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June 14, 2012

Mr. Dane Schneider, P.E.
Managing Engineer
Department of Public Works and Engineering
City of Houston
611 Walker
Houston, TX 77002

Attn: Mr. Lynn Stracener

Re: Rampart Drainage Improvements-Further Modeling Results for Storm Sewer Design for Rampart Project: Phase II-Final Design for Rampart Street (Beechnut St. to Glenmont)
Drainage Improvements Sub-Projects Number 1 and II
WBS #M-000265-0001-3
Klotz Associates, Inc., Project No. 0101.059.002

Dear Mr. Stracener:

Pursuant to our meeting with you on May 29, 2012, we are submitting this letter report to describe revised results to our previously submitted letter of April 11, 2012.

The drainage analyses described in this letter report use 2-dimensional modeling with XP-SWMM-2D (2009 Version) to evaluate both pipe flow and surface flow and inundation conditions in the Rampart Watershed.

Framework for Alternatives Description

The alternatives considered in this letter report include 1) a modification of the original "Preliminary Engineering Report, Storm Sewer Improvements to Westmoreland, Sharpstown, Braeburn, and Maplewood" dated November 2007 (PER) Alternative 3 (this modified Alternative 3 is referred to as the PER-Mod Alternative 3); 2) an alternative suggested by Mr. Lynn E. Stracener of the City of Houston (COH) and identified as the Stracener Alternative; and 3) a new alternative selected in light of the PER-Mod Alternative 3 and the Stracener Alternative, identified as Alternative 4. These alternatives incorporate changes based on the Stracener Alternative and upon considerations and features identified in the meeting of May 29, 2012. The trunklines for all these alternatives outfall via two parallel conduits (referred to as the "Renwick Outfalls" and identified as Out111 and Out112 in Exhibit 1) to Brays Bayou in the

vicinity of Mullins Dr. No modification by any alternative is proposed for the sewer lines or the Renwick Outfall pipes south of Beechnut or for any outfall in the entire SWMM-modeled area.

Description of PER-Mod Alternative 3

As originally developed in the PER, the Rampart Project proposed storm sewer improvements along Rampart St. between Glenmont Dr. and Pine St., along Pine St. from Rampart St. to Renwick Dr., and along Renwick Dr. between Pine St. and Beechnut St. (i.e., Renwick Dr. south of Pine St. and north of Beechnut St.).

In addition, two modifications to the proposed system as presented in the PER were made to further reduce inundation conditions. The first modification added a pipe between the Rampart trunkline and the Renwick trunkline at their most upstream end so that the Rampart and Renwick trunklines became part of a single hydraulic loop extending along the trunklines from the introduced connection to the improved sewer line along Pine St.

The second modification replaced the existing drainage ditches immediately southwest of the junction of the Rampart trunkline and sewer line along Pine St., converting an area of approximately 20 acres from ditch drainage to sewer drainage.

The proposed improvements for the PER-Mod Alternative 3 are shown in Exhibit 2.

Stracener Alternative

This alternative modifies the existing system by introducing localized pipe improvements to the existing pipe network at two locations, as shown in Exhibit 2 : 1) An east-west 60-inch collector bringing flow from the west starting at Ashcroft and going along Clarewood to Renwick; and 2) a 60-inch collector from approximately Valerie to Flack to Rampart to Beechnut to Renwick.

Alternative 4

This alternative is a variation of the PER-Mod Alternative 3 and the Stracener Alternative. It has a Rampart trunkline improvement (similar to the PER-Mod Alternative 3) that is shortened to extend from only Clarewood to Pine St. and thence along Pine St. to Renwick Dr.; see Exhibit 2. An extension of the shortened trunkline on the north collects flow from Clarewood St. and smaller subdivision streets immediately north of Clarewood St.

Roadway Improvements

At the suggestion of the City, certain roadway improvements (see Exhibit 3) were included as part of the storm sewer improvements. The roadway improvements removed high regions along key roadways so as to reduce or eliminate blockage of overland flow to sewer collection points in the area of storm sewer improvements. These improvements were incorporated into the topography for all improvement alternatives evaluated by modifying the LiDAR elevations to reflect the desired topographic changes in the area of concern.

Two changes in topography were made:

- Change along Rampart-Bissonnet to Bellaire: Rampart was lowered approximately 3 feet (ft) between Bissonnet and Bellaire to reflect roadway reconstruction, a distance of approximately 3,000 ft. This topography change was incorporated into PER-Mod Alternative 3 and Alternative 4 since both these alternatives envision sewer improvements along Rampart in this area of roadway elevation change.
- Change along Rampart-Valerie to Holly (near Flack Drive): Rampart was lowered approximately 3 ft between Valerie and Holly (a distance of approximately 200 ft). This topography change was incorporated into PER-Mod Alternative 3, the Stracener Alternative, and Alternative 4 since all these alternatives envision sewer improvements in this general area of Rampart.

Hydrology

Key factors in determining rainfall and runoff for the inputs to the SWMM model were the following. Additional hydrologic information is provided in the Appendix.

Watershed Delineation

For descriptive purposes, the Project incorporates three primary watersheds (see Exhibit 1): 1) the Rampart Watershed, which discharges storm waters collected directly by the sewer lines generally along Rampart St. and Renwick Dr. and discharges to the Renwick Outfalls; 2) the areas to the west of the Rampart St. watershed, referred to as the West Watershed, that have the potential for surface or subsurface drainage into or out of the Rampart St. Watershed; and 3) the areas to the east of the Rampart St. Watershed that have the potential for surface or subsurface

drainage into or out of the Rampart St. Watershed. The Rampart St. Watershed is essentially the watershed used in the Rampart PER, and represents the area targeted for improvement by construction of improvements. Collectively, these three watersheds cover approximately 4,500 acres. The SWMM modeling incorporated all three of these watersheds and analyzed the three watersheds as a single, combined watershed.

Storm Sewer Layouts

The existing and proposed alternative sewer layouts are shown in Exhibits 1 and 2, respectively. To address hydraulic model capacity limitations, greater detail in the hydrologic and hydraulic description was used in the Rampart St. Watershed than in the West and East Watersheds.

Rainfall Characteristics

Temporal variation of rainfall was described with an Exceedance Probability Rainfall Distribution Graph based upon intensity-duration-frequency data from the COH design criteria manual (Chapter 9).

Runoff Characteristics

Surface runoff hydrographs for inflow to the subsurface pipe system were determined using the Clark Unit Hydrograph Tc+R method in conjunction with the Rational Method to calibrate the R storage parameter in the Tc+R method.

Hydraulics

A 2-dimensional SWMM model was used for describing pipe flow and surface flow and inundation. The following summarizes specific hydraulic features of special interest. Additional hydraulic information is provided in the Appendix.

Inlets

Inlets were lumped at manholes, with greater manhole density and consequent detail of runoff description being used for the Rampart Watershed. In areas where conduit replacements were to be made, no limit of inlet capacity was imposed; detailed engineering design will use the computed maximum discharge to size necessary individual inlet capacity.

Outfall Characteristics

Existing pipe locations and depths were those used in the PER or modifications (which were determined by a combination of survey, review of GIMs data, collection and review of as-built drawings, and professional judgment). Field survey for the PER set the invert of the existing Rampart system outfall at 35.77 ft (based upon NAVD 88, 2001 adjustment); an incorrect value of 34.77 was used in prior SWMM modeling. The SWMM modeling reported herein uses the correct value of 35.77 ft.

As-built drawings showed the Rampart system outfall pipes to be two 12-ft x 12-ft box culverts. However, field survey for the PER as well as subsequent site inspection (with photographs) done for the SWMM modeling determined the outfall pipes to Brays Bayou to be two 12-ft wide by 13-ft high elliptical culverts (possibly differing from the as-built drawings because of construction difficulties at the outfall outlet). The elliptical culverts were used in the SWMM modeling of the Rampart system outfall.

Outfall Tailwaters

The following rules were used to set tailwater elevations:

For Modeling 2-Year Storm Events: Tailwater is set at the top of the highest outfall pipe for existing conditions for both PER and SWMM modeling.

For Modeling of Storm Events Larger than a 2-Year Storm: A critical level is defined as 2-ft below the top-of-bank. Tailwater level is set at a level equal to a FEMA or other similar reliable value for flood levels in the receiving water for the storm frequency of interest with the caveat that selected level cannot be higher than the critical level. The top-of-bank is estimated using best judgment in conjunction with site inspection, photographs, LiDAR and other topographic data, and FEMA river flow models to the extent available.

For the entire watershed (Rampart, East, and West Watersheds) for the Rampart system there are 18 outfalls, two of which directly discharge stormwaters from the Rampart sewer system. Other outfall locations are shown in Exhibit 2. Tailwater elevations are listed in Table A-2 in the Appendix.

Modeling Results

Modeling results are presented for the 2-, 10-, 50-, and 100-year flood frequencies for the existing conditions and the three previously described alternative improvements. Exhibits 4 to 7 provide for comparison purposes inundation plots for the 2-, 10-, 50-, and 100-year events for the three alternatives. The inundation plots show the extent and depth of maximum land surface inundation in excess of 3-inches during the entire course of the storm event. Visual comparison of the inundation conditions generally shows the following:

2-year storm events (Exhibits 4-1, 4-2, 4-3, 4-4)

Within the Rampart Watershed, existing conditions have some areas of inundation in the northern end of the watershed, the Flack Estates area south of Bissonnet along Pine, miscellaneous areas west of Rampart, and along and south of Beechnut.

- The PER-Mod Alternative 3 eliminates inundation in the Pine St. area while introducing some limited inundation northeast of the intersection of Bellaire and Renwick. Minor amounts of inundation for the existing condition along Rampart north of Bellaire are eliminated by the PER-Mod Alternative 3.

- The Stracener Alternative eliminates the inundation area near the intersection of Beechnut and Renwick and Pine and Rampart, but introduces new inundation in the vicinity of the Gulfton and Hillcroft intersection.

- Alternative 4 eliminates some of the inundation at the northern end of the watershed and virtually all other areas of inundation in Rampart Watershed north of Beechnut.

Overall, Alternative 4 appears to have the most beneficial impact on the 2-year inundation conditions.

10-year storm events (Exhibits 5-1, 5-2, 5-3, 5-4)

For the 10-year storm, areas of prominent inundation occur for existing conditions in the northern end of the Rampart Watershed, in the general area of Clarewood and Renwick, and the Flack and Pine St. areas between Rampart and Renwick.

- The PER-Mod Alternative 3 reduces the severity of flooding along Bissonnet, Pine, and Flack between Renwick and Hillcroft. Some flood reduction is also achieved along and near Clarewood. Conditions south of Beechnut are little changed.

- The Stracener Alternate does not reduce inundation in the northern end of the Rampart Watershed; inundation generally north of Bellaire is increased. Reduction in inundation occurs in the vicinity of Flack and Pine between Hillcroft and Renwick. Conditions south of Beechnut are little changed.

- Compared to the existing conditions, Alternative 4 reduces inundation in the Clarewood area and in limited areas north of Bellaire between Renwick and Rampart. Inundation is significantly reduced between Renwick and Rampart south of Bellaire and north of Beechnut. Conditions south of Beechnut are little changed.

Overall Alternative 4 appears to provide the greatest reduction in inundation over the Rampart Watershed.

50-year storm events

For the existing conditions, inundation is significant across much of the Rampart Watershed. The Clarewood St. and Flack-Pine St. areas are particularly severe.

- The PER-Mod Alternative 3 provides some inundation reduction along Bissonnet between Hillcroft and Renwick and in the Pine and Flack St. area between Hillcroft and Bissonnet.

- The Stracener Alternative provides some limited reduction of flooding along Rampart north of Bellaire and between Bellaire and Bissonnet between Rampart and Renwick. Flooding in the Flack St. area between Rampart and Renwick is also reduced.

- Alternative 3 provides limited but general reduction of inundation across much of the Rampart Watershed. Reductions between Bissonnet and Beechnut between Hillcroft and Renwick are noticeable.

Overall, while flooding is not reduced by the alternatives in major amounts, Alternative 4 appears to provide the greatest reduction.

100-year storm events

The 100-year existing flooding conditions have greater severity of inundation than the 50-year event, but are generally quite similar to the 50-year flood.

- The PER-Mod Alternative 3 provides some inundation reduction along Bissonnet and Bellaire between Hillcroft and Renwick and in the Pine and Flack St. area between Hillcroft and Bissonnet.

- The Stracener Alternative provides some limited reduction of flooding in the Pine and Flack St. area between Rampart and Hillcroft. However, inundation north of Bellaire is generally increased by the Stracener Alternative.

- Alternative 3 provides some limited inundation reduction north of Bellaire and noticeable reductions south of Bellaire between Renwick and Hillcroft. The reduction of Alternative 3 is generally greater than those of the PER-MOD Alternative 3.

Level of Service (LOS) Estimate

Estimating LOS is difficult in precise terms, but the observation indicates the general LOS conditions as follows:

All the alternatives provide sufficient improvements for a 2-year storm event to conclude they provide at least an approximate 2-year LOS. None of the alternatives provide a LOS as much as a 50-year LOS.

Within the Rampart Watershed, Alternative 4 appears to do well at providing a 10-year LOS while the PER-Mod Alternative 3 perhaps achieves a 10-year LOS. The Stracener Alternative clearly does not achieve a 10-year level of service. Based upon these observations, the LOS estimates are as follows:

- Alternative 4: Greater than a 10-year but well less than a 50-year LOS
- PER-Mod Alternative 3: Greater than a 2-year and almost a 10-yr LOS
- Stracener Alternative: Greater than a 2-year, less than a 10-year LOS, and less than the PER-Mod Alternative 3

Impact and Impact Mitigation

It is our understanding that for the Rampart Project discussed in this letter report, the impact potentially requiring mitigation is that arising from increased surface imperviousness due to roadway modification. Review of aerial photos for the two areas of roadway lowering suggests that the streets might be widened from approximately 22 ft to 28 ft to accommodate a typical concrete curb and gutter section.

For the street lowering along Rampart from Valerie to Holly (200 ft), a 6-ft street widening would increase impervious area by about 1,200 square-feet (sq-ft) = 0.03 acres. Since this amount is less than 15,000 square-ft, a detention rate (base upon guidance in the COH Design Criteria Manual, Chapter 9) of 0.2 acre-ft per acre (ac-ft/ac) would be required for mitigation. Thus a detention volume of 0.006 ac-ft would be required. This amount of storage is so small as to be negligible and can be likely readily accommodated by slight oversizing of storm sewers and laterals.

For the street lowering along Rampart from Bissonnet to Bellaire, (approximately 3,000 ft) a widening of 6 ft would create about 18,000 sq-ft = 0.4 ac of imperviousness. Based upon COH criteria, a detention rate of 0.50 ac-ft of storage per acre of new imperviousness would be required. Thus mitigation would require about 0.2 ac-ft of storage. This volume can likely be accommodated within the roadway ROW by oversizing of the storm sewer and laterals.

Construction Costs of Proposed Alternatives

Estimated constructions costs for the three alternatives are summarized in Table 2. Detailed cost estimates are attached to this letter report.

Table 2. Estimated Construction Costs of Alternatives

Alternative	Construction Cost
PER-Mod Alternative 3	**$18,642,000**
Stracener Alternative	**$6,515,000**
Alternative 4	**$10,356,000**

Recommendation

As summarized in the "Modeling Results' section of this report, based on XP-SWMM analysis, the Stracener Alternative, while having the lowest estimated construction cost, does not provide a level of service comparable to the other two alternatives. For the 2-year event it reduces ponding in some areas, while increasing it in others. For 10- and 50-year events, the Stracener Alternative increases levels of inundation when compared to the other alternatives. Based on our modeling and analysis we believe this phenomenon is due to the absence of a "relief" system along Rampart that is included in the other alternatives.

For the 2-year, 10-year, and 50-year events, Alternative 4 shows similar but somewhat improved results compared to PER-MOD-3. Based on similar levels of services and significantly lower estimated construction costs than PER-MOD-3, Klotz Associates recommends implementing Alternative 4.

Sincerely,

STATE OF TEXAS
MICHAEL A. COLLINS
39270
REGISTERED ENGINEER

Michael A. Collins, P.E., Ph.D.
Director of Hydrology and Hydraulics

MAC:az

Attachment

APPENDIX

Hydrology

Key hydrologic factors in determining inputs to the SWMM model were the following:

Watershed Delineation

For descriptive purposes, the Project incorporates three primary watersheds: 1) the Rampart St. Watershed, which discharges storm waters collected directly by the sewer lines generally along Rampart St. and Renwick Dr. and discharged to the Renwick Outfalls; 2) the areas to the west of the Rampart St. watershed, referred to as the West Watershed, that have the potential for surface or subsurface drainage into or out of the Rampart St. Watershed; and 3) the areas to the east of the Rampart St. Watershed that have the potential for surface or subsurface drainage into or out of the Rampart St. Watershed. The Rampart St. Watershed is essentially the watershed used in the Rampart PER and represents the general area targeted for improvement by construction of improvements.

The existing and proposed storm sewer layouts are shown in the exhibits. The exhibits also delineate the portions of the existing system for which the proposed improvements are intended to reduce flooding (i.e., the Rampart Watershed). To address hydraulic model capacity limitations, greater detail in the hydrologic and hydraulic description was used in the Rampart St. Watershed. The subsurface pipe systems for the East and West Watersheds were initially delineated using GIMS data. Generally, only larger pipes (24-inch and above) were retained for modeling to stay within model capabilities.

Collectively, the Project evaluation area composed of the three watersheds covers approximately 4,500 acres. In the SWMM modeling, all three watersheds were connected by subsurface conduits of various sizes and locations and by surface flow pathways. The SWMM modeling analyzed the three watersheds as a single, combined watershed with a total drainage area of approximately 4,500 acres. When overland flow naturally flowing toward external areas outside of these three watershed is accounted for, the surface flow potentially flowing to or affecting the collection system being modeled is reduced to 3693 acres.

Rainfall Characteristics

Temporal variation of rainfall was described with an Exceedance Probability Rainfall Distribution Graph based upon intensity-duration-frequency data from the COH Design Manual (Chapter 9).

Runoff Characteristics

Surface runoff hydrographs for inflow to the subsurface pipe system at nodal inflow points were determined using the Clark Unit Hydrograph Tc+R method in conjunction with the Rational Method. The R storage parameter was calibrated using the peak discharge as computed from the Rational Method for a 2-year storm event by making the SWMM computed 2-year peak discharge approximately match the Rational Method discharge.

The peak discharge at each nodal inflow point was computed for a 2-year storm event using the Rational Method. HEC-HMS (version 3.3) was used to model the runoff from the various drainage areas for a 2-year storm using the Tc+R method. The Tc value was estimated from travel time for overland flow and in channels and ditches. The R in the model input parameters was estimated by trial and error such that the peak 2-year discharge determined using the Rational Method was closely equal to the peak 2-year discharge determined using HEC-HMS modeling.

To account for topographic changes arising from proposed roadway lowering, the basic LiDAR data points are individually modified on a piece-by-piece (or zone-by-zone) basis. The modified LiDAR data is then used to form a TIN which defines the topography of the area to be modeled.

Hydraulics

A 2-dimensional SWMM model was used for describing in pipe flow and surface flow and inundation. Pipe flow is described by standard pipe friction loss and minor loss equations (junction loses were included) while the surface flow is described in individual grid cells in which Manning's equation is used to determine flow movement from one cell to another. The sources and sinks of the surface flow are inlets points (or similar) at which flow can enter or exit the pipe system.

Beyond the geometry of the pipe system (defined by the existing or proposed alternatives for the underground conduit system and the topography of the land surface described by LiDAR) the hydraulics and subsequent surface inundation are particularly dependent upon the following:

Inlets

For the modeling of this report, inlets were lumped at manholes, with greater manhole density and consequent detail of runoff description in the Rampart Watershed. Manhole capacity for existing manholes (either in existing conditions or alternatives in locations where improvements were not to be made) were based upon the number of inlets represented by the manholes and the estimated existing capacity of the inlets. In areas where conduit replacements were to be made, no limit on capacity was imposed.

Outfall Characteristics

Existing pipe locations and depths were those used in the PER (which were determined by a combination of survey, review of GIMs data, collection and review of as-built drawings, and professional judgment). Field survey for the PER set the inverts of the Rampart system outfall at 35.77 ft. (based upon NAVD 88, 2001 adjustment); this value was used in the PER. Subsequent SWMM simulations used a value of 34.77 ft and was in error; it should have been 35.77 ft. This error was corrected for the simulations described in this letter report. Outfall inverts for improvement alternatives were set equal to the existing condition.

As-built drawings showed the Rampart system outfall pipes to be two 12-ft x 12-ft box culverts. However, field survey for the PER as well as subsequent site inspection (with photographs) done for the SWMM modeling determined the outfall pipes to Brays Bayou to be two 12-ft wide by 13-ft high elliptical culverts (possibly differing from the as-built drawings because of construction difficulties at the outfall outlet). The elliptical culverts were used in the SWMM modeling of the Rampart system outfall.

Outfall Tailwaters

The following rules were used to set tailwater elevations:

For Modeling 2-Year Storm Events:

The tailwater is set at top of outfall pipe for existing conditions for both PER and SWMM modeling. If the top of pipe elevation changes for proposed conditions from that for existing conditions, use the top of pipe appropriate to the condition of interest.

For Modeling of Storm Events Larger than a 2-Year Storm

Situation 1: For situations where a FEMA or other similar reliable model is available to define flood levels in the receiving water:

1. Determine the top-of-bank at the outfall for existing conditions (see discussion below)
2. Use FEMA model to determine the water level for the flood frequency of interest in the receiving water. If a model is not available for the frequency of interest, estimate the receiving water level for the frequency of interest by interpolation.
3. If the flood level (for the frequency of interest) in the receiving water is below a level equal to 2-ft below the top-of-bank, set the outfall tailwater equal to the flood level of the receiving water, subject to the limitation that the minimum level is the top of outfall pipe.

4. If the flood level (for the frequency of interest) in the receiving water is equal to or above a level equal to 2-ft below the top-of-bank, set the outfall tailwater equal to a level 2-ft below the top-of-bank.
5. If the tailwater level determined by either rule 3 or 4 is less than the 2-yr tailwater level, set the tailwater level at the 2-yr tailwater (i.e., top of pipe).

Situation 2: The following rules are used for situation where a FEMA or other similar reliable model is not available to define the flood levels in the receiving water:

1. Determine the top-of-bank at the outfall
2. Determine the top of the outfall pipe for existing conditions.
3. Estimate a water surface elevation for the 100-year storm. In lieu of other information assume the 100-yr level to be equal to 2-ft below the top-of-bank.
4. Follow rules 3, 4, and 5 from above.

Top-of-bank Estimation

Outfall Tailwater Elevation Depends upon the estimated top-of-bank of the watercourse to which the outfall discharges. The following can complicate the estimation of the top-of-bank elevation:

- Erratic ground slope perpendicular to the channel axis in the vicinity of the channel sides
- Different potential barriers to lateral spread of waters which rise above the bank, with the consequent behavior of the barrier like a top-of-bank control
- The effectiveness of the potential barriers, i.e., is the barrier continuous or discontinuous along the axis of the channel alignment
- Distance of the actual outfall from the channel and what might be considered a barrier line, including different types of structures (e.g., bridges)
- The presence or non-presence of man-made barriers such as roadways along a channel, and distance of barrier from the channel

Determining the top-of-bank is usually not a precise determination; professional judgment is used when the top-of-bank was not readily distinguished. For the Rampart system outfalls, potential top-of-bank situations are as listed in Table 1. The elevation selected as the top-of-bank for modeling purposes is listed.

Table A.1 Top-of-Bank Estimates:

Estimated Top-of-bank Elevation	Estimated Top of Ground Location	Basis of Estimate
55.33	On natural ground close to Brays Bayou (about 150 downstream of outfall pipe exit)	HEC-RAS model for Brays Bayou, supplemented with LiDAR and Aerial Photo inspection
56.26	Used in SWMM modeling prior to June 2012	Early inspection of HEC-RAS and trying to find significant barrier to water spread
53.11 to 53.31	Roadway with bridge just downstream of outfall crossing outfall channel	Google review, LiDAR
53.70	Curb along edge of roadway with bridge just downstream of outfall crossing outfall channel	Google review, adding 6 inches for curb height to street level
51.85	As-built drawings with 5-ft adjust to bring to current datum	As-built drawings, with datum elevation
52.10	Top of pipe at end of outfall pipe	From HouStorm profile
55.33	**SELECTED for MODELING**	**Seems most reasonable choice of barrier affecting spread of flow**

There are 18 different outfalls for the entire watershed modeled. All were examined for top-of-bank conditions. Based upon that examination and rules for setting tailwater level described above, the tailwaters given in Table A-2 were selected.

Table A-2. Outfall Elevations

Outfall	Invert	Soffit	2-yr Tailwater	10-yr Tailwater	50-yr Tailwater	100-yr Tailwater	Top-of-bank
OUT100	54.0	59.0	59.00	63.49	64.39	64.50	66.50
OUT101	56.0	59.5	59.50	63.26	64.01	64.10	66.10
OUT103	53.6	57.6	57.60	62.17	63.09	63.20	65.20
OUT104	54.3	58.3	58.30	60.36	61.79	62.54	64.54
OUT105	54.8	57.3	57.30	60.36	61.86	62.54	64.54
OUT106	54.1	56.6	56.60	59.25	61.30	62.41	64.41
OUT107	39.8	49.8	49.80	53.70	54.48	54.58	56.58
OUT109	44.57	48.57	48.57	54.68	54.22	53.22	55.22
OUT110	45.00	47.5	47.50	54.4	54.20	53.30	55.30
OUT111	35.77	48.77	48.77	53.95	53.93	53.33	55.33
OUT112	35.77	48.77	48.77	53.95	53.93	53.33	55.33
OUT114	45.0	48.0	48.00	51.67	52.41	52.50	54.50
OUT115	45.0	48.0	48.00	50.86	51.43	51.50	53.50
OUT116	35.5	47.5	47.50	50.56	51.17	51.25	53.25
OUT117	45.74	50.24	50.24	51.06	51.23	51.25	53.25
OUT118	43.0	49.0	49.00	50.84	51.20	51.25	53.25

Shaded outfalls are Renwick outfalls; see Exhibit 1 for locations of all outfalls

RAMPART DRAINAGE IMPROVEMENTS
CONSTRUCTION COST ESTIMATE FOR
LES ALTERNATIVE

ITEM NO.	SPEC. SECTION	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE ($)	TOTAL PRICE($)
SITE PREPARATION						
ALL.01	01502	Mobilization	LS	1	150,000	150,000
ALL.02	01555	Traffic Control and Regulation in Accordance with Traffic Control Plan	LS	1	200,000	200,000
ALL.06	01555	Flagmen	LS	1	150,000	150,000
ALL.07	01561	Trench Safety System for Trench Excavations	LF	7,000	1.00	7,000
ALL.08	01562	Tree and plant protection	LS	1	20,000	20,000
STORM SEWER						
SW.04	2081	Type"C" manhole for up to 60-inch diameter sewers	EA	4	3,000.00	12,000
SW.14	02634	24-inch diameter storm sewer lead	LF	3,200	92.00	294,400
SW.17	02631	60 inch diamter stormj sewer by open cut	LF	3,500	400.00	1,400,000
SW.17	02631	84 inch diamter stormj sewer by open cut	LF	935	560.00	523,600
SW.17	02631	102 inch diamter stormj sewer by open cut	LF	1,460	680.00	992,800
SW.17	02631	120 inch diamter stormj sewer by open cut	LF	960	800.00	768,000
SW.20	02632	Type "BB" inlet	EA	40	1,800.00	72,000
PAVING						
SB.07	02221	Remove and dispose concrete sidewalk and driveway(all thickness)	SY	2,250	3.00	6,750
SB.08	02221	Remove And Dispose of Reinforced Concrete Pavement, With or Without Asphalt Overlay	SY	9,000	8.00	72,000
SB.11	02336	Lime stabilized subgrade, 8-inch	SY	10,000	3.00	30,000
SB.19	02741	Type D hot mix asphaltic concrete surface overlay (2")	Ton	1,600	120.00	192,000
SB.25	02751	9-inch reinforced concrete pavement	SY	9,000	35.00	315,000
SB.31	02754	6-inch concrete driveway	SF	20,000	4.00	80,000
SB.38	02771	6-inch concrete curb	LF	7,000	3.50	24,500
WATER LINE REPLACEMENT COSTS						
WA.04	02511	8-inch diameter water line by Open Cut	LF	2,900	60.00	174,000
SANITARY SEWER REPLACEMENT COSTS						
ALL.20	02221	Remove and Dispose of Existing Manholes	EA	4	100.00	400
ALL.24	02221	Remove and Dispose of 10-inch diameter sewer	LF	1,300	20.00	26,000
WW.02	02082	4-foot diameter precast concrete manhole	EA	4	3,000.00	12,000
WW.19	02531	10-inch diameter sanitary sewer by open cut	LF	1,300	110.00	143,000
SUB-TOTAL						**$ 5,665,450**
		Contingency(15%)				**$ 849,818**
GRAND TOTAL ALL ITEMS						**$ 6,515,268**

RAMPART DRAINAGE IMPROVEMENTS
CONSTRUCTION COST ESTIMATE FOR
PER ALTERNATIVE 3

ITEM NO.	SPEC. SECTION	ITEM DESCRIPTION	UNIT	PROP-03 TOTAL QUANTITY	UNIT PRICE ($)	PROP-01 TOTAL PRICE($)
SITE PREPARATION						
ALL.01	01502	Mobilization	LS	1	470,000	470,000
ALL.02	01555	Traffic Control and Regulation in Accordance with Traffic Control Plan	LS	1	200,000	200,000
ALL.06	01555	Flagmen	LS	1	150,000	150,000
ALL.07	01561	Trench Safety System for Trench Excavations	LF	14,500	1.00	14,500
ALL.08	01562	Tree and plant protection	LS	1	20,000	20,000
ALL.18	02221	Remove and dispose 18-inch thru 30-inch diameter concrete storm sewer	LF	5,000	16.00	80,000
ALL.18	02221	Remove and dispose 36-inch thru 48-inch diameter concrete storm sewer	LF	1,900	22.00	41,800
STORM SEWER						
SW.04	2081	Type"C" manhole for up to 48-inch diameter sewers	EA	4	3,000.00	12,000
SW.05	02081	Manhole for concrete box sewers	EA	33	3,000.00	99,000
SW.14	02634	24-inch diameter storm sewer lead	LF	1,400	92.00	128,800
SW.17	02631	6-foot by 6-foot box storm sewer by open cut	LF	680	400.00	272,000
SW.17	02631	7-foot by 7-foot box storm sewer by open cut	LF	2,950	530.00	1,563,500
SW.17	02631	8-foot by 8-foot box storm sewer by open cut	LF	2,280	610.00	1,390,800
SW.17	02631	9-foot by 9-foot box storm sewer by open cut	LF	1,300	750.00	975,000
SW.17	02631	10-foot by 10-foot box storm sewer by open cut	LF	3,950	910.00	3,594,500
SW.17	02631	10-foot by 12-foot box storm sewer by open cut	LF	1,970	1,360.00	2,679,200
SW.TBD		Cast-in-Place Junction Box	EA	4	100,000	400,000
SW.TBD		Cast-in-Place Junction Box at 66-inch PCCP	EA	1	150,000	150,000
SW.20	02632	Type "BB" inlet	EA	64	1,800.00	115,200
PAVING						
SB.07	02221	Remove and dispose concrete sidewalk and driveway(all thickness)	SY	8,000	3.00	24,000
SB.08	02221	Remove And Dispose of Asphaltic surface with or without base	SY	55,000	8.00	440,000
SB.08	02221	Remove And Dispose of Reinforced Concrete Pavement, With or Without Asphalt Overlay	SY	5,300	8.00	42,400
SB.11	02336	Lime stabilized subgrade, 8-inch	SY	5,700	3.00	17,100
SB.19	02711	Type A hot mix asphaltic base course, 8 inch	Ton	3,375	80.00	270,000
SB.19	02741	Type D hot mix asphaltic concrete surface 1 1/2 inch	Ton	638	120.00	76,560
SB.25	02751	9-inch reinforced concrete pavement	SY	14,000	35.00	490,000
SB.31	02754	6-inch concrete driveway	SF	13,000	4.00	52,000
SB.38	02771	6-inch concrete curb	LF	11,780	3.50	41,230
BISSONNET LATERALS						
ALL.07	01561	Trench Safety System for Trench Excavations	LF	803	1.00	803
ALL.18	02221	Remove and dispose 18-inch thru 30-inch diameter concrete storm sewer	LF	803	16.00	12,848
SB.08	02221	Remove And Dispose of Reinforced Concrete Pavement, With or Without Asphalt Overlay	SY	1,069	8.00	8,555
SB.11	02336	Lime stabilized subgrade, 8-inch	SY	1,150	3.00	3,450
SW.04	2081	Type"C" manhole for up to 48-inch diameter sewers	EA	1	3,000.00	3,000
SW.04	2081	Type"C" manhole for 48-inch to 72-inch diameter sewers	EA	2	4,400.00	8,800

RAMPART DRAINAGE IMPROVEMENTS
CONSTRUCTION COST ESTIMATE FOR
PER ALTERNATIVE 3

ITEM NO.	SPEC. SECTION	ITEM DESCRIPTION	UNIT	PROP-03 TOTAL QUANTITY	UNIT PRICE ($)	PROP-01 TOTAL PRICE($)
SW.14	2633	24-inch diameter storm sewer lead	LF	72	92.00	6,624
SW.14	02631	42-inch diameter storm sewer by open cut (Bissonnet-E)	LF	161	180.00	28,980
SW.14	02631	48-inch diameter storm sewer by open cut (Bissonnet-E)	LF	642	210.00	134,820
SW.20	02632	Type "BB" inlet	EA	6	1,800.00	10,800
GLENMONT LATERALS						
ALL.07	01561	Trench Safety System for Trench Excavations	LF	1,308	1.00	1,308
ALL.18	02221	Remove and dispose 36-inch thru 48-inch diameter	LF	794	22.00	17,468
ALL.18	02222	Remove and dispose 54-inch thru 72-inch diameter concrete storm sewer	LF	514	30.00	15,420
SB.08	02221	Remove And Dispose of Asphaltic surface with or without base	SY	2,437	5.00	12,186
SB.19	02711	Type A hot mix asphaltic base course, 8 inch	Ton	732	80.00	58,598
SB.19	02741	Type D hot mix asphaltic concrete surface 1 1/2 inch	Ton	137	120.00	16,481
SB.38	02771	6-inch concrete curb	LF	1,200	3.50	4,200
SW.04	2081	Type"C" manhole for 48-inch to 72-inch diameter sewers	EA	3	4,400.00	13,200
SW.14	2633	24-inch diameter storm sewer lead	LF	48	92.00	4,416
SW.14	02631	48-inch diameter storm sewer by open cut	LF	1,308	210.00	274,680
SW.20	02632	Type "BB" inlet	EA	4	1,800.00	7,200
ELM STREET LATERALS						
ALL.07	01561	Trench Safety System for Trench Excavations	LF	1,288	1.00	1,288
SB.08	02221	Remove And Dispose of Asphaltic surface with or without base	SY	1,572	5.00	7,859
SB.19	02711	Type A hot mix asphaltic base course, 8 inch	Ton	721	80.00	57,702
SB.19	02741	Type D hot mix asphaltic concrete surface 1 1/2 inch	Ton	135	120.00	16,229
SW.04	02081	Type"C" manhole for 48-inch to 72-inch diameter sewers	EA	3	4,400.00	13,200
SW.14	02631	24-inch diameter storm sewer lead	LF	48	92.00	4,416
SW.14	02631	48-inch diameter storm sewer by open cut(Elm)	LF	1,288	210.00	270,480
SW.20	02632	Type "BB" inlet	EA	4	1,800.00	7,200
WATER LINE REPLACEMENT COSTS						
WA.04	02511	6-inch diameter water line Open Cut	LF	360	50.00	18,000
WA.04	02511	8-inch diameter water line open cut	LF	840	60.00	50,400
WA.04	02511	12-inch diameter water line open cut	LF	260	80.00	20,800
WA.04	02511	24-inch diameter water line Open Cut	LF	130	150.00	19,500
WA.13	02513	6-inch diameter wet connection	EA	3	1,500.00	4,500
WA.13	02513	8-inch diameter wet connection	EA	11	1,800.00	19,800
WA.13	02513	24-inch diameter wet connection	EA	2	4,000.00	8,000
SANITARY SEWER REPLACEMENT COSTS						
ALL.20	02221	Remove and Dispose of Existing Manholes	EA	19	100.00	1,900
ALL.24	02221	Remove and Dispose of 8 - 24-inch diameter sewer	LF	884	20.00	17,680
ALL.24	02221	Remove and Dispose of 30-inch diameter sewer	LF	2,000	40.00	80,000
ALL.24	02221	Remove and Dispose of 36-inch Force Main	LF	2,000	40.00	80,000
WW.02	02082	4-foot diameter precast concrete manhole	EA	6	3,000.00	18,000
WW.02	02082	6-foot diameter precast concrete manhole	EA	8	4,500.00	36,000

RAMPART DRAINAGE IMPROVEMENTS
CONSTRUCTION COST ESTIMATE FOR
PER ALTERNATIVE 3

ITEM NO.	SPEC. SECTION	ITEM DESCRIPTION	UNIT	PROP-03 TOTAL QUANTITY	UNIT PRICE ($)	PROP-01 TOTAL PRICE($)
WW.19	02531	8-inch diameter sanitary sewer by open cut	LF	280	80.00	22,400
WW.19	02531	10-inch diameter sanitary sewer by open cut	LF	180	110.00	19,800
WW.19	02531	12-inch diameter sanitary sewer by open cut	LF	80	130.00	10,400
WW.19	02531	24-inch diameter sanitary sewer by open cut	LF	144	220.00	31,680
WW.19	02531	30-inch diameter sanitary sewer by open cut	LF	2,000	220.00	440,000
WW.22	02532	36-inch diameter sanitary force main, by open-cut	LF	2,000	240.00	480,000
SUBTOTAL						**16,210,661**
		Contingency (15%)				**2,431,599**
GRAND TOTAL ALL ITEMS						**18,642,260**

RAMPART DRAINAGE IMPROVEMENTS
CONSTRUCTION COST ESTIMATE FOR
ALTERNATIVE 4

ITEM NO.	SPEC. SECTION	ITEM DESCRIPTION	UNIT	TOTAL QUANTITY	UNIT PRICE ($)	TOTAL PRICE($)
SITE PREPARATION						
ALL.01	01502	Mobilization/General Requirements	LS	1	350,000	350,000
ALL.02	01555	Traffic Control and Regulation in Accordance with Traffic Control Plan	LS	1	200,000	200,000
ALL.06	01555	Flagmen	LS	1	150,000	150,000
ALL.07	01561	Trench Safety System for Trench Excavations	LF	8,450	1.00	8,450
ALL.08	01562	Tree and plant protection	LS	1	20,000	20,000
ALL.18	02221	Remove and dispose 18-inch thru 30-inch diameter concrete storm sewer	LF	4,950	16.00	79,200
ALL.18	02221	Remove and dispose 36-inch thru 48-inch diameter concrete storm sewer	LF	1,908	22.00	41,976
STORM SEWER						
SW.05	02081	Manhole for concrete box sewers	EA	25	3,000.00	75,000
SW.14	02634	24-inch diameter storm sewer lead	LF	1,000	92.00	92,000
SW.17	02631	8-foot by 8-foot box storm sewer by open cut	LF	1,300	610.00	793,000
SW.17	02631	9-foot by 9-foot box storm sewer by open cut	LF	4,000	750.00	3,000,000
SW.17	02631	7-foot by 7-foot box storm sewer by open cut	LF	1,400	530.00	742,000
SW.17	02631	42" dia storm sewer by open cut	LF	1,970	180.00	354,600
SW.17	02631	60" dia storm sewer by open cut	LF	1,970	400.00	788,000
SW.TBD		Cast-in-Place Junction Box	EA	2	100,000	200,000
SW.20	02632	Type "BB" inlet	EA	64	1,800.00	115,200
PAVING						
SB.07	02221	Remove and dispose concrete sidewalk and driveway(all thickness)	SY	5,400	3.00	16,200
SB.08	02221	Remove And Dispose of Asphaltic surface with or without base	SY	25,000	8.00	200,000
SB.08	02221	Remove And Dispose of Reinforced Concrete Pavement, With or Without Asphalt Overlay	SY	3,500	8.00	28,000
SB.11	02336	Lime stabilized subgrade, 8-inch	SY	3,800	3.00	11,400
SB.19	02711	Type A hot mix asphaltic base course, 8 inch	Ton	3,024	80.00	241,920
SB.19	02741	Type D hot mix asphaltic concrete surface 1 1/2 inch	Ton	567	120.00	68,040
SB.25	02751	9-inch reinforced concrete pavement	SY	10,400	35.00	364,000
SB.31	02754	6-inch concrete driveway	SF	7,680	4.00	30,720
SB.38	02771	6-inch concrete curb	LF	8,000	3.50	28,000
BISSONNET (EAST) LATERALS						
ALL.07	01561	Trench Safety System for Trench Excavations	LF	803	1.00	803
ALL.18	02221	Remove and dispose 18-inch thru 30-inch diameter concrete storm sewer	LF	803	16.00	12,848
SB.08	02221	Remove And Dispose of Reinforced Concrete Pavement, With or Without Asphalt Overlay	SY	1,069	8.00	8,555
SB.11	02336	Lime stabilized subgrade, 8-inch	SY	1,150	3.00	3,450
SB.25	02751	9-inch reinforced concrete pavement	SY	1,069	35.00	37,427
SW.04	2081	Type"C" manhole for up to 48-inch diameter sewers	EA	1	3,000.00	3,000
SW.04	2081	Type"C" manhole for 48-inch to 72-inch diameter sewers	EA	2	4,400.00	8,800
SW.14	2633	24-inch diameter storm sewer lead	LF	72	92.00	6,624
SW.14	02631	42-inch diameter storm sewer by open cut (Bissonnet-E)	LF	161	180.00	28,980
SW.14	02631	48-inch diameter storm sewer by open cut (Bissonnet-E)	LF	642	210.00	134,820
SW.20	02632	Type "BB" inlet	EA	6	1,800.00	10,800
WATER LINE REPLACEMENT COSTS						
WA.04	02511	6-inch diameter water line w/Restrained Joints in 10-inch Steel Casing by Open Cut	LF	240	130.00	31,200

RAMPART DRAINAGE IMPROVEMENTS
CONSTRUCTION COST ESTIMATE FOR
ALTERNATIVE 4

ITEM NO.	SPEC. SECTION	ITEM DESCRIPTION	UNIT	TOTAL QUANTITY	UNIT PRICE ($)	TOTAL PRICE($)
WA.04	02511	8-inch diameter water line w/Restrained Joints in 12-inch Steel Casing by Open Cut	LF	560	150.00	84,000
WA.04	02511	12-inch diameter water line w/Restrained Joints in 16-inch Steel Casing by Open Cut	LF	175	220.00	38,500
SANITARY SEWER REPLACEMENT COSTS						
ALL.20	02221	Remove and Dispose of Existing Manholes	EA	19	100.00	1,900
ALL.24	02221	Remove and Dispose of 8 - 24-inch diameter sewer	LF	884	20.00	17,680
WW.02	02082	4-foot diameter precast concrete manhole	EA	6	3,000.00	18,000
WW.02	02082	6-foot diameter precast concrete manhole	EA	8	4,500.00	36,000
WW.19	02531	8-inch diameter sanitary sewer by open cut	LF	280	80.00	22,400
WW.19	02531	10-inch diameter sanitary sewer by open cut	LF	180	110.00	19,800
WW.19	02531	12-inch diameter sanitary sewer by open cut	LF	80	130.00	10,400
WW.19	02531	24-inch diameter sanitary sewer by open cut	LF	144	220.00	31,680
WW.19	02531	30-inch diameter sanitary sewer by open cut	LF	2,000	220.00	440,000
SUBTOTAL						**9,005,372**
		Contingency (15%)				**1,350,806**
GRAND TOTAL ALL ITEMS						**10,356,178**