (other than identified separately).</p> <p>Primarily contractor-initiated value engineering. This is an opportunity on cost (net of investments/incentives). Steve says that MTO experience is >1% of tender cost.</p>	Allocate among 19, 20, 21, 27	50%	-1	0

Unconstrained Funding Scenario

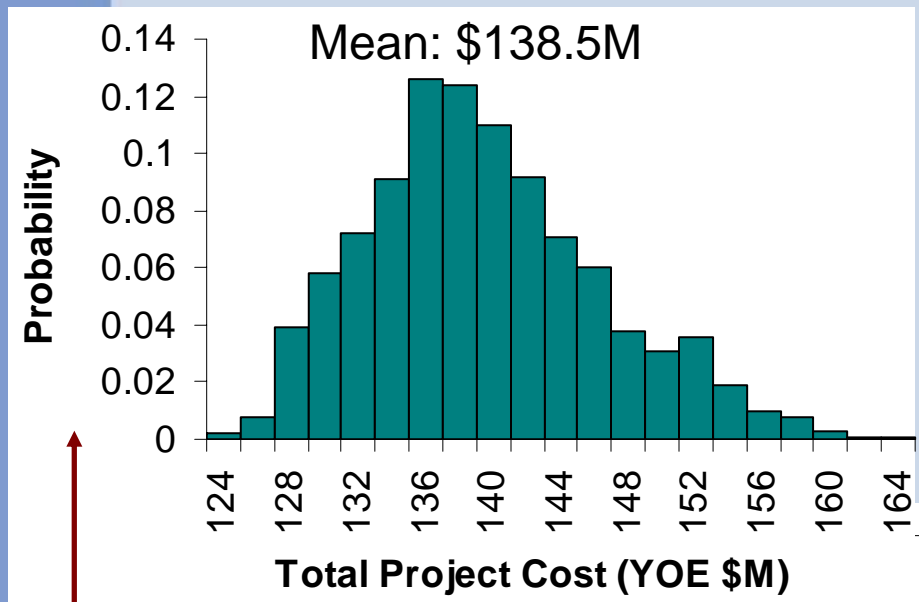
Value in 2004 \$



Base: \$103.7M

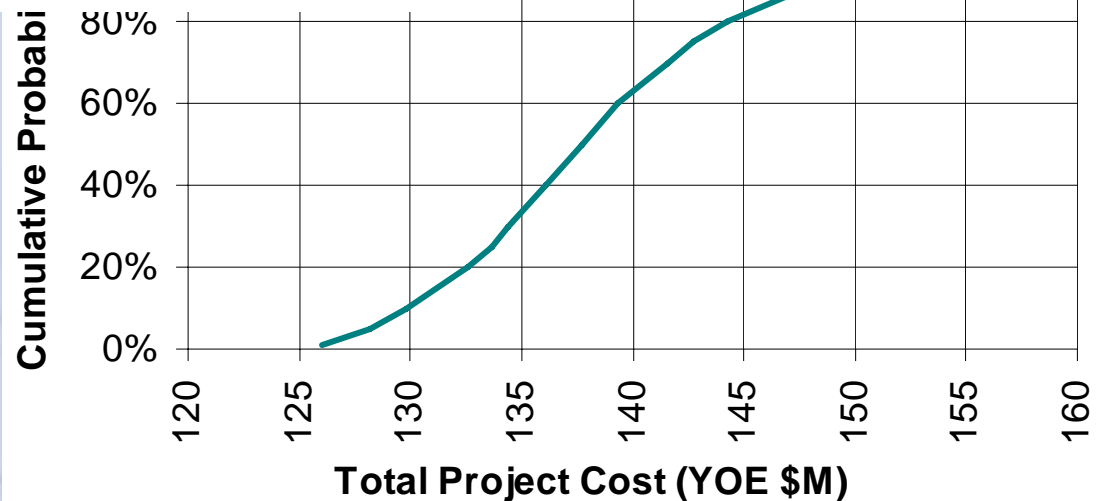


Unconstrained Funding Scenario

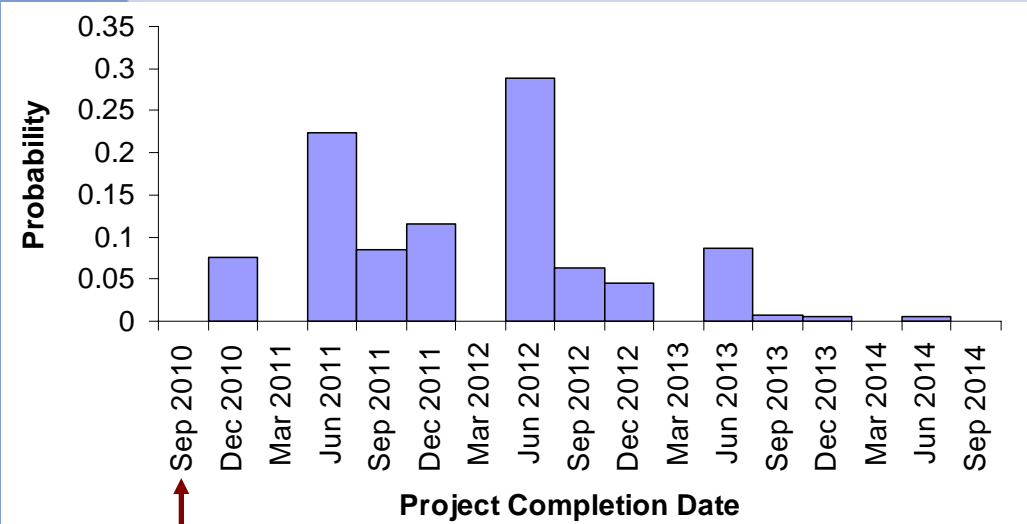


Year of
Expenditure Value

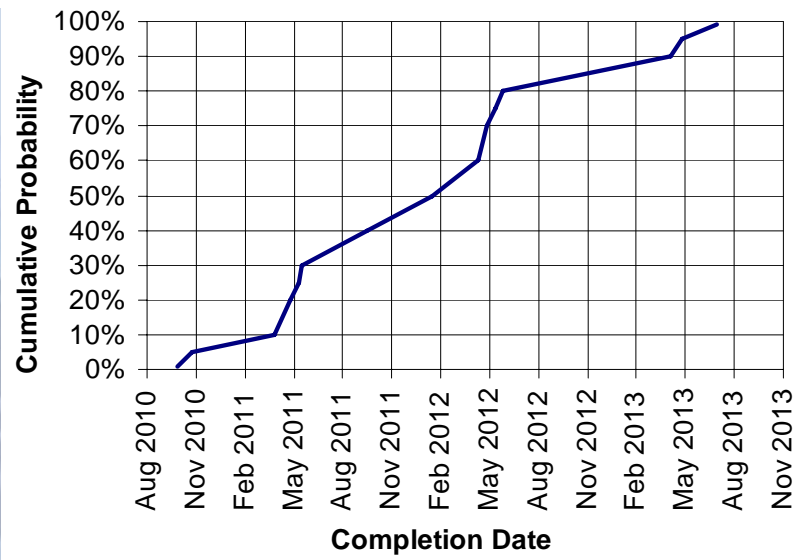
Base: \$116.2M



Unconstrained Funding



Base: September 2010



Cost Summary

Percentile	Unconstrained Funding		Constrained Funding	
	Current \$ (million)	YOE \$ (million)	Current \$ (million)	YOE \$ (million)
Base	103.7	116.2	103.7	116.2
10%	114.5	129.8	115.5	133.7
Mean	121.3	138.5	122.0	141.7
90%	129.7	148.5	129.6	151.0

Ranked List of Cost Risks (Mean)

Risk Rank	Contribution to Expected Cost Risk		Risk Event
	%	Current \$M	
1	18.6%	3.20	C14. Encounter unanticipated contaminated or hazardous materials during construction
2	17.2%	2.95	S1. Additional municipal enhancements required (excluding detours and design uncertainties within scope)
3	12.5%	2.15	D10. Uncertainty in retaining wall design (including scope changes)
4	9.9%	1.70	C6. Henley Bridges cost overruns and/or schedule delay
5	7.7%	1.33	D2a. Uncertainty in structure design - Martindale Road replacement structure
6	5.8%	1.00	C17. Design errors and/or omissions discovered during construction
7	4.7%	0.80	D4a. Uncertainty in structure design - Lake St replacement structure

Risk Management Targets

- Encountering contaminated materials — testing underway at time of workshop (risk reduced following analysis)
- Construction staging
- Additional municipal enhancements
- Henley Bridges project delays
- PHM 125 process
- Martindale Road bridge design uncertainty

RM/VE Targets

Martindale Road replacement structure

Base: \$3.05 M (excludes contingencies); 12 months

Uncertainties: Design uncertainty. Community wants better emergency access/capacity but no cost in base. Opportunity to use new materials/technologies. There may be interest in shortening construction time by investing in more expensive technology. There may be a compromise between MTO and community interests.

Potential mutually-exclusive outcomes from event tree:

- A. 2-lane bridge and no extra cost (base)
- B. 2-lane bridge and some extra cost
- C. 2-lane bridge and significant extra cost associated with new technologies
- D. 4-lane bridge with some extra cost for new technologies

RM/VE Targets

Uncertainty in retaining wall design (including scope changes)

Base: augment existing walls (\$4.5M).

Uncertainties: Rebuild the walls.

Includes uncertainty in wall types, sizes, and related noise, aesthetics, roadside protection, utility-relocation items (3 intersections at \$0.4M each), and removal of existing walls.

Potential mutually-exclusive outcomes:

A. Base

B. Augment some existing, replace some existing

C. Replace all with concrete cantilever walls, with aesthetic treatment, noise walls, and allowing for roadside protection during construction (3 intersections)

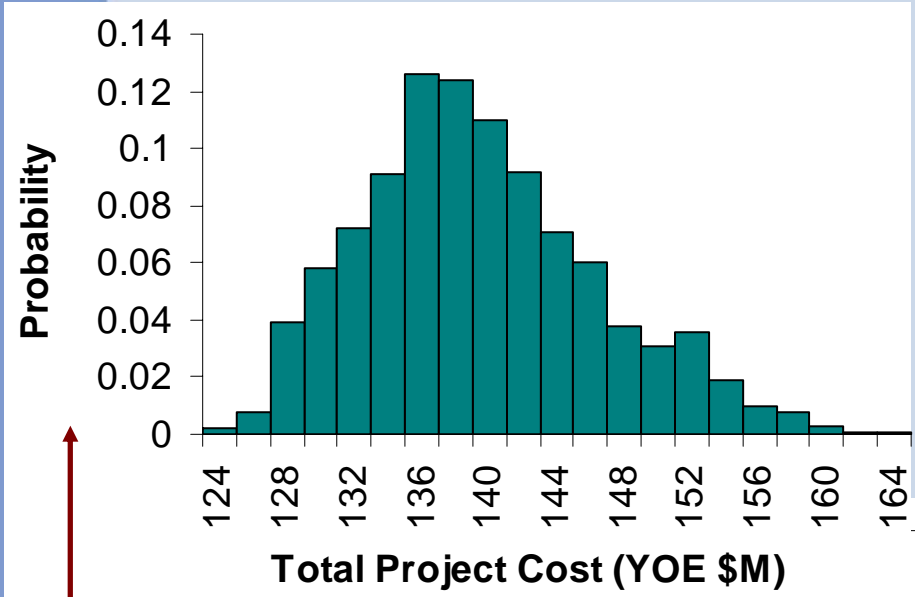
Reality

- Tendered 4 months later than planned, in Spring 2007
- One large contract
- QEW Welland Ave overpass replaced *not* widened
- VE completed following RBCSA – used results
- Henley Bridges \$>16M, 6 mos. behind schedule (p=10% to 20%)

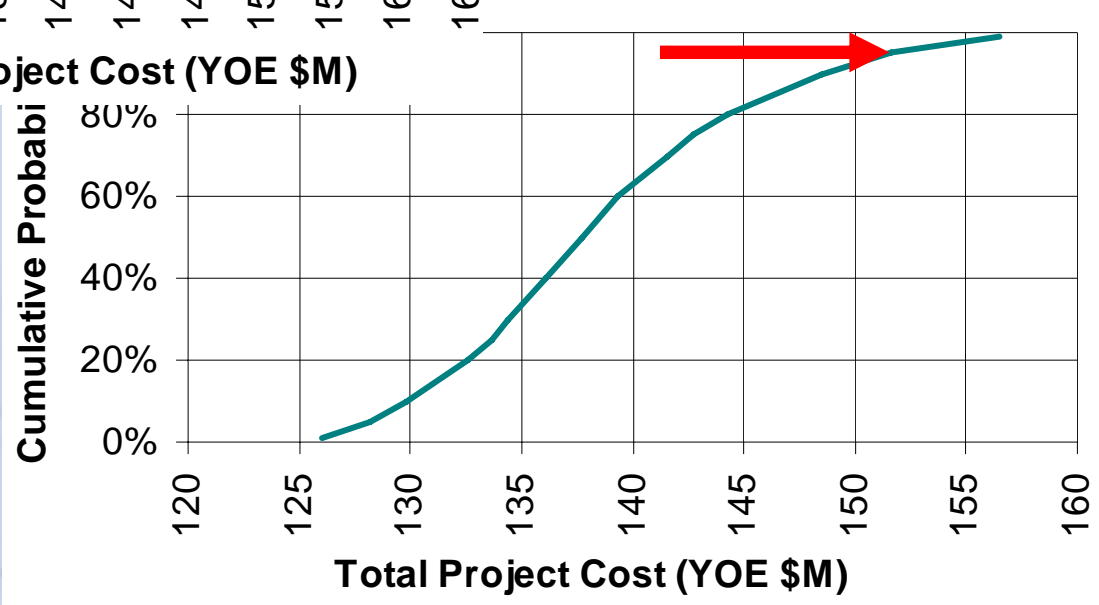
Reality

WHAT HAPPENED?

Bid Price \$153 M
96th Percentile



Base: \$116.2M



Design scope changes

- Martindale Road Design Scope: 2 lane bridge (base) became 4 lane bridge, **RI**, \$1.4M($p=75\%$)
- Lake Street Design Scope: 4 lane bridge (base) became 5 lane bridge **RU** \$1M to \$2M
- Wellend Street Overpass: pedestrian tunnel rebuild not required **RI** (*minor*)
- Additional Improvements: \$8M additional interchange and municipal service road improvements were required by municipal involvement, **RI**, \$7M($p=10\%$)

Threshold for Risk Identification: \$1M, 1 mo.

Reality

\$4.3M additional costs to date during construction:

- changed plan quantities due to field conditions/modifications, **RI**, \$1M($p=60\%$)
- modification to structure rehab Ontario St and Niagara St, **RI**, \$1M($p=10\%$)
- extra traffic control, traffic management, and staging issues, **RI**, \$1M($p=10\%$), \$1M($p=50\%$)
- pothole repairs, **RU** (\$0.35M)
- extra costs associated with utility relocation & protection, storm sewer modifications, **RI**, \$0.2M($p=20\%$)

Threshold for Risk Identification: \$1M, 1 mo.

Reality

\$4.3M additional costs to date during construction:

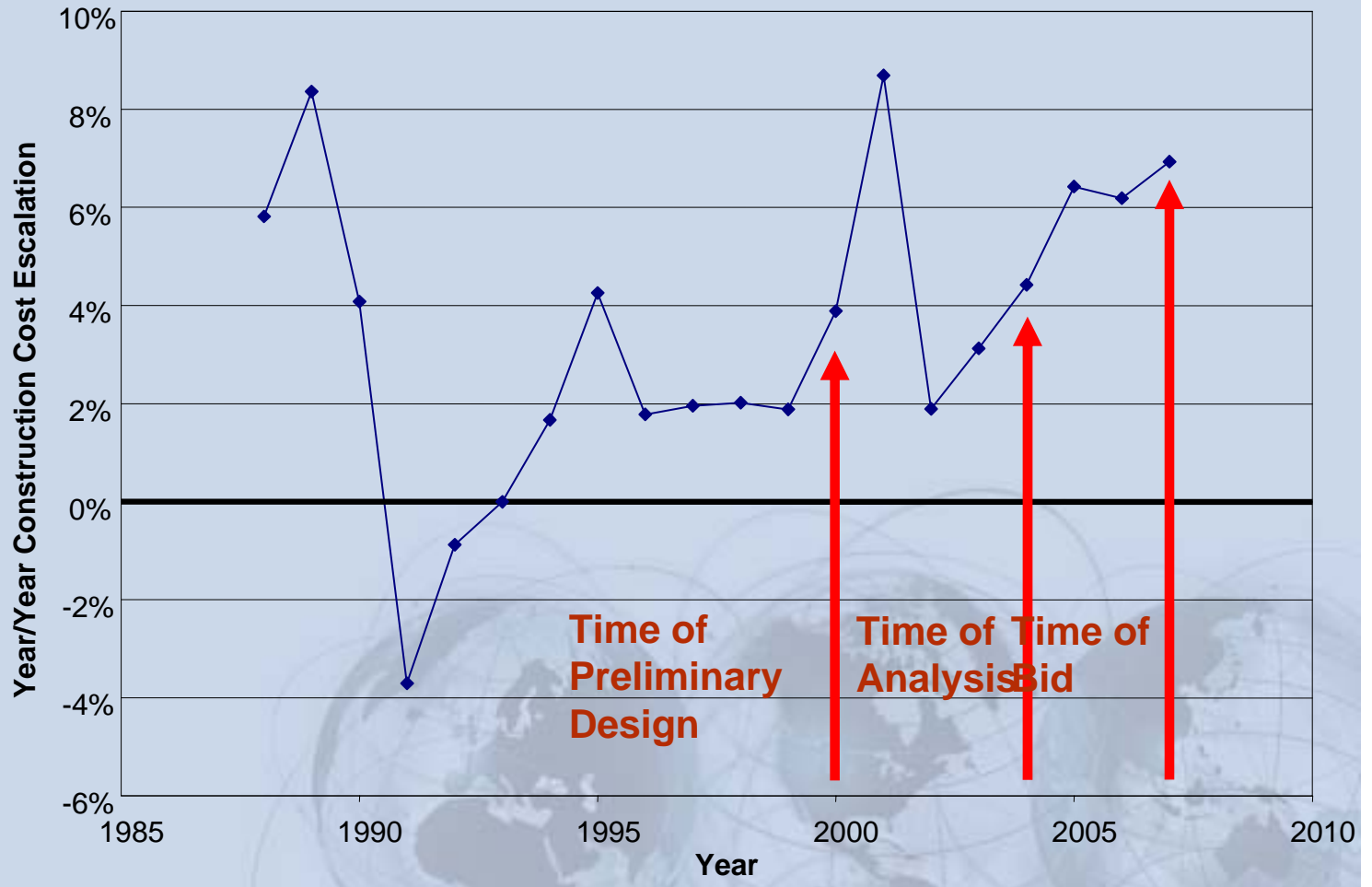
- replacing safety barrier ends, other items damaged by vehicular accident/spills (recoverable costs), **RU/NA**
- extra costs due to salt impacted soil, **RI**, \$0M($p=40\%$), \$3M($p=40\%$), \$10M(20%)
- modifications to temporary and permanent traffic signals extra temporary signage, **RU**
- completion of fish compensation work not originally included in the contract, **RU** (\$0.13M)
- extra surface course mainlane paving, **RU** (\$0.7M)
- stainless steel rebar substitution **RU** (\$0.53M)

Threshold for Risk Identification: \$1M, 1 mo.

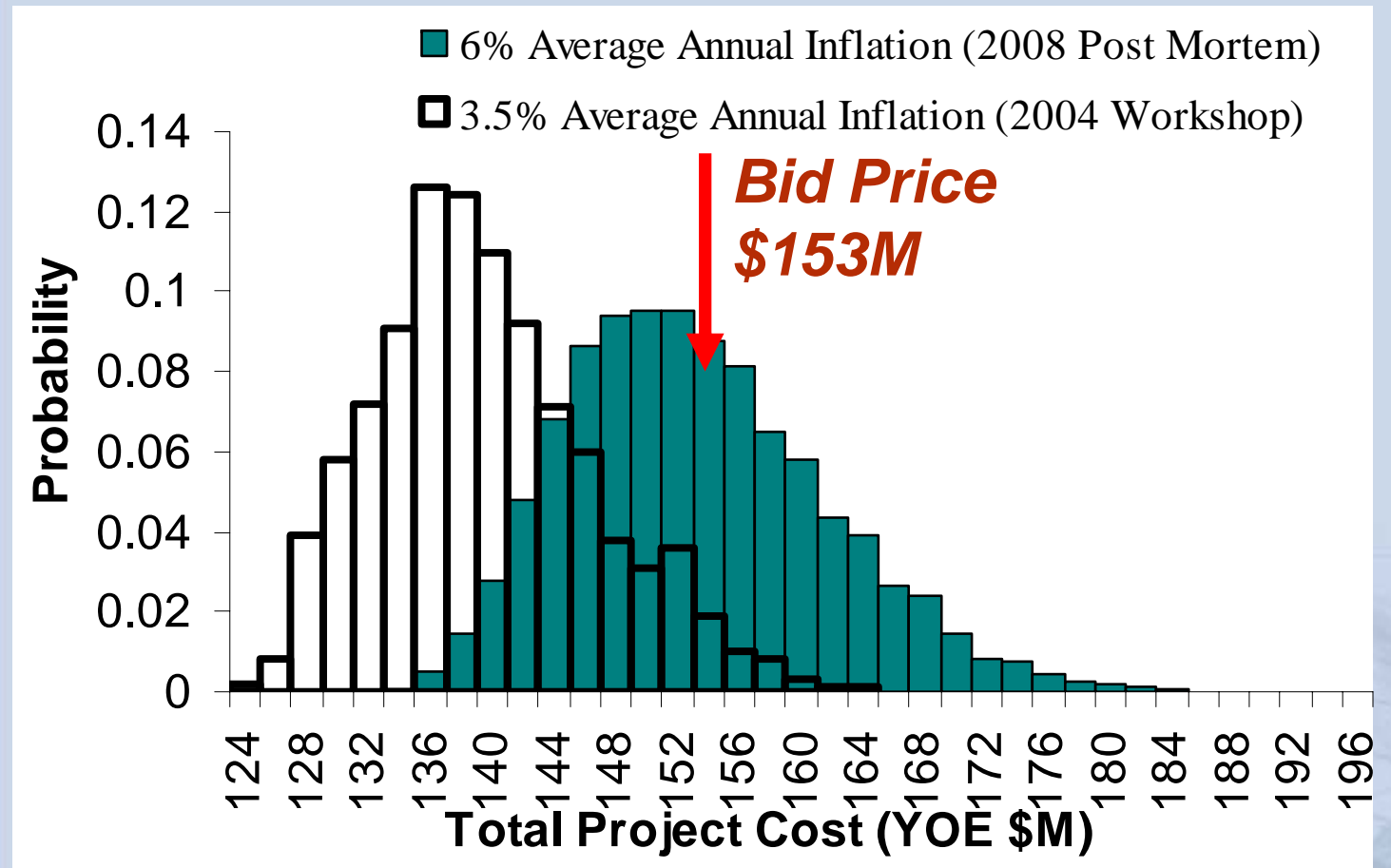
Reality

- Net total of major changes to project scope during design, approximately \$8M to \$11M
- Difference between bid price and mean YOE price of \$14.5M
- Bid price near upper limit of analysis (96th percentile)
- ***WHAT HAPPENED?***

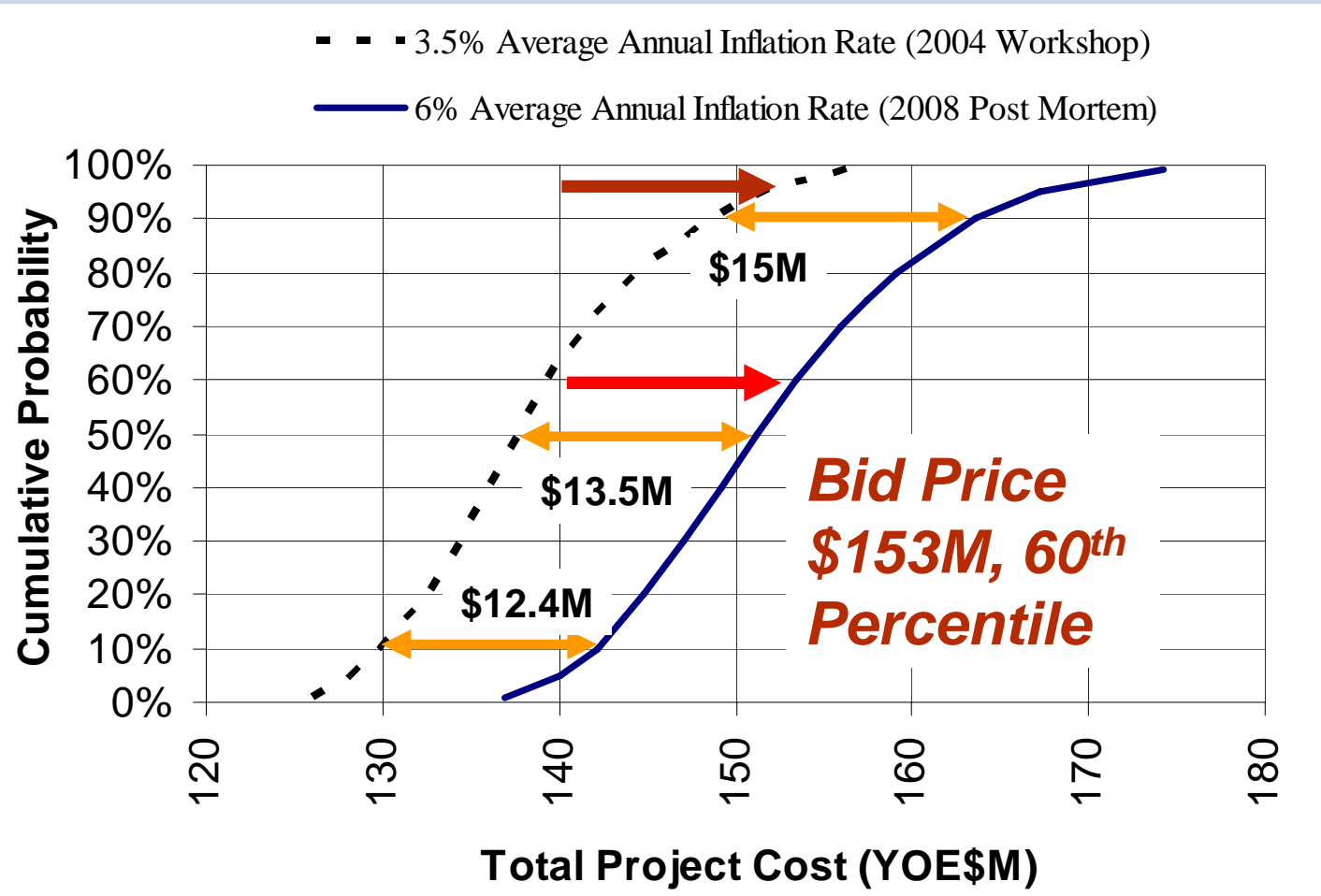
Reality



Reality



Reality

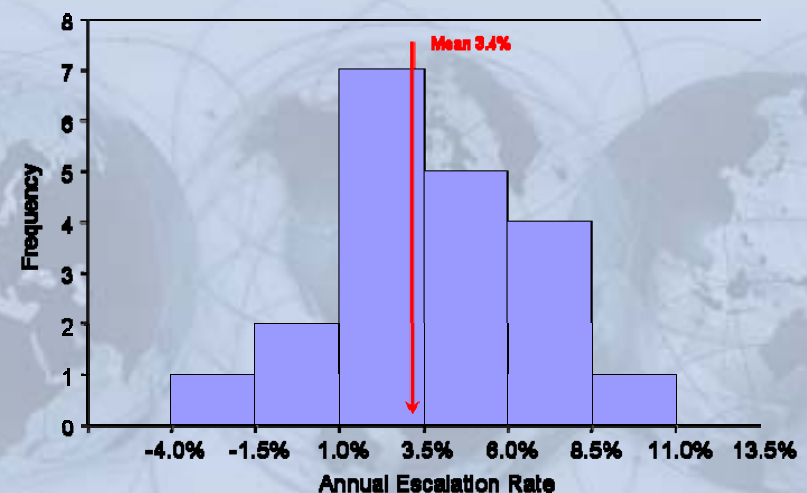


Conclusions

- Some scope risks occurred that were not anticipated, other anticipated risks occurred, and some anticipated risks did not occur
- Unanticipated risks generally fell below threshold and covered by minor risk item category
- Largest single factor in change in price between analysis and bid was change in year/year construction cost escalation
- If construction cost escalation was modelled as a distribution with higher upper bounds, bid price would have been within reasonable expected range

Conclusion

- Uncertainty in construction cost escalation rate should be included in analyses
- Changed (unanticipated) scope recognised during design but a second analysis was not completed





Thank you



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