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EXECUTIVE SUMMARY

Home to more than 53,000 people[1], the Kenai Peninsula Borough (KPB) encompasses over 24,000 square miles. Due in part to the development of diverse key resources such as fishing, tourism, oil and gas development and timber, communities and facilities are distributed throughout the Borough. The large size and substantial regional variations in climate and geographic features contribute to the Borough's vulnerability to natural hazards such as flooding, earthquakes, tsunamis, winter storms and wildfire. As such, it is important to identify and implement strategies to lessen the effects of these and other potential hazards on infrastructure, critical facilities and communities. While it is not possible to prevent natural disasters from occurring, it is feasible to minimize their impacts to life and property with well-defined comprehensive hazard mitigation planning.

This document is a multi-jurisdictional All-Hazard Mitigation Plan developed by the Kenai Peninsula Borough (KPB) in coordination with the incorporated cities within the KPB, the Alaska Division of Homeland Security and Emergency Management (DHS&EM), and the Federal Emergency Management Agency (FEMA). This plan is designed to assist Borough residents, local and private organizations and other parties interested in hazard mitigation planning, as well as to coordinate planning efforts between government agencies. The plan is a living document, which will be updated on a five year cycle or reviewed within 90 days of a Presidential Disaster Declaration and updated as necessary within the following twelve months.

Eight hazard sections were completed: floods and erosion, wildfires, earthquakes, weather, tsunamis and seiches, volcanoes, avalanches and human-caused hazards.

The Introduction (Section 1.0) contains information about plan development and process, outreach, plan implementation and update processes, community profiles, critical facilities and risk assessments. Each of the eight hazard-specific sections (2.0 – 9.0) contain: 1) a history of hazard events in the KPB; 2) facilities and populations at risk; and 3) potential strategies and implementation ideas to reduce loss from future hazard events. Most sections also include a resource directory.

All-Hazard Mitigation Plan Goals, Objectives and Strategies
Three overall goals were identified to mitigate the damaging effects of natural hazards that impact the Borough: ***protection, prevention and education.***

The following objectives were also identified to further define and direct the development of mitigation strategies. Strategies should:

- modify the impacts of hazard events by assisting individuals and communities to prepare for, respond to and recover from hazard events;
- reduce the susceptibility to damage and disruption by avoiding hazardous, uneconomic and unwise development in known hazard areas;
- protect the natural and beneficial values of floodplains, coastal areas and water resources; and

[1] Alaska Department of Labor 2009 Vintage Place Estimates 2009.

- reduce unnecessary economic losses and promote positive economic development by incorporating hazard assessment and mitigation into land use and development decisions.

For each hazard, strategies were further developed into implementation ideas and action items. The implementation ideas and action items are a detailed, though not exhaustive, list of suggestions to reduce threats to life and property from each hazard and ultimately accomplish the plan goals and objectives.

Contributing Plans

Six incorporated cities are located within the KPB: Homer, Kachemak City, Kenai, Seldovia, Seward and Soldotna. With the exception of Seldovia, each City has completed its own Hazard Mitigation Plan. They have identified their key hazards, examined their hazard history, identified critical facilities and structures at risk and identified potential mitigation measures to reduce damage to their communities from future events. The City plans are included as Annex Sections to this document and are also available from each City. In addition, the Port Graham Flood Mitigation Plan[1] and the Interagency All Lands / All Hands [Wildfire] Action Plan are included as Annexes to this plan. The All Lands / All Hands Plan was developed by an interagency coordinating committee[2], of which the KPB is a member. Recently renewed, the All Lands / All Hands Action Plan has been incorporated as the comprehensive Wildfire Hazard section of this plan.

The following table summarizes the implementation strategies developed for the eight completed natural hazard sections, including possible coordinating agencies, plan goals addressed, a timeline and the location of the strategy in the plan.

[1] Port Graham completed a Flood Mitigation Plan as a prerequisite for receiving Federal flood mitigation project funding. They do not currently intend to complete an all-hazard plan. Their Flood Mitigation Plan was included in this document to supplement the flood mitigation information for the Borough.

[2] Formally known as the "Kenai Forest, Wildland Fire and Fuels Management Coordinating Committee".

Mitigation Strategy	Potential Participants	Plan Goals			Timeline	Location in Plan
		Protection	Prevention	Education		
Floods and Erosion						
Complete a Borough-wide flood hazard risk assessment.	KPB, Incorporated Cities, Alaska Department of Transportation and Public Facilities (ADOT&PF), Permitting Agencies, Kachemak Bay Research Reserve (KBRR), Coastal Training Program Alaska (CTP Alaska).	X	X		In Progress	Section 2.0
Develop mechanisms to enhance floodplain permit compliance.	KPB Planning, Road Service Area, GIS, Assessing and Management Information Services Departments	X	X	X	1-2 years and ongoing	Section 2.0
Improve KPB floodplain mapping and identify other effective tools or methods to assist with flood hazard assessment.	KPB, U.S. Army Corps of Engineers (USACOE), FEMA, U.S. Geological Survey (USGS), Incorporated Cities, State of Alaska Dept. of Community and Economic Development (DCED), KBRR	X	X		1-5 years (as funding allows)	Section 2.0
Cooperate with the City of Seward and the Seward/Bear Creek Flood Service Area Board to identify, prioritize and implement cost effective strategies for controlling flood damage.	KPB, City of Seward, Seward/Bear Creek Flood Service Area Board, USACOE, USGS, FEMA, DCED	X	X		1-5 years (as funding allows)	Section 2.0
Review and appropriately revise floodplain development standards and requirements.	Affected KPB Departments, USACOE, FEMA, DCED, Incorporated Cities	X	X		1-5 years (as staff and funding permit)	Section 2.0
Research and implement alternative floodplain management strategies.	KPB, Incorporated Cities, U.S. Army Corps of Engineers, FEMA, DCED, KBRR, CTP Alaska		X	X	Ongoing	Section 2.0
Evaluate Borough-maintained roads for floodplain hazards and potential flood reduction projects.	KPB, Private Non-Profit Organizations, FEMA, Alaska Division of Homeland Security and Emergency Management (DHS&EM)	X	X		Ongoing	Section 2.0
Protect and maintain beneficial floodplain natural values.	KPB, Private Non-Profit Organizations, Environmental Protection Agency (EPA), FEMA, Alaska Department of Environmental Conservation (ADEC), DNR/Parks, DNR/Office of Habitat Management and Permitting (OHMP), CTP Alaska	X		X	Ongoing	Section 2.0

Promote positive economic development.	KPB, Private For-Profit and Non-Profit Organizations, EPA, FEMA, ADEC, DNR/Parks, DNR/OHMP		X	X	Ongoing	Section 2.0
Enhance existing emergency preparedness practices.	KPB, USGS, EPA, FEMA, USACOE, ADEC, DNR/Parks, DNR/OHMP	X		X	Both immediate and on-going	Section 2.0
Provide flood hazard and floodplain development education and information.	KPB, FEMA, Division of Community Advocacy, DCED, Cities of Homer and Seward			X	Ongoing	Section 2.0
Identify and develop partnership opportunities.	Local, State and Federal Agencies; Private For Profit and Non Profit Organizations and Other Interested Partners	X		X	Ongoing	Section 2.0
Wildfires[1]						
Goal 1: Improve Fire Prevention and Protection						
Increase firefighting readiness and reduce the risks to homes and private property through prevention education.	USFS, State of Alaska Division of Forestry, USDI Fish and Wildlife Service, USDI BLM, USDI National Park Service, KPB, USDI Bureau of Indian Affairs, Cook Inlet Resources	X	X		5 years	Annex H
Goal 2: Reduce Hazardous Fuels						
Promote defensible space fuel reduction from "the back porch out" on 17,550 parcels of private land parcels containing structures.	USFS, State of Alaska Division of Forestry, USDI Fish and Wildlife Service, USDI BLM, USDI National Park Service, KPB, USDI Bureau of Indian Affairs, Cook Inlet Resources	X		X	5 years	Annex H
Conduct mechanical and prescribed fire fuel reduction in the Wildland Urban Interface (WUI) and outside the WUI on about 97,000 acres.	USFS, State of Alaska Division of Forestry, USDI Fish and Wildlife Service, USDI BLM, USDI National Park Service, KPB, USDI Bureau of Indian Affairs, Cook Inlet Resources	X	X		5 years	Annex H
Conduct mechanical fuel reduction adjacent to 641 miles of power lines.	USFS, State of Alaska Division of Forestry, USDI Fish and Wildlife Service, USDI BLM, USDI National Park Service, KPB, USDI Bureau of Indian Affairs, Cook Inlet Resources	X	X		5 years	Annex H
Conduct mechanical fuel reduction adjacent to 222 miles of highway/road evacuation routes.	USFS, State of Alaska Division of Forestry, USDI Fish and Wildlife Service, USDI BLM, USDI National Park Service, KPB, USDI Bureau of Indian Affairs, Cook Inlet Resources	X	X		5 years	Annex H

[1] From the Interagency All Lands/All Hands Action Plan Executive Summary, July 2004 Final Draft, Warren Oja (Team Leader).

Goal 3: Restore Forest Health and Desired Ecosystems						
Restore forest cover on about 199,000 acres.	USFS, State of Alaska Division of Forestry, USDI Fish and Wildlife Service, USDI BLM, USDI National Park Service, KPB, USDI Bureau of Indian Affairs, Cook Inlet Resources		X		5 years	Annex H
Goal 4: Promote Community Assistance						
Collaborative development of 20 Community Wildfire Protection Plans in the KPB as per direction from the Healthy Forests Restoration Act of 2003.	USFS, State of Alaska Division of Forestry, USDI Fish and Wildlife Service, USDI BLM, USDI National Park Service, KPB, USDI Bureau of Indian Affairs, Cook Inlet Resources	X		X	5 years	Annex H
Earthquakes						
Identify and prioritize studies and retrofit measures for KPB critical facilities and infrastructure that are seismically vulnerable.	KPB, Incorporated Cities, Local Emergency Planning Committee (LEPC), FEMA, DHS&EM	X	X		1-5 years (as funding allows)	Section 4.0
Encourage the reduction of non-structural and structural earthquake hazards in homes, businesses and government offices.	KPB Office of Emergency Management (OEM) and Capital Projects Departments, LEPC, Community Schools Program (KPB School District), DHS&EM, Local Realtors, Local Construction Companies, Incorporated Cities	X		X	Ongoing	Section 4.0
Encourage KPB residents to purchase earthquake hazard insurance.	KPB OEM and Capital Projects Departments, Local Insurance Companies	X		X	Ongoing	Section 4.0
Identify oil and gas producing facilities that pose a risk to the Kenai Peninsula Borough due to their proximity to active faults.	KPB OEM, Alaska Division of Geological & Geophysical Surveys (DNR), USGS, Local Oil and Gas Companies	X	X		Ongoing	Section 4.0
Perform earthquake hazard mapping for the Kenai Peninsula Borough and improve technical analysis of earthquake hazards.	KPB OEM and GIS Departments, Alaska Division of Geological & Geophysical Surveys (DNR), USGS, Incorporated Cities	X	X		Liquefaction-susceptibility maps (2-4 years)	Section 4.0
Augment KPB communications and facility support.	KPB OEM, Capital Projects and Road Service Area Departments, ADOT&PF, Local Utility Companies	X		X	Ongoing	Section 4.0
Conduct mock emergency exercises to identify response vulnerabilities.	KPB OEM, LEPC, Emergency Service Divisions, Incorporated Cities			X	Ongoing	Section 4.0
Minimize damage to residential structures in the unincorporated areas of the Kenai Peninsula Borough.	KPB; Incorporated Cities, Local Insurance Companies	X		X	Ongoing	Section 4.0

Weather						
Increase public awareness of severe winter storm mitigation activities and emergency response.	National Weather Service (NWS), DHS&EM, KPB OEM, LEPC, Local Utility Companies, Incorporated Cities		X	X	Ongoing	Section 5.0
Enhance weather monitoring and warning systems.	NWS, DHS&EM, KPB OEM, LEPC, Incorporated Cities	X	X		Ongoing	Section 5.0
Expand local weather monitoring programs.	KPB OEM, NWS, DHS&EM, Police, Fire & Emergency Service Providers, Incorporated Cities	X	X		Ongoing	Section 5.0
Minimize damage to residential structures and private property in the Kenai Peninsula Borough.	NWS, KPB OEM, Capital Projects Division, LEPC, Community Schools Program (KPB School District), DHS&EM, FEMA, Local Realtors, Local Construction Companies, Incorporated Cities within the KPB	X	X	X	Ongoing	Section 5.0
Tsunamis and Seiches						
Increase public awareness of tsunami and seiche mitigation activities and emergency response.	Communities of Homer, Seward, Seldovia, Port Graham and Nanwalek, DHS&EM, KPB OEM, LEPC		X	X	Ongoing	Section 6.0
Conduct mock tsunami response exercises to identify response vulnerabilities.	KPB OEM, LEPC			X	Ongoing (2-4 years)	Section 6.0
Enhance tsunami-warning systems in KPB coastal communities.	NWS, DHS&EM, KPB OEM, LEPC, Incorporated Cities	X	X		Ongoing (2-4 years)	Section 6.0
Minimize tsunami damage to structures in the Kenai Peninsula Borough.	NWS, KPB OEM, Capital Projects Division, Planning, and Floodplain Programs, LEPC, Community Schools Program (KPB School District), DHS&EM, FEMA, Local Construction Companies, Incorporated Cities	X	X	X	Ongoing	Section 6.0
Volcanoes						
Conduct specific outreach to the Alaskan aviation community regarding the hazards posed by Alaskan and Russian volcanoes.	Alaska Volcano Observatory (AVO), DHS&EM, FAA, NWS, Alaska Air Carriers Association		X	X	Ongoing	Section 7.0
Ensure all Alaskan communities at risk from volcanic eruptions are aware of the hazard and what can be done to mitigate risk.	DHS&EM, AVO, USGS, DNR/DGGS, UAF/GI, ARC, DEC, Alaska Public Lands Information Center, KPB, Native corporations		X	X	Ongoing	
Ensure volcanic hazards are addressed in the ongoing revision of the State Emergency Response Plan.	DHS&EM, AVO, USGS, DNR/DGGS, UAF/GI	X			Ongoing	Section 7.0

Expand real time seismic monitoring to high-priority western Aleutian volcanoes.	AVO, USFWS, DOD	X	X		Ongoing	Section 7.0
Avalanches						
Reduce number of structures in high-hazard areas	KPB	X	X		Ongoing	Section 8.0
Increase awareness among property owners of avalanche hazard zones	KPB	X	X	X	Ongoing	Section 8.0
Encourage communities to develop avalanche overlay districts	KPB, DHS&EM	X	X	X	Ongoing	Section 8.0
Improve avalanche warning	Chugach National Forest Avalanche Information Center, Alaska Avalanche Information Center, DOT&PF, NWS	X	X	X	Ongoing	Section 8.0
Promote avalanche education	Alaska Avalanche School, Alaska Avalanche Information Center, KPB, DNR State Parks, USFS (Chugach National Forest)		X	X	Ongoing	Section 8.0
Encourage artificial avalanche release and snow management	DPS, DHS&EM, DOT&PF, DNR	X	X		Ongoing	Section 8.0
Human-Caused Hazards						
Promote public awareness of potential hazards associated with handling of toxic and hazardous substances in the community.	DHS&EM, DEC, KPB		X	X	Ongoing	Section 9.0
Identify any potentially harmful substances used or disposed of within the Borough that are not adequately regulated by state and federal agencies to serve as the basis for future planning, monitoring or enforcement activity.	DHS&EM, DEC, KPB, DOT&PF		X		Ongoing	Section 9.0
Develop interim emergency response capabilities in the event of an accidental discharge of toxic or hazardous substances.	DHS&EM, DEC, KPB, DOT&PF	X	X		Ongoing	Section 9.0

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1.0 INTRODUCTION

1.1 Purpose and Scope of Plan

Natural events such as earthquakes, floods, wildfire and severe winter weather affect all segments of the communities they strike, including individuals, businesses and public services. While it is not possible to eliminate disasters, it is feasible to reduce their impacts. The development and implementation of a Hazard Mitigation Plan is intended to lessen or eliminate losses from natural hazards, as well as from human-caused hazards such as accidental chemical releases.

The Kenai Peninsula Borough (KPB or Borough) has produced this All-Hazard Mitigation Plan (Plan) as part of a statewide multi-jurisdictional document[1]. The Plan focuses on several key hazards that are of concern to the Borough: earthquakes, floods/coastal erosion, wildfires, weather, volcanic activity/ash fallout, avalanches, tsunamis and seiches and human-caused hazards such as levee failure and accidental chemical releases. KPB strategies have been coordinated with those from the incorporated cities within the Borough (see city annex sections) to develop mitigation strategies and actions appropriate for our region and to cooperatively adopt the Plan and Annexes.

1.1.1 All-Hazard Goals, Objectives and Strategies

All hazard mitigation goals can be separated into three main categories: protection, prevention and education.

Protective measures can be structural or non-structural in nature. Examples of structural measures include seismic reinforcement of buildings and bridges and relocating or retrofitting hazard-prone structures. Non-structural mitigation measures include warning systems and emergency response programs.

Preventative measures are typically used to limit exposure to hazards, and may include the use of tools such as comprehensive land use plans, transportation plans, zoning, building codes or land subdivision regulations. Preventative actions might also include limiting development in known hazard areas, preserving open space, acquiring hazard-prone property and participating in outreach and education.

Outreach and education are important components of any hazard mitigation strategy. Community meetings, school activities, emergency preparedness outreach, ads in the media, workplace training, booths at fairs and home shows, brochures and video presentations all provide valuable outreach opportunities.

[1] Alaska Division of Homeland Security and Emergency Management (ADHS&EM). 2002b. State Hazard Mitigation Plan. DMA 2000 Updated September 2004.

Overall hazard mitigation planning objectives focus on saving lives and minimizing the direct and indirect costs of disaster damage[1]. Natural disasters affect all segments of the communities they strike, and their impacts, both measurable and immeasurable, produce long-lasting marks on the social and economic fabric of the community. The following objectives were identified to further define and assist with development of hazard mitigation strategies:

- modify impacts of hazard events by encouraging, assisting and training individuals and communities to prepare for, respond to and recover from hazard events;

- reduce susceptibility to damage and disruption by avoiding hazardous, uneconomic and unwise development in known hazard areas;

- protect natural and beneficial values of floodplains, coastal areas and water resources; and

- reduce unnecessary economic losses and promote positive economic development by incorporating hazard mitigation into land use and development decisions.

For each hazard, a number of mitigation strategies were developed and further expanded into implementation ideas and action items. The strategies and implementation ideas are a detailed, though not exhaustive, list of ideas and actions to reduce the threat to life and property from each hazard and ultimately accomplish the plan goals and objectives.

1.1.2 Overall Plan Development Guidelines

The following basic guidelines supplied by the Alaska Division of Homeland Security and Emergency Management (ADHS&EM) and the Federal Emergency Management Agency (FEMA) Local Mitigation Plan Crosswalk were used to guide the All-Hazard Mitigation Plan development (see Appendix H):

- implement a planning process that includes public involvement;
- conduct an assessment of hazard associated risks;
- determine the facilities or portions of infrastructure that are vulnerable to a disaster;
- develop mitigation strategies to reduce the loss of life and property damage;
- describe how the KPB will periodically evaluate, monitor, maintain and update the plan; and
- describe the process for implementing the plan after adoption by the KPB, and receiving ADHS&EM and FEMA approval.

[1] These objectives are consistent with FEMA hazard mitigation planning process guidelines.

1.1.3 Authority

The purpose of this Plan is to fulfill FEMA local Hazard Mitigation Plan requirements under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, Section 322 (a-d), Mitigation Planning, which were enacted by Section 104 of the Disaster Mitigation Act of 2000 (DMA 2000) (Public Law 106-390). This initiative provides new and revitalized approaches to mitigation planning. Section 322 emphasizes the need for state, local and tribal entities to closely coordinate mitigation planning and implementation efforts. As part of the implementation process, FEMA prepared an Interim Final Rule that clearly establishes the mitigation planning criteria for states and local and tribal governments. This Rule was published in the Federal Register on February 26, 2002, at 44 CFR Part 201.

The DMA 2000, Section 322 (a-d), as implemented through 44 CFR Part 201.6, requires local governments, as a condition of receiving federal disaster mitigation funds, to complete and adopt a mitigation plan that identifies hazards, assesses risks and vulnerabilities and identifies mitigation actions. This Plan was completed to fulfill these requirements for the KPB, and in October of 2004 was passed by the KPB Assembly as Ordinance 2004-33 and enacted in the KPB Code as Chapter 2.80 Hazard Mitigation.

A review and revision process conducted in 2009 and 2010 includes KPB and City adoptions of the Plan and Annexes as revised.

1.2 Plan Organization

Information in the mitigation plan is organized into an introduction overview, hazard-specific sections, city plans located in annexes, and appendices. Because of the size and geographic diversity of the area, the Borough's emergency response zones were used as necessary to further organize and summarize information within each section (Figure 1-1).

Section 1.0 – Introduction

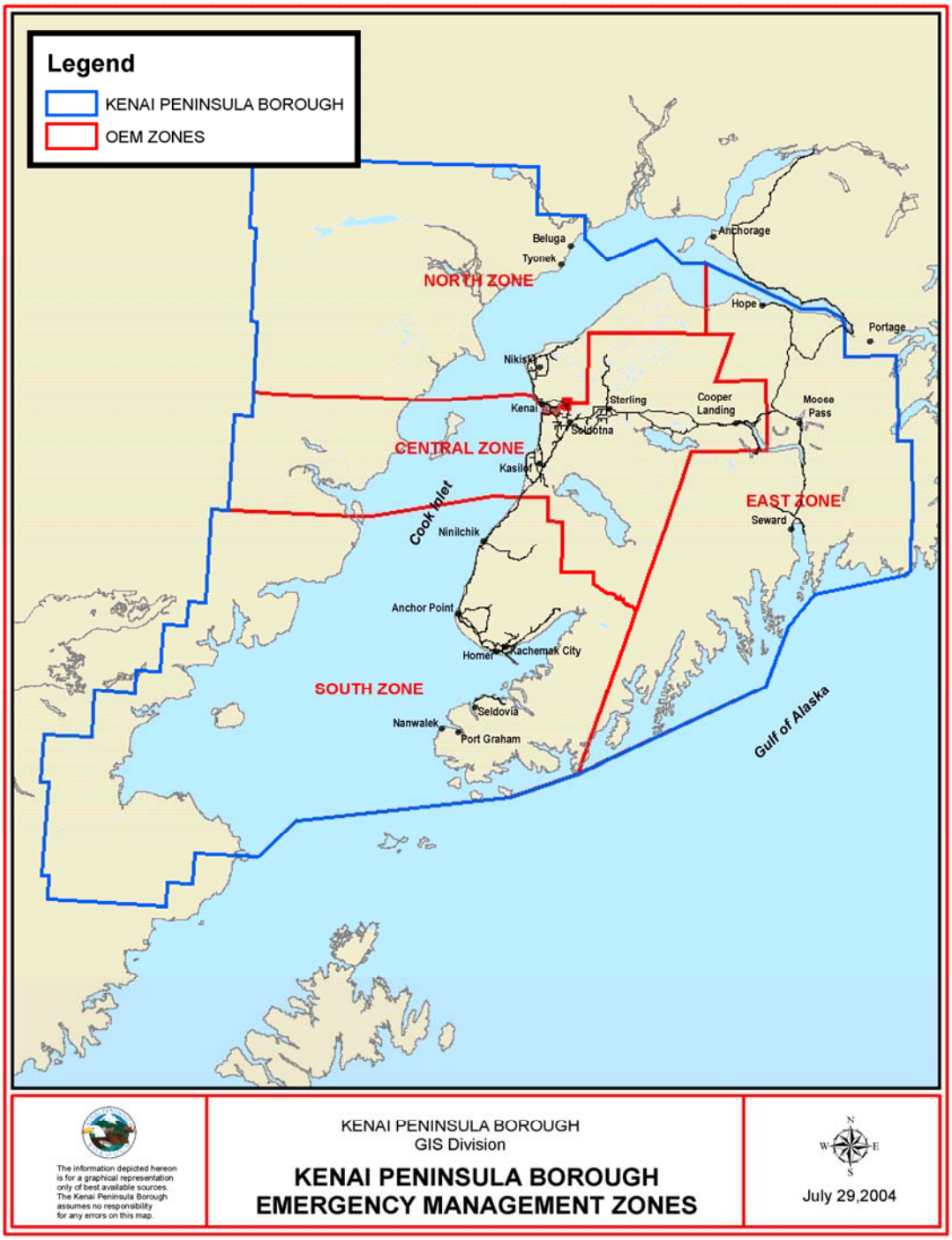
The introduction describes the purpose and planning process used to develop and revise the mitigation plan for the KPB. It includes general information for Borough communities, including: population and demographics, geography, climate, culture, economy, transportation infrastructure, facilities and services, hazard risk assessment and critical and essential facilities.

Section 2.0 – Flood and Coastal Erosion

The flood and coastal erosion hazard section contains information on historic floods, general types of flooding, zone-based risk assessments, a summary of existing programs, mitigation goals, strategies, current

Floodplain Task Force recommendations and Assembly actions, implementation ideas and a resource directory.

Figure 1-1. Kenai Peninsula Borough Emergency Management Zones.



Section 3.0 – Wildfire
Concurrent with the All-Hazard Mitigation Plan, the Borough has completed an interagency wildfire protection plan (Interagency All Lands/All Hands Action Plan). This comprehensive, multi-year draft plan provides detailed assessments of Borough-wide wildfire risk, existing programs and resources, and mitigation goals and strategies. A summary of the AL/AH Plan is included as Section 3.0 and the full report is provided in Annex H. In conjunction with Section 3.0, this annex serves as our wildfire mitigation plan. Revision of the AL/AH Plan is not part of this revision process, though various Community Wildfire Protection Plans have been developed and completed through a public meeting process and are referenced as (Community Name) CWPP in this plan.

Section 4.0 – Earthquake
The earthquake hazard section contains information on earthquake history, types of earthquakes, Borough-wide risk assessment, existing programs, mitigation goals, strategies, implementation ideas and a resource directory.

Section 5.0 – Weather
The weather hazard section contains information on historic KPB weather events, types of severe weather events that affect the Borough, a Borough-wide risk assessment, existing weather mitigation programs, mitigation goals, implementations ideas and a resource directory.

A summary of Kenai River ice jam activity and ice dam failure occurrences between the 2004 Plan approval and 2009 is included in this section of the Plan update.

Section 6.0 – Tsunamis & Seiches
The tsunami & seiche section describes tsunami & seiche events in the KPB, type of tsunamis, a Borough-wide risk assessment, an overview of coastal community All Hazard Alert Broadcast siren systems, existing mitigation programs, mitigation goals, implementation ideas and a resource directory. The City of Seward Annex includes a summary of that community's Tsunami Ready Program and Tsunami Surge Mapping information.

Section 7.0 – Volcanoes
The volcano section is derived from the Alaska Division of Homeland Security and Emergency Management's All-Hazard Mitigation Plan (October 2007). Although the original Plan text was edited slightly to focus on volcanoes with the highest potential to impact KPB communities, most of the description is state rather than region-specific. A summary of actual

KPB volcano activity and ash fallout occurrences between the 2004 Plan approval and 2009 is included.

Section 8.0 – Avalanches

The avalanche section is derived from the Alaska Division of Homeland Security and Emergency Management's All-Hazard Mitigation Plan (October 2007). Additional information and mitigation proposals specific to the Kenai Peninsula Borough have been added, including summaries of avalanche events affecting the power supply to the Seward and Hope/Sunrise areas and general avalanche activity affecting transportation.

Section 9.0 – Human-Caused Hazards

Although much of the focus of hazard mitigation is on natural hazards such as earthquakes and floods, there are also hazards that are human-caused. For the purpose of this Plan, "human-caused hazards" are technological hazards. These are distinct from natural hazards primarily in that they originate from human activity. On the Kenai Peninsula, some of these human-created hazards include sudden flooding due to potential dam and water diversion breaches and hazards related to the storage, use and transportation of hazardous materials.

Sections 10.0 - 12.0 - Additional Hazard Sections that may be included as funding becomes available or during plan updates.

Annexes

Local hazard mitigation plans provided by the Cities of Homer, Kachemak, Kenai, Seward and Soldotna are included as Annex Sections A, B, C, E and F, respectively. Annex D is reserved for incorporation of the City of Seldovia's All-Hazard Mitigation Plan.

The Port Graham Flood Mitigation Plan, the All Lands/All Hands Action Plan, and the Seward Bear Creek Flood Service Area Flood Mitigation Plan were also included as Annexes G, H, and I respectively. The Port Graham Flood Mitigation Plan provides supplemental information to the flood mitigation section of the Borough's Plan.

The Interagency All Lands/All Hands Action Plan is a comprehensive, multi-year plan that provides a detailed assessment of wildfire issues facing the Borough and its residents. It addresses the wildfire situation within the Kenai Peninsula Borough facilities and populations at risk from fire, goals and action items to mitigate fire risk, and an implementation schedule for identified plan goals. In conjunction with Section 3.0 this annex serves as the KPB wildfire mitigation plan.

Annex A: City of Homer All-Hazard Mitigation Plan
Annex B: Kachemak City All-Hazard Mitigation Plan
Annex C: City of Kenai All-Hazard Mitigation Plan
Annex D: Placeholder: City of Seldovia All-Hazard Mitigation Plan
Annex E: City of Seward All-Hazard Mitigation Plan
Annex F: City of Soldotna All-Hazard Mitigation Plan
Annex G: Port Graham Village Flood Mitigation Plan
Annex H: All Lands/All Hands Action Plan
Annex I: Seward Bear Creek Flood Service Area Flood Mitigation Plan

Appendices
Appendix A: Literature Cited
Appendix B: Public Participation Process
Appendix C: Glossary of Terms
Appendix D: List of Acronyms
Appendix E: KPB OEM Hazard Analysis Method
Appendix F: Snow and Skilak Glacier-Dammed Lake Information
Appendix G: Floodplain FIRM Spreadsheet Analysis
Appendix H: Completed FEMA Crosswalk
Appendix I: Plan Contributors
Appendix J: Bridges
Appendix K: Flood Forecasting and Stream-Gage Program
Appendix L: Project Prioritization and Cost/Benefit Analysis Process
Appendix M: Plan Adoption Documents

1.3 Methodology

To produce a plan that accurately reflects the needs and hazard risks of the KPB and its residents, information was solicited from a number of sources including the general public, local, state and federal agency personnel and professional researchers. This section details the approach used to produce a hazard mitigation plan and describes the process for implementing and updating the plan.

1.3.1 Planning Process

The plan revision was administered through the KPB Office of the Mayor, Office of Emergency Management (OEM) and KPB Planning Department (Planning). Per KPB Ordinance 2004-33, the steering committee, appointed by the Mayor and composed of department heads or their designees from the Mayor's Office, Planning, Donald E. Gilman River Center, OEM, Capitol Projects, Risk Management, Road Service Area, Solid Waste, Maintenance, Spruce Bark Beetle Mitigation Office and the Kenai Peninsula Borough School District, reviewed the Plan and submitted updates and suggested revisions.

Opportunity for public comment on revisions was provided at regular Planning Commission, Advisory Planning Commission, Road Service Area, Flood Service Area and Assembly meetings, as well as during other community meetings and

outreach programs, including review by the Local Emergency Planning Committee. Each City is responsible for providing similar opportunities in its community as it reviews the City Plans as an annex to the KPB Plan.

The Alaska Division of Homeland Security and Emergency Management (ADHS&EM) provides initial review of the final draft and returns it with recommendations for additions and changes that may be necessary to satisfy FEMA plan requirements.

Throughout the project, information and draft plans are coordinated and shared with the ADHS&EM, KPB Departments and the Cities of Homer, Kachemak, Kenai, Seldovia, Seward and Soldotna.

Tasks
The planning process consisted of the following steps:

- solicitation of public involvement;
- communication with agencies and organizations within the Borough;
- coordination with the incorporated Borough cities and the State of Alaska during the development of their associated hazard mitigation plans;
- assessment and inventory of Borough-wide hazards;
- review of existing mitigation activities;
- formulation of mitigation strategies and implementation ideas; and
- establishment of a schedule for maintaining and updating the plan.

Following the completion of a substantially complete draft, the plan was:

- submitted to the State Hazard Mitigation Office and FEMA Region 10 for preliminary review and approval;
- also available on the KPB Hazard Mitigation Website;
- available for public review and hearings at the Planning Commission, RSA, Flood Service Area, Assembly and other community meetings; and
- reviewed for adoption by the KPB Planning Commission and Assembly (see Appendix M for adoption documentation).

1.3.2 Public Participation and Outreach

To ensure public awareness of the planning process and to provide ample opportunities to be involved, the project was advertised in local newspapers and flyers, as well as on the OEM and KPB websites. Community meeting presentations and public hearings were also held.

Website
An informational website (www.borough.kenai.ak.us/emergency/hazmit/plan.htm) was established (Appendix B-1), with copies of the original 2004 Plan, 2010 Plan updates and revisions, public meeting notices, contacts, agency links, an informational flyer and links to other important hazard mitigation resources available there.

The site also contained an on-line survey that solicited community input on hazards that have impacted residents in the past and possible strategies to help offset future damage. In addition, the site provided a means for transferring project information and materials between the cities, Borough and state agencies.

Online Hazard Survey
The online survey was posted to allow residents to provide input into revisions of the All-Hazard Mitigation Plan (see Appendix B5 for a copy of the survey questions). Ten responses were received.

Survey respondents were asked to rank their level of concern for 24 natural and technological hazards. Borough-wide, the top ten hazards of concern were: 1) earthquake; 2) wildfire; 3) extended power outage; 4) transportation infrastructure failure; 5) communication infrastructure failure; 6) energy emergency (fuel/resource shortage); 7) severe windstorm; 8) landslide; 9) winter storm and 10) hazardous material accident.

The survey also asked people to indicate their level of support for nine types of hazard mitigation measures that could be used to reduce damage and loss of life. There were five rating choices for each measure, which were assigned values from 1 ("strongly disagree") to 5 ("strongly agree"), with 3 being "no opinion". On a Borough-wide basis, support for the proposed mitigation measures varied from little support to strongly supportive (i.e. 1 to 5) and were ordered as follows: 1) encourage FireWise building practices; 2) clear spruce-bark beetle killed trees; 3) improve hazard education; 4) encourage the creation of firebreaks; 5) increase accuracy of floodplain mapping; 6) restrict construction in areas with a high risk for natural hazards; 7) make hazard mitigation part of every land use proposal; 8) increase accuracy of other hazard maps and 9) implement building code changes. A brief summary of results Borough-wide and by zone is available in Appendix B5.

Ninety percent of survey respondents indicated they had an emergency plan in place, although most had not practiced the plan, and 50% were willing to spend their own money on structural measures to help hazard-proof their homes.

Project Flyer
More than 200 flyers were mailed Borough-wide to agencies, libraries, advisory planning commissions and others to alert them to the revision process, direct them to the website and provide contact information for KPB and city plan coordinators. The flyers were also posted at public locations around the peninsula and placed on the website for downloading and posting.

Newspaper Public Notices
Public notices for the project were placed in the following peninsula newspapers to run on February 25, April 1 and April 29, 2010: 1) The Peninsula Clarion (covering the Kenai Peninsula), 2) The Homer News (covering Homer, Anchor Point and surrounding communities) and 3) The Seward Phoenix Log (covering the communities of Seward, Moose Pass and Cooper Landing). The notices contained contact information for the Borough as well as the incorporated cities who were simultaneously drafting plans.

Agency Participation and Project Coordination
The KPB coordinated its efforts with the State of Alaska and the incorporated cities within the Borough to develop a multi-jurisdictional document.

Participation in the project was solicited in a number of ways:

Meeting Presentations
During the planning and drafting stages, meetings were held or attended to facilitate project coordination and solicit information and feedback:

Table 1-1. Kenai Peninsula Borough All-Hazard Mitigation Plan Outreach, 2010.

Date	Location	Outreach Activity
2-2-10	Anchor Point	Anchor Point Advisory Planning Commission meeting presentation and solicitation of feedback on plan introduction.
2-3-10	Cooper Landing	Cooper Landing Advisory Planning Commission meeting presentation and solicitation of feedback on plan introduction.
2-3-10	Moose Pass	Moose Pass Advisory Planning Commission meeting presentation and solicitation of feedback on plan introduction.
2-4-10	Hope	Hope/Sunrise Advisory Planning Commission meeting presentation and solicitation of feedback on plan introduction.
2-9-10	Soldotna	KPB Roads Service Area Board meeting presentation and solicitation of feedback on plan introduction.
2-16-10	Anchor Point	Anchor Point Advisory Planning Commission meeting presentation and solicitation feedback on plan introduction.
3-1-10	Seward	Seward-Bear Creek Flood Service Area Board Meeting presentation and solicitation of floods section feedback.
3-2-10	Anchor Point	Anchor Point Advisory Planning Commission meeting presentation and solicitation of floods section feedback.
3-3-10	Cooper Landing	Cooper Landing Advisory Planning Commission meeting presentation and solicitation of floods section feedback.
3-3-10	Moose Pass	Moose Pass Advisory Planning Commission meeting presentation and solicitation of floods section feedback.

3-4-10	Hope	Hope/Sunrise Advisory Planning Commission meeting presentation and solicitation of floods section feedback.
3-8-10	Soldotna	KPB Planning Commission meeting presentation and solicitation of floods section feedback.
3-9-10	Soldotna	KPB Roads Service Area Board meeting presentation and solicitation of floods section feedback.
4-5-10	Seward	Seward-Bear Creek Flood Service Area Board Meeting plan presentation and solicitation of feedback on remaining sections.
4-6-10	Anchor Point	Anchor Point Advisory Planning Commission presentation and solicitation of feedback on remaining sections.
4-7-10	Cooper Landing	Cooper Landing Advisory Planning Commission presentation and solicitation of feedback on remaining sections.
4-7-10	Moose Pass	Moose Pass Advisory Planning Commission presentation and solicitation of feedback on remaining sections.
4-8-10	Hope	Hope/Sunrise Advisory Planning Commission presentation and solicitation of feedback on remaining sections.
4-12-10	Soldotna	KPB Planning Commission meeting presentation and solicitation of feedback on remaining sections.
4-13-10	Soldotna	KPB Roads Service Area Board meeting presentation and solicitation of feedback on remaining sections.
5-4-10	Anchor Point	Anchor Point Advisory Planning Commission - review for adoption.
5-5-10	Cooper Landing	Cooper Landing Advisory Planning Commission - review for adoption.
5-5-10	Moose Pass	Moose Pass Advisory Planning Commission - review for adoption.
5-6-10	Hope	Hope/Sunrise Advisory Planning Commission - review for adoption.
6-8-10	Soldotna	KPB Assembly – Ordinance Introduction.
6-24-10	Soldotna	KPB Planning Commission – review for adoption.
8-3-10	Soldotna	KPB Assembly – Ordinance Adoption.

Plan Contacts

In addition to inviting agency participation via flyers and other notices (see Appendix B), direct input was sought with key individuals on hazard history, risk and mitigation strategies. Appendix I lists additional contributors to this plan.

Public Review and Adoption Process

The KPB Assembly and Planning Commission review and public hearings on the Final Draft Plan occurred between May 24 and July 6, 2010 (Table 1-1). The original Plan was adopted by Ordinance 2004-33 on October 26, 2004, with the revised Plan scheduled for adoption Ordinance on August 3, 2010. A copy of the adoption documents will be provided in Appendix M.

1.3.3 Contributing Reports

A significant contribution of information for this plan was provided from the following reports:

FEMA. 1999. Flood Insurance Study: Kenai Peninsula Borough, Alaska. Community Number 020012.

FEMA. 1997. Multi-Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy.

FEMA. 2003. Developing the Mitigation Plan: Identifying mitigation actions and implementation strategies. FEMA 386-3.

FEMA. 2001. Understanding Your Risks: Identifying hazards and estimating losses. FEMA 386-2.

Kenai Peninsula Borough. 1992. Kenai Peninsula Borough Comprehensive Plan. Soldotna, Alaska.

Kenai Peninsula Borough. 1996. Flood Mitigation Plan. Soldotna, Alaska.

Kenai Peninsula Borough. 2002. Situations and Prospects of the Kenai Peninsula Borough. Soldotna, Alaska.

Kenai Peninsula Borough. 2003. 2003 Comprehensive Economic Development Strategy Update. Kenai Peninsula Economic Development District, Inc.

HDR Alaska, Inc. and Kittelson & Associates, Inc. 2003. Kenai Peninsula Borough Transportation Plan. Soldotna, Alaska.

Oja, Warren. 2004b. Interagency All Lands/All Hands Action Plan. September 5, 2004, Final Draft.

Pinkston Enterprises. 2004. Kenai Peninsula Borough Emergency Response Plan. Prepared for the Office of Emergency Management, Kenai Peninsula Borough, Soldotna, Alaska.

Alaska Division of Homeland Security and Emergency Management (ADHS&EM). State Hazard Mitigation Plan - DMA 2000 Updated September 2004.

Alaska Division of Homeland Security and Emergency Management (ADHS&EM). State Hazard Mitigation Plan – October 2007.
Available at www.ak-prepared.com/plans/mitigation/statehazmitplan07.htm.

Other citations are footnoted as they appear in the document and are also included in Appendix A (Literature Cited).

1.3.4 Implementation of Mitigation Strategies

Mitigation strategies were developed to meet the overall Plan goals and objectives for each hazard. Implementation ideas and action items, potential participants and an estimate of the time required for implementation were identified for each mitigation strategy. With the exception of wildfire (see the Wildfire Mitigation Implementation section below), mitigation strategies and action items will be prioritized and implemented by an interdepartmental steering committee directed by the Mayor's office. As funding becomes available, mitigation projects will be prioritized based on the following criteria:

- a positive benefit/cost review to objectively determine which projects are cost-effective and provide maximum benefits;
- the extent to which a project can be coordinated with or integrated into scheduled maintenance, repair or capital improvement projects;
- the extent to which life, public infrastructure, property and historic areas will be protected;
- the extent to which repetitive losses will be reduced or eliminated;
- consistency with other plans, including the KPB Comprehensive Plan and Emergency Response Plan; and
- the extent to which areas with high natural mitigation value (e.g., floodplains, wetlands, riparian buffers) will be preserved or restored.

Coordination With Other Plans

The All-Hazard Mitigation Plan will be implemented in concert with the Interagency All Lands/All Hands Action Plan (See Annex H), as well as the Kenai Peninsula Borough Comprehensive Plan and Emergency Response Plan. Specific goals, objectives and action items included in the All-Hazard Mitigation Plan are also included in the 2008 Kenai Peninsula Borough Comprehensive Plan. In the future, as plans are developed or updated, they will be cross-referenced and coordinated with the All-Hazard Mitigation Plan to highlight and foster implementation.

Wildfire Mitigation Implementation

Mitigation strategies for wildfire were developed during a separate interagency planning process that overlapped development of the All-Hazard Mitigation Plan. Rather than duplicate the planning efforts, the All Lands/All Hands (AL/AH) Five-Year Action Plan was incorporated into the All-Hazard Mitigation Plan as Annex H. Wildfire mitigation strategies and action items were developed based on goals and guiding principles described in the AL/AH Action Plan. Additional

implementation details are included in Section 3.0 and Appendix E of the AL/AH Action Plan (Annex H).

FEMA Hazard Mitigation Grant Projects (HMGP)
In addition to the Borough's internal review, projects submitted for HMGP grant funding must meet FEMA's guidelines of being cost-effective, environmentally sound and technically feasible. HMGP projects compete on a statewide basis with projects submitted by other eligible local governments and are reviewed by the State Hazard Mitigation Advisory Committee (SHMAC) and prioritized according to whether they 1) protect life, 2) provide valuable planning or education or 3) serve other valuable mitigation purposes. A benefit/cost analysis (BCA) must be completed for each project. The BCA considers a number of factors, including total project costs, project life in years, effectiveness of the project, repair costs to pre-disaster conditions, annual maintenance costs, total past disaster costs, displacement costs and the frequency of disaster occurrence, annual maintenance costs, environmental impacts and permitting requirements. All projects submitted for FEMA funding must have a BCA ratio greater than 1.0 (see Appendix L for more detailed summaries of the State of Alaska's project review and prioritization process and FEMA's benefit/cost and cost-effectiveness analysis processes).

1.3.5 Plan Update Process

The All-Hazard Mitigation Plan will be evaluated and updated every five years. Two years before the end of the five-year cycle, the Office of Emergency Management will initiate the update planning process. Public outreach and plan-writing tasks will be initiated a year before the end of the five-year cycle. In addition, the Plan will be reviewed within ninety days of any Presidential Disaster Declaration and updated as necessary within the following twelve months. Depending on staff and financial resources, ongoing plan maintenance will include completing additional hazard sections, updating existing Plan information and adding or removing mitigation projects as priorities change and projects are completed.

The Borough OEM Director will also coordinate Plan revisions with an interdepartmental Hazard Mitigation Steering Committee as well as provide adequate public notice and opportunities for interested individuals and communities to participate in the plan update process. All future Plan updates will be reviewed and adopted using the normal Borough Planning Commission and Assembly public hearing processes, which allow time for and encourage public review and input. The Office of Emergency Management will also maintain the All-Hazard Mitigation Plan website[1] established during Plan development, which contains agency contact information, a copy of the final Plan available for download and hazard mitigation links.

[1] All-Hazard Mitigation Plan website www.borough.kenai.ak.us/emergency/hazmit/plan.htm.

1.4 Community Profile

This section provides general background information for the entire KPB. Additional detailed description relating to a particular hazard, such as possible transportation disruption following an earthquake, may be found in the associated section.

1.4.1 Geography

The Kenai Peninsula Borough lies directly south of Anchorage and is bordered by Prince William Sound on the east and the Gulf of Alaska to the south, and extends across Cook Inlet to the Chigmit Mountains of the Aleutian Range to the west (Figure1-2). The Borough covers 24,737 total square miles[1], of which 16,013 square miles is land[2]. Cook Inlet partitions the Borough into two landmasses. The peninsula proper, located on the east side of the Inlet, contains 99 percent of the Borough population as well as the vast majority of KPB development. The village of Tyonek, with 166 residents[3], is the largest settlement on the west side of Cook Inlet.

The Borough owns less than 1% of land within its boundaries. Land division is approximately 66% federal, 10% Native, 2.5% private, 20% state, and the remaining land is municipal and Native allotment (Figure 1-3). Major holdings of public land within the Borough include portions of the Chugach National Forest, Kenai National Wildlife Refuge, Kenai Fjords National Park and portions of Lake Clark and Katmai National Parks. There are six incorporated cities within the Borough: Homer, Kachemak, Kenai, Seldovia, Seward and Soldotna.

1 Kenai Peninsula Borough 2002 Situations and Prospects.
2 U.S. Census Bureau, County and City Data Book: 2000 (13th edition), Washington, DC, 2001, Library of Congress Card No. 52-4576.
3 Kenai Peninsula Borough (KPB). 2008 Community Population Estimates.

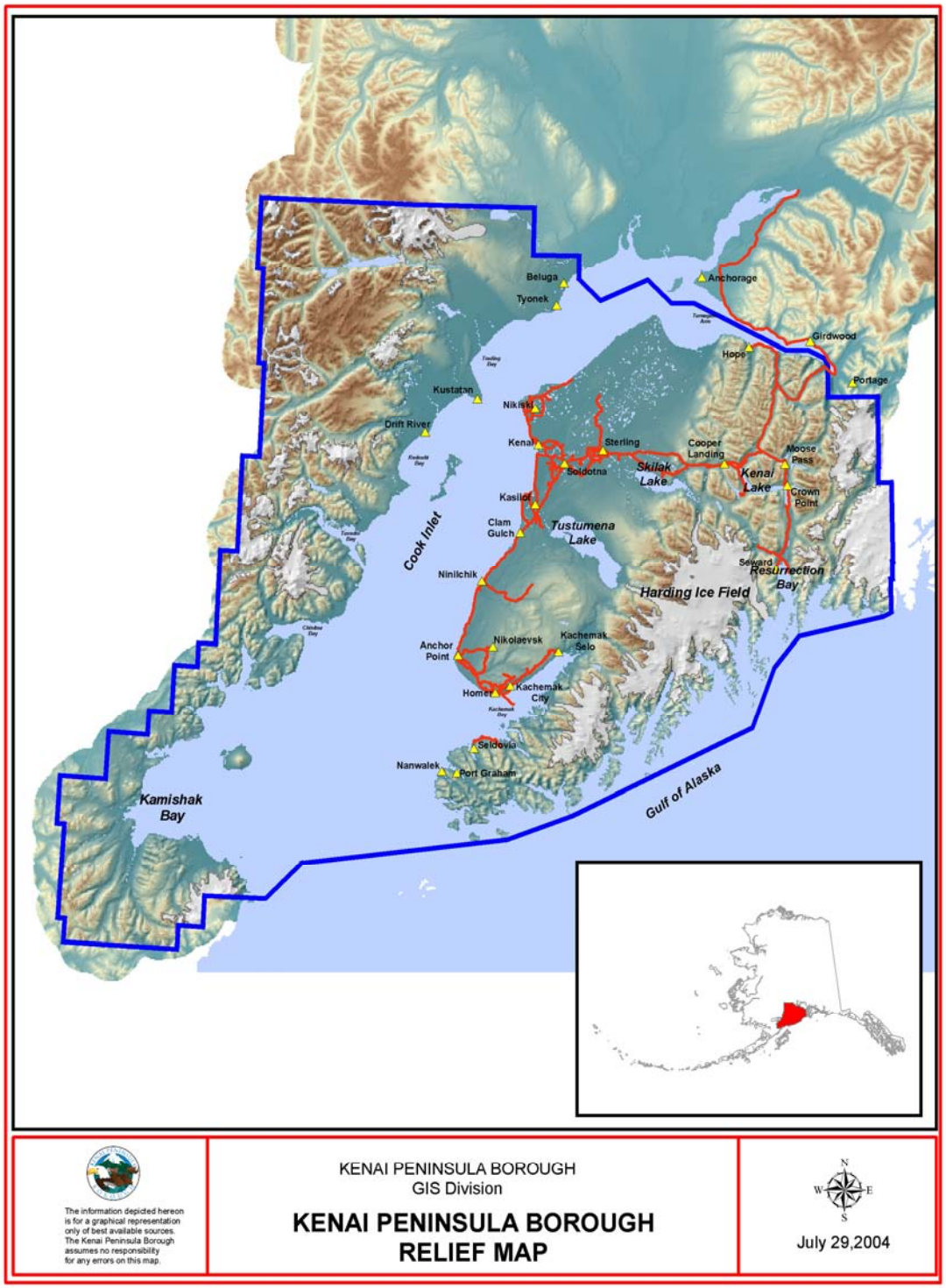


Figure 1-2. Kenai Peninsula Borough Boundaries.

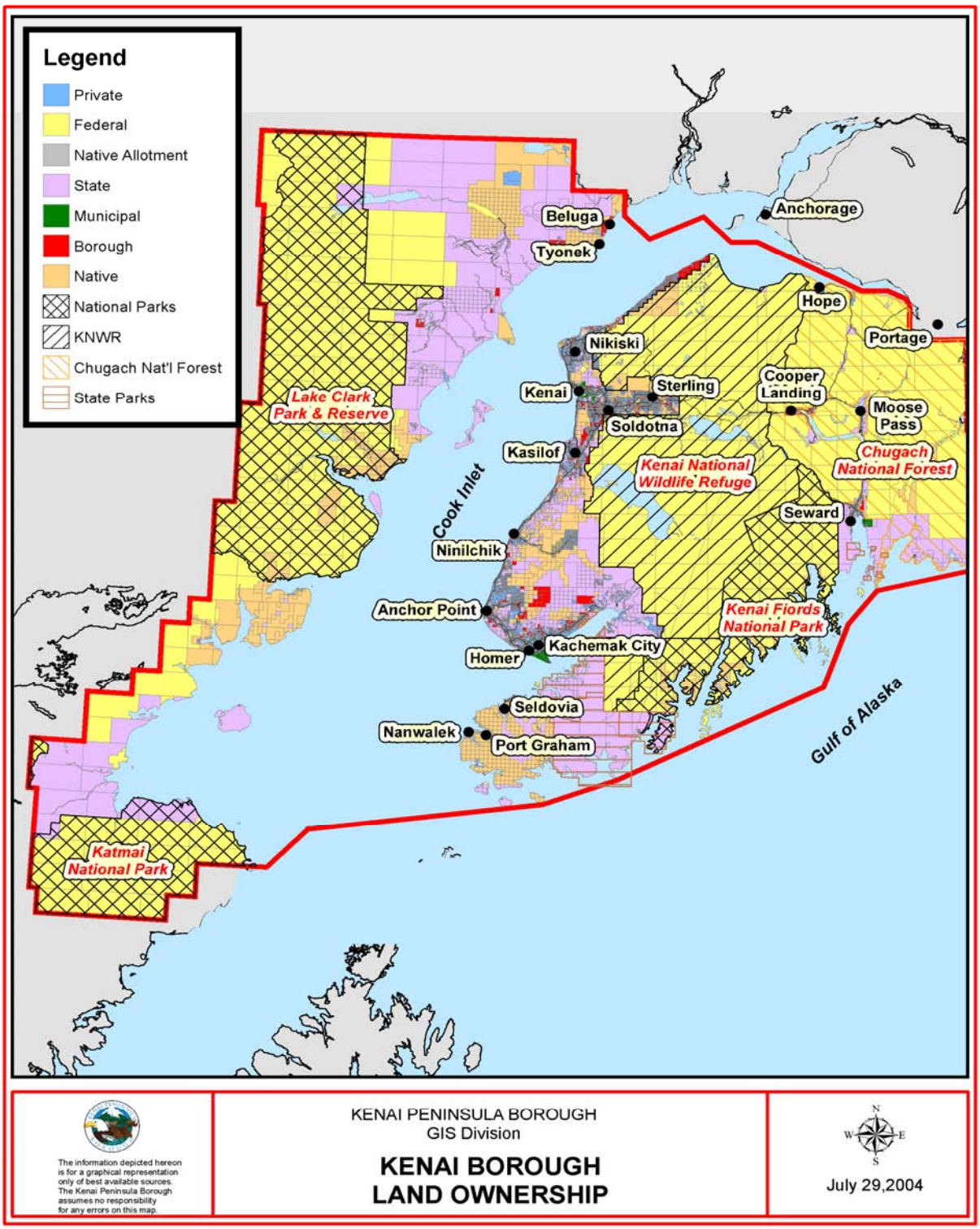


Figure 1-3. Kenai Peninsula Borough Land Ownership.

1.4.2 Climate

Although strong maritime influences from Cook Inlet, Prince William Sound and the Gulf of Alaska keep temperatures relatively mild in contrast with interior parts of the state, there is much local climate variability within the Borough due to weather influencing features such as the Harding Icefield, Chugach Mountains, Cook Inlet, and Skilak and Tustumena Lakes. To best describe these differences, climate information has been partitioned into emergency management zones and further separated by community (Table 1-2).

North Zone

The transitional North Zone is influenced by both maritime and continental climatic factors and therefore exhibits some characteristics of both zones: the dry, cold continental climate of interior Alaska and the relatively wet mild maritime climate of the Gulf of Alaska coastal areas. Annual rainfall is approximately 16-19 inches but has high seasonal variation. The total average winter snowfall is 55-65 inches. The Kenai Lowlands fall within the precipitation shadow of the Kenai Mountains. Temperatures range from an average low of 11° F in the winter to an average high of 53° F in the summer, with a record high of 93°F and a record low of -50° F.

Central Zone

The Kenai Mountains that run north-south on the peninsula divide the Central Zone into two distinct climatic regions. The Kenai lowlands to the west fall within the precipitation shadow of the Kenai Mountains and have a lower mean annual precipitation than the adjacent mountains to the east.

East Zone

Heavy precipitation, cool summers and mild winters characterize the primarily maritime climate of the East Zone. Major storm and prevailing winds from the southeast generated in the Gulf of Alaska influence this region. The outer coast receives about 50 inches of precipitation a year, with some areas of the Kenai Mountains receiving annual precipitation amounts exceeding 100 inches (falling mostly as snow). Much of this area is heavily glaciated (Harding Ice Field) and receives approximately 400 inches of snow a year.

South Zone

Climate within the South Zone is of two types. The southern end of the zone (including Homer) experiences a maritime climate characterized by heavy precipitation, cool summers and mild winters with major storm tracks and prevailing winds generated by the Gulf of Alaska. The rest of the South Zone experiences a transitional climate characterized by more extreme air temperatures with periods of extreme cold and/or high winds.

Table 1-2. Climate Data for Select Communities within the Kenai Peninsula Borough by Zone[1].

North Zone	
Kenai	Winter temperatures range from 4 to 22 F; summer temperatures typically vary from 46 to 65 F. Average annual precipitation is 19 inches. Average total annual snowfall is 61 inches.
Nikiski	Winter temperatures range from 5 to 27 F; summer temperatures vary from 44 to 65 F. Average annual precipitation is 18 inches. Average total annual snowfall is 18 inches.
Tyonek	Winter temperatures typically range 4 to 22 F; summer temperatures average from 46 to 65 F. Temperature extremes have been recorded from -27 to 91 F. Average annual precipitation is 23 inches.
Central Zone	
Cooper Landing	January temperatures range from 4 to 22 F; July temperatures vary from 46 to 65 F. Average annual precipitation is 20 inches.
Soldotna	Winter temperatures range from 6 to 24 F; summer temperatures range from 45 to 66 F. Average annual precipitation is 17.4 inches.
Sterling	Winter temperatures range from 4 to 22 F; Summer temperatures vary from 46 to 65 F. Average annual precipitation is 20 inches.
East Zone	
Seward	Winter temperatures average from 17 to 38 F; summer temperatures average 49 to 63 F. Annual precipitation includes 66 inches of rain and 83 inches of snowfall.
Moose Pass	Winter temperatures range from 14 to 27 F; summer temperatures vary from 45 to 65 F. Average annual precipitation is 28 inches. Average annual total snowfall is 83 inches.
Hope	Winter temperatures range from 5 to 30 F; summer temperatures vary from 45 to 65 F. Average annual precipitation is 22 inches. Average annual total snowfall is 39.5 inches.
South Zone	
Anchor Point	January temperatures range from 4 to 22 F; July temperatures vary from 46 to 65 F. Average annual precipitation is 20 inches.
Homer	During the winter, temperatures range from 16 to 33 F; summer temperatures vary from 45 to 65 F. Average annual precipitation is 25 inches. Average annual snowfall varies from 55 inches at the Homer Airport to 111 inches at higher elevations.
Nanwalek	Winter temperatures range from 14 to 27 F; summer temperatures vary from 45 to 60 F. Average annual precipitation is 24 inches.
Ninilchik	Winter temperatures range from 14 to 27 F; summer temperatures vary from 45 to 65 F. Average annual precipitation is 24 inches.
Port Graham	Winter temperatures range from 14 to 27 F; summer temperatures vary from 45 to 65 F. Average annual precipitation is 24 inches.
Seldovia	Winter temperatures in Seldovia average from 12 to 21 F; summer temperatures range from 48 to 65 F. Annual precipitation is 34.5 inches.

1.4.3 Culture

The Kenai Peninsula Borough has a rich and diverse cultural history that has been shaped by the abundant populations of fish, game and plant resources of the area. The Suqpiaq Alutiiq and Dena'ina Athabaskan people are among the

[1] Pinkston Enterprises. 2004. Kenai Peninsula Borough Emergency Operations Plan. Prepared for the Office of Emergency Management, Kenai Peninsula Borough, Soldotna, Alaska.

first inhabitants of the area. Archaeological evidence of the First Peoples of the region, such as barabaras (semi-subterranean dwellings), is still found in many areas throughout the Borough.

Russian fur traders established settlements on the Kenai Peninsula in the late 1700s and harvested large quantities of sea otter pelts and other fur-bearing animals. As the demand for these pelts decreased, a new wave of settlers came to the peninsula to pursue fishing and mining. The healthy populations of fish and wildlife continue to attract people to the peninsula each year.

Today the Borough's diverse culture is reflected in the many community, non-profit and governmental organizations. There are over 17 Native for-profit and non-profit organizations in the KPB that help promote the cultural and economic interests of their members. There are also many sport fishing, outdoor adventure, hunting, environmental, arts and tourism groups that support the diverse interests of Borough residents.

1.4.4 Economy

Commercial and sport fishing, oil and gas production and downstream industries, timber harvest, and recreation and tourism provide a diverse economic base for the KPB as well as one of the strongest regional economies in the state[1].

Commercial fisheries in the area began in the 1880s and today include five species of salmon, halibut, sole, cod, herring, pollock, crab, shrimp, clams and scallops. Potential new markets for farmed oysters, mussels, seaweed, sea urchin and sea anemone are presenting themselves[2].

The oil and gas industry, composed of exploration, extraction, storage, processing/manufacturing and transportation, accounts for approximately ten percent of private wage and salary employment on the Kenai Peninsula[3]. The North Zone contains a majority of the Borough's oil and gas development, including 14 offshore platforms and a number of pipelines and processing facilities centered in the North Kenai-Nikiski area (Figure 1-4). Processing facilities include the Tesoro Alaska fuel refinery, the Agrium ammonia and urea fertilizer plant (not currently in operation) and the ConocoPhillips Alaska petroleum liquid natural gas plant. Employment in the industry has declined in recent years with the closing of some manufacturing facilities. The importance of Cook Inlet natural gas is high, with Southcentral Alaska deriving almost all of its power generation and home and business heat from this region[4].

1 Kenai Peninsula Borough (KPB). 1992. Kenai Peninsula Borough Comprehensive Plan. Soldotna, Alaska.
2 Kenai Peninsula Borough (KPB). 2004b. Our Economy [www.borough.kenai.ak.us/geo01.htm].
3 Pers. Comm., Alyssa Shanks, State of Alaska, Department of Labor and Workforce Development, April 7, 2010
4 Kenai Peninsula Borough (KPB). 2002. Situations and Prospects of the Kenai Peninsula Borough. Kenai Peninsula Borough, Community & Economic Development Division [www.borough.kenai.ak.us].

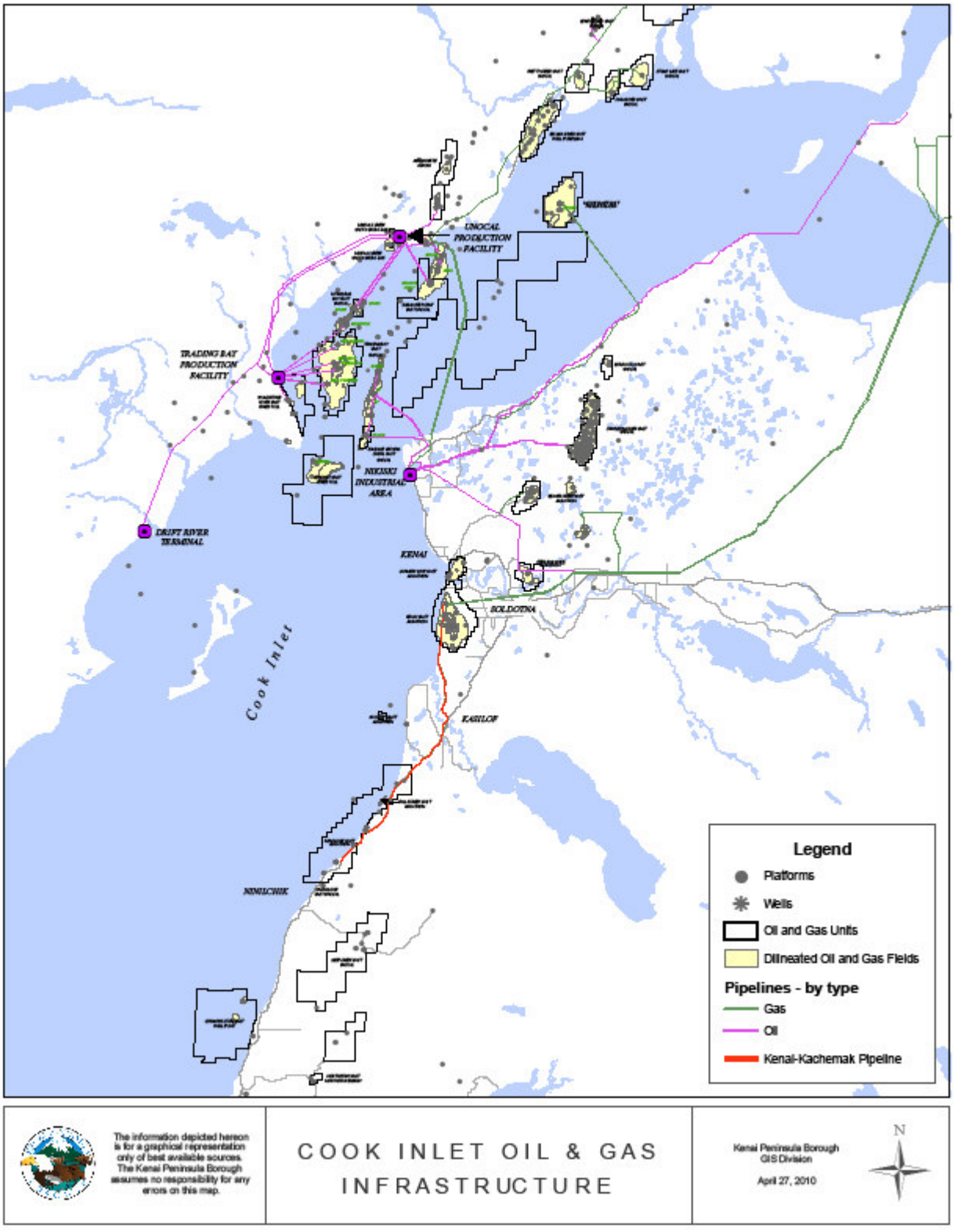


Figure 1-4. Cook Inlet Oil and Gas Infrastructure.

A network of petroleum and natural gas pipelines serves the Cook Inlet region within the North Zone. The Cook Inlet pipeline transports crude oil from production facilities at Granite Point to the Drift River Terminal on the west side of Cook Inlet. Oil is stored at the Drift River production facility and shipped by tankers to the Lower 48 states. Storage of oil in the Drift River Terminal storage tanks was discontinued during the 2009 eruption of Mt. Redoubt volcano and has not resumed as of April 2010. The Kenai Pipeline carries crude oil. One branch of this pipeline carries Swanson River crude oil to the Nikiski Marine terminal, and the other carries oil from the west side production facilities to Nikiski. The Tesoro Pipeline carries refined petroleum products, including gasoline, jet fuel, diesel fuel and fuel oil from the Nikiski refinery to the Port of Anchorage. The pipeline is approximately 70 miles long. Two natural gas pipelines, owned by Enstar, bring gas to the Anchorage area for domestic, industrial and commercial use. One pipeline connects Anchorage and the Kenai gas fields, and the other connects the Anchorage/Mat-Su region with the Beluga gas fields on the west side of the Cook Inlet. Both are approximately 95 miles long, and are buried along the entire route. Marathon and Union Oil own two natural gas pipelines. These pipelines, constructed in 1982, bring gas from Trading Bay and from the Kenai gas fields to the LNG plant in Nikiski. Beluga Pipe Line Company owns a natural gas pipeline that transports gas from the west side of Cook Inlet to the east side. The Kenai Kachemak pipeline (or KKPL), jointly owned by Marathon and Chevron, is the most recent and most southerly pipeline on the Kenai Peninsula. KKPL started shipping natural gas north from the Ninilchik field in 2003. A year later KKPL was extended inland 15 miles to the southeast to connect with Unocal's new Happy Valley gas field (Chevron later acquired Unocal).

Tourism is the fastest-growing industry in the Borough, and with railway and cruise ship access as well as the development of destination resorts, it is increasing. Tourist resources continue to develop to meet the demands of the growing interests and activities of visitors to the Borough. Subsistence and sport fishing have also gained momentum in recent years, and the KPB is a popular destination when the salmon and halibut seasons are open.

The timber industry has been severely affected by the spruce bark beetle infestation. The KPB responded with the development of the Spruce Bark Beetle Task Force in 1998 to develop an action plan to manage the impacts of the infestation on peninsula residents and to rehabilitate infested areas[1]. "While the abundance of available timber should have stimulated the economy, wood pulp and wood chips became the main marketable products from the diminished quality of beetle-killed spruce. In recent years, demand and prices for wood chips dropped to the extent that a major wood processor left the industry, leaving approximately 250 employees without work"[2].

[1] Spruce Bark Beetle Task Force (SSBTF). 2004. Program Narrative. Kenai Peninsula Borough. [www.borough.kenai.ak.us/sprucebeetle/New/narrative.htm].

[2] (Page 185) Kenai Peninsula Borough (KPB). 2002. Situations and Prospects of the Kenai Peninsula Borough. Kenai Peninsula Borough, Community & Economic Development Division [www.borough.kenai.ak.us].

1.4.5 Transportation

KPB transportation facilities are constructed and maintained by a number of different entities including: the Alaska Department of Transportation and Public Facilities (ADOT&PF), the Alaska Railroad Corporation (ARRC), the Kenai Peninsula Borough, the incorporated Cities of Homer, Kenai, Seldovia, Seward, and Soldotna and Native village corporations, as well as the private sector[1].

There are approximately 650 miles of state-maintained roads in the KPB and an additional 632 miles of Borough-maintained roads. The Seward, Sterling and Kenai Spur Highways provide the primary highway access. A number of secondary state and local roads provide access to communities and subdivisions along the highway corridor. Access to the west side of Cook Inlet and the southern tip of the Kenai Peninsula is limited to air and water. With the exception of roads that serve the communities of Tyonek and Beluga, most roads on the western side of Cook Inlet were constructed to support oil and gas facilities. A winter ice road provides access to the Beluga area from Point McKenzie.

Bridges are critical road infrastructure and are vulnerable to damage from natural events such as flooding and earthquake. There are approximately 60 significant bridges on the Borough's public road system, the majority of which are state-owned and maintained. The Borough owns and maintains 18 bridges (Figure 1-5, Table in Appendix J)[2]. By federal regulation, the ADOT&PF is required to physically inspect bridges that carry public traffic once every two years. The physical inspection includes measuring the depth across the streams and evaluating scour at the piers, abutments and banks. ADOT&PF also has a seismic retrofit prioritization program, which is based on a computer analysis of 1) seismic vulnerability (e.g. how earthquake prone is the region); 2) a review of each bridge's structural plans; and 3) the importance of the roadway in relation to the communities served, bridge length, available detours and proximity of other important infrastructure, such as pipelines[3].

Three public ports, four small boat harbors, 14 public airports, and numerous private facilities provide air and water access to communities and developed areas within the Borough (Figures 1-6 and 1-7)[4]. In addition, the Alaska Marine Highway System provides ferry service between Homer, Seldovia, Kodiak, Prince William Sound and the Alaska Peninsula nine months of the year. Ferry service is important for transporting residents, visitors and freight, particularly for Seldovia where road access is not available. The Alaska Railroad, operated by the State of Alaska, provides passenger and freight rail service between Anchorage and Seward.

1 HDR Alaska, Inc. 2003. Kenai Peninsula Borough Transportation Plan Update.
2 HDR Alaska, Inc. 2003. Kenai Peninsula Borough Transportation Plan Update.
3 Pers. Comm. Richard Pratt, P.E, Chief Bridge Engineer, ADOT&PF. 7/2/04.
4 HDR Alaska, Inc. 2003. Kenai Peninsula Borough Transportation Plan Update.

Figure 1-5. State, Borough and City Bridges.

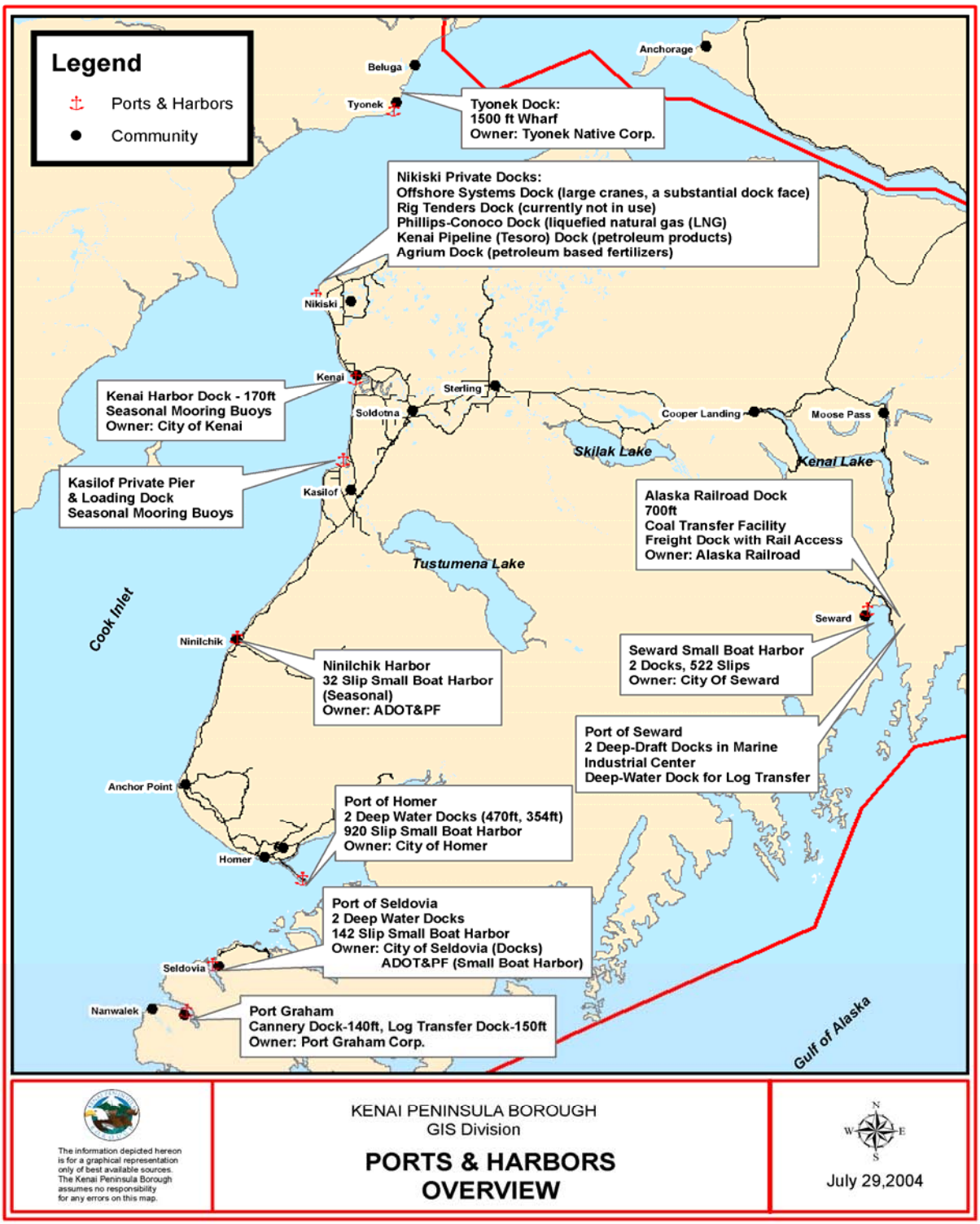


Figure 1-6. Overview of Kenai Peninsula Borough Ports and Harbors.

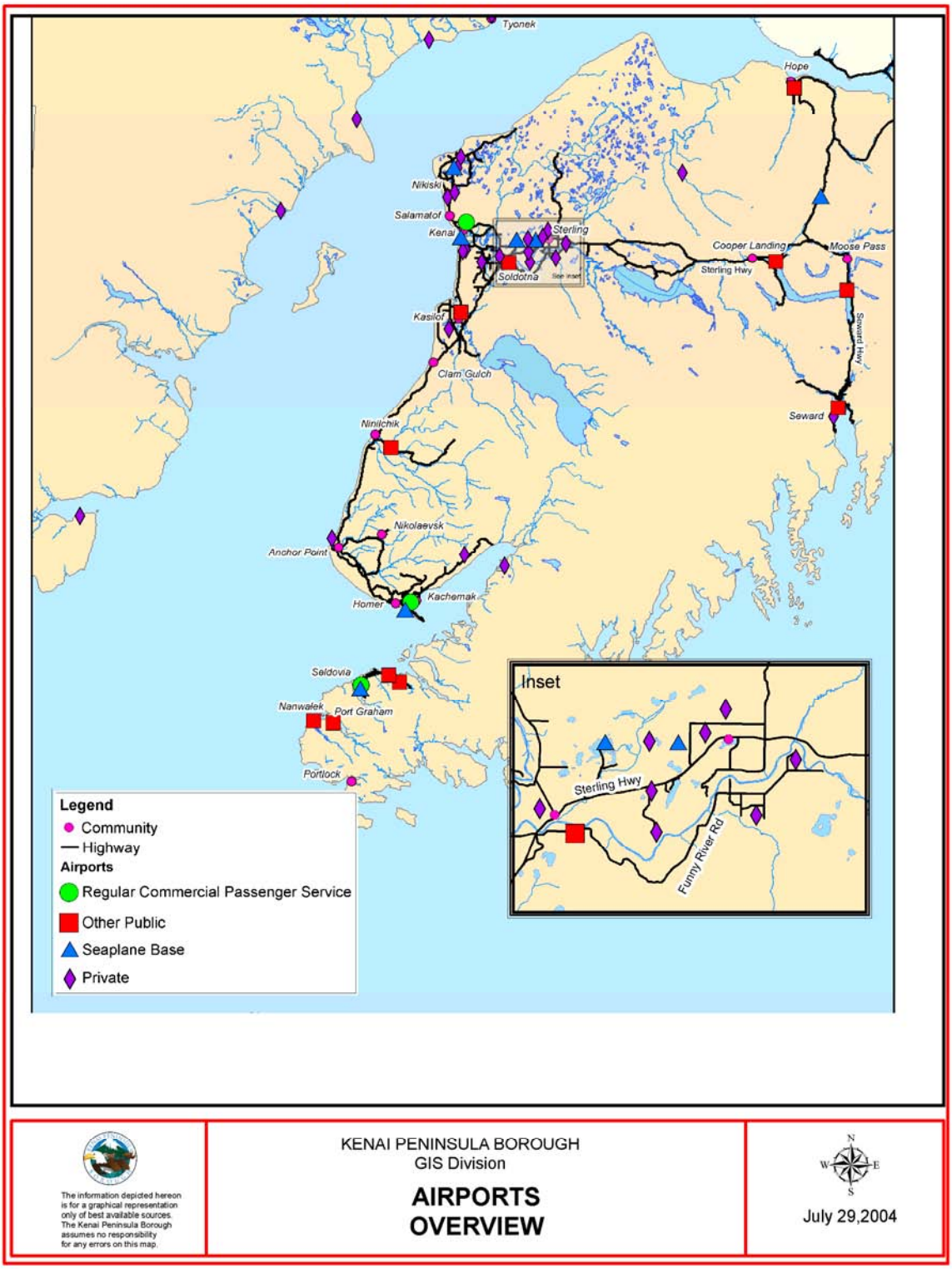


Figure 1-7. Overview of Kenai Peninsula Borough Airports.

North Zone
The Kenai Spur Highway is the primary north-south road in the North Zone, traversing from the City of Kenai north to Nikiski, then northeasterly to its terminus at Captain Cook State Recreation Area. Numerous secondary state, city and Borough roads connect the outlying areas. In addition, a 4.5-mile gravel road between Lamplight Road in Nikiski and Marathon Road in Kenai serves as an evacuation route for the Nikiski area in the event the Kenai Spur Highway ever becomes impassable.

There is a municipal airport located at Kenai and a community-owned airport at Tyonek, as well as private airstrips, beaches, lakes and rivers scattered throughout the zone that provide landing sites for small aircraft. Service is by small and medium commuter-type aircraft.

There are three deep-draft piers and two shallow-draft wharves in the Nikiski area that serve the industrial facilities. The Kenai City Dock and boat ramp are located near the mouth of the Kenai River. In the Kenai River there are also several private commercial fish-processing docks and seasonally-placed vessel mooring buoys.

Central Zone
The Kenai Spur Highway, Sterling Highway, Funny River Road and Kalifornsky Beach Road are the major state roads serving the Central Zone communities. Numerous secondary roads connect the communities and outlying areas. There are nine state-maintained highway bridges and one Borough-maintained bridge in the Central Zone (Appendix J).

There is a municipal airport in Soldotna, community airports at Kasilof and Quartz Creek and numerous private airstrips throughout the Central Zone. The Soldotna Municipal Airport provides aircraft maintenance and charter services.

East Zone
Traveling south from Anchorage, the Seward Highway (Alaska State Highway 1) traverses the East Zone from the Borough boundary near Turnagain Arm to the junction at Tern Lake and the Sterling Highway. Alaska State Highway 9 continues south to its terminus at the City of Seward. The Hope Highway branches off the Seward Highway at Mile 56.4 and terminates at the community of Hope. There are 38 bridges in the East Zone (Appendix J). A majority of these are state-owned and maintained, although the Borough maintains nine of these bridges.

The Alaska Railroad Corporation (ARRC) provides service between Anchorage and Seward, and is important for the transport of freight, timber, coal and other resources. In the summer months, the railroad provides daily passenger service

between Seward and Anchorage. The railroad closely parallels the Seward Highway through Moose Pass, Crown Point and the Seward area.

There are state-maintained airstrips located at Hope and Crown Point/Lawing, and a district airport with two paved runways in Seward, as well as local airstrips, beaches, lakes and rivers scattered throughout the zone that provide landing sites for small aircraft.

The Port of Seward is a deep-water, ice-free port and the only developed port in the eastern zone. Seward port facilities include the Municipal Pier, Seward Fisheries Wharf, the Alaska Railroad Dock and coal transfer facility, the City Dock, the Institute of Marine Science dock, the Marine Industrial Center and the Small Boat Harbor. The port facilities serve cruise ships, cargo barges and ocean freighters from Seattle and overseas. The Small Boat Harbor has two boat launch ramps and moorage for 700 boats.

South Zone
The Sterling Highway (Alaska State Highway 1) traverses the South Zone from Clam Gulch to the end of the Homer Spit. The communities of Seldovia, Nanwalek and Port Graham, as well as other populated areas across Kachemak Bay from Homer, can only be reached by water or air transportation. There are thirteen bridges on South Zone roads (Appendix J), of which eight are state and five are Borough-maintained.

Homer has a state-owned district airport, with a 6,700 foot asphalt runway, a float plane basin and a seaplane base at Beluga Lake. The city is served by several scheduled and chartered aircraft services. There are four additional private landing strips in the vicinity. Seldovia, Port Graham, and Nanwalek have state-owned gravel airstrips with direct daily charter flights between the communities and Homer.

Homer is served by the Alaska Marine Highway ferry system as well as local ferry and water taxi services. There are two deep-water docks, a small boat harbor with moorage for 920 vessels, additional transient moorage, 48.7 acre boat basin, two tidal grids, a five-lane boat launch ramp and a 386-foot-long commercial fish plant dock. Seldovia and Ninilchik have small boat harbors, and docking facilities are available in Port Graham and Nanwalek.

1.4.6 Population and Demographics

During the early 1980s, the population of the Kenai Peninsula Borough grew by a remarkable 8% each year. After 1986, the growth rated slowed and the overall growth rate for the entire 1980-1990 period averaged about 5%. Since that time, population growth has continued but at a slower rate. From 1990 to 2000 the Borough gained almost 9,000 residents, which represents a growth rate of 2%

each year[1]. Between 2002 and 2009, Borough population grew by an estimated 2,253 people, representing a continued decline in the growth rate[2].

There are six incorporated cities within the KPB: Homer, Kachemak City, Kenai, Seldovia, Seward and Soldotna[3]. Outside of the cities, there are thirty-two communities ranging in size from 19 individuals in Sunrise to 7,495 individuals in Kalifornsky (Table 1-3). Representation for the unincorporated communities includes local village councils, community councils, advisory planning commissions and chambers of commerce. However, some communities are not currently represented by local organizations.

Table 1-3. Kenai Peninsula Borough 2009 Community Population Estimates[4].

North Zone			**Total Population Estimate**		**12,725**
Community	**Population**	**Community**	**Population**	**Community**	**Population**
Beluga	24	Nikiski	4,465	Tyonek	166
Kenai*	7,115	Salamatof	855		
Central Zone			**Total Population Estimate**		**20,016**
Community	**Population**	**Community**	**Population**	**Community**	**Population**
Clam Gulch	166	Funny River	796	Ridgeway	2,050
Cohoe	1,332	Kalifornsky	7,495	Soldotna*	4,021
Cooper Landing	344	Kasilof	536	Sterling	5,348
East Zone			**Total Population Estimate**		**5,320**
Community	**Population**	**Community**	**Population**	**Community**	**Population**
Bear Creek	2,009	Lowell Point	76	Seward*	2,609
Crown Point	77	Moose Pass	189	Sunrise	19
Hope	151	Primrose	65		
South Zone			**Total Population Estimate**		**12,915**
Community	**Population**	**Community**	**Population**	**Community**	**Population**
Anchor Point	1,772	Happy Valley	561	Ninilchik	824
Diamond Ridge	860	Homer*	5,551	Port Graham	137
Fox River	604	Kachemak*	430	Seldovia City*	241
Fritz Creek	1,818	Nanwalek	226	Seldovia Village	166
Halibut Cove	27	Nikolaevsk	315		
Entire KPB			**Total Population Estimate**		**53,440**

* Indicates incorporated City.

1.4.7 Facilities and Services

A general overview of facilities and services available for KPB communities is organized by Zone and follows in Tables 1-4 through 1-7.

1 2005 KPB Comprehensive Plan Update – Chapter 2: Population
2 Alaska Department of Labor 2009 Vintage Place Estimates
3 An *All-Hazard Mitigation Plan* for each of these Cities is found in the Annexes
4 Alaska Department of Labor 2009 Vintage Place Estimates

Table 1-4. North Zone Facilities and Services.

Facilities and Services	Kenai	Nikiski	Tyonek
01. Airport	X		
02. Airstrips	X	X	X
03. Fire	X	X	X
04. Law Enforcement	X	X (AST*)	X (VPSO** / AST*)
05. Hospital			
06. Health Clinics	X		X
07. Schools	X	X	X
08. Electric	X	X	X
09. Telephone	X	X	X
10. Natural Gas	X	X	
11. Landfill / Transfer Site	X	X	X
12. Library	X		
13. Roads	X	X	X
14. Community Hall			X
15. Parks	X	X	
16. Civic Center	X		
17. Sports Center	X	X	
18. Private Business	X	X	X
19. Government and Tribal Offices	X	X	
20. Sewage Treatment Facility	X		X
21. Individual Septic Systems	X	X	X
22. Stores	X	X	X
23. Bridge	X	X	
24. Post Office	X	X	X
25. Radio Communications	X	X	X
26. Water Supply	X		X
27. Senior Center	X	X	
28. Church	X	X	X

*Alaska State Troopers
**Village Public Safety Officer

Table 1-5. Central Zone Facilities and Services.

Facilities and Services	Soldotna / Ridgeway / Kalifornsky	Sterling / Funny River	Cooper Landing	Kasilof / Cohoe
01. Airport	X			
02. Airstrips	X	X	X	X
03. Fire	X	X	X	X
04. Law Enforcement	X	X (AST*)	X (AST*)	X (AST*)
05. Hospital	X			
06. Health Clinics	X			
07. Schools	X	X	X	X
08. Electric	X	X	X	X
09. Telephone	X	X	X	X
10. Natural Gas	X	X		X
11. Landfill / Transfer Site	X	X	X	X
12. Library	X		X	
13. Roads	X	X	X	X
14. Community Hall			X	
15. Parks	X	X	X	X
16. Civic Center				
17. Sports Center	X			
18. Private Business	X	X	X	X
19. Government Offices	X			X
20. Sewage Treatment Facility	X			
21. Individual Septic Systems	X	X	X	X
22. Stores	X	X	X	X
23. Bridge	X	X	X	X
24. Post Office	X	X	X	X
25. Radio Communications	X	X	X	X
26. Water Supply	X			
27. Senior Center	X	X	X	
28. Church	X	X	X	X

*Alaska State Troopers

Table 1-6. East Zone Facilities and Services.

Facilities and Services	Seward	Moose Pass	Hope
01. Airport	X		
02. Airstrips		X	X
03. Fire	X	X	X
04. Law Enforcement	X	X (AST*)	X (AST*)
05. Hospital	X		
06. Health Clinics	X		
07. Schools	X	X	X
08. Electric	X	X	X
09. Telephone	X	X	X
10. Natural Gas			
11. Landfill / Transfer Site	X	X	X
12. Library	X	X	X
13. Roads	X	X	X
14. Community Hall	X	X	X
15. Parks	X		
16. Civic Center			
17. Sports Center			
18. Private Business	X	X	X
19. Government Offices	X		
20. Sewage Treatment Facility	X		
21. Individual Septic Systems	X	X	X
22. Stores	X	X	X
23. Bridge	X		
24. Post Office	X	X	X
25. Radio Communications	X	X	X
26. Water Supply	X		
27. Senior Center	X		
28. Church	X	X	

*Alaska State Troopers

Table 1-7. South Zone Facilities and Services.

Facilities and Services	Anchor Point	Homer	Nanwalek	Ninilchik	Port Graham	Seldovia
01. Airport		X				
02. Airstrips	X		X	X	X	X
03. Fire	X	X	X	X	X	X
04. Law Enforcement	X (AST*)	X	X (VPSO** / AST*)	X (AST*)	X (AST*)	X
05. Hospital		X				
06. Health Clinics	X	X	X	X	X	X
07. Schools	X	X	X	X	X	X
08. Electric	X	X	X	X	X	X
09. Telephone	X	X	X	X	X	X
10. Natural Gas				X		
11. Landfill / Transfer Site	X	X	X	X	X	X
12. Library	X	X		X		X
13. Roads	X	X	X	X	X	X
14. Community Hall		X	X	X	X	X
15. Parks	X	X		X		
16. Civic Center						
17. Sports Center						
18. Private Business	X	X	X	X	X	X
19. Government and Tribal Offices		X	X	X	X	X
20. Sewage Treatment Facility		X	X		X	X
21. Individual Septic Systems	X	X		X		
22. Stores	X	X	X	X	X	X
23. Bridge	X			X		
24. Post Office	X	X	X	X	X	X
25. Radio Communications	X	X	X	X	X	X
26. Water Supply	X	X	X	X	X	X
27. Senior Center	X	X		X		
28. Church	X	X	X	X	X	X

*Alaska State Troopers
**Village Public Safety Officer

1.5 Risk Assessment

1.5.1 What is a Risk Assessment?

A risk assessment provides a means to determine the possible loss of life and economic damage that could follow a disaster by evaluating community and infrastructure vulnerability. This phase of mitigation planning elicits critical information needed to appropriately develop mitigation strategies. FEMA identifies four important steps involved in a Risk Assessment (Table 1-8):

Table 1-8. The Four Steps of a FEMA Hazard Risk Assessment

1. Hazard Identification
Information is compiled on all hazards that may affect your community. This includes the geographic extent and intensity of the hazard, as well as possible recurrence intervals.
Location in this plan: Table 1-9 lists 12 hazards and the general probability of occurrence for each within the KPB. More detailed information is found in the appropriate hazard chapter.
2. Profiling of Hazard Events
Profiling hazard events involves describing the particular characteristics of hazards that have occurred in your area. The factors that contributed to a particular event, the affects of the event on population and infrastructure, and the geographic extent of the event are all unique and help to answer the question, How bad can it get?
Location in this plan: Found in the appropriate hazard chapter.
3. Inventorying Assets
Identification of the assets in a community that may be affected by a particular hazard event. This process combines information gathered about the extent and location of a hazard with the potential effects on community populations and infrastructure. Particular attention is paid to emergency and critical facilities that are critical following a hazard event.
Location in this plan: Section 1.5.3 and Tables 1-14 and 1-15 contain a review of critical and essential facilities within the Kenai Peninsula Borough. The threat to specific structures and populations from a hazard is found in the appropriate hazard chapter.
4. Estimating Potential Losses
This step examines possible injury, loss and damage of property from a hazard event in financial terms. This involves estimates of the value of existing structures, while taking into account future development trends in the region.
Location in this plan: Found in the appropriate hazard chapter.

The type and availability of information dictates the level of risk analysis that is possible for each hazard and for each community. Often, detailed hazard data is not available or is housed with different agencies and organizations, and is difficult to find and consolidate. If information deficits are serious, gathering information may be a prerequisite to developing useful mitigation strategies.

1.5.2 Probability of Hazard Occurrence

The overall probability of hazards occurring in the KPB was assessed for this Plan using 1) the State of Alaska's hazard rating matrix, 2) the KPB Emergency Management hazard risk assessment methodology and 3) the KPB Risk Management insurance risk rating table.

State of Alaska Hazard Plan Rating Matrix

The following matrix, developed for the State of Alaska Hazard Mitigation Plan[1], assesses the probability of occurrence of twelve separate hazards in the KPB. Each hazard was identified with the probability of occurrence, if known, and rated low, moderate or high.

[1] Alaska Division of Homeland Security and Emergency Services (ADHSES). State Hazard Mitigation Plan DMA 2000- Updated October 2007.

Table 1-9. 2010 Hazard Matrix for the Kenai Peninsula Borough

Flood	Wildland Fire	Earthquake	Volcano	Snow Avalanche	Tsunami & Seiche
Y – H	Y – H	Y – H	Y – H	Y – M	Y – M
Weather	**Landslides**	**Erosion***	**Drought**	**Technological**	**Economic**
Y – H	Y – L	Y – H	Y – H	Y – H	Y – M

*coastline and riverine erosion

ECONOMIC Y – M (platform and Drift River short & long term effects of closures due to hazards including volcanic ash, lahars and mud flows)

Y: Hazard is present in KPB but probability unknown
Y – L: Hazard is present with a low probability of occurrence
Y – M: Hazard is present with a moderate probability of occurrence
Y – H: Hazard is present with a high probability of occurrence
N: Hazard is not present
U: Unknown if the hazard occurs in KPB

KPB Emergency Management Hazard Assessment Method

The KPB Emergency Management Plan uses hazard-rating tables to provide a numeric aid for assessing relative risk (Tables 1-10, 1-11, 1-12). The calculations incorporate the probability of hazard occurrence, the maximum percentage of population and property that could be impacted, the history of occurrence and the vulnerability of lives and property to a hazard[1]. The highest possible hazard rating score is 240 (for a detailed explanation of calculation methods see Appendix E). This rating system was developed to compare hazard risk across KPB Emergency Response Zones for planning purposes[2]. For the purposes of the All Hazard Mitigation Plan, this information may be applied in much the same way: to help assess the varying degrees of hazard risk faced by residents of the KPB.

[1] In this plan vulnerability was defined as: "the susceptibility of people, property, and the environment to death, injury or damage if a hazard manifests its potential."
[2] This rating system was developed by Pinkston Enterprises for the KPB Emergency Operations Plan (2004).

Table 1-10. Hazard Rating for **Floods** in the Kenai Peninsula Borough by Emergency Management Zone[1]

Zone	History	Vulnerability	Maximum Threat	Probability	Total Points*
North Zone					
Severity	High	Low	Low	Moderate	
Points	20	5	10	35	70
Central Zone					
Severity	High	Moderate	Moderate	High	
Points	20	25	50	70	165
East Zone					
Severity	High	high	High	high	
Points	50	35	100	35	230
South Zone					
Severity	Moderate	Moderate	Low	Moderate	
Points	10	25	10	35	70

*240 points possible

Table 1-11. Hazard Rating for **Wildfire** in the Kenai Peninsula Borough by Emergency Management Zone

Zone	History	Vulnerability	Maximum Threat	Probability	Total Points*
North Zone					
Severity	Moderate	Moderate	Moderate	Moderate	
Points	10	25	50	35	120
Central Zone					
Severity	High	High	high	high	
Points	40	50	100	50	240
East Zone					
Severity	Moderate	Moderate	Moderate	Moderate	
Points	10	25	50	35	120
South Zone					
Severity	High	High	high	high	
Points	40	50	100	50	240

*240 points possible

Table 1-12. Hazard Rating for **Earthquakes** in the Kenai Peninsula Borough by Emergency Management Zone

Zone	History	Vulnerability	Maximum Threat	Probability	Total Points*
North Zone					
Severity	High	High	High	High	
Points	20	50	100	70	240
Central Zone					
Severity	High	High	High	High	
Points	20	50	100	70	240
East Zone					
Severity	High	High	High	High	
Points	20	50	100	70	240
South Zone					
Severity	High	High	High	High	
Points	20	50	100	70	240

*240 points possible

[1] *Pinkston Enterprises. 2004. Kenai Peninsula Borough Emergency Operations Plan. Prepared for the Office of Emergency Management, Kenai Peninsula Borough, Soldotna, Alaska.*

Table 1-13. Hazard Rating for **Weather**[1] in the Kenai Peninsula Borough by Emergency Management Zone

Zone	History	Vulnerability	Maximum Threat	Probability	Total Points*
North Zone					
Severity	Moderate	High	Moderate	Moderate	
Points	10	50	50	35	145
Central Zone					
Severity	Moderate	High	Moderate	Moderate	
Points	10	50	50	35	145
East Zone					
Severity	Moderate	High	Moderate	Moderate	
Points	10	50	50	35	145
South Zone					
Severity	Moderate	High	Moderate	Moderate	
Points	10	50	50	35	145

*240 points possible

Table 1-14. Hazard Rating for **Tsunamis** in the Kenai Peninsula Borough by Emergency Management Zone

Zone	History	Vulnerability	Maximum Threat	Probability	Total Points*
North Zone					
Severity	Low	Moderate	Moderate	Low	
Points	2	25	50	7	84
Central Zone					
Severity	Low	Moderate	Low	Low	
Points	2	25	10	7	44
East Zone					
Severity	Moderate	High	High	Moderate	
Points	10	50	100	35	195
South Zone					
Severity	Moderate	High	High	Moderate	
Points	10	50	100	35	195

*240 points possible

Table 1-15. Hazard Rating for **Volcanoes** in the Kenai Peninsula Borough by Emergency Management Zone

Zone	History	Vulnerability	Maximum Threat	Probability	Total Points*
North Zone					
Severity	High	High	High	High	
Points	20	50	100	70	240
Central Zone					
Severity	High	High	High	High	
Points	20	50	100	70	240
East Zone					
Severity	High	High	High	High	
Points	20	50	100	70	240
South Zone					
Severity	High	High	High	High	
Points	20	50	100	70	240

*240 points possible

[1] This rating was performed for "weather extremes" which includes ice storms, blizzards, extreme heat or cold, drought and high winds.

Table 1-16. Hazard Rating for **Avalanche** in the Kenai Peninsula Borough by Emergency Management Zone

Zone	History	Vulnerability	Maximum Threat	Probability	Total Points*
North Zone Severity Points	Not a significant hazard for the North Zone				
Central Zone Severity Points	Not a significant hazard for the Central Zone				
East Zone Severity Points	High 50	moderate 40	Moderate 50	High 70	210
South Zone Severity Points	High 20	Low 5	Moderate 50	High 70	145

*240 points possible

KPB Risk Management Insurance Rating Table

For insurance purposes, the KPB Risk Management Department has created a rating table that assesses the relative vulnerability of Borough assets from various hazards[1]. Table 1-13 is modified from the original table to highlight the potential affects of floods and earthquakes on identified property (and people) associated with Borough facilities.

Table 1-17. Assets at Risk from Earthquakes, Floods and Weather on the Kenai Peninsula According to the KPB Hazard Insurance Report.

Assets at Risk	Perceived Significant loss potential	Perceived Insignificant loss potential	No perceived risk
People	**E**	**F, W, I**	
Real property (Building)	**E, F, I**	**W**	
Personal property	**E, F, I**	**W**	
Transient property		**E, I**	**F, W**
Fuel tanks	**E**	**F, W**	**I**
Contractor's equipment			**E, F, W, I**
Boats	**E**	**W**	**F, I**
Vehicles	**E**	**W**	**F, I**
Computer systems/data processing	**E, F**	**W**	**I**
Roads/Bridges/Tunnels	**E, F, W, I**		

E = Earthquake; F = Flood; W = Wind/Storm/Hail; I = Ice/Freezing

1.5.3 Critical and Essential Facilities

Critical facilities allow for effective governmental response and recovery from a hazard event. They help in immediate assistance (e.g., fire, ambulance and police) and provide care and shelter for those in need (e.g., hospitals and

[1] This list is modified from KPB Hazard Insurance Report (in prep).

schools). Other community infrastructure, such as communication, transportation and utility services, are also essential. A list of KPB critical facilities is provided in Table 1-14 and 1-15. Mitigation strategies in this plan are intended to minimize hazard effects on these facilities and support their continued function following a hazard event.

Table 1-18. Emergency Response Facilities in the Kenai Peninsula Borough.

North Zone		
Emergency Services	**Hospital and Medical Services**	**Law Enforcement Resources**
Cook Inlet Spill Prevention & Response, Inc. (Nikiski)	Central Peninsula Family Practice (Kenai)	Kenai Police Dept. (Kenai)
Nikiski Fire Dept. (Nikiski)	Indian Creek Health Dept. (Tyonek)	Tyonek Village Public Safety Officer (Tyonek)
Indian Creek Health Dept. (Tyonek)	Kenai Health Center (Kenai)	Wildwood Correctional Center (Kenai)
Kenai Composite Squadron (Kenai)	Medicenter (Kenai)	
Kenai Fire Dept. (Kenai)	Peninsula Insta Care Medical Clinic (Kenai)	
	State of Alaska Public Health (Kenai)	
Central Zone		
Emergency Services	**Hospital and Medical Services**	**Law Enforcement Resources**
ADNR Division of Forestry – Kenai Kodiak Area (Soldotna)	Central Peninsula Hospital (Soldotna)	ADNR Division of Parks – Kenai River District (Soldotna)
ADNR Division of Parks – Kenai River District (Soldotna)		Alaska DPS – Fish and Wildlife Protection (Soldotna)
Central Emergency Services (Soldotna, Kalifornsky Beach, Sterling, Funny River, Kasilof)		Alaska State Troopers (Soldotna)
Cooper Landing Volunteer Ambulance & Fire Dept. (Cooper Landing)		Soldotna Police Dept. (Soldotna)
		USFWS – Kenai National Wildlife Refuge (Soldotna)
East Zone		
Emergency Services	**Hospital and Medical Services**	**Law Enforcement Resources**
Bear Creek Fire Dept. (Seward)	Chugachmiut North Star Health Clinic (Seward)	Alaska DPS – Fish and Wildlife Protection Seward (Seward)
City of Seward Harbor Master (Seward)	Harbor Medical Clinic (Seward)	Alaska State Troopers (Seward)
Hope/Sunrise EMS (Hope)	Providence Seward Medical and Care Center (Seward)	City of Seward Police Dept. (Seward)
Lowell Point Emergency Service Area (Lowell Point)		Kenai Fjords National Park
Moose Pass Volunteer Fire Co. & EMS (Moose Pass)		Spring Creek Correctional Center (Seward)
Seward Bear Creek Flood Service Area		U.S. Forest Service – Seward Ranger District (Seward)

Seward Civil Air Patrol (Seward)		
Seward Marine Service (Seward)		
Seward Volunteer Ambulance Corps (Seward)		
Seward Volunteer Fire Dept. (Seward)		
South Zone		
Emergency Services	**Hospital and Medical Services**	**Law Enforcement Resources**
ADNR Division of Forestry (Homer)	Kachemak Bay Medical Clinic (Homer)	ADNR Division of Parks – Kachemak Bay District (Homer)
ADNR Division of Parks – Kachemak Bay District (Homer)	Nanwalek (English Bay) Clinic (Nanwalek)	Alaska State Troopers (Homer)
Alaska DOT/PF Homer Airport & Homer Highways (Homer)	Ninilchik Community Clinic (Ninilchik)	Homer Police Dept. (Homer)
Anchor Point Volunteer Fire Dept. (Anchor Point)	Port Graham Clinic (Port Graham)	Nanwalek Village Public Safety Officer (Nanwalek)
City of Homer – Port & Harbor (Homer)	Seldovia Medical Clinic (Seldovia)	Port Graham Village Public Safety Officer (Port Graham)
Homer Volunteer Fire Dept. (Homer)	South Peninsula Hospital (Homer)	Seldovia Police Dept. (Seldovia)
Kachemak Emergency Services (Kachemak)		
Ninilchik Community Ambulance Assoc. (Soldotna)		
Ninilchik Volunteer Fire Dept. (Ninilchik)		

Table 1-19. Schools in the Kenai Peninsula Borough

North Zone	
Nikiski North Star Elementary (PS-6)	Sears Elementary (K-3)
Nikiski High School (7-12)	Mountain View Elementary (PS-5)
Kenai Elementary (4-6)	Kenai Central High School
Kenai Middle School (6-8)	Tebughna (formerly Bartlett) (K-12)
River City Academy (7-12)	Kaleidoscope (K-6)
Aurora Borealis Charter (K-8)	Kenai Youth Facility (7-12)
Kenai Alternative High School (PS, 9-12)	
Central Zone	
Cooper Landing (K-12)	Kalifornsky Elementary (K-6)
Tustumena Elementary (K-6)	Sterling Elementary (K-6)
Redoubt Elementary (K-6)	Soldotna Elementary (K-6)
Soldotna Middle School (7-8)	Skyview High School (9-12)
Soldotna High School (9-12)	Soldotna Montessori (K-6)
East Zone	
Hope (K-12)	Moose Pass (K-8)
Seward Elementary (K-6)	Seward High School (9-12)
Seward Middle School (7-8)	Spring Creek (9-12)
South Zone	
Nikolaevsk (K-12)	Ninilchik (K-12)
Chapman (K-8)	Port Graham (K-12)
Paul Banks Elementary (PS-2)	Nanwalek (K-12)
West Homer Elementary (3-6)	Susan B. English (K-12)
Homer Middle School (7-8)	McNeil Canyon (K-6)
Homer High School (9-12)	Fireweed Academy (3-6)
Homer Flex (9-12)	Kachemak Selo (K-12)
Razdolna School (K-6)	Voznesenka (K-12)

1.5.4 Regional Overview of Structures at Risk

Some hazards, such as weather, earthquake and wildfire may threaten structures throughout an entire community or region. Table 1-20 was developed for the wildfire risk assessment and modified here to provide an overview of the number and assessed values of residential structures as well as the assessed values of industrial and commercial structures in 20 KPB communities. Specific information for community wildfire risk is provided in Table A-7, Appendix A of the Interagency All Lands/All Hands Action Plan (Annex H).

Table 1-20. Assessed Values of Residential, Industrial and Commercial Structures by Community

Communities	Number of Residential Structures	Residential Structures* Assessed Value	Industrial Structures* Assessed Value	Commercial Structures* Assessed Value	Total Structure[3] Values
Anchor Point/Happy Valley/Nikolaevsk	1,799	$ 331,697,400	$ -	$ 12,164,600	$ 343,862,000
Fritz Creek/Fox River (East End Rd.)	1,860	$ 150,428,300	$ -	$ 929,200	$ 151,357,500
Homer/Diamond Ridge/Kachemak	3,550	$ 438,689,000	$ 1,166,200	$ 129,792,600	$ 569,584,800
Kasilof/Cohoe	1,654	$ 108,541,500	$ -	$ 5,216,600	$ 113,758,100
Kenai/Kalifornsky	7,076	$ 840,640,600	$ 2,060,900	$ 189,339,600	$ 1,032,041,100
Moose Pass/Crown Point/Primrose	354	$ 18,451,600	$ -	$ 4,465,500	$ 22,917,100
Ninilchik/Clam Gulch	1,399	$ 70,334,100	$ -	$ 12,903,700	$ 83,237,800
Nikiski/Salamatof	3,399	$ 241,710,700	$ 230,583,700	$ 95,747,400	$ 702,877,100
Hope/Sunrise	369	$ 13,012,800	$	$ 1,114,900	$ 24,127,700
Cooper Landing	549	$ 43,412,100	$ -	$ 5,668,300	$ 49,080,400
Seldovia/Seldovia Village	549	$ 32,277,000	$ -	$ 5,621,400	$ 37,898,400
Soldotna/Ridgeway	3,443	$ 379,458,400	$ -	$ 171,666,900	$ 551,125,300
Sterling/Funny River	5,666	$ 525,420,900	$ 487,200	$ 26,230,100	$ 552,138,200
Halibut Cove/Bear Cove	304	$ 12,590,600	$ -	$ 2,281,800	$ 14,872,400
Grey Cliffs/Moose Point	204	$ 1,523,800	$ -	$ -	$ 1,523,800
Summit	17	$ 211,200	$ -	$ 494,700	$ 705,900
Seward/Bear Cr./Lowell Point	2,243	$ 198,562,670	$ 329,900	$ 138,653,600	$ 337,546,170
Tyonek/Beluga	86	$ 1,889,400	$ -	$ 1,688,300	$ 3,577,700
Port Graham/Nanwalek	130	$ 8,102,500	$ -	$ 3,450,600	$ 11,553,100
Remaining structures in Remote Areas	691	$ 19,775,300	$ 211,400	$ 7,529,100	$ 27,515,800
Grand Total - Kenai Peninsula Borough	**36,276**	**$ 2,954,392,970**	**$ 234,839,300**	**$ 814,464,200**	**$4,136,080,870**

*Structure values are based on 2009 Kenai Peninsula Borough Property Tax Assessed Valuations and are considered conservative. These are not market values and land value is not included.

2.0 FLOOD AND COASTAL EROSION

2.1 Why Focus on Flood Hazard Mitigation?

Flooding is a dynamic natural process. Along rivers, streams and coastal bluffs, a cycle of erosion and deposition is continuously rearranging and rejuvenating the aquatic and terrestrial systems. Although many plants, animals and insects have evolved to accommodate and take advantage of these ever-changing environments, damage to property and infrastructure often occurs when people develop coastal areas and floodplains and natural processes are altered or ignored.

Flooding can also threaten life, safety and health, and often results in substantial damage to infrastructure, homes and other property. The extent of damage caused by a flood depends on topography, soils and vegetation in an area, the depth and duration of flooding, velocity of flow, rate of rise and the amount and type of development in the floodplain.

With miles of coastline, and numerous rivers, streams and lakes, most Kenai Peninsula Borough communities are subject to several types of flood hazards. Although flood conditions eventually subside, damage to public and private property is often costly. Unfortunately, some losses suffered during disaster events are impossible to recover, making the actual financial and emotional costs even greater than what is recorded.

Kenai River, Big Eddy Area, Sept. 1995

In 1986, 1989, 1995, 2002, 2006, 2007 and 2009, major fall rainstorms swept the Kenai Peninsula, leaving widespread damage in their wake. The 1986, 1995, 2002, 2006 and 2007 events were substantial enough to be declared local, state and federal disasters. Though not officially declared a federal disaster, damage in the Seward area from the 1989 storm was sufficient to warrant a state disaster declaration. In 1995, the combined public and private flood damage was estimated at over five million dollars[1]. The 2002 floods caused an estimated $24.5 million dollars in damage to roads and other public facilities and an additional $1.25 million in damage to private property[2]. The 2006 and 2007 flood events in the Seward area resulted in an estimated $3 million - $5 million in damages to public infrastructure and private property[3].

Additionally, the 2007 Kenai River ice jams and related flooding resulted in an

1 The 1995 damage estimates were provided by Alaska Division of Emergency Service (ADES) 1995 Damage Survey Reports, and Individual and Family Grant Program Summary, KPB Finance and Assessing Departments.
2 The 2002 flood damage estimates were compiled from summaries provided by the Alaska Division of Homeland Security and Emergency Management, Small Business Administration Loan Program and the FEMA- DR1445 Flood Summary.
3 Combined KPB, state and City of Seward preliminary damage assessments

estimated $2 million in public infrastructure damage and resulted in local, state and federal disaster declarations.

Although property location and value, availability of services and site development costs are normal considerations for residential, commercial and industrial development, the susceptibility of a particular site to naturally occurring events, such as flooding, may be overlooked or underestimated. When natural disasters do occur, such oversights can have tremendous social and monetary costs. As development continues to occur, even in areas susceptible to flooding, flood mitigation planning, including codifying permit/construction criteria for flood-prone areas, can help limit or prevent future loss of life and property.

Following a disaster, funding for damage repair is typically based on the concept of in-kind replacement, or "putting it back exactly as it was", which helps the community in the short term, but also means that similar damage will occur during the next flood cycle. Evaluating problem areas and implementing measures to stop or control damage is a productive and proactive way to end the cycle of repetitive loss.

2.1.1 Past Flood Hazard Mitigation Plans

The Alaska Railroad Corporation, City of Seward, Seward/Bear Creek Flood Service Area Board, Kenai Peninsula Borough and Village of Port Graham have all completed flood mitigation plans in the past as a prerequisite for receiving federal flood mitigation project funding.

Alaska Railroad Corporation, Flood Hazard Mitigation Plan, Milepost 0.0 to Milepost 355.0, 1986.

Hazard Mitigation Plan for the Seward Area, Prepared by the KPB Planning Department, September, 1987.

City of Seward, Flood Hazards Mitigation Plan, Prepared by City of Seward Community Development Department with Hensley Consulting Services, 1996.

Kenai Peninsula Borough Flood Mitigation Plan, Phase I, Prepared by the KPB Planning Department, 1996.

Final Flood Mitigation Plan, Port Graham, Alaska, Kenai Peninsula Borough, Prepared by Montgomery Watson and Parker Horn Company, March 2001.

KPB and City of Seward Resurrection River Debris Removal and Maintenance Plan, 2006.

Seward/Bear Creek Flood Service Area Flood Hazard Mitigation Plan, 2007.

2.1.2 Flood Terminology

A number of flood-related terms are frequently used in this plan and are defined below.

Flood Insurance Study (FIS): A *Flood Insurance Study* is the official report provided by the Federal Insurance Administration, which provides flood profiles, the flood boundary-floodway map, and the water surface elevation of the estimated 100-year base flood.

Flood Insurance Rate Map (FIRM): The Flood Insurance Rate Maps (FIRM) are the official maps on which the Federal Insurance Administration has delineated both the areas of special flood hazards and the risk premium zones applicable to the community.

Flood Insurance Zones (A, A2 through A10, V, B, C, D): In order to set actuarial insurance rates, the Federal Insurance Administration established the following flood hazard map zones:

Zone	Definition
A	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or Flood Hazard Factors determined.
AO	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; depths are shown, but no Flood Hazard Factors determined.
Zone A2 through A5, and A10	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to Flood Hazard Factors.
Zone V	Special flood hazard areas along coasts inundated by the 100-year flood, as determined by approximate methods, and that have additional hazards due to velocity (wave action); no base flood elevations shown or Flood Hazard Factors determined.
Zone V1 through V9, V11, V12, V16, and V19	Special flood hazard areas along coasts inundated by the 100-year flood, as determined by detailed methods, and that have additional hazards due to velocity (wave action); base flood elevations shown, and zones subdivided according to Flood Hazard Factors.
Zone B	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood, including areas of the 500-year floodplain that are protected from the 100-year flood by dike, levee, or other water control structure; also areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than one square mile. Zone B is not subdivided.
Zone C	Areas of minimal flooding.
Zone D	Areas of undetermined, but possible, flood hazard.

100-year Base Flood: Base Flood means the flood having a 1% chance of being equaled or exceeded in any given year. Also referred to as the "100-year flood". Designation on the floodplain (FIRM) maps always includes the letters A or V.

Floodplain: A floodplain is land adjacent to a lake, river, stream, estuary or other water body that is subject to flooding. If left undisturbed, the floodplain serves to store and discharge excess floodwater. In riverine systems, the floodplain includes the floodway.

Floodway: "Floodway" means the channel of a river or other watercourse and the adjacent areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot.

2.2 Floodplain Information Sources

Between 1976 and 1983, FEMA and the United States Army Corps of Engineers (USACE) cooperated to produce the KPB Flood Insurance Study (FIS) and 100-year and 500-year Flood Insurance Rate Maps (FIRM). Additional information about the National Flood Insurance Program (NFIP) and FIRM maps follows in Section 2.5: Floodplain Management.

For the Seward area, the approximate boundaries of the 1986 and 1995 floods are also available as map overlays in the KPB GIS system. These maps provide historic flood information that is useful for land use decisions.

Following the 2006-2007 flood events in the Seward area, KPB coordinated state, local and federal interagency efforts to begin FEMA FIRM mapping updates. This process continued through 2008, with new maps expected to be available in late 2010, after this plan is revised and published. It is expected that other flood events will occur that could negate the effective information of the updated mapping.

As a contingency measure for this possibility, the KPB Assembly convened a task force through 2009 to determine best practices for permitting, property title/insurance identification of flood prone properties, and a public information process that was presented to and mostly enacted by the KPB Assembly in the fall of 2009.

2.3 Types of Flooding

Flooding can occur in a number of ways, and many times are not independent of each other and can occur simultaneously during a flood event: Flooding on the Kenai Peninsula can be broken into a number of categories including:

- heavy rainfall;
- urban stormwater overflow;
- rapid snowmelt;

- rising groundwater (generally in conjunction with heavy prolonged rainfall and saturated conditions);
- chronic debris deposition in streambeds reducing effective stream depths, compounding saturation conditions and contributing to acute channel migration;
- riverine ice jams;
- flash floods;
- fluctuating lake levels;
- alluvial fan flooding;
- glacial lake outbursts (jökulhlaups);
- coastal storm surge run-up; and
- tsunami and seiche (see Section 6.0).

It is also important to note that the various types of flooding are not independent of each other and can occur simultaneously during flood events.

Heavy Rainfall: Based on normal weather patterns, it is not unusual for the Kenai Peninsula to receive heavy rain from mid to late summer through the fall. The rainfall intensity, duration, distribution and geomorphic characteristics, as well as the amount and type of development in each watershed, play a role in determining the magnitude of flood impacts. Runoff flooding is the most common type of flood and usually occurs in conjunction with intense, prolonged rainfall. In addition to surface flooding, saturated soils and rising groundwater can result in landslides and coastal bluff failures.

Urban Stormwater Overflow: As communities develop, natural vegetation is removed and replaced with buildings, streets and parking lots. Water that normally would be absorbed and slowly discharged into groundwater and stream systems rapidly runs off of hardened surfaces into ditches or stormwater systems. Stormwater systems can be overwhelmed by heavy rainfall, debris jams or icing, and it is not uncommon for water to temporarily back up on roads, parking lots and around buildings.

Snow Melt Floods: Floods from melting snow typically occur in the spring or early summer. Snowpack depth and spring and summer weather patterns influence the magnitude of flooding. Warm summer temperatures can rapidly melt mountain snowpack or glacier ice and raise the water level of streams and lakes.

Groundwater Floods: Groundwater flooding occurs as water accumulates and saturates the soil. The water table rises and floods low-lying areas, including crawl spaces and basements, septic tanks and other facilities. It often happens in conjunction with heavy rains and rising surface waters. It is a significant problem for communities situated on alluvial fans, such as Seward, as well as in areas such as the Homer bench where clay layers concentrate the seasonal groundwater table close to the surface.

Ice Jam Floods: Ice jam floods occur when the ice cover on a river is disrupted by rapidly changing temperatures or by a sudden glacier-dammed lake (jökulhlaup) release. Ice jams can also occur when a slushy colloidal suspension, known as "frazil ice", forms and is swept along until it becomes trapped and piles up beneath the surface ice. Ice jams also occur as the result of anchor ice formations or during spring breakup when the ice cover breaks into pieces and jams at bridges, bends or other natural constraints in the river.

Because of the unpredictable nature of ice jams, flooding can be worse than 100 or 500-year events[1]. Heavy damage can occur when ice jams give way, sending surges of ice and rapidly moving water downstream. Ice jams have the potential to significantly damage bridges, piers, levees, jetties and other structures along the riverbanks.

Glacial Outburst Floods (Jökulhlaups): A glacial outburst flood, also known as a jökulhlaup, occurs when water is suddenly released from a glacier-dammed lake. Releases occur when ice dams are overtopped, disrupted by earthquakes, melted by volcanic activity, or drained through sub-glacial conduits in the ice. Sub-glacial releases occur when enough hydrostatic pressure builds to float the ice dam. The Kenai Peninsula Borough has large expanses of ice fields and numerous glacier-dammed lakes. The two most notable for causing flood problems are the Snow and Skilak glacier-dammed lakes, which outlet into Kenai and Skilak Lakes respectively, and release every two to five years. Although Kenai and Skilak Lakes are large lakes and buffer the sudden influx of water, downstream flooding can be quite severe if the lakes or Kenai River are already high or frozen.

A jökulhlaup flood can occur at any time of the year, although in recent years it has occurred more frequently in the fall. One of the highest floods of record on the Kenai River happened in January 1969 when a sudden release from Skilak glacier-dammed lake lifted ice on the frozen river, severely scouring the banks as a surge of water and large ice chunks traveled downstream. At the Soldotna bridge, water levels were nine feet higher than any previous flood of record, including the 1995 100-year flood. In 2007 the water levels reached 20 feet at the Soldotna bridge, nearing the levels reached in 1969. *Maps and outburst history tables for the Skilak and Snow River Glacier-Dammed Lakes are available in Appendix F.*

1 FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska. Community Number 020012.

Flash Floods: Flash floods are characterized by a rapid rise in water level. They are often caused by heavy rain on small stream basins, ice jam formation or dam failure. They are usually swift-moving and debris-filled, causing them to be very powerful and destructive. Steep coastal areas in general are subject to flash floods. A number of steep alluvial streams in the Seward area are susceptible to flash flooding and debris slides. In October of 1986, after 15 inches of rain fell in a 24-hour period, widespread flood damage occurred as a result of debris avalanches and flash floods in Godwin, Lost, Box Canyon, Japanese and Spruce Creek basins[1]. Flash flooding and debris slides associated with steep alluvial streams also damaged property and roads in Homer and along the Homer bench.

Fluctuating Lake Level Floods: Although lakes can buffer downstream flooding due to their storage capacity, if inflow is excessive, flooding of the area around the lake can occur. The Kenai Lake area experiences periodic flooding due to rainfall, snowmelt and glacier-dammed lake releases.

Alluvial Fan Floods: Alluvial fans are areas of eroded rock and soil deposited by rivers. When various forms of debris fill an existing river channel on an alluvial fan, the river shifts to cut a new channel. Fast moving, debris filled water can cause erosion and flooding over large areas. Alluvial fan flooding in the Resurrection River, Lowell, Spruce, Box Canyon, Japanese Creek, Fourth of July and Salmon Creek drainages results in nearly annual road closures, as well as damage to property and infrastructure in the Seward area. Other eastern Peninsula alluvial streams that regularly damage road and railroad infrastructure include the Snow River, Trail Creek, Trail River, Victor Creek, Falls Creek and Ptarmigan Creek. Roads and property within the city of Homer and along the Homer bench have been damaged as a result of flash flooding and debris slides associated with steep alluvial streams.

Coastal Storm Surge and Wave Run-Up: Although the entire Borough coastline is susceptible to tidal storm surge, the coastal communities of Nanwalek, Port Graham, Homer, Ninilchik, Anchor Point, Hope, Seward and Seldovia are vulnerable to flooding from high tides, coastal erosion, storm surge wave run-up and storm water overflow as well as tsunamis and seiche waves.

Tsunami and Seiche: Tsunamis are sea waves of local or distant origin that typically are generated by earthquakes, volcanic activity or land or submarine slides. A seiche is an oscillating wave that occurs in a partially or totally enclosed body of water. Seiches can be generated by earthquakes, landslides, high winds or changes in atmospheric pressure. Because they are contained, seiche waves slosh repeatedly from side to side and continue to cause damage until the activity subsides. Tsunami and seiches are described in detail in Section 6.2.

1 Jones, S.H., and C. Zenone. 1988. Flood of October 1986 at Seward, Alaska. U.S. Geological Survey Water-Resources Investigations Report 87-4278.

2.4 Flood History

Peninsula-wide rivers, streams and coastal areas are a frequent source of flood and erosion damage. People are drawn to the natural beauty and resources available in these areas, and as development increases, so too do the costs associated with flooding.

The earliest flood records for peninsula streams date to the late 1940s. The Resurrection River near Seward inundated 400 acres near the airport in 1946[1]. Vulnerable due to its location on the Resurrection River alluvial fan, the airport has been damaged a number of times through the years. With the exception of a brief interval during the 1970s, flood records indicate the Resurrection River has flooded at least twice each decade since 1946[2] (summarized in Table 2-1).

Table 2-1. Floods of Record – Resurrection River, Salmon Creek, Kenai River and Anchor River[3]

Resurrection River	Salmon Creek	Kenai River	Anchor River
1946	1949	1947	1947
1951	1961	1964	1983
1957	1974	1967	1984
1960	1976	1969	1985
1961	1986	1974	1992
1962	1989	1977	2002
1986	1993	1986	
1989	1995	1989	
1993	2002	1993	
1995	2006	1995	
2002	2007	2002	
2006	2009	2007	
2007			

In the Central Peninsula, one of the earliest recorded floods occurred in 1947 on the Kenai River when waters rose above the level of the Sterling Highway and flooded homes in Cooper Landing. In January of 1969, the Skilak glacier-dammed lake released into a frozen river system, causing serious ice-jam flooding along the Kenai River. In 1995, out of approximately 2,000 parcels of land in the Kenai River's 100-year floodplain, 1,248 were somehow affected by the flooding. Of those, 324 dwellings were surveyed and water damage was estimated at $556,000[4]. Damage estimates did not include losses due to erosion or the wide array of fuel and septic tanks, steps, decks, walkways and docks that were swept away. The 1995 flooding also involved the Kasilof River, where access to the Grant Fritz Subdivision was cut off for ten days due to the area being inundated with approximately six feet of water.

1 FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska. Community Number 020012.
2 FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska. Community Number 020012.
3 Unless otherwise noted, information was excerpted from the1999 KPB FEMA Flood Insurance Study and KPB/Office of Emergency Management files. 2002 Flood Summary was excerpted from USGS Fact Sheet 2004-3023, and email and memos from the National Weather Service.
4 KPB Field Survey of Flood Damaged Homes, Oct. 1995.

As is typical of most of Alaska, detailed descriptions of historic floods on the Kenai Peninsula are rarely available. A summary of historic flood events follows in Table 2-2, and additional flood event information is included as appropriate within the subsequent Zone sections.

Table 2-2. Kenai Peninsula Borough Floods of Record[1]

Year	Location	Flooding Conditions
1883	English Bay	A debris slide into Cook Inlet during the 1883 eruption of Augustine Volcano, triggered a tsunami, which struck English Bay (Nanwalek) and Port Graham[2]. It was reported that the tsunami landed at low tide and caused only minor damage[3].
1946	Resurrection River	First recorded flood in vicinity of the Seward airport; 400 acres inundated.
1947	Cooper Landing	A few basements flooded; water above Sterling Highway in places.
1947	Anchor Point	November rains caused river to top banks but there were no structures in the flooded area at that time.
1949	Salmon Creek	Salmon Creek overflowed at approximately River Mile 4; flooded railroad and threatened railroad bridge; floodwaters surrounded Metcalf Country Store.
1951	Resurrection River	Floodwaters rose unexpectedly at night from heavy snowmelt in the mountains due to warm weather; wells polluted by surface water; water rose five feet in the Clear Creek area.
1957	Resurrection River	River eroded easterly into the Clear Creek drainage and headwaters area; old car bodies were used to reinforce the bank in an attempt to halt the erosion.
1957	Moose Pass	Water reached the school and flooded the railroad tracks and station.
1960	Resurrection River	River overflowed; heavy flood flows caused bank erosion along the east bank above the highway.
1961	Salmon Creek	Flooded 8,000 feet of Nash Road.
1961	Resurrection River	Flooded 500 feet of the airport, eroded the runway and damaged private homes.
1962	Resurrection River	Heavy flood flows across the river's eastern floodplain; severe bank erosion above and below the highway; washed out Airport Road bridge.
1964	Kenai River	Ice-jam flooding caused five families to evacuate their homes on Ciechanski and Rebel Run Roads.
1964	Seward	After the catastrophic March 27, 1964 Good Friday earthquake, Seward was heavily damaged by quake-generated 30-40 foot tsunami waves and large seiche waves that occurred from landslides into Resurrection Bay[4]. According

1 Unless otherwise noted, information was excerpted from the1999 KPB FEMA Flood Insurance Study and KPB/Office of Emergency Management files. 2002 Flood Summary was excerpted from USGS Fact Sheet 2004-3023, and email and memos from the National Weather Service.

2 Waythomas, C.F. and R.B. Waitt. 1998. Preliminary Volcano-Hazard Assessment For Augustine Volcano, Alaska. U.S. Geological Survey, Open File Report 98-106 [www.avo.alaska.edu/pdfs/augustine_ofr.pdf].

3 For additional information see Tsunami and Seiche Section 6.3.

4 Fenner, K.D., Edwards, S.E., and T.M. Neely. 1987. Hazard Mitigation Plan for the Seward Area. 28pp.

		to the Army Corps of Engineers Waterways Experiment Station in Vicksburg, MS, the teleseismic tsunami waves that struck Seward exceeded a 500-year flood event[1].
1964	South Peninsula	Ten- to thirty-foot tsunami waves generated by the Good Friday earthquake struck the communities of Homer, Seldovia, Nanwalek and Port Graham.
1964	Hope	The Good Friday earthquake caused the southern shoreline along Turnagain Arm to subside four to six feet, which caused spring tides to inundate areas five feet above the pre-earthquake tide levels. Homes in low-lying areas around town were flooded and the spring tides nearly reached the entrance to the General Store[2]. Similar tidal flooding occurred at the Homer Spit, where earthquake-induced subsidence lowered the Spit two to six feet and caused 70% inundation during the following autumn high tides.
1967	Kenai River	Ice-jam flooding caused 22 families (81 people) to evacuate their homes; docks, floatplanes, and many homes and businesses damaged; several trailer homes washed away.
1969	Kenai River	In the winter of 1969, a sudden surge release from the Skilak glacier-dammed lake caused a series of ice jams, serious flooding and ice scour damage from Sterling downstream to Soldotna's Rebel Run Subdivision.
1974	Kenai River	Ice-jam flooding washed out docks and boats and flooded several homes; an autumn jökulhlaup caused flooding and minor damage.
1974	Salmon Creek	Overbank flows and minor bank erosion; some minor property damage in the vicinity of the Nash Road bridge crossing.
1976	Cooper Landing	Floodwaters reached the top of the post office dock.
1976	Port Graham	Cannery flooded by coastal storm.
1976	English Bay	Airport runway partially flooded by coastal storm.
1976	Moose Pass	Water flooded sewer system, closing school.
1976	Salmon Creek	Over-bank flows and minor bank erosion. Some minor property damage in the vicinity of Nash Road crossing.
1977	Kenai River	Heavy snowmelt caused a 20-year flood in August; glacier lake dumping caused a 20-year flood in September; both resulted in moderate flooding at Salmon Run Acres (Big Eddy area).
1983	Anchor River	Flooding washed out two portions of the old Sterling Highway; erosion occurred along the south bank of the lower river, particularly along the Old Sterling Highway bridge and public campground.
1984	Anchor River	State Park flood damage included loss of a parking lot and a vaulted latrine, scouring of three other parking lots, and erosion of 500 linear feet of gabion-protected bank.
1985	Anchor River	High water in May and June washed away the bridge, flooded private property and caused significant erosion at the Anchor River State Recreation Area.

1 FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska. Community Number 020012.. For additional information see Earthquake (4.2) and Tsunami and Seiche (5.2) history sections in this plan.

2 Foster, H.L., and T.N.V. Karlstrom. 1967. The Alaska Earthquake. March 27, 1964. Regional Effects. Ground Breakage in the Cook Inlet Area. Geological Professional Paper 543-F.

1986	South Peninsula	Heavy rains caused minor erosion in Homer, Anchor River and Ninilchik; damage at Bradley Lake, Homer and along the Anchor River. Other damage included mudslides at the Ninilchik boat harbor.
1986	Kenai River	Heavy rains on October 10-12th damaged the Beaver Creek/Spur Highway culvert and caused major bank sloughing along the Kenai bluff.
1986	Seward	An intense storm from October 9-11th deposited 15 inches of rain in 24 hours across broad areas of the lower Resurrection River and Salmon Creek watersheds. Flooding was widespread and catastrophic as torrential waters rushed down steep gradient mountain canyons. Massive landslides caused severe erosion and debris dams in the Godwin, Lost, Box Canyon, Japanese and Spruce Creek basins. Subsequent "surge-release" flooding occurred in numerous places as the water backed up and the dams failed. The debris dam failure on Spruce Creek resulted in a water surge of 13,600 cubic feet per second, four times greater than any previously known discharge from the basin[1]. Borough-wide damages to roads, bridges, and other public facilities were estimated at around $2 million.
1989	Seward	Heavy rains on August 25-27th caused over $1 million in damage to homes, roads and bridges. Other areas of the Peninsula reported flooding, but sustained less damage.
1989	Kenai	In September flooding was observed along the south bank in the Riverside Lane area (River Mile 15.5). Some homes and trailers affected; up to one foot of water on the ground. A half-dozen cabins inundated with 1 to 1.5 feet of water in the Castaway Cove area (River Mile 14.5 to 14.7).
1989-90	Drift River	Redoubt Volcano eruptions created a series of mudflows (lahars) that filled and shifted the Drift River watercourse and flooded the Drift River Oil Terminal, which is located 35 kilometers east of Mount Redoubt and 5 kilometers inland from the mouth of the Drift River. The Drift River facility and surrounding area was inundated by extensive lahars and personnel were evacuated three times. Although the facility was threatened by flooding and mudflows, no damage was reported to the oil storage tanks[2].
1992	Anchor River	Flooding damage to one home was reported due to an ice jam on the north fork of the Anchor River.
1993	Seward	Heavy rains on August 26th caused Salmon Creek, Clear Creek and the Resurrection River to flood. Three homes and one business were damaged. The railroad tracks at the upper end of Kenai Lake were damaged, and parts of Primrose Road were submerged.
1993	Cooper Landing	Jökulhlaup flooding from the Snow glacial-dammed lake submerged yards and docks along the Kenai River.
1994	Homer	Storm undercut 1/2 mile of newly paved Homer spit road.
1994	Seldovia & Nanwalek	Storm damaged a park in Seldovia and seriously damaged the Nanwalek runway.
1995	Peninsula-wide	Heavy rains caused extensive stream flooding across Southcentral Alaska. Borough-wide damages to public facilities, commercial property and private residences exceeded $5 million. Fisheries and watershed damage, as well as

1 Jones, S.H., and C. Zenone. 1988. Flood of October 1986 at Seward, Alaska. U.S. Geological Survey Water-Resources Investigations Report 87-4278.

2 Waythomas, C.F., Dorava, J.M., Miller, T.P., Neal, C.A., and R.G. McGimsey. 1998 U.S. Geological Survey, Alaska Volcano Observatory, Alaska Open-File Report 97-857.

		damage to recreational facilities, trails, and roads on the Chugach National Forest, was estimated at an additional $3 million.
1995	Kenai River	Heavy rains from a series of severe seasonal storms caused overbank flows that damaged homes, washed out roads, caused well and septic pollution, washed away decks, boardwalks, other improvements and property, and caused severe bank damage in River Quest, Castaway Cove, Big Eddy, Poacher's Cove, Morgan's Landing, Dow Island and Kenai Keys subdivisions. Although the total amount of private property damage can never be completely assessed, out of approximately 2,000 parcels of land located in the Kenai River's 100 year floodplain, 1,248 were affected by the flooding in 1995. Of those, 324 dwellings were surveyed and water damage was estimated at $556,000[1].
1995	Kasilof River	Flooding occurred along the lower portion of the Kasilof River, east of the Sterling Highway (Mile 109), as well as on the south end of Pollard Loop Road. The river overflowed the embankment, destroyed the drainage crossing, a gravel levee, and inundated the Grant Fritz Subdivision. The area was under approximately six feet of water and road access was cut off for ten days.
1995	Seward Area	Heavy rains associated with a series of storm fronts caused severe flooding in the Seward and outlying areas. Area roads, bridges, the airport, harbor and many homes and businesses were damaged. Road and utility repairs alone were estimated at $3.5 million. Eastern Peninsula areas that flooded included Moose Pass, Falls Creek, Victor Creek, Primrose Creek, Snow River and Kenai Lake. In Moose Pass, rising water in Upper Trail Lake caused minor damage to a number of homes as well as to the first floor of the elementary school. South of Moose Pass, in the Victor Creek area, private lands were lost to erosion although no homes were damaged by the high water. Around the Primrose Area on Kenai Lake, homes were inundated and road access was blocked for approximately two weeks. In the outlying Seward area, flooding occurred along Lost Creek, Bear Creek, Glacier (Kwechak) Creek, Salmon Creek, Clear Creek, Box Canyon Creek and the Resurrection River. South of the city of Seward, substantial damage occurred to Lowell Creek Road due to high flows in both Lowell and Spruce Creeks[2]. Additional damage occurred within the Seward city limits from Japanese, Fourth of July, Godwin, Sawmill and Rudolph (Scheffler) Creeks[3].
2002	Peninsula-wide	Unusually warm temperatures, high winds and heavy rain lingered across the Kenai Peninsula from late September through the end of November 2002. Heavy rain during that time damaged areas from Portage (to the north), Cordova (to the east), Chignik (on the Alaskan Peninsula to the west) to Kodiak Island (to the south). The heaviest rains and most severe flooding occurred on the southwestern Kenai Peninsula between October 22-24 and November 23[4]. The National Weather Service Doppler radar system was inoperable for a number of hours on October 20, 23 and 24. As a result, crucial information about the amount of rain falling in the Caribou Hills region was not reported and the flooding that began on the Seward side of the Peninsula struck southwestern Peninsula streams without much warning. All told, the fall floods directly affected ten communities and damage to public facilities (roads, railroad, parks, utilities, buildings and equipment) was

1 Oct 1995, KPB Field Survey of Flood Damaged Homes.
2 Kenai Peninsula Borough. 1996. Flood Mitigation Plan.
3 City of Seward. 1996. Flood Hazard Mitigation Plan. City of Seward Community Development Department and Hensley Consulting Services.
4 Eash, J.D., Rickman, R.L., March 2004. Floods on the Kenai Peninsula, Alaska, October and November 2002. USGS Fact Sheet 2004-3023.

		estimated at over $24.5 million dollars[1]. Of that, damage to 62 sites on the highway system was estimated at $20.5 million, $781,000 to State Park facilities, $1.2 million to Borough roads and bridges and $425,000 to power lines and underground distribution lines[2]. Damage to private property totaled more than $1,225,000[3].
2003	Pile Bay Road	In October of 2003, 15 inches of rain caused serious flooding on the west side of Cook Inlet between Lake Iliamna and Iliamna Bay. A State Disaster Declaration was issued and flood damage to the 14-mile (state-maintained) Pile Bay Road between Williamsport and Pile Bay Village cost nearly half a million dollars to repair. Damage to 22 sites along the first six miles of the road within the KPB accounted for $176,800 of the total damage[4].
2003	Nanwalek	Wind-driven waves in November of 2003 eroded away a 500-foot long by 40-foot wide section about halfway down the English Bay airstrip on the bay side and a 400-foot long by 40-foot wide section of runway on the lagoon side[5].
2006	Seward area	On October 8, flooding, mudslides, heavy rains and extremely high winds occurred, threatening life and property in the Seward area. Seward was inaccessible by road due to flooding across the Seward Highway at mile 4. Lowell Point Bridge was heavily damaged, cutting off the Lowell Point community. Additional damage to bridge infrastructure required the replacement of the Forest Avenue and Lost Creek Bridges. Damage assessments included Old Mill Subdivision, Camelot Subdivision, Lowell Point and Old Exit Glacier Road. Initial Kenai Peninsula response costs approximated $150,000. Recovery estimates for roads, bridges and other infrastructure were between $3.1-$3.5 millon[6].
2007	Old Mill (Seward area)	Beginning May 17th, flooding occurred in the Old Mill Subdivision. Dredging was approved for 200 feet above and 100 feet below the Lost Creek Bridge. Approximately 100,000 cubic yards of gravel and silt were removed from Lost Creek. Flooding was a result of heavy deposits of gravel and silt from the headwaters of Lost Creek[7].
2007	Kenai River Ice jams	Beginning on January 25, the Skilak Glacier-dammed lake breached, releasing a four foot high surge of water into the Kenai River. This flood dislodged rafts of ice up to four feet thick and weighing several tons. Ice jams formed and overtopped the riverbanks, with ice piling up to 15 feet high in some places. Ice jams threaten the Soldotna Bridge when water levels rose above 20 feet. Significant ice damage occurred from the community of Sterling through the City of Soldotna. Initial response and damage to both public and private facilities approximated $5.5 million[8].
2009	Drift River Lahar flows	Mount Redoubt began intermittently erupting on March 22. The largest eruption occurred on April 4. The resultant lahars caused extensive flooding at the Drift River Oil Terminal. The dike system and secondary tank containment systems held during these lahar flooding events. An incident command post was activated at the Sheraton Hotel in Anchorage on March 31. The primary response objectives included the safety of response personnel and protection

1 Federal Emergency Management Agency (FEMA). 2002 Kenai Peninsula Flood Summary DR-1445.
2 Matthews, J. Planning and Project Management Coordinator, Homer Electric Assoc. Inc., (Email Memo).
3 Cowles, W. ADHS/ES, Private Assistance Grant Funding Summary, (email) and Jenkins, R., Small Business Administration, Private Homeowner and Business Loan Program (telephone communication).
4 Pers. Comm., Carol Sanner, Alaska Dept. of Transportation and Public Facilities, Central Region, Maintenance and Operations, Pile Bay Road Flooding Incident Spreadsheet, 3/30/04.
5 Trip Report: English Bay Runway Repairs, Nanwalek, Randel Jones, Homer Station Foreman, Alaska Dept. of Transportation and Public Facilities, 2/26/2004.
6 Seward Flood Situation Report 10/11/06 Media Release 10/13/06
7 OEM 2007 Seward Flooding File/ 6/15/07
8 Incident Fact Sheet/Claude Denver DMVA/DHS&EM/ 02/23/07

		of the environment. Prior to April 30, approximately 6.2 million gallons of crude oil were removed from the terminal. Subsequently, the remaining 13 percent, or another 841,000 gallons, of crude oil was transferred to a refinery in Hawaii[1].
2009	Seward	In late July, Seward experienced flooding due to heavy rains. Lowell Point Road was closed at the bridge access and in danger of washing away. Landslides blocked Lowell Point Road. Seward airport was closed. The levee in Box Canyon Creek washed out, causing considerable flooding along Old Exit Glacier Road, Lois Way and Wilma Avenue. Initial emergency response was $39,500. Recovery costs for road and bridge damage were approximately $73,000[2].

A list of publications and additional flood hazard resources is provided in the Flood Resource Directory at the end of this chapter.

2.5 Floodplain Management

2.5.1 National Floodplain Insurance Program (NFIP)

The KPB first entered the NFIP in 1970 with passage of a resolution committing to adopt a floodplain development ordinance. In March of 1980, the Borough was suspended from the NFIP for failure to adopt the necessary regulations. A few years later, after severe fall storms caused widespread flood damage, the Borough reapplied for the NFIP. On November 18, 1986, after passage of Chapter 21.06 Floodplain Management (KPB Res. 87-13), FEMA accepted the Borough back into the NFIP.

In 1981, the U.S. Army Corps of Engineers (USACE) provided the Borough with Flood Insurance Rate Maps (FIRM), which were revised in 1983. Subsequent revisions to the original FIRM maps include a 1984 Letter of Map Revision (LOMR) for a portion of Kwechak/Glacier Creek, a 1996 LOMR for a portion of the Resurrection River above the Seward Highway and a 1999 re-map of the Big Eddy area along the lower Kenai River.

Following the 2006-2007 flood events in the Seward area, KPB coordinated state, local and federal interagency efforts to begin FEMA FIRM mapping updates. This process continued through 2008, with new maps expected to be available in late 2010, after this plan is revised and published. It is expected that other flood events will occur that could negate the effective information of the updated mapping.

As a contingency measure for this possibility, the KPB Assembly convened a task force through 2009 to determine best practices for permitting, property title/insurance identification of flood prone properties and a public information process that was presented to and mostly enacted by the KPB Assembly in the fall of 2009.

On September 16, 2008, Ordinance 2008-18-19 was enacted by the KPB Assembly, accepting and appropriating a grant of $1,369,125 from the Natural Resources

1 Drift River Terminal Coordination/Unified Command/Situation Report/04/22/09
2 OEM Flood File/Seward Flooding 2009/07/30/2009

Conservation Service (NRCS) and $228,187 from the Division of Homeland Security and Emergency Management and providing for a local match and in-kind services for conducting a voluntary buyout program in the Old Mill Subdivision, Seward. Total estimated project was $1,825,500 and estimate for property acquisition was $1,140,300. Properties tagged for buyout reflected recurring flood damage estimated at $5 million with a near-term damage estimate of $1 million[1].

FEMA and the USACE prioritized stream and coastal areas for flood mapping based on the amount of at-risk existing development as well as the overall potential for future development. Areas with the most development were studied in detail, which provided floodway delineations and 100-year base flood elevations (BFEs) and wave run-up elevation predictions. Floodplain areas that have BFE information are referred to as ***numbered*** A and V Zones. Less-developed areas were studied by approximate methods, meaning the approximate boundaries of the 100-year flood were provided, but BFE information was not generated. Floodplain areas studied by approximate methods are referred to as ***unnumbered*** A and V zones[2].

Detailed studies were completed for the Kenai and Kasilof Rivers, Salmon Creek, Salmon Creek Bypass and a limited portion of the Resurrection River. In addition, detailed studies to delineate coastal storm surge flood elevations were completed for several communities along Cook Inlet, Kachemak Bay and Resurrection Bay.

KPB Chapter 21.06 established floodplain management regulations for the FIRM mapped floodplains outside of the incorporated cities of Kenai, Soldotna, Seward and Homer. The Cities of Homer and Seward regulate floodplain development for FIRM areas within their incorporated boundaries[3]. Kenai and Soldotna do not currently regulate floodplain development in their FIRM areas and do not participate in the NFIP.

2.5.2 Flood Insurance

The NFIP is a source of reasonably-priced flood insurance for property owners that build to floodplain standards. Although insurance helps recover losses, it does not provide a complete solution, as it only pays for damage to improved land and buildings, therefore sometimes encouraging rebuilding in areas subject to repetitive flooding. According to FEMA's community insurance information system, there are currently 271 policies in the KPB (Table 2-3). Although the number of policies appears small compared to the total number of properties at potential risk, it actually is close to the national average of 12%[4].

1 Kenai Peninsula Borough OEM Old Mill Buyout File/ 9/22/08
2 FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska. Community Number 020012.
3 Homer City Code – Chapter 12.12 Flood Damage Prevention; Seward City Code – Chapter 15.25 Floodplain Management.
4 Pers. Comm., Christy Miller, NFIP State Coordinator, Division of Community Advocacy, Department of Community and Economic Development, 6-2-04.

Table 2-3. Kenai Peninsula Borough Flood Insurance Summary[1].

Number of Policies	271
Total Premiums	$176,760
Insurance in Force	$57,259,200
Number of Paid Losses	34
Value of Paid Losses	$409,282

2.5.3 Repetitive Flood Losses

Although FEMA tracks repetitive insurance losses, it does not track uninsured losses, which have been significant in past flood events. A "repetitive loss property" is defined by FEMA as any property with two or more insurance claim losses in any ten-year period. If two losses occur within ten days of each other, only one loss is counted. In order for a property to be considered for repetitive loss status, the insurance claims must have occurred on or after January 1, 1978, be closed and involve at least $1,000 in payments.

In addition to repetitive loss claims, the Borough also tracks "substantially damaged" improvements, defined as those that cost more than 50% of the improvement's market value to repair. If a substantially damaged structure is located within a mapped floodplain, repair or reconstruction must comply with floodplain building standards. After flood waters subsided in 2002, three floodplain properties in the Seward area were identified as substantially damaged[2], and there were approximately five properties outside of mapped floodplains in the Anchor Point and Ninilchik areas that were identified with substantial damage[3]. Following the 2006/2007 flood events in the Seward area, properties in the Old Mill neighborhood were identified through the USDA Natural Resource Conservation Service (NRCS) Emergency Watershed Protection program as "buy-out" eligible to establish a conservation easement along the streams in that neighborhood. NRCS, KPB and residents of Old Mill are proceeding with that project as of December 2009.

2.5.4 Community Rating System Program

The KPB also participates in the NFIP Community Rating System, which is an incentive program that reduces premiums when communities exceed the minimum requirements of the NFIP. The KPB's Class 8 rating provides a 10% insurance premium reduction, which represents an average annual savings of $60 per policy[4].

1 Pers. Comm., Taunnie Boothby, NFIP State Coordinator, Division of Community Advocacy, Department of Commerce, Community and Economic Development, 2-10-10.
2 Pers. Comm., Christy Miller, NFIP State Coordinator, Division of Community Advocacy, Department of Commerce, Community and Economic Development, 6-2-04.
3 Pers. Comm., Jane Gabler, KPB Floodplain Administrator, 6-2-04.
4 Pers. Comm., Jeff Woodward, FEMA ISO/CRS Specialist

2.5.5 Coastal Erosion

The western portion of the Kenai Peninsula is composed of poorly consolidated materials deposited by glaciers and rivers. This material is extremely susceptible to erosion. Until now there has been no effort to map these historical erosion rates. Several roads and houses have been lost to erosion since the 1950s. The erosion therefore impacts property values for homeowners and the Borough. This coastline also has a rapidly growing population base, with many people building near the bluff edge and then reinforcing their property once the effects of erosion become apparent. Often erosion control remedies result in increased erosion on adjacent properties.

Calculations of bluff recession over time were measured at approximately 100-meter intervals within an 86-mile study area from Homer to Nikiski. Based on these observations, the study concluded that, on average, during the period 1952-2004 the bluff has eroded one foot per year. This observation must be tempered with the understanding that some areas experience little erosion and other areas experience significant erosion. Within each of the defined areas of study, bluff erosion occurs at various rates. Areas experiencing high erosion rates are called “hot spots”. These areas have been identified in the study. The area north of the Kenai River to the east Forelands has the greatest incidents of hot spot erosion. The area north of Anchor Point to the Kasilof River has the fewest such areas. The most significant hot spots experience erosion at the average rate of 2.3-5.7 feet per year. An important caveat in these observations is that erosion does not generally occur gradually. An area may not erode for many years and then suddenly slough a significant amount.

2.6 Flood Hazard Assessment Overview

The Kenai Peninsula Borough encompasses 24,737 square miles[1], which includes Cook Inlet, and is approximately equivalent in size to the combined states of Vermont, New Hampshire and New Jersey. Within Borough boundaries there are 16,013[2] square miles of land, of which 9,050 are located on the Kenai Peninsula and 6,450 on the west side of Cook Inlet (Figure 1-2).

Given the Borough’s large size and diversity of topography, geology, hydrology and weather, the flood hazard risk assessment is organized into a general Borough-wide overview (which includes references to tables and figures included in Section 1). More detailed floodplain information is provided in the KPB Emergency Management Zone (North, Central, East, and South) sections which follow (see Figure 1-1).

2.6.1 Risk and Vulnerability

The extent of damage caused by any flood depends on topography, soils, vegetative cover, depth and duration of flooding, velocity of flow, rate of rise, amount of development in the floodplain and the effectiveness of flood prevention and flood fighting efforts. Critical elements of a flood hazard assessment involve:

1 Kenai Peninsula Borough 2002 Situations and Prospects.
2 U.S. Census Bureau, County and City Data Book: 2000 (13th edition), Washington, DC, 2001, Library of Congress Card No. 52-4576.

- estimating the geographic areas at risk from flooding;
- the type and intensity of flooding;
- the probability of flood events; and
- the relative vulnerability of people and development.

Typically, communities use federally standardized Flood Insurance Studies and Flood Insurance Rate Maps (FIRMs) to identify risk and manage development in flood hazard areas. (As of January 2010, the KPB is pursuing funding through FEMA's Hazard Mitigation Grant Program to conduct risk and vulnerability assessments in the Seward area.)

2.6.2 Floodplain Maps and Flood Risk Prediction

The FEMA FIRM flood maps are currently the Borough's primary flood prediction and regulatory tool. It is important to realize that these maps represent the flood risk that was present at the time they were completed. As time goes by and significant natural and man-made changes occur within floodplains, the maps become less accurate for predicting flood risk. This is particularly true of the rapidly-changing alluvial streams in the Seward area. It is also true for south peninsula streams such as the Anchor and Ninilchik Rivers, where channel and floodplain characteristics were dramatically altered during the 2002, 2006 and 2007 floods.

Following the 2006-2007 flood events in the Seward area, KPB coordinated local, state and federal interagency efforts to begin FEMA FIRM mapping updates. This process continued through 2008, with new maps expected to be available in late 2010, after this plan is revised and published. It is expected that other flood events will occur that could negate the effective information of the updated mapping.

In addition to the loss of predictive power that accompanies aging maps, some areas were only assessed for approximate flood boundaries (unnumbered A and V zones) or development is so recent that mapping is not yet available. Unmapped developing areas include locations next to streams, lakes, local drainages and coastal areas. In addition, as paving and other development has increased impervious surfaces, storm-water runoff flooding in some communities has become more problematic.

Adding a layer of complexity for flood risk assessment is the rate and amount of land subdivision and subsequent development, which has been increasing steadily in recent years in both developed and remote areas of the Borough. Another complicating factor involves the death and harvest of thousands of acres of spruce bark beetle-infested forest across the Borough (see wildfire hazard section). In recent years, accelerated timber harvest has opened access to large portions of the central

and southern peninsula. Approximately 130,000 acres of infested timber on the Kenai Peninsula has been harvested, including lands in the Stariski Creek, Ninilchik River, Anchor River, North Fork Anchor River and Deep Creek watersheds. In addition to impacts from increased road building and other development, the death of millions of spruce trees is causing major ecological changes at a landscape scale, including changes to water retention and cycling processes. Concurrent with the harvest, the hydrologic cycle impacted by the mortality of mature spruce trees has increased runoff volumes significantly, affecting the flooding effects of our rivers and streams. The impact to the Borough's rivers, lakes, wetlands and other water systems from the removal (by death or harvesting) of millions of trees is still largely unknown.

Of the dozen FIRM floodplains in the KPB, nine have been entered into the KPB Geographic Information System (GIS) and linked to the Borough's tax assessment databases. GIS provides a powerful mapping and analysis tool that is useful for floodplain permitting and land management decisions. Tax parcel information provided by the GIS Department was also used for the floodplain risk analysis sections of this report.

Additional flood hazard risk assessment information specific to the communities of Seward, Kenai, Soldotna, Homer and Port Graham is included in the city annex sections at the end of this report.

As a contingency measure for this possibility, the KPB Assembly convened a task force through 2009 to determine best practices for permitting, property title/insurance identification of flood prone properties, and a public information process that was presented to and mostly enacted by the KPB Assembly in the fall of 2009.

2.6.3 Vulnerability Assessment

A vulnerability assessment identifies the population, property and environment that may be exposed to flooding, and is important for understanding and reducing risk and preventing future losses. Consequences to people from flooding include the possibility of injury or death as well as the possible need for emergency sheltering due to loss of homes. Consequences to property include partial or total destruction of improvements, equipment and services. Serious flooding has the potential to disrupt vital services such as water, sewer, power and gas; can damage roadways, bridges, buildings, railroads, airport facilities, residential, commercial and recreational development; and can cause additional natural and environmental emergencies such as landslides.

Because the data is not readily available to make site-specific predictions for 10-, 25-, 50-, 100-, or 500-year flood events, calculating each community's vulnerability to flooding is not straightforward. Although the Flood Insurance Rate Maps are somewhat dated and not predictive of all flood hazards, they currently represent the primary tool available to the Borough.

New FEMA FIRM mapping updates are expected to be available in late 2010, after this plan is revised and published. It is expected that other flood events will occur that could negate the effective information of the updated mapping.

As of January 2010, KPB is pursuing a mitigation grant to conduct this vulnerability assessment in the Seward area.

To assist with the vulnerability analysis section of this report, a GIS analysis of the 100-year FIRM floodplain overlays was used to calculate the number and value of parcels, improvements and acres that are within or intersect nine of the major KPB floodplains (Table 2-4). Unless otherwise noted, parcels that intersect the floodplain (and the associated structure and value estimates) were not differentiated from parcels that are completely within the floodplain. Total acreage was calculated in two ways: for parcels ***intersecting*** the floodplain and for total acres ***within*** the floodplain boundary (separate from parcel boundaries). Notes at the bottom of each summary table indicate which acreage calculation was used. Three of the KPB FIRM floodplains were not included in the GIS floodplain data analyses[1].

An overview of the mapped floodplains is provided in Table 2-4. More detailed floodplain population and development assessments are included in the Zone sections, which follow. Spreadsheets used for the floodplain parcel analysis are provided in Appendix G.

Table 2-4. Summary of Nine Mapped (FIRM) Floodplains[2].

Mapped Floodplains	Number of Parcels*	Total Value* (millions of $)	Number of Parcels* with Improvements	Number of Improvements*	Value* of Improvements (millions of $)	Total Acres**
Upper Kenai	115	$108	86	261	$20	1,000
Lower Kenai	2,591	$549	1,580	2,378	$424	8,813
Kasilof River	213	$28	102	168	$13	2,357
Anchor River	40	$3	19	25	$2	192
Resurrection Ck	63	$14	16	24	$0.5	898
Ninilchik	32	$32	15	18	$0.8	66
Seldovia	149	$14	73	85	$5.8	152
Seward	618	$179	314	460	$120.9	2,991
Trail River	107	$29	25	69	$4.8	1,634
TOTAL	**3,928**	**$926**	**2,230**	**3,488**	**$591.8**	**18,103**

Data Source: 2009 KPB GIS System and Tax Assessment Database.
* Value and number of parcels and improvements in the FIRM Flood Zone A includes properties that intersect but are not necessarily completely within the floodplain.
** Represents an estimate of acres completely within the FIRM Flood Zone A.

1 Due to technical problems with digitizing and geo-rectifying the FIRM maps, Nikiski, Nanwalek and Port Graham floodplains are not in the KPB GIS system and were not included in the mapped floodplain vulnerability summary.
2 Though not listed in this table, a floodplain parcel analysis was also completed for the lower 12.5 miles of the Kenai River that is within a FIRM area (see Appendix G). However the City of Kenai does not participate in the NFIP and this analysis only provides a brief overview and indication of the structures and parcels in the Kenai River floodplain.

2.6.4 Critical Facilities

Critical facilities provide essential services for public health and safety, emergency response and disaster recovery operations. They help in immediate assistance (e.g., fire, ambulance, and police) and provide care and shelter for those in need (e.g., hospitals and schools). The infrastructure that supports these services (e.g., roads, bridges, sewer and water facilities) is also essential. A list of KPB critical facilities is provided by Zone in Tables 1-18 and 1-19 in Section 1. Although a majority of the Borough's critical facility buildings and response equipment are located outside of mapped flood hazard areas, damage to roads, bridges or utility infrastructure can directly and indirectly impact the facilities and their response capabilities.

2.6.4.1 Roads

Maintaining road connections is critical for providing emergency response and evacuation. Road systems in the KPB are maintained by multiple jurisdictions. Federal, state, borough, city and village governments all have a stake in managing and protecting roads from flood damage. Borough-owned roads are managed and maintained through the Kenai Peninsula Borough Road Service Area.

According to the Road Service Area Department, there are approximately ten Borough-maintained roads that are subject to repetitive flood damage[1]. Because flood-prone roads often create access or safety issues and are expensive to maintain and repair, new roads currently must be engineered and constructed to minimize flood impacts before they are accepted into the Borough road maintenance program. The 2003 KPB Transportation Plan identifies the lack of alternative routes for evacuation and emergency access and the need for more site-specific flood hazard mapping as key issues for Borough roads[2].

An overview of KPB roads is available in Section 1.4.5 and more detailed information is available in the KPB Transportation Plan[3].

Bridges and other water crossing structures, such as culverts, are vulnerable links in road networks. Depending on the design of the structure and the magnitude and type of event, bridges and culverts can fail, endangering lives, seriously impacting the stream and riparian areas and interfering with emergency response. There are approximately 60 bridges on public roads in the KPB (Appendix J), a majority of which are state-owned and maintained as part of the highway system. The Borough owns and maintains 14 of the 60 bridges (see Section 1.4.5, Figure 1-5).

2.6.4.2 Communities and Flood Risk

Summary information for each community is included in Section 1 of this report and more detailed information specific to flood risk is provided for each zone in Sections 2.7, 2.8, 2.9 and 2.10.

1 Pers. Comm., Jim Conner, Kenai Peninsula Borough Road Service Area Inspector, 4/07/2010.
2 HDR Alaska, Inc. 2003. Kenai Peninsula Borough Transportation Plan Update (www.kpbtransplan.net).
3 Ibid.

2.6.5 Development Trends

For areas within each zone where GIS FIRM floodplain information is available, a brief description is included of the number and size of vacant private parcels that are within or intersecting the mapped floodplains. This information is intended to provide a general sense of land that may be available for development. For the purposes of assessing development trends, three general assumptions were made:

- that one- to five-acre lots represent properties that have been subdivided and have some type of development potential;
- parcels larger than five acres have potential to be further subdivided for additional development; and
- large tracts of public land currently designated as state or national forest, park land, wilderness or critical habitat areas will not be subdivided into small lots and sold for private development.

No specific evaluation was done to determine whether vacant parcels contained factors such as steep slopes, poor soils or wetlands that could limit actual development potential. Time and resources were not available to evaluate flood hazards and development trends in other than a general way for unmapped floodplain areas.

2.7 North Zone

2.7.1 North Zone Communities

The North Zone covers approximately 5,469 square miles and includes the following localities and communities:

> Kenai Lowlands, Cook Inlet and the west side of Cook Inlet, Beluga, Tyonek, Nikiski, Salamatof and the portions of the City of Kenai that lie north of the Kenai River.

The population of the zone is about 12,625 people, with an increase to about 20,000 during the summer tourist season. Communities with known flood hazard risks are described in Table 2-5 and shown in Figure 2-1.

Table 2-5. North Zone Communities with Flood Hazard Risk.

Central Zone Community or Area	2009 Population Estimate [1]	Water Body	FEMA FIRM Maps	Type of Flooding
Salamatof Nikiski	5,320	Cook Inlet, Swanson River, Bishop Creek	Nikiski – Limited un-numbered A Zones Cook Inlet – limited Numbered V Zone. Note: Nikiski FIRM maps are not entered in the KPB GIS system.	Lake, riverine, coastal storm
West Side – Drift River Oil Terminal	N/A	Drift River, Rust Slough, Cook Inlet	No Flood Mapping	Riverine, volcanic debris-surge, ice-jam, coastal storm
Beluga/Tyonek	190	Three Mile Creek, Chuit River, Cook Inlet	No Flood Mapping	Riverine, coastal storm
Kenai City	7,115	Kenai River, Beaver Creek, Cook Inlet	Numbered A and V Zones – although City of Kenai does not regulate floodplain development or participate in the NFIP	Riverine, ice-jam, jökulhlaup, coastal storm
Total North Zone Population				**12, 625**
Approx. population at direct risk from flooding[2]				**600**

1 Source of Population Estimates: Alaska Department of Labor and Workforce, Research and Analysis Section, Demographics Unit.

2 Estimate of the at-risk population was generated by adding the 2007 KPB Emergency Response Plan estimate of 150 people at risk to the estimated number of people residing in the City of Kenai FIRM area. The FIRM area estimate was derived by multiplying the number of developed recreational and residential parcels within the City of Kenai FIRM area (6 recreational and 73 residential parcels) by three people per parcel. 148 x 3 = 444+ 150 = 590, which was rounded to 600.

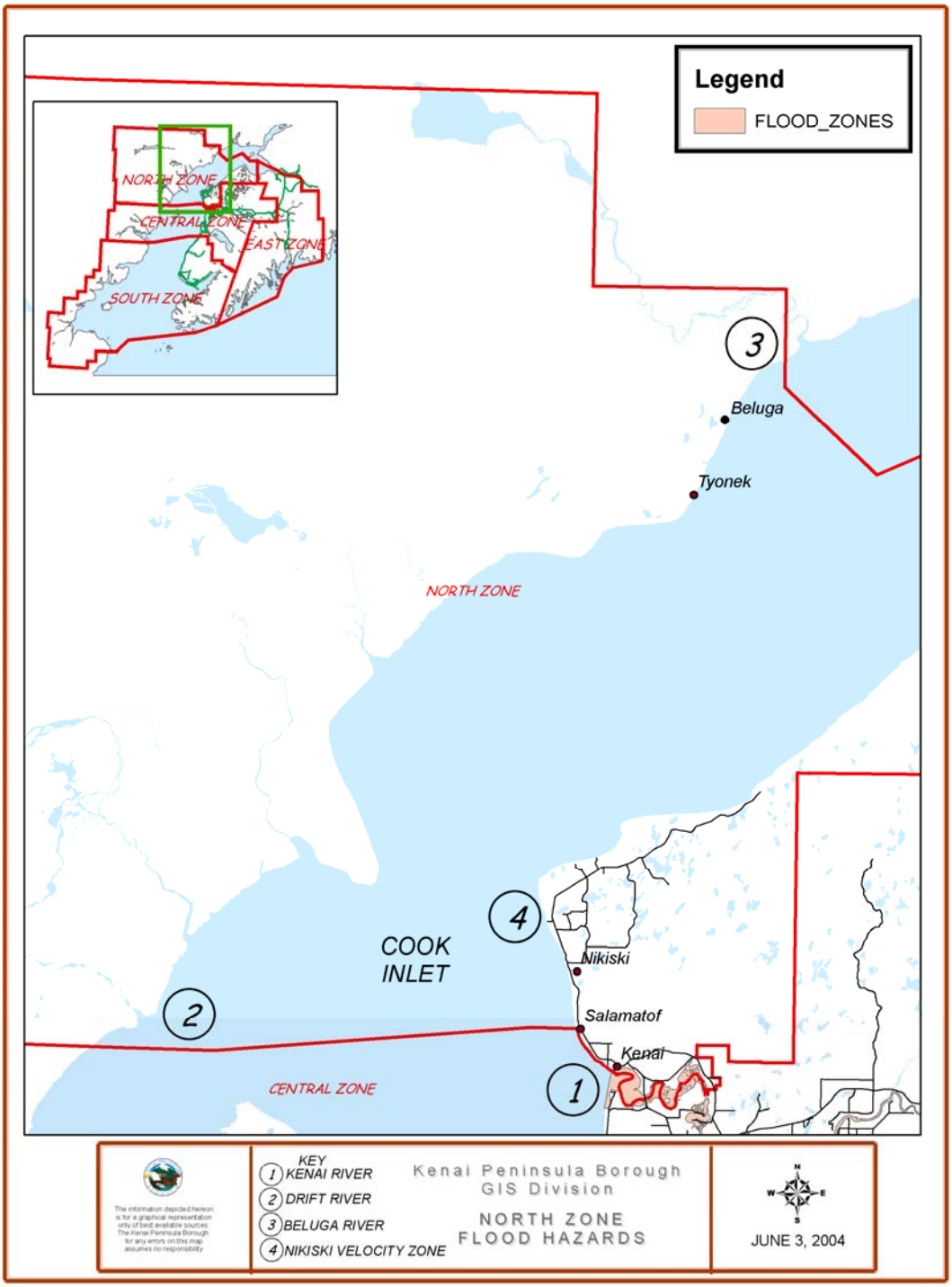


Figure 2-1. North Zone Communities and FEMA FIRM 100-Year Floodplains.

The North Zone contains a majority of the Peninsula's oil and gas development, including 14 offshore platforms, and a number of processing facilities centered in the North Kenai-Nikiski area (Section 1.4.4, Figure 1-4). Air, land and water transportation networks are described in Section 1.4.5 and facilities and services are listed in Table 1-4. Additional information for the City of Kenai is included in Annex C.

2.7.2 Characteristics of Flooding

Flooding in the North Zone could occur as the result of heavy precipitation, ice jams, rapid ice and snow melt, rapid release of glacial-dammed waters (jökulhlaup); urban storm-water runoff, tidal storm surge, coastal wave run-up, and tsunami and seiches (see also Section 6.0 Tsunami and Seiches). In addition, streams on the west side of Cook Inlet are subject to volcano lahar debris and surge release flooding.

The predominant risk of North Zone flooding involves the lower 12.5 miles of the Kenai River. With a mean tide range of nearly 20 feet on Cook Inlet, considerable backwater occurs at the mouth of the river during a high tide[1]. At the mouth, the bluffs to the north and the low-lying wetlands to the south are subject to periodic coastal storm-surge flooding and erosion, sometimes in combination with high river flows. High flows can occur during any season. Spring floods may occur as a result of above-normal snowfall during the preceding winter, followed by an unusually cold spring and then a rapid snowmelt. Summer and fall floods usually result from intense or prolonged rain storms.

The Kenai River is subject to glacial outburst (jökulhlaup) flooding from lakes formed in the Snow and Skilak glaciers. The Snow glacier-dammed lake releases into the Snow River, which outlets into Kenai Lake. The Skilak glacier-dammed lake releases into the Skilak River and Skilak Lake. Although the two large lakes help buffer the effect, jökulhlaup releases have caused flooding downstream on the Kenai River a number of times. A jökulhlaup can occur at any time of the year, although since 1953 the releases have generally occurred in the fall. The first recorded outburst of the Snow glacier-dammed lake was in December 1911 and the most recent occurred in November 2006 through January 2007 (*see outburst histories in Appendix F).* The highest river stage ever recorded at the Soldotna bridge occurred when the Skilak glacier-dammed lake released in January of 1969[2]. The ice jams and related flooding in 2007 reached similar levels and caused significant damage; however, flooding did not reach the mouth of the river, stopping near Big Eddy.

Although a number of glacier-dammed lakes exist in the vast ice fields on both the west and east sides of Cook Inlet, most drain into undeveloped areas and pose little flood risk to human populations. On the west side of Cook Inlet, the Beluga River is subject to periodic releases from a glacier-dammed lake high in the watershed. Prior to the 1989/1990 eruptions of Mount Redoubt Volcano, a glacier-dammed lake above

1 FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska. Community Number 020012.
2 National Oceanic and Atmospheric Administration (NOAA). Snow and Skilak Glacier-Dammed Lakes Dump History.

the Drift River Oil Tank Facility was monitored with monthly flyovers because of the perceived hazard to the facility[1]. After the eruptions the glacier receded enough that the lake no longer existed. During the eruptions, hot flowing lahars of mud, water and debris were carried down the Drift River Valley, surrounding and partially inundating the oil storage facility with hot mud and water. Fortunately, the oil storage tanks were not damaged. In 1990, to minimize future flood risk, a 2.5-mile, 20-foot high armored perimeter dike was built around the facility at a cost of $20 million[2]. Following eruptive activity beginning in January 2009, though no significant volcanic impingement occurred, the Drift River terminal and associated pipeline and platform services were shut down, pumped off and closed in. During the summer and spring of 2009 some services returned to basic levels at Drift River. While these actions provided a sense of security related to environmental concerns, they also created a significant financial impact to the area.

In 1986, and again in 1995, heavy precipitation from seasonal storms caused severe flooding along the Kenai River as well as on the eastern side of the Peninsula. Damage to public facilities and infrastructure totaled approximately $2 million in 1986 and around $4 million in 1995[3]. During the 1995 flood, the City of Kenai spent several weeks and thousands of dollars intercepting and removing debris that was swept into the lower river, including docks, sheds, fuel tanks and damaged boats[4]. The 2007 ice jams and floods resulted in approximately $2 million in public facility damages and an unknown dollar loss to private property.

In addition to riverine flood hazard, residential and commercial development adjacent to Cook Inlet is susceptible to high tides, erosion and storm surge wave run-up. In the fall of 2002, many of the Peninsula streams, including the Kenai River, were high due to extended heavy rain. Although overall property damage in the North Zone was minimal, high river water combined with high tides and wind to damage the Kenai City dock and two cannery dock bulkheads. High tides and wind also backed water up against the Bridge Access Road embankment, five miles upstream from the river mouth, at least twice during the fall storms. The City of Kenai is seeking funds to protect the bluff area of the city and associated infrastructure and private property.

The North Kenai lakes area consists of approximately 100 square miles of lakes and lowlands. The area is bounded by Cook Inlet to the north and west, Kenai to the south and the Kenai National Wildlife Refuge to the east. It is rapidly developing as a recreational and residential area. There are no major streams in the area, but interconnecting creeks between the numerous lakes constitute a possible flood threat[5].

1 Pers. Comm., David Strausser, Operations Supervisor, Drift River Oil Storage Facility, 4/29/04.
2 Pers. Comm., David Strausser, Operations Supervisor, Drift River Oil Storage Facility, 4/29/04.
3 1995 Alaska Department of Emergency Services Disaster Cost Index Report, Damage Survey Report Estimates; Individual and Family Grant Application Summary, and KPB Finance and Assessing Reports.
4 City of Kenai, Draft Local All Hazard Mitigation Plan (See Annex C).
5 FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska. Community Number 020012.

2.7.3 What is Susceptible to Damage During a Flood Event?

2.7.3.1 Critical Facilities

North Zone critical facilities (fire and police stations, medical facilities and schools) are located in areas designated by the FEMA Flood Insurance Study as Zone C or D (areas of minimal or undetermined flood hazard). North Zone emergency and school facilities are described in Tables 1-14 and 1-15 of Section 1.5.3.

2.7.3.2 Other Susceptible Areas or Facilities

With the exception of their docking facilities, the North Kenai refineries are located on top of steep bluffs and are not in danger of flooding. A number of the facilities have installed sheet-pile bulkheads at the toe of the bluff to minimize coastal erosion around their dock and pipeline facilities.

There are barge landings or private docks at Tyonek, Beluga and other sites on the west side of Cook Inlet. North Zone industrial facilities are served by three deep draft piers and two shallow draft wharves. The Kenai City Dock and boat ramp are located near the mouth of the Kenai River. A number of private docks and mooring buoys on the lower Kenai River support fish processing activities.

2.7.3.3 Bridges

There are two state-maintained bridges in the North Zone, including the Warren Ames Bridge at Kenai River Mile 5 and the Swanson River Bridge at Mile 38.4 of the Kenai Spur Highway. The bridges are evaluated every two years by the Alaska Department of Transportation and Public Facilities for erosion and scour damage.

2.7.3.4 FIRM Floodplain Analysis

The KPB GIS system was used to provide an overview of floodplain development within the City of Kenai, which includes the lower 12.5 miles of the Kenai River FIRM floodplain (Table 2-6 and 2-7, and Appendix G-3). A parcel summary for the Nikiski FIRM area, which primarily covers the coastal area around the North Kenai industrial plants, is not currently available in the KPB GIS and was not included in this analysis.

Table 2-6. City of Kenai FIRM Area Parcel Summary

City of Kenai FIRM Area	
Total Parcels	208
Total Value	$60,720,500
Total Acres	2,759
Number of Parcels with Improvements	104
Total # of Improvements	206
Total Improvement Value	$22,492,300

Note: Summary data is calculated for all parcels within or intersecting Flood Zone A.

There are a total of 208 (tax) parcels valued at nearly $61 million, which are within or

intersect the lower 12.5 miles of the Kenai River's mapped 100-year floodplain. The total assessed value of homes and other improvements on the 104 developed parcels is just over $22 million. Parcel information by ownership category is summarized in Table 2-7.

Table 2-7. City of Kenai[1] FIRM Area Summary by Ownership Category

Parcel Summary	Private	City of Kenai	State	Native Corp.	Misc.[2]	Total
Total Parcels	153	42	11	1	1	208
Total Value (millions of $)	$41.4	$12.3	$5.0	$0.9	$1.2	$60.8
Total Acres	574	1,625	357	76	35	2,667
# of Parcels with Improvements	96	7	1	0	0	104
Total number of Improvements	183	18	5	0	1	206
Total Improvement Value (millions of $)	$21.1	$1.2	$0.2	0	0	$22.5

Note: Summary data is calculated for all parcels within or intersecting Flood Zone.

Of the 208 parcels which are within or intersect the Kenai River FIRM, 153 are privately owned with an estimated combined value of $41.4 million. The City of Kenai owns 42 parcels (1,625 acres), which represents approximately 61% of the land (in acres) intersecting the FIRM Floodzone A.

Land use classification for floodplain parcels includes: 73 residential, 6 recreational, 2 mobile homes, 1 seafood processing plant, 3 accessory buildings, 1 parking lot and 7 commercial operations. There is also one city park (Cunningham) and two state parks (Pillars and Kenai River Flats), which provide recreational access to the Kenai River. Additional information on the City of Kenai's flood hazards is available in Annex C.

2.7.4 Development Trends

The Kenai Spur Highway currently terminates approximately twelve miles north of Nikiski at Captain Cook State Recreation Area. Discussions continue on cost-effective ways to develop the road north to the Moose Point and Gray Cliff recreational subdivisions. Access to the area has primarily been by four-wheel drive or snow machines along an unimproved trail in the vicinity of the Tesoro pipeline right-of-way. Although the bluffs along Cook Inlet are high in the area, they are subject to wave run-up and coastal erosion. The area contains numerous streams, lakes and wetlands. Several of the streams provide salmon spawning and rearing habitat. Flood hazard for the recreational subdivisions is largely undetermined, although development is likely to substantially increase once improved road service is available.

2.7.5 Coastal Erosion North Zone

Within the North Zone of the western Kenai Peninsula from Nikiski to the Kenai River, the range of bluff erosion is highly variable. At Nikiski the annual rate of erosion is 0.8

1 Includes only the lower 12.5 river miles within Kenai City Limits.
2 Miscellaneous parcels in tax foreclosure, lease, or Bureau of Indian Affairs restricted deed status.

feet per year. From Nikiski to the Kenai River, the average rate of annual erosion is 2.2 feet per year, the highest rate on the Peninsula. The North Zone is characterized by many “hot-spots” of erosion in the range of 4.0 - 5.7 feet per year.

2.8 Central Zone

2.8.1 Central Zone Communities

The Central Zone covers approximately 4,500 square miles and includes the following localities and communities:

> The portion of the City of Kenai lying south of the Kenai River, Kenai Gas Fields, Kasilof, Clam Gulch, Tustumena Lake, the City of Soldotna, Kenai River and surroundings, Sterling, Funny River, Skilak Lake and Cooper Landing.

The overall population of the Central Zone is about 20,038 people, with an influx of approximately 100,000 visitors during the summer season. A large volume of tourists and other seasonal visitors utilize the rivers and coastal areas from May to August. The Kenai Visitor and Cultural Center receives more than 43,000 visitors and Soldotna Visitor Center recorded over 36,000 visitors in a summer. Much of the area outside the population centers is largely uninhabited.

Communities with known flood hazard risks are described in Table 2-8 and shown in Figure 2-2.

Table 2-8. Central Zone Communities with Flood Hazard Risk.

Central Zone Community or Area	2009 Pop Estimate [1]	Water Body	FEMA FIRM Maps	Type of Flooding
Clam Gulch	166	Cook Inlet	None	Coastal storm, riverine
Cohoe	1,332	Kasilof River, Crooked Creek, Cook Inlet	Numbered and un-numbered A and V	Coastal storm, riverine
Cooper Landing	344	Kenai River, Kenai Lake	Un-numbered A	Riverine, jökulhlaup, ice jam
Funny River	796	Kenai River, Funny River, Killey River	Numbered and Un-numbered A	Riverine, jökulhlaup, ice jam
Kalifornsky	7,495	Kenai River, Slikok Creek	Numbered A and V	Coastal storm, riverine
Kasilof	536	Kasilof River, Crooked Creek, Cook Inlet	Numbered and un-numbered A and V	Coastal storm, riverine
Soldotna City	4,021	Kenai River, Soldotna Creek	Numbered and un-numbered A	Riverine, jökulhlaup, ice jam
Sterling	5,348	Kenai River, Killey River, Moose River, Funny River	Numbered and un-numbered A	Riverine, jökulhlaup, ice jam
Total Central Zone Population				**20,038**
Approx. Population at Direct Risk From Flooding[2]				**3,500**

1 Source of Population Estimates: Alaska Department of Labor, Research and Analysis Section, Demographics Unit.
2 According to the KPB GIS System, the Kenai River FIRM floodplain has 802 residential parcels and 293 recreational parcels; the Kasilof River FIRM floodplain has 63 residential and 8 recreational parcels. The total residential parcels (1166) were multiplied by 3 to generate an estimate of approximately 3,500 people.

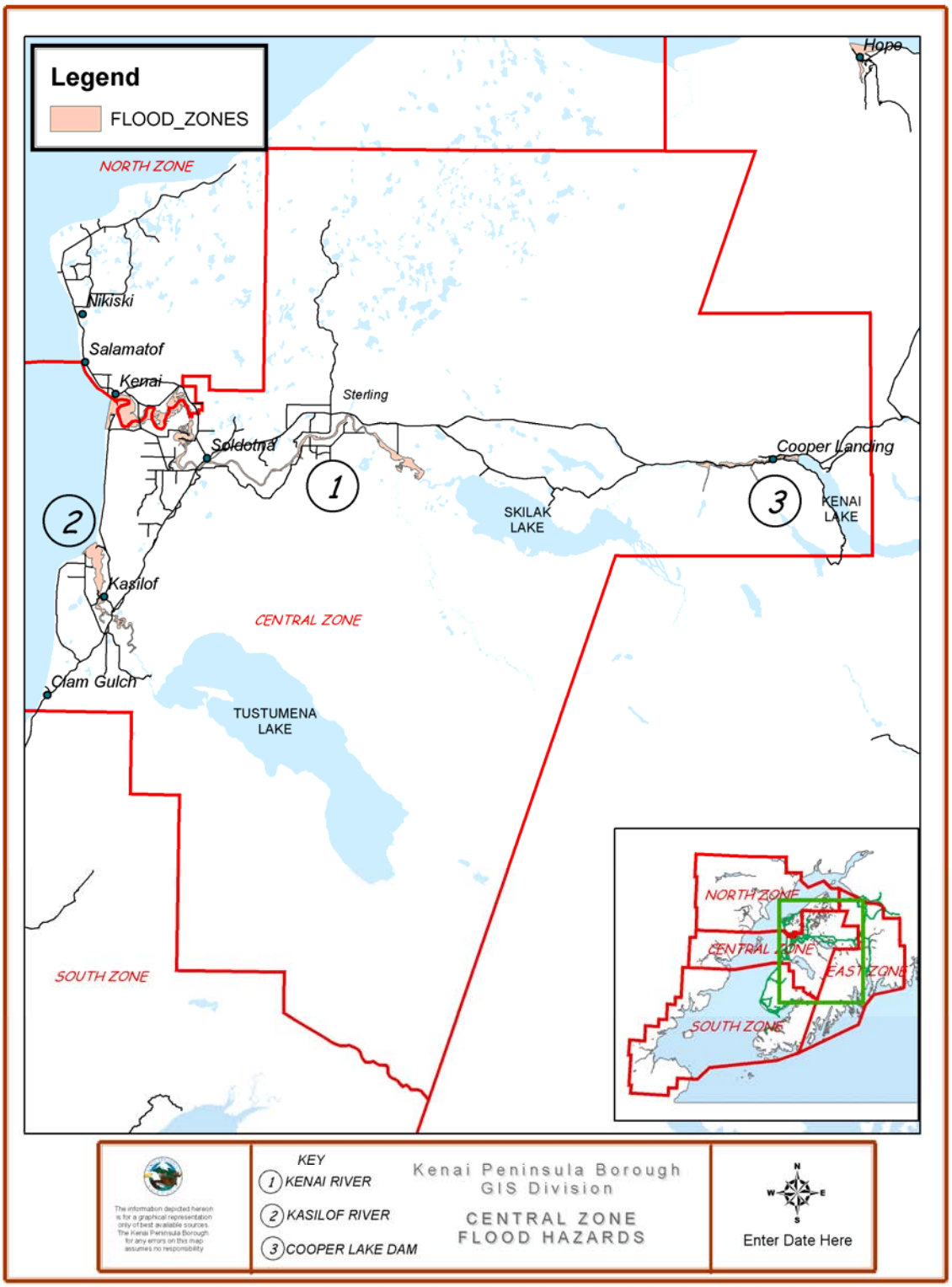


Figure 2-2. Central Zone Communities and FEMA FIRM 100-Year Floodplains.

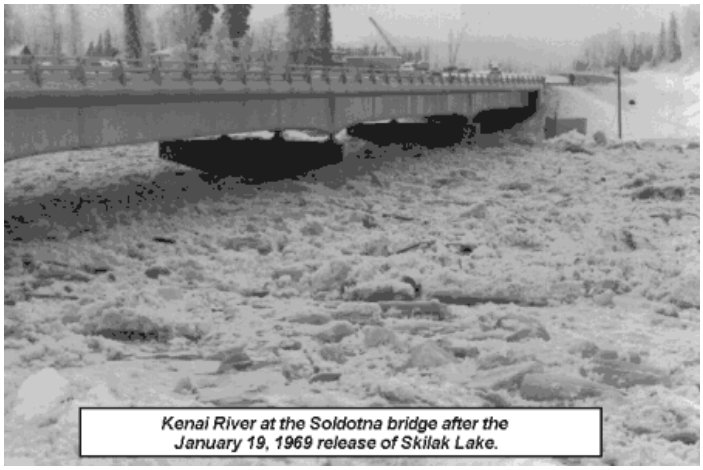
A description of Central Zone transportation infrastructure and facilities and services is available in Section 1.4.5 and Table 1-5. Facilities and services within the City of Soldotna are described in more detail in Annex F.

2.8.2 Characteristics of Flooding

Flooding in the Central Zone is predominately associated with the Kenai and Kasilof Rivers and their tributaries. In addition, development along the Cook Inlet coastline is vulnerable to high tides, erosion, storm surge wave run-up and tsunami and seiches (See Section 6.0 Tsunami and Seiches).

Flooding associated with the Kenai and Kasilof River systems can occur as a result of heavy rainfall, ice jams, rapid snow melt or a combination of these factors. Flood hazards unique to the Kenai River system include the possible failure of the Cooper Lake dam and periodic releases of the Snow and Skilak Glacier-dammed Lakes.

High river flows can occur during any season. On the Kenai River, the highest river stage ever recorded was 22.62 feet at the Soldotna Bridge, which occurred on January 19, 1969 as a result of a rapid release of the Skilak glacier-dammed lake (see photo below)[1]. The resulting surge of water and ice nearly reached the bridge decking and caused severe flooding and ice scour damage along the river from Sterling to Soldotna. A similar event occurred in 2007 with ice and water levels nearing those experienced in 1969. The 2007 Kenai River ice jams and related flooding resulted in an estimated $2 million in public infrastructure damage alone and resulted in local, state and federal disaster declarations.



Kenai River at the Soldotna bridge after the January 19, 1969 release of Skilak Lake.

In 1986, and again in 1995, heavy precipitation from seasonal storms caused severe flooding along the Kenai and Kasilof Rivers as well as on the eastern side of the Peninsula. Damage to Borough roads, bridges and other public facilities totaled approximately $2 million in 1986 and $4 million in 1995[2].

In October and November of 2002, heavy rains caused serious flooding across the Borough, impacting a widespread area from Seward, on the east side of the Peninsula, to Chuitna across Cook Inlet to the west. Although most of the serious damage occurred on the Southern Peninsula, high water on the Kenai River at MP 48.9 and MP 55 of the

1 Snow and Skilak Glacier-Dammed Lake Discharge History.
2 1995 Alaska Department of Emergency Services Disaster Cost Index Report, Damage Survey Report Estimates, Individual and Family Grant Application Summary, and KPB Finance and Assessing Reports.

Sterling Highway near Cooper Landing resulted in over $1 million dollars in road embankment repairs. Crooked Creek washed out the Johnson Lake Road culverts and flooded the Crooked Creek Hatchery compound. The Killey River rose from its normal 1,000 cubic feet per second (cfs) flow to an estimated 9,000 cfs[1] and caused minor flooding along low lying areas of the Kenai River from Kenai Keys subdivision downstream to the city of Soldotna.

Flooding along smaller streams, such as Soldotna Creek, Slikok Creek and Crooked Creek has occurred in the past when undersized culverts jam with ice or are overwhelmed by water. In recent years, several culverts have been replaced with larger structures to help remedy flood and fish passage problems.

2.8.3 What is Susceptible to Damage During a Flood Event?

2.8.3.1 Critical Facilities

Although it is always possible that a flood could affect public infrastructure, buildings and roads well outside of the mapped floodplain, the Central Zone's critical facilities (fire and police stations, hospital, and schools) are located in areas designated by the FEMA Flood Insurance Study as Zone C or D (areas of minimal or undetermined flood hazard).

Many of the Central Zone's critical facilities, including police and fire service, the Central Peninsula General Hospital, numerous medical clinics and a number of schools are located within the city of Soldotna. Although the Kenai River winds through the city, the banks are high and the 100-year floodplain is fairly confined. A majority of the developed property within the city was excluded from the FEMA Flood Insurance Study because it was believed to be at minimal flood risk. More information on Soldotna's flood hazards can be found in the City of Soldotna Hazard Plan (Annex F). A brief description of Central Zone critical facilities is available in Section 1.5.3 and Tables 1-14, 1-15 and Annex F.

2.8.3.2 Bridges

There are 11 state-maintained highway bridges (Figure 1-5, Section 1.4.5 and Appendix J) in the Central Zone, including:

- Kenai Lake Outlet
- Schooner Bend (Kenai River)
- Soldotna (Kenai River)
- Moose River
- Funny River
- Cooper Creek
- Quartz Creek (Quartz Creek Road)
- Quartz Creek (Sterling Highway)

1 National Weather Service (NWS), Event Meteorology Summary of Kenai Peninsula Floods- October 22-31, 2002, internal NWS memo.

- Daves Creek
- Kasilof River
- Crescent Creek

The Borough maintains one bridge across Crooked Creek at Running Water Road in Kasilof.

2.8.3.3 FIRM Floodplain Analysis

A summary of the number of parcels, improvements, acreage, and tax-assessed value within the Central Zone FIRM areas is provided in Table 2-9 and Appendices G-2 (Kasilof River), G-4 (Lower Kenai River) and G-5 (Upper Kenai River).

Table 2-9. Central Zone FIRM Areas Parcel Summary.

Parcel Summary	Upper Kenai	Lower Kenai	Kasilof	Total
Total Parcels*	115	2,320	214	2,649
Total Value* (millions of $)	$108.9	$620.2	$39	$768.1
Total Acres**	647	5,223	1,619	7,489
Number of Parcels with Improvements*	86	1,508	111	1,705
Total Number of Improvements*	260	2,363	219	2,843
Total Improvement Value* (millions of $)	$20	$246.1	$15.1	$281.2

Data Source: 2009 KPB GIS System and Tax Assessment Database. Value estimates are rounded to nearest $100,000.

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.

** Represents an estimate in acres of land that is completely within the FIRM Flood Zone A.

Kenai River

The Kenai River floodplain is divided into two units: the upper river, which begins at the Kenai Lake outlet and covers the Cooper Landing area, and the lower river, which covers the 47 river miles from Skilak Lake to Cook Inlet. A floodplain analysis follows for the upper and lower river floodplains.

Upper Kenai River

A majority of the upper Kenai River watershed lies within the Chugach National Forest and the Kenai National Wildlife Refuge. Parcel information within the different ownership categories in the upper river FIRM area is summarized in Table 2-10.

Table 2-10. Upper Kenai River FIRM Area Parcel Summary[1] by Ownership Category.

Parcel Summary	Private	Federal	State	Borough	Total
Total Parcels*	88	9	17	1	115
Total Value* (millions of $)	$35.6	$63.5	$9.6	$0.1	$108.8
Total Acres **	38	553	55	0.31	646
Total Acres *	174	70,235	567	0.73	70,976
# of Parcels with Improvements*	79	4	3	0	86
Total # of Improvements *	247	8	6	0	261
Total Improvement Value* (millions of $)	$19.7	$0.1	$0.2	$0	$20

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.
** Represents an estimate in acres of land that is completely within the FIRM Flood Zone A. Kenai River.

The upper river private floodplain development is centered around the community of Cooper Landing. Within or intersecting the FIRM there are 88 privately owned parcels with a total assessed value of $35.6 million. (Table 2-10). Land use designations for all parcels intersecting the FIRM include: 38 residential, 21 recreational, 12 commercial, 3 institutional (public parks), 1 mobile home, 4 accessory buildings and 39 vacant lots. Of the 39 undeveloped parcels, 14 are private (10.23 acres), 15 are state (652 acres) and 11 are federal (71,593 acres). There are also a number of private developed parcels along Kenai Lake in the vicinity of the lake outlet, which are outside of the FIRM area.

Lower Kenai River

Unlike the upper Kenai River where less than 1% of the mapped floodplain is in private ownership, over 27% of the land and 87% of the subdivided parcels within the lower river floodplain is privately owned. Parcel information for the major landownership categories in the lower river FIRM area is summarized in Table 2-11.

1 2009 KPB GIS System and Tax Assessment Database. Value estimates are rounded to nearest $100,000.

Table 2-11. Lower Kenai River FIRM Area Parcel Summary[1] by Ownership Category.

Parcel Summary	Private	Federal	State	City of Soldotna	City of Kenai	Borough	Native Corp.	Misc.[2]	Total
Total Parcels*	2,335	16	141	17	40	23	49	0	2,621
Total Value* (millions of $)	$563	$15.7	$86.2	$13.3	$30	$4.8	$25.6	$0	$738.6
Total Acres Within**	1,428	125	1,499	~330	1,369	13	376	91	5,223
Total Acres Intersecting*	4,112	1,286	4,197	349	1,318	235	3,377	0	14,874
# of Parcels with Improvements*	1,623	4	26	2	42	2	0	23	1,699
Total # of Improvements*	2,590	3	49	7	107	3	0	0	2,759
Total Improvement Value*(millions of $)	$262.3	$0.55	$16.1	$1.6	$14.4	$1.5	$0	$0	$151.45

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.
** Represents acreage completely within FIRM Flood Zone A.

A majority (77%) of the private parcels are subdivided into two acre or smaller lots, which are rapidly being developed for recreational, residential and commercial purposes. Within or intersecting the lower Kenai River mapped floodplain there are a total of 2,335 privately owned parcels, of which 1,623 have been developed (2,590 improvements) and have a total assessed value of $563 million (Table 2-11). Of the private parcels, 1,380 parcels are one acre or less in size, and an additional 528 are one to two acres in size. Only 104 privately owned parcels in the lower Kenai River FIRM area remain in five-acre or larger tracts.

Figure 2-3 shows the number of parcels in different ownership categories, and Figure 2-4 illustrates the acres of land in the same ownership categories.

1 2009 KPB GIS System and Tax Assessment Database. Value estimates are rounded to nearest $100,000.
2 Miscellaneous parcels in tax foreclosure, lease, or Bureau of Indian Affairs restricted deed status.

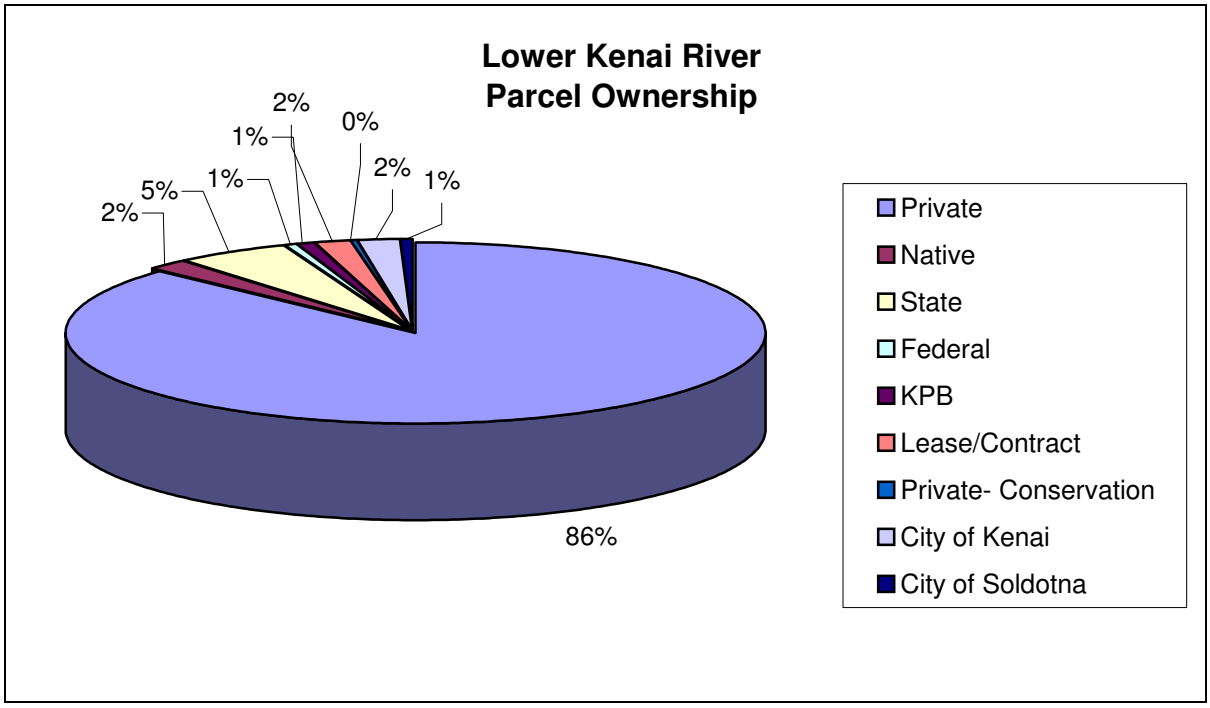


Figure 2-3. Comparison of Parcel Ownership in the Lower Kenai River FIRM Area.

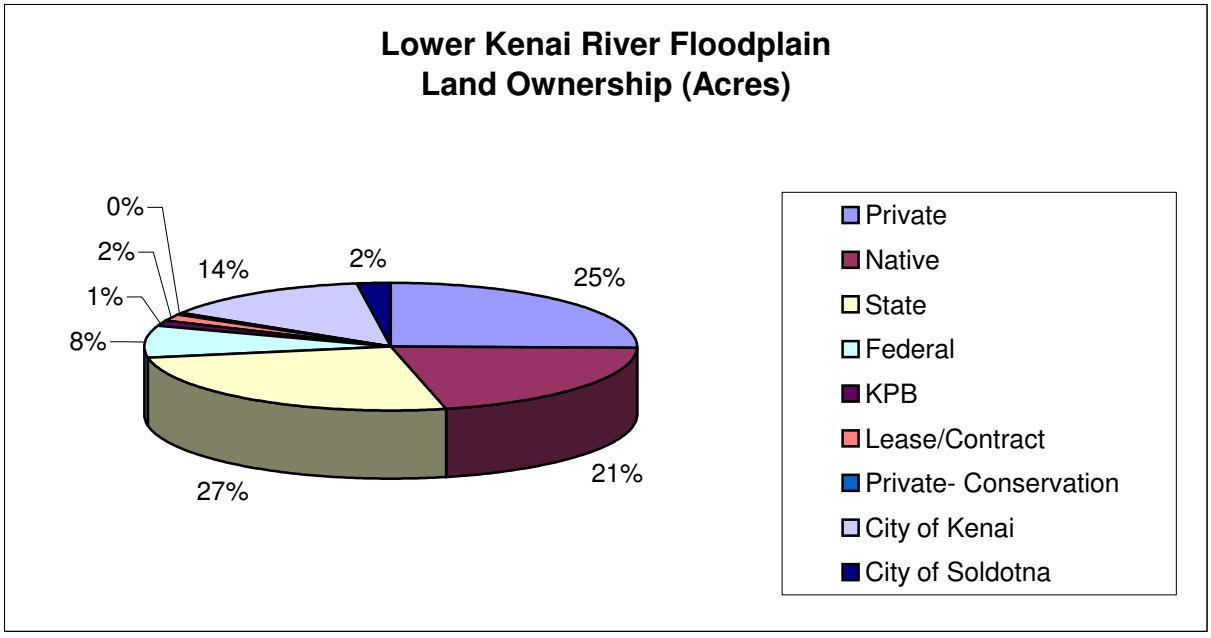


Figure 2-4. Comparison of Acreage by Ownership Category in the Lower Kenai River FIRM Area.

Kasilof River Floodplain

The Kasilof River, which originates at Tustumena Lake within the Kenai National Wildlife Refuge, meanders west for approximately 15 miles to its outlet at the community of Kasilof on Cook Inlet. The current population of the Kasilof area is estimated at 536.

Table 2-12. Kasilof River FIRM Area Summary by Ownership Category[1].

Parcel Summary	Private	Federal	State	Borough	State Lease	Native Corp.	Total
Total Parcels*	160	2	44	7	0	1	214
Total Value* (millions of $)	$30.5	$3.6	$5.1	$0.4	$0	$0.2	$39.8
Total Acres**	496	19	1,013	88	0	2	1,618
Total Acres *	1,729	10,740	2,601	186	0	73	15,329
# of Parcels with Improvements*	105	0	5	1	2	0	111
Total # of Improvements*	202	0	10	1	0	0	213
Total Improvement Value*(millions of $)	$15.0	$0	$0.2	$0	$0	$0	$15.2

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.
** Represents an estimate in acres of land that is completely within the FIRM Flood Zone A.

Much of the terrain along the Kasilof River corridor is comprised of steep banks and a relatively narrow floodplain[2]. Parcel information for the FIRM mapped floodplain is summarized by ownership type in Table 2-13. Currently, within or intersecting the 100-year floodplain there are a total of 214 parcels of land with an assessed value of $39.8 million. Of these, there are 160 private parcels, of which 105 have been developed (202 improvements) with a total assessed value of $30.5 million.

Land use classifications for floodplain parcels include 97 residential vacant, 10 residential improved land, 71 residential, 7 residential cabins, 3 residential mobile homes, 6 residential accessory buildings, 2 lodges, 7 commercial fish processors, 3 general commercial, 1 leased vacant, 4 leased commercial, 1 gravel pit, 1 institutional, and 2 institutional accessory buildings. There are also two public boat launch facilities, and numerous private launches. The Sterling Highway Bridge provides the only road crossing for the Kasilof River.

2.8.4 Development Trends

Kenai River

When the Borough incorporated in 1964, there were approximately 160 developed parcels in the lower Kenai River floodplain (Figure 2-5). By 2004, the same stretch of river had 1,392 improved parcels and an additional 853 subdivided but undeveloped parcels (Figures 2-6).

1 2009 KPB GIS System and Tax Assessment Database. Value estimates are rounded to nearest $100,000.
2 FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska. Community Number 020012.

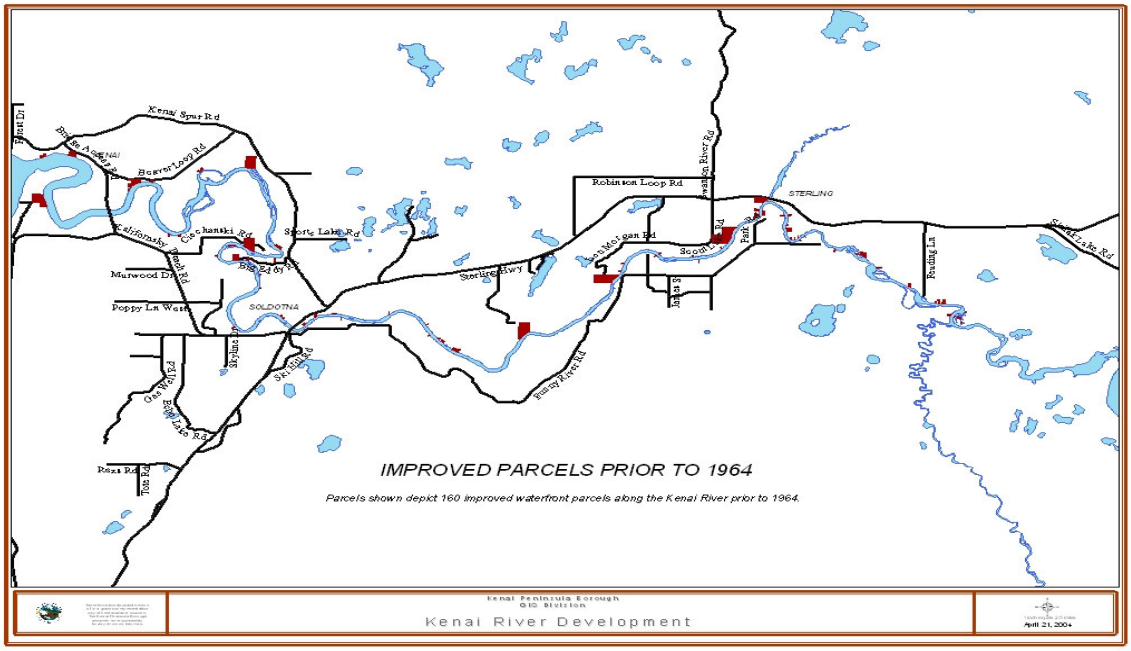


Figure 2-5. Location and Number of Improved Parcels Adjacent to the Kenai River Prior to1964.

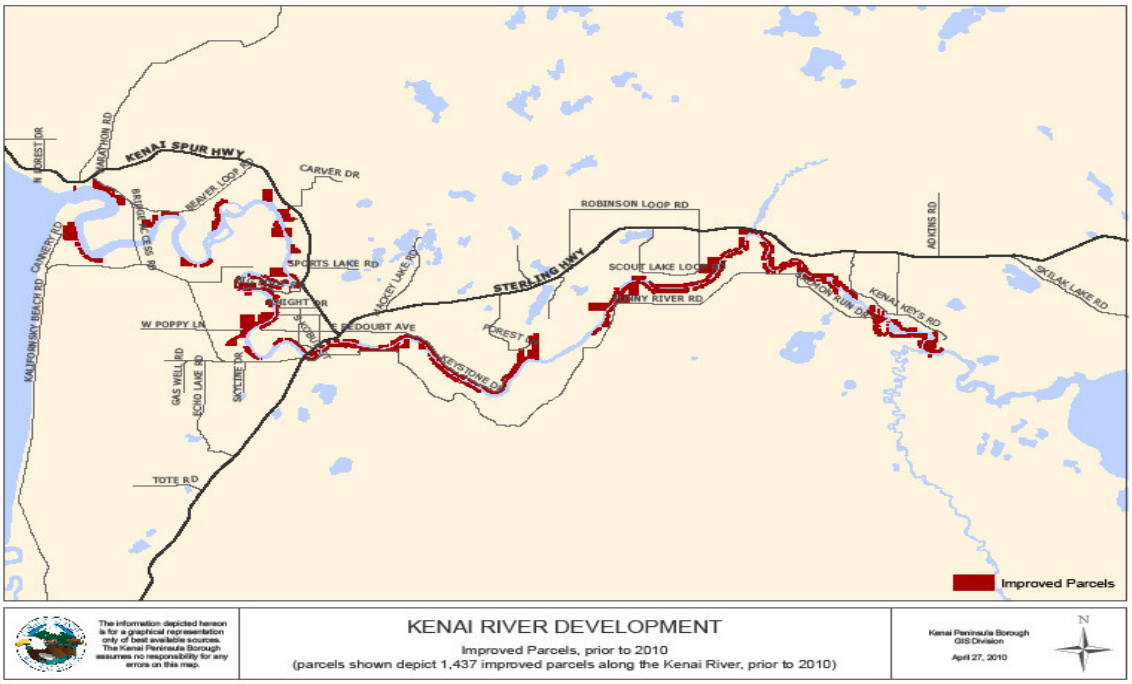


Figure 2-6. Location and Number of Improved Parcels Adjacent to the Kenai River in 2009.

A comparison between the 1996 *Flood Mitigation Plan* floodplain assessment [1] and the current 2009 GIS data, indicates a steady upward trend in private land subdivision, land value, and residential and recreational occupancy (Table 2-12).

Table 2-13. Floodplain Development Trends 1996 to 2009.

Year	# of Private Parcels	% Vacant	Estimated Value	Homes and Cabins	Estimated Population
1996	2,000	50 %	$127,869,900	820	1,400
2004	2,240	38%	$266,504,600	1,098	3,294
2009	2,335	40%	$725,207,200	1,584	
Difference	**+ 335**	**- 10%**	**+$597,337,300**	**+ 764**	**+**

Eighty-one percent or 2,140 parcels along the lower Kenai River are subdivided into two acre or smaller lots. Of these, 1,470 are developed with an estimated total assessed value of $418,951,800. Another 760 parcels, valued at approximately $39 million are vacant and (for the purposes of this analysis) are assumed to have some development potential. In addition, there are 242 private parcels (13,352 acres) remaining in five acre or larger tracts. These larger tracts represent potential for future subdivision. Development is also likely to occur on Cook Inlet Region, Inc. lands, which comprise 3,354 acres, or 22% of the total lower Kenai River floodplain.

Other large land tracts in the lower Kenai River floodplain are distributed between the state (4,021 acres in 69 parcels), Borough (229 acres in 5 parcels), City of Kenai (1,979 acres in 20 parcels), City of Soldotna (331 acres in 9 parcels) and the federal government (1,280 acres in 13 parcels). Although it is likely that a certain portion of lands owned by the Cities, Borough, and State University and Mental Health Trust systems will eventually be sold or developed, a majority of state land in the lower river floodplain was incorporated into the Kenai River Special Management Area and is currently being managed for habitat conservation, recreation and river access[2].

Kasilof River

Of the 160 private parcels within or intersecting the Kasilof River floodplain, only 49 are subdivided into two acre or smaller tracts, and 63 remain in parcels that are five acres or larger (Table 2-14). Depending on characteristics such as soils and topography, the potential for future land subdivision and development along the Kasilof River is substantial.

1 Kenai Peninsula Borough. 1996. Flood Mitigation Plan.
2 Alaska Department of Natural Resources, Division of Land, Division of Parks & Outdoor Recreation. Adopted Dec.1997. Kenai River Comprehensive Management Plan.

Table 2-14. Kasilof River FIRM Area - Private Land Parcel Size Summary.

Parcel Size (Acres)	Number	Number with Improvements	Assessed Value	Improvement Value	Number of Improvements	Acres
1	6	3	$653,100	$351,500	5	5
>1-2 acres	43	29	$5,720,100	$3,403,600	49	63
>2-5	48	28	$7,900,000	$3,991,700	45	160
>5-10	30	24	$7,801,200	$4,235,700	30	209
>10-40	22	13	$4,785,400	$1,896,300	25	555
>40 & larger	11	8	$3,532,500	$1,124,800	19	738

2.8.5 Coastal Erosion Central Zone

Within the Central Zone from the Kenai River to the Kasilof River, the rate of bluff erosion is 1.6 feet per year. From the Kasilof River to the Ninilchik River the erosion rate is 0.6 feet per year. The Central Zone is characterized by comparatively few "hot-spots" of erosion, but a number of areas are within the 2.3- 4.0 feet per year range.

2.9 East Zone

2.9.1 East Zone Communities

The East Zone covers approximately 4,960 square miles and includes the localities and communities of:

> Hope, Sunrise, Moose Pass, Crown Point, Lawing, Primrose, Bear Creek, Lowell Point and the city of Seward.

The population of approximately 5,320 people increases to about 15,300 during the summer tourist season. Much of the area outside the population centers is largely uninhabited.

Communities and areas with known flood risk are described in Table 2-15. The City of Seward participates in the National Flood Insurance Program and issues permits for floodplain construction using Flood Insurance Rate Maps provided by FEMA. Additional information for is provided in the City of Seward (Annex E).

Table 2-15. East Zone Communities with Flood Hazard Risk.

Community	2009 Population Estimate [1]	Water Body	FEMA FIRM Maps	Type of Flooding
Hope/Sunrise	170	Resurrection Cr., Six Mile Cr, Cook Inlet	*Hope* – unnumbered A and V Zones	Riverine, coastal storm
Moose Pass, Crown Point, Primrose	331	Trail Lake, Trail River, Kenai Lake, Primrose, Grant, Ptarmigan, Falls, Victor Creeks	Limited Unnumbered A Zones	Riverine, lake
Seward and outlying Lowell Point, Bear Creek areas	4,694	Resurrection Bay, Resurrection River, Lowell Cr., Spruce Cr., Japanese Cr., Kwechak/Salmon Cr., Clear Cr., Lost Cr., Sawmill Cr., Grouse Cr., Godwin Cr., Fourth of July Cr.	Numbered and unnumbered A and V Zones - Although FIRM flood maps do not accurately predict flood hazards due to rapid, continual changes in the alluvial stream systems.	Riverine, alluvial fan, surge-release/debris slide, ice jam, coastal storm, tsunami
Total East Zone Population			**5,195**	
Approx. Population at Direct Risk From Flooding			**5,195**	

Because of the unpredictable nature of alluvial fan flooding, the FIRM maps were not used to estimate the population at risk of flooding. An assumption was made that nearly all East Zone residents are subject to direct or indirect impacts due to the dynamic nature of the area's flood hazards. East Zone communities and FIRM mapped floodplain areas are shown in Figure 2-7.

East Zone transportation infrastructure and facilities and services information is available in Section 1.4.5 and 1.4.7 and Table 1-6. Facilities and services within the City of Seward are described in more detail in Annex E.

2.9.2 Characteristics of Flooding

The East Zone is vulnerable to flooding from the following causes:

- heavy precipitation, which can occur at any time, but typically occurs from August through October;
- alluvial fan flooding;
- surge-release flooding from landslides and debris jams;
- spring ice jams and rapid snowmelt;
- tidal storm surges and coastal wave run-up;
- tsunami and seiches (See Section 6.0 Tsunami and Seiches Section);
- glacial damming and glacial outburst (jökulhlaup) flooding; and

1 Source of Population Estimates: Alaska Department of Labor, Research and Analysis Section, Demographics Unit.

- failure of dikes, levees, or other diversion structures during high water events.

High stream flows can occur during any season but are most common as a result of rapid snowmelt in the spring or intense precipitation during late summer and fall. Many of the East Zone's steep-gradient mountain streams originate in unconsolidated glacial deposits, which over time have created the alluvial fans and deltas[1]. Flooding hazards associated with alluvial fans include[2]:

- high velocity (15 to 30 feet per second) floodwaters with tremendous potential for erosion, which can carry large amounts of sediment and debris, including boulders and trees; and

- the inability to confine floodwaters to a single channel. As channels fill and meander, they are capable of threatening development over a broad area.

1 U.S. Army Corps of Engineers, Alaska District. 1994. Seward Area Rivers Flood Damage Prevention Interim Reconnaissance Report.
2 The Association of State Floodplain Managers. 1985. Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials.

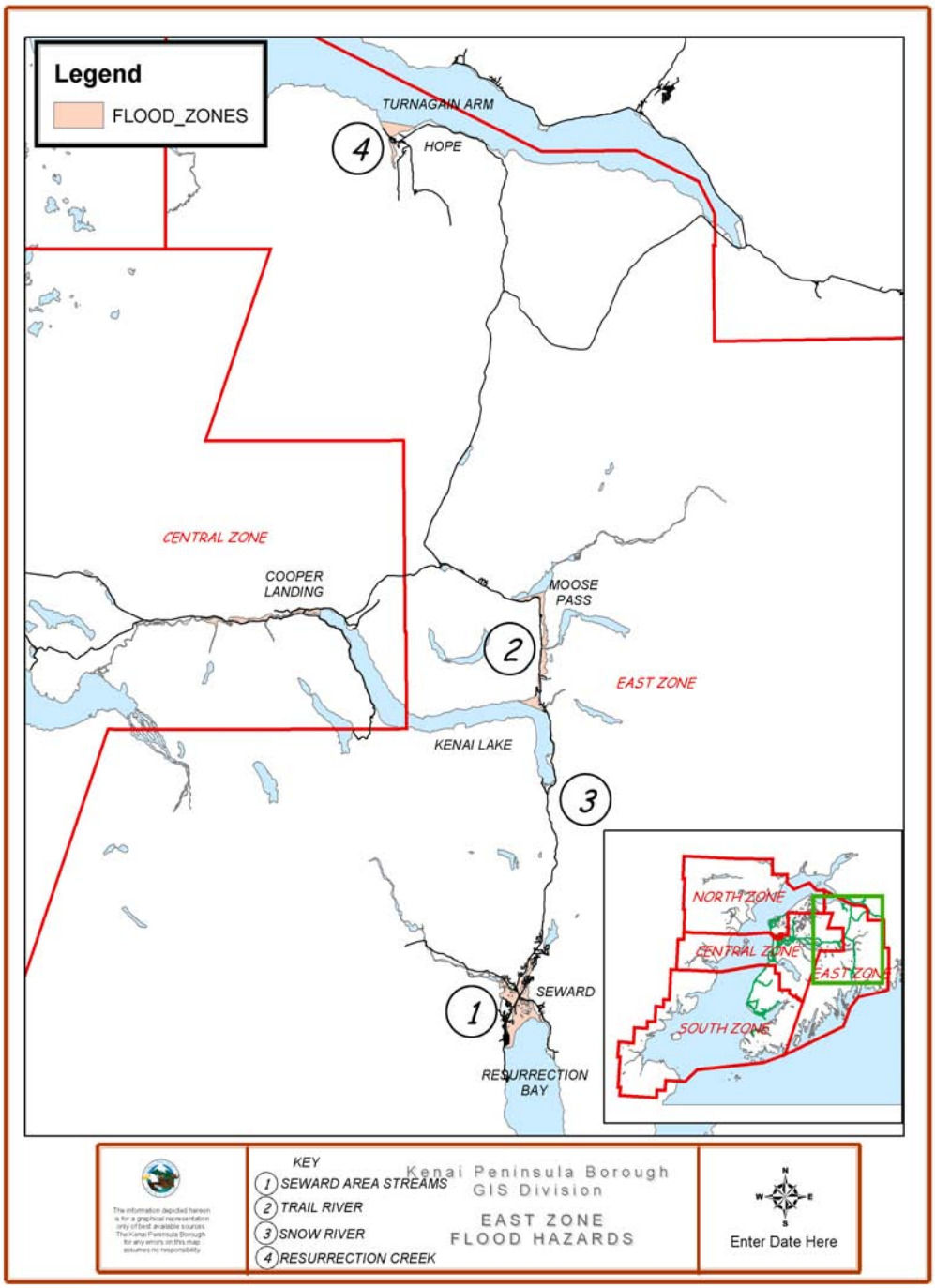


Figure 2-7. East Zone Communities and FEMA FIRM 100-Year Floodplains.

Although flooding occurs in many areas in the East Zone, a majority of the property and infrastructure damage occurs in the Seward area. The City of Seward and outlying developed areas are located primarily on alluvial fan deposits formed at the mouths of steep tributary valleys of Resurrection Bay. Streams that contribute to the alluvial fans include the Resurrection River, Box Canyon, Japanese, Lowell, Spruce, Fourth of July, Salmon, Glacier/Kwechak, Sawmill and Lost Creeks[1]. The fans have been built through time as large quantities of silt, sand and gravel were carried to the valley floor. Stream channels on the fans are highly unstable and regularly shift as material is deposited. Development on the fans is susceptible to flooding and erosion as the process of building and shifting continuously repeats.

Flooding problems are more pronounced during periods of heavy rainfall and rapid snowmelt. Saturated conditions contribute to slope failures, landslides, debris jams and surge-release flooding. As is typical of alluvial systems, streams frequently shift, and the corresponding changes in area, water depth and velocity contribute to unpredictable floods events.

The hazards associated with alluvial fan development have been repeatedly demonstrated in recent years. In October of 1986, the Seward area received over 15 inches of rain in a 24-hour period, saturating the steep slopes and causing severe erosion. In some areas, landslides and avalanches dammed stream channels, resulting in a surge of floodwater and debris when the dams failed. This material, which included boulders as large as eight feet in diameter, caused extensive damage to buildings and facilities located downstream on the alluvial fans[2].

Three years later in 1989, a state disaster declaration was issued when heavy rains in the Seward area caused over $1 million in damage to homes, roads and bridges. Again in September of 1995, flooding associated with Typhoon Oscar resulted in Borough, state, and federal disaster declarations and serious damage to roads, bridges, the airport, harbor and many homes and businesses. Road and utility repairs alone were estimated at $3.5 million. Figure 2-8 shows the areas that flooded in 1986 and 1995 as well as the predicted 100-year FIRM floodplain.

Although damage was not nearly as severe as in 1986, 1989 and 1995, heavy rains that began on October 22, 2002 caused the Resurrection River to rise 5.5 feet overnight. By the morning of October 23rd, homes, buildings and roads began flooding as Bear, Kwechak/Glacier and Salmon Creek waters reached flood stage. The National Park Service closed the Exit Glacier Park road when the Resurrection River reached the bottom of the bridge. Minor flooding on the lower Resurrection River closed Runway 12-30 at the Seward Airport. An emergency effort to remove gravel at Lowell Creek occurred during the night of October 22nd when the City became

1 Kenai Peninsula Borough. 1996. Flood Mitigation Plan, and City of Seward.1996. Flood Hazard Mitigation Plan.
2 Jones, S.H., and C. Zenone. 1988. Flood of October 1986 at Seward, Alaska. U.S. Geological Survey Water-Resources Investigations Report 87-4278.

concerned about water flow through the Lowell Creek tunnel[1]. Emergency in-stream gravel removal also occurred on Salmon Creek immediately downstream of the Mile 4.8 Alaska Railroad bridge to remedy water flowing down Nautical and Meridian Avenues in the Seward Park and Meridian Subdivisions.

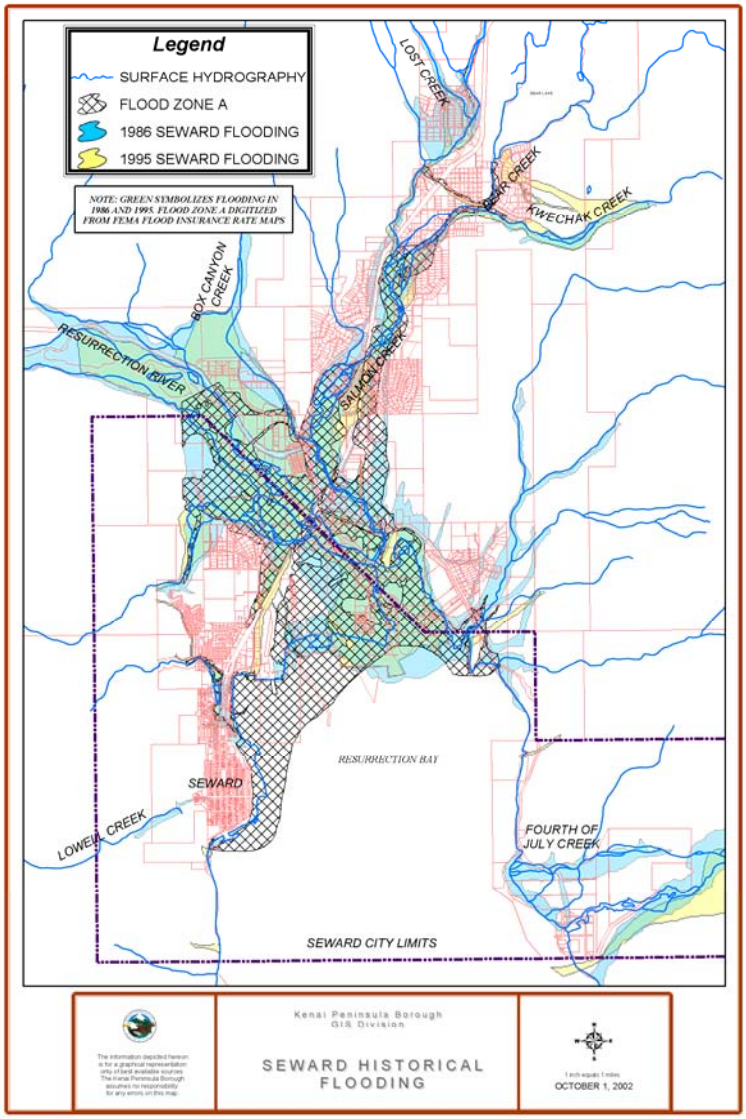


Figure 2-8. Seward Area 1986 and 1995 Floods and FEMA FIRM 100-year Floodplain Boundaries

1 National Weather Service (NWS), Event Meteorology Summary of Kenai Peninsula Floods- October 22-31, 2002, internal NWS memo.

To the north, heavy rains in the Snow and Trail River drainages caused Kenai Lake to rise four feet between noon on October 22nd and noon on October 24th1. Wind, waves and saturated conditions caused serious erosion to occur along the railroad embankment in more than a half-dozen locations along Kenai Lake. In addition, emergency repairs were needed at the Ptarmigan Creek railroad bridge as well as in several areas where the railroad tracks cross or closely parallel tributaries of Trail Creek and the Snow River. Minor flooding also occurred in the Primrose area along the southwestern shore of Kenai Lake.

In the last 30 years, as East Zone residential and commercial development has further encroached on riparian wetlands and alluvial streams, flooding has become more frequent and severe[2]. Roads, bridges, and culverts restrict stream movement and function as barriers to efficient water passage. Flood control structures require constant maintenance and have the potential for catastrophic failure or to divert flood problems to unprotected areas.

Although FIRM flood maps were generated for the Seward area, alluvial systems change rapidly and the base flood elevation and flood boundary predictions become less accurate each year. Although new maps would help, re-mapping is expensive and made less cost-effective by how quickly the maps become outdated. Unfortunately, even if funding can be found for new maps, the current flood prediction models are not capable of incorporating debris and gravel accumulation and movement, which are essential elements of alluvial fan flooding[3].

For many years, area residents and agency representatives have struggled to find viable solutions to the area's volatile and chronic flood problems. During a community forum on flood issues in November of 2002, the concept of forming a Flood Service Area was discussed and in 2003 was brought forward as a ballot proposition. The proposition passed and the Seward/Bear Creek Flood Service Area was formed. A Flood Service Area Board was appointed by the Borough mayor in early 2004 and began meeting on a monthly basis. During a May 27, 2004 Flood Service Area Board community work session, a number of chronic problem areas were identified and possible mitigation solutions were discussed. A summary of information generated at the meeting follows in Table 2-16 and Figure 2-9.

In 2009, the Kenai Peninsula Borough Flood Plain Task Force was created as an alternative to a building moratorium in the Seward area. The first meeting was held on March 4, 2009 tasked through ordinance with creating a flood hazard district and a review of all effects of floodplain management. These options included the reclassifying of gravel fees, a buyout program for flood-sensitive private property and alternative ways of controlling stream flow. Throughout 2009 and the first part of 2010,

1 National Weather Service (NWS), Event Meteorology Summary of Kenai Peninsula Floods- October 22-31, 2002, internal NWS memo.
2 City of Seward, 1996. Flood Hazard Mitigation Plan.
3 FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska. Community Number 020012.

the task force met periodically, formalizing these changes to floodplain management. Task force objectives included the following:

- Stream navigability determinations,
- Resolution of gravel royalty fees,
- Soils and flood zone surveys,
- Determination of repetitive loss parcels within flood hazard zones for purchase.
- Complete a watershed master plan including channel mitigation zones.

As a result of efforts by the task force, public input and other governmental agencies, the Borough has a new set of criteria when determining risk factors, mitigation and incident recovery for flooding in the alluvial plain surrounding Seward. An ordinance has been adopted for the express purpose of developing a flood master plan. A buyout program has been established using approximately $1.5 million dollars from grants to purchase 11 flood-sensitive properties in the Old Mill Subdivision. This is an ongoing project with more recommendations planned for introduction to the KPB Assembly.

Table 2-16. Flood Problem Areas and Possible Mitigation Measures[1].

Location	Map Reference (Figure 2-9)	Problem Areas	Possible Mitigation
Lost Creek	1	Old Mill Subdivision - area is flood-prone but not included in area floodplain mapping. Stream channels under bridges are filled with gravel and debris.	Obtain flood maps or otherwise regulate Lost Creek floodplain development; raise bridges or dredge gravel and debris to improve clearance and water conveyance.
Lowell Creek	13a and 13b	Potential for a tunnel blockage and diversion levee failure.	Construction of a second tunnel; continued monitoring and repair of existing tunnel.
Scheffler Creek	12	Culvert blockage in 1995 caused flooding across the Seward Highway and damage to a cannery and the harbor.	
Resurrection River	11a	ARRC pier supported bridges (situated downstream of the Seward Highway bridges) catch debris and contribute to back-water flooding above the Seward Highway.	Clear span bridges would help. In conjunction with ADOT&PF highway bridge upgrades, the ARRC plans to lengthen the span on the center bridge in the near future.
	11b	Airport runway- repetitive flood problems	ADOT/KPB/City of Seward – ongoing joint effort (which may not currently be funded?) to annually dredge the main stream channel and maintain water conveyance away from the airport.
	Not numbered	Exit Glacier Road- the river bed is filling and building and may soon overtop the armor reinforcement placed along the road embankment.	
Salmon Creek	7	ARRC Bridge- collects debris and fills with gravel.	Elevate, clear span or otherwise upgrade bridge to increase and maintain water conveyance.
	8	Nash Road Bridge- channel silting in with gravel and debris, clearance is no longer adequate. Also culverts in the vicinity are undersized or partially blocked and contribute to flood problems.	Raise bridge, remove gravel and debris. Oversize culverts or replace with bridges.
	9	Seriously floodprone private properties south of Nash Road.	Acquire and retain undeveloped land for floodplain conservation.
Clear Creek	6	The KPB is in the process of classifying, subdividing and selling part of a large parcel of land off of Old Exit Glacier Road. Selling these parcels will encourage more	Clear Creek originates in springs on the parcel and the area historically floods from both the Resurrection River and Box Canyon Creek. Meeting participants recommended the KPB classify the entire parcel as preservation and keep it

1 Seward/Bear Creek Flood Service Area Board Sponsored Work Session. 5/27/04

		commercial development in a floodprone area.	undeveloped to prevent future flood damage.
Box Canyon Creek	3	Debris slides/surge release flooding; stream makes a 90-degree bend as it comes out of the canyon. Past problems include overland surge flooding and problems at Exit Glacier Road.	
Kwechak/ Glacier Creek	4a & 4b	Floodplain is rapidly building at the canyon outlet, as well as in areas above and below Bruno bridge. The system is unstable system with a high probability that heavy rain or a debris jam in the upper watershed will cause major flood problems for down slope subdivisions (Meridian, Bear Creek, Woodrow, and Questa Woods).	Floodplain gravel extraction, particularly in the upper watershed at the canyon outlet.
	Not Numbered	Single road access into Questa Woods and Camelot-By-The-Sea, both of which are susceptible to flooding.	Identify alternative access routes. Possible alternatives include bridging Salmon Creek at a point north of Camelot-By-The-Sea and constructing a ridge road above the floodplain between Questa Woods and Camelot-By-The-Sea Subdivisions.
Bear Creek	2	During high water, Bear Creek causes localized flood damage as it tries to merge with Kwechak Creek.	
Sawmill Creek	10	Subject to debris jams and frequently causes localized damage in the vicinity of the Nash Road crossing.	

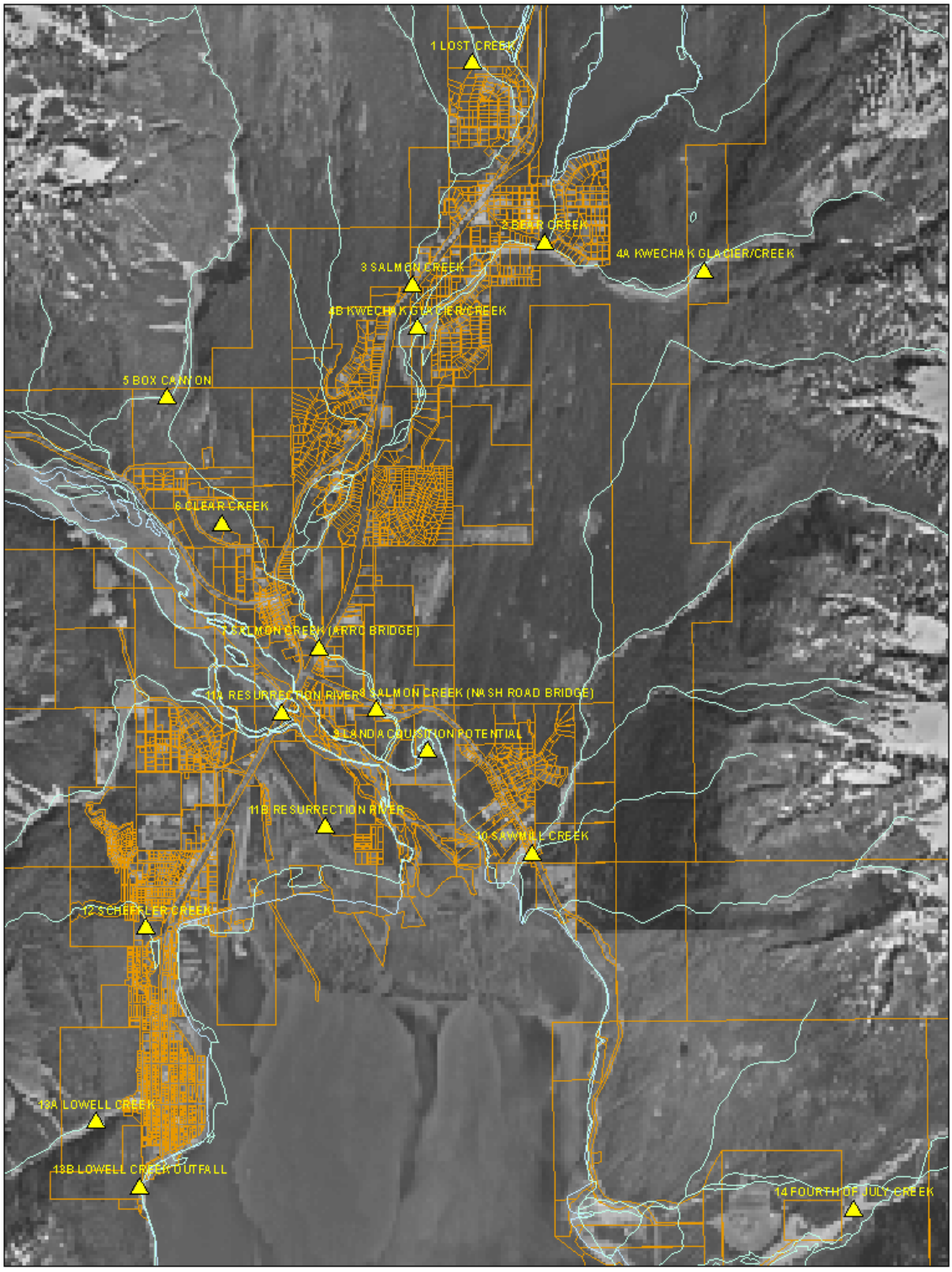


Figure 2-9. Seward Area – Chronic Flood Problems[1].

1 Seward/Bear Creek Flood Service Area Board Sponsored Work Session. 5/27/04.

2.9.3 What is Susceptible to Damage During a Flood Event?

In recent years, the return cycle for flooding along Seward area alluvial streams appears to be on the order of two to ten years, and as development in the area has increased, so too has the potential for flood related damage. Because the Seward area is largely comprised of steep mountains and alluvial floodplains, there is very little developable property that is hazard-free. Unfortunately, development and subsequent flood protection actions taken in one location often change or worsen the severity of flooding somewhere else. The question of how to protect life and property inside and outside of the mapped floodplains is difficult, often contentious, and continues to be the focus of ongoing community and agency efforts.

Situated adjacent to Turnagain Arm and Resurrection Creek, the FIRM area for the small community of Hope includes properties in unnumbered A and V zones. Flooding occurs from Resurrection Creek as well as from high tides and wind-driven waves along Turnagain Arm. As a result of the 1964 earthquake, the southern shoreline of Turnagain Arm subsided four to six feet in places. High tides the following spring flooded areas that previously had been five feet above the pre-earthquake tide levels. Homes in low-lying areas around town were flooded and the spring tides nearly reached the entrance to the General Store[1].

Past flood damage in and around the Trail River FIRM area, which includes the communities of Moose Pass, Crown Point and Primrose, has primarily affected road and railroad infrastructure.

2.9.3.1 Critical Facilities

Most of the East Zone critical facilities (fire and police stations, hospital, schools, public sewer system) are located in areas designated by the FEMA Flood Insurance Study as Zone C or D (areas of minimal or undetermined flood hazard). Given the nature of the Seward area flood hazards, however, it is difficult to accurately assess risk. For example, many of Seward's critical facilities, such as the hospital and the police station, are located below the Lowell Creek diversion levee and tunnel. If the tunnel were to block with debris and the diversion dike fail, serious impacts to the city center and emergency response facilities are likely. Similarly, the Spring Creek Maximum Security Prison and the Seward Marine Industrial Center depend on flood protection from a diversion levee upstream on Fourth of July Creek, and residential neighborhoods and the high school depend on the Japanese Creek Levee.

Levees, including those built by the U.S. Army Corps of Engineers, have been installed over the years and are an integral part of Seward's flood mitigation. Unfortunately, they may also foster a false sense of security and encourage development in fairly high risk areas. At a minimum, they require constant

1 Foster, H.L., and T.N.V. Karlstrom. 1967. The Alaska Earthquake. March 27, 1964. Regional Effects. Ground Breakage in the Cook Inlet Area. Geological Professional Paper 543-F.

maintenance and should be carefully monitored for function, longevity and behavior in a variety of flood scenarios. Many are on private or Native lands with landowners responsible for maintenance, which has been minimal.

More information on Seward area flood hazards is included in the City of Seward annex and in publications listed in the Flood Resource Section.

Although the Bear Creek Fire Station, which provides emergency services to the outlying Seward area, is located across the Seward Highway from the mapped Salmon Creek floodplain, it has flooded in recent years (2006/2007). This is mainly due to the fact that land subdivision and subsequent development in the area has restricted the stream to a limited portion of its fan. To address the rapid gravel deposition, the stream course and floodplain above and below the Bruno Road bridge has been subject to active dredging, bank armoring and levee maintenance activities for many years. Although gravel mining is also occurring in the Kwechak and Salmon Creek floodplains, it has not kept pace with the fan-building capacity of the streams.

The KPB Office of Emergency Management identifies schools as possible sources of emergency shelter. In Moose Pass, the elementary school floods when Trail Lake is high and the ground saturated from heavy rain. As the lake and ground water levels rise, water seeps into the concrete foundation of the school and must be pumped out. Although this situation has occurred several times and has not resulted in a threat to life or permanent damage to the structure, it may affect the use of the school as a source of emergency shelter[1].

2.9.3.2 Transportation

A majority of the air, land and water transportation infrastructure in the East Zone is subject to some degree of flood risk. The Seward Highway, Exit Glacier Road, Nash Road and many of the secondary subdivision roads in the Seward area have been closed by past flood events.

The Alaska Railroad closely parallels the Seward Highway through Moose Pass, Crown Point, and the Seward area. Flood damage to the railroad embankment and railroad bridges occurs regularly in places where the railroad crosses or parallels alluvial streams. Trail Creek and its tributaries, Snow River and its tributaries, the embankment along Kenai Lake and the Ptarmigan Creek bridge crossing are all areas that have experienced problems with flooding and erosion in recent years.

The Seward airport, an AKDOT&PF facility, is located on the terminus of the Resurrection River and Salmon Creek alluvial fans. In recent years, the Resurrection River has posed the most frequent and severe flood risk. A discussion of flood mitigation efforts for the airport is included in the City of Seward Annex E.

1 Pers. Comm., Nick Trudeau, Kenai Peninsula Borough Maintenance Department, 5/14/04.

The Seward Harbor was severely damaged by tsunamis after the 1964 earthquake (see Annex E). Damage also occurred at the harbor in 1995 when the lagoon outlet culverts jammed with debris, causing flooding and erosion in the harbor and serious damage to a cannery. The City of Seward is currently in the process of working to obtain permits to dredge the cruise and industrial ship areas of the harbor in order to accommodate vessels with a deeper draft.

In addition to the highly susceptible Seward area, the Trail River, Trail Creek, Kenai Lake, the Snow River and a number of tributary streams regularly flood and damage the road and railroad infrastructure. Railroad and highway bridges at Ptarmigan Creek, Victor Creek and Falls Creek have all been damaged in the past during high water events. Although the main highway embankment across the Snow River floodplain is well elevated, the road along Kenai Lake to Primrose is often subject to inundation and wave erosion from Kenai Lake.

2.9.3.3 Bridges

There are 41 bridges listed for the East Zone[1], of which 8 are owned and maintained by the Borough (see Section 1.4.5, Figure 1-5, and Appendix J). The remaining 32 bridges are state- and city-maintained.

2.9.3.4 FIRM Floodplain Analysis

According to the KPB GIS database, there are a total of 778 parcels of land with a value of $250.5 million within or intersecting the East Zone FIRM areas (Table 2-17). Of these, 373 parcels have 742 improvements valued at $134.3 million. Additional parcel information is available for the East Zone FIRM areas in Appendices G-7, G-9 and G-10.

Table 2-17. East Zone Overall FIRM Area Summary[2].

Mapped Floodplains	Resurrection Creek	Trail River	Seward	Total
Total Parcels*	63	104	611	778
Total Value* (millions of $)	$16.5	$38	$196	$250.5
Total Acres**	245	454	2,220	2,919
Number of Parcels with Improvements*	22	28	323	373
Total Number of Improvements*	32	66	644	742
Total Improvement Value* (millions of $)	$0.8	$7.4	$126.1	$134.3

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.
** Represents an estimate in acres of land that is completely within the FIRM Flood Zone A.

1 HDR Alaska, Inc. 2003. Kenai Peninsula Borough Transportation Plan (Update). Prepared for the Kenai Peninsula Borough, Soldotna, Alaska [www.kpbtransplan.net/]; Pers. comm., Gary Davis, Road Services Area Director, Kenai Peninsula Borough. Soldotna, Alaska 9/1/04.
2 2009 KPB GIS System and Tax Assessment Database. Value estimates are rounded to nearest $100,000.

Resurrection Creek FIRM Area

Resurrection Creek flows through the small town of Hope to outlet into Cook Inlet at Turnagain Arm. There are a total of 63 parcels within the Resurrection Creek FIRM area with a value of approximately $16,503,600 (Table 2-18). Of these, 52 are privately owned with an assessed value of $1,651,000 (Table 2-18). Twenty of the private parcels have improvements worth an estimated $765,000 (Table 2-18).

Table 2-18. Parcel Summary[1] for the Resurrection Creek FIRM Area by Ownership Category.

Parcel Summary	Private	Federal	State	Borough	Total
Total Parcels*	52	5	3	3	63
Total Value* (millions of $)	$1.65	$14.7	$0.15	$0.002	$16.5
Total Acres Within**	77	157	11	0.5	245.5
Total Acres Intersecting*	233	30,681	160.5	0.5	31,075
# of Parcels with Improvements*	20	2	0	0	22
Total # of Improvements*	27	5	0	0	32
Total Improvement Value* (millions of $)	$0.76	$0.07	$0	$0	$0.83

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.
** Represents acreage completely within FIRM Flood Zone A.

Land classifications for Resurrection Creek floodplain parcels include: 31 Residential Vacant, 3 Residential Improved Land, 10 Residential, 5 Residential Cabin, 3 General Commercial, 1 Institutional Accessory Building, and 10 Tidelands.

Trail River FIRM Area

The Trail River Firm area includes the communities of Moose Pass, Crown Point, and Primrose and covers portions of Trail Lake, Trail River, Kenai Lake, Primrose Creek, Falls Creek, Grant Creek, Victor Creek and Ptarmigan Creek (Figure 2-7). There are a total of 104 parcels within the Resurrection Creek FIRM area, worth just over $38 million (Table 2-19). Of these, 24 are privately owned with a total value of $3,823,100. Twenty-two of the private parcels are improved and the assessed value of improvements is estimated at $ $2.67 million.

1 2009 KPB GIS System and Tax Assessment Database. Value estimates are rounded to nearest $100,000.

Table 2-19. Parcel Summary[1] for the Trail River FIRM Area by Ownership Category.

Parcel Summary	Private	Federal	State	Borough	Total
Total Parcels*	24	8	71	1	104
Total Value* (millions of $)	$3.8	$20.3	$12.1	$1.8	$38
Total Acres Within **	29	113	312	0.4	454
Total Acres Intersecting*	63	19,325	5,697	3	25,089
# of Parcels with Improvements*	22	4	1	1	28
Total # of Improvements*	37	27	1	2	67
Total Improvement Value* (millions of $)	$2.67	$3	$0.005	$1.7	$7.38

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.
** Represents acreage completely within FIRM Flood Zone A.

Land use classifications for the parcels within the Trail River FIRM area include: 73 Residential Vacant, 1 Residential Improved Land, 16 Residential Units, 3 Residential Cabins, 2 Residential Mobile Homes, 2 Residential Accessory Buildings, 1 Commercial Vacant, 3 General Commercial, 1 Institutional School, and 2 Institutional Accessory Buildings.

Seward FIRM Area

The Seward Area FIRM analysis includes all parcels that lie within or intersect the A and V mapped zones both within the City and outlying areas. Flood mapped areas include portions of Resurrection Bay, the Resurrection River, Lowell Creek, Marathon Creek, Japanese Creek, Kwechak/Glacier Creek, and Salmon Creek. There are a total of 611 parcels within the Seward FIRM areas with an assessed value of approximately $196 million (Table 2-20). Of these, 531 are privately owned with an approximate value of $59 million. Of the private parcels, 303 have improvements (587 improvements) worth an estimated $40 million. A parcel breakdown by ownership category is included in Table 2-20.

Table 2-20. Parcel Summary[2] for the Seward FIRM Area by Ownership Category.

Parcel Summary	Private	Federal	State	Borough	Native Corp	Muni-cipal	Total
Total Parcels*	531	1	19	12	7	41	611
Total Value* (millions of $)	$59	$0.01	$51.9	$4.8	$0.3	$79	$195
Total Acres Within **	1,249	32	822	42	11	67	2,223
Total Acres Intersecting *	2,176	39	5,464	192	46	201	8,123
# of Parcels with Improvements*	303	0	2	2	1	14	323
Total # of Improvements*	587	0	17	6	1	34	644
Total Improvements Value* (millions of $)	$40	$0	$22	$0.01	$0.2	$62.7	$125.6

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.
** Represents acreage completely within FIRM Flood Zone A.

1 Ibid.
2 2009 KPB GIS System and Tax Assessment Database. Value estimates are rounded to nearest $100,000.

Land use classifications for the parcels within the Seward FIRM area include: 273 Residential Vacant, 28 Residential Improved Land, 177 Residential Units, 3 Residential Cabins, 26 Residential Mobile Home, 1 Condominium, 39 Residential Accessory Buildings, 6 Commercial Vacant, 1 Apartment Building, 2 Mobile Home Parks, 3 Lodges with Multiple Cabins, 1 Commercial Fish Processing, 26 General Commercial, 6 Commercial Parking Lots, 1 Commercial Accessory Building, 2 Leased Commercial, 1 Leased Industrial, 1 Leased Institutional, 2 Gravel Pits, 3 Institutional Vacant, 3 General Institutional, 3 Institutional Parking Lots, and 2 Institutional Accessory Buildings.

2.9.4 Development Trends

Resurrection Creek

Within or intersecting the mapped Resurrection Creek floodplain there are 52 privately owned parcels, of which 20 are developed and 32 are vacant (Table 2-18). Of the vacant parcels, 21 are one acre or less in size, and 6 are two to five acres in size. There are two private tracts that are greater than five acres in size. A majority of the surrounding land is Chugach National Forest, which is managed for multiple uses such as recreation, timber harvest and mining. Although there is some room for limited recreational and residential growth in the Hope area, much of area (including the floodplain) is federally owned and is unlikely to be developed in the near future.

Trail River

Within or intersecting the Trail River FIRM area, there are 24 privately owned parcels, of which 22 are developed (Table 2-19). With a majority of land in public ownership, floodplain development should remain relatively limited. State and Chugach National Forest lands are currently managed for multiple uses, including recreation, timber harvest and mining. Parcel information for the different ownership categories within the Trail River FIRM area is summarized in Table 2-19.

Seward Area

Within or intersecting the Seward FIRM area, there are 531 privately owned parcels of which 303 are developed and 228 are vacant (Table 2-20). Of the vacant parcels, 117 are one acre or less in size and 37 are two to five acres in size. The one- to five-acre lots typically represent properties that have already been subdivided for sale and development. There are 43 remaining privately owned parcels that are 5 acres or greater in size. A number of these may eventually be subdivided for future development. Although there may be some exceptions, it is highly probable that a majority of future development in the Seward area will have the same unpredictable flood hazard risk as existing development. Parcel information for the different ownership categories within the Seward Area FIRM is summarized in Table 2-20

2.10 South Zone

2.10.1 South Zone Communities

The South Zone covers approximately 8,386 square miles and includes the following communities and localities:

Ninilchik, Happy Valley, Anchor Point, Nikolaevsk, Diamond Ridge, Fritz Creek, Voznesenka, Razdolna, Kachemak Selo, Homer, Kachemak City, Seldovia, Port Graham and Nanwalek.

The overall population of the zone is about 13,000 people, with an increase to about 22,000 during the summer tourist season. Much of the area outside the population centers is largely uninhabited.

Communities with known flood hazard risks are shown in Table 2-21 and Figure 2-10. The City of Homer participates in the National Flood Insurance Program and issues permits for floodplain construction using Flood Insurance Rate Maps provided by FEMA. More detailed flood hazard information for the Cities of Homer and Kachemak is included in their respective annex.

Table 2-21. South Zone Communities and Known Flood Hazards.

Community	Population**	Water Body	FEMA FIRM Maps	Type of Flooding
Ninilchik	824	Ninilchik River, Deep Creek, Cook Inlet	Limited Unnumbered A & V Zones	Riverine, coastal Storm
Anchor Point, Nikolaevsk	2,087	Anchor and North Fork Anchor Rivers, Cook Inlet	*Anchor River* – Limited Unnumbered A & V Zones North Fork Anchor River - no flood mapping.	Riverine, ice jam, coastal storm
East End Road, Fritz Creek, Homer, Diamond Ridge, Kachemak City	8,659	Numerous streams including Fritz, Beaver, Fox and Bridge Creeks, the Bradley River, Kachemak Bay	*Homer* – Numbered A and V zones. *Outlying areas* – no flood mapping	Mud and debris slides, riverine, coastal storm
Nanwalek, Port Graham, Seldovia	810	Port Graham Bay, English Bay, Seldovia Bay, Fish Creek	Limited unnumbered A and V Zones	Coastal storm, tsunami, riverine
Total South Zone Population[1]				**12,308**
Approx. Population at Direct Risk From Flooding[2]				**357**

1 Alaska Department of Labor and Workforce Development, Research and Analysis Section, Demographics Unit.

2 According to the GIS database, the Anchor River FIRM floodplain has 17 residential parcels and 19 recreational parcels; the Ninilchik FIRM has 19 residential parcels and 2 recreational parcels; the Seldovia FIRM has 55 residential parcels and 7 recreational parcels. The total parcels (119) were multiplied by 3 to generate an estimate of approximately 357 people. The City of Homer FIRM areas were not included in this analysis.

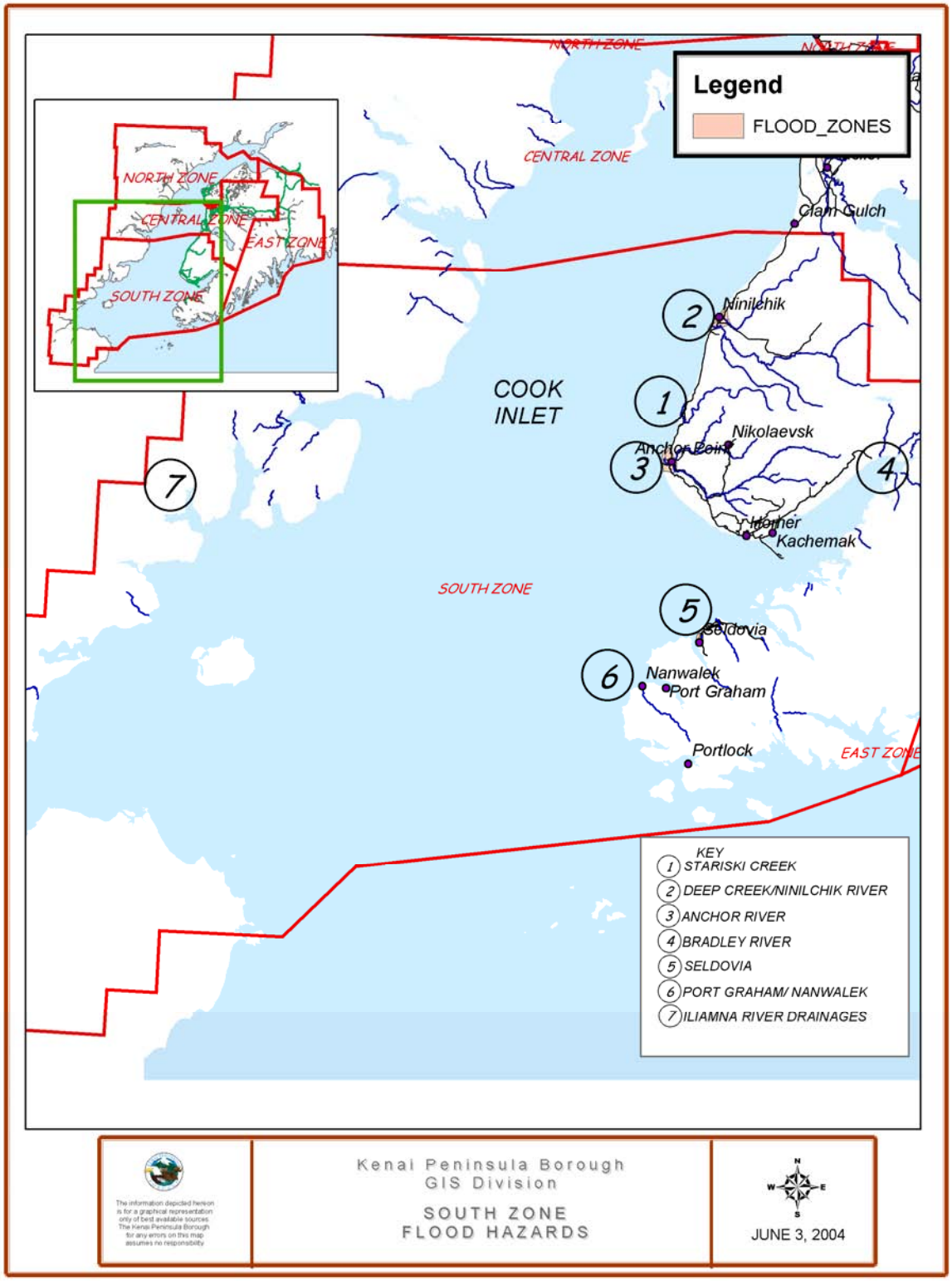


Figure 2-10. South Zone Communities and FEMA FIRM 100-Year Floodplains.

A description of South Zone transportation infrastructure and facilities and services is available in Section 1.4.5 and 1.4.7 and Table 1-7. Facilities and services within the Cities of Homer and Kachemak are described in more detail in their annexes.

2.10.2 Characteristics of Flooding

Riverine system flood damage in the South Zone is predominately associated with the Anchor and North Fork Anchor Rivers, Deep Creek and Ninilchik River, as well as numerous smaller tributaries. Flooding on these river systems can occur as a result of heavy rainfall, ice jams, rapid snow melt or a combination of factors.

Along the Homer Bench on Kachemak Bay's north shore, heavy rains quickly saturate alluvial soils causing the water table to rise and liquefy the clay trapped soils. Seeps form and the coastal bluffs are susceptible to slumping and landslides.

The coastal communities of Nanwalek, Port Graham, Homer, Ninilchik, Anchor Point and Seldovia are subject to flooding from high tides, coastal erosion, storm surge wave run-up and stormwater overflow, as well as tsunamis and seiche waves (See Section 6.0: Tsunamis and Seiches). The Nanwalek airstrip, which is adjacent to English Bay, is particularly vulnerable to coastal wind and wave action. In November of 2003, a 500-foot long by 40-foot wide section of Nanwalek's airstrip on the bay side and a 400-foot long by 40-foot wide section of runway on the lagoon side were eroded away during a storm[1].

Although flooding can happen during any season, the most serious floods of record for South Zone streams occurred in the fall of 2002. Starting in late September, unusually warm temperatures, high winds and heavy rain lingered across the Kenai Peninsula. The heaviest rains and most severe damage occurred between October 22-24 and November 23[2].

The 2002 fall floods directly or indirectly affected a majority of South Zone communities and public facilities. Damage to roads, railroad, park facilities, utilities, buildings and equipment was estimated at over $24.5 million dollars[3]. In addition to public infrastructure, private property damage totaled more than $1,225,000[4]. Total damage to 62 sites on the highway system was estimated at $20.5 million, with additional damages of $781,000 to State Park facilities, $1.2 million to Borough roads

1 Trip Report: English Bay Runway Repairs, Nanwalek, Randel Jones, Homer Station Foreman, Alaska Dept. of Transportation and Public Facilities, 2/26/2004.
2 Eash, J.D., Rickman, R.L., March 2004. Floods on the Kenai Peninsula, Alaska, October and November 2002. USGS Fact Sheet 2004-3023.
3 FEMA 2002. 2002 Kenai Peninsula Flood – DR-1445 Damage Summary.
4 Cowles, W. ADHS/ES, Private Assistance Grant Funding Summary, (email) and Jenkins, R., Small Business Administration, Private Homeowner and Business Loan Program (telephone communication).

and bridges and $425,000 to power lines and underground distribution lines[1]. The culverts on Johnson Lake Road at Crooked Creek near the Sterling Highway were washed out by the 2002 floods, and rather than replace them, the stream was restored and a salmon-viewing area established.

During the flooding, eight streams exceeded previous record flows and many others reached near-record discharges[2]. Rainfall in the Bradley River Basin at the head of Kachemak Bay was 400% above average. Stariski Creek, Deep Creek, Anchor River and the Ninilchik River all surpassed previous recorded peak flows as well as predicted 100-year flows. Bridge approach and culvert washouts occurred at Deep Creek, the Anchor River and Stariski Creek, closing the Sterling and Old Sterling Highways between Ninilchik and Homer in several places for a number of days. Miraculously, no one was seriously injured when two cars traveled, one after the other, across a five-foot breach in the Deep Creek bridge approach that later widened to fifteen feet. In addition to major highway and bridge washouts, telephone and power lines were damaged and numerous secondary roads washed out or were closed for safety.

North Fork Anchor River, Nikolaevsk Rd. Oct. 2002

The Ninilchik beach access road as well as the Ninilchik Village bridge approach washed away, closing access to the Village, beach and harbor. Similarly, the village of Nikolaevsk was isolated when the culverts at the North Fork Anchor River crossing washed out. Steep terrain and overbank stream flows combined to deposit mud over a considerable portion of west Homer. Culverts plugged or were overwhelmed and minor roadbed damage occurred along the East End Road at Bear and Fritz Creeks. A number of homes and driveways along the creeks were also damaged by erosion, water and mud[3]. In addition to major road and power outages, the Borough's Office of Emergency Management (OEM) received over 150 reports of private property damage, which included homes, driveways, septic systems, wells, businesses, and vehicles. Numerous Borough and private roads and bridges washed out, stranding at least 84 families in remote subdivisions.

1 Matthews, J. Planning and Project Management Coordinator, Homer Electric Assoc. Inc., (Email Memo).
2 Eash, J.D., Rickman, R.L., March 2004. Floods on the Kenai Peninsula, Alaska, October and November 2002. USGS Fact Sheet 2004-3023.
3 National Weather Service (NWS), Event Meteorology Summary of Kenai Peninsula Floods- October 22-31, 2002, internal NWS memo.

A month later, while emergency repairs from October's flooding were still underway, heavy rain over the Caribou Hills caused a second round of flood damage along south Peninsula streams. East End Road near Homer was closed by mudslides, and before the stream gauge was destroyed, the Anchor River was running nearly three feet above minor flood stage. During the November flooding, 17 of the State highway repair sites damaged in October were re-damaged and 15 new sites were added to the repair list. A number of Borough roads were also re-damaged[1]. The Sterling Highway was temporarily closed due to inundation between Mile 160.5 and 162, and the Anchor River bridge approaches were severely damaged on the new and old Sterling Highways. The recently repaired Ninilchik Village bridge approach washed out and isolated the village for a second time. As a result of the two back to back flood events, the Ninilchik River, Deep Creek and Anchor River and many of their tributaries suffered severe channel scour, sediment deposition, bank erosion and land slides[2].

2.10.3 What is Susceptible to Damage During a Flood Event?

2.10.3.1 Critical Facilities

South Zone critical facilities (fire and police stations, medical facilities and schools) are located in areas designated by the FEMA Flood Insurance Study as Zone C or D (areas of minimal or undetermined flood hazard). South Zone emergency and school facilities are described in Section 1.5.3, Tables 1-14 and 1-15. Information specific to critical facilities within the Cities of Homer and Kachemak are included in their annexes.

2.10.3.2 Bridges & Culverts

As was vividly demonstrated during the floods of 2002, bridges and culverts are key points of concern during flood events. The number of sites and magnitude of damage that occurred at bridges and culverts was substantial and accounted for a majority of the damage to public infrastructure. Failures of the Deep Creek and Ninilchik Village bridge approaches, as well as culvert washouts on Stariski Creek, the North Fork Anchor River and Silver Salmon Creek, closed roads and isolated several South Zone communities for a number of days.

Post-flood damage repairs on Borough roads included riprap reinforcement of road embankments, installation of oversized culverts and overflow culverts, and improved ditch systems.

Bridges located in the South Zone include:

- South Fork Anchor River, MP 17.6, Sterling Highway
- South Fork Anchor River, MP 15.3, Anchor River/Pioneer
- Anchor River, MP 8.4, Old Sterling Highway

1 The 2002 flood damage estimates were compiled from summaries provided by the Alaska Division of Homeland Security and Emergency Management, Small Business Administration Loan Program and the FEMA- DR1445 Damage Summary.

2 Eash, J.D., Rickman, R.L., March 2004. Floods on the Kenai Peninsula, Alaska, October and November 2002. USGS Fact Sheet 2004-3023.

- North Fork Anchor River, Chakok Rd (Borough)
- North Fork Anchor River, Cottonwood Lane (Borough)
- North Fork Anchor River, Dorothy Drive (Borough)
- North Fork Anchor River, MP 0.5, Anchor River/Pioneer
- Ninilchik River, MP 42.5, Sterling Highway
- Ninilchik River, MP 0.2, Ninilchik Road
- Ninilchik River, Brody Lane (Borough)
- Henry Creek, Lee Roy Ave. (Borough)
- Deep Creek, MP 40.9, Sterling Highway
- Seldovia Slough, MP 0.5 Seldovia Airport Rd.
- Barabara Creek, MP 4.8 Jakolof Bay Rd.

Five bridges are Borough-maintained (noted above in parenthesis), and the remaining nine are state-maintained. There are also two culverts at the Sterling Highway crossing of Stariski Creek (MP 27.0) and four culverts at the Anchor River (MP 21.0). After washing out during the 2002 floods, the Stariski Creek culverts were replaced. Unfortunately, severe scour and erosion caused the pipe outlets to perch above the stream, creating a waterfall that now poses a serious barrier to fish passage. ADOT&PF plans to replace the culvert pipes with a bridge in the near future.

2.10.3.3 FIRM Floodplain Analysis

According to the KPB assessing database, there are 422 parcels of land with a total value of $42.8 million within or intersecting South Zone FIRM areas (Table 2-22).

Table 2-22. South Zone Overall FIRM Parcel Summary[1].

Mapped Floodplains	Anchor River	Ninilchik	Seldovia	Total
Total Parcels*	107	109	206	422
Total Value* (millions of $)	$9.7	$21.4	$11.7	$42.8
Total Acres**	396	153	151	700
Number of Parcels with Improvements*	55	44	89	188
Total Number of Improvements *	80	82	102	264
Total Improvement Value* (millions of $)	$5	$17.2	$6.9	$29.1

* Represents information for parcels that are within or intersect the FIRM Flood Zone A and V.
** Represents an estimate in acres of land that is completely within the FIRM Flood Zone A.

The assessed value of homes and other improvements on the 167 developed parcels is approximately $19.5 million. Additional parcel information is included in Appendices G-1, G-6, and G-8.

Anchor River FIRM Area

The Anchor River FIRM area encompasses the portions of the North and South Forks of the Anchor River around the community of Anchor Point as well as the coastal area at the river mouth. There are a total of 107 total parcels within the Anchor River FIRM

1 2009 KPB GIS System and Tax Assessment Database. Value estimates are rounded to nearest $100,000.

area with an assessed value of approximately $9.7 million (Table 2-23). Of these, 85 (79%) are privately owned with an approximate value of $8.4 million. Of the 85 private parcels, 51 are improved and the improvements are assessed at around $4.9 million. A parcel summary by ownership category is included in Table 2-23

Table 2-23. Anchor River FIRM Area Parcel Summary[1] by Ownership Category.

Parcel Summary	Private	Federal	State	Borough	Total
Total Parcels*	85	1	20	1	107
Total Value* (millions of $)	$8.4	$1.1	$1.1	$0.03	$10.63
Total Acres **	231	15	149	1	396
Total Acres *	613	14	243	1	871
# of Parcels with Improvements*	51	0	4	0	55
Total # of Improvements *	72	0	8	0	80
Total Improvement Value* (millions of $)	$4.9	$0	$0.10	$0	$5

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.
** Represents an estimate in acres of land that is completely within the FIRM Flood Zone A.

Land use classifications for the Anchor River FIRM parcels include: 5 commercial, 19 recreational, 17 residential, 12 institutional (State Parks), 4 mobile homes and 48 vacant.

Ninilchik River FIRM Area

The Ninilchik River FIRM area encompasses the lower Ninilchik River, the lower portion of Deep Creek as well as the coastal area at the mouth of both streams. There are 109 total parcels intersecting the Ninilchik River FIRM area, with an assessed value of approximately $20.75 million (Table 2-24). Of these, 71 (66%) are privately owned with an approximate value of $6.85 million. Of the 71 private parcels, 41 have improvements assessed at around $4.3 million. The two Borough parcels are included in the FIRM summary because they have Cook Inlet frontage. The vacant parcel adjacent to the Ninilchik School is classified for future school use. The Ninilchik School is located on the other Borough parcel and has an assessed value of $7.7 million. Although the school parcel frontage is within the coastal velocity zone, the school itself is located on a high bluff above Cook Inlet and is outside of the mapped floodplain.

A parcel breakdown by ownership category is included in Table 2-24.

1 Ibid.

Table 2-24. Ninilchik River FIRM Area Parcel Summary[1] by Ownership Category.

Parcel Summary	Private	Borough	State	Native Corp	Total
Total Parcels*	71	3	32	3	109
Total Value* (millions of $)	$6.85	$13.1	$0.8	$0.001	$20.751
Total Acres **	53	11	89	0.3	153.3
Total Acres *	309	21.5	316	2	648.5
# of Parcels with Improvements*	41	1	0	0	42
Total # of Improvements*	70	1	0	0	71
Total Improvement Value* (millions of $)	$4.3	$12.7	$0	$0	$17

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.
** Represents an estimate in acres of land that is completely within the FIRM Flood Zone A.

Land use classifications for the Ninilchik River FIRM parcels include: 5 commercial, 2 institutional (State Parks), 1 school (see explanation above), 2 mobile homes, 2 recreational, 19 residential, 4 accessory buildings, 9 tidelands and 63 vacant.

Seldovia FIRM Area

Seldovia is a fishing village near the southern end of the Kenai Peninsula across Kachemak Bay from Homer. The FIRM area includes most of the eastern shore of Seldovia Bay (including the lagoon), which constitutes the primary flood threat to the city. There are 204 parcels intersecting the Seldovia FIRM area with a total assessed value of approximately $27.5 million (Table 2-25). Of these, 155 (75%) are privately owned with an approximate value of $21.2 million. Of the 155 private parcels, 92 are improved and have improvements assessed at around $11.2 million.

Table 2-25. Seldovia FIRM Area Parcel Summary[2] by Ownership Category.

Parcel Summary	Private	City	Lease	State	Native Corp	Total
Total Parcels*	155	36	1	10	2	204
Total Value* (millions of $)	$21.2	3.6	$0.1	$2.4	$0.2	$27.5
Total Acres **	89	13	1	31	17	151
Total Acres *	216	37.6	12.1	58.5	20	344.2
# of Parcels with Improvements*	92	9	0	1	0	102
Total # of Improvements*	138	16	0	1	0	155
Total Improvement Value* (millions of $)	$11.2	$1.5	$0	$0	$0	$12.7

* Represents information for parcels that are within or intersect the FIRM Flood Zone A.
** Represents an estimate in acres of land that is completely within the FIRM Flood Zone A.

Land use classifications for the Seldovia FIRM parcels include: 13 commercial, 4 institutional (3 city, 1 state airport) 2 mobile homes, 7 recreational, 55 residential, 10 accessory buildings, 1 parking lot and 112 vacant.

1 2009 KPB GIS System and Tax Assessment Database. Value estimates are rounded to nearest $100,000.
2 2009 KPB GIS System and Tax Assessment Database. Value estimates are rounded to nearest $100,000.

2.10.4 Development Trends

Anchor River FIRM Area

Of the 85 privately owned parcels in the mapped floodplain, 51 have some type of development and 33 are vacant (Table 2-23). Of the vacant parcels, 16 are an acre or less in size, 12 are one to five acres, 6 are five to ten acres and the remaining 6 parcels are ten acres or greater in size. There is also a sizeable quantity of private and Native Corporation land in the North and South Fork Anchor River floodplains that has not been assessed for flood hazard, but is accessible due to road building associated with timber harvest and land subdivision. Given the availability of vacant land and slow but steady population growth in the area, new development is likely to continue to occur in the mapped and unmapped floodplains of the North and South Fork Anchor Rivers.

Ninilchik River

There are 71 privately owned parcels in the mapped floodplain, of which 41 are improved and 30 are vacant (Table 2-24). Of the 39 vacant parcels, 9 are one acre or smaller, 21 are one to five acres and 9 are five acres or larger. Although development in the lower river floodplain is fairly minimal, there is a sizeable quantity of Native Corporation land in the upper Ninilchik River watershed. Much of the Native Corporation land has been subject to timber harvest and future use and development will depend on the Corporation's land management goals and objectives.

Seldovia

Within or intersecting the Seldovia FIRM area, there are 155 privately owned parcels, of which 92 are developed and 63 are vacant (Table 2-25). Of the 75 vacant parcels, 59 are subdivided into one acre or smaller lots, 12 are one to five acres and 4 are five acres or larger in size. Parcel information for the Seldovia FIRM area is summarized in Table 2-25. Development trends for the City of Seldovia will be discussed in more detail in the future when the City completes their All Hazard Plan annex.

2.10.5 Coastal Erosion South Zone

Within the Southern Zone from Ninilchik to Stariski Creek, the annual rate of erosion is 0.6 feet per year. From Stariski Creek to the Anchor River, the rate is 1.0 feet per year. From Anchor point to Homer, the rate is 0.7 feet per year. This zone is characterized by many erosion "hot-spots" ranging from 2.3 – 5.7 feet per year.

2.11 Flood/Erosion Mitigation Goals

All hazard mitigation goals can be separated into three main categories:

- protection;
- prevention; and
- education.

For the purposes of flood mitigation, protective measures can be structural or non-structural in nature. Structural projects include the creation of debris retention basins, diversion structures, dikes and levees, channel modification, and bridge, road, and

culvert alteration or replacement. These measures are often expensive, involve engineering and construction work and must be maintained to keep their effectiveness through time. They need to be carefully evaluated for the potential consequences of failure and the possibility that over time they may cost more than the development they are put in place to protect.

Non-structural flood mitigation measures include mechanisms such as flood warning systems, emergency response programs, relocation of flood prone structures or use of flood proofing techniques. Retrofitting or rehabilitating structures and facilities can be quite expensive, but in some cases can be done incrementally or as part of routine maintenance, thereby reducing upfront costs.

Protective measures associated with erosion mitigation can also be described as structural or non-structural. Adverse impacts to adjacent properties is of particular concern since some shore protection options change the natural coastal processes in ways that extend beyond the protected property. The responses to bluff and shore protection fall into two general categories: structural and non-structural measures, though some measures may include both types. In all cases, appropriate technical engineering by professionals in coastal processes should be utilized for both types of measures.

Non-structural measures: Non-structural shore protection includes vegetation, slope reduction, drainage control and beach nourishment. Vegetation of eroding slopes can be an affordable and effective measure, if not directly exposed to wave action and the slope is gradual.

Structural shore protection: Rigidly constructed erosion control methods are common and familiar to most coastal residents. Revetments protect slopes from erosion by waves and currents. Rocks or concrete shapes resist wave and current energy while holding down a permeable gravel layer or synthetic membrane that keeps native sediments in place. Seawalls are impermeable vertical structures built along the shore to protect property behind from wave attack. Seawalls may be built as bulkheads (earth retaining walls) or as free-standing walls. As with revetments, a seawall surrounding a single piece of coastal property will eventually extend its effect beyond adjacent unprotected property, ultimately blocking some longshore sediment supply. Seawalls are typically subjects of controversy among adjacent property owners when used in isolated circumstances solely for shore protection.

In 2007 the Borough installed an all-hazard alert broadcast system, which includes 14 outdoor warning sirens and three control centers. Sirens are concentrated in coastal communities, with six sirens in Seward, five in Homer and one siren each in the villages of Part Graham, Nanwalek and Seldovia. There are control centers in Seward and Homer, as well as an overall control center in Soldotna. The warning sirens are capable of automated activation via the National Weather Service Emergency Alert

System and can play pre-recorded messages. The sirens also have a live public address function that can be used for any purpose.

Preventative measures are typically used to limit people's exposure to hazards, and may include the use of tools such as comprehensive land use plans, transportation plans, zoning, building codes, or land subdivision regulations. In areas that suffer repetitive flooding, preventative measures may also include preserving open space, acquiring property and relocating structures to safer areas.

Outreach and education are important components of any hazard mitigation strategy. Community meetings, school activities, emergency preparedness outreach, ads in the media, workplace training, booths at fairs and home shows, brochures and video presentations all provide valuable outreach opportunities.

2.11.1 Accomplishing the KPB Flood/Erosion Mitigation Goals

The following are suggested as objectives or approaches to further define and accomplish the Borough's long-term flood/erosion mitigation goals:

- modify impacts of hazard events by assisting individuals and communities to prepare for, respond to and recover from hazard events;
- reduce susceptibility to damage and disruption by avoiding hazardous, uneconomic and unwise development in known hazard areas;
- protect natural and beneficial values of floodplains, coastal areas and water resources; and
- reduce unnecessary economic losses and promote positive economic development by incorporating hazard mitigation into land use and development decisions.

2.11.2 Existing Flood Mitigation Programs and Activities

To obtain hazard mitigation grant funding in the aftermath of the1995 floods, the Borough developed a flood hazard mitigation plan that focused on the communities that flooded in the eastern and central zones. This Plan expands the planning effort to include flood susceptible communities Borough-wide. In addition, the incorporated Cities of Seward, Kenai, Soldotna, Homer and Kachemak have included their Hazard Plans as annexes at the end of this document. Annex D has been reserved for future inclusion of the City of Seldovia's Hazard Mitigation Plan.

Within the Borough, an intricate mix of public and private facilities, infrastructure and landownership governs the possible blend of flood mitigation activities. Local, state, and federal planning and regulatory authorities must also be considered in the mix. This complexity necessitates a broad management perspective for flood mitigation

planning. It also offers a wider array of resources and mitigation opportunities through cooperative partnerships.

2.11.2.1 Floodplain Development Standards and Education
The Borough participates in the National Flood Insurance Program and the Community Rating System (CRS) Program with the following floodplain regulations, programs and activities:

- implementation of the Chapter 21.06 *Floodplain Management* code, which regulates land subdivision, residential and commercial construction, dredging, filling, mining, excavation and placement of manufactured homes within the FEMA FIRM-mapped Flood Zone A;

- implementation of Chapter 21.18 *Anadromous Streams Habitat Protection.* Although primarily enacted to protect salmon spawning and rearing habitat, the 50-foot habitat protection area also helps maintain stable well-vegetated banks and minimizes new development within 50 feet along 25 Peninsula streams. Section 21.18.050 also establishes permit requirements for fuel storage and logging activities within mapped floodplains;

- creation and maintenance of a floodplain permit database including name, tax parcel number, location, project description, permit date, and base flood elevation information;

- annual mail-out notices to floodplain property owners advising them of their compliance status as well as their responsibility to apply for floodplain development permits;

- mail notices to property owners in areas of historic flooding outside the FIRM floodplain areas;

- participation in the Community Rating System (CRS) program to help lower insurance rates for Borough property owners;

- development of a Borough-wide Multi-Hazard Mitigation Plan, including a section specifically for Flood Hazard Mitigation;

- continuing floodplain education and outreach through workshops and community meetings;

- providing a local source of information on proper floodplain building techniques;

- an in-progress review and revision of the KPB Floodplain Management

Ordinance to improve the clarity, implementation and enforceability of the floodplain code.

2.11.2.2 Emergency Response and Preparedness

The KPB's Office of Emergency Management (OEM) coordinates emergency response efforts during disaster events. Since 1995, the Borough has implemented the following measures to improve flood warning and response:

- created a website (www.borough.kenai.ak.us/emergency), which provides current weather watch and advisory information as well as links to the National Weather Service, FEMA educational materials, the Local Emergency Planning Committee, and other web resources such as The Weather Channel (www.weather.com);

- partnered with USGS for installation and maintenance of real-time stream and precipitation gages (see Appendix K);

- partnered with the National Weather Service to improve weather radio and emergency broadcast capabilities in the Central Peninsula by installing an additional NOAA weather radio station in Ninilchik;

- Developed two mobile sirens that can be moved to areas not served by the Borough's emergency siren warning system;

- Acquired, equipped and programmed a mobile strategic command vehicle (MCV) to facilitate Borough-wide communication and emergency response;

- coordinated with local and state emergency planning committees to develop, refine and implement cross-jurisdictional emergency response plans; and

- implemented a Reverse 911 system (aka Rapid Notify System) to telephone property owners with a recorded alert message in the event of flooding or emergency evacuation.

- Digital elevation mapping (DEM) data using LIDAR has been acquired for the Kenai Peninsula and is currently being processed. LIDAR (LIght Detection And Ranging) is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target. The Seward area was flown in January 2006 during a snow-free period, and the western Kenai lowlands were flown in the summer of 2008. The data acquired has a resolution of one pixel per four foot square and a vertical accuracy of plus or minus 20 centimeters. No data was acquired for the ice fields or for communities across Kachemak Bay/Cook Inlet.

2.12 Flood/Erosion Mitigation Strategies and Implementation Ideas

The flood events in recent years illustrate that the potential for loss of life and property increases where development intersects active floodplains. In addition to the major flooding events described in these pages, floods of lesser magnitude occur almost yearly. The dynamic and varied nature of the Peninsula's climate, geography, topography, geology and waterways suggest that flooding should be considered the norm and not the exception. Thus, as the Borough's population grows, so too does the importance of implementing measures to ensure growth proceeds in the *safest possible* manner.

Although restricting unwise development in floodplains is the most cost-effective way to limit long-term losses and liability, the Borough also needs strategies to protect existing development in vulnerable areas as well as plan for future growth. Because of the complexity of this task, a combination of strategies and implementation ideas are outlined to assist with formulating future flood mitigation actions.

Flood Mitigation Strategies

Strategy 1: Complete a Borough-wide flood and coastal erosion hazard risk assessment.

Implementation Ideas and Action Items

- Assemble a detailed inventory of problem areas and flood susceptible structures and infrastructure (e.g., buildings, critical facilities, roads, bridges, culverts, etc.).
- Identify potential retrofit or rehabilitation measures or activities.
- Seek grants and technical partnerships to complete comprehensive studies of the Homer bench to identify areas of slope instability. Studies would incorporate soil surveys, slope and drainage assessments and an evaluation of the effect of existing and proposed new development on slope stability.
- Use information gathered in the comprehensive studies to formulate mitigation strategies to minimize the risk of catastrophic slope failures in developing areas on the Homer Bench.
- Seek grants and technical partnerships to complete comprehensive coastal erosion studies. Studies would include identifying existing storm wave protection structures, establishing erosion rates,

completing a comprehensive digital elevation model and researching the oceanographic and coastal processes that affect the Kenai Peninsula coastlines.

- Develop a modeling tool to help predict bluff and coastal erosion.
- Use information gathered in the comprehensive studies to formulate mitigation strategies to develop cost-effective solutions to protect life, property and coastal resources.
- Coordinate with other agencies and organizations to identify permit requirements, partnership interests, funding sources.
- Review and update information on a periodic basis.

Potential Participants: KPB Road Maintenance, Public Works, and Planning Departments, ADOT&PF, Permitting Agencies, DCED, Incorporated Cities, Kachemak Bay Research Reserve, Coastal Training Program, Alaska.

Time Frame: Ongoing as part of the Hazard Mitigation Plan Implementation.

Strategy 2: Develop mechanisms to enhance floodplain permit compliance.

Implementation Ideas and Action Items

- Develop a project notification process to connect property owners with the appropriate floodplain, utility, and right-of-way construction permit information. This could be accomplished using a simple one page form that would be available on the Borough website as well as from the Planning, Assessing and Road Service Area Departments and the Donald E. Gilman River Center. The form could be given to property owners when they first contact the Borough for floodplain development, street addressing, KPB right-of-way, driveway or utility installation permit information.
- The notification form would provide an effective means to coordinate permitting between the various Borough departments and lessen permit confusion for the public. It would also help the Borough identify more projects prior to construction, reduce the number of non-compliant floodplain improvements, and result in fewer costly and complicated “after-the-fact” enforcement actions. More importantly, it would proactively insure that improvements, roads and utilities are built to proper standards and less susceptible

to flood damage and will not induce or worsen flood damage to other properties.

- Complete and verify the Floodplain Permit Database. Using the database and Borough GIS capabilities, complete an audit of existing floodplain development within regulated floodplains for permit compliance. Work with property owners to bring their improvements into compliance with floodplain development standards.

Potential Participants: KPB Planning, Road Service Area, GIS, Assessing and MIS Departments.

Time Frame: Implementation of Permit Notification Form: 3-6 months
Completion of Floodplain Permit Database: 1-2 years (ongoing)
Completion of Floodplain Development Audit: 1-2 years (ongoing.)

Strategy 3: Improve KPB floodplain mapping and identify other effective tools or methods to assist with flood hazard assessment.

With a few exceptions, the Borough's official Flood Insurance Rate Maps (FIRM) were completed in the early 1980's[1]. In many less populated communities, stream floodplains, seeping bluffs and coastal run-up zones were not studied or only studied by approximate methods. For these areas, base flood elevation (BFE) predictions were not generated, resulting in unnumbered A and V Zone maps. Although unnumbered zones roughly delineate the probable boundary of the 100-year flood event, they do not predict the BFE. In addition, natural stream processes, recent flood events or floodplain development have significantly altered the systems and the original BFE elevation modeling is no longer accurate.

Implementation Ideas and Action Items

- Perform detailed flood studies for FIRM Unnumbered A and V Zones to provide base flood and wave run-up elevations and floodway delineations.

  Areas that currently would benefit from more detailed maps include:

  - the upper Kenai River (Cooper Landing - 7 miles);
  - Ninilchik River (lower 16 miles);
  - main-stem Anchor River (lower 17 miles);

1 FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska. Community Number 020012.

- North Fork Anchor River (lower 19 miles);
- Deep Creek (lower 22 miles);
- Trail River (Moose Pass);
- Seldovia;
- Port Graham;
- Nanwalek;
- Seward (Bear Lake to Resurrection Bay – Alluvial Streams);
- Resurrection River (lower 6 miles);
- Resurrection Creek and Hope coastline; and
- North Kachemak Bay coastline.

- In addition to 100-year BFE and coastal storm surge predictions, generate detailed flood boundaries and predicted base flood elevations for 10-, 25-, and 50-year events in areas such as the Kenai River with significant floodplain growth and development.

- Correct geo-referencing problems with the Nikiski, Port Graham and Nanwalek FIRM maps so they can be entered into the KPB GIS System.

- Digitize, geo-rectify and enter floodway boundary lines into the KPB GIS System for all numbered A zones.

- Verify existing and install additional vertical elevation benchmarks in developing floodplains to facilitate accurate base flood elevation surveys for homeowners.

- Map actual flood boundaries after major flood events.

- Identify and map areas of active and severe riverine erosion along streams and rivers.

- Identify and map areas of active and severe coastal erosion.

- Install visible shoreline markers to collect erosion rate information in areas vulnerable to coastal storm run-up. Coastal processes, including sediment transport and erosion, are little-understood along KPB coastlines. Installing markers is a cost effective way to gather erosion information, which can be used by communities to help formulate and prioritize erosion mitigation solutions. To date, Port Graham is the only coastal community that has identified specific sites for installing erosion markers (see the Port Graham Flood Mitigation Plan[1] in Annex G).

1 Montgomery Watson and Parker Horn Company, Flood Hazard Mitigation Plan, Port Graham, Alaska, Kenai Peninsula

Potential Participants: KPB Planning, GIS, and Public Works Departments in cooperation with U.S. Army Corps of Engineers, FEMA, USGS, KPB communities, Alaska Dept. of Community and Economic Development, Kachemak Bay Research Reserve.

Time Frame: 1-5 Years (as funding can be generated)

Strategy 4: Cooperate with the City of Seward and the Seward/Bear Creek Flood Service Area Board to identify, prioritize and implement cost effective strategies for controlling flood damage.

Implementation Ideas and Action Items

- Seek grants and technical partnerships to complete comprehensive hydrologic studies of the Seward area alluvial streams from their headwaters to Resurrection Bay. The analysis should identify repetitive flood problems, evaluate channel morphology and stability, bed load transport and the location and effectiveness of existing flood control structures. In addition, important riparian, wetland and aquatic functions, such as water storage, filtering, changes in water quality or quantity and identification of salmon spawning and rearing habitat, should be evaluated and factored into decisions.

- Apply for grants and technical partnerships to obtain two-foot interval digital surface elevation data to assist with alluvial fan flood hazard evaluation as well as future FIRM map revisions.

- Investigate the feasibility of implementing an array of alluvial fan floodplain management alternatives, including: land use planning and zoning, stream channel migration zones, floodplain conservation areas, moving and elevating structures, acquiring properties subject to repetitive flooding, identifying areas, methods and markets for annual gravel and debris removal.

Potential Participants: Seward/Bear Creek Flood Service Area Board, KPB Public Works, Planning, Road Service Area Departments, City of Seward, U.S. Army Corps of Engineers, USGS, FEMA, Alaska Dept. of Community and Economic Development.

Time Frame: 1-5 Years (as funding allows)

Strategy 5: Review and appropriately revise KPB floodplain development standards and requirements.

Implementation Ideas and Action Items

Note: A number of the revisions to **Chapter 21.06 *Floodplain Management*** discussed below may also require other KPB Code sections to be reviewed and revised as appropriate.

- Review the definition section and add and clarify definitions as needed.

- In areas where base flood elevation (BFE) information is available, require the lowest floor of residential and commercial buildings to be elevated at least one foot above the BFE.

- Add emergency response permit provisions, including guidelines for issuing verbal and written permits during emergencies.

- Add regulations governing permanent and temporary storage of home heating oil, gasoline, diesel, and other hazardous materials. Minimum requirements might include setbacks from waterbodies, wells, and wetlands, proper anchoring of tanks or other storage containers, use of double-walled tanks or appropriate secondary containment, and insuring vents and openings are a minimum of one to two feet above BFE.

- Evaluate changing Chapter 21.06 *Floodplain Management* and Chapter 20.12.060 *Subdivisions* to limit or prohibit (with the exception of properly engineered and permitted stream crossings) the platting of new roads in floodways.

- Require all new subdivision lots to be of adequate size, orientation and elevation to insure there is developable space that is not unduly constrained by floodway, tideland, steep terrain, poor soils, wetlands or unmapped surface water drainages. Chapter 20.12.060 *Subdivisions* would also need to be revised as appropriate.

- Require new subdivision plats to show FIRM floodplain and floodway boundaries and carry appropriate plat notes. Chapter 20.12.060 *Subdivisions* may also need to be revised as appropriate.

- At the time of preliminary plat submittal, require an engineer-stamped drainage plan[1] that evaluates the surface water flow across the landscape and describes the methods that will be used to reduce flood damage exposure for all subdivisions that contain mapped floodway or are greater than five acres or five lots in the mapped floodplain. Chapter 20.12.060 *Subdivisions and* 14.06.150 *Road Construction Standards* may also need to be revised as appropriate.

- Develop a long-term (two to five year) permit exclusively for alluvial floodplain gravel extraction projects that will improve flood-water conveyance and reduce flood hazard. Permit applications would require submittal of a gravel removal plan describing the location, dimensions of the extraction area, a detailed analysis of anticipated changes to the hydrologic characteristics in the area, the dimensions and location of material and equipment storage areas and a description of associated floodplain/floodway road development or stream crossings. Plans should also show how activities will be conducted to minimize damage to stream banks (from mining activities or site access) and describe any necessary reclamation or restoration activities. Chapter 21.26 Material Site Permits would also need to be revised as appropriate.

- Review and revise Chapters 14.06.150 Road Construction Standards and 14.08 Utility Right-of-Way Permits as appropriate to ensure drainage plans and proper floodplain standards are incorporated into new road development as well as upgrades to existing road and utility services.

- Review all proposed code changes for consistency with KPB Coastal Management Program enforceable policies, and specifically include language in KPB 21.06, Floodplain Management, KPB 21.18, Anadromous Streams Habitat Protection, KPB 20.20, Subdivisions, KPB 14.06 Road Standards, KPB 14.08 Permits for Utility Right-Of-Ways, and Chapter 21.26 Material Site Permits, which specifies floodplain related development decisions must comply with the enforceable policies of the KPB Coastal Management Program.

1 Drainage plans typically address road and lot orientation, installation of ditches, water passage structures such as bridges or culverts, water retention swales, and set aside preservation areas such as wetlands and riparian vegetation, which store and filter runoff. Ideally, drainage plans would be submitted with the preliminary plat and include drawings or written descriptions of the location and construction plans for utility improvements such as water, sewer, natural gas, telephone and electrical facilities.

Potential Participants: Affected KPB Departments, U.S. Army Corps of Engineers, FEMA, Alaska Dept. of Community and Economic Development, the Incorporated Cities.

Time Frame: 1-5 Years (as staff and funding permit)

Strategy 6: Research and implement alternative floodplain management strategies.

Implementation Ideas and Action Items

- Create or encourage establishment of a revolving low-interest loan fund to help private property owners elevate or appropriately retrofit their improvements to meet floodplain standards. After the floodplain permit database and audit are complete, develop a list of residential properties that need retrofitting to qualify for permits and improved floodplain insurance rates. Establish procedures and implement the loan fund through private financial institutions or the KPB with the guidance of a community advisory group.

- Investigate use of waterway setbacks and special zoning overlay areas, including riparian and coastal bluff buffers and channel migration zones.

- Provide tax credits to people willing to institute non-development easements in mapped floodplains and floodways.

- Encourage the use of "flood service areas" for places and projects that require annual maintenance to control flooding hazards.

- Periodically meet with the Cities of Homer and Seward to share information and brainstorm ways to improve National Flood Insurance Program implementation.

- Encourage the Cities of Soldotna, Kenai, Kachemak and Seldovia to adopt their own floodplain regulations and join the NFIP.

- Acquire property or relocate structures in areas subject to severe flooding or erosion.

Potential Participants: Kenai Peninsula Borough, incorporated Cities within the KPB, U.S. Army Corps of Engineers, FEMA, Alaska Dept. of Commerce, Community and Economic Development, Kachemak Bay Research Reserve, Coastal Training Program Alaska.

Time Frame: On-going (as staff, funding and interest are generated).

Strategy 7: Evaluate Borough-maintained roads for floodplain hazards and potential flood reduction projects.

Implementation Ideas and Action Items

- Institute a revolving flood mitigation budget fund to assist with Borough maintained road and capital projects.
- Conduct joint site visits with key permitting agencies to evaluate repetitively damaged roads and formulate plans for flood mitigation upgrades.
- Identify and investigate the possibility of vacating existing platted but not yet constructed ***floodway*** roads.
- Evaluate the feasibility of constructing additional alternate road access to areas currently served by a single flood prone road.
- Identify and upgrade existing stream crossings to maximize flood-water conveyance, maintain fish passage, and reduce negative impacts to wetlands, rivers, and streams. According to the KPB Road Service Area Department, there are approximately 30 Borough-maintained culvert crossings that would be better served by clear span bridges[1].
- Identify and stabilize erosion prone cut-banks to decrease damage to KPB roads. There are approximately five locations where KPB roads would benefit from this type of structural mitigation[2].
- Clean, resize or relocate overflow ditches to facilitate water movement and minimize debris jam flooding.
- Install, upgrade or maintain protective dikes, dams, levees and as appropriate, conduct ongoing maintenance activities such as emergency gravel/debris removal or stream re-channelization. An important caveat for all structural projects is that they should be carefully evaluated for long-term consequences, including costly maintenance, the shifting of problems from one location to another,

1 Pers. Comm., Gary Davis, Kenai Peninsula Borough Road Service Area Director, 4/22/2004.
2 Pers. Comm., Gary Davis, Kenai Peninsula Borough Road Service Area Director, 4/22/2004

and adverse hydrological or environmental impacts. Structural protection can also create a false sense of security and encourage development in areas that could be catastrophically affected if the structure failures.

Potential Participants: KPB, Private Non Profit Organizations, FEMA, Alaska Division of Homeland Security and Emergency Management
Time Frame: Ongoing (Funding Dependent)

Strategy 8: Protect and maintain beneficial floodplain and shore zone natural values.

Floodplains often serve important functions in protecting the physical, biological, and chemical integrity of water resources. Important floodplain functions include the ability to store and convey flood water, maintain water quality, perpetuate groundwater recharge, and support large and diverse populations of aquatic and terrestrial organisms (plants, animals, fish, amphibians, and insects). Similarly, the natural accretion and erosion processes of shore zones play an essential role in sustaining sandy beaches and sub-tidal and intertidal habitats. Structures and control measures such as seawalls and bulkheads that are designed to protect individual properties can impact other property owners as well as the natural resources in these zones by changing erosion and accretion rates along the shoreline.

Land owners and managers of the Borough's rich and diverse rivers, streams and coastal areas have the additional responsibility of maintaining critical fish and wildlife habitats despite pressures from increasing use and development. In years to come, the health of the wild salmon runs will largely depend on whether the streams remain connected to unique and productive biological floodplain features such as wetlands, cutoff oxbows, sandbars, backwaters, undercut banks, floodplain pools and extensive high water tables.

In addition to their fisheries, wildlife and hydrologic values, the riverine and coastal floodplains and bluff zones are often of unique scientific interest as geological, archeological or historical sites and have extraordinary community value as open space resources[1].

Unfortunately, development that proceeds without considering the dynamic and beneficial functions unique to floodplains often increase flooding potential, and diminish the values that originally attracted people to these areas. Long-term

1 FEMA, 1986. Interagency Task Force on Floodplain Management. A Unified National Program for Floodplain Management. FEMA 100 March 1986.

floodplain management strategies should do the following:

Implementation Ideas and Action Items

- Work with other interested agencies to identify degraded floodplains and investigate the potential for restoring or improving water passage, removing repetitively damaged improvements and/or acquiring land to restore or preserve floodplain function.

- Work with other interested agencies and non-profit organizations to develop watershed and coastal bluff management plans that identify important natural water storage and flow features and recommend land management and development techniques to preserve critical floodplain function. General floodplain management recommendations include avoiding development in floodways, old meander channels and wetlands; identifying less hazard prone areas for development and encouraging proper construction techniques, including elevating structures and utilities; engineering proper road and drainage crossings, minimizing impervious surfaces and using vegetated swales and storm water basins to slow water run-off.

- Provide best management practices (BMP) education and information to landowners and contractors to help minimize floodplain project impacts. BMPs include scheduling projects during low water, using silt fences and other sediment control techniques to stabilize fill or disturbed areas and scheduling in-water work to periods less likely to impact salmon migration, spawning, incubation and rearing.

- Provide incentives to encourage proper stewardship and limit impacts from residential and recreational development adjacent to lakes, streams, coastal shoreline and bluffs (e.g., habitat protection tax credits and restoration project cost share programs).

Potential Participants: KPB Planning Dept., Donald E. Gilman River Center, private nonprofit organizations, EPA, FEMA, ADEC, DNR/Parks, ADF&G/Division of Habitat, Kachemak Bay Research Reserve, Coastal Training Program Alaska and Kachemak Heritage Land Trust.

Time Frame: Ongoing(Funding Dependent)

Strategy 9: Promote positive economic development.

It may appear difficult to balance the loss of economic opportunities when proposing that communities restrict growth in hazard-prone areas. However, when development proceeds unplanned in areas subject to flooding and erosion, there are always serious social and financial costs. Preventing unwise floodplain and floodway development can minimize disaster damage, increase property values and maintain many of the natural features that originally attracted people to an area. To achieve positive long-term economic growth, it is important to include floodplain and coastal development considerations in the comprehensive and long-range planning goals for each community.

Implementation Ideas and Action Items

- Incorporate floodplain, coastal bluffs and watershed planning in appropriate KPB planning documents such as the Comprehensive Plan, Transportation Plan and Coastal Management Program Plan.
- Require written disclosure of hazard prone areas (such as floodplain, tsunami run-up zones, coastal bluffs and other areas with high erosion potential) when property ownership is transferred.
- Enforce development standards to reduce or avoid flood vulnerability.
- Encourage planning concepts such as cluster development, floodplain open space, and riparian zone conservation easements.
- Develop incentive programs to encourage growth and development in less hazard prone areas outside of floodplains.

Potential Participants:	KPB Assembly, Planning, Economic Development and other appropriate departments, private nonprofit organizations, EPA, FEMA, ADEC, DNR/Parks, ADF&G/Division of Habitat, Kachemak Bay Research Reserve.
Timeline:	Ongoing (Funding Dependent)

Strategy 10: Enhance existing emergency preparedness practices.

Currently, the Office of Emergency Management (OEM) coordinates disaster response and participates in ongoing hazard assessments, emergency preparedness education and outreach. In addition to existing program activities,

the following implementation ideas and activities could be used to assist with flood warning and response efforts:

Implementation Ideas and Action Items

- In cooperation with the USGS, upgrade the Anchor River gage to a continuous real time system (approximate additional cost: $15,400), and find funding to return the Ninilchik River gage system to service (approximate cost $23,100) [1].

- Seek funding for digital elevation mapping (DEM). Digital elevation data can be used for hazard assessments as diverse as flooding, tsunami run-up, avalanche and wildfire behavior. Acquiring DEM data and maps for the major river systems and coastal areas would provide a multi-faceted tool for hazard assessment and emergency response planning.

- Add a permit liaison position to the KPB Incident Command Structure to coordinate emergency permitting with the appropriate regulatory agencies.

- Identify debris management sites.

- Maintain a revolving flood mitigation fund for the purpose of delivering clean water, sand and sand bags and other critical services to communities during flood emergencies.

Potential Participants:	KPB, USGS, EPA, FEMA, US Army Corps of Engineers, ADEC, DNR/Parks, ADF&G/Division of Habitat
Time Frame:	KPB Emergency – Incident Command Permit Liaison Position- Immediately KPB Revolving Flood Budget - Immediately DEM Mapping, Stream Gauges - Ongoing (Funding Dependent)

Strategy 11: Provide flood hazard and floodplain development education and information.

An informed public is crucial to achieving the Borough's flood mitigation goals. Providing education and outreach is an ongoing process and can always be improved or expanded.

1 Pers. comm., Steve Frenzel, Chief, Water Resources Office, USGS, Alaska Science Center, 4/20/04.

Implementation Ideas and Action Items

- Continue to send annual letters to all floodplain property owners notifying them of floodplain regulatory requirements.
- Expand the annual property owner mail-out to include homeowners in areas that are floodprone but are not currently within a KPB flood-mapped (FIRM) area.
- Continue to sponsor regular educational seminars with lending institutions, title companies, realtors, building contractors, surveyors, architects and engineers;
- Continue to provide "self-help" flood protection and structural retrofit information from FEMA as well as participate in area trade shows, and public meetings; and,
- Continue to provide information and individual permit assistance to property owners.

Potential Participants: KPB; FEMA, Division of Community Advocacy, Department of Commerce, Community and Economic Development; Cities of Homer and Seward.
Time Frame: Ongoing

Strategy 12: Identify and develop partnership opportunities.

By seeking and participating in partnerships, the KPB can capitalize on resources available in the public and private sectors, providing more benefit for less overall cost. Ideally, long-range hazard mitigation planning will involve everyone with interest, resources and ideas to share. In many cases, projects and management strategies that protect vital floodplain and water quality values simultaneously provide economic and protective benefits for property and infrastructure.

In the past, the Borough has cooperated on mitigation planning and projects with the Alaska Division of Emergency Services, Federal Emergency Management Agency, City of Seward, Alaska Railroad Corporation, U.S. Geological Survey, National Weather Service, U.S. Army Corps of Engineers, Alaska Department of Fish and Game, Alaska Division of Parks and Outdoor Recreation, Natural Resource Conservation Service, Alaska Department of Transportation and Public Facilities, Alaska Department of Environmental Conservation, U.S. Environmental Protection Agency and the U.S. Forest Service.

Potential Participants: Other potential partners include local nonprofit research, education, conservation and land trust groups, such as the ADF&G Kachemak Bay National Estuarine Reserve, Homer Soil and Water Conservation District, Cook Inlet Keeper, The Nature Conservancy, Kachemak Bay Research Reserve, Coastal Training Program Alaska, Kenai Watershed Forum, Kachemak Heritage Land Trust, and the Resurrection Bay Conservation Alliance.

Time Frame: Ongoing

Strategy 13: Encourage all incorporated Borough communities to participate in the National Flood Insurance Program.

Currently the Cities of Seward and Homer administer the National Flood Insurance Program for properties within their respective city limits. The Kenai Peninsula Borough administers the program for all other properties except those within the Cities of Kenai and Soldotna, which have chosen not to participate. Because flood insurance is only available to property owners in areas that participate in NFIP, this leaves residents in some areas of the Borough ineligible to purchase flood insurance.

By encouraging all incorporated communities to participate in NFIP, the number of property owners eligible for flood insurance can be increased, and building standards that reduce potential flood damage can be put in place.

Potential Participants: Kenai Peninsula Borough, City of Seward, City of Soldotna, City of Kenai, City of Homer, City of Seldovia, Kachemak City.

Time Frame: Ongoing

Erosion Mitigation Strategies

Strategy 1: Survey Borough shorelines to project rates of erosion and identify littoral zones

Implementation Ideas and Action Items

- Determine the longshore sediment drift.
- Determine rates of bluff and shoreline retreat.

Strategy 2: Determine the areas of highest hazard and implement appropriate development standards in those areas

Implementation Ideas and Action Items

- Standards may be in the form of guidance or setback requirements for high-hazard areas

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Strategy 3: Provide best available coastal process and hazard information to Borough residents

Implementation Ideas and Action Items

- Use GIS and Coastal Management websites as repositories of information
- Publications

2.13 Flood Resource Directory

Local Resources

Kenai Peninsula Borough (KPB)

Office of Emergency Management (OEM)

The KPB OEM has the primary responsibility for disaster management programs and activities. The overall objectives for OEM are disaster mitigation, preparedness, response, and recovery to all disaster incidents, whether natural or man-made. Flood information, including FEMA and American Red Cross brochures, checklists, and fact sheets are available online or by contacting the OEM office. The OEM website also provides links to the National Weather Service Alaska River Forecast Center and the USGS Real-time Stream Flow Data.

Contact: KPB/ Office of Emergency Management
Address: 253 Wilson Lane, Soldotna, AK 99669
Phone: (907) 262-4910
Website: www.borough.kenai.ak.us/emergency

Local Emergency Planning Committee (LEPC)

The 27-member KPB Local Emergency Planning Committee (LEPC) meets quarterly, and is comprised of: firefighters, community groups, media, hospital representatives, local & state law enforcement officials, industry representation, transportation, environmental groups, elected officials, Alaska State Defense Force representatives and interested members of the public. Anyone interested in emergency response planning is encouraged to attend. The mission of the LEPC is to prepare emergency response plans for all hazards, whether natural or manmade, and to establish procedures for receiving and processing requests from the public for information generated by SARA Title III reporting requirements.

Contact: KPB/Office of Emergency Management
Local Emergency Planning Committee (LEPC)

Address: 253 Wilson Lane, Soldotna, AK 99669
Phone: (907) 262-4910
Website: www.borough.kenai.ak.us/emergency/LEPC/lepchome.htm

Seward/Bear Creek Flood Service Area Board
The KPB Seward/Bear Creek Flood Service Area Board was established to provide flood protection, planning and mitigation services for the City Seward and outlying Bear Creek areas.

Contact: KPB/ Seward/Bear Creek Flood Service Area Board
Address: 302 Railway Suite #123, P.O. Box 1554, Seward, Alaska 99664
Phone: (907) 224-3340
Website: sewardbearcreekfloodservicearea.org/index.html

Donald E. Gilman River Center (RC)

The Donald E. Gilman River Center is a multi-agency permitting, information and education center. Three agencies and one non-profit organization are housed at the Center and work cooperatively to protect the rivers, watersheds and fish and wildlife resources of the Kenai Peninsula.

- ***Kenai Peninsula Borough Resource Planning Department*** - Programs administered by Borough staff include:

  Floodplain Management Program - The Borough participates in the National Flood Insurance Program (NFIP) by providing floodplain building information and standards, assisting with floodplain determinations, and issuing floodplain construction permits.

  50-foot Habitat Protection Area Conditional Use Area – Staff provide information and permit assistance for activities that occur within the 50-foot Habitat Protection Area setback along 25 salmon streams.

  Kenai Peninsula Borough Coastal Management Program - The borough provides local input and guidance to state and federal agencies involved in issuing permits or managing land and coastal resources. The program also provides an information base and policies to assist the borough in managing borough land and resource use decisions.

- ***Alaska Department of Fish and Game***

  Division of Habitat - Issues permits for activities and projects that occur below ordinary high water in anadromous waters (e.g., salmon streams). Also permit projects or activities that could affect fish passage in non-anadromous streams.

- ***Alaska Department of Natural Resources***

  Division of Parks and Outdoor Recreation - Issues permits for projects that occur below ordinary high water in the Kenai River Special Management Area, as well as for all commercial activity that takes place in State Parks on the Kenai Peninsula, including Kachemak Bay, Resurrection Bay and Prince William Sound.

- ***U.S. Environmental Protection Agency (EPA)*** – EPA staff at the KRC provide technical assistance for wetlands and other aquatic ecosystem conservation planning, oversee watershed research grants, and conduct waste and storm water inspections.

- ***The Kenai Watershed Forum*** - A local nonprofit citizens' group that provides the RC's school-based outreach and education programs.

  Contact: **For All Agencies** at the Donald E. Gilman River Center
  Address: 514 Funny River Road, Soldotna, AK 99669
  Phone: (907) 260-4882
  Website: www.borough.kenai.ak.us/KenaiRiverCenter

State Resources

Alaska Department of Fish and Game

For Central Kenai Peninsula Area Fishery and Wildlife Information
Address: 43961 Kalifornsky Beach Road, Soldotna, AK 99669
Phone: (907) 262-9368

For South Kenai Peninsula Area Fishery and Wildlife Information
Address: 3298 Douglas St., Homer, AK 99603
Phone: (907) 235-8191

Alaska Department of Natural Resources

Division of Parks and Outdoor Recreation

For Park Use Permits
Contact: Donald E. Gilman River Center
Address: 514 Funny River Road, Soldotna, AK 99669
Phone: (907) 260-4882

For Other Park Information or Business
Contact: Kenai/Prince William Sound Area, Morgan's Landing Office
Address: 35850 Lou Morgan Rd., Sterling, AK 99672
Phone: (907) 262-5581 (open year round)

Alaska Department of Environmental Conservation (ADEC)

Contact: ADEC
Address: Red Diamond Center, 43335 Kalifornsky Beach Rd., Suite 11, Soldotna, AK 99669
Phone: (907) 262-5210

Federal Resources

FEMA

FEMA's mission is to reduce loss of life and property and protect the nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery. FEMA provides flood hazard maps, publications related to flood mitigation, funding for flood mitigation projects and technical assistance. FEMA also operates the National Flood Insurance Program. FEMA's Region X office serves the northwestern states of Alaska, Idaho, Oregon and Washington.

Contact: FEMA, Federal Regional Center, Region 10
Address: 130 228th St. SW, Bothell, WA 98021-9796
Phone: (425) 487-4600
Website: www.fema.gov

To obtain FEMA publications:
Phone: (800) 480-2520

To obtain FEMA maps:
Contact: Map Service Center
Address: P.O. Box 1038, Jessup, Maryland 20794-1038
Phone: (800) 358-9616

To obtain National Flood Insurance Program (NFIP) and Community Rating System (CRS) Program information:
Contact: National flood Insurance Program
Website: www.fema.gov/nfip

Natural Resource Conservation Service (NRCS), U.S. Department of Agriculture

The NRCS provides a number of federal programs that assist state and local governments and landowners to mitigate the impacts of flood events. The Watershed Surveys and Planning Program and the Small Watershed Program provide technical and financial assistance to help participants solve natural resource and related economic problems on a watershed basis. The Wetlands Reserve Program and the Flood Risk Reduction Program provide financial incentives to landowners willing to set land aside that is either a wetland resource or experiences frequent flooding. The Emergency Watershed Protection Program (EWP) provides technical and financial assistance to clear debris from clogged waterways, restore vegetation, and stabilize riverbanks. The measures taken under EWP must be environmentally and economically sound and generally benefit more than one property. Program assistance may also be available through the three Soil and Water Conservation District Offices that serve the Kenai Peninsula.

Contact: NRCS, District Conservationist, Kenai Field Office
Address: 110 Trading Bay, Suite 160, P.O. Box 800, Kenai, AK 99611-0800
Phone: (907) 283-8732
Website: www.nrcs.usda.gov
www.ak.nrcs.usda.gov

Contact: Kenai Soil and Water Conservation District, District Manager
Address: 110 Trading Bay, Suite 160, P.O. Box 800, Kenai, AK 99611-0800
Phone: (907) 283-8732

Contact: Homer Soil and Water Conservation District, District Manager
Address: 4014 Lake Street, Suite 201, P.O. Box 4014, Homer, AK 99603
Phone: (907) 283-8732

Contact: Alaska Soil and Water Conservation, District, District Manager
Address: 510 “L” Street, Suite 280, Anchorage, AK 99501
Phone: (907) 271-2424

National Weather Service (NWS), Alaska Region Headquarters

The NWS provides flood watches, warnings and informational statements for rivers in Alaska. The website offers river, lake, marine, aviation and weather forecasts and warnings, and climate reports.

Contact: Alaska Region Headquarters
Address: 222 West 7th Ave, #23, Anchorage, AK 99513-7575
Phone: 907-271-5088
Fax: 907-271-3711
Website: www.arh.noaa.gov/sitemap.php

U. S. Geological Survey (USGS)

The USGS investigates the occurrence, quantity, quality, distribution and movement of surface and underground waters and disseminates the data to the public, state and local governments, public and private utilities, and other federal agencies involved with managing water resources. The USGS website also provides current stream flow information for 14 USGS gauging stations distributed across the Kenai Peninsula.

Contact: USGS Alaska Science Center
Address: 4210 University Dr., Anchorage, AK 99508-4664
Phone: (907) 786-7011
Email: dc_ak@usgs.gov
Website: waterdata.usgs.gov/ak/nwis
Stream gage information: waterdata.usgs.gov/ak/nwis/current/?type=flow

U.S. Fish and Wildlife Service (USFWS)

The USFWS provide financial and technical resources through the Partners for Fish and Wildlife and Fish Passage Programs to assist private landowners and the Cities of Kenai and Soldotna to restore and protect riverbanks and riparian habitat in the Kenai, Kasilof and Anchor River watersheds.

Contact: U.S. Fish and Wildlife Service
Address: Kenai Fishery Resource Office
43665 Kalifornsky Beach Rd., Soldotna, AK 99669
Phone: (907) 262-9863
Email: ak_fisheries@fws.gov
Website: alaska.fws.gov/fisheries/fieldoffice/kenai/index.htm

The Floodplain Management Association (FMA)

The FMA website provides full-text management articles, a calendar of events, a list of available job positions, an index of publications, a floodplain management consultant list, newsletters, information on the basics of floodplain management and a catalog of web links.

Contact: Floodplain Managers Association
Address: P.O. Box 712080, Santee, CA 92072-2080
Phone: 619-204-4380
Website: www.floodplain.org

The Association of State Floodplain Managers (ASFPM)

The association of State Floodplain Managers is an organization of professionals involved in floodplain management, flood hazard mitigation, the National Flood Insurance Program, and flood preparedness, warning and recovery. ASFPM provides technical advice to governments and other entities for actions or policies that will affect flood hazards, and encourages research, education and training. The ASFPM website includes information on how to become a member, information on upcoming conferences, a publication list and other useful information and web links.

Contact: The Association of State Floodplain Managers
Address: 2809 Fish Hatchery Road, Madison, WI 53713
Phone: (608) 274-0123
Website: www.floods.org

Northwest Regional Floodplain Managers Association (NORFMA)

This site provides technical information, articles, and web links in the field of floodplain, fisheries and river engineering management.

Contact: Northwest Regional Floodplain Managers Association
Website: www.norfma.org/

Additional Resources

Kachemak Bay Research Reserve

The Kachemak Bay Research Reserve (KBRR) performs and coordinates research and education related to estuarine, oceanic and watershed interests of the Kenai Peninsula and Gulf of Alaska. The

KBRR is a partnership between the National Oceanic and Atmospheric Administration (NOAA) and the State of Alaska and is administered through the Alaska Department of Fish and Game.

Contact: Kachemak Bay Research Reserve
Address: 95 Sterling Highway, Suite 2, Homer, AK 99603
Phone: (907) 235-6377
Email: dfg.dsf.kachemak-bay@alaska.gov
Website: www.habitat.adfg.state.ak.us/geninfo/kbrr/index.html

Coastal Training Program Alaska

The Coastal Training Program Alaska (CTP Alaska) provides science-based training and education services to assist policy makers and land managers make better decisions about coastal issues. CTP Alaska is a NOAA national initiative operated in conjunction with National Estuarine Research Reserves.

Contact: Kachemak Bay Research Reserve
Address: 95 Sterling Highway, Suite 2, Homer, AK 99603
Phone: (907) 235-6377
Email: Megan.Murphy@alaska.gov
Website: www.habitat.adfg.state.ak.us/index.cfm/FA/educationCoastal.home

Kachemak Heritage Land Trust (KHLT)

KHLT is a non-profit organization established in 1989 to preserve for public benefit land with significant natural, recreational or cultural values by working with willing landowners on the Kenai Peninsula.

Contact: Kachemak Heritage Land Trust
Address: 315 Klondike Avenue, Homer, AK 99603
Phone: (907) 235-5263
Fax: (907) 235-1503
Website: www.kachemaklandtrust.org

American Red Cross

The American Red Cross is a volunteer humanitarian organization, which provides relief to disaster victims and helps people prevent, prepare for, and respond to emergencies.

Contact: American Red Cross
Address: 235 E. 8th Avenue, Anchorage, AK 99501
Phone: (907) 646-5401
Website: alaska.redcross.org

Kenai Watershed Forum

The Kenai Watershed Forum is a local non-profit citizens' group, which focuses on issues and activities that promote the health of Kenai Peninsula watersheds.

Contact: Kenai Watershed Forum
Address: P.O. Box 2937, Soldotna, AK 99669
Phone: (907) 260-5449
Website: www.kenaiwatershed.org

Cook Inletkeeper

Cook Inlet Keeper is a private nonprofit organization, which conducts water quality monitoring, environmental education, and advocacy activities that promote clean water in the 47,000 square mile Cook Inlet watershed.

Contact: Cook Inletkeeper
Address: PO Box 3269, 3734 Ben Walters Lane, Homer, AK 99603
Phone: 907-235-4068
Website: www.inletkeeper.org

Resurrection Bay Conservation Alliance

RCBA is a non-profit organization that promotes quality of life and tracks environmental issues on the

eastern Kenai, from Seward to Portage, Cooper Landing to Hope.

Contact: Resurrection Bay Conservation Alliance
Address: P.O. Box 1092, Seward, AK 99664
Phone: (907) 224-4621
Email: info@rcba-alaska.org
Website: www.rcba-alaska.org

Publications

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U.S. Army Corps of Engineers, Alaska District. 1975. *Flood Plain Information, Kenai River, Phase II, Kenai Peninsula Borough, Alaska.*

Fenner, K.D., Edwards, S.E., and T.M. Neely. 1987. *Hazard Mitigation Plan for the Seward Area*. Kenai Peninsula Borough.

Kenai Peninsula Borough. 1996. *Flood Mitigation Plan, Phase I*.

Kenai Peninsula Borough. 2002. Situation and Prospects.

Jones, S.H. and C. Zenone. 1988. *Flood of October 1986 at Seward, Alaska,* United States Geological Survey, Water Resources Investigations Report 87-4278, Anchorage, Alaska.

Larson, L., Klitze, M.J., and D.A. Brown. 2003. *No Adverse Impact: A Toolkit for Common Sense Floodplain Management.* Association of State Floodplain Managers, Madison, WI.

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Nelson, G.L. 1981. *Hydrologic Reconnaissance near Fourth of July Creek, Seward, Alaska:* U.S. Geological Survey Water-Resources Investigations 81-21.

Nibler, G.J. 1986. *Report on the October 10-12, 1986, Heavy Rain and Flooding in Southcentral Alaska.* Alaska River Forecast Center Report.

Sloan, C.E. 1985. *Water Resources and Hydrologic Hazards of the Exit Glacier Area near Seward, Alaska:* U.S. Geological Survey Water-Resources Investigations 81-21.

U.S. Army Corps of Engineers, Alaska District. 1975. *Flood Plain Information, Resurrection River and Salmon Creek, Seward, Alaska.*

U.S. Corps of Engineers. 1994. *Seward Area Rivers Flood Damage Prevention Interim Reconnaissance Report.*

3.0 Wildfires

A detailed interagency[1] action plan for fire prevention and protection, hazardous fuel reduction, forest health, restoration, and rehabilitation and community assistance has been developed for the Kenai Peninsula Borough.

The *All Lands/All Hands Action Plan* is designed to be a working document that will implement the National Fire Plan (NFP) 10-Year Comprehensive Strategy and Healthy Forest Reforestation Act (HFRA) on Borough lands. To address local wildfire protection needs for Borough communities this plan is designed to facilitate the development of 20 Community Wildfire Protection Plans.

This comprehensive, multi-year plan provides a detailed assessment of wildfire issues facing the Kenai Peninsula Borough and its residents. It addresses the wildfire situation within the Kenai Peninsula Borough facilities and populations at risk from fire, goals and action items to mitigate fire risk and an implementation schedule for identified plan goals. Information is arranged into three primary sections with five appendices:

1.0 **Introduction**. This section includes the background and purpose of the plan, document organization and the relationship of this plan to others.
2.0 **Action Plan Goals, Principles, Actions, Outcomes, Performance Measures & Implementation Tasks**. This section describes in detail the four main goals of the plan, associated implementation tasks and as a schedule for monitoring and evaluating the plan strategy.
3.0 **All Lands/ All Hands Multi-Year Project Implementation Schedule, Outputs and Costs.**

Appendix A – Fuel Hazard and Wildfire Risk Assessment
Appendix B – Wildland Fire Protection Capability
Appendix C – Community Wildfire Protection Plans
Appendix D – Literature Cited
Appendix E – Individual Agency/Landowner 5-Year Project Implementation Plans

The entire *All Lands/All Hands Action Plan* is located in Annex H.

3.1 Wildfire History

The Kenai Peninsula Borough has an active wildfire history, with an average of 66 fires a year in the past 22 years. Many of these fires have been confined to a relatively small area, but active response plans are critical for fire control. The

[1] Participating agencies include: The Kenai Peninsula Borough, The USDA Forest Service (Alaska Region), State of Alaska Division of Forestry, USDI Fish and Wildlife Service (Alaska Regional Office), USDI Bureau of Land Management (Anchorage Field Office), USDI National Park Service (Kenai Fjords National Park), USDI Bureau of Indian Affairs, Cook Inlet Resources (Alaska Regional Office).

most recent large fire on the Kenai Peninsula occurred at Shanta Creek (2009) and burned a reported 13,200 acres (Table 3-1). In 2007, a fire in the Caribou Hills burned 56,000 acres and destroyed 88 homes and cabins, as well as 109 outbuildings. Other recent fires burning large areas have taken place at Glacier Creek (2004) and Fox Creek (2005) near Tustumena Lake, Tracy Avenue (2005) fire near Homer and the King County Creek fire near Skilak Lake on the central peninsula (2005).

Table 3-1. Select Historical Fires on the Kenai Peninsula.

Year	Location	Number of acres affected
1947	Skilak Lake	310,000
1969	Swanson River	79,000
1974	Pipeline Road	3,780
May-June 1991	Pothole Lake*	7,900
1994	Windy point	2,700
June 1996	Crooked Creek	17,500
May 1996	Hidden Creek and Voznesenka Village	5,200
July 1997	Kasilof	90
June 1999	Mansfield-Hutler Road	75
June-July 2001	Kenai Lake, Mystery Hills & Thurman	3,912[1]
2003	Pipe Creek	513
2004	Glacier Creek Fire	8,600
2005	Fox Creek	26,300
2005	Tracy Avenue	5400
2005	King County Creek	10,100
2007	Caribou Hills	56,000
2007	Swan Lake	2000
2009	Shanta Creek	13,200
2009	Mile 17 East End Road	1100

* Disaster Declaration

[1] This was actually three fires: Kenai Lake (3,200acres), Mystery Hills (697 acres) and Thurman (15 acres).

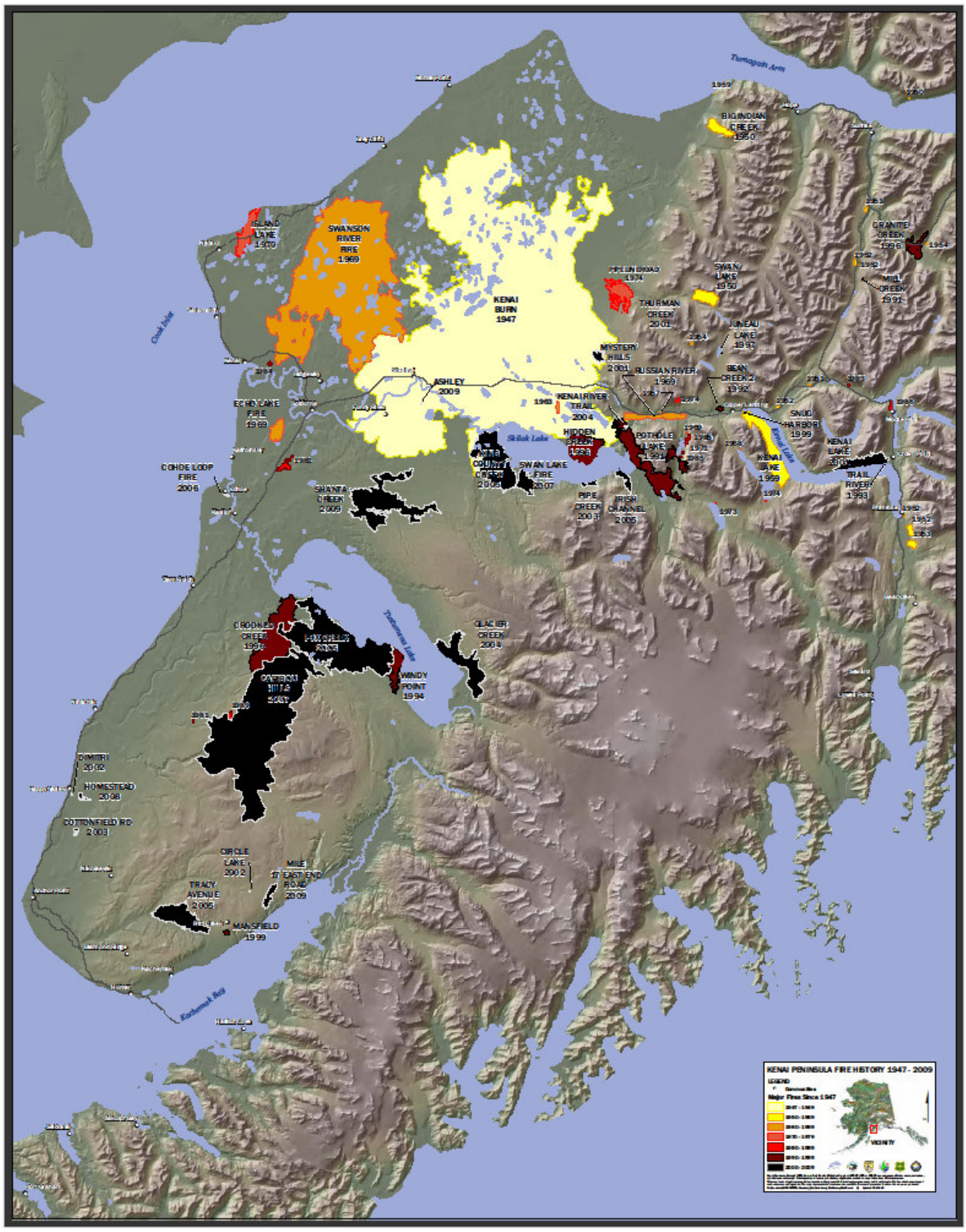

Figure 3-1. Fire History on the Kenai Peninsula, 1947-2009

For additional information on fire history on the Kenai Peninsula see the *All Lands/All Hands Action Plan*:

1) Map A9: Historical Fire Start Locations and Ignition Cause on the Kenai Peninsula from 1980-2002.

3.2 All Lands / All Hands Executive Summary

The All Lands / All Hands Executive Summary provides an overview of the project including goals and estimated implementation costs and outputs. Refer to Annex H for the complete All Lands / All Hands Action Plan.

4.0 Earthquakes

4.1 Why Focus on Earthquake Hazard Mitigation?

Approximately 11% of the world's earthquakes occur in Alaska and since 1904, Alaska has experienced three of the ten largest earthquakes anywhere on the globe[1]. High magnitude earthquakes in Alaska most commonly occur along the Aleutian Islands, the Alaska Peninsula and the Kenai Peninsula - an area referred to as the Alaska-Aleutian megathrust (Figure 4-1)[2].

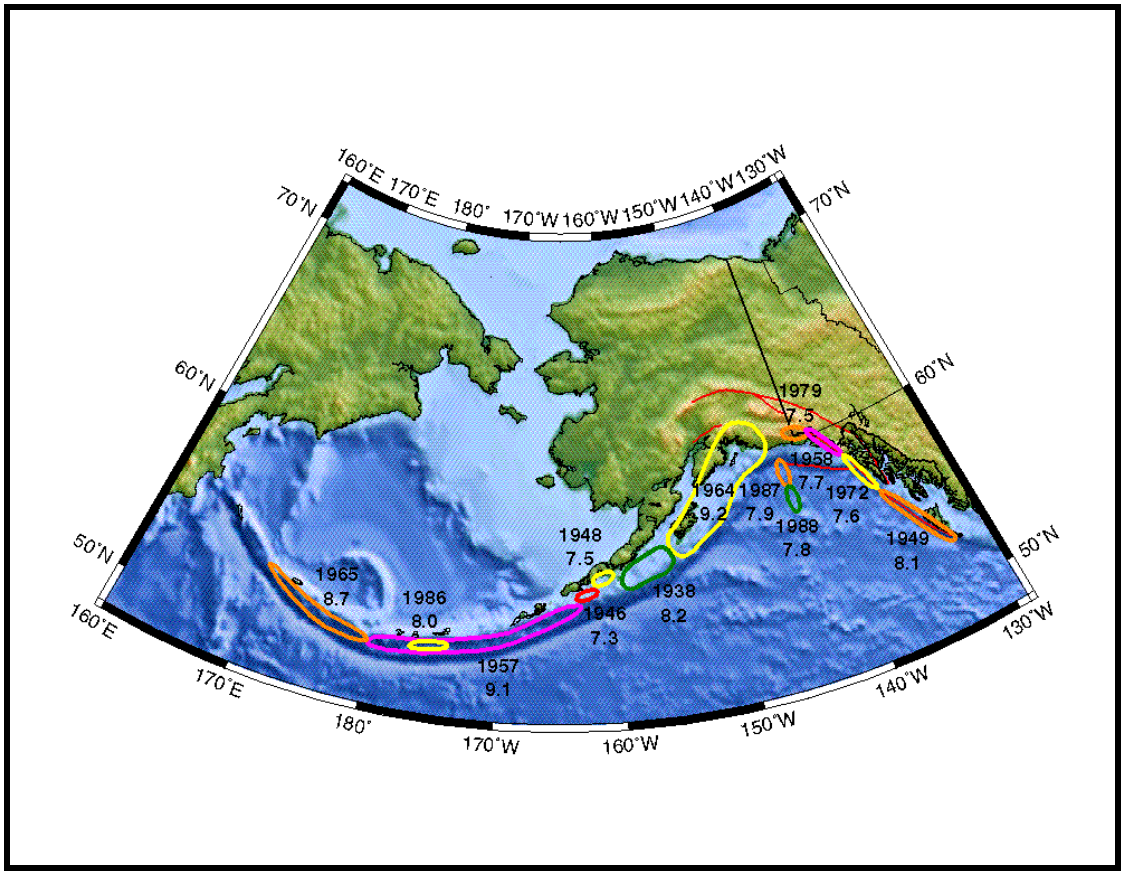

Figure 4-1. Rupture Areas and Dates of Large Earthquakes in the Alaska-Aleutian Region During This Century. Note that, with a few exceptions, virtually the entire boundary between the Pacific and North American Plates (*the Alaska-Aleutian Megathrust*) has ruptured during this period[3].

As crustal plates move past each other pressure is accumulated. The release of this stress is felt as an earthquake. Seismic events that are generated in the area between two plates are referred to as interplate events. Earthquakes may also be

[1] Haeussler, P. and G. Plafker. 2003. Earthquakes in Alaska (map). U.S. Geological Survey, Open File Report 95-624.
[2] Wesson, R., A. Frankel, C. Mueller and S. Harmsen. 1999. Probabilistic Seismic Hazard Maps of Alaska. U.S. Geological Survey, Open File Report 99-36.
[3] Plafker, G. J.C. Moore, and G.R. Winkler. 1994. Geology of the Southern Alaska Margin *in* Plafker, G. and H.C. Berg (editors). The Geology of North America, Vol G-1, The Geology of Alaska. The Geological Society of America, 1994, Boulder, Colorado.

generated in areas within a tectonic plate, such as along fault zones, and are then termed intraplate events. Both earthquakes generated within and between plates may produce significant ground shaking events.

The vast majority of the quakes on the Kenai Peninsula are subduction zone earthquakes that result from the oceanic northwestward-moving Pacific Plate colliding and then descending beneath the continental North American Plate (an interplate event). The release of built up stress in the subduction zone usually leads to very large earthquakes, such as the one that occurred on March 27, 1964. These may be very deep forces and typically cause strong shaking that may last several minutes. They can also cause significant permanent uplift or subsidence over great areas, large seismic sea waves (tsunamis), landslides and snow avalanches. Subduction zone earthquakes in this region have a recurrence interval of 300-800 years[1]. Despite the estimated interval between these seismic events, they are an on-going threat and continue to have the potential to produce large magnitude earthquakes in the Kenai Peninsula region.

Earthquakes may also occur on the Kenai Peninsula as a result of the movement of active faults (Figure 4-2). These intraplate earthquakes may occur at great distance from the plate boundaries. There is evidence that some young shallow intraplate faults that trap oil and gas in Cook Inlet may be seismically active and have the ability to produce large magnitude earthquakes on an infrequent basis[2] (Figure 4-3). The active Castle Mountain Fault and possibly the Bruin Bay Fault, both on the west side of Cook Inlet, are two sources of potentially damaging earthquakes. In fact, geologists exploring possible seismic hazards in upper Cook Inlet found that shallow intraplate earthquakes may present a greater short-term threat than subduction-zone earthquakes, which have a longer recurrence interval[3]. The connection of these faults with oil and gas facilities further underscores the importance of mitigation strategies to reduce the damage from a major earthquake event.

In addition, many of the small to moderate magnitude earthquakes felt in the Kenai Peninsula region occur in an area referred to as the Wadati-Benioff Zone, which is the portion of the Pacific Ocean crust that is being subducted beneath the North American Plate. Rather than occurring on the interface between the plates (subduction zone/interplate events), these deep intraplate earthquakes occur within the down-moving slab as the oceanic plate deforms[4].

More infrequently, Alaska may experience transform fault earthquakes, a special type of interplate strike-slip fault formed when crustal blocks slide by each other.

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1 Haeussler, P., R. Bruhn, and T. Pratt, 2000. Potential seismic hazards and tectonics of the upper Cook Inlet basin, Alaska, based on analysis of Pliocene and younger deformation. GSA Bulletin 112(9): 1414-1429.

2 Pers. comm., Peter Haeussler, Geologist, U.S. Geological Survey. Anchorage, Alaska, 2004.

3 Haeussler, P., R. Bruhn, and T. Pratt, 2000. Potential seismic hazards and tectonics of the upper Cook Inlet basin, Alaska, based on analysis of Pliocene and younger deformation. GSA Bulletin 112(9): 1414-1429.

4 Pers. comm., Rod Combellick, Acting Director, Alaska Division of Geological and Geophysical Surveys. Fairbanks, Alaska, 2004.

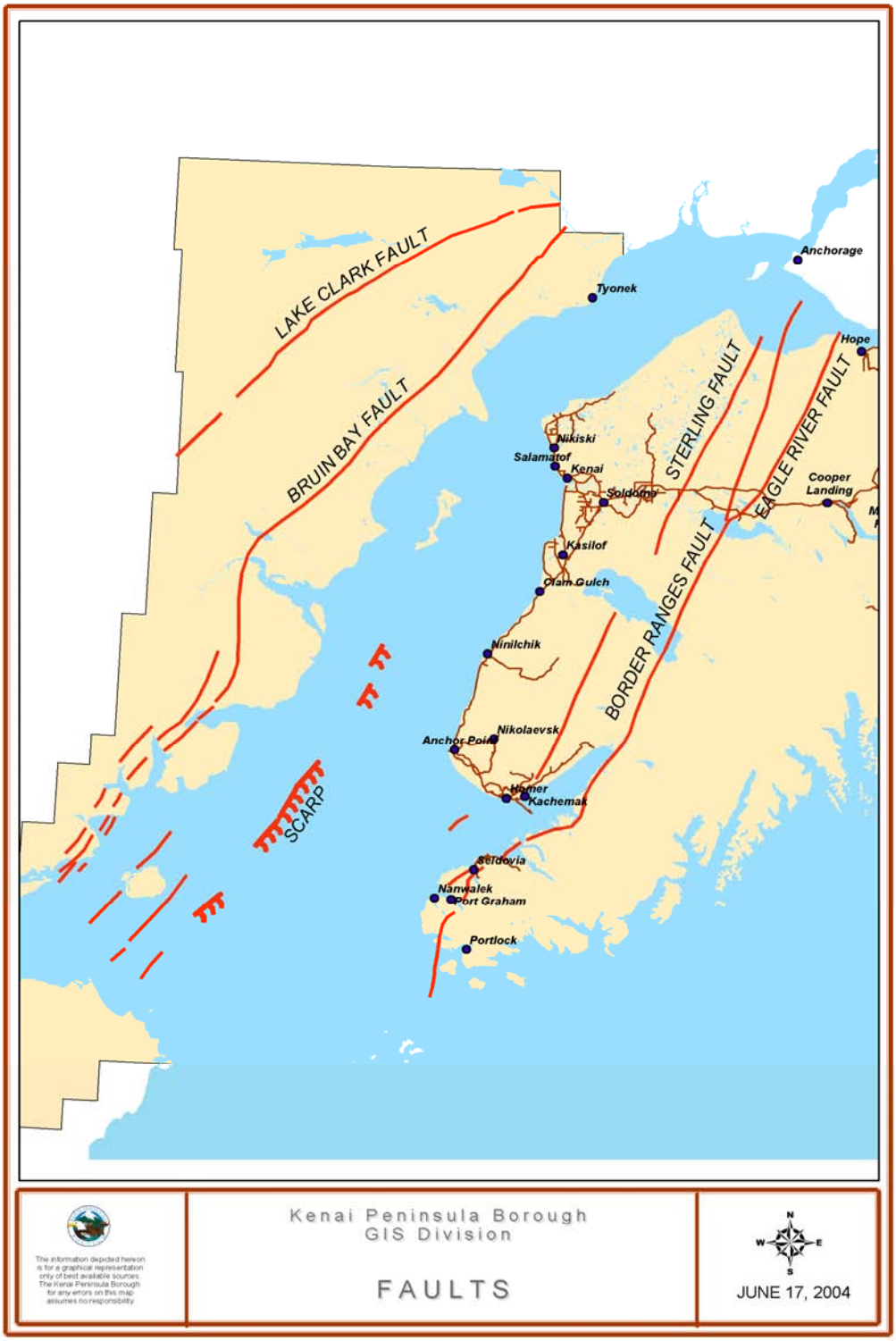

Figure 4-2. Major Faults in the Kenai Peninsula Borough.

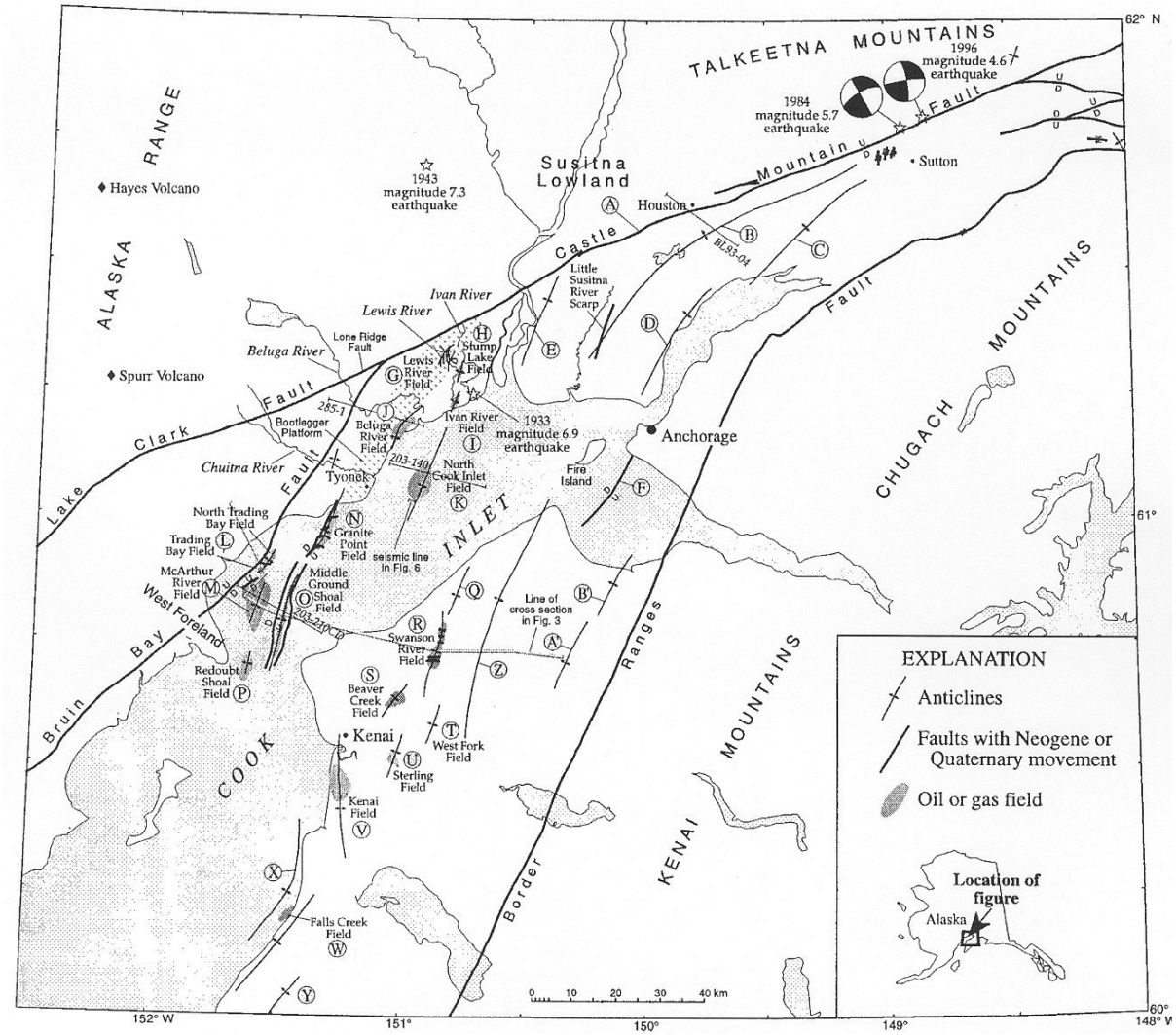

Figure 4-3. Tertiary Structures in Cook Inlet Basin. Approximate basin boundaries are the Castle Mountain Fault, Bruin Bay Fault, and Border Ranges Fault. Details of significant structures, demarcated by letters, are found in Table 4-1. Used with permission from Haeussler et al. 2000.

Table 4-1. Name of Structures and Labels in Figure 4-3[1].

Name of structure and label in Figure 4-3	Length (km)	Data sources
(A) Castle Mountain Fault	52	Magoon et al. 1976
(B) Big Lake - Pittman	76	Magoon et al. 1976
(C) Wasilla St. 1- Needham	~15	Magoon et al. 1976
(D) Lorraine-Alaska Gulf	~25	Magoon et al. 1976
(E) Bell Island	~22	Magoon et al. 1976
(F) Turnagain Arm	~22	ARCO data/well data
(G) Lewis River	8	AOGCC 1994
(H) Stump Lake	7	AOGCC 1994
(I) Ivan River	6	AOGCC 1994
(J) Beluga River	15	AOGCC 1994; ARCO data
(K) North Cook Inlet	23	Magoon et al. 1976
(L) Trading Bay (and NTB)	26	ARCO data
(M) McArthur River	17	AOGCC 1994
(N) Granite Point	11	Magoon et al. 1976, AOGCC 1994
(O) Middle Ground Shoal	17	Magoon et al. 1976
MGS + Granite Point	44	ARCO data
(P) Redoubt Shoal	11	Magoon et al. 1976
Redoubt Shoal + McArthur River	26	Magoon et al. 1976
(Q) Birch Hill	12	Magoon et al. 1976
(R) Swanson River	20	Magoon et al. 1976
(S) Beaver Creek	9	Magoon et al. 1976
(T) West Fork	9	Magoon et al. 1976
(U) Sterling	9	Magoon et al. 1976
(V) Kenai	12	AOGCC 1994
(W) Falls Creek	27	Magoon et al. 1976
(X) Kasilof	32	Magoon et al. 1976
(Y) Deep Creek	12	Magoon et al. 1976
(Z) Naptown - Sunrise Lake – Beaver Ck	55	Magoon et al. 1976
(A') Swan Lake	17	Magoon et al. 1976
(B') Pincher Creek	14	Magoon et al. 1976

As one of the fastest-growing boroughs in Alaska, the Kenai Peninsula Borough has a rapidly developing urban and transportation infrastructure that is vulnerable to a high level of earthquake hazard[2]. Only through increased hazard awareness and implementation of loss/reduction measures can potential risks be mitigated.

[1] Used with permission from Haeussler, P., R. Bruhn, and T. Pratt, 2000. Potential seismic hazards and tectonics of the upper Cook Inlet basin, Alaska, based on analysis of Pliocene and younger deformation. GSA Bulletin 112(9): 1414-1429.

[2] Pinkston Enterprises. 2004. Kenai Peninsula Borough Emergency Response Plan. Prepared for the Office of Emergency Management, Kenai Peninsula Borough, Soldotna, Alaska.

4.2 Earthquake History

The Kenai Peninsula Borough frequently experiences small earthquakes (below magnitude 4), which usually go unnoticed by area residents - only information collected at seismic stations detect the activity. Earthquakes are commonly noticed when they reach the 4 to 4.5-magnitude range, though property damage or injury is minimal at this level. However, once earthquakes exceed the 4.5 level, the possibility of damage and injury increases significantly. Over 82 earthquakes with a magnitude of 6.0 or greater have been recorded in the Cook Inlet region[1] since 1898, with 30 of these triggered directly within the KPB boundaries[2] (Table 4-2; Figure 4-4).

Table 4-2. Earthquakes with Their Epicenter Located in the Kenai Peninsula Borough with a Magnitude of 6.0 or Greater from 01/1898 Through 04/09/2010[3].

Date	Magnitude	Date	Magnitude
07/14/1899	7.2	10/03/1954	6.8
09/22/1911	6.9	01/24/1958	6.4
06/07/1912	6.4	12/26/1959	6.2
06/10/1912	6.9	09/05/1961	6.1
12/24/1931	6.2	06/24/1963	6.8
04/27/1933	7.1	03/28/1964	6.1*
06/13/1933	6.2	03/28/1964	6.1*
06/19/1933	6.0	03/28/1964	6.2*
06/18/1934	6.7	04/23/1968	6.5
10/11/1940	6.0	12/17/1968	6.2
07/30/1941	6.2	01/16/1970	6.1
12/05/1942	6.5	11/20/1993	6.0
01/12/1946	7.2	02/12/1995	6.1
09/27/1949	7.0	07/09/1998	6.3
06/25/1951	6.2	07/28/2001	6.3

* The three earthquakes listed for March 28, 1964 are associated with one major earthquake that had its epicenter north of Prince William Sound (61.04 N, 147.73 W) and a calculated moment magnitude of 9.2[4].

1 Pinkston Enterprises. 2004. Kenai Peninsula Borough Emergency Response Plan. Prepared for the Office of Emergency Management, Kenai Peninsula Borough, Soldotna, Alaska.
2 Alaska Earthquake Information Center (AEIC). 2004. AEIC Earthquake Database, Geophysical Institute, University of Alaska, Fairbanks.
3 ibid.
4 U.S. Department of Commerce, National Science Services Administration, U.S. Coast and Geodetic Survey. 1964. United States Earthquakes

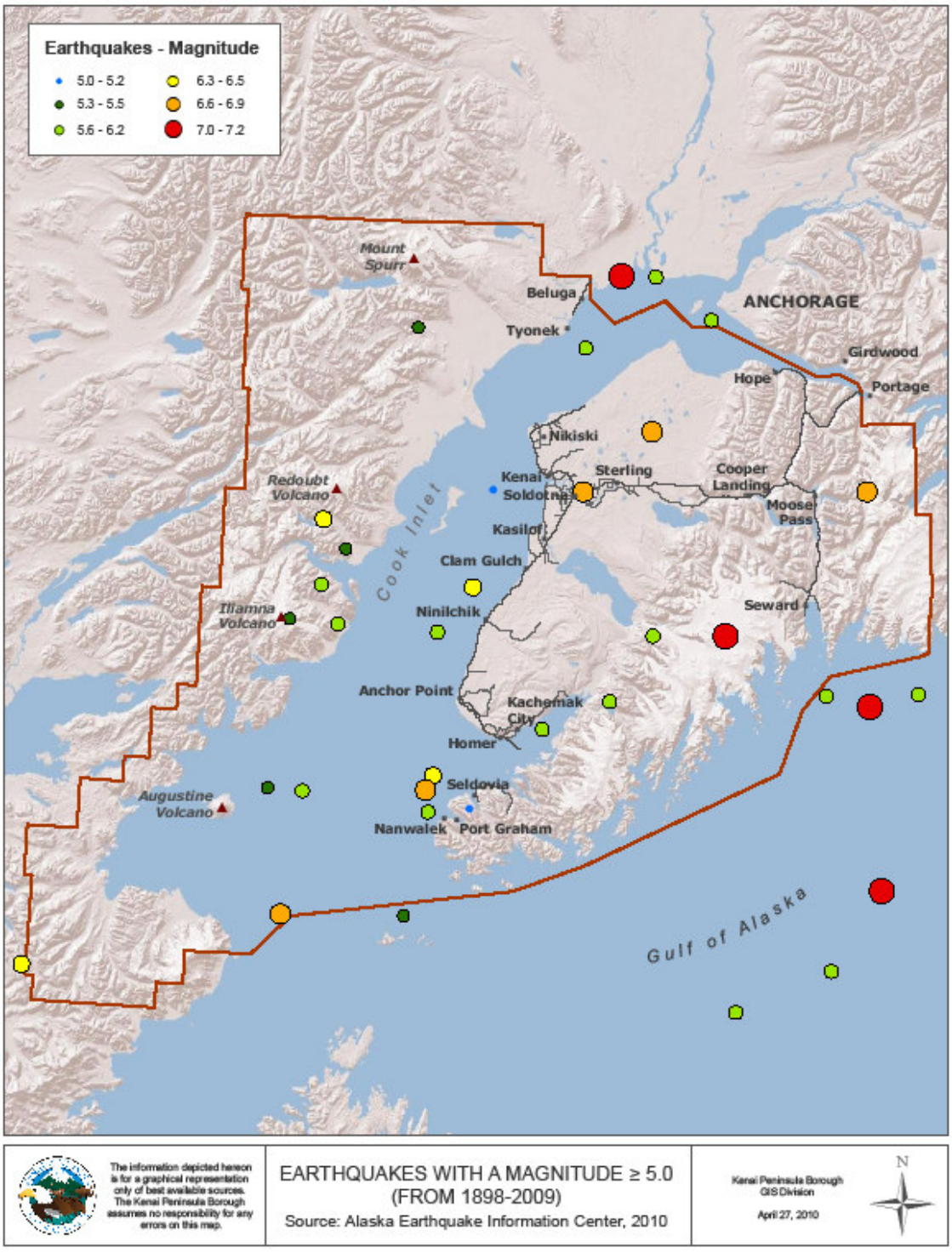

Figure 4-4. Location of Earthquakes Generated Within the Kenai Peninsula Borough Boundaries From 1898 Through April 2010 with a Magnitude ≥ 5.0 (Data source: Alaska Earthquake Information Center 2010).

March 27, 1964 (Good Friday) Earthquake

The second largest earthquake ever recorded, measuring 9.2[1] at its epicenter, occurred on March 27, 1964 in the northern part of Prince William Sound. The rupture was calculated to a depth of approximately 25 km and lasted four minutes[2]. It caused considerable ground breakage, loss of lives and significant economic and infrastructure destruction. Notable damage was documented for over 50,000 square miles of land and developed areas, and recorded for over 100,000 square miles of cracked river and lake ice[3]. In addition, at least 10,000 miles of shoreline experienced subsidence or uplift in south-central Alaska[4].

The Good Friday earthquake triggered landslides, avalanches, tsunamis and seiches[5] that caused extensive property damage and killed 115 people in Alaska, 106 of them as a direct result of tsunamis[6] (see Section 6.0). The death count could have been much higher if students had not been out of school for the Good Friday holiday, if the tide were high at the time of the quake or if building techniques (small, cross-braced houses) were not as resilient to earthquake related effects[7].

Two local slide-generated tsunamis occurred on the Kenai Peninsula: one at Seward and another in Kachemak Bay. According to Thomas Sokolowski with the West Coast & Alaska Tsunami Warning Center, following the 1964 earthquake, a 1070-meter section of the Seward water front slid into Resurrection Bay. This produced a large seiche wave, which was followed 20 minutes later by the first main tsunami wave. The 11-13 fatalities in Seward were due to the local and the main tsunamis (see Section 6.0).

Major structural damage occurred on parts of the Kenai Peninsula as a result of the earthquake: houses collapsed, fires were triggered that destroyed industrial and port facilities, and schools were damaged beyond use (Figure 4-5). In Seward alone, the estimated cost to replace and repair facilities affected from the earthquake was $22 million[8] (in 1967 dollars).

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1 An original measurement of magnitude 8.3-8.4 calculated surface wave magnitude. A moment magnitude of 9.2 was later recalculated for this earthquake. Moment magnitude is a better measurement of energy release for large earthquakes.

2 Christensen, D. 2004. The Great Alaska Earthquake of 1964. Geophysical Institute, University of Alaska, Fairbanks.

3 Lageson, D. 1988. Tectonics of the Kenai Peninsula and Seward Region, Alaska. *In* D. Reichmuth, D. Findorff and M. Leaverton. Hazard Mitigation in the Seward, Alaska Area. Geomax, P.C., Bozeman, Montana.

4 Stanley, K.W. 1968. Effects of the Alaska Earthquake of March 27, 1964: On Shore Processes and Beach Morphology. Geological Survey Professional Paper 543-J. United States Department of the Interior, Washington, D.C.

5 A seiche is the back and forth movement of a closed body of water. Earthquakes, strong winds or a change in barometric pressure, can trigger seiches.

6 A tsunami is large ocean wave caused by sea-floor displacement associated with earthquakes, landslides and volcanic eruptions.

7 Lageson, D. 1988. Tectonics of the Kenai Peninsula and Seward Region, Alaska. *In* D. Reichmuth, D. Findorff and M. Leaverton. Hazard Mitigation in the Seward, Alaska Area. Geomax, P.C., Bozeman, Montana..

8 Lemke, R. 1967. The Alaska Earthquake, March 27, 1964: Effects on Communities. Effects of the Earthquake of March 27, 1964, at Seward, Alaska. Geological Survey Professional Paper 542-E. United States Department of the Interior, Washington, D.C.

Figure 4-5. Earthquake-triggered Tsunami Damage in Seward at the North End of Resurrection Bay Following the Good Friday Earthquake. The photo depicts a grounded ship and a destroyed Texaco chemical truck (Photo courtesy of U.S. Department of the Interior).

Earthquakes often trigger a number of secondary events. Unconsolidated material, such as those found in alluvial fans, may become unstable as seismic shaking causes ground material to lose strength and act like a liquid (called liquefaction)[1]. Earthquakes can also cause land to subside or sink, which may be associated with liquefaction. As a result of the Good Friday earthquake, Seward subsided about 3.5 feet, flooding several areas along the margin of Resurrection Bay[2]. Subsidence in the Homer Spit shoreline in Kachemak Bay ranged from two two to six feet, causing 70 percent of the spit to be inundated by the high fall tides[3]. Similarly, the southern shoreline along Turnagain Arm at the town of Hope Hope dropped four to six feet and spring high tides inundated areas five feet above the pre-quake tide levels[4]. The Seldovia area subsided with a vertical drop drop of 6 ft (1.8 m), which completely changed its waterfront.[5]

[1] Lageson, D. 1988. Tectonics of the Kenai Peninsula and Seward Region, Alaska. *In* D. Reichmuth, D. Findorff and M. Leaverton. Hazard Mitigation in the Seward, Alaska Area. Geomax, P.C., Bozeman, Montana.
[2] Ibid.
[3] Alaska Department of Fish and Game. Homer Spit Pictorial History.
[4] Foster, H.L., and T.N.V. Karlstrom. 1967. The Alaska Earthquake. March 27, 1964. Regional Effects. Ground Breakage in the Cook Inlet Area. Geological Professional Paper 543-F.
[5] Suleimani, E.N., et al., Tsunami Hazard Maps of the Homer and Seldovia Areas, Alaska. State of Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, 2005

To a large extent, ground breakage associated with the 1964 earthquake occurred on thick deposits of unconsolidated sediments and consisted of: 1) fracturing or cracking, and 2) slumping and lateral extensions of unconfined faces[1]. Within the KPB, the majority of ground breakage occurred in the northern portion of the Kenai Lowlands (west of the Kenai National Wildlife Refuge and north of Kachemak Bay). Cracks were found as large as 30 feet across and 25 feet deep[2]. For additional information about the damage to the Seward area, see the City of Seward All-Hazard Plan (Annex E) and Tsunamis & Seiches Section 6.0.

As the population and infrastructure of the Kenai Peninsula grows, so does the need to prepare for other earthquakes of this magnitude. Predicting when another large earthquake may occur is difficult. Geologic evidence of prehistoric earthquakes, combined with historic records and seismologic monitoring, suggests an average recurrence interval of 600-800 years[3]. However, it would be misleading to interpret this to mean that another high magnitude earthquake is not due on the Kenai Peninsula for another 600-800 years; indeed, one could occur anytime.

Other Earthquakes on the Kenai Peninsula

Though earthquakes are frequently occurring on the Kenai Peninsula, very little damage to facilities or private homes has been recorded. Two classrooms in Chapman School in Anchor Point had cracked walls as a result of an earthquake in 1994[4]. Fortunately, the damage was cosmetic rather than structural. In 2002 a 7.9 magnitude earthquake along the Denali fault in the Alaska Range damaged several wells in Moose Pass and Sterling. In addition, a concrete subfloor in the Cooper Landing elementary school gym developed a crack that is suspected to be a result of the earthquake[5]. While earthquake damage has been minimal in the past few decades on the Kenai Peninsula, many structures are potentially at risk should a significantly large earthquake occur near developed areas. For additional information about earthquakes affecting the KPB, see the All-Hazard Plan annexes for the incorporated cities.

4.3 Earthquake Risk Assessment

The extent of damage from an earthquake is dependent on several factors, such as the magnitude of the quake, the geology of the area, distance from the epicenter, population concentration and structure design and construction. An earthquake greater than 6.0 on the Richter scale has a possibility of triggering potentially damaging events such as floods and landslides, and greater than 7.0

1 Foster, H. and T. Karlstrom. 1967. The Alaska Earthquake, March 27, 1964: Region Effects. Ground Breakage and Associated Effects in the Cook Inlet, Alaska, Resulting from the March 27, 1964, Earthquake. Geological Survey Professional Paper 543-F. United State Department of the Interior, Washington, D.C.

2 Ibid.

3 Combellick, R. 1997. Evidence of Prehistoric Great Earthquakes in the Cook Inlet Region, Alaska. In Karl, S., N. Vaughn and T. Hyherd (editors), Guide to the Geology of the Kenai Peninsula, Alaska. Alaska Geological Society, Anchorage, Alaska.

4 Pers. comm., Rob Robson, Director, Capital Projects Division, Kenai Peninsula Borough. Soldotna, Alaska, 2004.

5 Pers. comm., Dave Tressler, Director of Maintenance, Kenai Peninsula Borough. Soldotna, Alaska, 2004.

may trigger a tsunami[1]. It can also cause industrial and technological emergencies such as fires, explosions, and hazardous material spills or a disruption of vital services such as water, sewer, power, gas and transportation. An event of this scale can also damage or disrupt emergency response facilities, resources and systems. Clearly, it is important to develop and implement mitigation strategies to offset the damage to life and property in earthquake prone areas such as south-central Alaska.

The entire KPB lies within Zone 4 (highest earthquake hazard potential) of the former Uniform Building Code[2]. Zone 4 is susceptible to earthquakes of magnitude of greater than 6.0 in which major structural damage could occur. Current building codes rarely use numbered zones to identify at-risk areas; rather, they use probabilistic ground motion to show high-probability ground accelerations for an area[3] (Figure 4-6). Both building code models for predicting earthquake vulnerability place the Kenai Peninsula in a highly susceptible area.

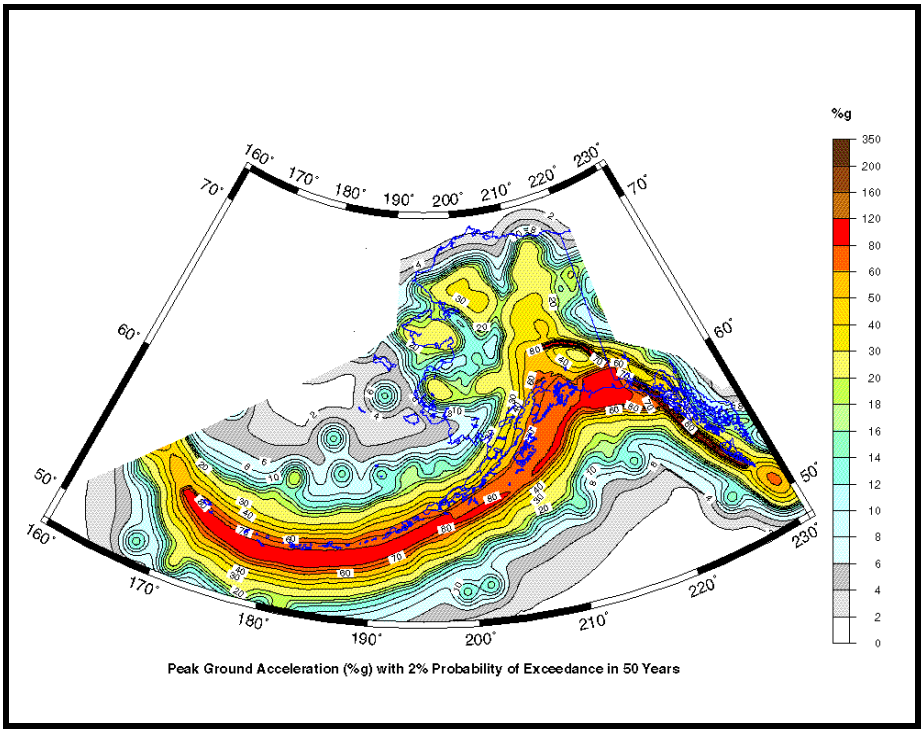

Figure 4-6. Peak Ground Acceleration (%g) with 2% Probability of Exceedance in 50 Years[4].

1 Oregon Department of Geology and Mineral Industries. 2001. Tsunami Warning Systems and Procedures: Guidance of Local Officials. Special Paper 35 prepared for the National Tsunami Hazard Mitigation Program.

2 Pers. comm., Rod Combellick, Acting Director, Alaska Division of Geological and Geophysical Surveys. Fairbanks, Alaska, 2004.

3 Maps in the current building code do not take into account additional potential hazards associated with areas that are subject to landsliding during earthquakes or are otherwise unstable due to soft, saturated ground (R. Combellick pers. comm., 2004).

4 Wesson, R., A. Frankel, C. Mueller and S. Harmsen. 1999. Probabilistic Seismic Hazard Maps of Alaska. U.S. Geological Survey, Open File Report 99-36.

4.3.1 Populations and Facilities at Risk

Because the entire Kenai Peninsula Borough is vulnerable to earthquakes, it is critical that particularly vulnerable facilities and populations be identified and prioritized so that appropriate mitigation strategies can be developed. Factors that should be considered when assessing earthquake risk include population and property distribution, location of housing and facilities relative to potential secondary hazards, building design and construction, and disaster readiness for the region. Refer to Table 1-20 in Section 1.5.4 for a summary of the tax assessed value of residential, industrial and commercial structures in KPB communities.

Major damage may be caused by secondary earthquake hazards. Landslides, floods, avalanches, tsunamis, uplift, subsidence, infrastructure failures and soil liquefaction are all powerful events. The severity of the damage is a result of several factors: soil and slope conditions, proximity to the epicenter, earthquake magnitude, and the type of earthquake[1]. Many of these earthquake-associated hazards will be addressed in detail in their own chapters in subsequent additions of this plan.

Maintaining or rapidly repairing infrastructure and communication systems is critical following a hazard event. Disruption to facilities and services such as roads, rail service, businesses, lifelines and critical services can seriously affect a community's ability to respond to a large-scale earthquake. Fires, debris buildup, death and injury are all potential emergencies that require the infrastructure and communication that may be damaged during an earthquake.

4.3.1.1 Transportation

As was clearly demonstrated in 1964, large earthquakes have the potential to disrupt important transportation infrastructure. Of the three main types on the Peninsula (land, water, air), land-based transportation is likely to be the most seriously affected by a large earthquake[2]. However, runways (for air travel) and docks and harbors (for water travel) are also at risk. There are approximately 630 miles of Borough-maintained roads and 650 miles of state (ADOT&PF) maintained roads in the Kenai Peninsula Borough[3] (see Figure 1-5).

The central region of the ADOT&PF is, in part, responsible for the maintenance and construction of the Seward Highway from Anchorage to Seward, and the Sterling Highway from the Seward "Y" to Homer. The earthquake readiness of state-owned bridges is analyzed using a three-part computer seismic retrofit

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1 Combellick, R., R. Reger and C. Nye. 1995. Geologic Hazards in and near Proposed State of Alaska Oil and Gas Lease Sale 85A (Cook Inlet). Department of Natural Resources, Division of Geological & Geophysical Surveys, Public-Data File 95-36; Oregon Natural Hazards Workgroup (ONHW). 2002. Clackamas County Natural Hazards Mitigation Plan. *Report for* Clackamas County Emergency Management *prepared by* Resource Assistance for Rural Environments/Oregon Natural Hazards Workgroup. Eugene, Oregon.

2 HDR Alaska, Inc. 2003. Kenai Peninsula Borough Transportation Plan (Update). Prepared for the Kenai Peninsula Borough, Soldotna, Alaska.

3 Ibid.; Pers. comm., Gary Davis, Road Service Areas Director, Kenai Peninsula Borough. Soldotna, Alaska, 2004.

analysis program: 1) seismic vulnerability (e.g., how earthquake prone is the region?); 2) structural vulnerability (based on bridge plans and structural factors such as length and vulnerability of piers and abutments); 3) route importance (evaluation and prioritization based on factors such as importance of the highway connection, communities served, bridge length, available detours and proximity to other important infrastructure, such a pipelines)[1]. All of the Kenai River bridges have been seismically retrofitted. The Cooper Creek Bridge is seismically vulnerable and will eventually need to be replaced[2]. The timing and priority for replacement depends in large part on which route is selected for the Cooper Landing Highway improvement project, which is pending.

Although outside of the Kenai Peninsula Borough, the bridges on the Seward Highway along Turnagain Arm at Ingram and Portage Creeks and the Placer and Twenty-mile Rivers have the potential to disrupt access to the Peninsula. These bridges are older and possibly in need of replacement or retrofitting[3]. Continuing south along the Seward Highway, the Canyon Creek bridge was recently replaced and many of the bridges between MP 18-25 (Snow River to Crown Point) are slated for upgrade (two bridges at Snow River) or replacement (Falls, Victor and Ptarmigan Creeks) in conjunction with an upcoming highway improvement project. The three highway bridges crossing the Resurrection River at the city of Seward were recently replaced and meet current seismic standards[4]. The upgrade of at least one of the Resurrection River railroad bridges is planned for the near future.

The KPB has 14 bridges in the road maintenance program with a total value of approximately $3,000,000. Seward has nine bridges, Anchor Point has four, and Kasilof and Ninilchik each have one. The three newest bridges are the Cottonwood Bridge in Anchor Point, the Brody Bridge in Ninilchik and the Tinker Lane Bridge in Seward. The other bridges are older but sturdy. In terms of maintenance priority, the Henry Creek Bridge in Anchor Point is first[5]. Other points of concern involve locations where the failure of roads or culverted stream crossings could isolate residents in remote or even urban areas.

4.3.1.2 Other Facilities

Of the 56 borough buildings, only the five most recently built are known to meet Zone 4 International Building Code requirements. Although all new structures are now mandated to meet this standard, the majority of KPB buildings were constructed before this requirement was established[6]. The necessary seismic studies to determine whether older Borough buildings meet current earthquake standards would cost $25,000 - $60,000 per building, totaling approximately $2.0 -3.0 million dollars for an examination of all KPB buildings. Although it is

1 Pers. comm., Richard Pratt, Alaska Department of Transportation and Public Facilities. Alaska, 2004.
2 Ibid.
3 Ibid.
4 Ibid.
5 Pers. comm., Gary Davis, Road Service Areas Director, Kenai Peninsula Borough. Soldotna, Alaska, 2004.
6 Ibid; Pers. comm., Rob Robson, Director, Capital Projects Division, Kenai Peninsula Borough. Soldotna, Alaska. 2004

important that vulnerable facilities in each community be identified and prioritized for seismic retrofitting, funding to complete the necessary structural upgrades would need to be obtained.

The KPB does own some state-of-the art earthquake "ready" buildings. The new Seward Middle School and the addition to Central Peninsula Hospital are recently-completed projects that are built to current earthquake standards. The new Nikiski Fire Station Number Two was also designed and constructed utilizing the current building code earthquake loading requirements (IBC 2006). The Baler Building at the Soldotna Landfill has rigid moment design and is one out of only two buildings in the state of Alaska constructed with this design[1].

Additional key resources that are vulnerable to earthquake-related damage include: wells, water and sewer lines, oil and gas pipelines, electric, gas and phone utilities, schools, prisons, airports, hospitals, police, fire and evacuation support. For a complete listing of facilities, structures and populations at risk, see Tables 1-4, 1-5, 1-6, 1-7, 1-14 and 1-15.

Because the entire KPB lies within Zone 4 (highest earthquake hazard potential)[2] of the former Uniform Building Code, all structures, facilities and populations listed above are vulnerable to earthquake related hazards. The KPB Hazard Insurance Report (in prep.) analyzed the risk to Borough-owned assets from earthquake and flood hazards into categories of *significant, insignificant or no perceived risk.* (Table 1-13). Hazard prediction tools, such as FEMA's HAZUS model and liquefaction-susceptibility mapping as well as additional active fault research[3] could help identify particularly vulnerable locations on the Peninsula.

4.3.2. Emergency Communications

During design development of the All Hazard Alert Broadcast System (AHAB), KPB coastal communities were evaluated utilizing tsunami inundation maps (among other considerations). AHAB sirens are located in Homer, Seward, Seldovia, Port Graham and Nanwalek.

The warning sirens operate on DC power and are capable of generating their own power through a wind turbine, reducing their reliance on commercially provided power distribution systems. The AHAB siren system can operate independently and activate automatically via radio frequency NWS Emergency Alert System alerts.

1 Pers. comm., Gary Davis, Road Service Areas Director, Kenai Peninsula Borough. Soldotna, Alaska, 2004; Pers. comm., Rob Robson, Director, Capital Projects Division, Kenai Peninsula Borough. Soldotna, Alaska, 2004.

2 Zone 4 it is susceptible to earthquakes of Richter magnitude 6.0 to 8.8; a level at which major structural damage is probable.

3 Pers. comm., Peter Haeussler, Geologist, U.S. Geological Survey. Anchorage, Alaska, 2004.

4.3.3. Community Preparedness

4.3.3.1 Community Emergency Response Teams

The Citizen Corps program, coordinated through the Kenai Peninsula Borough Office of Emergency Management, has implemented the Community Emergency Response Team (CERT) program. As of March 2010, approximately 160 CERT volunteers in communities throughout the Peninsula have received training in emergency preparedness and response, including light search and rescue, triage and emergency first aid, suppression of small fires and incident command systems. These teams are trained to act as first responders in an emergency until professional rescuers and responders can arrive.

4.3.3.2 TsunamiReady Program

Based on the NWS StormReady model, the TsunamiReady Program is a National Weather Service (NWS) initiative that promotes public safety and tsunami hazard preparedness. It is a collaborative program that combines the efforts of federal, state and local emergency management agencies, the public, and the NWS tsunami warning system.

In 2002, Seward and Homer became Alaska's first TsunamiReady communities (Figure 6-5). Before a community can be declared tsunami ready, it must meet five guidelines under the categories of communications and coordination, tsunami warning reception, warning dissemination, awareness and program administration[1].

4.4 Earthquake Mitigation Goals and Objectives

Although it is not possible to eliminate the threat that earthquakes pose to Borough residents, it is possible to identify ways to reduce vulnerability. Three primary goals were identified to mitigate the damaging effects of earthquakes: *protection*, *prevention* and *education.* These goals encompass both agency and individual responsibilities.

Protective earthquake measures could include such activities as safeguarding life and property by minimizing development on unstable soil and encouraging earthquake-ready building design. Increasing knowledge of areas vulnerable to landslide and liquefaction would also be beneficial for preventing loss of life and damage from earthquake activity. In addition, promoting public awareness and individual preparedness helps to increase the capacity of Borough residents to safeguard their homes and families.

Hazard mitigation planning objectives focus on saving lives and minimizing the direct and indirect costs of disaster damage. Earthquakes have the potential to affect all segments of the communities they strike and the following objectives

[1] Guidelines detailed online at www.tsunamiready.noaa.gov/guidelines.htm

were identified to further define and guide the development of mitigation strategies:

- modify potential impacts by assisting individuals and communities to prepare for, respond to, and recover from earthquake events;
- reduce susceptibility to damage and disruption by avoiding hazardous, uneconomic and unwise development in known hazard areas (such as landslide, avalanche, or liquefaction zones);
- protect the natural and beneficial values of floodplains, coastal areas and water resources; and
- reduce unnecessary economic losses and promote positive economic development by incorporating earthquake hazard mitigation into land use and development decisions.

4.5 Earthquake Mitigation Strategies and Implementation Ideas

Following an assessment of facilities and populations at risk, identifying strategies that minimize or eliminate those risks provides long-term direction for planning purposes. The regional, on-going nature of earthquake risk in the Kenai Peninsula Borough necessitates the implementation of short and long-term strategies that protect both existing and future structures and communities. The following mitigation strategies are intended to augment existing activities, such as public education, as well as identify potential new activities, such as soil-liquefaction mapping. Various stakeholders' ideas and concerns were taken into consideration in the development of the mitigation strategies for the KPB. City specific mitigation strategies may be found in the incorporated city annexes.

Strategy 1*: *Identify and prioritize studies and retrofit measures for KPB critical facilities and infrastructure that are seismically vulnerable.

The Borough owns and maintains a number of structures that provide both critical and non-critical services for area residents. While it is important to reduce earthquake vulnerability of all Borough structures, protecting critical facilities will help promote effective and efficient response when events occur. To be best prepared and able to respond to a hazard event, it is key to reduce the vulnerability of these facilities from hazard damage and keep them functionally operative.

Implementation Ideas and Action Items

- Assemble prioritized lists of Borough structures needing seismic studies to identify necessary changes or retrofits to meet current

earthquake building standards. Seismic studies should be prioritized as follows:

1. Emergency response facilities. These buildings are highest priority following a hazard as they provide fire protection, police, and emergency medical response and rescue.

2. Hospitals. Available medical treatment is critical in an emergency situation.

3. Schools. Schools provide a source of temporary shelter, and central location for the distribution and dissemination of necessary supplies and information.

4. Other Borough facilities such as support buildings and storage facilities.

- Identify potential retrofit and rehabilitation measures and activities.

  Long term: Once seismic vulnerabilities have been identified for KPB facilities, it is possible to outline steps required to retrofit them. The cost and time associated with this action will depend on the findings from the seismic study.

  Short term: Perform economical retrofit projects for schools and other critical facilities. Such projects could include:

  - securing ceiling tiles with clips
  - seismic bracing of loose equipment; bolting bookcases.

  A list of additional actions for work spaces and homes may be found on the KPB Office of Emergency Management website: www.borough.kenai.ak.us/emergency.

- Analyze benefits/costs and prioritize seismic studies and retrofit projects.

- Coordinate with other agencies and organizations to identify permit requirements, partnership interests and possible funding sources.

- Review and update project priorities on an annual basis.

Potential Participants: Capital Projects Division (KPB), Maintenance Department (KPB), Office of Emergency Management (KPB), Solid Waste Department (KPB) Risk Management (KPB), School District (KPB), Hospitals (KPB), Incorporated Cities within the KPB.

Time Frame: For seismic study: 18 weeks per building - includes plan development and approval
For retrofit activities and projects: Ongoing (1-5 years as funding permits)

Estimated Cost: For seismic study: $25,000-60,000 per building

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Strategy 2*: *Encourage the reduction of non-structural and structural earthquake hazards in homes, businesses and government offices.

Implementation Ideas and Action Items

- Augment existing homeowner earthquake safety programs. This should include distribution of information on safe building design and retrofitting techniques.
- Explore partnerships to provide retrofitting classes for homeowners, renters, building professionals and contractors.
- Target development located in potential fault zones or in unstable soils for intensive education and retrofitting resources.

Potential Participants: Office of Emergency Management (KPB), Capital Projects Division (KPB), Local Emergency Planning Committee, Community Schools Program (KPB School District), AK State Division of Homeland Security and Emergency Management, FEMA, Local Realtors, Local Construction Companies, Incorporated Cities within the KPB

Time Frame: Ongoing (1-5 years as funding permits)

Strategy 3*: *Encourage KPB residents to purchase earthquake hazard insurance.

A very low number of Kenai Peninsula Borough residents have earthquake insurance[1]. This is due in part to the high cost of the insurance (roughly $300-$700 dollars a year). However, some combined hazard insurance plans are available, which would group earthquake, flood and landslide hazards together and may make the insurance more affordable.

Implementation Idea and Action Item

[1] Pers. comm., Sherri Jackson, Insurance Agent, Acordia of Alaska. Soldotna, Alaska, 2004.

- Coordinate with insurance companies and organizations such as the Alaska Division of Insurance to produce and distribute earthquake insurance information.

Potential Participants: Office of Emergency Management (KPB) Capital Projects Division (KPB), Local Insurance Companies
Time Frame: Ongoing (1-5 years as funding and time permits)

Strategy 4: Identify oil and gas producing facilities that pose a risk to the Kenai Peninsula Borough due to their proximity to active faults.

Although a few active faults, such as the Castle Mountain Fault and Bruin Bay Fault (Figure 4-3), have been identified, the extent and subsurface trends of many associated faults are speculative[1] and the determination of truly active structures in the Cook Inlet Region remains difficult. As some of the oil and gas infrastructure appears to be associated with active shallow faults[2], potential earthquake events at or near the location of onshore and offshore oil and gas facilities pose a significant risk for the Kenai Peninsula Borough.

Presently, most of the existing seismic data is closely-held proprietary property of oil and gas companies and is not generally available to government agencies. According to Peter Haeussler, geologist with the U.S. Geological Survey, the seismic reflection data held by the oil and gas companies would be extremely useful for identifying the best locations for boreholes to reveal the age of folded subsurface layers. With this information, seismic structure activity, deformation rates, activity occurrence intervals and potential quake magnitude could be determined. Unfortunately, the cost of commissioning new seismic surveys for the region is prohibitive to governmental agencies and organizations.

Implementation Ideas and Action Items

- Contact the oil and gas companies to encourage cooperation and data sharing with state and federal geoscientists to enable them to better predict areas vulnerable to seismic damage. Prioritize data acquisition for areas with larger oil and gas producing structures in the Cook Inlet region.

[1] Combellick, R., R. Reger and C. Nye. 1995. Geologic Hazards in and near Proposed State of Alaska Oil and Gas Lease Sale 85A (Cook Inlet). Department of Natural Resources, Division of Geological & Geophysical Surveys, Public-Data File 95-36.

[2] Haeussler, P., R. Bruhn, and T. Pratt, 2000. Potential seismic hazards and tectonics of the upper Cook Inlet basin, Alaska, based on analysis of Pliocene and younger deformation. GSA Bulletin 112(9): 1414-1429.

- After this information is obtained, cooperate with researchers at the U.S. Geological Survey and the Alaska Department of Geophysical and Geological Survey to develop projects that determine fault activity and generate earthquake risk information. This data could then be used in mitigation planning for high-risk areas.

Potential Participants: Office of Emergency Management (KPB), Alaska Division of Geological & Geophysical Surveys (DNR), U.S. Geological Survey, Oil and Gas Companies (ConocoPhillips, Cook Inlet Pipeline, Forest Oil, Pelican Hill, XTO Energy, Marathon Oil Company, Tesoro Alaska, Unocal, Aurora Gas, British Petroleum), Incorporated Cities within the KPB

Time Frame: Ongoing (longer term 3-5 years as funding and time permits)

Strategy 5: Perform earthquake hazard mapping for the Kenai Peninsula Borough and improve technical analysis of earthquake hazards.

The Kenai Peninsula Borough presently has little site-specific information to assist with identifying areas at particularly high risk to earthquakes. The Federal Emergency Management Agency (FEMA) has produced a model (HAZUS-MH) that has the capacity to integrate national, regional and local hazard information to estimate potential loss from earthquakes (as well as floods and hurricanes). This model generates hazard maps, compiles potential damage and economic loss information for buildings and infrastructure and predicts the effects of different earthquake scenarios on populations.

Although time and resources were not available to accomplish the task, the possibility of conducting HAZUS-MH modeling for this mitigation plan was explored. Rod Combellick[1] with the Alaska Division of Geological and Geophysical Surveys recommended assembling a group of knowledgeable geoscientists to develop a credible and scientifically defensible earthquake event to run through the model. In addition, the model requires an up-to-date structure inventory and recent population census data.

It is important to note that a Level I HAZUS run does not incorporate variations in soil and rock types, and therefore will not identify areas vulnerable to landslides or liquefaction. Unfortunately, these earthquake associated hazards often cause the most damage[2].

[1] Rod Combellick was one of a group of scientists involved in a HAZUS analysis sponsored by the Army Corps of Engineers in the Anchorage area and has had two levels of training in this program.

[2] Pers. comm., Rod Combellick, Acting Director, Alaska Division of Geological and Geophysical Surveys. Fairbanks, Alaska, 2004.

Available seismic maps for the Kenai Peninsula indicate a high probability of ground acceleration for the region, indicating possible change in ground velocity during an earthquake. Increased ground velocity (or ground speed) means amplified ground movement and therefore a greater possibility of damage to above ground structures. However, the maps do not factor in variations in local geologic conditions, which would help identify areas particularly susceptible to landslides, liquefaction and other severe earthquake damage. Liquefaction-susceptibility maps would address these conditions and provide more site-specific information.

Implementation Ideas and Action Items

- Conduct HAZUS-MH modeling for the Borough.

- Develop liquefaction-susceptibility maps for the urban and industrial areas at the scale of 1:25,000. It is possible to derive liquefaction susceptibility from existing geologic maps (available for much of the Borough); however, this effort requires particular expertise.

Potential Participants: Office of Emergency Management (KPB), Alaska Division of Geological & Geophysical Surveys (DNR), U.S. Geological Survey, GIS Department (KPB), Incorporated Cities within the KPB
Time Frame: HAZUS modeling (shorter term 1-2 years)
Liquefaction-susceptibility maps (longer term 2-4 years)
Estimated Cost: Liquefaction-susceptibility maps ($300,000 per year)

Strategy 6*: *Augment KPB communications and facility support.

Implementation Ideas and Action Items

- Perform a Peninsula-wide assessment of communication system vulnerability. This information could be obtained through HAZUS-MH modeling.

- Promote interagency scenario planning to anticipate unique seasonal problems (i.e., transportation or long-term power outages during winter or the availability of useful construction equipment during off seasons[1]).

[1] Montgomery & Assoc. 2000. Catastrophic Earthquake Damage Workshop. Review Draft, December 2000. Produced for the U.S. Army Corps of Engineers, Alaska District, Anchorage, Alaska.

Potential Participants: Office of Emergency Management (KPB), Capital Projects Division (KPB), Road Maintenance (KPB), Alaska Department of Transportation and Public Facilities, Utility Companies (ACS, Chugach Electric Association Inc., Enstar Natural Gas, GCI, HEA)

Time Frame: Ongoing (shorter term 1-3 years; performed in conjunction with HAZUS modeling, Strategy 5)

Strategy 7: Conduct mock emergency exercises to identify response vulnerabilities.

Implementation Ideas and Action Items

- Conduct simulated exercises to determine vulnerabilities in emergency response and facilities. This will help identify areas that need further attention, resources and training.

Potential Participants: Office of Emergency Management (KPB), Local Emergency Planning Committee, Incorporated Cities within the KPB

Time Frame: Ongoing (longer term 2-4 years)

Strategy 8: Minimize damage to residential structures in the unincorporated area of the Kenai Peninsula Borough.

Currently, there are no enforced residential building codes within the unincorporated areas of the Kenai Peninsula Borough for structures smaller than a four-plex. The State Fire Marshall's Office in Anchorage permits residential structures that are equal to or larger than a four-plex, as well as commercial structures (regardless of size). Permitting regulations currently follow the 2006 edition of the International Building Code. The Fire Marshall's Office expects to adopt the 2009 edition in the early fall of 2010.

Building code certification is a mechanism employed by many communities to insure structures are built to a reasonably safe standard. Homebuyers can be more confident in their investment if the home meets international building standards. It may also increase the value of a home, protect against damage and lawsuits, and provide a measure of safety to residents.

Although the Borough does not currently enforce building codes, homeowners who wish to obtain financing from the Alaska Housing Finance Corporation (AHFC), must present verification that demonstrates structures built after July 1,1992 meet the Uniform Building Code and International Residential Code standard. Currently there are twelve private inspectors

listed with AHFC with International Code Council (ICC) certification on the Kenai Peninsula who provide this service[1]. Implementation of building codes would require this structural review process Borough-wide.

Building codes are usually administered through a permit application process. There are two common approaches to determine the permitting cost for a structure: 1) based on the total square footage or 2) based on a estimated home value. In the City of Kenai, permit fees are calculated using 28 cents per square foot for a house and 14 cents per square foot for a garage. In addition to the permit fee, there is a plan review fee that is typically about 50% of the permit fee[2].

The City of Kenai's program information was used to estimate the cost of implementing a residential building permit program for the Borough. Roughly 4,178 new structures were built outside of city limits in the KPB between 1998 and May 2004[3].

The total square footage of new structures was estimated at 6,118,297, which was multiplied by 28 cents per square foot to arrive at an estimated $1,713,123 in funds accrued from permitting fees. By adding an estimated $856,562 in plan review fees (50% of permit fees), $2,569,685 in possible revenue may be generated.

The City of Kenai, which has one full time permitter and one support staff, reviews an average of 100 permits a year[4]. If there are an estimated 700new home starts each year in the Borough, then roughly seven full time permitters and at least one support staff may be required to implement plan review and issue building permits. For the City of Kenai, the permitting fees roughly cover the cost of running the program[5]. The same should be possible for the Borough.

Implementation Ideas and Action Items

- Implement building codes for residential structures (smaller than 4-plexes) outside of city limits.

Potential Participants: KPB, Incorporated Cities within the KPB, Local Insurance Companies
Time Frame: Ongoing (longer term 3-5 + years

1 Alaska Housing Finance Corporation (AHFC). 2010. ICBO certified inspectors.
2 Pers. Communication, Robert Springer, City of Kenai Building Official.
3 Figure derived from KPB Assessing Department data. Structures coded as 3 or 4 family residences (R3) are included. Because some of these structures may be 4-plexes, these numbers may be slightly high.
4 Pers. Comm., Nancy Carver, City of Kenai Building Official. Kenai, Alaska, February 2010
5 Pers. Comm., Robert Springer, City of Kenai Building Offical. Kenai, Alaska, July 2004.

4.6 Earthquake Resource Directory

Local Resources

Kenai Peninsula Borough (KPB)

Office of Emergency Management (OEM)

OEM was established to coordinate disaster management response between the Kenai Peninsula Borough, the State of Alaska, FEMA, other municipalities, as well as other response and recovery organizations. OEM has the primary responsibility for overseeing disaster management programs and activities, including mitigation, planning, response and public education.

Contact: Office of Emergency Management
Address: 253 Wilson Lane, Soldotna, AK 99669
Phone: (907) 262-4910
Website: www.borough.kenai.ak.us/emergency

State Resources

Alaska Earthquake Information Center

AEIC serves as an integration center for all seismic networks within Alaska and archives and processes data from the Alaska Tsunami Warning Center in Palmer, Alaska and the Alaska Volcano Observatory in Fairbanks and Anchorage. The center operates with a real-time data acquisition system at the Geophysical Institute.

Contact: Geophysical Institute, University of Alaska Fairbanks
Address: 903 Koyukuk Drive, P.O. Box 757320, Fairbanks, Alaska 99775-7320
Phone: (907) 474-7558
Website: www.giseis.alaska.edu/

State of Alaska, Department of Natural Resources

Division of Geological and Geophysical Surveys (DGGS)

DGGS collects, analyzes, interprets, and publishes data on Alaska's geologic resources for use in state land management as well as private sector development and exploration. DGGS is divided into five sections that address different aspects of geology, they are: minerals, energy, engineering geology, geological communications and the geological materials center.

Contact: DGGS Information
Address: 3354 College Road, Fairbanks, AK 99709
Phone: (907) 451-5020
Website: www.dggs.dnr.state.ak.us/index.html#

State of Alaska, Division of Homeland Security and Emergency Management

This agency in part conducts hazard preparedness and mitigation workshops. They also coordinate the State of Alaska's All-Hazard Mitigation Plan. Their community response program works with communities during a crisis as well in recovery and planning phases.

Contact: AK Division of Homeland Security and Emergency Management
Address: P.O. Box 5750, Fort Richardson, AK 99505-5750
Phone: (907) 428-7000 OR (800) 478-2337
Website: www.ak-prepared.com/

Federal Resources

US Geological Survey (USGS)

Earthquake Hazards Program

The USGS maintains an active earthquake hazards program website that catalogues information on worldwide earthquake activity, the mitigation of earthquake related damage and earthquake science research. They also have seismic hazard maps for the United States.

Contact: USGS/Earthquake Hazards Program
Address: 4210 University Dr., Suite 201, Anchorage, AK 99508-4626
Phone: (907) 786-7447
Website: earthquake.usgs.gov

Building Seismic Safety Council (BSSC)

The Building Seismic Safety Council develops and promotes structural earthquake risk mitigation regulatory provisions for the nation. They manage complex regulatory, technical, social, and economic issues involved in developing and disseminating building earthquake mitigation regulatory requirements.

Contact: Building Seismic Safety Council; National Institute of Building Sciences
Address: 1090 Vermont Avenue, N.W., Suite 700, Washington, D.C. 20005
Phone: (202) 289-7800
Website: www.nibs.org/index.php/bssc/

Additional Resources

GSC Pacific-Sidney; Pacific Geoscience Centre (PGC)

Research conducted at the PGC involves the geology and geophysics within the region of Western Canada known as the "Canadian Cordillera", as well as along the continental margin that is Canada's West Coast. Specific research foci include earthquake seismology, geodynamics, Cordilleran and Continental margin tectonics and marine geoscience.

Contact: GSC Pacific-Sidney; Pacific Geoscience Centre
Address: 9860 West Saanich Rd.; North Saanich, BC, Canada V8L 3S1
Phone: (250) 363-6500
Website: gsc.nrcan.gc.ca/org/sidney/index_e.php

Natural Hazards Center (NHC)

The NHC is an international center cataloging and disseminating information about the social science and policy aspects of disasters, including earthquakes. The mission encompasses hazard preparedness, response and mitigation. A primary goal of the NHC is to foster communication among researchers, individuals, organizations and agencies concerned with minimizing damage from hazards. They maintain an active searchable literature database, publish papers and reports and host an annual hazard workshop.

Contact: NHC
Address: University of Colorado, 482 UCB, Boulder, CO 80309-0482
Phone: (303) 492-6818
Website: www.colorado.edu/hazards/

Benfield Hazard Research Centre (BHRC)

The Benfield Hazard Research Centre, based in London, UK gathers and transmits information on natural hazard and risk research among the academic, government and various international agencies. They maintain links to much current hazard research, provide education and training and catalogue an extensive list of publications.

Contact: BHRC
Address: Aon Benfield UCL Hazard Research Centre
Department of Earth Sciences, University College London
136 Gower Street (Lewis Building)
London, WC1E 6BT, UK
Phone: +44 (0)20 7679 3449/3637
Website: www.abuhrc.org/Pages/index.aspx

Applied Technology Council

Produces technical documents to inform those interested in design details to reduce structural and content damage due to earthquakes.

Contact: Applied Technology Council
Address: 201 Redwood Shores Parkway, Suite 240, Redwood City, CA 94065
Phone: (650) 595-1542
Website: www.atcouncil.org

Earthquake Engineering Research Institute (EERI)

With an international focus, this agency strives to produce the most current technical information on earthquake hazard mitigation and response. It is a technical, non-profit agency with a membership comprised of engineers, researchers, planners and architects.

Contact: EERI
Address: 499 14th St., Suite 320, Oakland, CA 94612-1934
Phone: (510) 451-0905
Website: www.eeri.org

The Global Earthquake Response Center

This web page is a source for information and supplies about earthquake preparedness. Links to many online services (e.g., insurance information, engineering resources and emergency supply kits) are provided. No contact information is provided.

Website: www.earthquake.com

American Red Cross

The American Red Cross is a volunteer humanitarian organization, which provides relief to disaster victims and helps people prevent, prepare for, and respond to emergencies.

Contact: American Red Cross
Address: 235 E 8th Avenue, Anchorage, AK 99501
Phone: (907) 646--5401
Website: alaska.redcross.org

Publications

Bolton, P., S. Heikkala, M. Greene, P. May. 1986. Land Use Planning for Earthquake Hazard Mitigation: A Handbook for Planners. University of Colorado, Institute of Behavioral Science, Natural Hazards Research and Applications Information Center, Special Publication No. 14. Boulder, Colorado.

Combellick, R.A. 1985. Geologic-hazards mitigation in Alaska: A review of federal, state, and local policies. Alaska Division of Geological and Geophysical Surveys. Special Report 35.

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5.0 Weather

5.1 Why Focus on Mitigation for Weather Events?

According to the National Weather Service StormReady website[1], 90% of federally declared disasters are weather related, leading to approximately 500 deaths per year and nearly $14 billion in damage. Severe weather events often impact large geographic areas and pose a significant threat to life and property by creating conditions that disrupt utilities, transportation and telecommunication systems. It is critical that communities have appropriate warning of severe weather events and have undertaken realistic mitigation planning. Since 2000, the KPB has been included in four weather-related presidential disaster declarations (DR 1316, DR 1445, DR 1461 and 1669)[2].

The KPB regularly experiences winter storms, high winds, seasonal heavy rainfall, coastal storm and storm surge events. Severe winter weather is often accompanied by high wind, freezing rain, icing conditions, heavy snowfall and extended periods of cold temperatures. Winter storms can make driving and walking extremely hazardous, damage structures and utilities, and result in substantial repair and snow removal costs.

Prolonged extreme cold (-20 to -50 degrees Fahrenheit) coupled with little or no snow cover may lower the ground frost level, rupture underground water and sewer utilities, congeal fuel in storage tanks and supply lines and interfere with vehicle and equipment operation. Extended periods of severe cold can form ice in Cook Inlet, which when disrupted by the tides creates hazards for ship traffic. It also increases the likelihood of ice jams and associated flooding along rivers and streams.

5.2 Types of Weather Events

Weather hazards on the Kenai Peninsula can be broken into a number of categories including:

- winter storm
- heavy snow
- extreme cold
- ice storms
- high winds
- thunderstorms and lightning
- coastal storm
- storm surge

[1] www.stormready.noaa.gov.

[2] DR1316 – 2000 Snow storms and avalanches; DR1445 – Oct/Nov 2002 Floods; DR1461 – 2003 Wind Storm; DR 1669 - 2006 Severe Flooding.

It is important to note that weather hazards can occur in combination or in rapid succession, which can significantly increase the potential for damage.

Winter Storms

Winter storms originate as mid-latitude depressions or cyclonic weather systems. High winds, heavy snow, and cold temperatures usually accompany them. To develop, they require:

- *cold air* - subfreezing temperatures in the clouds and/or near the ground to make snow and/or ice;
- *moisture* - the air must contain moisture in order to form clouds and precipitation; and
- *lift* - the mechanism that raises moist air to form clouds and cause precipitation. Lift may be provided by any or all of the following: 1) the flow of air up a mountainside, 2) fronts where warm air meets cold air and rises over the dome of cold air, and 3) upper-level low pressure troughs.

Heavy Snow

Heavy snow, generally more than 12 inches of accumulation in less than 24 hours, can immobilize a community by compromising or halting the use of airports and major roadways, which in turn stops the flow of supplies and disrupts emergency and medical services. Accumulations of snow can collapse roofs, fell trees and power lines, damage light aircraft and sink small boats. In the mountains, avalanche risk increases with fast large accumulations of snow. A quick thaw after a heavy snow can cause substantial flooding, especially along small streams and in urban areas. The cost of snow removal, damage repair and the loss of business can have serious economic impact on cities and towns.

Injuries and deaths related to heavy snow usually occur as a result of vehicle accidents. Casualties also occur due to overexertion while clearing snow and hypothermia caused by overexposure to the cold weather.

During the winter, Alaska's weather is greatly influenced by large areas of high pressure that can persist for weeks at a time over Siberia, interior Alaska and northwestern Canada. While a well-developed mass of cold air dominates the interior, storms crossing the North Pacific often move into the Gulf of Alaska depositing large amounts of precipitation over the southern coastal region, affecting the KPB.

Extreme Cold

What is considered an excessively cold temperature varies according to the normal climate of a region. In areas unaccustomed to winter weather, near freezing temperatures may be considered "extreme cold." In the Cook Inlet region of Alaska, extreme cold usually involves temperatures below -40 degrees Fahrenheit (F). Excessive cold may accompany winter storms, be left in their wake, or occur without storm activity.

Low temperatures and ice fog conditions can ground aircraft, shutting down commuter flights and airfreight shipments. Extended periods of -20 to -40 degrees F causes ice in Cook Inlet, which can close or disrupt shipping in the upper inlet. Extended cold also increases the likelihood of riverine ice jams and associated flooding. The lowering of ground surface temperatures affects frost levels and break underground utility lines.

Frostbite occurs when tissue exposed to extreme cold freezes. Frostbite causes a loss of feeling and exposed skin turns white or pale in color. As frostbite progresses it can lead to serious infections or the loss of extremities.

Hypothermia occurs when the internal body temperature drops below 98.6º F. Internal temperatures below 95ºF can be life threatening. Hypothermia can occur from a short period of exposure to extreme cold or prolonged exposure to temperatures above freezing.

The greatest danger from extreme cold is to people. Prolonged exposure to the cold can cause frostbite or hypothermia and become life threatening, particularly for the very young and elderly. The risk of hypothermia due to exposure greatly increases during episodes of extreme cold, and carbon monoxide poisoning is possible as people use supplemental heating devices.

Ice Storms

Ice storms are instances when damaging accumulations of ice develop during freezing rain (rain that becomes super-cooled and freezes on impact with cold surfaces). Freezing rain most commonly occurs in a narrow band within a winter storm that is also producing heavy amounts of snow and sleet in other locations. Ice storms are among the most devastating of winter weather phenomena and often cause airplane and automobile accidents, power outages and personal injury.

Freezing rain develops as falling snow encounters a layer of warm air in the atmosphere deep enough for the snow to completely melt and become rain. As the rain continues to fall, it passes through a thin layer of cold air just above the earth's surface and cools to a temperature below freezing. The drops themselves do not freeze, but rather they become super-cooled. When these super-cooled drops strike surfaces such as frozen ground, power lines and tree branches, they instantly freeze. Within the state, atmospheric conditions that can lead to ice

storms most frequently occur in southwestern Alaska, along the Alaska Peninsula and around Cook Inlet, affecting the KPB.

High Winds

Winds in excess of 60 mph occur frequently over coastal areas along the Gulf of Alaska due to coastal storms. High winds can also combine with loose snow to produce blinding blizzard conditions and dangerous wind chill temperatures. Winds can reach hurricane force and have the potential to seriously damage port facilities, the fishing industry and community infrastructure (especially above ground utility lines).

In mountainous areas, down-slope windstorms created by temperature and pressure differences across the terrain can produce winds in excess of 100 mph. These windstorms can be particularly damaging as they are gusty in character and may seem to come from several directions.

Localized downdrafts, downbursts and microbursts, are also important hazards in Alaska. Downbursts and microbursts can be generated by thunderstorms. Downburst winds are strong concentrated straight-line winds created by falling rain and sinking air that can reach speeds of 125 mph. The combination induces strong wind downdrafts due to aerodynamic drag forces or evaporation processes. Microburst winds are more concentrated than downbursts and can reach speeds up to 150 mph. They can last five to seven minutes and cause significant damage. Because of wind shear and detection difficulties, they can create a severe hazard for aircraft landings and departures.

Thunderstorms & Lightning

Thunderstorms are caused by the turbulence and atmospheric imbalance that arise when rising warm air, lift, and moisture combine. The result is unstable weather that includes lightning and heavy rainfall, which can quickly intensify into severe damaging hail, high winds, and flash flooding. A thunderstorm is considered severe if winds reach or exceed 58 mph, a tornado develops, or it drops surface hail at least 0.75 inches in diameter.

Lightning. Image courtesy of NOAA Photo Library, NOAA Central Library; OAR/ERL/National Severe Storms Laboratory (NSSL)

Thunderstorms affect relatively small areas. The average thunderstorm is about 15 miles in diameter and lasts less than 30 minutes in any given location. Lightning exists in all thunderstorms. It is caused by a buildup of charged ions within the thundercloud. When lightning connects with a grounded object, electricity is released which can be harmful to humans and can start fires. Lightning induced wildfires are fairly rare in the Borough, although they do occur.

Between 1980 and 2002, two percent or 27 of the 1,454 recorded wildfire ignitions were caused by lightning[1].

Coastal Storms

From fall through spring, low pressure cyclones develop in the Bering Sea and Gulf of Alaska or are brought to the region by wind systems in the upper atmosphere that steer storms in the north Pacific Ocean toward Alaska. When these storms impact the shoreline, they often bring wide swathes of high winds and occasionally cause coastal flooding and erosion. The intensity, location and local topography influence storm impacts.

Along Cook Inlet, shoreline erosion occurs from a number of natural processes, including tides, wind, storms, ice, and the freezing and thawing of bluff soils and ground water seeps. With increased development of waterfront properties, coastal erosion is of high concern to KPB coastal communities.

In addition to accelerating coastal erosion, the north shore bench above Kachemak Bay is susceptible to slope slippage and landslides when seasonal heavy rains saturate and liquefy unstable soil and clay layers. The heavy rain in 2002 resulted in slope failures and debris slides in numerous places in Homer and along East End Road. The risk of slope failures has become more serious as vegetation removal, road construction and development has increased along the steep north shore bench.

The Seward area is also susceptible to damage from coastal storms. A December 2009 weather event paired an extreme 12.6 foot high tide with a heavy winter storm Significant damage to infrastructure resulted in a local and state disaster declaration.

Homer and Halibut Cove, on Kachemak Bay, also received some damage as a result of the December 2009 storm event.

Storm Surge

Storm surges, or coastal floods, occur when the sea is driven inland above the high-tide level onto normally dry land. Often, heavy surf conditions driven by high winds accompany a storm surge adding to the destructive force of the flooding waters. The conditions that cause coastal floods may also cause significant shoreline erosion as the floodwaters undercut roads and other structures.

The meteorological parameters conducive to coastal flooding include low atmospheric pressure, strong winds (blowing directly onshore or along the shore

[1] Figure A6; Annex H – Interagency All Lands/All Hands Action Plan, 9-5-04 Final Draft.

with the shoreline to the right of the direction of the flow), and winds maintained from roughly the same direction over a long distance across the open ocean.

Communities that are situated on low-lying coastal lands with gradually sloping bathymetry near the shore and exposure to strong winds with a long fetch over the water are particularly susceptible to coastal flooding. The five-mile-long Homer Spit has a moderate exposure to coastal flooding due to the consistent effects of erosion and the extraordinary tidal range in the region. In November of 2002, a storm surge that followed the heavy rains in October and November resulted in flooding on the Homer Spit. The English Bay airstrip in Nanwalek is also vulnerable to coastal storms. Situated on a gravel spit at the entrance to the bay, it is subject to the dynamics of the beach on the northern boundary and the lagoon on the southern boundary. The runway was significantly damaged by wind driven tides in November of 2003.

5.3 Historical Severe Weather Events

Borough history details significant damage to life and property due to such severe weather events as heavy snowfall, ice storms, avalanches and high winds. As a direct result of severe weather events within the Borough, highway closures, power outages, structural damage and loss of life have occurred. Some weather occurrences may both produce benefits and create problems. For example, heavy snowfall may replenish reservoir waters above the Cooper Lake Hydroelectric Facility, while simultaneously increasing avalanche risk, snow load damage and flooding concerns for area residents. Though it may not be possible to alter the occurrence of extreme weather events on the Kenai Peninsula, it is important (both economically and socially) to mitigate their potential negative effects. Additional information about flooding in the KPB (often caused by extreme weather occurrences) may be found in Section 2.0: Floods and Section 7.0: Tsunamis.

1951 – Seward Area Flooding

In the Resurrection River in the eastern Kenai Peninsula, floodwaters rose unexpectedly at night from heavy snowmelt in the mountains due to warm weather. As a result, surface water run-off polluted local wells.

1986 – Seward Area Flooding

A severe storm in Seward occurred between October 10th and12th and deposited 15 inches of rain in 24 hours across large areas of the Resurrection River and Salmon Creek watersheds. Flooding was widespread and catastrophic as torrential waters rushed down steep gradient mountain canyons. Borough-wide damages to roads, bridges, and other public facilities were estimated at around $2 million.

1989 – Extreme Cold

The cold snap in January 1989 affected a large geographic area of the state of Alaska, including the Kenai Peninsula. Extreme, prolonged low temperatures caused pipes to freeze, obstructed motor operations and damaged sewer and water utilities. Homer experienced five days of new record low temperatures including the lowest temperature (-24 degrees F) for the area[1].

1999-2000 - Winter Storms and Avalanches

A series of severe winter storms struck the Kenai Peninsula Borough between December 21, 1999 and February 23, 2000, triggering avalanches and flooding in southcentral Alaska. Power lines were downed by high winds causing outages in schools and homes. A series of avalanches struck the Peninsula during these months. The Seward Highway was closed from Jan. 30 – Feb. 4, 2000[2] as debris from avalanches was removed and the continued threat of additional avalanches loomed. Road closures directly affected the communities of Hope, Sunrise, Moose Pass, Crown Point and Seward, as well as temporarily interrupting transportation and supply services to the rest of the Peninsula. Avalanche locations along the Seward Highway included MP 97.8, MP 62.5, MP 50 and 49, MP 45.5, MP 44, MP 23.7, MP 20.5 and between MP 18 and 18.5[3] (Figures 5-1 and 5-2). A slide also occurred on the Sterling Highway just west of Quartz Creek Road. The Alaska Department of Transportation and Public Facilities (ADOT&PF) spent a considerable amount of money on mitigation activities, such as controlled avalanche activation requiring the use of explosives and extended helicopter time. There was also a large ADOT&PF work force focused on snow and debris removal and guardrail repair.

A generator and fuel was delivered to the community of Hope, which was without power for an extended period of time. Over 2,000 homes in Seward, Moose Pass, and Cooper Landing also lost power for several days due to the storm[4]. The Alaska Railroad suspended Peninsula service for about one week and accrued approximately $1 million dollars in unrecoverable lost revenue[5]. A heavy equipment operator was swept into Cook Inlet and killed by a second avalanche while clearing debris from an earlier slide along Turnagain Arm[6].

The Borough mayor declared the avalanche damage a disaster on Feb. 3, 2000; the State of Alaska followed suit on Feb. 4, 2000 and a presidential disaster declaration was issued on February 17, 2000[7] (DR 1316). The Municipality of

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1 Wendler, G. 1989. Alaska's Cold Spell of January, 1989. Alaska Science Forum, Article No. 912.
2 Ibid.
3 Pers. comm. Terry Onslow, Safety and Emergency Supply Specialist, Alaska Department of Transportation and Public Facilities (email), 9/3/04.
4 Clark, M. 2000. Disaster Emergency Declared on Peninsula. Peninsula Clarion, Feb. 4, 2000.
5 Pers. comm. Alaska Railroad Corporation representative. 9/2/04.
6 Since 1995, 9 people have been killed on the Kenai Peninsula due to avalanches. (www.avalanche.org/accidents.php)
7 Kenai Peninsula Borough (KPB). 2000. Kenai Peninsula Borough Ordinance 2000-26. Soldotna, Alaska.

Anchorage, the Kenai Peninsula Borough, the Matanuska-Susitna Borough and the Valdez-Cordova Census Area subsequently received disaster funding to help pay for snow and debris removal, emergency services and repair of public facilities damaged by the weather and avalanche events.

The Borough incurred in excess of $618,500 in storm damage to facilities and structures[1]. The incorporated cities within the Borough together experienced over $590,000 in damage. Combined with damages incurred by Providence Hospital in Seward, Chugach Electric Association, Homer Electric Association and the Spring Creek Correctional Facility, there was over 3.3 million dollars of damage to public facilities on the Kenai Peninsula[2].

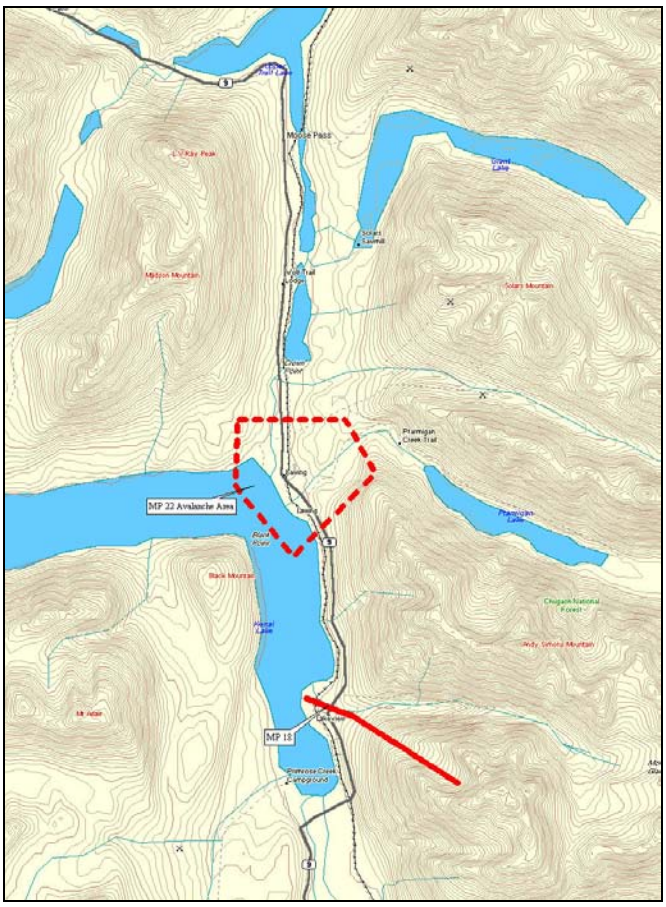

Figure 5-1. Location of Avalanche Between Mileposts 22 and 23 of the Seward Highway Resulting from the 2000 Winter Storm.

[1] Pers. comm. Cowles, W. ADHS&EM, FEMA report from computerized tracking system. 09/02/04.This is the portion of damages that FEMA and the State of Alaska agreed to cover.

[2] Ibid.

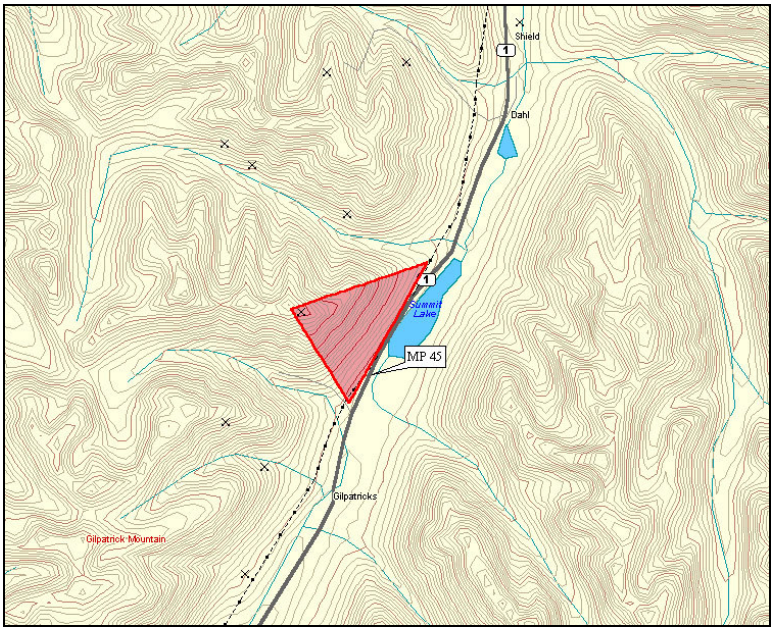

Figure 5-2. Location of Avalanche at Milepost 45 of the Seward Highway Resulting from the 2000 Winter Storm.

2001 - Christmas Storm

A National Weather Service winter storm warning was issued on December 25, 2001 covering the area from the Kenai Mountains east to Prince William Sound. Heavy snow and strong winds hit the entire region. Homer Electric Association reported power outages throughout the Peninsula with a total of $866,294 in emergency costs and $367,711 in permanent rebuild costs[1].

2002 - October/November Flooding

In October and November of 2002, unseasonably warm temperatures coupled with heavy rain contributed to flooding and coastal storm surge on the Kenai Peninsula that resulted in a presidential disaster declaration (DR 1445). For more information on the location and extent of flood damage see Flood Section 2.10.2 and Table 2.2.

Unusually warm temperatures, high winds and heavy rain lingered across the Kenai Peninsula from late September through the end of November 2002. The storm damaged areas from Portage (to the north), Cordova (to the east), Chignik (on the Alaskan Peninsula to the west) to Kodiak Island (to the south). The heaviest rains and most severe flooding occurred on the southwestern Kenai Peninsula between October 22-24 and November 23[2]. The National Weather

[1] Pers. Comm., J. Matthews, Homer Electric Association, Inc. Homer, Alaska. March 2004.
[2] Eash, J.D., Rickman, R.L., March 2004. Floods on the Kenai Peninsula, Alaska, October and November 2002. USGS Fact Sheet 2004-3023.

Service Doppler radar system was inoperable for a number of hours on October 20, 23, and 24. As a result, crucial information about the intensity of the storm over the Caribou Hills region was unrecorded and flooding that began on the Seward side of the Peninsula struck southwestern Peninsula streams with little warning.

The 2002 floods directly affected 10 communities and damage to public facilities was estimated at over $24.5 million dollars[1]. Total damage included: 62 sites on the Peninsula highway system ($20.5 million), State Park facilities ($781,000), Borough roads and bridges ($1.2 million) and power line and underground distribution line damage ($425,000[2]). Reported damage to private property totaled more than $1,225,000[3]. In the city of Homer, flooding was followed by a November storm surge, which partially inundated the Homer Spit[4].

2002 - Winter Snow Storm

Record heavy snow occurred just north of the Kenai Peninsula in Anchorage on March 17, 2002 when two to three feet of snow fell in less than 24 hours over portions of the city. Fortunately, the storm began on Sunday morning when very few businesses were open. Military bases, universities, and many businesses remained closed the following day; Anchorage schools remained closed for two days. It took four days for snowplows to reach all areas of the city. The snowfall also impacted the Kenai Peninsula, causing airport closures, travel delays and disrupting the flow of goods to local communities.

2003 - Spring Wind Storm

In the spring of 2003, a presidential disaster declaration (DR 1461) was issued when strong winds swept the Kenai Peninsula uprooted trees, causing widespread power outages, damaging structures and fanning the flames of a 150-acre wildfire in Anchor Point. Temperatures around 12 degrees F and winds up to 60 miles per hour were measured in Anchor Point in the vicinity of the fire.

Borough-wide the windstorm caused over $895,000 in damage to federal, state, borough, city and private property[5]. The high winds and freezing temperatures between March 6 and March 14, 2003 resulted in approximately 48 power outages to 4,000 Peninsula homes. Temporary power was restored to homes through contractors hired by Homer Electric Association. Emergency electrical supplies cost over $51,000 and permanent repairs cost nearly $206,000[6].

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1 FEMA 2002 Kenai Peninsula Flood Summary DR-1445.
2 Matthews, J. Planning and Project Management Coordinator, Homer Electric Assoc. Inc., (Email Memo).
3 Cowles, W. ADHS/ES, Private Assistance Grant Funding Summary, (email) and Jenkins, R., Small Business Administration, Private Homeowner and Business Loan Program (telephone communication).
4 Annex A: 2004 Draft City of Homer All-Hazard Mitigation Plan.
5 Kenai Peninsula Borough (KPB). 2003. Resolution 2003-050; A Resolution Authoring Application for Public Assistance from State of Alaska Department of Military and Veterans Affairs, Division of Emergency Services, for the 2002 Flooding and Winter Storm Disaster.
6 Pers. Comm., J. Matthews, Homer Electric Association, Inc. Kenai, Alaska. March 2004.

2003 - Pile Bay Road Flooding

In October of 2003, 15 inches of rain fell over a short period of time causing serious flooding on the west side of Cook Inlet between Lake Iliamna and Iliamna Bay. A state disaster declaration was issued and flood damage to the 14 mile (state-maintained) Pile Bay Road between Williamsport and Pile Bay Village cost nearly half a million dollars to repair. Damage to 22 sites along the first six miles of the road within the KPB accounted for $179,800 of the total damage[1].

2003 - English Bay Airport Runway Washout, Nanwalek

The English Bay Airport runway was significantly damaged by wind driven waves during a storm in November of 2003. Situated on a gravel spit at the entrance to English Bay, the airstrip is vulnerable to the dynamics of the beach on the northern boundary and the lagoon on the southern boundary. During the November 2003 storm, a section of runway measuring approximately 500 feet by 40 feet was eroded away on the bay side and an area 400 feet by 40 feet was also damaged on the lagoon side.

2006 - Fall Flooding, Seward

On October 8, 2006, flooding, mudslides, heavy rains and extremely high winds occurred, threatening life and property in the Seward area. Seward was inaccessible by road due to flooding across the Seward Highway at mile 4. Lowell Point Bridge was heavily damaged, cutting off the Lowell Point community. Additional damage to bridge infrastructure required the replacement of the Forest Avenue and Lost Creek Bridges. Damage assessments included Old Mill Subdivision, Camelot Subdivision, Lowell Point and Old Exist Glacier Road. Initial Kenai Peninsula response costs approximated $150,000. Recovery estimates for roads, bridges and other infrastructure were between $3.1-$3.5 millon[2]. This event was declared a local, state and federal disaster.

2007 - Flooding in Old Mill Subdivision, Seward

Beginning May 17th, 2007, flooding occurred in the Old Mill Subdivision as result of heavy deposits of gravel and silt from the headwaters of Lost Creek[3]. Dredging was approved for 200 feet above and 100 feet below the Lost Creek Bridge. Approximately 100,000 cubic yards of gravel and silt were removed from Lost Creek.

2007 – Kenai River Ice Jam Flooding, Sterling and Soldotna

In January and February of 2007, the Kenai River experienced an ice jam flood event triggered by the release of the Skilak Glacier-Dammed Lake. The lake began releasing around the 16th of January 2007, eventually raising the level of

1 Pers. Comm., Carol Sanner, Alaska Department of Transportation and Public Facilities, Central Region, Maintenance and Operations, Pile Bay Road Flooding Incident Spreadsheet, 3/30/04.

2 Seward Flood Situation Report 10/11/06 Media Release 10/13/06

3 Kenai Peninsula Borough OEM 2007 Seward Flooding File/ 6/15/07

the Kenai River at Skilak Lake by about 3.8 feet. The river below Skilak Lake experienced a broad crest on January 27th, measuring 20 feet above flood stage at the Soldotna bridge. The rise in water levels caused the ice cover to break up and form ice jams and localized flooding in the Soldotna vicinity. Rapid water level increases and moving ice caused significant property damage.

2009 – Sea Storm and Tidal Surge, Seward

A Dec 1, 2009 weather event paired an extreme 12.6 foot high tide with a heavy winter storm that included strong southeast winds blowing toward the north. T 2 ½ mile Lowell Point Road, the protective seawall at Alaska SeaLife Center and the paved bike/ foot path adjacent to the city campgrounds at Resurrection Bay received significant damage. This event was declared a local and state disaster.

5.4 Weather Risk Assessment

The extent of damage caused by severe weather depends on a number of factors including temperature, type and amount of precipitation, wind speed and event duration. Strong maritime influences from Cook Inlet, Prince William Sound and the Gulf of Alaska combine with geographical features such as the Harding Ice Field and Chugach Mountains to create diverse climactic differences across the Kenai Peninsula (see Section 1.4.2 and Table 1-2 for community-specific climate information).

Severe weather events have the potential to damage or disrupt water, sewer, power, gas, transportation and communication infrastructure as well as emergency response facilities and systems. Heavy rains, high wind, extreme cold and winter storms have all directly affected the KPB in recent years. Storm events that closely follow each other, or occur in combination with other hazards have the potential to directly or indirectly affect all Borough residents. There is a moderate to strong probability in any given year that some type of severe weather event will occur[1].

5.4.1 Populations and Facilities at Risk

KPB communities, critical facilities and transportation infrastructure are described in Sections 1.4.5, 1.4.6, 1.4.7, and 1.5.3. Depending on the event, damage to critical infrastructure up to and including the complete abandonment of key facilities may result. Indirect effects may include road closures that isolate residents, impact public safety (access and response capabilities) and limit availability of perishable commodities. Refer to Table 1-20 in Section 1.5.4 for a summary of the tax-assessed value of residential, industrial and commercial structures in KPB communities.

[1] Pinkston Enterprises. 2004. Kenai Peninsula Borough Emergency Operations Plan. Prepared for the Office of Emergency Management, Kenai Peninsula Borough, Soldotna, Alaska.

5.5 Weather Mitigation Goals

Although it is not possible to completely eliminate the threat that weather hazards pose to Borough residents, it is possible to identify ways to reduce vulnerability and minimize adverse impacts. To this end, three goals have been identified to guide mitigation planning and ultimately help protect KPB residents. These goals, objectives and mitigation strategies that follow encompass both agency and individual responsibilities. Although the goals broadly apply to all hazards, the mitigation strategies in this section are tailored for severe weather events.

All-hazard mitigation goals:

- protection;
- prevention; and
- education.

Protective measures could include minimizing development in high hazard areas, such as along steep eroding bluffs, floodplains, avalanche zones and landslide prone areas. Likewise, using proper building design and construction can reduce susceptibility to hazards such as heavy snow loads, flooding, or wind damage.

Risk can often be mitigated by timely weather warnings, particularly when flooding, glacier dammed lake outbursts or severe winter storms are forecast. Ongoing educational efforts promote public awareness and individual preparedness and increase the capacity of residents to safeguard their homes and families.

5.5.1 Accomplishing KPB Weather Mitigation Goals

The following are suggested as objectives to further define, guide and help achieve the Borough's weather mitigation goals:

- modify the impacts of weather by assisting individuals and communities to prepare for, respond to, and recover from these events;
- reduce susceptibility to damage and disruption by avoiding hazardous, uneconomic and unwise development in high-risk areas;

- protect the natural and beneficial values of Peninsula floodplains, coastal areas and water resources; and

- promote positive economic development.

5.5.2 Existing Weather Mitigation Programs and Activities

Emergency Response and Preparedness

The KPB Office of Emergency Management (OEM) was established to coordinate disaster management response between the Kenai Peninsula Borough, the State of Alaska, FEMA and other municipalities as well as other response and recovery

organizations. OEM has the primary responsibility for overseeing Peninsula disaster management programs and activities that include mitigation, planning, response and public education.

Since 1995, the Borough has taken the following steps to improve weather warning and response:

- created a website (www.borough.kenai.ak.us/emergency) that provides current weather watch and advisory information as well as links to the National Weather Service, FEMA educational materials, the Local Emergency Planning Committee, and other web resources such as The Weather Channel (www.weather.com);

- engaged in cost-share partnerships with USGS to install and maintain additional real-time stream and precipitation gages (see Appendix K);

- partnered with the National Weather Service to improve weather radio and emergency broadcast capabilities in the Central Peninsula by installing an additional NOAA weather radio station in Ninilchik;

- purchased two mobile sirens that can be moved to areas not served by the Borough's emergency siren warning system;

- acquired a mobile strategic command vehicle to facilitate Borough-wide communication and emergency response;

- participated with local and state emergency planning committees to develop, refine and implement cross-jurisdictional emergency response plans; and

- implemented a reverse 911 (Rapid Notify) system to telephone property owners with a recorded alert message in the event of flooding or emergency evacuation; and

- promoted individual use of weather radios, obtained grants to procure and distribute small quantities of same; and

- initiated partnership with NWS for Storm Ready Community programs to be provided in schools by NWS; and

- participated in tests of Emergency Alert System and national Emergency Alert Network; and

- installed All Hazard Alert Broadcast System (AHAB) warning sirens in the communities of Homer (five sirens), Seward (six sirens), Seldovia, Port Graham and Nanwalek (one siren per community). The AHAB siren system can operate independently and is programmed to activate automatically via radio frequency NWS Emergency Alert System alerts.

StormReady Program

StormReady is a nationwide community preparedness program that uses a grassroots approach to help communities develop plans to handle all types of severe weather. The program encourages communities to take a new, proactive approach to improving local hazardous weather operations by providing emergency managers with explicit guidelines for improving their hazardous weather operations.

To be officially StormReady, a community must:

- establish a 24-hour warning point and emergency operation center;
- have more than one way to receive and pass along severe weather forecasts and warnings;
- have a system for monitoring local weather conditions;
- promote the importance of public readiness through community seminars;
- develop a formal hazardous weather plan, which includes training severe weather spotters and holding emergency exercises; and
- demonstrate a capability to disseminate warnings.

Currently, the Cities of Homer and Seward are the only KPB communities that participate in the StormReady program. StormReady provides different guidelines for different sized communities. More information on the StormReady program is available by contacting the National Weather Service Office in Anchorage[1]. The National Weather Service and Kenai Peninsula Borough have initiated discussions about bringing the StormReady program to the rest of the Peninsula as NWS resources permit.

Digital Elevation Mapping for Kenai Peninsula

Digital elevation mapping (DEM) data using LIDAR has been acquired for the Kenai Peninsula and is currently being processed. LIDAR (LIght Detection And Ranging) is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target. The Seward area was flown in January 2006 during a snow-free period, and the western Kenai lowlands were flown in the summer of 2008. The data acquired

[1] National Weather Service, Anchorage Forecast Office, 6930 Sand Lake Road, Anchorage, AK 99502, (907) 266-5117, http://www.stormready.noaa.gov/.

has a resolution of one pixel per four foot square and a vertical accuracy of plus or minus 20 centimeters. No data was acquired for the ice fields or for communities across Kachemak Bay/Cook Inlet.

5.6 Weather Mitigation Strategies and Implementation Ideas

After experiencing three presidentially-declared weather-related disasters in the past four years, it is clear that severe weather poses a significant risk to the Borough. The dynamic and varied nature of the Peninsula's climatic patterns and geographic features suggest that winter storms and other severe weather events are likely an ongoing threat. As the Borough's population grows, so does the importance of improving emergency response and warning, and implementing measures to insure development proceeds in the safest possible manner as well as in the safest places. The strategies in this section, as well as those developed for the Flood Section (2.12), are intended to augment existing activities and identify potential new measures to minimize damage and prevent loss of life from future severe weather events. Specific mitigation strategies for borough cities may be found in their respective Annex Sections.

Strategy 1: Increase public awareness of severe winter storm mitigation activities and emergency response.

Implementation Ideas and Action Items

- Participate in statewide outreach and awareness activities such as Winter Weather Awareness Week and Flood Awareness Week.
- Continue weather preparedness outreach and education activities for Borough residents.
- Coordinate with local utility organizations to increase homeowner education about potential storm effects and possible mitigation activities.
- Expand public awareness about the NOAA Weather Radio service continuous weather broadcasts and warning tone alert services.

Potential Participants:	National Weather Service, Alaska Division of Homeland Security and Emergency Management, Office of Emergency Management (KPB), Local Emergency Planning Committee, Local Utility Companies, Incorporated Cities within the KPB
Time Frame:	Ongoing

Strategy 2: Enhance weather monitoring and warning systems.

Implementation Ideas and Action Items

- Evaluate the need for additional weather stations and/or weather instrumentation across the Kenai Peninsula Borough.
- Evaluate current weather warning systems and explore the need to employ redundant methods of receiving and distributing weather warnings to Borough residents.
- Support ongoing coordination between the incorporated cities, KPB, local utilities and state and federal agencies to promote disaster warning and preparedness planning.
- Add a permit liaison position to the KPB Incident Command Structure to coordinate emergency permitting with regulatory agencies during disaster events.
- Maintain the revolving flood mitigation fund for the purpose of delivering clean water, sand bags and other critical services or supplies to communities during flood emergencies.

Potential Participants:	National Weather Service, Alaska Division of Homeland Security and Emergency Management, Office of Emergency Management (KPB), Local Emergency Planning Committee, Incorporated Cities within the KPB
Time Frame:	Ongoing

Strategy 3: Expand local weather monitoring programs.

The Borough currently participates in the Alaska Warning System (AKWAS)[1] and can receive weather warning information from the National Weather Service; additional site-specific information could augment the Borough and state weather warning systems.

Implementation Ideas and Action Items

- Investigate participation in the National Weather Service all-season storm spotter network.

[1] National Warning System (NAWAS) website: www.fas.org/nuke/guide/usa/c3i/nawas.htm.

- Partner with the National Weather Service to use their all-hazard warning system (weather radio) to initiate alerts and provide Borough specific hazard warnings.

Potential Participants:	Office of Emergency Management (KPB), National Weather Service, Division of Homeland Security and Emergency Management, Local Police and Fire Departments, Incorporated Cities within the KPB
Time Frame:	Ongoing

Strategy 4: Minimize damage to residential structures and private property in the Kenai Peninsula Borough.

Weather resistant materials and building practices can help structures withstand weather events with minimal damage. For example, bracing and strapping roofs can prevent damage during high winds, grounding buildings will reduce or eliminate lightning damage, and constructing sloped rather than flat roofs will prevent or reduce snow damage.

Implementation Ideas and Action Items

- Encourage use of weather resistant materials and construction practices by implementing Uniform International Building Code Standards for residential structures smaller than four-plexes outside of city limits (see Section 4.5, Strategy 8).

- Require written disclosure of hazard prone areas (such as floodplain, tsunami run-up zones, and areas with high erosion potential) when property ownership is transferred.

- Augment existing homeowner winter storm safety programs. This should include distribution of information on safe building design and retrofitting techniques.

- Explore partnerships to provide retrofitting classes for homeowners, renters, building professionals and contractors.

- Encourage non-participating local communities to join the StormReady program to help prepare for weather events.

Potential Participants:	National Weather Service, Office of Emergency Management (KPB), Capital Projects Division (KPB), Local Emergency Planning Committee, Community Schools Program (KPB School District), AK State Division of Homeland Security and Emergency Management, FEMA, Local Realtors, Local Construction Companies, Incorporated Cities within the KPB
Time Frame:	Ongoing

5.7 Weather Resource Directory

Local Resources

Kenai Peninsula Borough Office of Emergency Management (OEM)

KPB/OEM was established to coordinate disaster management response between the Kenai Peninsula Borough, the State of Alaska, FEMA and other municipalities, as well as other response and recovery organizations. OEM has the primary responsibility for overseeing disaster management programs and activities, including mitigation, planning, response and public education.

Contact: Office of Emergency Management
Address: 253 Wilson Lane, Soldotna, AK 99669
Phone: (907) 262-4910
Website: www.borough.kenai.ak.us/emergency

State Resources

State of Alaska, Division of Homeland Security and Emergency Management

This agency in part conducts hazard preparedness and mitigation workshops. They also coordinate the State of Alaska's All-Hazard Mitigation Plan. Their community response program works with communities during a crisis as well in recovery and planning phases.

Contact: AK Division of Homeland Security and Emergency Management
Address: P.O. Box 5750, Fort Richardson, AK 99505-5750
Phone: (907) 428-7000 OR (800) 478-2337
Website: www.ak-prepared.com

University of Alaska, Fairbanks, Geophysical Institute

The mission of the Geophysical Institute is to promote understanding of basic geophysical processes, especially as they pertain to Alaska; train graduates and undergraduates to play leading scientific roles in society; solve applied geophysical problems and develop related technologies of importance to the state and the nation; and satisfy the intellectual and technological needs of fellow Alaskans through public service.

Contact: Geophysical Institute
Address: 903 Koyukuk Drive, Univ. of Alaska, Fairbanks, AK 99775-7320
Websites: Main University: www.uaf.edu
Geophysical Institute: www.gi.alaska.edu

University of Alaska, Fairbanks, Alaska Climate Research Center

The primary mission of the Center is to respond to meteorology and climatologic inquiries concerning Alaska from public, private, and government agencies, as well as researchers around the world. The Center archives digital climate records, develops climate statistics, and writes monthly weather summaries (published in several newspapers around the state as well as in *Weatherwise* magazine). Services are provided free of charge for small requests. The Center also conducts research on a number of high latitude meteorological and climatological topics and provides useful links for related data.

Contact: Alaska Climate Research Center
Address: 903 Koyukuk Drive, P.O. Box 757320, Fairbanks, AK 99775-7320
Phone: (907) 474-7885
Website: climate.gi.alaska.edu

Federal Resources

FEMA: Mitigation Division

FEMA's Mitigation Division manages the National Flood Insurance Program and oversees a number of mitigation programs and activities, which provide protection (with flood insurance), prevention and partnerships to communities throughout the country.

Contact: FEMA/Region X
Address: 130 228th Street, SW, Bothell, WA 98021
Phone: (425) 487-4600
Website: www.fema.gov/about/regions/regionx/index.shtm

National Oceanic and Atmospheric Administration (NOAA)

NOAA's historical role has been to predict environmental changes, protect life and property, provide decision makers with reliable scientific information, and foster global environmental stewardship.

Contact: National Oceanic and Atmospheric Administration
Address: 1401 Constitution Avenue NW, Room 5128, Washington, DC 20230
Phone: (202) 482-6090
Fax: (202) 482-3154
Website: www.noaa.gov

National Weather Service (NWS), Alaska Region Headquarters

The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure, which can be used by other governmental agencies, the private sector, the public, and the global community.

Contact: National Weather Service/ Alaska Region Headquarters
Address: 222 West 7th Avenue #23, Anchorage, AK 99513-7575
Phone: (907) 271-5088 OR 1-800-472-0391 (Alaska Weather Line)
Fax: (907) 271-3711
Website: Alaska: www.arh.noaa.gov
National: www.nws.noaa.gov

Federal Aviation Administration (FAA)

The FAA's mission is to provide a safe, secure and efficient global aerospace system that contributes to national security and the promotion of aviation safety. As the leading authority in the international aerospace community, FAA is responsive to the dynamic nature of customer needs, economic conditions, and environmental concerns. Local flight service stations provide aviation weather briefings, in-flight advisories and pilot reports as well as other aviation related services.

Contact: FAA/Alaska Region
Kenai Flight Service Center
Address: 470 North Willow Street
Kenai, AK 99611-7707
Website: www.faa.gov/about/office_org/headquarters_offices/ato/service_units/systemops/fs/alaskan/alaska/ena

Additional Resources

Public Assistance Debris Management Guide

Federal Emergency Management Agency (July 2000).
The Debris Management Guide was developed to assist local officials in planning, mobilizing, organizing, and controlling large-scale debris clearance, removal, and disposal operations. Debris management is generally associated with post-disaster recovery. While it should be compliant with local and county emergency operations plans, developing strategies to ensure strong debris management is a way to integrate debris management within mitigation activities. The *Public Assistance Debris Management Guide* is available in hard copy or on the FEMA website.

Contact: FEMA Distribution Center
Address: 130 228th Street, SW, Bothell, WA 98021-9796
Phone: (800) 480-2520
Fax: (425) 487-4622
Website: www.fema.gov/government/grant/pa/demagde.shtm

Alaska Science Forum

Information and articles provided as a public service by the Geophysical Institute, University of Alaska Fairbanks, in cooperation with the UAF research community:

Contact: Geophysical Institute
Address: 903 Koyukuk Drive, University of AK, Fairbanks, AK 99775-7320
Website: Geophysical Institute: www.gi.alaska.edu OR
www.gi.alaska.edu/ScienceForum/weather.html

National Weather Radio (NWR)

NOAA National Weather Service Weather Radio

NWR is a nationwide network of radio stations broadcasting continuous 24-hour weather information direct from a nearby National Weather Service office. NWR is an “all hazards” radio network, making it a comprehensive weather and emergency information source. NWR also broadcasts warning and post-event information for all types of hazards.

Contact: NOAA, National Weather Service
Office of Climate, Water and Weather Services
Address: 1325 East West Highway, Silver Spring, MD 20910
Website: National: www.nws.noaa.gov/nwr

Contact: NOAA/NWR Anchorage Forecast Office
Address: 6930 Sand Lake Road, Anchorage, AK 99502
Websites: Alaska NWR Locations: www.nws.noaa.gov/nwr/stations.php?State=AK
Anchorage Forecast Office: pafc.arh.noaa.gov
Phone: 1-800-472-0391 (Alaska Weather Line)

NWS/StormReady Program

StormReady is a nationwide community preparedness program that uses a grassroots approach to help communities develop plans to handle all types of severe weather. The program encourages communities to take a new, proactive approach to improving local hazardous weather operations by providing emergency managers with clear-cut guidelines on how to improve their hazardous weather operations. StormReady guidelines, examples, and applications also may be found on the Internet or by contacting the National Weather Service, Anchorage Forecast Office.

Contact: National Weather Service, Anchorage Forecast Office
Address: 6930 Sand Lake Road, Anchorage, AK 99502
Phone: (907) 266-5117
Website: www.stormready.noaa.gov

NWS/TsunamiReady Program

Based on the NWS StormReady model, the Tsunami Ready Program is a National Weather Service (NWS) initiative that promotes tsunami hazard preparedness to provide consistent and location specific mitigation activities for communities as risk. This is a collaborative program that combines the efforts of Federal, state and local emergency management agencies, the public, and the NWS tsunami warning system. TsumamiReady guidelines, examples, and applications also may be found on the Internet or by contacting the West Coast and Alaska Tsunami Warning Center.

Contact: West Coast & Alaska Tsunami Warning Center
Address: 910 S. Felton St., Palmer, AK 99645
Phone: (907) 745-4212
Website: wcatwc.arh.noaa.gov

American Red Cross

The American Red Cross is a volunteer humanitarian organization, which provides relief to disaster victims and helps people prevent, prepare for and respond to emergencies.

Contact: American Red Cross
Address: 235 E. 8th Avenue, Anchorage, AK 99501
Phone: (907) 646-5401
Website: alaska.redcross.org

Western Regional Climate Center

The Western Regional Climate Center (WRCC) is one of six regional climate centers in the United States. The Regional Climate Centers Program is administered by the National Oceanic and Atmospheric Administration and funded through the NOAA Cooperative Institute for Atmospheric Sciences and Terrestrial Applications (CIASTA). They have several key objectives: 1) to coordinate applied climate activities in the western United States, 2) to conduct applied climate related research in the west, 3) to maintain a historic climate database for the west, and 4) to respond to climate data requests.

Contact: Western Regional Climate Center
Address: 2215 Raggio Parkway, Reno, Nevada 89512
Phone: (775) 674-7010
Website: www.wrcc.dri.edu

Kachemak Bay Research Reserve

The Kachemak Bay Research Reserve (KBRR) performs and coordinates research and education related to estuarine, oceanic and watershed interests of the Kenai Peninsula and Gulf of Alaska. The KBRR is a partnership between the National Oceanic and Atmospheric Administration (NOAA) and the State of Alaska and is administered through the Alaska Department of Fish and Game.

Contact: Kachemak Bay Research Reserve
Address: 95 Sterling Highway, Suite 2, Homer, AK 99603
Phone: (907) 235-6377
Website: www.habitat.adfg.state.ak.us

Coastal Training Program Alaska

The Coastal Training Program Alaska (CTP Alaska) provides science-based training and education services to assist policy makers and land managers make better decisions about coastal issues. CTP Alaska is a NOAA national initiative operated in conjunction with National Estuarine Research Reserves.

Contact: Kachemak Bay Research Reserve
Address: 95 Sterling Highway, Suite 2, Homer, AK 99603
Phone: (907) 235-6377
Website: www.habitat.adfg.state.ak.us/index.cfm/FA/educationCoastal.home

6.0 Tsunamis & Seiches

6.1 Why Focus on Tsunami & Seiche Hazard Mitigation?

Tsunamis are sea waves (sometimes referred to as tidal waves) of local or distant origin that occur as a result of large-scale seafloor displacement.

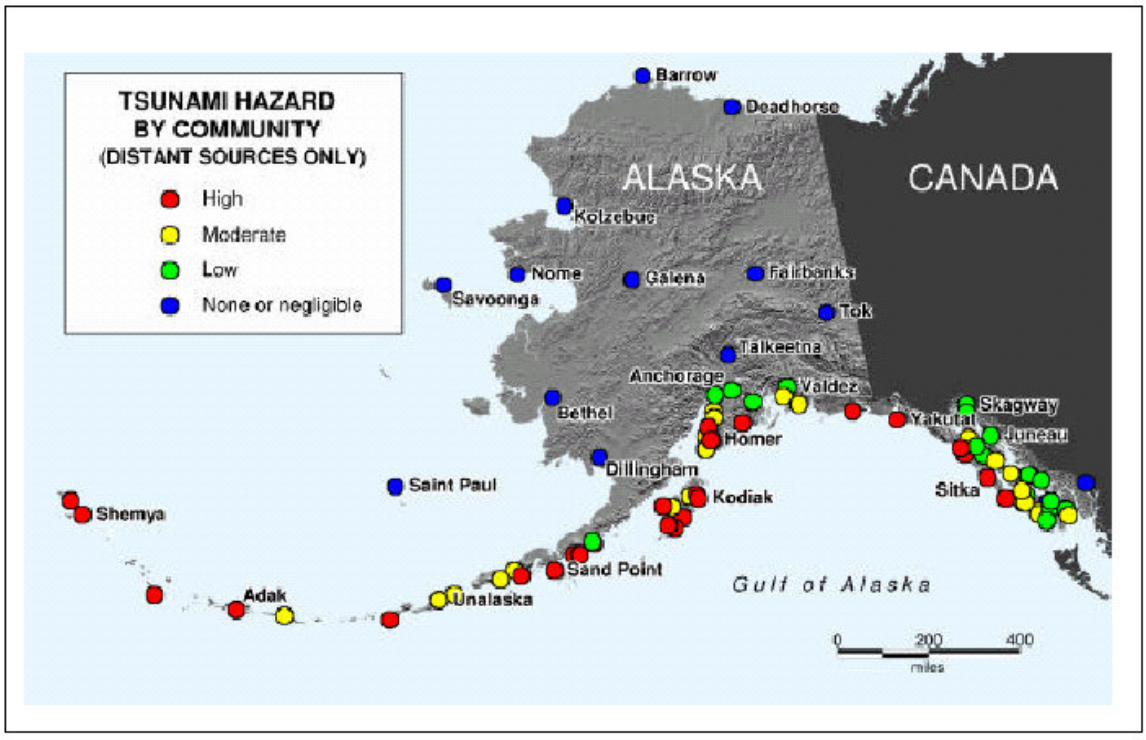

Figure 6-1. Alaska Tsunami Hazard by Community.

Typically, seismic activity, volcanic activity or landslides (above or below sea in origin) generate the uplift or drop in the ocean floor. Within Alaska, the most tsunami-vulnerable regions are the low-lying coastal zones along the Gulf of Alaska and the Pacific Ocean, including much of the Kenai Peninsula Borough shoreline.

The potential for tsunamis to cause tremendous damage to the KPB is well documented. On March 27th, 1964, the city of Seward was devastated by a series of waves generated by a 9.2[1] magnitude earthquake. With four active volcanoes and a high potential for earthquakes of magnitude 6.0 or greater, Borough coastal communities (tsunamis are generated by earthquakes with a magnitude of 7.0 or greater[2]).

[1] U.S. Department of Commerce, National Science Services Administration, U.S. Coast and Geodetic Survey. 1964. United States Earthquakes.

[2] Oregon Department of Geology and Mineral Industries. 2001. Tsunami Warning Systems and Procedures: Guidance of Local Officials. Special Paper 35 prepared for the National Tsunami Hazard Mitigation Program.

Coastal areas with the greatest tsunami risk are generally less than 50 feet above sea level and within one mile of the shoreline[1]. There are three primary sources of damage from tsunamis: inundation (the extent the water goes over the land), wave impact (both incoming and receding currents) and coastal erosion.

The direction or path, the wave energy, the coastal configuration and the offshore topography influence the terminal height (or run-up) of the wave and therefore the potential for damage[2]. As tsunamis reach the coastal shoals wave velocity decreases but wave height increases. Waves can reach heights of more than 100 feet and strike coastal areas with extraordinary force.

A seiche is a wave that oscillates in partially or totally enclosed bodies of water and can last from a few minutes to a few hours. The resulting effect is similar to bathtub water sloshing repeatedly from side to side. The reverberating water can continue to cause damage until the activity subsides. Events such as earthquakes, landslides, avalanches, high winds or changes in atmospheric pressure may trigger seiches. Similar to locally-generated tsunamis, the onset of the first wave from the causal event may take only a few minutes, giving virtually no warning.

6.2 Types of Tsunamis

The four primary types of tsunamis that could impact the KPB include:

- tele-tsunami
- volcanic tsunami
- seismically generated tsunami
- landslide-generated tsunami

Tele-Tsunami

Tele-tsunami is the term used when a tsunami travels 1,000 kilometers or more from its source. In many cases, tele-tsunamis allow for sufficient warning time and evacuation. According to the State All-Hazard Mitigation Plan, Alaska's coastal areas are believed to be at relatively low risk of experiencing high magnitude tele-tsunamis[3]. To date, no damage from tele-tsunamis has been recorded within the Kenai Peninsula Borough.

Magnitude	*Height (ft)*
-2 to -1	<1.0 to 2.5
-1 to 0	2.5 to 4.9
0 to 1	4.9 to 9.9
1 to 2	9.9 to 19.7
2 to 3	19.7 to 34.2
3 to 4	34.2 to 79.0
4 to 5	79.0 to >105.0

Table 6-1. Tsunami Magnitude and Height Relationships.

1 Federal Emergency Management Agency. 2004. Fact Sheet: Tsunamis
2 Pararas-Carayannis, G. 2004. The Tsunami Page. www.drgeorgepc.com/TsunamiFAQ.html.
3 Alaska Division of Homeland Security and Emergency Management (DHS&EM). State Hazard Mitigation Plan. DMA 2000 - Updated September 2004.

Volcanic Tsunamis

Volcanoes that are situated in the sea or near the coast can initiate tsunamis by generating earthquakes, pyroclastic flows, submarine explosions, debris avalanches, caldera collapse, pyroclastic surges, lahars and airwaves from explosions, and lava avalanches into the sea[1]. Factors governing tsunami magnitude include the volume of debris that enters the sea, the velocity of the avalanche and the water depth in the run-out zone[2].

There are five active volcanoes within the KPB on the west side of Cook Inlet: Fourpeaked, Augustine, Iliamna, Redoubt and Mount Spurr (Figure 6-2).

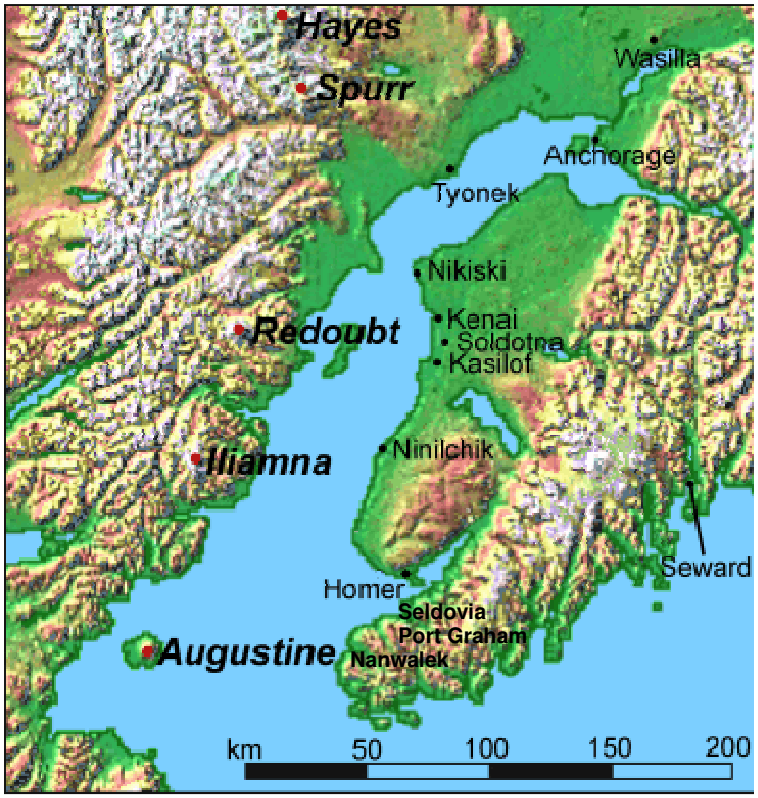

Figure 6-2. Volcanoes in the Cook Inlet Region[3].

Located at the southern end of Cook Inlet approximately 90 kilometers west of Nanwalek, Augustine Volcano has the potential to generate tsunamis. A number of anecdotal records indicate that an 1883 eruption of Mt. Augustine caused a

[1] Waythomas, C.F. and R.B. Waitt. 1998. Preliminary Volcano-Hazard Assessment For Augustine Volcano, Alaska. U.S. Geological Survey, Open File Report 98-106.
[2] Ibid.
[3] Modified from Ray Sterner, Johns Hopkins University, Applied Physics Laboratory (Copyright 1998).

series of tsunami waves to strike the villages of Nanwalek and Port Graham[1]. Information suggests wave heights of 20 to 30 feet hit the communities within 30 minutes of the eruption. Low tide at the time of the tsunami was reported as the reason for minimal damage.

Seismically-Generated Local Tsunamis

Although in recent years most of the seismically-generated local tsunamis have occurred along the Aleutian Arc, seismic activity is common in the KPB (see Section 4.0 Earthquakes) and is often associated with the active volcanoes. An island in Cook Inlet, Augustine has high probability of generating tsunamis waves that could impact communities in lower Cook Inlet.

Landslide-Generated Tsunamis

Submarine and surface landslides can generate large waves. Surface landslides have greater associated kinetic energy than submarine landslides so they typically trigger larger tsunamis. Earthquakes often trigger multiple landslides and landslide-generated tsunamis. Submarine landslides occur more readily at low tide when water-saturated sediments are exposed and lack the support of the water. Additional loading from human activities, such as warehouses, canneries and freight yards can increase a delta's instability. In Alaska, landslide events usually occur in heavily glaciated areas such as Resurrection Bay, Kachemak Bay and Prince William Sound.

Landslide-generated tsunamis are often the deadliest, because they quickly follow the triggering event with little to no warning. The Seward harbor was seriously damaged in 1964 when a large section of waterfront slid into Resurrection Bay during the Good Friday earthquake. The landslide-generated waves were followed a short time later by quake-generated tsunami waves. The city of Homer was impacted by a landslide-generated tsunami when a large debris slide near the Grewingk Glacier sent a wave of water across Kachemak Bay[2].

Seiches

A seiche is a wave that oscillates in partially or totally enclosed bodies of water. Seiches can last from a few minutes to a few hours as a result of an earthquake, surface or submarine landslide or atmospheric disturbance. The resulting effect is similar to bathtub water sloshing repeatedly from side to side. The reverberating water will continue to cause damage until the activity subsides. Similar to a local tsunami, the onset of the first wave may happen in only minutes, giving virtually no time for evacuation or warnings.

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1 Montgomery Watson and Parker Horn Company. 2001. Flood Hazard Mitigation Plan, Port Graham, Alaska, Kenai Peninsula Borough, Feb. 2001. Waythomas, C.F. and R.B. Waitt. 1998. Preliminary Volcano-Hazard Assessment For Augustine Volcano, Alaska. U.S. Geological Survey, Open File Report 98-106.

2 City of Homer All-Hazard Mitigation Plan (Annex A).

In Alaska, seiches are commonly generated by the collapse of deltas into deep glacial lakes. They may also be associated with deltas built through time by alluvial streams, which typically consist of unconsolidated gravel, rock and debris. Within the Kenai Peninsula Borough, slide-induced waves have occurred on Kenai, Tustumena and Skilak Lakes[1].

6.3 Historical Tsunami Events

1883 Tsunami

Records indicate that Augustine erupted in 1883, and a large debris avalanche slid into Cook Inlet, causing a series of four 15- to 30-foot waves to strike the village of English Bay (now known as Nanwalek)[2]. An entry in the Alaska Commercial Company trading post daily log (University of Alaska Archives), indicated that wave heights were six meters above the "usual" level[3]. Nearby, Port Graham residents also reported several 15-foot waves striking within a half-hour of the eruption. Because the tide was low at the time, damage was minor but boats were swept into the harbor and several residences were flooded[4]. If a similar event occurred during high tide, damage to low-lying areas in the communities of Seldovia, Port Graham, Nanwalek and Homer could be substantial[5].

1964 Tsunami

The 1964 earthquake triggered several tsunamis: one major tectonic tsunami and about 20 local submarine and surface landslide tsunamis. The major tsunami hit south-central Alaska between 20 and 45 minutes after the earthquake. The local tsunamis struck between two and five minutes after the quake and caused a majority of the fatalities. Overall, the tsunamis were responsible for more than 90% of the earthquake related deaths, killing 106 Alaskans as well as 17 people in California and Oregon[6].

In Seward, the earthquake caused a 1,070 meter section of the Seward waterfront to collapse into Resurrection Bay (Figure 6-3). The landslide generated a 30-foot local tsunami that destroyed most of the facilities near the waterfront, including a fuel tank farm, which started the first of many fires.

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1 Foster, H. and T. Karlstrom. 1967. The Alaska Earthquake, March 27, 1964: Region Effects. Ground Breakage and Associated Effects in the Cook Inlet, Alaska, Resulting from the March 27, 1964, Earthquake. Geological Survey Professional Paper 543-F. United State Department of the Interior, Washington, D.C.; McCulloch, D. 1966. Slide-Induced Waves, Seiching and Ground Fracturing Caused by the Earthquake of March 27, 1964, at Kenai Lake, Alaska. Geological Survey Professional Paper 543-A. United State Department of the Interior, Washington, D. C.

2 Waythomas, C.F. and R.B. Waitt. 1998. Preliminary Volcano-Hazard Assessment For Augustine Volcano, Alaska. U.S. Geological Survey, Open File Report 98-106.

3 Ibid.

4 Montgomery Watson and Parker Horn Company. 2001. Flood Hazard Mitigation Plan, Port Graham, Alaska, Kenai Peninsula Borough. March 2001.

5 Troshina, E.N., 1996. Tsunami waves generated by Mt. St. Augustine Volcano, Alaska: Fairbanks, University of Alaska, M.S.thesis, 84pp in Waythomas, C.F. and R.B. Waitt. 1998. Preliminary Volcano-Hazard Assessment For Augustine Volcano, Alaska. U.S. Geological Survey, Open File Report 98-106.

6 Sokolowski, T. 2004. The Great Alaskan Earthquake & Tsunamis of 1964. West Coast & Alaska Tsunami Warning Center, Palmer, Alaska.

Smaller tsunamis then spread the burning fuel floating on the water surface and started another fire at the Texaco Petroleum tank farm further inland[1].
In the small boat harbor, landslide-induced waves collapsed the dock and sank 30 fishing boats and 40 pleasure craft. The railroad yards were also heavily damaged, as were freight cars in the marshalling yards. The waves struck with sufficient force to move a 120-ton locomotive 100 feet and sweep a 75-ton locomotive 300 feet inland.

About twenty minutes after the first local tsunami hit the Seward waterfront, a 40-foot earthquake-generated wave struck. This wave carried a wall of flaming oil into Seward, destroying and setting fire to a large section of town. All told, about 95% of Seward's industrial base was lost and 15% of the town's residential properties were totally destroyed or heavily damaged. There were 12 fatalities, 200 injuries[2] and approximately $14 million in damage[3].

1 KPB All-Hazard Plan, Annex E: City of Seward. 2004. All-Hazard Mitigation Plan.
2 Alaska Division of Homeland Security and Emergency Management (DHS&EM). State Hazard Mitigation Plan. DMA 2000 - Updated September 2004.
3 Sokolowski, T. 2004. The Great Alaskan Earthquake & Tsunamis of 1964. West Coast & Alaska Tsunami Warning Center, Palmer, Alaska.

Figure 6-3. Tsunami Damage to the City of Seward Waterfront Following the March 27,1964 Earthquake[1].

Although 10- to 30-foot quake generated tsunami waves were also reported in Homer, Seldovia, Port Graham and Nanwalek[2], there were no fatalities and much less damage. The primary damage in Homer involved two to six feet of earthquake-induced subsidence along the five-mile-long Homer Spit road. As a result, 70 percent of the Spit flooded during the following autumn high tides. In Seldovia as well as other coastal areas, many boats and some waterfronts were damaged[3]. The land in much of Seldovia subsided four feet, necessitating the rebuilding and relocation of much of the village.[4]

6.4 Tsunami & Seiche Risk Assessment

Tsunami vulnerability is greater when coastal communities have beaches that open to the ocean or are located near bay entrances, tidal flats and shores of

1 Source: John Combs Seward Part 2 website: www.alaskarails.org/historical/earthquake/earthquake-seward2.html.

2 United States Army Corps of Engineers, May 1968. Coastal Engineering Research Center, Technical Memorandum No. 25, The Tsunami of the Alaskan Earthquake, 1964, Engineering Evaluation ***in*** FEMA. 1999. Flood Insurance Study, Kenai Peninsula Borough, Alaska (revised). Community Number 020012.

3 Sokolowski, T. 2004. The Great Alaskan Earthquake & Tsunamis of 1964. West Coast & Alaska Tsunami Warning Center, Palmer, Alaska [wcatwc.arh.noaa.gov/64quake.htm].

4 Suleimani, E.N., et al., Tsunami Hazard Maps of the Homer and Seldovia Areas, Alaska. State of Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, 2005

coastal rivers. Within the KPB, the most significant threat is from local tsunamis generated in Resurrection Bay, Alaska Pacific waters and Cook Inlet. Communities at primary risk include Seward, Homer, Seldovia, Port Graham and Nanwalek.

The entire KPB lies within Zone 4 (highest earthquake hazard potential) of the former Uniform Building Code[1]. Zone 4 is susceptible to earthquakes of magnitude greater than 6.0 in which major structural damage could occur. A strong earthquake that lasts more than 20 seconds can also generate a tsunami[2]. See Section 4.0 for additional KPB earthquake information.

According to the KPB Emergency Response Plan[3], coastal communities in the East and South Zones are highly vulnerable to tsunami events, which have a moderate probability of occurring. Residents of North and Central Zone coastal communities are moderately vulnerable to tsunamis, although the probability of occurrence is low due to the shallow depth of upper Cook Inlet and the lack of substantial submarine structures.

Table 6-2. Population and Facility Tsunami Hazard Vulnerabilities for the Kenai Peninsula Borough[4].

Zone	Population within vulnerability zone*	Property that may be damaged	Probability of occurrence
North	2,000	Structures, vehicles and equipment, port and harbor facilities, transportation facilities, airports	Low
Central	2,000		Low
East	7,000		Moderate
South	7,500		Moderate

* Numbers are for "worst case" occurrence in summer.

Tsunamis have the potential to damage structures, vehicles, boats, equipment, harbor and transportation facilities. The probability of simultaneous emergencies following a tsunami is rated as high in the KPB Emergency Response Plan[5]. Associated events include industrial/technological emergencies (resulting from fire, explosions and hazardous materials incidents), disruption of vital services (such as water, sewer, power, gas and transportation) and damage and disturbance to emergency response facilities and resources.

1 Pers. comm., Rod Combellick, Acting Director, Alaska Division of Geological and Geophysical Surveys. Fairbanks, Alaska, 2004.
2 National Disaster Education Coalition. 1999. Tsunami. In: *Talking About Disaster: Guide for Standard Messages*. Washington, D.C. Available at http://www.fema.gov/pdf/rrr/talkdiz/tsunami.pdf.
3 Pinkston Enterprises. 2004. Kenai Peninsula Borough Emergency Operations Plan. Prepared for the Office of Emergency Management, Kenai Peninsula Borough, Soldotna, Alaska.
4 Pinkston Enterprises. 2004. Kenai Peninsula Borough Emergency Operations Plan. Prepared for the Office of Emergency Management, Kenai Peninsula Borough, Soldotna, Alaska.
5 Ibid.

6.4.1 Populations and Facilities at Risk

Overall

Depending on the epicenter and magnitude, an earthquake-generated tsunami could result in significant damage to KPB coastal communities. The tsunami inundation maps for the communities of Homer, Seldovia and Seward provide a tool to more accurately assess the number of people and development that is at risk in those communities. Risk assessments for the other unmapped communities, at least in the near term, will be based on available historical or estimated information.

The DHS&EM (formerly Alaska Division of Emergency Services), with input from an interagency committee, established a statewide priority list for tsunami inundation mapping. As part of this effort, maps for Homer and Seldovia have been finalized[1] and Seward is scheduled to receive maps in early 2010. The tsunami maps can be used to more accurately predict the number of people and development at risk, as well as assist with land use and emergency response planning.

Due to resource limitations, the smaller KPB coastal communities are currently not scheduled for tsunami mapping. Without inundation maps, communities must rely on historical or estimated information for land use and evacuation route planning.

North Zone

Coastal areas with potential tsunami risk in the North Zone begin at the north side of the mouth of the Kenai River and continue north up the coast, including the west side of Cook Inlet. Due to the relatively shallow depth of upper Cook Inlet and the substantial distance from areas to the south with significantly higher risk, the upper Inlet is believed to have low tsunami risk[2].

Central Zone

The areas of concern in the Central Zone begin at the south side of the mouth of the Kenai River and continue south to Clam Gulch. Due to the relatively shallow depth of upper Cook Inlet and the substantial distance from the lower end of Cook Inlet, the Central Zone is believed to have a low tsunami risk.

East Zone

Surface and submarine landslides could hit both the east and west shores of Resurrection Bay, which increases Seward's vulnerability to both local seiche waves and earthquake generated waves (see Section 6.3 Historical Tsunami Events).

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1 Pers. comm., Rod Combellick, Acting Director, Alaska Division of Geological and Geophysical Surveys. Fairbanks, Alaska, 2004.

2 Pers. comm., Rod Combellick, Acting Director, Alaska Division of Geological and Geophysical Surveys. Fairbanks, Alaska, 2004; For project status visit [http://www.aeic.alaska.edu/tsunami/index.htm].

South Zone
The South Zone communities are vulnerable to earthquake, volcano and surface and submarine landslide induced tsunamis that originate in Prince William Sound, the Gulf of Alaska and Cook Inlet. Typical peak wave heights from large tsunamis in the Pacific Ocean over the last 80 years have been between 21 and 45 feet at the shoreline. A few waves, however, have been higher locally - as much as 100 feet in a few isolated locations[1].

Tsunamis could impact both the east and west shores of Cook Inlet. Potentially vulnerable communities include Port Graham, Nanwalek, Seldovia, Homer, Anchor Point, Ninilchik and other small communities along the water.

Both Port Graham and Nanwalek are at risk from tsunami damage. As part of their Flood Hazard Mitigation Plan[2] (Annex G), the community of Port Graham used the 100-foot elevation contour to map their potential tsunami hazard zone (Figure 6-4). This map did not take into account site-specific shoaling effects or wave diffraction that may impact water run-up – factors that are included in the interagency-produced inundation maps (described above). According to the Port Graham Flood Mitigation Plan:

Current development is concentrated in the coastal areas, making the community vulnerable to flooding from tsunamis and extreme events. Much of the available land is owned by the Port Graham Village, allowing them to a certain extent to control the development of the community. Future development could occur along existing roads, preventing the need for costly road construction. Duncan Heights Road, Second Street, and A Street could all accommodate additional development. Structures along these roads, while still in the Tsunami Hazard Zone, would be out of immediate danger from storms or coastal erosion. (Annex G, p. 6-1)

1 Earthquake Education Center. 1996. *Tsunami! How to Survive the Hazard on California's Coast*. Humboldt State University. http://www.wsspc.org/tsunami/CA/CA_survive.html.
2 Montgomery Watson and Parker Horn Company. 2001. Flood Hazard Mitigation Plan, Port Graham, Alaska, Kenai Peninsula Borough, Feb. 2001.

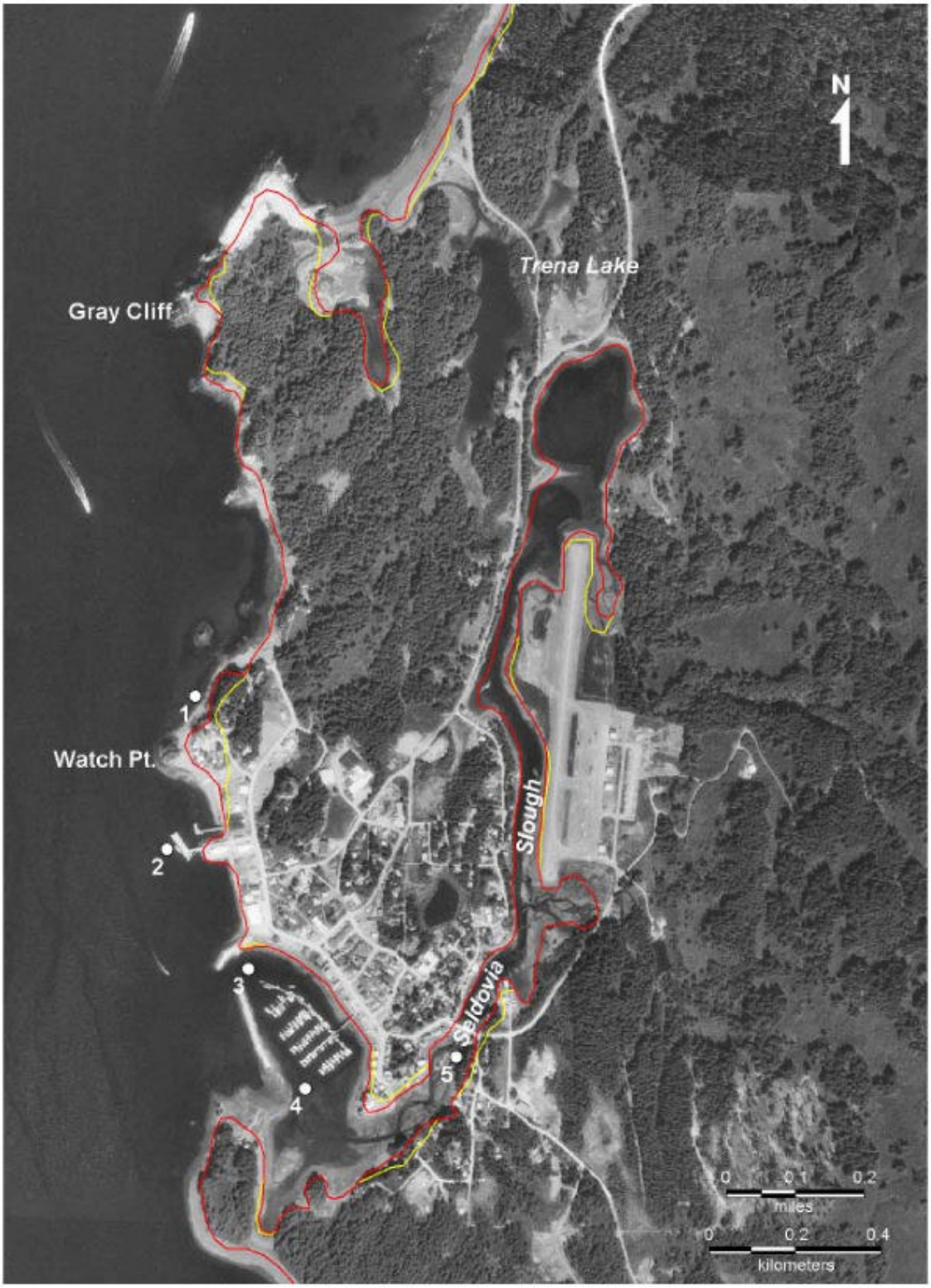


Figure 6-5. Tsunami Hazard Map for Seldovia, Alaska

Figure 6-6. Port Graham Tsunami Hazard Zone[1].

6.5 Tsunami & Seiche Mitigation Goals

Although it is not possible to eliminate the threat that tsunami hazards pose to Borough residents, it is possible to identify ways to reduce vulnerability. To this end, three goals were identified to best serve and protect the Kenai Peninsula Borough from tsunami and seiche related hazards. These goals encompass both

[1] Montgomery Watson and Parker Horn Company. 2001. Flood Hazard Mitigation Plan, Port Graham, Alaska, Kenai Peninsula Borough, Feb. 2001.

agency and individual responsibilities and are the same for all hazards, although mitigation strategies are tailored to the specific nature of each hazard.
All-hazard mitigation goals include:

- protection;
- prevention; and
- education.

6.5.1 Accomplishing KPB Tsunami and Seiche Mitigation Goals

The following are suggested as approaches to further define and accomplish the Borough's long-term tsunami mitigation goals.

- modify the impacts of tsunamis and seiches by assisting individuals and communities to prepare for, respond to and recover from these events;

- Reduce susceptibility to damage and disruption by avoiding hazardous, uneconomic and unwise development in tsunami hazard areas.

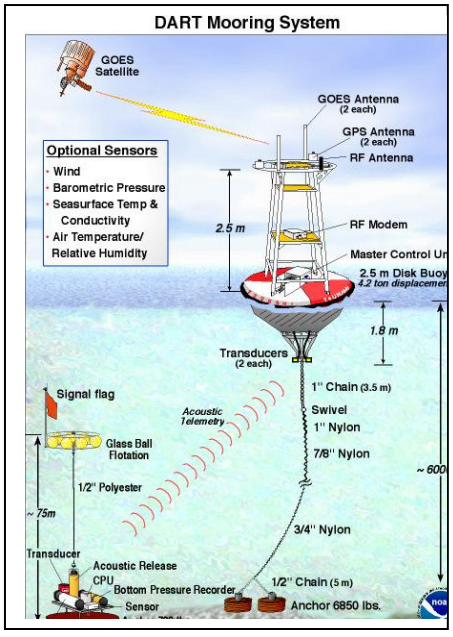
- protect the natural and beneficial values of Peninsula floodplains, coastal areas and water resources;

- Promote positive economic development.

6.5.2 Existing Tsunami & Seiche Mitigation Programs and Activities

6.5.2.1 Deep-Ocean Assessment and Reporting of Tsunamis (DART)

The DART project is a component of the larger U.S. National Tsunami Hazard Mitigation Program (NTHMP). The NTHMP is a comprehensive Federal and State effort to reduce loss of life and property due to tsunami inundation along U.S. coastlines. Cooperating U.S. agencies include NOAA, FEMA, USGS, and the Emergency Management agencies of the five Pacific States: Alaska, California, Hawaii, Oregon and Washington.



The DART project is an ongoing effort to develop and implement early detection and real-time reporting of tsunamis in the open ocean. Project goals are designed to:

- reduce the loss of life and property in U.S. coastal communities; and

- eliminate false alarms and the high economic cost of unnecessary evacuations.

To ensure early detection and acquire information critical to real-time tsunami forecasting, DART stations were sited in regions where destructive tsunamis have been generated in the past. A DART system consists of a seafloor bottom pressure-recording device (BPR) capable of detecting sea surface elevation changes as small as one centimeter, and a moored surface buoy for real-time communication. An acoustic link is used to transmit data from the BPR on the seafloor to the surface buoy. The data are then relayed via a GOES satellite link to ground stations, which modulate and transfer the signals to NOAA Tsunami Warning Centers and the Pacific Marine Environmental Laboratory (PMEL).Tele-tsunami warnings generated by the DART systems are expected to provide more accurate tsunami wave predictions for coastal communities in the Pacific Northwest and Alaska. Several DART stations are located in the central and western Gulf of Alaska and extend westward to the end of the Aleutian Chain.

6.5.2.2 TsunamiReady Program

Based on the NWS StormReady model, the TsunamiReady Program is a National Weather Service (NWS) initiative that promotes public safety and tsunami hazard preparedness. It is a collaborative program that combines the efforts of federal, state and local emergency management agencies, the public, and the NWS tsunami warning system.

In 2002, Seward and Homer became Alaska's first TsunamiReady communities (Figure 6-5). Before a community can be declared tsunami ready, it must meet five guidelines under the categories of communications and coordination, tsunami warning reception, warning dissemination, awareness and program administration[1].

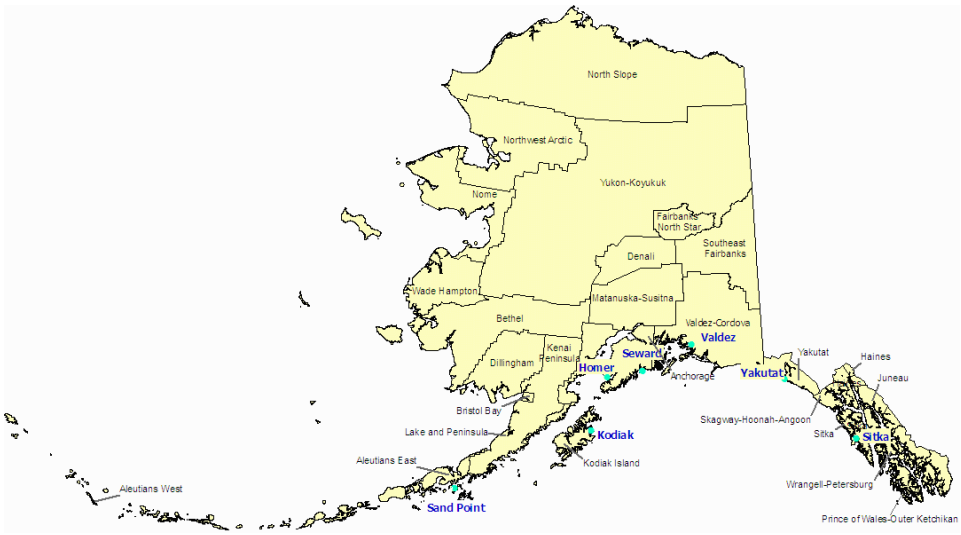


Figure 6-7. Communities in Alaska that Participate in the TsunamiReady Program[2].

[1] Guidelines detailed online at www.tsunamiready.noaa.gov/guidelines.htm

[2] Image Source: www.tsunamiready.noaa.gov/ts-com/ak-ts.htm.

6.5.2.3 Tsunami Inundation Mapping Program
As part of a larger federal program, Alaska is generating tsunami inundation maps for communities along the Gulf of Alaska. The DHS&EM, in cooperation with the University of Alaska Fairbanks, the Division of Geological and Geophysical Survey, the West Coast and Alaska Tsunami Warning Center, the National Weather Service and NOAA have completed detailed studies to predict tsunami threats for the cities of Homer and Seldovia. The study for Seward is due to be completed in April 2010. With data from these studies, detailed tsunami inundation maps can be generated. The studies and resulting maps will greatly assist the cities with future emergency planning efforts such as delineating evacuation routes. The maps will also be useful for land-use planning and development decisions. These maps will require maintenance and upgrades as new data becomes available and coastal changes occur.

6.5.2.4 West Coast/Alaska Tsunami Warning Center (WC&ATWC)
The WC&ATWC was established in Palmer, Alaska in 1967 as a direct result of the Good Friday earthquake that occurred in Prince William Sound on March 27, 1964. The earthquake alerted state and federal officials to the need for a facility to provide timely and effective tsunami warnings and information for Alaska's coastal areas.

In 1982, the WC&ATWC's area of responsibility (AOR) was enlarged to include California, Oregon, Washington, and British Columbia. In 1996, the responsibility was again expanded to include all Pacific-wide tsunamigenic sources that could affect the California, Oregon, Washington, British Columbia and Alaska coasts.

Tsunami warnings are of two types: regional warnings for tsunamis produced in or near the AOR and warnings for tsunamis generated outside the AOR. Regional warnings are issued within 15 minutes of earthquake origin time and are based solely on seismic data. Warnings are issued for any earthquake in the WC&ATWC's AOR over magnitude 7. Warnings outside the WC&ATWC's AOR are issued after coordination with the Pacific Tsunami Warning Center in Ewa Beach, Hawaii. The warnings are based on seismic data, along with historical tsunami records and recorded tsunami amplitudes from tide gauges.

In addition to evacuation warning messages, the WC&ATWC also provides informational messages for earthquakes that may be felt strongly by local citizens but are not large enough to generate a tsunami. Each year, the WC&ATWC staff responds to more than 250 alarms (an average of five per week). The informational messages are important for preventing needless evacuations since citizens near coastal areas are taught to move to higher ground when earthquakes occur. The WC&ATWC provides the public with critical, correct and timely tsunami information.

6.5.2.5 Tsunami Warning and Environmental Observatory for Alaska (TWEAK)
TWEAK is a program to collect tsunami information and biological and oceanographic data. Its efforts are focused on the following areas:

- tsunami research
- water quality
- ocean productivity
- weather prediction
- education and outreach

The information generated by TWEAK is expected to enhance the productivity and improve utilization of the ocean resources available in Kachemak Bay, Cook Inlet and the Gulf of Alaska.

6.5.2.6 Digital Elevation Mapping for Kenai Peninsula
Digital elevation mapping (DEM) data using LIDAR has been acquired for the Kenai Peninsula and is currently being processed. LIDAR (LIght Detection And Ranging) is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target. The Seward area was flown in January 2006 during a snow-free period, and the western Kenai lowlands were flown in the summer of 2008. The data acquired has a resolution of one pixel per four foot square and a vertical accuracy of plus or minus 20 centimeters. No data was acquired for the ice fields or for communities across Kachemak Bay/Cook Inlet.

6.6 Tsunami & Seiche Mitigation Strategies and Implementation Ideas

Tsunami damage associated with the 1883 volcanic eruption and the 1964 earthquake (see 6.3 Historical Tsunami Events) highlight the ongoing vulnerability of KPB coastal communities to this hazard. Though it is not possible to prevent tsunamis and seiches from occurring, both agencies and individuals can participate in mitigation activities to greatly lessen or eliminate damage. Potentially cost-effective ways to offset losses include increasing public awareness of tsunami prone areas, improving and practicing emergency warning and response measures, minimizing non-water dependent development in tsunami runup zones, and implementing measures to help water-based facilities withstand or deflect tsunami wave forces. The mitigation strategies that follow were developed to reduce tsunami-associated loss of life and property while simultaneously fulfilling the overall hazard mitigation plan goals of protection, prevention and education. Additional tsunami mitigation recommendations can be found in the Homer and Seward City Annex Sections.

Strategy 1: Increase public awareness of tsunami and seiche mitigation activities and emergency response.

Implementation Ideas and Action Items

- Continue tsunami education activities for coastal residents (such as development of personal disaster preparedness kits for resident's homes and vehicles).
- Increase public awareness of the All-Hazard Alert and Broadcast (AHAB) siren system and the reverse 911 community notification system (Rapid Notify).
- Maintain the number and visibility of warning signs to alert visitors and residents when entering tsunami hazard areas.
- Continue to ensure that evacuation routes and assembly areas are clearly marked in the event of emergency.
- Coordinate with coastal communities to develop additional evacuation routes.
- Work with local health services, emergency services and American Red Cross officials to identify people with mobility impairments who live or work in tsunami vulnerable areas and develop plans for providing evacuation assistance.

Potential Participants:	Communities of Homer, Seward, Seldovia, Port Graham and Nanwalek, Alaska Division of Homeland Security and Emergency Management, Office of Emergency Management (KPB), Local Emergency Planning Committee
Time Frame:	Ongoing

Strategy 2: Conduct mock tsunami hazard response exercises to identify response vulnerabilities.

Implementation Ideas and Action Items

- Conduct simulated exercises to determine vulnerabilities in emergency response and facilities. This will help identify areas that need further attention, resources and training.

Potential Participants: Office of Emergency Management (KPB), Local Emergency Planning Committee, Tsunami Vulnerable Communities
Time Frame: Ongoing (longer term 2-4 years)

Strategy 3: Enhance tsunami-warning systems in KPB coastal communities.

Implementation Ideas and Action Items

- Evaluate the need for additional tsunami warning systems in coastal communities across the Kenai Peninsula Borough.
- Continue to partner with the NWS to use their all-hazard warning system (weather radio) to initiate alerts and provide KPB area-specific hazard warnings.
- Seek funding to complete tsunami run-up maps for Port Graham and Nanwalek.
- Support ongoing coordination between the incorporated cities, KPB, local utilities and state and federal agencies to promote disaster warning and preparedness planning and training.
- Add a permit liaison position to the KPB Incident Command Structure to coordinate emergency permitting with regulatory agencies during and immediately following disaster events.
- Maintain the revolving flood mitigation fund for the purpose of delivering clean water, sand bags or other critical services or supplies to communities during disaster emergencies.

Potential Participants: National Weather Service, Alaska Division of Homeland Security and Emergency Management, Office of Emergency Management (KPB), Local Emergency Planning Committee, Incorporated Cities within the KPB
Time Frame: Ongoing (longer term 2-4 years)

Strategy 4: Minimize tsunami damage to structures in the Kenai Peninsula Borough.

Land use planning and regulatory steps such as zoning can help limit tsunami damage by reducing or preventing certain types of "non-water-dependent" development in high-risk areas. Risks to coastal development can be minimized in many ways, including: encouraging elevation and bracing of buildings, positioning structures on the highest available ground, using the lower floors as non occupied spaces and encouraging the development of site planning regulations requiring streets and structures to be perpendicular to potential waves so there is less resistance and erosive force. Water-based facilities like ferry terminals and shipping docks should be built to withstand tsunami wave forces.

Implementation Ideas and Action Items

- Use tsunami inundation maps (when available) to assist with land use planning, zoning and permitting decisions and processes.

- Support the development of tsunami inundation maps for all vulnerable KPB coastal communities that haven't yet been mapped.

- Encourage residents to explore building options to make property and structures more resistant to tsunami damage. Options may include such activities as elevating coastal homes, identifying ways to possibly divert water away from coastal structures and implementing sound site planning, building design and construction.

- Require written disclosure of hazard prone areas (such as coastal storm surge - FIRM V Zones, tsunami run-up zones and areas with high erosion potential) when property ownership is transferred.

- Encourage non-participating local communities to join the TsunamiReady program to help them prepare for tsunami events.

- Explore partnerships to provide retrofitting information or classes to homeowners, renters, building professionals and contractors who work or live in tsunami vulnerable locations.

Potential Participants:	National Weather Service, Office of Emergency Management (KPB), Capital Projects Division (KPB), KPB Planning and Floodplain Programs, Local Emergency Planning Commission, Community Schools Program (KPB School District), AK State Division of Homeland Security and Emergency Management, FEMA, Local Construction Companies, Incorporated Cities within the KPB
Time Frame:	Ongoing

6.7 Tsunami & Seiche Resource Directory

Local Resources

Kenai Peninsula Borough Office of Emergency Management (OEM)

KPB/OEM was established to coordinate disaster management response between the Kenai Peninsula Borough, the State of Alaska, FEMA and other municipalities, as well as other response and recovery organizations. OEM has the primary responsibility for overseeing disaster management programs and activities, including mitigation, planning, response and public education.

Contact: Office of Emergency Management
Address: 253 Wilson Lane, Soldotna, AK 99669
Phone: (907) 262-4910
Website: www.borough.kenai.ak.us/emergency

State Resources

State of Alaska, Division of Homeland Security and Emergency Management

This agency in part conducts hazard preparedness and mitigation workshops. They also coordinate the State of Alaska's All-Hazard Mitigation Plan. Their community response program works with communities during a crisis as well in recovery and planning phases.

Contact: AK Division of Homeland Security and Emergency Management
Address: P.O. Box 5750, Fort Richardson, AK 99505-5750
Phone: (907) 428-7000 OR (800) 478-2337
Website: www.ak-prepared.com

Alaska Earthquake Information Center

AEIC serves as an integration center for all seismic networks within Alaska and archives and processes data from the Alaska Tsunami Warning Center in Palmer, Alaska and the Alaska Volcano Observatory in Fairbanks and Anchorage.

Contact: Geophysical Institute, University of Alaska Fairbanks
Address: 903 Koyukuk Drive, P.O. Box 757320, Fairbanks, Alaska 99775-7320
Phone: (907) 474-7320
Website: www.aeic.alaska.edu/

Federal Resources

FEMA: Mitigation Division

FEMA's Mitigation Division manages the National Flood Insurance Program and oversees a number of mitigation programs and activities, which provide protection (flood insurance), prevention and partnerships to communities throughout the country.

Contact: FEMA/Region X
Address: 130 228th Street, SW, Bothell, WA 98021
Phone: (425) 487-4600
Website: www.fema.gov/about/regions/regionx/

National Oceanic and Atmospheric Administration (NOAA)

NOAA's historical role has been to predict environmental changes, protect life and property, provide decision makers with reliable scientific information, and foster global environmental stewardship. NOAA supports the West Coast and Alaska Tsunami Warning Center.

Contact: National Oceanic and Atmospheric Administration
Address: 1401 Constitution Avenue, NW, Room 5128, Washington, DC 20230
Phone: (202) 482-6090
Fax: (202) 482-3154
Website: www.noaa.gov

National Weather Service, Alaska Region Headquarters

The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure, which can be used by other governmental agencies, the private sector, the public, and the global community.

Contact: National Weather Service/ Alaska Region Headquarters
Address: 222 West 7th Avenue #23, Anchorage, AK 99513-7575
Phone: (907) 271-5088 OR 1-800-472-0391 (Alaska Weather Line)
Fax: (907) 271-3711
Website: Alaska: www.arh.noaa.gov/
National: www.nws.noaa.gov/

The National Tsunami Hazard Mitigation Program

The program is designed to reduce the impacts of tsunamis through warning, mitigation and hazard assessment.

Contact: National Tsunami Hazard Mitigation Program
Address: Box 50027, Honolulu, Hawaii 96850-4993
Phone: (808) 541-1657 or 1658
Fax: (808) 541-1678
Website: www.pmel.noaa.gov/tsunami-hazard/

Additional Resources

International Tsunami Information Center (ITIC)

The ITIC is maintained by the U.S. National Oceanic and Atmospheric Administration for the Intergovernmental Oceanographic Commission to mitigate the effects of tsunamis throughout the Pacific.

Contact: International Tsunami Information Center
Address: Box 50027, Honolulu, Hawaii 96850-4993
Phone: (808) 541-1657 or 1658
Fax: (808) 541-1678
Website: www.geophys.washington.edu/tsunami/general/mitigation/itic.html

Public Assistance Debris Management Guide

Federal Emergency Management Agency (July 2000).
The Debris Management Guide was developed to assist local officials in planning, mobilizing, organizing, and controlling large-scale debris removal and disposal operations. Debris management is generally associated with post-disaster recovery. The *Public Assistance Debris Management Guide* is available in hard copy or on the FEMA website.

Contact: FEMA Distribution Center
Address: 130 228th Street, SW, Bothell, WA 98021-9796
Phone: (800) 480-2520
Fax: (425) 487-4622
Website: www.fema.gov/government/grant/pa/demagde.shtm

Alaska Science Forum

The Alaska Science Forum provides information and articles as a public service of the Geophysical Institute, University of Alaska Fairbanks (UAF) in cooperation with the UAF research community.

Contact: Geophysical Institute
Address: 903 Koyukuk Drive, University of AK, Fairbanks, AK 99775-7320
Websites: Geophysical Institute: www.gi.alaska.edu/ OR
www.gi.alaska.edu/ScienceForum/weather.html

National Weather Radio (NWR)

NOAA National Weather Service Weather Radio

NWR is a nationwide network of radio stations broadcasting continuous 24-hour weather information directly from a nearby National Weather Service office. NWR is an “all hazards” radio network, making it a comprehensive weather and emergency information source. NWR also broadcasts warning and post-event information for all types of hazards.

Contact: NOAA, National Weather Service
Office of Climate, Water and Weather Services
Address: 1325 East West Highway, Silver Spring, MD 20910
Website: National: www.nws.noaa.gov/nwr

Contact: NOAA/NWR Anchorage Forecast Office
Address: 6930 Sand Lake Road, Anchorage, AK 99502
Websites: Alaska NWR Locations: www.nws.noaa.gov/nwr/stations.php?State=AK
Anchorage Forecast Office: pafc.arh.noaa.gov/
Phone: 1-800-472-0391 (Alaska Weather Line)

NWS/TsunamiReady Program

Based on the NWS StormReady model, the TsunamiReady Program is a National Weather Service (NWS) initiative that promotes tsunami hazard preparedness to provide consistent and location specific mitigation activities for at-risk communities. This is a collaborative program that combines the efforts of federal, state and local emergency management agencies, the public, and the NWS tsunami warning system.

TsumamiReady guidelines, examples, and applications also may be found on the Internet or by contacting the West Coast and Alaska Tsunami Warning Center.

Contact: West Coast & Alaska Tsunami Warning Center
Address: 910 S. Felton St., Palmer, AK 99645
Phone: (907) 745-4212
Website: www.tsunamiready.noaa.gov/

American Red Cross

The American Red Cross is a volunteer humanitarian organization that provides relief to disaster victims and helps people prevent, prepare for, and respond to emergencies.

Contact: American Red Cross
Address: 235 E. 8th Avenue, Anchorage, AK 99501
Phone: (907) 646-5401
Website: alaska.redcross.org

Publications

Oregon Department of Geology and Mineral Industries. 2001. Tsunami Warning Systems and Procedures: Guidance for Local Officials. Special Paper 35. Available at www.preventionweb.net/english/professional/publications/v.php?id=1474

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7.0 Volcanoes[1]

The following hazard description is derived from the Alaska Division of Homeland Security and Emergency Management's All-Hazard Mitigation Plan (October 2007). Although the text was edited slightly to focus on volcanoes with the highest potential to impact KPB communities, most of the description is state rather than region-specific. The State Plan is available at www.ak-prepared.com/plans/mitigation/mitigationplan.htm.

The term volcano is used to describe both the vent at the Earth's surface through which magma (molten rock) and associated gases erupt, and the landform built by effusive and explosive eruptions. Alaska is home to 52 historically active volcanoes stretching across the entire southern portion of the state from the Wrangell Mountains to the far western Aleutians[2]. An average of one to two eruptions per year occur in Alaska. Volcanoes display a wide variety of shapes, sizes, and behavior; however, they are commonly classified among three main types: cinder cone, composite and shield.

Volcanoes are also categorized according to the age of their eruptive activity. Active volcanoes are those that are currently erupting or showing signs of unrest, such as unusual earthquake activity or significant new gas emissions. Dormant volcanoes are those that are not currently active, but could become restless or erupt again. Extinct volcanoes are those that are considered unlikely to erupt again. This can be difficult to determine as a volcano could go tens of thousands of years, or longer, between eruptions. There are over 80 volcanic centers in Alaska but only 52 are considered active.

Redoubt Volcano – a composite volcano - is one of the active volcanoes of the Cook Inlet region. Steam and volcanic gas rise above the summit crater of the volcano during the 2009 eruption. Photograph courtesy of G. McGimsey, USGS/Alaska Volcano Observatory.

There are five active volcanoes within the KPB on the west side of Cook Inlet: Fourpeaked, Augustine, Iliamna, Redoubt and Mount Spurr.

1 Alaska Division of Homeland Security and Emergency Management (ADHS&EM). 2007. State Hazard Mitigation Plan.

2 Alaska Volcano Observatory 2010.

7.1 Types of Volcanoes

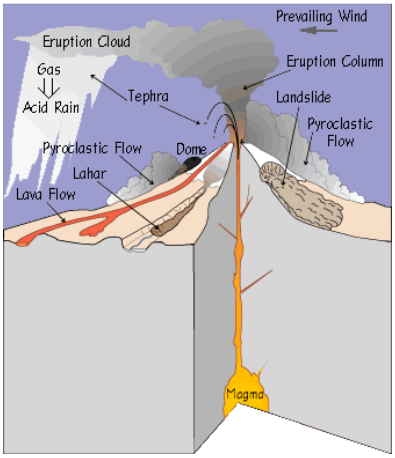
Cinder cones

Cinder cone volcanoes are built from particles and blobs of congealed lava ejected from a single vent. As the lava is blown into the air, it breaks into small fragments that solidify and fall as cinders and bombs around the vent to form a circular or oval cone. Most cinder cones have a bowl-shaped crater or craters at the summit and are rarely more than a thousand feet above their surroundings. Cinder cones may form as flank vents on the sides of larger composite or shield volcanoes. They often occur in clusters and produce lava flows. Cinder cones are common in western North America.

Composite volcanoes

Composite volcanoes, sometimes called stratovolcanoes, are typically steep-sided, symmetrical cones of large dimension built of alternating layers of lava flows, volcanic ash, blocks and bombs and may rise as much as 8,000 feet above their bases.

Composite volcanoes have a principal conduit system through which magma from a reservoir deep in the earth's crust rises to the surface repeatedly to cause eruptions. The volcano is built up by the accumulation of material erupted through the conduit and increases in size as lava, ash, etc., are added to its slopes. Stratovolcanoes tend to erupt explosively because of the silica-based nature of magmas associated with these volcanoes. Some stratovolcanoes produce enormous explosive eruptions that destroy a large part of the volcano itself, leaving a wide, roughly circular depression called a caldera. Eruptions that produce calderas are among the most explosive and largest eruptions known. Most Alaskan volcanoes are stratovolcanoes, including Fourpeaked, Redoubt, Spurr and Iliamna in the Cook Inlet Region.



Volcanic hazards.

Shield volcanoes

Shield volcanoes are formed by lava flowing in all directions from a central summit vent, or group of vents, or rift zones building a broad, gently sloping cone with a dome shape. They are built up slowly by the accretion of thousands of highly fluid lava flows that spread widely over great distances, and then cool in thin layers.

7.2 Volcanic Hazards

Lava Flows

Lava flows are streams of molten rock that flow from a volcano. The distance traveled by a flow (typically 6-30 miles) is dependant on several variables including viscosity, volume, slope steepness and obstructions in the flow path. Lava flows cause damage by burning, crushing, or burying people and objects. The high flow temperatures may trigger wildfires or cause flooding by melting ice and snow.

A pyroclastic flow sweeping down the north flank of 1,282-m (4,206 ft) high Augustine Volcano. Image courtesy M.E. Yount, USGS.

Pyroclastic Flows

Pyroclastic flows are high-density mixtures of hot gasses and dry rock that are usually released explosively from a volcano. The flows travel at speeds of 30 to 90 miles per hour (or greater) and the debris or associated high winds can destroy or move objects.

Pyroclastic Surges

Pyroclastic surges are turbulent low-density clouds of rock debris, air, and other gases that move over the ground at speeds similar to pyroclastic flows. There are two types: hot surges consisting of dry materials over 212ºF and cold surges consisting of cooler rock debris and water or steam.

Cleaning up ash from the 1992 Mt. Spurr eruption. Photographer Bill Roth, Anchorage Daily News (file 920917).

Lava Domes

Volcanic or lava domes are formed when viscous lava erupts slowly from a vent. This causes it to solidify near the vent forming the dome instead of flowing away from the vent. A dome grows largely by expansion from within. As it grows its outer surface cools and hardens, then shatters, spilling loose fragments down its sides. Volcanic domes commonly occur within the craters or on the flanks of large composite volcanoes.

Volcanic Ash and Bombs

Volcanic ash, also called tephra, consists of fine fragments of solidified lava ejected into the air by an explosion or rising hot air. The fragments range in size, with the larger falling nearer the source. Ash is a problem near the source

because of its high temperatures (may cause fires), burial (the weight can cause structural collapses), and impact of falling fragments. Further away from the source the primary hazard to humans is decreased visibility and lowered air quality. Ash also interferes with mechanical equipment operation.

Volcanic Gases
Volcanic gases consist mostly of steam, carbon dioxide, sulfur dioxide, hydrogen sulfide and chlorine compounds, but may include other substances. The gases can damage eyes, respiratory systems and cause suffocation in high concentration (usually near the vent). They can also be very corrosive.

Lateral Blasts
Lateral blasts are inflated mixtures of gases, ash and hot rock debris. They may be hundreds of feet thick and travel at speeds up to 370 miles per hour. They cause damage through abrasion, impact, burial, and heat. They may also trigger pyroclastic flows or surges.

Debris Avalanches
A debris avalanche is a sudden downward movement of unconsolidated material (mostly rock and soil). They occur without warning and travel quickly. Debris avalanches can extend over 300 square miles causing damage from impact or burial.

Debris Flows
Debris flows, also known as lahars, are rapidly flowing mixtures of rock debris and water that originate on the slopes of a volcano. They form in a variety of ways including the rapid melting of snow and ice by pyroclastic flows, the intense rainfall on loose volcanic rock deposits, the breakout of a lake dammed by volcanic deposits, or as a consequence of debris avalanches. They generally have the consistency of wet cement and have the ability to destroy or bury anything in their path.

Lahars from the 1989 to 1990 eruptions of Redoubt Volcano inundated this structure near the mouth of Drift River. Photograph courtesy of C. Gardner, USGS.

7.3 Historic Volcanic Activity

The largest volcanic eruption of the 20th century occurred at Novarupta Volcano in June 1912. It started by generating an ash cloud that grew to become thousands of miles wide during the three-day event. Within four hours of the eruption, ash started falling on Kodiak, darkening the city. It became hard to breathe because of the ash and sulfur dioxide gas. The water became

undrinkable and unable to support aquatic life. Roofs collapsed under the weight of the ash. Some buildings were destroyed by ash avalanches while others burned after being struck by lightning from the ash cloud. Similar conditions could be found all over the area. Some villages ended up being abandoned, including Katmai and Savonoski villages. The ash and acid rain also negatively affected animal and plant life. Large animals were blinded and many starved because their food was eliminated.

The ash fall from this eruption was significantly greater than the recent eruptions of Fourpeaked, Redoubt, Spurr and Augustine Volcanoes. Fourteen earthquakes of magnitude 6 to 7 were associated with this event. At least ten Alaskan volcanoes are capable of this type of event.

A more recent eruption occurred on Augustine Volcano in 2006. An ash plume disrupted air traffic and deposited ash in Homer, Nanwalek, Port Graham, Seldovia, Iliamna and Kodiak. A dome formed in the crater, and caused some to fear it would subsequently collapse and trigger a tsunami along the east shore of Cook Inlet, as happened in 1883.

Redoubt Volcano erupted in 1989-1990 and again in 2009. Both events resulted in debris flows. This caused the temporary closing of the Drift River Oil Terminal in 1989/90, and more extensive closures of the terminal and associated Cook Inlet platforms in 2009. In 1990, a KLM 747 jet aircraft, Flight 867, temporarily lost power in all four engines when it entered the volcanic ash plume. It would have crashed into the mountains had they not been able to restart their engines about 4,000 feet (1,219 meters) above ground.

7.4 Volcano Risk Assessment

The responsibility for hazard identification and assessment for the active volcanic centers of Alaska falls to the Alaska Volcano Observatory (AVO) and its constituent organizations (USGS, DNR/DGGS, and UAF/GI). AVO is in the process of publishing individual hazard assessments for each active volcano in the State. As of January 2010, published or in-press hazard assessments cover the following volcanoes: Hayes, Spurr, Okmok, Great Sitkin, Kanaga, Redoubt, Iliamna, Augustine, the Katmai Group, Aniakchak, Shishaldin, Akutan, and Makushin[1]. Each report contains a description of the eruptive history of the volcano, the hazards they pose and the likely effects of future eruptions on populations, facilities and ecosystems.

AVO has the primary responsibility to monitor all of Alaska's potentially active volcanoes and to issue timely warnings of activity to authorities and the public. During episodes of volcanic unrest or eruption, AVO is also the agency responsible for characterizing the immediate hazards and describing likely

[1] Alaska Volcano Observatory 2010

scenarios for an evolving volcanic crisis. AVO uses a four-color Level of Concern Color Code to succinctly portray its interpretations of the state of activity and likely course of unrest at a given volcano.

Basic information about vulnerable assets and populations are identified in these assessments. However, DCCED and other state agencies could work with AVO map data to integrate quantitative, current information regarding communities and other at-risk elements to improve our analysis of vulnerability. The NWS participates in producing weather models to assist in producing ash travel and possible fall at various elevations. NWS is able to provide this information in approximately six-hour increments, greatly enhancing ability to notify the public and to minimize impact on community health.

One of the most vulnerable sectors is the aviation industry, which is at risk from the effects of airborne volcanic ash. The significant trans-Pacific and intrastate air traffic in Alaska, directly over or near 52 potentially active volcanoes, has necessitated development of a strong communication and warning link between AVO, other government agencies with responsibility in aviation management, and the airline and air cargo industry.

The following maps depict approximate extent of ash fallout for eruptions of four of the five volcanoes within the KPB. These maps are from four U.S. Geological Survey Open-File reports:

Waythomas, C.F., J.M. Dorava, T.P Miller, C.A. Neal and R.G. McGimsey. 1998. Preliminary Volcano-Hazard Assessment for Redoubt Volcano, Alaska. U.S. Geological Survey, Open File Report 97-857 [www.avo.alaska.edu/pdfs/redoubt.hazards.ofr.pdf].

Waythomas, C.F. and R.B. Waitt. 1998. Preliminary Volcano-Hazard Assessment for Augustine Volcano, Alaska. U.S. Geological Survey, Open File Report 98-106 [www.avo.alaska.edu/pdfs/augustine_ofr.pdf].

Waythomas, C.F. and T.P Miller. 1999. Preliminary Volcano-Hazard Assessment for Iliamna Volcano, Alaska. U.S. Geological Survey, Open File Report 99-373 [www.avo.alaska.edu/pdfs/Iliamna.Haz.OFR.99.373.pdf].

Waythomas, C.F. and C.J. Nye. 2002. Preliminary Volcano-Hazard Assessment for Mount Spurr Volcano, Alaska. U.S. Geological Survey, Open File Report 01-482 [www.avo.alaska.edu/pdfs/of01-482.pdf].

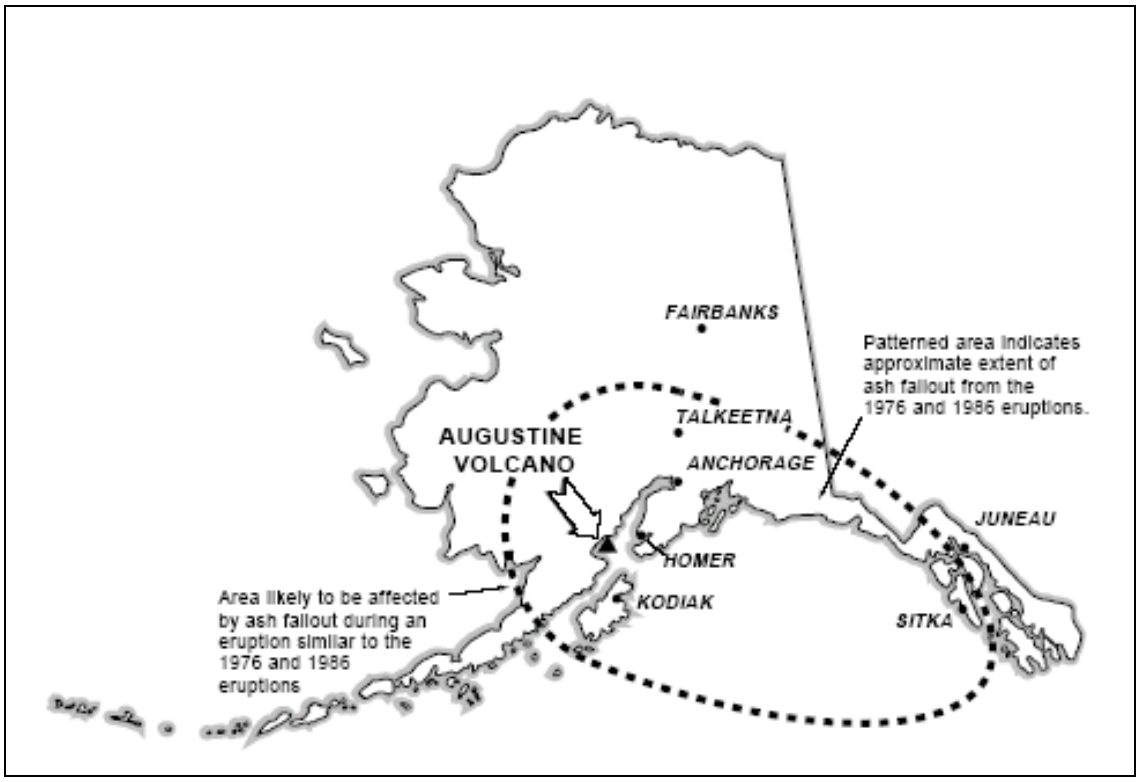


Figure 7-1. Area likely to be affected by ash fallout during a typical eruption of Augustine Volcano. Specific area of ash fallout depends on wind direction[1].

[1] Waythomas, C.F. and R.B. Waitt. 1998. Preliminary Volcano-Hazard Assessment For Augustine Volcano, Alaska. U.S. Geological Survey, Open File Report 98-106 [http://www.avo.alaska.edu/pdfs/augustine_ofr.pdf].

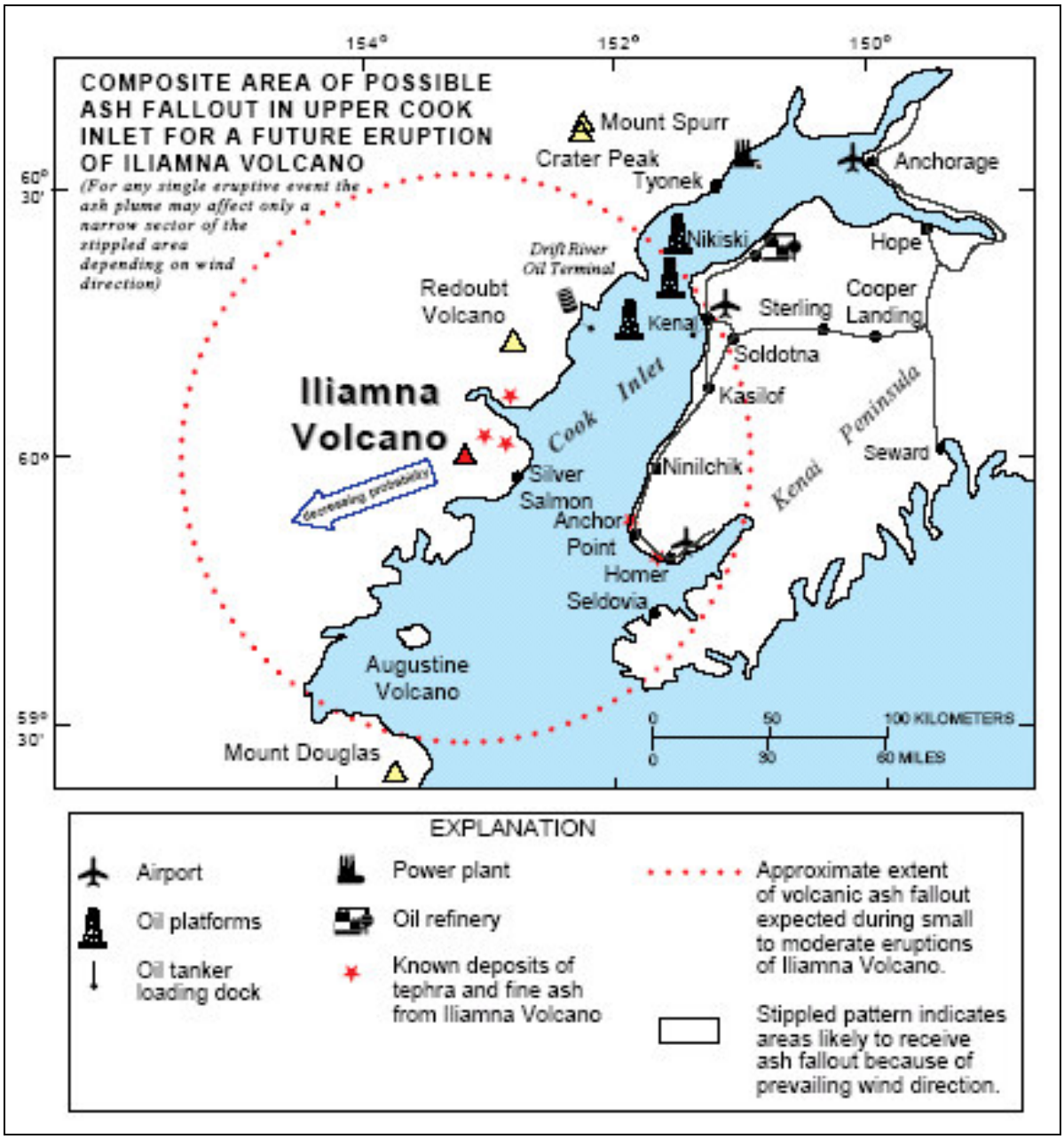


Figure 7-2. Approximate extent of volcanic ash fallout for small to moderate eruptions of Iliamna Volcano[1].

[1] Waythomas, C.F. and T.P Miller. 1999. Preliminary Volcano-Hazard Assessment For Iliamna Volcano, Alaska. U.S. Geological Survey, Open File Report 99-373 [www.avo.alaska.edu/pdfs/Iliamna.Haz.OFR.99.373.pdf].

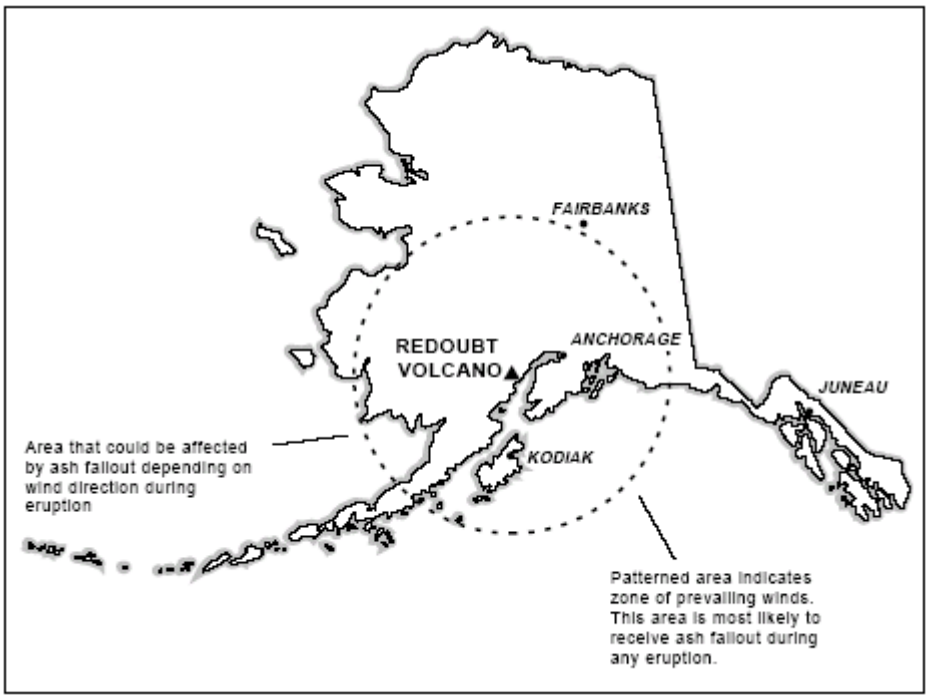


Figure 7-3. Area likely to be affected by volcanic ash fallout from eruptions similar to 1989-90 eruption of Redoubt Volcano[1].

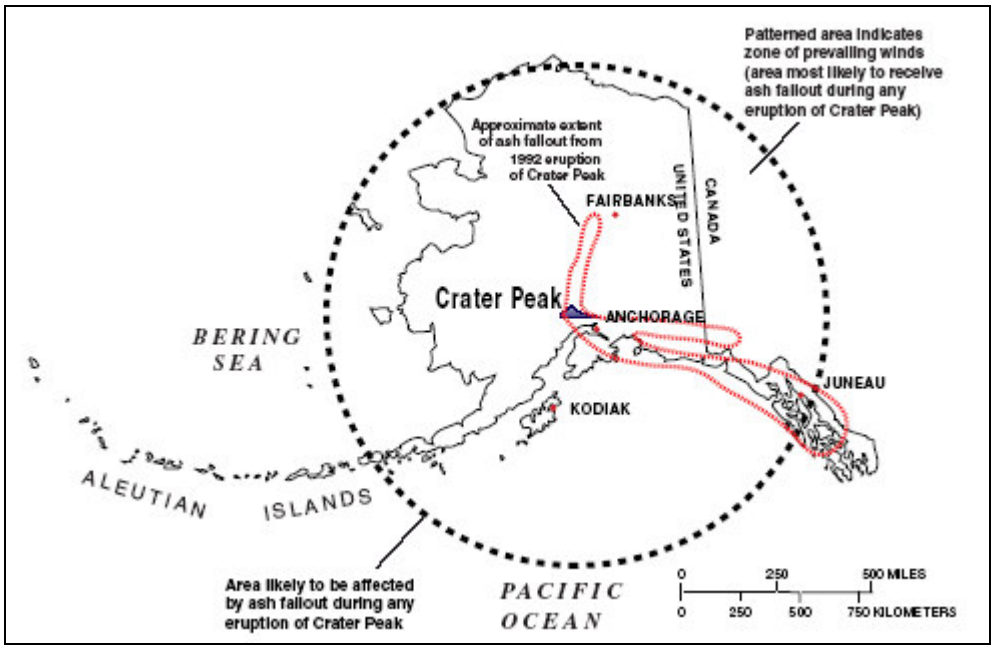


Figure 7-4. Areas most likely to receive ash fallout from future eruption of Crater Peak [a vent associated with Mount Spurr Volcano], given prevailing winds[1].

[1] Waythomas, C.F., J.M. Dorava, T.P Miller, C.A. Neal and R.G. McGimsey. 1998. Preliminary Volcano-Hazard Assessment for Redoubt Volcano, Alaska. U.S. Geological Survey, Open File Report 97-857 [www.avo.alaska.edu/pdfs/redoubt.hazards.ofr.pdf].

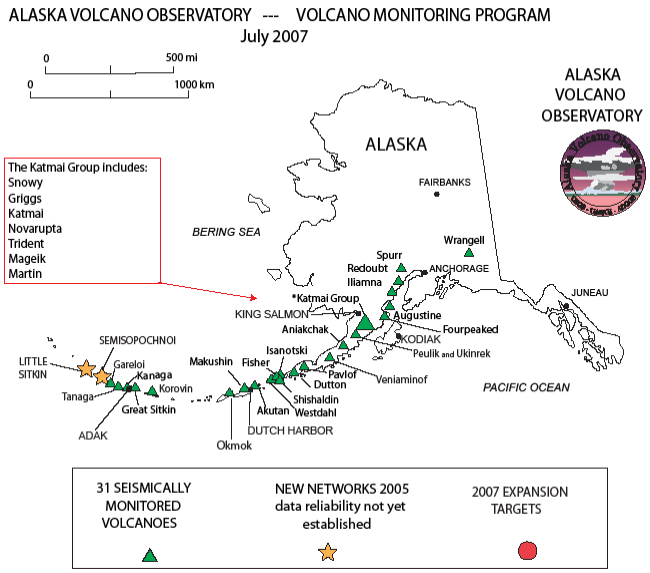
7.5 Existing Programs

Alaska Volcano Observatory[2]

The Alaska Volcano Observatory, a joint program of USGS, DNR/DGGS, and UAF/GI, is the State's principal agency with responsibility to assess, monitor, and issue early warning of volcanic activity and hazards in Alaska. AVO was formed in 1988, and uses federal, state and university resources to monitor and study Alaska's hazardous volcanoes, to predict and record eruptive activity, and to mitigate volcanic hazards to life and property.

As of February 2010, AVO maintains seismic monitoring networks on 27 of Alaska's 52 active volcanoes. Data from these networks are recorded 24 hours a day and examined for precursory signs of eruptive activity. Several times a day, AVO also examines satellite images of Alaskan, Kamchatkan and northern Kuril volcanoes for signs of eruptive activity or possible precursory heating of the ground. These two primary data streams are used routinely to assess the likelihood and character of volcanic activity. Additional monitoring methods such as space-based satellite radar interferometry, are under development.

AVO regularly disseminates information about the status of volcanoes in Alaska and neighboring Kamchatka. Each week, AVO distributes a written status report to federal, state and local agencies, the media and the public. Volcanic crises, or if precursors to eruptive activity are noted, AVO follows a rigid emergency call-down protocol, as well as using Internet and fax outlets to notify authorities, the media, the aviation industry, and the public.



1 Waythomas, C.F. and C.J. Nye. 2002. Preliminary Volcano-Hazard Assessment for Mount Spurr Volcano, Alaska. U.S. Geological Survey, Open File Report 01-482 [www.avo.alaska.edu/pdfs/of01-482.pdf].

2 Alaska Volcano Observatory website [www.avo.alaska.edu].

7.6 Hazard Mitigation Successes

Alaska Volcano Observatory

Since its formation 1988, AVO scientists have responded to numerous volcanic crises in Alaska, providing early warning for such explosive eruptive events at Redoubt (1989-90/2009) and Mt. Spurr (1992) and Augustine (2006). Advanced warning of eruptions and accurate analysis of data from seismic monitoring networks and satellite platforms prevents needless evacuations and economic impacts to the aviation industry. AVO staff works closely with Russian colleagues in Kamchatka to monitor, track and disseminate warnings of eruptions and ash clouds from volcanoes in the Russian Far East that may threaten Alaskan air space.

Interagency Plan for Volcanic Ash Episodes

In December 1989, a KLM flight 867 that encountered an ash cloud from Redoubt Volcano highlighted a serious weakness in the aviation and volcanic ash warning system. Following this incident, a consortia of federal, state and private sector parties worked to develop an improved early warning system and ash avoidance protocols for the heavily traveled North Pacific airways. In Alaska, this effort resulted in the growth and increased capacity of the AVO and formal adoption of a Alaska Interagency Plan for Volcanic Ash Episodes (signatories include USGS, NOAA/NWS, Federal Aviation Administration (FAA), Department of Defense (DOD) /United States Air Force (USAF), and DHS&EM. An updated plan was adopted in April 2004, with the United State Coast Guard and the Alaska Volcano Observatory as additional participants. The plan documents specific responsibilities and protocols for each agency before, during, and after a volcanic event. Since the 1989 KLM ash encounter, no serious ash-aircraft incidents have been reported in Alaska, despite dozens of additional eruptions. This multi-agency early warning and response program is a model endorsed by the International Civil Aviation Organization and emulated in many volcanically active regions around the world.

7.7 Volcano Mitigation Goals

Below are hazard mitigation goals and objectives taken from the State of Alaska October 2007 All-Hazard Mitigation Plan[1]. KPB-specific volcano mitigation goals will be developed in the next KPB All-Hazard Mitigation Plan update.

Goal 1: Public Education

Mitigation Measures: Educational

Priority: Medium

Objective: 1.1 Conduct specific outreach to the Alaskan aviation community regarding the hazards posed by volcanoes.

[1] Alaska Division of Homeland Security and Emergency Management (ADHSEM). 2007. State Hazard Mitigation Plan.

Lead Agency: AVO
Support Agencies: DHS&EM, FAA, NWS, Alaska Air Carriers Association
Time Frame: Ongoing

Action 1.1.1: Revise the fact sheet on Volcano Hazards and Aviation Safety.

Lead Agency: AVO
Support Agencies: DHS&EM, FAA, NWS, Alaska Air Carriers Association

Action 1.1.2: Develop a fact sheet about mitigating the risk to aviation from Kamchatkan volcanoes.

Lead Agency: AVO
Support Agencies: DHS&EM, FAA, NWS, Alaska Air Carriers Association

Objective 1.2: Ensure all Alaskan communities at risk from volcanic eruptions are aware of the hazard and what can be done to mitigate risk.

Lead Agency: DHS&EM, AVO
Support Agencies: USGS, DNR/DGGS, UAF/GI, ARC, DEC, Alaska Public Lands Information Center, local jurisdictions, Native corporations
Time Frame: Ongoing

Action 1.2.1: Distribute free USGS literature on volcano hazards.

Lead Agency: AVO
Support Agencies: USGS
Time Frame: Ongoing

Goal 2: Increase planning for volcanic hazards

Mitigation Measures: Educational; Preventative

Priority: Medium

Objective 2.1: Ensure volcanic hazards are addressed in the ongoing revision of the State Emergency Response Plan.

Lead Agency: DHS&EM
Support Agencies: AVO, USGS, DNR/DGGS, UAF/GI
Time Frame: Ongoing

Action 2.1.1: Revise State ERP[1]

Lead Agency: DHS&EM
Support Agencies: All Agencies

[1] Submitted to the Governor for promulgation summer 2004.

Goal 3: Improve monitoring

Mitigation Measures: Educational; Preventative

Priority: Medium

Objective 3.1: Expand real time seismic monitoring to high-priority western Aleutian volcanoes.

Lead Agency: AVO
Support Agencies: USFWS, DOD
Time Frame: Ongoing (in progress)

Action 3.1.1: Install monitoring equipment on selected volcanoes

Lead: AVO
Timeline: Ongoing

7.8 Volcano Resource Directory

Alaska Department of Environmental Conservation, Division of Air Quality

The Division of Air Quality, Air Monitoring & Quality Assurance Program operates and oversees air quality monitoring networks throughout Alaska.

Contact: Division of Air Quality, Alaska Dept. of Environmental Quality
Address: 619 E. Ship Creek, Ste. 249, Anchorage, AK 99501
Phone: (907) 269-6249
Website: www.dec.state.ak.us/air/am/aq_sr.htm

Alaska Volcano Observatory

The Alaska Volcano Observatory (AVO) is a joint program of the United States Geological Survey (USGS), the Geophysical Institute of the University of Alaska Fairbanks (UAFGI), and the State of Alaska Division of Geological and Geophysical Surveys (ADGGS).

Contact: Alaska Volcano Observatory
Address: 4200 University Drive, Anchorage, AK 99508
Phone: (907) 786-7497
Email: avo_sci@usgs.gov
Website: www.avo.alaska.edu

American Red Cross

The American Red Cross is a volunteer humanitarian organization, which provides relief to disaster victims and helps people prevent, prepare for, and respond to emergencies.

Contact: American Red Cross
Address: 235 E. 8th Avenue, Anchorage, AK 99501
Phone: (907) 646-5401
Website: alaska.redcross.org

National Weather Service, Alaska Region Headquarters

The National Weather Service provides information on wind and weather patterns and ashfall predictions in the event of an eruption.

Contact: Alaska Region Headquarters
Address: 222 West 7th Ave, #23, Anchorage, AK 99513-7575
Phone: 907-271-5088
Fax: 907-271-3711
Website: pafc.arh.noaa.gov/volcano.php

National Weather Service, Anchorage Center Weather Service Unit

The Anchorage CWSU supports Air Traffic Managers at the Anchorage Center through verbal briefings and written warnings. Center Weather Advisories (CWA) are short-term warnings, valid for zero to 2 hours, of hazardous weather conditions provided to all aviation interests including private pilots, towers, flight service stations, and commercial airlines.

Contact: CenterWeather Service Unit
Address: 700 North Boniface Parkway, Anchorage, AK 99506
Phone: 907- 338-1010
Fax: 907- 338-1510
Website: cwsu.arh.noaa.gov

NOAA Air Resource Laboratory

The National Oceanic and Atmospheric Administration Air Resource Laboratory provides ashfall trajectory forecasts for several Alaska volcanoes.

Contact: NOAA Air Resource Laboratory
Address: Silver Spring Metro Center #3, Rm. 3316, 1315 East West Highway, Silver Spring, Maryland 20910
Phone: (301) 713-0295
Website: ready.arl.noaa.gov/READY_traj_alaska.php

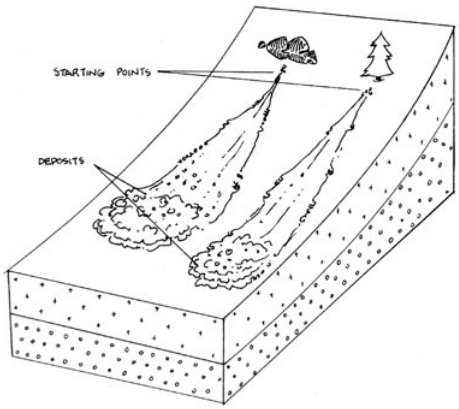
8.0 Snow Avalanches

The following hazard description is derived from the Alaska Division of Homeland Security and Emergency Management's All-Hazard Mitigation Plan (October 2007), although the text was edited slightly to focus on avalanche potential to impact KPB communities. The State Plan is available at www.ak-prepared.com/plans/mitigation/mitigationplan.htm.

Many snow avalanches occur in Alaska every year. The exact number is undeterminable, as most occur in isolated areas and are unreported. Avalanches tend to occur repeatedly in localized areas and can shear off trees, cover communities and transportation routes, destroy buildings and cause death. Alaska leads the nation in avalanche accidents per capita.

Avalanches cause two primary hazards: road blocks and death or significant injury. Fatalities are the best-documented impact related to avalanches and are significant simply because of the nature of the hazard. Furthermore, there are costs associated with search and rescue efforts and removal of the injured or deceased.

Road blocks are another major concern where roads intersect an avalanche path. The major costs associated with road blocks are snow removal and traffic diversion, which both necessitate personnel and equipment. Another less frequent issue is the costs associated with rescuing motorists if they were involved in the avalanche. Because the Kenai Peninsula is connected to Anchorage and the rest of the state by a single highway and rail line, avalanches blocking either can effectively isolate the Peninsula.



Loose Snow Avalanche
Image courtesy of the Canadian Avalanche Association

8.1 Hazard Analysis/Characterization

A snow avalanche is a swift, downhill-moving snow mass. Damage extent is related to avalanche type, composition and consistency of the material in the avalanche, the volume of snow and debris involved, force and velocity of the flow, and the avalanche path.

8.1.1. Avalanche Types

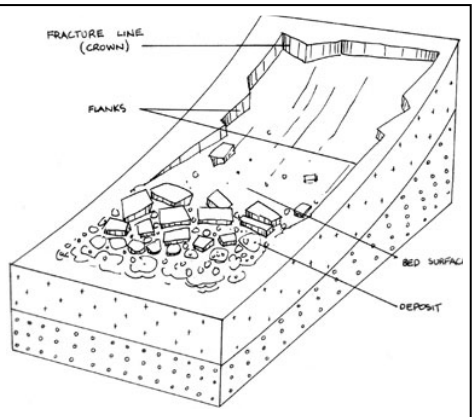
There are two main types of snow avalanches: loose snow and slab. Other types that occur in Alaska include cornice collapse, ice and slush avalanches.

Loose snow avalanches
Loose snow avalanches, sometimes called point releases, generally occur when a small amount of non-cohesive snow slips and causes more non-cohesive snow to go downhill. They occur frequently as small local cold dry 'sloughs' which remove excess snow (involving just the upper layers of snow) keeping the upper slopes relatively safe. However they can also be large and destructive. For example, wet loose snow avalanches occur in the spring and are very damaging. Loose snow avalanches can also trigger slab avalanches.

Loose snow avalanches typically occur on slopes greater than 35 degrees, leaving behind an inverted V-shaped scar. They are often caused by snow overloading (common during or just after a snowstorm), vibration or warming (triggered by rain, rising temperatures or solar radiation).

Slab Avalanches
Slab avalanches are the most dangerous types of avalanches. They happen when a mass of snow breaks away from and travels down the mountainside. As it moves, the slab breaks up into smaller cohesive blocks.

Slab avalanches usually require structural weaknesses within interfacing layers of the snowpack. The weakness exists when a relatively strong, cohesive snow layer overlies weaker snow or is not well bonded to the underlying layer. The weaknesses are caused by changes in the thickness and type of snow covers due to changes in temperature or multiple snowfalls. The interface fails for several reasons. It can fail naturally by earthquakes, blizzards, temperature changes or other seismic and climatic causes, or artificially by human activity. Slab releases accelerate, gaining speed and mass as they travel downhill.



Slab Avalanche
Image courtesy of the Canadian Avalanche Association

The slab margin is defined by fractures. The uppermost fracture delineating the top line of the slab is termed the "crown surface", the area above that is called the crown. The slab sides are called the flanks. The lower fracture indicating the base of the slab is called the "stauchwall". The surface the slab slides over is called the "bed surface". Slabs can range in thickness from less than an inch to 35 feet or greater.

Cornice Collapse
A cornice is an overhanging snow mass formed by wind blowing snow over a ridge crest or the sides of a gulley. The cornice can break off and trigger bigger snow avalanches when it hits the wind-loaded snow pillow.

Ice Fall Avalanche
Ice fall avalanches result from the sudden falling of broken glacier ice down a steep slope. They can be unpredictable as it is hard to know when ice falls are imminent. Despite what some people think, they are unrelated to temperature, time of day or other typical avalanche factors.

Slush Avalanches
Slush avalanches occur mostly in high latitudes such as in the Brooks Range of Alaska. They have also occurred in the mountain areas of the Seward Peninsula and occasionally in the Talkeetna Mountains near Anchorage. They are more common in high latitudes because of rapid snowmelt in the spring. Slush avalanches can start on slopes from 5 to 40 degrees but usually not on slopes greater than 25 to 30 degrees. The snowpack is totally or partially water saturated. The release bed surface is nearly impermeable to water. It is also commonly associated with heavy rainfall or sudden intense snowmelt. Additionally, depth hoar is usually present at the base of the snow cover. Slush avalanches can travel slowly or reach speeds over 40 miles per hour. Their depth is variable as well, ranging from one foot to over 50 feet deep.

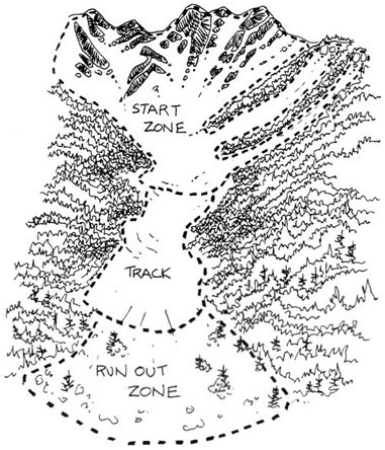
8.1.2. Avalanche Terrain Factors
There are several factors that influence avalanche conditions, with the main ones being slope angle, slope aspect and terrain roughness. Other factors include slope shape, vegetation cover, elevation, and path history. Avalanches usually occur on slopes greater than 25 degrees. There usually is not enough stress on the snowpack to get it to slide when the slope angle is less than 25 degrees. The snow tends to slough off and does not have the opportunity to accumulate when greater than 60 degrees. Avalanches can occur outside this slope angle range, but are not as common.

Slope aspect, also termed orientation, describes the direction a slope faces with respect to the wind and sun. Leeward slopes loaded by wind-transported snow are problematic because the wind-deposited snow increases the stress and enhances slab formation. Intense direct sunlight, primarily during the spring months, can weaken and lubricate the bonds between the snow grains, weakening the snowpack. Shaded slopes are potentially more unstable because the weak layers are held for a longer time in an unstable state.

Terrain and vegetation influence snow avalanches because trees, rocks, and general roughness act as anchors, holding snow in place. However, once an anchor is buried by snow, it loses its effectiveness. Anchors make avalanches less likely but do not prevent them unless the anchors are so close together that a person could not travel between them.

Avalanche Path
The local terrain features determine an avalanche's path. The path has three parts: the starting zone, the track and the run-out zone.

The starting zone is where the snow breaks loose and starts sliding. It is generally near the top of a canyon, bowl, ridge, etc., with steep slopes between 25 and 50 degrees. Snowfall is usually significant in this area.



Avalanche path
Image courtesy of the Canadian Avalanche Association.

The track is the path taken or created by an avalanche. The track has milder slopes, between 15 and 30 degrees, but this is where the snow avalanche will reach maximum velocity and mass. Tracks can branch, creating successive runs that increase the threat, especially when multiple releases share a run-out zone.

The run-out zone is a flatter area (around 5 to 15 degrees) at the path base where the avalanche slows down, resulting in snow and debris deposition.

The impact pressure determines the amount of damage caused by a snow avalanche. The impact pressure is related to the density, volume (mass) and velocity of the avalanche.

8.2 Historical Avalanche Events

Alaska has a long history of snow avalanches. It has been estimated that there have been over 4,500 avalanche disaster events in the past 200 years. The Palm Sunday avalanche of April 3, 1898, is considered to be the deadliest event of the Klondike gold rush. Multiple slides occurred that day along the Chilkoot Trail near Skagway, including three with multiple fatalities. The first fatal slide killed three people. The second one killed the entire Chilkoot Railroad and Transportation Company crew who were trying to evacuate an avalanche-prone area further up the trail. The third slide occurred in about the same location as the second, killing approximately 70 people who were following the trail left by the construction crew. The exact death toll is unknown because of the transient nature of those involved and inefficiencies in the identification process.

In late 1999 and early 2000, avalanches occurred in Cordova, Valdez, Anchorage, Whittier, Cooper Landing, Moose Pass, Summit, Matanuska Susitna Valley, and Eklutna from the Central Gulf Coast Storm. The most damaging avalanche occurred in Cordova, near milepost 5.5 of the Copper River Highway, and was approximately ½ mile wide. It resulted in one death, at least ten damaged structures and about one million dollars in damage. Avalanches had struck in that spot before, including one in 1971.

Snow avalanches can occur in many area of the State. All major highways, railroads, and several towns face an avalanche danger. The following map shows the areas that face a snow avalanche threat.

8.3 Avalanche Hazard Areas on the Kenai Peninsula

Avalanches that can affect infrastructure are a hazard primarily in the East Zone of the Kenai Peninsula Borough. Although the Central and South Zones also have terrain where avalanches are possible, these slopes are generally away from roads and developed areas. One exception is the Sterling Highway near Cooper Landing.

Between March of 1999 and January of 2010, 14 people were killed in avalanches on the Kenai Peninsula, most commonly in the area around Turnagain Pass. Most were engaged in off-road recreation, but one was a railroad worker, working to clear the Seward Highway from an earlier avalanche, whose D6 Caterpillar was swept 400 feet off the road by a second avalanche.

Areas of high avalanche hazard along major roadways[1] include:

Mile 18 – 23 Seward Highway (Crown Point)
Mile 61 – 67 Seward Highway (Turnagain Pass)
Mile 28 – 39 Seward Highway (Moose Pass to just north of Tern Lake)
Mile 38 – 39 Sterling Highway (just west of Tern Lake)
Mile 1 – 4 Hope Highway
Mile 9 – 15 Hope Highway

Several areas of the Alaska Railroad tracks also run through avalanche terrain and are frequently impacted.

Although the eastern Kenai Peninsula is the most avalanche-prone, other areas have avalanche terrain as well. In December 2001, an avalanche in the Kenai National Wildlife Refuge near Skilak Glacier, approximately 30 miles south of Skilak Lake, killed at least 143 caribou. Although there is little infrastructure in the south-central part of the peninsula, the area is extremely popular for outdoor recreation, particularly snowmobiling.

[1] Kenai Peninsula Borough Coastal Management Plan 2008

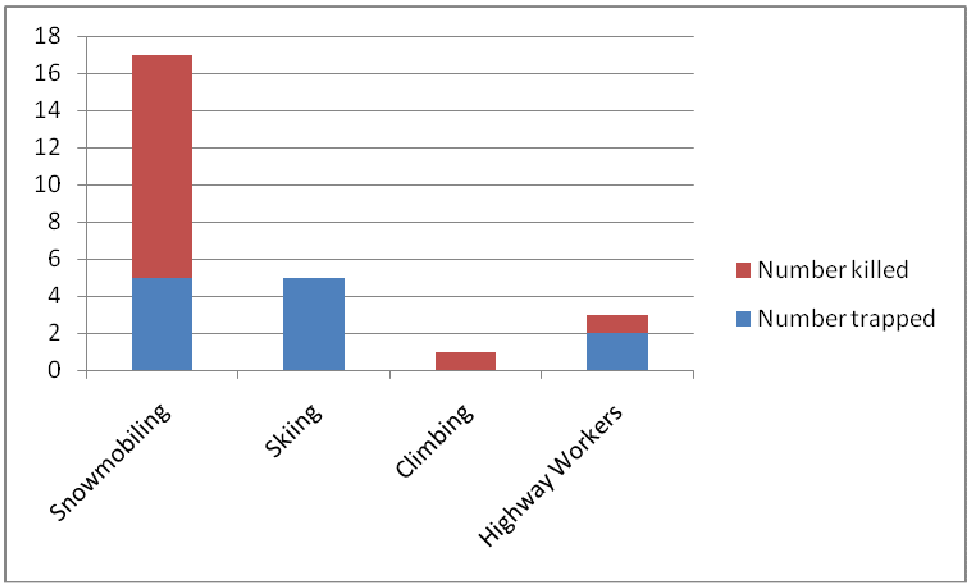


Figure 8-1. Number of People Killed and/or Trapped in Avalanches on the Kenai Peninsula Since 1999[1]

8.3.1. Significant Recent Avalanches on the Kenai Peninsula

A prolonged winter storm in late January and early February 2000 resulted in a series of avalanches that cut off the Kenai Peninsula for five days. On February 1, a snow slide killed a highway worker and the state closed mountainous areas of the Seward and Sterling Highway. Significant avalanches blocked the Seward Highway at Mile 23 and Mile 44. Power lines were damaged, resulting in the communities of Hope and Sunrise being without power, and the city of Seward operating on generator power, for several days. Hope, Sunrise, Moose Pass, Crown Point and Seward were cut off from road, rail and air access, and faced shortages of groceries and other supplies.

On February 9th, 2006, three avalanches closed the Seward Highway at Mile 21, Mile 33 and Mile 84. The road was reopened Feb. 10. The avalanche at Mile 21 trapped a car with two occupants (both were rescued) and buried the road under 18 feet of snow. On the same day, an avalanche near Hope cut off the town's power supply. The City of Seward was also cut off from its regular power supply and forced to operate on generator power. On February 11, another avalanche destroyed 2000 feet of power transmission and distribution line serving Seward and surrounding areas. The City of Seward estimated costs from the event at $1.06 million[2].

1 Chugach National Forest Avalanche Information Center, 2010
2 City of Seward, Declaration of Local Emergency Disaster Addendum Two, 3/6/2006

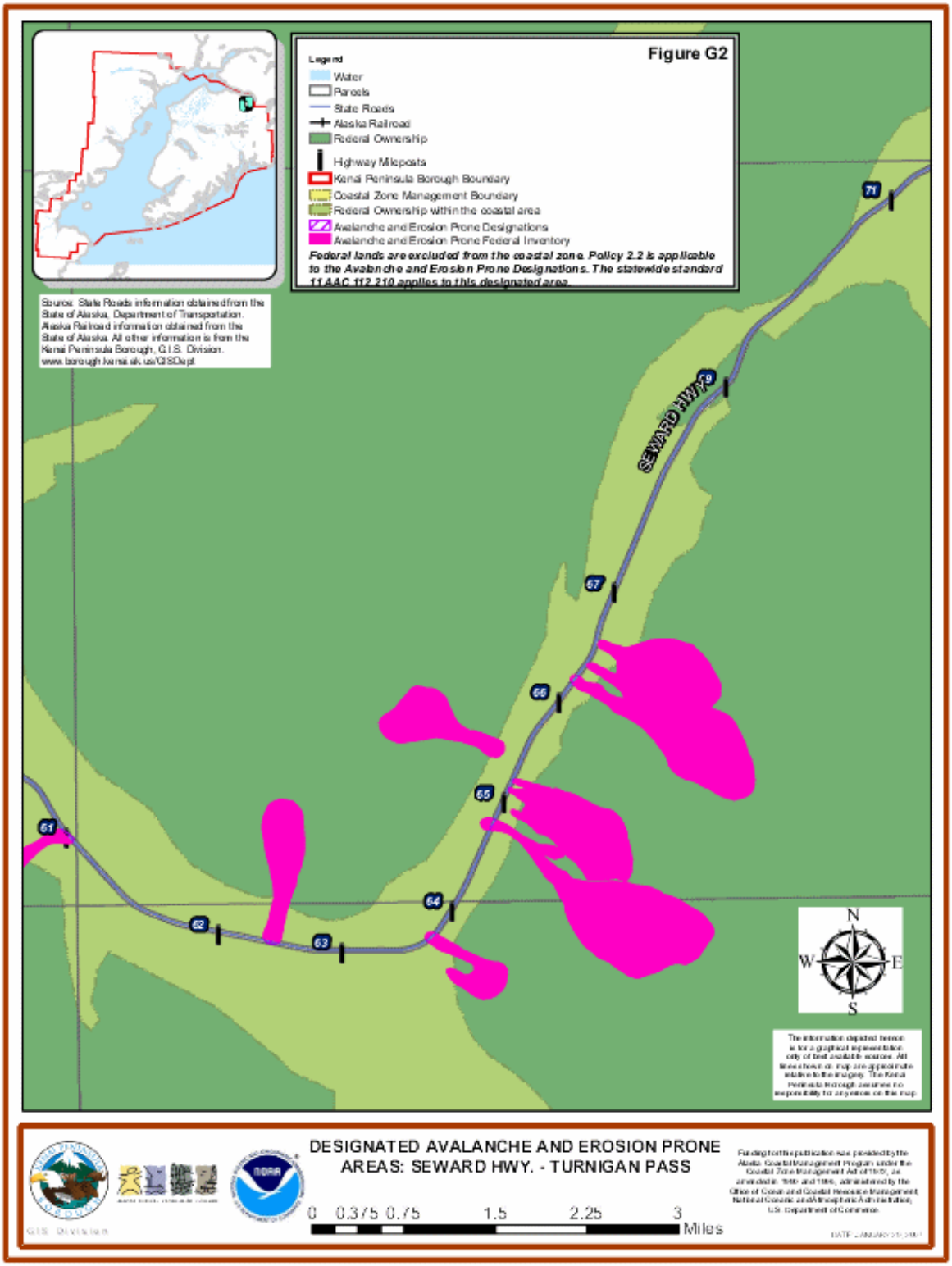


Figure 8-2. Avalanche Zones in Turnagain Pass, Seward Highway, Alaska

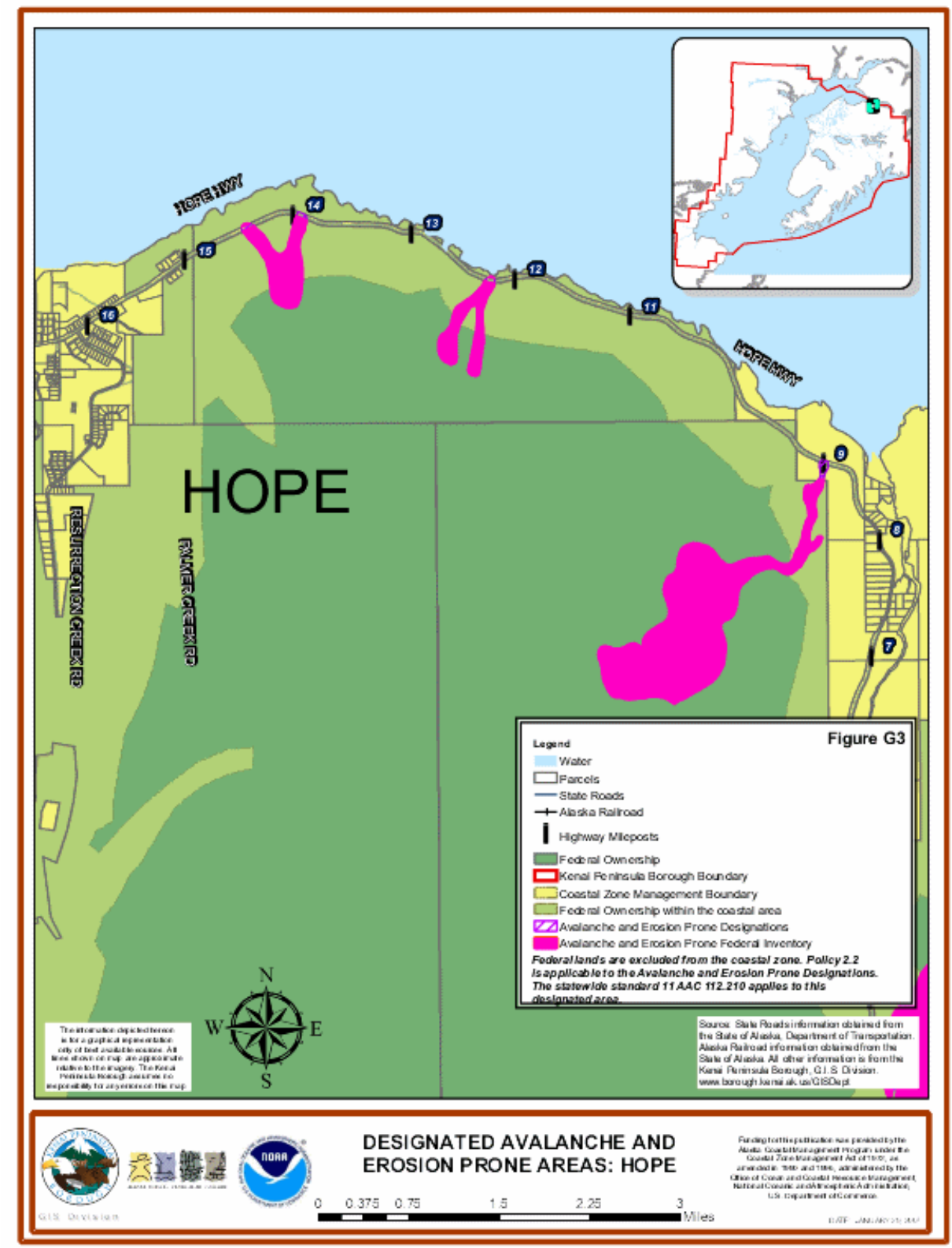


Figure 8-3. Avalanche Zones near Hope, Alaska

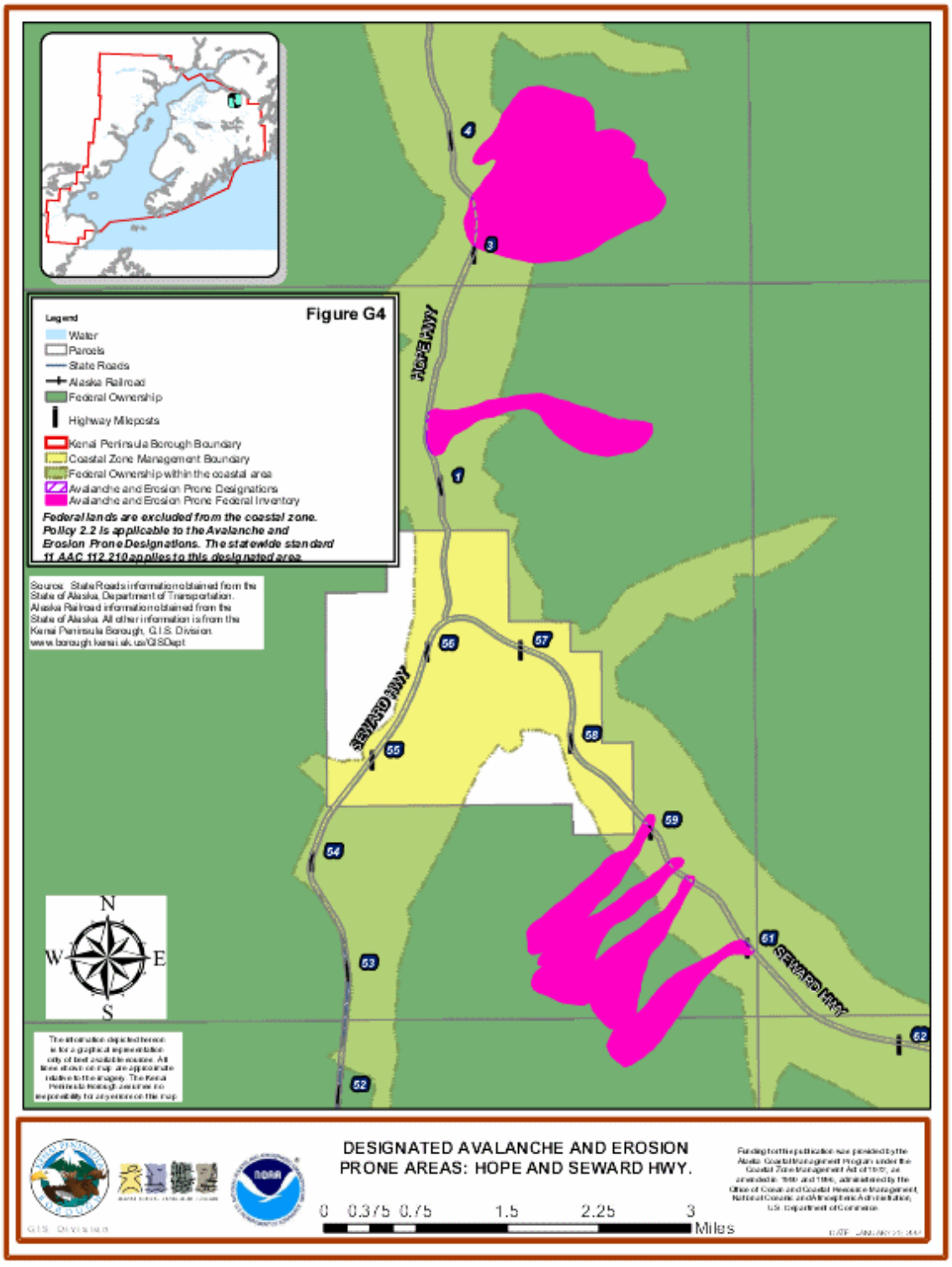


Figure 8-4. Avalanche Zones near Junction of Hope and Seward Highways, Alaska

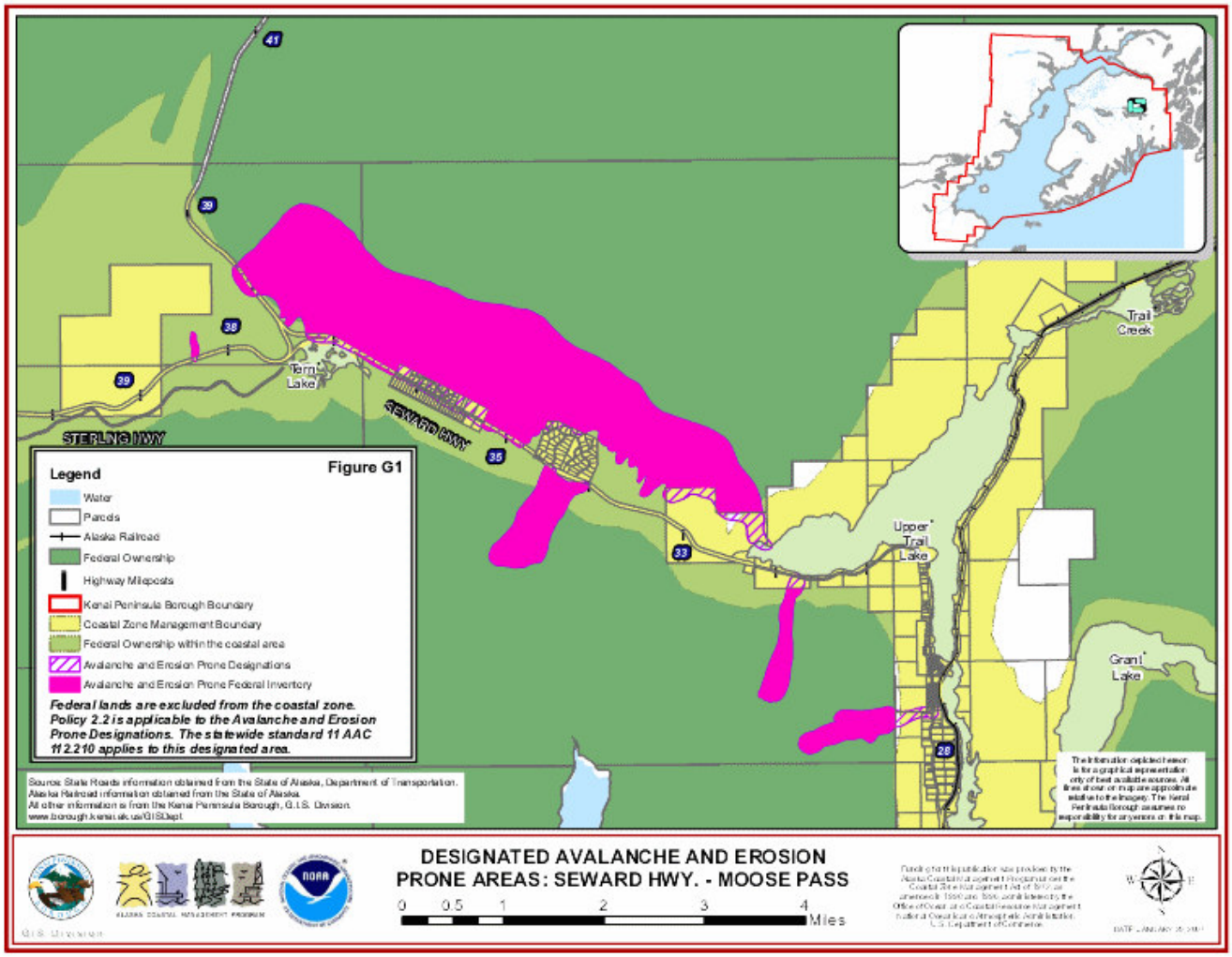


Figure 8-5. Avalanche Zones along the Seward Highway near Moose Pass, Alaska

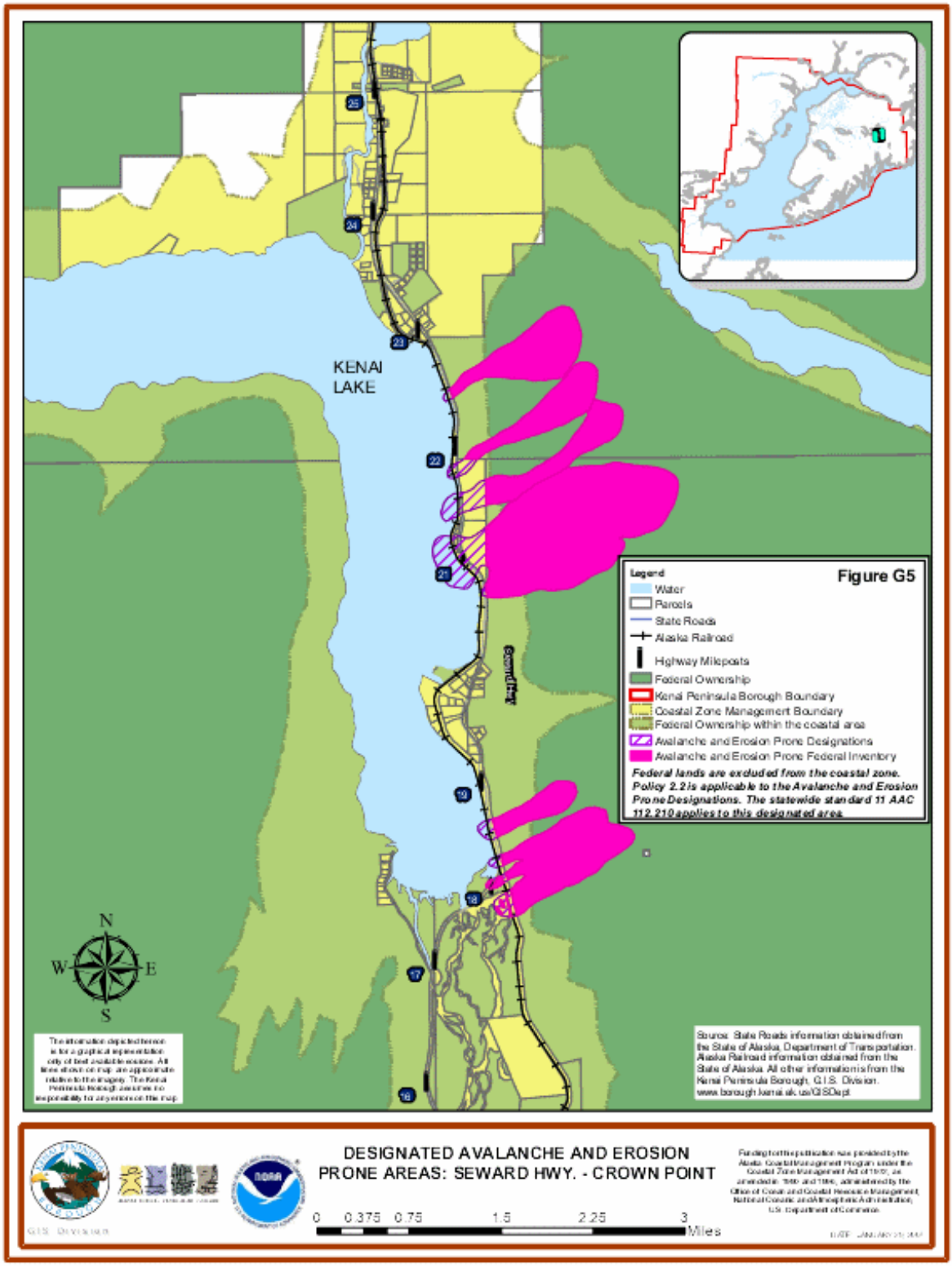


Figure 8-6. Avalanche Zones along the Seward Highway near Crown Point, Alaska

8.4. Existing Programs and Strategies

Avalanche Awareness Month
The Alaska State Legislature adopted, and the Governor signed, Senate Concurrent Resolution (SCR) 16 proclaiming the month of November as Avalanche Awareness Month. It urges further education on recognizing avalanche risks, response to avalanches, and using appropriate equipment in avalanche areas. It also urges schools, community groups, and other public and private agencies to increase public awareness.

Alaska Mountain Safety Center (AMSC)
The AMSC is a non-profit organization specializing in avalanche hazard evaluation, mitigation, forecasting, and education. The AMSC also operates the Alaska Avalanche School, which offers field-oriented classes on mountain safety training and avalanche hazard evaluation.

8.4.1. Hazard Mitigation Successes

Alaska Railroad Avalanche Program
The Alaska Railroad Avalanche Program is a three-year program to improve existing avalanche risk management tools and create new control systems. The program involves improving data acquisition and management, improving explosive delivery support, upgrading snow clearing and explosives-control equipment, constructing a central avalanche office and a secure gun storage facility in Girdwood.

Chugach Electric
Before Chugach Electric sends any of its maintenance crews to do work in a known avalanche area in the winter, it requires an avalanche assessment to ensure worker safety.

Alaska Department of Transportation and Public Facilities
ADOT&PF has identified and signposted stretches of the Seward and Sterling Highways that are in avalanche hazard zones. Signs mark both the beginning and end of each section, warning motorists not to stop within the zones in winter. There are also gates that can be lowered to block off sections of highway when danger is extreme and/or avalanche-clearing work is underway.

8.4.2. Avalanche Policies

Kenai Peninsula Borough 2008 Coastal Management Plan
In section G-2.4 of the “Enforceable Policies” section, the 2008 Coastal Management Plan reads, “Unless there are no practicable alternatives, new development should avoid designated natural hazard areas subject to landslide, mass wasting and avalanche hazards.”

Summary of local capabilities, goals and actions

Kenai Peninsula Borough
Capabilities: Using GIS technology, ordinance adoption for snow load and avalanche control measures.
Goals: Reducing vulnerability to avalanche hazards by prohibiting new construction in avalanche zones, buyout and relocation, harden existing structures for increased snow load capabilities, public education activities, and increase warning and forecasting capabilities.

Seward
Capabilities: Rescue capabilities for homes and automobiles. Heavy equipment for removal of snow and debris and access to avalanche probes from neighboring fire departments.
Goals: Public education, develop avalanche GIS mapping layers, develop avalanche program at Lowell Canyon that includes signs, designating safe parking zones, retaining wall and renovate tunnel access.

8.5 Snow Avalanche Mitigation Strategies and Implementation Ideas

Strategy 1: Reduce number of structures in high-hazard areas

Implementation Ideas and Action Items
Encourage relocating existing development from known avalanche areas. It is not a question of if an avalanche will strike these areas. It is only a question of when and whether people will be injured or killed and how much damage will result.

- Foreclosed property within high & moderate hazard areas should be kept in borough land base rather than re-sold.
- When possible, acquire private properties located in high-hazard areas
- Do not allow repairs/rebuilding of homes in high hazard areas if damage to home (from any cause) is more than 50% of the home's assessed value
- Do not allow expansion of homes in high hazard areas if expansion would allow for an increase in occupancy. In moderate hazard zones, develop building requirements designed to increase resistance to avalanche damage for all structures undergoing structural renovation/expansion.
- Limit development of property within high-hazard areas to uses/structures suitable for summer and shoulder-season use only, with grandfathered

- development rights for current property owners. Development ban would take effect when the property is sold. For properties where development is limited to prevent avalanche-season occupancy, re-assess property values to reflect limitations on use.

Potential Participants: KPB

Strategy 2: Increase awareness among property owners of avalanche hazard zones

Implementation Ideas and Action Items

- Add Geologic Hazard Layer to Kenai Peninsula Borough's on-line GIS mapping system
  Lead: KPB

- Send annual/semiannual mailers to property owners with high and moderate hazard areas, reminding them of the property classification, relevant borough codes and ordinances and giving suggested mitigation measures.

- Require all property sales disclosure documents to include notice of high avalanche hazard.

Potential Participants: KPB

Strategy 3: Encourage communities to develop avalanche overlay zones.
Development of these zones would provide several benefits, for example: communities could require building to a more stringent standard to ensure structures would be able to withstand potential avalanches or to allow recreational or building use during non-avalanche season.

Implementation Ideas and Action Items

- Complete avalanche area GIS mapping

Potential Participants: KPB, DHS&EM

Strategy 4: Improve avalanche warning.

Implementation Ideas and Action Items

- Add avalanche conditions and warnings to the ADOT&PF 511 road condition phone recording and website. This activity would provide travelers with information about avalanche risks and avalanche forecasts along major travel routes.

Potential Participants: Chugach National Forest Avalanche Information Center, Alaska Avalanche Information Center, DOT&PF, NWS

Strategy 5: Promote avalanche education.

Education is the best way to reduce fatalities, injuries, and property damage from avalanches. Residents, recreational enthusiasts, elected officials and others need to be aware of the dangers associated with avalanches and how to avoid them.

Implementation Ideas and Action Items

- Host workshops in communities and schools to teach avalanche awareness.

- Encourage avalanche safety training for snow machine riders. Snow machines frequently trigger avalanches with deadly consequences. Training programs to teach people how to identify high-risk conditions and what to do if they are caught in an avalanche could save numerous lives annually.

- Conduct voluntary avalanche safety courses and encourage manufacturers and vendors to distribute avalanche awareness videos with their products.

Potential Participants: Alaska Avalanche School, Alaska Avalanche Information Center, Kenai Peninsula Borough, Alaska State Parks, DNR, USFS Chugach National Forest

Time Frame: on-going

Strategy 6: Encourage artificial avalanche release and snow management.

Implementation Ideas and Action Items

- Promote using artificial release and avalanche control measures to include: pre-positioning avalanche release equipment and deflection structures in existing developed avalanche prone areas.

- Identify avalanche areas for artificial release.
  Lead: DPS
  Support: DHS&EM, DOT&PF, DNR
  Timeline: on-going (No funding source is identified to date)

8.6 Snow Avalanche Resource Directory

Alaska Avalanche Information Center

The mission of the Alaska Avalanche Information Center is to provide public avalanche forecasts, education and the exchange of snow stability observations for Alaska.

Contact: Alaska Avalanche Information Center
Address: PO Box 2988, Valdez, AK 99686
Phone: (907) 835-4488
Website: www.alaskasnow.org/home

Alaska Avalanche Specialists

Alaska Avalanche Specialists is a Juneau, Alaska-based firm that specializes in all phases of avalanche work, including consulting, planning, training, artificial release and structural mitigation, research, risk analysis, mapping, and management.

Contact: Alaska Avalanche Specialists
Address: PO Box 22316, Juneau, AK 99802-2316
Phone: (907) 523-8900
Website: akavalanches.com/index.html

Alaska Avalanche School

The mission of the Alaska Avalanche School is to promote safety in and around the mountain environment through education, research, publishing, and consulting.

Contact: Alaska Avalanche School, Inc.
Address: PO Box 100145, Anchorage, AK 99510-0145
Phone: (907) 345-0878
Website: www.alaskaavalanche.com/Site/Homepage.html

American Red Cross

The American Red Cross is a volunteer humanitarian organization, which provides relief to disaster victims and helps people prevent, prepare for, and respond to emergencies.

Contact: American Red Cross
Address: 235 E. 8th Avenue, Anchorage, AK 99501
Phone: (907) 646-5401
Website: alaska.redcross.org

Chugach National Forest Avalanche Information Center

The mission of the Chugach National Forest Avalanche Information Center is to increase public awareness in the Turnagain area through advisories and public education. Forecasts are updated seven days a week.

Contact: CNFAIC
Address: PO Box 129, Girdwood, AK 99587
Phone: (907) 754-2346
Website: www.cnfaic.org

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9.0 Human-Caused Hazards

Although much of the focus of hazard mitigation is on natural hazards such as earthquakes and floods, there are also hazards that are human-caused. For the purpose of this Plan, "human-caused hazards" are technological hazards. These are distinct from natural hazards primarily in that they originate from human activity. In contrast, while the risks presented by natural hazards may be increased or decreased as a result of human activity, they are not inherently human-induced.

The term "technological hazards" refers to the origins of incidents that can arise from human activities such as the manufacture, transportation, storage, and use of hazardous materials. For the sake of simplicity, this Plan assumes that technological emergencies are accidental and that their consequences are unintended. On the Kenai Peninsula, some of these human-created hazards include sudden flooding due to potential dam and water diversion breaches and hazards related to the storage, use and transportation of hazardous materials.

9.1 Hazards By Zone

Table 9-1. Examples of Facilities Posing Potential Hazards – North Zone

Facility	Operator	Hazard Type
Fertilizer Plant*	Agrium Kenai Nitrogen Operations	chemical
Natural Gas Liquefaction	ConocoPhillips Alaska, Inc.	chemical
Refinery	Tesoro Alaska Co.	chemical
Gas Fields, Production Facility	Marathon Alaska Production LLC	chemical
Oil Platforms and Storage	Union Oil Co. of California (Chevron)	chemical
Gas To Liquids Plant*	BP Exploration	chemical
Municipal Airport	City of Kenai	aviation fuel

* Currently being decommissioned

Table 9-2. Examples of Facilities Posing Potential Hazards – Central Zone

Facility	Operator	Hazard Type
Sterling Gas Field	Marathon Alaska Production LLC	chemical
Swanson River Oil Field	Union Oil Co. of California (Chevron)	chemical
Municipal Airport	City of Soldotna	aviation fuel
Cooper Lake Dam	Chugach Electric Association	flooding

Table 9-3. Examples of Facilities Posing Potential Hazards – East Zone

Facility	Operator	Hazard Type
Seafood Plants	Polar Seafoods, Icicle Seafoods	chemical
Coal Loading Facility	Alaska Railroad Corporation	air quality
Ship Repair Facility	Seward Ship's DryDock	air quality
Chemical Transfer Area	ConocoPhillips Alaska, Inc.	chemical
Diversion Levees and Tunnel	City of Seward	flooding
Municipal Airport	City of Seward	aviation fuel

Table 9-4. Examples of Facilities Posing Potential Hazards – South Zone

Facility	Operator	Hazard Type
Ninilchik Gas Fields	Marathon Alaska Production LLC	chemical
Seafood Plant	Icicle Seafoods	chemical
Municipal Airport	City of Homer	aviation fuel

9.2 SUDDEN FLOODING

9.2.1. Sudden Flooding Hazards

Although there are few dams on the Kenai Peninsula, there are a few structures that could pose a threat to human safety and infrastructure in the case of failure.

Cooper Lake Dam – Central Zone

Cooper Lake Dam is located near Cooper Landing. This rock-and-fill structure at the outlet of 3000-acre Cooper Creek is a hydroelectric dam owned by Chugach Electric Association. The dam was originally licensed in 1957, completed in 1959 and relicensed in 2007 (to expire in 2057). The dam has a storage capacity of approximately 127,000 acre-feet of water from the dam base to the dam crest.[1] Cooper Creek joins the Kenai River at approximately mile 50.5 of the Sterling Highway, just west of the outlet of Kenai Lake. This means that any outburst from Cooper Lake would generally follow the Kenai River, adjacent to the Sterling Highway, until Mile 58 where the Kenai turns south of the highway and flows toward Skilak Lake. Skilak Lake would act as a buffer to slow the release of floodwaters. Nonetheless, flooding would be expected downstream all the way to the mouth of the Kenai River, as well as upstream to the mouth of Kenai Lake. The first approximately five miles of the Kenai downstream from the mouth of Skilak Lake are part of the Kenai National Wildlife Refuge and are thus undeveloped. From the refuge boundary downstream, however, development is fairly heavy, with both seasonal and year-round residences and commercial development. Flood levels from a dam failure could surpass the 1% flood event level.

[1] Chugach Electric Association, Cooper Lake Hydroelectric Project Emergency Action Plan, December 2009

Table 9-5. Possible Flood Levels from a Failure of Cooper Lake Dam[1]

Location	Estimated Time to Wave Front	Max. Elevation Above Normal
Kenai RM 0	3 hours 6 minutes	12.5’
Kenai RM 3.0	2 hours 36 minutes	25.7’
Kenai RM 7 (Russian River)	3 hours 6 minutes	29.7’
Kenai RM 12	5 hours 36 minutes	34.5’
RM 13.25	5 hours 36 minutes	47.3

Lowell Creek Diversion Tunnel and Dam – East Zone

Lowell Creek is a glacier-fed stream that runs three miles through a talus strewn canyon above Seward and then used to flow over an alluvial fan on which Seward’s original town site was built. The stream channel through the canyon is prone to landslides and avalanches that dam the stream and can lead to surge-release type flooding. The volume and velocity of Lowell Creek is powerful enough during flood events to pick up large boulders and huge amounts of sediment and carry them downstream.

Much of Seward’s critical infrastructure, including the hospital, police station, fire station and city hall, is located within this alluvial fan area, as well as businesses, homes and a senior citizen housing structure. The creek currently is diverted from its original path by a dam and diversion tunnel built by the US Army Corps of Engineers. The dam is located just inside the mouth of Lowell Canyon and is 400 feet long and 25 feet high. The uncontrolled spillway is about 400 feet long with a sharp drop at the tunnel entrance to increase the velocity of the water enough to ensure that all debris will pass into and through the tunnel. From the dam, the waters of Lowell Creek are funneled through a diversion tunnel 2,068 feet long and 10 feet in diameter through Bear Mountain and into Resurrection Bay via a spillway above Lowell Point Bridge at the southern edge of the city. A 40-foot-long emergency spillway was originally designed to direct flood waters into the old creek bed through the center of town but that outlet no longer exists as this area has been fully developed.

The history of Lowell Creek flooding since 1940 has been one of repeated and expensive repairs to the tunnel and intake system and near disaster in 1966 and 1986 due to blockage of the tunnel during major flood events. The tunnel has deteriorated due to debris abrasion. The railroad rails armoring the tunnel’s floor have been torn out through the years and the floor has periodically eroded to bedrock.

[1] Chugach Electric Association, Cooper Lake Hydroelectric Project Emergency Action Plan, December 2009

Japanese Creek Levee – East Zone
Following several flood events, Japanese Creek Levee was constructed in 1986, rebuilt in 2001 and underwent a major renovation in 2007. Infrastructure at risk on the Japanese Creek alluvial fan includes all three Seward schools, Seward Sanitary Landfill, major businesses, the Seward Military Resort and several highly developed subdivisions. In 2007 the City of Seward chose a tract of land also in the risk area on which to build the future Seward Long Term Care Facility. Currently there is only one access and evacuation route to this highly populated area.

Fourth of July Creek Levee – East Zone
Fourth of July Creek is located on the east side of Resurrection Bay and is known for continuously shifting its channels. Fourth of July Creek and its tributaries have created a segmented alluvial fan on which has been constructed commercial and industrial facilities and the $80 million dollar Spring Creek Correctional Facility, a maximum security state prison. In 2007, further development of the Seward Marine Industrial Complex was approved by the Seward City Council as well as a project to add on to Spring Creek Correctional Institution.

Flood control levees were constructed in 1982 to protect the infrastructure and development on the alluvial fan. However, flood events in 1982, 1986 and 1989 caused extensive damage to these levees. Failure of the Fourth of July Creek dike would result in considerable damage to public and private infrastructure, including the Spring Creek Correctional Center, the City of Seward's water supply and the Seward Marine Industrial Center.

9.2.2. Levee and Dam Failure Mitigation Strategies

Strategy 1: Promote public awareness of potential hazards associated with dam and levee failure.

Implementation Actions

- Cooperate with residents, industry and state and federal agencies through the Office of Emergency Management and the Local Emergency Planning Committee to develop and disseminate information about areas in danger of flooding from levee or dam failure.

Strategy 2: Decrease possibility of levee or dam failure

Implementation Actions

- Support efforts by City of Seward and other responsible parties to procure funding for ongoing maintenance of water retention and diversion structures.

Strategy 3: Limit hazards to health and safety in case of dam or levee failure

Implementation Actions

- Prepare contingency plans for sudden flood events, including public notification plans, evacuation routes and emergency shelters

9.3. HAZARDOUS MATERIAL RELEASE

9.3.1. Nature of the Hazard

Because of their chemical, physical, or biological nature, hazardous materials can pose a potential risk to health and safety, property, and the environment. In addition, many chemicals that are not categorized as hazardous can adversely affect human health and safety and the environment if spilled or otherwise released in sufficient quantities. Precautions against spills and releases, plus quick response, containment, and cleanup, are key to limiting the hazardous materials and chemical hazard.

Given its vast acreage and potential resources, the Borough is still relatively lightly developed and populated. Large parts of the Borough remain largely free from the environmental contamination associated with urban and industrial areas. However, there are sites in the Borough with contamination from waste spills or unsafe disposal.

Sources of Pollution and Impacts

Even though it is lightly populated, the Kenai Peninsula Borough ranks as one of the most industrialized parts of Alaska, with many onshore and offshore oil and gas fields, a petroleum refinery, liquid natural gas plant and numerous seafood processing plants. These industries, as well as various activities of private individuals, generate or use an assortment of toxic and hazardous substances, which are sometimes released into the environment through emissions, spills or unsafe disposal.

Characteristics of the Hazard

Hazardous materials are chemical substances that, if released or misused, can pose a threat to human health and safety and the environment. These chemicals are used in industry, agriculture, medicine, research, consumer goods, and in the home. Hazardous materials may be in the form of explosives, flammable and combustible substances, poisons, and reactive materials. Hazardous materials are routinely transported through the Peninsula via truck, railroad and pipelines. Hazardous materials also travel in and out of Kenai by air transport. The majority of chemical accidents occur in the home from misuse of flammable or combustible materials; however, these are typically small-scale accidents affecting individuals. Larger incidents involving hazardous materials typically occur because of accidents at an industrial facility or during transportation.

The presence of a hazardous material may or may not be readily evident. Some hazardous materials do not have an odor or taste. Some hazardous materials can cause immediate physical reactions such as nausea or watering eyes.

Hazard Categories

Regulatory requirements establish four categories of hazard for chemicals and materials:

1) Reactivity
2) Ignitability/flammability
3) Corrosivity
4) EP toxicity

Reactivity refers to a material's characteristics when mixed with water. A solid waste is categorized as a hazardous waste if, when mixed with water, it: (1) reacts violently; (2) forms potentially explosive mixtures; or (3) generates toxic gases, vapors, or fumes in a quantity sufficient to be harmful to human health of the environment.

The DOT system defines flammable materials as those with a flashpoint of 100°F or less; combustible materials as those with a flashpoint between 100°F and 200°F; and those with a flashpoint of <200°F as nonflammable. EPA designates those wastes with a flashpoint of less than 140°F as ignitable hazardous wastes.

The corrosivity hazard relates to acids and bases, and is defined in terms of pH (i.e., wastes are considered hazardous if they have a pH < 2 or > 12.5). Acids and bases are typically highly soluble in water. Concentrated solutions will attack skin and other materials; bases are generally worse than acids as they will penetrate the skin.

EP toxicity is a measure of a material's toxicity to humans.

Hazard Identification

An accident involving hazardous materials could occur anywhere. Communities located near industrial facilities that use or store large quantities of hazardous chemicals are particularly at risk. However, given that hazardous materials are routinely and frequently transported on local roadways and railways, all communities on the Kenai Peninsula are potentially exposed. Because of the limited highway infrastructure on the Kenai Peninsula, an accident that blocked the highway at nearly any point would cut communities off from each other. Only between Kenai and Soldotna is an alternate route available.

Table 9-6. Some Hazardous Materials Transported on Kenai Peninsula Highways[1]

Material	Classification	Communities
Anhydrous Ammonia	Extremely Hazardous	Kenai, Homer, Seward
Formaldehyde	Extremely Hazardous	Kenai, Homer
Sulfuric Acid	Extremely Hazardous	Kenai, Homer, Seward
Chlorine	Extremely Hazardous	Kenai
Nitric Acid	Extremely Hazardous	Kenai, Seward
Acetylene	Hazardous	Kenai, Homer, Seward
Oxygen	Hazardous	Kenai, Homer, Seward
Nitrogen	Hazardous	Kenai, Seward
Argon	Hazardous	Kenai, Homer, Seward
Aviation Fuel	Oil	Kenai, Homer
Gasoline	Oil	Kenai, Homer, Seward, Nikiski
Diesel, Heating Oil	Oil	Kenai, Homer, Seward, Nikiski

Pipelines

Natural gas supplies are transported by pipelines from Cook Inlet drilling platforms and other fields on the Kenai Peninsula and the west side of Cook Inlet to facilities located in Trading Bay, Granite Point and Nikiski. Twelve- and sixteen-inch pipelines run from the Kenai Peninsula, with a sub-marine portion at Turnagain Arm, to Anchorage and the Matanuska-Susitna Valley. Tesoro Alaska ten-inch pipeline transports Jet A fuel, gasoline and diesel #2 from Nikiski to the Anchorage Terminal.

Railroad

The Alaska Railroad Corporation (ARRC) transports nine classes of hazardous materials on its system. Hazardous materials enter the state at the ports of Seward, Anchorage and Whittier and then switch to rail systems. The majority of materials moved on ARRC's main track are comprised of Class 3 flammable liquids and gases, with fuel being the greatest tonnage of any single commodity moved. The majority of

[1] ADEC HazMat Community Flow (2).doc-6/28/2005

these hazardous materials shipments have Seward as a destination, although ethylene refrigerant gas and liquefied petroleum are transported to the siding at Crown Point.[1]

Table 9.7. Examples of Hazardous Material Events on the Kenai Peninsula

Date	Location	Substance/Amt	Source	Injuries
4/1986	Crown Point	Formaldehyde, trimethylamine	Leaking railcar	
1/1992	Soldotna	Chlorine gas	Wastewater Treatment Plant	
4/1994	Kenai	Explosives	Halliburton – explosion and fire	1 killed, 4 injured
5/1997	Nikiski	12,000 lbs. ammonia	Unocal Chemical Plant	
9/1997	Ninilchik	Sulfur, 17 tons	Overturned container	
10/1997	Nikiski	17,946 lbs. Ammonia	Unocal valve failure	
4/1998	Nikiski	49,605 lbs. Ammonia	Unocal valve failure	
7/1998	Homer Spit	35,000 lbs. Ammonia	Icicle Seafood Plant fire	
8/1999	Nikiski	9000 lbs. MDEA, 500 lbs. Ammonia	Unocal tank explosion	3 injured
10/2001	Cooper Landing	Fuel - 8800 gallons	Overturned tanker	1 injured
7/2004	Nikiski	13,200 lbs. Ammonia	Agrium – human error	
7/2005	Nikiski	324 gallons Hydrochloric Acid	Corrosion – OSK Dock	
5/2009	Nikiski	20,000 lbs. Sulfur Dioxide	Tesoro Refinery	

9.3.2. Regulations, Planning and Monitoring Programs

Borough

The Borough has no specific ordinance regulating toxic and hazardous substances.

The Kenai Peninsula Borough Emergency Operations Plan (EOP) does incorporate response checklists for oil/hazardous material releases. The EOP response checklist for transportation accidents also includes steps to be taken in the event that hazardous materials are involved.[2]

State

The State Emergency Response Commission (SERC) oversees regional and local government contingency planning for releases of oil and hazardous substances through

[1] ADEC HazMat Community Flow (2).doc-6/28/2005

[2] Kenai Peninsula Borough Emergency Operations Plan, August 2008

the formation of LEPCs. ADEC's Division of Spill Prevention and Response is in charge of oil spill prevention, preparedness, and response. The State has prepared Geographic Response Strategies (GRS) for the Cook Inlet and nine other regions.

The Cook Inlet region is divided into seven geographic response zones, five of which are wholly or partially within the Borough. Response strategies are prepared for specific sites within each response zone by a workgroup consisting of natural resource agency representatives, oil spill response professionals, and tribal organization representatives. The objective of these strategies is to improve response time and efficiency in the event of future oil spill incidents.

In accordance with ADEC criteria, ten petrochemical operators also have jointly sponsored a nonprofit response unit (Cook Inlet Spill Prevention and Response, Inc.) to respond to emergency spills. This organization is also a primary participant in the Cook Inlet Geographic Response Strategies program.

Federal

The Resource Conservation and Recovery Act of 1976 (RCRA) and subsequent federal acts give the EPA the authority to regulate the generation, transportation, treatment, storage, and disposal of hazardous waste. The EPA's Office of Solid Waste manages the RCRAInfo system, an online database that contains many types of information about hazardous wastes and disposal practices regulated by the EPA.

9.3.3. Resources

Borough Resources

The Kenai Peninsula Borough maintains three decontamination trailers. One is based in Kenai/ Soldotna, one in Seward and a third in Homer.

The Kenai Peninsula Borough contracts with RapidNotify, an emergency notification service that, in the event of an emergency, can be used to alert affected residents of the emergency and provide instructions to evacuate or shelter in place. This system can be activated by the KPB Office of Emergency Management or any of the four emergency dispatch centers located on the Peninsula (Soldotna, Kenai, Seward and Homer).

As of March 2010, none of the firefighting and emergency medical response services within the Borough has HazMat capabilities, although some individual members of the services do have training in HazMat response. Formal response capability is limited to establishing safety zones and basic spill containment.

State Resources

Alaska Statewide Hazardous Materials Response Team

The Statewide Hazmat Team is composed of several teams capable of deploying to any location in the state to respond to a hazardous materials release. The team is 'Level A' capable (i.e. the highest level of capability for response). Teams are based in Anchorage, Fairbanks, Kodiak and Valdez and are available for callout through the Alaska Department of Environmental Conservation. The teams are available for emergency response only, and not for cleanup and recovery operations. Once the emergency phase is terminated, the teams will be returned to their location of origin.

As of February, 2010, The Alaska Department of Environmental Conservation (ADEC), Tesoro Alaska Co. and Cook Inlet Spill Prevention & Response, Inc. (CISPRI) have Kenai Peninsula-based gas monitors capable of detecting dangerous gases including hydrogen sulfide, benzene, ammonia, chlorine and volatile organics. ADEC also has a radiation detector located on the Peninsula.[1]

ADEC also maintains containers with spill response equipment in Kenai and Seldovia. The communities of Kenai, Homer and Seldovia have Community Spill Response Agreements.[2]

Federal Resources

U.S. Department of Transportation
U.S. Coast Guard
U.S. Environmental Protection Agency

9.3.4. Ongoing Mitigation

The Emergency Planning and Community Right to Know Act (EPCRA) of 1986

In response to the disaster in Bhopal and other hazardous materials releases, on October 17, 1986, the Superfund Amendments and Reauthorization Act of 1986 (SARA) was signed into law. Title III: The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986, within SARA, establishes requirements for federal, state, and local governments, and industry regarding emergency response planning and community right-to-know on hazardous chemicals. Title III requires state and local governments and industries to take action to inform citizens about chemical hazards in their communities and to develop emergency plans. Title III also requires each community to establish a Local Emergency Planning Committee (LEPC) to be responsible for developing an emergency plan for responding to chemical emergencies in the community.

[1] Alaska Department of Environmental Conservation, February 24, 2010
[2] Alaska Department of Environmental Conservation, January 27, 2010

The U.S. Department of Transportation employs a labeling and placard system for identifying the types and characteristics of hazardous materials being carried by truck, rail, and barge or shipping. The placard system allows local emergency officials to identify the nature and potential health threat of chemicals under transport, and to determine the proper response procedures in the event of an accident involving hazardous materials.

In Alaska, the State Emergency Response Commission (SERC) is the leading entity in the implementation of SARA at the state level to mitigate the effects of an accidental release or spill of hazardous materials. The SERC establishes Local Emergency Planning Districts within Alaska and manages the State's Local Emergency Planning Committees (LEPC). Alaska statute also directs the SERC to be an all-hazard SERC. This means that the Alaska SERC is tasked to address hazardous materials issues and all other hazards and threats that might create an emergency situation in Alaskan communities. Select the SERC Home link for SERC information. Alaska Statute 26.23.071 establishes the Alaska SERC and specifies its duties.

Each Local Emergency Planning District (LEPD) has its own LEPC. LEPC members are volunteers who live in the LEPD. The SERC approves LEPC members. The LEPC implements EPCRA at the local level. The Kenai Peninsula Borough LEPC compiles information on hazardous materials stored and transported on the Kenai Peninsula.

The responsibility to coordinate SERC and LEPC activities in Alaska resides with the Department of Military and Veterans Affairs, Division of Homeland Security and Emergency Management.

9.3.5. Hazardous Material Release Mitigation Strategies and Implementation Ideas

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Strategy 1: Promote public awareness of potential hazards associated with handling of toxic and hazardous substances in the community.

Implementation Actions

- Cooperate with residents, industry and state and federal agencies through the Office of Emergency Management and the Local Emergency Planning Committee to develop and disseminate information about the location, types and amounts of toxic or hazardous substances within the Borough.

- Request that responsible parties and regulatory agencies give adequate public notice and conduct a public hearing, if appropriate, prior to approval of new permits for use or disposal of toxic or hazardous substances.

Strategy 2. Identify any potentially harmful substances used or disposed of within the Borough that are not adequately regulated by state and federal agencies to serve as the basis for future planning, monitoring or enforcement activity.

Implementation Action
A. Coordinate with state and federal agencies to evaluate the materials identified by LEPC, identify any regulatory deficiencies and work towards solving any problems.

Strategy 3. Promote public knowledge of how to react to chemical release

Implementation Actions

- Develop public education program to teach residents about sheltering in place and developing emergency preparedness plans and kits.

- Develop evacuation plans for all areas on the Kenai Peninsula road system, and provide public education about where to find evacuation information.

Strategy 4. Develop interim emergency response capabilities in the event of an accidental discharge of toxic or hazardous substances.

Implementation Actions

- Support training programs for local first responders, including borough, municipal and volunteer fire departments and law enforcement officials, in hazardous material response.

- Support efforts by local responders to obtain appropriate equipment for responding to hazardous material releases.

- Support the formation and efforts of a Kenai Peninsula Hazardous Materials Team to coordinate training and response efforts among fire departments, law enforcement and other emergency response personnel located on the Kenai Peninsula. This team should be capable of responding at the technician level, with support from additional responders trained to operations level.

- Support efforts to conduct a hazardous materials risk analysis specific to the materials used and transported in the Kenai Peninsula Borough.

9.4 Human-Caused Hazards Resource Directory

Alaska West Training Center
A division of Alaska West Express, inc., the Alaska West Training Center specializes in competency based, "hands-on" experience for hazardous materials training in transportation, emergency response, work place safety and hazardous waste operations.

Contact: Alaska West Training Center
Address: 1095 Sanduri Street, Fairbanks, AK 99701
Phone: (907) 456-2223
Website: www.awtc.lynden.com/info.html

Alaska DEC Division of Spill Prevention and Emergency Response
The Division of Spill Prevention and Response (SPAR) prevents spills of oil and hazardous substances, prepares for when a spill occurs and responds rapidly to protect human health and the environment.

Contact: AKDEC Division of Spill Prevention and Response
Address: 410 Willoughby Avenue, Ste. 303, PO Box 111800, Juneau, AK 99811-1800
Phone: (907) 465-5250
Website: www.dec.state.ak.us/spar/index.htm