Appendix C. Cost Estimation of the Bolivar Roads Barrier Using Recent Methods for Cost Estimation

This appendix presents further information with respect to the cost estimate for the proposed storm surge barrier at Bolivar Roads. For these cost estimates the method from Kluijver et al. (2019) has been used. The model is based on the costs of existing barriers around the world, and the dimensions of the various barrier features. It utilizes the following formula:

$$Cost = €157,000 \ x \ Navigable \ Area + €102,000 \ x \ Auxiliary \ Area + €26,000 \ x \ Dam \ Area$$

Auxiliary area refers to the environmental gates; all areas in m^2; price levels in 2019 Euros. The exchange rate at this moment is € 1 = $ 1.20 and this value has been assumed here.

The above formula does include planning, engineering and design costs. It produces an expected (50%) cost value. A 90% confidence interval can be defined based upon the dataset analyzed with the following slope intervals: +/- €60,000 on the Navigational area (NA) term coefficient, +/- €54,000 on the Auxiliary flow area (AA) term coefficient and +/- €13,500 on the Dam or static term (DA) term coefficient (Kluijver et al 2019).

As inputs to the formula information on the gates has been derived from the engineering report and Annex 19. For estimating the height of navigational and environmental gates the channel depths plus an additional 10 ft was used. This estimate presented here does not include the earthen levee on Bolivar peninsula, nor visitor building. Table C-1 presents the barrier dimensions. Table C-2 presents the cost estimates based on these barrier dimensions. Table C-3 summarizes some main metrics related to the width of the barrier and its various elements. Table C-4 presents an alternative cost estimate using the unit cost proposed by Mooyaart (2017) which is based on a unit cost of 2.47 MEuro/m per meter gate width.

Table C-1. Barrier elements and dimensions

Section	amount	width (ft)	width (m)	total width (m)	Avg. height (ft)	Avg. height (m)	total cross section (m2)
Combi wall	1	5300	1616	1616	22	6,7	10838
Environmental gate shallow	16	96	29	468	26,5	8,1	3783
Environmental gate large 20ft	8	300	91	732	30	9,1	6692
Environmental gate large 40ft	7	300	91	640	50	15,2	9760
Navigational gate - large	2	650	198	396	70	21,3	8459
Navigational gate - small	2	125	38	76	50	15,2	1162

Table C-2. Barrier elements and dimensions and costs according to the model of Kluijver et al (2019)

Section	total cross section (m2)	Unit cost (E/m2 avg)	Unit cost (low)	Unit cost (high)	Total cost (Euro Avg)	total Cost (ME)	Total cost (M$)	Total cost (ME low)	Total cost (ME high)
Combi wall	10838	26000	12500	39500	2,82E+08	282	338	135	428
Environmental gate shallow	3783	102000	48000	156000	3,86E+08	386	463	182	590
Environmental gate large 20ft	6692	102000	48000	156000	6,83E+08	683	819	321	1044
Environmental gate large 40ft	9760	102000	48000	156000	9,96E+08	996	1195	468	1523
Navigational gate - large	8459	157000	97000	217000	1,33E+09	1328	1594	820	1835
Navigational gate - small	1162	157000	97000	217000	1,82E+08	182	219	113	252
Total cost (MEuro)						**3856**		**2040**	**5673**
Total cost (M$)						**4627**	**4627**	**2448**	**6807**

Table C-3. Width of various barrier sections

Element	width (m)	Element	width (m)
total with combi wall	3929	navigational gates	473
total without combi wall	2313	environmental gates	1840
navigational gates	473	Dam	1616

Table C-4. Alternative cost estimate using the unit cost proposed by Mooyaart (2017) which is based on a unit cost of 2.47 MEuro/m per meter gate width.

	Expected	Lower bound	Upper bound
Cost (ME)	5713	2313	9251
Cost (M$)	6855	2775	11101

References

Kluijver M, Dols C; Jonkman SN, Mooyaart LF (2019): Advances in the Planning and Conceptual Design of Storm Surge Barriers – Application to the New York Metropolitan Area. In: Goseberg N, Schlurmann T (eds.): Coastal Structures 2019. Karlsruhe: Bundesanstalt für Wasserbau. S. 326-336.

Mooyaart LF, Jonkman SN (2017) Overview and design considerations of storm surge. ASCE Journal of Waterway, Port, Coastal, and Ocean Engineering Vol. 143 Issue 4