Rio Grande, Sandia Pueblo to Isleta Pueblo, CO, NM, TX Ecosystem Restoration Feasibility Study and Environmental Assessment

Appendix D

Economics

U. S. Army Corps of Engineers

Albuquerque District

US Army Corps of Engineers ®
Albuquerque District

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 - AREAS OF CONSIDERATION

The Rio Grande originates in southern Colorado and reaches 1,865 miles to the Gulf of Mexico, constituting the fourth largest river in the United States in terms of length and drainage area. The river bisects New Mexico in a north-to-south direction and delineates the 1,250-mile international boundary between Texas and Mexico. This study is focusing on the Rio Grande bosque in central New Mexico between the northern boundary of the Sandia Pueblo and the southern boundary of the Pueblo of Isleta (Figure 1).

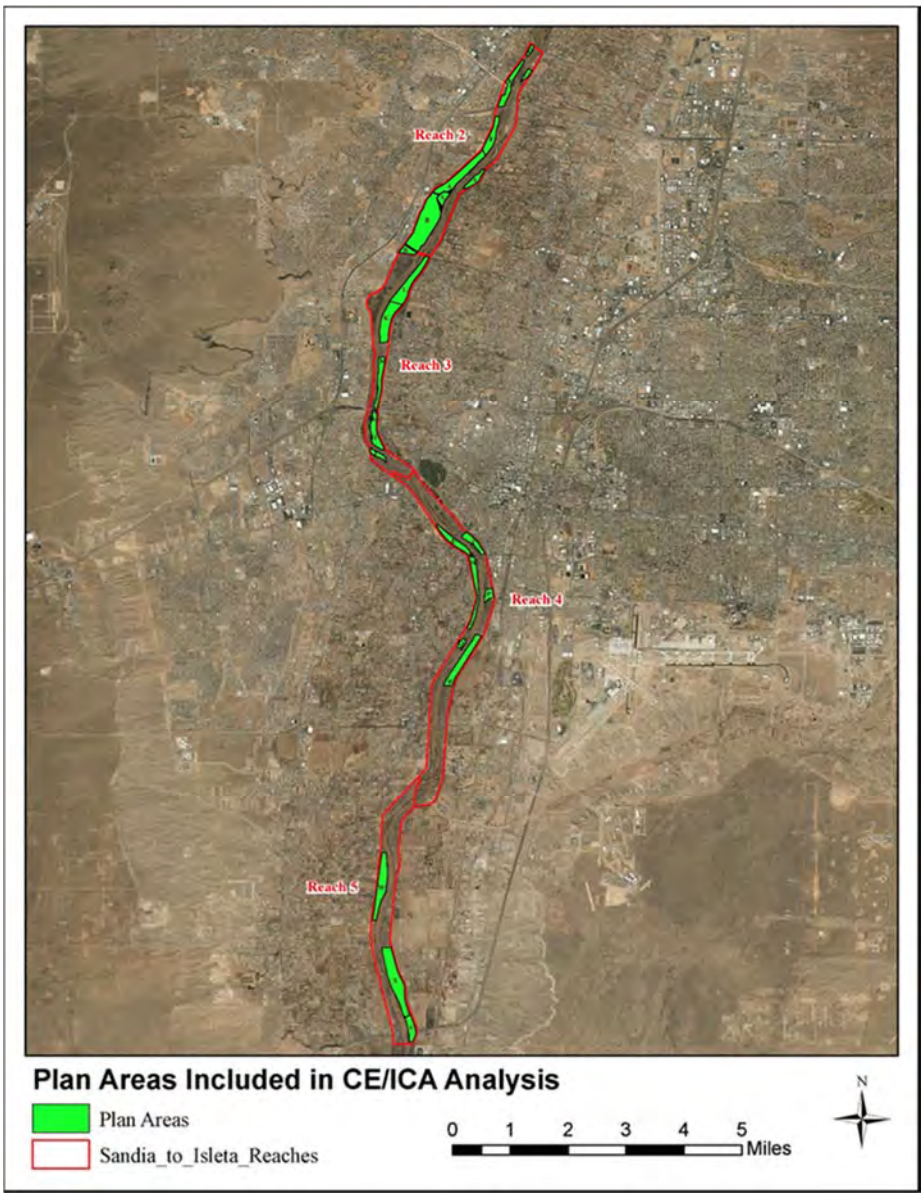

Figure 1 - Study Area

2 - NER PLAN SELECTION CRITERIA

United States Army Corps of Engineers (USACE) policy, presented in Engineer Regulation 1105-2-100, Planning Guidance Notebook, requires that potential ecosystem restoration projects be analyzed for cost effectiveness and incremental benefits gained from various restoration alternatives. The plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the federal objective, is selected and identified as the National Ecosystem Restoration (NER) Plan. Cost effectiveness and Incremental Cost analyses (CE/ICA) is the technique used by the USACE to identify cost-effective restoration projects. Analysis of cost effectiveness, in general, compares the relative costs and benefits of alternative plans. The most efficient plans that provide the greatest increase in output for the least increase in cost are called the Best Buys. The least expensive Best Buy, which meets the restoration objective, is usually selected as the recommended plan.

Specifically, cost-effectiveness analysis compares the costs and expected environmental outputs among various alternative plans. If different alternative plans can produce the same level of output, only the least expensive (least-cost) choice makes economic sense for that level of output; economically inefficient alternative plans can be eliminated from further consideration. Similarly, if one alternative plan can produce a greater level of output for the same or less cost than others (cost-effective), only the greater output choice makes economic sense; economically ineffective alternative plans can be eliminated. After elimination of inefficient and ineffective alternative plans, there remain several least-cost, cost-effective alternative plans offering a range of output values from which to identify the means of meeting the ecosystem restoration objective(s).

3 - COST EFFECTIVENESS ANALYSIS

In this analysis, a management area is described as a group of features or activities that can be implemented at a specific geographic site to, fully or partially, address one or more planning objectives, which combined together make up alternative plans. An alternative plan can consist of a system of structural and/or non-structural sub-reaches/reaches, measures, strategies, or programs formulated to meet the identified study planning objectives subject to planning constraints.

Restoration measures along four different reaches that contain a total of 20 individual management areas were considered in this analysis. In order to perform the CE/ICA, each of the 20 individual management areas required a cost and output. Implementation and Operation, Maintenance, Repair, Rehabilitation and Replacement (OMRR&R) costs for each area were estimated using experience with similar constructed projects and parametric cost data. These assumptions were used to develop a consistent basis for costs to avoid skewing the CE/ICA process, and to support unbiased plan selection.

Benefits for this analysis are described as Habitat Units (HU). Habitat value is difficult to express in monetary terms, therefore the productive output of project features is measured in habitat units. Habitat units were obtained from Best Buy plans from the MRG Bosque Restoration Study (USACE, 2007) and were re-evaluated to determine whether or not actions had been implemented in those areas. For areas that had not had restoration activities, the Product Delivery Team (PDT) reviewed the previously recommended measures and how they contributed to meeting the current study objectives.

HUs were entered into the IWR Planning Suite Annualizer module to compute the projects AAHU (Average Annual Habitat Unit). Using AAHU as a metric, plans can be compared over time based on the forecast conditions. In this way, it is possible to quantify a change in habitat by implementing the project and if that change is cost effective. Costs for each measure include construction costs, adaptive

management costs and OMRR&R costs. Table 1 displays each of the restoration management areas entered into USACE Institute for Water Resources (IWR) Planning Suite (IWR-Plan), which includes the No Action option for each management area.

Table 1 - Habitat Restoration Management Areas and Measures - (2017 Price Level x $1000 @ 2.75%, 50 yr. Period of Analysis)

Plan Area*	Study Reach	Measures
A	2	Wet meadow, Treat-Retreat-Reveg, Groundwater Channel, Willow Swale, Bankline terrace, Hi-flow Channel, Divert outfall flows
B	2	Bankline terrace, Hi-flow Channel, Willow swale, Treat-Retreat-Reveg, Wetland
C	2	Wet meadow, Treat-Retreat-Reveg, Willow swale, Enhance ditch for wet habitat
D	2	Willow swale, Treat-Retreat-Reveg
E	2	Willow swale, Treat-Retreat-Reveg, Hi-flow Channel
F	2	Willow swale, Treat-Retreat-Reveg
G	2	Willow swale, Treat-Retreat-Reveg, Wetland
H	3	Willow swale, Treat-Retreat-Reveg, Bankline terrace, Hi-flow Channel, Remove berm
J	3	Wetland, Willow swale, Treat-Retreat-Reveg
K	3	Wetland, Treat-Retreat-Reveg
L	3	Willow swale, Treat-Retreat-Reveg
M	3	Wetland, Willow swale, Treat-Retreat-Reveg
N	4	Willow swale, Treat-Retreat-Reveg, Hi-flow Channel, Remove berm and Jetty Jacks
P	4	Treat-Retreat-Reveg, Hi-flow connection
Q	4	Wet meadow, Connection to River, Enhance ditch for wet habitat
R	4	Willow swale, Treat-Retreat-Reveg, Water feature
S	4	Willow swale, Treat-Retreat-Reveg, Hi-flow Channel
T	4	Willow swale, Treat-Retreat-Reveg, Divert outfall flows
U	4	Willow swale, Treat-Retreat-Reveg, Hi-flow Channel
V	5	Willow swale, Treat-Retreat-Reveg, Wetland, Connect wetlands, Connect to river
W	5	Willow swale, Treat-Retreat-Reveg, Enhance outfall
X	5	Treat-Retreat-Reveg, Bankline terrace, Wetland, Hi-flow Channel

Scaled Solution Effects on Variables

Code		Name	Cost	Output
A	0	No Action	0	0
A	1	A	385187.59	131
B	0	No Action	0	0
B	1	B	692980.59	134
C	0	No Action	0	0
C	1	C	246862.41	136
D	0	No Action	0	0
D	1	D	26527.97	104
E	0	No Action	0	0
E	1	E	141740.93	131
F	0	No Action	0	0
F	1	F	138080.07	118
G	0	No Action	0	0
G	1	G	39985.57	132
H	0	No Action	0	0
H	1	H	178154.43	110
J	0	No Action	0	0
J	1	J	69319.85	106
K	0	No Action	0	0
K	1	K	208091.29	103
L	0	No Action	0	0
L	1	L	229164.74	109
M	0	No Action	0	0
M	1	M	154954.29	120
N	0	No Action	0	0
N	1	N	211487.76	36
P	0	No Action	0	0
P	1	P	57722.69	39
Q	0	No Action	0	0
Q	1	Q	56620.87	63
R	0	No Action	0	0
R	1	R	231322.64	34
S	0	No Action	0	0
S	1	S	100777.65	62
T	0	No Action	0	0
T	1	T	113595.59	80
U	0	No Action	0	0
U	1	U	162194.99	70
V	0	No Action	0	0
V	1	V	133834.32	40
W	0	No Action	0	0
W	1	W	250125.64	71
X	0	No Action	0	0
X	1	X	571519.44	141

3.1 Combinability and Dependability

Combinability and dependency, although not used in this study, are two types of relationships used in the CE/ICA analysis. In a typical USACE study, management measures or areas may or may not be mutually exclusive, and it is the property of combinability that allows planners to mix and match measures into different plans. Conversely, some measures may preclude others, and this will limit the ability to mix and match the measures. In consideration of combinability, two measures might be mutually exclusive because of:

- Location, where two different measures cannot occupy the same space at the same time;

- Function, where two different measures may work against one another.

In addition to being combinable, many measures may be dependent on other measures in order to be implemented. Dependency relationships between two measures may exist for several reasons, including:

- *Necessary to function;*
- *Reduce risk or uncertainty;*
- *Improve performance.*

3.2 Plan Generation

Within IWR-Plan, and once a planning study comprised of variables, outputs, and attributes has been defined with the plan editor, the plan generation module is used to populate a new planning set with plan alternatives. IWR-Plan displays generated planning sets with the information needed to assist planners manage the plans and keep the plans in context.

Two main models were created due to the complexity and the number of measures in this study area. The first model was separated into two "sub-models" which separated the study area into two areas and are described in this appendix as the "Northern Reach" and "Southern Reach". The Northern Reach contained 11 management areas from reaches 2 and 3 and the Southern Reach contained 9 management areas from reaches 4 and 5. Reaches 2-5 were similar to the MRG Bosque Restoration Study reaches analyzed in 2007. Reach 1 was not included in this particular evaluation, as prior projects in the reach have been completed and the PDT deemed that further work in the reach was unnecessary. It should be noted that no alternatives were coded "I" or "O" as those two letters are often confused for the numbers "1" and "0." Alternatives "C" and "S" were eliminated because those areas were addressed by other governmental agencies. Figure 2 displays the process used to determine the final arrays of Best Buy Plans.

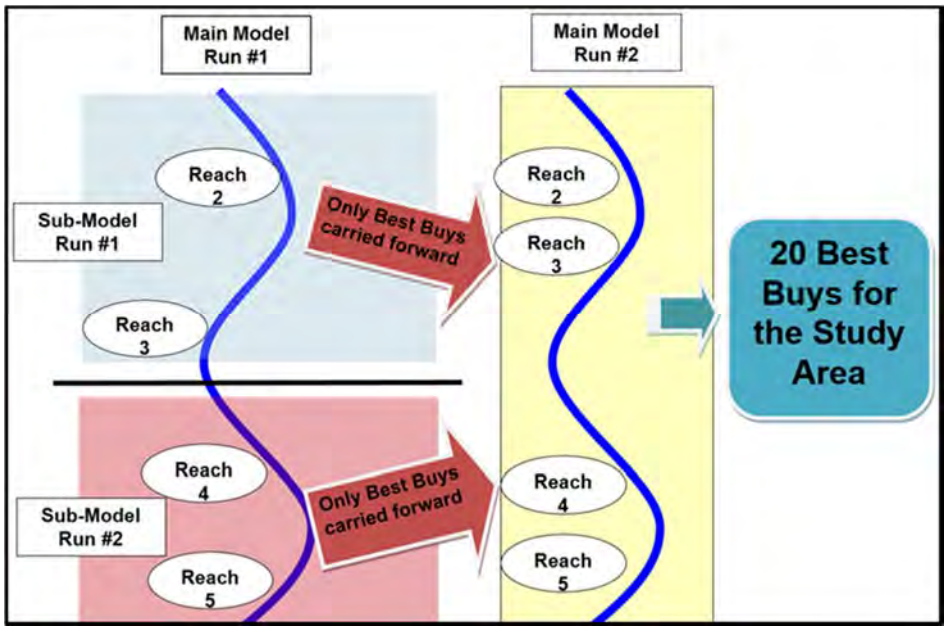

Figure 2- Diagram of Cost Effectiveness Analysis Process

3.3 Preliminary Findings and Incremental Analysis

The array of alternatives, their costs and outputs from Table 1 above, were put into two IWR-PLAN sub-models. Each sub-model would contain only those measures that are applicable to either the Northern or Southern Reach. The Northern Reach sub-model contained management areas A-M (excluding "C" and "I"). After completing the cost effectiveness analysis, the Northern reach had a total of 2,047 plans and of those 35 were Cost Effective and 11 were Best Buy Plans. The Southern Reach sub-model contained management areas N-X (excluding "O" and "S"). After completing the cost effectiveness analysis, the Southern reach had a total of 511 plans and of those 26 were Cost Effective and 9 were Best Buy Plans.

Table 2 displays the results of the first model run and the new CEICA Codes created to input into the second model run. The findings from the first model confirm the overall PDT assumption that the areas that have previously been addressed (ecologically restored) by other governmental agencies or were already deemed to have adequate habitat experienced little "lift" or improvement of habitat value between the without and with project condition, compared to the cost of restoring that particular area and therefore were determined by the model to be less effective and efficient as other areas within the study area.

Table 2- Results from the First Model Run

New CEICA Codes	Model 1 Best Buy Plans
Nothern Reach	
	No Action Plan
NR1	A0B0D1E0F0G0H0J0K0L0M0
NR2	A0B0D1E0F0G1H0J0K0L0M0
NR3	A0B0D1E0F0G1H0J1K0L0M0
NR4	A0B0D1E1F0G1H0J1K0L0M0
NR5	A0B0D1E1F1G1H0J1K0L0M0
NR6	A0B0D1E1F1G1H0J1K0L0M1
NR7	A0B0D1E1F1G1H1J1K0L0M1
NR8	A0B0D1E1F1G1H1J1K1L0M1
NR9	A0B0D1E1F1G1H1J1K1L1M1
NR10	A1B0D1E1F1G1H1J1K1L1M1
NR11	A1B1D1E1F1G1H1J1K1L1M1
Southern Reach	
	No Action Plan
SR1	N0P0Q1R0T0U0V0W0X0
SR2	N0P0Q1R0T1U0V0W0X0
SR3	N0P1Q1R0T1U0V0W0X0
SR4	N0P1Q1R0T1U1V0W0X0
SR5	N0P1Q1R0T1U1V1W0X0
SR6	N0P1Q1R0T1U1V1W1X0
SR7	N0P1Q1R0T1U1V1W1X1
SR8	N1P1Q1R0T1U1V1W1X1
SR9	N1P1Q1R1T1U1V1W1X1

The second main model run uses only the Best Buys from the previous model runs as the "management areas" for the second model. Table 3 displays each of the restoration management areas (i.e. previous models Best Buy plans) entered into IWR-Plan.

Table 3 - Model 1 Best Buy Plans - (2017 Price Level x $1000 @ 2.75%, 50 yr. Period of Analysis)

Scaled Solution Effects on Variables

Code	S	Name	Cost	Output
NR	0	No Action	0	0
NR	1	Reaches 2 & 3	26.52797	104
NR	2	Reaches 2 & 3	66.51354	236
NR	3	Reaches 2 & 3	135.83339	342
NR	4	Reaches 2 & 3	277.57432	473
NR	5	Reaches 2 & 3	415.65439	591
NR	6	Reaches 2 & 3	570.60868	711
NR	7	Reaches 2 & 3	748.76311	821
NR	8	Reaches 2 & 3	956.8544	924
NR	9	Reaches 2 & 3	1186.01914	1033
NR	10	Reaches 2 & 3	1571.20673	1164
NR	11	Reaches 2 & 3	2264.18732	1298
SR	0	No Action	0	0
SR	1	Reaches 4 & 5	56.62087	63
SR	2	Reaches 4 & 5	170.21646	143
SR	3	Reaches 4 & 5	227.93915	182
SR	4	Reaches 4 & 5	390.13414	252
SR	5	Reaches 4 & 5	523.96846	292
SR	6	Reaches 4 & 5	774.0941	363
SR	7	Reaches 4 & 5	1345.61354	504
SR	8	Reaches 4 & 5	1557.1013	540
SR	9	Reaches 4 & 5	1788.42394	574

The second main model contained management areas NR1-NR11 (Northern Reach, reaches 2 & 3) and SR1-SR9 (Southern Reach, reaches 3 & 4). After completing the cost effectiveness analysis, the study area had a total of 119 plans and of those 43 were Cost Effective and 20 were Best Buy Plans. Figures 3 and 4 display the Incremental Cost and Output scatter and bar graphs.

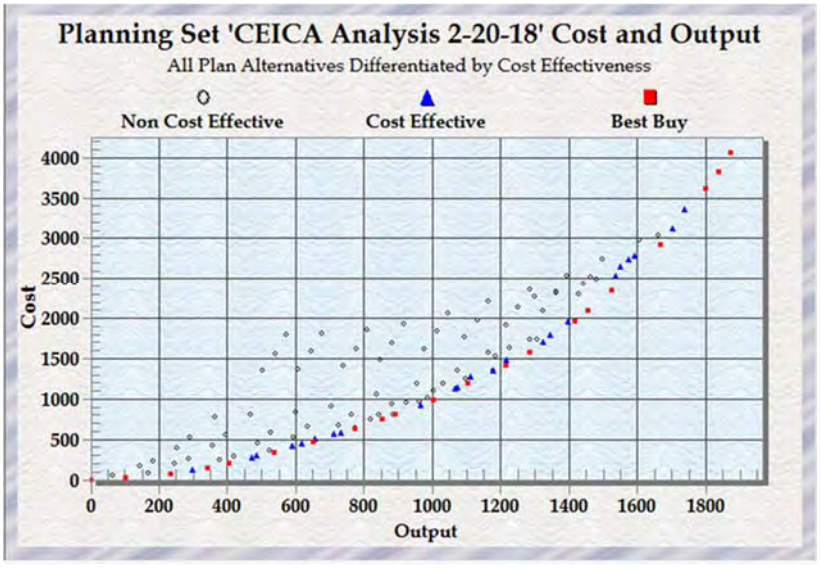

Figure 3 - Cost and Output Scatter Plot, Northern and Southern Reaches

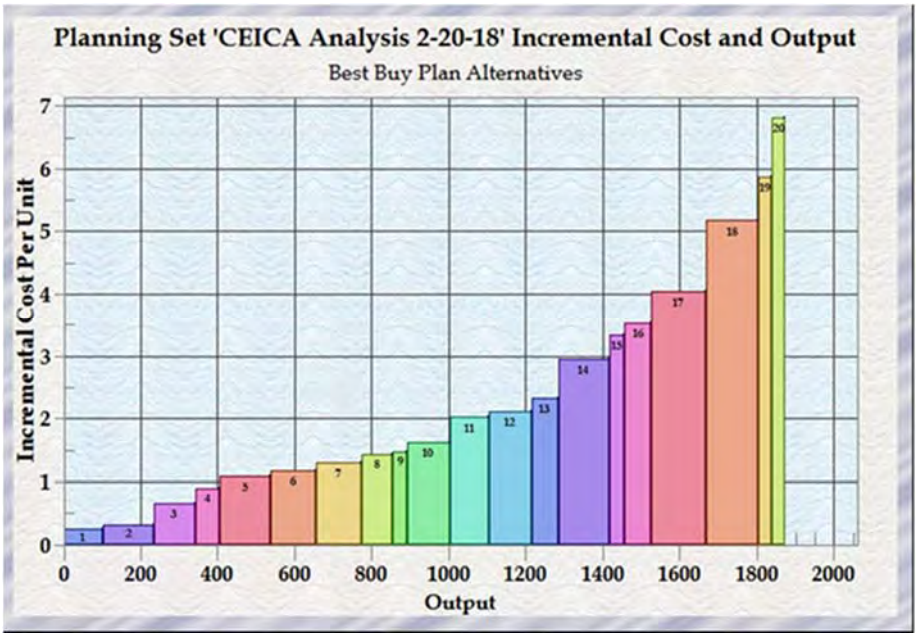

Figure 4 - Incremental Cost and Output Graph, Northern and Southern Reaches

4 - INCREMENTAL COST ANALYSIS

As a result of the second CE/ICA analysis, 20 Best Buy plan alternatives were carried forward for additional analysis and are further described in Table 4. Working from the problems and opportunities identified in Section 4.4 of the main report, the key objectives of the feasibility study were developed and include:

- Improve habitat quality and increase the amount of native Bosque communities to a sustainable level. Sustainability of Bosque habitats refers to the habitat's ability to perform key riparian functions that perpetuate those habitats. Using the Bosque Community Index Model, a habitat score of 0.50 to 0.59 is considered "moderately high functionality" (discussed in Appendix D). The objective of the restoration project is to achieve a moderately high functionality or higher habitat value over 30 percent or more of the areas of consideration. This value will be achieved in 20 years or less after project implementation and be sustained for the remaining 30 years of the period of analysis.

- Restore hydraulic processes between the Bosque and the river characterized by a more natural overbank inundation pattern and higher riparian groundwater levels. A 25 percent or more increase in the area of inundation during flow events of 3,000 cfs or greater is the objective of the Sandia to Isleta restoration project.

- Protect, extend, and improve areas of potential habitat for listed species within the Bosque. For RGSM, overbank flooding provides areas for hatching and rearing; therefore, a 25 percent or more increase in area of inundation as described above would significantly increase minnow

reproduction. The project objective is to provide an over-25-percent increase in high quality habitats suitable for migration and feeding by the SWFL.

Table 4 - Best Buy Plans (2nd Model)

BB #	Plan	Total Cost	Avg Ann Cost	AAHU's	Plan Areas Reach 2&3	Plan Areas Reach 4&5	Reaches	Notes
0	No Action Plan	$0	$0	0	Do Nothing	Do Nothing	0	
1	NR1SR0	$597,313	$26,528	104	D	Do Nothing	2	
2	NR2SR0	$1,512,486	$66,514	236	D G	Do Nothing	2	
3	NR3SR0	$3,226,430	$135,833	342	D G J	Do Nothing	2, 3	
4	NR3SR1	$4,557,193	$192,454	405	D G J	Q	2,3,4	1st time work is done in Northern and Southern Reaches
5	NR4SR1	$7,687,228	$334,195	536	D E G J	Q	2,3,4	
6	NR5SR1	$10,840,879	$472,275	654	D E F G J	Q	2,3,4	
7	NR6SR1	$14,523,346	$627,230	774	D E F G J M	Q	2,3,4	
8	NR6SR2	$17,154,476	$740,825	854	D E F G J M	Q T	2,3,4	Minimally meets objectives
9	NR6SR3	$18,370,270	$798,548	893	D E F G J M	P Q T	2,3,4	
10	NR7SR3	$22,587,023	$976,702	1003	D E F G H J M	P Q T	2,3,4	
11	NR8SR3	$27,092,859	$1,184,794	1106	D E F G H J K M	P Q T	2,3,4	
12	NR9SR3	$32,222,140	$1,413,958	1215	D E F G H J K L M	P Q T	2,3,4	
13	NR9SR4	$35,886,658	$1,576,153	1285	D E F G H J K L M	P Q T U	2,3,4	
14	NR10SR4	$44,826,997	$1,961,341	1416	A D E F G H J K L M	P Q T U	2,3,4	
15	NR10SR5	$47,828,053	$2,095,175	1456	A D E F G H J K L M	P Q T U V	2,3,4,5	1st time work is done in all reaches
16	NR10SR6	$53,771,996	$2,345,301	1527	A D E F G H J K L M	P Q T U V W	2,3,4,5	
17	NR10SR7	$67,093,395	$2,916,820	1668	A D E F G H J K L M	P Q T U V W X	2,3,4,5	
18	NR11SR7	$83,248,043	$3,609,801	1802	A B D E F G H J K L M	P Q T U V W X	2,3,4,5	
19	NR11SR8	$88,193,558	$3,821,289	1838	A B D E F G H J K L M	N P Q T U V W X	2,3,4,5	
20	NR11SR9	$101,363,892	$4,052,611	1872	Do All	Do All	All	

The first project objective, which is to improve habitat quality and increase the amount of native Bosque communities to a sustainable level, is not achieved until Best Buy 8. The metric used to define this sustainable level is having a habitat score between 0.50 and 0.59, which signifies a moderately high functionality habitat (Based on the Bosque Community Index Model). The goal for this restoration project is to achieve this value over 30 percent, or more, of the areas of consideration. This value will have to be achieved in 20 years or less after project implementation and be sustained for the remaining 30 years of the period of analysis. Although Best Buy 8 is the first time this objective is fully met, moving incrementally from the No Action alternative, all plans prior to Best Buy 4 fail to meet the metric described above. More importantly these plans do not have plan areas in the Southern Reach, eliminating a significant portion of the study area, which gave the PDT the rationale to completely eliminate Best Buy plans 1-3. Additionally, these plans don't address objectives 2 and 3 in any capacity.

The second objective, which is to restore hydraulic processes between the Bosque and the river characterized by a more natural overbank inundation pattern and higher riparian groundwater levels, is not achieved until Best Buy 10. In addition to including management areas "T" and "P" in the Southern Reach, which the PDT determined to be important as it assists in the diversification of restoration areas in the study area, Best Buy 10 also introduces management area "H" (bankline terrace lowering) to the Northern Reach. This management area was a highly desired feature for the PDT as it is the first time the management measure is included in a management area.

The third objective is to protect, extend, and improve areas of potential habitat for listed species within the Bosque. Although no specific management areas specifically address this objective, it is not until Best Buy 10, where it was determined by the PDT, that the metrics for this objective (as well as the metrics for the other two objectives) were completely met. Therefore Best Buy 10 is the plan selected as the Tentatively Selected Plan (TSP).

Table 5 - Summary of Best Buy Plans 7-12

Alternative	Plan Areas	Approx. First Cost	Average Annual Cost	AAHU's	Approx. Area (acres)
7	D E F G J M Q	$14,523,346	$627,230	774	168.39
8	D E F G J M Q T	$17,154,476	$740,825	854	197.19
9	D E F G J M P Q T	$18,370,270	$798,548	893	213.01
10	D E F G H J M P Q T	$22,587,023	$976,702	1003	260.71
11	D E F G H J K M P Q T	$27,092,859	$1,184,794	1106	337.74
12	D E F G H J K L M P Q T	$32,222,140	$1,413,958	1215	415.54

4.1 Final Findings

Based on the analysis presented above, the PDT has selected Best Buy Plan 10 as the TSP. The TSP incorporates the following measures: 42 Willow swales, 15 Treat-Retreat-Reveg, 5 Hi-flow Channels, 3 Wetlands, 2 Connections to River, 1 Enhance ditch for wet habitat, 1 Wet Meadow, 1 Divert outfall flows, 1 Bankline terrace, 3 Remove berms. The TSP has an approximate cost of $22,587,023 implementing measures over approximately 261 acres and provides for an increase of 1,003 AAHUs.

This plan was the first plan to minimally meet the project objectives and the metrics for the objectives. Moving to the next Best Buy, the PDT determined, wasn't worth it incrementally. The incremental cost and output analysis determined that for an additional 103 AAHUs and $4.5 million would only get an additional restoration area in the Northern Reach, which for the PDT did not justify the selection of Best Buy 11.

5 - ADDRESSING THE FOUR ACCOUNTS (NED, NER, OSE, RED)

The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (March 10, 1983) establishes four accounts to facilitate the evaluation and display of effects of alternative plans. They are described in ER 1105-2-100, Planning Guidance Notebook, paragraph 2-3. The evaluation of the recommended plan against those accounts follows:

- The National Economic Development (NED) account displays changes in the economic value of the national output of goods and services. The damages and benefits described in this appendix describe NED impacts of Flood Risk Management in the study area.

- The Environmental Quality (EQ) account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans. The arrays of plans described in this appendix have ecosystem restoration as their stated goals.

All of the best buy plans would contribute to the EQ account by increasing the amount and quality of high value habitat in the study area by their respective quantity of outputs. All best buy plans provide an increase in habitat and therefore benefits to the EQ account as quantified by AAHU's discussed in this appendix. Benefits to the EQ account increase with plan outputs as does the costs for the project and

incremental costs for each AAHU. Benefits would increase in the following criteria as the amount and quality of habitat increases.

Water Quality – Reconnection of the river channel to overbank area would provide some improvements to water quality through natural filtration in riparian areas. An increase in wetland area particularly those located at storm water outfalls would filtration of water and beak down of some pollutants through biologic processes.

Air Quality – An increase in the number and acres of plants would contribute to absorption of carbon dioxide and release of oxygen in this urbanized area. The Bosque also acts as a heat sink during warmer months providing a corridor of shady, relatively moist environment that contrasts the urban asphalt and concrete.

Wildlife – The increase in habitat diversity would provide for an increase diversity and density of wildlife species.

Essentially the larger the project is the more benefits to this account would be. The cost effective analysis has provided a measure of efficiency to determine what the cost of incremental of these outputs would be.

- The Regional Economic Development (RED) account displays changes in the distribution of regional economic activity (e.g., income and employment). This account is typically used to capture the regional impacts of a large capital infusion of project implementation dollars on income and employment throughout the study area through the use of income and employment multipliers. A recent study for the Nuclear Watch of New Mexico suggests that public sector multipliers tend to be below 1.5, while the Department of Energy claimed multipliers of 2.4 to 3.5 in fiscal year 1998 . The important point to be made here is that a large infrastructure project in the Albuquerque area will have a positive impact on local income and employment.

- The Other Social Effects (OSE) account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others. In most cases, impacts of proposed projects not covered in other accounts are described and evaluated here. Primary affects to OSE from the proposed restoration would benefit health, standard of living and education by providing a public area of improved aesthetics, air quality and providing recreational and educational opportunities. There would be significant benefits to the community from the facilities provided from the recreation component of the project, increase in quality of the recreational experience and educational opportunities within the project area.