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7. Constraints and Opportunities to Developing an Integrated River Management Strategy

7.1 Introduction

In this section we evaluate constraints and opportunities to developing an Integrated River Management Strategy, with respect to natural processes and human land uses within the river system. The previous section provided a number of independent spatial and non-spatial assessments of hydrologic, biologic and institutional elements comprising the Tillamook Bay river system. These assessments were selected from a larger set of assessments detailed in Appendix A. This chapter combines selected individual assessments to accomplish the following:

– divide the Tillamook Bay Basin landscape into management areas based on physical processes;
– describe how the natural and human environments inter-relate;
– where possible, locate functionally important or sensitive areas within the river system;
– spatially identify constraints and opportunities for managing the system in an integrated way.

The dynamic and complex relationships between human land uses and natural processes were simplified into generalized features of the natural and human environment, in order to divide the Tillamook Bay Basin landscape into management areas. These management areas were then divided into discrete landscape zones, based on the spatial extent of common natural processes and landforms. Ultimately, the landscape zones provided a logical breakdown of the river system for assigning common river management actions. The zones also provide a means to prioritize the actions as part of the IRMS itself.

To identify specific constraints and opportunities, selected human land uses, such as roads, stream crossings, dikes and levees, presented in the previous chapter, were spatially overlaid in different combinations on the landscape zones. The resulting composite mapping showed how the natural and human environments interrelate spatially, and allowed a visual evaluation of some of the constraints and opportunities for developing an IRMS. This evaluation provided the foundation for the development of the planning level recommendations that make up the IRMS, Non-spatial constraints and opportunities were also evaluated from a public policy standpoint.

This chapter ends with a possible future vision of the Tillamook Bay river system, if an integrated system-based approach is not taken. This view is intended to articulate potential lost opportunities and increasing constraints as time continues and the river system continues to be managed as it has been. This hypothetical scenario leads into the discussion of an alternative future scenario for the river system in the next chapter. A comparison of these two future scenarios provides a basis against which the benefits and values of an integrated approach to managing the river system can be measured.

7.2 Tillamook Basin Spatial Zones

7.2.1 Management Areas

Within the river system, the physical structure of the natural environment and the features of human land use were initially evaluated by breaking the landscape down into generalized features of the landscape and land use. Many of the land uses within the basin are confined to specific physical landscape features. For example, agriculture dominates the flatter lowland areas while forestry prevails on the steeper slopes. By spatially dividing the basin based on land use and physical features, the relationships between specific land uses and natural processes are revealed. In some cases, land use and natural processes conflict, while in others there is a more beneficial relationship.

The river system was initially divided into the general physical features of bay, estuary, lowland and upland. The extent of these physical features is schematically shown in Figure 7-1. The bay was assumed to extend up to the limit of Mean Lower Low Water (MLLW). The estuary was considered as land extending above MLLW to Mean Higher High Water (MHHW). The lowlands generally extend from MHHW to the natural change in slope between the lowland valley and the uplands. The uplands extend from there up to the boundaries of the watershed.

The varying physical features of the basin provide varying opportunities for human use of natural resources throughout the river system. They help to sustain the economy and lifestyle of the residents of, and tourists to, the area. Human use of the land initially evolved with recognition of constraints imposed by the natural environment, such as flooding. Flooding still represents one of the predominant natural constraints to human land use in the river system. Conversely, it represents one of the best natural opportunities for recovery of salmon. Seasonal flooding, which helped to shape the lush lowland landscapes that have attracted human populations over the centuries, has also sustained salmon populations over the millennia.

Recent work by Smith (1999) addresses human land use within the river system and the jurisdictions of the institutions dealing with salmon issues in the Tillamook Bay basin. Figure 7-2 shows a generalized division of these interests and their extent. The varied ownership and land uses within the river system impart constraints to the management of the river system as a whole. For example, upland public and private forest land uses are governed by forest practices rules of the Oregon Forestry Board; lowland agricultural land uses are administered by the Oregon Department of Agriculture; and lowland urban land uses are overseen by the local incorporated and unincorporated governments. The goals and objectives for managing the land for flood risk reduction and salmon recovery by the different institutions often do not coincide or are not coordinated. As Smith (1999) notes, "this spatial fragmentation…suggests weak power to obtain desired actions."

Human land use is more intense in the lowlands. Interventions are more prevalent and significant in this part of the river system, and the potential for flood and fish impacts is greater. Obstacles to the development of an IRMS are more prevalent and inflexible here, because of the longevity of the human presence and established infrastructure. Opportunities include features and processes of the natural environment that, if allowed to function in a natural manner, would demonstrate the natural resiliency of the river system.

7.2.2 Tillamook Basin Landscape Zones

The management areas of the landscape were further refined into landscape zones. The landscape zones reflect in more detail the natural processes occurring in the river system. The upland, lowland and estuary landscape zones and the methods for their development are described below and mapped in Figures 7-3 and 7-4. These spatial zones were considered in the evaluation of constraints and opportunities to the development of an IRMS.

Upland Management Area:

1. Forested zone. This zone represents the general extent of the western hemlock/Douglas fir forest. This zone was defined as land area above 500 feet in elevation.

2. Transition zone. This zone was defined as land area below 500 feet elevation and above the elevation of the FEMA 100-year floodplain. This area generally corresponds to the landscape historically dominated by Sitka spruce forest.

Lowland Management Area:

3. Floodplain zone. A majority of the lowland valley area was defined as the floodplain zone. This zone corresponds to the regulatory FEMA 100-year floodplain. The use of the FEMA floodplain boundary to define this management area results in a smaller area than would be obtained if the lowlands were defined by the natural change in slope between the lowland valley and the steeper upland terrain. However, this delineation is considered appropriate for this work because it focuses attention on the more dynamic and functional portion of the lowlands that experiences more frequent flooding.

The floodplain zone is above normal tidal influences, but includes areas that are inundated by extreme tidal storm surges. As such, it includes areas located between MHHW (4.2 feet, NGVD) and 10.0 feet, NGVD. The latter elevation is the 100-year stillwater elevation adopted from the FEMA flood insurance study for Tillamook County, and represents an extreme tide level from the combined effects of an astronomical high tide and storm surge that has a 1 in 100 chance of happening in any given year. Tidally-influenced river reaches are included in this zone and extend inland within the banks of the mainstem river channels up to the heads of tide. The head of tide represents the inland extent of normal tidal influence on river water elevations.

4. Active floodplain zone. This zone is located within the FEMA 100-year floodplain and represents river reaches, and their associated floodplains, that are considered to be actively meandering. This zone was determined by evaluating bank stability and comparing the relative change in historic channel planform patterns.

Estuary Management Area:

5. Tidal zone. This zone extends from MLLW (3.8 feet, NGVD) to MHHW (4.2 feet, NGVD). MHHW represents the average height of the higher high tides and can be characterized in the field as the transition between low marsh and high marsh vegetation. High marsh vegetation could be expected inland to an elevation of about 10 feet. Both the MLLW and MHHW elevation contours were delineated using a 10-meter (33-foot) DEM. This zone consists primarily of intertidal habitat and includes both salt and brackish water aquatic ecosystems.

The tidal zone is divided by the brackish/freshwater interface (Figure 7-4). Though the natural process of tidal inundation is the same on both sides of this interface, the habitats supported in the brackish and fresh water zones are unique.

6. Subtidal zone. This zone is below the elevation of MLLW (3.8 feet, NGVD). It includes the open water habitat of the bay and tidal channels that are deep enough to remain inundated at all tidal elevations.

7.3 Spatial Evaluation of Constraints and Opportunities

In this section, selected spatial features of salmon distributions and habitat, and human land uses (e.g. roads, stream crossings, dikes and levees), are overlaid in different combinations at the basin extent and the lowland valley floodplain extent. The maps are intended to integrate key assessments from the previous chapter to define spatially the constraints and opportunities for the development of an IRMS in the Tillamook Bay Basin. The selected maps support some of the significant conclusions from this study, which are italicized as headings in the following sections.

7.3.1 Constraints and Opportunities in the Uplands

Salmon are distributed throughout the Tillamook Bay river system.

Constraints: Figure 7-5 provides a map of salmon distributions in the Tillamook Bay Basin overlaid with selected vegetation zones. The distribution of individual fish species is indicated by progressively thinner lines on the map, so that overlaps in distribution can be seen. A larger number of species utilize the lowlands and lower portions of the uplands; however, multiple species are distributed among the headwater reaches of the uplands. This wide geographic distribution of salmon within the drainage network implies that salmon can be affected by human activities nearly anywhere in the basin.

***Opportunities**:* The fact that nearly all the mainstem rivers and major tributaries are accessible to salmon means that there are abundant restoration opportunities in the area. Priority should be given to recovery efforts where multiple fish and other species are present, and where watershed conditions are relatively intact. Emergent and forested wetlands in the brackish-freshwater transition area of river systems should be prioritized for restoration because these areas are important for juvenile salmon rearing and acclimatization to salt water (Northwest Fisheries Science Center, 2001).

Opportunities for large-scale salmon recovery may be most practical where species diversity and availability of productive habitat exists on public lands.

Constraints: Large-scale salmon recovery efforts on private lands may face difficulty because of the variety of land ownership, land uses and land management techniques. Ecosystem restoration is most effective if actions are implemented at a watershed scale, without the constraints of imposed property boundaries.

Opportunities: Opportunities for large-scale salmon recovery efforts in the uplands exist where salmon habitat exists on public lands. A GIS-based analysis was performed to identify and rank opportunities for watershed conservation with consideration given to habitat abundance, species diversity and patterns of land ownership. The method used in this spatial evaluation is described below.

Many watersheds or stream corridors within the Tillamook Bay basin have already been recognized in previous regional scientific assessments as particularly important to salmon and other aquatic species in the near term. These include Aquatic Diversity Areas (ADAs) identified by the Oregon Chapter of the American Fisheries Society (Li et al. 1995), federal Key Watersheds (FEMAT 1994), and Core Areas mapped by the Oregon Department of Fish and Wildlife (OCSRI 1997). These previously-identified important areas were combined into a group of nine watersheds worthy of near-term emphasis in aquatic conservation. The watersheds were delineated to include the Oregon Chapter's ADAs, federal Key Watersheds, and other catchments that have relatively high densities (mi/mi2) of ODFW Core Areas. After identifying the nine priority watersheds, GIS-based analyses were conducted to develop values for a variety of metrics related to salmon and watershed conditions. The analyses were based on spatial data layers readily available from public sources. Metrics developed for each priority watershed included drainage area (mi^2); abundance (mi/mi^2) of Core Areas; abundance of habitat for native coho, chum, fall chinook, spring chinook, and winter steelhead; and the percent of publicly-owned land. These metrics were then used to rank the relative priority of the watersheds by following a three-step process similar to that outlined by Huntington and Frissell (1997).

1. Regional Biodiversity Value. Watersheds designated as federal Key Watersheds, AFS ADAs, or reserves in Noss's (1993) Coast Range conservation plan scored 10000 on this criterion and watersheds failing to meet this selection criterion were given no score. This was intended to identify those watersheds of relatively higher regional importance to terrestrial species, in better condition than adjacent watersheds, or with greater restoration potential.

2. Salmon Value. The relative importance of a watershed to salmon conservation was calculated from normalized values scaled 0 to 100 for metrics on the abundance of ODFW core areas and on the abundance of habitat for each of five species of salmon found in the basin. The algorithm used in the calculations was intended to emphasize the importance of productive habitat and of species diversity. Salmon value was calculated as follows:

Salmon Value = ((normalized abundance of ODFW core areas) + (mean of normalized utilization values for all five species of salmon))/2

3. Salmon Conservation Priority. The influence that conservation on public lands could have on salmon and their ecosystem should be related to the proportion of the landscape in public ownership, because large blocks of state or federal land can be more comprehensively committed to conservation purposes than traditionally managed private lands. The relative conservation priority of each watershed was calculated as the score assigned for its Regional Biodiversity Value plus the product of its Salmon Value (from 2.) and the percent public ownership:

Salmon Conservation Priority = Regional Biodiversity Value + (Salmon Value) x (Percent public ownership)

Salmon Conservation Priority scores were developed for each of the nine priority watersheds within the basin (Table 7-1). Scores ranged from 1164 for the Tillamook watershed with only 14% public land to as high as 14835 for the Kilchis watershed, an Oregon AFS ADA with 90% public ownership. These watersheds are shown on Figure 7-6. The more darkly shaded watersheds are those having been previously recognized as having a high Regional Biodiversity Value. The Tillamook watershed had the highest Salmon Value score but scored low on Conservation Priority because of limited public ownership. This makes it an area where conservation efforts by private landowners and local watershed groups will be particularly important. Historically, lower elevation habitats were some of the most productive areas for salmon, but they are now typically degraded from land use activities and separated from healthy ecosystems (Nehlsen, 1997). The lowland river reaches tributary to the upland priority watersheds for salmon recovery (Figure 7-6) should be prioritized for short term actions to restore connectivity to the uplands.

Table 7-1. Salmon conservation priority scores for watersheds in the Tillamook Bay Basin

		Normalized values								Cons.
		Core Areas and utilization by species						Salmon	Percent	Priority
Rank	Watershed	Cores	Coho	Chum	ChF	ChS	StW	Value	Public	(score)
1	Kilchis R.	34	69	48	96	87	71	54	90	14834
2	N.Fk. Trask R.	62	58	0	43	100	38	55	77	14221
3	Little N.Fk. Wilson R.	31	49	39	100	0	45	39	97	13759
4	Miami R.	55	85	100	76	0	80	62	56	13428
5	Devil's Lk. Fk. Wilson R.*	71	89	0	42	36	67	59	80	4702
6	Cedar Cr.*	53	37	0	69	0	60	43	100	4289
7	S.Fk. Trask R.*	22	83	0	89	92	63	44	87	3789
8	North Fork Wilson R.*	46	46	0	58	0	60	40	71	2806
9	Tillamook R.*	100	100	86	63	0	100	85	14	1164

* watersheds not previously recognized as having a high Regional Biodiversity Value (not Key Watersheds, parts of reserves recommended by Noss (1993), or Oregon Chapter AFS ADAs)

The location of human infrastructure intersecting the river system occurs throughout the uplands and lowlands.

***Constraints*:** The location of upland activities for flood risk reduction and salmon recovery may be partially guided by an understanding for the location of human infrastructure intersecting the river system. As an example, consider the spatial distribution of roadway stream crossing and water diversions shown in Figure 7-7. Floodplain stream crossings, many associated with logging roads, extend throughout the watershed and are primarily concentrated in the Wilson River floodplain and along the Highway 101 corridor. Water diversions are evident along the entire length of the Trask and Kilchis Rivers, and near the head of the lowlands along the Wilson and Tillamook Rivers. As expected, diversions are not located in or near the estuary because of the presence of brackish water in the river channels and groundwater. These points of existing infrastructure may represent constraints to flood risk reduction and salmon recovery efforts. These constraints in the uplands are significant because if they are not addressed, IRMS efforts taken in the lowlands and estuary may be compromised by excessive amounts of water, sediment and organic materials transported down the river system.

***Opportunities*:** A spatial understanding of the distribution and condition of road crossings and water diversions may enable an effort to consolidate these encroachments in the river system. Efforts to decommission old logging roads can be guided by upland salmon habitat distribution and flood potential. Opportunities for conservation and restoration of the river system might be prioritized where this infrastructure is not as prevalent, such as in the Kilchis River basin and the upper Trask River basin.

A majority of the channel reach morphology throughout the Tillamook Bay Basin is steep-sloped and debris-flow dominated, but discrete transitions to fluvial-dominated reaches exist where sediment transport may be managed.

Constraints: Upland land slopes were classified in Chapter 6 into zones of source, transport and response. Slopes between 3 and 10 percent can be generalized as a step-pool channel reach morphology for Pacific Northwest rivers (Montgomery and Buffington, 1997). These reaches constitute the upper limit of the transport zone, where fluvial processes dominate and are contiguous upstream to the lower limit of debris-flow dominated processes. This slope class was mapped using a GIS and a 10-meter Digital Elevation Model (DEM), and the step-pool channel morphology was assumed to occur within land areas identified in this slope class (Figure 7-8). These channel reaches are characteristically confined by valley walls, and may receive direct sediment loads from hillslope failures. Many species of salmon are distributed throughout these reaches (Figure 7-5) and, consequently, these reaches may represent critical areas in the basin where sedimentation may first impact salmon habitat.

Opportunities: It is apparent from a map of this slope class (Figure 7-8) that the lowlands and many locations along the mainstem rivers are fringed by this type of reach morphology. The step-pool reaches in the uplands may be considered as opportunities within the river system where the movement of sediment and wood from debris flows may be attenuated as a part of restoration efforts.

As development pressures continue in the watershed, it becomes increasingly important to preserve or restore the natural morphology of the river system to achieve a more natural rainfall-runoff relationship. Otherwise, as the effects of development accumulate, the Tillamook lowlands may experience progressively larger floods.

7.3.2 Constraints and Opportunities in the Lowlands and Estuary

There is an extensive amount of infrastructure in the lowland floodplains.

Constraints: Figure 7-9 shows the major linear features, such as roads and railroads, dikes and levees, that intervene on the lowland floodplain. These land use features are overlaid on a map of the lowland and estuary landscape zones described earlier. The 100-year floodplain is also delineated, to show the relationship of these lowland features within the floodplain. Road and levee networks are spread throughout the area. Lateral constraints on the river channels from these features tend to increase in a downstream direction. Few roads are located near the channels where they first enter the lowlands. Roads and railroads run parallel to and cross the rivers within the 100-year floodplain zone. In the tidal zone, there are few roads but numerous dikes and levees that constrain the river channels and tidal inundation.

Opportunities: The lack of infrastructure in the upper reaches of the lowlands, in the active channel landscape zones, provides opportunities for managing delivery and deposition of sediment and organic matter from the uplands, before these materials reach the more encroached areas of the lowlands further downstream. These areas are primarily in agricultural production, so management actions should be taken to reduce flood risks to this land use, while allowing for the restoration of natural processes for ecosystem recovery. This may include actions to localize the deposition of fine sediments that would otherwise spread across pastureland and fields and ruin crops or soil conditions. This zone also corresponds to reaches of meandering channel and erosion-prone riverbank soils. The lack of infrastructure aligned parallel to the river channels may provide economical opportunities for setbacks and terracing of the floodplain. These may be lost if future development compromises existing levels of flood risk. Conversely, development on the floodplain may still occur, as long as conveyance or flow paths are not jeopardized.

An extensive system of dikes and levees encompasses the tidal zone in the lowlands.

Constraints: Dikes and levees are prevalent in the estuary and tidal lowlands (Figure 7-10). Shaded areas indicate the remaining land areas assumed to be freely exposed to tidal action. These areas represent a small portion of the area designated as the tidal zone (Figure 7-4), which was delineated without consideration for dikes or levees. A comparison of the two areas shows the extent to which dikes and levees have removed high tidal mud flats and marshes from tidal inundation. Since the dikes and levees were primarily designed to prevent saltwater intrusion onto reclaimed pasturelands, they are low in height and vulnerable to overtopping from river flood events. When these structures are overtopped, floodwaters are detained from reaching the bay and pasturelands remain inundated longer that what might occur naturally. The levee systems, which are open to inland river flood flows, are most prone to this condition. This is evident in the Tillamook River and Kilchis River floodplains. Collectively, the levee and dike system forms a constriction to both tidal and river flows, and this likely affects the transport of sediments and the heights and durations of water levels in the lowlands.

Opportunities: The existing dikes and levees offer an excellent opportunity to manage and direct tidal and river flows through the estuarine and tidal reaches of the system. Use of monitoring and computer simulations can help predict salinity intrusion, tidal circulation and flushing characteristics under a variety of restoration scenarios. A wide range of alternatives are possible for managing salinity, inundation duration and water quality, while protecting agricultural interests and improving habitat. In some areas, different levees and dikes along the water bodies are in different jurisdictions, e.g. the City of Tillamook vs. Tillamook County. Therefore, wherever dikes and levees are considered for modification as part of restoration efforts, these jurisdictions should be encouraged to coordinate their open space plan elements with respect to linear parks or open spaces in riparian corridors.

Numerous tide gates and culverts are located in the lowlands that regulate tidal and river flows, and may impede the seasonal migration of salmon.

Constraints: The dispersed locations of culverts and tide gates (Figure 7-11) represents a patchwork of flood control structures that modifies and complicates the natural flow of tidal and stream flows in the lowlands. The elimination of periodic flooding and sediment deposition means that the rate of sea level rise exceeds natural sedimentation rates, such that marshes are gradually inundated - or become mudflats/subtidal if restored. This problem is exacerbated in areas that have been diked and drained for agricultural use. Land protected in this way may subside through compaction and loss of organic matter. This subsidence may accelerate over time, and with use of the land. Subsidence can greatly constrain the success of restoration for tidal wetlands (Frenkel and Morlan, 1991). Over time this can be a problem to farmers as well, as their property gradually becomes lower relative to the ocean levels, and more prone to waterlogging and standing water from rainfall runoff. The freshwater wetlands that result from this ponding are often colonized by soft rush (*Juncus effusus*) and slough sedge (*Carex obnupta*) which are unpalatable to cattle. Multiple ownership of the structures may constrain the ability of a system-wide effort to retrofit or remove these structures to reduce regional flood risk and restore large contiguous areas of habitat. Unforeseen circumstances, such as debris blockages after flood events, may create localized maintenance problems and lead to unintended consequences in the operation of the gates. Tidegated diversion structures or backwaters may also strand fish that have entered and then cannot get out, dying as side channels dry out or getting washed into fields.

Opportunities: Many culverts with fish passage issues are located on streams tributary to the mainstem lowland rivers and outside of the FEMA 100-year floodplain. The retrofit of culverts for fish passage often requires extensive permitting and design considerations if insurable structures are located nearby, because changes in the size of a culvert may change flood elevations. The relatively undeveloped state of the agricultural lands may provide opportunities for economical culvert retrofitting with immediate flood risk reduction and fish passage benefits. The large number and distribution of tide gates in the lowlands may provide opportunities for managed flooding and restoration of tidal lands. These locations of existing infrastructure are logical places to modify the original flood control function of the gates for flood management purposes. Several local initiatives have been undertaken to do this, in response to past flood damages and continued flood risk. The majority of these projects are in the estuary/tidal zone, with the exception of the projects located on the Wilson River upstream of Highway 101. The estuary/tidal zone projects are intended to reduce the detention effects of the tidal dike and levee system. Larger tide-gates and dedicated floodways are proposed to increase the drainage of floodwaters as flooding recedes (Jones, 1999). Opportunities exist to build upon these identified projects by expanding or linking them to other projects that will restore full tidal action and lead to the recovery of salmon habitat. Diked-off lands with remnant tidal channels may offer particular opportunities for restoration. This is because the remnant channels may be able to carry restored tidal flow into the site in a natural fashion, or alternatively, they may provide guidelines for excavation work to channel reintroduced tidal flow. Recently altered sites may still have more of the original vegetation (in the seed bank, if not above ground), and may have undergone less subsidence compared to sites altered long ago.

Lowland flood damages have been numerous and repetitive, and have occurred on salmon-bearing rivers and sloughs.

Constraints: Flood damage claims are an indication of human features exposed to flood risk, and repetitive claims underscore the severity of this risk. Figure 7-12 shows locations of FEMA and NRCS flood claims with respect to the lowland and estuary landscape zones. A limited number of damage claims occur in the tidal floodplain zone. Repetitive damage claims are clustered along the Highway 101 corridor as expected, within the 100-year floodplain zone along the Wilson River. However, a higher repetition of claims occurs along Dougherty and Hoquarten Sloughs. No FEMA damage claims are evident further upstream of the Highway 101 corridor in the 100-year floodplain zone and active floodplain zone. NRCS road system damages are frequent within the tidal and lowland floodplain zones of the Trask River and along the Southern Pacific Railroad crossing of the Trask and Wilson Rivers. These damages are associated with human features in the floodplain that have been impacted by flooding. Conversely, these features likely impact the natural process of flooding.

Opportunities: There is an opportunity to reduce the economic and social costs of flood damages by understanding where, and how frequently, damages occur. Segments of the river system near damage claim locations should be prioritized for evaluation of the cause of damages. The objective would be to formulate flood response plans that incorporate alternative emergency actions aimed at reducing future flood risks and restoring natural floodplain processes and habitat. In addition, FEMA has implemented a policy to discourage repetitive claims for properties that have experienced damages from multiple events. Future development in the County should be concentrated outside of the floodplain. Implementation of such a policy could be aided by creation of incentives among multiple jurisdictions such as the County and the City.

An extensive amount of lowland floodplain vegetation has been converted to agricultural lands, but relatively large contiguous wetlands exist in tidal portions of the lowlands.

Constraints: Figure 7-13 shows the location and extent of wetland plant communities as indicated on the National Wetland Inventory (NWI) maps for the Tillamook lowlands. Palustrine wetlands, or wetlands that are temporarily flooded, are concentrated in the tidal portions of the lowland valley and in sporadic locations along the mainstem river channels. The lack of existing wetland communities along the mainstem rivers may constrain the incentives and ability to restore floodplains in the fluvial portions of the lowlands. Many streams and sloughs in the Tillamook lowlands have been straightened and channelized in order to drain the land and improve pasture and farmland. Once a stream has been ditched and straightened, land use and ownership patterns make it nearly impossible to re-establish a meandering channel across a large area.

Opportunities: Large areas of intact wetland plant communities exist in the tidal portions of the lowlands. The brackish-to-freshwater reaches of the marshes, sloughs and rivers present habitat opportunities for salmonids including osmotic transition, a highly productive foraging environment (NOAA, 1990) and deep channels for predator avoidance (Lebovitz, 1992). Tidal forest is still found in very limited areas of the lowlands. The largest remaining area is the forest surrounding Hoquarten Slough within the Urban Growth Boundary of the City of Tillamook (Wilson et al, 1997, and Brophy, 1999b). Other areas are found in upper Squeedunk Slough, and near the mouth of Hall Slough. All of these areas provide opportunities for protection. In addition to their meandering channels, Hoquarten Slough and Dougherty Slough provide habitat for anadromous fish. Additional value comes from their landscape position. These sloughs are located in areas of major flood concern, and they extend far enough up the valley that they provide extensive opportunities for hydrologic restoration. Habitat value may also be gained from straight ditches and channels with terracing, vegetation and the reintroduction of tidal action.

These spatial constraints and opportunities to an IRMS in the lowlands are summarized in a schematic diagram of the natural zones of the river system (Figure 7-14) and a diagram of the primary human interventions in the system (Figure 7-15). The figures illustrate the increasing complexity of natural processes and land use in the lowland river system as the single river channels in the active floodplain zone transition into multiple fluvial and tidal channels within the floodplain.

7.4 Public Policy Constraints and Opportunities

Institutional constraints and opportunities in the management of the lowland valley floodplains were evaluated based on an assessment of the existing public policy concept. The evaluation generally consisted of a review and analysis of flood response permit activities, tools and techniques for policy implementation and enforcement, and policy frameworks. Since a key finding is that public policy activities are not spatially-oriented, this section is not presented with maps, but as a narrative with selected schematic diagrams. As with the mapping from the previous section, the narratives support some of the significant conclusions from this study.

Permit Activity Lacks a Cumulative or Interactive Impact Analysis.

Constraint: Fragmentation and complexity of the permitting process is an enormous and well-documented problem. There are numerous examples of policy "disconnect." For example, joint permit DSL/COE applications may occur where the COE can be cut out of the review process if a fish waiver is claimed. The most prevalent forms of these permits pertain to fill and dredging. The underlying intent of these permits does not correspond to the primary concerns of an IRMS (habitat restoration, water quality and quantity, fish passage, flood hazard reduction) and, consequently, cumulative impacts on the function of the river system can be significant. Permit review and compliance are based on internal review criteria rather than on a cumulative environmental impacts assessment of the individual permit activity or the interactive impacts of multiple permits issued within any watershed. In order to evaluate activity in the Tillamook Bay Basin, the 187 permits issued in 1997 were mapped by sub-watershed, and are summarized in Table 7-2. It should be noted that multiple permits are often issued for a single property, so while the total number may be high, it does not necessarily give an accurate overview of the extent of the disturbance to the habitat. In granting the permits, cumulative impacts of the 187 actions were not evaluated by the various agencies.

Table 7-2 Post Flood Permits Issued in 1997 (multiple permits can be issued for one location)

Tillamook Bay River System Permits

	DSL	NRCS	COE	FEMA	TOTAL
Tillamook	21	4	4	13	42
Trask	31	4	4	15	54
Wilson	22	3	7	10	42
Kilchis	14	2	2	2	20
Miami	15	1	3	10	29
TOTAL	**103**	**14**	**20**	**50**	**187**

Opportunity. Two existing vehicles could be adapted to facilitate integrated planning and assessment. The NEPA framework, together with the OWEB Watershed Assessment Manual, provide a structure to define baseline resource and ecosystem conditions, and to evaluate implications of actions in relation to development standards and environmental impact. The cumulative impact analysis component of NEPA can be used to correlate actions with the three main ESA concerns (flow rates, water quality and habitat) and to define impacts on thresholds as specified by Oregon Plan benchmarks. As a preliminary idea, targets would include elements addressed in cumulative analysis:

1. Flow regime: in-stream flow volumes and in-stream flow rates;
2. Water quality: temperature, chemicals, nutrients, sediment load, other;
3. Habitat: a) upper watershed - near shore, forested uplands, riparian corridors, other; b) lower flood plain/near shore - wetlands, riparian corridors; c) in-stream.

Public planning and policy structure is aspatial and/or is not adaptable to spatial correlation.

Constraint: Review of the Oregon Plan benchmarks and the Tillamook Bay CCMP reveals little relationship to existing spatially-defined policies and relations that regulate land use actions. The Oregon Plan is aspatial because benchmarks have been defined by agency mandates rather than spatial limits or jurisdictions. Furthermore, under the plan each agency is directed to goals with respect to fish recovery in each river. It should be noted that benchmarks have not been translated into specific local agency strategies.

Opportunity: A strategy is needed to strengthen the capacity of existing bodies such as the watershed councils to achieve interagency coordination (state, federal and local). Considering that each jurisdiction is required to adopt a comprehensive plan, and that administrative guidelines exist for implementing Goal 5 (natural resources, science and historic areas, and open spaces), it is assumed that a strong framework now exists for implementation of the Oregon Plan targets. The Oregon Plan increases responsibility and accountability at the local level. The issue at this point is to translate accountability (including benchmarks) into the spatial dimensions of a multi objective IRMS.

There is a need to specify spatial information in a format that can be used to refine the implementation framework to achieve flood hazard reductions and habitat restoration. The difficulty of correlating regulatory requirements with ecological regimes is illustrated in Figure 7-15. Landscape features based on an ecological regime have been identified by other components of this project. In order to translate them into existing regulatory tools, the categories must initially be correlated with the existing regulatory context. An example of this is shown in Table 7-3.

Table 7-3
Correlation of Landscape Features to Existing Regulatory Tools

Landscape Features	**Existing Regulatory Tools**
Watershed	watershed councils; counties
Shorelands	200 feet from higher high tide or top of bank and Goal 17
Estuaries	Goal 16 Coastal Zone Management
Riparian Corridors	75 from top of bank, Goal 5
Wetlands	404 COE and DSL, Goal 5 and County
In stream	402 review

Existing GIS data sets often do not facilitate policy analysis because base data is difficult to correlate spatially.

Constraint: From a review and evaluation of the GIS data used in this project, it was apparent that the data do not necessarily support planning or regulatory needs. For example, because of a lack of spatial definition, it is impossible to correlate critical cultural features (such as legally mandated riparian corridors, shorelands, and zoning boundaries) with ecological and geomorphological features such as riparian habitat.

Extensive data is available regarding permit activity; however, a lack of precision in activity location makes interpretation difficult. For example, attribute data were not available for the 187 permits reviewed, and permit purpose was therefore unclear, e.g. whether a given permit was issued as part of a flood response or a land use action.

A lack of metadata associated with data points can lead to erroneous conclusions. For example, permits issued for the same action appeared at different locations on the map because of differing location tracking systems. The FEMA data appears to be based on damage survey reports for public facility repair from the 1996 flood. The data incorporate a large number of actions including debris removal and roadway and culvert repair, and do not necessarily reflect activity types comparable to the DSL data points.

Another problem occurs with the overlaying of point data onto polygon map data. Using the FEMA data set correlated with land ownership, represented by large polygons, results in erroneous conclusions because the public vector data (roadways) and spotty parcels of public ownership have not been included. For example, DSL permit location data, available by section, township and range, are represented as raster data, while features such as rivers are vector data. Thus, important policy issues such as number of permits issued within the regulatory riparian corridor are impossible to show. Although the resulting map is helpful for estimating the approximate number of permits, it does not give an accurate idea of where these permits were located.

Opportunity: A case study utilizing GIS or new three-dimensional imaging techniques could be applied to one basin, such as the Wilson or Trask, to present a 2D or 3D view of problems and cumulative impacts. The case study could illustrate hydrologic concerns for the rivers and then project the implications of alternative actions.

There is a lack of a multi-objective policy framework.

Constraint: Flood hazard reduction efforts administered by the COE and FEMA (diking practices, zero net rise in Base Flood Elevations) are often solely based on hydraulic criteria and can be in conflict with habitat restoration and other ESA related issues that are based on biological and geomorphic criteria. The discrepancies in mission are compared for three key types of issues in Table 7-4.

Table 7-4 Prototype Issues: Comparison of Flood Hazard Reduction with Salmon Habitat Restoration Perspectives

Prototype Issues	**Flood Hazard Reduction**	**Restoration Perspectives**	**Remarks**
Stream Channel and Habitat Assessments	Minimize opportunity for water level rise i.e. minimize encroachment into the use of channel	Maximize salmon resting places i.e. through placement of LWD	Conflicting priorities
Uses in the flood plain	Minimize risk of property to damage; insurance exposure	Minimize wetland and riparian habitat conversion	No convergence of issues
Stream Biotic Condition and Ambient Water Quality	Minimize erosion and excess sedimentation	Assess impacts of diversion on water temperature and on flow, etc.	No convergence

Multi-objective management is difficult for agencies to address within their statutory and organizational mandates. Regulations and programs of individual agencies have been established to meet specific mandates, which are typically single-objective and task oriented. For example, the NRCS uses the floodplain as defined from a geomorphic standpoint--a critical concept for habitat restoration. This differs from the regulatory floodplain definition under FEMA's NFIP, which is a statistical construction (1% annual chance of flooding) and adopted as part of a participating community's comprehensive plan. This makes it difficult for property owners and communities to establish clear and consistent policies. Figure 7-16 compares the regulatory with the geomorphic floodplain.

Opportunity: The complex mission of an IRMS is to balance ESA objectives with flood hazard reduction objectives. Increasingly, funding of flood restoration has emphasized multi-objective projects under its competitive grant programs. These grants are available to help communities reduce the effects of flooding, while also improving habitat for threatened and endangered species. In addition, the Oregon Plan is requiring a multi-objective process. The IRMS is inherently multi-objective because it advocates:

1. the restoration of floodplain functionality,
2. the reduction of flood impacts;
3. the improvement of aquatic and terrestrial habitat.

Local governments are required to develop a program to achieve Goal 5 for all significant resource sites through the adoption of comprehensive plan provisions and land use regulations. Goal 5 resources include water areas, fish habitat, adjacent areas, and wetlands within the riparian boundary. It therefore represents an ideal vehicle to implement the multi-objective IRMS approach. The strategy to comply with Goal 5 would consist of four steps:

1. Identify conflicting uses;
2. Determine the impact area;
3. Analyze the economic, social , environmental, and energy (ESEE) consequences that could result from a decision to allow, limit, or prohibit a conflicting use;
4. Develop a program to achieve Goal 5.

It should be noted that according to the Goal 5 administrative rule, "the riparian corridor boundary is an imaginary line measured upland from the top of bank. The local governments may determine the boundaries of significant riparian corridors using a standard setback distance form all fish-bearing lakes and streams … as follows:

1. Along all streams with average annual stream flow greater than 1,000 cfs, the riparian corridor boundary shall be 75 feet upland from the top of each bank.
2. Along all lakes and fish-bearing streams with average annual stream flow less than 1000 cfs, the riparian corridor boundary shall be 50 feet from the top of bank.
3. Where the riparian corridor includes …significant wetland…the boundary shall be measured from and include the upland edge of the wetland."

There is a lack of an integrated, comprehensive planning viewpoint.

Constraint: Both flood hazard reduction planning and salmon restoration efforts have emphasized restrictions on property uses within the floodplain. Currently, there is a notable lack of incentive to develop in a manner that conserves and restores habitat. Furthermore, government actions often tend to encourage additional encroachments in the floodplain. One example is the current funding for improvements of the Highway 101 corridor in Tillamook County. The improvements reinforce the conventional wisdom that economic vitality requires extensive parking and pedestrian amenities (sidewalks, covered walkways). These amenities are available to new sites and in conjunction with restoration of damaged structures after flooding. Additional pressures on land owners are caused by restrictions on uses of land in the floodplain, limited land area available for development and economic use, and the existence of virtually no incentive to develop within the existing urban area. In Tillamook, all these factors have created a highly negative attitude among significant segments of the population.

Opportunity: Implementation of creative means to strengthen and increase the drawing power of existing commercial centers located outside of flood-prone areas could be a vehicle to alleviate the ever-increasing development pressures on the floodplain. A prototype concept plan could illustrate the use of incentives that could encourage both prudent floodplain urbanization and implementation of a range of restored habitat environments. This prototype demonstration could explore and apply tools including economic development funding, Smart Growth Initiatives, wetland banking, transfer of development rights, trading credits for provision of additional riparian habitat and other vehicles. Figure 7-17 indicates areas of prototype concern.

Regarding portions of the basin targeted for enhancement, the priority would be to target core areas per OCSRI.:

"'Core areas' are stream reaches (including their connected sub-basins) or watersheds within individual coastal basins that currently support relatively high densities of spawning and/or rearing. Therefore, they are of critical importance to the persistence of salmon populations that inhabit the basin. These reaches or basins have been provisionally identified on maps to provide information that can help prioritize efforts to conserve and restore habitats that support salmon."

A range of strategies and tools could be developed consistent with administrative strategies in Goal 5 and any forthcoming Section 7 guidelines. Cumulative impacts of these measures could be analyzed, either in conjunction with Section 7 consultations, resulting in a prototype HCP, or in conjunction with county efforts. Section 7 of the ESA regulations recognizes that an emergency (e.g. a natural disaster or other calamity) may require expedited consultation (50 CFR 402.05). NMFS has strongly urged the development of a programmatic consultation so that identified adverse effect determinations can be addressed and implemented to protect listed species or critical habitat during emergency actions. This prototype could be integrated into the programmatic Section 7.

7.5 A Future Vision of Lost Opportunities and Increased Constraints

This section provides a possible future vision of the Tillamook Bay river system if an integrated system-based approach is not taken. This view is intended to articulate potential lost opportunities and increasing constraints as time continues and if the river system continues to be managed as it has been. One purpose of this exercise is to establish "no-action" conditions from which to gauge the relative effect of management actions that may be taken within the river system. The following hypothetical considerations of the Tillamook Bay river system summarize potential conditions over the next 100 years if no actions are taken to adapt human activities to natural processes.

7.5.1 The Continued Evolution of the River System

- The physical processes of erosion and sedimentation, orchestrated by climate and streamflow, will continue to exert influences to shape the landscapes and fluvial systems of the Tillamook Bay

Basin. Disturbances such as flooding, drought, landslides, fire and sea level change, occurring naturally or with human inputs, will contribute to the evolution of the river systems of Tillamook Bay by altering the structure and function of these systems.

▪ Climate change and its effects on sea level change will play an increasing role in shaping the future estuarine landscapes along the margins of Tillamook Bay. Sea-level rise, coupled with subsidence of the land mass in the Tillamook area, results in the area being submerged at an estimated rate of about 2 millimeters per year, or 8 inches in 100 years.

▪ For dikes encompassing the Stillwell Drainage District, this elevation change would reduce by nearly half the original 2-foot freeboard design criteria for the 50-year flood event (U.S. Army Corps of Engineers, 1956). The rise in sea level would raise the Mean High Water tidal datum to the elevation of the current Mean Higher High Water datum and cause the limits of tidal marsh vegetation to recede to the new MHHW datum. For a typical intertidal mudflat slope in Tillamook Bay of one foot vertical to 250 feet horizontal, this implies marsh vegetation could retreat inland up to 170 feet.

▪ Recent investigations of sediment accumulation in the bay indicate an average rate of 5 centimeters per century, with these deposits occurring primarily along the margins of the bay (McManus et al., 1998). As such, the river deltas are extending into the bay, lengthening the lower reaches of confined river channels and flattening river slopes. The gentler river gradients and longer reach lengths would reduce the energy available in the river flows to transport sediments. This condition, combined with higher tidal elevations imposed by sea level rise, would lead to increased channel deposition in the tidally influenced reaches of the rivers.

▪ Flood control improvement projects constructed in the estuary will provide increasingly fewer benefits over time, because the relative rise in sea level was not accounted for in the original design of this infrastructure. In addition, a lack of management actions in the uplands will lead to excessive volumes of water and sediment transported to the lowlands, invalidating the original design criteria. Maintenance costs will skyrocket and retrofits will be necessary to maintain the function of the structures.

▪ The characteristics of the Tillamook Bay lowland valley 100 years from now may be drastically changed if a major subduction zone earthquake were to occur within this time frame. The estimated maximum subsidence from past earthquakes along the northern Oregon coast is one meter, based on paleosubsidence records. Rapid subsidence of this magnitude in the Tillamook Bay area could lead to drastic changes in hydraulic and geomorphic processes. The ensuing adjustments of the river systems to these tectonic changes would extend over a significant time period and require short- and long-term adjustments to human infrastructure and cultural conditions.

7.5.2 Flood event and flood damage trends

▪ After a lull in severe flood events through the late 1970s and 1980s, the Tillamook Bay area, and communities throughout Oregon, have recently experienced significant repetitive flood events. Flood events may continue to be more pronounced in the Pacific Northwest during the next 100 years. Climate researchers have predicted a trend toward warmer winters as a result of global warming (Long, 1998). With warmer winter temperatures there is an increased chance for winter rain and rain-on-snow flood events. This anticipated trend in climatic conditions, coupled with the plan for renewed harvest of timber from the Tillamook State Forest, may lead to changes in flood damage trends in the lowland valleys of Tillamook Bay.

▪ The significance of recent and future flooding and flood damages is, in part, due to the increased development of floodplain lands that has placed human property in harm's way. This is especially true in Tillamook, where buildout along the Highway 101 commercial corridor has progressed dramatically. If buildout continues in this low-lying area north of the City of Tillamook, more commercial property will be at risk from flood damage. Sewerage and hazardous materials associated with this development may be exposed to flood waters and discharged into swollen rivers, increasing environmental and human health risk. Since the dikes and levees along riverbanks represent unnatural features on the lowland valley landscape, the forces of weathering and erosion from seasonal climate conditions and flooding will continue to necessitate maintainance and repair of these features by landowners. The deposition of sediments in the river channels will be exacerbated by dikes and levees along the riverbanks which prevent sediment deposition on floodplain lands during flood events.

▪ Public safety and rescue operations will become more prevalent during flood events. Increasing numbers of people will be stranded in homes, motels and businesses designed to be elevated above the 100-year flood, separated by transportation routes severed by quickly rising floodwaters.

▪ Many of the habitat improvement projects designed and implemented without consideration for the overall river system have been damaged or completely washed out by the excessive force of floodwaters constrained between dikes and levees.

▪ Increasing amounts of earth fill placed in the floodplain, to raise cowpads, new bridge approaches, elevated homes and new development above the 100-year floodplain, have further obstructed the flow of floodwaters in the lowlands. These obstructions have increased flood heights and erosion during subsequent flooding.

7.5.3 Flood hazard mitigation efforts

▪ If flood hazard mitigation efforts in the county continue to emphasize the elevation and "flood-proofing" of existing flood-prone structures, and the construction of new structures on fill material to elevations above the published 100-year base flood elevation, the success and cumulative effects of these efforts is uncertain. These mitigation projects, while pursued with good intentions, have major limitations to their effectiveness, because of their underlying reliance on 30-year-old statistical flood data, and because they are implemented without the benefit of a comprehensive flood management plan.

▪ The use of old flood elevation data from the 1977 FEMA flood insurance study to design new flood hazard mitigation measures would impart uncertainity to the success of the measures, because the statistical value of the 30-year-old 100-year flood estimate, and the associated flood elevations, may have changed in the intervening time period, especially given the significant flood events in 1996 and 1998.

▪ The reliance on "flood-proofing" and building elevation as mitigation measures would probably decrease, but not eliminate, risk to commercial and residential property owners. With the next severe flood, raised homes may remain dry and insurable contents protected, yet the inhabitants would be surrounded by flood waters and isolated if they choose to remain on their property. The potential need for rescue and medical emergency services in these situations would continue to place demands on local governments that could otherwise be directed to other aspects of flood response and recovery.

▪ Continued development in the floodplain, insofar as it includes new commercial property on raised earthen foundations and elevated cow pads, will provide some measure of protection against flood hazards. However, the cumulative effect of this filling in the floodplain will reduce the natural storage capability of floodplains and may lead to higher flood elevations upstream of these obstructions. As a flood wave passes downstream, flood flow velocities are concentrated along the edges of floodplain fill, submerged structures and other obstructions, resulting in increased chances for localized erosion and scour at these encroachments. Erosion impacts may be further increased if a flood wave coincides in time with an outgoing tide.

- If Oregon coastal salmon populations continue to decline, the federal government and the state will receive increased pressure from the public to enforce the ESA and CWA. In Tillamook, pressure will also come from the shellfish and commercial fishing industries. These groups will have to watch their livelihoods diminish as the estuary receives an increasing amount of toxic pollutants from urban runoff and flood washoff.