Appendix G
Economic Appendix

Flat Creek Watershed
Aquatic Ecosystem Restoration
Detailed Project Report

Economic Appendix

US Army Corps of Engineers
Mobile District

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1. Introduction

1.1 Background

Through a partnership between the U.S. Army Corps of Engineers-Mobile District (USACE-Mobile), Hall County, and the City of Gainesville, the Flat Creek watershed has been identified for federal support through Section 206 of the Water Resources Development Act of 1996 (WRDA 96), as amended, "to carry out ecosystem restoration and protection projects if determined that such projects will improve environmental quality, are in the public interest, and are cost-effective" (Public Law 104-303). The objective of federal ecosystem restoration planning (one of the primary missions of the Civil Works program) is to contribute to increase the net quantity and/or quality of ecosystem resources.

The Flat Creek watershed is located in the Chattahoochee River Basin in Hall County, Georgia, upstream of Lake Sidney Lanier. The Chattahoochee River Basin is part of the larger Apalachicola-Chattahoochee-Flint Rivers Basin (ACF Basin), which flows south to the Gulf of Mexico and drains portions of Alabama and Florida (Figure 1-1). The watershed encompasses 7,337 total acres (698 acres of which are inundated by Lake Lanier) and contains 31 stream miles (6 miles of main stem and 25 miles of tributaries). Roughly 38 percent of the watershed is within the City of Gainesville and less than 1 percent in the City of Oakwood (Figure 1-2). The watershed was identified for an aquatic ecosystem restoration feasibility study based on degraded habitat throughout the watershed, which does not support a diverse, robust, biological community. Instream and riparian habitat have been adversely affected by changes to the natural stream hydrology, which has led to a scarcity of riffle/pool habitat, limited availability of woody debris and shade, and increased instream sedimentation and substrate embeddedness.

1.2 Organization of Detailed Project Report

The *Flat Creek Watershed Aquatic Ecosystem Restoration Detailed Project Report,* including this Economic Appendix, was developed to identify, evaluate, and recommend to decision makers an appropriate, coordinated, and implementable solution to the water resources problems and opportunities in the Flat Creek watershed. The feasibility report details ecosystem restoration problems and opportunities in the watershed and recommends the most cost-effective strategy for ecosystem restoration. The feasibility study incorporates a systematic approach that follows the six-step planning process outlined in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G), adopted by the Water Resource Council and required for all federal water resource projects.

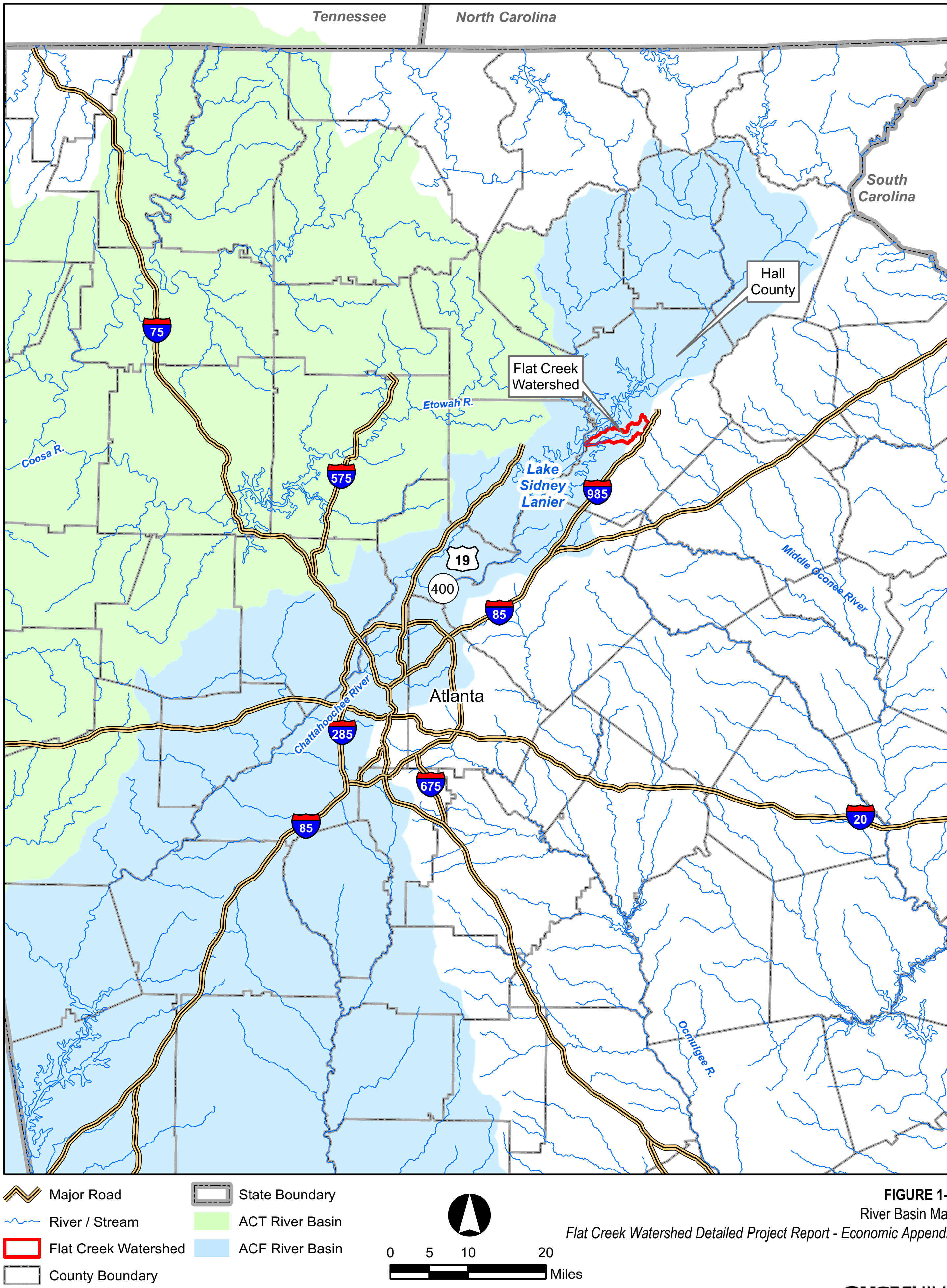

FIGURE 1-1
River Basin Map
Flat Creek Watershed Detailed Project Report - Economic Appendix

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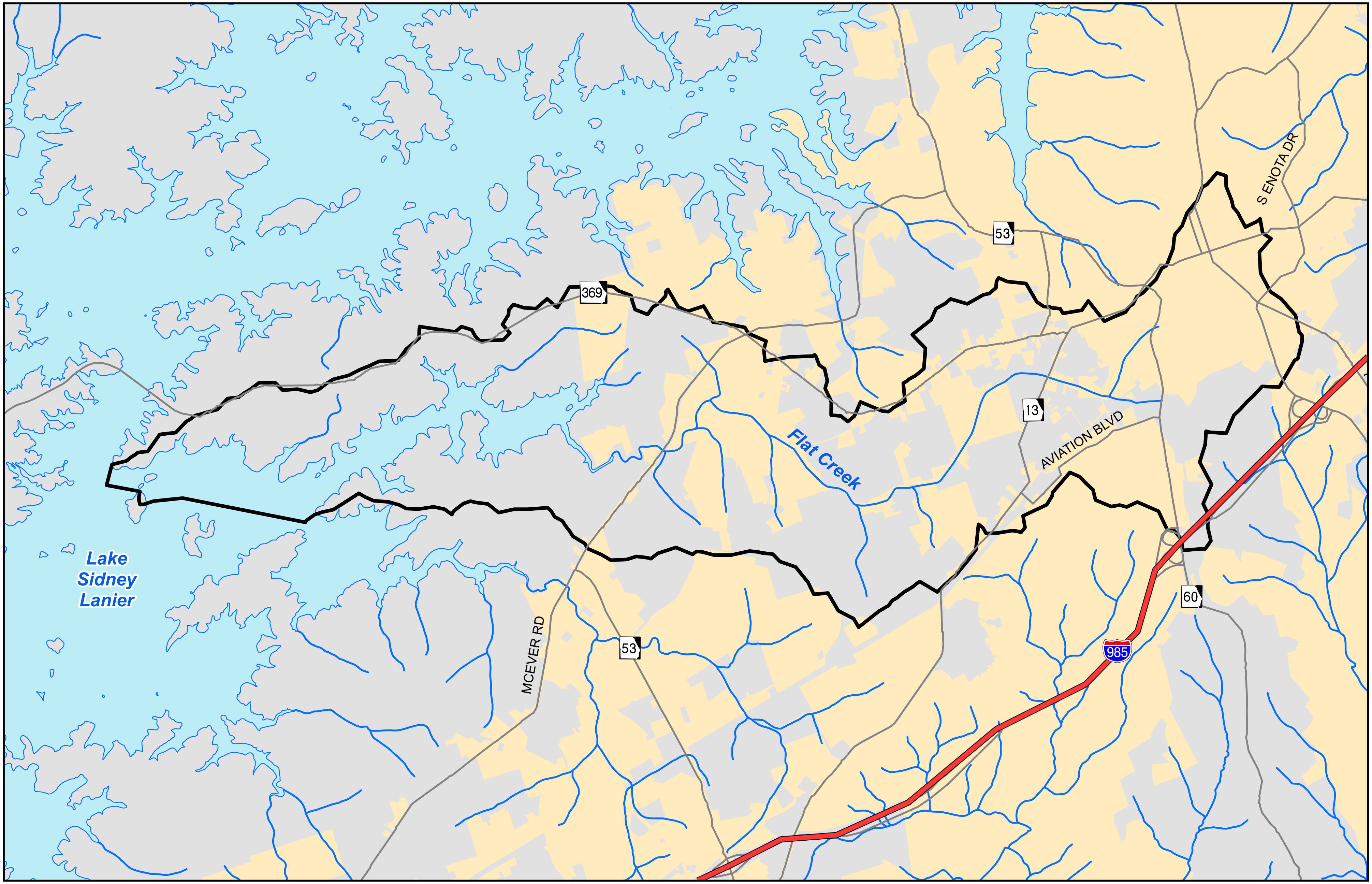

FIGURE 1-2

Flat Creek Watershed

Flat Creek Watershed Detailed Project Report - Economic Appendix

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The six planning steps are presented in Figure 1-3 and are detailed in the feasibility report. The Economic Appendix is associated with Steps 3 through 6, as shown in Figure 1-3, and details the economic analyses conducted as part of the identification of the recommended plan for the Flat Creek watershed. Since the benefits of ecosystem restoration projects are not measured in dollars, traditional cost-benefit analysis is not practical for such projects. To address this limitation, the P&G planning framework outlines specific analyses that must be used to prioritize federal water resource planning projects and. The economic analyses conducted for the Flat Creek watershed, in accordance with the P&G, are summarized below and detailed in this appendix.

1.3 Efficiency: IWR Planning Suite

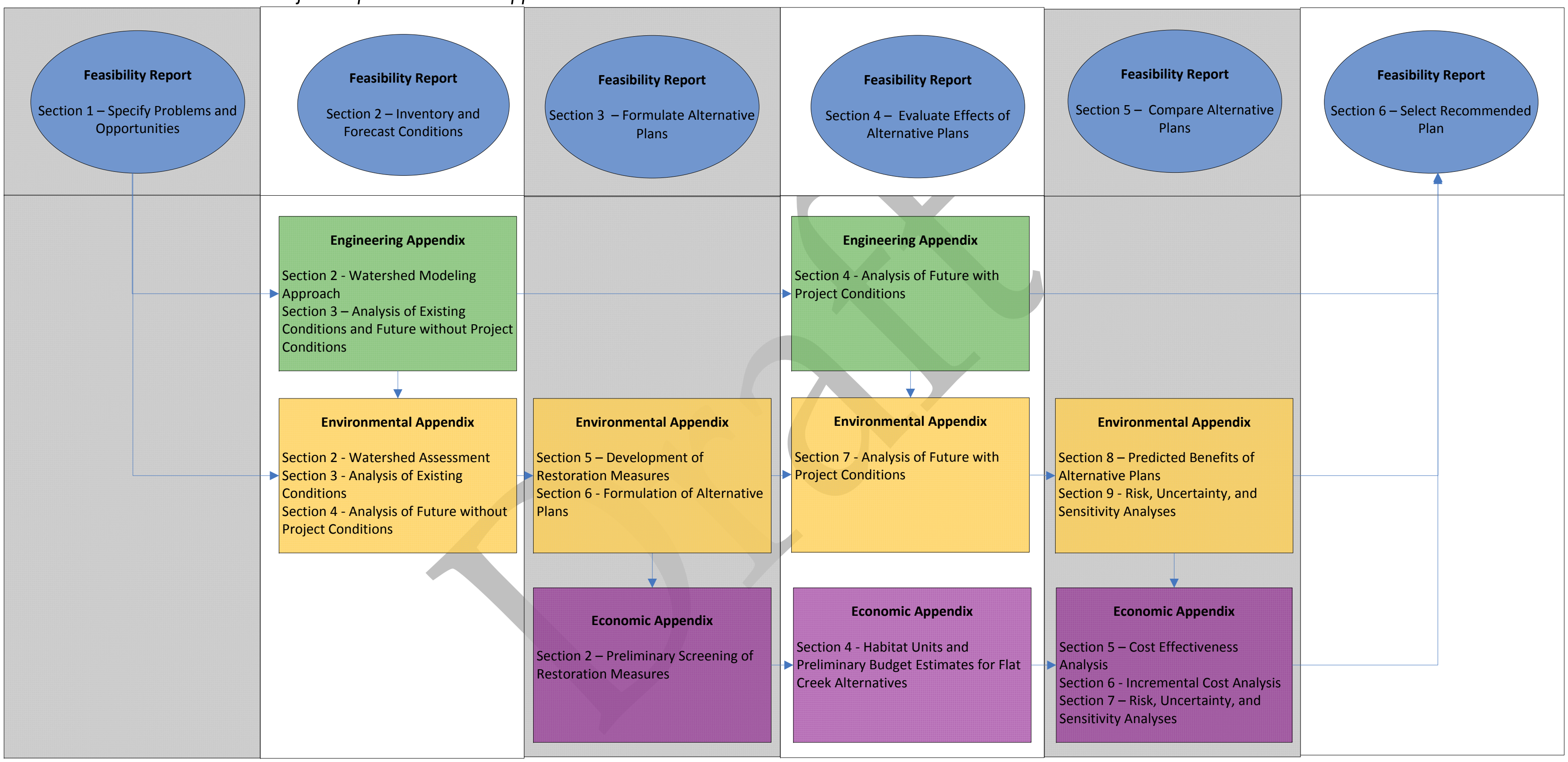
As outlined in the P&G, alternative plans should be evaluated based on four primary criteria: completeness, effectiveness, efficiency, and acceptability. Economic analyses are important primarily in the evaluation of efficiency. Economic analyses also play a role in the evaluation of the acceptability of an alternative, based on its estimated implementation cost, and the completeness of an alternative, based on identifying all potential costs that could result from implementation.

The USACE Institute for Water Resources (IWR) Planning Suite tool was developed in response to the intricacies of environmental and ecosystem restoration planning studies and performs cost-effectiveness and incremental cost analyses (CE/ICA) on combinations of water resources alternatives.

The CE Analysis determines which alternatives are "cost-effective," or the least costly for a given level of environmental output. The ICA evaluates the **efficiency** of the cost-effective alternatives, to determine which are best buy alternatives, or which provide the greatest increase in output for the least increase in cost.

To identify the Flat Creek alternative or alternatives that would provide the greatest benefit compared to cost, CE/ICA were conducted to compare predicted future benefits (quantified by habitat units) to estimated costs for each alternative identified in the Environmental Appendix to the feasibility report. For the purposes of employing the IWR planning suite, the habitat units predicted by the Ecosystem Response Model (ERM) provide a quantifiable measure of the ecosystem output and alternative estimate of the average annual cost for each alternative, developed in this appendix, are used to compare these outputs. The IWR planning suite evaluates the cost-effectiveness and efficiency of these alternatives, and the results are used to guide decision makers in developing a plan for Flat Creek that maximizes net benefits as they pertain to ecosystem restoration measures as required by the P&G document.

FIGURE 1-3
Organization of the Detailed Project Report in Relation to the Six Planning Steps
Flat Creek Watershed Detailed Project Report - Economic Appendix



2. Approach to Development of Alternative Cost Estimates

2.1 Reformulated Alternative Plans Included in Economic Analysis

As detailed in the Detailed Project Report, the final reformulation of alternatives for the Flat Creek watershed resulted in a total of 24 ecosystem restoration alternatives in addition to the No Action Alternative (i.e., future without project conditions). Alternatives are comprised of at least one stream problem site and/or at least one stormwater detention problem site (Figure 2-1). Table 2-1 outlines the problem sites included in each of the alternatives. The measures listed below under each formulated alternative were selected to address the specific problems observed at the site during field assessments. During formulation, the PDT considered many combinations of measures to address problems, avoid constraints, and meet the planning objectives. The problems in Flat Creek varied by severity (such as amount of sedimentation in a given area) and extent (distance along the stream). However, they were similar in type, where most stream reaches were channelized with degraded habitat because of sedimentation and a limited riparian ecosystem. As a result, the PDT formulated one alternative plan to address each individual problem site. Measures were selected and combined to address the specific problems observed. Other measures were eliminated if they did not specifically address the problem, were less effective than the selected measures, did not meet the planning objectives, or could not be implemented because of site constraints.

Each alternative is described below, along with a discussion of how the PDT applied measures to address problems.

No Action Alternative

The No Action Alternative represents the option of not implementing any restoration measures in the watershed. It provided a baseline for comparison of the potential impacts of the proposed action. If no action was to be taken, it was expected that the Flat Creek watershed would continue to degrade as additional development occurred, and it was likely that water quality, fish communities, and benthic macroinvertebrate communities would continue to decline.

Alternative A (Stream Problem Site 1)

Alternative A is in a residential subdivision in the upper reaches of a tributary to Flat Creek, between sampling stations FLG-4 and FLG-5 (near Atlanta Highway and Cronic Street). The site is characterized by a widening and incising stream channel, displaying a lack of adequate velocity/depth regimes and riffle substrate. The stream reach includes about 300 feet of moderate bank erosion (50 to 75 percent bare soil) and 150 feet of severely eroded (> 75 percent bare soil) banks. Banks range in height from 4 to 12 feet. To address channel widening and incising, the instream measures listed below were selected for grade control and to deflect flow from eroding banks. The bank stabilization measures listed below were selected to restore the eroded banks and to protect the streambanks from continued degradation.

Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures are not necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. No riparian measures were selected for Alternative A because the riparian ecosystem is intact, with mature woody vegetation along both sides of the stream. If Alternative A were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Create bankfull bench	None selected	None selected
J-hooks	Bank grading		
Cross vanes	Bank stabilization matting		
Boulders	Streambank planting		

Alternative B (Stream Problem Site 2)

Alternative B is located within a business district near Banks Street and in the headwaters of Flat Creek. The site includes a 900-foot stream reach characterized by a widening and incising channel section. Riparian ecosystems include lawns, open fields, impervious structures, and areas dominated by kudzu. A collapsing section of box culvert was observed within the problem site. The downstream part of the site includes a 400-foot reach consisting of severe erosion on both banks (10-foot bank height) and a sewer pipe impeding flow. The middle section of the project site includes a 350-foot piped section, whereas the upstream 150-foot reach consists of lower (4-foot) banks having moderate erosion.

To address channel widening and incising, the instream measures listed below were selected for grade control and to deflect flow from eroding banks. The bank stabilization and riparian ecosystem enhancement measures listed below were selected to restore the eroded banks and to protect the streambanks and riparian ecosystem from continued degradation. Maintenance of the collapsing box culvert is included as a selected restoration measure. Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures would not be necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Create bankfull bench	Planting of native hardwoods	None selected
J-hooks	Bank grading	Seeding and mulching	
Cross vanes	Bank stabilization matting		
Boulders	Streambank planting		
Culvert			

replacement

Alternative C (Stream Problem Site 18)

Alternative C is located in a residential subdivision on a tributary to the mainstem of Flat Creek, upstream of sampling station FLG-5, in the Lower Flat Creek subwatershed. The total stream length is roughly 150 feet, including a 50-foot segment exhibiting severe erosion (> 75 percent bare soil) and a 12-foot headcut that is actively eroding. In the stream segment immediately upstream of Alternative C, drain pipes from surrounding residential areas are present, trash has been dumped in the stream, and severe erosion is present. To address headcutting, the instream measures listed below were selected for grade control and to deflect flow from eroded banks. The bank stabilization measures listed below also were selected to restore the eroded banks and to protect the streambanks from continued degradation.

Based on watershed model results for erosivity and sediment production, which account for changing flow conditions, flow attenuation measures would not be necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. No riparian measures were selected for this alternative, because the riparian ecosystem is intact with mature woody vegetation along both sides of the stream. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Create bankfull bench	None selected	None selected
J-hooks	Bank grading		
Cross vanes	Bank stabilization matting		
Boulders	Streambank planting		

Alternative D (Stream Problem Site 23)

Alternative D is located in a residential subdivision (near Wood Avenue and west of Atlanta Highway) on a tributary to the mainstem of Flat Creek, in the Lower Flat Creek subwatershed. The site is characterized by an actively widening channel with severe erosion (75 to 100 percent bare soil) for roughly 200 feet. The left bank riparian corridor was cleared for a parallel utility, and the riparian areas are dominated by invasive species, including Chinese privet. The site has limited velocity/depth regimes and a lack of adequate riffles.

To address channel widening and incising, the instream measures listed below were selected for grade control and to deflect flow from eroded banks. In addition, the bank stabilization and riparian ecosystem enhancement measures (including invasive species management) listed below were selected to restore the eroded banks and to protect the existing streambanks and riparian ecosystem from continued degradation. Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures are not necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Create bankfull bench	Planting of native hardwoods	None selected
J-hooks	Bank grading	Seeding and mulching	
Cross vanes	Bank stabilization matting		
Boulders	Streambank planting		

Alternative E (Stream Problem Site 25)

Alternative E is located in a residential subdivision (near Hilton Drive) on a tributary to the mainstem of Flat Creek, in the Upper Flat Creek subwatershed. The tributary's confluence with the mainstem is just downstream of sampling station FLG-4. The problem site extends roughly 250 feet in length, and consisted of banks 5 feet tall and severely eroded (75 to 100 percent bare soil). There was also a steep drop in streambed elevation (known as a knick point) that was causing the stream to incise and erode. The knick point will move upstream if left unchecked.

To address the eroded banks and to protect the streambanks from continued degradation (particularly upstream of the knick point), the instream and bank stabilization measures listed below were selected for grade control, bank stabilization, and flow deflection. Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures are not necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. No riparian measures were selected for this alternative because the riparian ecosystem is intact with mature woody vegetation along both sides of the stream. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Create bankfull bench	None selected	None selected
J-hooks	Bank grading		
Cross vanes	Bank stabilization matting		
Debris jam removal	Streambank planting		
Boulders			

Alternative F (Stream Problem Site 26)

Alternative F is located in an industrial/commercial area in the Upper Flat Creek subwatershed (near E. E. Butler Parkway and Chestnut Street). The site is characterized by a widening and incising stream channel, displaying a lack of adequate velocity/depth regimes and riffle substrate. The total stream reach is roughly 900 feet, with 250 feet having moderate bank erosion (50 to 75 percent bare soil). The riparian ecosystems consisted of some buildings/structures on both sides of the stream, primarily near the southern extent of the problem site. These structures pose a minor constraint in implementing riparian ecosystem enhancement for a small part of the reach. Invasive species, including Chinese privet, dominate the riparian corridor.

To address channel widening and incising, the instream measures listed below were selected for grade control and to deflect flow from eroded banks. The bank stabilization and riparian measures (including invasive species management) listed below were selected to restore the eroded banks, protect the streambanks and riparian ecosystems from continued degradation. Based on watershed model results for erosivity and sediment production, which account for changing flow conditions, flow attenuation measures are not necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Bank stabilization matting	Planting of native hardwoods	None selected
J-hooks	Streambank planting	Seeding and mulching	
Cross vanes			
Boulders			

Alternative G (Stream Problem Site 28)

Alternative G is located in a residential/commercial area in the Upper Flat Creek subwatershed, between Grove Street and Maple Street. Within this 200-foot reach, most of the right bank riparian corridor consists of buildings and paved parking areas, with one business significantly losing property because of severe streambank erosion. The right bank is roughly 8 feet high and severely eroded (75 to 100 percent bare soil) for a distance of about 100 feet, whereas the left bank is roughly 5 feet high and moderately eroded (50-75 percent bare soil) for a distance of about 150 feet. The left bank riparian corridor had been cleared for the maintenance of a parallel utility.

To address channel widening and bank erosion, the instream and bank stabilization measures listed below were selected to deflect flow from eroded banks, restore the eroded banks, and protect the streambanks from continued degradation. Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures would not be necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. No riparian measures were selected for this alternative because of constraints associated with floodplain buildup (including paved surfaces, buildings, and an existing utility easement). If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
J-hooks	Create bankfull bench Bank grading Bank stabilization matting Streambank planting	None selected	None selected

Alternative H (Stream Problem Site 29)

Alternative H is located in the Upper Flat Creek subwatershed on city-owned property near Pine Street and High Street. The total stream reach is roughly 600 feet, with about 200 feet having moderate bank erosion (50 to 75 percent bare soil). The remaining 400 feet of the reach had been piped. The segment of stream not channelized by piping has eroded banks resulting in an overwidened, unstable stream channel. The riparian ecosystems consisted mainly of open space, but invasive species, including Chinese privet and kudzu, occur along both banks of the open channel section.

To address channel widening, the instream measures and bank stabilization measures listed below were selected to deflect flow from eroded banks, restore the eroded banks, and protect the existing streambanks from continued degradation. Restoring 250 feet of the channelized/piped segment of stream was selected to reestablish a natural stream section and restore ecosystem habitat. Finally, riparian measures (including invasive species management) listed below were selected to restore and enhance the riparian ecosystem. Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures are not necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
J-hooks Debris jam removal	Bank stabilization matting Streambank planting	Planting of native hardwoods Seeding and mulching	None selected

Alternative I (Stream Problem Site 32)

Alternative I is located along the mainstem of Flat Creek in a residential/commercial area just downstream of sampling station FLG-A (between Atlanta Highway and Dorsey Street). The site includes a channelized and actively widened 1,800-foot stream. Banks are roughly 9 feet high and moderately eroded (50 to 75 percent bare soil) over at least 700 feet of the reach. The right bank riparian corridor has lawns throughout most of the reach, and the left bank riparian corridor was cleared for a parallel utility.

To address channel widening and bank erosion, the instream and bank stabilization measures listed below were selected to deflect flow from eroded banks, restore the eroded banks, and protect the streambanks from continued degradation. The riparian measures listed below were selected to enhance vegetative protection along segments of the ecosystem affected by clearing and development. Based on watershed model results for erosivity and sediment production, which account for changing flow conditions, flow attenuation measures would not be necessary to sustainably address problems, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Rootwads	Planting of native hardwoods	None selected
Boulders	Bank grading	Seeding and mulching	
Stone toe protection	Bank stabilization matting		
	Streambank planting		

Alternative J (Stream Problem Site 33)

Alternative J is located along the mainstem of Flat Creek in a commercial/industrial area just upstream of sampling station FLG-4 and downstream of Highland Terrace. The site includes a channelized and actively widened 700-foot stream reach. Banks are roughly 8 feet high, steep, and moderately to severely eroded throughout the site. The riparian corridor on the right bank includes lawns throughout most of the reach. The riparian corridor on the left bank was cleared for a parallel utility.

To address channel widening and bank erosion, the instream and bank stabilization measures listed below were selected to deflect flow from eroded banks, restore the eroded banks, and protect the existing streambanks from continued degradation. The riparian measures listed below were selected to enhance vegetative protection along segments of the ecosystem that had been affected by clearing and development. Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures would not be necessary to sustainably address problems, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Bank grading	Planting of native hardwoods	None selected
Stone toe protection	Bank stabilization matting	Seeding and mulching	
	Streambank planting		

Alternative K (Stream Problem Site 39)

Alternative K is located along the mainstem of Flat Creek in a commercial/industrial area just upstream of sampling station FLG-A, near Pearl Nix Parkway and Dorsey Street. The total site reach extends roughly 750 feet and includes a 200-foot segment of severe erosion on the right bank. The riparian ecosystems had been significantly affected, with buildings and paved parking surfaces situated on both sides of the channel. The channel is partially lined with concrete for roughly 200 feet, which would be removed and replaced with a natural stream section if this alternative were selected. The physical habitat at the site scored very low, primarily because of significant channel alteration, poor bank stability and vegetation, disrupted riparian ecosystems, and an inadequate amount of substrate and cover.

To address bank erosion, the instream and bank stabilization measures listed below were selected to deflect flow from eroded banks, restore the eroded banks, and protect the streambanks from continued degradation. The riparian measures listed below were selected to enhance vegetative protection along segments of the ecosystem that had been affected by clearing and development. Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures would not be necessary to sustainably address problems, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
J-hooks	Adjust stream meander Bank grading Create bankfull bench Bank stabilization matting Streambank planting	Planting of native hardwoods Seeding and mulching	None selected

Alternative L (Stream Problem Site 42)

Alternative L is located near Lee Gilmer Airport, in the headwaters of Flat Creek. The site is characterized by a widening and incising stream channel, displaying a lack of adequate velocity/depth regimes and riffle substrate. The overall reach extends 800 feet and includes a 200-foot segment of severe erosion on both banks. The riparian ecosystems are severely affected, with buildings and paved parking surfaces on the right bank and residential lawns on the left. The physical habitat at the site scored low, primarily because of poor bank stability and vegetation, disrupted riparian ecosystems, a low frequency of riffles, and an inadequate amount of substrate suitable for aquatic organisms.

To address channel widening and incising, the instream measures listed below were selected for grade control and to deflect flow from eroded banks. In addition, the bank stabilization and riparian ecosystem enhancement measures listed below were selected to restore the eroded banks and to protect the streambanks and riparian ecosystem from continued degradation. Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures would not be necessary to sustainably address problems, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
J-hooks	Adjust stream meander Create bankfull bench Bank grading	Planting of native hardwoods Seeding and	None selected

	Bank stabilization matting	mulching	
	Streambank planting		

Alternative M (Stream Problem Sites 1 and 23)

Alternative M addresses the degraded ecosystem conditions observed at problem sites 1 and 23. Existing conditions at those sites are discussed under Alternatives A and D. A combined list of selected measures is listed below. Recognizing that the amount and success of habitat improvements may benefit from restoring multiple stream reaches in a similar segment of the watershed, Alternative M combines Alternatives A and D. Combining the stream problem sites into a stand-alone alternative was done primarily because of proximity of location (each site is located along a tributary to mainstem Flat Creek, within about a quarter mile of each other), and also similarities in degraded ecosystem conditions and selected measures necessary to address problems.

Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures are not necessary to sustainably address problems, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
J-hooks	Create bankfull bench	Planting of native hardwoods	None selected
Cross vanes	Bank grading	Seeding and mulching	
Boulders	Bank stabilization matting		
	Streambank planting		

Alternative N (Stream Problem Site 25 and Stormwater Detention Structure Problem Sites A10687 and CH033)

Alternative N addresses degraded ecosystem conditions observed at stream problem site 25, combined with flow attenuation/peak discharge reduction opportunities identified for Stormwater Detention Structure Problem Sites A10687 and CH033. It was formulated to evaluate benefits of peak flow attenuation in conjunction with physical stream restoration. Existing conditions at stream problem site 25 are discussed under Alternative E. In Alternative N, stormwater detention structure problem sites A10687 and CH033 are combined with this stream problem site because of proximity to the stream segment (within one-half mile), relative location immediately upstream of the stream site, and potential to reduce peak flows released to the stream.

Stormwater detention structure problem site A10687 is a dry detention basin in Lower Flat Creek near Browns Bridge Road. Based on design standards in the GSMM, the site does not provide adequate water quality or channel protection volume. The selected measures include increasing the storage volume by excavating the sides and bottom of the basin, modifying the outlet control structure, and adding a trash rack. The outlet control structure half-round also needs perforations and reinstallation.

Stormwater detention structure problem site CH033 is a dry detention pond in Lower Flat Creek near Browns Bridge Road, and also near stormwater detention structure problem site A10687. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of the basin to increase capacity. The combined stream restoration and flow attenuation measures selected for Alternative N are listed below. No riparian measures are selected for this alternative because the riparian ecosystem is intact with mature woody vegetation along both sides of the stream. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles J-hooks Cross vanes Debris jam removal Boulders	Create bankfull bench Bank grading Bank stabilization matting Streambank planting	None selected	Retrofit of outlet control structure Expansion of existing detention basin

Alternative O (Stream Problem Site 33 and Stormwater Detention Structure Problem Sites A14199, CH015, CH016, CH027 and CH106)

Alternative O addresses degraded ecosystem conditions observed at stream problem site 33, combined with flow attenuation/peak discharge reduction opportunities identified for Stormwater Detention Structure Problem Sites A14199, CH015, CH016, CH027 and CH106. It was formulated to evaluate benefits of peak flow attenuation in conjunction with physical stream restoration. Existing conditions at stream problem site 33 are discussed under Alternative J. Stormwater Detention Structure Problem Sites A14199, CH015, CH016, CH027 and CH106 are combined with the stream problem site because of their proximity to the stream segment (within one-half mile), their relative location immediately upstream of the stream site, and their potential to reduce peak flows released to the stream.

Stormwater detention structure problem site A14199 is a wet detention basin in Upper Flat Creek near Delta Drive. It does not provide adequate channel protection volume. Selected measures included retrofitting the site to an extended wet detention basin by retrofitting the outlet control structure orifice to reduce peak flow discharge rates.

Stormwater detention structure problem site CH015 is a dry detention pond in Upper Flat Creek near Shallowford Road and also near stormwater detention structure problem site CH016. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

Stormwater detention structure problem site CH016 is a dry detention pond in Upper Flat Creek near Skelton Road and also near stormwater detention structure problem site CH015. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

Stormwater detention structure problem site CH027 is a dry detention basin in Upper Flat Creek near Lyman Street. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity. The outlet control structure also requires maintenance to remove debris.

Stormwater detention structure problem site CH106 is a dry detention basin in Upper Flat Creek near Browns Bridge Road and Pearl Nix Parkway. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity. The basin requires maintenance to remove sediment buildup from the bottom of the pond. The combined stream restoration and flow attenuation measures selected for Alternative O are listed below.

If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Bank grading	Planting of native hardwoods	Retrofit of outlet control structure
Stone toe protection	Bank stabilization matting	Seeding and mulching	Expansion o existing detention basin
	Streambank planting		

Alternative P (Stream Problem Site 32 and Stormwater Detention Structure Problem Site CH048)

Alternative P addresses degraded ecosystem conditions observed at stream problem site 32, combined with flow attenuation/peak discharge reduction opportunities identified for Stormwater Detention Structure Problem Site CH048. Existing conditions at stream problem site 32 are discussed for Alternative I. Stormwater detention structure problem site CH048 was combined with the stream problem site because of its proximity to the stream segment (about one-half mile), its relative location upstream of the stream site, and its potential to reduce peak flows released to the stream. CH048 is a dry detention basin in Upper Flat Creek near Airport Parkway. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity. The combined stream restoration and flow attenuation measures selected for Alternative P are listed below. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Rootwads	Planting if native hardwoods	Retrofit of outlet control structure
Boulders	Bank grading	Seeding and mulching	Expansion of existing detention basin
Stone toe protection	Bank stabilization matting		
	Streambank planting		

Alternative Q (Stormwater Detention Structure Problem Sites A14911, A15015, CH036, CH048 and CH062)

Alternative Q includes flow attenuation/peak discharge reduction at multiple stormwater detention structure problem sites in the same headwaters part of Flat Creek, where flow attenuation might have the greatest downstream benefit (A14911, A15015, CH036, CH048 and CH062). The PDT formulated this alternative isolates the potential aquatic ecosystem benefits that could occur with flow attenuation but without instream ecosystem restoration. The alternative covers multiple locations to maximize the potential of the alternative to have a significant benefit. If these 5 locations were formulated in other combinations (that is 2 locations only, or 4 locations only), watershed model results indicate that they would not have a significant effect on downstream flows in Flat Creek.

Stormwater detention structure problem site A14911 is a dry detention basin in Upper Flat Creek near West Ridge Road and also near stormwater detention structure problem site A15015. The site does not have adequate water quality or channel protection volume. Selected measures include retrofitting the site to a dry extended detention basin by retrofitting the outlet control structure and decreasing the size of the 18-inch outlet control pipe.

Stormwater detention structure problem site A15015 was a dry detention basin in Upper Flat Creek near West Ridge Road and also near stormwater detention structure problem site A14911. The site does not provide adequate water quality or channel protection volume. Selected measures include retrofitting the site to an extended dry detention basin by replacing the outlet control structure and excavating the sides or bottom of the basin to increase capacity.

Stormwater detention structure problem site CH036 is a dry detention pond in Upper Flat Creek near Aviation Boulevard. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

Stormwater detention structure problem site CH048 is a dry detention basin in Upper Flat Creek near Airport Parkway. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

Stormwater detention structure problem site CH062 is a dry detention basin in Upper Flat Creek near Airport Parkway. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by replacing the outlet control structure and excavating the sides or bottom of basin to increase capacity.

The stream restoration and flow attenuation measures selected for Alternative Q are listed below.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
None selected	None selected	None selected	Retrofit of outlet control structure Expansion of existing detention basin

Alternative R (Stream Problem Site 42 and Stormwater Detention Structure Problem Sites A15094 and CH025)

Alternative R addresses degraded ecosystem conditions observed at stream problem site 42, combined with flow attenuation/peak discharge reduction opportunities identified for stormwater detention structure problem sites A15094 and CH025. Conditions at stream problem site 42 are discussed under Alternative L. Stormwater detention structure problem sites A15094 and CH025 were combined with the stream problem site because of their proximity to the stream segment (within one-quarter mile), their relative location near the stream site, and their potential to reduce peak flows released to the stream.

Stormwater detention structure problem site A15094 is a dry detention pond in Upper Flat Creek near Dean Street. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

Stormwater detention structure problem site CH025 is a wet detention pond in Upper Flat Creek near Marler Street. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended wet detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

The combined stream restoration and flow attenuation measures selected for Alternative R are listed below. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
J-hooks	Adjust stream meander Create bankfull bench Bank grading Bank stabilization matting Streambank planting	Planting of native hardwoods Seeding and mulching	Expansion of existing detention basin

Alternative S (Stream Problem Site 26 and Stormwater Detention Structure Problem Site CH022)

Alternative S addresses degraded ecosystem conditions observed at stream problem site 26, combined with flow attenuation/peak discharge reduction opportunities identified for stormwater detention structure problem site CH022. Existing conditions at site 26 are discussed under Alternative F. Stormwater detention structure problem site CH022 was combined with the stream problem site because of its proximity to the stream segment (within one-half mile) and its potential to reduce peak flows released to the stream.

Stormwater detention structure problem site CH022 is a wet detention pond in Upper Flat Creek near Bradford Street Extension. The site does not provide adequate water quality and channel protection volume. Selected measures included retrofitting the site to an extended wet detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

The combined stream restoration and flow attenuation measures selected for Alternative S are listed below. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles J-hooks Cross vanes Boulders	Bank stabilization matting Streambank planting	Planting of native hardwoods Seeding and mulching	Expansion of existing detention basin

Alternative T (Stream Problem Sites 2, 28, and 29)

Alternative T addresses degraded ecosystem conditions at stream problem sites 2, 28, and 29. Existing conditions at those sites are discussed under Alternatives B, G, and H. A combined list of selected measures is provided below. Recognizing that the amount and success of habitat improvements may benefit from restoring multiple stream reaches in a similar part of the watershed, this alternative combines Alternatives B, G, and H. Implementation of stream restoration at these sites would introduce various measures aimed at restoring instream habitat communities, stabilizing eroded streambanks, and enhancing the riparian ecosystems. Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures would not be necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles J-hooks Cross vanes Debris jam removal Boulders	Create bankfull bench Bank grading Bank stabilization matting Streambank planting	Planting of native hardwoods Seeding and mulching	None selected

Alternative U (Stream Problem Sites 2, 28, 29, and 39)

Alternative U addresses degraded ecosystem conditions observed at stream problem sites 2, 28, 29 and 39. Existing conditions at those sites are discussed under Alternatives B, G, H, and K. A combined list of selected measures is listed below. Similar to Alternative T, and recognizing that the amount and success of habitat improvements may benefit from restoring multiple stream reaches in a similar part of the watershed, this alternative combines Alternatives B, G, H, and K. By including stream problem site 39, Alternative U introduces an additional highly affected problem site in the mid-Upper Flat Creek subwatershed. Implementation of stream restoration at the sites would introduce various measures aimed at restoring instream habitat communities, stabilizing eroded streambanks, and enhancing the riparian ecosystems. Based on watershed model results for erosivity and sediment production, which account for changing flow conditions, flow attenuation measures would not be necessary to sustainably address problems in this location, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Adjust stream meander	Planting of native hardwoods	None selected
J-hooks	Create bankfull bench	Seeding and mulching	
Cross vanes	Bank grading		
Debris jam removal	Bank stabilization matting		
Boulders	Streambank planting		

Alternative V (Stream Problem Sites 32 and 33, and Stormwater Detention Structure Problem Sites A14199, CH015, CH016, CH027, CH053, and CH106)

Alternative V addresses degraded ecosystem conditions observed at stream problem sites 32 and 33 combined with flow attenuation/peak discharge reduction opportunities identified for stormwater detention structure problem sites A14199, CH015, CH016, CH027, CH053, and CH106. Existing conditions at stream problem sites 32 and 33 are discussed under Alternatives I and J. Recognizing that the amount and success of habitat improvements may benefit from restoring multiple stream reaches in a similar area of the watershed, Alternative V combines Alternatives I and J. Stormwater detention structure problem sites A14199, CH015, CH016, CH027, and CH106 were combined primarily for stream problem site 33 because of their proximity to the stream segment (within one-half mile), their relative location immediately upstream of the stream site, and their potential to reduce peak flows released to the stream. Stormwater detention structure problem site CH053 was combined primarily for stream problem site 32 because of its proximity to the stream segment (within one-half mile), its relative location upstream of the stream site, and their potential to reduce peak flows released to the stream.

Stormwater detention structure problem site A14199 is a wet detention basin in Upper Flat Creek near Delta Drive. It does not provide adequate channel protection volume. Selected measures included retrofitting the site to a wet extended detention basin by retrofitting the outlet control structure orifice to reduce peak flow discharge rates.

Stormwater detention structure problem site CH015 is a dry detention pond in Upper Flat Creek near Shallowford Road (and near stormwater detention structure problem site CH016). The site does not provide adequate water quality and channel protection volume. Selected measures included retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

Stormwater detention structure problem site CH016 is a dry detention pond in Upper Flat Creek near Skelton Road and also near stormwater detention structure problem site CH015. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

Stormwater detention structure problem site CH027 is a dry detention basin in Upper Flat Creek near Lyman Street. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity. The outlet control structure requires maintenance to remove debris.

Stormwater detention structure problem site CH053 is a dry detention basin in Upper Flat Creek near Industrial Boulevard. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

Stormwater detention structure problem site CH106 is a dry detention basin in Upper Flat Creek near Browns Bridge Road and Pearl Nix Parkway. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity. The basin requires maintenance to remove sediment buildup from the bottom of the pond.

The combined stream restoration and flow attenuation measures selected for Alternative V are listed below. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles	Rootwads	Planting of native hardwoods	Retrofit of outlet control structure
Boulders	Bank grading	Seeding and mulching	Expansion of existing detention basin
Stone toe protection	Bank stabilization matting		
	Streambank planting		

Alternative W (Stream Problem Sites 26 and 42, and Stormwater Detention Structure Problem Sites A15094, CH022, and CH025)

Alternative W addresses degraded ecosystem conditions observed at stream problem sites 26 and 42, combined with flow attenuation/peak discharge reduction identified for stormwater detention structure problem sites A15094, CH022, and CH025. Existing conditions at stream problem sites 26 and 42 are discussed under Alternatives F and L.

Recognizing that the amount and success of habitat improvements may benefit from restoring multiple stream reaches in a similar part of the watershed, Alternative W combines Alternatives F and L. Stormwater detention structure problem sites A15094, CH022, and CH025 were combined primarily for stream problem site 42 because of their proximity to the stream segment (within one-half mile), their relative location to the stream site, and their potential to reduce peak flows released to the stream.

Stormwater detention structure problem site A15094 is a dry detention pond in Upper Flat Creek near Dean Street. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended dry detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

Stormwater detention structure problem site CH022 is a wet detention pond in Upper Flat Creek near Bradford Street Extension. The site does not provide adequate water quality and channel protection volume. Selected measures include retrofitting the site to an extended wet detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

Stormwater detention structure problem site CH025 is a wet detention pond in Upper Flat Creek near Marler Street. The site does not provide adequate water quality and channel protection volume. Selected measures included retrofitting the site to an extended wet detention pond to increase efficiency by retrofitting the outlet control structure and excavating the sides or bottom of basin to increase capacity.

The combined stream restoration and flow attenuation measures selected for Alternative W are listed below. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

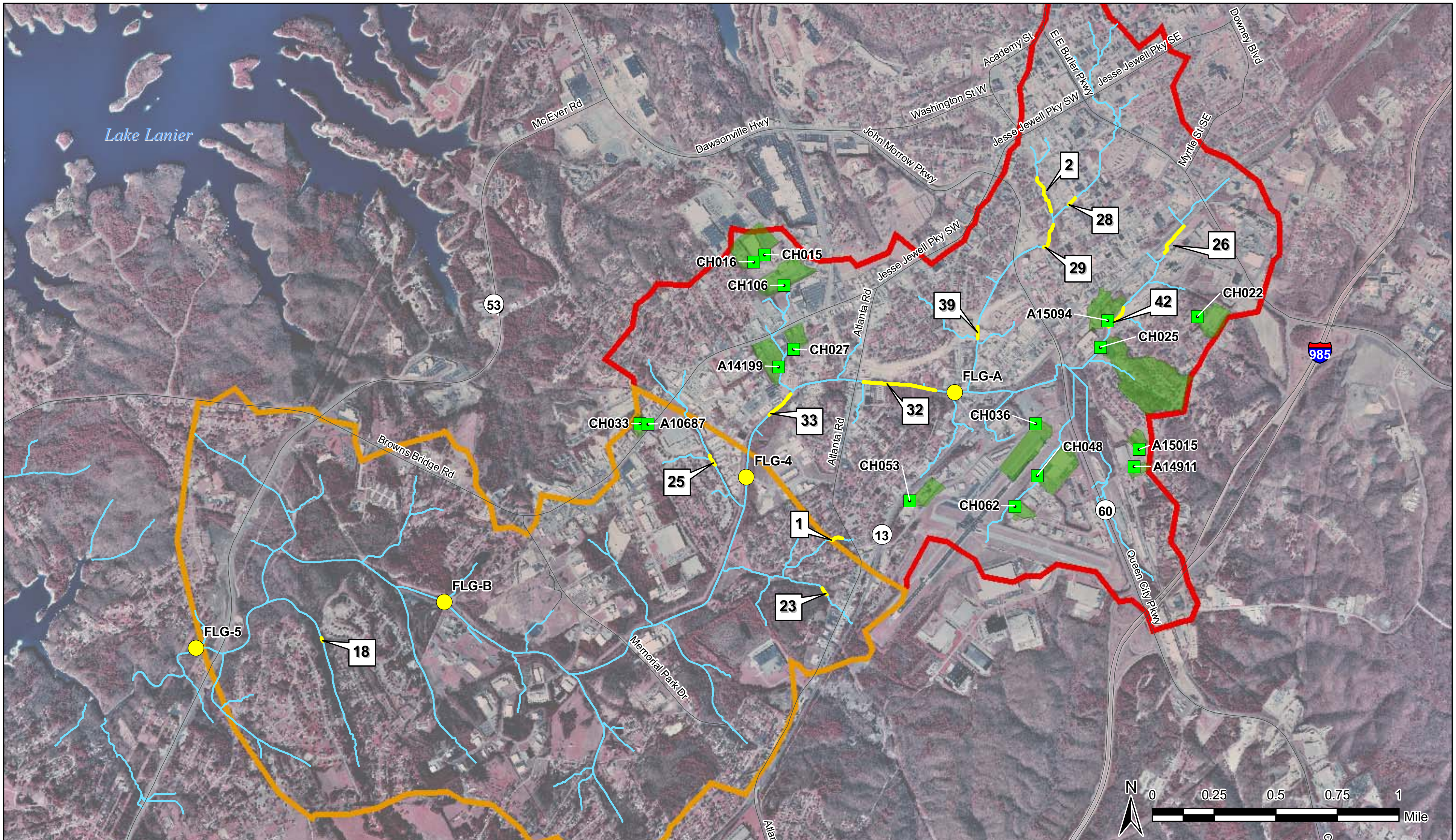
Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles J-hooks Boulders	Rootwads Create bankfull bench Bank grading Bank stabilization matting Streambank planting Riprap	Planting of native hardwoods Seeding and mulching	Expansion of existing detention basin

Alternative X (Stream Problem Site 32 and 33)

Alternative X addresses degraded ecosystem conditions observed at stream problem sites 32 and 33. Conditions at these sites are discussed under Alternatives I and J. Selected measures are listed below. Recognizing that the amount and success of habitat improvements may benefit from restoring multiple stream reaches in a similar part of the watershed, Alternative X combines Alternatives I and J. Combining these stream problem sites into a stand-alone alternative was done partially because of proximity (each site is along the Flat Creek mainstem and within a half mile of each other) and because of similarities in degraded ecosystem conditions and selected measures necessary to address the current problems.

Alternative X includes restoration of a combined length of 2,500 feet of a highly degraded segment of Flat Creek. Based on watershed model results for erosivity and sediment production, which accounts for changing flow conditions, flow attenuation measures are not necessary to sustainably address problems, reduce sedimentation, and restore aquatic ecosystems. If this alternative were selected for implementation, a construction easement would be required to access the stream channel along whichever bank better facilitates site entry while minimizing removal of trees and other vegetation. Following construction, the easement would be maintained for future site access.

Instream Measures:	*Bank Stabilization Measures:*	*Riparian Measures:*	*Flow Attenuation Measures:*
Engineered riffles Boulders Stone toe protection	Rootwads Bank grading Bank stabilization matting Streambank planting	Planting of native hardwoods Seeding and mulching	None selected



ERM Sampling Station
Stormwater Detention Problem Site
Streams
Stream Problem Areas
Stormwater Detention Drainage Area
Lower Flat Creek Subwatershed
Upper Flat Creek Subwatershed

FIGURE 2-1

Problem Sites Included in Final Array of Alternative Plans

Flat Creek Watershed Detailed Project Report - Economic Appendix

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TABLE 2-1
Potential Ecosystem Restoration Alternatives
Flat Creek Watershed Detailed Project Report - Economic Appendix

Alternative ID	Stream Problem Sites												Stormwater Detention Structure Problem Sites															
	1	2	18	23	25	26	28	29	32	33	39	42	A10687	A14199	A14911	A15015	A15094	CH015	CH016	CH022	CH025	CH027	CH033	CH036	CH048	CH053	CH062	CH106
A	X																											
B		X																										
C			X																									
D				X																								
E					X																							
F						X																						
G							X																					
H								X																				
I									X																			
J										X																		
K											X																	
L												X																
M	X			X																								
N					X								X										X					
O										X				X				X	X			X						X
P									X																X			
Q															X	X								X	X		X	
R												X					X				X							
S						X														X								
T		X					X	X																				
U		X					X	X			X																	
V									X	X				X				X	X			X				X		X
W						X						X					X			X	X							

TABLE 2-1
Potential Ecosystem Restoration Alternatives
Flat Creek Watershed Detailed Project Report - Economic Appendix

Alternative ID	Stream Problem Sites												Stormwater Detention Structure Problem Sites															
	1	2	18	23	25	26	28	29	32	33	39	42	A10687	A14199	A14911	A15015	A15094	CH015	CH016	CH022	CH025	CH027	CH033	CH036	CH048	CH053	CH062	CH106
A	X																											
B		X																										
C			X																									
X									X	X																		

2.2 Stream Restoration Alternative Cost Estimates

Planning-level cost estimates were developed for stream restoration alternatives as part of identifying the alternative that would provide the greatest benefit compared to cost. Alternative estimates were developed based on 2007 unit costs for various design and construction elements and on average 2007 real estate costs in the Gainesville area. Post-construction costs, including annual operations and maintenance and pre- and post-construction monitoring, are also included in the cost estimates provided in this section and used the CE/ICA. Table 2-2 summarizes the estimates of various cost components.

2.2.1 Preliminary Engineering and Modeling

The engineering, surveying, and hydraulic, and hydrologic modeling costs were based on the expected level of effort and historical costs. The costs vary, depending on the type of stream restoration proposed (Table 2-2). For example, preliminary engineering and modeling for a restoration involving restructuring the stream channel is more costly than the same activities for a restoration that involves spot repairs and maintains the channel form ($30,000, as compared to $15,000). The unit cost of surveying is also expected to be lower, on average, for smaller areas, than for larger areas, due to the economies of scale. The primary difference in cost is the hydraulic and hydrologic modeling, which is much more involved and costly for a greater level of restoration effort.

2.2.2 Design and Construction

Design and construction costs for stream restoration projects were based on the type of stream restoration proposed, stream order, length of restoration, and restoration area (calculated from the buffer and restoration length). Generally, as the length of restoration increases, the cost per foot of the restoration decreases due to the economies of scale associated with these types of projects. As would be expected, the cost per foot of the stream restoration increases as the level of effort associated with the restoration increases (see Table 2-2). Design and construction was estimated to vary between $400/foot for restoration involving reshaping the channel, to $320/foot for restoration that does not change the channel form.

2.2.3 LERRDs

As required by the USACE, alternative estimates should consider necessary lands, easements, rights-of-way, relocations, and dredge disposal areas (LERRDs). The cost of LERRDs in the alternative estimate includes land acquisition only. Most areas adjacent to the identified stream restoration sites are on private property, so land acquisition would likely be a factor in implementation costs. No relocations are expected to occur, but some additional costs may affect individual components, such as easements, rights-of-way, and dredge disposal areas. The cost of land will vary depending upon current ownership, land use, location, and other factors. An average estimated land cost of $20,000 per acre was used in this analysis based on a sampling of 2007 listings for undeveloped properties within the City of Gainesville (see Table 2-2). The required construction area of the restoration was calculated assuming a total buffer width of 150 feet. Using the restoration area, the cost for the land necessary to implement the alternative was estimated, including land necessary for all alternative aspects listed above.

2.2.4 Contingency

Costs will vary based on construction materials, vegetative plantings, right-of-way negotiations, and other variables. A contingency factor of 20 percent of the estimated cost of preliminary engineering, design, and construction, was applied to account for unforeseen conditions of the cost estimates. A contingency factor of 20 percent of the estimated LERRDs cost was also applied to the cost estimate to account for uncertainty when evaluating the cost of lands. The LERRDs contingency is not intended to account for inflation.

TABLE 2-2
Basis for Stream Restoration Alternative Cost Estimates
Flat Creek Watershed Detailed Project Report - Economic Appendix

Implementation Activity	Alternative Cost Estimate for Restoration Type[a]			
	Adjust Stream Meander/Add Bends	Raise Bankfull Bench	Maintain Bankfull Bench	Spot Repair
Preliminary Engineering and Modeling				
Preliminary engineering	$25,000	$25,000	$25,000	$12,500
Survey	$4,167/acre	4,167/acre	4,167/acre	$2,500/acre
Hydraulic and hydrologic modeling [b]	$25,000	$16,667	$8,333	$0
Final Design and Construction				
Design and construction	$333/ft.	$317/ft.	$300/ft.	$267/ft.
LERRDs				
Land acquisition	$16,667/acre			
Contingency				
Contingency (20 percent of items above)	$10,000 + $4167/acre + $67/ft.	$8,333 + $4167/acre + $63/ft.	$6,667 + $4167/acre + $60/ft.	$13,500 + $3833/acre + $53/ft.
Operations and Maintenance				
Inspection	$1,200/year.			
Stone replacement[c]	$100 to $120/ yd^3 /25 yrs.			
Monitoring				
Pre-construction monitoring	$10,000/site, one event			
Post-construction monitoring	$10,000/site, biannually			

[a] Costs will vary based on construction materials, vegetative plantings, right-of-way negotiations, and other variables.

[b] Additional cost for hydraulic and hydrologic (H&H) modeling based on stream order ($5,000 for SO = 2, $10,000 for SO = 3, $20,000 for SO = 4, and $30,000 for SO = 5).

[c] Based on stone size needed.

2.2.5 Operation and Maintenance

Post-construction costs include annual operations and maintenance. Operations and maintenance costs for the Flat Creek alternative estimates were based on 2007 unit prices and on issues that may be included in the maintenance of stream restoration sites (Table 2-2). For stream restoration, these include stone replacement approximately every 25 years and an annual inspection. Property acquired in conjunction with nonstructural measures must be maintained and operated to comply with USACE requirements. Cost of operation and maintenance account for the uncertainty in the maintenance/stone replacements that will be necessary, due to a lack of historical data on long-term restoration maintenance requirements.

2.2.6 Monitoring (Pre-construction and Post-construction)

For stream restoration sites, pre- and post-construction monitoring activities include fish and benthic macroinvertebrate sampling, along with physical habitat assessments. Detailed monitoring and reporting procedures are provided in the *Flat Creek Watershed Aquatic Ecosystem Restoration Project Monitoring Plan* (see the Environmental Appendix). Biological monitoring will be conducted before and following construction (biannually) to evaluate restoration success based on the objectives described in Section 2 of the Detailed Project Report. Monitoring data can also be used to evaluate the accuracy of the ERM tool used to quantify ecosystem benefits in terms of habitat units. As outlined in ER 1105-2-100 (*Planning Guidance Notebook* for ecosystem restoration projects), costs for monitoring will not exceed 1 percent of the total costs for the features to be monitored (ER 1105-2-100). Unit pricing for monitoring (Table 2-2) was used for development of pre-construction and post-construction monitoring costs. Pre-construction monitoring (one event) and post-construction monitoring (two events) are assumed to be $10,000 per event for stream restoration sites.

2.3 Stormwater Detention Structure Retrofit Alternative Cost Estimates

Planning-level cost estimates were also developed for stormwater detention structure retrofits, to conduct CE/ICA on alternatives including stormwater detention structures. Alternative estimates were developed based on 2007 unit costs for various design and construction elements. Post-construction costs, including annual operations and maintenance and pre- and post-construction monitoring, are included in the cost estimates provided in this section and used in the CE/ICA. The estimates of various cost components are summarized in Table 2-3 and detailed below.

2.3.1 Construction

Construction elements were separated into general categories of work associated with each type of stormwater detention structure installation and retrofit activity. Most installation and retrofit activities were categorized under pipe installation/rehabilitation, earthwork (grading, dredging, excavation, etc.), or installation/modification of the outlet control structure. Table 2-3 lists individual unit costs for piping, earthwork, and control structure installation used in developing cost estimates for alternatives. Mobilization and other

TABLE 2-3
Basis for Stormwater Detention Structure Retrofit Alternative Estimates
Flat Creek Watershed Detailed Project Report - Economic Appendix

Implementation Activity	Alternative Estimate for Stormwater Detention Structure Size		
	< 0.25 acre	**0.25 to 1 acre**	**> 1 acre**
Construction			
Piping [a]	$7,500	$10,000	$17,500
Earthwork [a]	$62,500	$75,000	$112,500
Control structure installation [a]	$22,500	$30,000	$37,500
Mobilization/incidental construction costs	$125,000	$150,000	$200,000
Engineering			
Engineering design and procurement (25 percent of construction cost)[b]	$66,875	$78,750	$110,625
Services during Construction			
Services during construction (20 percent of construction cost)[b]	$53,500	$63,000	$88,500
Preliminary Engineering and Modeling			
Preliminary Engineering and Modeling	$50,000	$50,000	$75,000
Contingency			
Contingency (20 percent of items above) [c]	$77,575	$91,350	$128,325
Operations and Maintenance			
Annual inspection	$1,200/yr.		
Sediment removal	$25/ yd^3/5 yrs.		
Mowing	$1440/acre/yr.		
Monitoring			
Pre-construction monitoring	$5,000/site, one event		
Pre-construction monitoring	$5,000/site, biannually		

[a] Cost estimates were developed based on the site-specific techniques, which may not necessarily include all the construction elements listed above.
[b] Percentages are applied to the total of the construction costs of each alternative.
[c] This percentage was applied to the sum of all aspects of the alternative, including construction, engineering, and services during construction.

incidental construction costs were also accounted for in construction costs. Depending on the size of the stormwater detention structure stormwater detention structure, mobilization and other incidental construction costs ranged from $125,000 to $200,000.

2.3.2 Engineering, Design, and Procurement

Engineering design was included in the alternative estimate for each stormwater detention structure retrofit. The cost was estimated as 25 percent of the total construction cost for each stormwater detention structure retrofit (Table 2-3), with the total construction cost including piping, earthwork, control structure installation, and mobilization / incidental construction costs.

2.3.3 Services During Construction

Estimated costs for services during construction were also included in the alternative estimate. Similar to engineering design and procurement costs, they were estimated as 20 percent of the total construction cost for each alternative (Table 2-3).

2.3.4 Preliminary Engineering and Modeling

An allowance for preliminary engineering and modeling was included in the alternative estimate for each stormwater detention structure retrofit. Depending on the size of the stormwater detention structure, estimated preliminary engineering and modeling costs range from $50,000 to $75,000.

2.3.5 Contingency

A contingency factor of 20 percent of the estimated cost of construction, engineering, design, and services during construction was applied to the cost estimates account for unforeseen conditions of the cost estimates.

2.3.6 Operation and Maintenance

Post-construction costs include annual operations and maintenance. Operations and maintenance costs for the Flat Creek alternative estimates were based on 2007 unit prices and on potential issues that may be included in the maintenance of stormwater detention structures (Table 2-3). For stormwater detention structures, these include annual inspection, sediment removal, and periodic mowing. Additionally, any property acquired in conjunction with non-structural measures must be maintained and operated to comply with USACE requirements.

2.3.7 Monitoring (Pre-Construction and Post-Construction)

As required, hydrologic monitoring at stormwater detention structure outlets will be conducted prior to construction and following construction (at Year 1 and Year 3 following construction). Detailed monitoring and reporting procedures are provided in the Flat Creek Watershed Aquatic Ecosystem Restoration Project Monitoring Plan (see Environmental Appendix).

Costs for monitoring will not exceed one percent of the total costs for the features to be monitored. Pre-construction monitoring (single event) and post-construction monitoring (two events) are assumed to be $5,000 per event for stormwater detention structure sites.

2.4 Combination Alternatives Cost Estimates

Single-site alternative costs were estimated using the methods described in Sections 2.2 and 3.2. Each single-site alternative will be designed to provide ecological benefits when constructed individually; however grouping of single-site alternatives into combination alternatives will maximize watershed benefit, and implementation of multiple single-site alternatives in conjunction can allow for a decrease in overall costs due to consolidated labor and equipment needs. Based on historical restoration costs, it was assumed that actual construction, engineering design, and services during construction costs can be reduced by 11 to 25 percent if multiple single-site alternatives are grouped. Reasons for the construction, engineering, and survey cost savings include economies of scale and consolidated labor or costs for the following elements:

- Mobilization
- Staging areas and access points
- Project management work
- Survey activities
- Field visits
- Client progress meetings
- Submittals (30, 60, and 90 percent designs)

Table 2-4 shows the estimated cost savings which were used for combining alternatives in the Flat Creek watershed. Cost savings were subtracted from the overall alternative estimate for project first cost for each combined alternative, as presented in Section 3.

TABLE 2-4
Estimated Cost Savings for Combined Alternatives
Flat Creek Watershed Detailed Project Report - Economic Appendix

Number of Sites	Construction Savings	Services During Construction Savings	Engineering Savings	Average Cost Savings
	(percent cost savings)			
2	11	15	11	12
3	12	15	12	13
4	13	15	13	14
> 4	15	25	15	18

3. Habitat Units and Cost Estimates for Flat Creek Alternatives

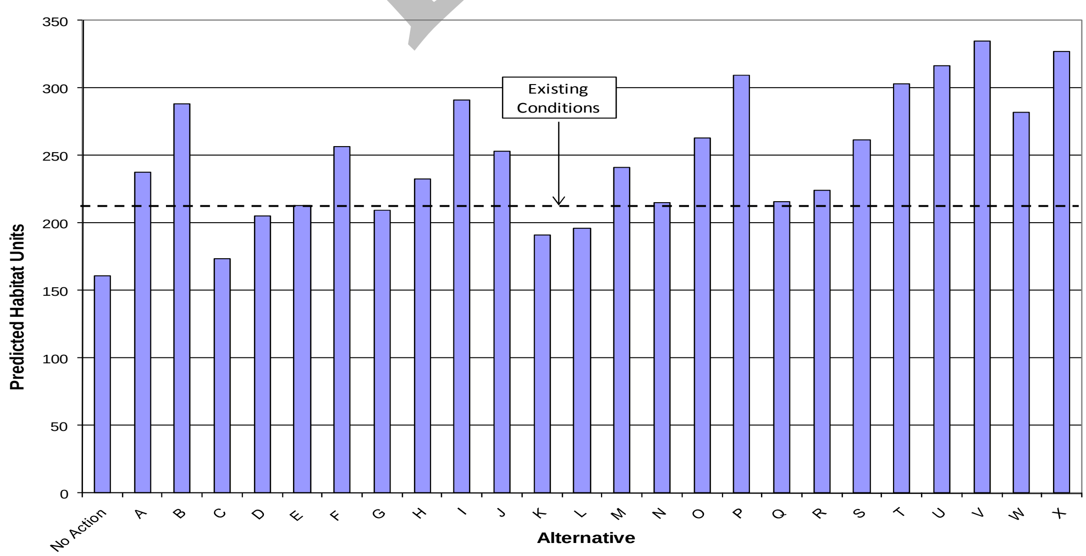
3.1 Habitat Units

The 24 alternatives and the No Action Alternative (future without project conditions) were evaluated using the Ecosystem Response Model (ERM) to project ecosystem outputs, or habitat units, as detailed in the Environmental Appendix. The habitat units are based on 25 years in the future, due to the availability of projected future land use for this period. The habitat units are used to quantify the non-monetary benefits of the alternatives used in the CE/ICA conducted with the IWR Planning Suite. The habitat units for each Flat Creek alternative are shown in Figure 3-1, and a detailed summary of the calculation of the habitat units is provided in Table 3-1.Technical details for development of Habitat Unit scores are presented in the Environmental Appendix.

3.2 Alternative Estimates for Final Array of Alternative Plans

To facilitate economic analyses, alternative estimates were developed for the alternatives using the methods presented above. The alternative estimate for project first cost is shown in Table 3-2. This cost includes the initial investments that must be made to implement the alternative. Table 3-3 summarizes the alternative estimate of the average annual costs for each alternative. This includes interest during construction on the investments in Table 3-2 (assumes 9-month construction time for stream restoration and 6-month construction time for detention pond retrofits) and annual monitoring and O&M costs over the period of analysis (25 years). The economic analyses (Section 4) were conducted using the estimated average annual costs.

FIGURE3-1
Predicted Habitat Units for 24 Restoration Alternatives and the No Action Alternative
Flat Creek Watershed Detailed Project Report - Economic Appendix



Note:The No Action Alternative is equivalent to future without project conditions

TABLE 3-1
Predicted Future Scores Summary (Existing Conditions, Future Without Project, and Future with Project)
Flat Creek Watershed Detailed Project Report - Economic Appendix

Alternative	**Fish IBI Score**				**BMI Score**				**Physical Habitat Score**				Combined Stream Health Score	Habitat Units
	FLG-A	**FLG-4**	**FLG-B**	**FLG-5**	**FLG-A**	**FLG-4**	**FLG-B**	**FLG-5**	**FLG-A**	**FLG-4**	**FLG-B**	**FLG-5**		
Existing Conditions	14	10	26	16	17	36	40	37	81	98	130	153	36	213
Future without Project	12	10	18	12	16	22	25	30	73	73	90	114	27	160
Future with Project														
A	12	10	28	28	16	22	54	59	73	73	146	165	40	237
B	22	25	25	24	45	45	46	55	116	118	132	152	48	288
C	12	10	18	18	16	22	25	37	73	73	90	133	29	173
D	12	10	24	21	16	22	40	44	73	73	133	152	34	205
E	12	10	25	24	16	22	44	48	73	73	130	149	35	213
F	19	20	25	23	34	36	43	48	102	103	130	149	43	256
G	17	15	21	17	25	31	35	37	87	85	111	132	35	209
H	18	18	23	20	29	34	39	42	94	94	120	140	39	233
I	18	26	28	28	34	47	53	55	100	120	142	156	49	291
J	12	24	26	26	16	44	50	50	73	110	133	142	42	253
K	14	14	20	16	16	29	33	35	73	83	108	129	32	191
L	15	15	20	16	17	30	34	36	74	84	109	130	33	196
M	12	10	29	29	16	22	55	60	73	73	147	166	40	241
N	12	10	26	25	16	22	44	48	73	73	129	149	36	215
O	12	26	27	28	16	46	52	52	73	114	135	145	44	263
P	19	28	30	30	23	55	55	57	105	135	163	183	51	309
Q	15	15	21	17	22	34	39	42	83	94	120	140	36	216
R	16	18	21	21	24	36	34	44	85	95	112	143	37	224
S	20	21	25	23	36	38	44	48	103	104	130	149	44	262
T	22	25	27	27	40	45	58	58	112	118	148	164	50	303
U	22	26	28	28	45	49	60	60	116	123	150	170	53	316
V	22	28	30	30	45	52	63	68	116	130.5	159.5	179	56	335
W	22	23	27	25	40	43	48	51	107	109	135	152	47	282
X	20	28	30	30	36	52	63	68	115	130.5	159.5	179	55	327

TABLE 3-2
Alternative Estimates, Project First Cost
Flat Creek Watershed Detailed Project Report - Economic Appendix

Alternative ID	Sites Included	*Engineering*[a]	*+ Design & Construction*[a]	*+ LERRDs*[a]	*+ Contingency*[a,b]	*- Cost Savings*[c]	= *Alternative Estimate, Project First Cost*
No Action	None	-	-	-	-	-	$0
A	1	$45,971	$95,000	$14,348	$34,508	-	$190,000
B	2	$58,747	$285,000	$43,044	$87,689	-	$475,000
C	18	$13,146	$20,000	$3,587	$8,207	-	$45,000
D	23	$44,537	$63,333	$9,565	$25,783	-	$144,000
E	25	$49,420	$79,167	$11,957	$30,978	-	$172,000
F	26	$56,594	$237,500	$35,870	$74,602	-	$405,000
G	28	$18,388	$53,333	$9,565	$18,553	-	$100,000
H	29	$46,109	$180,000	$28,696	$57,848	-	$313,000
I	32	$67,355	$450,000	$71,740	$135,037	-	$725,000
J	33	$55,877	$210,000	$33,478	$67,906	-	$368,000
K	39	$69,094	$225,000	$35,870	$74,602	-	$405,000
L	42	$65,645	$241,667	$38,261	$78,297	-	$424,000
M	1, 23	$90,508	$158,333	$23,913	$60,290	$40,080	$293,920
N	25, A10687, CH033	$159,304	$770,750	$14,348	$158,020	$143,390	$959,610
O	33, A14199, CH015, CH016, CH027, CH106	$317,052	$1,941,375	$40,174	$395,910	$485,280	$2,210,720
P	32, CH048	$130,826	$877,875	$86,088	$94,793	$142,920	$1,048,080
Q	A14911, A15015, CH036, CH048, CH062	$250,000	$1,758,250	$0	$401,650	$433,800	$1,976,200

TABLE 3-2
Alternative Estimates, Project First Cost
Flat Creek Watershed Detailed Project Report - Economic Appendix

Alternative ID	Sites Included	*Engineering*[a]	*+ Design & Construction*[a]	*+ LERRDs*[a]	*+ Contingency*[a,b]	*- Cost Savings*[c]	= *Alternative Estimate, Project First Cost*
R	42, A15094, CH025	$203,774	$1,194,500	$45,913	$215,083	$215,800	$1,444,200
S	26, CH022	$117,913	$691,750	$43,044	$99,959	$114,480	$839,520
T	2, 28, 29	$123,244	$518,333	$81,306	$164,090	$115,440	$772,560
U	2, 28, 29, 39	$192,338	$743,333	$117,176	$238,692	$181,020	$1,111,980
V	32, 33, A14199, CH015, CH016, CH027, CH053, CH106	$447,879	$2,819,250	$126,263	$490,703	$699,480	$3,186,520
W	26, 42, A15094, CH022, CH025	$321,687	$1,886,250	$88,958	$315,042	$470,340	$2,142,660
X	32, 33	$124,000	$660,000	$105,833	$203,167	$131,160	$961,840

[a] Using methods outlined in Sections 2.2. and 2.3

[b] Includes contingency for engineering, design, construction, and LERRDs

[c] For combination alternatives

TABLE 3-3
Alternative Estimates, Average Annual Cost
Flat Creek Watershed Detailed Project Report - Economic Appendix

Alternative ID	Sites Included	*Alternative Estimate, Project First Cost*[a]	*+ Interest During Construction*[b]	*= Investment Cost*	*+Average Annual Investment Cost*[c]	*+Average Annual Monitoring and O&M Cost*[d]	= *Alternative Estimate, Average Annual Cost* [e]
No Action	None	$0	$0	$0	$0	$0	$0
A	1	$190,000	$2,600	$192,600	$12,000	$3,181	$15,181
B	2	$475,000	$6,500	$481,500	$31,000	$3,339	$34,339
C	18	$45,000	$600	$45,600	$3,000	$3,121	$6,121
D	23	$144,000	$2,000	$146,000	$9,000	$3,154	$12,154
E	25	$172,000	$2,400	$174,400	$11,000	$3,167	$14,167
F	26	$405,000	$5,600	$410,600	$26,000	$3,300	$29,300
G	28	$100,000	$1,400	$101,400	$6,000	$3,154	$9,154
H	29	$313,000	$4,200	$317,200	$20,000	$3,260	$23,260
I	32	$725,000	$9,800	$734,800	$47,000	$3,498	$50,498
J	33	$368,000	$5,000	$373,000	$24,000	$3,286	$27,286
K	39	$405,000	$5,600	$410,600	$26,000	$3,300	$29,300
L	42	$424,000	$5,800	$429,800	$27,000	$3,313	$30,313
M	1, 23	$293,920	$4,000	$297,920	$19,000	$6,335	$25,335
N	25, A10687, CH033	$959,610	$9,000	$968,610	$61,000	$8,158	$69,158
O	33, A14199, CH015, CH016, CH027, CH106	$2,210,720	$20,600	$2,231,320	$142,000	$17,121	$159,121
P	32, CH048	$1,048,080	$12,500	$1,060,580	$67,000	$6,518	$73,518

TABLE 3-3
Alternative Estimates, Average Annual Cost
Flat Creek Watershed Detailed Project Report - Economic Appendix

Alternative ID	Sites Included	*Alternative Estimate, Project First Cost*[a]	*+ Interest During Construction*[b]	*= Investment Cost*	*+Average Annual Investment Cost*[c]	*+Average Annual Monitoring and O&M Cost*[d]	= *Alternative Estimate, Average Annual Cost* [e]
Q	A14911, A15015, CH036, CH048, CH062	$1,976,200	$16,700	$1,992,900	$126,000	$18,105	$144,105
R	42, A15094, CH025	$1,444,200	$14,400	$1,458,600	$93,000	$17,318	$110,318
S	26, CH022	$839,520	$9,200	$848,720	$54,000	$7,703	$61,703
T	2, 28, 29	$772,560	$10,600	$783,160	$50,000	$9,754	$59,754
U	2, 28, 29, 39	$1,111,980	$15,100	$1,127,080	$71,000	$13,053	$84,053
V	32, 33, A14199, CH015, CH016, CH027, CH053, CH106	$3,186,520	$31,800	$3,218,320	$204,000	$23,283	$227,283
W	26, 42, A15094, CH022, CH025	$2,142,660	$22,300	$2,164,960	$137,000	$25,021	$162,021
X	32, 33	$961,840	$13,000	$974,840	$62,000	$6,784	$68,784

[a] See Table 3-2

[b] Assumes construction = 6 months for detention basins and 9 months for stream restorations; FY2011 discount rate = 4.125%

[c] Calculated over 25 years with discount rate = 4.125%

[d] Includes one pre-construction monitoring event and (assumes) two post-construction monitoring events; Includes Operations and Maintenance costs for the period of analysis (25 years); assumes a half foot of sediment removal every 5 years for B stormwater detention structures and 0.1 yd^3/linear feet of stream restoration of stone replacement needed every 25 years; calculated over 25 years with discount rate = 4.125%

[e] Average Annual Cost over the period of analysis (25 years)

4. Cost Effectiveness Analysis

4.1 Overview of Analysis

Cost-effectiveness analysis is conducted to eliminate the least economically effective restoration alternatives. To determine whether an alternative is cost-effective, they are compared based on their predicted level of output (habitat units). For each level of output, only the least expensive alternative is cost-effective. The inputs to the IWR Planning Suite include the predicted habitat units (output) for each alternative and the average annual cost for each alternative. The habitat units included in the IWR analysis are based on 25 years in the future, due to the availability of projected future land use for this period.

Tables 4-1 through 4-4 demonstrate the process used by the IWR Planning Suite to determine the cost-effectiveness of the Flat Creek alternatives. Single-site alternatives are evaluated first to determine which are cost-effective. The single-site alternatives for Flat Creek are shown in Table 4-1. In Table 4-2, the single-site alternatives are sorted in order of increasing habitat units, so that each level of output can be evaluated. Beginning with the alternative predicted to provide the least habitat units (in this case, the No Action Alternative), the average annual cost of each alternative is evaluated to determine whether it is more costly than an alternative predicted to provide greater habitat units. As shown in Table 4-2, the No Action Alternative is less costly than any other alternative, so it remains. Alternative C is less costly than any other alternative, so it also remains. Alternative K, however, is more costly than at least one alternative with greater habitat units (e.g., Alternative D), and therefore this alternative is considered not cost-effective, and is eliminated from further analysis. Following this same process for all single-site alternatives, a total of 4 alternatives are eliminated from further evaluation (Table 4-2).

After evaluating single-site alternatives, those which are deemed cost-effective are grouped with all combination alternatives (see Table 4-3). The same process is repeated on this set of alternatives to determine which alternatives are the least costly for a given level of output. Following this process again, 8 additional alternatives are eliminated from further evaluation (Table 4-4).

TABLE 4-1
Average Annual Cost and Output of Single-Site Alternatives
Flat Creek Watershed Detailed Project Report – Economic Appendix

Single Site Alternatives	Alternative Estimate, Average Annual Cost	Habitat Units
No Action	$0	160
A	$15,181	237
B	$34,339	288
C	$6,121	173
D	$12,154	205
E	$14,167	213
F	$29,300	256
G	$9,154	209
H	$23,260	233
I	$50,498	291
J	$27,286	253
K	$29,300	191
L	$30,313	196

Begin with the single-site alternatives for the first evaluation.

TABLE 4-2
Cost-Effectiveness Analysis of Single-Site Alternatives
Flat Creek Watershed Detailed Project Report – Economic Appendix

Single Site Alternatives	Alternative Estimate, Average Annual Cost	Habitat Units
No Action	$0	160
C	$6,121	173
K	$29,300	191
L	$30,313	196
D	$12,154	205
G	$9,154	209
E	$14,167	213
H	$23,260	233
A	$15,181	237
J	$27,286	253
F	$29,300	256
B	$34,339	288
I	$50,498	291

Sort single-site alternatives in order of increasing Habitat Units. Remove any alternatives that are more costly than an alternative with greater Habitat Units. The remaining (highlighted) alternatives will be in order of increasing cost.

TABLE 4-3
Average Annual Cost and Output of Alternatives
Flat Creek Watershed Detailed Project Report – Economic Appendix

Alternative ID	Alternative Estimate, Average Annual Cost	Habitat Units
No Action	$0	160
C	$6,121	173
G	$9,154	209
E	$14,167	213
A	$15,181	237
J	$27,286	253
F	$29,300	256
B	$34,339	288
I	$50,498	291
M	$25,335	241
N	$69,158	215
O	$159,121	263
P	$73,518	309
Q	$144,105	216
R	$110,318	224
S	$61,703	262
T	$59,754	303
U	$84,053	316
V	$227,283	335
W	$162,021	282
X	$68,784	327

Combine the remaining single-site alternatives with all combination alternatives.

TABLE 4-4
Cost-Effectiveness Analysis of Alternatives
Flat Creek Watershed Detailed Project Report – Economic Appendix

Alternative ID	Alternative Estimate, Average Annual Cost	Habitat Units
No Action	$0	160
C	$6,121	173
G	$9,154	209
E	$14,167	213
N	$69,158	215
Q	$144,105	216
R	$110,318	224
A	$15,181	237
M	$25,335	241
J	$27,286	253
F	$29,300	256
S	$61,703	262
O	$159,121	263
W	$162,021	282
B	$34,339	288
I	$50,498	291
T	$59,754	303
P	$73,518	309
U	$84,053	316
X	$68,784	327
V	$227,283	335

Sort the alternatives in order of increasing Habitat Units. Remove any alternatives that are more costly than an alternative with greater Habitat Units. The remaining (highlighted) alternatives will be in order of increasing cost.

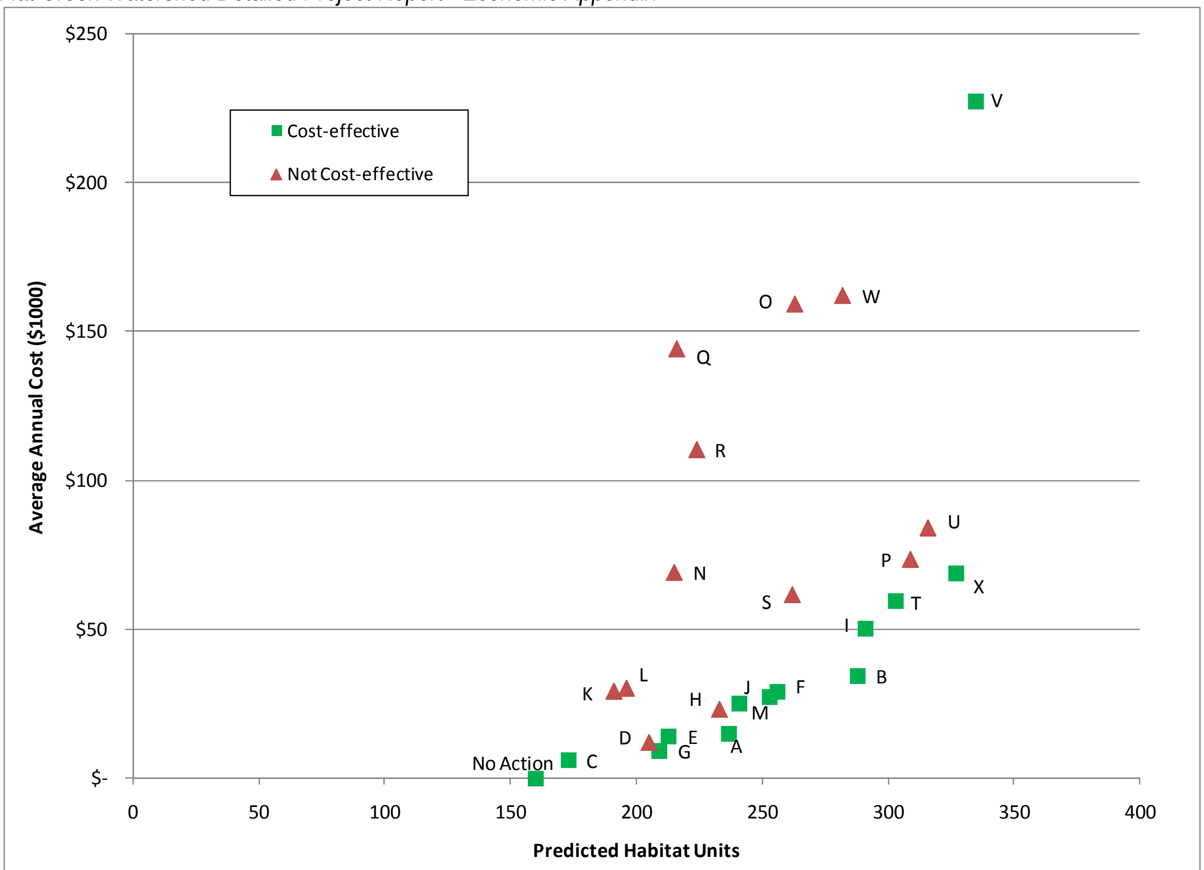
4.2 Results

As a result of the cost-effectiveness analysis detailed above, a total of 13 alternatives (including the No Action Alternative/future conditions without project) are considered cost-effective. Table 4-5 presents all single-site and combination alternatives, along with alternative estimates and predicted habitat units, and the results of the cost-effectiveness evaluation. Figure 4-1 shows the predicted habitat units (benefit) and the average annual cost for each alternative, and demonstrates those that are cost-effective (13 alternatives) and those that are not cost-effective (12 alternatives).

TABLE 4-5
Results of Cost Effectiveness Evaluation
Flat Creek Watershed Detailed Project Report - Economic Appendix

Alternative ID	Alternative Estimate, Average Annual Cost	Habitat Units	Cost-Effective?
No Action	$0	160	Yes
A	$15,181	237	Yes
B	$34,339	288	Yes
C	$6,121	173	Yes
D	$12,154	205	No
E	$14,167	213	Yes
F	$29,300	256	Yes
G	$9,154	209	Yes
H	$23,260	233	No
I	$50,498	291	Yes
J	$27,286	253	Yes
K	$29,300	191	No
L	$30,313	196	No
M	$25,335	241	Yes
N	$69,158	215	No
O	$159,121	263	No
P	$73,518	309	No
Q	$144,105	216	No
R	$110,318	224	No
S	$61,703	262	No
T	$59,754	303	Yes
U	$84,053	316	No
V	$227,283	335	Yes
W	$162,021	282	No
X	$68,784	327	Yes

FIGURE 4-1
Cost-Effectiveness of Flat Creek Restoration Alternatives
Flat Creek Watershed Detailed Project Report - Economic Appendix



5. Incremental Cost Analysis

5.1 Overview of Analysis

With consideration to the efficiency criterion for federal water resource projects, ICA is conducted on the cost-effective alternatives to reveal changes in average annual costs as output levels are increased. ICA serves to eliminate less economically effective solutions. Given one alternative with a greater level of output for the same or less average annual cost, then only the alternative with the greater output is economically preferred. ICA is used to compare increases in average annual cost to increases in benefits, which are quantified in habitat units, among the alternatives being considered. As detailed in Section 4, several of the originally proposed ecosystem restoration alternatives for the Flat Creek watershed are not cost-effective and were eliminated from further consideration. For this analysis, only the cost- effective solutions are considered.

ICA is conducted to determine which alternatives provide the greatest increase in output for the least increase in average annual cost. The No Action Alternative does not have an associated cost and is therefore always considered a best buy alternative. The next costly best buy alternative is identified by calculating the incremental cost of each alternative over the No Action Alternative. The alternative with the lowest incremental cost (in this case, Alternative G) is then selected as the next best buy alternative. This process is repeated to identify the alternative with the lowest incremental cost in terms of moving from Alternative G. Following this same process until there are no alternatives remaining to calculate incremental cost, all best buy alternatives can be determined. This process is outlined in Table 5-1.

TABLE 5-1
Incremental Cost Analysis of Cost Effective Alternatives
Flat Creek Watershed Detailed Project Report - Economic Appendix

Cost-Effective Alternative ID	Alternative Estimate, Average Annual Cost	Habitat Units	Incremental Cost/Unit After Previous Best Buy [a]				
			Step 1 – Calculate from No Action	***Step 2 - Calculate from Alternative G***	***Step 3 – Calculate from Alternative A***	***Step 4 – Calculate from Alternative B***	***Step 5 – Calculate from Alternative X***
No Action	$0	160					
C	$6,121	173	$471				
G	$9,154	209	$187				
E	$14,167	213	$267	$1,253			
A	$15,181	237	$197	$215			
M	$25,335	241	$313	$506	$2,539		
J	$27,286	253	$293	$412	$757		
F	$29,300	256	$305	$429	$743		
B	$34,339	288	$268	$319	$376		
I	$50,498	291	$385	$504	$654	$5,386	
T	$59,754	303	$418	$538	$675	$1,694	
X	$68,784	327	$412	$505	$596	$883	
V	$227,283	335	$1,299	$1,731	$2,164	$4,105	$19,812
[a] Minimum Incremental Cost (Best Buy)			Alternative G	Alternative A	Alternative B	Alternative X	Alternative V

Sort the remaining (cost-effective) alternatives in order of increasing average annual cost (see Table 4-2b). Calculate the incremental cost per habitat unit from the No Action Alternative (Step 1) and determine the minimum incremental cost. This alternative will be included in the group of best buys. Continue to calculate the incremental cost per habitat unit of moving from the previous step's best buy to alternatives with greater habitat units.

5.2 Results

Using the results from evaluating incremental cost per habitat unit as presented above, cost-effective alternatives were further subdivided into best buy alternatives and cost-effective alternatives (Figure 5-1, Table 5-2). Of the cost-effective alternatives, 6 are considered best buy alternatives. Excluding the No Action Alternative, average costs per habitat unit for the Flat Creek watershed best buy alternatives range from $478 for Alternative G to $9,512 for Alternative X. For the purposes of this study, it is assumed that each habitat unit provides the same level of ecosystem restoration benefit. However, it is important to also consider the incremental cost of the best buy alternatives when selecting the Tentatively Selected Plan. This is discussed in the next section.

FIGURE 5-1
Best Buy and Cost-Effective Alternatives
Flat Creek Watershed Detailed Project Report - Economic Appendix

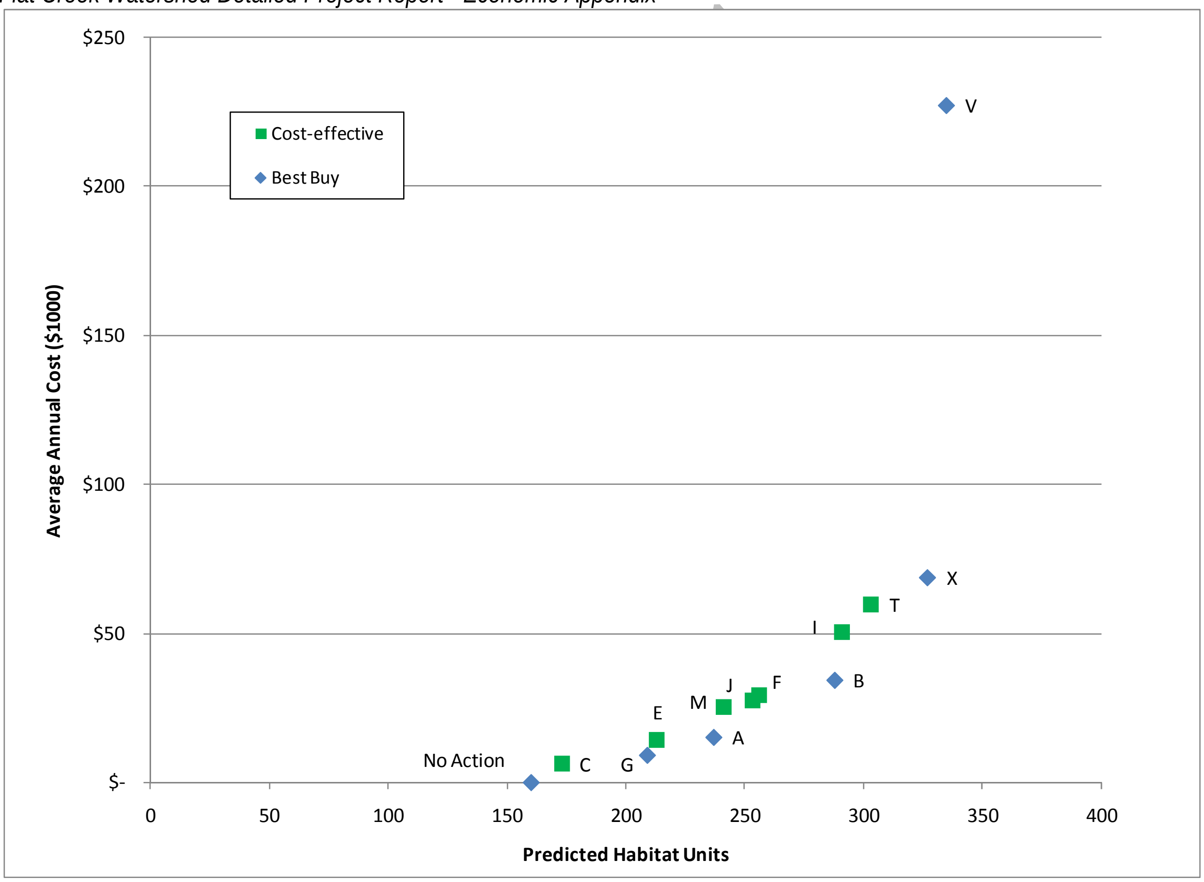


TABLE 5-2
Best Buy and Cost Effective Alternatives
Flat Creek Watershed Detailed Project Report - Economic Appendix

Alternative ID	**Alternative Estimate, Average Annual Cost**	**Habitat Units**	Best Buy/Cost Effective
No Action	$0	160	**Best Buy**
A	$15,181	237	**Best Buy**
B	$34,339	288	**Best Buy**
C	$6,121	173	Yes
E	$14,167	213	Yes
F	$29,300	256	Yes
G	$9,154	209	**Best Buy**
I	$50,498	291	Yes
J	$27,286	253	Yes
M	$25,335	241	Yes
T	$59,754	303	Yes
V	$227,283	335	**Best Buy**
X	$68,784	327	**Best Buy**

5.3 Incremental Cost of Best Buy Alternatives

The best buy alternatives as presented in Figure 5-1 and Table 5-2 were chosen for further consideration. Table 5-3 and Figure 5-2 present the results of the ICA of these best buy alternatives. Table 5-3 presents best buy alternatives sorted by increasing average annual cost. The change in habitat units between each successively more costly alternative was determined, and the incremental cost per Habitat Unit associated with each successive increase in habitat units was also determined. The ICE was conducted on the best buy alternatives only. Figure 5-2 demonstrates the incremental cost, or the increase in cost per increase in 1 additional Habitat Unit, for each of the best buy alternatives. As shown, implementation of Alternative A instead of Alternative G would cost approximately on average $215 annually per additional Habitat Unit (that is, habitat units beyond the 209 offered by Alternative A). Likewise, implementation of Alternative B instead of Alternative A would cost approximately $376 more per additional Habitat Unit. The results of the ICA provide insight into the effectiveness of additional project funds and should be considered in the determination of the Tentatively Selected Plan.

5.4 Curve Anomalies

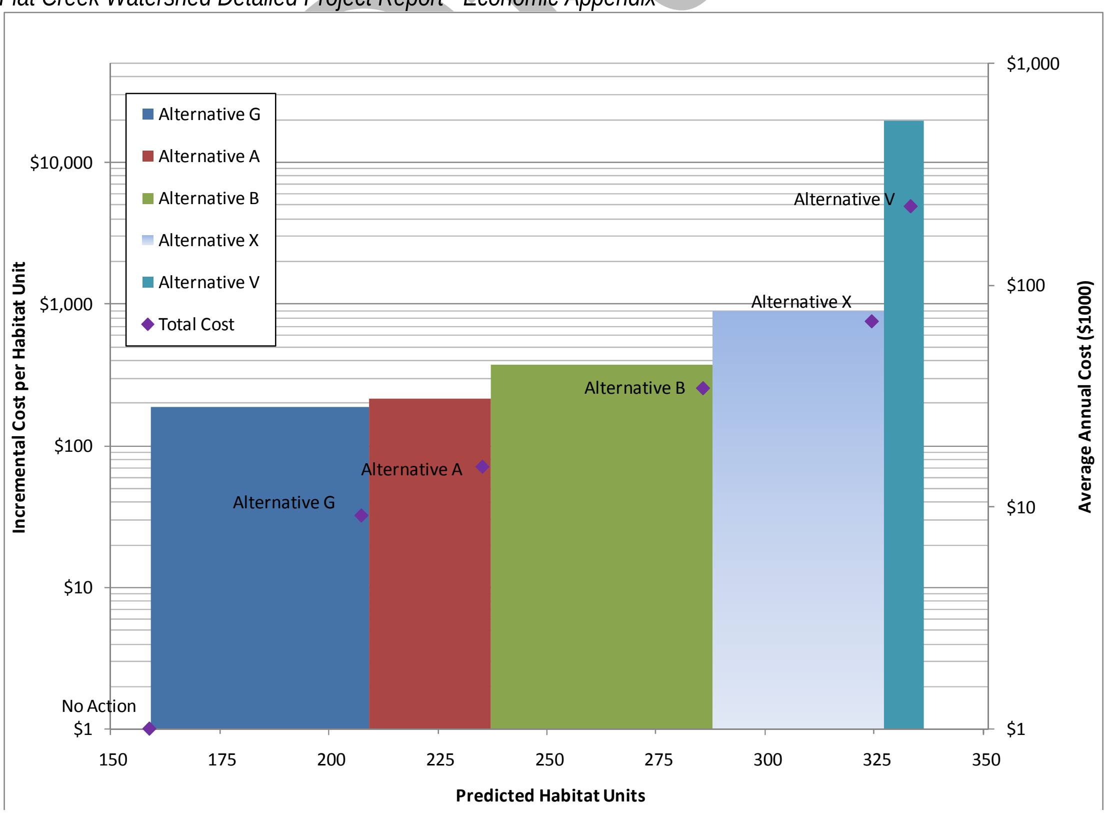
Based on ICA of the cost effective alternatives, the cost-benefit curve shown in Figure 5-1 demonstrates an increase in slope between Alternatives X and V. The cost increases more sharply between alternatives that have habitat units higher than Alternative X, than the increase demonstrated for alternatives with habitat units less than that of Alternative X.

While the incremental cost of moving between best buy alternatives is at most $883 for habitat units less than or equal to 327, the incremental cost of moving from 327 habitat units is $19,812 per habitat unit. The curve anomaly will be considered in the selection of the Recommended Plan (see Section 6 of the Detailed Project Report); however it should be noted that Alternative V is still considered a best buy alternative.

TABLE 5-3
Incremental Cost of Best Buy Alternatives
Flat Creek Watershed Detailed Project Report – Economic Appendix

Alternative ID	Alternative Estimate, Average Annual Cost	Habitat Units	Change in Average Annual Cost	Change in Habitat Units	Incremental Cost
No Action	$0	160			
G	$9,154	209	$9,154	49	$187
A	$15,181	237	$6,027	28	$215
B	$34,339	288	$19,158	51	$376
X	$68,784	327	$34,445	39	$883
V	$227,283	335	$158,499	8	$19,812

FIGURE 5-2
Incremental Cost Analysis Results for Best Buy Alternatives
Flat Creek Watershed Detailed Project Report - Economic Appendix



5.5 Summary of Best Buy Alternatives

Based on the analysis described in the Economic Appendix, six alternatives were carried forward for consideration in the selection of the Tentatively Selected Plan. Table 5-4 summarizes the best buy alternatives in order of increasing habitat units, with brief descriptions and estimated construction costs. The No Action Alternative is, by default, a best buy alternative, since it has no cost. The five restoration alternatives that are considered to be complete, acceptable, effective, and efficient include Alternatives A, B, G, X, and V. Alternatives A, B, and G are single-site stream restoration alternatives aimed at addressing problem sites 1, 2 and 28, respectively. Alternative X addresses stream problem sites 32 and 33, and Alternative V includes stream problem sites 32 and 33, as well as six stormwater detention structure retrofits. Alternative V is also a best buy alternative, by default, since it has the greatest value of habitat units.

TABLE 5-4
Summary of Best Buy Alternatives
Flat Creek Watershed Detailed Project Report - Economic Appendix

Alternative	Description	Alternative Estimate, Project First Cost	Alternative Estimate, Average Annual Cost	Habitat Units	Net Habitat Units
No Action	No restoration would be completed in the watershed.	--	--	160	0
G	200 feet of stream restoration including bank stabilization (spot repairs), flow deflection, and riparian buffer enhancement.	$100,000	$9,154	209	49
A	300 feet of stream restoration including grade control, bank stabilization, flow deflection, and riparian buffer improvements.	$190,000	$15,181	237	77
B	900 feet of stream restoration including grade control, bank stabilization, flow deflection, box culvert repair/removal, and riparian buffer enhancement.	$475,000	$34,339	307	147
X	2,500 feet of stream restoration including grade control, bank stabilization, flow deflection, riparian buffer enhancement.	$961,840	$68,784	327	167
V	2,500 feet of stream restoration including grade control, bank stabilization, flow deflection, riparian buffer enhancement, and retrofit of six existing dry detention basins.	$3,186,520	$227,283	335	175

6. Risk, Uncertainty, and Sensitivity Analyses

6.1 Potential Economic Risks

Risk is inherent to water resources planning and ecosystem restoration projects, and must be defined to the extent practical throughout the planning process. Characterizing risk and uncertainty early in the planning process allows time to develop adaptive management and contingency plans to promptly address unforeseen conditions. Risks were taken into consideration during the alternative formulation, evaluation, and selection processes. With regard to project economics, potential risks include unexpected plan implementation cost and residual risks. These risks are described in more detail below, including a brief discussion of planning efforts established to minimize risks and potential impacts to the extent practical. Section 8 of the Detailed Project Report provides the Risk Management Plan, Monitoring Plan, and Long-Term Management Plan that were prepared in response to the identified risks and uncertainties, and to establish plans to mitigate potential adverse effects.

6.1.1 Risk of Unexpected Plan Implementation Cost

An alternative cost estimate has been prepared for the 25 ecosystem restoration alternatives considered for Flat Creek. Development of the alternative estimates is described in detail in Section 2, with estimates for each alternative including a 20 percent contingency for unforeseen implementation costs. Risk of unexpected cost considered in this section relates to unforeseen costs exceeding the contingency established within the alternative estimates. Although unexpected, any additional costs beyond that included as contingency would be unplanned cost, and could impact federal or non-federal sponsor budgetary limitations.

The federal participation limit for project implementation under the Section 206 authority is $5 million (representing 65 percent of the total plan implementation cost). The City of Gainesville has budgeted approximately $600,000 for its plan implementation cost-share, which is 35 percent of total costs. If unexpected costs cause the implementation to be much higher than anticipated, the sponsors may not have the capability of funding under the proposed authority and timeline.

6.1.2 Residual Risk

Residual risks are primarily related to prolonged or excessive maintenance or repairs required following project completion. Although minor residual risks are anticipated, significant residual risks are not expected. Residual risk associated with a stormwater detention structure retrofit might include an unexpected amount of sediment requiring removal, excessive outlet control structure clogging, or required re-planting of vegetation that may not have established along the detention basin banks. Stream restoration residual risks might be associated with isolated areas of continued erosion, re-planting of stream banks or riparian buffers, repairs to instream structures or flow deflection measures, or replacement of dislodged stone. Residual risks associated with the Recommended Plan are addressed in the Risk Management Plan, with specific procedures to be followed outlined in the Adaptive Management and Contingency Plan and the Long-Term Management Plan (see Section 8 of the Detailed Project Report).

6.2 Economic Uncertainties

Similar to the potential economic risks described above, economic uncertainties are also inherent to water resources and ecosystem restoration projects. Uncertainties are primarily related to development of alternative estimates and unknown market conditions at the time of plan implementation. Alternative cost estimates have been developed for the alternatives based on conceptual design plans only. Actual implementation costs should be adjusted as project elements become better defined and more detailed design is completed. Also, market conditions at the time of plan implementation (including contractor interest, competition and availability) will impact costs. These uncertainties are discussed below

6.2.1 Alternative Cost Estimate Variability

Alternative costs are based upon alternative estimates outlined in Section 3. Uncertainties in alternative costs could result from variation in anticipated land acquisition cost, complexities in design, unforeseen site conditions that impact contraction costs, or unanticipated maintenance/repairs. With these variables in mind, estimated construction costs are considered to be within a range of +50 to -30 percent. The sensitivity analysis in Section 6.3 below further describes cost variability, with the range of uncertainty shown graphically in Figure 6-1.

6.2.2 Market Conditions and Other Uncertainties

Other economic conditions that create uncertainty include contractor availability, interest, and competition among contractors at the time the project is bid. These market conditions are dynamic in nature, and create some degree of uncertainty as future market conditions are difficult to predict. In developing plan implementation cost for Flat Creek, estimated costs have not been escalated, assuming that construction will begin in FY 2011 and will be completed within a one-year timeframe. Any delay in the anticipated schedule could further create uncertainties related to plan implementation cost.

6.3 Sensitivity Analysis

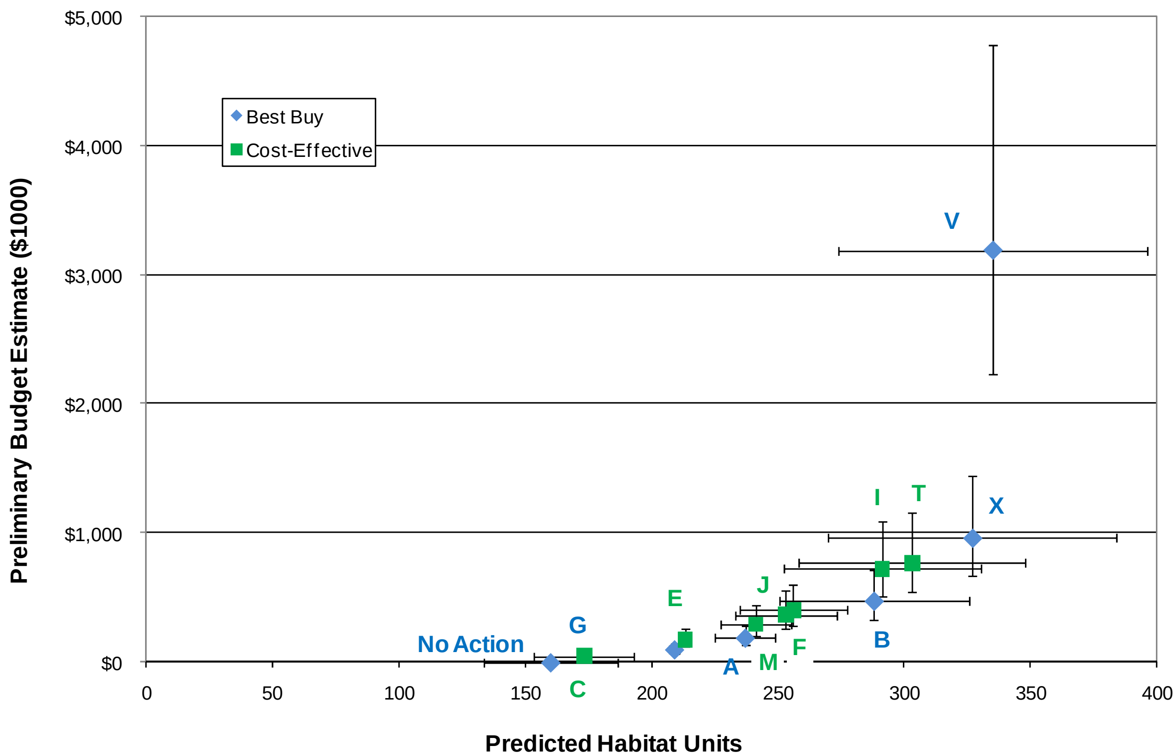
A sensitivity analysis is provided to establish a range of predicted benefits and costs for the cost effective restoration alternatives. This analysis takes into account the inherent variability in predicted habitat units and cost of ecosystem restoration projects. The alternative estimates and predicted benefits provided in this Detailed Project Report provide a necessary tool to plan future budget allocations and evaluate predicted alternative benefits. As discussed above, uncertainties in alternative cost estimates and predicted benefits for each of the cost-effective and best buy alternatives must be considered, especially during the planning stages.

The planning-level estimates are considered accurate to within +50 to -30 percent. Given the dynamic nature of pricing for materials, equipment, and construction, implementation costs will vary depending on the time of implementation. Because of the multiple variables inherent in implementation, costs can be more accurately estimated during detailed design once the Tentatively Selected Plan is further defined and developed.

In terms of predicted benefits, although extensive modeling and documented analysis were conducted to predict biological scores, subjectivity in applying best professional judgment to the scoring process and unforeseen changes in environmental conditions contribute to uncertainty in actual scores. It was assumed that uncertainty in the future score prediction was less than 50 percent of the predicted change from existing conditions. Based on the CE/ICA, the cost-effective alternatives were evaluated, and can be compared for sensitivity to variations in cost and predicted benefits.

Figure 6-1 demonstrates the range of uncertainty for preliminary costs estimates and predicted habitat units, for the cost effective alternatives. Variability in predicted costs and benefits for each of the alternatives are similar in terms of percent deviation from the predicted values. Overall variability therefore increases as either predicted benefits or estimated costs increase. Based on the analysis presented in this Economic Appendix, the Best Buy alternatives (No Action, G, A, B, X, and V) are considered further for selection of the Tentatively Selected Plan. The selection of the Tentatively Selected Plan is detailed in Section 6 of the Detailed Project Report (Selecting Recommended Plan).

FIGURE 6-1
Estimated Range of Uncertainty for Alternative Estimates and Predicted Habitat Units
Flat Creek Watershed Detailed Project Report - Economic Appendix



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