COCKREHAM ISLAND BUY-OUT FEASIBILITY STUDY SKAGIT COUNTY, WASHINGTON

MAY 14, 2007

FOR
SKAGIT COUNTY PUBLIC WORKS

GeoEngineers

File No. 00220-077-01

GeoEngineers

May 14, 2007

Skagit County Public Works
1800 Continental Place
Mount Vernon, Washington 98273

Attention: Ric Boge

Subject: Report
Cockreham Island Feasibility Study
Lyman-Hamilton, Washington
File No. 0220-077-01

GeoEngineers is pleased to submit this draft final report for the Cockreham Island Flood Hazard Reduction Buy-Out Study located roughly between the communities of Lyman and Hamilton. We value the importance of this project to Skagit County Public Works and have enjoyed being involved in the complex and challenging effort. This report was compiled with collective assistance from our project team:

- GeoEngineers, Inc.
- Anchor Environmental, L.L.C.
- Northern Economics, Inc.
- HDR Engineering, Inc.
- Miller Consulting
- Leonard, Boudinot & Skodje, Inc.

We appreciate the opportunity to provide these services to Skagit County Public Works. If you need any additional information or have any questions regarding this report please don't hesitate to call.

Sincerely,

GeoEngineers, Inc.

Tracy A. Drury, PE
Associate

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Cockreham Island Flood Damage Reduction Feasibility Study
File No. 00220-077-01

May 14, 2007

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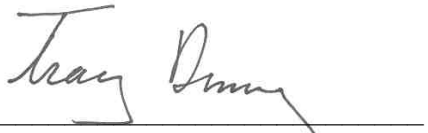

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TABLE OF CONTENTS

List of Tables

List of Figures

TABLE OF CONTENTS (CONTINUED)

ACRONYM LIST

ALEA	Aquatic Lands Enhancement Account
BCA	Benefit Cost Analysis
BCR	Benefit Cost Ratio
BMP	Best Management Practices
BBN	Bring Back the Natives
CREP	Conservation Reserve Enhancement Program
CAP	Continuing Authorities Program
DDF	Depth-Damage Function
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EMS	Emergency Medical Service
ESA	Endangered Species Act
EPA	Environmental Protection Agency
FPP	Farmland Preservation Program
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GIS	Global Imaging System
HEC-RAS	Hydrologic Engineering Center River Analysis System
IAC	Office of the Interagency Committee
LWCF	Land and Water Conservation Fund
MBC	Migratory Bird Conservancy
NFWF	National Fish and Wildlife Federation
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resource Conservation Service
NPCI	Native Plant Conservation Initiative
NAWCA	North American Wetland Conservation Act
NEI	Northern Economics, Inc.
OMB	Office of Management and Budget
PCA	Plant Conservation Alliance
PDM	Pre-Disaster Mitigation Program
PSE	Puget Sound Energy
RFP	Request for Proposals
RM	River Mile
SRFB	Salmon Recovery Funding Board
SCL	Seattle City Light
SCD	Skagit Conservation District

SCPW	Skagit County Public Works
SSH	South Skagit Highway
TEA-21	Transportation Equity Act for the 21st Century
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WDFW	Washington Department of Fish and Wildlife
WAG	Watershed Assistance Grants
WHIP	Wildlife Habitat Incentive Program
WPDG	Wetland Program Development Grants
WWRP	Washington Wildlife and Recreation Program

COCKREHAM ISLAND BUY-OUT FEASIBILITY STUDY
SKAGIT COUNTY, WASHINGTON

EXECUTIVE SUMMARY

The Cockreham Island site is located roughly between the Towns of Lyman and Hamilton in Skagit County, Washington. The site is adjacent to the Skagit River, primarily composed of low lying floodplain, and has a history of flooding and flood related damages. The Cockreham Island Levee was first constructed in the mid-nineteen hundreds by local landowners to provide protection for agricultural lands on the island. While the levee does affect flooding, the island continues to be flooded by flow moving around the levee, spilling over banks to the south, and backwatering up into local slough channels and creeks. Flooding occurs during frequent discharge events, and during infrequent large floods the majority of the island is inundated.

A group of present landowners, that collectively own a large portion of the island, have requested that the county investigate the possibility of a buy-out of the island properties. These landowners have experienced repetitive damages over time that have not been covered by insurance or other relief funds. At this time they desire to relocate from the island.

Cockreham Island is not currently an island in the literal sense in that roads extend onto the island that are accessible except during floods when flood waters cut off access to the island. The dominate river feature in this area is a set of complementary bends (large S-shaped turns) that are being held in place by the Cockreham Island Levee and bank protection placed along the South Skagit Highway. These "training" structures limit channel movement, force the river to travel up the valley grade, and lock the river into this un-natural configuration. During flooding events the river will try to straighten and travel directly down the valley grade. This exerts pressure on the levee and protection along the South Skagit Highway and periodic maintenance has been required to maintain the integrity of these structures.

A benefit cost analysis has established that a buy-out of the Cockreham Island properties is potentially cost-effective. This analysis compared the cost of buying properties on the island to the cost of future flood damages and maintenance of infrastructure. The analysis considered discount rates of both 3.0 percent and 7.0 percent to compute the net present value for future costs and benefits. A discount rate is a means of presenting future value in present dollars. Most Federal programs use the 3.0 rates, while FEMA uses the 7.0 rate. A benefits/cost ratio was calculated using the 3.0 and 7.0 percent rates resulting in benefit to cost ratios of 4.8 and 2.5 respectively. The larger these ratios, the higher the buy-out will be rated when applying for grant funding through Federal programs.

Buy-out of the Cockreham Island parcels will not likely occur from one funding source or through one large scale action. It is more likely that a buy-out would occur using multiple funding sources over an undefined period of time. This suggests that it would be prudent to prioritize parcels for buy-out and develop a plan to acquire parcels over time as funds become available. We recommend the following spatial buy-out prioritization:

1. All properties located south of Snider Road, west of Cockreham Island Road, and south of the Cascade Trail
2. All properties south of Jim's Slough
3. All properties south of SR 20 that are inundated under 10-year recurrence flow conditions
4. All remaining properties

Prioritizing buy-out within each of these spatial prioritization levels could be done by comparing purchase costs, parcel level benefit-cost ratios, gains in ecological benefit, landowner willingness, flood frequency, or by using a combination of criterion. Approximate costs for purchase of properties within each prioritization area are summarized below.

- Priority Area 1: $5.7 million
- Priority Area 2: $2.3 million
- Priority Area 3: $4.0 million
- Priority Area 4: $1.8 million

The property cost acquisition estimate is based on the property values published by the Skagit County Assessors' office plus demolition costs. The Assessors' value is often less than market value. To account for this difference we entered into discussions with Assessors' office staff. They recommended that the assessed value be increased by 30% (multiplied by 1.3).

In some cases the assessed value did not include the value of land. This exclusion occurs when a property owner has an exemption from paying taxes (e.g. exemptions are categorized for open space, agricultural, disability or seniors). In these cases, an adjustment was made to include the land market value in the acquisition costs.

Adjusting the accessed value for each parcel as described above resulted in a total acquisition cost of approximately $12.5 million. In addition to the property acquisition cost of $12.5 million, demolition costs for removing residences and outbuildings was estimated to be approximately $1.3 million for Cockreham Island. Therefore, total property acquisition and demolition costs were estimated to be approximately $13.8 million.

Once sufficient properties have been secured, we recommend that the lower portion of the Cockreham Island Levee be removed. This would allow the river to create a new mainstem channel through the island reducing present risk of levee failure, flood backwatering, and maintenance costs. The levee will need to be removed in phases to allow for the river to adjust incrementally. Determining the extent and timing of feasible levee removal requires further study. It is possible that much of the levee can be removed through time as the river adjusts. However, the levee currently provides valued protection for SR 20 and the Town of Lyman. The river would likely migrate toward and threaten these locations if the levee were removed or failed. Hence, continued protection of SR 20 and the Lyman area will be a requirement of future river management activities for this area. In the meantime, the upper portion of the levee should be closely monitored and maintained to stave off a levee failure event.

Purchasing these properties and sequentially removing the Cockreham Island Levee would result in immediate habitat benefit as well as vast opportunities for future habitat restoration. In addition, the transfer into public lands (coupled with similar public acquisitions upstream and downstream) would provide a large open space for various recreation opportunities related to the river, local fish, fowl, and wildlife, and the Cascade Trail.

Moving forward with a buy-out will require a number of action items to gain additional information, clarify outstanding issues, and establish a formal pathway for landowners. Some action items may be best completed by Skagit County Public Works, while other tasks will likely require landowner and/or

additional stakeholder involvement. Below is a list of potential next steps that could be taken to move the buy-out process forward. This list is presented in no particular order of sequence or importance.

- Investigate current zoning and possible re-zoning to accommodate future land uses, including possible actions to restrict development/new construction

- Adopt the recommended action in this report as Skagit County's vision for future management and discontinue maintaining the lower portion of the levee

- Present Skagit County's vision for future land use on the island to potential funding sources

- Make a formal presentation to those entities controlling mitigation funds for FERC re-licensing of the local dams in hopes that they may get involved in buy-out of Cockreham Island parcels

- Develop buyout priority zones based upon proposed future land use

- Develop a buyout priority list by parcel, based upon the parcel's benefit/cost ratio and location within the buyout priority zones

- Negotiate a mitigation plan with the tribes and other resource managers that will allow some or all of Skagit County's (or other entities) future mitigation to occur in the form of buy-out on the island (This would suggest that the Skagit County purchase the property ranked highest on the priority list. If the mitigation requirement is not enough to purchase that property, those funds would be placed into an account and added to with future mitigation monies until the purchase amount was accrued). This may or may not include deeding these properties to a local non-profit or directly to the tribes

- Establish a formal process for landowners to voluntarily express an interest in being bought out and develop a list of those interested

- Assist individual landowners in developing FEMA grant applications to acquire monies for purchase of their properties

- Establish a floodplain buy-out fund within the county to be used for future purchases on Cockreham Island

COCKREHAM ISLAND BUY-OUT FEASIBILITY STUDY
SKAGIT COUNTY, WASHINGTON

INTRODUCTION

This report presents the results of our technical and economic analyses associated with a floodplain buy-out feasibility study for Cockreham Island located in Skagit County, Washington (Figure 1). Cockreham Island is located roughly between the Towns of Lyman and Hamilton, from approximately River Mile (RM) 35 to 39 on the Skagit River (Figure 2). The study area includes properties located between the communities of Lyman and Hamilton and south of SR 20 (Figure 3). At the time of this study, there were 144 parcels within our study area, owned by approximately 69 private and corporate landowners. Many of these properties are repetitive damages sites, meaning that they have received flood damages more that twice over the course of the last few decades. Repetitive damage sites are prioritized for buy-out funding by the Federal Emergency Management Agency (FEMA) and typically rank high within funding criteria for a variety of grant programs.

PROJECT UNDERSTANDING

Private landowners on Cockreham Island have been experiencing flood damages for decades. Some of these damages have been recoverable through farm aid or flood damage assistance programs, however much of these costs have been borne by the individual landowners. Skagit County Public Works (SCPW) has also expended a significant amount of money on and around the island for repair of flood damages and maintenance of local public infrastructure and the existing levee. These costs can be significant and are likely to continue into the future. It is speculated that with expected pressure to increase fish habitat protection efforts, these costs may only increase in the future.

SCPW would like to investigate the feasibility of floodplain buy-out throughout Cockreham Island and how such a buy-out might be achieved. Interest in a buy-out of these properties was initiated by a group of local landowners that collectively own a majority of the Cockreham Island area. Floodplain buy-out would remove these and other private landowners from the island thereby reducing the need for public infrastructure and the associated maintenance costs. In addition, it may reduce the need for maintenance of the existing "training" levee and repetitive flood damage repairs for infrastructure along the South Skagit Highway (SSH). Altering the future management of the levee would need to consider the impacts to the island, its adjacent communities, and SR 20. Informed decision making relative to levee management will require an understanding of the current and expected future geomorphic conditions within the river and its floodplain. This will provide the basis for management decisions aimed at reducing human influences on river dynamics while minimizing potential risks to existing private properties and public infrastructure.

Purchasing private properties on the island could provide for a wide range of possible future land use and land management approaches. These possibilities include, but are not limited to, continued agricultural use, open space for aquatic and terrestrial habitat, development for public access and use, and river and floodplain restoration. Because of the physical size of the area and costs associated with buy-out, it is likely that the entire island would not be purchased by one entity or through one grant. Hence a buy-out will likely include a combination of funding sources and land uses.

REPORT ORGANIZATION

This report covers a variety of technical, economic, and practical topics. Some of these topics are directly related, while others support analyses or can be considered relatively independent. For purposes of

clarity, we have summarized some of these topics in the body of the report and included the detailed data, analyses, and explanations in appendices in the back of this report.

In general, the body of the report describes the Skagit River Valley and the Cockreham Island site conditions, followed by a summarization of the Benefit Cost Analysis (BCA). Next the present, historic, and potential future geomorphic conditions are described. Geomorphic conditions drive/affect channel/floodplain dynamics. Understanding these processes helps make informed decisions about future management of the levee and Cockreham Island. A brief discussion of flood data used in this analysis is presented, followed by a discussion of river management implication for the island and local area. A summary of the possible future land use alternatives is presented along with a discussion of potential funding source opportunities. Finally, we present recommendations based upon the results of the study. Additional data and supporting information can be found in the following appendices toward the latter part of this report.

- Appendix A Hydrology and Hydraulic Analysis
- Appendix B Benefit Cost Analysis
- Appendix C Land Management Suitability
- Appendix D Funding Source Evaluation

REGIONAL SETTING

The Skagit River is 127 river miles (RM) long from the Canadian border to its mouth and is the largest river to drain into Washington's Puget Sound. The majority of the basin's area is located in the upper tributaries beginning in the Northern Cascades range with peaks greater than 10,000 feet in elevation. Its extensive dendritic headwaters drain much of the western slope (wetter climate) of the range, from Glacier Peak to north and east of Mount Baker and into southern Canada. A number of its major tributaries (Sauk, Cascade, and Baker Rivers: Figure 1) originate from glaciers and have moderately high sediment production. Hydro power/flood storage dams are located on the Upper Skagit and Baker Rivers. The 50+ year old dams cut off the upstream sediment supply of these rivers. Currently the Sauk River, classified as a 'wild and scenic river' is the largest source of sediment to the river system.

Downstream of the Sauk River confluence, near RM 67, the Skagit River enters a transitional section of the basin. The river flows westerly within a 30-mile long glacially formed u-shaped valley. The valley was carved from bedrock during the last alpine glaciation that affected this area approximately 17,000 years ago. The valley subsequently filled with glacial sediments and younger alluvium that now compose the valley floor. The valley has a flat floor with a gentle gradient and steep valley walls. The valley floor broadens from approximately 4,000 to 12,000 feet as it progresses downstream.

The steep bedrock/landslide prone valley walls drain many tributary streams (with small drainage areas and high gradients) that shed off the valley walls and flow into the mainstem of the Skagit River or its side channels. The tributary streams transport sediment from the valley walls to the valley floor where alluvial fans have developed along much of the edge of the valley floor. In addition to the alluvial fans, numerous terraces composed of glacial sediments and Holocene volcanic lahars partially constrict channel movement on the valley floor.

SITE DESCRIPTION

Cockreham Island is located on the north side of a large bend in the Skagit River between RM 35 and 39. However, Cockreham Island is not currently an island in the literal sense but can be more accurately

described as a portion of the right floodplain (Figure 4). Jim's Slough traverses the floodplain, and this slough is likely a former mainstem channel that remained connected to the river for a long period of time. It is likely that the Cockreham area was referred to as an island (named) when Jim's Slough had a constant connection with the mainstem Skagit River. Currently, there are roads leading to the island that are accessible except during flooding events. Much of the island is low floodplain although some areas, mostly those further from the river, are up to 30 feet above the level of the riverbed.

Historically, the Lyman Ferry used to operate near the southern most portion of the island (Figure 4). The island was cleared for agricultural use during the early 1900's. The Cockreham "training" Levee was constructed to prevent future channel migration of the river and prevent the mainstem channel from eroding through the island via Jim's Slough (Figure 4). Much of the island is currently in agricultural use, primarily as grass lands for cattle grazing and/or green chop.

The Cockreham Island area possesses an integrated tributary and slough channel network that is currently uncommon in the Skagit River system and not found at all upstream of this site. Several tributary creeks that drain the steep valley hillslopes to the north traverse the valley floor and Cockreham Island prior to reaching their confluence with the Skagit River (Figure 4). Some of these creeks enter Jim's Slough, while others confluence directly into the Skagit River near the west portion of the island. These creeks have relatively long channel lengths at lesser gradients relative to tributary creeks further upstream in the basin. The valley becomes narrow upstream of Cockreham Island and tributary channels tend to converge quickly with the Skagit River once descending from the valley walls.

While the ecological role that this area plays in the overall system is uncertain, the confluence area (near RM 35) is known to be heavily utilized by juvenile salmonids. Tributary channels in this area provide relatively long lengths of low gradient channel with high habitat value. Jim's Slough is also considered valuable habitat, although water quality issues during low flow limit the overall productivity. It can be speculated that this area may provide two critical roles in salmonid life history: It may be a destination for many spawning fish that don't find like habitat upstream, and it may be the first location downstream for fish incubated in the upper watershed to escape the mainstem and rear in more preferable habitat conditions. What is certain is that the lower area near the confluence with the Skagit River is heavily used by juveniles for rearing.

During flooding events, floodwaters converge upon the island from multiple sources and directions. Backwater from the Skagit River swells up Jim's Slough, inundating the western portion of the island. Tributary channels draining the north valley slope converge with these backwaters and spill across the island. Flood waters from the Skagit River back-flow up the Muddy Creek channel flooding the area along Davis Slough and the Lyman-Hamilton Road. These floodwaters eventually converge into the Jim's Slough channel (Figure 4). Collectively, flood waters overwhelm culverts and roadways and isolate the southern portion of Cockreham Island from vehicle access. At the same time, flood waters from the mainstem Skagit River overtop the banks and traverse the island from the east and south inundating much of the island.

The Cockreham Island training levee forms the boundary of the active channel along a majority of the right bank of the Skagit River from approximately RM 38 to 39, and is approximately 6000 feet in length (Figure 4). The channel side of the levee is lined with large riprap that extends down below the low water elevation. This levee was built by local residents some time in the late 1940's or early 1950's in order to protect the agricultural lands on Cockreham Island. The primary function of the training levee is to maintain the existing channel location and prevent high-velocity flows from exiting the existing channel

and cutting a new channel across Cockreham Island. Without the levee in place, it is likely that the river would re-capture Jim's Slough as a major flow path, potentially converting it to the mainstem channel.

It should be noted that the Cockreham Island Levee is intended only to prevent the river from cutting a new channel across the island during minor to moderate flood events and not to prevent the island from flooding. Additionally, it should be noted that the removal of this levee would not provide any significant flood control benefits to the valley downstream. The island area is relatively flat and gets inundated by floodwaters from several locations and sources. Therefore, the levee affects the location and rate of floodwaters flowing out of the river. Floodwater flows onto Cockreham Island around each end of the levee allowing for lower velocities and a more gradual flooding of the island which reduces the potential for out-of-bank flows to cut a new channel through the Jim's Slough area.

Based on accounts presented by Skagit County engineers, the levee has suffered notable damage during previous flood events that occurred in 1980, 1990, and 1995. A large levee breach occurred during 1980. The 1990 floods caused the levee to fail in the middle and caused severe erosion on the backslope, requiring repairs over the entire backslope of the levee. During the 1995 flood event, the ends of the levee failed as floodwaters flowed out of the channel around the ends of the levee. More recently, concerns were raised about damages that occurred in 2003 and maintenance activities have been conducted in the years 2003-2005.

BENEFIT COST ANALYSIS

The purpose of the Total Benefit Cost Analysis (TBCA) is to estimate the benefits and costs associated with the proposed buy-out of Cockreham Island. Currently, much of the land within Cockreham Island floods with some frequency. The TBCA compares an estimate of future flood damage costs, which would be avoided if a buy-out occurs, to the costs of the proposed buy-out. If a proposed buy-out occurs and the levee is removed reconnecting the river to a floodplain, ecological benefits could occur. The TBCA includes this value through the addition of ecosystem goods and services.

The categories of benefits and costs included in the TBCA are listed and described in the text below.

Table 1. Benefit and Cost Categories

Benefit and Cost Category	Description
Benefits	
Traditional avoided costs of flood (includes):	
Building damage	Damage to homes and out-builds that result from a flood
Agricultural damage	Damage to farm fields and agricultural operations that result from a flood
Loss of function	Business income, such as farm sales that are lost to a flood
Displacement	The costs associated with flood victims housing costs while they are waiting to return to their homes
Road maintenance	Annual cost of maintaining the roads on the island plus the cost of repairing the roads following a flood
Levee maintenance	Annual cost of maintaining the roads on the island plus the cost of repairing the roads following a flood
Ecosystem goods and services	The value of goods and services provided by naturally functioning landscapes

Benefit and Cost Category	Description
Costs	
Property acquisition	Cost of purchasing the private property from land owners
Demolition of buildings	Cost of removing residences, farm buildings, and other out buildings
Removal of infrastructure	Cost of removing roads and public utilities
Lost tax revenue	Loss of the annual tax revenue currently paid to the County from the landowners

Traditional Benefit Cost Analysis of flood damage, considers the avoided costs of flood damage and levee maintenance as the Study benefits. The proposed buy-out would retire land from production which is prone to frequent flooding. The buy-out would eliminate the need to repair flood damage to buildings, roads, and farm fields after a flood has occurred as well as the avoided displacement costs of the residents. Additionally, the proposed buy-out would eliminate or reduce the need for public investment in levee maintenance.

The second category of benefit is referred to as the **Ecological Economic Analysis** which considers the value of the ecosystem goods and services that may become available as the purchased land returns to historical conditions. Ecosystem goods are measured in terms of something that an ecosystem produces, such as habitat or increased recreational opportunities. Ecosystem services are measured in terms of regulating functions, such as potential water quality improvements, like temperature reductions and uptake of nitrogen that can occur in a natural riparian zone.

Summary results of the TBCA are displayed in Figure A and B below. Figure A shows the present value of estimates for costs and benefits using a 3.0 percent discount rate, and Figure B shows results using the 7.0 percent discount rate.

Figure A. Present Value Estimate of Total Benefits and Costs 3% Discount Rate ($2005)

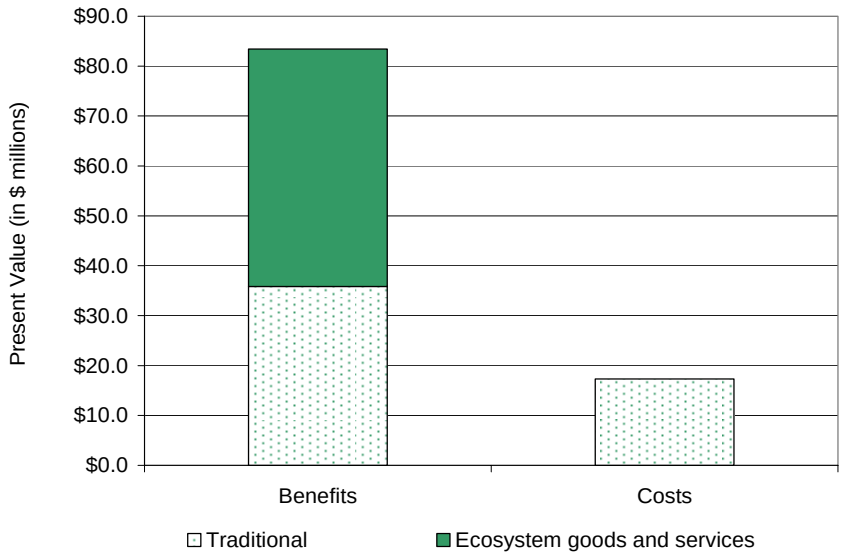
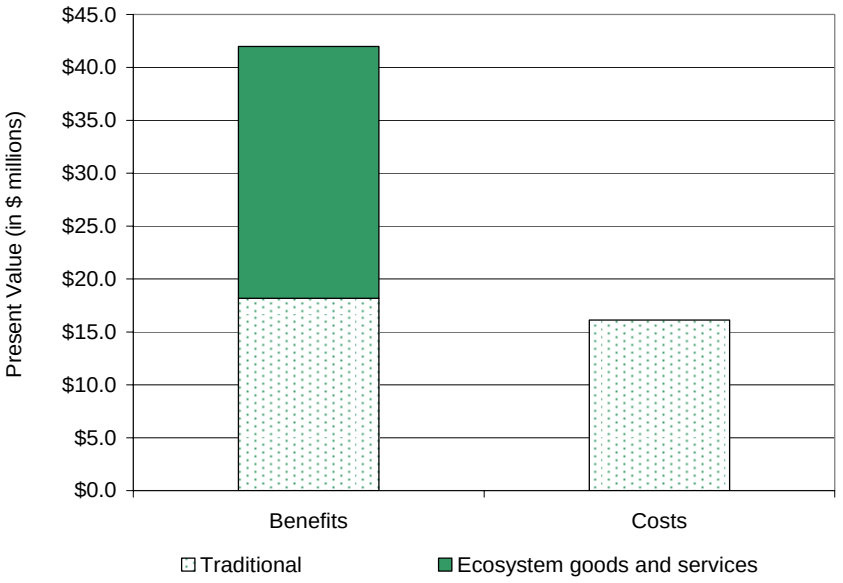


Figure B. Present Value Estimate of Total Benefits and Costs 7% Discount Rate ($2005)



Benefits and costs of the proposed buy-out occur over many years. The TBCA must calculate the present value of all benefits and costs over the life of a project. A present value analysis considers the stream of annual future value of benefits and costs over a 100-year time frame. The 100-year timeframe is a standard assumed value given the permanency of the proposed buy-out. In order to add the stream of future benefits and costs they must be expressed in present dollars. Discount rates are used to express values in present dollars. Two discount rates were used for the BCA because the Federal Office of Management and Budget (OMB) specifies that agencies should use a 3.0 percent discount rate for projects

(OMB, 2006a), while Federal Emergency Management Agency (FEMA) requires the use of a 7.0 percent discount rate for its grant applications (FEMA, 2005b).

The higher the discount rate, the lower the present value of future benefits or costs, therefore the net effect of the FEMA mandate to use a 7.0 percent discount rate is to value benefits or cost savings that occur closer to the present time much more than savings that occur farther in the future.

Depending upon the discount rate, the present value of estimated total benefits over the 100-year time period ranges from $39.8 million to $83.4 million. The present value of estimated total costs over the 100-year time period ranges from $16.1 million to $17.3 million.

Clearly demonstrated in Figures 1 and 2 is the value of ecological services. When the present value of ecological services is added in the present value of estimated benefits of the proposed buy-out are greatly increased. Further, the benefit-cost ratios increase to between 2.5 and 4.8. A benefit cost ratio greater than one indicates that benefits are greater than costs. The larger the benefit cost ratio, the larger the benefits relative to costs. The benefit cost ratios are provided in Table 2.

Table 2. Summary of Total Benefits and Costs ($2005)

Category of Benefit and Cost	Three percent discount			Seven percent discount		
	Benefits	**Costs**	**BCR**	**Benefits**	**Costs**	**BCR**
	($millions)	($millions)	(B/C)	($millions)	($millions)	(B/C)
Traditional BCA	$35.8	$17.3		$16.0	$16.1	
Ecosystem Goods and Services	$47.6	$0.00		$23.8	$0.00	
Total	$83.4	$17.3	4.8	$39.8	$16.1	2.5

The complete benefit cost analysis and detailed parcel level information are presented in Appendix B of this report. Figures B-1 through B-9 display the results of the benefit cost analyses on a parcel level.

GEOMORPHIC ASSESSMENT

A geomorphic assessment evaluates the geomorphic conditions and processes that may influence a site over time. Evaluating these processes helps to understand how the river will likely affect our project site and adjacent lands in the future. In addition, it helps to understand how alternative actions may influence ongoing geomorphic processes and what the implications of the each alternative may be to conditions in the river and/or adjacent properties.

To help understand the geomorphic conditions that may influence a specific site over time it is important to understand the site's location in relation to large-scale geomorphic influences; i.e. the geomorphic context of the site. Understanding the geomorphic context of the site means understanding how the existing conditions at the site are a product of and influenced by basin-scale and reach-scale geomorphic controls. Hence, understanding the geomorphic context of the site clarifies site conditions that may be either stagnant or dynamic in the future.

Basin Scale geomorphic influences

Basin-scale influences on river morphology are often geologically derived, but can also be a by-product of human interaction with the river system. The following paragraphs describe these processes and the implications on the present day river.

Geologic influences

Past geologic processes, mainly glacial and volcanic activity, have shaped the Skagit River Valley into what we observe today. The greatest influence on the geomorphology of the Skagit Valley has been Pleistocene glaciation, more specifically the latest Fraser Glaciation (approximately 21,000 to 10,000 years B.P.). Glacial deposits from the Fraser Glaciation mantle the valley walls and partially fill the Skagit River Valley (Figure 5). The earliest phase of the Fraser Glaciation is the Evans Creek Stade which was primarily an advance of alpine glaciers traveling down river valleys including the Skagit. Glacial till deposits from this advance are found down valley at least as far as Lyman (Dragovich et al., 2000). A period of retreat ensued after the Evans Creek Stade and prior to the advance of the continental ice sheet. The advance of the continental ice is called the Vashon Stade of glaciation. The Vashon ice sheet moved down from Canada and blocked many of the major drainages that flow from the Cascades, often forming glacially dammed lakes prior to traveling up the valleys. The Vashon Stade continental ice traveled up the Skagit River valley overlying and compressing prior Evans Creek Stade glacial deposits. Vashon glacial deposits are mapped as far east as river mile (RM) 80 along the Skagit River.

The geologic history of the Skagit River can still be seen in the landscape today. The river valley upstream of RM 42 is dominated by glacial deposits which have been slightly reworked by the Skagit River over time. From approximately RM 40 down stream to the mouth of the river, the valley floor is dominated by volcanic mudflow deposits that have been considerably reworked by the Skagit River over time. The deposits are the result of likely just one or two massive mudflows mid to late Holocene in age (5,000 to 1,700 years before present) that originated from Glacier Peak (Dragovich et. al., 2000). These extensive deposits spread out and came to rest across the entire width of the valley floor but were subsequently scoured out by the Skagit River. However, intact fragments of these mudflow deposits scattered across the valley floor indicate that the Skagit River has not utilized the entire width of the valley since the time of deposition.

Human Influences

As described previously, there are large hydro power/flood storage dams located on the Upper Skagit and Baker Rivers. In the upper Skagit River, the Gorge Dam is the furthest downstream and was originally constructed in 1924 as a wooden weir. It was replaced with a concrete structure in 1961. Diablo Dam was built in 1930 further upstream and Ross Dam, the furthest upstream, was constructed in stages from 1940 through 1953. On the Baker River, the lower dam was built in 1925 and the upper dam was completed in 1959. These dams cut off the upstream sediment supply from the Upper Skagit River and Baker River to the middle and lower Skagit River. A reduction in sediment supply in a fluvial system increases the transport capacity of the system, meaning that the river/stream has more energy available to move sediments than it would prior to the reduction in sediment supply. This excess energy is typically expended through erosion of the river banks and/or bed. Therefore, the river may meander more than under prior conditions, or it may down-cut into the valley and meander less. Factors determining which process occurs typically include the bank and bed materials' resistance to erosion, channel and/or valley slope, and hydrologic regime. Therefore, it is possible, and in fact quite common, that some segments of the river tend to increase meander activity while other segments incise and remain relatively stagnant in channel location within the floodplain.

Basin scale geomorphic characterization

Evaluating the basin-scale river morphology of the Skagit River involves assessing the river valley, floodplain, and channel. In many river systems, there are locations within the basin where changes in valley characteristics coincide with changes in floodplain and channel characteristics. Our evaluation looked for the locations of these changes and how these changes may affect Cockreham Island. For

purposes of clarification we have separated this discussion into characterization of the river valley/floodplain and river channel.

Valley/Floodplain Characterization

The Skagit River valley and floodplain change in character upstream, downstream, and through the Cockreham Island site. From RM 65 near the confluence of the Sauk River to RM 42, the valley is relatively narrow and the floodplain does not display much evidence of past channel migration or river occupation. A transition point in valley and floodplain character occurs near RM 42, near the town of Hamilton (Figure 6). The width of the valley transitions from an average of less than 1 mile wide upstream of this point to over 2 miles wide downstream (Dragovich et. al., 2000). This location also marks a change in valley slope where the valley gradient upstream is steeper than it is downstream (Figure 6). In addition, downstream there are many meander scars and oxbows that show evidence of past channel locations in the floodplain (Figure 7). In summary, RM 42 is the transition point from a narrow valley with little channel migration history in the floodplain to a wide, broad valley with extensive historical channel migration through the floodplain.

Channel Characterization

Channel characterization provides a means of describing channels that look and behave similarly. This also provides a means of comparing one river channel to another or of differing segments of a given river. In the basin upstream of Cockreham Island, the river's character is that of a single-thread mainstem with few side-channels or evident channel migration activity. Just downstream of Lyman, the character of the river abruptly changes; the active river channel widens and splits into multiple channels separated by tree-covered islands and large gravel bars. In general the active river channel below RM 35 occupies a much broader width of the floodplain and displays much more channel migration activity than upstream segments; including Cockreham Island (Figure 7).

Discussion

Fluvial systems are dynamic, change is often relative, and there is commonly a relationship between the characteristics of the river, floodplain, and channel. What this means is that a change in the character of the valley and floodplain is often closely correlated with a character change in the active river channel. As described above, a change in valley/floodplain character occurs near RM 42, while a change in the character of the active channel occurs near RM 35. Based upon our site assessment and review of information, we would expect to see a change in the river morphology at the same location where the valley/floodplain character change occurs (i.e.; near RM 42). The reason for this disconnect may be better explained by land use and/or human influences between RM 42 and 35 and will be discussed within the following reach characterization section of this report.

REACH SCALE CHARACTERIZATION

The dominant fluvial feature within our study area is a set of "complementary" bends within the broad (~8,000 foot wide), relatively flat valley (Figure 8). Complementary bends are a set of meander bends that evolve through time in an interrelated manner. Channel migration of one bend typically results in an associated change in the other. Likewise, management to limit or alter channel movement of one bend will likely affect the other. Hence, there is a need to consider the bends conjunctively when making management decisions.

Complementary bends typically evolve in one of three general patterns: 1) coupled downstream migration, 2) successive meander cutoff, or 3) channel avulsion. 1) Coupled downstream migration occurs when migration rates on the outside or downstream segment of each meander bend are relatively equal. Each bend erodes through the floodplain, primarily along the downstream portion of the bend, and

the two bends slowly move down the valley grade together. In some cases, this progression can continue for long distances. However, in most instances this propagation evolves into one of the other modes of movement. 2) Successive meander cutoff occurs when one bend cuts off its meander amplitude and begins to migrate rapidly relative to the other. This changes hydraulic conditions in the complimentary bend typically leading to a similar meander cutoff. In this way, the two bends may move down the valley grade through a series of alternating meander cutoffs. 3) Channel avulsion occurs when the upstream bends cuts through the floodplain and reconnects with the river downstream of the lower bend, thus leaving the lower bend disconnected from the active channel. Essentially, the river abandons its current channel for a newly created channel or re-accesses a formerly abandoned channel. This typically straightens the river channel and ends the relationship between the two bends.

Evidence of past channel locations and movement can be identified in the floodplain when evaluating the aerial photos and digital elevation model. It is recognized from this review that the upper complimentary bend once traversed the area north of the community of Hamilton (Figure 9). A meander cutoff of this bend led to the upper bend's present day location. When reviewing the historic photo record, it can be seen that the upper bend was migrating rapidly toward Jim's Slough during the early 1900's. Left unmitigated, channel migration would likely have led to an avulsion through the Jim's Slough area. However, it is possible that a cutoff of the lower complimentary bend would also have occurred, depending upon multiple hydrologic and geomorphic parameters (Figure 9).

The installation of the dams in the upper watershed and the Baker River tributary channel has reduced the volume of sediment being delivered to and transported down the river valley. Comparing present day aerial photos (2001) to those taken in 1937, a dramatic reduction in the presence of gravel bars through the system can be noticed. In the 1937 aerial photos, gravel bars are present along the entire active river channel. In many locations, the river travels between large patches of recently developed gravel bars. In the 2001 aerial photos, gravel bars are much smaller and only found sporadically along the river. Many former gravel bars have become vegetated and stabilized.

The noted reduction in observed gravel bars and the growth of vegetation on formerly active gravel bars indicates that the river is, and has been, going through a process of change. The reduction in sediment supply caused by dam installation in the headwaters and tributaries has altered the character of the river. In 1937, the river through the Cockreham area was transporting much more sediment down the valley. As sediment delivery decreased, deposition and temporary sediment storage through this area also decreased. Since sediment deposition in the river channel is the primary driver for channel migration, active channel migration rates have also likely decreased significantly since 1937. The decrease in sediment supply to the project area has also disrupted the balance between sediment supply and transport capacity. Under current conditions, transport capacity appears to exceed the volume of sediment available for transport resulting in excess energy available for erosion of the river bed or banks. Through the Cockreham Island area, channel migration has been very minimal since 1937. Therefore, it is apparent that more energy has been expended on the riverbed and the river has incised as it has transported much of the available riverbed materials out of the area. This is clearly recognized in the area just upstream of Cockreham Island to approximately RM 47. In the 1937 photo, this segment has abundant un-vegetated gravel bars and displays traits of an active river channel. In the 2001 photo, few gravel bars are present, former bars have become vegetated and incorporated into the floodplain, and the width of the active channel has decreased and become uniform. All of these changes are indicative of a channel that has cut down into its bed and/or has experienced a reduction in hydraulic energy during floods.

Human interaction with the river has altered the natural channel migration patterns through the island. The Cockreham Island Levee has halted channel migration of the upper meander bend in both the lateral and downstream directions. In addition, protection measures associated with the SSH have limited channel migration of the lower bend (Figure 8). These infrastructure placements have essentially locked the channel in place from approximately RM 37 – 39. Through this section, the river travels up the valley grade before encountering the SSH where it turns south then west. While it is not uncommon for big rivers to travel up the valley grade for short spatial lengths, it is uncommon for a big river at this valley grade to maintain this spatial configuration for an extended time period.

Hydraulic conditions in the river are also affected by the levee and current spatial configuration of the river. The levee prevents flood flow across the island and backs water up through the bend during high flows. This increase in water surface level in the river increases back-flow up Muddy Creek and increases the flood elevation in the river upstream likely to and past the Town of Hamilton. As a result, sediment transport in this area is affected. During flood events, sediment transported from upstream can deposit in the slow moving backwaters upstream of the levee increasing bar deposits both upstream and across the river from the levee (Figure 8). To compensate for this bar development, the river needs to either migrate laterally, or incise (cut down) into the riverbed. It is also likely that an increase in flood elevations would also occur based on temporary sediment deposition during certain flooding conditions. Personal communications with local landowners, data presented by Pentec (2000), and recent data collected by SCPW all confirm that bar development across the river from the levee continues and that the river channel directly adjacent to the levee has deepened and narrowed. It can be expected that bar development will continue and that the toe of the levee will continue to be an area of concern in the future.

In summary, without the installation of the Cockreham Island Levee the present day channel and floodplain conditions would not likely exist. It is likely that the upper bend would have continued to migrate both laterally and downstream, likely capturing Jim's Slough and avulsing through the island. This would abandon the current mainstem channel from approximately RM 35 – 39, resulting in an avulsion and the dissolution of the complimentary bends. It is also possible that a meander cutoff of the lower bend would have occurred through a portion of the island prior to an avulsion. However, based upon the conditions within the floodplain on the island and river dynamics upstream of the island, it is likely that the river would have avulsed through the island primarily traversing through Jim's Slough (Figure 9).

FLOOD ASSESSMENT

A flood assessment across Cockreham Island is a vital component of the floodplain buy-out feasibility study. Modeling flood events provides a basis for delineating flood damages across the island and extrapolating known damages to areas on the island where damages were less known. In addition, correlating the magnitude of flood damages to the frequency of these occurrences allows for the extrapolation of potential damages well into the future. The following report sections describe the hydraulic modeling effort performed. How this information was used in the benefit cost analysis is described in more detail in Appendix B.

Skagit River Model

A HEC-RAS model of the entire lower Skagit River system (RM 0 to 78) was obtained from Ted Perkins (USACE, Seattle District) on October 20, 2005. To update the model for the present analysis, the river reach from Sedro-Woolley to Concrete was clipped out from the original model (RM 23.2 to 55.75). Additionally, the inflow boundary conditions were modified from flood hydrographs to steady-state peak

flows according to the published regulated flow rates for the Skagit River (USACE, 2004). A normal depth downstream boundary conditions was also applied at river mile 23.2.

In the vicinity of Cockreham Island, the updated model contains 6 measured cross-sections as shown on Figure A-1. These data were combined with survey data collected by SCPW across Cockreham Island (Figure A-1). A complete topographic surface of the project area (digital terrain model ([DTM]) was created by combining the 2-foot contour information for the overbank areas in Cockreham Island with the HEC-RAS cross-sections geometry for the channel itself (Figure A-2). Ultimately, a single surface was developed that contains the elevation information of both the riverbed and overbank areas, and this combined DTM was used in modeling flood flows.

River Discharge Data

The steady-state peak flow added to the HEC-RAS model was reported by the United States Geological Survey (USGS) in the *Skagit River Flood Damage Reduction and Ecosystem Restoration Project* (USGS, 2004) and the USACE technical hydrology report *Skagit River Flood Damage Reduction Feasibility Study* (USACE, 2004). These values are recognized by the Corps of Engineers, thereby would be the necessary evaluation data if applying for federal buy-out funding. Table 3 summarizes the regulated flow rates used in the model.

Table 3. Flood Frequency at Skagit River Near Concrete, WA

Flood Recurrence Interval (years)	Regulated Flow (cfs)
100	232,778
50	190,687
25	157,032
10	119,600
5	93,410
2	73,998
1	60,267

Inundation Mapping

Hydraulic modeling results were exported into our GIS for spatial display. This allows for an accurate assessment of which parcels become inundated under specific discharge conditions. In addition, we were able to delineate the depth of flooding for each parcel and compare that elevation to the elevation of houses and outbuildings. Flood damages for residential houses and outbuilding were determined separately. Structures evaluated in the study are displayed in Figure B-1. Model output for the recurrence flows displayed in Table 3 are presented in Figures A-3 through A-9. These figures display the area inundated by each respective flow as well as the distribution of inundation depths.

RIVER MANAGEMENT FOR COCKREHAM ISLAND

River management decisions for the Cockreham Island Levee have an impact on more than just the public infrastructure and private properties located on the island. The current configuration of the levee focuses energy toward the SSH where maintenance issues persist. Backwaters induced by the levee spill up Muddy Creek and likely contribute to flooding in the Town of Hamilton. Inadequate maintenance of the levee could result in catastrophic failure during flood events, potentially impacting SR 20 and/or the

Town of Lyman. Each of these considerations should play a role in the evaluation of alternative management actions and ultimately in decision making with respect to the future of Cockreham Island.

We understand that if a buy-out plan is implemented for Cockreham Island, SCPW would like to reduce maintenance activities and costs associated with the levee. However the levee currently provides valued protection for SR 20 and the Town of Lyman. The river would likely migrate toward and threaten these locations if the levee were removed or failed. Hence, continued protection of SR 20 and the Lyman area will be a requirement of future river management activities for this area. It has also come to our attention that some funding sources may desire removal of the levee and the re-establishment of more natural river and floodplain conditions. The following report sections discuss opportunities and constraints related to future management of Cockreham Island if a buy-out strategy is implemented.

Maintaining the Existing Levee

As described previously, the current levee restricts channel migration of the river, directs the river up the valley grade, and focuses energy along the SSH. This configuration backs up the river during floods promoting sediment deposition and gravel bar growth along the inside of the upper bend. The river has been adjusting to these conditions by eroding the riverbed directly adjacent to the Cockreham Levee. This has resulted in undercutting of the levee and some partial levee failure. While maintaining the levee by periodically placing additional rock along the water ward side of the levee will likely stave off any large scale failure, erosion along the toe of the levee is likely to continue. Growth of the gravel bar across the river will also likely continue; hence increased hydraulic and hydrostatic pressure on the levee can be expected. In simple terms, as gravels are deposited across the river from the levee, the river must erode the bed or banks in order to maintain conveyance. If neither occurs (because of continued placement of large rock) then an increase in flood elevations can be expected.

Increased flood elevations along the levee can pose a number of problems. Backwaters may extend further upstream increasing flooding in the Town of Hamilton. Floodwaters moving onto the island by overtopping or end-running the levee will have greater hydraulic energy potentially causing greater damages while traversing the island. And perhaps most problematic may be the additional flow traveling up Muddy Creek and spilling down the Lyman-Hamilton Road, into Davis Slough and ultimately into Jim's Slough. Backwater flood flow from the Skagit spilling out of Muddy Creek combines with runoff from tributaries to the north to isolate the island. Increasing these flows will increase the frequency of isolating events and potentially the damages incurred during these events.

Maintenance of the SSH adjacent to Cockreham Island can be thought of as a corollary activity to maintenance of the Cockreham Island Levee itself. If the Cockreham Island Levee continues to be maintained in its present configuration, continued maintenance of the SSH can be expected. Because of this connection, we suggest considering management implications along the SSH when evaluating management options for Cockreham Island

Levee Removal

Assuming that a buy-out plan for Cockreham Island is implemented, project proponents (funding sources and/or future land managers) may desire to remove the levee to restore more natural channel processes through this area. Levee removal will undoubtedly promote change in the system and likely result in the development of new and/or multiple channels. This will likely reduce flood elevations upstream of the levee and increase the habitat value of the river and floodplain. However, proponents for the removal of the Cockreham Island Levee will need to consider the potential implications of such a removal. The

following paragraphs describe the types of considerations that will need to be evaluated in more detail prior to pursuing removal of the levee.

Levee removal will alter the frequency and magnitude of flows overtopping the river banks and moving across the island. These flows will be distributed across a large area and the spatial distribution of frequently occurring flood events will likely be greater than under present day conditions. As described previously, these overbank flows will inundate much of the area south of SR 20 and will tend to collect in Jim's Slough and flow back into the Skagit River. This will lead to an increase in the frequency that Cockreham Island is isolated by flood flows and should be considered by potential future land managers.

While increasing overbank flows during low to moderate flood events will not likely affect the Cockreham Island area, the same may not be true during high discharge floods. During low discharge flows (annual flooding) the river will tend to erode along the margins and river bends will tend to expand and lengthen. During extreme high flows, the river will try to straighten and head down the valley grade. At Cockreham Island that means that the river will want to flow through the Jims' Slough area and towards the Town of Lyman. This could lead to erosion along Jim's Slough and an expansion of the Jim's Slough channel. As this expansion progresses, the channel becomes capable of conveying increased flows effectively and more and more water can be transported across the island. Typically this expansion begins at the lower end of these channels and travels (head cuts) up the channel. Once this expansion reaches the upstream end of the island, an avulsion would occur and the mainstem channel switches locations into the recently expanded channel.

While we can be fairly certain that the process of channel expansion and avulsion would likely begin in the Jim's Slough area, it is much more uncertain where the mainstem channel may settle in after an avulsion occurs. The river would be going through a great deal of change and this change is not inherently predictable. Channel expansion could occur through the middle of the island progressing through the southern most portion of Jim's Slough. Similarly, expansion could occur through the northerly portion of Jim's Slough, move toward SR 20, and reconnect with the river near the Town of Lyman. In either situation, it is likely that the river will continue to change position during subsequent high flow events. If channel expansion were to occur to the north, the Town of Lyman would likely be at risk either during the avulsion occurrence or during subsequent channel migration. In addition, a portion of the cascade trail would certainly be lost and the river could threaten SR 20 if migration continued to move toward the north.

Removal of the levee would also reinitiate channel migration along the upstream complimentary bend. As described previously, this could lead to one of three potential outcomes. However, we feel that the most likely scenario would be translation of the upper bend toward the northwest. This translation of the meander bend would increase overbank flows during flooding and promote the likelihood of an avulsion. In addition, it would become more likely that an avulsion would occur to the north resulting in the potential impacts described in the previous paragraph.

Channel migration activities would also likely increase upstream of the island near RM 40 across from the Town of Hamilton. This area is likely backwatered during existing conditions, but removing the levee would increase velocities here and likely result in a translation of the river away from Hamilton. The floodplain area along the left bank is low-lying and several small channels are present. As migration progresses, it is possible that additional and larger channels could develop through this area of the floodplain.

Partial Levee Removal and Adaptive Management

Reducing long term maintenance costs associated with Cockreham Island will be most effective if the geomorphic and hydraulic conditions of the site are considered in evaluating management alternatives. As we have described, the river is currently in an unstable configuration and a great deal of pressure is being exerted along the levee. The levee is currently maintaining these conditions and removing or modifying the levee will undoubtedly promote change. Promoting change that is consistent with unmitigated geomorphic processes will likely result in more predictable evolution of the river. Based upon review of available data and personal communications with local landowners, floodwaters have eroded channels into Cockreham Island on several occasions in the past 50 years. If these channels had been allowed to expand and capture the mainstem river channel, the lower bend would have been cut-off and the river would have abandoned the mainstem channel through the area adjacent to the SSH. We suggest that the first step in reducing maintenance requirements for the levee is to allow, if not promote, this occurrence.

In order to promote a predictable meander cut-off of the lower bend, partial removal of the Cockreham Island Levee would be necessary and some preliminary channel excavation would be recommended. The downstream portion of the levee would need to be removed extending approximately 2,500 – 3,000 feet in length (Figure 10). This will allow for floodwaters to access the island near RM 38.5. Based upon observations during the October 2003 flood, these overbank flows will likely traverse the island roughly along the current route of Snider Road, cross the current Cockreham Island Road location near the intersection of Snider and Cockreham Island Roads, and proceed down an old channel scar to connect back to the river near RM 35. We recommend that some channel excavation be conducted that will promote the reconnection to the current mainstem near RM 36. This reconnection point will serve the purpose of relieving pressure along the levee, while minimizing the likelihood of impacts to the Town of Lyman.

Further levee removal should be considered as a part of a monitoring and adaptive management plan. Monitoring of the meander cut-off described in the previous paragraph should evaluate the effects of the new channel configuration upstream, through the island, and downstream. The following list identifies some of the important components that the monitoring plan should evaluate:

- Erosion and channel migration upstream near RM 40
- Riverbar development near RM 39
- Erosion of the downstream portion of the levee that remains intact near RM 38.5
- Exact location that the new channel occupies relative to predicted location
- Expected direction of future channel movement
- Potential downstream impacts of current state
- Potential downstream impacts of future actions

We expect that it will be feasible to remove an additional section of the levee without creating adverse impacts once the river has adjusted to the initial partial levee removal. Additional study will be necessary to determine the extent of additional levee removal that is feasible. Technical evaluation of channel modifications that occur after the first segment of levee removal will also factor into future removal. Additional levee removal will likely result in an increase in the frequency and magnitude of overland flow moving across the floodplain and into Jim's Slough for a given discharge event. However, the risk of

channel avulsion will likely be reduced because of the adjusted channel conditions after the meander cut-off.

LAND MANAGEMENT PLAN

Cockreham Island has a diverse composition of morphology and land forms that can be suitable to a variety of future land uses. In evaluating the future land management possibilities, we considered suitable uses throughout the study area based upon soil capability, topography, inundation frequency, hydrology, expected geomorphic changes, existing habitat conditions and current uses. Based on these characteristics we delineated areas that were suitable for habitat restoration, agricultural use, and public access and recreation (Figures C-1 through C-3).

Much of the island area is suitable for multiple future land uses. Low lands can be reconditioned into wetlands or planted to provide riparian areas. Much of the uplands is suitable for agriculture, yet would provide for an array of recreation opportunities. Restoration opportunities are abundant and routing more surface water through Jim's Slough is a desired outcome. In addition, the future morphology of the river and its relationship with the levee remain key determining factors in the type and spatial distribution of future land uses.

As an example for use in discussion, we developed a composite land use distribution assuming that the lower portion of the levee was removed and the river was allowed to cut a new channel through the southern portion of the island (Figure C-4). Figure C-4 displays one option for future land use that is consistent with recommended river management actions, expected future geomorphic conditions, and potential restored habitat conditions. This potential land use distribution attempts to blend suitable land use within the island area while also reducing maintenance needs and costs.

The spatial suitability of each land use type is described in the following report sections along with the opportunities and benefits. Figures displaying this information are found in Appendix C.

Habitat Restoration

Within the Cockreham Island area, a multitude of habitat restoration options are suitable and many opportunities are present. Land use actions through the 19th century have limited the river's interaction with tributary channels and reduced surface water flow through Jim's Slough. Restoration could re-connect up to 3.7 miles of historic sloughs and numerous new perennial and ephemeral channels could be created and/or enhanced. In addition, there is ample area for floodplain planting with native vegetation to establish valuable adjacent riparian areas.

These restoration activities would be consistent with basin wide restoration planning. It has been estimated that the Skagit River system has lost roughly 45 percent of the off-channel slough salmon rearing habitat (Beechie et al, 1994). This off-channel slough habitat is used mainly for rearing by most of the salmon species that reside in the river including coho and Chinook salmon. Research has shown that restoring isolated habitat such as a slough results in dramatic increases in smolt production.

The opportunities to create and reconnect valuable, diverse, and complex habitat to the river system would benefit fish, waterfowl, and other aquatic and upland animals. A substantial amount of off-channel salmonid rearing habitat could be enhanced by reintroducing flow from the Skagit River into Jims Slough. Creating an opportunity for the river to avulse into a new channel through the southern portion of the island will allow for the establishment of a large, off-channel slough complex where the current channel is located. In addition, with a new channel flowing through the island, the opportunity for

secondary channels to be reformed and created in historic channel locations and low-lying areas on the island will be greatly enhanced. The increase in off-channel habitat created and enhanced will potentially increase salmonid smolt production. It has been estimated that in a restored Jims Slough alone, coho smolt production could potentially increase by 4,300 smolts and that Chinook smolt production could increase by 550 smolts (Pentec, 2000).

A diversity of habitat types could be established ranging from perennial and ephemeral channels, off-channel sloughs, wetlands, reestablished and enlarged riparian areas along channels, and restored upland areas (Figure C-1). The distributions of potential habitat conditions displayed in Figure C-1 is based upon site assessment and potential habitat restoration studies conducted by the Upper Skagit Indian Tribe and the Skagit River Systems Cooperative through separate contracts with SCPW. The type of habitat communities, their location, size, and species makeup is affected by the soils, hydrology, elevation, and frequency and duration of inundation at specific locations on the island. When reviewing topography and the inundation maps (Figures A-1 – A – 5) it is clear that the downstream 1/3 of the island (river mile 35 – 37) is more suitable for the development of a large wetland complex. There are also some locations on the island that remain above flood water even during the 10 and 25-year events where opportunities for the establishment of upland habitat are present.

Restoration of Cockreham Island is consistent with the goals and objectives of numerous local and regional interests including those of the *Skagit Chinook Recovery Plan 2005*. The Puget Sound community has come together under a Shared Strategy to save several salmon species from extinction (Puget Sound Salmon Recovery Plan, 2005). The Skagit chapter of the plan proposes several key strategies and actions that support salmon recovery. Habitat protection and restoration is an important action that if implemented, would help meet watershed recovery goals. Restoration of Cockreham Island is one of the actions proposed in the plan because "habitat value is very high, flood risks and associated costs are high, and the overall density of houses and infrastructure is relatively low" (Skagit Chinook Recovery Plan, 2005).

Agricultural use

Much of the Cockreham Island area is suitable for agricultural use and residential areas could be converted to farmland (Figure C-2). Some essential agricultural structures located above the 20-year flood could remain on the island to support continued agricultural activities, however residences would be removed. Soils with Capability Class II would remain in active agricultural use while lands with wet soils would not likely provide feasible agricultural benefits and would remain as wooded floodplain or wetlands. Hydrologic conditions would not be modified and the river would be allowed to overflow the island during high water events similar to how it currently functions, but without the resultant threat to safety and damage to residential structures and infrastructure.

Promoting agricultural conservation is consistent with the desired goals of agricultural interests in Skagit County by retaining lands for agricultural purposes. A concerted effort to conserve agricultural lands has occurred in the river delta area particularly. The Skagit Farmland Legacy Program is a Skagit County program that purchases agricultural easements on farmland that will remain in agricultural use in perpetuity. There are several agricultural groups who represent the interests of the agricultural community (Skagit Farm Bureau, Western Washington Agricultural Association, Skagitonians to Preserve Farmland). An additional benefit to be considered with this land use option is that not all properties would need to be a fee-simple purchase. Residential structures would be purchased and removed and development rights would be extinguished but landowners could continue to farm, lease the land for agricultural use, or sell the property to another with the intent of farming.

Public Access/ Recreation

The Cockreham Island area is suitable for a variety of active and passive outdoor recreation opportunities including: hunting, fishing, camping, picnicking, wildlife viewing, hiking, and environmental education (Figure C-3). With the installation of a boat ramp, trail heads, and parking areas these opportunities could be used by a wide variety of the public. The area would provide opportunities for hunting and fishing as well as bird watching, a gentle walk through fields and along creeks, or a vigorous bike ride along the Cascade Trail.

At the south end of the island a recreation site could be located on higher ground and provide camping, recreation vehicle (RV) use and possibly rental cabins. Cabins could be used almost year-round for summer holidays and hunting and fishing groups in the fall. Seasonal tent cabins on permanent platforms could be used instead of permanent, structured cabins. These structures would be more resilient to flood damage. The area around the historic Lyman Ferry site could become a day-use area with a ramp to launch boats and numerous day-use picnic sites. A boat-in and hike-in camp could be provided just down river from the historic ferry site on higher ground.

Two trailheads could provide public access for a variety of activities. The intersection of Cockreham Road and SR 20 would provide direct access to the Cascade Trail, and a second within the interior upland area would provide access to hikers, hunters, wildlife viewers and the interpretive trail system. A large portion of the low-lying west end of the island that is inundated at the 5 and 10-year floods could be set aside for wetlands and backwater sloughs and planted with native vegetation. The east end is higher in elevation and would be managed as upland habitat with possible agricultural cropping activities related to wildlife watching and hunting. Interpretive trails through these areas would allow one to view a variety of plants and animal species within a short walk or run. The trails could circumnavigate the island passing through a diversity of habitats and provide interpretive locations for the telling of stories attached to the intrinsic cultural, natural, and historic resources found on the site and within this reach of the river. The trail should be a soft path system with boardwalks and plank trail sections provided to cross wet areas and open water. The trail would connect to the Cascade Trail at several locations.

Providing additional open space, public access, and recreation benefits would provide desired recreation resources. According to the Skagit County Comprehensive Parks & Recreation Plan (2004), a new regional park, boat ramp, public shoreline, camping, and picnicking, and the ever popular non-motorized trails are much desired and needed facilities and activities in Skagit County. Incorporating these features into the Cockreham Island site would provide the residents of the county enhanced opportunities to participate in and experience the many outdoor activities available in this reach of the Skagit River valley.

Potential Future Land Use Distribution

In developing the potential land use distribution, the suitability of the differing land uses was evaluated along with public interests and potential changes in the local morphology. Perhaps the most important factor is the future management of the river and how the river may evolve. The combined land use distribution presented here is based upon the mainstem river occupying a new channel through the southern portion of the island (Figure C-4). With this new configuration, we can generally segregate the island area into three distinct areas: south of the new channel, between the new channel and Jim's Slough, and north of Jim's Slough. These areas are described in more detail in the following paragraphs.

The area south of the new channel would be isolated from Cockreham Island by the mainstem river. Active habitat restoration activities would likely be limited, although a significant habitat benefit would be realized in this area. Perhaps the greatest habitat benefit would be the long-term evolution of the

slough channel (current mainstem) and the upland areas being converted to meadows and forest. Recreation opportunities would likely be limited to day use hike-in or boat-in type activities. The primary access may be from the south, however property along the existing left bank is publicly owned both up and downstream of the island. This would result in a large, continuous area becoming available for remote hiking, hunting, fishing, etc. It is likely that agricultural use will not be suitable for this area.

Between Jim's Slough and the new channel a number of possibilities exist. This area will likely be an area where adaptive management based on evolution of the channel and floodplain will determine what is implemented. As presented in Figures C-1 through C-3, this area is suitable for a variety of habitat restoration, agricultural, and recreational opportunities. Figure C-4 presents one option of how this area could be used.

North of Jim's Slough, also provides a wide variety of potential future uses. This area will be impacted the least by the recommended realignment of the river, and may provide the best opportunities for economical agricultural use. The presence of the creek systems and the Cascade Trail provide for ample opportunities for restoration and recreation improvements as well.

The land use delineation in Figure C-4 represents one potential distribution of uses. Clearly the opportunities to mesh these uses are endless. What is certain is that this site provides many opportunities for long term habitat restoration and outdoor recreational activities that appeal to the broad cross-section of Skagit County residents and visitors. The variety of passive and non-consumptive uses include: camping, boating, hiking, wildlife viewing, water play, and interpretation of natural and cultural resources, while consumptive uses include fishing and hunting. The exact distribution of future land use will be greatly influenced by the funding sources secured for the purchase and the long term management of the property.

FUNDING SOURCE EVALUATION

Implementation of a management plan will require a coordinated and cooperative approach to funding. Given the size and complexity of the project and land use options, potential funding will likely not come from a single entity, but from a variety of Federal, state and other sources and will depend on whether project proponents are seeking money for acquisition, restoration or long-term stewardship.

Based on a review of the applicability of potential programs and past experiences with several of the funding sources, we feel that the following list of programs and organizations may provide the greatest opportunity for funding the buy-out of the island:

- Federal Emergency Management Agency
    - Pre-Disaster Mitigation Program (PDM) - This national program provides a consistent source of funding to State, Tribal and local governments for pre-disaster mitigation planning and projects primarily addressing natural hazards. National Flood Insurance Program (NFIP) repetitive flood loss properties are a priority. There is a $3M cap on the Federal share per project for mitigation projects and no cap for mitigation planning.
- US Fish and Wildlife Service
    - North American Wetlands Conservation Act Grants (NAWCA) - NAWCA grants support activities under the North American Waterfowl Management Plan. The plan is an international agreement between the US, Canada and Mexico for the long-term protection of wetland/upland habitats on which waterfowl and other migratory birds in North

America depend. Grants (up to $1 Million) deliver funding to on-the-ground projects through the protection, restoration, or enhancement of wetland habitats.

- National Resources Conservation Service
    - Watershed Protection and Flood Prevention Program - This program provides technical and financial assistance to address resource and related economic problems on a watershed basis. Projects related to watershed protection, flood prevention, water supply, water quality, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, and public recreation are eligible for assistance.
- National Fish and Wildlife Federation
    - Bring Back the Natives (BBN) - BBN supports on-the-ground habitat restoration projects that benefit native aquatic species. Projects generally involve riparian habitat restoration and supporting native aquatic communities. Funding is provided by various federal agencies and national organizations.
    - Migratory Bird Conservancy Grants - This program is aimed at habitat conservation and management projects and is funded through the Migratory Bird Conservancy. Projects that directly address conservation of priority bird habitats through acquisition, restoration, and improved management of habitats are program priorities.
- Washington State Interagency Committee (IAC)
    - Aquatic Lands Enhancement Account - This grant program provides support for the purchase, improvement, and/or protection of aquatic lands for public purposes and for providing and improving access to such lands.
    - Washington Wildlife and Recreation Program - this program supports the acquisition and development of state and local park and recreation areas that guarantee perpetual public outdoor recreation opportunities
    - Salmon Recovery Funding Board - Projects are funded by the board to protect and restore salmon habitat and include: habitat acquisition and restoration, watershed assessments, feasibility studies and monitoring
- Seattle City Light and Puget Sound Energy - These energy companies have mitigation plans, developed as part of their dam relicensing programs, that provide funds for various acquisition and restoration and recreation access projects.
- Puget Sound Salmon Recovery Plan - This plan provides a framework for ecosystem and salmon restoration in Puget Sound. A three-year workplan for the Skagit is currently being developed and includes actions for Cockreham Island.

More detail is provided on selected funding sources in Appendix D: Funding Source Evaluation.

RECOMMENDATIONS

Based upon our technical and economic analyses, we feel that management actions can be taken to alleviate public and private costs associated with repetitive flood losses and reduce ongoing maintenance costs associated with infrastructure on Cockreham Island. We recommend initiating a buy-out of properties based upon the following prioritization:

1. All properties located south of Snider Road, west of Cockreham Island Road, and south of the Cascade Trail
2. All properties south of Jim's Slough
3. All properties south of SR 20 that are inundated under 10-year recurrence flow conditions
4. All remaining properties

A spatial distribution of this prioritization is presented in Figure 11. We recommend removing the lower portion of the Cockreham Island training levee (approximately three thousand feet) and allowing or promoting the river to cut a new channel through the south portion of the island as displayed in Figure 10. The specifics of exactly where and how to do this should be determined through a more detailed hydraulic and engineering analysis. If the river were to attain the configuration displayed in Figure 10 the following benefits will be realized:

a. Reduced maintenance costs associated with maintaining the levee
b. Reduced risk of catastrophic failure of the levee
c. Reduced erosion along the toe of the remaining levee
d. Reduced or no river induced bank maintenance along the South Skagit Highway
e. Reduced hydraulic energy along the levee at Lyman
f. Reduced backwater and flooding up Muddy Creek
g. Enhanced in-stream and off-channel habitat conditions
h. Increased open space along the river corridor

We recommend contacting the identified funding sources for the acquisition of the property and establishing partnering relationships with potential future land managers. Funding used in purchasing the properties can be used as matching funds for additional grants to restore natural habitat conditions and/or establish improved public access and recreational use.

Moving forward with a buy-out will require a number of action items to gain additional information, clarify outstanding issues, and establish a formal pathway for landowners. Some action items may be best completed by Skagit County Public Works, while other tasks will likely require landowner and/or additional stakeholder involvement. Below is a list of potential next steps that could be taken to move the buy-out process forward. This list is presented in no particular order of sequence or importance.

- Investigate current zoning and possible re-zoning to accommodate future land uses, including possible actions to restrict development/new construction.
- Adopt the recommended action in this report as Skagit County's vision for future management and discontinue maintaining the lower portion of the levee
- Present Skagit County's vision for future land use on the island to potential funding sources
- Make a formal presentation to those entities controlling mitigation funds for FERC re-licensing of the local dams in hopes that they may get involved in buy-out of Cockreham Island parcels
- Develop buyout priority zones based upon proposed future land use

- Develop a buyout priority list by parcel, based upon the parcel's benefit/cost ratio and location within the buyout priority zones

- Negotiate a mitigation plan with the tribes and other resource managers that will allow some or all of Skagit County's (or other entities) future mitigation to occur in the form of buy-out on the island (This would suggest that the Skagit County purchase the property ranked highest on the priority list. If the mitigation requirement is not enough to purchase that property, those funds would be placed into an account and added to with future mitigation monies until the purchase amount was accrued). This may or may not include deeding these properties to a local non-profit or directly to the tribes.

- Establish a formal process for landowners to voluntarily express an interest in being bought out and develop a list of those interested

- Assist individual landowners in developing FEMA grant applications to acquire monies for purchase of their properties

- Establish a floodplain buy-out fund within the county to be used for future purchases on Cockreham Island

It is important to note that these recommendations are based upon existing information, observations during floods, personal communications with local landowners and SCPW, and professional experience in river management and hydrodynamics. Specific design analyses will need to be conducted to validate these management concepts if and as they undergo further consideration.

LIMITATIONS

We have prepared this report for the exclusive use of SCPW and their authorized agents. This report is not intended for use by others and the information contained herein is not applicable to other sites. No other party may rely on the product of our services unless we agree in advance, and in writing, to such reliance. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with our negotiated contract and generally accepted engineering and environmental science practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

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APPENDIX A
HYDROLOGY AND HYDRAULICS

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APPENDIX B
BENEFIT COST ANALYSIS

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APPENDIX C
LAND MANAGEMENT SUITABILITY

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APPENDIX D
FUNDING SOURCE EVALUATION