DUCK CREEK WATERSHED

Management Plan

Juneau, Alaska
July 1999

Cover: Sequence of restoring salmon spawning habitat and channel morphology in Duck Creek between Taku Blvd. and Mendenhall Blvd., Juneau, Alaska. Pictured on front cover: left, stream clogged with fine sediment and iron floc from decades of neglect and poor land-use management; right, hydraulic dredge used to remove fine sediment. Pictured on back cover: left, redefined stream channel with clean gravel bottom; right, revegetated floodplain with the redefined channel.

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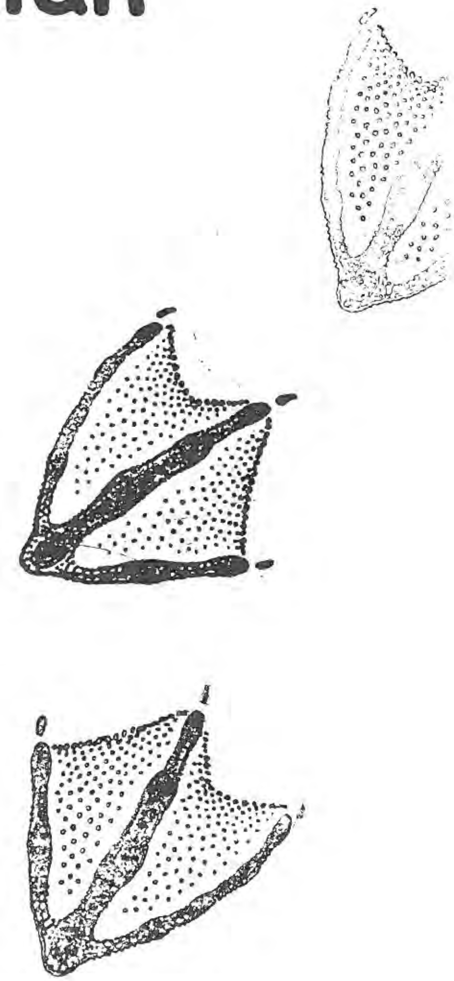
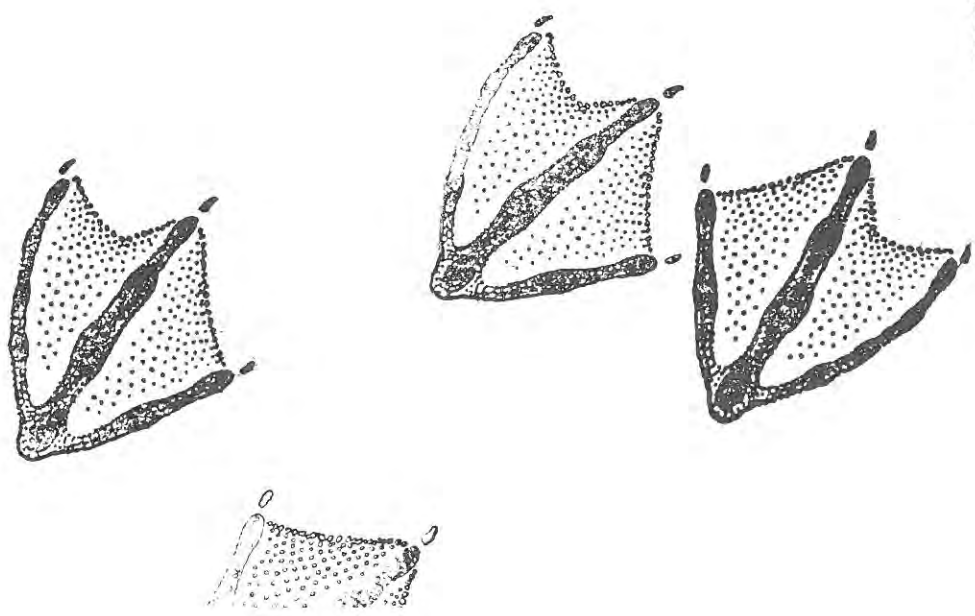
Prepared for:
The Duck Creek Advisory Group
and
The 319 Program of The Clean Water Act

July 1999





PREFACE

This document is **a plan to restore water quality and anadromous fish habitat to Duck Creek**, a small stream adversely affected by urban development in Juneau, Alaska. The Plan is designed to improve the watershed for the local community and to demonstrate management and restoration approaches that may be useful elsewhere. The intended audience is primarily land-use managers and the general public with an interest in The Duck Creek Watershed or similar urban watersheds. The recommended projects and policies will test ways to maintain and restore the health of small streams and wetlands in an urban environment, and will underscore the importance of long-term aquatic habitat protection.

This Plan provides the City and Borough of Juneau (and state, federal, and non-governmental organizations) with the background data and scientific rationale necessary to make the decisions concerning how to protect and restore Duck Creek. It should, perhaps, be called "A Better Plan for Duck Creek" because there have been plans before that for various reasons were never implemented. A plan is now a necessity, because Duck Creek is currently listed by the State of Alaska as impaired, and the Environmental Protection Agency (EPA) requires that a restoration plan be prepared and implemented to meet water quality standards. The responsibility to implement action falls on the City and Borough of Juneau, and failure to adopt restoration measures to remove Duck Creek from the EPA's list could unfortunately result in litigation against the municipality.

This Plan is about improving the Duck Creek watershed, but it is also a "wake-up call" to Alaskans about their need to maintain healthy aquatic habitat to protect their salmon heritage.

The Plan takes a watershed approach which is considered the best framework for managing urban water resources on a sustainable basis. An important aspect of this Plan is that it incorporates science into the management and stewardship of the watershed. The health of the Duck Creek watershed has been scientifically assessed, and that assessment has been used to develop "proven" strategies for managing and improving watershed conditions. Also, because of the scientific database, the Plan's success can be evaluated. Success in this case does not necessarily mean bringing Duck Creek back to a pre-disturbance condition, because in an urban setting restoration must be defined by community needs. It is impractical, if not impossible, to restore Duck Creek to pre-disturbance conditions, but it can be restored to a condition that provides multiple benefits for the community.

If the Plan at times appears to have been written by a committee, it was. Many individuals and agencies contributed to the development of this Plan, which is a product of the community-based efforts of the Duck Creek Advisory Group. This document is volume 1 of 2; it contains the Plan plus background information. (Volume 2 is a Technical Supplement, a separate "reference" document primarily of interest to managers implementing the Plan which contains detailed baseline data, recommended management practices and policies, and other supplemental information.) The Plan appears "up front" in this document to make it accessible and encourage its use. Consequently, the Background section that follows The Plan contains some repetition.

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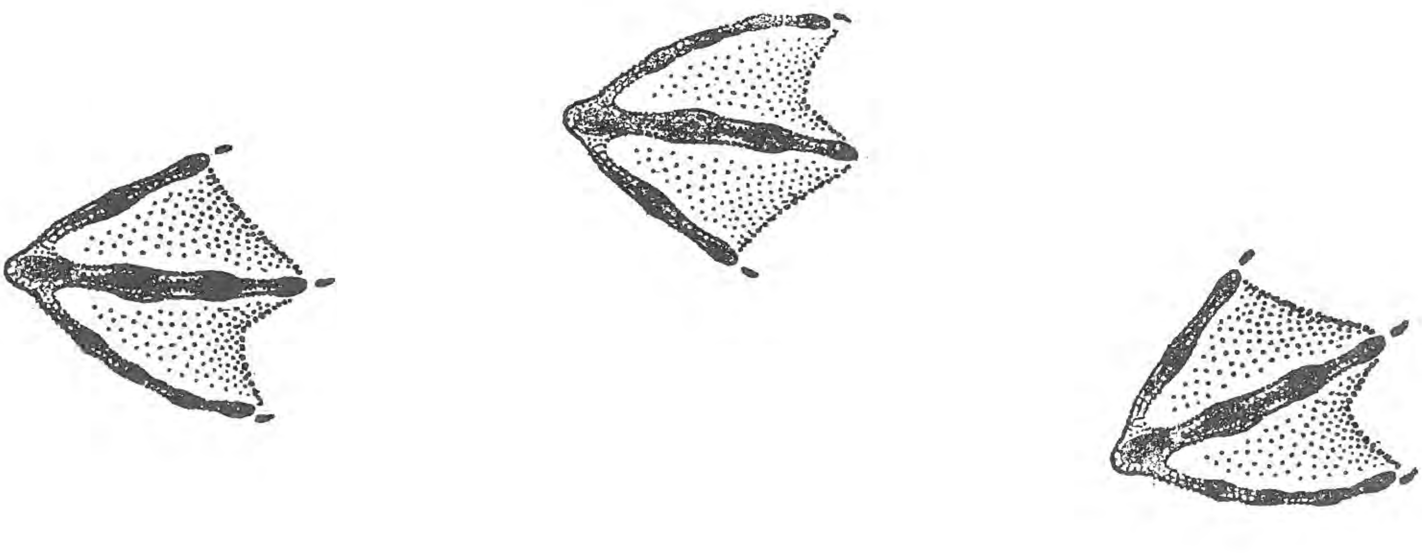


Photo opposite page: Aerial view of Mendenhall Valley, Juneau, Alaska. Duck Creek drains most of the developed area between Mendenhall River (center of photo) and Thunder Mountain (right side of photo). (Photo by Bob Johnson).

I

A PLAN for DUCK CREEK

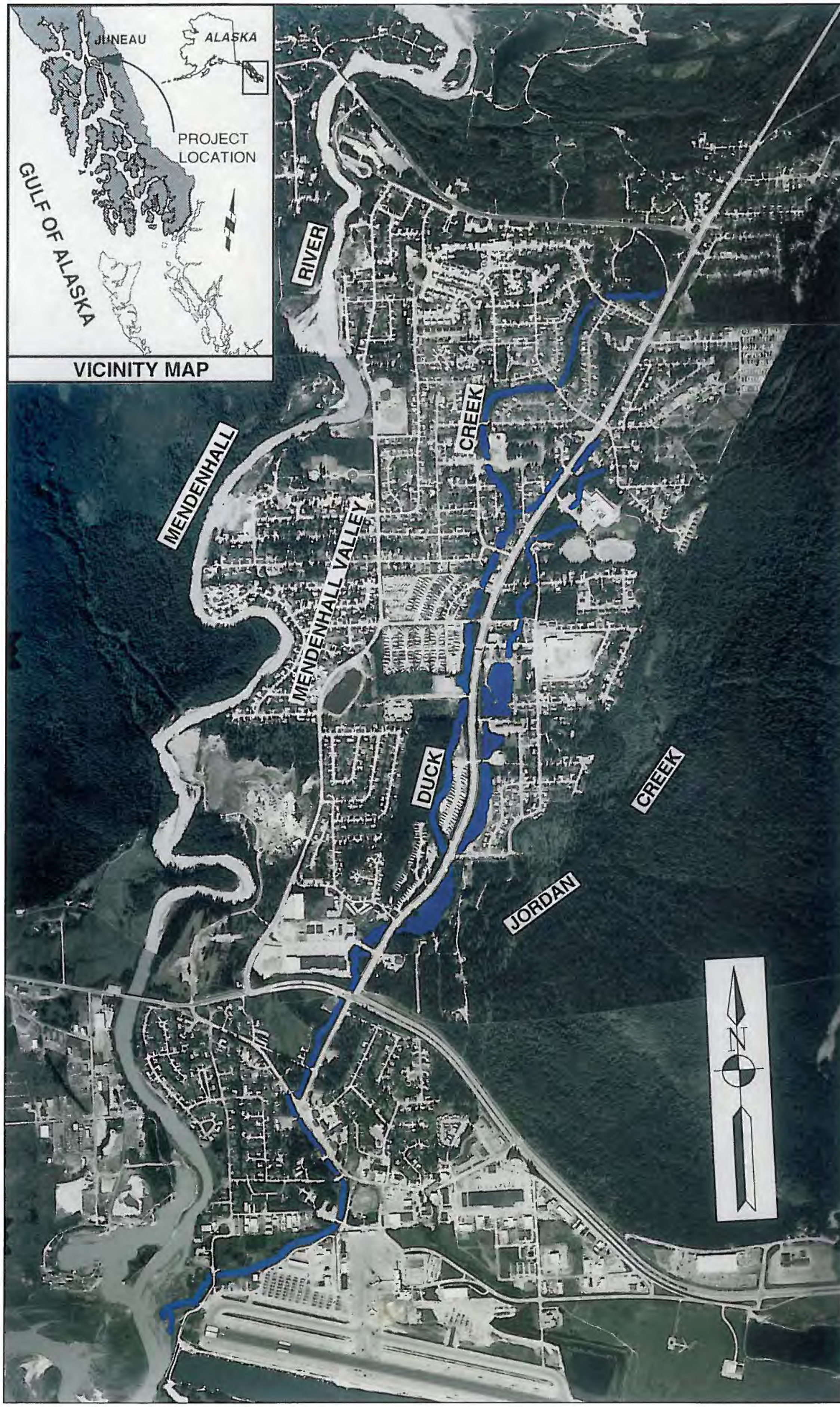


Figure 1.--Aerial photo of Duck Creek in Mendenhall Valley, Juneau, Alaska.

1 INTRODUCTION

1.1 PHYSICAL SETTING

Duck Creek is located near Juneau, Alaska (Fig.1) in the Mendenhall Valley, a watershed that drains several streams into one of only a few major estuarine wetlands in Southeast Alaska. The Mendenhall Wetlands encompass approximately 4,000 acres of tidal marsh that support an abundance and variety of flora and fauna. Duck Creek is a small stream over 3 miles in length that flows south through the middle of the heavily populated Valley and enters the Mendenhall River and Wetlands directly upstream of the Juneau International Airport runway. Based on descriptions from early residents, the stream originally had numerous beaver ponds and clear water that flowed year-round. Presently the stream varies from about 5 to 15 feet in width and from a few inches to several feet in depth. Duck Creek has two main tributaries: East Fork and El Camino; combined with the main stream, these drain approximately 1080 acres (1.7 mi^2) (for detailed watershed description see Beilharz 1998, and Carstensen 1995).

The stream channel has been modified extensively over time due to channel relocation, gravel mining, streambank encroachment, and road crossings. Several large borrow pits and dredge ponds characterize the East Fork. The stream typically has an orange color because of iron pollution from exposure of underlying iron deposits and groundwater sources.

1.2 RATIONALE FOR A DUCK CREEK PLAN

Most of the problems outlined in this Plan have been community concerns since the mid 1960s. During the past 30 years, the community has drafted several plans to resolve those concerns. But plans have repeatedly been deferred for reasons ranging from lack of enforcement to lack of funding, and from lack of awareness to lack of cooperation. Despite its problems, Duck Creek continues to be a primary drainage corridor and a heavily used recreational greenbelt that produces salmon and supports waterfowl and other wildlife. If key concerns can finally be resolved, the community would benefit significantly. Duck Creek would be a safer and healthier human environment, the capacity to support fish and wildlife would increase, and the frequency and amount of flood damage would decrease. This Plan identifies the key unresolved problems and provides cost-effective models for developing, funding, and implementing solutions.

In addition to local concern, Duck Creek is now listed by the State of Alaska as an impaired waterbody polluted by urban runoff. That means State and Federal agencies now require that the stream be brought into compliance with water quality standards. By implementing this Plan to address the violations, the City and Borough of Juneau (CBJ) may avoid regulatory mandates, third party litigation, or even denial of State and Federal funding for other projects.

Finally, for better or worse, Duck Creek is already a "laboratory" for developing and demonstrating urban watershed practices for Alaska. Senior land-use and resource managers, policy advocates, and policy makers stationed in the State capitol see Duck Creek every day as an example of how urban watersheds are managed in Alaska. By Implementing this Plan, the community can demonstrate that impaired urban watersheds can be cost-effectively improved to meet both community and statutory needs. Furthermore, the watershed can provide a forum for interdisciplinary research on how Alaska's urban watersheds can be managed to keep them from becoming impaired.

1.3 NOTED PROBLEMS IN THE DUCK CREEK WATERSHED

There are two key "roots" to Duck Creek problems: 1) the non-point source of the pollution, and 2) land-use management that does not protect the watershed.

The main source of pollution in Duck Creek is urban runoff. Urban runoff is the leading cause of water quality degradation in Alaska (Fig. 2), and Duck Creek is among 30 streams in Alaska (5 in the CBJ) listed by the state (ADEC 1996) as impaired by urban runoff from non-point sources. As the name implies, non-point source pollution is difficult to control at the source because sources are widespread and the pollution being generated can vary daily in both content and volume. Solving the problem requires remedies that are wide-ranging but that do not place a burden on individuals or the community.

Alaska's Impaired Surface Waters

Pollution Source	Listed Waters
Urban Runoff	30
Oil Development	18
Mining	7
Forest Products	5
Seafood Processing	4
Landfill	3

Source: ADEC. 1996. Alaska Water Quality Assessment

Figure 2.--Waters listed by the State of Alaska as impaired and the primary pollution sources.

Another key problem is land-use management in the watershed. In general, Alaska lags behind many states in providing for urban land-use that complies with watershed management laws and policy guidelines. That is not all bad, since we can learn from others' mistakes. Stormwater quality regulations, drainage and flood control, and wetland development are three key areas where watershed management must be closely coordinated with urban development. Lack of coordination in the past has led to tremendous damage to Duck Creek watershed functions and resources. The modest amount of residential, commercial, and industrial land in the Juneau area also requires that watershed management be well-planned, and that land-use policies protect not only watershed resources but also the economic vitality of the community.

Salmon and trout abundance in Duck Creek has seriously declined as a result of development activities in the Valley. Fish have been a major focus of studies on Duck Creek because of their importance to local fisheries, their role in the social culture of Alaska, and because they are indicators of stream and watershed health. Salmon and trout in Duck Creek and other Mendenhall Valley streams should be considered the proverbial "canaries in the coal mine." The continued monitoring of these fish populations--in terms of both abundance and diversity--will provide a reliable indicator of the health of the stream, the environment, and the "quality of life" in the Mendenhall Valley.

Salmon and trout... should be considered the proverbial canaries in the coal mine.

1.4 POTENTIAL SOLUTIONS

Results of recent studies and review of past plans led the Duck Creek Advisory Group (DCAG) to advocate three general approaches to controlling non-point sources of pollution and to developing better land-use practices in the Duck Creek watershed: **Enforcement, Management, and Restoration** (Fig. 3). The DCAG and the Mendenhall Watershed Partnership (MWP) shown on the chart below are both local citizens' organizations that provide community involvement in watershed issues.

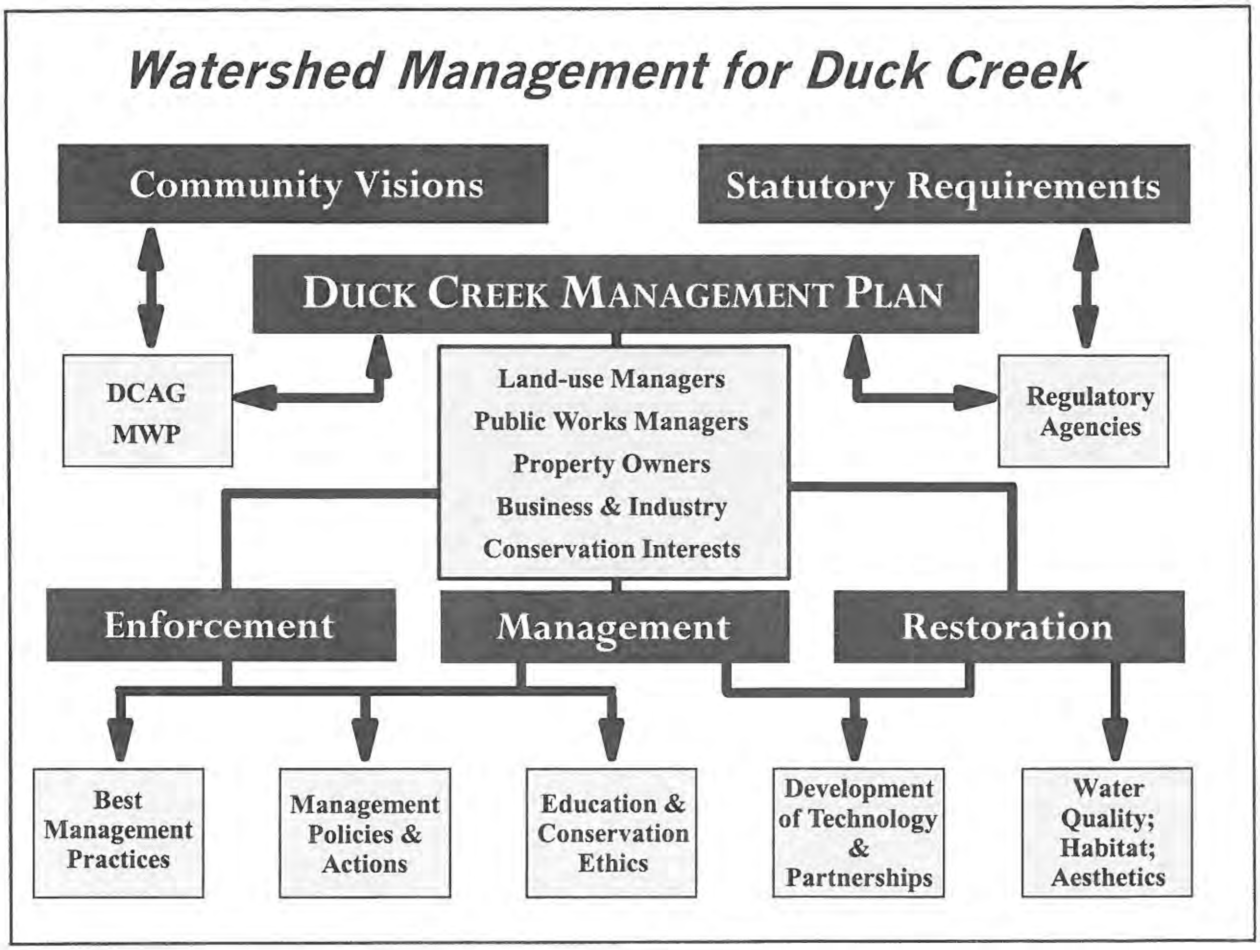


Figure 3.--Flowchart showing the framework for implementing Duck Creek watershed management.

- **Enforcement** of the statutes to protect public health, prosperity, and resources could have prevented many existing problems. Inadequate enforcement has been a key factor in the emergence of issues such as poor water quality, habitat loss, sedimentation, flooding, and inadequate stream flow.
- **Management** of urban land use has a large effect on how conflicts between desired land-use, watershed functions, and pollution are resolved. This Plan advocates two levels of land-use management: an institutional and commercial level, and a community stewardship level.

  The watershed approach to institutional and commercial land management presented in this Plan is unfamiliar to many of Alaska's land managers. The watershed approach requires management to be organized by geographic rather than demographic areas. The watershed is broadly considered the best framework for managing urban land-use on a sustainable basis, however, many land-use managers are apprehensive about adopting that approach. That approach allows managers to plan for and understand how development affects critical and protected watershed functions, such as flood control, water quality control, and fish and wildlife habitat.

This Plan also advocates a community stewardship approach to land use. Individuals can greatly influence development practices and non-point source pollution--part of the work done by the DCAG has been to inform the community and foster their participation. The premise is that as people who depend on or are interested in the watershed begin to understand the value of watershed functions and develop a conservation ethic, they are less likely to allow or participate in the loss of those functions.

- **Restoration** is also a key component in the recovery of the Duck Creek watershed. Due to the current level of pollution and the significant loss of stream resources, enforcement and conservative management will not be enough to revive the stream's functions or bring it into statutory compliance. At this stage, significant restoration will have to be done to meet that goal. The Plan identifies restoration opportunities and sources of funding, and also provides demonstration projects as examples.

2 THE PLAN

2.1 ENFORCEMENT

*The Duck Creek Watershed Management Plan relies on **enforcement, management,** and **restoration** to be effective. General **recommendations are summarized on page 21.***

Many of Duck Creek's problems could have been prevented had existing ordinances been followed and watershed-based planning been done. Probably because of cost, watershed protection and enforcement have not been high priorities for CBJ. Regulations exist to protect natural resources that the community and region have determined to be important. Those regulations are based on the best available science and technology and are structured to provide public safety and not be an obstacle to development. Watershed education that includes discussions of regulations and ordinances could help the community better understand requirements for stream protection and help foster a sense of ownership and a demand for stricter enforcement. Planning is essential to good watershed management, and when used with enforcement can effectively prevent both land-use conflicts and resource impairment.

Statutory Framework

Since the 1970s, resource managers at all government levels have been directed by lawmakers, courts, and regulations to protect public watershed resources. That protection is accomplished in two ways: 1) direct enforcement of statutory environmental standards, and 2) a regulatory permit process based on whether proposed land-use activities comply with or mitigate for environmental standards. The standards for both means of watershed protection apply to public and private lands, and must meet the strictest provisions of Federal, State, and local statutes. Land and resource management agencies or private landowners may also manage land under their jurisdiction with stricter standards than those provided for by statute.

The primary Federal law regulating development activities in the Duck Creek watershed is the 1977 Federal Clean Water Act (CWA). The CWA stipulates maintenance of water quality and habitat standards to protect environmental health. As part of that Act, States must list impaired waterbodies, and must schedule reduction of impairments "to the greatest extent practicable." The CWA also requires restoration of impaired waters to achieve designated beneficial uses such as public health, groundwater recharge, and fish habitat. Regulatory provisions of the CWA are administered either by the U.S. Army Corps of Engineers or the U.S. Environmental Protection Agency (EPA), with comments on permit proposals required from the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS).

In Alaska, some State agencies have statutory authority to protect public health or resources through enforcement of State standards. There are enforceable State standards for water quality, water use, coastal land use, and fish and wildlife habitat protection. Water, fish, and wildlife are public resources in Alaska managed and regulated by State agencies including the Departments of Environmental Conservation (ADEC), Natural Resources (ADNR), and Fish and Game (ADFG). Land-use agencies within the State also affect water quality and habitat through their land-use practices and their management and maintenance of drainage systems. The ADEC, ADNR, ADFG, and Alaska Department of Transportation (ADOT) each control land-use activities on various categories of State land.

Local statues specify land management policies that protect property and maintain or enhance natural benefits provided by aquatic and riparian habitat. The CBJ manages and maintains most drainage corridors in the Borough, particularly those adjacent to City roads. Drainage is managed primarily to protect public and private property, although State and Federal water quality standards apply as well. That drainage eventually enters public waters in designated streams or marine areas where water quality and habitat capability are regulated by ordinances.

Juneau City and Borough Land Use Ordinance 87-49 states that all streams within the CBJ "shall be managed to protect natural vegetation, water quality, important fish or wildlife habitat, and natural water flow." Municipal regulations and regulatory jurisdictions provide several specific means of administering that ordinance and maintaining public access to stream resources.

- When land is sold into private ownership, the City must retain land within 200 feet of anadromous fish streams as a buffer.
- All streams in the CBJ are protected from disturbance of any kind within 25 feet and from construction within 50 feet of their "ordinary high water mark," regardless of adjacent land ownership.
- Restoration of natural resource values is required within the boundaries of many new development projects (regardless of the original cause of degradation).
- A General Federal CWA Permit allows the CBJ jurisdiction over dredge and fill permits in the lower value type "C" and "D" wetlands covered under the Juneau Wetlands Management Plan (JWMP).

Regulatory Framework

Federal, State, and local statutes each require reviews and regulatory permits for development plans that may affect public resources. Local permits are required for nearly all new development (e.g., grading, drainage, building, etc.). Federal or State permits are also required for any development that may impact water, air quality, soil, fish, game, habitat, wetlands, or tidelands. Designated agencies may issue or deny permits based on how development plans protect or mitigate for impacts on resources. The Alaska Division of Governmental Coordination in the Governor's Office oversees any State permitting process that involves any Federal agency or more than one State agency.

2.2 MANAGEMENT

Most of the impairment to Duck Creek is from urban runoff, pollutants dumped directly into the stream, and development that violates environmental standards. Control of these activities in the watershed is the necessary first step to halt abuses to Duck Creek and to begin the recovery process. Runoff is an evasive and difficult pollutant to control; however, many source control practices are available, and once runoff is concentrated into drainage ditches as stormwater it can be treated to improve quality by removing sediments, heavy metals, oils, and other pollutants before it enters the stream. Best Management Practices (BMPs) have been developed specifically for managing nearly any activity that may affect water quality or fish habitat. (See Section H of the Technical Supplement).

Best Management Practices

Best Management Practices are generally considered one of the best means of implementing measures to protect natural resources. BMPs for urban runoff can be generally defined as methods required to restrict delivery of pollutants from human activities to water resources and are an effective way to implement pollution control.

Most urban stormwater BMPs were developed to prevent impacts to the physical and biological integrity of surface and ground water. **BMPs can be either structural** (e.g., sediment basins, fencing, oil/water separators) **or managerial** (e.g., runoff routing, fertilizer management, snow management and removal practices).

To effectively reduce non-point source pollution, various types of BMPs must usually be combined. The process of selecting and using BMPs has three elements: 1) a comprehensive evaluation of the type of pollution present (or expected); 2) an understanding of the mechanisms of pollutant control; and, 3) consideration of the management goal. Site-specific factors such as climate, environmental conditions, and economics should also be considered so that BMPs are sized, placed, and coordinated where they will do the most good. Reliable performance, however, often depends most on the experience and commitment of BMP system designers and users. In practice, no single "best" BMP system to control a particular pollutant exists and sometimes several BMP systems must be coordinated for the best result. That is particularly true in urban areas where single pollutants rarely dominate and where pollutants vary considerably among source areas. Consequently, hundreds of BMPs have been designed and dozens of manuals written.

When developing BMP systems one thing should always be kept in mind: BMPs that provide source control of pollutants and pre-treatment of stormwater before it reaches receiving waters should always be considered superior to BMPs that employ existing wetlands to treat pollution. In practice, source controls to prevent the generation or release of pollutants from potential sources are almost always more effective and less costly than stormwater treatment. An example of a key BMP for the Duck Creek Watershed is the stream setback or "buffer zone." Although this 50 ft setback is considered less than the minimum requirement, it is perhaps the most important source control BMP for the protection of stream resources.

*BMPs that provide source control of pollutants and pre-treatment of stormwater **before** it reaches receiving waters should always be considered superior...*

The DCAG identified several broad categories of resources in the Duck Creek watershed to protect using BMPs: 1) water quality, 2) floodways, 3) habitat, and 4) aesthetics. Some categories have minimum statutory requirements to guide BMP goals. For example, land owners and managers must obtain permits for certain activities that may affect water quality, floodways, or aquatic habitat.

Property owners and land managers may also choose BMP goals that are more stringent than those required through regulation. For example, some owners in the Duck Creek watershed consider site-specific scenic or wildlife values important, which may lead them to adopt BMPs that protect or enhance those resources. Owners and managers also need to consider how their activities affect regional economics (e.g., tourism, fisheries) and "quality of life."

Clearly, many current land-use practices must change to make BMPs a standard for both development and land management. To be effective, BMPs must also be retrofitted to previous development, a requirement in local ordinances that is rarely enforced. A great deal of work also remains to assure that stormwater pollution control is cost-effective; that pollutant removal goals of the BMPs can be met; and that progress towards improving water quality can be measured.

The Duck Creek watershed provides an ideal "laboratory" for the design and use of BMPs for urban stormwater in Alaska. Its small size, variety of impacts, and coalition of citizen and agency support provide many opportunities for evaluation of BMP measures for use in other urban watersheds.

Recommended Policies and Actions

In addition to BMPs, certain policies and actions must also be taken by the community in order to begin watershed recovery. Stormwater quality regulations, drainage and flood control, wetland development, and riparian protection are key areas where watershed resource management may conflict with urban development. Those issues are complicated by Juneau's limited land base, where managers must consider watershed management policies that protect the watershed while minimizing adverse effects on the existing inventory of residential, commercial, and industrial land.

Drainage and Flood Control

Drainage and flood control are of great concern to residents of low-lying areas in the Duck Creek watershed. Most want runoff to drain away as rapidly as possible. Land managers, however, must balance those concerns with uses of that water for other watershed resources, such as water quality and fish and wildlife habitat. Replacement of inadequate culverts will alleviate many flood risks and reduce insurance premiums.

Stormwater Quality

Stormwater management is the key to bringing Duck Creek into statutory compliance with water quality and habitat standards. The scientific evaluations done to provide a baseline for this Plan have identified shortfalls in stormwater management in the Duck Creek basin. Generally, current plans call for extensive use of underground storm drainage and high maintenance treatment structures such as oil/water separators and sediment traps. These should be replaced or augmented by lower maintenance treatments such as vegetated surface channels and stormwater treatment areas.

Wetland Management

Currently the wetland development process involves a sequence of avoiding wetland impacts wherever possible, or on-site mitigation for impacts to wetland values when complete avoidance is impossible. Developers, agencies, conservation groups, and the general public are often frustrated by the complex and sometimes political nature of the decision making required by that process. That frustration has sometimes led to resource losses and costly litigation. Developing freshwater marshes in some of the old dredge ponds will help improve water quality, as will creation of pocket wetlands and stormwater detention wetlands throughout the watershed.

Riparian wetlands are particularly important for protecting channel morphology and determine the distribution of anadromous fish habitat. Riparian areas also provide storage of surface water, moderate ground-water discharge, dissipate flooding, and provide nutrient cycling and removal of pollutants. In urban settings like Duck Creek, riparian vegetation buffers the effects of development on all waterbodies. Research shows that the width of a riparian buffer should be at least 100 feet on each bank (Murphy and Koski 1989, Johnson and Ryba 1992).

The habitat standard in the CBJ Code for the protection of riparian habitats falls far short of that minimum and needs to be modified. In three places the CBJ Code refers to regulation of stream habitats: in the 1) Juneau Comprehensive Management Plan (JCMP) enforceable policies, 2) the Juneau Wetlands Management Plan (JWMP) enforceable policies, and, 3) the old "sensitive areas" portion of the Code. Each of three sections of CBJ code has regulatory language to protect stream riparian areas and anadromous habitats but they conflict in their regulatory affect on the riparian zone.

Thus, one of the first steps in the Plan to protect Duck Creek and other streams in Juneau is to ensure that Proposed Code Modifications to the Habitat Standard (prepared on December 16, 1997) are adopted and enforced. Adopting those modifications will extend habitat protection to all cataloged salmon streams, clarify the measurements of the 50 foot setback, and clarify allowable activities within the setback. The 50 ft setback must be adhered to in currently developed areas, otherwise, problems will continue on our streams. In new developments, setbacks should be extended to a minimum of 100 ft.

Conservation Ethic

To make the Plan work, the DCAG, the Mendenhall Watershed Partnership, and enforcement personnel must continue work to develop a personal conservation ethic that addresses everyone's daily activities in how they treat water use, runoff from yards and parking lots, potential pollutants, streamside vegetation, instream habitat, and fish and wildlife. Developing a sense of ownership and community pride can help the restoration process and prevent future "Duck Creeks" elsewhere.

When sites are being developed for any purpose, a conservation ethic needs to be considered and applied. The Center for Watershed Protection (1998) has developed a set of 22 model principles for improving development and conservation through better site design. These principles are classified into three human habitat types (for automobiles, for living and working, and for undeveloped open areas) and give specific guidance for better site design. (See Technical Supplement, Section H).

Through the DCAG and Mendenhall Watershed Partnership (MWP), the public can help develop strategies to protect or restore Duck Creek and other Mendenhall Valley streams. Although this Plan provides technical background on the problems and strategies to solve them, the community needs to decide the relative importance of issues such as free-flowing streams with salmon and trout, health concerns, and flood risks.

2.3 RESTORATION

Statutory environmental standards and the substantial loss of aquatic resources in the watershed will require not only that CBJ development policies be changed and BMPs applied, but also that significant restoration be done to bring the watershed into compliance with statutory and community needs. The process of restoring the watershed, however, can and should be used to achieve community objectives beyond compliance with environmental standards, including better flood control, watershed resource enhancement, water quality improvement, wetland management (e.g., mitigation banking), and educational and recreational programs. Timing of the various restoration activities is critical because the expected benefits may be dependent on having specific functions restored in sequence.

Water Quality

The DCAG recommends that the community implement the following types of projects in the Duck Creek watershed to accomplish multiple community goals and help restore water quality: 1) create stormwater treatment wetlands; 2) develop riparian greenbelts; and 3) reduce dissolved iron levels in the stream.

Stormwater Wetlands

Wetlands that function as stormwater treatment systems are already being created on a significant scale at several sites in the Duck Creek watershed and have excellent expansion potential. Nearly 15 acres of potential stormwater wetlands have been identified and nearly 3 acres have already been developed (see Sections D and G of the Technical Supplement for additional details). Those wetlands are generally old dredge pits that have little functional value as wetlands in their present state and in some cases are actually sources of pollution (e.g., high iron, low oxygen groundwater). All of the wetlands developed or being considered are listed in the Juneau Wetlands Management Plan (CBJ 1997) as having potential for restoration or enhancement (EP Category) and for use in mitigation banking. If restored, those wetlands could function as centrally located treatment sites for urban runoff (Phillips et al. 1993, Horner et al. 1994,) while also eliminating minerals from groundwater discharge and providing habitat for waterfowl, fish, and small mammals (Polasek et al. 1995).

To help restore Duck Creek water quality:
- *create stormwater treatment wetlands*
- *develop riparian greenbelts*
- *reduce dissolved iron*

Riparian Greenbelt Development

Significant water pollution could be avoided or minimized by providing adequate setbacks from streets, homes, and businesses. Nearly 45 acres of riparian wetlands have been identified in the watershed where stream channels could be moved away from pollution sources, and functional riparian and fluvial (stream) wetlands could be restored. (See Section E of the Technical Supplement). Establishment of a mitigation bank or placement in conservation easements that would allow appropriate restoration could provide significant filtration of stormwater and highway runoff.

Reducing Dissolved Iron

A major factor limiting biological productivity as well as the aesthetics of Duck Creek is the high concentration of dissolved iron in the stream water. The levels of dissolved iron must be reduced to begin restoration of water quality and fish habitat.

The primary source of the dissolved iron is groundwater that enters Duck Creek in various areas (see Section 3.2 and the Technical Supplement, Section F). Those areas can be identified by red staining and floc in the stream channel, tributary ditches, and many of the ponds. Some form of treatment is needed where iron concentrations are highest. Potential methods for reducing dissolved iron include:

- ***Cap source areas with organic fill*** :
    a. Stream - Place fill to precipitate or bind iron in seep areas along the mainstem upstream of Taku Blvd. and in the mainstem downstream of Berners Avenue.
    b. Ponds - Fill with earth and top with organic material to a level above the groundwater inflow depth and establish vegetation. Reaction of iron and oxygen at the plant roots will precipitate iron oxide in the substrate rather than enter the water column. Several ponds on the East Fork and the main channel (e.g. Duran Street Pond and McGinnis Pond) would be candidates for this treatment. (Section F of the Technical Supplement).
- ***Plant riparian/aquatic plants*** *capable of oxidizing iron at their root/soil interface in known areas of iron concentrations.*
- ***Aerate the water*** *mechanically at the sources of dissolved iron or construct a gallery of aeration pipes.*
- ***Increase the volume of flow*** *to dilute the dissolved iron and flush the floc.*

Fish Habitat

Habitat is affected by nearly all the problems on Duck Creek that affect water quality and thus can often be dealt with simultaneously with other restoration activities. Urbanization has caused widespread detrimental changes to the physio-chemical condition of the stream and its salmon habitat including: seasonal loss of stream flow, impaired water quality, loss of riparian zone functions, and fish passage. The interactive, cumulative impacts of those changes make it difficult to say which has been or is the most damaging. Restoration of fish habitat must address the changes that have most directly impacted the habitat, including:

- changes in hydraulic functions of the channel and fish passage at stream crossings;
- changes in substrate composition due to sedimentation from winter road sanding and from construction;
- sterile (anoxic) conditions due to high levels of dissolved iron and low levels of dissolved oxygen in exposed groundwater;
- fish mortality (Fig. 4 and 5) from chronic lack of stream flow due to subsurface flow and changes in runoff routing; and,
- loss of riparian vegetation cover (woody debris and overhanging vegetation) that provided structure for the stream channel and temperature moderation.

Because Duck Creek flows into the Mendenhall Wetlands and Fritz Cove, there must also be concern over the effects of pollutants and fluctuating freshwater discharge on the health of marine invertebrates and fish downstream. Eulachon, sandlance, capelin, herring, salmon, and Dungeness crab are a few of the important species that utilize those areas for rearing or spawning.

Stream Hydrology

Restoration of the stream hydrology will involve much of the drainage infrastructure in the Mendenhall Valley. Changing the drainage in one area, for example, will have downstream consequences and in some cases upstream consequences. In a groundwater-dominated system like Duck Creek, excavation must also be carefully considered. All recommendations to lower or divert the stream channel must be evaluated in relationship to the problems of iron and loss of flow.

Flooding. Several improvements to reduce flooding were recommended by R&M Engineering (1996) in a drainage plan developed for the CBJ. In general, those improvements could also improve fish passage during low flow, but would not necessarily restore flow to stream sections that chronically go dry. The DCAG recommendations for improving existing stream crossings for "habitat" (page 11) will also reduce flooding risks.

Figure 4 (above).--dead salmon and Dolly Varden stranded by the lack of flow. (Photo by Kevin Brownlee, ADFG).

Figure 5 (left).--Lack of flow at perched culvert. (Photo by NMFS).

Stream Flow. Increased stream flow would improve water quality and enhance biological productivity. Continuous flow to facilitate downstream smolt migration can probably be restored to many sections of Duck Creek. Key considerations include length of stream reach, which methodology to use, and cost. Several approaches have been considered to help restore a continuous minimum flow. (For more details, see Section 3.2 and the Technical Supplement, Section J).

Add water. Adding water could keep the stream flowing during critical periods. That would likely require adding up to 5 cfs to the channel at times when the stream flow dropped below 4 cfs (which occurs 75% of the year). Approximately 3 cfs of this would probably be lost to groundwater, and groundwater levels would be maintained at higher than current levels in some areas. Several options for adding flow to the Duck Creek channel were explained in a preliminary feasibility study conducted by the Natural Resource Conservation Service (Cobb 1997).

- Siphon water from the Dredge Lakes area of the National Forest and direct it under Back Loop Road through the existing culvert near Conifer Street and into the mainstem through a culvert under Taku Boulevard. That option has the advantage of adding water at the uppermost point. Construction cost was estimated at $130,000; maintenance cost would be low.
- Draw water from the base of Thunder Mountain, either from existing wells or diversions designed for that purpose. Place the water as far upstream as possible (the El Camino Fork is the most logical route). The preliminary cost estimate was $95,000, however maintenance cost would likely be high.

- Reconstruct a pipe to carry water from Nugget Creek, either to the Dredge Lakes system then into Duck Creek, or directly into the mainstem, using existing culverts under main roads. That option provides the most reliable source of water, but is also the most expensive to construct. The old AJ diversion dam and tunnel upstream of Nugget Falls would have to be reconstructed to divert the water into a buried pipeline. The cost was estimated at $363,000.

Line the channel. Lining the channel to reduce its permeability and width could minimize loss of surface water in problem areas. Approximately 7,000 feet of channel dried up in March of 1998. Areas of the stream that are very low gradient and on the most permeable floodplain soils are most likely to lose surface flow to groundwater. The design of the channel should provide for two main uses--fish habitat and storm runoff conveyance. Fish migration and overwintering habitat require a minimum of 9 inches in depth in the riffle sections. For example, a 2 cfs flow (equal to flow at Nancy Street most of the year) that would provide for fish passage and rearing could be maintained in a low flow channel approximately 2 feet wide. A 15-18 ft.-wide floodplain would provide for stormwater runoff.

Line the channel and add water. Perhaps the best approach to restoring minimum stream flow is a combination of channel modification and streamflow augmentation. By selectively lining areas of the channel, much less flow augmentation would be required.

Stream Crossings

Restoration of aquatic habitat and channel morphology will require improved culvert sizing and placement, as well as restoration of flow. A number of options for improving culverts for fish passage and improving flood flows are available. Choices must be made thoughtfully, however, because a change in the elevation of one culvert may limit the possible elevations of adjacent culverts; If some large culverts are too expensive to replace, it may not be effective to change other culverts. (Additional details and cost estimates are discussed in Section 3.2).

***Needed improvements*:**

- Unused driveway crossings in the Glacier View Mobile Home Park and in Kodzoff Acres should be removed to improve channel gradient. The culvert under the end of Radcliff Road, at the end of the airport runway, is also not needed by vehicular traffic and could be replaced by a pedestrian bridge.
- All culverts from Egan downstream to Berners Avenue need to be replaced. This involves making improvements to the private driveways between Berners and Old Glacier Highway, and improving or removing the Del Rae crossing. Egan Way culverts should be replaced, but until adequate financing is available, grade control structures downstream of Glacier Highway and Egan Way could improve fish passage through those culverts at low flow. The option may exist to lower the channel grade several feet from Egan Way downstream to the river, however, the elevation may be limited by sewer lines under the existing channel.

  Lowering the channel elevation between Berners and Egan Way must be designed with understanding of the risk of intercepting water with high iron content. This may result in its associated increase in iron floc in the substrate. Improvement of culverts in this area was the second highest priority in the 1983 Mendenhall Valley Drainage Study (EMPS 1983).
- The stream crossing on Mendenhall Blvd. needs improvement where four 18 inch culverts currently restrict the stream flow and cause high velocities.
- R & M Engineering (1996) recommended to CBJ a number of improvements to the Mendenhall Valley drainage system, including those listed above. That study also recommended replacement of the crossing at Aspen Street, because it is undersized, resulting in upstream flooding. A larger culvert would improve fish passage.

3 PROJECTS

3.1 DEMONSTRATION PROJECTS

Some restoration projects that were needed--and that could be done in conjunction with ongoing work to save time and money--were implemented before this Plan was finished (Fig. 6). Construction projects, CBJ maintenance programs, and homeowner projects provided these "early windows of opportunity" to improve Duck Creek. Restoration objectives were incorporated into plans for these projects so that both the stream and the project benefitted and realized cost-savings. These projects will serve as demonstrations to evaluate methods and provide guidance for future restoration. The creation of a freshwater marsh on Duck Creek, for example, demonstrated to the community not only the benefits of restoration but also the value of partnerships in implementing costly restoration projects. Brief accounts of the demonstration projects follow.

Stream Crossings

During the past 5 years, improvements were made on the following stream crossings:

- Kiowa Drive and south El Camino crossings of the El Camino Fork of Duck Creek were replaced with pipe arch culverts with concrete floors covered with gravel and the grade was lowered about 1 ft (structural concrete floors had to be used due to underlying sewer pipes);
- A 17-ft wide bottomless pipe arch was installed at Stephen Richards Boulevard (Fig. 7 and 8);
- The El Camino Fork crossing of Mendenhall Loop Road was enlarged and grade was lowered approximately 1 ft;
- Culverts on two private driveways downstream of Nancy Street were replaced with wooden bridges (Fig. 9).

The following crossings are currently being worked on or are in planning stages for improvement:

- Replace Cessna Drive culvert and sewer pipe near the airport fuel tank farm with a 17-ft arch and fish trap;
- Design investigations for replacing the McGinnis Street Crossing;
- Design investigations for replacing the Del Rae Street Crossing.

Snow Management

An experimental "snow fence" designed to limit plowing of snow and road sand into Duck Creek was installed on the Nancy Street Crossing, but has not yet been evaluated for effectiveness. Similar fences are proposed for other areas, particularly along Mendenhall Loop Road, but right-of-way permits have been denied by the Alaska Department of Transportation.

Revegetation

A number of revegetation projects have been completed with the help of Southeast Alaska Guidance Association (SAGA). SAGA serves as a key partner in acquiring and planting willow stakes and marsh vegetation, and seeding areas with grass. Those efforts have included streambank revegetation and channel modification at Stephen Richards Drive and Nancy Street crossing replacement sites, revegetation of a CBJ constructed ditch near St. Brendan's Episcopal Church, and revegetation of the riparian zone at Taku Blvd., the site of the pilot study described below.

Sediment Removal and Channel Reconfiguration

A pilot study was conducted to determine the feasibility of restoring salmon spawning habitat by reconfiguring the stream channel, removing fine sediment, and increasing dissolved oxygen levels. The site was a 500-meter reach in the upper watershed between Mendenhall Boulevard and Taku Street. The reach was entirely

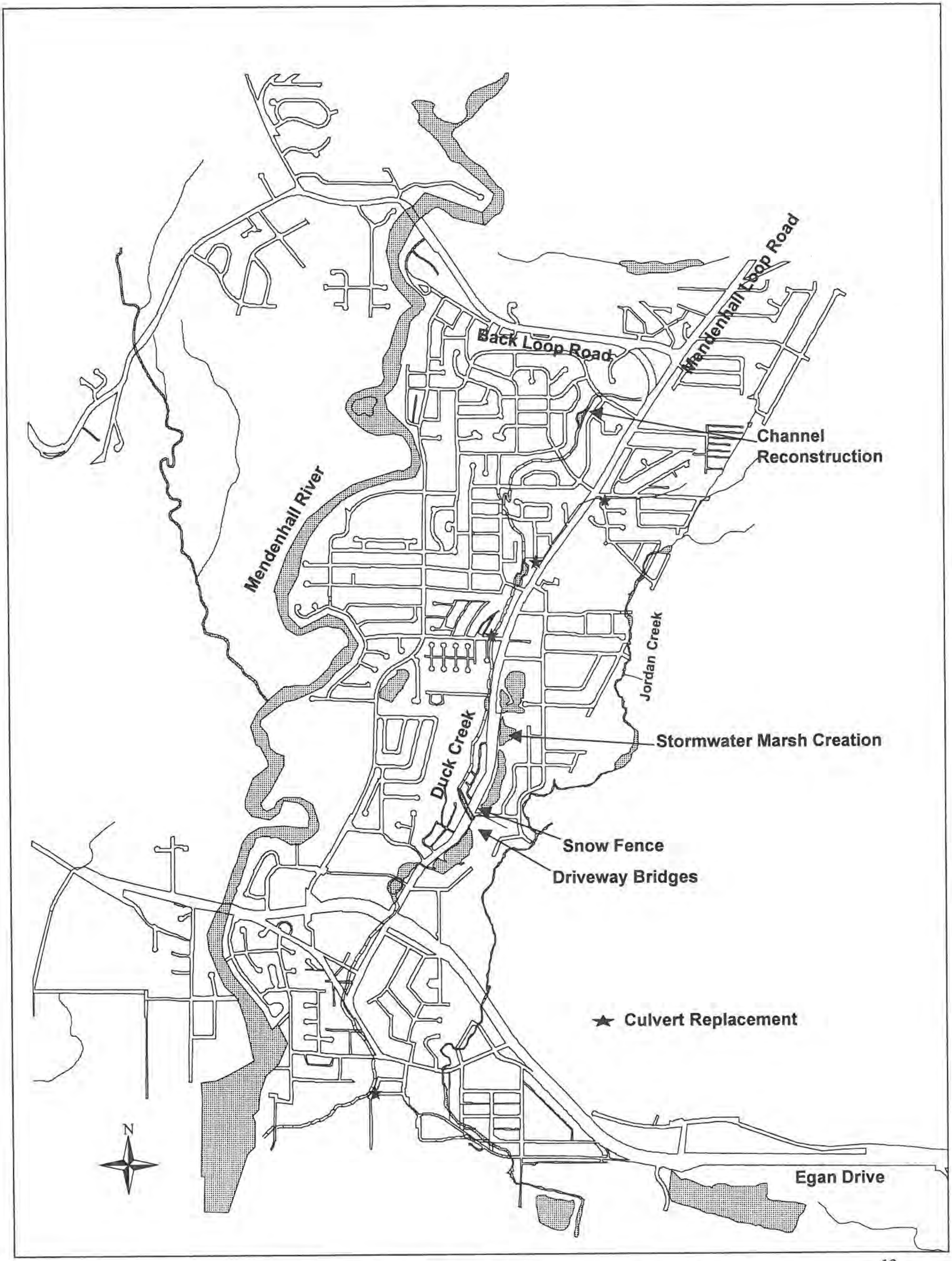


Figure 6.--Map of Duck Creek demonstration project sites.

within the CBJ's Duck Creek Greenbelt and did not involve any private property. Prior disturbances to the stream had removed most of the woody debris that provides natural structural diversity and the stream channel widened, became shallow, and had little turbulence. Some coho salmon spawn in this reach and it contains potentially the best spawning habitat remaining in the stream. Suction dredges (Fig.10) were used to remove fine inorganic and organic sediment from the streambed, the channel was constricted, and rock and wood structures were used to facilitate interchange between surface and intragravel water.

Wetland Creation

A stormwater treatment marsh (i.e., wetland) was created from a 2-acre borrow pit near the Church of the Nazarene on the East Fork of Duck Creek (Fig. 11 and 12). The purpose of creating the wetland was to improve water quality and fish habitat using aquatic plants to filter the heavy load of suspended sediment and iron floc that exist in the pond and main channel downstream. In addition, the fill material used to create the wetland also served as a cap over the source of iron-rich groundwater coming into the pond.

The project serves as a model for what can be accomplished through community-based partnerships. The project was developed as part of a CBJ plan to install a stormwater drainage system in a subdivision near the East Fork of Duck Creek. The stormwater project was to generate about 20,000 cubic yards of fill material that would require disposal. A nearby dredge pond excavated in the1940-50s to build roads had become a source of poor water quality and contributed to high mortality of over-wintering coho salmon, and was selected as a restoration site by DCAG. A cooperative partnership was developed between CBJ, Arete Construction, Howell Construction, the Church of the Nazarene, and NMFS to use fill material from the storm drain project to convert this dredge pond into a wetland. Besides being more aesthetically pleasing and improving habitat for rearing salmon and waterfowl, the wetland reduced the risk of children falling in the deep, steep-banked dredge pond. The site was filled in April 1998. Native plants obtained from Duck Creek and the Dredge Lake area were then planted by volunteers from SAGA Youth Corps.

A similar wetland was created in the summer of 1998 at the Floyd Dryden Middle School where a pond on a tributary to Duck Creek was considered a safety risk to children. A wetland designed to serve as an outdoor education facility, in addition to improving water quality and providing wildlife habitat, was created with donated materials and services.

Figure 7.--Perched culverts being replaced with an arch culvert at Stephen-Richards Drive. (Photo by Jan Caulfield, CBJ).

Figure 8.--Water flowing through new arch at Stephen-Richards Drive. (Photo by NMFS).

Figure 9.--Timber bridge used to replace a perched culvert on a private driveway. (Photo by NMFS).

Figure 10.--An Americorps crew using dredging equipment to remove fine sediment from a salmon spawning area in Duck Creek. (Photo by NMFS).

Figure 11.--Development of a stormwater treatment marsh in a dredge pond on the east fork of Duck Creek. (Photo by NMFS).

Figure 12.--The dredge pond that was developed into a stormwater treatment marsh. (Photo by NMFS).

3.2 FUTURE PROJECTS

Many of the projects discussed in Section 2.3 are also listed here as future projects because of the pending plan with the Army Corps of Engineers (COE). NMFS and DCAG have worked with the COE to develop a funding plan for priority restoration projects on Duck Creek. Preliminary cost estimates for the following eight projects total about $3,700,000. The COE's 206 Program (administered under the CWA) is expected to fund most of the costs, but the CBJ community share will be about 35%. The CBJ expenses can be in-kind-services and/or projects already planned to improve water quality or habitat on Duck Creek. The success of this partnership with the COE could lead to additional restoration projects on other streams in the Valley such as Jordan Creek or the Mendenhall River. The COE will review the restoration options and provide engineering designs for the preferred methods. Public support of the COE proposal and CBJ involvement will help ensure that restoration needs in the Mendenhall Valley can be met.

Control of Dissolved Iron

This problem is a major factor in limiting productivity of the stream ecosystem--it is important to control levels of dissolved iron. Several alternative approaches (see details on page 9) are being evaluated: 1) cap sources of iron with organic fill; 2) plant aquatic and /or riparian plants; 3) aerate the water mechanically at the source; or 4) construct a gallery of aeration pipes in the streambed and flood plain upstream of Taku Blvd. to precipitate the iron and trap it below the surface; or 5) increase stream flow.

Alternative 3, mechanically aerating the water, is the preferred alternative because it is a proven method, requires the least maintenance, and is easiest to install and operate. The project would require the construction of a small building to house equipment, and plumbing to critical reach(s) of the stream. Estimated cost is about $40,000. The CBJ would operate and maintain the facility. Apparently, a similar effort to reduce iron was previously made in the Mendenhaven subdivision (Ron Hansen, personal communication).

Alternatives 1, 2, and 4 would require the placement of large amounts of fill material spread within the stream corridor. Alternative 2 would require gathering and planting aquatic and riparian vegetation which can be difficult and requires an unknown balance between the amount of plants and the dissolved oxygen output.

Streamflow Restoration

Ditching, groundwater pumping, channel diversions, etc. have reduced stream flow in Duck Creek as well as in Jordan Creek. The highly permeable streambed in the lower Duck Creek also permits the stream to lose surface flow during low precipitation. Several alternatives for augmenting flow have been suggested (Beilharz 1998).

Nugget Creek. Reconstruct an existing dam, tunnel, and pipeline to convey Nugget Creek water to Dredge Lakes for distribution into Duck Creek and possibly Jordan Creek. New connecting ditches or pipelines would be required to convey water through existing right-of-ways to these streams. A preliminary plan and cost estimate for this project was completed in 1997 by NRCS.

Dredge Lakes. Transport water from these Lakes in the National Forest by siphoning water out of Dredge Lakes through a pipe and directing it through a culvert under back loop road to an existing stream channel of Duck Creek.

Thunder Mountain. Utilize groundwater sources from the east edge of Thunder Mountain by using existing wells or diversions and route the water to Duck Creek via the El Camino fork.

Groundwater Pumping. Several springs adjacent to Duck Creek or former stream channels filled by development activities (e.g., Taku St., Aspen St.) could possibly be tapped by wells or infiltration galleries to access subsurface water to be pumped into Duck Creek.

Jordan Creek. The Draft Airport Plan suggests diverting Jordan Creek into Duck Creek somewhere in the Nancy Street area. If that idea were to be accepted, drainage structures and channel dimensions downstream of the diversion would have to be reconstructed to prevent flooding.

The Nugget Creek alternative is preferred at this time, as it will provide the most reliable water source. Water from Nugget Creek was historically diverted for hydropower and a diversion dam already exists. That dam would be refitted to divert water from the stream into pipes to Dredge Lake. Water would then be siphoned from Dredge Lake to Duck Creek. Approximately 14,000 feet of 12-inch diameter pipe would be required. Inlet and outlet structures will be required on both segments of the pipeline. Estimated flow in the proposed system is approximately 2 ft^3/sec. This is the most costly alternative, estimated at $363,000.

The Dredge Lake alternative would require only 3,600 feet of pipeline to deliver water to Duck Creek. However, no studies have been done to determine the effect on Dredge Lake and surrounding groundwater levels if between 2 and 5 ft^3/sec were siphoned into Duck Creek. If Dredge Lake is able to supply sufficient water without detrimental effects to the lake and surrounding groundwater table, this alternative would be preferred because of the reduced cost. The estimated cost to supply 2 ft^3/sec of water from Dredge Lake is $94,500.

The Jordan Creek alternative depends on a surplus of stream flow from Jordan Creek. Jordan Creek provides habitat for fish and wildlife resources and continuous flow is required to maintain these resources. There may not be sufficient water to accommodate both streams. Although the cost for this alternative is estimated at $95,300, the lack of a dependable water supply probably excludes this alternative.

The Thunder Mountain alternative would tap a groundwater source, and it is not known what volume of water could be supplied or what effect lowering the groundwater table will have on the surrounding area, including Jordan Creek. If, during the next phase of this study, information is gathered to indicate enough water and no adverse effects, this alternative will be considered.

Stream Crossings

Improper sizing and installation of culverts has created major problems on Duck Creek. The damming affect created at each crossing has seriously degraded the stream channel and the stream no longer properly flushes sediments or passes water efficiently. The recommended approach has been to replace culverts with bottomless structures (e.g., bridges or arch culverts) as opportunities arise. The cost of installing bottomless crossings has been 15-20% higher than design estimates for culvert crossings. The cost of a 17-ft wide arch at Stephen Richards Drive was about $65,000 in 1995 and two attractive wood bridges on floating concrete piers were installed in 1998 at $25,000 each. At a minimum, ten other stream crossings need replacement or improvement so that other restoration work (on fish habitat, streamflow augmentation, and channel morphology) can proceed.

The estimated cost of replacing those 10 critical stream crossings is $317,000 ($250,000 for bridges and $67,000 for an arch culvert). The use of bridges has been stressed because they seem much more cost effective than arch culverts for the load ratings required for private crossings. Bridges cost less to install and maintain because much less instream work or water diversion is needed. Bridges are made of locally available materials (unlike culverts) and their design life and long-term maintenance needs are comparable to culverts. The most critical stream crossing work includes:

- Remove unused driveway crossings (Glacier View Mobile Home Park and Kodzoff Acres);
- Replace culvert crossings at Berners Avenue, Mendenhall Plaza Road, Valley Paint Road, FAA Road, Glacier Highway, Del Rae, Egan Expressway, Aspen Drive, and Mendenhall Boulevard.

Wetland Creation

Because of the extensive loss of wetlands in the Duck Creek watershed, new wetlands need to be created as natural filters for dissolved iron and sediment, and to attenuate stream flow. A recent demonstration project created a wetland from a dredge pond near the Juneau Church of the Nazarene. The wetland was created through a partnership and most of the materials and services were contributed by the partners. The cost of creating the 2 acre wetland was estimated at about $110,000/acre. That cost per acre is relatively high when compared to other wetland creation projects because of the quantity of fill needed per surface acre. A combined area of about 12 acres is available for similar wetland creation to continue improving water quality in Duck Creek. Permits have been issued for 7 acres on the Nancy Street pond and hopefully a partnership can be developed to complete that segment. The COE plan allots $550,000 for the remaining acreage of wetland creation. There is also need to create wetlands in several smaller "residential" ponds along Duck Creek to enhance fish habitat as well as improve water quality.

Streambed Lining/Sealing

Several reaches of stream "dry up" during the salmon smolt migration each year, killing on average 25% of the downstream migrant salmon smolt. "Drying up" occurs in very permeable reaches which allow the surface water to flow directly into the ground. The permeable conditions may be attributed to an old residual glacial outwash channel, but are probably due to physical alteration of the streambed. Restoration options include lining the streambed with an impervious geotextile or synthetic rubber material (e.g., Sweetwater Heavy Duty Liners), or pumping (clay) bentonite into the substrate to reduce porosity. Up to 7000 ft of channel can be dry at any one time, however, it may be feasible to restore stream flow by treating areas where the problem is most acute. The COE estimated it would cost about $11,200 to cover about 2,000 lineal or 20,000 ft^2 of streambed with a synthetic material ($0.56/$ft^2$ for materials and labor). A USFS engineer is currently preparing a plan and cost estimate for fixing the channel to convey water through known problem areas.

Fine Sediment Removal

Large amounts of fine sediment in the streambed and low dissolved oxygen concentrations are the result of riparian zone encroachment, highway maintenance practices, pollution, and exposure of groundwater containing dissolved iron. Given the size of substrate and poor channel morphology in much of the stream, simply changing culvert elevations will not provide enough water velocity to transport sediments and regrade the channel. However, by removing culverts and reconstructing the stream channel in selected reaches, adequate water velocity could be developed to keep stream gravels in those areas relatively free of fine sediment. Cleaning the stream gravels (as demonstrated by the pilot study at Taku Boulevard) in conjunction with new stream crossings and reducing dissolved iron would restore spawning habitat for coho salmon and cutthroat trout.

The pilot study used jet pumps and suction dredges to remove fine organic and inorganic sediment from the streambed. Dredged material was sorted and gravel (> 1/4 inch) was screened and returned to the streambed, whereas finer sediment was placed in sand bags for use in constructing new streambanks and constricting channel width. Americorps Volunteers provided much of the labor for the dredging and channel improvement study. About 5000 feet of additional stream channel in Duck Creek needs cleaning, at an estimated cost of $28,000.

Suction dredging and side casting excess material along the banks of the stream is the least costly alternative. A small 4 inch dredge can be floated down the stream, requiring only one entry/exit site. Mechanical dredging would require the equipment to be walked down the middle of the stream, which could cause problems with bank stability, streamside vegetation, and access through the deeper pools. Since fine sediment is to be removed, a grizzly would be used to sort the material, and gravel (> 1/4 inch) would be returned to the streambed. With minor modification to the impeller, the suction dredge can be used to pick up only the fine sediment. Other methods of sediment removal include flushing; however, there is currently no sufficient source of water to accomplish this task. An additional option to consider involves adding washed gravel to reaches with inadequate gravel supplies.

Riparian Zone Revegetation

Loss of riparian vegetation has contributed significantly to Duck Creek degradation. Encroachment of residences, businesses, and roads has left little or no buffer between development and the stream. Most vegetation adjacent to highways has been removed, contributing to high sedimentation rates from winter road sanding. Loss of streamside vegetation has impaired fish habitat and degraded water quality by accelerating streambank erosion, loss of streamside trees, and removing sources of woody debris. Revegetation options include:

- Acquire/establish additional greenbelt areas along stream;
- Thin dense stands of vegetation in existing greenbelts to promote growth of larger trees;
- Plant vegetation along reaches exposed to road sanding and plowing;
- Construct snow fences to protect vegetation; and
- Place woody debris (e.g., tree boles, root wads) in selected stream reaches for instream habitat.

The estimated cost for revegetating riparian habitat is about $1,100.00/acre for clearing and grubbing. The cost for installing willow live stakes is about $4.00/each, coir logs at $14.00/ft, vegetative mat at $10.00/ft^2, and $1000.00 for installation of a root wad.

Public Access and Education

"What we have failed to realize is that what we are doing to our water resources, we are doing to ourselves and to our children."

Herbst, 1992

The DCAG advocates the construction of a "pilot" trail system in the CBJ greenbelt between Taku Blvd. and Aspen Avenue. Since most area sidewalks run east and west, the proposed trail would provide a safer corridor for north-south pedestrian access through subdivisions. The trail also would be relatively easy to construct in the greenbelt, connect dedicated "pocket parks," provide better access for demonstration use of the restored stream channel, and be used to evaluate the pros and cons of a more extensive trail system. By eventually linking Duck Creek trails with other trail systems, a safe and enjoyable pedestrian corridor through much of the central Mendenhall Valley residential area could be created. Although trail plans for Duck Creek "greenbelts" have met with some resistance from adjacent landowners, the Duck Creek Advisory Group advocates making these public lands more accessible. Concerns over vandalism and habitat damage can be mitigated by proper construction and maintenance, and by education. Construction of vehicle barriers and the consistent presence of pedestrians may also deter the chronic illegal dumping of litter and waste that occurs in that greenbelt.

SUMMARY

Table 1.--Summary of recommended policies and actions needed to implement the Duck Creek Watershed Management Plan.

Enforcement

- Enforce existing ordinances that protect watershed functions - Local, State, and Federal
- Enforce policies supporting land-use activity and BMPs that protect watershed functions
- Inform, educate, and develop a community conservation ethic to limit the need for enforcement

Management

- Develop more local expertise on integrating watershed protection BMPs into local situations
- Establish partnerships to produce broadly beneficial solutions to watershed issues
- Explore alternative means of wetland management (e.g., mitigation banking, conservation easements)
- Adopt BMPs based on functional standards (e.g, vegetated surface treatment areas are more efficient and less costly to maintain that structural sediment and oil/water separators)
- Implement proactive management policies for developing issues (e.g., stormwater treatment)
- Decrease pollution from management activities (e.g., snow management, transportation, utilities)
- Maintain specific drainage boundaries and protect stream flow
- Develop construction standards that limit water quality problems from low dissolved oxygen and iron pollution through less exposure of groundwater
- Use standards for stream crossings that provide for channel maintenance and fish passage, rather than simply flow routing
- Provide incentives for development that minimizes land-use (e.g., cluster development, infilling, redevelopment)
- Require new development to integrate stormwater management into construction
- Develop policies and incentives to reduce traffic and parking demands
- Limit use of garden chemicals
- Require runoff from impervious areas (e.g., roofs, roads) and disturbed soils to be routed to treatment areas
- Utilize landscaping areas (lawns, flower beds, medians, etc.) as stormwater treatment areas
- Manage riparian areas to benefit water quality, fish habitat, flood attenuation, and aesthetics
- Consider aesthetics in management and development

Table 1. (continued)

RESTORATION

- Create wetlands in borrow pits to function as stormwater treatment systems
- Develop adequate riparian setbacks along stream channels and untreated drainages to filter pollutants before they reach regulated waters
- Reduce levels of dissolved iron from discharging groundwater by capping such areas with organic fill, planting with riparian/aquatic plants, mechanically aerating water at the source, or increasing flow volume to dilute and mobilize iron floc
- Augment flow in the mainstem of Duck Creek
- Line sections of the stream channel that go dry with impervious material
- Replace stream crossings that are poorly designed for flood capacity or fish passage
- Fence areas or develop riparian buffers where snow is customarily plowed into stream channels or untreated drainage areas
- Restore channel form and substrate in salmon spawning areas

Photos opposite page: Duck Creek has a history of a wide variety of problems, including loss of flow, sedimentation, garbage, iron floc, and declining aquatic resources.

II

BACKGROUND

TWO CENTURIES ON DUCK CREEK

Richard Carstensen 1997 *Discovery Foundation* for ALASKA WATER WATCH

1750

Mendenhall Glacier reached its farthest downvalley position of the last 13,000 years. Duck and Jordan Creeks were strong rivers gushing from the ice face, building up the valley floor with new sediment. The Mendenhall floodplain probably resembled today's Chilkat Valley, with flood-tolerant cottonwood forests and occasional young spruce patches on slightly higher ground. Land was 5 to 10 feet lower than today, and probably not yet rising appreciably. The future Mendenhall Mall site was right on the beach. The Auk people called this place *ta.cuwe*.

1910

The newly-formed Mendenhall River was now the only glacial channel. Part of its load settled in the emerging Mendenhall Lake, so the river cut downward and eventually could no longer overflow onto its abandoned floodplain. Duck and Jordan Creeks flowed clear, fed only by groundwater and storm runoff. On lower Duck Creek century-old spruces replaced cottonwoods on the now inactive floodplain. Land was rising, probably at close to the modern rate of ~0.6"/yr. At the stream mouth, meadows of tall herbs covered former tidal marsh with hundreds of acres of prime wildlife habitat (increasingly shared with cows).

1962

Although the upper valley was still largely undeveloped, most of the human alterations to Duck Creek had already occurred. At the headwaters, Mendenhaven displaced flow westward. Much of the middle section was dredged, and at the airport the lower creek passed through a large borrow pit. Duck Creek's clearwater days were over. The Glacier Valley School site was clearcut, while other places were high-graded, like the area marked "selectively cut" at left center of the panel. Duck Creek itself was devastated, but its watershed still contained fine habitat for all but the shyest wildlife.

1997

The Duck Creek channel has been moved little since 1962 but road crossings (counting both forks) have increased from 18 to 39, and most of the creek is now within a stone's throw of a road or house. Pavement and roofs send storm runoff directly into the creek, which exaggerates flood hazards even though much of the creek now goes dry during low flows. Only shreds of the original forest and wetland remain, and these patches are mostly isolated from the channel, making it hard for wildlife to use the stream, which has the least remaining natural habitat of any watershed in Southeast Alaska.

Figure 13.--Two centuries of development on Duck Creek. (Maps by Richard Carstensen, Discovery Foundation).

4 HISTORY OF DUCK CREEK

The Mendenhall Valley and streams have played an important role in the growth and development of Juneau since the 1890s. From the early establishment of dairy farms on Duck Creek and Jordan Creek, to the discovery of gold in Nugget Creek, to the development of the Juneau International Airport (Fig. 13), the Valley has been a focal point for Juneau and Southeast Alaska. Over one-third of Juneau's population currently lives in the Valley. The main access road to Valley homes and the Mendenhall Glacier parallels Duck Creek. Local residents, visitors to Alaska's capitol city, and tourists en route to Mendenhall Glacier can assess the community by the care and stewardship it has afforded Duck Creek over the past century.

In 1885, Daniel Foster claimed a 160-acre homestead near the mouth of a stream he called "Duck Creek." Soon several homesteaders started raising livestock (Fig. 14) and produce to supply the mining towns of Juneau and Douglas. Around 1900, a road was built through the watershed to access a hydroelectric plant being constructed on Nugget Creek (near Mendenhall Glacier) and to procure ice for cold storage. During the 1920s, thousands of salmon were harvested from Duck Creek to feed mink and fox raised in the Valley's dozen fox farms. Duck Creek salmon were also a major subsistence food source for native Tlingits and other local residents. Waterfowl were hunted in the many beaver ponds that existed on the stream. During World War II, the U.S. Army constructed additional roads and building complexes and expanded the small airstrip into an airport surrounded by levees and gun emplacements. At that time, Duck Creek was diverted into Mendenhall River. Many wetlands adjacent to the stream were drained for agriculture in the 1940s. A predominately rural character persisted in most of the watershed until the late 1950s when suburban residential and commercial development of the watershed began.

Figure 14.--Farm in the Duck Creek watershed ca. 1910. (Photo from the Winter and Pond Collection).

Residential and commercial development accelerated in the 1960s and continues today. Nearly 7,000 people now reside in the Duck Creek watershed and numerous businesses and the airport flank the stream. To accommodate development, much of the watershed was disturbed by excavation or filling, and much of the runoff to the stream was rerouted. Currently about 36% of the watershed has been developed to an "impervious" state. In 1998, the watershed area was estimated to be 1.7 square miles (R&M Engineering 1996), less than one-half the estimated 3.42 square miles mapped in 1969 (McConaghy 1969). Over ten years ago, wetland area had declined by at least 60 percent (Adamus et al. 1987). Urbanization impacts resulted in degraded water quality, which caused the Alaska Department of Environmental Conservation to list Duck Creek (ID No. 10301-005) as an impaired water body (ADEC 1990, 1992, 1994, 1996).

5 IMPORTANCE of DUCK CREEK

Despite its impairment, the Duck Creek watershed still provides the surrounding community with beneficial and often essential resources such as drainage and flood control, fish and wildlife habitat, recreation, aquatic education, open-space, and aesthetics. Engineering and hydrology studies (EMPS 1979; EMPS 1983; FEMA 1990) show that Duck Creek is an essential and cost-effective drainage corridor for much of the east Mendenhall Valley and, with proper management, a drainage corridor that presents little flood hazard (FEMA 1990; Paustian et al. 1992). The stream provides students at Juneau schools and the University of Alaska with an outdoor laboratory (Figure 15) to study water quality and aquatic ecology, and is valued by area residents for hiking and wildlife viewing.

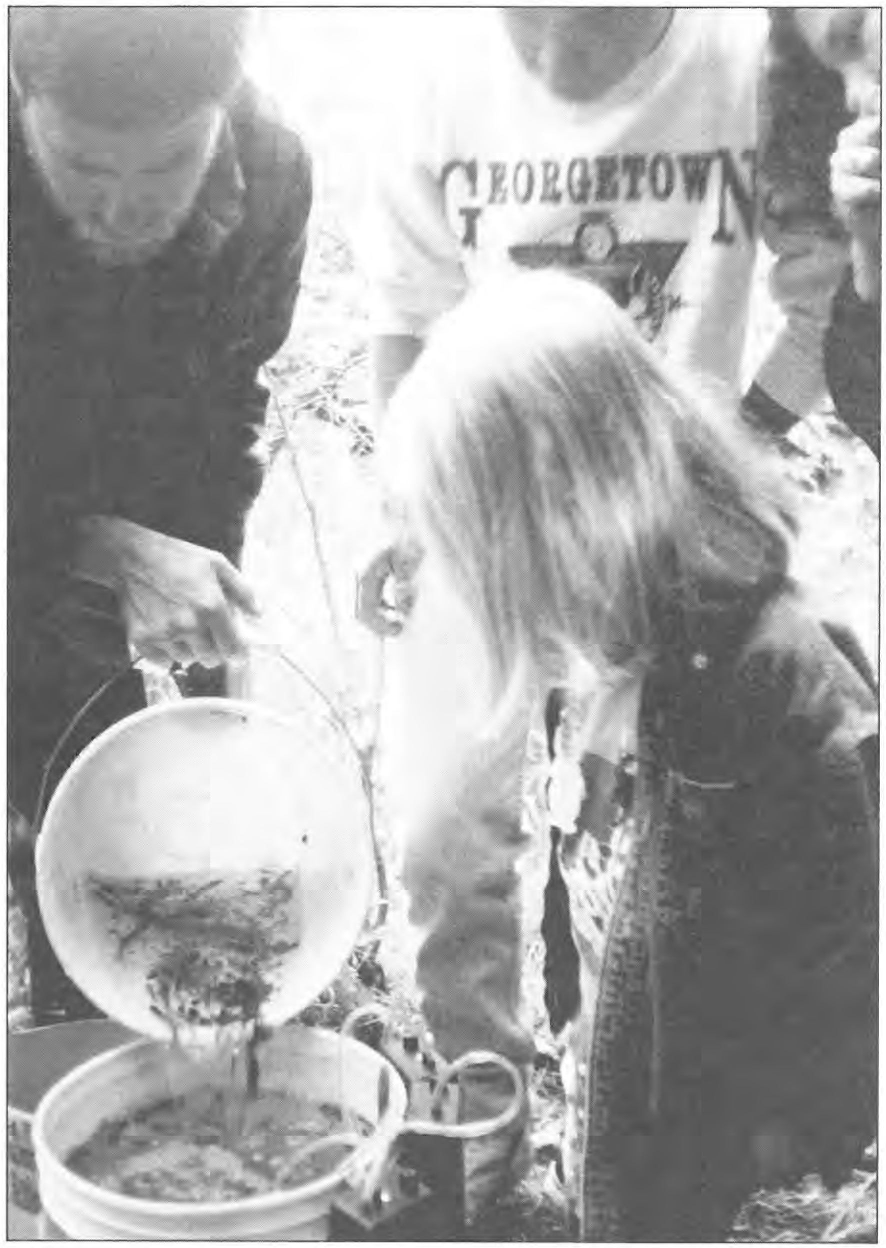


Figure 15

5.1 PUBLIC PERCEPTION

Public attitude and perception toward the importance Duck Creek are changing as a result of this study. The demonstration projects have exhibited the past neglect and have shown the community the benefits of restoration and the importance of habitat protection in urban areas. Fecal coliform contamination of the stream from old septic tanks and animal husbandry operations created health concerns, particularly for children playing in or near the stream. Runoff containing hydrocarbons, heavy metals, and other pollutants caused fish kills, affected salmonid survival, and reduced the overall productive capability of the stream and wetlands. Iron-stained water, litter, and channelization resulted in the stream resembling a drainage ditch. Consequently, many residents were not aware that at one time this was a productive salmon stream.

Public awareness of the impacts of habitat loss on small streams such as Duck Creek has immeasurable value in protecting and restoring salmonid habitat. About 85% of the streams in the nation are small 1st to 3rd order streams like Duck Creek. These small streams provide spawning and rearing habitat and make up the backbone of coho salmon production along the Pacific Coast. In Southeast Alaska, more than 80% of the coho production comes from streams less than 20 feet wide and more than 60% of pink salmon and 90% of Dolly Varden also come from these small streams. Alaska currently produces more than 90% of the nation's salmon and is the last stronghold for these species. Because of the degraded habitat and the number of threatened or endangered salmonid species in the Pacific Northwest, Alaska has a responsibility to protect and maintain its wild salmon resources. The loss of small streams and the salmon resource in urban areas of Puget Sound, the Fraser River Valley, and the Columbia River basin attest to the challenge of maintaining habitat for salmon in Alaska.

5.2 FISH and WILDLIFE HABITAT

Duck Creek and its riparian corridor provide substantial habitat for a variety of fish and wildlife. The stream is an anadromous fish stream (Alaska Dept. of Fish and Game [ADFG] Catalog No. 111-50-10500-2002) that has provided habitat for coho, pink, chum, and sockeye salmon, Dolly Varden, and cutthroat trout (Bethers et al. 1993). Salmon from Duck Creek still contribute thousands of dollars annually to local and regional economies through commercial and sport fisheries. Many other fish species--including stickleback, sculpin, herring, capelin, eulachon, and flatfish--use the streams, ponds, or tidal wetlands associated with the watershed. Songbirds, shorebirds, waterfowl, and raptors use the watershed extensively either as residents or as migrants. Mammals such as muskrat, red squirrel, porcupine, voles, and mice use the corridor year-round, while black bear, black-tailed deer, mink, and otter are occasional visitors.

"The salmon runs are a visible symbol of life, death and regeneration, plain for all to see and share. Their abundant presence on the spawning beds is a lesson of hope, a reassurance that all is still well with water and land, a lesson of deep importance to the future of man."

Roderick Haig-Brown, 1974

5.3 ECONOMICS

Duck Creek is located in a setting that is in one of the most scenic areas in the world. That natural landscape is the foundation for major regional industries such as tourism and fishing. Continued impairment of watershed resources in developed areas like Mendenhall Valley, however, will reduce future options for these and other industries in the region. Land-use planning and development in the Mendenhall Valley and other urban areas of Juneau must take more responsibility for sustaining the resource needs of both the immediate community and important regional industries.

Coho salmon provide an example of a watershed resource where economic analyses have been done that indicate their importance to the regional economy. Whether harvested for $500 a fish by lodge clients or for thirty cents a pound by commercial fishermen, snagged for winter subsistence, or simply observed as wildlife in a stream, coho salmon are a conspicuous part of the socio-economic fabric of Alaska. More than one-half of all mature coho are harvested in commercial, recreational, or subsistence fisheries for use in dozens of "products" ranging from caviar to cat food and from eco-tourism to fish leather.

Coho salmon are particularly important in Southeast Alaska (Table 2). Nearly one-third of all residents of the region are employed in businesses that rely in some way on salmon resources. More than 4,000 commercial fishing permits for coho salmon fisheries are held by Southeast fishermen and thousands of people are employed in catching, processing, and marketing salmon. More than 200,000 people sport fish for coho salmon each year in Southeast Alaska where nearly 1,100 sportfishing guides were licensed in 1997. In the Juneau area alone, more than 50,000 anglers and 400 guides fished for coho in 1997.

Table 2.--Averages of recent annual harvest and value estimates for commercial and sport-caught coho salmon.

	Commercial (1994-1997)		Sport (1994-1996)		
Area	**Harvest**	**Value***	**Harvest**	**Value****	**Sum of Value**
Southeast	3,460,000	$21,213,000	150,200	$38,301,000	$59,514,000
Juneau	No Data	No Data	39,790	$10,146,450	-----------
Dredge Lakes	170	$1,100	13	$3,200	$4,300
Duck Creek	47	$290	4	$1,020	$1,310

*Based on the "Bluesheet"(http://www.cf.adfg.state.ak.us/geninfo/FINFISH/SALMON/catchval/blusheet/)

**Based on values reported in Southeast Alaska Sport Fishing Economic Study (Jones & Stokes 1991)

Continued impairment of the watershed could also result in a reduction in recreational and tourism opportunities in the Mendenhall Valley and along Duck Creek. That reduction could be translated as lost income to businesses providing support of recreational pursuits such as hiking, fishing, wildlife viewing, etc. In addition, impairment of the stream affects the economic vitality of the area by depressing property values next to the stream and increasing flood insurance rates for property owners.

5.4 ECOSYSTEM VALUES

Along with contributing to regional economies, salmon also benefit other regional resources. Adult salmon provide important food for bald eagles, terrestrial mammals (e.g., brown bear, black bear, river otter), marine mammals (e.g., Steller sea lion, harbor seal, orca), and salmon sharks. Adult salmon transfer essential nutrients from marine to freshwater and riparian environments through decomposition of carcasses and eggs. Juveniles provide food for birds (e.g., gulls, kingfishers, cormorants, terns, herons, mergansers), other fish (e.g., Dolly Varden, rainbow trout, cutthroat trout), and mammals (e.g., mink, river otter, water shrew).

All of the streams draining the Mendenhall Valley support a diverse and abundant fauna and flora in the Mendenhall Wetlands and State Game Refuge. The streams provide the critical freshwater inflow, both volume and quality, necessary to maintain the diversity of aquatic vegetation and invertebrates important in the various fish and wildlife food chains. The popular Mendenhall Wetlands provide residents with year-round recreational opportunities, including seasonal activities like bird watching, waterfowl hunting, fishing, boating, hiking, and sightseeing.

These wetlands also provide a corridor for juvenile and adult salmonids migrating through the area as well as a nursery habitat for juveniles from local streams. Forage species such as eulachon, sand lance, herring, and capelin also use the wetlands as essential habitat. Eulachon, an important subsistence species, spawn in the Mendenhall River and provide food source for eagles and other species. Flatfish--including starry flounder, rock sole, and yellowfin sole--and crab species--including Dungeness and king--also utilize the intertidal habitats of the wetlands. All of these species and others contribute to the tangible value provided by the wetland and stream ecosystems of the Mendenhall Valley.

6 DUCK CREEK ADVISORY GROUP

The DCAG was formed in 1993 to coordinate, plan, initiate, and carry out activities to restore water quality and anadromous fish habitat in Duck Creek and its freshwater and estuarine wetlands. The Advisory Group provides education and facilitates work with the CBJ, State and Federal agencies, private businesses, conservation organizations, and homeowners in the design of restoration projects and pollution control throughout the watershed. Schools, youth groups, citizens and agency researchers have been involved in baseline data collection in order to help understand the problems and make decisions on how to improve and best manage Duck Creek.

***Objectives** of the DCAG:*

- *Restore beneficial resources including water quality, flood control, and fish habitat.*
- *Provide information on the status and value of aquatic resources and options for maintenance and restoration of such resources.*
- *Evaluate the effectiveness of restoration protocols for improving water quality and fish habitat.*
- *Instill a "conservation ethic" and perspective in the community on the importance of neighborhood streams to "quality of life."*
- *Develop Duck Creek as a local, regional, and national demonstration site for restoration.*

The Group performs the following functions:

1. Explores opportunities for collaboration and cooperation with other interested parties and serves as the coordinator for any monitoring, research, or restoration activities on Duck Creek, its watershed, and adjoining aquatic habitats;
2. Assists in the preparation of draft Memoranda of Understanding or Cooperative Agreements as needed for approval that deal with specific activities by two or more of the participants;
3. Reviews project plans of the different participants for need and attainability and identifies those facets of the plans appropriate for cooperation;
4. Identifies long and short-term project needs and objectives which could be most effectively conducted as cooperative efforts by two or more parties;
5. Recommends suitable procedures and protocols to follow in order to accomplish objectives and effective habitat restoration;
6. Creates and maintains a Duck Creek data base and source of scientific information for access by all interested parties;
7. Identifies funding opportunities to support restoration activities;
8. Arranges participation of appropriate experts or consultants to assure best possible understanding of problems, solutions, planning and execution of restoration activities;
9. Recommends specific plans for sharing manpower, facilities, equipment, and logistics for all aspects of the restoration project; and
10. Meets monthly or as often as the consensus of the Group indicates. Meeting locations and chair rotates among participating public organizations and not agencies if possible. Meeting minutes are recorded. Progress reports and annual reports by participants are required.

The DCAG does not have authority and only makes recommendations based on the technical expertise of the membership. Each member of the DCAG is responsible for keeping their organization informed of the Group's progress and for facilitating parent agency actions and approvals necessary to accomplish the Group's objectives. Membership of the DCAG consists of representatives from numerous groups:

Public Organizations
Juneau Trout Unlimited
Duck Creek Homeowners
Southeast Alaska Guidance Association
Mendenhall Watershed Partnership
Southeast Conference
Juneau Youth Services

Local Government
City and Borough of Juneau
Juneau Public Schools

Small Businesses
Gastineau Guiding
Discovery Foundation
Hanna Construction

Tribal Government
Douglas Indian Association

State Government
Alaska Department of Environmental Conservation
Alaska Department of Fish and Game
Alaska Department of Natural Resources
Alaska Department of Transportation and Public Facilities
Alaska Division of Governmental Coordination

Federal Government
National Marine Fisheries Service (Alaska Region and Auke Bay Laboratory)
U.S. Fish and Wildlife Service
Environmental Protection Agency
U.S. Geological Survey
Federal Highway Administration
U.S. Corps of Engineers
U.S. Forest Service
Natural Resource Conservation Service

Community and statutory concerns that are the focus of this Plan originated from public outreach and agency consultation through the DCAG forum. The public scoping process included four public scoping meetings, more than 70 monthly meetings of the Duck Creek Advisory Group, ten newsletters each distributed to nearly 150 local households, and numerous presentations to community interest, environmental, school, business, and professional groups. Consultation with public resource managers and regulatory agencies at all levels of government was done continually throughout the scoping process. More than a dozen agencies have participated in discussions of this Plan. As key concerns were identified, agency staff and community members discussed alternative solutions to the problems and raised the issues at meetings, in presentations, and in the newsletter. The Mendenhall Watershed Partnership, a citizens group working toward a healthier Mendenhall watershed, was organized in 1998 and evolved from the DCAG.

7 THE SCIENCE-BASED APPROACH

The DCAG has used a science-based approach to plan for and accomplish effective restoration of Duck Creek. That approach has four phases: 1) establish baselines of conditions; 2) implement pollution control measures; 3) implement restoration projects; and 4) evaluate effectiveness based on established baselines. Additional information on baseline data collected is presented in Appendix C and in the separate Technical Supplement.

The Duck Creek Watershed Management Plan considers more than just the stream--it takes a watershed approach. Watersheds are nature's boundaries for water resources. When rain falls it either flows downhill through wetlands and ditches into streams and into the ocean or it may percolate through the soil to become ground water. As it flows, water picks up pollution, sediment and debris. As a result, physical, chemical, and biological processes--including human activities--within a watershed affect the quantity and quality of water in the stream or groundwater. Technically, a watershed is defined as: " an area of land that drains water, sediment, and dissolved materials to a common outlet at some point along a stream channel" (Dunne and Leopold 1978 from Stream Corridor Restoration book p 1-8).

A watershed management approach is also the best way to inventory and protect essential "common property" resources. The Watershed approach:

- fosters coordinated and more efficient development of programs to control pollution, reduce flooding, enhance or restore essential habitat, and protect drinking water;

- highlights the value of "common property" resources in the health, safety, and economy of the watershed community;
- fosters commitment and contribution from local communities, private landowners, and citizens to maintain clean streams, lakes, wetlands, and coastal areas.

8 MANAGEMENT and RESTORATION ISSUES

8.1 REGULATORY FRAMEWORK

A framework to ensure environmental compliance, consisting of statutes and a permitting system, has been in place within the governmental agencies in Juneau for a long time (Fig. 16). Unfortunately, as Duck Creek, Jordan Creek, and the other impaired waterbodies in Juneau demonstrate, that framework has generally failed to protect these streams and their watersheds. The inadequacy of the regulatory framework became clear during the DCAG's activities on Duck Creek. While gathering baseline information and working on restoration, threats to the stream and wetlands were routinely encountered. Many problems were resolved

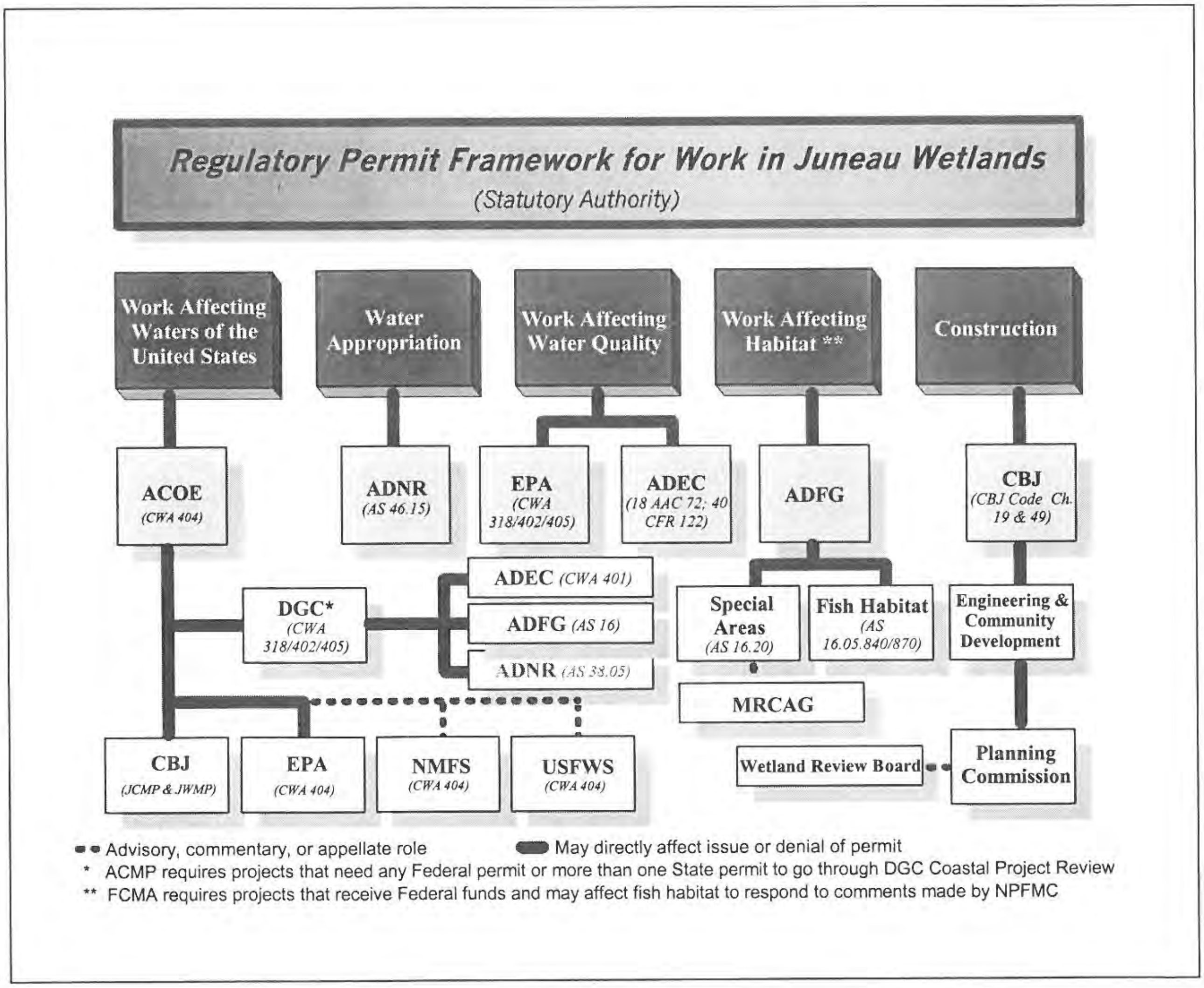


Figure 16

by working with the land owner or developer to satisfy both the stream and developer needs and the statutory regulations. Several key factors in the regulatory framework appear to be either lacking or in need of reinforcement: agency coordination, watershed and land-use planning, enforcement, and a conservation ethic.

Although there is State coordination of the permitting process involving State and Federal projects affecting the coastal zone, more communication is needed on these proposed projects at the local or community level. Expertise exists within the community that is not always utilized as thoroughly or timely as possible. The DCAG, the MWP, Juneau Trout Unlimited and other forums could provide information for permit review if specifically requested or if they could be more involved in the permit process. State and Federal agencies and the CBJ should flag all projects potentially affecting any stream or wetlands in the Mendenhall watershed and route them to DCAG and MWP for review.

The DCAG advocates managing Duck Creek using a watershed framework where all activities in the watershed are planned and developed to minimize disturbances to waterbodies. The watershed is important to the entire community because it provides flood and erosion control, drinking water, fish and wildlife habitat, recreation, and aesthetics. Land-use planning using a watershed approach would establish areas that can be developed without disturbing the stream and establish greenbelts and setbacks that must be maintained for watershed protection. Planning themes should include management of stormwater, snow, drainage and flooding, litter and pollutant disposal, and riparian zones. Representatives from all interested forums (e.g., DCAG, MWP, Trout Unlimited, etc.) should be involved in the planning process.

Perhaps the biggest factor in an effective regulatory framework is enforcement. Enforcement of local ordinances appears to be inadequate, particularly in sensitive watersheds where streams have been designated as impaired. During construction activities little effort is made to prevent sediment and other contaminants from entering the streams or to maintain sediment control structures (such as straw bales or silt fences) once they are in place. Encroachment on the riparian zone is common, and the stream setback ordinance is not enforced as thoroughly as needed. Public education would be beneficial concerning stream setback requirements and the need to protect riparian habitat.

Littering and dumping of trash in Duck Creek is also a common problem. Aside from aesthetics, much of the trash is probably harmless; however, car batteries, oil and fuel containers, aerosol containers, etc. can introduce toxic substances to the stream.

The scoping for this Plan shows that the public understands that enforcement will have to change to make the regulatory framework effective. A conservation ethic must also be developed in the community so that perspectives of the value of local streams and wetlands improve. An ethic that makes people want to protect and restore these resources is needed. The cumulative impacts of development have made many residents view Duck Creek as a ditch rather than the productive salmon stream that it once was.

8.2 HABITAT

Salmonid Abundance

Historically, Duck Creek was an important source of salmon for local fisheries and subsistence use. According to Bethers (1995) and our observations, spawning escapements into Duck Creek have ranged from 10,000 chums in 1940 to no more than 20 coho in 1999. There has been no observed fry survival from either coho or chum spawning in the stream since this study began in 1994. Coho production in Duck Creek is the result of juveniles migrating into the stream in the fall. Winter refuge habitat, primarily ponds, provided by the stream yields 2000-4000 coho smolts annually. Coded wire tagging of these smolts over the last six years has shown that they are contributing to both the recreational and commercial fisheries in the Juneau area. Winter habitat is apparently as good or better in Duck Creek as in either Jordan Creek or Dredge Lakes; In fall and winter, juvenile coho salmon are at least as abundant in Duck Creek as in neighboring streams. However, coho abundance is low compared to similar habitat in other Southeast Alaska areas (Fig. 17). Summer rearing habitat for coho is poor in Duck Creek because of poor water quality (e.g., temperature, dissolved oxygen, pollutants), lack of food, lack of consistent flow, and a high level of parasitism.

Anadromous cutthroat trout in Duck Creek are able to spawn and produce fry in this habitat that is not capable of supporting coho or chum salmon. A similar response by cutthroat to the effects of urbanization has been observed in Puget Sound (Lucchetti and Fuerstenberg 1992).

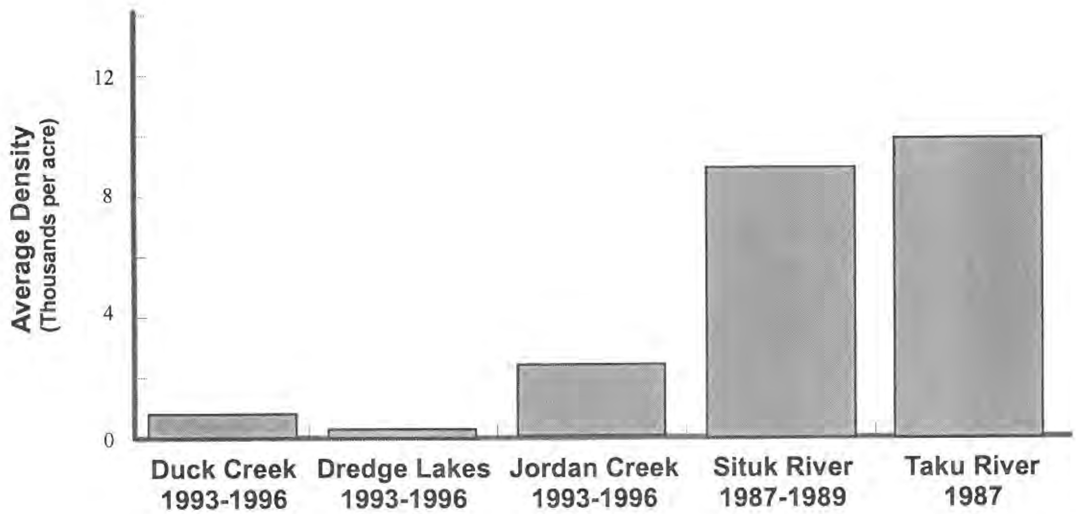


Figure 17.--Juvenile coho density during fall at five Southeast Alaska areas.

Fish Passage

Salmonids in Duck Creek need migratory access up and down the stream for both rearing and spawning. Culverts on Duck Creek that are of wrong size or placed in the streambed at the wrong elevation affect the movement of juveniles and adult salmonids. Fish passage at both high and low flows not only impedes movement but results in mortality when fish are delayed in either their spawning or smolt migration (Fig. 18).

Culverts also create problems with stream channel morphology because of the "damming" they create at each crossing. The damming affect reduces the water velocity that provides the energy to move sediment and shape the stream channel. Duck Creek no longer properly flushes sediments or passes water efficiently in many areas. The accumulation of sediment has caused the stream channel to widen, reduce its sinuosity, fill with vegetation, and become poor fish habitat. There are about 20-25 culverts of various sizes and configurations on Duck Creek that have adversely affected channel morphology and habitat, and that need to be replaced.

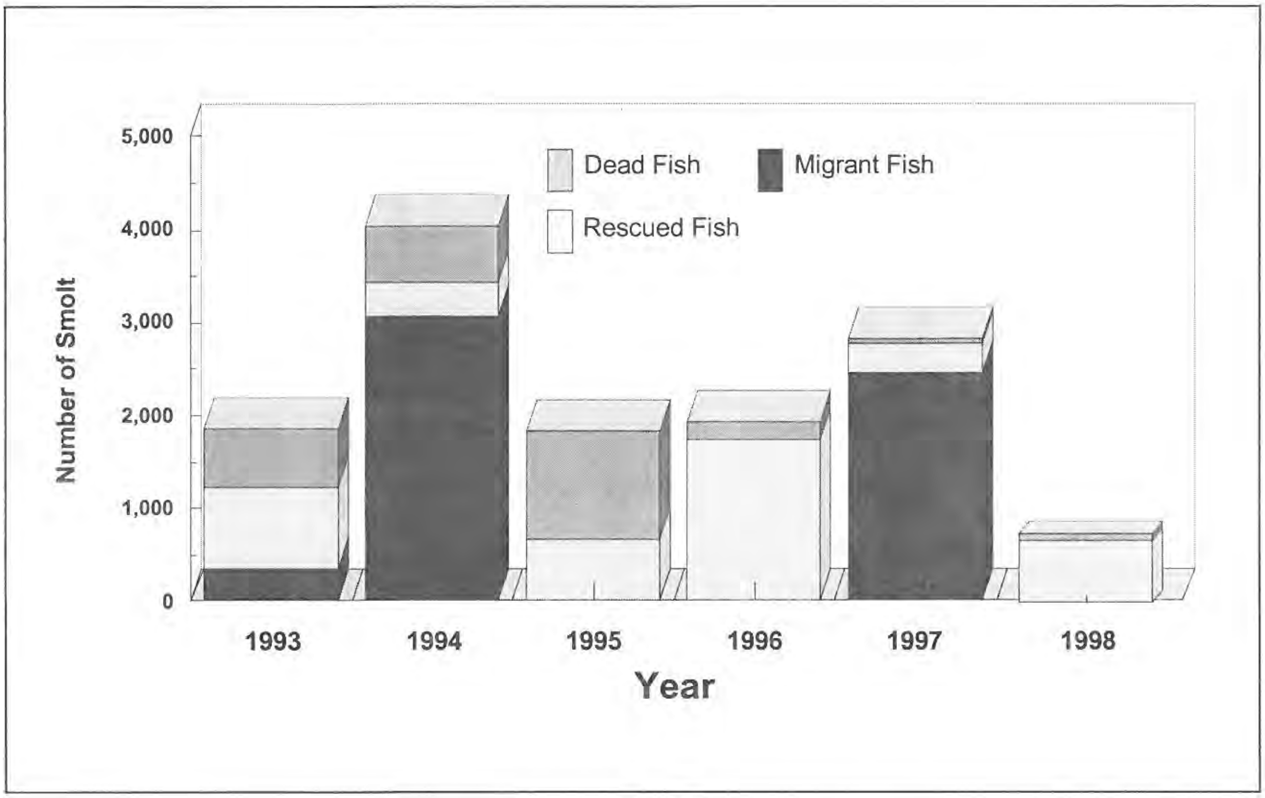


Figure 18.--Coho smolt migration in Duck Creek.

Riparian Vegetation

Riparian vegetation is a key component of any healthy stream ecosystem and is directly related to available fish habitat. Trees and other riparian vegetation link upland areas to the stream and provide the stream with sources of energy, maintain water quality, and help regulate physical structure and stream flow. Woody debris falling into the stream is probably the most important function of the riparian zone. Such debris contributes to channel morphology, helps to route and store sediment, and forms diverse and complex habitat for fish (Koski 1992).

Loss of riparian vegetation has contributed to the degradation of aquatic habitat in Duck Creek. Encroachment of residences, businesses, and roads on the riparian corridor have often left little or no buffer between development and the stream (Figure 19). As a consequence, streambank erosion has degraded water quality and habitat structure is reduced. Removal of vegetation adjacent to roads and intersections allows sediment from winter road sanding to easily enter the stream. Habitat complexity has been reduced by removal of woody debris and filling of pools with sediment. Destruction of the riparian zone has also eliminated future sources of woody debris.

Stream Flow

Natural variation in stream flow as a result of seasonal differences in precipitation is a characteristic feature of most streams, and salmon can adapt to many spatial and temporal changes in flow regime. In Duck Creek, however, ditching, water diversion, and highly permeable reaches of streambed have reduced flow and available habitat to levels that are marginal for fish survival. Typically, several reaches of stream "dry up" during the salmon smolt migration each year, and on average 25% of the smolt are killed outright and others must be rescued and transported to sea in order to survive.

A hydrology baseline study of surface water and groundwater (Beilhartz 1998) found that "drying up" occurred in reaches that were very permeable and allowed surface water to seep into the ground. The permeable conditions are characteristics of residual glacial outwash channels but are most likely associated with physical alteration of the streambed, such as ditching or channel relocation. Existing channels that are extremely wide and overgrown with grass vegetation also tend to aggravate the water loss problem.

To prevent continued diversion of water from Duck Creek, the Juneau Chapter of Trout Unlimited filed for an instream flow reservation from the Alaska Department of Natural Resources (DNR) in 1993. The reservation was for a minimum of 8 cfs for maintenance of fish habitat. As of March 1999, DNR has not adjudicated that water reservation, however, in the interim the application reserves that water ahead of all other proposed uses.

Figure 19.--Sediment (sand) entering Duck Creek in an area devoid of riparian vegetation.

8.3 WATER QUALITY and STREAM FLOW

The quality of water is the most important environmental factor affecting stream biota. Quality refers to the physio-chemical features of water including light penetration, temperature, dissolved oxygen, nutrients, chemicals, heavy metals, toxic substances, pH, and other materials suspended (e.g., sediment) or transported by flow. Unlike physical alteration of the stream, many habitat problems associated with water quality are invisible and are difficult to control because they enter the stream through "nonpoint" sources of runoff. Human activities generate most nonpoint source water pollution, and in Duck Creek those pollutants often exceed enforceable water quality standards. Those pollutants can cause public health problems, are toxic to aquatic organisms, and can enter the human food chain and drinking water supply. Since 1990, Duck Creek has been listed as a polluted water body under provisions in Section 305(b) of the 1987 Federal Clean Water Act (ADEC 1990, 1992, 1996). Control of such nonpoint pollution can be a dilemma and requires a watershed approach to management and restoration.

Alaska Water Quality Standards

Standards for water quality in Alaska law (18 AAC 70) involve three components: 1) Designated uses; 2) Criteria or threshold levels to protect designated uses, and; 3) Antidegradation clauses. Except in cases of short term variance or specific antidegradation clauses, drinking water standards are enforceable in all State waters. Seven designated uses for fresh waters and seven designated uses for marine waters are defined. Criteria to protect those uses are also defined. For the purpose of enforcement, waters impaired in more than one water quality category require protective measures for the most stringent water quality criteria of all affected categories.

Designated uses applicable to Duck Creek include freshwater categories for drinking water, agriculture, contact recreation, secondary (incidental contact) recreation, and propagation of aquatic life and wildlife.

Those categories apply to the stream because domestic water supply wells and wellheads are located within the floodplain and the stream is a source of water for animal husbandry. The stream is also used for swimming, boating, and hiking (i.e., contact and secondary recreation) and provides habitat for wildlife and aquatic organisms including commercially marketed fish (e.g., coho salmon).

Antidegradation clauses are designed to allow specific exceptions to water quality standards but also assure that existing uses are protected. Degradation of water quality under these clauses are only allowed when necessary for important economic or social development. Examples of such clauses in Alaska law include exceptions for water quality in thermal effluents from power plants and mixing zones for some point source discharges. When exceptions are granted, the State must ensure that water quality is protected to an extent that supports all existing uses, aquatic life, and contact recreation.

Duck Creek water quality violates State standards for each designated use in the categories of fecal coliform bacteria, dissolved oxygen, iron, manganese, and zinc. Protection criteria for all designated uses except secondary recreation are also exceeded by turbidity, pH, temperature, and sediment. Dissolved oxygen, lead, mercury, iron, silver, zinc, and polyaromatic hydrocarbon levels also exceed those observed to have lethal or sublethal effects on coho salmon.

Degraded water quality resulting from nonpoint source pollutants in urban runoff is among the most problematic of impairments to Duck Creek. Other sources of pollution that impair Duck Creek water quality include sewage, erosion and sedimentation, landfills, and nutrient introduction from fertilizers, yard wastes, and animal husbandry. Aesthetically, orange stains and bacterial blooms produced by dissolved metals and excess nutrients are also a major nuisance to the community.

The following water quality parameters are discussed in more detail because of their major influence on fish habitat and the entire stream ecosystem.

Dissolved oxygen

Alaska water quality standards stipulate concentrations greater than four milligrams per liter for dissolved oxygen in water used for drinking, contact recreation, or secondary recreation. Levels greater than seven milligrams per liter are required for aquaculture or growth and propagation of aquatic life and wildlife. For spawning of anadromous fish, those standards also require stream gravels to contain at least five milligrams per liter of oxygen in interstitial water.

Dissolved oxygen levels in the substrate (i.e., intragravel water) of Duck Creek are often less than 2.0 mg/l, too low to support incubating salmon eggs and most aquatic invertebrates. At the bottom of dredge ponds and in stream gravels oxygen levels are often near zero. Even in flowing areas oxygen levels are often less than 4.0 mg/l. Some reasons for this include: 1) exposure by excavation of high volumes of groundwater containing low dissolved oxygen and high levels of oxidizing minerals (e.g., iron, manganese); 2) diversion of well-oxygenated surface runoff to other stream basins; 3) chronic input of nutrients and organic material that requires large amounts of oxygen to decompose (e.g., yard wastes, fertilizers, livestock/pet waste); 4) extensive elimination of flowing reaches of stream; 5) extensive use of deicing agents (e.g., ethylene and propylene glycol, salt, urea) and detergents that break down with high chemical oxygen demand.

Hydrocarbons

Duck Creek is listed as impaired by urban runoff and petroleum products (ADEC 1992, 1994, 1996). Runoff from roads, parking lots, and private vehicle oil changes are likely the main chronic sources of oil or hydrocarbon contamination in Duck Creek. Spills of heating oil, leaking fuel tanks, gasoline, and dumping of used motor oil and other petroleum products are also common, and probably contribute to site specific or episodic pollution. Such refined hydrocarbons have moderate water solubility and soil absorption potential and when released into surface water have moderate to high toxicity to aquatic organisms. Once attached to soil particles they are not easily flushed from the area.

The compounds in refined petroleum products that are of primary concern are referred to as polycyclic aromatic hydrocarbons (PAHs). Refined motor oil, for example, has much higher concentrations of PAHs than crude oil and is consequently more toxic. Used motor oil is also contaminated with metals and other toxic compounds generated by combustion.

Some PAHs are known or suspected carcinogens and exposure to low concentrations in drinking water or through the consumption of contaminated soil by children could be harmful. Some PAHs do not rapidly biodegrade and tend to bioconcentrate (be found at levels in living tissue far higher than present in the general surroundings) in the environment, such as in fish eggs. Monthly monitoring of hydrocarbons in Duck Creek found concentrations as high as 45 ppb. Simulated PAH levels of 15 ppb were enough to kill salmon eggs in laboratory experiments with coho and chum salmon (Timko 1992, unpublished manuscript).

Heavy Metals

Water quality testing shows that levels of iron, manganese, mercury, and zinc in Duck Creek exceed State water quality standards. Water quality standards are generally expressed in micrograms per liter of water (μg/l). In Duck Creek, iron was measured at 25,000 μg/l, manganese at 880 μg/l, mercury at 2.16 μg/l, and zinc at 150 μg/l. State standards allow for 300 μg/l of iron, 50 μg/l or manganese, and 2 μg/l of mercury. The standards for zinc depend on the hardness of the water. About 85 mg/l of $CaCO_3$ occurs in Duck Creek and that limits the level of zinc to 122 μg/l as the lowest observed level for acute toxicity and 107 μg/l for the lowest observed level for chronic effects on aquatic life. The primary sources of most toxic metals, such as zinc and mercury, are residues from synthetic rubber (tires), paint, or brakes delivered to the stream through stormwater runoff.

Dissolved Iron

Parts of the Mendenhall Valley are underlain with relatively high concentrations of iron mineralization that dissolves in groundwater supplying Duck Creek. When this iron-rich groundwater surfaces and is exposed to dissolved oxygen through ditching, excavations, or other disturbances of the land, it forms a heavy precipitate (floc) that blankets the substrate. Before the valley floor was developed, native soils (peat bogs and organic soils) oxidized and adsorbed most of the iron before it surfaced. As those organic soils were stripped and replaced with mineral soils (sand and gravel) more and more iron reached the surface. Surface water samples obtained over the entire length of stream now have concentrations of dissolved iron that range from 0 to 25,000 μg/l.

The groundwater usually has very little oxygen in it, and consequently the iron it contains is in a "dissolved" or "soluble" form that is easily transported in moving water. Once that water comes into contact with oxygen, however, iron is converted to oxidized forms that result in iron floc and "slime" that are observed in many areas of Duck Creek and other low gradient streams. Floc settles on the stream bottom, filling spaces in the gravel and drastically reducing habitat quality for fish and insects. The conversion process also consumes dissolved oxygen, leaving little for aquatic life. The chemical reduction of the dissolved iron and the action of iron bacteria reduce dissolved oxygen levels to less than 2.0 mg/l. Those oxygen levels are lethal to fish and most invertebrates and render the stream nearly sterile in many reaches. Key locations of groundwater containing dissolved iron have been identified, but they may be difficult to treat because of the wide extent of emergence from the ground.

High concentrations of dissolved iron from ground water and the resultant low concentration of dissolved oxygen are the major water quality factors limiting the biological communities in Duck Creek. Although alleviation is complex, restoration of water quality and fish habitat must be attempted. This is an important issue because many streams and wetlands in the Juneau area potentially face the same problems that Duck Creek has today.

Turbidity/Sediment

Sediment is a natural component of stream hydrology that is important in forming the channel bed and banks. Sediment usually enters streams during periods of high runoff and is quickly sorted and transported into natural deposition areas along the channel. When sediment enters streams in amounts too large to be quickly redistributed, however, efficient channel morphology and aquatic life can be impaired.

In urban areas, large amounts of sediment are often pumped, plowed, or swept into streams during periods of moderate or low flow. Excavation, snow plowing, and street sweeping, for example, are often easiest during periods of low rainfall and low stream flow. Hydrocarbons, metals, and other toxic pollutants easily adhere to sediment particles. Consequently, sediment entering urban streams not only damages habitat by clogging spawning gravels and filling pools, but also introduces toxic pollutants. The low gradient, poor channel morphology, and numerous grade controls in Duck Creek aggravate that problem.

Sediment less than 4mm in size is of greatest concern for several reasons: first, it can clog interstitial spaces in spawning gravel preventing water flow that provides oxygen and carries away waste from developing salmon eggs; second, by clogging the gravel it prevents fry emergence from the redds or spawning nests into the water column; and third, toxic pollutants adhere best to finer particles.

Three main sources of fine sediment are evident in the Duck Creek basin. One source of sediment is runoff from disturbed ground at construction and utility installation sites. Another major source is sand that is applied to roads in winter. The third source is iron oxide from intercepted groundwater. Stream areas most affected are those directly adjacent to construction sites, streets, and gravel excavations.

Fecal Coliform Bacteria

Fecal coliform bacteria are constituents of human sewage and/or animal waste (Figure 20) and can be found in most natural waters. A few strains of coliform bacteria may produce serious human illness, but their abundance is primarily an indicator for the presence of other more virulent pathogens associated with sewage (e.g., hepatitis, cholera, typhoid, virulent parasites, etc.).

State drinking water and contact recreation standards allow for 20 fecal coliform bacteria per 100 milliliters of surface water and ten times that for secondary recreation or agriculture. Measurements of fecal coliform bacteria in Duck Creek water commonly exceed drinking water and contact recreation standards and have exceeded 1600 bacteria per 100 milliliters of water during the period of this study.

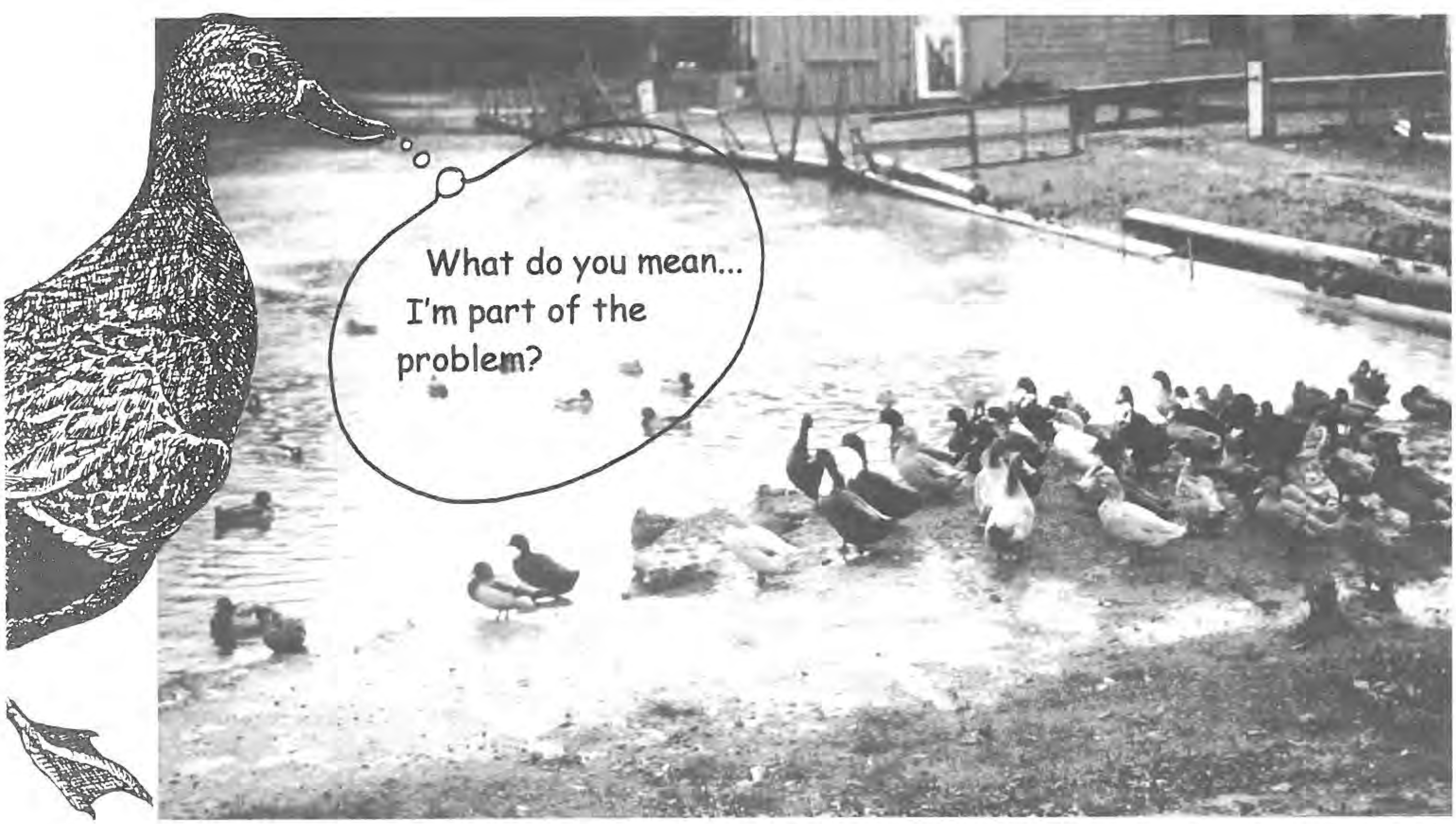


Figure 20.--Animal waste contributes to high fecal coliform bacteria in Duck Creek.

8.4 HYDROLOGY

Construction of roads, dikes, ditches, and stormwater conduits have changed the watershed boundaries of Duck Creek and adjacent sections of Jordan Creek and the Mendenhall River. Prior to construction of the military revetments and airport in the 1940s, Duck Creek flowed directly into salt marshes along Mendenhall Bar rather than into Mendenhall River. Based on the presence of abandoned channels and the narrative history of the area told by residents, until at least the 1950s significant flow into Duck Creek originated from drainage from Thunder Mountain. Consequently, the Duck Creek basin may have decreased in size by as much as 60 percent between 1940 and 1970. Relative to earlier changes in watershed area, surface watershed boundaries of Duck Creek have been relatively consistent over the past 30 years. In some areas, however, watershed boundaries continue to change, primarily due to constructed stormwater drainage systems. Groundwater dynamics in the watershed have probably changed due to diversions, excavations, and fills. Comparisons of recent mapping to earlier maps and air photos show that the stream was diverted into constructed channels or archaic outwash channels in several locations. Such channels may be more or less porous than original channels, causing changes in contact with various groundwater sources. In the Dredge Lakes area, flood control and surface drainage systems designed to reduce flooding and divert water to a common outfall at Mendenhall River may have depleted the supply of water to Duck Creek's headwater springs. Long-time residents report that discharge from headwater springs declined soon after a dike and surface drainage system was constructed in the Dredge Lakes area. Excavations and fills have altered the dynamics of both deep and shallow groundwater underlying the basin. Excavations up to 40 feet deep in some areas have exposed formerly contained sources of groundwater. Connections between stream channels and shallow groundwater have been changed by fills that compressed porous ground and cutoff subsurface flow.

In addition, the highly permeable streambed in the lower reach of Duck Creek permits the stream to lose surface flow during periods of low precipitation. Based on Beilhartz (1998) the lower reaches become dry when the stream flow upstream at the USGS gage is between 1.6 to 5.2 cfs. When the stream flow is less than 7 cfs, more than 50% of the flow is lost underground and when the flow is 12 cfs or more the lower reach has the same flow as at the gage site.

Stormwater Runoff

Duck Creek's location in the heart of the Mendenhall Valley residential and business area makes it particularly vulnerable to urban runoff. As a consequence, high levels of heavy metals and hydrocarbons are delivered by stormwater to the stream. Hundreds of drainage structures convey stormwater runoff in the Duck Creek basin, yet flooding is still a problem and stream drying events are increasing. As more land is covered by impermeable surfaces and runoff peaks increase, existing drainage systems rapidly become inadequate.

Flooding often results as water backs up behind drainage structures that are undersized, poorly maintained, or are not constructed at appropriate slopes (FEMA 1990). The extent of that problem in the Duck Creek basin was confirmed during a September 1996 high water event when only one mainstem crossing did not retard flow (Bruce Bigelow, U.S. Geological Survey, pers. commun., May 1997). Since the water now runs off faster, less flow is available to sustain stream flow during periods without rain.

Although Juneau is exempt from requirements to treat stormwater for pollutants (because the population is >50,000), in practice it is almost always more effective and less costly to treat the stormwater rather than the receiving water (i.e., streams and wetlands) when the receiving waters violate pollution standards because of polluted stormwater runoff.

Over 60% of the original wetlands in the Duck Creek watershed were eliminated by 1989, and more have been eliminated since. Many of those wetlands functioned as filters for the watershed's high levels of dissolved iron and also attenuated flows, thereby improving water quality and stabilizing stream flow. Future water quality and stream flow in Duck Creek may depend on restoration of similar wetland functions wherever possible in the watershed. There are several large dredge ponds that could be restored for such functions.

Low Flow

Low flows are a concern in Duck Creek because as areas of the stream become completely dry aquatic habitat is lost. Critical periods are between April and June and August to October. Stream flow data collected at Nancy Street from 1994 through 1998 shows a fairly consistent trend. More than 7.4 cfs or more flow is present more than 10% of the time, 2.2 cfs or more is present 50% of the time, and 1 cfs or more is flowing 90% of the time. Flow levels during critical fish (both adult and juvenile) migration periods are the major issue. In 1997, flow at Nancy Street was less than 7 cfs nearly 90% of the time during key fish migration periods (April through September).

Peak Flow

Duck Creek is needed as a conduit for stormwater because extensive development has left little space for stormwater retention or dispersal. Culverts and other drainage structures in the watershed, however, should be redesigned, replaced, and maintained so that the chance of flooding on property adjacent to the creek is minimized.

Several estimates of peak flow characteristics have been modeled from both simulated and observed data collected from Duck Creek over the years (Table 3). USGS calculations are preliminary, because they are based on only 4 years of data. That estimate, however, is based on actual streamflow records that included an event that produced the second highest stream flows in 46 years of record on other streams in the Juneau area. That estimate is notably similar to the FEMA estimate that was based on a model using precipitation, runoff area, and the effects of existing culverts.

Table 3.--Estimated peak flow (discharge in ft^3/sec) in Duck Creek at various locations and recurrence intervals.

Data Source	10 year event	25 year event	50 year event	100 year event
		Discharge at Nancy Street		
USGS	53	60.3	65.6	70.0
FEMA	51		62	
R&M Engineering		110		
		Discharge at Radcliff Road		
FEMA	140		209	254
R&M Engineering		120		

R&M (1996) estimates were inconsistent with USGS and FEMA estimates but may be more representative of actual flows at the Radcliff Road Crossing. R&M estimates for the Radcliff Road crossing were lower than FEMA estimates because FEMA assumed that Jordan Creek would overflow into Duck Creek in the Glacier Highway area. Observations during a 1996 storm event, however, indicate that such overflow is unlikely in anything less than a 200 year recurrence event (Beilharz 1998).

The CBJ is currently developing new stormdrain projects at Taku Boulevard, Tongass Boulevard, and McGinnis Drive, and has other projects in the Duck Creek watershed scheduled for future construction.

8.5 ECONOMICS

In Alaska, natural resources drive most economic development, a trend likely to continue. Here in Juneau, government employment has provided a relatively stable economy; however, State economic forecasts (Tromble 1998) indicate that stability could decline due to lack of diversity. Like the rest of Alaska, natural resources are probably the key to Juneau's future economic diversity and sustained development.

Natural resources have always provided Juneau with a wide variety of economic uses including consumptive uses like mining, renewable uses like fishing, and non-consumptive uses through tourism. To allow more diverse economic use of such resources, planners must be able to develop careful and conservative land-use practices that provide for new development at the least risk to beneficial or protected resources.

A watershed framework for land-use is clearly the most practical management strategy for sustained economic use of natural resources. However, current land-use management in Juneau focuses primarily on human demographics, whereas the basis for new economic development--natural resources--are distributed geographically. A watershed management strategy would provide both geographic land-use management and more informed consideration of economic "costs" and "benefits" associated with new development. For example, development costs might include consumption or degradation of common property resources economically important to the community (e.g., water quality, fisheries, drainage capacity, and aesthetics). Benefits might include new or better paying jobs and lower costs for utilities, transportation, or safety. Based on such principles, the economic return and the resource protection provided by land-use strategies could be better tested in the planning phase.

Rights to use property must always be provided to owners, but property owners must also be more accountable for the broader economic cost of their property uses. If new development creates "common property" economic costs (e.g., maintenance and insurance costs of flood control) or reduces business opportunities (e.g., fishing, tourism), those costs should not be paid fully by the public or business community. Conversely, owners of property that includes significant protected or "common property" resources should receive incentives or compensation for maintenance and restoration of those resources. Current land-use management cannot really account for benefits and costs of new development and has not promoted resource protection incentives. Under current management, benefits (e.g., sewer extensions, flood control, water quality treatment) may be unrealized and costs (e.g., maintenance, insurance, safety) may be passed through to the community rather than being paid by the developer. Again, a watershed management strategy will provide the best means of applying land-use policies to equitably distribute those net economic costs. By using distinct indicators of watershed health, such as water quality and aquatic productivity, land-use managers and the community can also monitor and rapidly evaluate management effectiveness within a watershed.

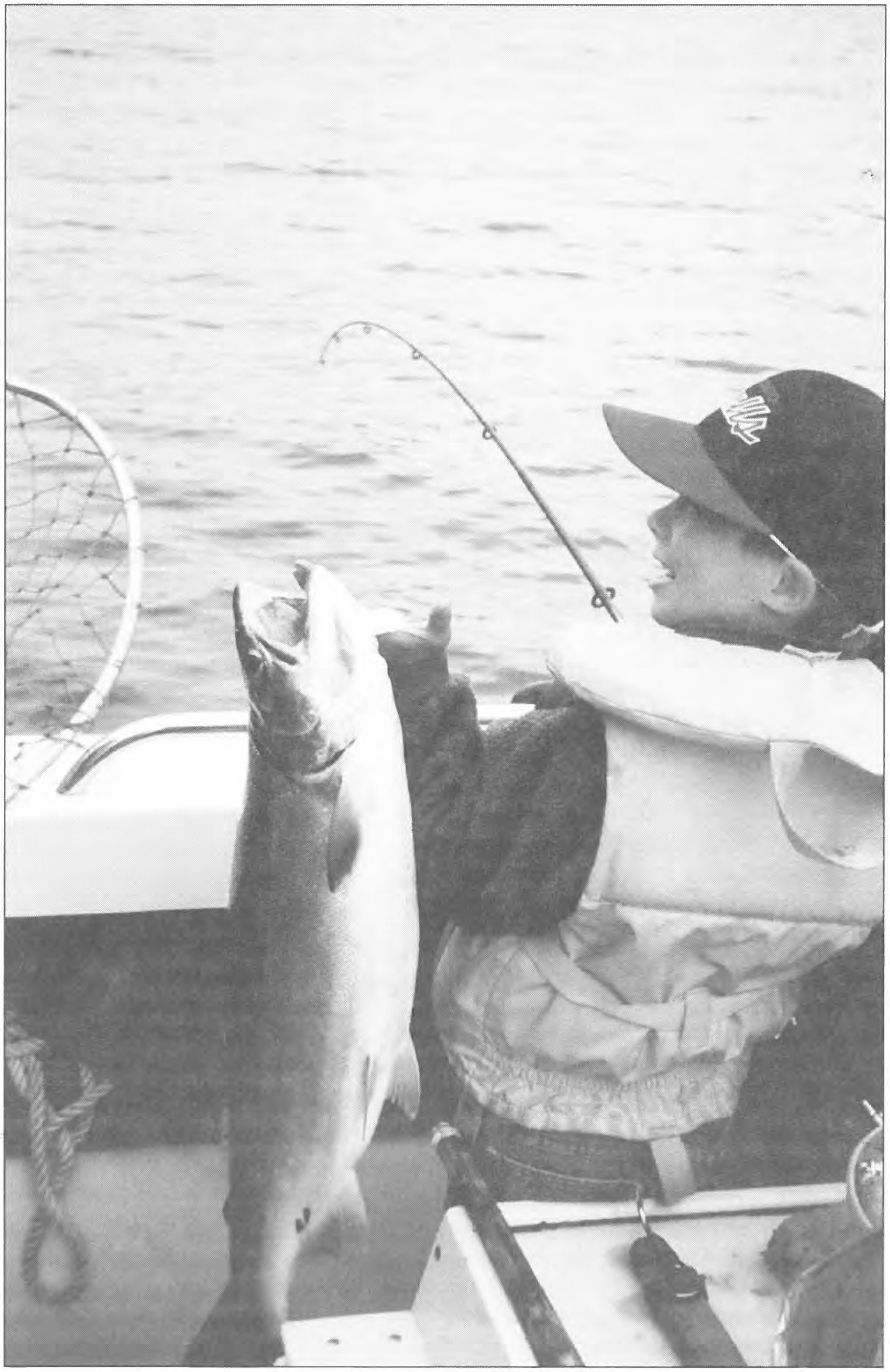
In developing this Plan, the DCAG has demonstrated the use of a watershed framework to implement such economic principles through partnerships between agencies, conservation groups, property owners, and developers (see section 3.0). Those partnerships have provided the DCAG with the matching funds and "in-kind" cooperation needed to obtain restoration funding from agencies and conservation groups. Property owners and development partners have been compensated by reducing their costs or liabilities. By involving municipal, State, and Federal land-use managers, many more opportunities than the DCAG had can be made available to develop economic incentives and funding.

8.6 RECREATION

Prior to its degradation, the Duck Creek watershed was used extensively for recreation. Many long-time residents recall sportfishing, hiking, berry picking, hunting, and trapping in the watershed up until the late 1960s. Careless urban development has resulted in a degraded watershed where most of those recreational uses are now either dangerous, aesthetically repulsive, or prohibited. Accepting that some recreational uses cannot be fully restored and that others (e.g., hunting) would be too dangerous to resume, the DCAG advocates restoration that will develop the remaining riparian areas and waterways for low impact recreation (e.g., hiking, sportfishing, and wildlife viewing).

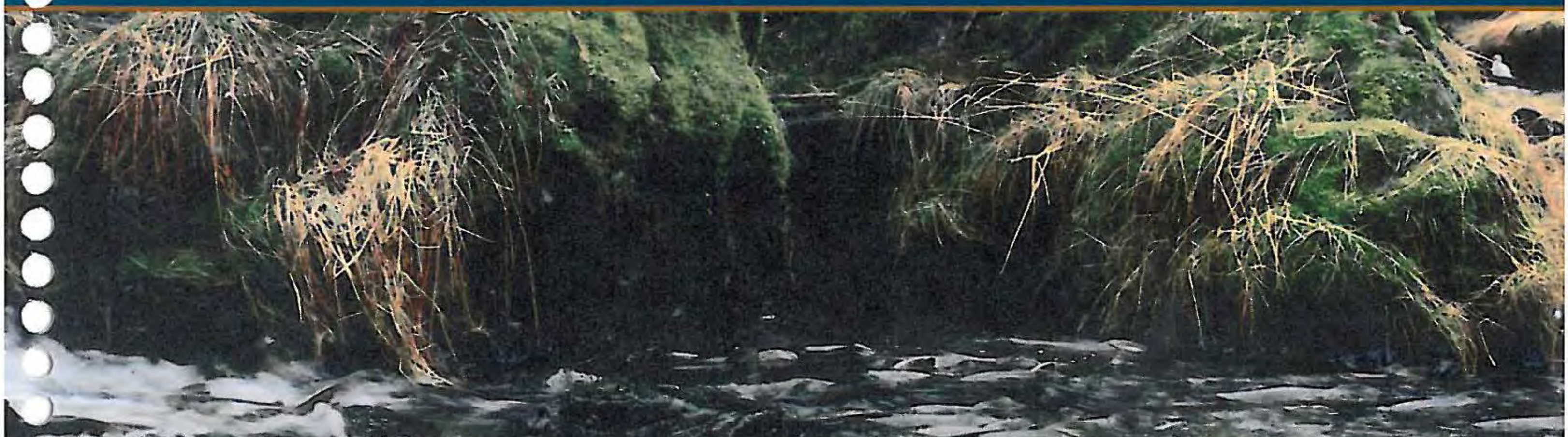
In urban communities, growth and congestion consistently increase the value of open space provided by protected wetland and waterway areas. "Greenbelt" and "floodway" areas are protected from filling and construction primarily to maintain features such as community health standards, flood prevention, and aquatic habitat, but can also be used for low-impact recreation. Trails are already being developed in similar areas of the Mendenhall Valley, and with thoughtful planning, could be developed in some protected areas in the Duck Creek watershed. Hopefully use of the watershed by fish and wildlife will increase, and some areas may eventually be reopened to sportfishing.

Sportfishing and wildlife viewing would also be excellent recreational uses of Duck Creek. DCAG studies indicate that if water quality and habitat are improved, fish numbers could increase sevenfold. As restoration proceeds, the Department of Fish and Game should monitor fish numbers closely to evaluate whether fishable populations exist. Wildlife viewing is a pastime currently enjoyed by many watershed residents that would also improve through habitat restoration. The creation of shallow marshes and placement of nesting boxes, for example, could substantially expand use of the area by waterfowl and shorebirds.



III

APPENDICES



Effective and strong partnerships are the key for both restoring impaired watersheds and sustaining healthy ones.

APPENDIX A ACKNOWLEDGMENTS

Many individuals and agencies have contributed to Duck Creek restoration and protection. In the mid-1960s members of the Alaska Chapter of the American Institute of Fisheries Research Biologists, particularly Theodore Merrell, Jr., W. Sheridan, George Y. Harry, and Fred Thorsteinson, provided insights and involved the community in protecting and restoring Duck Creek. Juneau Trout Unlimited received the initial grant for Duck Creek restoration from TU's national Embrace-A-Stream program. The grant rallied professional interest and provided resources--both financial and human--for initiation of baseline development. Without the financial support provided by EPA's CWA Section 319 Nonpoint Pollution Program through Christine Kelly, EPA Region 10, the Duck Creek Watershed Program would not have succeeded. Many federal, state, and municipal government mangers and scientists incorporated DCAG into their already full agendas; and non-governmental or educational groups, businesses, the local news media, and interested individuals played a key role in representing other interests and contributing to the program.

USFWS: Sue Walker, Julee Beasley
NMFS: Brandee Gerke, Jim Papoi, Linda Shaw, Shawna Rudio, Mark Timko, Carol Tocco, Doris Alcorn
USGS Water Resource Division: Harold Seitz, Kevin Linn, Bruce Bigelow, Ed Neil, Randy Host
USFS: Margaret Beilharz, Keith Carpenter, Don Martin, Jim Stapleton
EPA: Christine Kelly, Steve Torok, Lee Daneker
NRCS: Bob Tribelhorn, Jay Cobb, Jim Schmidt
COE: Ralph Thompson, John Burns
ADEC: Drew Grant, Bill Janes, Mark Anderson, Carl Schrader, Kenwyn George, Steve Willingham, Jim Powell
ADFG: Janet Schempf, Kevin Brownlee, Jon Lyman, Clayton Hawkes, Ben Kirkpatrick, Mark Schwan
ADGC: Jackie Timothy, Steve Wright
ADNR : Rick Noll, Brian Sonner
ADOT: Van Sundberg, Kris Benson
Southeast Conference: Berne Miller
CBJ: Bill Smith, Terry Stone, Joe Buck, Jeff Carpenter, Ben Pollard, Dave Miller, Allan Heese, Karen Brown
Southeast Alaska Guidance Association: Mark Ramonda, Joe Parrish, Leah Bower, Vita Wilson, Ian Dinneford
Juneau Trout Unlimited: Steve Kessler, Ron Dunlap, Dave Gregovich, John Hudson, Ken Montoure
Discovery Foundation: Richard Carstensen
Juneau Youth Services: Pat Quigley
Juneau Rotary Clubs: Jon Scribner
Juneau Public Schools: Maggie Jacoby, John Norton
Douglas Indian Association: Douglas Dobyns, Helen Dangel
Goldbelt Inc.: Randy Wanamaker
University of Alaska: Randy Stahl, Mike Stekol, Bill Smoker
Arete Construction: Ed Sessions
Hanna Construction: Dave Hanna
Channel Construction Inc: Ray Derosier
Howell Construction: Don Howell
Landscape Alaska: David Lendrum
Jensen Yorba Lott Inc.-Architects: Chris Mertl
Homeowners along Duck Creek: Wilson Valentine, Steve Seymour, Grey Pendelton, Victoria Thomas, Doug Redburn
Mendenhall Watershed Partnership: Barb Sheinberg, Jan Caulfield

Funding for **NMFS** participation came from the **ABL Habitat Program** and **NMFS Restoration Center**. Protection of anadromous fish habitat has long been an important goal of the National Marine Fisheries Service Auke Bay Laboratory (ABL). Restoration of an urban stream such as Duck Creek is an increasingly important aspect of maintaining Pacific salmon.

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APPENDIX C BASELINE PARAMETERS

The baseline assessments and parameters used to develop this Plan are shown in Table 4 and the study site locations in Figure 21. Those assessments provided both the means to establish restoration goals and the basis for scientific evaluation of the effectiveness of the Watershed Management Plan. Paired comparison of assessments in different watershed provides the means of evaluating the plan and restoration strategies.

Biological assessments included aquatic invertebrate diversity, and measurements of biological stress associated with water and substrate pollution. Key habitat features such as stream flow, water quality, water temperature, substrate composition, and riparian vegetation characteristics were also measured seasonally or periodically. Continuous measurements of stream flow for Duck Creek and Jordan Creek were contracted to the USGS.

Coho salmon serve as representative or indicator species with which to estimate overall habitat capability for fish and wildlife. Studies conducted seasonally from 1994 included rearing habitat capability, smolt yield and marine survival, and egg-to-fry survival. Coho were selected for several reasons: 1) they are relatively abundant, economically important, and practical to enumerate and monitor throughout their life history; 2) they use nearly all wetted areas of the watershed during some part of their life history; 3) their general habitat use and response to degraded water quality and habitat function is relatively well documented; and 4) smolt yield is an accepted measure of habitat condition and restoration effectiveness. Specific sampling and analysis methods were published by Lorenz (1997).

Baseline data collected are presented in detail in the Technical Supplement. A summary of some important findings for salmonids in Duck Creek includes:

- The native run of chum salmon is extinct, although there are strays from DIPAC Hatchery in lower Duck Creek.
- The coho run has declined from about 500 (1960s) to less than 20 (1998).
- Nearly all, if not all, coho rearing in Duck Creek migrated there from outside the watershed.
- Egg to fry survival of coho and chum salmon is zero because of poor spawning habitat condition; however, cutthroat trout are able to reproduce in the same habitat.
- Few juvenile coho reside in Duck Creek during summer, however, the average number of overwintering coho (1994-97) was more than 6,000.
- Average fall density of juvenile coho per acre was about 88 in Duck Creek, 87 in Jordan Creek, and 17 in Moose Lake (Dredge Lakes).
- Winter survival rates of juvenile coho, though not significantly different between streams, averaged 50% in Duck Creek, 39% in Moose Lake, and 36% in Jordan Creek over the three year study.
- Salmonid winter survival rates in Duck Creek ranged from 6% in East Fork ponds to 76% in the Super Bear pond.
- In fall, few coho in Duck Creek were visibly parasitized; however, by spring they were visibly parasitized at nearly twice the rate of coho in either Jordan Creek or Moose Lake.
- Between 1,700 and 3,200 coho smolt migrate from Duck Creek each year. Because of inadequate stream flow in the lower reaches, 66% of the smolt require assistance getting to sea and over 25% die.
- Based on a biological condition factor, Duck Creek coho were about 20% lower in condition than coho from Dredge Lakes.
- Coded wire tagged coho from Duck Creek returned to the commercial and sport fisheries at a significantly lower rate than those tagged in other streams in the region. Duck Creek and Dredge Lakes coho were significantly more likely to be caught in more lucrative sport fisheries than fish tagged in either Taku or Berners Rivers.
- Sedimentation from urban development has heavily impacted spawning habitat in Duck Creek; the stream has as much as 30% more fine sediments than study reaches in either Steep Creek or Jordan Creek.
- Salmonid Egg to fry survival in buried Whitlock-Vibert bioassay boxed in 1996 and 1998 was lowest in Duck Creek, highest in Steep Creek, and moderate in Jordan Creek.

Table 4.--Baseline monitoring in Duck Creek: measures of watershed condition and health.

Parameter	Method	Date	Location	Status
		Water Quality		
Temperature	thermograph & Hydrolab®	1993-1998	multiple sites	ongoing
Dissolved oxygen	YSI meter & chemical (surface / intragravel)	1993-1998	multiple sites	complete
Pollutant screening				
ADEC	chemical	1994-1995	5 sites	incomplete
USGS	chemical	1997/1998	multiple sites	incomplete
Hydrocarbons	SPMD/mass spectrometer	1996-1997	multiple sites	complete
Coliform bacteria	culture	1992-1993, 1998	multiple sites	complete
Nutrients				
USGS	chemical	1997	multiple sites	incomplete
Student	chemical	1996	multiple sites	complete
Sediment	USGS	1995	multiple sites	incomplete
Conductivity, pH, redox	Hydrolab®	1994-1997	multiple sites	complete
Dissolved iron	chemical	1997-1998	multiple sites	ongoing
		Stream Flow		
Continuous	gaging station	1993-	1 site	ongoing
Point	staff gages	1993-	multiple sites	ongoing
		Groundwater		
Well levels	USGS	1996 -	2 sites	ongoing
	Beilharz (USFS)	1997	multiple sites	complete
	Knoll (ADNR)	1995	multiple sites	complete
		Anadromous Fish		
Juveniles				
density	population estimates	1993-1997	multiple sites	complete
survival	population estimates	1993-1997	multiple sites	complete
Smolts				
yield	counts	1993-1998	2 streams	complete
species	counts	1993-1998	2 streams	complete
Adults				
escapement	counts	1993-1997	3 streams	complete
survival	CWT	1994-1998	2 streams	complete
catch	CWT	1994-1998	2 streams	complete
Eggs				
survival	Whitlock box	1996, 1997	3 streams	complete
survival	excavation	1996	2 streams	complete

Parameter	Method	Date	Location	Status
		Marine Fish		
Species	fykes/seines	1996/98	estuary	incomplete
		Stream Invertebrates		
Species	Serber	1994-1995	multiple	complete
Microtox	bioassay	1994	multiple	complete
Fish food	gut analysis	1995	multiple	incomplete
		Habitat		
Rearing				
stream	measurements	1993-1997	multiple	complete
ponds	measurements	1993-1997	multiple	complete
estuary	measurements	1995/1998	multiple	incomplete
Spawning				
gravel	% composition	1996	multiple	complete
gravel	% composition	1998	multiple	incomplete
permeability	standpipes	1996	multiple	complete
oxygen	standpipes	1996/98	multiple	complete
iron	standpipes	1996/1998	multiple	complete
		Stream Channel		
Topographic profile	survey	1994	Duck Creek mainstem	complete
Topographic profile	R&M Engineering	1997	Duck Creek mainstem	complete
Cross-sections	survey	1994	stream	complete
Reach profile	HGM	1996	multiple	complete
		Riparian Vegetation		
Species	Discovery Foundation	1996	multiple	complete
		Aerial Photos/Maps		
Discovery Foundation	watershed map	1996	watershed	complete
Grotefendt	aerial photos	1996	stream	complete
Grotefendt	maps	1996	reach/basin	incomplete
R & M Engineering	drainage boundary map	1997	basin	complete
		Land Development Activities		
Comprehensive Plan	CBJ	1997	Borough wide	complete
Wetlands Management Plan	CBJ	1997	wetlands	complete
		GIS Database		
CBJ	ArcInfo® map	1998	Mendenhall Valley	complete

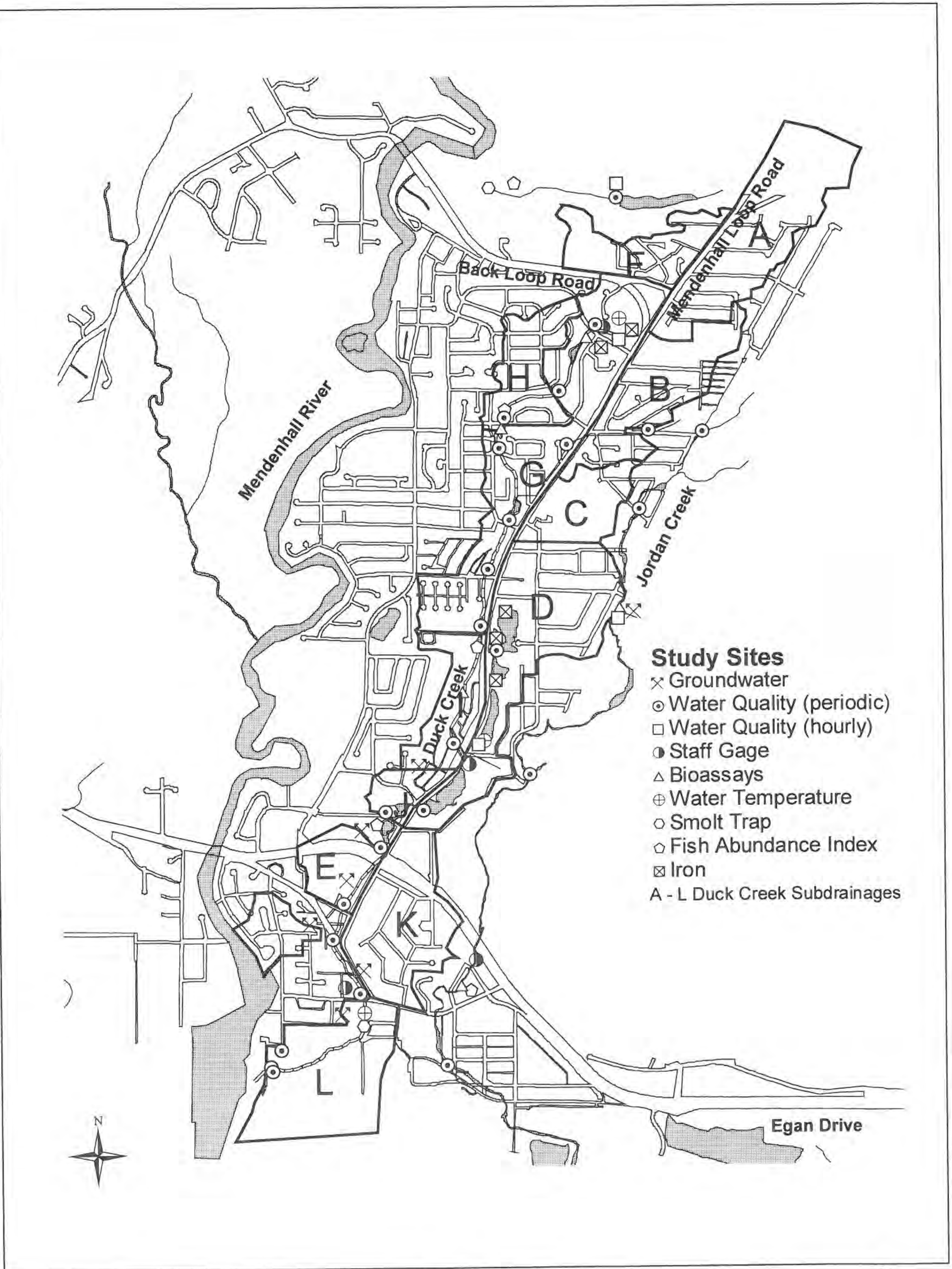

Back Loop Road
Mendenhall Loop Road
Mendenhall River
Jordan Creek
Duck Creek
Egan Drive
A
B
C
D
E
F
G
H
I
J
K
L
Study Sites
Groundwater
Water Quality (periodic)
Water Quality (hourly)
Staff Gage
Bioassays
Water Temperature
Smolt Trap
Fish Abundance Index
Iron
A - L Duck Creek Subdrainages
N

Figure 20

APPENDIX D GLOSSARY

AC (Alaska Administrative Code): Regulations enacted by State agencies.

ADEC (Alaska Department of Environmental Conservation)

ADFG (Alaska Department of Fish and Game)

ADGC (Alaska Division of Governmental Coordination)

ADNR (Alaska Department of Natural Resources)

ADOT (Alaska Department of Transportation)

AS (Alaska Statute): State laws enacted through legislation.

BMP (Best Management Practice): As defined by federal code: "A best management practice (BMP) is a means of practice or combination of practices that is determined by a state (or designated area-wide planning agency) after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals. "

Borrow Pit: a gravel mining area.

Buffer: 1) An area of land separating two distinct land uses that acts to soften or mitigate the effects of one land use on the other. 2) The area that surrounds a wetland and that reduces adverse impacts to it from adjacent development.

Catalogued salmon stream: Streams listed in the *Catalog of waters Important for the spawning, rearing, or migration of anadromous fishes* compiled and published by the Alaska Department of Fish and Game.

CBJ (City and Borough of Juneau)

CFR (Code of Federal Regulations): Regulations enacted by Federal agencies.

COE (Army Corps of Engineers)

CWA (Clean Water Act): 1. Common usage name for the Water Pollution Control Act of 1972 and its amendments. 2. The primary Federal laws restricting activities that affect watershed resources. The CWA stipulates maintenance of water quality and habitat standards to protect environmental health.

DCAG (Duck Creek Advisory Group): A community group formed in 1993 to bring together technical experts, community members, and funding sources to provide a catalyst for applying community-based concepts for watershed management and restoration.

EPA (Environmental Protection Agency)

FEMA (Federal Emergency Management Agency)

Instream flow reservation: A water right provided under AS 46.15.145, that protects specific instream water uses, such as fish spawning or recreation. The reservation sets aside the water necessary for specified instream activities and prevents later water appropriation from affecting that activity.

Interstitial water: Water in spaces between particles of the substrate; as opposed to surface water.

Iron floc: Particulate clumps of oxidized iron.

JCP (Juneau Comprehensive Plan): The long-range plan of the CBJ intended to guide growth, safeguard the environment, provide affordable housing, and establish reasonable controls over land development and public services.

JWMP (Juneau Wetlands Management Plan): A planning covenant that provides a means of wetland classification, specifies protection, development, and mitigation policies for those wetlands, and allows more predictability in the permit process for wetland development within its jurisdiction.

Mitigation banking: A process that establishes 'credits' for creating, restoring, enhancing, or permanently preserving wetlands that may then be held or sold for use in mitigating wetland impacts caused by development.

MWP (Mendenhall Watershed Partnership): A citizens' group, formed January 1998, to maintain and enhance the environmental quality and economic vitality of the Mendenhall watershed (of which Duck Creek is part) in Juneau, Alaska. The Partnership consists of a diverse group of people who affect, and are affected by, environmental and economic conditions in the Mendenhall watershed including home and land owners, builders and developers, business owners, conservationists, realtors, engineers, landscape architects and teachers. Partnership activities focus on public education and action, consideration of land-use planning and development in the watershed, and watershed restoration and enhancement projects.

NMFS (National Marine Fisheries Service)

Non-point source pollution: Pollution for which a specific point of origin is not easily defined. For example, crankcase oil in stormwater runoff from streets may be a significant pollutant, but probably accumulates inconspicuously from many different vehicles.

Ordinary High Water Mark [Source: 33 CFR § 328.3(e)]: "That line on the shore established by the fluctuations of water and indicated by physical characteristics such as clear, natural lines impressed on the bank, shelving, changes in the character of the soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas."

PAH (polycyclic aromatic hydrocarbon): Hydrocarbon compounds that are generally considered the most toxic of petrochemicals. Pollution by such compounds makes water unfit for consumption and increases cancer risks for humans.

Permit: A regulatory contract that specifies conditions under which certain activities can occur, generally to assure compliance of the activity with legal and safety requirements.

Regulation: Means used by appropriate agencies to apply legislated or court ordered directives.

Riparian (riparian zone): The area and vegetation such as trees, shrubs, and grasses along the banks of a stream, lake, or wetland. The riparian zone plays an important role in maintaining stream flow, water quality, and fish and wildlife habitat.

SAGA (Southeast Alaska Guidance Association)

Statute or Code: Legal format of laws and ordinances.

Stewardship: A cooperative form of planning and management of natural resources in which all users and managers share the responsibility for management and conservation. Stewardship embodies a new ethic of caring for local ecosystems in the interests of long-term sustainability.

Stream crossing: Man-made traverse of a waterbody (e.g., bridge, culvert, ford).

Technical Supplement: The Technical Supplement to the Duck Creek Watershed Management Plan is a reference volume, a separate document for those implementing the Plan. It contains baseline data from Duck Creek studies, BMPs, suggested reading, and other supplemental information.

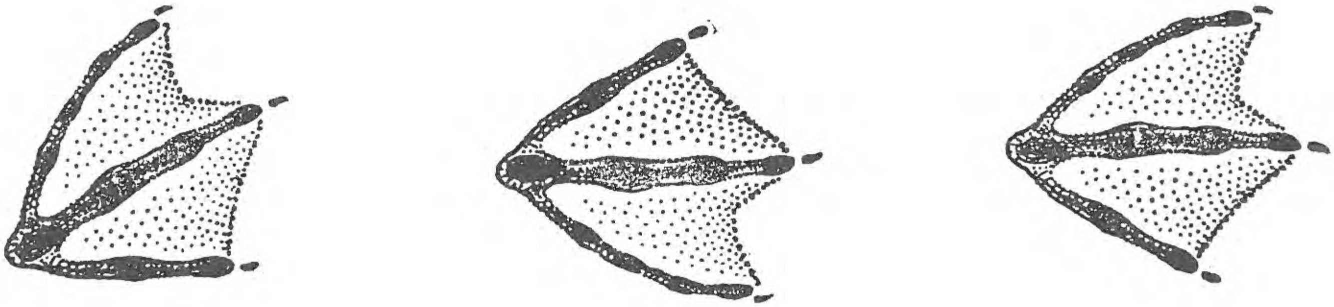
USC (United States Code): Federal laws enacted by legislation.

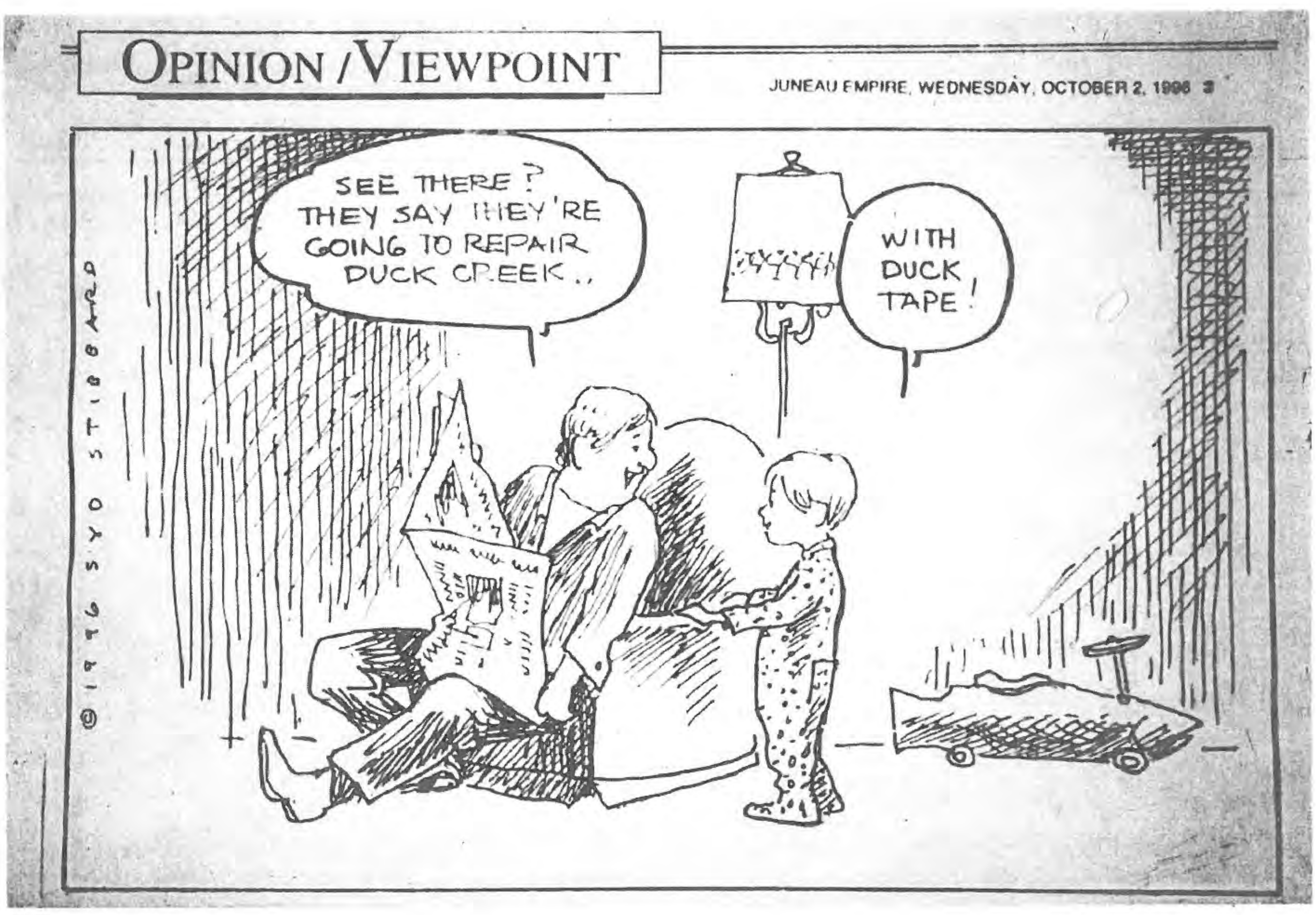
USFS (U.S. Forest Service)

USFWS (U.S. Fish and Wildlife Service)

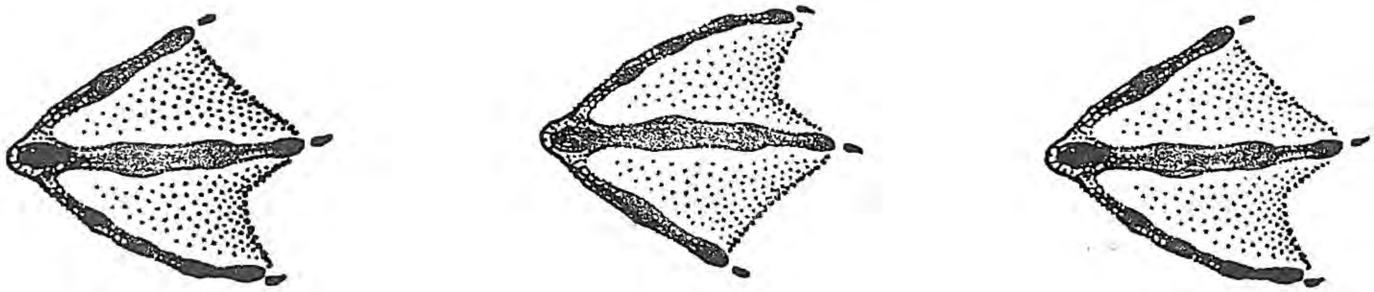
USGS (U.S. Geological Service)

Watershed: 1. The complete area within which water flows to a common point, including both surface and groundwater that discharges to or receives from that surface water. 2. A waterway and the surrounding land that drains water into it. 3. Watersheds are nature's boundaries for water resources. When rain falls or when snow melts, water flows downhill through rivulets, brooks, wetlands, drains, and ditches into streams, rivers, and lakes, and eventually to the ocean.





Courtesy of the *Juneau Empire*.



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