6.0 ALTERNATIVES ANALYSIS

The development and analysis of flood damage reduction alternatives for Huntington consisted of a three-step plan formulation process and is described below.

Phase 1 – Hydraulic Analysis of Preliminary Alternatives – Initially, preliminary alternatives, including levees and dredging, were evaluated using the hydraulic model to determine their effect on flood levels.

Phase 2 – Development and Evaluation of Preliminary Concept Plans - Based on results of Phase 1, Fairfax County and the Corps identified which alternatives should be developed and evaluated further. For these alternatives, which included levees, dredging, buyouts, and flood proofing, the team developed preliminary 5% concept plans and conducted a preliminary economic analysis to determine rough economic costs and benefits. The Phase 2 alternatives were reviewed by Fairfax County. The Phase 2 alternatives that were cost prohibitive, did not solve the flooding problem, and/or were not favored by the residents and/or the county were not pursued further.

Phase 3 – Development and Evaluation of Final Concept Plans - For the remaining alternatives, which included a levee and a levee/dredging combination, the concept designs were further refined to a 25% concept level and the levees were evaluated for three different heights of protection to determine the optimal plan. An economic analysis of these final alternatives was conducted and was used to assist the county in selecting a final plan for design.

6.1 PHASE 1 – HYDRAULIC ANALYSIS OF PRELIMINARY ALTERNATIVES

A hydraulic model was used to determine the effectiveness of alternative plans to reduce flood levels at Huntington. The hydraulic modeling was completed using HEC-RAS version 3.3. The original model is a HEC-RAS model created by VDOT (PCC, 2002) and was updated by the Corps for this study. The HEC-RAS model includes the Route 1 improvements that VDOT has recently completed, however, it does not include the proposed improvements to Telegraph Road and the Capital Beltway (I-495/I-95) upstream of Huntington. The hydrologic flow values were also updated to reflect changes based on a recent hydrologic study performed by the Corps for FEMA for Cameron Run (USACE, May 2007). Table 2.1 shows the discharges based on that report. The 1% annual discharge used for this analysis was 25,410 cfs downstream of Pike Branch at the Telegraph Road Bridge.

The team identified the following preliminary levee and dredging alternatives and evaluated their effectiveness in reducing flood levels at Huntington and their impact on other areas by using the HEC-RAS model. Appendix G3 has further information on this hydraulic analysis.

- **Preliminary Levee Alignment #1 –** This alternative is the construction of a levee as close to Cameron Run as possible, approximately 200 feet from the stream centerline (Figure 6.1). The levee would be high enough to contain the 1% annual chance flood. Advantages of the alignment include more available area behind the levee for interior

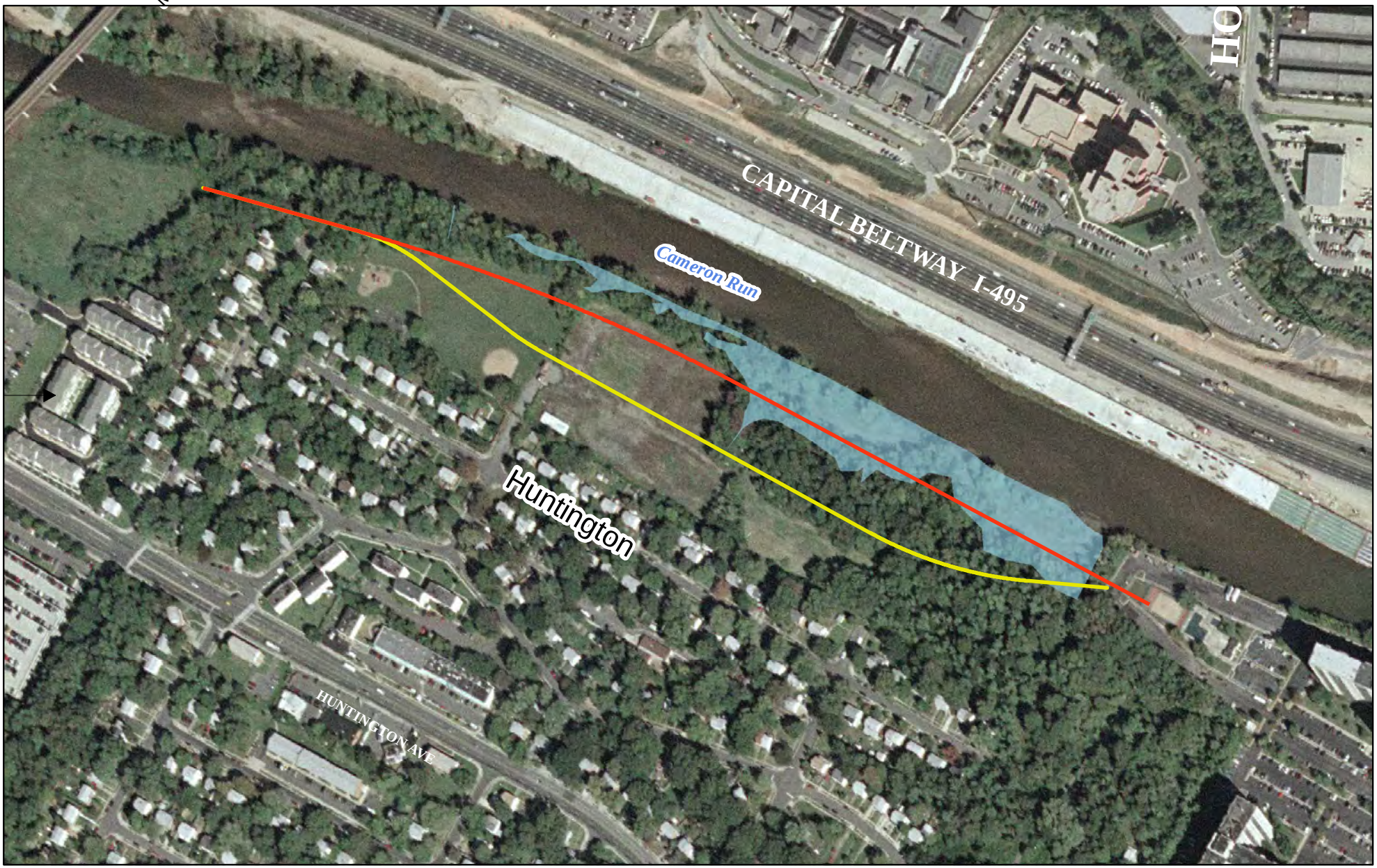

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Figure 6.1

Levee Alignments

0 300 600 1,200 Feet

1 inch = 300 feet

Aerial Photograph dated 2004 courtesy of AerialExpress

Legend

- Levee alignment #1
- Levee Alignment #2
- Delineated Wetlands

N

flooding storage and for recreational purposes. Disadvantages include impacts to existing wetlands and higher increase in flood levels upstream of Huntington. The hydraulic model shows that Levee Alignment #1 would contain the 1% annual chance flood and provide protection to Huntington. However, it would raise the 1% annual chance flood levels by up to 0.7 feet upstream of the levee.

- **Preliminary Levee Alignment #2** – This alternative is the construction of a levee further away from the channel bank, approximately 350 feet from the stream centerline (Figure 6.1). The levee would be high enough to contain the 1% annual chance flood. Advantages of this alignment include increased flood capacity of the channel and avoidance of the wetland areas. Disadvantages include decreased interior flood storage and major impact to the recreational areas.

  The hydraulic model shows that Levee Alignment #2 would contain the 1 percent annual chance flood and provide protection to Huntington. However, it would raise the 1 percent annual chance flood levels by up to 0.5 feet upstream of the levee.

  Note that aligning the levee as far from Cameron run and as close to the houses as possible was not considered due to interior drainage concerns. Ample storage space is required on the landward side of the levee for the interior rainfall to collect and pond before it can be pumped over the levee to the stream. Not providing this space would likely cause the houses to flood from this interior rainfall.

- **Preliminary Dredging Alternative #1 –** This alternative includes dredging the Cameron Run channel from Telegraph Road downstream to the confluence with the Potomac River (Figure 6.2). The channel would be dredged 5 feet below the current channel bottom for a width of 150 feet (Figure 6.3). Deepening the channel by 5 feet would restore the channel back to a condition similar to its shape in the 1960's in the Huntington area. The 1965 cross section shown on the figure is from the USGS Floodplain Delineation (USGS, 1976) and the 1999 cross section is from the VDOT Woodrow Wilson Bridge Report (PCC, 2002). For this dredging alternative, the channel invert slope was set at 0.0004 to maintain a constant slope throughout the system. An advantage of this alternative is more flood capacity within the channel. Disadvantages include project sustainability since the channel would have to be routinely dredged and infrastructure issues would have to be resolved. One impediment to this alternative is that there is a major sanitary pipe system (sanitary siphon with 3 large pipes) located just downstream of Huntington that is only about 3 feet below the channel bed. This pipe system would have to be relocated deeper. It may also be difficult to dredge around the many bridge piers in the channel without adversely affecting their stability. This would have to be evaluated in depth. Another disadvantage to dredging is that there could be environmental impacts such as disturbing aquatic and benthic habitat.

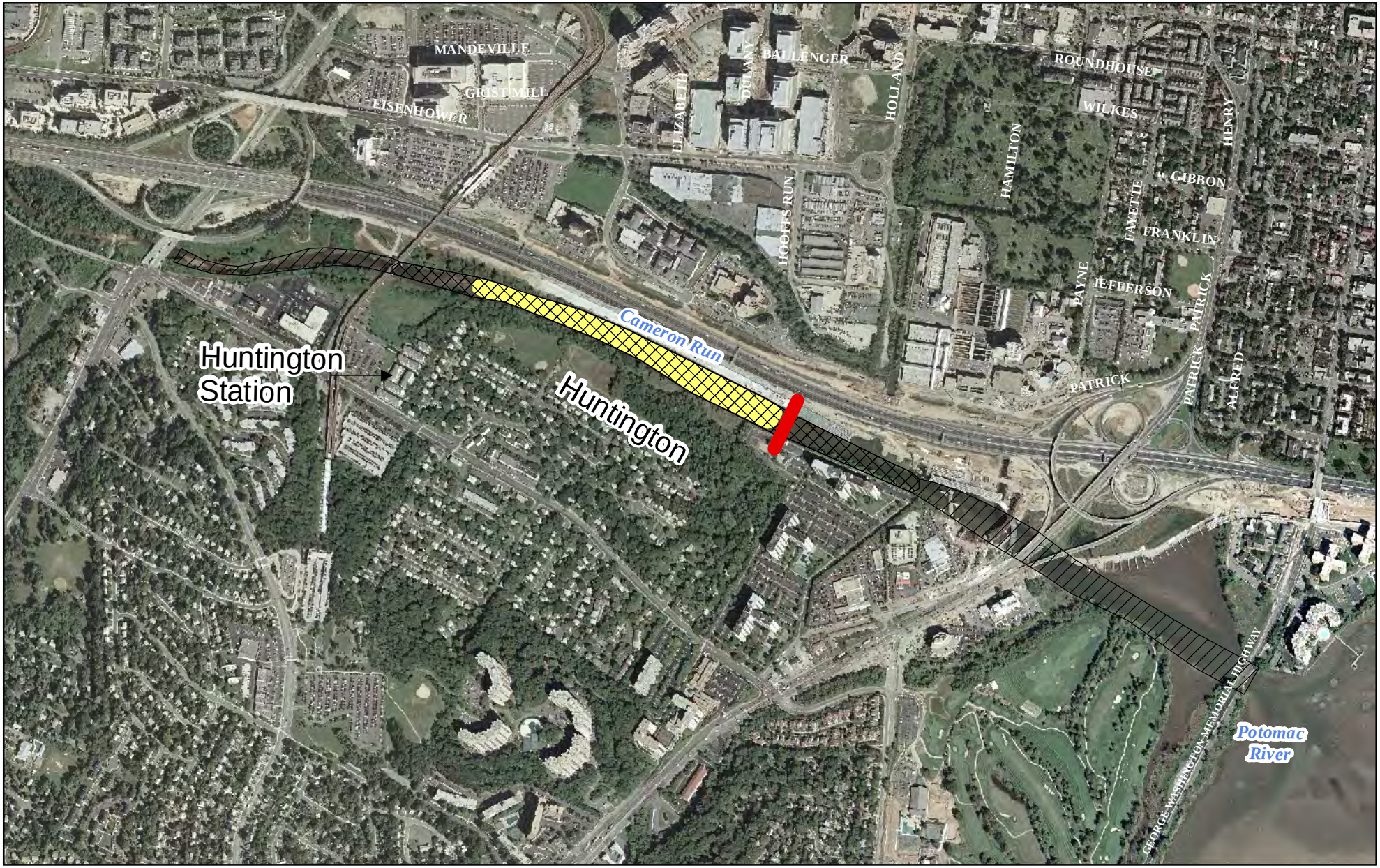

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Figure 6.2

Preliminary Dredging Alternatives

0 1,000 2,000 4,000 Feet

1 inch = 1,000 feet

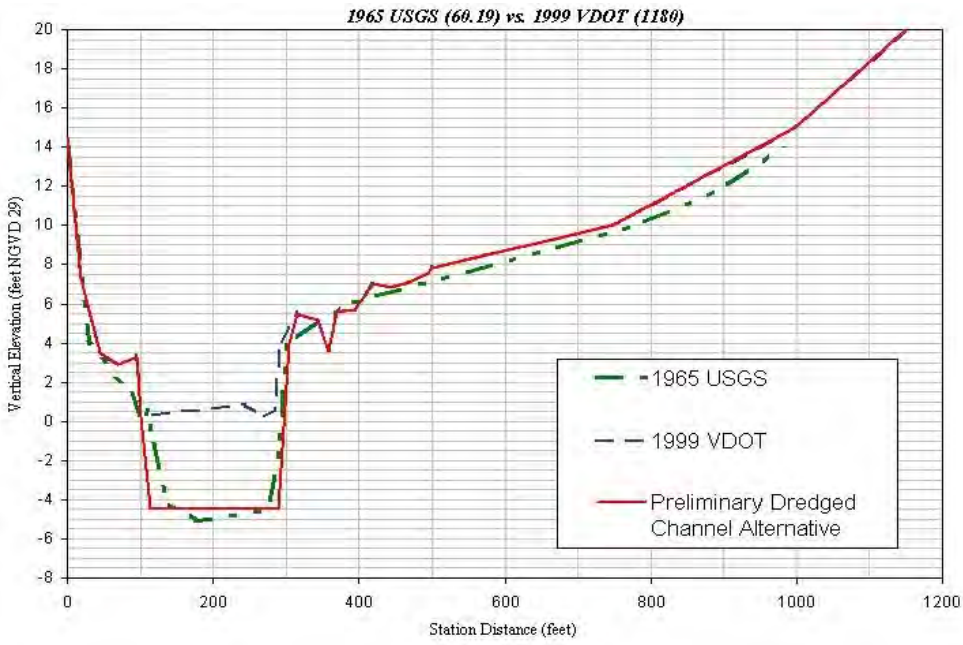
Aerial Photograph dated 2004 courtesy of AerialExpress

Legend

- Preliminary Dredging Alternative #1
- Preliminary Dredging Alternative #2
- Preliminary Dredging Alternative #3
- Sanitary Siphon

N

Figure 6.3: Dredging Alternative at Cross Section #1180 (VDOT)



The hydraulic model shows that Dredging Alignment #1 would lower the 1% annual chance flood levels by approximately 1.7 feet at Huntington; which would not be enough to prevent damages to all of the houses Approximately 157 houses would still be flooded during a 1% annual chance flood with this alternative.

- **Preliminary Dredging Alternative #2 –** This alternative is similar to Alignment #1 except that the extent of dredging is limited. The dredging would extend from the Metro bridge upstream of Huntington downstream to just upstream of the Route 1 bridge (Figure 6.2). There would be more flood capacity within the channel than there currently is, however, it would be less than Alignment #1. The project sustainability and sanitary siphon are still disadvantages. This alternative would have less issues regarding the impact on the bridge piers since the dredging stops prior to Route 1. However, since the dredging is stopped near Route 1 and does not continue to the confluence, there would be an inverse slope created at the Route 1 bridge, and therefore, the channel would likely fill in more quickly.

  The hydraulic model shows that Dredging Alignment #2 would lower the 1 percent annual chance flood levels by approximately 1.2 feet at Huntington. Approximately 160 houses would still be flooded during a 1% annual chance flood with this alternative.

- **Preliminary Dredging Alternative #3 –** This alternative is similar to the other two dredging alternatives except that the extent of dredging is more limited to avoid the relocation of the sanitary siphon. The dredging would extend from upstream of the Huntington community downstream to just upstream of the sanitary siphon (Figure 6.2).

The advantages and disadvantages of this alternative are similar to Dredging Alignment #2, except that the sanitary siphon would not have to be relocated.

The hydraulic model shows that Dredging Alignment #3 would lower the 1 percent annual chance flood levels by approximately 0.6 feet at Huntington. A minimum of 160 houses would still be flooded during a 1% annual chance flood with this alternative.

- **Preliminary Combined Dredging and Levee Alternative #1 –** This alternative combines Dredging Alternative #2 and Levee Alignment #2 so that the dredging would lower the flood levels enough to offset the increase created by constructing a levee.

  The hydraulic model shows that this alternative would contain the 1 percent annual chance flood and provide protection to Huntington, and would lower the 1 percent annual chance flood level by approximately 1 foot. Therefore, there would be no increase in flood levels caused by the levee.

- **Preliminary Combined Dredging and Levee Alternative #2 –** This alternative combines the shortest dredging plan, Dredging Alternative #3, with a refined levee alignment (Levee Alignment #3). The third dredging option extends from the upstream end of Huntington to the sanitary sewer pipe. Levee Alignment #3 is similar to Levee Alignment #2 with some refinements made to avoid wetland areas and tie into high ground (Figure 6.4). Levee alignment #2 was used to model Levee Alignment #3 because the minor differences in the levee alignments have a negligible effect on the flood stages.

  The advantages of this combination of alternatives are largely based on constructability and cost rather than hydraulic factors, but do include the benefits of dredging offsetting the increased flooding created by the levee. The sanitary siphon would not have to be relocated. Disadvantages are the same as those associated with Levee Alignment #2 including decreased interior flood storage.

  The hydraulic model shows that this alternative would contain the 1 percent annual chance flood and provide protection to Huntington, and would lower the 1 percent annual chance flood level by approximately 0.4 feet. Therefore, there would be no increase in flood levels caused by the levee.

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Figure 6.4

Levee Alignment #3

0 300 600 1,200 Feet

1 inch = 300 feet

Aerial Photograph dated 2004 courtesy of AerialExpress

Legend

Levee Alignment #3

Delineated Wetlands

N

6.2 PHASE 2 – DEVELOPMENT AND EVALUATION OF PRELIMINARY CONCEPT PLANS (5%)

Based on the results of Phase 1, the County identified alternatives to be pursued further. For these alternatives, the team developed a preliminary concept plan (5% design) and conducted an economic analysis to determine rough costs and benefits. The concept plans are described below. A table comparing the alternatives is at the end of Section 6.2.

6.2.1 Dredging and Levee Preliminary Concept Plans

Preliminary Dredging Concept Plans D1a and D1b– This concept plan was based on Preliminary Dredging Alternative #1 and would include dredging a 5-foot deep and 100 to 150-foot wide channel from Telegraph Road to the Potomac River for a distance of 9,100 feet. The channel would be dredged a maximum of 100 feet wide (base of trapezoid), except in the area adjacent to Huntington, where the waterway is wider and could be dredged 150 feet wide.

For cost estimating purposes, a location to place the dredged material had to be assumed. At the time of the analysis, no sediment testing had been performed so it was unknown whether or not there were any contamination concerns. For Concept Plan D1a, it was assumed that the material was "clean" and could be placed at the nearby Anderson landfill in Prince George's County (approximately 25 miles from Huntington). Plan D1b assumed the material had some contaminants and would need to be placed at a site that would accept it; the King and Queen County landfill was assumed for Plan D1b (approximately 130 miles from Huntington). Cost estimates for these two placement sites were developed. However, a third option is to place the material at Dyke Marsh for wetland restoration if the material is suitable. If dredging is pursued, this could be a viable option and should certainly be considered.

This concept plan would include dredging approximately 187,000 cubic yards of material for the initial dredging. It was assumed that the dredging would be accomplished mechanically (using a track hoe or similar equipment) and trucking the material for disposal. To estimate operation and maintenance costs, a sedimentation rate of 0.2 feet/year was used (based on 1982 CDM study). It was assumed that 75,000 cy of material would have to be dredged every 10 years to remove 2 feet of sediment.

For this concept plan, it was assumed that the set of sanitary pipes (referred to as sanitary siphon) that run approximately 3 feet under the channel just downstream of Huntington would be relocated (for an approximate cost of $7 million, cost provided by Fairfax County) and would not be an impediment to dredging. Dredging around the many piers that exist in the channel (under Route 1 bridge and along the Capital Beltway) could be physically challenging (Figure 6.5). A detailed evaluation of how far the dredged channel must be from the piers would be needed. This could impact the effectiveness of dredging.

Figure 6.5: Route 1 Bridge Ramps Downstream of Huntington

As the hydraulic model showed for Dredging Alignment #1, this concept plan would lower the 1% annual chance flood levels by approximately 1.7 feet at Huntington. This analysis assumed the channel could be dredged close to the piers, which is probably unlikely. Therefore, the actual reduction in flood levels would likely be less. Based on the flood levels being lowered by 1.7 feet, approximately 157 houses would still be flooded during a 1% annual chance flood with this alternative.

The initial dredging for Concept Plan D1a (including relocating the sanitary siphon) is estimated to cost $21.9 million. The maintenance dredging, that would need to occur approximately every 10 years (and could be more frequently) would cost $5.5 million each cycle.

The initial dredging for Concept Plan D1b (placing material at King and Queen County Landfill) is estimated to cost $26.6 million. The maintenance dredging, that would need to occur approximately every 10 years would cost $7.2 million each cycle.

Preliminary Dredging Concept Plan D2a and D2b – This concept plan was based on Preliminary Dredging Alternative #2 and would include dredging a 5-foot deep and 100 to 150-foot wide channel from the Metro bridge to just upstream of the Route 1 bridge for a distance of 3,550 feet. As in Plan D1a, the channel would be dredged a maximum of 100 feet, except in the area adjacent to Huntington, where the channel is wider and a width of 150 feet was assumed. Placement of the material at the two landfills was evaluated.

This concept plan would include dredging approximately 85,000 cubic yards of material for the initial dredging. It was assumed that the dredging would be accomplished mechanically and trucking the material for disposal. To estimate operation and maintenance costs, a sedimentation rate of 0.2 feet/year was used (based on 1982 CDM study). It was assumed that 34,000 cy of material would have to be dredged every 10 years to remove 2 feet of sediment.

As in D1a, it was assumed that the set of sanitary pipes would be relocated as part of this concept plan and would not be an impediment to dredging. With this concept plan, the dredging stops

prior to the Route 1 bridge, so it avoids the challenge of dredging around these bridge piers; however there are still bridge piers along the Capital Beltway ramp that would have to be considered.

As the hydraulic model showed for Dredging Alignment #2, this concept plan would lower the 1% annual chance flood levels by approximately 1.2 feet at Huntington. Approximately 160 houses would still be flooded during a 1% annual chance flood with this alternative.

The initial dredging for Concept Plan D2a (including relocating the sanitary siphon and placing the material at the Anderson Landfill) is estimated to cost $14.3 million, assuming a dredging and hauling cost of $60/cy. The maintenance dredging, that would need to occur approximately every 10 years, would cost $2.5 million each cycle.

The initial dredging for Concept Plan D2b (placing material at King and Queen County Landfill) is estimated to cost $16.3 million, assuming a dredging and hauling cost of $80/cy. The maintenance dredging, that would need to occur approximately every 10 years would cost $3.3 million each cycle.

Preliminary Levee Concept Plan L1 – The levee #2 alignment was refined and adjusted to minimize impacts to the wetlands and tie into high ground (alignment now referred to as levee alignment #3). The concept levee is approximately 2,600 feet in length with a maximum height of about 11 feet. The top of the levee elevation is equivalent to the 1% annual chance flood elevation (with no height added to account for risk and uncertainty). At the upstream end, the top elevation is 15.6 feet, at the downstream end it is 13.9 feet. It has a 10-foot wide crest and 2.5H:1V side slopes. The levee embankment would be constructed of select earth material. Since no soil borings had been taken during this phase of the study, it was assumed that the soil conditions were poor (based on previous studies) and that the project would include excavating and replacing 6 feet of the foundation over the whole length.

A pumping station would be required as part of this concept plan. Based on a preliminary analysis, it was estimated that a 45,000 gpm pump would be required to prevent existing homes from incurring flood damages from interior drainage.

Based on hydraulic modeling, this levee concept plan would increase the 1% annual chance flood elevation by 0.5 feet just upstream of the project.

The project cost for Concept Plan L1 is estimated to be $15.6 million. The cost to operate and maintain the project is estimated to cost $150,000 annually. Maintenance tasks will include items such as mowing and repairing the levee as needed, dredging the outfall channels, and repairing and replacing parts of the pump station and drainage structures as needed.

Preliminary Levee/Dredging Combination Concept Plans LD2a and LD2b – Concept Plans LD2a and LD2b combined Levee Alignment #3 (Preliminary Concept Plan L1) and the shorter dredging plan (Preliminary Dredging Concept Plan D2). The purpose of combining the levee with a dredging plan was to reduce the hydraulic impact of the levee on the area upstream of Huntington. All of the project features of both Plan L1 and Plan D2 would be part of this

concept plan. Concept Plan LD2a assumes that the dredged material will be placed at the Anderson Landfill and Concept Plan LD2b assumes that it will be placed at the King and Queen County Landfill.

With this concept plan, there would be no increases in the 1% annual chance flood elevation caused by the project.

The project cost for Plan LD2a is estimated to be $29.9 million and the maintenance dredging would cost $2.5 million approximately every 10 years.

The project cost for Plan LD2b is estimated to be $31.9 million and the maintenance dredging would cost $3.3 million approximately every 10 years.

6.2.2 Buy-Out Preliminary Concept Plans (B1a and B1b)

Another flood damage reduction option that was considered during the study was the acquisition (or "buy-out") of the floodprone houses. It is Corps' policy during flood studies that could possibly lead to the construction of a federal project, that all feasible structural and non-structural solutions should be evaluated, including buy-outs. Under a buy-out, the government could purchase the houses and restore the land back to a natural floodplain. This could potentially include wetland restoration or other natural restoration. Development on the land would be prohibited or limited.

For this concept plan, the cost was based on fair market value for the houses, demolition costs, administrative costs, and housing benefits and moving costs. Two cost estimates were developed: voluntary buyout and involuntary buyout. The only difference is that for a voluntary buyout, only tenants receive housing benefits and moving costs; for an involuntary buyout, tenants and owners receive housing benefits and moving costs.

The cost estimates assumed acquisition of 166 duplex houses in Huntington in the 1% annual chance floodplain and restoring the land back to natural floodplain. The estimated cost for a voluntary buyout (Preliminary Concept Plan B1a) is $96 million and for an involuntary buyout (Preliminary Concept Plan B1b) is $99 million.

6.2.3 Flood Proofing Preliminary Concept Plans

As part of the study, two flood proofing techniques were considered for the Huntington duplex houses, one was evaluated for the community center, and one for the Huntington Station townhouses. Each of the three areas – the Huntington duplexes, the community center and the Huntington Station townhouses – could be flood proofed using separate measures providing flood protection to the entire study area. The flood proofing plans would not impact the hydraulics along Cameron Run; the 1% annual chance flood elevation would remain as it currently is.

Preliminary Flood Proofing Concept Plan FP1 – This concept plan involves filling in the basements of the Huntington duplex houses and providing additional living space on the back

side of the first floor, 18" above the 1% annual chance floodplain elevation (Figure 6.6), to compensate for the lost basement space. Fairfax County requires that all new structures or substantial improvements to existing structures must be located 18" above the floodplain. Improvements/additions not classified as substantial can be located just at the floodplain. For this concept plan, it was assumed that the additional living space would be constructed 18" above the floodplain. In figure 6.6, it shows the new addition being at the same elevation as the current first floor, however, this may not be the case for a number of the houses. Many of the new additions may be higher than the first floor and there may need to be steps up to the new addition, The heating/cooling equipment and other utilities would be relocated to the new 1st floor, above the floodplain. There were a number of houses that only had basements flood during the June 2006 event, and this plan would prevent flood damages to the basements since the basements would be eliminated. However, the level of protection varies with each house because the existing house will not be elevated above the existing flood elevation (as in Concept Plan FP2 below). Each house would only be protected from damages up to the existing first floor elevation.

A disadvantage of this concept plan is that exterior items, such as sheds, would be flooded during a storm event. Vehicles would incur damages unless they were moved to higher ground prior to the flood. Residents would also need to relocate away from their home for approximately 6 weeks during construction. Another concern is the dual ownership of the structure. Both owners would have to agree on the flood proofing plan.

The estimated project cost for this concept plan is $13.6 million.

Figure 6.6: Concept Plan FP1 Showing New Addition to Backs of Houses

Front View

Rear View

Preliminary Flood Proofing Concept Plan FP2 – This concept plan involves filling in the basements of the Huntington duplex houses, elevating the house 18" above the 1% annual chance floodplain elevation (per county regulations), and providing additional living space on the back side of the new first floor (Figure 6.7). The heating/cooling equipment and other utilities would be relocated to the new 1st floor. The modified houses would be protected from the 1% annual chance flood.

As in the previous flood proofing plan, a disadvantage of this concept plan is that vehicles and all other exterior items are not protected. Residents would also need to relocate away from their home for approximately 12 weeks during this extensive construction. Another concern is the dual

ownership of the structure. Both owners would have to agree on the flood proofing plan. The estimated project cost for this concept plan is $23.4 million

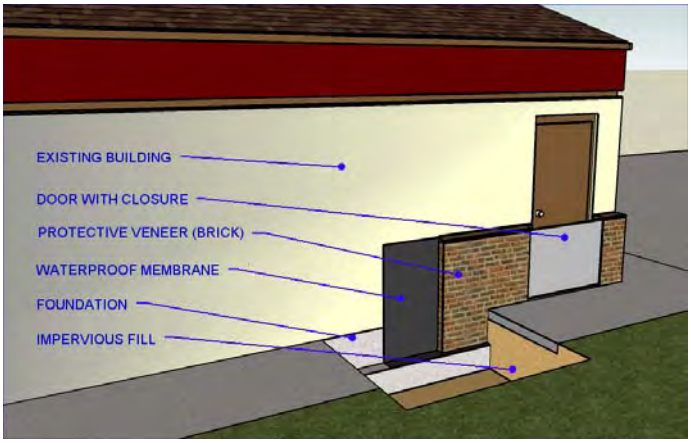
Figure 6.7: Concept Plan FP2 Showing Elevation of House and New Addition

Front View Rear View

Preliminary Flood Proofing Concept Plan FP3 – This concept plan involves dry flood proofing the Huntington Community Center (Figure 6.8) as part of an overall flood proofing plan. The first floor of the community center is at elevation 12.5 feet and the 1% annual chance flood elevation is approximately 14.7 feet. For this concept plan, a water proof membrane and protective covering would be applied to the exterior of existing walls. It would protect up to an elevation 18 inches above the 1% annual chance flood elevation. Therefore, the building would be protected against the 1% annual chance flood event. Closure structures would be placed across all opening, which must be manually closed prior to a flood. Interior sump pumps with emergency power would be installed.

The estimated project cost for Concept Plan FP3 is $172,000.

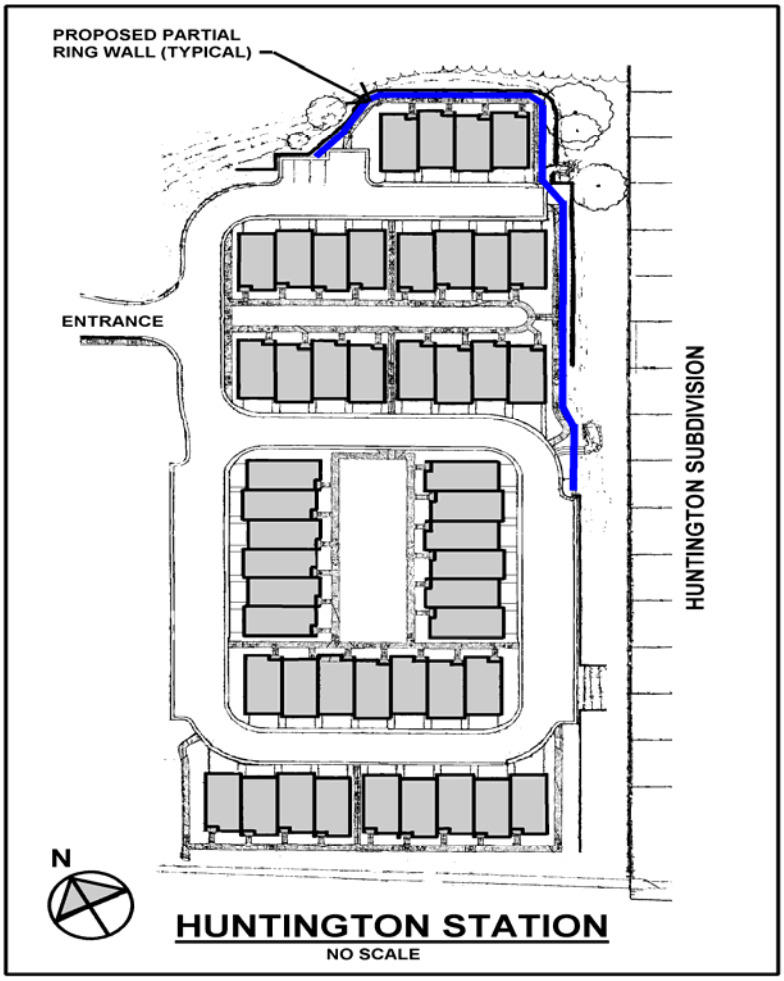
Figure 6.8: Preliminary Flood Proofing Concept Plan FP3 (Huntington Community Center)



Preliminary Flood Proofing Concept Plan FP4 – This concept plan involves constructing a partial ringwall around the northeast corner of the Huntington Station Community (Figure 6.9) as part of an overall flood proofing plan. Since there is a lower risk of flooding in this area and the flood levels would be low during a 1% annual chance flood, it was decided that the plan would be to construct a low masonry or concrete wall. The top of the wall would be equivalent to the 1% annual chance flood elevation. Higher levels of protection may be possible but they would increase the cost significantly. This low partial ring wall, however, would not meet FEMA certification requirements and the Huntington Station residents in the floodplain would still be required to purchase flood insurance. As part of this concept plan, the interior drainage would have to be modified and sump pumps with emergency power would be installed. The stormwater and sanitary sewer systems would be modified to prevent the backflow of flood waters.

The estimated project cost for Concept Plan FP4 is $276,000.

Figure 6.9: Preliminary Flood Proofing Concept Plan FP4 (Huntington Station Ringwall)



6.2.4 Evaluation and Comparison of Preliminary Concept Plans

As part of the study, Fairfax County requested that the Corps conduct an economic analysis of the alternative plans to determine if any of the plans would meet the requirements for federal funding. An analysis was conducted to compare the costs and economic benefits of each of the alternative plans. For a project to meet the requirements for federal funding, the annualized benefits must be larger than the annualized costs, and the benefit-to-cost ratio must be greater than 1.0. Costs were estimated based on the 5% concept plans and are preliminary. Project costs include the construction cost, design cost, construction management costs, real estate costs, escalation costs, and contingency.

The economic benefits of each alternative plan were estimated as the estimated reduction in future damage costs. The calculation takes into account the reduction in damages to structures (both residential and commercial), vehicles, utilities, as well as the reduction of costs related to emergency services during and following a flood event. Using various models, future flood elevations are predicted and the amount of flood damages that would occur are estimated for each of the flood events. These damages are then translated into an estimated annual damages figure. The estimated future without-project damages are compared to the future with-project damages (compare damages without a levee against damages with a levee). The difference between these two figures is the annual economic benefit of the project.

The details of the economic analysis are included in Appendix D. An alternatives analysis matrix showing the costs and benefits for each alternative plan is shown in Table 6.1. The table includes the construction cost without escalation (using 2007 prices) that was used in the economic analysis. It also includes the construction cost with escalation, assuming that construction will begin in FY10. A rough annual cost for operation and maintenance has been estimated, for items such as mowing the levee, repairing and replacing parts of the pump station and drainage structures, and maintenance dredging. The costs and benefits were estimated for a 50-year duration, and then were translated into annualized costs and benefits. The annualized net benefits for the alternative are the annualized benefits minus the annualized costs. The benefit-cost-ratio is the annualized benefits divided by the annualized costs. As mentioned previously, for a project to meet the requirements for federal funding, the annualized benefits must be larger than the annualized costs, and the benefit-to-cost ratio must be greater than 1.0. The summary table also includes whether or not the alternative addresses the 2% annual chance (or 50-year) flood, a description of the main risks associated with each plan, and some additional notes of interest.

For the preliminary alternative plans that were evaluated during this study, all of the benefit-to-cost ratios were well under 1.0.

Dredging alone would not provide the level of protection set out in the project objectives (to provide a minimum of 50-year level of protection). The county and the residents, based on the public meetings, were not interested in flood proofing the individual houses. The County Supervisor is in support of maintaining the community and therefore, buy-outs are not favored. Furthermore, buyouts are the most expensive plan. Therefore, the county pursued two plans: a levee and levee/dredging combination.

Table 6.1: Phase 2 of Plan Formulation
Huntington Flood Damage Reduction 5% Concept Plan Alternatives Analysis Matrix
Prepared 10 July 2007

Alternative	Cost without escalation used for economic analysis (w/design, const mgmt, any real estate)	Escalation Cost	Construction Year	Total Project Cost	O&M Cost	Annualized Costs	Annualized Benefits (each low opening)[1]	Benefit to Cost Ratio (BCR)[2]	Addresses 50-Year Event (6/06) or Greater and Meets Local Requirements/Guidelines	Reason If "No"	Main Risk	NOTES
D1a - Longer dredge (5 feet deep from Telegraph Rd to Potomac), place at Anderson landfill	$20.4M	$1.5M	FY10	$21.9M	$5.5M every 10 years	$1.5M	$343,000	0.22	No	Not adequate protection; Only reduces flood levels by approx. 1.4' during 100-year flood	Channel may fill in with sediment quickly, especially following a storm event, and may not have expected reduction in flood levels	Does not provide adequate protection (reduces 100-yr flood level by approx. 1.4'); assumes "clean" dredged material that can be placed at Anderson landfill; assumes sanitary siphon relocated for $7M; O&M rate of dredging 2 feet every 10 yrs based on CDM study rate of 0.2 feet/year but could be more or less frequent; reduction in flood levels based on being able to dredge up to VDOT piles - may need setback which will make flood levels higher; would require dredging permit
D1b- Longer dredge (5 feet deep from Telegraph Rd to Potomac), King and Queen Co landfill	$24.8M	$1.8M	FY10	$26.6M	$7.2M every 10 years	$1.9M	$343,000	0.18	No	Not adequate protection; Only reduces flood levels by approx. 1.4' during 100-year flood	Channel may fill in with sediment quickly, especially following a storm event, and may not have expected reduction in flood levels	Does not provide adequate protection (reduces 100-yr flood level by approx. 1.4'); assumes "poor" dredged material with chemical contaminants; assumes sanitary siphon relocated for $7M; O&M rate of dredging 2 feet every 10 yrs based on CDM study rate of 0.2 feet/year but could be more or less frequent; reduction in flood levels based on being able to dredge up to VDOT piles - may need setback which will make flood levels higher;would require dredging permit
D2a - Shorter dredge (5 feet deep from U/S end of Huntington down to U/S end of Route 1), place at Anderson landfill	$13.3M	$1M	FY10	$14.3M	$2.5M every 10 years	$900,000	$207,000	0.23	No	Not adequate protection; Only reduces flood levels by max. of 0.8-1' during 100-year flood	Channel may fill in with sediment quickly, especially following a storm event, and may not have expected reduction in flood levels	Does not provide adequate protection (reduces 100-yr flood level by max. of 0.8-1'); assumes "clean" dredged material; assumes sanitary siphon relocated for $7M; O&M rate of dredging 2 feet every 10 yrs based on CDM study rate of 0.2 feet/year but could be more or less frequent; reduction in flood levels based on being able to dredge up to VDOT piles - may need setback which will make flood levels higher; would require dredging permit
D2b - Shorter dredge (5 feet deep from U/S end of Huntington down to U/S end of Route 1), King and Queen Co landfill	$15.2M	$1.1M	FY10	$16.3M	$3.3M every 10 years	$1.1M	$207,000	0.19	No	Not adequate protection; Only reduces flood levels by max. of 0.8-1' during 100-year flood	Channel may fill in with sediment quickly, especially following a storm event, and may not have expected reduction in flood levels	Does not provide adequate protection (reduces 100-yr flood level by max. of 0.8-1'); assumes "poor" dredged material with chemical contaminants; assumes sanitary siphon relocated for $7M; O&M rate of dredging 2 feet every 10 yrs based on CDM study rate of 0.2 feet/year but could be more frequent; reduction in flood levels based on being able to dredge up to VDOT piles - may need setback which will make flood levels higher; would require dredging permit
L1 - Levee with pumping station	$14.2M	$1.4M	FY10-FY12	$15.6M	$150,000 each year	$900,000	$560,000	0.61	No	Levee increases 100-yr flood elevation by up to 0.5' u/s which is not within County guidelines	Higher flood event could overtop levee and cause more catastrophic damages	Assumes top of levee at 100-year flood elevation; levee increases 100-yr flood elevation by up to 0.5' u/s which is not within County guidelines; project costs/benefits do not reflect mitigation or induced damages; cost includes 1 pumping station (very rough analysis showed need for 45,000 gpm capacity); levee can be overtopped which can cause more catastrophic damages
LD2a - Levee and dredging combination, place at Anderson landfill	$27.5M	$2.4M	FY10-FY12	$29.9M	$2.5M every 10 years, and $150,000 each year	$1.8M	$560,000	0.31	Yes		Higher flood event could overtop levee and cause more catastrophic damages; also, channel may fill in with sediment quickly and may not have expected reduction in flood levels (levee may increase flood levels upstream)	Top of levee at 100-year flood elevation; levee can be overtopped which can cause more catastrophic damages; assumes "clean" dredged material; assumes sanitary siphon relocated for $7M; O&M rate of dredging 2 feet every 10 yrs based on CDM study rate of 0.2 feet/year but could be more or less frequent; no increase in flood levels; reduction in flood levels based on being able to dredge up to VDOT piles - may need setback which will make flood levels higher; would require dredging permit
LD2b - Levee and dredging combination, place at King and Queen Co landfill	$29.4M	$2.5M	FY10-FY12	$31.9M	$3.3M every 10 years, and $150,000 each year	$2M	$560,000	0.28	Yes		Higher flood event could overtop levee and cause more catastrophic damages; also, channel may fill in with sediment quickly and may not have expected reduction in flood levels (levee may increase flood levels upstream)	Top of levee at 100-year flood elevation; levee can be overtopped which can cause more catastrophic damages; assumes "poor" dredged material with chemical contaminants; assumes sanitary siphon relocated for $7M; O&M rate of dredging 2 feet every 10 yrs based on CDM study rate of 0.2 feet/year but could be more or less frequent; no increase in flood levels; reduction in flood levels based on being able to dredge up to VDOT piles - may need setback which will make flood levels higher; would require dredging permit
B1a - Voluntary buyout	$90M	$19M	FY10	$96M	minimal (assume $0)	$4.8M	$700,000	0.15	Yes		None	Includes $11M for demolition; includes admin costs, fair market value ($375k), housing benefits and moving costs for tenants only; includes 1% escalation cost per month; could restore land to natural floodplain, add to existing wetlands, redevelop area
B1b - Involuntary buyout	$92M	$19M	FY10	$99M	minimal (assume $0)	$4.9M	$700,000	0.15	Yes		None	Includes $11M for demolition; includes admin costs, fair market value ($375k), housing benefits and moving costs for tenants and owners; includes 1% escalation cost per month; could restore land to natural floodplain, add to existing wetlands, redevelop area
FP1 - Hunt duplex, fill basement, add room	$12.4M	$1.2M	FY10-FY12	$13.6M	$0	$670,000	$380,000	0.57	No	Protects houses up to first floor elevation (some less than 50-yr protection), but vehicles, other exterior structures not protected	Exterior items not protected; existing first floors not protected	Duplexes are protected up to first floor elevation (no basements to be flooded); vehicles, other exterior items are not protected; residents must relocate for approx 6 wks during construction; dual ownership problematic; not favored by residents
FP2 - Hunt duplex, elevate, fill basement, add room	$21.4M	$2M	FY10-FY12	$23.4M	$0	$1.15M	$490,000	0.43	Yes/No	Protects houses to 18" above 100-year elevation, but vehicles, other exterior structures not protected	Exterior items not protected	Duplexes are elevated to 18 inches above the 100-year flood elevation; vehicles, other exterior items are not protected; residents must relocate for approx 12 wks during construction; dual ownership problematic; not favored by residents
FP3 - Hunt Community Ctr veneer wall	$160,000	$12,000	FY10	$172,000	minimal (assume $0)	$8,600	$3,300	0.38	Yes		Gates must be closed prior to flood event for protection	Closures must be manually closed prior to flood; provides protection to 18" above 100-year flood elevation
FP4 - Hunt Station ring wall	$257,000	$19,000	FY10	$276,000	minimal (assume $0)	$13,800	$6,100	0.44	Yes		Higher flood event could overtop ring wall	Top of low masonry or concrete wall at 100-year flood elevation; install back flow preventers and pumps with emergency power

Notes:

Project costs are based on 5% concept-level plans and are subject to change

For costing purposes, the team identified two potential placement sites - Anderson Landfill and King and Queen County landfill; however, additional placement sites such as Dyke Marsh should be considered if dredging is pursued

1/Benefits based on using low opening elevations for each structure

2/To meet Corps economic justification requirements, benefit-to-cost ratio must be greater than 1.0; however, due to limited funding, the Corps is prioritizing projects and only the projects with the highest BCR's are being included in the budget

6.3 PHASE 3 - DEVELOPMENT AND EVALUATION OF FINAL CONCEPT PLANS

For the remaining two alternatives, a levee and a levee/dredging combination, the concept designs were fine-tuned to a 25% concept level and the levees were evaluated for three different heights of protection to determine the most cost-effective flood damage reduction plan for the county to implement. The three tops of protection included the 1% annual chance (100-yr) elevation, the 2% annual chance (50-yr) flood elevation plus additional height for risk and uncertainty, and the 1% annual chance flood plus additional height for risk and uncertainty. The reason higher tops of protection above the 1% and 2% annual chance flood elevations were evaluated is that the project must incorporate risk and uncertainty. If the levee is constructed exactly to the 1% annual chance flood elevation, it may not be able to contain the 1 % annual chance flood. There are uncertainties in the analysis, such as the hydrology and the hydraulic model, therefore, a higher levee is needed to be relatively certain that it will protect against the 1% annual chance flood. See Appendix G3 for additional information regarding the risk and uncertainty analysis. An economic analysis of these final alternatives was conducted and was used to assist the county in selecting a final plan for design (Appendix D).

6.3.1 Final Concept Plan 2 - Levee

Final Concept Plan 2 is a modified version of Preliminary Concept Plan L1. The levee would be constructed along alignment #3. Three top of protection elevations were evaluated for the levee:

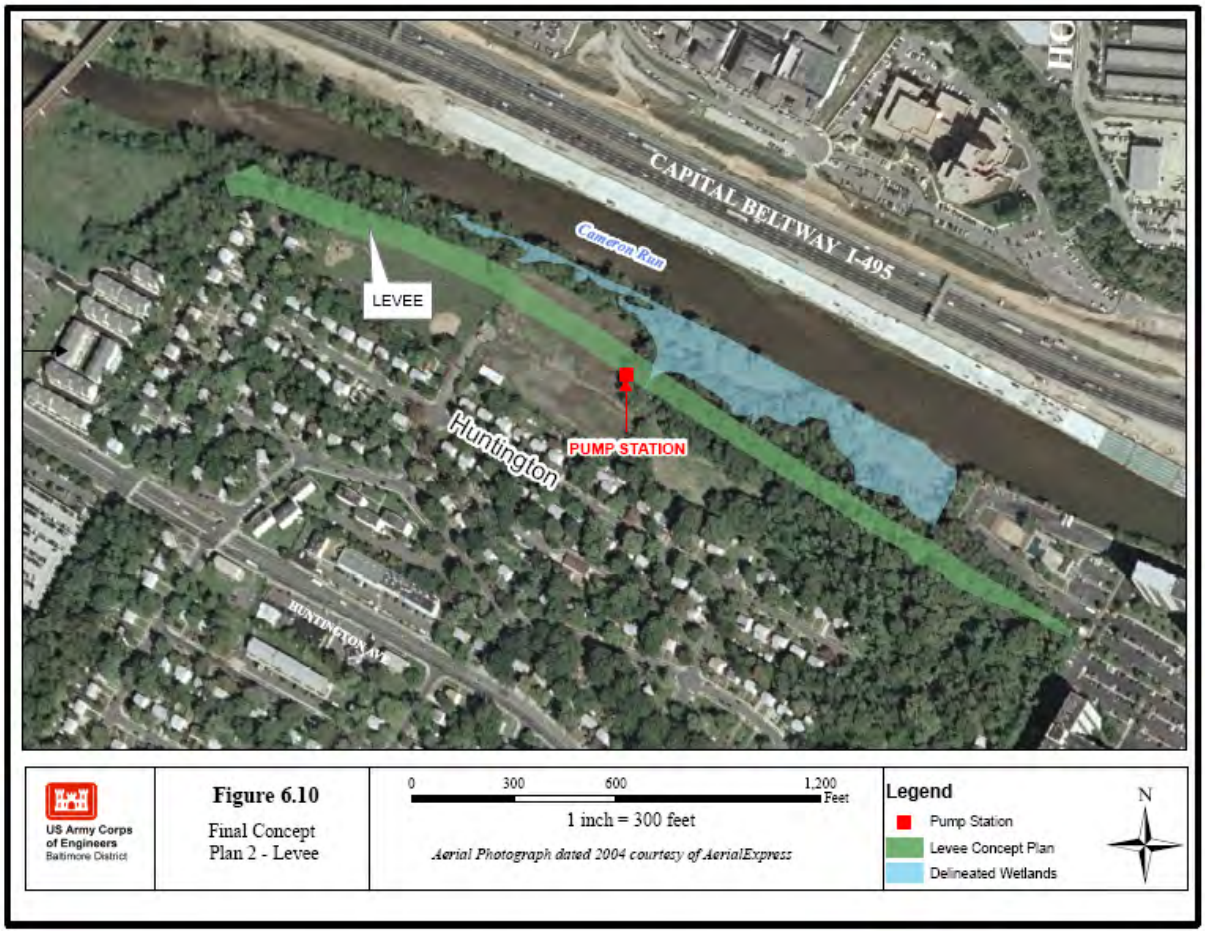
Plan 2a – Levee with a crest elevation at the upstream end of 15.6 feet (equivalent to the 1% annual chance flood elevation)

Plan 2b - Levee with a crest elevation at the upstream end of 17.6 feet (equivalent to 3.4 feet above the 2% annual chance flood event (50-yr) at the upstream end or 2 feet above the 1% annual chance flood elevation)

Plan 2c – Levee with a crest elevation at the upstream end of 19.6 feet (equivalent to 4 feet above the 1% annual chance flood elevation at the upstream end)

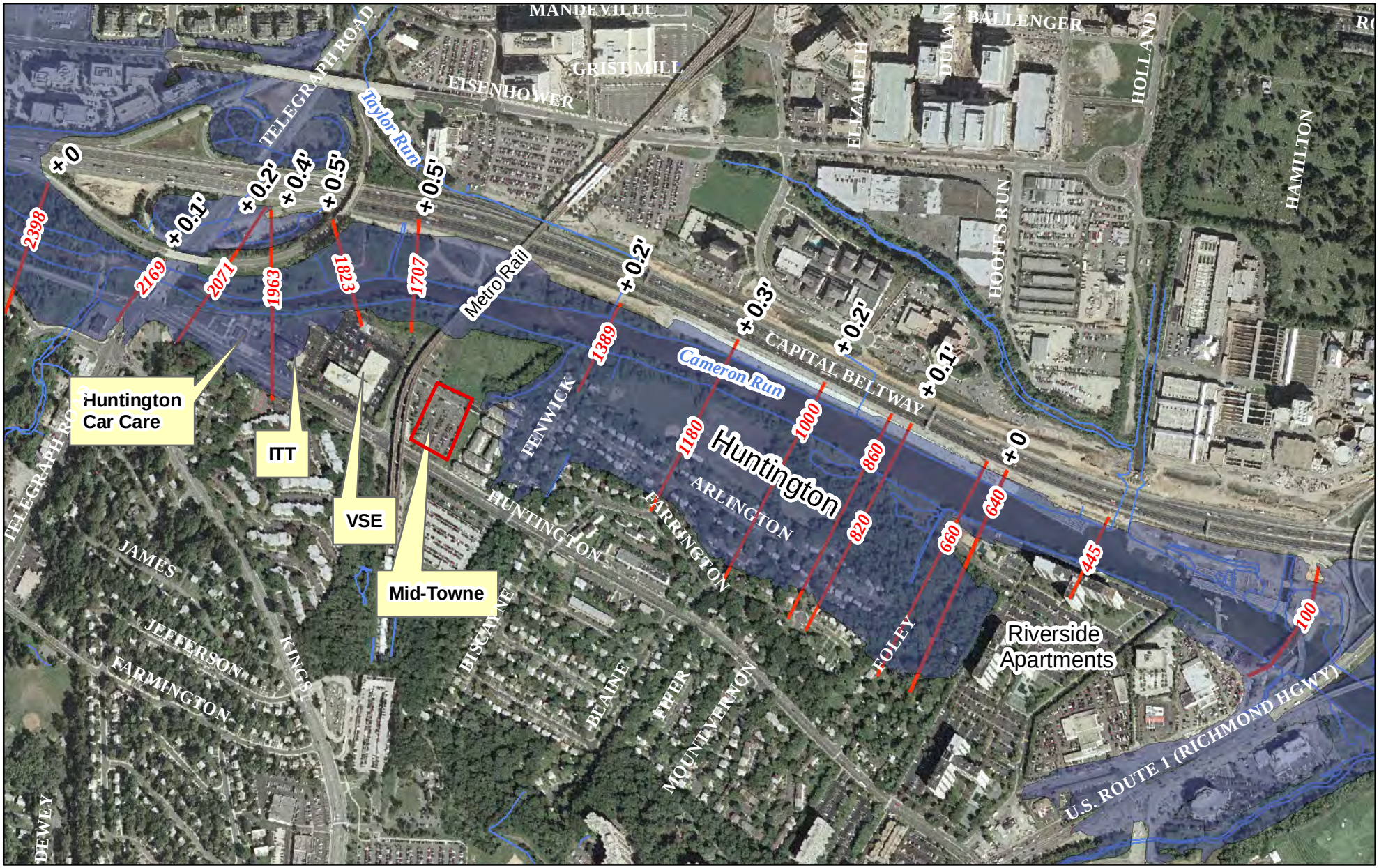
The concept levee is approximately 2,600 feet in length (varies for the three different tops of protection). The maximum heights range from about 10 feet (Plan 2a) to 15 feet (Plan 2c). The levee has a 10-foot wide crest and 2.5 (horizontal) to 1 (vertical) side slopes. The levee embankment would be constructed of select earth material. Since no soil borings had been taken during this phase of the study, it was assumed that the soil conditions were poor (based on previous studies) and that the project would include excavating and replacing 6 feet of the foundation over the whole length. Figure 6.10 shows the concept layout of Plan 2.

Figure 6.10: Plan 2 – Levee Concept Plan



A pumping station would be required as part of this concept plan. A preliminary interior residual flooding analysis was conducted and it was determined that a 60,000 gpm pump would be required for interior drainage to maintain a pond elevation of 9.0 feet during a 100-year rainfall. The lowest low opening into the Huntington houses is elevation 9.1 feet; just below this is considered the "zero damage" elevation. When the original residual flooding analysis was conducted, it was done to determine what size pump would keep the residual ponding level below the lowest opening and the zero damage elevation (see Appendix G5 for further information).

Based on hydraulic modeling, these levee concept plans would increase the 1% annual chance flood elevation by up to 0.6 feet just upstream of the project. Figure 6.11 shows the increase in 1% annual chance flood elevation caused by the levee.



US Army Corps of Engineers
Baltimore District

Figure 6.11

Increases in 1% Annual Chance Flood Elevations Caused by Levee

0 750 1,500 3,000 Feet

1 inch = 700 feet

Aerial Photograph dated 2004 courtesy of AerialExpress
Elevations referenced to NGVD29 datum

Legend

100-year Floodplain (USACE 2007 Model)

N

The increase in flood elevations extends from Huntington upstream to Telegraph Road. This increase will affect four structures just upstream of Huntington. However, two of them have low openings above the 1% annual chance flood, so the levee will have no impact during a 1% annual chance flood. The other two buildings, Mid-Town High Rise (only the loading dock/underground garage, not the first floor) and Huntington Car Care, are already located in the floodplain and would be flooded during a 1% annual chance flood with or without the levee. Table 6.2 shows the existing flood stages and the flood stages with the construction of the levee.

Table 6.2: Existing and With-Levee Flood Stages for the Properties Upstream of Huntington

Name	Mid-Town High Rise	VSE Building	ITT Building	Huntington Car Care
Address	2451 Midtown Ave.	2550 Huntington Ave.	2560 Huntington Ave.	2600 Huntington Ave.
Function	Condominiums	Office Building	Office Building	Auto Repair
Cross Section	1597	1823	1963	1963
Year Built	2001	1969	1976	1963
# of Floors	15	5	5	1
1% Annual Chance Flood (100 Year Flood Stage), Existing Conditions	15.6	15.9	16.6	16.6
1% Annual Chance Flood (100 Year Flood Stage), With Levee	16.2	16.4	17	17
First Floor	16.71	20.48	20.57	15.23
Low Point	12.61 – Loading Dock/Entrance to Underground Garage	18.58– rear entrance	20.57 – no basement	15.23 – no basement

These increases in the 1% annual chance water surface elevations may be allowed by FEMA. Fairfax County's Public Facilities Manual (PFM 6-1403.4E) states that there should be no adverse effect upon the adopted 100-yr floodplain. Notwithstanding, Fairfax County's Zoning Ordinance (ZO 2-903.7) permits all public uses and public improvements performed by or at the direction of the county. Since these two buildings are already vulnerable to flooding, flood proofing the individual buildings could be considered.

Upstream of Telegraph Road, the levee has no impact to the water surface elevations. The increase in 1% annual chance flood elevation at Telegraph Road is 0.1 feet, so the impact to the

bridge is negligible. The Corps and Fairfax County have coordinated closely with VDOT throughout this study, and the hydraulic analysis was provided to VDOT for their review in November 2007.

Project cost estimates were developed for the three levee plans (Table 6.3). The costs include design, construction management, real estate, contingency and escalation.

Table 6.3: Project Costs for Final Concept Plan 2

Plan	Total Estimated Project Cost
Plan 2a	$16.3 million
Plan 2b	$17.6 million
Plan 2c	$19.1 million

6.3.2 Final Concept Plan 1 - Combination Levee and Dredging

Final Concept Plan 1 is a modified version of Preliminary Concept Plan LD2a and would include both the construction of a levee and dredging. The levee component is the same as the Final Concept Plan 2 as described above, with the same three levee heights. For this final concept plan, the dredging component was adjusted based on the sediment modeling that was conducted.

The three variations of Plan 1 are:

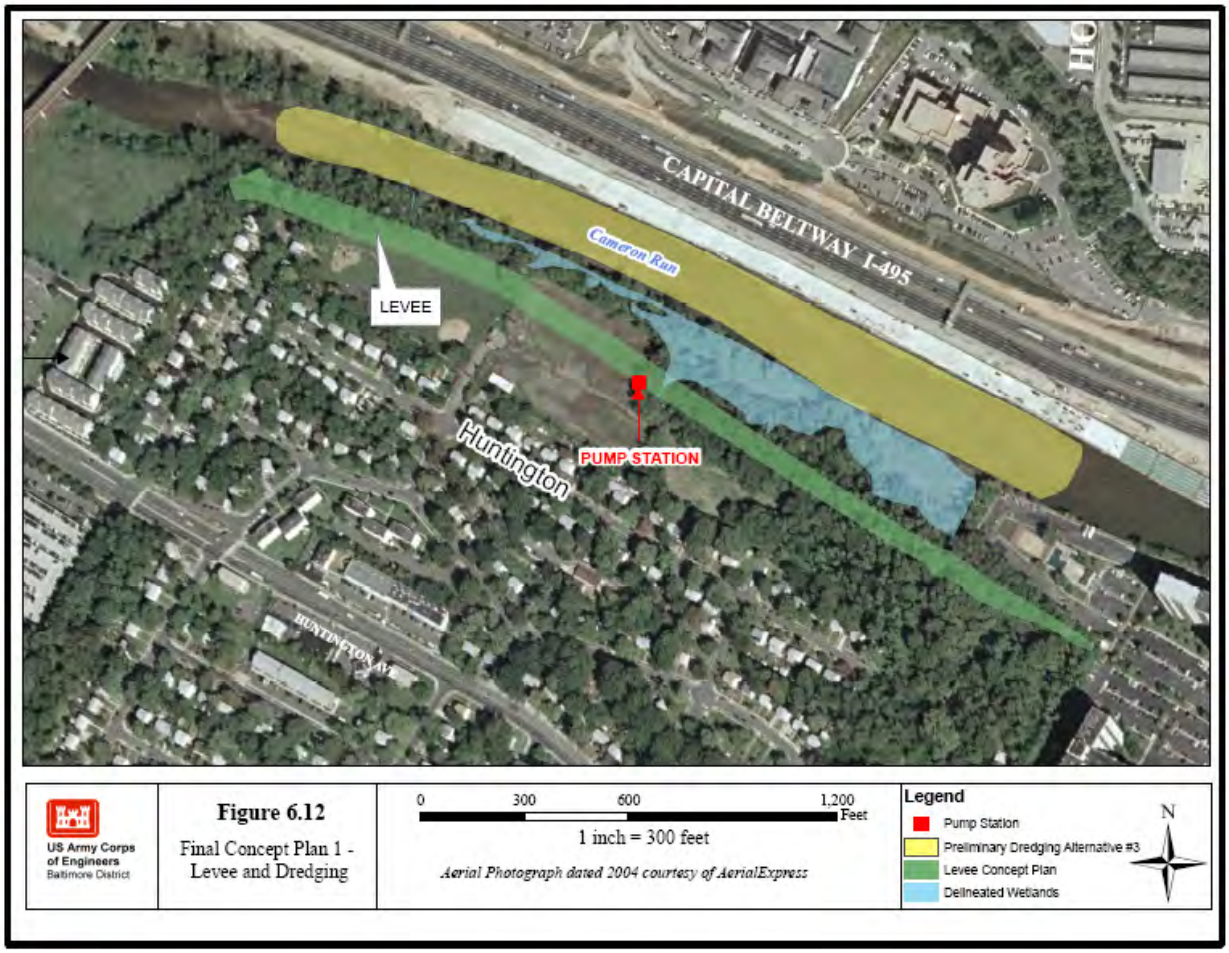
Plan 1a – Levee with a crest elevation at the upstream end of 15.6 feet (equivalent to the 1% annual chance flood elevation) **and shortened dredging**

Plan 1b - Levee with a crest elevation at the upstream end of 17.6 feet (equivalent to 3.4 feet above the 2% annual chance flood event (50-yr) at the upstream end or 2 feet above the 1% annual chance flood elevation) **and shortened dredging**

Plan 1c – Levee with a crest elevation at the upstream end of 19.6 feet (equivalent to 4 feet above the 1% annual chance flood elevation at the upstream end) **and shortened dredging**

Since the levee would increase flood elevations slightly upstream of Huntington, dredging to offset this increase was evaluated. The team determined the area and depth of dredging that would be required to offset the levee impacts. It was decided that since the sanitary siphon below Cameron Run would cost approximately $7 million to relocate, the dredging would begin just upstream of the siphon to avoid relocating it. This would also avoid the challenges of dredging through and around the bridge piers. The sediment study that was done concurrently with this study determined that a channel must be dredged 2.5 feet deep from the Metro rail to just upstream of the sanitary siphon to offset the impacts of the levee. Since the channel will fill in with sediment, the plan includes dredging 5’ deep to allow space for the sediment to fill in and when the sediment fills back in to a depth of 2.5 feet, the channel will be dredged again. This dredging would be conducted in addition to the construction of the levee (Figure 6.12).

Figure 6.12: Final Concept Plan 1 - Levee and Dredging



The trapezoidal channel would be approximately 5 feet deep, up to 150 feet wide, and 3,100 feet in length. Maintenance dredging would need to be performed on an as-needed basis, as soon as the channel filled in with approximately 2.5 feet of sediment. The sediment study indicated that this would occur roughly every 5 years or after a 10-year storm event; however, dredging should not be performed unless bathymetric surveys or other measures verify the sediment deposition. It is estimated that 86,000 cy of material would be dredged during the initial construction, and 43,000 cy would be dredged every 5 years for maintenance.

Three potential placement sites had been identified – King and Queen County landfill, Anderson Company landfill and Dyke Marsh. Based on physical and chemical sampling, the material is sandy and the parameters tested appear to have levels low enough for placement into typical landfills and may be suitable for restoration at Dyke Marsh. For cost estimating purposes, the assumption was made to take the material to the Anderson Company landfill in Prince George's County.

It was assumed that dredging would be accomplished using mechanical means (using a back hoe or similar equipment) and then transported by truck for disposal. Prior to transport, it is

anticipated that the material would need to be placed onsite for drying (approximately 3 days). Ramps would have to be included in the levee design for dredging and transport. Existing roads should be used whenever possible for transport of the material. Based on the calculation that each truck would hold roughly 10 cy of material, approximately 8,600 trucks would be required for the initial dredging and 4,300 for subsequent dredging.

The duration of dredging is dependent on several factors including community concerns, traffic, bucket size, weather conditions, and the current operating hours of the landfill, but is expected to be between 150 and 180 days (5 to 6 months) for the initial dredging and 75 to 90 days for maintenance dredging (2.5 to 3 months). Recommendations from the National Oceanic and Atmospheric Administration, National Marine Fisheries Service and the Virginia Department of Game and Inland Fisheries include a time of year restriction for the protection of alewife and blueback herring from February 15th to June 30th each year. Initial dredging and maintenance dredging will also disturb aquatic and benthic habitat, temporarily increase turbidity and may temporarily impact water quality.

Project cost estimates were developed for the three combination levee/dredging plans (Table 6.4). The dredging cost was based on a dredging and hauling cost of $45/cy. The costs include design, construction management, real estate, contingency and escalation.

Table 6.4: Project Costs for Final Concept Plan 1

Plan	Total Estimated Project Cost
Plan 1a	$21.5 million
Plan 1b	$22.8 million
Plan 1c	$24.2 million

6.3.3 Evaluation and Comparison of Final Concept Plans

The economic benefits, project costs and risks were evaluated for each of the Plan 1 and Plan 2 final concept plans. They were evaluated both with a pumping station and without one. The details of the economic analysis are included in Appendix D. The Phase 3 alternatives analysis matrices compare the final plans (Table 6.5 shows plans with a pumping station and Table 6.6 shows plans without a pumping station). The tables are located at the end of this section. The tables include the construction cost without escalation (using 2007 prices) that was used in the economic analysis. They also include the construction cost with escalation, assuming that construction will begin in FY10. A rough annual cost for operation and maintenance has been estimated. The costs and benefits were estimated for a 50-year duration, and then were translated into annualized costs and benefits. The benefit-cost-ratio is the annualized benefits divided by the annualized costs. For a project to meet the requirements for federal funding, the annualized benefits must be larger than the annualized costs, and the benefit-to-cost ratio must be greater than 1.0. The summary table includes whether or not the alternative meets the current local requirements, a description of the main risks associated with each plan, and some additional notes of interest. The table also includes the probability of non-exceedance for the event with a

1% chance of occurrence. This is based on the preliminary risk and uncertainty analysis and shows the probability that the levee will not be overtopped during the 1% annual chance flood event.

All of the benefit-to-cost ratios for the final concept plans were well under 1.0; the highest BCR for a plan with a pumping station is 0.5 for Plan 2c. Plans 1c and 2c with a pump station have a high probability of non-exceedance (98%) based on an initial analysis. For FEMA certification of a levee, it must have a probability of non-exceedance above 90%.

For the alternatives without a pumping station, Plan 2c has the highest BCR, 0.6. This BCR is higher than the same plan with a pumping station because the cost of the levee project without a pump station is much less than the cost with one. Based on the concept plan, the pump station increases the cost by approximately $4.5 million, which lowers the BCR. However, there is a greater risk of flood damages to homes due to interior ponding without a pump station. The annual damages that would be prevented (or benefits of the plan) are $509,000 for the without pump plan and $565,000 for the with pump plan. There is not a large difference in damages in the with-project condition between the with and without pumps scenarios due to the relatively few structures that are impacted by ponding. For the rainfall event with a return interval of 10 years it is expected that two structures would receive damages. For the 25-year event, that number is expected to increase to ten and for the 50-year event, 19. Expected annual damage for the with-project condition under both scenarios is weighted more heavily by the infrequent events resulting in overtopping of the levee/floodwall system. To prevent any houses from flooding from rainfall on the landward side of the levee, a pump station would be required.

6.3.4 Selection of Final Plan

Based on the evaluation and comparison of the final concept plans, Fairfax County selected Plan 2c (the highest levee alternative) with a pumping station for implementation. The county funded the Corps, using voluntary contributions, to design the levee project to approximately a 65% level of design. Additional technical work, such as surveys, soil borings and testing were conducted in order to complete the design. The design work is discussed in Section 7.

Table 6.5:**Phase 3**
Huntington Flood Damage Reduction Concept Plan Alternatives Analysis
Alternatives with Pump Station
Prepared 14 Jan 2008

Alternative	Cost without escalation used for economic analysis (w/design, const mgmt, any real estate)[1]	Escalation Cost	Construction Year	Total Project Cost	O&M Cost	Annualized Costs	Annualized Benefits (each low opening)[2]	Benefit to Cost Ratio (BCR)[3]	Height of Protection	Probability of Non-Exceedence for the Event with a 1 % Chance of Occurrence[4]	Meets Current Local Guidelines	Reason If "No"	Main Risk	NOTES
Plan 1a - Levee and Dredging with 60,000 gpm pump; levee top elevation at 15.6 feet at Fenwick; dredge from Metro rail to siphon	$19,600,000	$1,900,000	FY10-FY12	$21.5M	$2.4M every 5 years, and $150,000 each year	$1,690,000	$372,000	0.22	15.6 feet at Fenwick is equivalent to the 100-yr flood elevation	54%	Yes		Higher flood event could overtop levee and cause more catastrophic damages; also, channel may fill in with sediment quicker than expected and may not have expected reduction in flood levels (levee may increase flood levels upstream)	Top of levee at elevation 15.6' (100-year flood elevation with no additional height for risk and uncertainty); one pumping station with 60,000 gpm capacity to maintain 100-y rainfall peak pond elevation at 9 feet; O&M rate of dredging 2.5 feet every 5 yrs (43,000 cy); no increase in flood levels for 100-yr event; initial dredging of 86,000 cy material (dredge cost is $5.2M); dreding permit would be required
Plan 1b - Levee and Dredging with 60,000 gpm pump; levee top elevation at 17.6 feet at Fenwick; dredge from Metro rail to siphon	$20,800,000	$2,000,000	FY10-FY12	$22.8M	$2.4M every 5 years, and $150,000 each year	$1,758,000	$452,000	0.26	17.6 feet at Fenwick is equivalent to the 50-year flood elevation plus 2.4 feet at downstream end and 3.4 feet at upstream end (allows for some risk and uncertainty)	80%	Yes		Higher flood event could overtop levee and cause more catastrophic damages; also, channel may fill in with sediment quicker than expected and may not have expected reduction in flood levels (levee may increase flood levels upstream)	Top of levee at elevation 17.6' at Fenwick; one pumping station with 60,000 gpm capacity to maintain 100-yr rainfall peak pond elevation at 9 feet; O&M rate of dredging 2.5 feet every 5 yrs (43,000 cy); no increase in flood levels for 100-yr event; initial dredging of 86,000 cy material (dredge cost is $5.2M); dreding permit would be required
Plan 1c - Levee and Dredging with 60,000 gpm pump; levee top elevation at 19.6 feet at Fenwick; dredge from Metro rail to siphon	$22,000,000	$2,200,000	FY10-FY12	$24.2M	$2.4M every 5 years, and $150,000 each year	$1,826,000	$565,000	0.31	19.6 feet at Fenwick is equivalent to the 100-year flood elevation plus 3 feet at downstream end and 4 feet at upstream end (allows for some risk and uncertainty)	98%	Yes		Higher flood event could overtop levee and cause more catastrophic damages; also, channel may fill in with sediment quicker than expected and may not have expected reduction in flood levels (levee may increase flood levels upstream)	Top of levee at elevation 19.6' at Fenwick; one pumping station with 60,000 gpm capacity to maintain 100-yr rainfall peak pond elevation at 9 feet; O&M rate of dredging 2.5 feet every 5 yrs (43,000 cy); no increase in flood levels for 100-yr event; initial dredging of 86,000 cy material (dredge cost is $5.2M); dreding permit would be required
Plan 2a - Levee with 60,000 gpm pump; top elevation 15.6 feet at Fenwick	$14,800,000	$1,500,000	FY10-FY12	$16.3M	$150,000 each year	$985,000	$340,000	0.35	15.6 feet at Fenwick is equivalent to the 100-yr flood elevation	49%	No	Levee increases 100-yr flood elevation by up to 0.6' u/s which is not within current County guidelines	Higher flood event could overtop levee and cause more catastrophic damages	Top of levee at elevation 15.6' at Fenwick; one pumping station with 60,000 gpm capacity to maintain 100-yr rainfall peak pond elevation at 9 feet; levee increases 100-yr flood elevation by up to 0.5' u/s which is not within County requirements; project cos includes increased damages at upstream buildings;
Plan 2b - Levee with 60,000 gpm pump; top elevation 17.6 feet at Fenwick	$16,000,000	$1,600,000	FY10-FY12	$17.6M	$150,000 each year	$1,053,000	$447,000	0.42	17.6 feet at Fenwick is equivalent to the 50-year flood elevation plus 2.4 feet at downstream end and 3.4 feet at upstream end (allows for some risk and uncertainty)	79%	No	Levee increases 100-yr flood elevation by up to 0.6' u/s which is not within current County guidelines	Higher flood event could overtop levee and cause more catastrophic damages	Top of levee at elevation 17.6' at Fenwick; one pumping station with 60,000 gpm capacity to maintain 100-yr rainfall peak pond elevation at 9 feet; levee increases 100-yr flood elevation by up to 0.5' u/s which is not within County requirements; project cos includes increased damages at upstream buildings;
Plan 2c - Levee with 60,000 gpm pump; top elevation 19.6 feet at Fenwick	$17,400,000	$1,700,000	FY10-FY12	$19.1M	$150,000 each year	$1,132,000	$565,000	0.50	19.6 feet at Fenwick is equivalent to the 100-year flood elevation plus 3 feet at downstream end and 4 feet at upstream end (allows for some risk and uncertainty)	98%	No	Levee increases 100-yr flood elevation by up to 0.6' u/s which is not within current County guidelines	Higher flood event could overtop levee and cause more catastrophic damages	Top of levee at elevation 19.6' at Fenwick; one pumping station with 60,000 gpm capacity to maintain 100-yr rainfall peak pond elevation at 9 feet; levee increases 100-yr flood elevation by up to 0.5' u/s which is not within County requirements; project cos includes increased damages at upstream buildings;

Notes:
1/Project costs are based on concept-level plans and are subject to change; for costing purposes, the team identified a potential upland placement site
2/Benefits based on using low opening elevations for each structure

3/To meet Corps economic justification requirements, benefit-to-cost ratio must be greater than 1.0; however, due to limited funding, the Corps is prioritizing projects and only the projects with the highest BCR's are being included in the budget
4/Probability of Non-Exceedence for the event with a 1% chance of occurrence - Probability that the levee will not be overtopped during the 100-yr event (based on risk and uncertainty using the FDA model; however, H&H risk/uncertainty not included)

Table 6.6: **Phase 3**
Huntington Flood Damage Reduction Concept Plan Alternatives Analysis
Alternatives without Pump Station
Prepared 14 Jan 2008

Alternative	Cost without escalation used for economic analysis (w/design, const mgmt, any real estate)[1]	Escalation Cost	Construction Year	Total Project Cost	O&M Cost	Annualized Costs	Annualized Benefits (each low opening)[2]	Benefit to Cost Ratio (BCR)[3]	Height of Protection	Probability of Non-Exceedence for the Event with a 1 % Chance of Occurrence[4]	Meets Current Local Guidelines	Reason If "No"	Main Risk	NOTES
Plan 1a - Levee and Dredging with no pump; levee top elevation at 15.6 feet at Fenwick; dredge from Metro rail to siphon	$15,400,000	$1,300,000	FY10-FY12	$16.7M	$2.4M every 5 years, and $75,000 each year	$1,379,000	$319,000	0.23	15.6 feet at Fenwick is equivalent to the 100-yr flood elevation	54%	Yes		Structures will incur damages due to interior ponding during the 10-year rainfall and higher; Higher flood event could overtop levee and cause more catastrophic damages; also, channel may fill in with sediment quicker than expected and may not have expected reduction in flood levels (levee may increase flood levels upstream)	Does not solve problem because some of the houses may still flood from interior ponding since it does not include a pump station; top of levee at elevation 15.6' (100-year flood elevation with no additional height for risk and uncertainty); O&M rate of dredging 2.5 feet every 5 yrs (43,000 cy); no increase in flood levels for 100-yr event; initial dredging of 86,000 cy material (dredge cost is $5.2M)
Plan 1b - Levee and Dredging with no pump; levee top elevation at 17.6 feet at Fenwick; dredge from Metro rail to siphon	$16,600,000	$1,600,000	FY10-FY12	$18.2M	$2.4M every 5 years, and $75,000 each year	$1,446,000	$436,000	0.30	17.6 feet at Fenwick is equivalent to the 50-year flood elevation plus 2.4 feet at downstream end and 3.4 feet at upstream end (allows for some risk and uncertainty)	80%	Yes		Structures will incur damages due to interior ponding during the 10-year rainfall and higher; Higher flood event could overtop levee and cause more catastrophic damages; also, channel may fill in with sediment quicker than expected and may not have expected reduction in flood levels (levee may increase flood levels upstream)	Does not solve problem because some of the houses may still flood from interior ponding since it does not include a pump station; top of levee at elevation 17.6' at Fenwick; O&M rate of dredging 2.5 feet every 5 yrs (43,000 cy); no increase in flood levels for 100-yr event; initial dredging of 86,000 cy material (dredge cost is $5.2M)
Plan 1c - Levee and Dredging with no pump; levee top elevation at 19.6 feet at Fenwick; dredge from Metro rail to siphon	$17,900,000	$1,700,000	FY10-FY12	$19.6M	$2.4M every 5 years, and $75,000 each year	$1,520,000	$509,000	0.33	19.6 feet at Fenwick is equivalent to the 100-year flood elevation plus 3 feet at downstream end and 4 feet at upstream end (allows for some risk and uncertainty)	98%	Yes		Structures will incur damages due to interior ponding during the 10-year rainfall and higher; Higher flood event could overtop levee and cause more catastrophic damages; also, channel may fill in with sediment quicker than expected and may not have expected reduction in flood levels (levee may increase flood levels upstream)	Does not solve problem because some of the houses may still flood from interior ponding since it does not include a pump station; top of levee at elevation 19.6' at Fenwick; O&M rate of dredging 2.5 feet every 5 yrs (43,000 cy); no increase in flood levels for 100-yr event; initial dredging of 86,000 cy material (dredge cost is $5.2M)
Plan 2a - Levee with no pump; top elevation 15.6 feet at Fenwick	$10,600,000	$1,000,000	FY10-FY12	$11.6M	$75,000 each year	$674,000	$313,000	0.46	15.6 feet at Fenwick is equivalent to the 100-yr flood elevation	49%	No	Levee increases 100-yr flood elevation by up to 0.6' u/s which is not within current County guidelines	Structures will incur damages due to interior ponding during the 10-year rainfall and higher; Higher flood event could overtop levee and cause more catastrophic damages	Does not solve problem because some of the houses may still flood from interior ponding since it does not include a pump station; top of levee at elevation 15.6' at Fenwick; levee increases 100-yr flood elevation by up to 0.5' u/s which is not within County requirements; project cost includes increased damages at upstream buildings;
Plan 2b - Levee with no pump; top elevation 17.6 feet at Fenwick	$11,800,000	$1,200,000	FY10-FY12	$13M	$75,000 each year	$742,000	$435,000	0.59	17.6 feet at Fenwick is equivalent to the 50-year flood elevation plus 2.4 feet at downstream end and 3.4 feet at upstream end (allows for some risk and uncertainty)	79%	No	Levee increases 100-yr flood elevation by up to 0.6' u/s which is not within current County guidelines	Structures will incur damages due to interior ponding during the 10-year rainfall and higher; Higher flood event could overtop levee and cause more catastrophic damages	Does not solve problem because some of the houses may still flood from interior ponding since it does not include a pump station; top of levee at elevation 17.6' at Fenwick; levee increases 100-yr flood elevation by up to 0.5' u/s which is not within County requirements; project cost includes increased damages at upstream buildings;
Plan 2c - Levee with no pump; top elevation 19.6 feet at Fenwick	$13,100,000	$1,300,000	FY10-FY12	$14.42M	$75,000 each year	$815,000	$509,000	0.62	19.6 feet at Fenwick is equivalent to the 100-year flood elevation plus 3 feet at downstream end and 4 feet at upstream end (allows for some risk and uncertainty)	98%	No	Levee increases 100-yr flood elevation by up to 0.6' u/s which is not within current County guidelines	Structures will incur damages due to interior ponding during the 10-year rainfall and higher; Higher flood event could overtop levee and cause more catastrophic damages	Does not solve problem because some of the houses may still flood from interior ponding since it does not include a pump station; top of levee at elevation 19.6' at Fenwick; levee increases 100-yr flood elevation by up to 0.5' u/s which is not within County requirements; project cost includes increased damages at upstream buildings;

Notes:
1/Project costs are based on concept-level plans and are subject to change; for costing purposes, the team identified a potential upland placement site
2/Benefits based on using low opening elevations for each structure

3/To meet Corps economic justification requirements, benefit-to-cost ratio must be greater than 1.0; however, due to limited funding, the Corps is prioritizing projects and only the projects with the highest BCR's are being included in the budget
4/Probability of Non-Exceedence for the event with a 1% chance of occurrence - Probability that the levee will not be overtopped during the 100-yr event (based on risk and uncertainty using the FDA model; however, H&H risk/uncertainty not included)