Appendix 1

Explanation of information sources, data, and scoring systems

I. VALUE OF SALMONID POPULATIONS IN ECOSYSTEM TO ESU

I.1. Need for conservation (condition of stocks in WRIAs)

I.1.a. *Healthy stocks and ESUs not at-risk*

Importance of the healthy stocks and ESUs component: The expected benefits of maintaining healthy stocks through properly functioning ecosystems and sound fish management depend on three basic factors: underlying ecosystem productivity, stock diversity, and the condition of the habitat. ISAT used the measure of healthy stocks as one of the indicators of the overall benefit of conservation actions (both protection and restoration). Basic information on stock status and ESA listing status is essential to understand the extent and distribution of the most healthy stocks among WRIAs. Just as there are different geological processes that formed and maintain stream characteristics (e.g., glacial runoff vs. rainfall), different WRIAs contain streams that vary in the complexity of salmonid stock structure. ISAT expects the greatest benefits to Washington's salmonids from conservation efforts will be in WRIAs where the stock diversity and health are the greatest.

Data source: Data on stock status were obtained from the 1993 Salmon and Steelhead Stock Inventory (SASSI) (WDF et al. 1993) and 1998 Bull Trout/Dolly Varden Salmonid Stock Inventory (SaSI) (WDFW 1998). Preliminary stock status updates were provided by WDFW where possible. ESA listing status information was also used to rank each WRIA. In addition to information on formal or proposed listing status, where ESA stock status reviews are still ongoing, scores were used based on WDFW's assessment of potential for listing. Attachment 2 of the SSRS presents this information in tabular format.

Limitations: The data used to identify healthy stocks of salmon and steelhead is somewhat outdated (WDF et al. 1993). WDFW is planning to update this information soon.

Scoring: Healthy stock and ESA status scores were plotted on the potential effectiveness (Y) axis. Individual scores in Attachment 2 of the SSRS were assigned as in the table below. Summary scores were developed for each WRIA. Ranked totals were essentially rated on a curve. Based on the top score the 66th and 33rd percentiles were determined. A score of 57/87 = 66% and a score of 29/87 = 33% (100-66%=10, 65-33%=5, 33-0%=-0). These scores are not the opposite of unhealthy stocks and ESUs at-risk because of the different numbers of total stocks in WRIAs.

Healthy stocks and ESUs			
SASSI/SaSI		ESA	
Healthy	3	Not warranted	3
Depressed	0	Candidate	0
Critical	0	Threatened	0
Unknown	0.5	Endangered	0

I.1.b. ***Unhealthy stocks and ESUs at-risk***

Importance of the unhealthy stock and ESUs component: Focusing habitat restoration actions where there are at-risk stocks are important recovery tools. Basic information on stock status and ESA listing status is essential to understand the extent and distribution of unhealthy stocks within and among WRIAs.

Data source: Data on stock status were obtained from the 1993 Salmon and Steelhead Stock Inventory (SASSI) (WDF et al. 1993) and 1998 Bull Trout/Dolly Varden Salmonid Stock Inventory (SaSI) (WDFW 1998). Preliminary stock status updates were provided by WDFW where possible. ESA listing information was also used to rank each WRIA. In addition to information on formal or proposed listing status, where ESA stock status reviews are still ongoing, scores were used based on WDFW's assessment of potential for listing. Attachment 3 of the SSRS presents this information in tabular format.

Limitations: The data used in to identify unhealthy salmon and steelhead stocks are somewhat outdated (WDF et al. 1993). WDFW expects to update this information for use in the future.

Scoring: Unhealthy stock and ESU scores were plotted on the relative condition (X) axis to emphasize restoration activities for those WRIAs with large numbers of unhealthy stocks and protection actions for those WRIAs with the least numbers of unhealthy stocks. Individual scores in Attachment 3 of the SSRS were assigned as in the table below. Summary scores were developed for each WRIA. Ranked totals were essentially graded on a curve. Based on the top score the 66th and 33rd percentiles were determined. A score of 25/37 was used at the 66% cutoff and 12/37 was used as the 33% cutoff (100-66%=0, 65-33%=5, 33-0%=10).

Unhealthy stocks and ESUs			
SASSI/SaSI		ESA	
Healthy	**0**	**Not warranted**	**0**
Depressed	**2**	**Candidate**	**1**

Critical	**3**	**Threatened**	**2**
Unknown	**0.5**	**Endangered**	**3**

I.1.c. *Stock origin*

Importance of the stock origin component: The naturally spawning salmonids in Washington streams can have different origins due to past and present fish management practices. Many streams contain stocks that are native to that stream Other stocks are comprised primarily of an interbreeding mixture of native and fish from other watersheds, and in some locations, a stock has become established outside of its original range (by completely displacing the native stock or starting a natural population where the species did not exist historically). Physical marks, coded-wire tag recoveries, hatchery planting records, migration barrier removals, and genetic investigations were used to identify the origin of stocks in each WRIA. ISAT expects greater benefits to Washington salmonids from habitat conservation actions (both protection and restoration) will occur where there are the greatest numbers of native stocks. The WFWC's Wild Salmonid Policy (WSP) also prioritized native fish over mixed and localized nonnative fish.

Data source: Data for stock origin of seven species types were taken from WDF et al. (1993).

Limitations: An update of SASSI is needed and this should more broadly distribute the scores.

Scoring: The number of stocks for each stock origin category by WRIA was totaled. A few stocks overlapped WRIAs (e.g., Samish/MS Nooksack fall chinook counted for both WRIA 1 & 3). The number of native origin stocks in each WRIA received a multiplier of 5, the number of mixed-origin stocks 1, and the number of nonnative origin stocks, -5 (unknown and unresolved stocks were given a value of 0). Non-native in SASSI refers to the individual basin, not the state. The stock origin value for each WRIA was the sum of the native, mixed and nonnative scores. This stock origin score was divided by the total possible score (the number of stocks X 5) for that WRIA to get the scaled percentage (100-66%=10, 65-33%=5, 33-0%=0). Scores for stock origin were put on the potential effectiveness axis (Y) to prioritize native, wild spawning stocks.

I.1.d. *Production type of natural spawners*

Importance of the production type component: The subjects of the ESA are "natural fish" in determining the health and recovery of ESUs. Natural fish are those which came from parents that spawned naturally in the wild (sometimes referred to as natural origin recruits). The Washington Fish and Wildlife Commission's WSP uses this same definition for wild fish. The reason for this distinction is that information is not typically available to identify the hatchery or wild ancestry of fish on an individual basis once they have been born in the wild. The WSP prioritizes native fish over localized nonnative fish and limits the number of hatchery-origin fish that spawn in the wild (except for formal supplementation programs).

Data source: Data for production (spawner) type for the seven species were taken from SASSI (1993).

Limitations: An update of SASSI is needed and planned by WDFW; ISAT expects use of that revised information would likely broaden the distribution of scores.

Scoring: The number of stocks for each spawner type was totaled by WRIA. A few stocks overlapped WRIAs (e.g., Samish/MS Nooksack fall chinook counted for both WRIA 1 and 3). Multipliers for different types were: wild = 5, composite = 1, and cultured = -5 (unknown and unresolved were given a value of 0). The value for each WRIA was the sum of the native, mixed and nonnative scores. This score was divided by the total possible score (the number of stocks times 5) to get the scaled percentage (100-66%=10, 65-33%=5, 33-0%=0). Scores for spawner type were put on the potential effectiveness axis (Y) to prioritize native, wild spawning stocks.

I.1.e. *Genetic diversity*

Importance of the genetic diversity component: Knowledge of genetic diversity is fundamental to the protection and recovery of salmonid species. The genetic diversity information in this category summarizes important core population genetic types within and among the salmonid species in Washington. These are groups which represent genetic attributes (as identified primarily by allelic data from allozymes) that are not found to a substantial degree in other WRIAs or streams. Genetic differences are not always large enough to identify the group as an ESU, but it still represents an important component of the genetic diversity of the species in Washington.

Data source: The NMFS coastwide stock status reviews produced for ESA deliberations and WDFW's documents describing genetic diversity units (e.g., WDFW 1995) were used to develop scores for each WRIA.

Limitations: It is difficult to generalize genetic diversity given the multitude of salmonid species in each WRIA. The WRIA scores for this category did not differ much.

Scoring: A score of 5 indicated that the WRIA contained two or more distinct genetic stocks that in ISAT's opinion represented an important part of the diversity for that species in Washington. A score of 3 indicated that at least one of the populations in the WRIA was an important component of the species. All WRIAs had at least one stock important for stock diversity except San Juan and Island (WRIAs 2 and 6). Stock diversity information was plotted the relative condition (X) axis to identify WRIAs with large numbers of genetic diversity core populations (for protection) and to identify WRIAs with low salmonid genetic diversity for restoration.

I.2. Fisheries management context

I.2.a. *Overfished stocks*

Importance of the overfished stocks component: Prioritization of efforts to protect and/or restore habitats must include information on the extent to which harvest management provides sufficient spawners to spawning areas. Overfished stocks are those wild stocks that were intentionally harvested at rates that cannot be sustained by natural production so that intermixed hatchery fish could be harvested at the higher rate. The expected benefits from habitat restoration and protection efforts depend on the ability of the stocks in the watershed to respond. An insufficient number of spawners due to fisheries will likely hamper recovery.

Data source: For each WRIA, information on the number of salmon stocks over fished was taken from those listed in the Wild Salmonid Policy FEIS (Table II-1, page 9). No changes were assumed when SASSI stocks did not match exactly (i.e., the number of stocks of a species in SASSI did not agree perfectly with the number in Table II-1).

Limitations: As is the case in general with SASSI, this information may not be fully current.

Scoring: For each WRIA, the number of over fished salmon stocks was divided by the total number of salmon stocks (excluding steelhead stocks) to obtain the percentage over fished. Point scores were assigned to groupings as follows: 100-66%=10, 65-33%=5, 33-0%=0. These values were plotted on the relative effectiveness (Y) axis because restoration and protection efforts will not be successful if the number of natural wild spawners is insufficient to take advantage of the improved habitat conditions.

I.2.b. *Spawner numbers*

Importance of the spawner numbers component: Spawner numbers are values representing the proportion of the stocks of a species for each WRIA that meet or exceed their escapement goal on a consistent basis. The difference between this component and the stocks Overfished component is that this measure also includes both habitat conditions and non-directed harvest and is based on escapement goals for Pacific salmon. Even where fish management activities allow adequate numbers of wild fish to spawn naturally, some areas do not achieve goals for spawner escapement because of changes in habitat conditions and bycatch.

Data source: Data were from Pacific Fisheries Management Council annual reports and WDFW unpublished.

Limitations: The accuracy of spawner numbers varies due to the assessment method, species and stream conditions. For example, weirs give a count of fish moving upstream, but are not widely used due to cost and stream size. Spawning ground surveys are better for mainstem spawners such as chum and pink salmon. The accuracy of redd counts depends on stream conditions such as glacial water sources and patterns of annual runoff). This information is more current than SASSI and is based on "escapement" estimates (which were only one component of the stock status rating in SASSI).

Scoring: For each WRIA, a score of 10 indicates that the escapement goal for most stocks of a species is met, a score of 5 indicates that around half of the stocks of a species meet their escapement goals, and a score of 0 indicates that most of the stocks of a species do not meet their escapement goals on a consistent basis. Scores were plotted on the relative condition (X) axis so that salmon and steelhead areas that are achieving their escapement goals will receive protection, and restoration will be emphasized where these species do not meet those levels.

I.2.c. *Hatchery fish identification*

Importance of the hatchery fish component: Releases of hatchery fish are known to pose both genetic and ecological risks to wild salmonids. This category refers to the implemented ability to effectively distinguish those fish released from hatcheries from those that were naturally produced. This prioritization factor is used to identify WRIAs where an assessment of the type of fish spawning naturally is possible. Identification of hatchery or wild origin is very useful for monitoring the effects of restoration or protection efforts, especially in the context of genetic and ecological interactions.

Data source: WDFW data. Both internal marks and tags (e.g., coded-wire tags, PIT tags, otolith and genetic marks and tags), and external marks (excised fins) were used for this category.

Limitations: Fish marking and monitoring procedures and processes are in a state of rapid change.

Scoring: Scores were developed for each WRIA. A score of 10 indicates that hatchery fish for most of the species can be identified, 5 indicates some of the species (coho and steelhead and maybe chinook), and 0 denotes situations where only a few of the species if any can be differentiated. Hatchery fish scores were plotted on the relative effectiveness (Y) axis to emphasize WRIAs where the best understanding exists regarding associated factors affecting natural production.

I.2.d. *Natural production*

Importance of the natural production component: Knowledge of freshwater production is important for distinguishing between the relative influences of freshwater and marine survival on salmonid abundance (because both can vary by an order of magnitude). This natural production component reflects the level of understanding about the numbers of wild salmonids produced in WRIAs and the factors that influence that production. Restoration and protection efforts can affect freshwater and near-shore marine areas, but not marine productivity. The expected benefits of restoration and protection actions will likely be more effective where a database exists and where an assessment of natural production is possible.

Data source: StreamNet database; WDFW unpublished data.

Limitations: The methods and effectiveness of natural production monitoring varies by species and watershed characteristics.

Scoring: For each WRIA scores were assigned according to the following: existing long-term juvenile and adult counts/weir databases = 10 (favorable), WRIAs having recent and candidate evaluations = 5 (medium), minimal natural production evaluation effort = 0 (unfavorable). Natural production scores were plotted on the relative effectiveness (Y) axis to emphasize WRIAs where there is the best understanding of factors affecting natural freshwater production.

I.2.e. *Hatchery-natural ratio*

Importance of the hatchery-natural ratio component: The hatchery-natural ratio is the number of hatchery fish released in a WRIA compared to the estimated number of naturally produced salmonids. This component is a reasonable surrogate for ecological interactions risk. ISAT only considered the hatchery:natural ratios of each species and did not include specific efforts to address or minimize ecological interactions risks. ISAT also did not attempt to account for risks of interspecific ecological interactions. Both of these components are to be included in future iterations. The expected response of wild salmonids from habitat protection and restoration actions will be most effective where cultured production is minor compared to the abundance of naturally produced salmonids.

Data source: ISAT used four primary sources as a basis for the prioritization scores: (1) for coho and chinook salmon, the 1998 Pacific Salmon Treaty preseason report I, Stock Abundance Analysis (estimated adults) for 1998 Ocean Salmon Fisheries, prepared by the salmon technical team, Pacific Fisheries Management Council, Portland; (2) NMFS species status reviews; (3) WDFW hatchery operation plans and performance summaries; and (4) WDFW natural production estimates. Four species - chinook, coho, chum, and steelhead, were included in this component.

Limitations: High quality estimates of natural production are generally limited. WRIA 15 (Kitsap) is a good example of the diversity of conditions that occur within a WRIA. For coho, the Puget Sound portion (that portion in the Central Puget Sound subregion) of the WRIA contains almost all hatchery production, but its Hood Canal portion (that portion in the Southwest Puget Sound subregion) is almost all natural coho production.

Scoring: If the estimated hatchery production was two times the natural production for a species, that species received a score of 0. If the natural and hatchery production was approximately equal, ISAT a score of 5 was assigned. If natural production was two times the cultured production, 10 points were assigned. The scores were averaged (total score divided by four (except where one species did not occur - like chum in lake Washington where the total score was divided by three)). Even though the ratio of hatchery to naturally produced salmonids changes annually, the three groupings ISAT used for this measure appeared to be fairly stable over time. This component was placed on the Y-axis because the anticipated benefits to wild salmonids will be the greatest in WRIAs where they comprise the majority of the production.

I.2.f. ***Ecological interactions***

Importance of the ecological interactions component: Fishery management activities have the potential to create situations where ecological risks are imposed on wild stocks as a result of efforts targeting other species. For example, risks to wild salmonids can occur from competition and predation by other artificially propagated salmonids, or by non-salmonid warmwater exotic species. In addition, recovery efforts targeting a species have the potential to adversely impact another at-risk or other species. Reconciling significant conflicting goals and implementation issues associated with ecological interactions risks will be important to help ensure successful recovery of targeted species.

Data Source: None available or known meeting criteria for inclusion.

Limitations: Not applicable.

Scoring: Not applicable.

I.2.g. ***Fish health management***

Importance of the fish health management component: Fish diseases can occur in both natural and artificial circumstances. Various preventative treatments can be applied to hatchery production to manage (reduce or eliminate) the occurrences of harmful fish diseases.

Data Source: None available or known meeting criteria for inclusion.

Limitations: Not applicable.

Scoring: Not applicable.

II. VALUE OF ECOSYSTEMS TO SALMONIDS

II.1. Present ecosystem conditions

II.1.a. *Estuary development*

Importance of the estuary component: Anadromous salmon are known for their use of both the freshwater and ocean environments during their life history. The freshwater as a place to spawn and for the young to begin their growth, and the ocean as a place to feed and grow to adulthood. Migration from freshwater to saltwater as juveniles, and back again as adults, requires an important adaptation called osmoregulation. Estuaries are the ecotone where saltwater and freshwater mix, and for salmon it is also a place to begin their ocean life. By definition (Pritchard 1967), an estuary is a region where saltwater of the ocean is measurably diluted by freshwater runoff from the land within a constricted body of water. Thus, the salinity gradient that juvenile salmon encounter when migrating through estuaries depends upon the inflow of freshwater and the strength of the tides, which influences the degree of mixing, and the depth to which the juvenile salmon penetrate the water column.

Estuaries provide important rearing habitat for all seven species of salmon, but especially so for juvenile chinook and chum. They are also known to be very important rearing areas for juvenile and sub-adult anadromous bull trout. Juvenile salmon residing in estuaries prefer shallow salt marsh habitat at high tide and flowing tidal channels at low tide. Here salmon feed on a wide variety of prey that is of both aquatic and terrestrial origin. There is a great degree of variability in the size and configuration of Washington estuaries. From the large and complex estuary of the Columbia River, to the vast estuaries of rivers that flow into inland marine waters such as Puget Sound, Grays Harbor, and Willapa Bay, to the truncated and highly limited estuaries of steep coastal rivers and streams.

Estuarine wetland habitat loss has been extensive in Washington. Since Euro-American settlement, development has accounted for a major percentage of the loss of estuarine wetlands. Urban development includes urbanization, port development, industrial use, dredging and filling, and other similar activities (Bortleson et al. 1980; Simenstad et al. (1982); Boule et al. 1983; Sherwood et al. (1990); National Research Council (1996)).

Data source: Information sources used for the estuary development component were Bortleson et al. (1980); Boule et al. (1983); WDNR (1998); National Research Council (1996, pages 184-185); and ISAT knowledge.

Limitations: Although considerable information is available for much of western Washington, there were some gaps in coverage that required ISAT interpretation.

Scoring: For the purpose of rating the degree of estuary loss due to development, each estuary was placed into one of three categories of loss: favorable = 0-33% loss, medium = 34-67% loss, and unfavorable = 68-100% loss. Scoring was as follows: favorable = 10, medium = 5, and unfavorable = 0. Ratings were based on scattered and sometimes incomplete information found in the following references: Bortleson et al. (1980), Boule et al. (1983), National Research Council (1996; pages 184-185).

If more than one WRIA was located upstream on a single river, the same estuary loss value was applied to each of these WRIAs (i.e., fish from the Cowlitz, Klickitat, and Grays-Elochoman WRIAs all use the same estuary, that being the Columbia River estuary; anadromous fish in the upper Skagit WRIA use the lower Skagit WRIA estuary). Also, when two rivers refer to the same WRIA area, or when other important salmon streams were in that WRIA, we used an average estuary loss value (i.e., Lower Skagit-Samish). The most recent information was always used whenever two different references gave conflicting information.

Estuary development scores were plotted on the relative effectiveness (Y) axis because the expected response of wild salmonids from habitat protection and restoration actions will be most effective where estuary conditions are still relatively intact.

II.1.b. *Nearshore marine condition*

Importance of the nearshore marine condition component: The percentage of modified shoreline was selected as an indicator of the condition of nearshore habitat. Shoreline modification by human activities affect habitat quantity and quality directly through habitat conversion and indirectly through altering was dynamics and other physical shoreline characteristics (Thom and Shreffler 1994). Common types of shoreline modification include dredging, filling, diking, bulkheading, and riprap.

Data source: The percentage of modified marine shoreline was estimated for each western Washington WRIA by applying basin scale estimates from Bailey et al. (1998). Each WRIA was spatially nested within the appropriate basin, and the percent modification estimate for the basin as a whole was then applied to the WRIA. Bailey et al. (1998) did not estimate percent modification along the outer coast and the Columbia River. For these areas, estimates were assigned based on expert knowledge and general development patterns. Consequently, the percent of relatively undeveloped, rocky outer coast areas were classified as low. Gray's Harbor, Willapa Bay, and Columbia River areas were classified as medium due to the comparatively long history of navigation, diking, agriculture, and aquaculture.

Limitations: As noted above, information on modification along the outer coast and the Columbia River was estimated based on expert knowledge and general patterns of development.

Scoring: The percent of modified marine shoreline was estimated for each WRIA by applying basin scale estimates as noted above. Based on inspection of the distribution of data, results were grouped into the following categories: less than 25% of marine shoreline modified = favorable (10 points), 25 to 50% = medium (5 points), and more than 50% = unfavorable (0 points). Nearshore marine condition scores were plotted on the relative effectiveness (Y) axis.

II.1.c. *Forage fish*

Importance of the forage fish component: The status of forage fish populations that spawn in estuarine or lower riverine ecosystems was selected as an indicator for the general level of salmonid food resources production and availability in the estuarine ecotone. Forage fish populations are important as prey base for salmonids at numerous life history stages for both predator and prey species. Reductions in the abundance of forage fish populations is believed to have the potential to adversely affect salmonid populations. Further, a demonstrated close relationship between rates of growth and survival for salmonids suggests that even modest reductions in available prey resources may constrain salmonid population levels.

Data source: Data on forage fish stock status for herring, surf smelt, sand lance and eulachon were obtained from the Washington Department of Fish and Wildlife Forage Fish Management Plan (WDFW 1998). For herring, the individual stocks listed in table 3 of the Forage fish Management Plan were used with the additions of a Grays Harbor stock based on recent spawning observations and a Columbia River stock based upon Emmett et al. (1981). Stocks were clustered into the marine basins adapted from by Bailey et al. (1998) and each WRIA was assigned to the appropriate basin in the same manner as in the above nearshore modifications section. The exercises differ in that the San Juan - Strait of Georgia and Straits of Juan de Fuca basins are split here, but are combined in the nearshore modifications analysis. Also note that the scoring for herring in the Columbia River was only assigned to the lower most WRIA that is actually adjacent to the spawning areas. For surf smelt and sand lance, each documented spawning beach is presently considered to be a separate stock (WDFW 1998). The relatively large number of stocks were, therefore, not listed but assigned a rank of high, medium, or low by basin. Again, basin scale scores were assigned to each WRIA that was spatially nested within it. Only a single eulachon stock, occurring in the lower Columbia River and tributaries is noted in Washington. The basin scale score was assigned to each WRIA adjacent to the tidally influenced area of the mainstem..

Limitations: The data used to identify healthy and unhealthy forage fish stocks is relatively limited and is variable in quality between stocks and species (WDFW 1998). Surf smelt and sand lance stock numbers by basin were ranked as high, medium or low by visual interpretation of the documented spawning site maps in the Forage Fish Management Plan (WDFW 1998). Some stock status scores along the Strait of Juan de Fuca and outer coast were estimated based upon expert knowledge.

Scoring: Both healthy and unhealthy stock status scores were generated for the herring, surf smelt, sandlance and eulachon stocks described in the Forage Fish Management Plan (WDFW 1998) following the scoring schedule below. The resulting healthy and unhealthy scores were combined into a single forage fish ecosystem functions score. The combined forage fish score was plotted on the potential effectiveness (Y) axis. Ranked totals were essentially rated on a curve. Based on the top score the 66th and 33rd percentiles were determined. A score of 57/87 = 66% and a score of 29/87 = 33% (100-66%=10, 65=33%=5, 33-0%=-0).

Forage Fish Stock Status and Scoring			
Healthy stocks		**Unhealthy stocks**	
Healthy	3	Healthy	0
Depressed	0	Depressed	2
Critical	0	Critical	3
Unknown	0.5	Unknown	0.5

II.1.d. *Percentage of urban development*

Importance of the percentage of urban development component: Urban development can affect the quality of salmon habitat in a number of different ways. Urban development may result in the loss of physical complexity naturally inherent in western Washington streams. Streams may be cleaned out, channelized, relocated, or in some cases, run through culverts to accommodate development. Adequate riparian buffers may be encroached upon or removed resulting in reduced entrainment of large woody debris and other vegetative or ecosystem components necessary to maintain physical or biological integrity. The expected response of wild salmonids from habitat protection and restoration actions will be most effective where the source of the harm to the ecosystem can be remedied. ISAT expects the benefits to be the greatest in nonurban areas.

Data source: Data were obtained from the Washington State Land Use/Land GIS cover (LULC_L1) completed in 1996 and last updated 1997. Original data are from the mid-1970s on a 1:250,000 scale. The data were calculated as percent urban area of the WRIA area. This is identical to the data presented in Attachment 6 (III.F.4) in the draft SSRS.

Changes in watershed and stream hydrology may constitute the biggest impacts from urbanization. Large areas of impervious surfaces result in intensified peak flows and lack of water during summer droughts. For instance in a study of urbanization effects in Puget Sound lowland streams, May et al. (1997) found that "As the level of basin development increased above 5% TIA [*total impervious area*], results indicated a precipitous initial decline in biological integrity as well as the physical habitat conditions (quantity and quality) necessary to support natural biological diversity and complexity." It should be noted however that the percentage of an urban area in a watershed is not necessarily the best surrogate of TIA and will be represented in the prioritization model with road density or other suitable surrogate.

Limitations: The primary limitation of this data set is its age (see previous comment under Data Source). If the data are indeed from the mid-1970s, dramatic changes would be expected in percent urbanization in western Washington during the past two-and-a half decades.

Another possible limitation is that the percentage of urban areas may be a delineation of planning boundaries used by local planning departments or other agencies and therefore would not represent actual urban areas. More information is needed on the derivation of this data set.

Scoring: For the purpose of rating the percentage of urban development, information was placed into one of three categories: favorable, medium, and unfavorable. Scoring was as follows: favorable = 10, medium = 5, and unfavorable = 0. Information on this component was plotted on the relative effectiveness (Y) axis since urbanization is probably the least reversible form of habitat disruption and highly urbanized WRIAs will probably most often demand the most effort to achieve protection or restoration.

II.1.e. *Human population growth*

Importance of the human population growth component: People, their communities, and economies require many services and place various demands on watersheds. The size of the human population within a WRIA and the rate at which that population changes can provide key indicators about the pressures placed on wild salmonid resources. ISAT expects that emphasizing protection of WRIAs that are still experiencing low growth and restoration for WRIAs that are experiencing high growth will best recover wild salmonids.

Data source: The data for this component are estimates taken from Attachment 7 in the draft SSRS (Chapter III.F.4). Data represent human population growth data for 1990 and change projected to the year 2010. The source of this information was OFM census data.

Limitations: The state, county and local efforts to control impacts from growth were not able to be quantified and added to this measure.

Scoring: Human population growth scores were assigned according to the following: less than 10,000 = favorable (10 points); 10,000 to 50,000 = medium (5 points); over 50,000 = unfavorable (0 points). Human population growth information was plotted on the relative condition (X) axis.

II.1.f. *Water quality*

Importance of the water quality component: Good quality water is essential to maintain healthy individuals and stocks of salmonids (Reiser and Bjornn 1991; Spence et. al. 1996). Elevated stream temperatures influence salmonid health and survival at all life stages. Temperature affects appetite, metabolic rates and food conversion efficiency, as well as hatching and emergence timing. Bull trout are among the most cold-water adapted salmonids, requiring colder water temperatures than other salmonids for egg incubation and juvenile rearing. Various studies have shown (e.g., Scrivener 1988) that with increased incubation temperatures fry of anadromous salmonids emerge and migrate earlier than they otherwise would. This may result in smolt arrival to the ocean when conditions are less favorable for growth and survival (Spence et.

al. 1996). Salmonids also require high levels of dissolved oxygen. Reduced concentrations of dissolve oxygen can affect growth and development of embryos and alevins, growth of fry as well as swimming ability of adult and juvenile migrants (Spence et. al. 1996). In addition, mortality can be caused by high temperatures and by low dissolved oxygen (e.g., MacDonald et. al. 1991).

Data source: Data were obtained from a GIS-linked database of the 1996 303(d) list. Stream miles for each listed parameter were tallied by WRIA. Based on ISAT discussions, temperature and dissolved oxygen were the only parameters included in this component. This was due primarily to: (1) the importance of these parameters above all others to the direct impact on salmonid health and survival, and (2) the paucity of 303(d) listings for other parameters.

Washington State Water Quality Standards (WAC 173-201) for temperature are based on the class of waterbody. The four classes for freshwater streams are: AA-extraordinary; A-excellent; B-good; and C-fair. Temperature and dissolved standards for the four classes are as follows:

Class	**Temp. Std. (°C)**	**DO Std. (mg/L)**
AA	16.0	9.5
A	18.0	8.0
B	21.0	6.5
C	22.0	4.0

Limitations: The primary limitation is that only a small percentage of stream miles across the state have been assessed for water quality. However, it should be noted that assessments are generally conducted in waterbodies suspected of having poor water quality. In most cases, water quality assessments lead to inclusion on the 303(d) list.

Waterbodies are dropped from 303(d) by: (1) demonstrating they meet water quality standards, or (2) establishing a TMDL (total maximum daily load). A waterbody with a TMDL may be removed from 303(d) even if it doesn't meet WQ standards. Therefore, the 303(d) list does not offer a true picture of water quality. Only a handful of TMDLs have been implemented so far although Ecology has an agreement with EPA to have TMDLs for all 636 listed waterbodies within the next 15 years.

Finally, the data used for this component is from the 1996 303(d) list. EPA has not yet approved the more recent 1998 list.

Scoring: Scoring was done on the relative condition (X) axis to emphasize restoration in WRIAs that have poor water quality conditions and protection for WRIAs that have the best water quality. Water quality information for each WRIA was categorized based on inspection of the data distribution for natural break points. This resulted in scores for each WRIA being assigned to one of five categories as follows: 10 (0 miles); 8 (0-10 miles); 6 (10-50 miles); 4 (50-100 miles); 2 (100-150 miles); 0 (>150 miles). The use of five categories for this component departs from most other components that typically broken down into three categories. However, ISAT felt this approach was justified and consistent with the available information.

II.1.g. Percentage of land in agricultural use

Importance of the agricultural land use component: Agriculture is a large, diverse, and important component of Washington's economy. Because it is such a large component, agricultural practices can have major effects on the landscape, including the structure and function of watersheds and fish communities. These influences can have a major impact wild fish resources (e.g., Platts 1991; National Research Council 1996; Spence et al. 1996).

Data source: Data for the agricultural land use component were obtained from the Washington State Land Use/Land GIS cover (LULC_L1) completed in 1996 and last updated 1997. Original data are from the mid-1970s on a 1:250,000 scale. The data were calculated as the total agricultural acreage as a percentage of the total WRIA area. This is identical to the data presented in Attachment 4 (III.F.4) in the draft SSRS.

Limitations:

Scoring: Agricultural land use scores were assigned according to the following: less than 25%, favorable = 10, 25-75%, medium = 5; over 75%, unfavorable = 0. Agricultural land use information was plotted on the relative condition (X) axis.

II.1.h. Forest seral stage along streams

Importance of the forest seral stage along streams component: Forests along Washington's salmonid streams (riparian forests) are of key importance for water temperature moderation, nutrient/food web production, and sustenance of normal sediment and erosion processes. In addition, these forests provide the large trees and other wood that falls into streams allowing restoration and maintenance of complex pool/riffle habitats used by salmonids.

Data source: Information from Lunetta et al. (1997) was used for this component. That work was sponsored by the U.S. Environmental Protection Agency and was directed at WRIAs in Western Washington. First, streams were classed into source, transport and response reaches (as per Montgomery and Buffington 1993) through GIS evaluation of a 1:24,000 scale hydrography layer and 1:24,000 digital elevation model. Response reaches (those with slopes <0.04) were identified as the reach type most likely to contain anadromous salmonid habitat. These reaches were then coupled with Landsat data (1988 with updates from 1991 and 1993) for late and mid seral stages.

Late seral stage was defined by Lunetta et al. as: coniferous crown cover greater than 70%; more than 10% crown cover in trees greater than or equal to 21 inches diameter breast height (dbh);. mid seral stage: coniferous crown cover greater than 70%, and less than 10% crown cover in trees greater than or equal to 21 inches dbh. A riparian area width of 30 meters each side of the stream was used.

Using the above information, the percent of late and mid seral stages along response reaches was calculated for each WRIA.

Limitations: The associations between individual salmonid species and gradient needs to be further considered. For example, fish species/stocks using stream reaches with gradients >4% (e.g., native resident trout and char species) are not covered with this approach.

Scoring: Scores were assigned as follows:

Groupings	Rating	Score
Top 1/3 percentile of WRIAs	Favorable	10
Middle 1/3 percentile of WRIAs	Medium	5
Lowest 1/3 percentile of WRIAs	Unfavorable	0

These scores are plotted on the relative condition (X) axis. Maintaining or restoring mid to late seral stage riparian areas is of primary importance for salmonid protection and restoration.

II.1.i. *Channel gradient - productivity*

Importance of the channel gradient component: Generally, the diversity of stream fish communities (including salmon) decreases from the lower portions of river basins to their steep headwater channels (Reeves et al. 1998). One of the strongest controls on salmonid access into drainage basins is stream channel gradient. The higher the gradient, the steeper the channel, and the more difficult it is for salmon to migrate. Typically, one can expect to find the bulk of anadromous salmon species in the lower gradient channels close to saltwater.

In many cases salmon and cutthroat trout distributions mirror the distribution of gradient ranges typical for different channel morphologies. For example, the cutthroat trout-only zone correlates with stream gradients >3%, the chinook zone correlates with gradients <1%, and the coho zone correlates with gradients of 1-3% (Montgomery et al. 1999).

It is probably reasonable to assume that the greatest numbers of commercially valuable salmon species are produced in gradients of 4% or less (Lunetta et al.1997). However, it is important to point out that many important nonanadromous forms of fish, such as rainbow, cutthroat and bull trout, can also be found in headwater streams approaching 20-30% gradients. Bull trout spawning occurs primarily in low gradient reaches of higher gradient headwater streams.

For present purposes ISAT assumed that the WRIAs having streams with gradients of 4% or less, have the greatest potential to produce anadromous salmonids.

Data source: The source of information for this component was Lunetta et al. (1997) [see also the forest seral stage along streams component.

A stream channel classification system suggested by Montgomery and Buffington (1993) broadly stratifies channel morphology influences of LWD, and can be applied over large areas on the basis of correlations with reach gradient. That study identifies three kinds of reaches: source, transport, and response. Source reaches tend to be located in the high gradient headwaters of rivers, transport reaches tend to be in the middle gradient morphologies, and response reaches tend to be in the lower gradient channels - where most salmonids reside.

Field data used to validate stream channel type predictions were provided as part of an on-going salmon habitat inventory and management effort by Lunetta et al. (1997). Inventory efforts focused primarily on stream reaches with relatively low channel gradients (<4 %) and were compiled on 1:12,000-scale orthophotos.

Limitations: As noted for the Forest cover - seral stage component, the 4% gradient condition is unlikely to apply equally well to all salmonid species. For example, nonanadromous salmonids, such as rainbow, cutthroat and bull trout, can also be found in high gradient headwater streams approaching 20-30% gradients.

Scoring: WRIA scale data on response channel density from Lunetta et al. (1997) were rated from low to high. Based on the range of density values across WRIAs, scores were assigned after the rated data were sorted into percentiles by thirds. Scores were assigned as follows: favorable density = 10, medium = 5, and unfavorable density = 0. Channel gradient scores were plotted on the relative effectiveness (Y) axis.

II.1.j. *Impervious surfaces - road density*

Importance of the impervious surfaces component: Human activities, including road building, can increase or decrease streamflows, cause flows to become more or less variable than the natural discharge regime, and alter the timing of seasonal runoff patterns. This can force large quantities of water through channels in a more frequent time-span than would otherwise occur under natural conditions. Changes in stream flow result from water impoundments, water withdrawals, enlargement or shrinkage of the effective drainage network, increase in the imperviousness of soil surface, altering the rapidity of runoff, altering groundwater quantities or movements, altering the depth of coarse and fine sediments in the stream, altering streamside and hillslope vegetation via forest-management practices, and the conversion of forest land to other uses such as agriculture and urbanization (National Research Council 1996).

When forest land is converted to other purposes, the result is that less water is able to be absorbed into the soil mantle and reach the groundwater. Forest roads, highways, parking lots, rooftops, and all other impervious surfaces, force precipitation to directly run off into drainage channels, and eventually end up in salmon streams. Logging affects surface and groundwater hydrology in complex ways (Chamberlin et al. 1991), and studies have indicated that the frequency and magnitude of stream discharge peaks are sometimes increased after clearcutting. Forestry activities-including increased road construction, timber falling and yarding, slash burning, and mechanical scarification-can all cause water to reach streams more rapidly (Harr et al. 1975). Although soil compaction can occur with almost any type of land use, effects are often most pronounced in urban and industrial settings, where extensive roads and paving can effectively double the frequency of hydrologic events that are capable of mobilizing stream substrates (Booth 1991).

For the purpose of estimating the extent of impermeable surfaces within WRIAs, ISAT used road density information as a surrogate index.

Data source: WDNR Geographic Information System - Digital Data Layers (i.e., WRIA, transportation).

Limitations: Although road density was felt to be a reasonable broad scale surrogate of the relative extent of impervious surface in western Washington, factors other than road density contribute to impervious surfaces, and to the extent feasible, should receive additional consideration in future iterations.

Scoring: For the purpose of rating the extent of impermeable surfaces, road density information for each WRIA was partitioned into either favorable, medium, or unfavorable categories. Scoring was: favorable = 10, medium = 5, and unfavorable = 0. Scores were plotted on the X (relative condition) axis.

II.1.k. *Extent of hydrologic modification*

Importance of the hydrologic modification component: The extent of hydrologic modification is an indicator of the extent of flow pattern change among WRIAs. The process of impounding streams alters stream characteristics and removes flowing water habitat when reservoirs fill. This information is part of EPA's index of watershed indicators (IWI) and relates to the extent of reservoir impoundments in a watershed.

Data source: EPA's Index of Watershed Indicators. The index was based on relative reservoir impoundment volume in a watershed. Hydrologic modification information was assessed by EPA

Limitations: The Index of Watershed Indicators is a broad characterization of watersheds and does not contain detailed site-specific information on the impacts of individual dams or the estimated cumulative effects of them on wild salmonids.

Scoring: EPA scored each H.C. (hydrologic condition) as high, medium and low. ISAT scored these assessments for WRIAs as 10 = favorable, 5 = medium, and 0 = unfavorable, respectively. Where geographic boundaries of H.C.'s were not the same as WRIAs and the H.C. scores were different, ISAT averaged the EPA scores. ISAT scored this measure on the Y axis because the greater the hydrologic modification, the lower the anticipated efficiency and benefit of restoration and protection efforts.

II.1.l. *Fish passage constraints*

Importance of the fish passage constraint component: Fish passage can seriously limit access of the capacity or extent of area available to juvenile and/or adult salmonids to needed habitats during one or more phases of their life cycle.

Data source: Fish passage constraints were determined by the fish passage task force (WDFW and WSDOT). ISAT used the number of identified WSDOT barrier culverts as an indicator of the magnitude of passage constraints in the WRIA (Johnson et al. (1998), Appendix 1, Sept. 1998 report). ISAT chose WSDOT culvert passage barriers as a measure of restorable migration barriers by WRIA. This report summarized 564 culvert crossings and identified 233 that needed repair, 183 that needed further evaluation, and 159 that had insufficient habitat gain. All categories were included as the indicator of the extent of barriers in each WRIA.

Limitations: State highways are one type of development that may result in blockages to fish migrations. The data used here represent WSDOT's work and may not represent overall characteristics within all WRIAs to the extent that differing types of development or land use are involved.

Scoring: WRIA 20 had the most barriers with 45 so ISAT multiplied .67 X 45 = 30, and .33 X 45 = 15 as the break points. WRIAs with large numbers of barriers (>30) were unfavorable (0 points), 15- 30 barriers = medium (5 points), and <15 barriers = favorable (10 points). ISAT scored this data on the X-axis to emphasize restoration in areas with the most barriers and protection in areas with fewer barriers.

II.2. Water availability and distribution

II.2.a. *Water availability for fish*

Importance of the water for fish component: Wild salmonids need water in adequate amounts at the right times and in the right places. An adequate quantity of cool, clean water is a critical habitat requirement for sustainable fish production in streams. Fish have adapted over millennia to the natural flow regimes in individual watersheds. Without adequate water, survival of fish is simply not possible.

Natural flow conditions have been affected by various human activities in the past century (Chamberlin et al. 1991; National Research Council 1996; Spence et al. 1996) including diversions for irrigation, municipal, and industrial uses; storage in reservoirs for hydropower, groundwater withdrawals, and accelerated runoff due to logging, roadbuilding, and other increases in impervious surfaces due to growth and human development.

Data source: The data source for the water for fish component was the draft SSRS, Chapter III.B.5. and Appendix III.B.5. Numerous reports and IFIM studies were used in compiling information for that chapter, including watershed assessments conducted by the Washington Department of Ecology in 1995, WDFW's Watershed Recovery Inventory Program (1997), and other information from Ecology and WDFW.

The draft SSRS provides a comprehensive overview of the water availability for fish and its relationship to the establishment of instream flows. The data include lists of basins: (I) that are overappropriated, (II) where instream flows are set but are inadequate for fish, (III) where adequacy of water for fish is unknown, (IV) where no instream flows are set, but high development pressure exists, and (V) where no instream flows are set, but low development pressure exists.

Limitations: Determining the adequacy of flows to meet the all the ecosystem and life history needs of salmonids is extremely challenging. There are few data sources that are available on a comprehensive basis. ISAT felt the information in the draft SSRS was adequate for this prioritization exercise. However, ISAT felt that the relationship between flows and the needs of salmonids, and actual databases on water available for that purpose, could be improved.

Scoring: Information on the adequacy of water available for fish was rated as favorable (10 points), medium (5 points), or unfavorable (0 points) based on the five categories mentioned above (category I=unfavorable, II-IV=medium, V=favorable). The category groupings were viewed in combination with the narrative descriptions provided in Appendix III.B.5 of the draft SSRS to rate each WRIA.

II.2.b. *Frequency of peak flows*

Importance of the frequency of peak flows component: Hydrographs in undisturbed watersheds typically are much different from those in watersheds that have received some extent of natural of anthropogenic disturbance. One common and important characteristic of hydrographs in disturbed watershed is that peak flows tend to occur more often. This can have serious adverse consequences for wild salmonids at one or more stages in their life cycle. For example, it is not unusual for the frequency of peak flows to increase in seasons and at times when wild spawners are in the process of, or have recently, deposited eggs in stream gravels for incubation. Increased peak flow frequencies can cause large losses of incubating eggs.

Data Source: Basin-wide evaluations of change in peak flow frequency are not available for western Washington. The USGS has information useful for this work.

Limitations: Not applicable.

Scoring: Not applicable.

II.2.c. *Low flow limitations (compared to natural state flows)*

Importance of the low flow limitation component: As with peak flows, in undisturbed watersheds the life histories of wild salmonids are well matched to hydrographs so that water is available at the right times and places. Life histories can be severely disrupted or even eliminated if water becomes overly limited at critical times.

Data Source: Basin-wide evaluations of change in low flows are not available for western Washington. As with peak flows, the USGS has information useful for this work.

Limitations: Not applicable.

Scoring: Not applicable.

II.3. Extent of intact ecosystem

II.3.a. *Extent of protected lands*

Importance of the protected lands component: In general, a direct relationship exists between salmonid habitat quality/quantity and areas that are managed specifically to protect natural values. This relationship is embodied by the identification of "key watersheds" in the Northwest Forest Plan (FEMAT 1993) and other conservation systems. These areas, in which development or other human uses are strictly regulated or avoided, generally receive the greatest level of protection from development and other activities that can affect wild salmonid resources. For present purposes, the percentage of land in each WRIA managed in the following designations was identified: U. S. National Park Service, U. S. Forest Service "Wilderness Areas", and Washington State Department of Natural Resources "Natural Resource Conservation Area" and "Natural Area Preserve" lands. For each WRIA, the total percentage of these protected lands was obtained by totaling the amount of land area in these four categories and dividing that number by the total area of the respective WRIA.

Data source: The information came from the Washington Department of Natural Resources Geographic Information System Digital Data Layers (i.e., WRIA layer, NRC/NAPA public lands data base).

Limitations: The level of protection afforded to fish by different land management classifications can be variable. In general, ISAT used broad land management categories that provided a high degree of natural resource protection, and on a comprehensive scale. ISAT recognizes that other land management classifications may also protect salmonids; these can be considered in the future.

Scoring: The WRIAs were evenly divided into favorable, medium, and unfavorable categories. The favorable category contained WRIAs with the most protected land (12-52%) and got 10 points, the medium category (1.6-10%) received 5 points, and the unfavorable category (0-1%) received 0 points. As noted earlier WRIAs containing the highest levels of protected lands are most likely to have the best opportunities for additional land protections, or might be best able to contribute to networks or systems of protected lands in adjacent areas. Thus, scores were plotted on the relative condition (X) axis.

II.3.b. *Extent of stronghold areas*

Importance of the stronghold areas component: The presence of strong or abundant populations of wild salmonids usually reflects conditions that have been and continue to be favorable for population persistence. These can be important in providing sources for stock rebuilding into less favorable adjacent areas as they respond positively to protection and restoration efforts. In general, because strongholds provide the best examples of existing "principle" from which "interest" may accrue, they should receive high priority protection emphasis.

Data Source: None available or known meeting criteria for inclusion at this time.

Limitations: Not applicable.

Scoring: Not applicable.

II.3.c. *Aquatic biodiversity*

Importance of the aquatic biodiversity component: Similar to the stronghold areas component above, the presence of diverse aquatic communities of species that are indigenous to Washington in watersheds generally reflects more favorable existing conditions for wild salmonids than in watersheds where the type and extent of native aquatic biodiversity has been reduced. The presence of non-salmonid fishes, amphibians, and invertebrates are important indicators of watershed condition and thus would be important areas for protection and restoration of habitat for wild salmonids.

Data Source: None available or known meeting criteria for inclusion at this time.

Limitations: Not applicable.

Scoring: Not applicable.