

Appendix F - Economics Appendix

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INTRODUCTION

In order to make better informed decisions with regard to the development and eventual selection of the NER Plan, a cost effectiveness analysis and incremental cost analysis was conducted on the alternatives that were carried forward for evaluation and comparison. This included nine alternatives, in addition to the no action plan, in the northeast branch of the study area, and six alternatives, in addition to the no action plan, in the northwest branch of the study area. As required by USACE Planning Guidance (ER 1105-2-100, Appendix E, E-36), these analyses were conducted utilizing annualized costs, annualized non-monetary benefits, and the IWR-Planning Suite Software (version 2.0.6).

Cost effectiveness analysis identifies the plan, or plans, that produce(s) a level of environmental output that cannot be produced at a lower cost, or a greater level of output cannot be produced at the same or less cost. The environmental outputs, however measured, in turn reflect the environmental benefits, such as biological diversity, fish and wildlife habitat, and nutrient cycling, provided by the plan or plans. Incremental cost analysis examines the changes in costs and the changes in environmental outputs for each additional increment of environmental output. The Best Buy Plans represent those plans that produce the greatest increases in environmental outputs for the least increases in cost.

DESCRIPTION OF ALTERNATIVES

The alternatives included in this analysis were divided into the Northwest Branch and the Northeast Branch, as seen in the following figure. The Northwest Branch included various combinations of sites along the Northwest Branch and Sligo Creek subwatersheds. The Northeast Branch included various combinations of sites along the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds. These alternatives were formulated based on ecological dependencies of sites identified by the project team.

Two conceptual design alternatives were initially carried forward for evaluation for each project site. As the planning process progressed, one conceptual design alternative per site was selected for input into the final cost effectiveness analyses for the recommendation of

the selected plan. The selection of the conceptual design alternative for each site was based on site constraints that became known during the planning process (e.g. rare plant at site 11 and landfills adjacent to site 5) or on an initial evaluation of cost effectiveness. The full set of conceptual designs are shown in Appendix E, and Section 4 of the main report includes figures and descriptions illustrating the designs that are included in the TSP. As designs progress to feasibility level, significant detail will be added to the designs, including the locations and details of the in-stream features.

The following alternatives, and the associated naming codes used in IWR Planning Suite, were carried forward for the cost effectiveness and incremental cost analysis:

TABLE 1. ALTERNATIVES CARRIED FORWARD FOR CE/ICA

Alternative Plan	Northwest Branch Sites and Design Alternative (1)
NW-A	3 (alt 2)
NW-B	3 (alt 2), 9 (alt 2)
	3 (alt 2), 9 (alt 2), 10 (alt 2)
	3 (alt 2), 13 (alt 1)
NW-C	3 (alt 2), 9 (alt 2), 13 (alt 2)
NW-D	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)
Alternative Plan	Northeast Branch Sites Design Alternative (2)
	11 (alt 2), 15 (alt 2)
NE-A	11 (alt 2), 15 (alt 2), 5 (alt 2)
	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)
NE-B	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)
	11 (alt 2), 15 (alt 2), 1 (alt 2)
	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)
NE-C	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)
	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)
NE-D	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)

- (1) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.
- (2) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

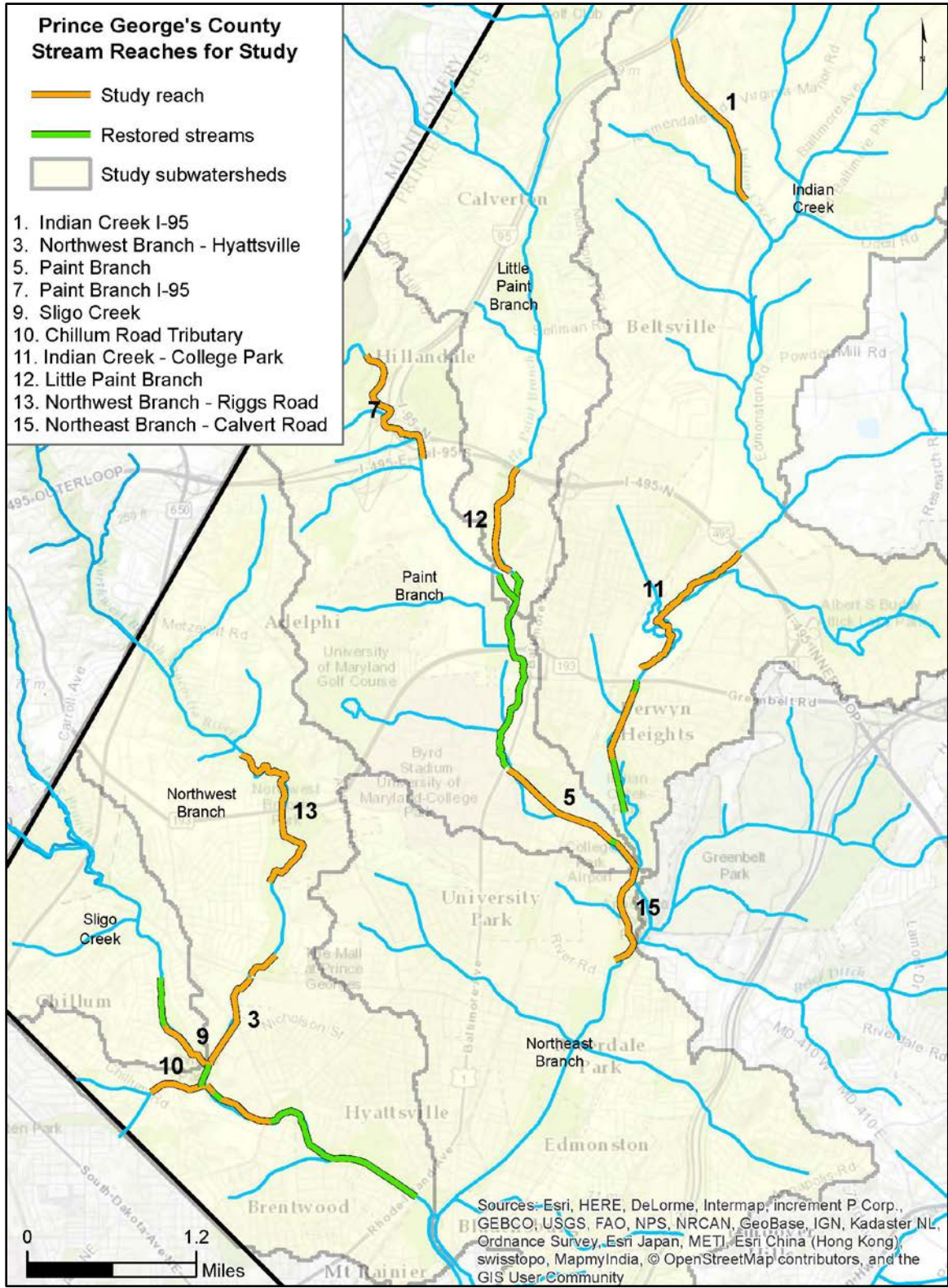


FIGURE 1. PROJECT AREA REFERENCE MAP

ANALYSIS OF CONCEPTUAL DESIGN COSTS AND BENEFITS

DESCRIPTION OF COSTS

The costs for constructing the different alternatives, as discussed in the main report, were developed for the 10-percent level concept designs. Parametric costs were estimated by linear foot based on concept cost estimates contained in 2012 bid data for Northwest Branch Package 2 and for the Paint Branch CAP project, and escalated to October 2015 costs using the Civil Works Construction Cost Index System. All costs used in this comparison between alternatives are in October 2015 (Fiscal Year 2016) price levels, with a 3-1/8-percent discount rate used in present value and annualized over a 50-year period of analysis with a base year of 2021. The costs used in this analysis differ from the costs currently shown in Appendix G, which have been updated subsequent to this analysis. The costs were updated with an increase in the percentage of contingency, preconstruction engineering and design, and construction management. This analysis will be updated as the study and design is developed further and more refined cost information is obtained.

The costs for each alternative plan include the following: preconstruction, engineering and design (PED); real estate; construction; construction management; contingency; and annual monitoring.

After the total costs were determined, the cost of interest during project construction was calculated based on a nine month period of construction for each of the alternatives and a 3-1/8-percent discount rate. The total costs plus the costs of the interest during construction yield the investment cost, as seen in the following table.

**TABLE 2. INVESTMENT COST OF ALTERNATIVES
(FY-16 PRICE LEVEL, 3.125 PERCENT DISCOUNT RATE)**

Plan	Northwest Branch Sites and Design Alternatives (1)	Total First Cost (\$)	Interest During Construction (\$)	Total Investment Cost (\$)
NW-A	3 (alt 2)	5,586,200	72,200	\$5,658,400
NW-B	3 (alt 2), 9 (alt 2)	7,090,100	91,600	\$7,181,800
	3 (alt 2), 9 (alt 2), 10 (alt 2)	8,554,600	110,600	\$8,665,200
	3 (alt 2), 13 (alt 1)	12,140,300	156,900	\$12,297,200
NW-C	3 (alt 2), 9 (alt 2), 13 (alt 2)	13,644,200	176,400	\$13,820,500
NW-D	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	15,108,600	195,300	\$15,303,900
Plan	Northeast Branch Sites and Design Alternatives (2)	Total First Cost	Interest During Construction	Total Investment Cost
	11 (alt 2), 15 (alt 2)	15,245,300	197,100	\$15,442,400
NE-A	11 (alt 2), 15 (alt 2), 5 (alt 2)	23,617,700	305,300	\$23,923,000
	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)	32,307,600	417,600	\$32,725,200
NE-B	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	29,716,700	384,100	\$30,100,800
	11 (alt 2), 15 (alt 2), 1 (alt 2)	19,455,900	251,500	\$19,707,400
	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)	27,828,300	359,700	\$28,188,000
NE-C	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)	33,927,300	438,600	\$34,365,800
	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)	38,406,600	496,500	\$38,903,000
NE-D	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	42,617,200	550,900	\$43,168,100

- (1) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.
- (2) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

Monitoring Costs

Annual monitoring will be conducted for each of the alternatives to ensure that project objectives are being fulfilled. The cost associated with monitoring is estimated to be one percent of project construction costs annually for the first 5 years after completion of construction of the project.

Average Annual Costs

Using the total investment costs and annual monitoring, the average annual equivalent costs were derived for each alternative plan, based on a 50-year period of analysis, a 3-1/8-percent discount rate, and October 2015 (FY 2016) price levels. The interest and amortization, average annual monitoring costs, and total average annual costs for the alternatives carried forward for evaluation can be found in the following table.

Table 3. AVERAGE ANNUAL COST OF ALTERNATIVES
(FY-16 PRICE LEVELS, 3.125 PERCENT DISCOUNT RATE)

Plan	Northwest Branch Sites and Design Alternatives	Average Annual Construction Cost (\$)	Annualized IDC (\$)	Annualized Monitoring (\$)	Total Average Annual Cost (\$)
NW-A	3 (alt 2)	222,300	2,900	2,000	227,200
NW-B	3 (alt 2), 9 (alt 2)	282,200	3,600	2,600	288,400
	3 (alt 2), 9 (alt 2), 10 (alt 2)	340,400	4,400	3,100	347,900
	3 (alt 2), 13 (alt 1)	483,100	6,200	4,400	493,800
NW-C	3 (alt 2), 9 (alt 2), 13 (alt 2)	543,000	7,000	5,000	554,900
NW-D	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	601,200	7,800	5,500	614,500
Plan	Northeast Branch Sites and Design Alternatives	Average Annual Construction Cost (\$)	Annualized IDC (\$)	Annualized Monitoring (\$)	Total Average Annual Cost (\$)
	11 (alt 2), 15 (alt 2)	606,700	7,800	5,500	620,000
NE-A	11 (alt 2), 15 (alt 2), 5 (alt 2)	939,800	12,200	8,600	960,500
	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)	1,285,600	16,600	11,700	1,314,000
NE-B	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	1,182,500	15,300	10,800	1,208,600
	11 (alt 2), 15 (alt 2), 1 (alt 2)	774,200	10,000	7,100	791,300
	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)	1,107,400	14,300	10,100	1,131,800
NE-C	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)	1,350,100	17,500	12,300	1,379,800
	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)	1,528,300	19,800	14,000	1,562,000
NE-D	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	1,695,900	21,900	15,500	1,733,300

- (1) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.
- (2) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

DESCRIPTION OF ENVIRONMENTAL BENEFITS

Two environmental benefit metrics were estimated for each of the alternatives in order to capture the most complete value of benefit from the project, Project Specific In-Stream Benefits and Aggregate Benefits. The In-Stream Benefit metric, measured in stream habitat units (SHUs), estimates the quantity and quality of stream habitat within the stream restoration area. The Aggregate Benefit, measured in SHUs, incorporates the quantity and quality of both fish passage and connectivity of the project restored stream area to previously restored stream areas. It is assumed it will take nine months to construct each alternative, and the environmental benefits will reach the full amount estimated within the first year of the project, remaining constant after that time. Since benefits are fully achieved within the first year of analysis, the amount of SHUs is assumed to be the same each year over the fifty year period of analysis, resulting in an equivalent average annual benefit.

While both of these metrics are measured in SHUs, the SHUs are not equivalently comparable, since one is measured based on area that will be restored, whereas the other is based on previously restored area. Since it is not appropriate to simply add the two metrics together for evaluation purposes, a combined normalized score was calculated. Normalization allows benefit categories with different units of measurement, in this case units of measurement with potentially different values, to be evaluated together in one analysis. Within the Planning Suite software, using the two metrics for each separate branch, each metric was normalized using the maximum amount of SHUs for the appropriate branch and added together with equal weighting to obtain a raw weighted score in a range of 0 to 1 for each alternative. The maximum amounts for each branch are the highest amount of estimated SHUs, one for the in-stream benefit and one for the aggregate benefit, which can be achieved by this particular project. The combined benefit index was calculated as follows for each alternative within each branch, with the maximum amounts shown as the denominators of the following formulas:

$$\begin{aligned} & \text{Northwest Branch Combined Benefits} \\ & = 0.5 \times \frac{\sum \text{In Stream Benefit}}{5953} + 0.5 \times \frac{\sum \text{Aggregate Benefit}}{59640} \end{aligned}$$

$$\begin{aligned} & \text{Northeast Branch Combined Benefits} \\ & = 0.5 \times \frac{\sum \text{In Stream Benefit}}{13932} + 0.5 \times \frac{\sum \text{Aggregate Benefit}}{76602} \end{aligned}$$

The average annual benefits for the in-stream metric, aggregate metric, and resulting combined benefit score can be seen in the following table for each alternative. As explained previously, the combined benefit index was calculated based on the previous formulas for each of the alternatives being evaluated.

Table 4. AVERAGE ANNUAL ENVIRONMENTAL BENEFITS

Plan	Northwest Branch Sites and Design Alternatives (1)	Project Specific In-Stream (SHU)	Aggregate (SHU)	Combined Northwest Branch Index (0-1)
NW-A	3 (alt 2)	2068	53679	0.62
NW-B	3 (alt 2), 9 (alt 2)	2738	58330	0.72
	3 (alt 2), 9 (alt 2), 10 (alt 2)	2860	59640	0.74
	3 (alt 2), 13 (alt 1)	5162	53679	0.88
NW-C	3 (alt 2), 9 (alt 2), 13 (alt 2)	5832	58330	0.98
NW-D	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	5953	59640	1.00
Plan	Northeast Branch Sites and Design Alternatives (2)	Project Specific In-Stream (SHU)	Aggregate (SHU)	Combined Northeast Branch Index (0-1)
	11 (alt 2), 15 (alt 2)	7975	22703	0.43
NE-A	11 (alt 2), 15 (alt 2), 5 (alt 2)	10626	63131	0.79
	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)	12035	69507	0.89
NE-B	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	11666	67846	0.86
	11 (alt 2), 15 (alt 2), 1 (alt 2)	8832	25083	0.48
	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)	11483	65511	0.84
NE=C	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)	12523	70226	0.91
	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)	13075	74222	0.95
NE-D	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	13932	76602	1.00

- (1) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.
- (2) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS

The average annual costs and average annual benefits (combined benefit score) identified previously were used to conduct cost effectiveness and incremental cost analyses, using IWR Planning Suite version 2.0.6. The results of the cost effectiveness analysis indicated nine of the considered plans to be cost effective for the northeast branch, and six for the northwest branch. The cost-effective plans can be found in the following table. Each of these plans is the least-costly means of providing the associated level of output or benefit. The following figures illustrate the cost-effectiveness analysis results, showing average annual environmental benefits (horizontal axis) and average annual costs (vertical axis) of the alternatives, as well as the No Action Plan, which is carried forward for comparison purposes only.

Table 5. RESULTS OF COST-EFFECTIVENESS ANALYSES

Plan	Northwest Branch Sites and Design Alternatives (1)	Combined Northwest Branch Index (0-1)	Average Annual Cost (\$)
NW-A	3 (alt 2)	0.62	227,200
NW-B	3 (alt 2), 9 (alt 2)	0.72	288,400
	3 (alt 2), 9 (alt 2), 10 (alt 2)	0.74	347,900
	3 (alt 2), 13 (alt 1)	0.88	493,800
NW-C*	3 (alt 2), 9 (alt 2), 13 (alt 2)	0.98	554,900
NW-D	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	1.00	614,500
Plan	Northeast Branch Sites and Design Alternatives (2)	Combined Northeast Branch Index (0-1)	Average Annual Cost (\$)
	11 (alt 2), 15 (alt 2)	0.43	620,000
NE-A*	11 (alt 2), 15 (alt 2), 5 (alt 2)	0.79	960,500
	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)	0.89	1,314,000
NE-B	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	0.86	1,208,600
	11 (alt 2), 15 (alt 2), 1 (alt 2)	0.48	791,300
	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)	0.84	1,131,800
NE-C	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)	0.91	1,379,800
	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)	0.95	1,562,000
NE-D	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	1.00	1,733,300

(1) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.

(2) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

*Tentatively Selected Plan

Figure 2. COST-EFFECTIVE PLANS NORTHWEST BRANCH

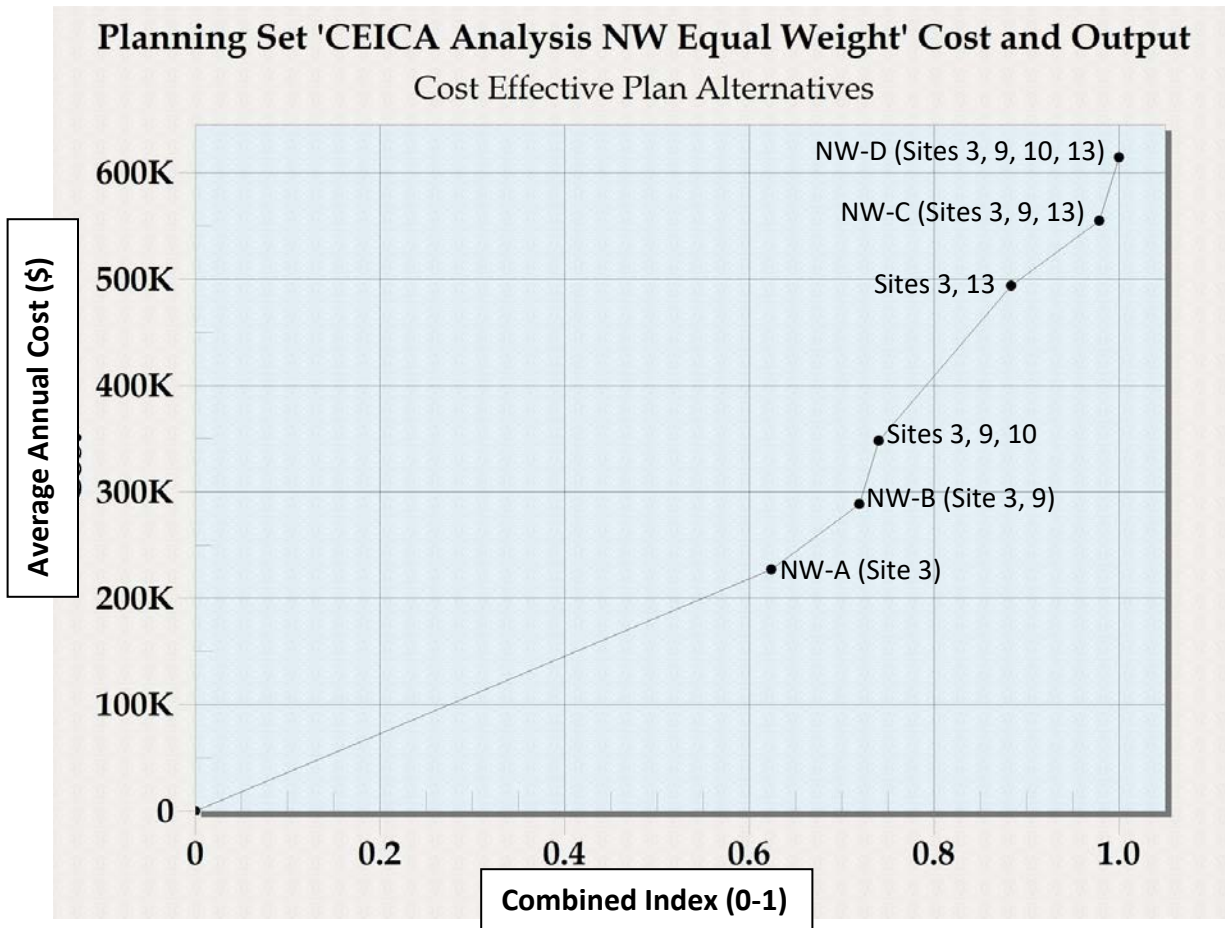
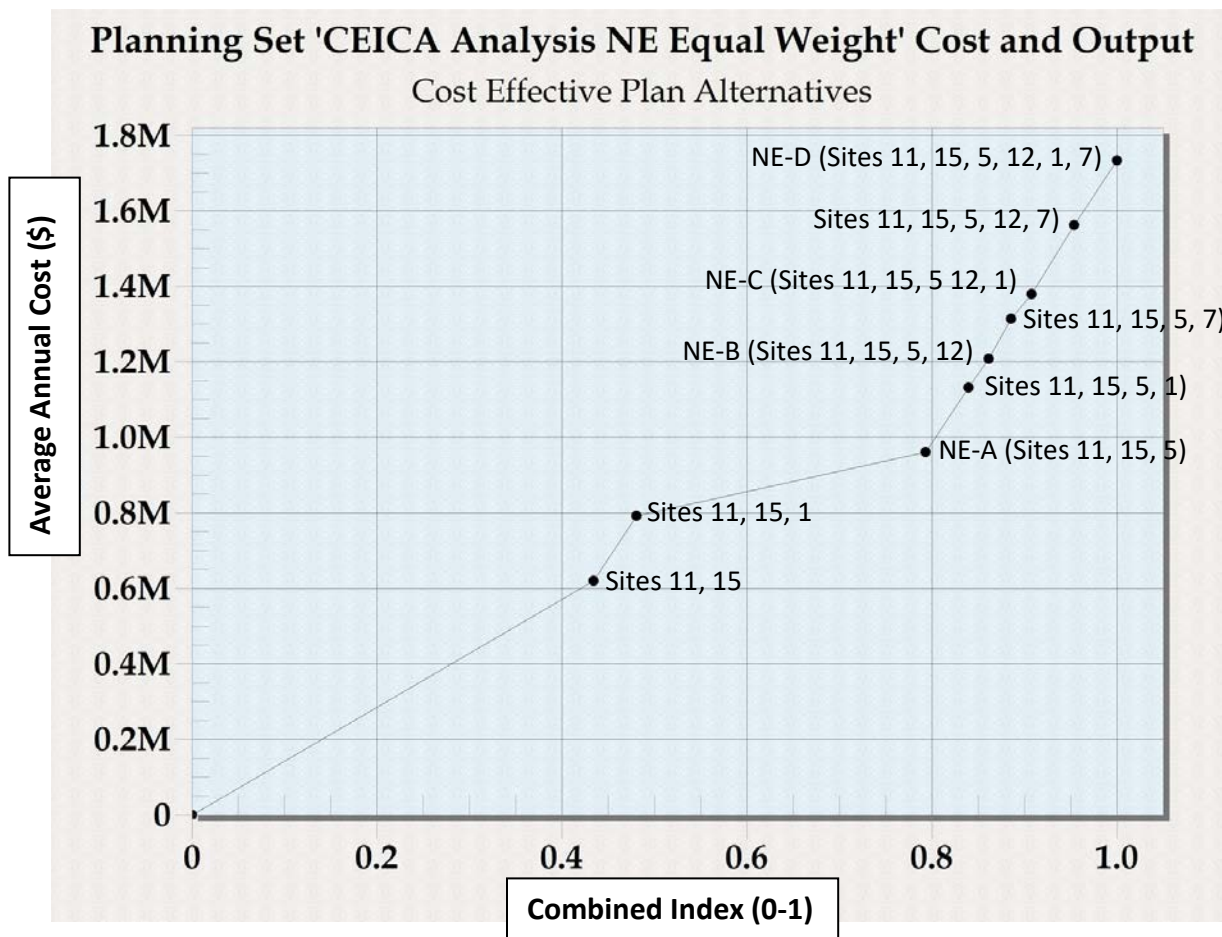


Figure 3. COST-EFFECTIVE PLANS NORTHEAST BRANCH



After conducting the cost effectiveness analysis, incremental cost analysis examines the changes in costs and changes in environmental benefits for each additional increment of output. For each best buy plan there are no other plans that will give the same level of output at a lower incremental cost. The plan with the lowest overall average cost per unit of output, advancing from the No Action Plan, is the first Best Buy Plan. After the first Best Buy Plan is identified, subsequent incremental analyses are done to calculate the change in costs and change in outputs of advancing from the first Best Buy Plan to all of the remaining (and larger) cost-effective plans. The results of the incremental cost analysis indicated four of the considered plans, in addition to the no action plan, to be best buy plans for the northeast branch, and four for the northwest branch. The following tables summarize the information from the incremental cost analysis of the alternatives, and the figures display the information graphically.

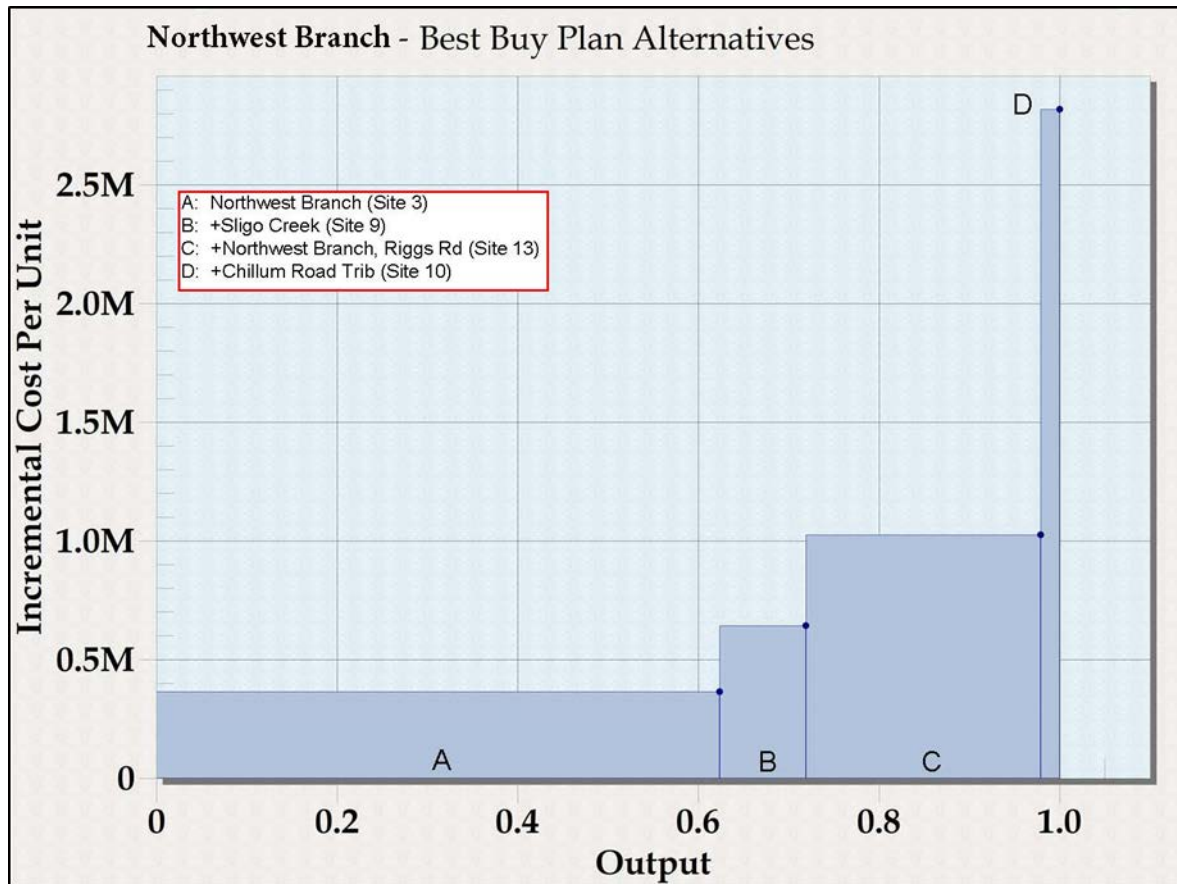
Table 6. RESULTS OF INCREMENTAL COST ANALYSIS (BEST BUY PLANS)

NORTHWEST BRANCH

Plan	Sites Included	Total Restoration Length (ft)	Average Annual Costs (\$)	Combined Index (0-1)	Incremental Cost (\$)	Incremental Output	Incremental Cost/Output (K)
No Action	-	0	\$0	-	0	0	-
NW-A	3	7,285	227,200	0.62	227,200	0.62	\$364
NW-B	3, 9	9,526	288,400	0.72	61,200	0.10	\$642
NW-C*	3, 9, 13	17,216	554,900	0.98	266,500	0.26	\$1,026
NW-D	3, 9, 13, 10	19,312	614,500	1.00	59,600	0.02	\$2,819

*Tentatively Selected Plan

Figure 4. BEST BUY PLANS NORTHWEST BRANCH

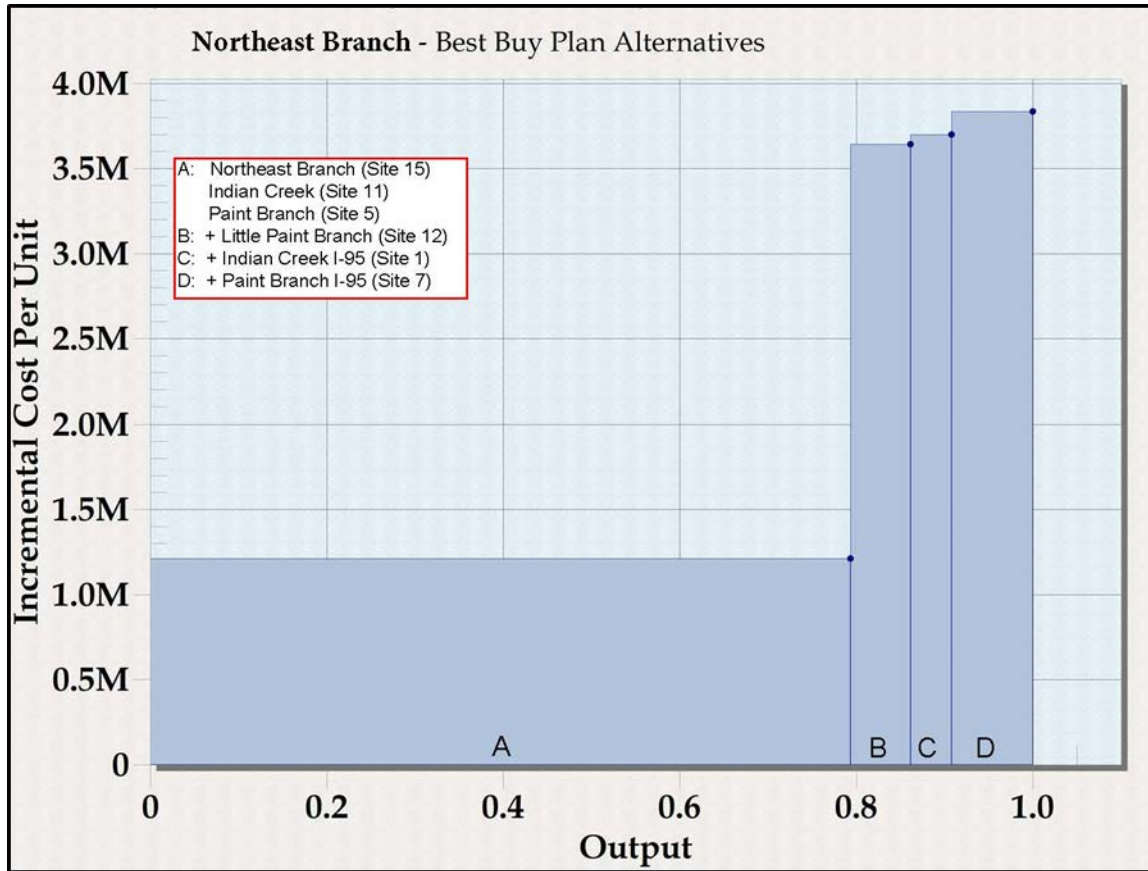


**Table 7. RESULTS OF INCREMENTAL COST ANALYSIS (BEST BUY PLANS)
NORTHEAST BRANCH**

Plan	Sites Included	Total Restoration Length (ft)	Average Annual Costs (\$)	Combined Index (0-1)	Incremental Cost	Incremental Output	Incremental Cost/Output (K)
No Action	-	0	\$0	-	0	0	-
NE-A*	15, 11, 5	18,946	960,500	0.79	960,500	0.79	\$1,211
NE-B	15, 11, 5, 12	23,476	1,208,600	0.86	248,100	0.07	\$3,643
NE-C	15, 11, 5, 12, 1	30,434	1,379,800	0.91	171,200	0.05	\$3,698
NE-D	15, 5, 11, 12, 1, 7	36,310	1,733,300	1.00	353,500	0.09	\$3,835

*Tentatively Selected Plan

Figure 5. BEST BUY PLANS NORTHEAST BRANCH



SENSITIVITY ANALYSIS

The original cost/benefits analysis was completed using equal weighting on the two metrics. In order to assess the effect on the outcome of the CE/ICA if greater importance was given to either of the benefit parameters, a sensitivity analysis was performed to evaluate the effect of various weights on the results of the analysis. The analysis was rerun with use of 100 percent weight on In-Stream benefits (0 percent weight on Aggregate benefits), and 75 percent weight on In-Stream benefits (25 percent weight on Aggregate benefits). Overall, the results of the sensitivity analysis support the tentatively selected plan for both the Northwest and the Northeast branches. While there are other best buy plans that are identified by the incremental sensitivity analysis, the recommended plan is consistently identified as a best buy plan by each of the analyses. A summary of the results of the sensitivity analysis can be seen in the following table.

Table 8. RESULTS OF SENSITIVITY ANALYSIS (Best Buy Plans)

Northwest Branch Sites and Design Alternative	Equal weight on metrics	75% weight In-Stream/ 25% weight Aggregate	100 percent weight In-Stream metric (SHUs)
3 (alt 2)	X	X	
3 (alt 2), 9 (alt 2)	X	X	
3 (alt 2), 9 (alt 2), 10 (alt 2)			
3 (alt 2), 13 (alt 1)			
3 (alt 2), 9 (alt 2), 13 (alt 2)	X	X	X
3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	X	X	X
Northeast Branch Sites and Design Alternative	Equal weight on metrics (index)	75% weight In-Stream/ 25% weight Aggregate (index)	100 percent weight In-Stream metric (SHUs)
11 (alt 2), 15 (alt 2)		X	X
11 (alt 2), 15 (alt 2), 5 (alt 2)	X	X	X
11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)			
11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	X		
11 (alt 2), 15 (alt 2), 1 (alt 2)			
11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)		X	X
11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)	X		X
11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)		X	
11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	X	X	X

CONFIRMATION OF THE RECOMMENDED PLAN

Once the Tentatively Selected Plan was endorsed by USACE as the recommended plan, the conceptual level (10%) designs and associated costs for sites in the recommended plan were further refined to the feasibility level design (35%). Feasibility level costs include estimates (Appendix E) for the locations and quantities of instream structures and materials. Similarly, with defined limits of disturbance, real estate costs are more accurately quantified (Appendix G). Also, as a result of agency review of the draft report, the benefits calculations used as input in the original CE/ICA were revised slightly to use relationships established by USFWS (2003) for drainage area and stream width in the calculation of stream quantity, rather than using stream order as a proxy for stream width. Given these revisions to costs and benefits for the project, the recommended plan needed to be re-confirmed for the project.

REVISED COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS

An additional CE/ICA was conducted, based on the revised costs and benefits as described in the previous section, to confirm the tentatively selected plan did not change with more detailed information on designs and real estate plans. Minor revisions, such as inclusion of monitoring and adaptive management, operations and maintenance, and slight design modifications, were made subsequent to the CE/ICA discussed in this section. However, it can be assumed that these revisions would be proportionally consistent amongst plans, and not change the results of the CE/ICA.

The updated costs and benefits were annualized in the same manner as the original analysis, and the updated average annual costs and average annual benefits (combined benefit score) were used to conduct cost effectiveness and incremental cost analyses, using IWR Planning Suite version 2.0.6. The results of the revised cost effectiveness and incremental cost analyses can be seen in the following tables and figures. The revised CE/ICA resulted in slight changes to some of the cost-effective and best buy plans (identified as Plan X in the following tables and figures), as compared to the original analysis. However, as seen in the following tables and figures, the revised analysis supports justification of the same tentatively selected plans identified in the original analysis for both the Northwest and Northeast branches.

Table 9. RESULTS OF REVISED COST-EFFECTIVENESS ANALYSES

Plan	Northwest Branch Sites and Design Alternatives (1)	Combined Northwest Branch Index (0-1)	Average Annual Cost (\$)
NW-A	3 (alt 2)	0.61	234,500
NW-B	3 (alt 2), 9 (alt 2)	0.71	323,700
	3 (alt 2), 9 (alt 2), 10 (alt 2)	0.73	387,200
	3 (alt 2), 13 (alt 1)	0.87	414,400
NW-C*	3 (alt 2), 9 (alt 2), 13 (alt 2)	0.98	503,600
NW-D	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	1.00	567,100
Plan	Northeast Branch Sites and Design Alternatives (2)	Combined Northeast Branch Index (0-1)	Average Annual Cost (\$)
	11 (alt 2), 15 (alt 2)	0.45	282,600
	11 (alt 2), 15 (alt 2), 1 (alt 2)	0.50	459,700
NE-A*	11 (alt 2), 15 (alt 2), 5 (alt 2)	0.74	463,200
	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)	0.79	640,300
NE-B	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	0.81	726,300
	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)	0.87	829,900
	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)	0.94	1,093,100
NE-D	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	1.00	1,270,300

(3) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.

(4) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

*Tentatively Selected Plan

Table 10. RESULTS OF REVISED INCREMENTAL COST ANALYSIS (BEST BUY PLANS) NORTHWEST BRANCH

Plan	Sites Included	Total Restoration Length (ft)	Average Annual Costs (\$)	Combined Index (0-1)	Incremental Cost (\$)	Incremental Output	Incremental Cost/Output (K)
No Action	-	0	\$0	-	0	0	-
NW-A	3	7,285	234,500	0.62	234,500	0.61	\$385
NW-X	3, 13		414,400	0.87	179,900	0.27	\$678
NW-C*	3, 9, 13	17,216	503,600	0.98	89,200	0.10	\$868
NW-D	3, 9, 13, 10	19,312	567,100	1.00	63,500	0.02	\$2,756

*Tentatively Selected Plan

Figure 6. REVISED BEST BUY PLANS NORTHWEST BRANCH

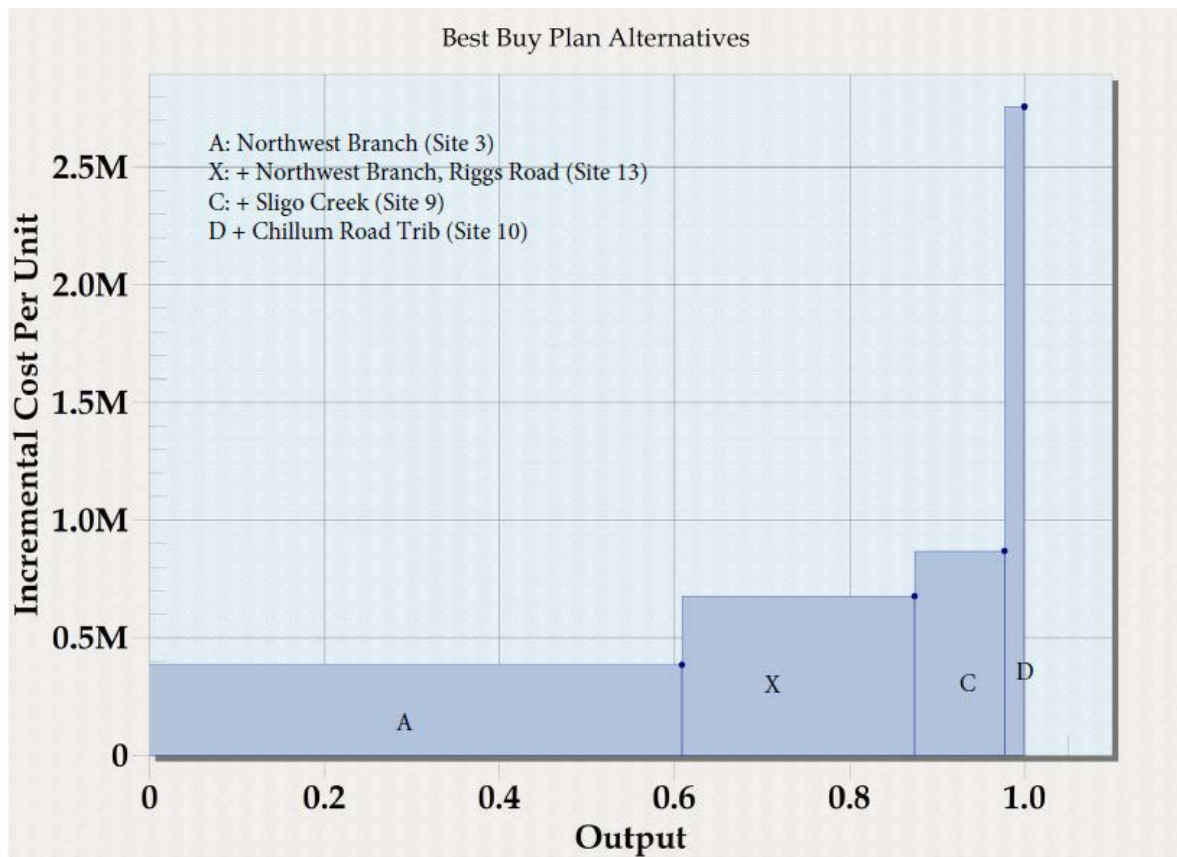


Table 11. RESULTS OF REVISED INCREMENTAL COST ANALYSIS (BEST BUY PLANS) NORTHEAST BRANCH

Plan	Sites Included	Total Restoration Length (ft)	Average Annual Costs (\$)	Combined Index (0-1)	Incremental Cost	Incremental Output	Incremental Cost/Output (K)
No Action	-	0	\$0	-	0	0	-
NE-A*	15, 11, 5	18,946	463,200	0.74	463,200	0.74	\$627
NE-X	15, 11, 5, 7		830,0	0.87	366,800	0.13	\$2,767
NE-D	15, 5, 11, 12, 1, 7	36,310	1,270,300	1.00	440,300	0.13	\$3,406

*Tentatively Selected Plan

Figure 7. REVISED BEST BUY PLANS NORTHEAST BRANCH

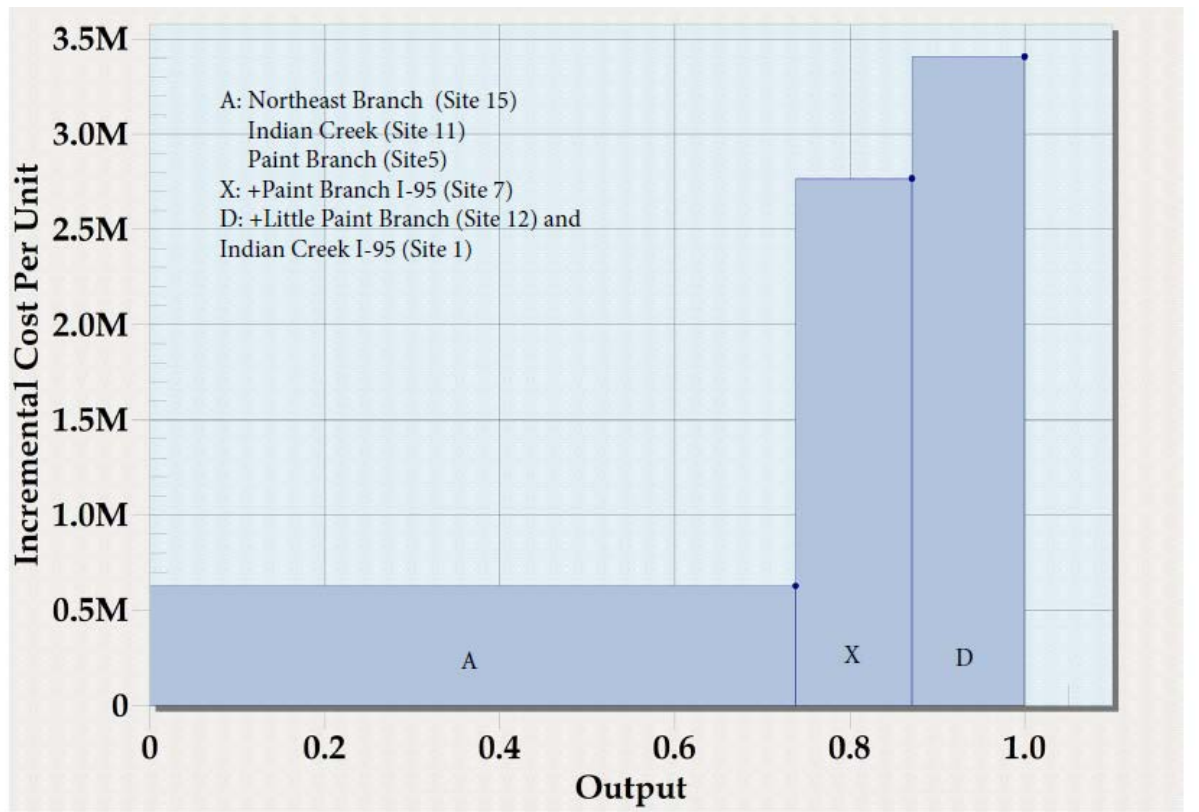


Table 12. RECOMMENDED PLAN AVERAGE ANNUAL COSTS AND BENEFITS

Federal Discount Rate FY19 = 2.875%, 2019 Price Levels, 50-Year Period of Analysis			
Element	NE-A	NW-C	Total
Project First Costs			
Construction	\$ 13,147,000	\$ 13,051,000	\$ 26,198,000
Relocations	\$ 897,000	\$ 0	\$ 897,000
Adaptive Management	\$ 212,000	\$ 237,000	\$ 449,000
Design	\$ 1,982,000	\$ 1,888,000	\$ 3,870,000
Real Estate	\$ 108,000	\$ 252,000	\$ 360,000
Construction Management	\$ 1,199,000	\$ 1,133,000	\$ 2,332,000
Total Project First Costs	\$ 17,545,000	\$ 16,561,000	\$ 34,106,000
Average Annual Costs			
Construction	\$ 665,800	\$ 628,500	\$ 1,294,300
Interest during construction	\$ 7,900	\$ 7,500	\$ 15,400
Annual OMRR&R	\$ 10,800	\$ 11,200	\$ 22,000
Total Average Annual Cost	\$ 684,500	\$ 647,100	\$ 1,331,700
Average Annual Benefits			
Project Specific SHUs	1.58	2.34	3.92
Aggregate SHUs	18.3	16.05	34.35
Total SHUs	19.88	18.39	38.27

*Costs in fiscal year 2019 price levels with updated contingency, PED, and construction management assumptions.