Lower Columbia Regional Culvert Inventory and Tidegate Assessment
Final Report

Prepared for

Lower Columbia Fish Recovery Board
2127 8th Avenue
Longview, WA 98632

by

Wahkiakum Conservation District
PO Box 67
Cathlamet, WA 98612

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EXECUTIVE SUMMARY

The Lower Columbia Region Culvert Inventory builds upon work completed by a number of entities including barrier assessment contributions by several entities to the Washington State Department of Fish and Wildlife Salmon Habitat Inventory and the initial Lower Columbia Region barrier assessment project conducted by Clark Conservation District.

Wahkiakum Conservation District worked with the Lower Columbia Fish Recovery Board to collect additional barrier assessment data and generate the information needed to develop region priorities for barriers in the region. Tidegate assessments, additional level A barrier assessments, and physical habitat surveys were conducted.

Seventy-two (72) tidegate locations were identified. Barrier assessments were conducted on fifty-six (56)of these sites. Access was denied at the remaining sites. Twelve sites (12) had stream habitat gain above the tidegate. Physical habitat surveys were conducted on Malone Creek, Impie Creek, Seal River, Nikka Creek and one unnamed tributary. Access was denied or streams did not meet physical criteria for salmon streams above the remaining tidegates. Data was tabulated into a tidegate decision matrix and an initial prioritization model applied to the data.

A procedure was developed to identify barrier assessment data gaps. Priority was placed on filling data gaps on non industrial, state, and local government ownership. Three hundred and twenty-three additional level A site assessments were conducted. All available barrier assessment data was merged into a region barrier data layer.

Physical habitat surveys were attempted on streams during tidegate assessments. Several issues immediately surfaced that curtailed efforts to generate a meaningful priority index. The major issue was the inability to obtain permission from landowner to access the streams in areas where the district typical realizes good working relationships with landowners. Unsurveyed stream reaches in the physical habitat survey resulted in questionable confidence in priority indexes generated from the data. Generation of region priorities shifted to a data and map based approach.

A prioritization model was developed that could be applied to all stream crossings in the region. The model was applied to the upper extent of the watershed feeding an assessed barrier. The model was not applied to the upper Toutle, upper Cowlitz, and upper Lewis River subwatersheds where industry or federal government ownership is dominant and no barrier assessment data exists. A geographic information system based data analysis was conducted to generate the information necessary to develop the model. This included two thousand seven hundred and thirty-seven (2737) culverts with barrier assessments completed and nineteen hundred and forty-eight (1948) remaining data gaps.

Geographic Information System data was compiled into region layers and incorporated into a map project to visualize the data. Tabulated data was compiled into a relational database linked by a site ID to the GIS data. Barrier assessment data sets were combined

into a single data table. The region prioritization data was incorporated into the data base and an initial model applied to the data to generate priorities. The database tables can be linked to the GIS application to visualize the data. Additional models can be applied to the data base. The database allows the user to access priorities by region, WRIA, Lower Columbia Subwatershed, or a primary stream of interest. Data can be accessed to generate barrier assessment data forms or to generate a "barrier profile" for an area of interest. The barrier profile consists of the raw data that was tabulated to generate region priorities. It is an overview of the barriers and habitat gains in the area of interest.

Contents

1. INTRODUCTION

1.1 Background

Historic, predevelopment conditions for the Lower Columbia region supported viable populations of salmonid species. These species have evolved varied life history strategies that often rely on all areas of a watershed to successfully complete fresh water life stages. Culverts, tidegates, and other barriers reduce productivity within a watershed by limiting the availability of one or more critical habitats for these different life stages. Tributary habitat provides a majority of the spawning and rearing habitat for chum, Chinook, steelhead, coho, and cutthroat, and is often disconnected by culverts and other road crossings.

Development of the region has caused disruption and destruction of habitat. Among other impacts, the loss of access to critical tributary habitats has contributed to the depressed and threatened condition of Lower Columbia salmonid populations (Wade, 2002).

Upper watersheds in the region are typically dominated by industrial timber lands. Road densities are high, exceeding six miles per square mile in many watersheds. Road crossings designed without consideration for fish passage restrict adult fish access to spawning habitat, and block juvenile access to rearing habitats. Road crossings also disrupt sediment transport and other channel processes due to channel width constriction and artificial grade control.

.Dominant land uses in the tidally influenced reaches of the Chinook, Grays, Elochoman, Skamokawa, and Mill/Abernathy/Germany subbasins are rural residential or agricultural. The tidally influenced reaches of the Cowlitz, Kalama, Lewis, Salmon, and Washougal subbasins are typically urban or industrial. Tidegates and dikes originally built to reclaim tidal lands for agriculture prevent tidal circulation, contributing to water quality degradation. Tidegates also represent partial or complete fish passage barriers, preventing anadromous utilization. In the lower reaches the region's rivers, habitat value can vary greatly from stream to stream. For example, substrate in neighboring streams can be basalt dominated or consist of sandstone/ siltstone which can greatly influence spawning habitat quality and quantity. The degree to which land management has affected or continues to affect streams varies greatly by subbasin.

The Lower Columbia Salmon Recovery 6-Year Habitat Work Schedule for the project area subbasins identifies evaluation of potential barriers (culverts, tidegates, and dams) as an assessment need. High quality spawning and rearing habitats become immediately available through barrier removal, providing direct benefits to salmonid populations. Barrier removal or replacement also restores more natural hydrology and sediment transport within the watershed, improving habitat conditions below the corrected barrier.

Clark Conservation District completed a partial inventory of culverts in the region in October, 2007. Clark Conservation District also submitted a proposal during the 2005 SRFB funding cycle to conduct a second phase of a regional culvert inventory focused on generating regional priorities. Concurrently, Wahkiakum Conservation District submitted a proposal to conduct a barrier assessment of tidegate structures. Per request of the Lower Columbia Fish Recovery Board Technical Advisory Committee these funding proposals were combined and eventually the grant was awarded to the Lower Columbia Fish Recovery Board in partnership with the Wahkiakum Conservation District.

The grant proposal outlined the general objectives of the project. The grant scope of work was translated into contract agreement between the Wahkiakum Conservation District and the Lower Columbia Fish Recovery Board with a performance period of October 2007 through June 2010.

1.2 Regional Culvert Inventory: Phase I

Clark Conservation District managed the first phase of the regional culvert inventory funded by the SRFB. Existing data was compiled and analyzed to provide the foundation for the project and identify barrier data gaps. Four hundred and sixty-eight sites were surveyed using protocols provided by the Washington State Department of Fish and Wildlife Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual (CCD, 2006).

Barrier assessment data was managed in a Microsoft Access database application developed by the Washington State Department of Fish and Wildlife (WDFW). Barrier data was exported to create several Geographic Information System (GIS) feature classes used to provide a visualization of the project results.

While this phase of the regional culvert inventory provided a fairly comprehensive list of fish passage barriers in the region, the list was not prioritized for action. The Clark Conservation District did not directly address tidegates in the original phase, many of which block large areas of fish habitat from anadromous populations.

1.3 Regional Culvert Inventory and Tidegate Assessment Project Objectives

The Regional Culvert Inventory and Tidegate Assessment build upon the Clark Conservation District's effort to achieve a regional comprehensive fish barrier assessment. The project intent was to compile existing culvert inventory work (e.g., DNR RMAP, USFS, County Public Works), close data gaps, assess habitat, develop priorities, and provide designs for future culvert replacement projects.

The WDFW protocol used for the culvert portion of the project identifies all tidegates as barriers, and barrier evaluation ceases once the tidegate field on the site form is checked (WDFW, 2009). This project collected data on tidegate structures by adding

fields appended to standard protocol forms. Additional data gathered included stream habitat gain, estuary gain (calculated), infrastructure protected by the tidegate, and the level of current landowner interest.

The resulting data was compiled into a decision matrix to identify restoration opportunities, and made available to stakeholders as a data management system.

1.4 Work Completed and Future Needs

Seventy-two (72) tidegate locations were identified. Barrier assessments were conducted on fifty-six (56) of these sites. Access was denied at the remaining sites. Twelve sites (12) had stream habitat gain above the tidegate. Physical habitat surveys were conducted on Malone Creek, Impie Creek, Seal River, Nikka Creek and one unnamed tributary. Data was tabulated into a tidegate decision matrix and an initial prioritization model applied to the data.

A procedure was developed to identify barrier assessment data gaps. Priority was placed on filling data gaps on non industrial, state, and local government ownership. Three hundred and twenty-three additional site assessments were conducted. All available barrier assessment data was merged into a region barrier data layer.

A prioritization model was developed that could be applied to all stream crossings in the region. The model was applied to the upper extent of the watershed feeding an assessed barrier. The model was not applied to the upper Toutle, upper Cowlitz, and upper Lewis River subwatersheds where industry or federal government ownership is dominant and no barrier assessment data exists. A geographic information system based data analysis was conducted to generate the information necessary to develop the model. This included two thousand seven hundred and thirty-seven (2737) culverts with barrier assessments completed and nineteen hundred and forty-eight (1948) remaining data gaps.

Geographic Information System data was compiled into region layers and incorporated into a map project to visualize the data. Tabulated data was compiled into a relational database linked by a site ID to the GIS data. Barrier assessment data sets were combined into a single data table. The region prioritization data was incorporated into the data base and an initial model applied to the data to generate priorities. The database tables can be linked to the GIS application to visualize the data. Additional models can be applied to the data base. The database allows the user to access priorities by region, WRIA, Lower Columbia Subwateshed, or a primary stream of interest. Data can be accessed to generate barrier assessment data forms or to generate a "barrier profile" for an area of interest. The barrier profile consists of the raw data that was tabulated to generate region priorities. It is an overview of the barriers and habitat gains in the area of interest.

Wahkiakum District was not able to commit engineering time to prepare preliminary

designs as required by the grant agreement and contract with the LCFRB. Available data was reviewed and shared with the family forest fish passage program during their regional prioritization process. A site in Wahkiakum County and one in Clark County was funded and fish passage is being restored.

The data management system developed during this project is a combination of relational database and GIS application and it is relatively static. Opportunities should be explored to fully integrate the data management system into a dynamic GIS application. An opportunity would be to contact college and university GIS departments to determine if there is interest to develop the application.

Photographs of the culvert sites are available on the enclosed discs. Time constraints did not allow these to be attached to culvert form in the relational database. A user can manually access the pictures, but it would help round out the database features if they could be viewed and printed along with the barrier assessment data.

2. FINAL DATA SYSTEM

The primary product completed as part of this project is a data management system viewable with ArcGIS software. The system is capable of meeting the needs of a wide range of end-users and is easily updated to ensure utility into the future. The data management system is a combination of a relational database and GIS application.

2.1 Data Management System Utilization

The Lower Columbia Fish Recovery Board, as the regional salmon recovery lead entity, intends to use the DMS to:

1. Develop and update a dynamic, regional, prioritized list of barrier correction opportunities;

2. Assist in prioritizing habitat restoration projects; and,

3. Assess fish passage project proposals.

The data system is also readily accessible to project sponsors, who can use it to:

1. Generate fish barrier and habitat project proposals; and,

2. Educate landowners on opportunities available to improve fish passage.

2.2 Data Management System Features

The DMS provides for management of tabular data and visualization of the data at multiple scales, including individual culverts, stream basins, subbasins, WRIA, and regional.

The culvert scale allows the user to select an individual culvert to access site specific data. Site specific data includes the barrier assessment form and photographs of the site.

At the stream scale, users have the option to look at barriers upstream and downstream. The stream basis involved delineating subbasins into streams basis such as the WDFW stream catalog. Subdivision would be limited to breaking the stream layer at the confluence of the tributary with the main stem water body in the subbasin. At the stream scale users can access tabular data of the barriers located within the area of interest. The tabular data includes incremental and potential habitat gain,

The subbasin scale contains the subbasins delineated by the salmon recovery plan. At the subbasin, WRIA, or regional scale the user has access to tabulated priorities.

The regional culvert inventory and tidegate assessment project data management system consists of two parts:

1. An ArcGIS-based application that is used to tabulate and illustrate data, and

2. A Microsoft Access database application used to manage and analyze tabulated data.

The GIS application provides a visualization of the data. It consists of the existing feature classes described in appendix C along with a few created feature classes necessary to generate the data used to model regional priorities. The additional feature classes include point intersects of the transportation layer with the EDT stream reach and tier 5 stream reach layers. These feature classes identify crossings that were considered data gaps and barriers.

The relational database provides a tabular dataset that is linked to the GIS barrier feature classes through a barrier "site ID" field. The database provides an easy, powerful platform through which prioritization models can be explored and priorities generated on a broad range of spatial scales. Reporting functions allow for recreation of barrier assessment data forms and imagery for individual culverts.

Details regarding the development of the MSAccess relational database are located in appendix B. This includes a description of the data tables, queries, and forms used to develop the database.

Details regarding the development of the GIS application are located in Appendix C. This includes the feature classes used, the linkage to the relational database, and recommendations for its use.

2.3 Recommendations for DMS Development and Refinement

Wahkiakum Conservation District recommends that opportunities to develop a GIS based data management system continue to be explored. Opportunities include coordinating with local college and university GIS programs to determine if student interest exists in developing the applications or components of an application.

3.0 Regional Culvert Inventory

3.1 Existing Data

The district initiated the project by obtaining all available existing data including database information, images, reports and GIS feature classes. The LCFRB provided several GIS layers, database information, and prior reports associated with the initial regional culvert inventory. GIS layers used for the project include:

1) 2008 Ecosystem Diagnosis and Treatment (EDT) Stream Reaches: This data layer is the 2008 EDT stream reaches which provides tier designations based on populations present and the reach's potential for those populations.

2) DNR Transportation: This layer provided the DNR road network for the entire Lower Columbia Region. Clark PUD noted during a meeting that the road layer does not adequately capture all of the roads in the urban areas of Clark County.

3) DNR Hydro Layers: Layers defined by the "Fish / No Fish" model and the "Stream Type" model. The Fish / No Fish model was used to identify "tier 5 stream reaches and was used to identify barrier assessment data gaps.

4) County Assessor Layers for Clark, Cowlitz, and Wahkiakum Counties. These layers were used to identify barrier data gaps located on non industrial private ownership or managed by local government and to identify ownership in order to obtain permission to access each site.

5) LCFRB Watershed and Subwatershed boundaries: This is a polygon layer of the subbasin and subwatershed identified by the salmon recovery plan.

6) Public Legal Land Survey data: This includes sections, township, and range.

7) Aerial photography: The Wahkiakum CD was able to obtain and utilize aerial images made available to us by the USDA NRCS for Cowlitz, Wahkiakum, Pacific, and portions of Lewis Counties. LCFRB contributed Clark County aerial photos.

9) WDFW Barrier Assessment (LCFRB Region): This data includes barrier assessment data collected using the WDFW FPDSI Barrier Assessment Protocol, including some collected by Clark Conservation District under the Regional Culvert Inventory.

10) Clark Conservation District Barrier Assessment Data: This data set consisted of a large number of GIS files containing barrier assessment data parsed by type of barrier and subbasin.

11) Wahkiakum Conservation District Barrier Assessment Data: This data set consisted of the raw barrier assessment data collected by the district through a project funded by Washington State Department of Transportation. This data set is a large component of the WDFW Barrier Assessment (LCFRB Region) identified in number 9 above. This data set was used to resolve data conflict issues of null values in the site ID in the WDFW data set.

In addition to the GIS feature files, LCFRB provided the Microsoft Access database utilized by Clark Conservation District to manage barrier assessment data collected during the initial regional culvert inventory project. The database was developed by WDFW to facilitate transmittal of barrier assessment data and incorporation into the statewide data system managed by the department.

Projections were identified and assigned to feature classes when metadata were unavailable.

Numerous "0" or null values were found in the site ID column in the WDFW mega data dataset and the Clark Conservation District barrier assessments. The site ID is used in the relational database to link data tables and must contain unique values. Null site ID's were converted to a unique value by cross referencing the data set with raw data sets when available or by assigning a unique ID.

Barrier assessments conducted by Clark Conservation District for non culvert sites (bridges) were not a component of the WDFW barrier assessment data layer. The data collected by both Clark and Wahkiakum Conservation District was exported from the MSAccess database into district barrier layer to ensure that all sites were accounted for.

For several culvert sites, multiple barrier assessment entries were identified in

the WDFW data set. Some of these entries were for multiple culverts at one site, but many were repeat entries from distinct assessments. The District assigned the site ID from the most recent barrier assessment to the data set generated for prioritization.

3.2 Data Gaps

3.2.1 Data Gap Identification

Existing data were imported into GIS. Point intersects were created where the transportation layer intersect the EDT stream reaches and the "Fish" streams in the DNR Hydro layer. Point intersects not overlaid by barrier assessment data were considered data gaps. This exercise identified over 2,000 data gaps in the region.

One aspect of the project was securing barrier assessment data from the USDA Forest Service and the DNR Road Maintenance and Abandonment Plan programs. The District therefore focused data gap identification efforts on non-industrial private and local government lands. Codes in the assessor parcel feature classes allowed masking state, federal, and industrial forest ownership. This narrowed the data gap set to approximately 600 crossings. Approximately 200 of these crossing were located on EDT reaches.

3.2.2 Data gap prioritization

The District began filling data gaps in Wahkiakum County by surveying tidegates during low tides and higher elevation culverts at higher tides. Based on guidance from an advisory committee of regional stakeholders, the District focused on data gaps on fish-bearing streams in the East Fork Lewis River, North Fork Lewis River, Cowlitz River, Coweeman River, and Kalama River subbasins to maximize benefits to populations critical to achieving regional recovery goals. Crews also recorded bridges as they were identified in the field.

3.2.3 Measures taken to fill data gaps

Assessors' data were used to identify ownership at each data gap. The white pages and internet were used to obtain phone numbers to contact owners to obtain permission. When phone contact failed the crew knocked on doors when in the area. As access was obtained Level A barrier assessments were scheduled. Field crews used the Washington Department of Fish and Wildlife Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization protocols (WDFW protocol) to assess stream crossing

structures. Photographs were taken of the upstream, inlet, crossing, outlet, and downstream views. Site forms were completed for bridge sites in route to conducting Level A barrier assessments. Data was compiled into the MSAccess database obtained from Clark Conservation District and incorporated into the data management system.

4.0 Regional Tidegate Assessment

Tidegate locations were determined by contacting a wide range of entities involved in their management. This included diking districts, county and city public works departments, and land managers. The locations of known structures were initially plotted in GIS to guide assessment efforts until GPS coordinates could be obtained. Additional tidegate locations were identified in the field as assessments were conducted.

Wahkiakum County provided the district with preliminary parcel data to help identify ownership at each tidegate location. Landowners were called and provided project information to encourage participation.

4.1 Field Assessment

Structure Assessment: Field crews used the Washington Department of Fish and Wildlife Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization protocols (WDFW protocol) to assess tidegate structures. WDFW recognizes tidegate structures as barriers and the protocol terminates once the tidegate box is checked. For the purposes of this tidegate assessment, the level A barrier assessment protocol was applied to the gated structure. Additional information recorded included the type of tidegate (material, shape, hinge location…) and whether the tidegate was functional. If the tidegate was not functional, the malfunctions were recorded.

4.1.1 Stream Habitat Assessment

DNR stream type maps and EDT fish distribution maps were used to identify potential stream habitat upstream of a tidegate installation. In the field, DNR physical criteria for fish bearing streams were applied to determine whether a habitat survey would be conducted. All streams considered fish bearing above tidegates were to be assessed in accordance with WDFW physical habitat survey protocols upstream to the point where physical criteria were no longer met. Twelve sites (12) had stream habitat gain above the tidegate. Physical habitat surveys were conducted on Malone Creek, Impie Creek, Seal River, Nikka Creek and one unnamed tributary.

4.1.2   Estuary Habitat Assessment

The objective of the estuary habitat assessment was to quantify estuary habitat gained by tidegate modification or removal. The District analyzed likely estuary gain based on landownership as well as topography and tide elevations.

Bare earth ascii files of lidar x-y-z data were downloaded from the Puget Sound Lidar Consortium(PSLC). These are based on flights made from 1/10/2005 to 2/12/2005. The data is on the NAD83 horizontal datum and the NAVD88 vertical datum (Project Report-Lower Columbia by Terra-Point PSLC contract 2265-H 12/29/2005). These files were used to develop surface models in Civil 3-D 2009 ACAD. These models were used to produce 1 foot contours in the areas of interest.

Tidal data was downloaded from NOAA for the Tongue Point Or Tide Gage (9439040). This data is monthly high tides on the NAVD88 datum for the water years from 1980 to the present. The highest tide for each water year was selected and ranked. A Weibull plotting position was calculated and a probability assigned. The 20 year recurrence of approximately 12.6 feet was chosen for a design water surface. For the Deep River, Chinook and most of Grays River areas, this was rounded up to 13 feet. For the uppermost sites in the Grays River and Skamokawa, 14 feet was used. For the Lake River area the FEMA 100 year flood elevation of 26 feet(1929 datum) or 29.3 feet(NAVD88) was used. The contour closest to the chosen water surface was extracted from ACAD and converted to a ArcMap shape file for use in the inundation area analysis.

Inundation analysis generated polygons that were input into Arcmap. The polygon area was unioned to the tidegate data to generate the potential estuary gain. The potential estuary gain polygon was unioned with the parcel boundary for the ownership on which the tidegate was located. If the union resulted in a smaller area, the smaller area was determined to be the incremental estuary habitat gain.

4.1.3   Infrastructure Affected: After the estuary polygon was established, we measured the length of road, acres of farm ground, and number of structures potentially impacted by tidegate removal.

4.1.4   Local Interest in Salmon Recovery Opportunities: The initial contact to request access from the landowner was used to convey the purpose of the Regional Barrier Assessment Phase II project. A few landowners adamantly denied access and did not want any part of the project. These tidegate locations are identified with a point on a GIS layer and tagged with a "no access" data label. None of the landowners contacted have stated interest in removing their tidegates. Rather, they have granted access and were willing to discuss opportunities.

Tidegate assessment data was compiled and managed within the Access database constructed by WDFW for use in the Clark Conservation District project. This tool will allow for sharing data with WDFW and extracting information as needed into the final data management tool format as defined by the advisory committee.

4.2   Implementation of Tidegate Assessments

Seventy-two (72) tidegate locations were identified. Barrier assessments were conducted on fifty-six (56) of these sites. Access was denied at the remaining sites. Twelve sites (12) had stream habitat gain above the tidegate. Data was tabulated into a tidegate decision matrix and an initial prioritization model applied to the data and is illustrated in the following table.

4.3 Tidegate Matrix

LCRCI Tidegate Matrix

SIG: Stream Incremental Habitat Gain Above Site
SPG: Stream Potential Habitat Gain Above Site
BAPGAdj: Adjustment to SPG for Barrier Above
Babove: Number of Barrier Above Site

Bbelow: Number of Barriers Below Site
Priority: Region Priority Model Result
PI: WDFW Priority Index
EPG: Estuary Habitat Potential Gain

EIG: Estuary Habiat Incremental Gain
Prop Prot: Type of Land Protected
Per_Rd_mi: Perimeter road affected by TG
Int_Rd: Interior Road affected by TG

Buildings: # affected by TG
Owner P: Owner Interest

Site ID	Site_Text	WRIA	Subbasin	Stream	Ownership	SIG	SPG	BAPGAdj	Babove	Bbelow	Priority	PI	EPG	EIG	Prop Prot	Per_Rd_mi	Int_Rd_mi	Buildings	Owner_P
1350233		26	Cowlitz	Unnamed	County	0	0		0	0		0	0	0					Unk
1602002	SKA002	25	Eloch-Skam	Historic Skamokawa Creek	County	0.13	0.254	0.064	3	0	0.19	0	197	30	Farmland	0.54	0.63	25	M
1602005	SKA005	25	Eloch-Skam	Unknown	Private	0	0		0	0		0	383	85	Farmland	0.65	0.18	4	L
1602006	SKA006	25	Eloch-Skam	Unknown	Private	0	0		0	0		0	383	85	Farmland	0.65	0.18	4	L
1602007	SKA007	25	Eloch-Skam	Unknown	Private	0	0		0	0		0	383	85	Farmland	0.65	0.18	4	M
1602008	SKA008	25	Eloch-Skam	Unknown	County	0	0		0	0		0	383	116	Farmland	0.65	0.18	4	
1602009	SKA009	25	Eloch-Skam	Unknown	County	0	0		0	0		0	383	116	Farmland	0.65	0.18	4	
1603001	JBH001	25	Eloch-Skam	Unknown	County	0	0		0	0		0	392	392	Refuge	0	0	0	M
1603102	JBH002	25	Eloch-Skam	Unknown	County	0	0		0	0		0	392	392	Refuge	0	0	0	M
1603106	JBH006	25	Eloch-Skam	Unknown	County	0	0		0	0		0	392	392	Refuge	0	0	0	M
1607004	GRA012	25	Grays	Unknown	County	0	0		0	0		0	30	0.04	Farmland	0	0	0	
1650001	DEP001	25	Grays	Unknown	County	0	0		0	0		0	165	15	Farmland	0.94	0.27	0	M
1650002	DEP002	25	Grays	Unknown	County	0.017	0.055	0.028	1	0	0.04	0	165	51	Farmland	0.94	0.27	0	
1650003	DEP003	25	Grays	Unknown	County	0	0		0	0		0	5.5	5.5	Wet	0.45	0	0	Unk
1650008	DEP008	25	Grays	Unknown	County	0	0		0	0		0	41	37	Farmland	0	0	0	
1650009	DEP009	25	Grays	Unknown	County	0	0		0	0		0	4	4	Farmland	0	0	0	
1650010	DEP010	25	Grays	Unknown	County	0.022	0.022	0.022	0	0	0.04	0	161	7	Farmland	1.91	0.38	3	
1650011	DEP011	25	Grays	Unknown	County	0	0		0	0		0	161	29	Farmland	1.91	0.38	3	
1650012	DEP012	25	Grays	Unknown	County	0	0		0	0		0	161	21	Farmland	1.91	0.38	3	
1650013	DEP013	25	Grays	Unknown	County	0.011	0.094	0.031	2	0	0.04	0	161	48	Farmland	1.91	0.38	3	
1650014	DEP014	25	Grays	Unknown	County	0	0		0	0		0	161	48	Farmland	1.91	0.38	3	
1650015	DEP015	25	Grays	Unknown	County	0	0		0	0		0	58	34	Farmland	1.67	0.09	6	
1650016	DEP016	25	Grays	Unknown	County	0	0		0	0		0	161	29	Farmland	1.91	0.38	3	
1650017	DEP017	25	Grays	Campbell Creek	County	0.02	0.393	0.066	5	0	0.09	0	161	18	Farmland	1.91	0.38	3	
1650018	DEP018	25	Grays	Unknown	County	0	0		0	0		0	58	34.5	Farmland	1.67	0.09	6	
1650019	DEP019	25	Grays	Unknown	County	0	0		0	0		0	145	11	Farmland	0.29	0.31	3	
1650020	DEP020	25	Grays	Unknown	County	0	0		0	0		0	145	11	Farmland	0.29	0.31	3	
1651003	GRA003	25	Grays	Unknown	County	0	0		0	0		0	169	10	Farmland	0.5	0.52	8	
1651006	GRA006	25	Grays	Unknown	County	0	0		0	0		0	185	55	Farmland	0.69	0.36	4	
1651007	GRA007	25	Grays	Unknown	Private	0.105	0.182	0.061	2	0	0.17	0	16	16	Farmland	0	0.1	9	L
1651008	GRA008	25	Grays	Unknown	Private	0	0		0	0		0	214	90	Farmland	0	1.26	2	L
1651009	GRA009	25	Grays	Unknown	Private	0	0		0	0		0	214	90	Farmland	0	1.26	2	L
1651010	GRA010	25	Grays	Unknown	Private	0.105	0.732	0.366	1	0	0.47	0	0	0				0	L
1651011	GRA011	25		Unknown	Private	0	0		0	0		0	214	56	Farmland	0	1.26	2	L
1651013	GRA013	25	Grays	Nikka Creek	Private	0.463	0.463	0.463	0	0	0.93	0	214	56	Farmland	0	1.26	2	M
1651014	GRA014	25	Grays	Unknown	Private	0	0		0	0		0	214	56	Farmland	0	1.26	2	L
1651016	GRA016	25	Grays	Unknown	Private	0	0		0	0		0	34	34	Farmland	0	0	0	L
1651017	GRA017	25	Grays	Unknown	Private	0	0		0	0		0	46	15	Farmland	0	0	0	L
1651025	GRA025	25	Grays	Unknown	County	0.032	0.032	0.032	0	0	0.06	0	57	43	Farmland	0.36	0	0	VL
1651027	GRA027	25	Grays	Unknown	County	0	0		0	0		0	185.5	43	Farmland	0.69	0.36	4	
1651028	GRA028	25	Grays	Unknown	Private	0.042	0.042	0.042	0	0	0.08	0	214	45	Farmland	0	1.26	2	
1655001	GER001	25	Grays	Germany Creek	County	0	0		0	0		0	5	5	Wetland	0	0	0	Unk

SIG: Stream Incremental Habitat Gain Above Site
SPG: Stream Potential Habitat Gain Above Site
BAPGAdj: Adjustment to SPG for Barrier Above
Babove: Number of Barrier Above Site

Bbelow: Number of Barriers Below Site
Priority: Region Priority Model Result
PI: WDFW Priority Index
EPG: Estuary Habitat Potential Gain

EIG: Estuary Habiat Incremental Gain
Prop Prot: Type of Land Protected
Per_Rd_mi: Perimeter road affected by TG
Int_Rd: Interior Road affected by TG

Buildings: # affected by TG
Owner P: Owner Interest

Site ID	Site_Text	WRIA	Subbasin	Stream	Ownership	SIG	SPG	BAPGAdj	Babove	Bbelow	Priority	PI	EPG	EIG	Prop Prot	Per_Rd_mi	Int_Rd_mi	Buildings	Owner_P
2009002	GRA002	25	Grays	Unknown	Private	0.106	0.246	0.049	4	0.16		0	169	106	Farmland	0.5	0.52	8	L
2009006	GRA005	25	Grays	Unknown	County	0	0		0	0		0	185	55	Farmland	0.69	0.36	4	
201101	GRA001	25	Grays			0	0	0	0	0	0	0	0	0					VL
201102	GRA015	25	Grays			0	0	0	0	0	0	0	0	0					VL
201103	GRA021	25	Grays			0	0	0	0	0	0	0	0	0					VL
201104	GRA022	25	Grays			0	0	0	0	0	0	0	0	0					VL
201105	GRA023	25	Grays			0	0	0	0	0	0	0	0	0					VL
201106	GRA024	25	Grays			0	0	0	0	0	0	0	0	0					VL
201107	DEP004	25	Grays			0	0	0	0	0	0	0	0	0					VL
201108	SKA002	25	Eloch-Skam			0	0	0	0	0	0	0	0	0					VL
201109	SKA003	25	Eloch-Skam			0	0	0	0	0	0	0	0	0					VL
201110	SKA004	25	Eloch-Skam			0	0	0	0	0	0	0	0	0					VL
201111	SKA010	25	Eloch-Skam			0	0	0	0	0	0	0	0	0					VL
201112	SKA011	25	Eloch-Skam			0	0	0	0	0	0	0	0	0					VL
201113	SKA012	25	Eloch-Skam			0	0	0	0	0	0	0	0	0					VL
201114	JBH003	25	Eloch-Skam		Federal	0	0	0	0	0	0	0	0	0					VL
201115	JBH004	25	Eloch-Skam		Federal	0	0	0	0	0	0	0	0	0					VL
201116	JBH005	25	Eloch-Skam		Federal	0	0	0	0	0	0	0	0	0					VL
3040		27		Daybreak	Private	0	0		0	0		0	2131	2131	Refuge			0	Unk
981451		28		Shillapoo	Private	0	0		0	0		0	2131	2131	Refuge				Unk
981457		28		Shillapoo	Private	0	0		0	0		0	2131	2131	Refuge				Unk
981467		28		Unnamed	State	0	0		0	0		0	2131	2131	Refuge				Unk
981478		27		Unnamed	Unknown	0	0		0	0		0	9	9	Farmland				
981853		28		Buckmire	State	0	0		0	0		0	2131	2131	Refuge				Unk
981854		26		Buckmire	County	0	0		0	0		0	2131	2131	Refuge				Unk
990371		25	Grays	Seal Cr	State	0.08	0.313	0.078	3	0	0.16	0	57	11	Farmland	0.36	0	0	M
990818		25		Unnamed	State	0	0		0	0		0	233	233	Farmland	0	0	0	
ONM2		25	Grays	Unnamed		0	0	0	0	0	0	0	43.5	43.5	Farmland	0.25	0.45	0	VL
ONM3		25	Grays	Unnamed		0	0	0	0	0	0	0	43.5	43.5	Farmland	0.25	0.45	0	VL
ONM4	Grays	25	Grays	Unnamed		0	0	0	0	0	0	0	43.5	43.5	Farmland	0.25	0.45	0	VL

5.0 Physical Habitat Surveys and Priority Index

The grant agreement required conducting physical habitat surveys to calculate priority index values for 100 prioritized sites within the region. Several problems immediately surfaced with this approach that led to a different methodology to generate regional priorities for barrier correction work.

By the summer of 2009, so little field time remained in the period of performance that the committee recommended focusing on closing data gaps in the region instead of performing time consuming habitat surveys. The District presented alternative, map-based techniques that would allow field crews to close as many data gaps as possible in the limited time remaining. The map-based techniques also did not share problems with surveyor inconsistency and private property access.

5.1   Surveyor Inconsistency

The field crew was trained in the implementation of physical habitat surveys during the tidegate assessment. During their work, the crew members noted irregularities in coding habitat types. Although the majority of the calculation is based on physical measurements of habitat, interpretation of these measurements (e.g., what constitutes a pool) can greatly influence the resulting PI.

5.2   Access Issues
Access to assess tidegate structures and to conduct physical habitat surveys was frequently denied to field crews. Local landowners, especially in the Grays River area, expressed concern regarding salmon recovery activities. Most of the landowners simply did not want to participate with the fear that they would draw attention to a situation for which they would be held to correct. In more densely populated areas such as Clark County, parcels are so small that over 100 landowners would have had to grant permission to survey a single stream. Contacting several hundred landowners individually was cost prohibitive.

5.3   Habitat survey alternatives

The District explored the opportunity to use existing habitat survey data collected between 1996 and 1998. If usable, district data could have provided a habitat quantity and quality surrogate for the majority of barrier sites in Wahkiakum and Cowlitz County. Unfortunately, replicating habitat surveys was unsuccessful because of transient habitat features and inconsistent habitat coding by different survey crews.

Analysis of the difference between physical habitat survey PI values and those calculated from district habitat survey data indicated a plus or minus variation of about 30%. The district considered this variability too high to reliably prioritize actions throughout the region.

The District discussed project prioritization with Washington Department of Fish and Wildlife employees working in the Family Forest Fish Passage Program (FFFPP). The program currently uses a map based PI calculation. The calculation includes length of habitat, species utilization, passability of the culvert, and presence of downstream barriers. Channel toe width and a qualitative habitat quality score are also considered, but habitat quality data gaps are common. . Budget cuts and low staffing levels prevented extensive WDFW involvement in this project's prioritization exercise. Ultimately, the District abandoned the habitat survey portion of the project in favor of other prioritization methods.

5.4   Regional Prioritization Criteria
The physical habitat survey and resulting PI calculation is an excellent methodology to compare two culverts for priority across a large geographic area. However, when considering a regional prioritization model, additional attributes become important. These additional attributes could significantly modify the ranking of barrier priorities when compared to the PI. These additional attributes include:

Application of the "% Passability" Data Field: This attribute takes into consideration the value of providing adult fish passage versus providing unrestricted juvenile migration. In some cases, culverts identified as barriers may only restrict upstream juvenile passage. While these barriers may be important in the long term, adult passage is the most important factor in most tributaries.

Incremental Habitat Gain: The PI ranks the "potential" benefits of correcting a barrier regardless of upstream barriers. Regional prioritization should recognize potential as well as incremental gain (i.e., habitat quantity to the next upstream barrier). Downstream barriers, as considered in the calculation of the PI also factor into regional prioritization.

EDT as Habitat Quality Region Wide:

Considerable effort has been placed in the development of the Ecosystem Diagnostic and Treatment (EDT) model for the Lower Columbia Region. Reach-level EDT outputs provide information on population use and habitat quality, among other traits. While limited by the quality of inputs, EDT provides a consistent basis on which to prioritize barriers across the region. For example, Tier 1 stream length can be weighted by 1.0, Tier 2 stream length can be weighted by 0.75, etc. When combined with potential and incremental stream lengths

gained, EDT provides a convenient and repeatable region-wide prioritization method.

Number of Downstream Barriers: Priority should decrease with increasing number of barriers downstream of a culvert.

Number of Upstream Barriers: Priority should decrease with increasing number of culverts upstream of the culvert.

6.0 Regional Site Prioritization Methodology

The District developed a method to tabulate data from the available GIS data and barrier assessments that would provides a region -wide priority matrix for all known barriers and data gaps. The decision matrix is similar to that employed for tidegates, providing a dynamic model that can be easily modified and updated. It encompasses the considerations and existing data discussed in section 3 and the concerns for regional prioritization discussed in section 5 of this report. The District staff tabulated data in ArcGIS and exported the data into an Access database. The database facilitates prioritization calculations, querying areas of interest, and reporting. The database is linked to the barrier feature classes in the GIS application so that prioritization can be visually represented.

7.0 Final Project Data System Evaluation and Project Ranking

Two thousand six hundred twenty-four (2624) barrier site, two thousand seven hundred and thirty-seven (2737) culvert, seventy-eight (78) dam, sixty-three (63) fishway, three hundred thirty-eight (338) other, and forty-three level B, field evaluations were compiled into the relational database. Relationships were established between the tables to allow navigation through the data. Forms were constructed to view and print the data in field form format.

Regional prioritization data was tabulated and compiled into the relational data base for four thousand fifty-four barrier locations. This includes barriers identified through the barrier assessment and the remaining data gaps. Tabulated includes the WRIA, LCFRB Subwatershed, local stream name(s), incremental habitat gain, potential habitat gain, number of barriers above the site, and number of barriers below the site. Through the database relationships any of the available data fields can be appended to the dataset.

An initial prioritization model was applied to the dataset. A series of queries were compiled that allow for tabulating priorities on a range of spatial scales. The region wide priority query was used to create a data table that is linked to the barrier ID of the feature classes in the ArcMap application. This allows for selection and visualization of the spatial distribution of the higher priority barrier sites. Additional

models can be developed. Care should be given to ensure that the user is clear on what model results are being viewed.

Additional queries were created that compiles the region prioritization model data into a barrier profile. This allows the user to generate data formatted as it was collected (i. e. sequentially in an upstream direction). Data can be compiled and viewed at several predefined spatial scales. This data can be useful if a user is planning a watershed scale project or intends to restore passage at a site. The barrier profile for the stream in which the project is located provides basic information for all sites.

The database is menu driven. The user starts at the introduction screen with two choices; either to view prioritization data or the data access menu. Selecting prioritization data generates a menu that allows the user to identify the area of interest and view the prioritized data based on the current model. Selecting the data access option opens a menu that allows the user to access data as field survey forms or in the form of a barrier profile. Selecting the site location form allows the user to select the site of interest and navigate through the available field forms. Selecting the barrier profile option allows the user to select the area of interest and generate the profile.

7.1 Region Prioritization Initial Model

The relational database is used to query the regional prioritization tabular data set and apply prioritization models. An initial basic model has been incorporated into the database and the results linked to the ArcMap application. The model includes the stream tier, increment habitat gain, the potential habitat gain, the barriers above the site, and the barriers below the site.

The incremental habitat gain is the sum of the miles of habitat above the site to the next upstream barrier(s) weighted by stream tier. The weight factor for the tiers is:
Tier 1 – 1.0
Tier 2 – 0.75
Tier 3 – 0.50
Tier 4 – 0.25
Tier 0 – 0.20
Tier 5 – 0.10

The weighted tier lengths were summed to obtain a weighted increment habitat gain value. The potential habitat gain was calculated similarly but includes all of the potential habitat length upstream of the site. The weighted potential habitat sum was adjusted down by the number of barriers located in the potential gain above. The potential gain was simply divided by the number of barriers above plus 1. The incremental gain and potential gain was then summed. The sum in gain was further reduced by a straight subtraction of the number of culverts downstream of the site

7.2 Regional Prioritization Results Based on Initial Model

Regional Barrier Prioritization Model 1

Cabove: # of Barriers above   **Igain:** Incremental Habitat gain   **BAPGAdj:** Adjustment to Pgain per Babove
Cbelow: # of Barriers below   **Pgain:** Potential habitat gain   **Priority:** Resulting Priority Rating

WRIA	SUBWS	LSWS	Str_1	Str_2	CID	Cabove	Cbelow	IGain	PGain	BAPGAdj
27	EF Lewis	East Fork Lewis			EEF41	167	1	8.6865	42.9015	0.255366
27	North Fork	Cedar Creek			NFL264	135	1	6.961	15.673	0.115243
29	Wind				EWD033	146	2	7.465	42.4945	0.289078
26	Cowlitz	Lacamas			ECZ158	25	2	6.8035	8.4595	0.325365
26	Cowlitz	Salmon			ECZ179	127	1	5.2745	23.4995	0.18359
27	EF Lewis	East Fork Lewis			EEF57	17	2	5.7015	13.0105	0.722806
29	Wind				EWD047	211	1	4.9355	62.8605	0.296512
25	Skam	Skamokawa Creek	Middle Valley		1060017	5	0	3.109	4.747	0.791167
26	Cowlitz	Salmon			ECZ177	131	0	3.643	27.533	0.208583
26	Cowlitz	Lacamas			ECZ157	49	1	4.171	14.586	0.29172
29	Wind	Little Wind			EWD001	6	2	4.295	4.454	0.636286
27	North Fork	Cedar Creek	Bitter Creek	Unamed	NFL162	0	4	0.067	6.7	6.7
25	MAG	Abernathy Creek			EAC16	2	0	1.6745	2.834	0.944667
26	Cowlitz	Arkansas	Delamter	Monahan	1070055	12	0	2.22	3.6415	0.280115
27	North Fork	Cedar Creek			15121513	194	0	2.363	20.74	0.106359
25	Skam	Skamokawa Creek	Skamokawa		EVEDT01	11	0	1.7555	4.7805	0.398375
25	MAG	Abernathy Creek	Creek		EAC01	6	1	2.4115	3.463	0.494714
25	Grays	Grays River	Grays River		EGR001	0	0	0.9355	0.9355	0.9355
27	Salmon	Lake River			ESC039	173	1	2.6975	28.5656	0.16417
25	Skam	Elochoman River			3066	103	0	1.712	0	0
27	Kalama	Gobar			ER021	17	0	1.2885	5.2325	0.290694
25	Grays	Grays River	Klints Creek		1	1	0	1.031	1.057	0.5285
26	n	Goble			1350210	24	0	1.474	1.135	0.0454
27	EF Lewis	East Fork Lewis			EEF40	171	0	1.2	44.2695	0.257381
26	Cowlitz	Arkansas	Delameter		1070054	48	0	1.1805	8.732	0.178204
27	EF Lewis	East Fork Lewis	Creek		EEF08	14	0	1.1995	1.7615	0.117433
25	MAG	Abernathy Creek	Slide Creek		1350404	2	0	0.95	1.0825	0.360833
26	Cowlitz	Olequa	Stillwater	Brim	ECZ113	5	1	1.9595	2.0035	0.333917
25	MAG	Mill Creek			EMC16	24	0	1.0195	5.942	0.23768
26	Cowlitz	Arkansas			1070046	33	0	1.063	6.083	0.178912
26	n	Goble	NF Goble		1070146	22	0	1.0615	3.3365	0.145065
27	Salmon	Lake River			ESC060	182	0	1.027	30.4266	0.166266
25	Skam	Skamokawa Creek	Left Fork		MVEDT06	2	0	0.741	1.333	0.444333
27	EF Lewis	East Fork Lewis	South		EEF42	56	2	2.9295	13.563	0.237947
27	EF Lewis	East Fork Lewis	South		EEF43	47	3	3.937	10.2295	0.213115

8.0 Engineering Designs

Wahkiakum District was not able to commit engineering time to prepare preliminary designs as required by the grant agreement and contract with the LCFRB. Available data was reviewed and shared with the family forest fish passage program during their regional prioritization process. A site in Wahkiakum County and one in Clark County was funded and fish passage is being restored. Engineering assistance will continue to be provided by conservation districts in the Lower Columbia region to restore fish passage as implementation funds are made available.

9.0 References

Wade, G. 2002. Salmon and Steelhead Habitat Limiting Factors Water Resource Inventory Area 25. Washington State Conservation Commission Final Report, Lacey, WA.

Clark CD, 2000. Clark Conservation District's Regional Culvert Inventory Report. Unpublished. 29pp.

WDFW, 2000. Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual. Washington Department of Fish and Wildlife. Olympia, WA. 158pp.

10.0   APPENDIX A: GIS Data/Application Development

GIS Data Development and Existing Data

Existing data were used for the initial GIS application. The projection was set to State Plane 1983 Feet; Washington South Zone. The following feature classes were added to the data frame:

HydroFS – The District merged DNR Hydro 2008 layers for each county to create a regional hydro layer. F and S water type (fish bearing) were selected to create the Tier 5 stream reach layer.

EDT 2008 – LCFRB provided the most recent EDT reach Tier layer. There are 5 Tiers that should be color coded by category (tier): 0-Black, 1-Red, 2-Orange, 3-Yellow, 4-Green to coordinate with LCFRB Habitat Strategy maps.

Subbasin – These are the Salmon Recovery Plan subbasin boundaries. The subbasin boundary layer provided the base for clipping data and for tabulating data. The feature classes were clipped to this polygon area for editing and tabulation and then were rejoined to create a single region wide layer.

IWA_Results – Subwatershed boundary layer generated as part of the Integrated Watershed Analysis for the Lower Columbia Region.
Hydro Layers – Include stream labels unavailable in EDT and other data sets.

WDFWMega Data – SHIAPP Barrier data set. The data set includes some, but not all,of the Clark CD regional culvert inventory data. When the site ID code contained text characters, null values ("0") were substituted upon export into GIS. We were able to locate the original data for the region and overlaid the data to identify sites codes. Codes were updated to a numeric ID and the attribute table edited manually.

CCDWCBACORR- Clark and Wahkiakum Barrier Assessment dataset. Some of the data in the database exists in the WDFWMegaData feature class. Duplicate sites were deleted, keeping the most current entry..

Lower Columbia Trans – This appears to be DNR transportation data merged and then clipped to the region boundary. This layer was used to identify crossing data gaps. Note: stream layer must be first in list for points to snap to the stream layer.

As data layers were added and clipped to the subbasin boundary the need to continually check to ensure that projections remained constant for the resulting layers to ensure that subbasin subsets of data could be merged back into a region layer. The order in which layers are selected and combined to generalize of union data dictates the resulting feature class

projection. The following provides a table of the feature class and the projection.

```
WSDOTSites              = GCS_WGS_84
SUB Mega Data        = GCS_NA_83
*SUB CWCDBA          = State Plane 1983 ft Washington South Zone
*SUB EDT TRANS INT  = State Plane 1927 Washington South Zone
*SUB T5 TRANS INT    = State Plane 1983 ft Washington South Zone
*SUB EDT08               = State Plane 1983 ft Washington South Zone
*SUB TIER5                = State Plane 1983 ft Washington South Zone
Trans                       = State Plane 1927 Washington South Zone
SUBWS                    = State Plane 1927 Washington South Zone
```

The HydroFS, EDT 2008, WDFWMegaData, and CCDWCDBA layers were clipped to the subbasin boundary. This produced manageable data sets and allowed for multiple users to edit data at the same time. The subbasin data sets were merged to regenerate an edited region layer when project was complete.

The model required creation of three new feature classes. The first of the three included "Fish" water within the DNR hydro layer, which was treated as a "Tier 5" stream for prioritization. The second and third layers included point intersections of EDT stream reaches and DNR hydro (Tier 5) stream reaches with the transportation layers.

To create the "Tier 5"stream reaches, EDT reaches were overlaid on the DNR Hydro layer displaying just the "F" and "S" stream segments. The tier 5 stream layer was created by selecting all of the "F" and "S" stream segments extending beyond the EDT reach for a stream and dissolving the segments into a single polyline. The DNR Hydro segments underlying EDT reaches were deleted. Three data fields were added to the subbasin layer to help code segments into independent stream reaches. These include:

```
Str_Code   Text             24
Tier                Short Integer   4
LWS                Text             30
```

The "Str_Code" field was used to identify DNR hydro layer segments that were to be dissolved into a distinct stream reach.

Once the coding was completed, the layer was checked for breaks and corrected using editing tools. By setting snaps to endpoints of EDT2008 and vertices of the hydroFS layer helped ensure contiguous line segments. The select command was used to extract the Tier 5 segments, creating the "subbasin_tier5" layer. The dissolve command was used consolidate reaches. This creates a single line segment for all of the DNR reaches with same stream code. The dissolved layer checked for continuity problems and a Length_Mi field was added

to the attribute table in order to calculate the segment length.

Two additional layers were created by generating the point intersects of the transportation layer with EDT Tiered (1-4) and DNR fish (Tier 5) layers. Three data fields were added to both these feature class attribute tables including:

Cross_ID   Text   24
FISHPASS   Double
Comment   Text   24

Barrier assessment data was overlain on the intersect features and the duplicates removed. The resulting layers represent remaining data gaps on EDT stream reaches and existing data gaps on Tier 5 stream reaches.

The available source data for the WDFW mega data file were located and incorporated into the map. This allowed creation of a unique identifier for sites with null culvert IDs. The WDFW data set was appended with previously omitted crossings.

The EDT stream reaches and Tier 5 stream reaches were segmented at every crossing location by using the split line editing tool. Snaps were employed in order to accurately split the line. Once the splits were complete the length field in the attribute tables was recalculated. The resulting data was added as a label feature to the EDT and Tier 5 stream reaches. This provided a view of all the crossing (by passability) with the length in miles between barriers labeled (to the nearest $1/100^{th}$ of a mile).

The following data was manually tabulated in a MS Excel spreadsheet from the GIS application:

Location Data: Including WRIA, Subbasin, Stream, and Tributary information

Incremental habitat gain: Length in miles between barriers, classified by stream tier,

Potential habitat gain: Cumulative length in miles upstream of the barrier, classified by stream tier,

Crossings below: Number of barriers downstream of the subject barrier
Crossings above: Number of barriers upstream of the subject barrier
Ownership: non-industrial private, industrial private, state, federal, county, other.

Toe width: Toe width (m) of the stream downstream of the culvert outlet influence.

The subbasin spreadsheets were then imported into a MS Access database to facilitate data management.

11.0   Appendix B: MSAccess Relational Database Development

Data was extracted from the MSAccess database used to manage the Regional Culvert Inventory (Clark CD data) and Lower Columbia Region Culvert and Tidegate Inventory to provide the foundation of the relational database.

The following tables were generated to manage barrier assessment data:

Barrier Assessment Data
LCRCI Site
CulvertAppend
DamAppend
FishwayAppend
Gravity
OtherAppend
Pump

Barrier assessment data was imported from the WDFW data layer, parsed, and appended to the appropriate data table

Tabulated regional priority data was imported into the database by individual subwatershed (PD_"SUBWS"). These data tables were appended into the LCRCI Priorities data table. The Crossing ID field was set as a key field to resolve duplication errors in the data table. Three prioritization model queries were created that construct the priority value. Three additional queries were created that allow the data to be viewed by predefined spatial scales.

Data access is provided through a series of forms that provide the menu structure and data views. The startup menu was used to have the LCRCI MAIN form appear on startup and the program menus turned off. This can be bypassed to allow full access to the database application. The menu structure for the database application is illustrated below:

LCRCI MAIN MENU

Data Access Menu	Prioritization Screen

Site Location Form	Barrier Profile Form		Region Priorities

	WRIA	WRIA Priorities

	Subwatershed	Subwatershed Priorities

	Local SWS	Stream Priority

	Stream	
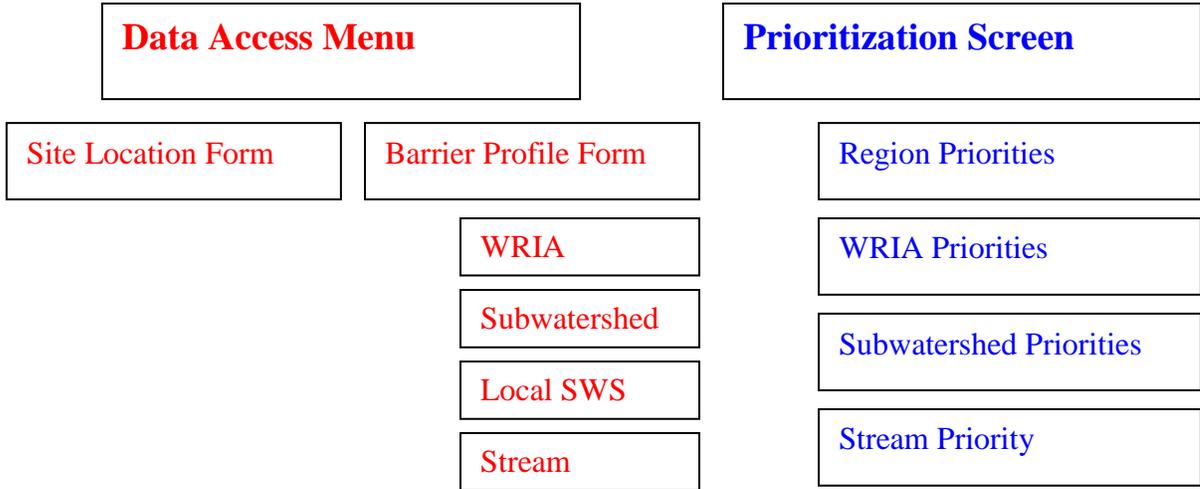
To use the Site Location form to view barrier assessment data, the user must know the site ID. The site ID is selected from a drop down box in the forms header. The selected ID will be carried through as additional forms are selected.

The data has been displayed in read only forms. It can be viewed or printed. More experienced user can export the resulting data set into an Excel Spreadsheet for additional management.

12.0 Appendix C: ArcMap Application Development

The Arcmap application was developed in ArcMap 9.2. The layer coordinate system was set to state plane 83 feet Washington South Zone. The following layers were incorporated into the application.

IWA_results: This layer is used to label the Lower Columbia Fish Recovery Board subwatersheds.

Subwatershed boundaries (14): Subwatersheds are colored to allow for distinction at large scales. These data layers could probably be merged or grouped in the data frame to consolidate the feature classes.

DNR hydro2008FS: This is feature class created by merging the county DNR Hydro Layer 2008 feature classes and only contains the F&S water. Layer features are not displayed (symbology set to no color), but is used in the application to generate stream labels.

Lower_Columbia_Trans: Road layer that is not displayed until zoomed in closer than 1:80,000

EDT 0408reaches: This feature class was generated from the EDT_reach_April08 feature class and has been edited by breaking line segments where barriers intersect in order to tabulation habitat gain. It is set to not display beyond 1:250,000 scale.

Tier5_StreamReaches: This feature class was created from the DNR Hydro layer. It contains the F&S streams that are not overlain by the EDT reaches. The extending line segments were dissolved and then split where barriers interest in order to tabulate habitat gain. is set to not display beyond 1:250,000 scale.

RCI_Tier5_Trans_Interesect: This feature class was created by intersecting the Tier5_StreamReach feature class with the Lower_Columbia_Trans(DNR) feature class. Points overlain by the barrier data were removed from the dataset. The remaining points represent data gaps on tier 5 stream reaches and were provided a unique crossing ID. These crossings were included in the regional priority data tabulation process.

EDT_Trans_intersect: This feature class was created by intersecting the EDT_reach_April08 feature class with the Lower_Columbia_Trans(DNR) feature class. Points overlain by the barrier data were removed from the dataset. The remaining points represent data gaps on tier 5 stream reaches and were provided a unique crossing ID. These crossings were included in the regional priority data tabulation process.

WDFW_Megadata: This feature class was provided by LCFRB. It contained a number of null site ID's. A large portion of the data originated from a barrier assessment conducted by

Cowlitz and Wahkiakum Conservation Districts. Most of the null values were resolved by cross referencing sites with the original data set. The remaining null sites were provided unique Site ID's. For display purposes this feature class and the RCI_GIS_Complete feature class could be merged or grouped to prevent duplicate labeling of site ID.

RIC_GIS_Complete: This feature class was created from data managed in the WDFW database that housed both the Regional Culvert Inventory (Clark CD) and the Regional Culvert and Tidegate Inventory data. All of the data was exported from the database because the original data export to WDFW omitted the Site forms for bridge locations. Time constraints prevented removal of duplicate site ID's. As a result duplicate labels appear in Arcmap. Merging the two databases is difficult due to inconsistency in field names the resulting merge would become a massive data table. Duplicate labels may be resolved by grouping the feature classes in the data frame.

Additional data sets are provided but not incorporated into the application. These include the barrier assessment data collected by Cowlitz and Wahkiakum District under the Washington State Department of Transportation funded program and the Grays River Road Inventory data collected by Wahkiakum Conservation District under a program funded by Washington State Department of Ecology.

The RIC_GIS_Complete, WDFW_Megadata, edt_trans_intersect, and Tier5_Trans_Intersect feature classes are joined to the relation database via the site ID and Cross_ID fields. The link is with the LCRCI RP Model 1 table in the database. This allows the regional priorities managed in the relational database to be visualized in the ArcMap application. The joins must be deleted and reformed if a new model is constructed or if the data is moved and the link jeopardized.

The select by attributes menu should allow for selecting barriers based on the regional priority, however error messages were encountered when exploring this avenue. Priorities can be visualized by opening the attribute tables, sorting the priority field in descending order, and manually selecting the attributes of interest (i. e. priority values greater than #). This must be done in each of the 4 barrier feature classes. The sites will be highlighted on the screen.