Floodplain Ecosystem Services Valuation for Carson Valley

Prepared for:

Carson Water Subconservancy District
Carson River Coalition River Corridor Working Group

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SECTION 1

Introduction

The Carson Water Subconservancy District (CWSD) and the Carson River Coalition (CRC) River Corridor Working Group is interested in preserving floodplain along the Carson River and enhancing the viability of agriculture in the floodplain areas. One potential approach is to pay landowners for the ecological services provided by land that floods. ENTRIX has been retained by the CWSD to develop background economic information that may be used to assess a reasonable range of appropriate dollar values for such payments. Although there are many mechanisms to provide such payments, for the purpose of the rest of this report it is assumed that the CWSD and CRC will be interested in paying landowners in annual lease terms.

The economic information is developed through the use of several different approaches. The first is to assess the cost of alternative man-made flood control structures, engineered wetlands, and other constructed solutions designed to replicate natural floodplain function. The second method is to review comparable payment programs throughout the U.S. Finally, a modeling technique is used to consider the actual floodplain services provided to the downstream Carson community for a portion of the floodplain. The latter effort is intended to provide a preliminary sense of the types of benefits that may result from floodplain protection under simulated flood events. Other methods considered include a more thorough assessment of flood damages (and avoided damages), and an analysis of what farmers would be willing to accept for placing development restrictions on their land. Based on discussions with the CRC River Corridor Working Group it was determined that the most appropriate methodologies to explore at this time should include the cost of alternatives, and comparable payment programs at minimum. Also, based on discussions with the group and work conducted by Mitch Blum at HDR a hydrology model was developed to gauge the magnitude of services provided by the natural floodplain. The remainder of this report describes the methodology and results of these approaches to valuing ecosystem services of the natural floodplain of the Carson River.

1.1 PREVIOUS RESEARCH

Most studies of the value of flood protection provided by wetlands have relied on proxy techniques. The dominant approaches are the “alternative cost” method and the “damage costs avoided” approach. The U.S. Army Corps of Engineers (ACOE) used the avoided damage costs approach in a previous study of the Carson River in the 1960’s, as explained further in the Section 2.2 (Carson Previous Analyses). Another ACOE project that is often cited was published in the 1970s, in which flood profiles in two Massachusetts Rivers were compared. The study quantified the loss of wetlands in the headwaters of the Charles River (see Section 3.1.3 Boston – Charles River for more detailed information).

One of the best examples of research in this area was written in October of 1997 the Washington State Department of Ecology (DOE). The title of the paper is “The Economic Value of Wetlands,” and in this, the paper describes the role of wetlands in floodplain protection in western Washington. The paper argues that the economic valuation of wetlands’ flood protection services can provide a strong rationale for Western Washington communities to protect their remaining wetlands. The authors use the “alternative cost” method to produce a proxy for the value of the flood protection services that many wetlands currently provide for "free." Cost estimates for engineered hydrologic enhancements to wetlands are used to establish proxies for the value of the flood protection provided by natural wetland areas.[1]

The results of this report are worth reviewing. In western Washington, more than half of the wetlands that once existed had been lost. Often the cause is agricultural conversion, but more recently wetlands had increasingly been at risk due to urban and suburban development. In the late 1990's western Washington was one of the fastest growing regions in the country, and the remaining wetlands in rapidly developing areas were increasingly valuable for the flood protection function that they provided. At the same time, the increasing pace and density of development resulted in the natural wetlands systems that were capable of absorbing urban runoff to become fragmented, even as the need for flood protection grew more critical.[2]

The results of the DOE analysis produced three estimates of "whole system" wetlands value for flood protection, which range from about $36,000 per acre to about $51,000 per acre. A separate analysis reported in the same publication for the North Scriber Creek wetland revealed lower values, ranging from $8,000 to $12,000 per acre. The lower value is consistent with expectations, as it is based on benefits that are more local in character and on the relative cost efficiency with which additional storage capacity can be added to this particular wetland.

Table 1 displays the wetland value estimates from the DOE study both in terms of per acre estimated wetland values, and annualized per acre values. The annualized values represent the per acre value of wetlands that might best approximate the annual flood control benefits provided by the wetland As is seen in this case in Washington State, the current (2009) dollar annual benefit estimates range from $320 to just over $2,000 per acre. The wide range of estimates suggests that flood control benefits depend on key economic and hydrologic conditions. The specific conditions for each wetland influence the overall value estimate. These values may represent the annual public benefits, and ideally a lessee would negotiate an annual lease payment less than this amount in order to gain value from the transaction.

Table 1 Cost of Alternatives Summary

	Wetland Value per Acre	Annualized Value*
Whole System High	$51,000	$2,045
Whole System Low	$36,000	$1,444
Scriber Creek High	$12,000	$481
Scriber Creek Low	$8,000	$321

*Annualized Value calculated using 3 percent discount rate into perpetuity and update to 2009 dollar values using the Consumer Price Index (CPI)
Source: Leschine, Thomas, and Katharine Wellman, and Thomas Green, Washington State Department of Ecology, Northwest Regional Office, Ecology Publication No. 97-100, October 1997.

The valuation effort for ecosystem services provided by the natural floodplain of the Carson River followed a similar methodology as the study for Washington State DOE. The proxy costs used in the Carson River assessment were engineered enhancements to the floodplains of the Truckee River, as explained in more detail below.

1.2 ORGANIZATION OF REPORT

This remainder of this report is organized into four sections. The first identifies and quantifies the alternative costs associated with floodplain functions in the Carson River. Next a discussion of comparable payment programs across the United States, including transfer of development right programs (agriculture easements)

1 Leschine, Thomas, and Katharine Wellman, and Thomas Green, Washington State Department of Ecology, Northwest Regional Office, Ecology Publication No. 97-100, October 1997.
2 Ibid.

is provided. A subsequent section explains the hydrologic modeling that was performed for this analysis, and the results of the two scenarios modeled in the reach between Highway 395 and Carson City. Finally, the summary section presents a summary of all of the analyses and conclusion to the study.

SECTION 2

Cost of Alternatives

There are numerous cases where man-made structures were proposed or implemented in an attempt to replicate the flood control and other benefits provided by natural floodplains. The costs of implementing these projects provide a basis with which to compare the natural floodplain. This analysis focused on the Truckee River as a comparable watershed. The Truckee provides an excellent comparison as projects were implemented in that watershed for irrigation and flood control measures in the 1950's and 1960's. Currently a project with costs exceeding one billion dollars is being implemented along the Truckee River to re- establish floodplain areas and reduce floodplain damages. Previous US Bureau of Reclamation (BOR) studies within the Carson watershed were also analyzed as a possible gauge in the cost of alternatives approach to valuing the ecosystem services provided by the floodplains in the Carson Valley.

2.1 TRUCKEE EXAMPLES

Irrigation in the Truckee Meadows was initiated by settlers in 1861. Soon after 1900, the demand for irrigation water in western Nevada resulted in water appropriations exceeding summer flows. The BOR's Washoe Project was designed to develop water supplies to meet additional needs by conserving excess runoff in project reservoirs. The plan also called for the use of storage capability to regulate flows for such non-consumptive purposes as flood control, fishery improvement, and power production.[3]

The project involved three dams on the Truckee River: Prosser Creek Dam, Stampede Dam, and Marble Bluff Dam. Construction of Prosser Creek Dam was completed in 1962, Stampede Dam and Reservoir were completed in 1970, and Marble Bluff Dam and Pyramid Lake Fishway construction were completed in 1975. While these projects have served their purposes of irrigation, it is not clear how the projects provided benefits to flood control purposes. These BOR projects actually led to channelization of the river resulting in accelerated streambank erosion, sediment pollution, loss of wetland areas and riparian vegetation, and altered habitat.[4] With the channelization of the river, came the loss of buffer zones that were essential in enabling the Truckee River to establish a natural, sinuous channel and dissipate the rivers energy while filtering pollutants.

Recent restoration efforts in the Truckee River are focusing on restoring a natural, sinuous channel to slow flows, allow floodplain access, and re-establish riparian habitat. The expected benefits of these projects include an enhancement of ecosystem services provided by a natural floodplain, which involve habitat, water quality, flood control, and others.

In this analysis, the costs of restoration are used as an alternative cost. Because the original Washoe project was the incorrect economic choice for flood control purposes, the current restoration projects represent costs that the public is willing to pay to convert the floodplain back to a natural state. The current restoration projects are similar in function to the current conditions in the natural floodplain found in the Carson watershed. Pertinent data regarding the restoration projects in the Truckee are provided below.

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3 Washoe Project Plan Description, Bureau of Reclamation, accessed August, 2009 online at http://www.usbr.gov/projects/Project.jsp?proj_Name=Washoe%20Project.

4 About the Truckee River Watershed, News 4 (KRNV), accessed September 2009 online at http://krnv.envirocast.net/index.php?pagename=ow_about_truckee.

2.1.1 McCarran Ranch Project

McCarran Ranch is located 15 miles east of Reno, Nevada on the Truckee River. The 205 acre property runs along both sides of the Truckee River for five miles. In 1962, as part of a flood control project, the channel at McCarran Ranch was straightened to allow flow to pass through the area to limit flood damage. Because of this straightening, the channel has entrenched downward by roughly three feet. This entrenchment has caused the groundwater to drop beyond the reach of river-side vegetation. The entrenched channel also caused a disconnect between the stream and the natural floodplain, which means the overbank areas along the McCarran Ranch do not receive flood waters as frequently as they had in the past.

The goal of the McCarran Ranch Pilot Restoration Project, overseen by The Nature Conservancy (TNC), is to reconnect the Truckee River to its floodplain, increase the frequency of flooding in the overbank areas, and replenish the vegetation in the area. Restoration plans will reduce the width of the channel from approximately 200 feet to 120 feet, reintroduce meanders in the channel, and raise the bed of the channel by construction a grade control structure at the downstream end of the study area.[5]

According to the most recent (November 2009) cost projections, it is anticipated that $5.2 million will be spent on the McCarran Ranch project by the time re-vegetation efforts are completed.[6] This is equivalent to just over $25,000 per acre in restoration costs. Using a three percent discount rate, and an assumed project life into perpetuity, this is equivalent to an annual payment of $761 per acre. This breakdown on a per acre basis provides a general gauge of the willingness to pay for restoration efforts in the Truckee River, but caution should be used in the application to other areas such as the Carson River as it is not clear how the attenuation capacity of the project will be enhanced.

2.1.2 102 Ranch Project

The 102 Ranch is another of the 11 restoration projects for the Truckee River Flood Project. The primary purpose of the 102 Ranch project is to restore the physical and biological functions of the riverine ecosystem, thereby improving water quality and enhancing habitat for both aquatic and terrestrial native species. The restored river channel and floodplain will provide a variety of benefits in terms of flood management, water quality, habitat for special-status species, biological productivity and diversity, noxious weed abatement, restoration of native plants, and recreation opportunities.

The original project straightened and widened the channel from 75 feet to 200 feet in many reaches, cutting the channel down roughly 12 feet and depressing the groundwater table. As part of the restoration project there will be two new river meanders, five cobble riffles, and five wetland areas created. Roughly 25,000 tons of rounded river rock will be used to construct the channel riffles. Following earth-moving activities, approximately 115 acres will be re-vegetated with native riparian and upland plant species.[7]

The project is anticipated to cost $6.436 million. This is equivalent to $55,965 per acre for restoration activities. Assuming a discount rate of 3 percent, the annualized per acre amount is equivalent to $1,679.

2.1.3 Lockwood Project

The primary purpose of the Lockwood restoration project is to restore the physical and biological functions of the riverine ecosystem, thereby improving water quality and enhancing habitat for both aquatic and terrestrial

5 Truckee River at McCarran Ranch Ecosystem Functions Model Application, US Army Corps of Engineers, Hydrologic Engineering Center, October 2005, PR-61, p.2.

6 Personal Communication with Patricia Bakker, Truckee River Project Manager, The Nature Conservancy Nevada Field Office, November 9, 2009.

7 102 Ranch Restoration Project Fact Sheet, Truckee River Flood Project, September 16, 2008.

native species. The restored river channel and floodplain will provide benefits in terms of flood management, water quality, habitat for special status species, biological productivity and diversity, noxious weed abatement, restoration of native plants, and recreation opportunities.

The Lockwood Restoration Project will also be constructed by The Nature Conservancy (TNC) for the Truckee River Flood Management Project on property currently owned by Washoe County. After the 1997 flood, the Lockwood Mobile Home Park was condemned by the Federal Emergency Management Agency (FEMA) and subsequently deeded to Washoe County. As part of this restoration project, TNC will construct new river channel meanders and riffles; create new wetlands; and re-vegetate approximately 28 acres. The Lockwood restoration project also includes a future Washoe County Park with recreational elements such as a non-motorized trailhead, onsite parking, bike racks, portable restroom facilities, picnic tables, interpretive signs, river fishing access, and a kayak and small inflatable boat launch facility. The total projected costs for this project are $5,819,400.[8] This was not included as an appropriate data point in this analysis due to the formation of the parks and recreation facility.

2.1.4 Mustang Ranch Project

The Mustang Ranch site is located east of Reno/Sparks and downstream of the Lockwood restoration site. The ranch was the site of a famous brothel owned by Joe Conforti, and when the IRS seized the property as payment for tax evasion, it was deeded it to the Bureau of Land Management. The Mustang Ranch Restoration Project supports the “living river” approach developed by the Flood Project Community Coalition with active participation by the ACOE.

The most recent estimate for costs of the restoration project is $7.9 million.[9] The Mustang Ranch is 420 acres, thus the restoration is equivalent to $18,810 per acre. The annualized per acre restoration costs under a three percent discount rate is equivalent to $564 per acre.

2.2 CARSON: PREVIOUS ANALYSES

The Washoe Project, which resulted in the reservoir developments in the Truckee River, originally included plans for development in the drainage basin of the Carson River as well. In fact, the Hope Valley division (dam and reservoir) were considered for the West Fork Carson River, while the Watasheamu Division (dams, reservoirs, canals, laterals, power plants and drains) were considered for the East Fork Carson River. BOR reports from the early 1960’s indicate that the Watasheamu dam and reservoir were planned for completion in 1967. However, funding fell short for these projects, and the authority to construct the facilities were ultimately revoked by Public Law 101-618 dated November 16, 1990. However, the planning studies from this era did report flood control benefits associated with the planned project. Although completed long ago, the estimates provide another data reference point which is useful because it pertains to the Carson River itself. The pertinent data from the BOR studies published in the 1960s is included below.

2.2.1 Watasheamu Division

In April of 1961 BOR released a draft report of the benefits and costs associated with the Watasheamu project.

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[8] Fact Sheet, Lockwood Restoration Project & Future Washoe County Park, accessed from personal communication with Danielle Henderson, Natural Resource Manager, Truckee River Flood Project.

[9] Personal Communication with Danielle Henderson, Natural Resource Manager, Truckee River Flood Control Project, November 2, 2009.

In the report it describes the Watasheamu dam as being a rolled earth and rock fill dam 293 feet high, 2,000 feet long, located on the East Fork of the Carson River approximately 4 miles downstream of the California/Nevada State line. The normal reservoir capacity behind the dam would have been 160,000 acre feet.[10] Of this amount, it was reported that 35,000 acre-feet would have been kept as flood control storage in the reservoir from November to April of each year.[11]

The flood control benefits reported in the Appendix to the main report were derived by BOR using an average flood damage reduction approach. The analysis evaluated historical floods, field appraisals, and inventories of flood damages, and used these values to derive an average annual flood damage of $313,000. The analysis then cited the flood capacity design in the proposed project, and resulting downstream flows of operating the dam to estimate that most of the flood damages could be avoided. In fact, the estimate reported in the draft study is that an annual benefit of $250,000 for flood control could be associated with the Watasheamu project.

In hindsight this benefit calculation figure seems aggressive given the problems associated with flood control and flows in the Truckee. However, we can use this estimate as another gauge to value flood control, as it was the perceived benefit of flood control reductions in 1961. By using the Consumer Price Index (CPI) this figure can be updated to over $1.8 million in current 2008 dollars.[12] This translates into an annual per acre foot value of $51.43 in current 2008 dollars for just flood control benefits.

2.2.2 Hope Valley Division

The Hope Valley Division was proposed as a project with a storage capacity of 100,000 acre-feet. The ACOE estimated the flood control benefits in this study at $34,000 in 1961 dollars. It is not clear how these benefits were derived, or even the flood control capacity within the 100,000 acre foot total storage capacity.

In this analysis, we assumed that the flood control capacity proportion was similar to the Watasheamu Dam, which leads to a total of nearly 22,000 acre-feet. Updating the reported flood control benefits, results in a total of $244,823 in flood control benefits in 2008 dollars. Therefore, the per acre foot value in current dollars is equivalent to $11.19 for the Hope Valley Division, for flood control benefits only.

While the comparison of benefit estimates for the proposed Hope Valley Division and Watasheamu Division are interesting, they do not provide a current assessment of the true value of flood control benefits. This is largely due to the fact that any sort of flood damage assessment completed in the 1950's or 1960's only accounted for homes and structures in the watershed at the time. While updating the flood benefits to current dollars using the CPI is appropriate for the valuing flood benefits for homes and structures pre 1960, it does not take into account any homes and structures that were constructed post 1960. Also, the focus of the valuation of ecosystem services in the published reports for the proposed projects on the Carson River was flood control benefits. This does not take into account the other services that the natural floodplain would provide such as water filtration, wildlife habitat, fish habitat, aesthetics, and others. Due to these limitations in the analyses of the previous studies in the Carson River, these are not further developed in this analysis. The Truckee examples provide more complete, and up to date values associated with alternative costs for providing comparable ecosystem service benefits from the natural floodplain.

[10] United States Department of the Interior, Bureau of Reclamation, Region 2, Sacramento California, Watasheamu Division, Washoe Project, Nevada-California, p. ii, Draft as of April, 1961, accessed by Genie Azad, Program Manager, Carson Water Subconservancy District.

[11] United States Department of the Interior, Bureau of Reclamation, Region 2, Sacramento California, Watasheamu Division, Washoe Project, Nevada-California, Appendix, Draft as of April, 1961, accessed by Genie Azad, Program Manager, Carson Water Subconservancy District.

[12] Consumer Price Index, accessed online at ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt.

2.3 COST OF ALTERNATIVES SUMMARY

The above referenced costs of alternatives cited cost estimates in both the Truckee and Carson watersheds. The Truckee examples provide the closest and best alternative evaluation for the purposes of this analysis because they are current, and they focus on a host of ecosystem services and not simply flood prevention. Based on the information presented for the Truckee River restoration projects, the cost for restoration suggests that annual ecosystem service payments range from $564 to $1,679 per acre. This range of costs provides an estimate of what society may be willing to pay for ecosystem services similar to those provided by the Carson River (see Table 2).

Table 2 Cost of Alternatives Summary

	Acres	Restoration Costs	Per Acre Costs	Annualized Per Acre Costs*
McCarran Ranch	205	$5,200,000	$25,366	$761
102 Project	115	$6,436,000	$55,965	$1,679
Lockwood Project**	28	$5,819,400	$207,836	$6,020
Mustang Ranch	420	$7,900,000	$18,810	$564

*Annual payment based on 3 percent discount rate into perpetuity (see Appendix A for a discussion on the discount rate used.)

** The Lockwood Project costs include recreation facilities, and therefore is not a relevant data point for this analysis

It is important to note that these cost figures include the acquisition costs, as well as other costs that may not be directly associated with restoration efforts in the floodplain. Due to these inconveniences in using the Truckee projects as proxy costs, it is possible that the value of ecosystem services reported in this study is overstated. The annualized values per acre for ecosystem services provided by the natural floodplain of the Carson River were found to range from $564 to $1,679. This also represents the recommended lease value of agricultural lands in the Carson River watershed

2.3.1 Sensitivity of Discount Rate

The annualized per acre costs reported in Table 2 above were calculated with a three percent discount rate, which is a conservative estimate based on long term maturing government backed securities (See Appendix A for more detail). However, the discount rate is largely a subjective determination of a group's social rate of time preference and time value of money. The lower the rate the more equivalent future payments are to current values, which results in a lower payment per acre in this analysis. Appendix A presents historical data on long term treasury security rates, which provides justification for possibly using a lower discount rate in this analysis (2 percent average real rate). On the other hand, current rates of US Treasury Securities are at 4.69 percent,[13] and inflation was essentially 0 percent in 2009, providing justification for the use of a slightly higher discount rate. In the table below, the estimated annualized per acre costs are displayed for discount rates ranging from 2 percent through 7 percent. These results demonstrate that given different discount rate assumptions, the range of Truckee restoration annual project per acre costs could be interpreted to be between $376 and $3,918 depending on both the type of project and assumptions about discounting.

[13] Based on 30 year T-Bond, as of close of business on February 12, 2010, accessed online at: http://forecasts.org/10yrT.htm.

Table 3 Sensitivity of Discount Rates – Annualized Per Acre Costs

	2%	3%	4%	5%	6%	7%
McCarran Ranch	$507	$761	$1,015	$1,268	$1,522	$1,776
102 Project	$1,119	$1,679	$2,239	$2,798	$3,358	$3,918
Lockwood Project**	$4,013	$6,020	$8,027	$10,033	$12,040	$14,047
Mustang Ranch	$376	$564	$752	$940	$1,129	$1,317

SECTION 3

Comparable Payment Programs

The threats that watersheds face are numerous: pollution, development, fire, soil erosion, drought, flooding, and others. Payment for Ecosystem Service (PES) programs and agriculture easement programs are both established to mitigate the risks posed to watersheds by linking payments for hydrologic services to conservation, restoration, and / or land acquisition projects. This section explores various PES and agriculture easement programs across the country. The distinction between the two is that PES programs are established for a variety of hydrologic services (i.e. thinning in the forest to reduce fire risk and associated impacts from erosion and water quality), whereas agriculture easements are specific to the preservation of farmland. Agriculture easements often serve as a tool for preservation of ecosystem services by limiting development in a sensitive area.

3.1 PAYMENT FOR ECOSYSTEM SERVICE PROGRAMS

For this analysis PES programs were explored throughout the United States to gather information about effective measures that have been implemented in other areas and the resulting enhancement and preservation of ecosystem services within the watershed. In general these case studies show how cost effective measures can be implemented to protect or enhance ecosystem services. PES programs can be effectively designed around providing sellers with financial incentives that would improve or maintain ecosystem services to the buyer at a lower cost than the available alternatives.

3.1.1 New York – Catskill and Delaware Rivers

There are 19 reservoirs that are used to supply water to New York City, the nation's largest metropolitan area. The Safe Drinking Water Act led to the EPA requiring the city to either find a way to get cleaner water to its citizens or put in an expensive filtration system. The water filtration system would have cost the city between $6 and $8 billion up front and approximately $300 million annually in operating expenses. In order to avoid these costs the City chose an aggressive watershed plan for the Catskill and Delaware Rivers. In 1997 the city entered into a groundbreaking new watershed memorandum with 76 signatories. The agreement established a far-reaching program to protect all of the city's watersheds. The agreement includes direct city investments in upstate water pollution controls, provides financial incentives and technical resources to enable land stewardship that is in the City's best interest to control water pollutants. The City is also purchasing land and conservation easements on land for watershed protection. Land purchases were determined based on prioritization criteria to determine which tracts are most essential. The prioritization involved GIS modeling, planners, and hydrology studies. A result of the aggressive plan implemented in 1997 is a decrease in phosphorus loads from wastewater treatment of 65.7 percent.[14] Unfortunately, no information is available about the costs of this program.

[14] Postel, S.L. and B.H. Thompson, Jr., Watershed Protection: Capturing the Benefits of Nature's Water Supply Services, 29 Nat. Resources, p. 98-105, 2005.

3.1.2 Salem – North Santiam River

Almost 80 percent of the land in the North Santiam River watershed in Oregon is owned by the Forest Service, Bureau of Land Management, and Oregon Department of Forestry. A few growing communities are also located along the river. In 1996 an unusual amount of flooding occurred in the North Santiam. The City of Salem was forced to take drastic steps to provide potable water. Their existing filtration system at the time was a slow sand filter that would clog in high turbidity scenarios. The city declared a 'water emergency' due to the high turbidity and inadequate water supplies. They eventually had to spend $200,000 just to get adequate water supplies to its customers, and another $1 million in a permanent chemical pretreatment system. After the flood events it was revealed in a GAO report that timber harvests and related road construction in the watershed had contributed significantly to the heavy soil erosion and resulting high turbidity in the river. Since the report was published the city has worked closely with local, state, and federal agencies to implement better watershed management practices to avoid future episodes of contamination. A Memorandum of Understanding (MOU) was developed with all federal agencies in the watershed that outlines goals. Another result of the MOU was an online watershed monitoring program.[15]

3.1.3 Boston – Charles River

The Charles River Natural valley Storage Project is an ACOE project that helps control flooding in Boston, Massachusetts by preserving nearly 8,000 acres in 17 existing wetlands. The ACOE spent $10 million in land and preservation easement purchases to accomplish their storage goal. The alternative costs for an equivalent storage capacity in a man made dam would have been $100 million, or ten times as much as the natural project. The City of Boston also saves an estimated $17 million annually in flood damage avoidance because of the project. Furthermore, an estimated 1.5 percent premium has been added to the values of homes in the area due to flood protection and amenity values provided by the wetlands.[16]

3.1.4 Littleton – Platte River

A 625 acre park was created from an area that was extensively mined for gravel over the past 30 years. The area was within the 100 year floodplain of the Platte River in Colorado. A partnership between the city of Littleton, South Suburban Park and Recreation District, ACOE, Colorado Water Conservation Board, and numerous property owners was responsible for the establishment of the park. Local bonds and federal grants paid for the floodplain acquisition and transformation. Today, the park is home to more than 225 species of birds (including bald eagle, retailed hawk and blue heron), beavers, muskrats, skunks, raccoons, deer, coyotes, and foxes along with 23 species of fish. The park also receives 350,000 visitors annually.[17]

3.1.5 Arnold – Mississippi River

FEMA granted $2 million in disaster assistance to the community of Arnold, Missouri after flooding by the Mississippi and Meramec Rivers in 1993. The large award was partly due to the strong flood management plan developed by Arnold, which included purchasing damaged and destroyed properties as a greenway along the Mississippi River floodplain. In 1995 another flood event occurred in Arnold, but this time the damage amounted to less than $40,000 because of the public acquisition of flood prone and flood damaged properties.

[15] Hill, B.T., Oregon Watershed: Many Activities Contribute to Increased Turbidity During Large Storms, U.S. General Accounting Office (RECD), 98-220, 1998.

[16] Morrison, Jim, How Much is Clean Water Worth?, National Wildlife, Feb./March 2005.

[17] Parmelly, Nichole, Partnership Brings New Park to Littleton Along the South Platte, Arapahoe County News Release, June 15, 2009

It was estimated that the program resulted in cost savings of approximately $100 million in reduced future disaster damages.[18]

3.1.6 Tulsa – Arkansas River

In Tulsa, Oklahoma, residents and businesses located along the Arkansas River floodplain were experiencing devastating floods every decade. In addition to loss of human life, thousands of buildings were damaged with millions of dollars lost in 1976 and 1984 Memorial Day floods. Tulsa responded by moving vulnerable buildings out of the floodplain. Managers implemented a watershed wide approach to storing and draining the vast amounts of stormwater runoff during heavy rains. In essence, wetlands were allowed to become wetlands once more. As a result, Tulsa's flood insurance rates have dropped by 25 percent and are now among the lowest in the nation. The tradeoffs for protecting natural system functions often can be win-win situations, as seen by Tulsa's lower insurance rates and less flood damage when floodplains are protected from human development.[19]

3.1.7 Summary

The programs mentioned above are all aimed at protecting or restoring natural floodplain functions within a watershed. Not all of the programs are structured in the same manner, and thus, represent several possibilities for implementation in the Carson River. Below is a summary table of the programs and results that are discussed in the section above.

Table 4 Summary of PES Programs Identified

	Program	Payments	Avoided Costs	Other Results
Catskill and Delaware Rivers	MOU to protect watershed		$6 to $ 8 billion	Decrease in phosphorus loads by 65.7%
North Santiam	MOU to protect watershed		$1 million	MOU and online watershed monitoring program
Charles River	Wetland Acquisition and preservation	$10 million	$100 million	Flood damages avoided, 1.5% premium to value of homes
Platte River Park	Restoration Program			Conversion of gravel mine to park with wildlife habitat
Arnold-Mississippi	Greenway along Mississippi floodplain	$2 million	$100 million	Public acquisition of flood prone and flood damaged properties
Tulsa – Arkansas River	Wetland approach to storing and draining runoff			Less flooding, flood insurance rates drop 25%

3.2 AGRICULTURE EASEMENT PROGRAMS

According to the American Farmland Trust there are 1.8 million acres of farmland nationwide in agricultural easement programs at a combined cost of $2.3 billion. Agricultural easements could be used as a tool to effectively help redirect or influence urban growth. The concept to achieve this would require close

18 Missouri Flood Buyouts
19 RAND Corporation, Nature's Services: Ecosystems Are More than Wildlife Habitat, accessed online at http://www.rand.org/scitech/stpi/ourfuture/NaturesServices/section1.html

collaboration with local government planning policies, zoning, and other land use regulations to implement development limitations. [20]

3.2.1 Easement Evaluation

Land classification systems, called Land Evaluation and Site Assessments (LESA) Systems, are often used to assess and identify agricultural lands. LESA Systems are an analytical tool to help decision makers systematically assess and identify prime agricultural lands through the use of a consistent rating scheme. Land classification systems have been in use since the 1930's in the United States. The current model LESA system was developed in 1971. Nationally, over 200 LESA systems are in use by various state and local governments. Many LESA Systems have a water resource protection factor included as part of the criteria. This factor measures the relative extent of features related to the protection of water resources on the parcel. The logic for this factor assumes that agricultural land uses have beneficial impacts on adjacent water resources when compared to other land uses (with utilization of Best Management Practices). Two categories of water resources are identified in LESA Systems, either: the proportional area within the FEMA designated 100-year floodplain; or within a 200 foot wide buffer along perennial water bodies where no floodplain delineation has been made. The proportion of the parcel fitting the factor description is used to determine the factor scale. See below for an example of a LESA worksheet, site assessment factor number 8 is the water resource protection. [21]

[20] Sokolow, Alvin and Anita Zurbrugg, A National View of Agricultural Easement Programs, abstract, accessed online at http://www.aftresearch.org/research/publications/detail.php?id=d72dd282ec8bff1b153c17fc3ca602ab.

[21] Montana Statewide Land Evaluation and Site Assessment System, page17, accessed online at http://www.farmlandinfo.org/documents/30029/LESA_MT.pdf.

Montana Statewide Land Evaluation and Site Assessment Worksheet

	Factor	Factor Rating	Factor Weight	Weighted factor rating	% of site/area (fraction)	Partial Rating	Total Score
Land Evaluation Factors	Important Farmland	80	0.25	20.00	0.50	10	
	Soil Productivity	90	0.15	13.50	0.50	6.75	
	Land Capability	75	0.10	7.50	0.50	3.75	
	Important Farmland	100	0.25	25.00	0.50	12.5	
	Soil Productivity	90	0.15	13.50	0.50	6.75	
	Land Capability	75	0.10	7.50	0.50	3.75	
	LE Subtotal						43.50
Site Assessment Factors	1 Compability of Adjacent Uses	80	0.0750	6			
	2 Percent in Agricultural Use	100	0.0625	6.25			
	3 Average Size	75	0.0625	4.6875			
	SA-1 Subtotal			16.9375			
	4 Proximity to Protected Ag Land	70	0.0750	5.25			
	5 Distance to Services	100	0.0750	7.5			
	SA-2 Subtotal			12.75			
	6 Open Space Strategic Value	100	0.0600	6			
	7 Historic Buildings/Arch. Sites	0	0.0400	0			
	8 Water Resource Protection	75	0.0500	3.75			
	SA-3 Subtotal			9.75			
	SA Subtotal						39.44
Total LESA Score							82.94

Enter scale values for the parcel in light yellow blocks from LESA scoresheet. Enter LE relative % area fraction in dark blue blocks. Spaces provided for two soil units. Ratings and scores will be calculated in rose blocks. Final scores in gold blocks.

Source: Montana Statewide Land Evaluation and Site Assessment System, page 7, accessed online at http://www.farmlandinfo.org/documents/30029/LESA_MT.pdf.

Figure 1 Example of LESA Worksheet

3.2.2 National Programs

The National Assessment of Agricultural Easement Programs published features of 46 programs across the country. The analysis specifically excluded programs that acquired easements on agricultural lands primarily for their natural resource, habitat, or other open space values. However, the assessment found that most local programs are in the suburban and semi-rural parts of major metropolitan areas, with county populations of more than 100,000 and facing rapid population growth. Consequently, these programs are relevant to the Carson River Valley. For all programs in the national study, the direct cost of purchasing easements averages approximately $2,000 an acre. The direct cost is generally the difference between the market and farming values, and in many cases the development rights are worth more than $2,000 per acre. In these cases the added value of the development right is contributed as full or partial donations by the landowner for tax benefits. State governments provide most easement funds, with lesser amounts coming from local taxes, federal funds and nonprofit sources. Finally, while there is a potential to use easements to complement local planning and land use policies in protecting farmland, few agricultural easement programs work this way.

One reason for this is because easement activities and local planning efforts are often managed by separate organizations.[22]

The section below provides descriptions of agricultural easement programs that have multiple purposes, of which include limiting development for the protection of natural resources.

Buckingham Township – Pennsylvania

Buckingham is a rapidly growing municipality in the middle of Bucks County that experienced a 73 percent population increase in the 1990's. Voters in 1995 and 1999 approved bond issues proposed by township supervisors for the purpose of agricultural easements. Buckingham also operates a Transfer of Development Rights (TDR) program that was originally created in 1975 and revised in 1994. To date, $22.1 million has been spent for all acquisitions by both township and county programs in Buckingham on 2,437 agricultural acres. Easement crops are in field crops, dairy, vegetable and fruit orchards. A formula similar to a LESA ranking is used to evaluate applications when more than one has been submitted. Equal weights are given to four categories: Farmland Value, Historic Value, Location and Scenic or Natural Resource Value. The township's 1974 Comprehensive Plan highlighted preservation as a primary goal. At that time about one-fifth of the land areas was in a development district and the rest was designated as agricultural and resource protection districts. Most new growth since that time has occurred in the development district.[23]

Vermont – State Program

The Vermont Housing and Conservation Board (VHCB) is unique in combining the multiple purposes of farmland protection, affordable housing, natural resource protection, and historic preservation under one agency. VHCB partners with the Vermont Department of Agriculture and other entities like Vermont Land Trust to acquire agricultural easements. The acquisition criterion is heavily weighted toward the resources of the land as well as the location. The Vermont program was the first in the nation to receive federal dollars for easements under the 1990 pilot Farms for the Future program. The funding of some acquisitions is assisted by mitigation funds from the urban development of farmland. To date over 100,000 acres have been placed in easements on 318 parcels.[24]

Virginia Beach City – Virginia

Virginia Beach is one of the only urban areas in the United States that operates a significant agricultural easement program. The easement program is funded exclusively by local revenues and uses Installment Purchase Agreements (IPA) to purchase development rights. The goal of the program is to place 20,000 acres in the agriculture reserve using $13.5 million in funding that has been collected to date. A formal rating system with 100 maximum points gives top priority to natural resource values, farm management, agricultural quality and contiguity. Development potential, development proximity, strategic location and urgency are given less weight.[25]

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[22] Sokolow, Alvin and Anita Zurbrugg, A National View of Agricultural Easement Programs, abstract, accessed online at http://www.aftresearch.org/research/publications/detail.php?id=d72dd282ec8bff1b153c17fc3ca602ab.

[23] Ibid, page 114.

[24] Ibid, page 160.

[25] Sokolow, Alvin and Anita Zurbrugg, A National View of Agricultural Easement Programs, Report 1 – Profiles and Maps, American Farmland Trust, September 2003, page 164.

3.2.3 Summary

Agricultural easements via a transfer of development right program are another possibility to explore in assisting in meeting the goal of the living river concept. Douglas County and Churchill County have both established TDR Programs, perhaps there is a way to expand or enhance these programs to better protect natural floodplain function. The scoring for such an easement program could be adapted to target those agricultural lands that provide the highest level of function in the watershed. The above cited examples are summarized in the table below.

Table 5 Summary of Agricultural Easement Programs Identified

	Program	Payments	Other Results
Buckingham Township	Transfer of Development Rights	$22.1 million	Agriculture easements on 2,437 acres, new growth in development district
Vermont State Program	1990 Farms for the Future Program		100,000 acres in easement on 318 parcels
Virginia Beach City	Installment Purchase Agreement to purchase Development Rights	GOAL: $13.5 million	GOAL: 20,000 acres

3.3 DESIGNING A PAYMENT PROGRAM

The examples provided above do not present a distillable per acre cost or value, but do represent similar types of programs that are focused on water quality preservation, flood control benefits, or place a high emphasis on natural resource preservation. In light of this it may be most useful for CWSD to design and implement a unique PES program, individualized to suit the specific needs and goals of the group. There have been several published articles on this very subject, including numerous publications by non-profit groups, such as the Trust for Public Lands, Forest Trends and the Katoomba Group. Many of these publications offer guidelines for developing watershed PES systems, or “best practices.” In “Protecting the City’s Water: Designing a Payment for Ecosystem Services Program,” Greenwalt and McGrath (2009) address nine critical action items to ensure the creation and implementation of an effective PES program, including:

1. Calculate the economic value of water and other ecosystem services provided by the watershed to consumers as well as the cost to landowners for future watershed maintenance.
2. Negotiate contracts for long term enhanced management of sensitive areas.
3. Conduct a far-reaching program to educate stakeholders about both the economic benefits and costs of any proposed watershed management plan.
4. Build an extensive watershed-monitoring program that involves citizens’ groups and make the results available to the public.
5. Evaluate monitoring results frequently and use them as part of an adaptive management strategy.
6. Establish the preferred funding mechanism (tax, bond, user fee), considering legal and political implications of each. Choose a mechanism that fits within existing institutional conditions and seek additional sources of funding.
7. Maintain public trust by making all PES transactions transparent and explicit
8. Share experiences of the PES program early and often, especially with decision makers and stakeholders.
9. Consult guides, such as PES Getting Started Primer[26] for more details about drawing up contracts, valuing resources and selecting payment schemes.

[26] Payments for Ecosystem Services, Getting Started: A Primer, Produced by Forest Trends and the Katoomba Group, published in May 2008, ISBN: 978-92-807-2925-2, Job Number: DEP/1051/NA.

S E C T I O N 4

Estimating Magnitude of Services

In order to better understand the magnitude of the environmental services potentially provided by the un-encroached floodplain in the Carson River, a simplified hydraulic model was developed for this study. Based on actual flood flow data from the Carson reach of the river (immediately upstream of Carson City) a model was designed to simulate actual flood events on the Carson River. Then the same event was repeated in a modified version designed to simulate what might have happened were the floodplain to have been developed. A comparison of the results showing that the un-encroached floodplain reduces the volume, velocity, and peak flow of a flood event. This section presents results of the hydrology model.

This model is a rough estimate of the potential behavior of flooding downstream of Highway 395 on the Carson River. It is not detailed, nor long enough of a reach to provide scientifically significant results. In addition there are no structures modeled which can significantly influence hydraulics. This model is only to be used a general approximation of floodplain behavior in this reach, and intended to be used only for preliminary planning purposes.

The flood event simulation was conducted with the aid of the ACOE Hydrologic Engineering Center River Analysis System model (HEC-RAS). The geometric parameters of the model were altered under the assumption that the floodplain within the reach now had been developed to the maximum extent possible for a community still wishing to qualify for National Flood Insurance Program. This allows floodplain modifications to occur only to the extent that the 100-year flood stage is increased by one foot, which is considered a regulatory floodway. Two flood events were modeled under both the assumption of the un-encroached (undeveloped) and the encroached or developed floodplain. Selection of the flood events was limited by the availability of 15 minute interval data which has only been available since 1989. Hence the two largest flood events since then were used – the New Year's Day flood of 1997, and the New Years Day flood of 2006. The flood in January of 1997 represented a peak flow of 30,500 cfs at the Carson Gauge near Carson City, and the estimated percent chance of a flood of this size is once every 50 to 100 years.[27] The flood in January of 2006 represented a peak flow of 11,900 cfs at the Carson Gauge near Carson City, and the estimated percent chance of a flood of this size is once every 10 to 25 years.[28] The changes in results of estimated peak flow, volume, and time provide an understanding of the benefits provided by the unaltered floodplain (see Table 6).

[27] Carson Water Subconservancy District, 2008, *Carson River Watershed Regional Floodplain Management Plan,* Appendix A Carson River Watershed Flood History Table, page 86.

[28] Carson Water Subconservancy District, 2008, *Carson River Watershed Regional Floodplain Management Plan,* Appendix A Carson River Watershed Flood History Table, page 87.

Table 6 Flood Simulation Results for Encroached and Un-encroached Floodplain (50-100 Year Flood Event)

1997 (50-100) Year Flood Event	Unencroached	Encroached	Difference
Peak flow (cfs) top of reach	30,500	30,500	
Peak flow (cfs) bottom of reach	30,181	30,319	
Reduction in peak flow (cfs)	*319*	*181*	*138*
Percent of total peak flow	*1.0%*	*0.6%*	*0.5%*
Percent loss with encroachment			*43%*
Volume (AF) top	154,637	154,637	
Volume (AF) bottom	154,183	154,196	
Change in Volume (AF)	*454*	*441*	*13*
Percent of total peak flow	*0.294%*	*0.285%*	*0.0%*
Percent loss with encroachment			*3%*
Peak Flow Time at top	6:20	6:30	
Peak Flow Time at bottom	10:00	8:40	
Total Time	*3:40*	*2:10*	*1:30*
Percent loss with encroachment			*41%*

Source: Elaborations on HEC-RAS model simulation results provided to ENTRIX by Mitch Blum, HDR, Inc. 2010.

The results emulating the flood in 1997 (which is estimated to have a 50-100 year frequency, or a 1 -2 percent probability in any given year) suggest that an encroached floodplain would not have reduced the flow of the peak event as much as the un-encroached floodplain. The model suggests that while the un-encroached floodplain reduced the flow by 319 cfs, the smaller floodplain represented by the developed scenario would only have reduced the flow by 181 cfs. This also suggests that large floods would arrive at Carson City with a slightly faster flow rate than with the open floodplain, with the difference being 138 cfs, or a 43 percent decrease in the capacity of the floodplain at that reach to decrease the flow of the flood. Although this represents less than one percent of overall flow of such a large flood, the results of the modeling demonstrate what the effect might be in a simplified scenario, and just for the one reach. If other reaches were also developed in the future, the results would be different throughout the river though still most likely provide swifter flows.

Results for the difference in flood volume (related to the flow results above) are shown in Table 4 in terms of acre-feet. The same process of comparing model results with, and without the hypothetical development suggest that the floodplain would attenuate 13 acre feet of water during such an event that would not be attenuated in the developed scenario. Of the overall 454 acre feet, the 13 acre feet represent a three percent decline in the water attenuated by the floodplain.

For an irregular flood event such as the 1997 flood, perhaps the most important result from this modeling exercise is that the peak flow actually takes much longer to pass through the floodplain. Under the simplified assumptions of the model, an encroached floodplain, with a swifter flood flow, would result in the peak flow arriving at the bottom of the reach (near Carson City) fully an hour and a half sooner than with the un-encroached floodplain. This represents a decrease of 41 percent in the timing of the flood through the reach, and has implications for emergency warning and planning time.

For the less frequent flood event represented by the 2006 flood simulation, a collection of similar results are seen (see Table 7). First, the flood flow is decreased less in the developed floodplain than it was in the actual event. The model suggests that the un-encroached floodplain reduced the flow by 87 cfs more than the developed scenario, or a 67 percent decrease in this ecological service. The related volume of water attenuated is 11 percent less, or 18 acre feet less for the developed floodplain. Finally, in terms of emergency response timing, the un-encroached floodplain delayed the peak flow for 5 hours and 30 minutes, compared with the developed floodplain which only slowed the event by 3:40 (should this be 3 hours and 40 minutes?) minutes thereby providing an extra hour and 50 minutes for emergency responders to prepare.

Table 7 Flood Simulation Results for Encroached and Un-encroached Floodplain (10-25 Year Flood Event)

2006 (10-25 Year) Flood Event	Unencroached	Encroached	Difference
Peak flow (cfs) top of reach	11,900	11,900	
Peak flow (cfs) bottom of reach	11,771	11,858	
Change in flow (cfs)	*129*	*42*	*87*
Percent of total peak flow	*1.1%*	*0.4%*	*0.7%*
Percent loss with encroachment			*67%*
Volume (AF) top	60,042	60,042	
Volume(AF) bottom	59,872	59,890	
Change in Volume (AF)	*170*	*152*	*18*
Percent of total peak flow	*0.283%*	*0.253%*	*0.0%*
Percent loss with encroachment			*11%*
Time at top	11:00	11:01	
Time at bottom	4:30	2:40	
Total Time	*5:30*	*3:40*	*1:50*
Percent loss with encroachment			*33%*

Source: Elaborations on HEC-RAS model simulation results provided to ENTRIX by Mitch Blum, HDR, Inc. 2010.

Possibly the most interesting result of the model is that the emergency preparedness time of the encroached scenarios would be significantly less than the un-encroached scenarios. Under the conditions of the 1997 flood event in the encroached scenario, the peak flow would arrive at the bottom of the reach (near Carson City) an hour and a half sooner than with the un-encroached floodplain. Similarly, the 2006 event results show that the difference between encroached and un-encroached represent an hour and fifty minutes of time. The economic damages reported from flood events are often too narrowly focused on the value of damaged property structures. A comprehensive view of the economic impacts would include not only damages to physical structures but also impacts to overall quality of life as part of the long term economic damages. While these impacts are often difficult to quantify, and are not predictable, they are nevertheless a real cost of decreased emergency response time due to encroachment into the floodplain. An economic valuation of the costs to society from decreased response time could be another step in the determination of benefits derived from the natural floodplains.

EMERGENCY RESPONSE TIME

Flood advisories are communicated to residents by providing information and resources necessary for floodplain occupants to take actions to reduce their vulnerability to flooding. Timely flood advisories give residents time to prepare for the anticipated floods by lifting or removing the contents of their homes and businesses, putting up temporary flood barriers (i.e. sandbags, sealing entrances) to reduce structural damage and clean up costs, and to evacuate, if necessary. Advanced warning also gives time for emergency services to prepare for the flood event by putting into place evacuation and disaster relief (shelter, food, medicine) procedures.

Benefit-cost analyses were performed for several municipalities in the Pacific Island Countries to assess the impacts of improving flood forecast and warning systems. While the correlation between these studies and the situation on the Carson is not perfect it does lend evidence to the economic importance of an early warning system. One such case that was explored by Woodruff and Holland was in the Navua town and surrounding area. The warning system under analysis would initially be able to provide up to three hours warning prior to a "flash" flood. Once the system has been operating for some time, it is expected to provide up to six hours warning time. The basic infrastructure was expected to cost FJ $145,000, and there will be lesser operational costs associated with it as well. The benefits examined of the new warning system were estimated at between $2.1 to $4.2 million over the life of the system (20 years), resulting in a benefit cost ratio of 3.7: 1 to 7.3: 1. It is important to note that this study is not perfectly correlated with the situation in the Carson watershed. However, it does point to the extraordinary economic benefits associated with increased time for emergency preparation during a flood event.

Source: Flood Risk Reduction: Bridging the Gap between Science and Policy in Pacific Island Countries, for 2nd Australian Natural Hazards Management Conference, Wellington, New Zealand, July 2008, pg. 8, accessed online at http://www.sopac.org/data/virlib/MR/MR0696.pdf.

SECTION 5

Summary and Conclusions

The ecosystem functions provided by the natural floodplain of the Carson River provide many benefits to the region. However, these benefits are not directly tied to a specific market value, and are therefore difficult to understand in monetary terms. The purpose of this analysis is to provide information about the monetary value of these functions using several approaches.

One approach involves exploring the cost of alternatives. That is, what would happen if the floodplain were to be developed and ecosystem functions that are provided by the floodplain had to be re-created. The Truckee River provides an excellent comparison and a wealth of information on this topic, as there are several ongoing restoration projects in that watershed that are attempting to mimic the functions provided by a natural floodplain. The restoration costs of these projects can be considered society's willingness to pay for the benefits of a natural floodplain, and a suitable proxy for alternative costs. Based on information provided by The Nature Conservancy, and the Truckee River Flood Control Project the equivalent annualized costs per acre range from $564 to $1,679, assuming the benefits will accrue annually in perpetuity. When considering transferring this value to the Carson River, it is important to consider the potential overstatement of values due to the possible inclusion of costs that are not directly related to floodplain restoration (e.g. acquisition costs). Further, if watershed users are considering an annual lease, the dollar value of the lease should be lower than the estimated value of the services provided to watershed users if a net gain in value from the transaction is desired.

There are several other factors that may be considered when determining an appropriate lease value and mechanism. For example, the current development pressures along the Carson River raise the question of whether a long term conservation easement would be an ideal solution. However, given the uncertainty associated with population fluctuations and trends within the U.S. it is possible that this pressure will abate within 20 years or so. Furthermore, the recent housing bubble bust has resulted in surplus housing in major metropolitan areas like Phoenix and Las Vegas. Like any prudent investor, watershed users should carefully consider how much longer there will be development pressure in the watershed. Given the uncertainty, an annual lease may be most appropriate. By incorporating flexibility into the mechanism for land preservation, such as shorter term leases, landowners could be provided with the real economic value of the function of their floodplain, while at the same time protecting themselves against the possibility of a drop in development pressure, and thus being locked into what would essentially be a "non-performing" contract. Also, as development continues in the watershed, the value of the function that the existing natural floodplains provide could continue to rise. In this case, annual lease payments might be adjusted to respond accordingly.

The third section in this report covered details on relevant conservation easement and payment programs across the country. Information was presented concerning the structure of the programs, payments to participants, and potential results of each program implemented. Transferable Development Right (TDR) programs are developed based on a subjective set of criteria depending on the goals of managing entity. A similar program with a customized set of criteria could be developed for the Carson River, based on natural resources of the floodplain area, development pressures specific to the reach, and / or other objectives. On the other hand, this modeling can be complicated, and costly in terms of time as well as resources, and a simpler approach might be preferred. Instead, watershed users could develop one comprehensive value for the floodplain leases and offer a uniform payment to all landowners. This type of program could achieve the same results without the high transaction costs.

Finally, a preliminary hydrologic model was developed for the reach of the Carson River between Highway 395 and Carson City. Mitch Blum, with HDR, modeled a development in the floodplain of approximately 1,377 encroached floodplain acres. From this model he was able to estimate the additional impacts that would have occurred under two flood events, the New Year's Day events of 1997 and 2006. While the results of this model are only appropriate for discussion regarding preliminary planning they are important to consider carefully. The un-encroached floodplain (natural state) would have reduced the flow in the 1997 event by 319 cfs, and by 181 cfs in the 2006 flood event. Similarly, the attenuation capacity of the un-encroached floodplain was a full 18 acre feet greater in the 2006 event, and 13 acre feet in the 1997 event. In addition emergency response time was increased in the unencroached floodplain as compared with the developed floodplain.

Also, the hydrologic model provides a rough estimate of the potential behavior of flooding downstream of 395 on the Carson River. It is neither detailed nor long enough of a reach to provide scientifically accurate results. The hydrologic model results developed by Mitch Blum can only be used as a general approximation of floodplain behavior in this reach. While this model is very helpful for preliminary planning purposes, the limitations of the model are such that it is not appropriate to use as scientifically accurate. Another potential next step would be to develop a more detailed and comprehensive model to determine potential behavior of flooding in this and other reaches of the Carson River. Such a model could potentially be used as a scoring metric in a program where development rights are leased or purchased, as explained above.

For the purpose of this analysis every effort has been made to convert representative values to an annualized payment so the District might understand more about possible annual lease payments. However, much of the information and data available on this subject is in reference to acquisition or permanent easement payment programs which are not entirely compatible to an annual lease value.[29]

In conclusion, annual lease values for the Carson River floodplain are likely to fall between a few hundred dollars per year to just under $2,000 per year for very high-valued floodplain properties. At this juncture, the District might wish to pursue a more in-depth analysis of the specific values afforded by different properties in different reaches or alternatively offer an initial lease value to some landowners, and analyze the efficacy of the program after a trial period. Information about the income needs of landowners would also be helpful in determining an appropriate lease price.

[29] For a good discussion of annual preservation mechanisms see: Greene, Duncan and T.C. Richmond, Gretchen Greene, and Travis Greenwalt, "An Evaluation and Comparison of the Use of Certain Land Preservation Mechanisms," Prepared for Washington State Recreation and Conservation Office, Pursuant to SHB 1957 (2009), November 19, 2009.

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APPENDIX A

Discount Rate

Capital investment projects, such as the restoration projects evaluated in this analysis, invariably involve streams of benefits and costs over time. In this analysis the costs of the restoration projects are essentially represented as societies "willingness to pay," which in turn is used to value the ecosystem service benefits of the restoration project. The comparison and ranking of alternative investments or projects necessitates that these benefit and cost streams be expressed consistently. The consistency requirement, in turn, entails the use of present value and discounting methods for financial calculations. Discounting is a method that is essentially the reverse of compounding; discounting involves the expression of future values in present terms. The measure of this "time value of money" is thus the discount rate.

The discount rate has been the subject of a great deal of controversy in the economics literature, for a variety of reasons. One reason is that, in contrast to interest rates, the discount rate is not observable and is therefore subjective. Another reason is that interest rates and discount rates are not interchangeable. An interest rate measures the return that a present investment will provide over time. In contrast, a discount rate refers to the valuation of benefits today versus the future. The discount rate includes an expression of the "social rate of time preference." It reflects that individuals are naturally impatient and generally prefer present to future consumption; hence, individuals typically require more than one dollar in promised future benefits if they are to give up one dollar of consumption today.

In spite of the controversy, there is one aspect of the discount rate for which most economists are in general agreement: a real (as opposed to nominal) rate, which is free of inflation, should be used. A real rate is important because it provides a measure of the value of resources today versus the future, absent inflation. The real rate, therefore, plays an important role in evaluating investments. Similarly, it is logical to use an inflation free discount rate because benefits and costs are measured in real terms and not distorted by inflation in this analysis.

In the Carson River floodplain management plan, the concept of a living river is introduced as a way to protect the natural floodplain function and value.[30] Because this concept implies that benefits that accrue to future generations are considered as important as any which may accrue to the present generation, a discount rate should weigh these benefits equivalently. The lower the discount rate, the closer future values become to present values.

The U.S. Department of the Interior recommends the use of a discount rate equivalent to the water resources planning discount rate (currently 4.875 percent), as published annually in the Federal Register.[31] This rate is set by a federal planning board and is based on the nominal, or market, interest rate. Therefore, the rate may not be closely related to the true "social time preference" of money. If this rate were adjusted to reflect a real, or inflation free, rate the impact of inflation must be incorporated. Inflation has recently been between 2 and 3.5 percent annually. This results in a calculation of a real discount rate between 1.375 and 2.875 percent. As the policy is only a recommendation and not a requirement, it is not used in this economic study of the floodplain benefits of the Carson River for reasons stated above. However, it is evident that the calculated real rate from the suggested water resource planning discount rate is similar to the suggested discount range of two to four percent.

In this analysis, a discount rate of three percent is applied when annualizing present capital expenditures of restoration projects and associated floodplain benefits. This discount rate is approximately equivalent to the following economic measurements:

- the long-term average of (risk-free) U.S. treasury bonds;

[30] Carson River Floodplain Management Plan, pg. 10.
[31] *Federal Register,* 2007, Vol. 72, No. 221, p. 64669.

- the average real (inflation-free) interest rate for commercial loans; and
- the "pure" rate of time preference across generations, which is not affected by relatively short-term financial risk.

U.S. treasury bonds with long maturities (20 and 30 years) are a good measure for the discount rate for a couple of reasons. First, bonds with long-term maturities reflect the extended period of investment for large water projects (generally over 20 years). Secondly, U.S. treasury securities are considered risk free assets because the U.S. government backs them.

Table A-1 Rates for Long Term Maturing Treasury Securities, 1919-2006

Year	Nominal	Inflation	Real	Year	Nominal	Inflation	Real	Year	Nominal	Inflation	Real
2006	5.00%	2.71%	2.29%	1976	6.78%	5.76%	1.02%	1946	2.19%	8.33%	-6.14%
2005	4.64%	3.39%	1.25%	1975	6.98%	9.13%	-2.15%	1945	2.37%	2.27%	0.10%
2004	5.04%	2.66%	2.38%	1974	6.99%	11.04%	-4.05%	1944	2.48%	1.73%	0.75%
2003	4.96%	2.28%	2.68%	1973	6.30%	6.22%	0.08%	1943	2.47%	6.13%	-3.66%
2002	5.43%	1.58%	3.85%	1972	5.63%	3.21%	2.42%	1942	2.46%	10.88%	-8.42%
2001	5.63%	2.85%	2.78%	1971	5.74%	4.38%	1.36%	1941	2.05%	5.00%	-2.95%
2000	6.23%	3.36%	2.87%	1970	6.59%	5.72%	0.87%	1940	2.26%	0.72%	1.54%
1999	6.20%	2.21%	3.99%	1969	6.10%	5.46%	0.64%	1939	2.41%	-1.42%	3.83%
1998	5.72%	1.56%	4.16%	1968	5.25%	4.19%	1.06%	1938	2.61%	-2.08%	4.69%
1997	6.69%	2.29%	4.40%	1967	4.85%	3.09%	1.76%	1937	2.74%	3.60%	-0.86%
1996	6.83%	2.95%	3.88%	1966	4.66%	2.86%	1.80%	1936	2.69%	1.46%	1.23%
1995	6.94%	2.83%	4.11%	1965	4.21%	1.61%	2.60%	1935	2.79%	2.24%	0.55%
1994	7.41%	2.56%	4.85%	1964	4.15%	1.31%	2.84%	1934	3.12%	3.08%	0.04%
1993	6.46%	2.99%	3.47%	1963	4.00%	1.32%	2.68%	1933	3.31%	-5.11%	8.42%
1992	7.52%	3.01%	4.51%	1962	3.95%	1.00%	2.95%	1932	3.68%	-9.87%	13.55%
1991	8.16%	4.21%	3.95%	1961	3.90%	1.01%	2.89%	1931	3.34%	-8.98%	12.32%
1990	8.74%	5.40%	3.34%	1960	4.01%	1.72%	2.29%	1930	3.29%	-2.34%	5.63%
1989	8.58%	4.82%	3.76%	1959	4.07%	0.69%	3.38%	1929	3.60%	0.00%	3.60%
1988	8.98%	4.14%	4.84%	1958	3.43%	2.85%	0.58%	1928	3.33%	-1.72%	5.05%
1987	8.64%	3.65%	4.99%	1957	3.47%	3.31%	0.16%	1927	3.34%	-1.69%	5.03%
1986	8.14%	1.86%	6.28%	1956	3.08%	1.49%	1.59%	1926	3.68%	1.14%	2.54%
1985	10.75%	3.56%	7.19%	1955	2.84%	-0.37%	3.21%	1925	3.86%	2.34%	1.52%
1984	11.99%	4.32%	7.67%	1954	2.55%	0.75%	1.80%	1924	4.06%	0.00%	4.06%
1983	10.84%	3.21%	7.63%	1953	2.94%	0.75%	2.19%	1923	4.36%	1.79%	2.57%
1982	12.23%	6.16%	6.07%	1952	2.68%	1.92%	0.76%	1922	4.30%	-6.15%	10.45%
1981	12.87%	10.32%	2.55%	1951	2.57%	7.88%	-5.31%	1921	5.09%	-10.50%	15.59%
1980	10.81%	13.50%	-2.69%	1950	2.32%	1.26%	1.06%	1920	5.32%	15.61%	-10.29%
1979	8.74%	11.35%	-2.61%	1949	2.31%	-1.24%	3.55%	1919	4.73%	14.57%	-9.84%
1978	7.89%	7.59%	0.30%	1948	2.44%	8.07%	-5.63%				
1977	7.06%	6.50%	0.56%	1947	2.25%	14.36%	-12.11%	Average	5.16%	3.09%	2.07%

*Sources: US Bureau of Labor Statistics, All Urban Consumers Current Series, accessed online at http://www.bls.gov/cpi/, January 3, 2007.

Northwest Economic Associates (NEA), 1997, Economic Quantification of Nambe Reservation Reserved Water Rights, prepared for U.S. Department of Justice.

Federal Reserve Statistic Releases, Historic Data, accessed online at http://www.federalreserve.gov/RELEASES/h15/data.htm.

The negative real rates reported in Table A-1 above are not indicative of "normal" conditions. The negative rates could be an indication of something out of balance in the system, such as hyper inflation. In the table above the negative real rates artificially bring down the long term average, and thus it could be argued that a higher discount rate is appropriate for the social rate of time preference. In this analysis, it is suggested that a 3 percent discount rate be implemented for discounting, and annualizing the one time proxy costs over the useful life of the project.