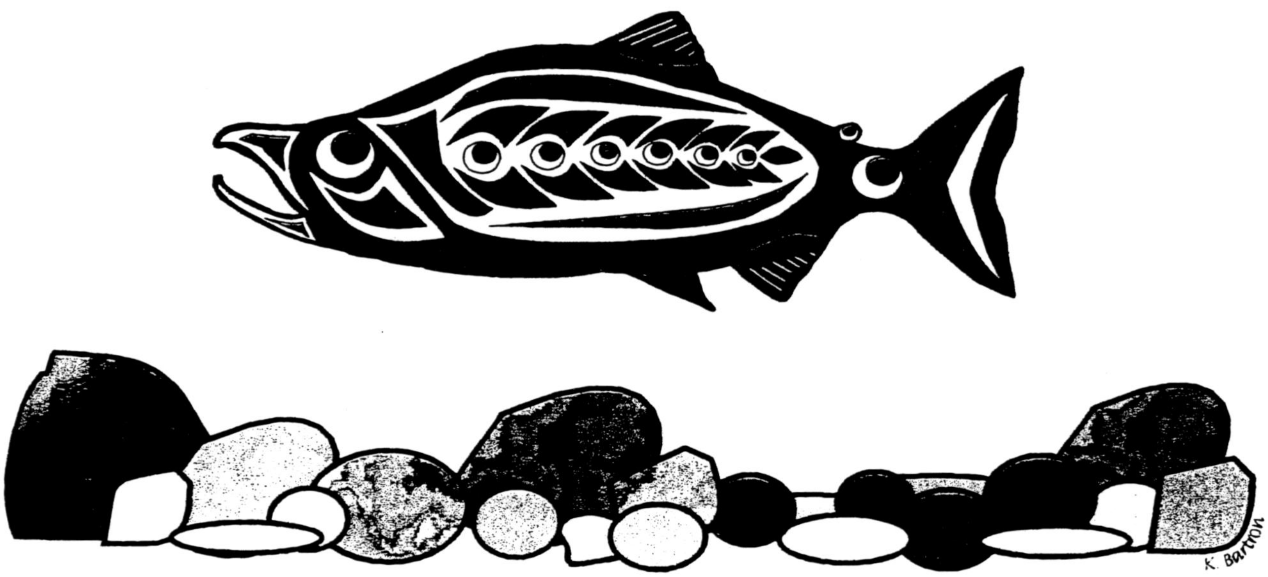
Gravel Disturbance Impacts on Salmon Habitat and Stream Health

VOLUME I: SUMMARY REPORT

A report for the
Oregon Division of State Lands



Prepared by the
Oregon Water Resources Research Institute
March 1995

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THE STUDY CHARGE

Interagency Agreement

An interagency agreement was signed between the Oregon Division of State Lands (ODSL: Division) and the Oregon Water Resources Research Institute at Oregon State University (OWRRI; OSU) as a result of the requirements in Senate Bill 81, Section 102, enacted by the Oregon Legislature in 1993. The Oregon Department of Fish and Wildlife (ODFW) is a co-participant with ODSL in this study.

The agreement was to "conduct a study to examine the relationship between removal of material from streams and stream health in support of essential indigenous anadromous salmonid habitat..."

The objectives of the study were to:

1. Examine the relationship between the removal of material[1] from streams and stream health in support of "essential indigenous anadromous salmonid habitat" as defined in Section 101 of Oregon Revised Statute 196.810, as amended in 1993[2];
2. Enhance ODSL's knowledge of stream processes and impacts on salmon habitat for application to the review of permit requests to remove gravel bars;
3. Examine potential benefits and problems of gravel removal in-streams; and
4. Answer questions about gravel removal impacts on salmon habitat such as pool depths, sedimentation at spawning beds, stabilization of riverine habitat, removal rate vis-à-vis recruitment rate, channel and bank stability.

Basis for the Charge – Legislative and Agency Actions

The ODSL prepared a "Salmon Habitat Protection Work Plan" in March 1994 (ODSL, 1994a). This reviews the history and basis for the salmon habitat study. The ODSL also prepared a scope of work for the salmon habitat and stream health study in March 1994 (ODSL, 1994b). Parts of these documents are quoted directly in the following paragraphs without further citation.

"ODSL is charged by statute to require a permit for the fill or removal of more than 50 cubic yards of material in all waters of this state, including wetlands. Within state scenic waterways, ODSL requires a permit for all removal and fill activity. The unregulated fill or removal of less than 50 cubic yards of material in-streams may have contributed to the depletion of indigenous anadromous salmonid species – especially during their lifecycle stages of spawning and rearing."

"Senate Bill 81, Section 101 (*Fish Habitat*) seeks to help remedy this problem by having ODSL identify 'essential indigenous anadromous salmonid habitat,' adopt administrative rules and require a permit for any fill or removal of material from state waterways. The legislation also requires the ODSL to undertake a separate study to examine the relationship between removal of material from streams and stream health in support of essential indigenous anadromous salmonid habitat. For the purposes of the legislation, 'essential' salmonid species are defined as chum, sockeye, chinook and coho salmon, and steelhead and cuthroat trout listed as sensitive, threatened or endangered by the state or federal government, under respective Endangered Species law."

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[1] Definition in ORS 196.800 (9). "Material" means rock, gravel, sand, silt and other inorganic substances removed from waters of this state and any materials, organic or inorganic, used to fill any waters of this state.

[2] Definition in Section 101.ORS 196.810 as amended in 1993. "(A) Essential indigenous anadromous salmon habitat' means habitat that is necessary to prevent the depletion of indigenous anadromous salmonid species during their life history stages of spawning and rearing. The habitat shall not exceed more than twenty percent of any particular waterway."

"Senate Bill 192 was introduced by Senator Joyce Cohen during the 1993 Oregon legislature session. The Oregon Legislature passed and the Governor signed into law this legislation as part of Senate Bill 81 (attached as an Appendix). Sections 101 and 102 of this bill (*fish habitat*) revised the statutory requirements of ORS 196.810 (*Permits required to remove material from bed or banks or water; exceptions*) and directs the Oregon Division of State Lands (ODSL) to:

- *Require a permit for 'any removal or fill activity ... proposed in essential indigenous anadromous salmonid habitat,' except for specific activities defined in the legislation.*
- *'Conduct a study to examine the relationship between removal of material from streams and stream health in support of essential indigenous anadromous salmonid habitat for the purposes of carrying out the provisions of ORS 196.810 as amended...'"*

"The latter citation refers to the Division's existing authority to require a permit for removal or fill of more than 50 cubic yards of material from the waters of the state. The more recent permit requirement – as specified in Senate Bill 81 – is for any fill or removal located in 'essential indigenous anadromous salmonid habitat.'"

"During the legislative session (February 1993), a very comprehensive study was discussed ... to help resolve ... issues. A tracking survey was contemplated every five years after the study. The study approach was to be a physical assessment of habitat and process and a biological assessment of impacts. This included assessing habitat quantity and quality, and geomorphic processes as affected by gravel removal disturbance. The study was expected to assess spawning success and juvenile rearing and survival as affected by gravel removal disturbance. These clearly were meant to be actual field research studies on specific streams through time."

"At an April 1993 meeting of the Senate Committee on Agriculture and Natural Resources, Senator Joyce Cohen summarized the study purpose by stating, 'The study will enhance their (Division's) knowledge in terms of what is the best way to permit or not permit removal of a gravel bar ... and to look at these gravel bars and look at the sort of impact downstream ... so that you would have some enhanced ability ... to execute permits.' It was also clear that the aggregate removal industry hoped the study would answer questions about whether gravel removal helps or hurts stream health."

"The general consensus of the legislature hearing discussions was that the study would look at the potential benefits and problems of gravel removal in-streams and answer questions such as:

- Do the deep pools – created by gravel removal – help salmonids?
- Does gravel removal create sedimentation impacts to spawning beds?
- Does the removal of gravel bars help stabilize the riverine habitat such that the spawning gravel stays in place and doesn't get washed out?
- Is gravel removal in excess of natural recruitment causing the loss of spawning gravel quantity and quality?
- Does gravel removal or disturbance affect channel and bank stability?"

"Declining state revenues resulted in the legislature underfunding this study. The Division now has the challenge of trying to answer these questions through a much more cost-effective approach."

As developed by ODSL, "The purpose of the study is to conduct a physical (geomorphological) and biological (salmonid habitat) assessment of the impacts of gravel disturbances – especially gravel removal through bar scalping and dredging – to stream health. This includes such considerations as: gravel transport, gravel size and distribution, water quality from changes in-channel morphology, water temperature and velocity."

"The study will focus on how these activities impact indigenous anadromous salmonids during their lifecycle, especially from spawning through juvenile rearing. The study will include an analysis of direct on-site impacts, indirect upstream and downstream impacts, and the general relationship with the surrounding watershed."

RESPONSE TO THE STUDY CHARGE

Scope of Report

In this report, a response is given to the charge of this study. **Volume I: Summary Report** includes a synopsis of the technical considerations followed by the main findings and recommendations. The full technical background for these summary statements is given in detail in **Volume II: Technical Background Report**, and is intended for the reader who seeks the supporting information and documentation.

Mounting Concerns

The evidence presently facing managers related to removal-fill operations is that salmonid populations are declining in the Pacific Northwest. Survival of many species is at stake. This is evidenced by the Endangered Species Act (ESA) listing of some species, the petitions for ESA listing that have been submitted and are likely to be submitted in the near future, and data that show the extent of the stocks decline.

Stream condition is one of the key issues for these at-risk stocks. The stream conditions are often cumulatively described as stream "health." This implies that the stream condition can be assessed in terms of the "health" or viability of the stream's ecosystem. To this end, habitat quality is a primary indicator of stream health. Habitat degradation, habitat restoration to reverse past degradation, and habitat enhancement have been stream management issues for the past three decades.

What is Essential Indigenous Anadromous Salmonid Habitat?

The National Marine Fisheries Service (NMFS) of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, is responsible under federal law with administering the Endangered Species Act (ESA) for anadromous fish. NMFS has addressed the question of <u>essential habitat</u> for the Snake River salmonid species that were listed under ESA as either threatened or endangered in 1991 and 1992.

The NMFS conclusion, published in the Federal Register (December 28, 1993), states that such habitat consists of four components:

1. spawning and juvenile rearing areas;
2. juvenile migration corridors;
3. areas for growth and development to adulthood; and
4. adult migration corridors.

These Habitat components (Table 1) apply as well for all species of salmon in the Pacific Northwest only the specific streams and species may differ. Each is <u>essential</u> at some phase of salmon growth and development and must be present for continued species survival. Each must be considered when evaluating proposed human activities.

Human impacts on the essential features of the four habitat components are often quite difficult to assess. An important part of this study was to develop an understanding of these impacts for use in the regulatory process of removal-fill permits.

The federal definition of "essential habitat" does not correspond to the State definition under Section 101.ORS. 196.810. Specifically, the federal definition does not limit "essential habitat" to a portion of the waterway, such as the 20% value suggested under Oregon Statute.

Table 1. ESSENTIAL FEATURES OF SALMON HABITAT

(Adapted From: Federal Register December 28, 1993; Vol. 58, No. 247, 68543-68545)

Spawning and Juvenile Rearing Areas	Juvenile Migration Corridors	Areas for Growth and Development to Adulthood	Adult Migration Corridors
spawning gravel	substrate	*	substrate
water quality	water quality		water quality
water quantity	water quantity		water quantity
water temperature	water temperature		water temperature
water velocity	water velocity		water velocity
food	food		
cover/shelter	cover/shelter		cover/shelter
riparian vegetation	riparian vegetation		riparian vegetation
access	safe passage conditions		safe passage conditions
space	space		space

* *Pacific Ocean areas used by listed salmon for growth and development to adulthood are not well understood. Essential areas and features have not been identified in the Federal Register.*

Salmon Habitat in Oregon

Historical Distribution and Abundance of Salmonids

Spawning populations of chinook, coho, chum, and sockeye are distributed across the entire Pacific rim. This huge range is occupied by thousands of "stocks" with a diverse array of life history characteristics. Most salmon populations in the Pacific Northwest have invaded post-glacial sites within the last 10,000 years. Varying rates of stock extinction and recolonization are associated, in part, with the geomorphic dynamics within basins as well as oceanic conditions. The stream ecosystems are in continual states of flux with respect to habitat conditions required for salmon production. Historically, stock depletion or extinction may have resulted from "natural" events such as debris flows in lower order (headwater) streams or El Niño weather anomalies.

Prior to European settlement, salmonids migrated through the Pacific Northwest every month of the year, as juveniles or adults (Li et al., 1987). Historically, adult chinook salmon could be found in every month in all but the smallest coastal streams. The summer runs were soon fished to extinction, and the remnant peaks are now considered separate, seasonal "runs."

Current Status and Extent of Impacts on Salmon Populations

The extent of human impacts on salmon populations is dramatic. Over one-third of the original Columbia River salmon stocks are now extinct, including entire populations as defined by run time and/or geographic location (Nehlsen et al., 1991; ODFW, 1994). Many populations (as defined by run time and/or geographic location) are known to be extinct (ODFW, 1994). As a result, commercial and recreational fisheries have steadily declined.

Major impacts to Pacific Northwest salmonids result from habitat loss or alterations, hatchery influences, commercial fishing on the salmon, their predators and their prey, introduction of exotic (non-native) species, and alteration of the trophic relationships in the ocean and in freshwater systems. The relative contribution of each individual impact to the decline of salmon is unknown and may be impossible to determine. Many impacts have occurred simultaneously, others cumulatively. The collective impact of industrial society on entire species complexes has undoubtedly been a major cause of threatened and endangered species.

Quantitative information on pre-European (before 1850) abundance of salmon in Oregon is rare. Predevelopment estimates of total run size of all Columbia Basin chinook, coho, sockeye, chum and steelhead populations are between ten and sixteen million fish (NPPC, 1986). Current estimates of total salmon in the Columbia Basin are around two million (Alkire, 1993) with artificially produced (hatchery) fish outnumbering wild fish (Kaczynski and Palmisano, 1992).

Information on historical distributions of salmonids and on reduction of historical distributions is also available. The historical range of chinook salmon included the entire Columbia Basin and all but the smallest coastal streams. The construction of dams has resulted in range reductions of spawning and rearing throughout Oregon. Many of these dams made no accommodation for fish passage. Chinook salmon are now extinct in Oregon above the Hells Canyon Dam complex on the Snake River, Pelton/Round Butte dam complex on the Deschutes River, and above upper basin dams in the Willamette, Umpqua, Rogue, Umatilla and Walla Walla. Numerous other populations have been lost from other basins such as the fall chinook in the John Day Basin and the spring chinook in the Hood River Basin.

The federal Endangered Species Act of 1973 was enacted to identify and protect species on the verge of extinction. A species is listed as **threatened** if it is likely to become endangered in the near future, and is listed as **endangered** if it is in danger of extinction throughout all or a significant part of its range (NMFS, 1991).

Oregon's categories of threatened and endangered fish are for the most part equivalent to federal categories, due in part to a cooperative agreement between ODFW and the U.S. Fish and Wildlife Service for the purpose of carrying out research and conservation programs under the auspices of the federal ESA (Oregon Natural Heritage Program, 1993).

The State of Oregon, through ODFW, also maintains a sensitive species list in order to "help prevent species from qualifying for federal listing as threatened or endangered" (Marshall et al., 1992). Sensitive species are defined as "those naturally-reproducing native animals which are likely to become threatened or endangered throughout all or any significant portion of their range." Categories used in this listing are critical, vulnerable, peripheral (naturally rare), and undetermined.

Distribution and status of ten species and major races of Pacific salmon were summarized from Nehlsen et al. (1991), Frissell (1993), Moyle et al. (1989), Moyle (1976), and Lee et al. (1980) and subsequently mapped (Bolle Center, 1993). Figure 1 illustrates the status and trends in salmon populations in a geographic context. Collapsing ranges and geographic isolation of formerly productive stocks may indicate widespread ecological problems.

Forty-four percent of Oregon's native fishes are either endangered, threatened or of special concern (Williams et al., 1989; Warren and Burr, 1994). A major reason for this decline is that watershed catchments have deteriorated in quality because of human developments and poor land use practices (FEMAT, 1993; McIntosh et al., 1994; Li et al., 1994; Karr and Chu, 1994; Wissmar et al., 1994). Perceptive management will be required to avoid the listing of these Oregon fish species under the Endangered Species Act.

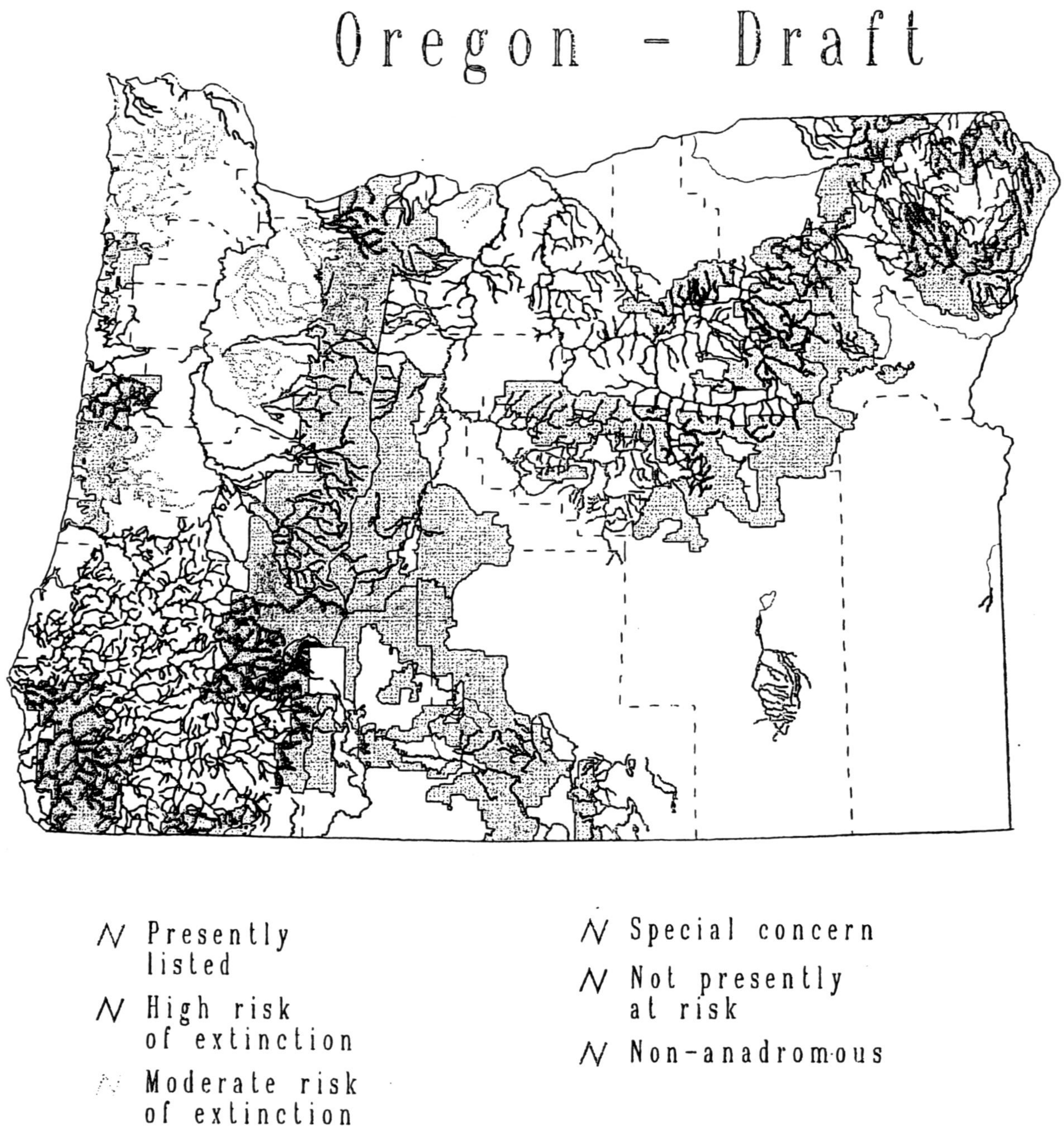

Figure 1. Distribution and Status of Ten Species and Major Races of Pacific Salmon in Oregon.

Human-Induced Gravel Disturbance Activities in Oregon

Common Purposes and Methods for Gravel Disturbance

The gravel resources of streams and adjacent lands are part of the essential basic materials for salmon habitats. They provide a variety of natural functions, including substrate and habitat for the spawning and rearing of fish. They are also highly valued for many human uses.

Gravel resources are highly valued for road construction material, concrete aggregate, fill and landscaping. Consequently, gravel extraction is a major activity and can have a significant impact on aquatic habitat and salmonids. The demand for gravel resources is greatest if there is a nearby market or a convenient, economical mode of transport (e.g., by barge) to more distant markets. Hence, impacts tend to be concentrated in particular areas.

Bank erosion is a common feature of many streams throughout the State. In smaller streams, particularly those that seasonally become dry or nearly dry, bulldozing of streambed gravel against the banks has been a common practice to retard erosion. In bigger streams, the dumping of rock, broken old concrete, and mixtures of material (i.e., rocks, dirt, branches) along the banks has been a common practice. Each approach to erosion control may involve the disturbance of an appreciable length of local channel and riparian zone. Furthermore, some measures likely provide only temporary relief against erosion and must be repeated frequently. Hence, they tend to be chronic measures rather than one-time-only measures. Consequently, the impacts of such disturbances also tend to be chronic and cumulative.

Low banks and adjacent wetlands or low floodplains frequently are altered by fill. This is typically done to create higher ground and firmer supporting surfaces for riparian and shoreline developments. Such fills have been made along many streams in Oregon. There is a tendency for the fills to be concentrated in particular reaches of streams related to waterfront recreational homesites and commercial zones. Such fills tend to be one-time-only measures, intended to be permanent, at a given site. However, they are often accompanied by similar activities at nearby sites and overtime the cumulative effects can become significant.

Mining of the streambed for precious and semi-precious minerals represents activities having a wide range of potential impacts. Recreational gold mining with a pan or small dredge can locally disturb streambeds and associated habitat. Commercial mining, on the other hand, is likely to involve activities at such a large scale that total disturbance and movement of the channel may be involved. This latter category of activities falls outside of the charge of this report and requires special consideration separate from other activities discussed in this report.

Dredging to increase water depth for boating is another common reason for gravel disturbance. This may occur laterally in a stream between the shoreline and deeper offshore water to provide bank access. Or it may occur along the length of the channel to deepen shoals and riffles between stream reaches having deeper flows. These activities are often associated with recreational homesites, recreational access, commercial development, and river navigation. While most likely to occur in or near population centers, they may also be part of dispersed recreation along rivers in less-populated areas. Such dredging may be accompanied by rockfill for dikes and ramps to enhance boating use. These channel-disturbance activities may be one-time-only or may be periodically repeated, depending on the specific nature of the measure and the local river conditions. They may occur as closely spaced activities along some river reaches, but may be widely dispersed and separated elsewhere.

Dredging to extract sand and gravel is a major long-standing activity along many rivers near population centers. Occasionally, gravel extraction is a one-time-only activity, such as to obtain fill material. More commonly, it is a repeated activity, often contingent on the rate of natural gravel re-supply to the site. Gravel extraction activities are common at multiple sites along a given stream. Consequently, the impacts are likely to be chronic and cumulative. When the rate of gravel extraction exceeds the rate of re-supply over an extended period of time, a net "mining" occurs due to the cumulative loss of gravel.

A variety of methods have been used to extract gravel, sand, and cobbles from channels. Each has different impacts and each is likely to impact different portions of the aquatic ecosystem.

A primary method for gravel extraction in the past was dredging from within main channels that carry flow at all times. Such dredging occurred from barges or from the shore (drag lines and hydraulic excavators being typical shore-based methods). The practice has largely been halted because of potential adverse impacts. However, dredging still occurs occasionally in conjunction with development projects on larger rivers.

Another principal method for gravel extraction is to remove material from seasonally exposed stream bars. This may involve wet-pit mining, to remove material from below the water table, or dry-pit mining, on exposed bars and the ephemeral streambeds that can be excavated by bulldozers, scrapers and loaders (Kondolf, 1994).

"Scalping" of sediment – removing the tops of river gravel bars without excavating below the summer water level – is one of the most common methods of gravel extraction practiced today. Because channel bars are submerged by higher flows, bar scalping generally occurs at times of seasonal low flow. This maximizes the amount of material exposed, and hence maximizes the amount of material that may be removed. The bars are almost always attached to the banks and are frequently located on the inside of bends (i.e., point bars). Vehicle access may be from adjacent uplands or across riffles from other bars or by barges.

Excavation of floodplain and river terrace deposits adjacent to an active or former channel is a third common method for gravel extraction. If water table seepage is a constraint, gravel excavation from pits may only occur to the level of seasonal flow. Excavation below the level of seasonal flow may require pumpage of seepage water or underwater extraction from a pond. As active channels naturally move, the channel may migrate into the excavated area. The chance of this occurring is increased in the event of a flood.

Oregon's gravel removal is currently dominated by floodplain, river terrace, and bar skimming operations. Wet-pit operations are limited to the Columbia River, the Willamette River below Newberg, and the lower reaches of the Umpqua River. One approach for managing the amount of in-channel gravel removed is the so-called "safe yield" mining, where extraction is limited to removal of the annually replaced gravel (Sandecki, 1989). This requires the ability to evaluate gravel recruitment at any site of interest. Gravel recruitment information is lacking for most of Oregon's streams.

Gravel Removal in Oregon

Removal of river gravel for commercial purposes has occurred for several decades in Oregon. In general, stream gravel is more economical to mine since it is cleaner than upland sources and is already exposed. In addition, the gravel extracted from rivers is stronger than other aggregates since sediment transport processes wear and fracture the less-resistant materials, leaving only the stronger material intact.

Where gravel removal activities occur within the "waters of the state" (ORS 196.800), a permit through the Division of State Lands (ODSL) is required. Since 1967, the ODSL has issued over 4,300 permits for removal of material from streams, rivers, and wetlands throughout Oregon. These permits include removal of material for dredging (over 1,100 permits), roads and bridges (over 900 permits), pipe/cable/utility lines (over 400 permits), and commercial gravel mining (over 100 permits). The number of permits alone does not indicate the volume of material under each category. The permitted volume of material removed vary dramatically by permit type. From 1967 to 1994 the greatest volume of material removed was for dredging; the next greatest amount of material removed was for unknown or unspecified purposes (primarily a mix of erosion control projects). In total they constituted about 350 million cubic yards. The third highest amount of material was removed for commercial gravel (about 100 million cubic yards). All these removal and fill activities could cause on-site and cumulative effects to streams.

Commercial gravel removal is not uniformly conducted throughout the State, but is dependent on supply and demand. There tends to be greater gravel extraction from streams in areas experiencing large population growth. The Willamette Valley has the greatest amount of permitted gravel removal. The combination of the growing population of the Portland metropolitan area and the abundance of gravel from the Willamette River creates high gravel usage from the River. Other areas of large supply and demand are in the Umpqua Basin. The eastern portion of the

State contains little commercial gravel removal except for small amounts in the northeast portion.

Gravel usage changes through time with changing trends in population and construction of major projects such as dams and freeways. The total annual volume of permitted gravel removal for the state has tripled since 1967, reaching 4.5 million cubic yards in 1990 (see Figure 2).

Evaluation of the amount of permitted gravel removal is very difficult because the amount permitted and the amount actually removed are seldom equal. Furthermore, only the amount permitted is readily known. It is estimated that the permitted volumes are approximately 30-50% higher than the amounts actually removed. Thus, use of the amount that is permitted is likely to give an overestimation of the amount actually removed. The volume of annual gravel removal is dependent upon both the demand and hydrologic conditions which influence availability. For example, there is not likely to be significant gravel deposition during the high-flow season of a year with below-normal precipitation.

Important Stream Processes

Conceptual Framework

The System and Human Impacts

Oregon's streams have been seen as important physical resources since Euro-American exploration began in the early 1800s. The waterways were the means for transportation, water supplies and food. As the State's population grew, alterations of stream systems became greater, including the damming and diverting of significant amounts of water. These and a growing variety of other in-channel and land-use practices impacted the streams and their aquatic ecosystems.

Oregon's streams are the physical settings for extensive and complex aquatic ecosystems. They provide important biological resources. Among these, perhaps the most significant are the anadromous fish resources. Virtually all streams with hydraulic connection to the Pacific Ocean once contained

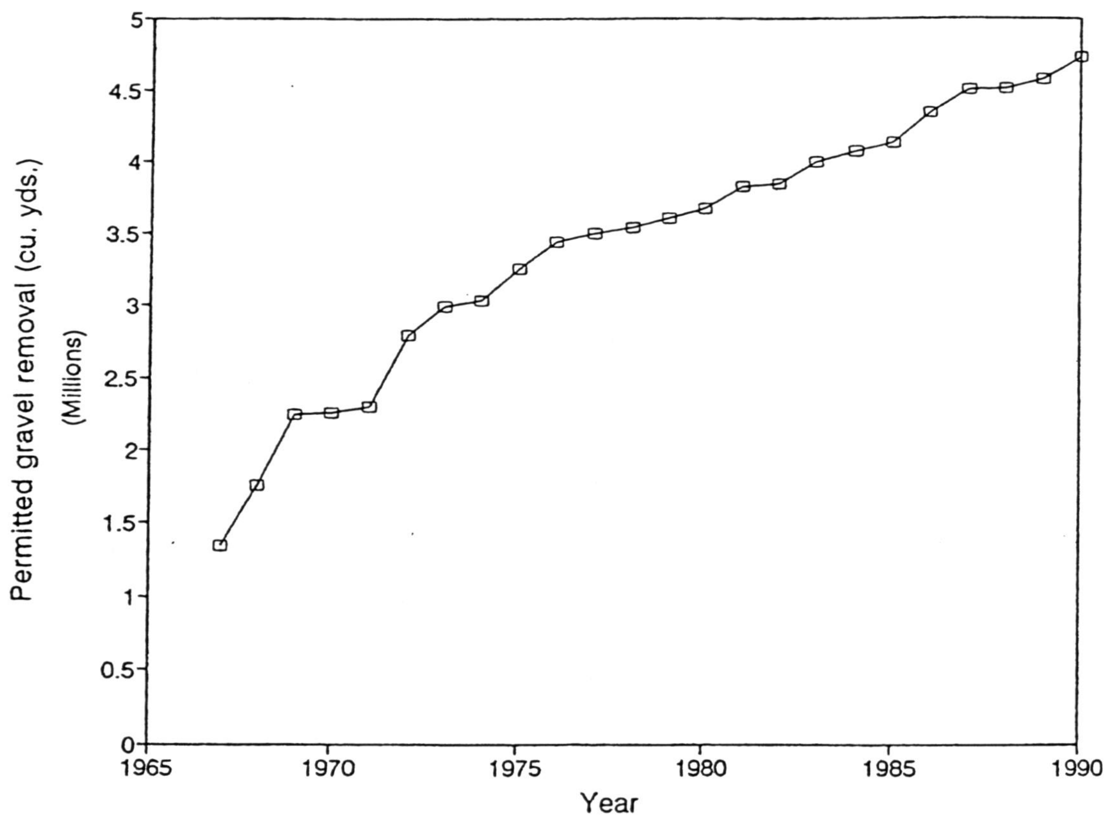

Figure 2. Recent Trends in Total Annual Permitted Commercial Gravel Removal in Oregon.

salmon or steelhead. These species migrated from natal streams to the ocean and back over lifespans of three-to-six years. They were part of the cultural and religious life of the Native Americans. They quickly became significant to the Euro-Americans settling in the region in the 1800s.

The viability of aquatic ecosystems for salmonids depended upon the physical, chemical and biological integrity of their streams. The health condition of other species were important because of food web relations. The "health" condition of the physical habitat itself was critical because of the dependence of salmonids on stream habitat during early stages and the final stages of their lifecycles.

From an ecological perspective, the stream ecosystems were never absolutely stable. Natural events occurred sporadically or regularly over time that caused the river systems to be disturbed. Changing the physical systems led to changes in the aquatic ecosystems. For example, seasonal floods and rarer floods would often result in abrupt channel movement or would stimulate meandering. Landslides would load headwater streams with loosened sediment, rocks and toppled trees that might work their way downriver to valley floors over time.

Large-scale and large-magnitude natural disturbances tended to be separated by periods when the stream and aquatic ecosystem recovered. The term "dynamic equilibrium" could be used to describe the behavior of such systems in that changes often occurred that affected the systems, but the systems tended to have an equilibrium or balance when viewed over a longer period of time. In addition, dynamic equilibrium allowed these systems to evolve slowly over time. For example, the channel profile evolved slowly as erosion continued to deliver sediment from headwater areas to the lower reaches of streams.

Human impacts to these systems began in the early 1800s with the trapping and destruction of extensive beaver populations. Harvesting of riparian forests and removal of instream large woody debris was common. The pond habitats of many streams became lost and the channels began to erode and cut downward. The riparian zones along such reaches no longer received abundant water year-around, and they too began to change. Then irrigation diversions began, leaving stretches of some streams dewatered, or nearly so, during dry summer months critical to survival of aquatic organisms. Physical disconnections and water quality changes occurred in many streams. Later, the problems were compounded by dredging and the removal of gravel, causing further physical changes to the system.

These human activities occurred <u>without</u> intervening periods of no activity to allow system recovery. They were instead applied with persistence and often with growing magnitude over time. The result for streams and aquatic ecosystems was that the natural dynamic equilibrium was overcome by general shifts in directions of change and conversion. Impacts of human activities became cumulative in terms of the changes that occurred. These impacts were often directly physical, with indirect consequences through changes of water quality and resulting effects on aquatic organisms and aquatic-riparian ecosystems.

Human conversion of natural stream systems has occurred directly through activities in-channels and less directly through land-use practices affecting streams. The direct activities have included construction of dams for water supply and hydroelectric energy, diversion of water for irrigation, and sand-and-gravel extraction for construction materials. The land-use practices affecting streams have included agricultural practices, livestock grazing practices, forest practices, wetland fill, and general urban and industrial development and encroachment.

Concept for System Evaluation

Effective management of streams and aquatic ecosystems should be based on knowledge of how those systems function and how they respond to various human activities – individually, in combination, or cumulatively. Accomplishing this requires a broad perspective, including consideration of important stream properties and recognition of the historical, physical-geomorphic and ecological contexts of particular activities. There must be understanding of the likely consequences to a wide range of physical and biological processes. Similarly, spatial and temporal consequences must be considered. Effective management requires strategies for addressing the on-site, off-site, and cumulative impacts of human activities.

One approach for applying basic principles to evaluate proposed human activities involves consideration of the physical and biological connectedness of streams. This provides a "continuum" framework for stream analysis that includes space and time as well as physical, chemical, biological and overall ecological characteristics and conditions.

Physical Connectedness and Continuum

The physical connectedness of streams is illustrated by conceptual diagrams such as that shown in Figure 3. In this case, the dominant longitudinal connectedness is emphasized, from headwaters to mouth of river systems. Lateral and general spatial connectedness are also vital for ecosystems. Principal physical-geomorphic forms are also identified, as well as the general locations of typical human activities. Within channels, the physical forms of the boundary change from place to place, offering variety of habitat. The lateral and spatial connectedness also extends beyond the banks to the adjacent riparian zones, floodplains and hillslopes.

Stream connectedness provides networks that allow water, sediment, woody debris, and nutrients to move downstream under the influence of gravity, while fish and other mobile organisms can move either upstream or downstream. Events in one part of a river network can also propagate both upstream and downstream, affecting other parts of the network.

Another attribute of stream systems is "memory" or the tendency of present behavior to be influenced by past events as well as current events. The stream setting at any given time is a composite of past disturbances, set in the framework of dynamic processes that may not operate continually but can be triggered by energizing events such as flood flows or dredging. Severe disturbances tend to be ameliorated over time by the "memory" of the system, which causes it to seek to readjust to some former condition that represents long-term balances of driving forces such as gravity, shear stresses on boundaries, and resistance posed by boundary conditions.

A key aspect of stream systems is that there may be appreciable time lags before changes in system behavior emerge. A threshold level of disturbance may first be required, such as the rising waters of a flood. If there have been many types of lesser disturbances to the system in the intervening period, the stream's response to an energizing threshold event may not be predictable. It is conceivable that the combination of events may set the river processes off in some new direction of adjustment, which may or may not resemble earlier adjustments. Hence, there is no assurance that a stream will eventually return to its pre-existing state following a disturbance, particularly when human disturbances are involved.

A "healthy" stream system in the physical sense is one where dynamic processes tend to produce a long-term "equilibrium" condition, rather than to drive the system toward further changes away from its former equilibrium.

Cumulative effects have an important bearing on stream health. Such effects arise in situations where the incremental effects of separate activities, even if small or isolated in space and time, become additive through interaction. The interactions may even be synergistic (i.e., the combined effect is greater than the sum of individual effects). Large-scale changes may occur due to cumulative effects, even if individual actions are too small to produce such changes when taken alone.

One consequence for management decision making is that individual activities must be evaluated in a broader context than site-specific direct impacts <u>if</u> cumulative effects are to be considered. Account must be given to the possibilities for insidious, synergistic or pervasive cumulative effects.

Biological Connectedness and Continuum

The biological connectedness of streams is illustrated by Figure 4. As streams extend downstream from headwater areas, many changes occur. The average channel width increases. This results in various changes that involve the physical habitat, substrate characteristics, light and shade, forms of nutrient input, abundance of large woody debris, photosynthesis and respiration, food production, and essential biological groups that are describable as producers, collectors, shredders, and predators.

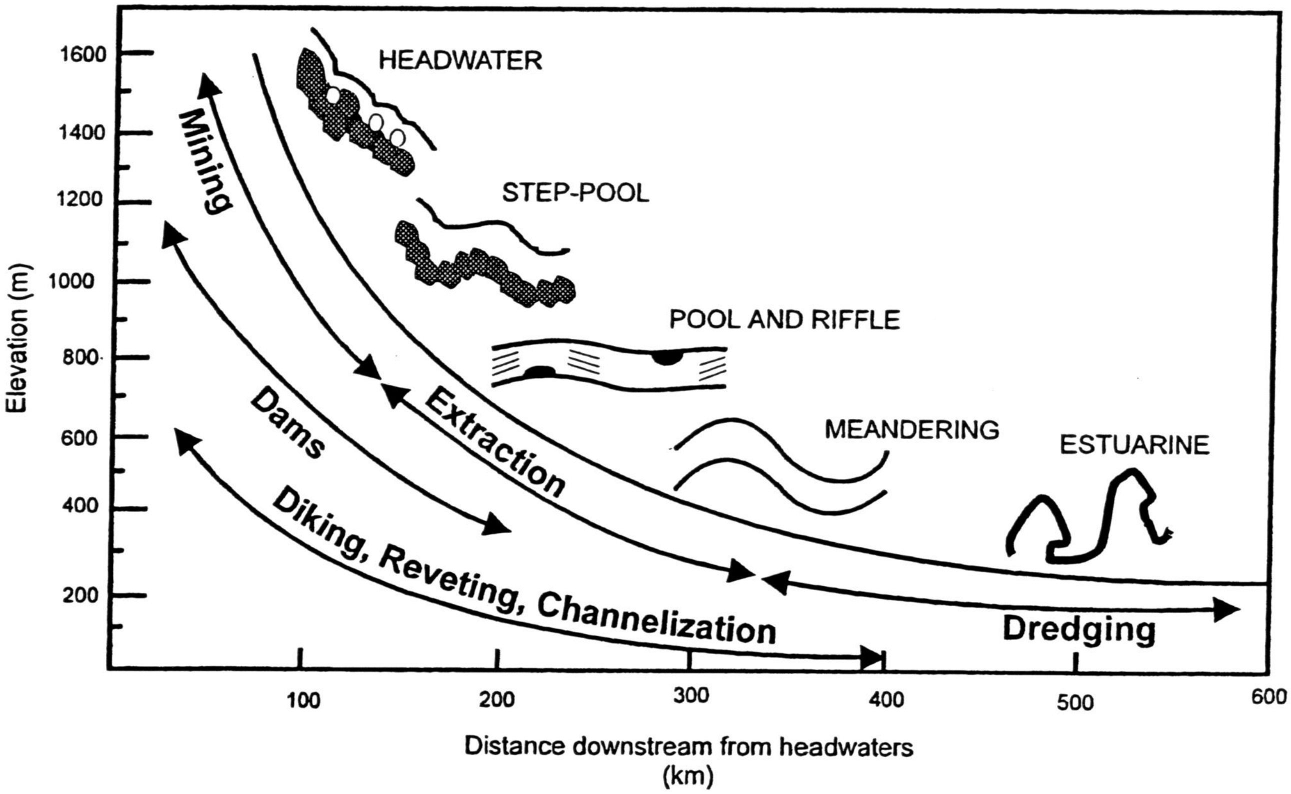

Figure 3. Schematic Diagram of River Physical Connectedness, Channel Morphology and Human Activities (Hjort, R.C. et al., 1984). ***REVISED***

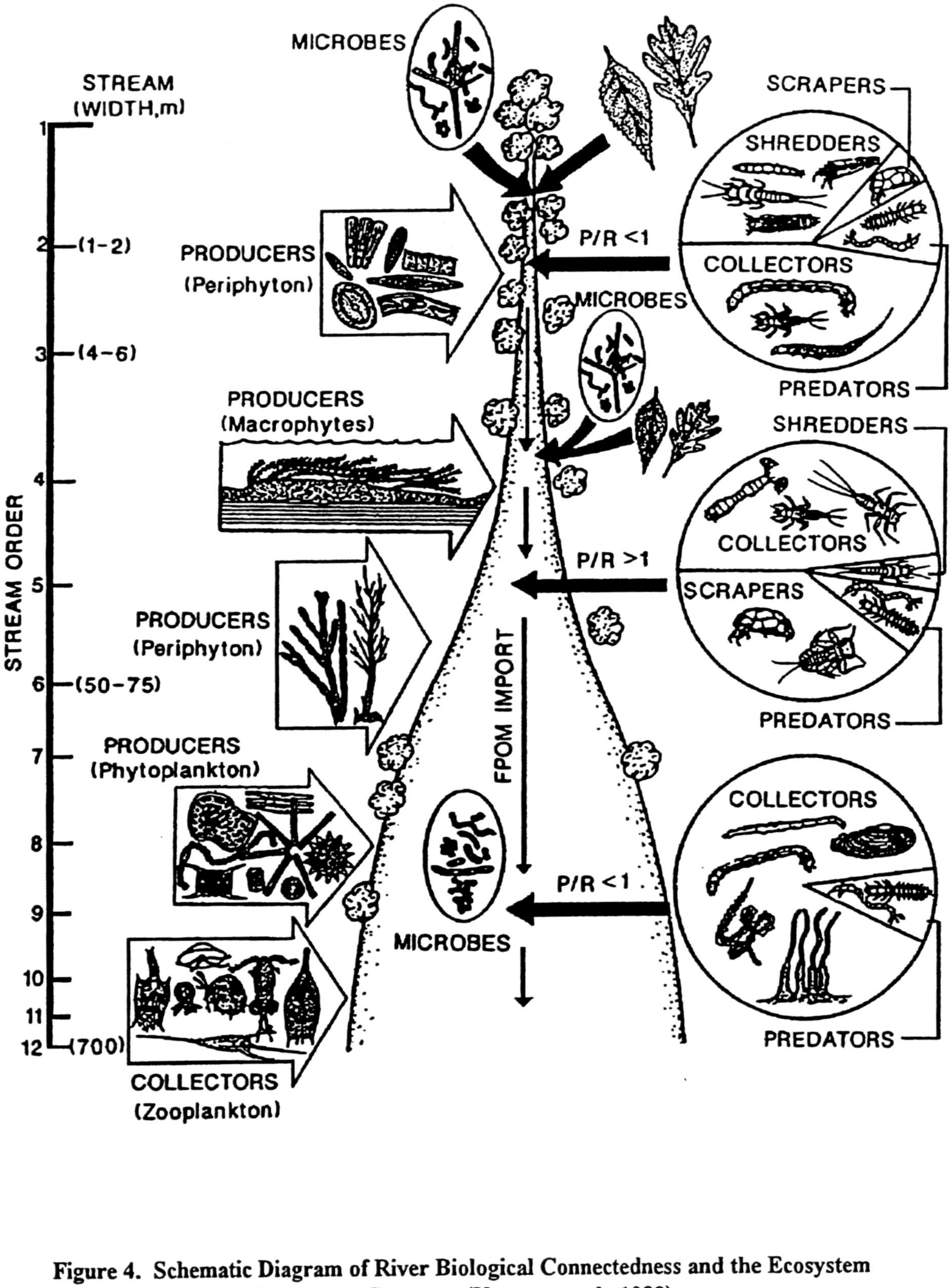

Figure 4. Schematic Diagram of River Biological Connectedness and the Ecosystem Continuum Concept. (Vannote et al., 1980)

The cumulative number of tributaries increases in the downstream direction. This is reflected by changes in-stream flow amounts and patterns over various time intervals. There is an increasing complexity of bio-physical relations from headwater basins to lower reaches of natural rivers.

The distribution of stream organisms depends on food availability and physical conditions. These are predictable in undisturbed streams according to location along the longitudinal stream continuum (Cummins, 1974; Vannote et al., 1980).

Riparian zones represent the relatively moist borders that line the stream banks throughout the network of stream channels. These linear systems provide lateral transitions between terrestrial and aquatic ecosystems. They connect upstream and downstream ecosystems. They produce matter and nutrients and are loci for receiving and storing energy and material from upland zones. They also act as filters during the passage of energy and matter to and from stream systems due to land drainage or periodic floods.

Riparian zones have important influences on the functions, processes, and structural components of streams and the near-channel environment. These influences include nutrient and temperature modification, storage of water, trapping of sediment and organic debris, provision of large woody debris, and food-web support. In addition, riparian zones influence channel equilibrium and morphology.

As streams approach the ocean, the estuarine transition zone is reached. Here, fresh and saltwater mix in a rapidly changing environment that is driven by interactions of river flow and ocean tides. The resulting ecosystems include wetland, riverine, slough, marsh, bay and marine subsystems. Collectively, these are among the most productive on earth.

Disturbance activities can disrupt the ecological continuum in many ways. Local channel changes can propagate upstream or downstream and can trigger lateral changes as well. Alterations of the riparian zone can allow changes in-channel conditions that can impact aquatic ecosystems as much as some in-channel activities.

One consequence of the interconnectedness of channels and riparian systems is that potential disruptions of the riparian zone must be evaluated when channel activities are being evaluated. For example, aggregate mining involves the channel and boundary but requires land access and material storage that could adversely affect riparian zones; bank protection works are likely to influence riparian systems beyond the immediate work area.

Hydrology and Hydraulics

Stream hydrology encompasses the amount and timing of water runoff through the network of tributary streams and main channel of a drainage basin. Water enters this drainage network by direct precipitation and by surface and subsurface runoff from the adjacent land. Many natural variables affect stream hydrology, including precipitation characteristics and basin features such as vegetative cover, soil types, topography and geology. Human impacts on stream hydrology are generally related to the conversion of basin vegetative cover from one type to another (e.g., from trees to crops), compaction of the land surface and associated reduction of infiltration, and obstruction of the channel itself (e.g., roads along the banks or dams across the stream).

The hydrologic characteristics of streams are variable over the years and within any given year. For Oregon's streams, the wet season resulting in large stream discharges occurs in late fall, winter, and early spring months. The period of year when streamflows reach natural minimal values is in late summer and early autumn. Seasonality is important to ecosystem function. Hence, the timing of human-induced disturbance activities may be significant.

Aspects of stream hydrology important to salmonids include the river discharge, stream temperature, and dissolved constituents. At certain times of year, one or another of these parameters may be of dominating importance, whereas the other parameters may fall within an acceptable range of usability and habitat "health." The seasonal and shorter-term variations in-streamflow and associated water quality are important for salmon during the riverine portions of their lifecycles.

The hydraulics of water flow in-stream encompasses water velocities, water depths, flow widths, irregularities of boundary shape, and the associated three-dimensional flow patterns. Hydraulic conditions are governed by hydrologic patterns and water input to the channel, channel slope in the downstream direction, cross-sectional shape of the channel, channel boundary, roughness, channel morphology, and local variations in all of these parameters. All of these hydraulic conditions are important for salmonids.

The physical connectedness of streams from headwaters to lowlands involves many longitudinal changes in hydrologic and hydraulic characteristics. Each tributary represents a point of potential abrupt change. Flows progressively or abruptly increase in magnitude and the duration of high-flows increases in the downstream direction. Channel dimensions increase in the downstream direction to accommodate the larger flows. These are all accompanied by shifts in ecosystem features and organisms. Hence, they have varying effects on salmon habitat, including provision of a range of conditions to accommodate chum, chinook, coho, steelhead and other members of the family *Salmonidae*.

Channel Morphology and Sediment Transport

Channel Morphology

Channel morphology involves the shape and form of stream boundaries and the associated boundary materials. Morphological features include channel width, irregularities of bank shape, bank slope, bank overhang or undercut, the presence of bars, riffles, rapids and pools within the channel, and the corresponding depths of flow at different locations in the channel. These features change spatially in lateral and longitudinal directions. They are quite important in establishing the flow hydraulics of the channel.

In addition, channel geomorphology encompasses any tendencies of the channel to shift location. This occurs through the processes of channel erosion and deposition. Such processes may be gradual or abrupt. The abrupt changes are usually associated with flood events.

Some fairly consistent trends in-channel morphology can be described from headwater to lowlands. For example, headwater reaches of streams are typified by steep slopes and narrow streams, dominated by step-pools and pool-riffle sequences. Lowland stretches of streams are typified by flat, wide meandering streams, dominated by numerous bars and opposing eroding banks. Other morphological features, such as riffles and steep banks, are more variable in place of occurrence and may appear in upstream, middle and downstream reaches.

Morphologic features of streams are important in affecting sediment transport processes and locations for sediment storage in-channels. Channel slope is particularly important. In combination with width-depth relations and flow patterns, it controls the shear stresses exerted against sediment particles and the channel boundary. The resisting forces of gravity and cohesion counteract shear forces. The net balance of these forces at any given location and time determines whether sediment will remain in place or be transported.

Sediment Supply and Transport

Channel sediment is a renewable natural resource. For the sediment at a given point in a channel to be renewed, there must be erosion of the channel or adjacent land somewhere upstream. The renewability of sediment also depends upon the magnitudes and patterns of streamflows over time.

The rate of sediment production and supply from watersheds is highly variable. Many natural and artificial activities cause soil disturbance and make sediment available for movement. Some of the more severe and relatively rapid events that produce sediment include a wide variety of landslides. Slower processes include soil creep, rockfalls and weathering. Flowing water supplies the available material to stream systems whenever watershed conditions allow sediment delivery. Differences in storm patterns, topography, geology, soil properties, soil erosion potential, vegetation, natural disturbances, and land use activities influence the timing and amount of sediment delivered to streams.

Sediment is contributed from within channels through processes such as bank erosion and local scour of the streambed. The relative contribution of channel sediment compared to watershed sediment tends to be small in headwater areas, where sediment input from hillslope sources is very important. In contrast, bank erosion and erosion of channel bars become much more significant in the lower portions of stream systems where lateral meandering occurs through previously deposited alluvial sediment.

Sediment transport in-streams encompasses the timing and amount of inorganic matter being dislodged and moved by flowing water and the deposition of this matter wherever streamflows are unable to sustain motion. Sediment transport is governed by sediment availability and flow capability. There must be transportable sediment available and the water discharges must be large enough to produce turbulence and shear stresses that are capable of moving the sediment that is present.

The longitudinal physical changes in-streams from headwaters to lowlands also involve changes in sediment transport processes and in sediment availability. In headwater reaches of streams, sediment transport tends to be intense over short periods of time. Farther downstream, transport tends to be sustained for longer periods by the greater flows that take longer to drain from the larger tributary area.

Temporal variability in flows can have a major effect on sediment transport and channel features. Flow alignments, depths and velocities are likely to change as water discharge changes. Large floods cause large discharges of bed-materials and may result in major changes of bed features and channel morphology. Flushing of fines and sedimentation of voids occur on rising and falling limbs of runoff hydrographs, respectively. Debris is picked up or deposited as water levels change. Organic matter in benthic zones change as bed-material is moved and re-deposited.

Sediment is transported in-streams either as suspended load (carried in suspension by flowing water) or as bedload (sliding, dragging, rolling and bouncing along the river bed). The particular mode of transport depends on the size and density of the sediment, the channel shape, the water discharge, and flow strength.

Small particles such as clay and silt are almost always carried in suspension. These reduce light passage and cause the water to appear turbid. During floods, suspended sediment transport may move very large amounts of small-size sediment over distances of many miles and deposit over wide-spread areas (e.g., floodplains). As flood flows recede, suspended load transport diminishes and the water clears. At low flows there is little or no transport, except in the immediate vicinities of local bed disturbances.

Bed load transport typically includes sand, gravel and cobbles. Because bed load transport is proportional to water discharge, most bed load is moved during periods of higher discharge caused by rainfall-runoff and snowmelt runoff. The short intervals when bed load transport occurs result in generally short distances of motion between successive long periods of particle rest. Such transport distances are likely to be measurable in tens or hundreds of feet, rather than in miles.

Large woody debris in-channels has an important influence on hydraulic characteristics and sediment transport. Debris tends to deflect flows and cause local scour and deposition of sediment. Large accumulations of woody debris may act as partial dams, retarding and deepening the approaching flow and allowing sediment and moving organic matter to collect and be stored. When streamflows or human activities cause the loosening and movement of debris accumulations, the local hydraulic conditions change and stored materials are released to downstream reaches.

Bed-material in gravel-bed channels has a wide range of particle sizes. This leads to vertical and lateral variability, with resulting habitat variability. When the surface layer is armored by the bigger particles, gravel-bed channels tend to be stable during larger flows and for longer periods than if the surface layer is disturbed. During high-flows, incipient motion in gravel-bed channels may be abrupt due to breakup of armor layers and quick mobilization of subsurface bed-material. The heterogeneity and coarseness of surface layers may allow siltation of subsurface material through surface voids. If there is a large supply of small sediment but little scouring action from flows, bed surfaces may become embedded and even buried with fine material.

The Nature of Channel Change

The hydrologic, hydraulic, geomorphic, and biologic (i.e., riparian plant communities) conditions in-streams combine to create and maintain aquatic habitats for salmonids. Sediment transport is an important component of habitat creation and maintenance.

The stream system and aquatic habitat can be strongly affected by a variety of natural processes and human activities. Changes occur over time. For stable systems, the changes appear to occur around some "middle-ground" long-term conditions and a dynamic physical and ecological equilibrium can be said to prevail. For disturbed systems, the nature and magnitude of disruption may determine whether the system can restore its former state or will instead shift to some other state.

Land uses and a wide variety of human activities influence aquatic habitat through direct physical changes, streamflow changes, alterations of riparian vegetation, and effects on water quality. For example, material removal-fill activities and channel alterations result in local impacts and cumulative impacts related to stream hydraulics morphology and sediment transport. The scope of impacts is related to the magnitude, location, timing, and repetitive nature of the activity.

Channel hydraulics, sediment transport, and morphology are directly affected by human activities such as gravel mining and bank erosion control. The immediate and direct effects are to reshape the boundary, either by removing or adding materials. The subsequent effects are to alter the flow hydraulics when water levels rise and inundate the altered features. This can lead to shifts in flow patterns and patterns of sediment transport. Local effects also lead to upstream and downstream effects.

Impacts of gravel extraction on flow hydraulics, channel morphology, and sediment transport can include the following (Collins and Dunne, 1989; Lagasse et al., 1980):

- Bed degradation at the site that can expose and undermine structure supports in rivers;
- Head-cutting, bed degradation, and bank undercutting upstream of the site due to steepened local river gradient, with exposure and undermining of river structures;
- Bed degradation downstream of the site due to interception of sediment at the site from upstream sources, with exposure and undermining of river structures;
- Depletion of gravel depth and exposure of other substrate materials;
- Bank destabilization, destruction of riparian vegetation, and potential for aggravated bank erosion;
- Increased channel meandering due to greater bank erosion;
- Adverse effects on groundwater levels and vegetation in riparian zones due to lowered bed elevation; and
- Adverse effects on aquatic habitat and spawning sites.

A variety of other human activities and practices have also impacted channel morphology, sediment transport in-streams, and recruitment of sediment from upstream or upland sources. Among these, the loss of meandering areas due to channelization has resulted in significant loss of habitats (both in amount and variety). The bank stabilization measures needed to maintain these unnatural channel configurations have resulted in reduction of natural characteristics and replaced them with linear flow characteristics, with the subsequent reduction in recruitment source areas for gravel.

Aquatic Habitat

Stream Ecosystems

Stream ecosystems vary from headwaters to lower reaches of streams. Aquatic habitat is affected by upstream and downstream conditions, and riparian zone and floodplain conditions, in addition to local channel conditions. The stream continuum concept (Vannote et al., 1980) and other similar approaches help describe fluxes of water, sediment, debris, food, biomass, energy and nutrients through river systems. The ease of movement affects the quality, availability and usability of particular habitats along the channel.

The stream food web is a critical part of aquatic ecosystems – it is the energy pathway for organisms. Salmonids and other biota derive energy directly or indirectly from two sources in this complex web: (1) plants (algae and rooted aquatic plants) that convert solar radiation into organic biomass; and (2) leafy and woody litter that falls into streams and provides the energy base for microbial fungi and bacteria. Herbivorous invertebrates and fish consume algae. Detritivorous invertebrates (shredders) consume decomposing leaves and litter. The invertebrates are the food base for many fish, particularly young salmonids and adult trout that feed on drifting organisms. Salmonids also prey on other fish. Hence, the feeding and rearing of young salmonids is based on a strong interdependence of aquatic species.

The amount of food available helps to set the carrying capacity of the system for various aquatic species (i.e., the number of organisms that can be sustained in the habitat at any given time). Because of the various kinds of food-web (or food-chain) interconnections, alterations of the physical environment or any of the biota in lower levels of the food chain can also affect the upper levels of the chain, such as salmonids. Events and alterations that affect either algal or microinvertebrate production will also alter the production of fish. Hence, the carrying capacity of the ecosystem is affected by system alterations, whether natural or human-induced. Effects may occur at points near and far from the origin of disturbance.

Healthy riparian zones are vital to the proper functioning of stream ecosystems. These zones are sources and storage locations for nutrients and energy, as well as materials that affect the physical characteristics of aquatic habitat. Riparian zones create aquatic microclimates through shade-sunlight variations, temperature control and humidity control. Riparian zones also affect the boundary stability of streams and aquatic habitats with their root systems and recruitment of large woody debris.

Ecosystem integrity depends upon maintenance of natural processes; ability of organisms to cope with stress; ability of the system to defend against invasion by exotic species, pest, or diseases; and system capability to survive and recover from perturbations. Indicators of stress in aquatic ecosystems include the diminution of dominant species (e.g., salmonids), decreased habitat diversity and complexity, overall reduction in the diversity of organisms present, increased exotic species, and homogeneity of stream states and conditions.

Habitat Characteristics and Conditions

Diversity is an important attribute for healthy, thriving aquatic ecosystems. A variety of organisms occupy aquatic habitats. The types and range of species in gravel-bed streams depend on many ecological constraints. Physical factors, water quality, and many other factors influence the type and condition of aquatic habitat (Adams et al., 1990).

Species adaptation and ability to colonize are important considerations. The species present at any location are those that have adapted to the local habitat or microhabitat characteristics. If the habitat experiences dynamic changes (either periodic or irregular), different organisms may be present (more adapted for variable conditions) than in a comparable stable habitat. Some aquatic habitats may need periodic flood pulses to thrive. If a habitat is briefly altered by dynamic changes (e.g., a flood), organisms may seek shelter, move to a more stable micro-environment, or be swept downstream with the water, bed load and detritus. Such a habitat could become depleted of organisms for a brief period. Re-colonization and re-establishment of the aquatic community to something like its former condition occurs on various time scales, from days to weeks to years. If sediment transport alters the habitat or microhabitat, there may be shifts in the types and numbers of organisms present.

Aquatic habitats are often classified and evaluated by stream reach, based on physical features of the channel. Stream reach definition is usually based on channel patterns (straight, meandering and braided reaches), gradient changes, geologic controls, or tributary locations.

Aquatic habitat types reflect particular sets of physical features in a reach. Gravel-river habitat classification is based on major bedforms with pools and riffles as the most common habitat components. For smaller streams, these tend to be mainly longitudinal features. In wider streams, they also take on lateral variability, with many shallow side bars and point bars. Runs and glides differ from riffles mainly due to greater lengths and flatter local channel slopes. Rapids are longer and have swifter flows than riffles, usually with scattered large boulders. Cascades and step pools are indicative of steep, broken channel slopes.

Microhabitats are small components of habitats (e.g., pool, riffle, or side-channel microhabitats). On the microhabitat scale, additional physical features are important in ecological evaluations. These features include actual particle sizes of bed and bank sediments, details of embeddedness and imbrication of coarse surface particles, bed permeability, presence of large boulders, and presence of woody debris. Zones of local bed and bank scour and deposition of sediment, with variations of water depth and velocity over short distances, are also quite important in the definition and description of microhabitats.

Sediment transport and bed mobilization in gravel-bed rivers determine the character and quality of aquatic habitat. They also impose changes on the habitats present and the factors influencing them. In spite of such dynamics, aquatic habitats in gravel-bed streams tend to exhibit a high degree of stability. This is particularly the case when the load of large woody debris or ice is moderate and discharges are not too large or rapidly fluctuating. The main features of channel morphology may be "fixed" by local controls on stream width and channel slope, and by erosion resistant banks. The beds may be coarse enough to be "armored" against movement during much of the year, other than during large discharges. Thus, there may be long periods of bank stability and only short periods of bed mobility when physical channel adjustments can occur that might modify habitats.

Spatial variability of bed surface characteristics in coarse-bed channels provides much diversity and variability in aquatic habitat. The heterogeneous bed-materials cause bed relief features, textural associations, differing structural arrangements, and diverse changes in local turbulence and transport capacity and, therefore, influence local aquatic habitat characterizations and associations.

Salmon Habitat Requirements

Adult salmon return to natal streams to spawn. Spawning occurs sometime during the autumn, depending on the particular species and population. Once the adults are at the spawning area, they may wait for a period of time until the right conditions occur.

To spawn, nests (redds) are first made by the female, using her tail to rearrange the gravel. The female then deposits eggs in the redd which are simultaneously fertilized by the male and then covered over with gravel by the female. The reshaping process loosens silt from the gravel voids, which is swept away by the current. The resulting redd is sufficiently porous that intragravel flow of water occurs around the deposited eggs, providing oxygen and carrying away wastes. The fertile eggs develop in the gravel several inches below the gravel surface until they hatch to form alevins, immature fish that remain in the gravel and complete their development. Once matured, the resulting fry emerge from the gravel. This typically happens in the winter or early spring, a few weeks to several months after spawning.

The redds are built at locations where suitable water depths and currents occur and where the substrate gravel is of suitable size and quality. Redds may cover up to several square meters of the bed surface, depending on the size of the adult fish. When spawning habitat is limited, there is competition for space. A female will dislodge previously laid eggs from another female in order to dig a redd for her own eggs. This limits the number of successfully constructed redds and reduces the overall salmon production.

The emerged fry rear and grow in freshwater for a period of time depending upon the particular species and population. Some will only remain in the spawning stream for a few days. Others may remain there or in nearby streams for many weeks. Some species may spend the remainder of the year in freshwater rearing habitat before leaving in the following spring.

Pools and riffles are essential habitats for ecological units needed by rearing salmonids. Both habitats are important to healthy fish populations. In a simplistic sense, riffles and pools function as the aquatic equivalent of kitchen and dining rooms for salmonids. The food drifts from riffles into pools, where the salmon feed from various vantage points. To maximize these functions, riffles must be relatively free of silt, have high levels of dissolved oxygen, the ability to trap organic debris, high algal productivity, and invertebrates which will feed there until they drift toward the pools. The pools must have sufficient depth for mobility and contain boulders, logs and edge conditions that allow refuge and hiding from predators. Cover for shading and temperature control is essential. Edge habitat is used extensively by juveniles for protection from high-flow velocities and predators. Side channels are also used for rearing. They are particularly important refuge areas during high-flow events.

The space needed by rearing fish depends upon food abundance, competitors and predators, and the physical features of the habitat. The space requirements increase as the fish mature.

Once the fry reach a stage of juvenile development they respond to the urge to migrate towards the ocean. During this outmigration phase, they continue to feed and grow rapidly. They also begin to undergo a physiological conversion called smoltification which prepares them to leave fresh water and live in salt water.

The smolts migrate to the ocean to feed and grow into adults. In the ocean, the salmon range for many hundreds of miles – far from the Oregon coast. They then return to their natal stream at some point in their adult life in response to the need to spawn and complete the lifecycle. They may reach the mouth of the stream early in the year, in mid-year or in early autumn. At some time they enter the estuary, perhaps waiting there for many days to weeks until streamflows increase and trigger the upriver migration process. They then ascend to their natal stream.

Hence, basic salmon habitat requirements include:

1. An adult migration corridor that provides resting and waiting areas, unlocked passage, and good water quality, including sufficient dissolved oxygen, suitable cool water temperatures, and low turbidity.
2. Adequate cover, shelter and shade to protect adults from disturbance, predation and high water temperatures while waiting to spawn;
3. Sufficient amounts of relatively clean spawning gravel in a suitable range of sizes at locations having suitable water quality and sufficient discharge, with proper depth and velocity, during the spawning period and until the young fish emerge from the gravel;
4. Rearing habitat with abundant food, high quality water, suitable water depths and flows, diverse habitat features such as pools, riffles and side channels, numerous refuge locations, and perhaps safe space for overwintering; and
5. A juvenile outmigration corridor that is safe from predators, free from obstructions, and offers food and favorable water quality for additional growth.

Essential Habitat for Indigenous Anadromous Salmonids

Critical or essential habitats are those habitats needed for each stage of an organism's lifecycle, if that organism is to survive. Essential habitats vary from species to species and from stream to stream, depending on the characteristics of the streams and the lifecycle requirements of each species.

Fish populations such as salmon are controlled and limited by available spawning, rearing and overwintering habitats. Several types of habitats may be critical at different times. Thus, any disturbance that degrades these habitats may reduce the essential, critical habitat for salmon.

One difficulty in identifying the "essential" habitat is that different salmon populations use different parts of stream systems. For example, pink and chum salmon may spawn in the lower reaches of streams, some chinook salmon may use the mainstem river, coho salmon and steelhead trout may use the lower-elevation tributaries, and other chinook salmon and steelhead trout may use upper-basin tributaries. Rearing may occur in spawning streams or elsewhere, depending on life-stage, stream hydrology, water quality, food supplies and completion among species. Thus, most of a particular river system may be used by the various salmon and trout species throughout the year. Most or all parts of river systems are ecologically linked and each component is critical to ecosystem function.

Floods and other disturbances erode banks, shift gravel bars, and move the debris that helps build habitats. Hence, salmon habitats and the associated salmon populations are dynamic, changing over time. This adds to the difficulty in identifying "essential" habitat.

Consequently, there is no ecological basis for setting a quantitative limit on "essential indigenous anadromous salmonid habitat." The natural connectedness of aquatic ecosystems will mean that activities outside a designated zone of "essential habitat" will have impacts within that zone. The division of habitat into essential and non-essential is too simplistic and is not a useful paradigm for salmon management.

Impacts of Gravel Disturbance on Stream Condition and Salmon Habitat

General Disturbance Impacts on Stream Condition and Aquatic Habitat

Stream channel environments and riverine ecosystems are largely governed by sediment transport processes. These processes depend on the dynamic variability of streamflow, channel morphology, the availability of sediment, and characteristics of riparian areas. These change over time and space due to natural and human influences.

Alluvial rivers seek to balance forces and achieve dynamic equilibrium in transporting their sediment loads. This involves adjustments of channel slope, shape, roughness, and bed-material movement. Long periods of bed stability are interrupted by shorter periods of bed mobility when major changes and corresponding adjustments occur.

Disturbance of bed-material affects channel condition, benthic habitat, and associated habitats and aquatic communities. Spatial and temporal variations in aquatic habitat occur. The extent of such variations depends on the degree of bed disturbance. After disturbance, further spatial and temporal adjustments occur in hydraulic conditions and sediment transport processes. Thus, the nature and stability of aquatic habitat are affected by both the disturbances and the adjustments to disturbance.

Stream ecosystems have evolved within natural disturbance regimes. Aquatic biota have all evolved behavioral, morphological, and physiological responses that allows them to experience, tolerate and cope with a range of natural disturbances. Organisms are adapted to natural daily and seasonal disturbances, such as fluctuations in daily temperature, summer warming and winter freezing, winter-spring wet seasons and flooding, and summer dry seasons and drought. When disturbances occur outside the expected range and boundaries of adaptation, organisms may respond differently than they do for disturbances within the normal range of tolerance. The nature and extent of response depends upon the extend of the perturbation.

Organism response can be measured in several ways (Pickett and White, 1985): (a) frequency (number of occurrences over time; disturbances may recur during given intervals with a specific degree of probability); (b) duration (the length of time that the perturbation is acting); (c) magnitude (the areal extent of the disturbance on the landscape); (d) intensity (force exerted by the perturbation on the landscape); and (e) severity (biological response of the biota to the frequency, duration, magnitude and intensity of the perturbation).

After disturbance episodes, ecosystems usually have time to undergo a period of adjustment, during which different species re-colonize disturbed areas, gradually change the microhabitat, and then yield to other species. This ecological process is referred to as succession. If disturbance episodes result from differing causes and if the timing of occurrences overlap, ecological succession can become more complex, with parts of the ecosystem adjusting differently than other parts because of the differing natures of the disturbances.

Human disturbances have some important differences from natural disturbances. The changes tend to be permanent or very long-term, rather than transient like most natural disturbances. Human-induced disturbances may uncouple the important ecological processes that link ecosystem components within the watershed (Stanford and Ward, 1992). Hence, the aquatic ecosystems may be less adaptable to human-induced impacts. Many types of potential human activities including, dam building, stream channelization, forest clearcutting, road building, salvage of large woody debris from channels, and conversion of riparian vegetation can affect geomorphic processes, channel form, landscape patterns, ecological function and biotic interactions.

Human-induced changes may alter the physical and ecological thresholds in-streams and watersheds. This may change the ways in which the stream-watershed system responds to natural events.

Human-induced disturbances can result in localized on-site impacts, off-site impacts, and cumulative impacts. Physical changes in-streams that involve large-scale processes and long-term disturbances are likely to result in widespread cumulative effects. Such physical changes may be described according to five main categories (Chamberlin et al., 1991):

- changes in timing or magnitude of runoff events;
- changes in-streambank stability;
- changes in sediment supply to channels;
- changes in retention, especially involving large woody debris; and
- changes in energy relationships involving temperature, snowmelt, and freezing.

The biological responses to these major physical changes can occur on several spatial and temporal scales, from microhabitat to watershed to region, and on daily to decade-long intervals. The consequences range from momentary effects to those which change life history patterns and regional distribution patterns. Biological responses include:

- changes in abundance and diversity of biotic assemblages along the stream continuum;
- changes in dominant life history patterns associated with altered timing of physical processes; and
- changes in trophic processes and food webs resulting from changes in energy resources.

The degree to which gravel disturbance activities are severe events with significant impacts will depend upon the extent to which they deviate from natural stream patterns and processes. Unnatural disturbances can shift the ecological "rules" that govern biological community structure, making the recovery of damaged biota difficult or even impossible (Resh et al., 1988; Poff and Ward, 1989; Bayley and Li, 1992). When substrate availability, hydraulics and water quality are changed, the abundance and health of particular species can be affected and the connectivity within assemblages and fundamental biological processes can change.

Disturbance Impacts on Salmon Habitat

Gravel-bed rivers are of primary importance to freshwater indigenous anadromous salmonid habitat. There are important interrelations of gravel disturbance with salmon habitat characteristics and stream condition for gravel-bed rivers.

The effects of some forms of disturbance on salmon habitat have been studied in detail, whereas other forms of disturbance activities have not undergone extensive study. For example, while the effects of forest practices on salmon in Oregon have been well-documented through numerous scientific studies, the effects of gravel extraction on salmonids and their habitat are not as well understood. However, many estimated effects are likely to be similar to those from forest practices, due to channel disturbance by equipment or debris and to the increased availability of fine-sized sediment from disturbance activities.

In general terms, the broad impacts of gravel removal-fill/alteration activities for the stream system and its watershed are:

- disruption of connectivity of physical processes such as gravel transport; and
- disruption of fundamental biological processes and the associated assemblages of aquatic organisms.

These impacts occur on several spatial and temporal scales. They range spatially from microhabitat to watershed to regional patterns. They range temporally from day-long to decade-long intervals. The consequences range from momentary effects to those which change the life history patterns and regional distribution of organisms.

The most disruptive effects of gravel extraction and related activities are likely to result from in-channel removal, including removal of material from seasonally exposed bars. These locations affect flow hydraulics during the period of large river flows that are most important in changing channel morphology. The disturbance activities make greater amounts of fine sediment available that can alter habitat quality through siltation. Some fill/alteration activities have similar effects.

Bar scalping offers an example of how human-induced changes may alter physical thresholds in-streams. Bar scalping to remove gravel changes the effective size of the remaining surface particles and reduces the threshold flows at which bar particles are disturbed and sediment transport will occur. An associated effect is that bar scalping lowers the overall elevation of the bar surface and can reduce the threshold water discharge at which sediment transport occurs. Similarly, bank fill that encroaches on a channel can affect physical thresholds by constricting flows, increasing velocities, increasing local scour, and thus increasing depth.

Some of the important direct on-site effects of gravel extraction related to salmon habitat, aquatic ecosystems, and biotic community interactions include:

- simplification of the otherwise complex morphology of the channel, reducing the diversity of habitats;
- net lowering of the general bed elevation (channel incisions; bed-degradation), perhaps to the extent of disconnecting the channel from its riparian zone and floodplain;
- removal, undercutting or other instability of channel banks;
- potential local destabilization of the river bed by removal of form resistance that is important to energy dissipation;
- increased suspended sediment availability, transport, water turbidity, and gravel siltation;
- decreased light penetration (from greater turbidity) that can have impacts on benthic organisms and energy relations;
- removal of spawning gravel from streams, reducing the amount of usable spawning habitat;
- direct damage to spawning areas;
- changed substrate composition by removal of material from particular locations, with impacts on habitat and bed stability; and
- disturbance of redds and destruction of eggs or developing embryos, even if gravel extraction occurred earlier, due to potentially greater foot and vehicle access by others to spawning sites due to access needed for gravel extraction.

Removal of gravel-size material from rivers can have either positive or negative effects on channel morphology (form) and channel stability. Some examples of the positive impacts of gravel extraction from a channel include:

- reduction in the scoring stresses exerted by the flow against an eroding bank, by removing material from the opposite bank and enlarging the river cross section to reduce the flow velocities;
- re-direction of flow through the deepened zone by dredging or bar scalping to achieve some other beneficial purpose; and
- improvement of fish or boat passage where the water depth is inadequate for fish or vessels, by dredging a path through a riffle or shoal.

Some of the important downstream effects of gravel extraction related to salmon habitat, aquatic ecosystems, and biotic community interactions include:

- downstream erosion due to interruption of the gravel supply from upstream;
- increased suspended material reaching streambeds and downstream habitats from the disturbance sites;
- increased water turbidity and decreased light penetration, affecting benthic organisms and energy relations;
- embedded stream gravel in or under a layer of fine silt;
- covering of the non-gravel bed with sand, silt and mud, especially in deep or slow-moving parts of the river; and
- alteration of aquatic community composition, leading to cumulative effects on the food chain.

Some of the important upstream effects of gravel extraction related to salmon habitat, aquatic ecosystems, and biotic community interactions include:

- blockage of access of adult salmon migrants due to physical or thermal changes at the work site or downstream from the site; and
- headcutting, erosion, increased velocities and concentrated flows upstream of the worksite due to lowered bed-bar elevations at the site.

Cumulative effects of these disturbance activities can also occur. They may be most pronounced in local river reaches and the downstream estuaries. Some of the important cumulative effects of gravel extraction related to salmon habitat, aquatic ecosystems, and biotic community interactions include:

- decreased primary productivity due to decreases in diatoms and other benthic algae;
- increased densities of rooted aquatic plants that may be unusable to most aquatic invertebrates;
- changed invertebrate assemblages due to changes in species composition;
- reduction in drifting organisms that are primary food sources for salmon;
- slow biotic colonization or recolonization onto substrates;
- reduced food availability to fish;
- loss of well-aerated gravel for spawning and incubation of eggs, leading to increased fish egg and fry mortality; and
- decreased fish biomass and fish species diversity due to less food and to covering of spawning grounds with fine sediment.

The extent of cumulative effects depend on the conditions present in the watershed and channel prior to removal-fill operations. The cumulative effects of removal-fill operations are compounded by interactions that occur due to multiple extraction sites other land use disturbances, or natural disturbances. Direct, off-site and cumulative effects can be reduced or aggravated by the safeguards, or their lack, that are undertaken by operators to protect against known potential impacts and unanticipated impacts.

The physical changes resulting from gravel extraction do not always occur immediately. Often gravel removals occur during periods of small river discharges. Yet, it may take a large discharge that lasts for several hours-to-days before the consequential physical changes begin to happen. Sometimes ordinary high waters do not bring about the main changes – which instead must wait to occur during periods of major floods. Hence, the causes and effects of gravel extraction are not necessarily closely connected in time.

Sometimes the physical and biological impacts of gravel extraction are experienced at great distances downstream. The extent to which this is likely will depend upon the intervening channel characteristics below the point of gravel mining.

Management Options

Management options are available to address problems caused by channel disturbance and change. Actions can be taken to deal with each component of the problem of poor stream health, adversely impacted habitat, and generally poor conditions for salmonids in the waters of the State. Some of these actions are available through the regulatory powers of state, federal and other jurisdictions over public lands and waters. Some are available through legal recourse when actions on private lands affect public resources or resources considered to be held in the public trust.

The regulatory process may be either onerous or beneficial, depending upon how it is applied. Either way, it is a "stick" approach to protection of the environment with the rights of some limiting the rights and actions of others. Therefore, it is essential to devise procedures based on fairness and reason, underlain by sound scientific principles and evidence of ecosystem health management.

Permits for removal-fill in-streams and wetlands represent one way to limit adverse impacts for salmon and aquatic habitat. These can be used as carrot-and-stick approaches by preventing adverse actions and requiring more benign methods. While the permit process has the advantages of identified standards, clear regulatory authority, and ease of administration, it has shortcomings even when applied with the best of intentions for the public good. One shortcoming is an insufficient understanding of cause-effect interactions of removal-fill operations, especially in relation to indirect impacts. Another shortcoming is the limited agency staff time to evaluate each permit application. Both of these severely limit the permit process in its effectiveness for management of natural systems to achieve long-term health and sustainability.

The spectrum of choices available for responding to removal-fill permit applications ranges from "**business-as-usual**" at the one extreme to "**stop-everything**" at the other extreme. Shifts from "**business-as-usual**" to "**stop**" could result from reactive responses to habitat destruction, growing numbers of endangered species, and irreversible losses of salmonids. This action also prevents potential impacts to stream reaches that have not previously experienced removal-fill operations. There are several "middle-ground" possibilities as well. The spectrum of choices and their likely consequences may be stated as follows:

- **Business-as-Usual**: Probable long-term loss of sustainability; loss of aquatic habitat and worsening conditions over time as more permits are issued and resources exploited.

- **Business-NOT-as-Usual; Innovations and New Approaches**: Potential stable or improved habitat over time with continued removal-fill operations.

- **Stop**: No more gravel extraction.

Review of current conditions raises concern about an unchanged "**business-as-usual**" approach as a continuing mode of operation. This approach is too narrowly focused on only controlling the direct on-site and immediate downstream impacts of removal-fill/disturbance activities. Too much good habitat has been lost and many remaining habitats are presently being adversely impacted. A "**business-as-usual**" approach will only continue this degradation.

Recommendations for modification and improvements (including management of potential losses from indirect, off-site, and cumulative impacts) are addressed in the "**business-not-as-usual**" approach.

Widespread indiscriminate use of the extreme "**stop everything**" approach should be discouraged. Economic conditions aside, this approach should not be adopted in many circumstances because it may ignore opportunities to improve aquatic habitat or avoid channel problems through carefully selected actions. However, in some local instances the "**stop everything**" approach may be a last resort if better solutions can not be implemented to minimize removal-fill/disturbance activities that would cause salmon habitat degradation and place salmon at risk.

The Permit Process to Regulate Removal-Fill in State Waters

The Permit Process

The State of Oregon owns most land beneath tidal navigable waters, extending up to mean or ordinary high water. Title to these lands came from the federal government when Oregon was admitted to the Union in 1859. The public trust doctrine gives public waterway rights to navigate on or over the water, to harvest fish and shellfish, and to use the water as a highway of commerce (OSU Extension, 1982). For non-navigable streams, private ownership includes the beds and banks but not the water.

Several public agencies (federal, state, and local) are involved in regulating development activities and uses along streams where the bed ownership may be either public or private. The basis for such responsibilities derives from various laws. Federal laws include Section 10 of the Rivers and Harbors Act of 1899, Section 404 of the Clean Water Act and Amendments, The National Environmental Policy Act of 1969, The Fish and Wildlife Coordination Act, and The Coastal Zone Management Act of 1972. The State of Oregon and local jurisdictions have laws and rules that affect waterways. Collectively, there is a multi-layered pattern of responsibilities that affect and constrain the actions that may be taken by waterway owners and users.

Oregon has developed a Removal-Fill Law and a supporting administrative program to regulate the removal and filling of materials in waters of the state.

The program is designed to conserve, protect and manage Oregon's water resources for the benefit of present and future generations (Oregon Administrative Rules; ODSL, 1986; ODSL undated). Individuals or entities wishing to undertake an activity that falls within the purview of the Oregon Removal-Fill Law must make application to the director of ODSL for a permit.

The ODSL program emphasizes the use of permits to regulate activities that could pose potential concern for water and aquatic systems. The permit process gives government agencies and the general public opportunities to become aware of activities that could jeopardize the State's water resources before the permits are implemented. Through this process, unsuitable activities may be prevented or regulated to assure conditions beneficial to natural resources.

The federal permit process, when it applies to a proposed action, has been combined with the State's permit process. The U.S. Army Corps of Engineers and ODSL have a joint permit application for the numerous proposed activities that involve federal and state jurisdictions. The joint process facilitates application processing and review. Ultimately if the proposed action needs federal and state action and is approved, separate permits are issued from the U.S. Army Corps of Engineers and ODSL. A permit must be obtained from both agencies before the applicant proceeds.

A state permit is needed for any activity that would cause the removal or movement by artificial means (alteration) of more than 50 cubic yards of material or the fill by artificial means of 50 or more cubic yards of material within the bed and banks of the waters of the State of Oregon unless specifically exempted by Statute. Under new regulations of Section 4 of the Clean Water Act, permits will be required of all activities by the Corps of Engineers.

State Land Board approval is also required for the filling or removal of any material, regardless of the amount, within the bed and banks of any waterway designated as a State Scenic Waterway.

Typical examples of activities and projects requiring state permits include: gravel removal, dredging, gold mining, riprap placement, land reclamation, channel alteration or relocation, pipeline crossings, and construction of bulkheads.

Problems with the Current Permit Process

From an administrative perspective, the permit process has been well thought out and appears to be very sound. However, there are several areas where improvements could be made in relation to magnitude of impacts, assessment, and non-localized effects.

There is an implied inference that for removal-fill volumes of 50 cubic yards or less, the impact will be local and minor. However, this is not necessarily true, particularly if there is a lack of concern for the aquatic ecosystem when an activity is carried out. It behooves those undertaking such activities to follow good resource management practices. If not, other laws may become applicable that carry penalties for infractions of the law – such as violations of state/local water quality standards, water rights, or zoning ordinances. Yet there are no assurances, nor any in-place inspection process, to guarantee the protection of the aquatic ecosystem when volumes of 50 or less cubic yards of material are removed, filled, or altered. On the contrary, many examples can be found of small activities that disrupt the local ecosystem. Bulldozing the streambeds against the banks of small creeks to retard bank erosion is one of the more common examples.

Natural aquatic systems are complex. Often, individuals submitting applications for permits are not technically trained to design environmentally sound projects and make the supporting assessments of impacts. Assistance from others is often essential and assistance available through ODSL helps to fill this gap. Nevertheless, ODSL staff must often review seemingly complete but less-than-optimum applications. This burdens the staff with decisions that potentially involve judgments of environmental risk. Hence, a risk assessment must be made. Reliance must also be placed upon reviews by knowledgeable staff from review agencies. Several individuals may end up depending on several other individuals to participate in an assessment, each from a different background and with limited time available. Impacts may be overlooked in situations where there is interdependency in the decision-making process. The alternatives are to conduct impact assessments for most permits or to devise a means to categorized risks and decisions made from general principles for selected, difficult cases. A "burden of proof" approach can be implemented so that disagreements may be more efficiently resolved.

The permit process and its review tend to focus on localized immediate effects and impacts. Such an approach is inconsistent with the broader nature of impacts, which can extend off-site and which can become cumulative over time or through multiple actions. Suggestions are made in Appendix 2 of **Volume II: Technical Background Report** for additional permit form information to help address these broader concerns.

A broader management approach such as the watershed management strategies of some state and regional natural resource needs to be adopted. Such an approach would focus on determining the appropriate removal-fill/alteration activities that can be assimilated by a stream within a given watershed and still maintain a healthy stream. A system of adaptive management might be used that includes numerous pilot projects with extensive monitoring and the cooperative efforts of all stakeholders. By such means, the broader impacts of removal-fill/alteration can become more clearly understood.

BEYOND PERMITS: SEEKING INNOVATIONS

Burden of Proof

Salmon have thrived and survived natural ecological changes in the Pacific Northwest for many millennia. Historically, the salmon have been an important economic resource and revered cultural symbol. However, the development of modern society has created technological challenges and ecological changes that have brought the salmon to the brink of extinction. The decimation of salmon runs is the cumulative impact of exploitation and errant development over many years. It was not society's intent to destroy the salmon runs and thus destroy a significant part of regional identity; nevertheless, it is the result.

The historical and present cultural and economic value of salmon requires that natural resource stewards carefully examine current resource management paradigms and practices. The burden of proof is a critical concern that underscores resource management decisions.

In the long-term, the cumulative environmental effects of many separate decisions pose serious problems that current decision-making practices are unable to adequately address. When facing individual decisions, the evidence of a specific project's contribution(s) to cumulative impacts may often be unclear and less than conclusive.

In the absence of clear and conclusive evidence of adverse environmental impacts, decisions to proceed with a particular project are largely determined by the burden of proof presumed at the time of decision. Although it requires a change in thinking, it is appropriate to apply the concept of burden of proof to identify where responsibility lies when making decisions on gravel removal-fill activities that have cumulative impacts. Burden of proof is the level of requirements and demands that must be met for a decision to go one way rather than another. The concept is introduced at this point to stimulate and complement the reader's thinking and evaluation of the stream processes. With respect to evidence and burden of proof, specific decisions can be characterized by a position on Figure 5. For example, if available evidence is conclusive regarding potential project impacts, then a position within the upper region of the figure is likely to occur. In these situations, decision outcomes tend to be determined by evaluation and analysis of the existing evidence and factual information. However, if the evidence is less than conclusive (a situation common to many projects that cause incremental ecosystem shift over time or are distributed throughout a drainage), a position lower in Figure 5 is appropriate. In these situations, decision outcomes (e.g. approval or disapproval) are largely determined by burden of proof.

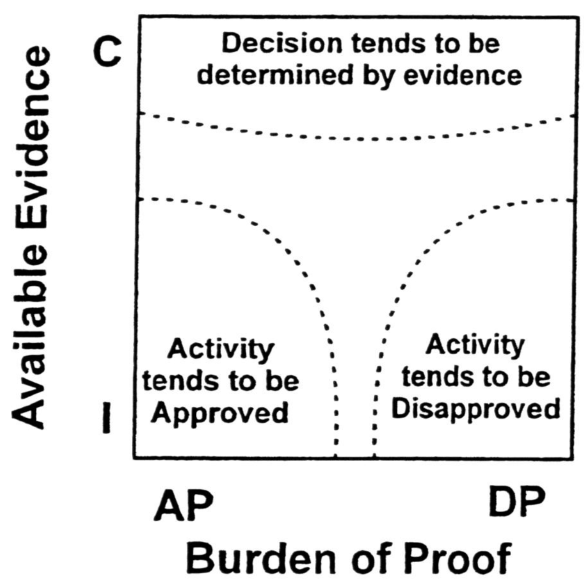

Figure 5. Decision Plane: Decisions can be characterized by positions on this plane:

AP = Approval Presumed; strong, overriding, and exceptional justification must be given for disapproval.

DP = Disapproval Presumed; strong, overriding, and exceptional justification must be given for approval.

C = Conclusive evidence.

I = Inconclusive and incomplete evidence.

The current salmon crisis is largely a cumulative consequence of numerous decisions (over time and across watersheds) made with implicit burdens of proof that tended to protect institutions rather than ecosystems. If aquatic ecosystem protection and restoration are required to arrest or reverse declines in salmonid populations, then decisions can be improved by defining strategic guidelines that shift the burden of proof to account for potential cumulative. The following guidelines are recommended:

1. Activities more likely to result in irreversible environmental changes call for a burden of proof that shifts toward "disapproval presumed." To overcome this position, an agency or project proponent would have to provide a relatively high level of justification and understanding of environmental consequences for the project to move forward.
2. Activities that are likely to shift a system away from its natural disturbance regime also call for a burden of proof that shifts toward "disapproval presumed." However, where an activity tends to shift a system toward its natural disturbance regime, the more the burden of proof should shift toward "approval presumed."
3. When activities occur within or threaten relatively natural (less disturbed) ecosystems, the shifts in burden of proof should be greater.

Note: Even though the burden or proof may shift for various projects, the decision to approve or disapprove a project continues to reside with the appropriate regulatory agency. For project decisions that are in the lower half of Figure 5, additional information, analysis, and evaluation of environmental effects are necessary to reverse the presumed decision. This additional effort may be undertaken by the agency, the project's proponent, or other affected groups.

Meander Zone Re-establishment

The meander zone of a river is the lateral space over which the river has migrated over time. This zone is represented by historical and existing channels and lowland floodplains. Its width is identifiable from maps, photographs, and on-the-ground inspection. Evidence includes the present location of the main channel and all secondary channels, as well as past channel locations that are indicated by remnant channels, oxbow sloughs and lakes, and depressions where siltation has not completely hidden older river beds. The limits are typically identifiable by remnants of eroded river banks adjacent to higher terraces and flat land above existing floodplains.

Extensive lateral meandering of the Willamette River appears to have occurred over recent centuries, particularly upstream of Newberg (Klingeman, 1973; Klingeman, 1987). Upstream of Corvallis, abandoned and present channels indicate that the meander zone covered a five-mile width in some places, even though the channel is only about 300 feet wide. In many areas the zone was over two miles wide. Downstream of Newberg, the river appears to be somewhat entrenched in the valley floor with little room for lateral meandering, even though there are remnant oxbow lakes in the vicinity that suggest that the entrenchment may be relatively recent.

The Willamette has been constrained over the past century by a combination of factors. Principal among these have been bank revetments that stabilize the river against lateral migration and channel dredging that has allowed the river to become vertically more entrenched. The present active meander zone of the Willamette River in most places is little more than one channel width.

The recent geological history of the Willamette Valley suggests that the removal of river gravel over the past several decades represents a net "mining" with little replenishment from other than local sources, with degradation approaching one foot per decade. Upriver sources tend to be the foothill tributaries in the Cascade Mountains, where dams block the larger tributaries. Local sources tend to be the river banks when the river meanders, and these processes have been arrested in many places by revetments.

The results of meander constraint have been significant. The main channel has become "simplified" in nature, lateral connectedness has been diminished, secondary channels and backwater sloughs have become isolated from the main channel, river bars and bends have been restrained from further changes, replenishment of gravel to the active system from local sources has been nearly lost, and habitat diversity has been greatly reduced.

The meander zone of the river can also be described as a longitudinal "belt" of some width, extending from upstream to downstream. For the Willamette River upstream of Corvallis, this is illustrated in Figure 6. The width of the meander belt near the time of statehood was considerably wider than its present configuration. Currently, it is only about 1/3 of its former width.

The changes in meander belt width and meander zone lateral connectedness have important implications for system hydraulic functions and ecological functions. Among these are the loss of flood-water storage capacity in the reduced lowland floodplain, the reduction in overall riparian zone, the reduction in-channel complexity, and associated impacts on aquatic biota.

Concurrent with the human alteration of the river channel and meander zone has been the development of gravel mining pits on the floodplain. These have created isolated "lakes" of standing watertable water. They do not offer connection to the river other than by groundwater seepage. The quality of water in such pits can differ appreciably from that of the river system, owing to greater thermal heating in summer and associated algal growths.

The lowland floodplain represents a major storage location for river gravel. As demand for this resource continues to grow, more attention will need to be given to gravel extraction in such areas. Floodplain gravel removal may offer opportunities to develop off-channel habitats that have been lost due to river channelization.

An intentional policy of meander zone re-establishment would be effective in reversing many of the negative physical and biological impacts to riparian/aquatic ecosystems. Re-establishing channel diversity and connectivity to off-channel habitats is an important ecological goal. To do so requires full regard for connectedness and continuum concepts for river ecosystems, as well as habitat needs for various aquatic species (for more detailed discussion of these concepts see Volume II of this report).

A management approach quite different from past and current practices would involve removing bank protection in selected areas to allow the expansion of the meander zone. Gravel would be added to the river by natural bank erosion to replenish amounts lost where extraction exceeded re-supply. Instead of removing gravel from the former meander zone through pit mining, this approach would allow the river to behave in a more natural way. Eventually, greater gravel removal from the downstream river might again be permitted. At the same time, meander zone habitats could recover.

Currently, development in some potential meander zones is limited due to high flood risks. Public policy has good reason to limit and even reduce development in these regions due to the cost associated with flood damage. In contrast, the ecological value of these regions is potentially high. A meander zone expansion approach might recover lost ecological benefits, while at the same time enhancing re-supply of gravel to rivers for the purpose of ecosystem recovery and commercial use.

In brief, there may be locations where meander zone expansion could be a realistic alternative to the current practice of shoreline protection, meander zone reduction, habitat loss, and pit mining. In our view, it is an alternative that deserves consideration. In more general terms, it illustrates the kind of strategic thinking that we believe is necessary: seek out and implement those management alternatives that come closer to natural processes and natural disturbance regimes.

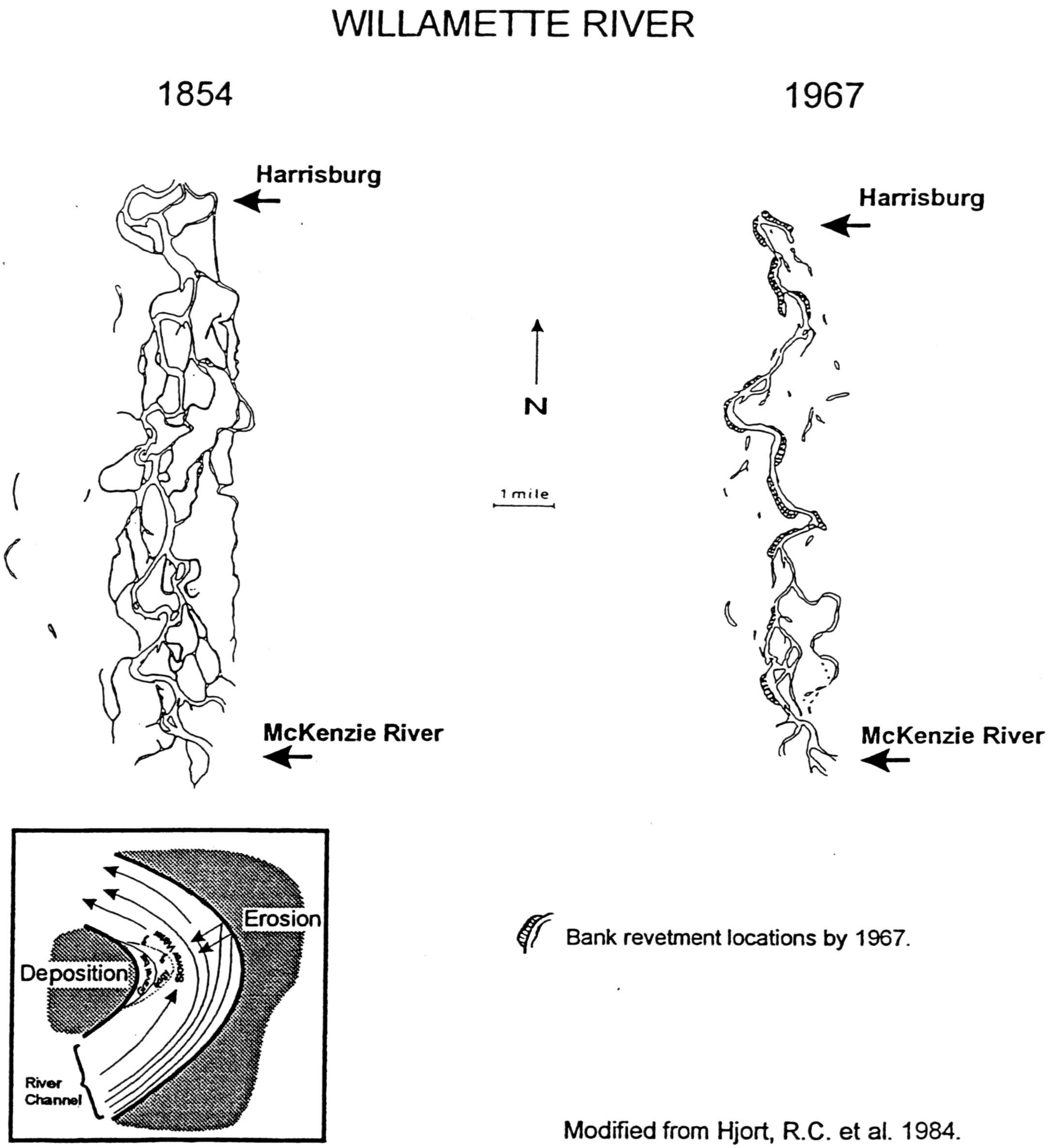

Figure 6. Meander Zone of the Willamette River Upstream of Harrisburg, Showing the Effects of Channel Confinement by Bank Stabilization Works.

STUDY CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions are made related to the charge given for this study:

1. Excessive gravel removal from streams can adversely affect stream health through a variety of physical and biological impacts. Many of these impacts will directly or indirectly affect essential indigenous salmonid habitat. Except for isolated sites of permitted deep water dredging, streams should be managed so that gravel removal rates are less than natural gravel recruitment rates in order to maintain or re-establish aquatic habitat.

2. Material removal from streams does not appear to result in any general ecosystem benefits. Examples of using gravel removal to improve habitat and water quality are limited and isolated.

3. Present removal-fill operations by the gravel industry, in conjunction with the ODSL permitting process, have limited direct impacts such as sedimentation of spawning beds, high turbidity during salmon migration, direct removal of spawning beds, and destabilization of streambeds and streambanks. However, uncontrolled activities including gravel removal, push-up dams, water diversion, and bank stabilization appear to have resulted in significant direct impacts.

4. The potential indirect (off-site, multiple-causes, long-term, cumulative) impacts of removal-fill operations are a threat to the sustained health of Oregon's streams. Typical impacts include aggregate siltation and changes in size distribution, altered channel morphology, lost diversity of habitat, and reduction of bed elevation. These interactions are poorly understood and are not effectively addressed in the present ODSL-permitting process. Removal-Fill operations are just one of many other human activities in-streams that are contributing to cumulative effects associated with the decline in salmon populations.

5. Indirect effects can be managed by adopting conservative evaluation of permits for removal-fill operations. For proposed operations that are likely to significantly shift streams away from natural conditions, it is recommended that the burden of proof of insignificant impact be shifted to the permit applicant.

6. Deep pools created by material removal in-streams appear to attract migrating salmon for holding. From experiences on the Chetco River, such concentration of fish tends to result in high losses due to predation and recreational fishing.

7. Generation of fine material and resulting sedimentation from gravel removal can range from minimal to extensive. Gravel removal from those parts of channels where fines tend to accumulate, such as on upper portions of channel bars and the margins of streams, tends to create siltation problems because of the large quantities of entrapped fine materials released. Sedimentation may be a delayed impact because gravel removal typically occurs at low flow when the stream has the least capacity to transport the fines out of the system.

8. In specific cases, gravel removal can be effectively used to remove stresses on streambanks and streambeds resulting in greater stabilization. In this manner,

gravel removal can result in reduced needs for fill, less streambank stabilization, and greater stability of some spawning beds.

9. Gravel removal from streams in excess of natural recruitment is likely to cause long-term shifts in-channel morphology, including reduced surface area of usable spawning gravel, channel diversity, and lowered bed elevation.

Recommendations to Improve Present Management of Removal-Fill Operations

Removal-Fill operations are presently managed primarily to control direct (local, single-cause, short-term) impacts through regulation by the Oregon Division of State Lands and the U.S. Army Corps of Engineers. The objective of this regulatory process is to avoid large-scale environmental impacts, while allowing those removal-fill operations necessary to support Oregon's economy. Such regulation typically is applied on a site-by-site basis through individual permits and clearly defined requirements for approval. The following recommendations are related to proposed improvements in this "business-as-usual" regulatory process that would assist the achievement of the regulatory objectives.

1. **Improve Data Collection Related to Removal-Fill Operations**

1.a. Conduct monitoring and research to evaluate impacts.

Despite the statement in Oregon's removal-fill law mandating state officials to provide "protection, mitigation, minimizing, rectifying or reducing impacts," not a single Oregon-specific study was found to evaluate and/or monitor the environmental impacts of material extraction or filling. This lack of specific field data to support the removal-fill permit process thwarts the goals of protection, preservation, and best use of water resources stated under ORS 196.805.

This lack of monitoring and research support related to impacts on natural resources is not in the best interest of Oregon's citizen. Regulators simply need more information to manage Oregon's natural resources effectively. The adaptive, watershed-wide management approach proposed in this study will require greatly improved information and analysis. A mechanism is needed to continually support such monitoring related to removal-fill operations.

In addition to monitoring of permitted operations, a research and technology transfer program is needed to continually develop methods for removal-fill operations that result in reduced environmental impacts. A myriad of new approaches to removal-fill operations are being applied throughout the Pacific Northwest; a mechanism needs to be developed such that the results of innovative approaches can be disseminated to natural resource managers in this regulatory process. For example, new biological methods for stabilizing streambanks hold immense promise for reducing fill activities with secondary benefits of increased shading and production of large woody debris. Such methods need to be encouraged by the regulatory process at all levels.

1.b. Improve ODSL database capabilities and use.

ODSL needs to develop methods for better removal-fill documentation and incorporate these records into Geographic Information System (GIS) supported analysis. The present ODSL data collection process is incapable of adequately monitoring removal-fill activities. For example, the database containing permitted volumes for gravel extraction is not connected to the database containing actual amounts extracted and royalties collected. ODSL lacks easy retrieval of either quantity or location of removal-fill operations. This information is vital to understanding and managing ecological effects of ODSL-permitted operations. Personal computers and off-the shelf database programs could handle these records at a relatively low cost. These database records should be readily available to assist outside agencies' planning efforts.

1.c. Implement GIS-based resource management.

ODSL needs to further implement a GIS-based resource management system for removal-fill activities. Such a system could be used to address a variety of issues. Entire regions, watersheds, or the State could be viewed using GIS technology to evaluate areas of highest resource use. Areas identified as essential habitat for sensitive, threatened or endangered species could be viewed and compared to areas of resource use or permit application. Aggrading/degrading reaches could be identified by plotting water gage heights state-wide. Sediment budget information could identify watersheds or reaches with depleted gravel reserves and inadequate gravel re-supply from upstream sources. Estuaries could be evaluated for fill rates over time. Maps could be constructed showing prospective permittees areas open for permit application and areas restricted due to habitat importance or reduced resource abundance. Permitted amounts could be compared to actual extraction rates by watershed or region. Watershed restoration projects might be displayed to avoid inadvertent gravel extraction.

As ODSL continues its transition to GIS-resource management, expert opinion should be solicited on recommended hardware, software, training, import of data to GIS, and best monitoring procedures. After the GIS is fully in place, permit records for the past decade(s) should be updated and geo-referenced as accurately as possible for inclusion. A GIS coverage for fill and another for removal should be constructed and examined in conjunction with the ODFW GIS-layer on essential salmon habitat to avoid disturbance of these critical areas. The GIS information on sensitive species should be expanded to include habitat of other sensitive, threatened or endangered fish and aquatic-dependent species.

To import the updated database information from ODSL permit and royalty records into the GIS, an accurate geographic location must be associated with each permit. Presently, the permit application asks only for drawings of "general location" of the project and a plan view showing location of waterways, wetlands, high water and low water lines, location of fill or removal, adjacent properties, and a cross-section. This method of locating the site is not sufficiently geo-referenced to incorporate into GIS. The permit requirements need to be altered to require decimal latitude-longitude coordinates of the site obtained by a global positioning system. Inclusion of aerial photos in permit applications would assist in geo-referencing the site and could be used for measurements of extraction volumes and evaluation of impacts over time. Such data should be required as soon as possible in anticipation of future GIS mapping systems.

1.d. Allocate sufficient financial resources and staff to monitor resource abundance, condition, and use.

ODSL personnel often lack time for site visits to monitor operations and verify extraction amounts and environmental safeguards. Royalties from gravel extraction appear adequate to collect information to insure permit compliance and minimal environmental impacts. However, such royalties presently are not used directly for staff, but are transferred to the general school fund. It is recommended that a direct linkage be developed between royalties and support for staff who monitor and issue permits for removal operations.

All monitoring should be addressed towards testing of specific, identified hypotheses. ODSL resource management staff should develop long-term research plans that can be supported by the monitoring program. A linkage of monitoring and research would support an adaptive management approach for removal-fill operations. Such an improved information base resulting from long-term monitoring could be achieved at nearly zero additional cost by proper coordination and planning.

2. Minimize Additional Degradation of Salmonid Habitat

2.a. Prohibit, regulate, or otherwise manage small operations.

Small operations (less than 50 cubic yards) presently are not regulated by ODSL. Such operations can potentially contribute to direct and indirect impacts and should be prohibited, regulated, or otherwise managed. For example, 50 cubic yards (four or five dump truck loads) of gravel from a prime salmon spawning gravel bed (redd) during egg incubation could result in a large impact.

The recent enactment of the "Excavation Rule" by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act should provide the regulation of such small operations. Under this rule, persons desiring to remove small gravel quantities will be required to show that such operations are the "least environmentally damaging practicable sites." In addition, sites can not be in wetlands or riffle/pool complexes. Proposed operations by resource agencies can not conflict with ESA recovery plans, cultural and historic protection, requirements under the Coastal

Zone Management Act, or the Oregon DEQ's water quality requirements. It is recommended that strong support be given to the U.S. Army Corps of Engineers to use the "excavation rule" to regulate these small gravel removal operations.

2.b. Conduct removal-fill operations in a manner to minimize potential impacts on salmonid habitats.

Methods to minimize impacts of removal-fill operations on salmonids include several obvious items. No gravel extraction operation should be permitted in or upstream of salmon spawning grounds except when such operation could benefit salmon survival (e.g., if deposition after a major flood has threatened a spawning area). Gravel removal quantities should be limited so that accumulation rates are adequate to avoid extended impacts on channel morphology and salmonid habitat. Gravel removal-fill operations should not interfere with salmon migration past the particular site.

Because of the adverse or even lethal effects of suspended sediment on salmonids and other species and their habitats, removal-fill operations causing sediment re-suspension should be monitored and maximum allowed turbidity levels strictly enforced. Extracted sediments should never be washed directly in the stream or river.

Many of these approaches are present standard practice for ODSL. It is recommended that ODSL develop a manual-of-practice that records and describes successful methods to minimize impacts to salmonid habitats. Such practices are presently maintained by individuals and various "gray" literature publications. This approach has the distinct disadvantages of inaccessibility to new personnel and potential loss due to lack of institutional memory. The "handbook" could be supported by periodic conference presentations and academic journal publications. ODSL personnel should be regional experts in minimization of removal-fill impacts and, as a disciplinary community, they should have written documents that support and foster that expertise.

2.c. Allow bar skimming gravel removal under restricted conditions.

It is recommended that bar skimming be allowed under the following restricted conditions:

- the gravel bar is not an active spawning, rearing, or feeding area for salmonids;
- adequate gravel recruitment exists so that the bar is typically replenished each year;
- berms and buffer strips be used to control stream flow away from the location of gravel removal;
- gravel is removed only during low flows and from above the low-flow water level; and
- the final grading of the gravel bar does not significantly alter the flow characteristics of the river at high-flows.

It needs to be noted that present management practices that allow removal of seasonal gravel accumulations may not adequately protect streams because such accumulation may represent only a local non-equilibrium condition. This may not be an indication that excess gravel accumulation is occurring in the watershed or in long stream reaches. If in-stream reaches show a recent history of rapidly eroding bars or lowering of streambeds, bar skimming should not be allowed.

A continual review of management practices for bar skimming is recommended. Bar skimming operations need to be monitored to insure that such operations are not adversely affecting gravel recruitment downstream or stream bed profiles either upstream or downstream. Field studies coupled with monitoring should be used to test proposed new improved techniques for this gravel removal technique.

2.d. Restrict deep water dredging for gravel production to areas where presently practiced

Deep water dredging of gravel represents a significant and permanent alteration of the elevation of streambeds. The potential environmental effects resulting from such practices are often chronic and difficult to assess at downstream sites. However, effects do occur such as the collection of fine materials within the Newberg Pool. Such materials may result in localized exposure of fish and invertebrates to high levels of toxic compounds and transfer of such compounds through food chains.

Deep water dredging should not be initiated at new sites or extended beyond its present application without extensive review because of the lack of knowledge of long-range direct and indirect impacts of this practice. Present locations of such practices on the Columbia, the lower Willamette, and the Umpqua Rivers should be allowed to continue since the existing environmental damage, at least in the short run, is judged to be not incrementally altered by present operations.

2.e. Do not allow a net loss of wetlands for all removal-fill operations.

Riverine wetlands provide essential salmonid rearing habitat and also support the aquatic food web necessary for salmonids. Preference should be given to protection and preservation of natural wetlands over reconstructed wetlands resulting from mitigation. This recommendation should be supported by careful monitoring over time as wetland loss is often an unintended, insidious process. Wetlands produced from flood-plain gravel removal should be used for mitigation of other necessary fill operations, thus providing incentive for the conversion of former gravel removal sites into functioning wetland systems.

2.f. Use biological streambank stabilization methods where possible.

The technology of biological streambank stabilization has advanced in recent years to where it is a viable alternative to "harder" approaches such as riprap or concrete groins or abutments. Biological methods should be recommended because they provide benefits to salmonid populations including shading and generation of large woody debris.

Recommendations to Improve Comprehensive Management of Removal-Fill Operations

The serious decline of salmonid populations in the Pacific Northwest can be attributed to a wide range of natural and man-related activities. Forestry, agriculture, fishing, and power production practices are undoubtedly major factors in fishery decline and habitat loss. Removal-Fill operations in-stream are also a contributing factor through both direct and indirect impacts. While most direct impacts from removal-fill operations are presently regulated and hopefully minimized, indirect impacts resulting in cumulative loss of aquatic productivity are of significant concern. It is recommended that some significant shifts in present regulatory approaches be adopted to control these far-field, multiple-cause, long-term, cumulative impacts. *Failure to adopt such regulatory changes will probably result in continued decline of salmonid populations in the State of Oregon regardless of how effective the "business-as-usual" regulatory process controls direct impacts. "Business-as-usual" management of Oregon streams can not continue, nor is there time to wait for more definitive studies.*

Even though a total understanding of the impacts of gravel removal on salmonids is not available, adequate information is present to improve present policy. The following recommendations are related to proposed improvements in regulating indirect impacts; such regulation can be considered a "not-business-as-usual approach." As such, opposition to these recommendations can be expected from persons or organizations that are accustomed to interacting with state and federal agencies with a focus on direct impacts.

In addition, present political climates expounding "less government" are not expected to be receptive to these recommendations. It must be realized, however, that these complex indirect impacts typically result from negative externalities resulting from private sector activities, the classic "tragedy of the commons" problem. The only rational response is to regulate these indirect impacts, returning as many external costs as possible back to the private sector decision-making process. A clear example is the long-term, gradual streambed erosion from gravel extraction undermining bridge piers resulting in increased state highway costs (Kondolf, 1993).

1. Improve Present Policy by the Burden of Proof of "No Significant Impact" Shifting to Permit Applicants

The indirect impacts of removal-fill operations on specific salmon stocks cannot be either accurately predicted or measured because of the complex mix of affected variables. For example, salmonid populations vary greatly from year to year and from watershed to watershed. Data on salmon populations can only be analyzed over time periods of decades to provide statistically-significant measures of decreases (Bledsoe et al., 1989). The adequate sampling of such populations including definition of each stocks and important environment conditions would require immense resources. Resources to clearly identify such linkages between removal-fill operations and various indirect impacts are not currently, and may never be, available.

In the absence of a clear understanding of removal-fill impacts, salmonids and their habitats need to be conservatively protected. For those proposed activities that are projected to result in significant indirect impacts, it is recommended that the burden of proof of "no significant impact" be shifted to the persons proposing the activities. "In the absence of statistically significant data trends, the burden of proof should favor conservative management; no activity that could (significantly) harm habitat or stocks should be allowed unless monitoring data indicate it is safe to proceed" (Bolle Center, 1993). Resource agencies cannot be expected to prove definitively that a stock has been or would be harmed by a particular removal-fill operation. Permit applicants need to demonstrate that a required level of environmental protection will be achieved.

Resource coordinators for ODSL need to develop and adopt criteria that will assess what proposed activities can be adequately regulated by "business-as-usual" approaches, and which ones cannot. It is proposed that all activities that will shift streams significantly away from natural habitat conditions be considered ineligible for the normal permitting process. A proposed analysis scheme has been outlined for such assessment in **Volume II: Technical Background Report Appendix II**. This scheme needs to adapted, refined, and expanded by natural resource managers based upon further experiences and new knowledge.

2. Do Not Allow Gravel Extraction From Reaches of ODSL-Managed Streams that Support Sensitive, Threatened or Endangered Species

Gravel extraction should not be allowed in reaches of ODSL-managed streams that support spawning, rearing, and feeding of sensitive, threatened or endangered fish species (salmonid and others). The "sensitive, threatened or endangered" designation is society's legal manifest to stop "business-as-usual." In addition, it is recommended that this restriction be applied to streams supporting chum or coho salmon because of their seriously declining populations. The severity of the population declines and the lack of definite predictions as to potential impacts of removal-fill operations make this recommendation the only reasonable and prudent approach to responsible management of these populations.

3. Do Not Allow Gravel Extraction from Reaches of ODSL-Managed Streams that are Part of Aquatic Diversity Areas or Support Source Salmon Populations

Gravel extraction should not be allowed from ODSL-managed rivers and streams that support the best remaining examples of aquatic biodiversity and salmon populations (i.e., the aquatic diversity areas identified by the Oregon Chapter of American Fisheries Society and the source watersheds for salmon being identified by the Oregon Department of Fish and Wildlife). Because such areas represent focal points for recovery of important ecosystems and need to be protected from additional degradation, it is important to protect these remaining, relatively intact, aquatic ecosystems. These areas have become few in number due to development, yet are significant baseline representations of healthy ecosystems against which to measure the impacts of activities such as gravel disturbance.

4. Promote Recycling Efforts

ODSL needs to work cooperatively with other state agencies such as the Department of Geology and Mineral Industries (DOGAMI), Department of Environmental Quality (DEQ), and the Department of Transportation (ODOT) to encourage aggregate recycling to reduce the demand for stream gravel resources.

Recommendations for Research Activities Related to Removal-Fill Operations

Some activities appear to offer positive solutions to reduce or mitigate the impacts of removal-fill operations. Clearly, the win-win situation for all stakeholders is to develop management practices that support salmonid and ecosystem sustainability, while continuing to conduct removal-fill operations necessary for the Oregon economy. However, many of the activities developed by the research team can only be labeled as "unproved." As such, it is recommended that means be developed to support research such that such ideas can be demonstrated and accepted by regulatory agencies.

1. Develop Plans to Increase Gravel Availability

Nearly all current removal-fill activities in Oregon's streams result in a decrease of streambed gravel. While gravel removal is increased or maintained, gravel production from upstream sources is often reduced through erosion control, much of which is fill activities. Coupled with large-scale flood-control projects that reduce upland flooding, erosion, and bed-load transport, the availability of gravel in-streams is clearly declining.

Expansion of "meander zones" to more natural widths should be examined as a long-term proactive management strategy for streams undergoing gravel removal or large-scale bank protection. For example, many presently controlled streams are limited with respect to the overall width of bottomlands through which the streams are free to meander. ODSL in conjunction with the U.S. Army Corps of Engineers should attempt to develop substantial areas of meander zones along streams. The wider meander zones should again approach the natural pre-statehood widths of active and abandoned channels mixed with low-lying flood plain lands. This wider zone would need to be protected from development. Revetments and other constraining structures would be removed over time and the river would be allowed to re-establish meander forming processes during high-flow, resulting in erosion of adjacent streambanks. This would allow for an increase in gravel availability within a river system which could result in increased areas for salmonid spawning and replenishment of depleted reaches. A portion of the increased gravel from erosion could be allocated for removal by the gravel industry.

2. Develop Strategies to Increase Salmonid and Aquatic Habitat

2.a. Develop methods to convert former flood plain gravel pits into productive habitat.

Lakes and ponds remaining from floodplain gravel operations may represent a valuable resource for creation of additional aquatic habitat. ODSL needs to work cooperatively with the gravel mining industry and local planning authorities to develop efforts to re-establish and restore these areas for aquatic habitat. Every effort should be made to have these lands transferred to state ownership and to have restoration projects initiated to develop healthy, active aquatic habitat. The restoration of these ponds and lakes, and associated riparian plant communities, into aquatic habitat should become a top priority for local planning agencies. Residential development should be discouraged.

Such former gravel removal sites should be considered for hydraulic connection to the riverine systems where ecological benefits to riparian/aquatic ecosystems can be attained. These areas could provide significant juvenile rearing areas and adult feeding. Pilot projects should be initiated to demonstrate best methods of development and the advantages and disadvantages of specific approaches.

2.b. Use gravel mining as a potential method for developing wetlands, off-stream channels, lakes and ponds, and potential salmonid spawning beds.

Resource maps should be developed by ODSL of old stream channels in the flood plain that contain economically-recoverable quantities of gravel. Cooperative ventures should be developed so that portions of such gravel can be removed to form needed wetlands, channels, lakes, ponds, and spawning areas. ODSL and the DOGAMI should develop cooperative plans to facilitate permit applications for such efforts.

Restoration plans should be included into the initial plans for development, similarly to approaches used in upland mining. Restoration of areas from which gravel has been removed should be conducted immediately after the final removal. Research should be conducted to monitor the effectiveness of these areas to support wildlife. Little is known about how well such areas would re-populate or support healthy salmonid populations.

3. Ensure Compatibility of Policies with Existing Watershed Initiatives in Oregon

ODSL needs to develop a watershed approach to management of gravel resources and this effort needs to be closely coordinated with other state watershed programs. A number of programs are underway to assess conditions and integrate multiple interests within watersheds in Oregon.

Restoration programs can be quite expensive and should be protected from interference by contradictory actions. ODSL policies should not erode options of future watershed initiatives nor create conditions requiring subsequent restoration. Removal-Fill operations must be consistent with these watershed programs to ensure efficient use of public funds. ODSL needs to continue to be an active participant in these programs:

- The Oregon Watershed Health Program. This involves eleven state agencies at a cost of ten million and is concentrating initially on two watersheds, the Grande Ronde and South Coast, in this eighteen-month program. Goals are to restore watershed health and economic viability, increase positive community and government interactions through formation of watershed councils, and produce visible results. Coordination efforts need to be included in ODSL's gravel management activities.
- The Watershed Assessment, Oregon Strategic Water Management Group (SWMG) and the Governor's Watershed Enhancement Board (GWEB). Stage 1 has been completed in draft form and is an assessment of watershed conditions using common evaluative criteria to prioritize watersheds for the Watershed Health Program, set funding goals for enhancement, and coordinate agency efforts. The GIS map products from this project depict watershed conditions by hydrologic unit and display risk of potential loss of functional attributes in each watershed (Steve Daggett, personal communication) and should be adopted by ODSL for their management efforts.
- The Oregon Coastal Salmonid Restoration Plan. This has two components: a primary strategy to identify priority watersheds as either source watersheds to be protected or recovery watersheds for restoration to alleviate potentially limiting conditions, and a secondary strategy to apply short-term interim measures in critical areas (Nichelson et al., 1993). ODSL needs to coordinate this effort.
- A committee of nearly thirty scientists and specialists from state and federal agencies, Indian tribes, private land owners and environmental groups. They were originally convened by Senator Bill Bradbury to recommend a process to prioritize state watersheds for restoration and protection (Willa Nehlsen, personal communication). The committee will develop a framework targeting strategies that provide the greatest ecological benefits for native fishes and ecosystems. This framework is expected to help in the prioritization of restoration projects and funds across the Pacific Northwest.
- Watershed Councils. These are being formed in various areas of the state, either in conjunction with the Oregon Watershed Health Program, mentioned above, or as part of a separate process. The McKenzie River Integrated Watershed Management Plan is designed to build consensus, define common problems, and seek solutions to watershed health issues in the McKenzie River Basin. Several other community groups are forming similar watershed partnerships (e.g., the Applegate Partnership, Siuslaw Institute of Watershed Arts and Sciences, Coquille Watershed Association).
- Ecosystem management of federal lands, which make up a large percentage of the state. Both the Forest Ecosystem Management Assessment Team (FEMAT, 1993) and the Eastside Forest Ecosystem Health Assessment (EFEHA) (Everett, 1993) prescribe management of federal lands based on ecosystems as delineated by watersheds. These programs advocate the use of adaptive management, an experimental approach for managing complex ecosystems under changing environmental conditions and social priorities.

ODSL should anticipate management changes needed to cope with additional listings of species under the Endangered Species Act. It is anticipated based upon present trends that more salmonid species in expanded geographical regions will be listed as threatened or endangered under the Endangered Species Act. The State of Oregon decided in 1994 <u>not</u> to list the coho salmon, but ODSL should develop a high-level proactive team to plan for the consequences of such listings to their operations. In relation to gravel removal, such an approach could help transition the gravel industry to a new set of rules and regulations with reduced dislocations and financial impacts.

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APPENDIX – SENATE BILL 81

APPENDIX A

57th Oregon Legislative Assembly - 1993 Regular Session

CONFERENCE COMMITTEE AMENDMENTS TO

C-ENGROSSED SENATE BILL 81

August 5

FISH HABITAT (SB 192)

"SECTION 101. ORS 196.810 is amended to read:

"196.810. (1)(a) Except as otherwise specifically permitted under ORS 196.600 to 196.905, no person or governmental body shall remove any material from the beds or banks or fill any waters of this state without a permit issued under authority of the Director of the Division of State Lands, or in a manner contrary to the conditions set out in an order approving a wetlands conservation plan.

"(b) Notwithstanding the permit requirements of this section and notwithstanding the provisions of ORS 196.800 (5) and (12), if any removal or fill activity is proposed in essential indigenous anadromous salmonid habitat, except for those activities customarily associated with agriculture, a permit is required. 'Essential indigenous anadromous salmonid habitat' as defined under this section shall be further defined by rule by the division in consultation with the State Department of Fish and Wildlife and in consultation with other affected parties.

"(c) No permit shall be required under paragraph (b) of this subsection for construction or maintenance of fish passage and fish screening structures that are constructed, operated or maintained under ORS 498.248 to 498.268 or 509.600 to 509.645.

"(d) Nothing in this section shall limit or otherwise change the exemptions under ORS 196.905.

"(e) As used in this section:

"(A) 'Essential indigenous anadromous salmonid habitat' means the habitat that is necessary to prevent the depletion of indigenous anadromous salmonid species during their life history stages of spawning and rearing. The habitat shall not exceed more than 20 percent of any particular waterway.

"(B) 'Indigenous anadromous salmonid' means chum, sockeye, Chinook and Coho salmon, and steelhead and cutthroat throat, that are members of the family Salmonidae and are listed as sensitive, threatened or endangered by a state or federal authority.

"(2) No governmental body shall issue a lease or permit contrary or in opposition to the conditions set out in the permit issued under ORS 196.600 to 196.905.

"(3) Subsection (1) of this section does not apply to removal of material under a contract, permit or lease with any governmental body entered into before September 13, 1967. However, no such contract, permit or lease may be renewed or extended on or after September 13, 1967, unless the person removing the material has obtained a permit under ORS 196.600 to 196.905.

"(4) Subsection (1) of this section does not apply to removal of material from the beds or banks or filling of any waters of this state in an emergency, for the purpose of making repairs or for the purpose of preventing irreparable harm, injury or damage to persons or property, when notice of such emergency removal or filling is given to the Division of State Lands within 24 hours following the start of such activity. The division, not later than 24 hours following notice, shall inspect the emergency activity, and deny or approve; provided, however, that in emergency actions involving highways, the appropriate highway authority having jurisdiction over the highway in which the work is being performed, shall notify the division within 72 hours following the start of such activity.

"Section 102. The Division of State Lands shall conduct a study to examine the relationship between removal of material from streams and stream health in support of essential indigenous anadromous salmonid habitat for purposes of carrying out the provisions of ORS 196.810 as amended by section 101 of this Act. For purposes of this section, 'essential indigenous anadromous salmonid habitat' has the meaning given that term under ORS 196.810.