Responding to Emergencies

U.S. Geological Survey photo by Robert Krimmel

Chapter Five
Responding to Emergencies

"While it is hoped that the mountain will again become dormant, it is impossible to predict what it might do. In the meantime, it is hoped that good engineering practices and common sense will prevail to permit us to stay one step ahead of being caught by surprise."
Colonel Terence J. Connell, 1980

Crude oil from the 1989 Alaska oil spill in Prudhoe Bay

Working the 1996 flood

Surveying at Spirit Lake after the Mount St. Helens eruption in 1980

Disaster Relief

Disaster relief has been a part of the Corps' civil works responsibilities since the 19th century. Public Law 84-99 (1955) authorized the agency to provide flood assistance, and Public Law 93-288 (1974) authorized it to assist the Federal Emergency Management Authority (FEMA) for other disasters. As part of this work, districts across the nation prepared emergency management plans, detailing how the agency would aid communities struck by a disaster. In 1983, the duties of the Corps' Emergency Management Branch expanded to include coordination with the FEMA for flood hazard mitigation and participation in Regional Response Committees. The following year, Executive Order 11490 added emergency water preparedness to the branch's responsibilities.[1]

From 1980 to 2000, the Portland District responded to a wide range of disasters, results of both natural phenomenon and human error. Agency personnel combated volcanic eruptions, floods, earthquakes, hurricanes, and oil spills, both within the United States and abroad. The District's combination of technical expertise, heavy-duty engineering equipment, and the ability to mobilize quickly and efficiently proved essential in many emergency situations, such as the eruptions of Mount St. Helens and Mount Pinatubo, the Alaska Oil Spill, and the Flood of 1996.

In responding to disasters, Portland District personnel became heroes to the public. Unlike many water resource development projects, which were often controversial, the Corps' emergency relief work was generally applauded. Following the Mount St. Helens eruption, for example, Patrick Keough, Chief of Planning Branch, directed the Cowlitz-Toutle River Restoration effort. At one point he discovered just one hour before a public meeting that the "USGS had told the media they expected 400,000,000 cubic yards of material to come into the Cowlitz during the 1980-81 water year." The moment stood out in his mind because, rather than being alarmed, locals had confidence in the Corps, believing that the agency "would do the job." This experience was "a treasured change from the stereotypic bad guy image we often hear."[2]

Mount St. Helens before May 18, 1980

Mount St. Helens Erupts

The May 18, 1980 eruption of Mount St. Helens was one of the largest natural disasters to strike the Pacific Northwest in the 20th century. While the mountain had displayed warning signs of volcanic activity and had erupted in previous centuries, few were prepared for the events that unfolded that day. The Corps, with its experience in navigation and flood control, played a vital role in the earliest phases of the emergency. In particular, the Portland District successfully combated the massive amounts of sediments Mount St. Helens had released into the Toutle, Cowlitz, and Columbia rivers.

Prior to its eruption, Mount St. Helens was part of a recreational landscape that included state, private, and national forest lands. On the north side of the mountain was Spirit Lake, a focal point for camping, fishing, and boating. The area provided habitat for a wide variety of wildlife, including large game animals and small mammals and birds. The Toutle River and its tributaries, along with Spirit Lake and the Lower Cowlitz, supported large populations of resident and migratory fish. The Toutle River, which originated on the slopes of the mountain, was a spawning ground for winter and summer run steelhead, chinook, and coho salmon, and sea-run cutthroat trout; the Lower Cowlitz provided spawning area for Columbia River smelt, whose spring runs supported a large dip-net fishery.[3]

For most people in the region, Mount St. Helens was a scenic landmark, a reminder of the grandeur of the Pacific Northwest. "You could not miss Mount St. Helens' beauty on cloudless days en route between Seattle and Portland up Interstate 5," recalled one writer. "Even at sixty miles per hour, Mount St. Helens looked as delectable as a scoop of vanilla perched atop a sugar cone. Few freeway motorists thought 'volcanic cone' until now, that is."[4]

The mountain, however, was more than a pleasant vista – it was also a geologically active volcano. As part of the Cascade Range, Mount St. Helens is one of a series of active volcanoes that are part of the "Ring of Fire," a circle of volcanic and earthquake activity rimming the Pacific Ocean. Located 45 miles northeast of Portland, the mountain is a relatively young volcanic cone formed within the last 2,500 years, which sits on the remains of an older volcano, some 37,000 years old. Geologic evidence revealed numerous past explosive eruptions of the older volcano, and there were ample signs of more recent activity as well. After a dormant period of approximately 150 years, in 1800 there was a large pumice eruption. Over the next 50 years the volcano was intermittently active, until it settled into dormancy for almost 130 years.[5]

Series of 6 eruption photos taken by Vern Hodgson on May 18th, 1980.

Mount St. Helens after May 18, 1980

Because of the mountain's active and violent history, geologists had predicted for several years that a major eruption could occur, but most people discounted these warnings. Even after earthquakes began in March 1980, sightseers crowded the area, ignoring barricades and refusing to recognize the potential for disaster. Early on May 18, 1980, a 5.1 magnitude earthquake precipitated a colossal landslide – the largest ever witnessed in human history – on Mount St. Helens' north flank.[6] "About 8:20 we were overcome by a strange feeling," one eyewitness recalled. "Everything was quiet. It felt like something was going to happen. There was no noise, no animals chattering, it felt like a surrealistic dream."[7] According to one report by the Corps, "The effect was much like that of removing the lid from a pressure cooker: billions of gallons of superheated groundwater trapped inside the mountain flashed into steam; explosions sent material almost 14 miles straight up; pyroclastic flows moved down the mountain at nearly 100 miles an hour. Almost every living thing within a wide arc up to 16 miles from the mountain was killed."[8]

As the landslide careened down the mountain, it incorporated debris, rock, trees, and glacial ice, eventually plunging into the North Fork of the Toutle River Valley. Water from lakes and melting snow mixed with the debris, causing mudflows that coursed down stream and river valleys. Salmon in the Toutle and Lower Cowlitz leapt from the rivers to the banks to avoid the searing conditions. Witnesses described these mudflows, carrying over 50 percent solids by volume, as the consistency of pancake batter.[9]

The blast affected an area of 150 square miles around the mountain. The toll on people, wildlife, and resources was extremely heavy: 59 people, 2,300 big game animals, millions of juvenile salmon and steelhead, 1.6 billion board feet of lumber, and thousands of acres of forest were killed and destroyed.[10] "I've never seen anything like it," commented President Carter on a flight over the area. "The moon looks like a golf course compared to what's up there."[11] Larry Magura, Emergency Management Coordinator, was also moved by the scene of destruction. He recalled the event a year after his helicopter flight: "We flew into the clouds and then we saw the entire North Toutle Valley through the clouds and it was a vast panorama of utter devastation – just awesome, mind boggling. And I remember standing by a stump that was just toothpicks, and we were like five miles away from the mountain."[12]

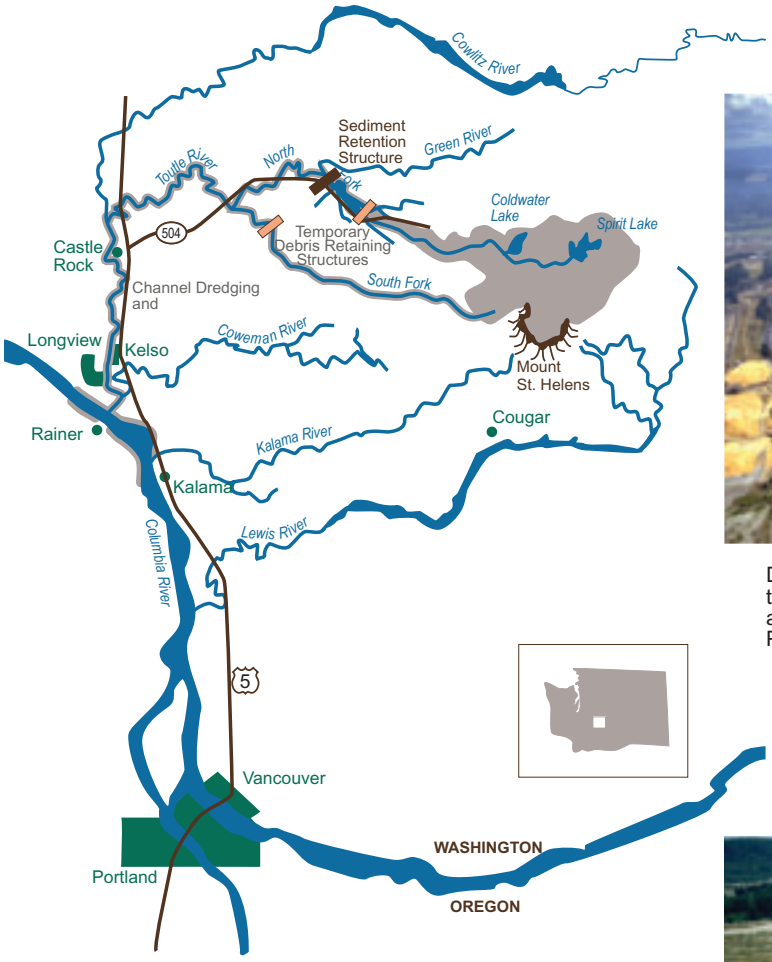
Recognizing the magnitude of this event, on May 19, the Corps and other federal, state, and local agencies established a communications system from a temporary FEMA headquarters, located in Vancouver, Washington, to coordinate the recovery effort.

Surveying the Mount St. Helens eruption damage

These agencies evaluated the impacts to general populations, public utilities, and other public and private facilities, as they formulated plans for both immediate action and longer-range considerations. In these early days of the crisis, one obstacle was simply determining what issues needed to be addressed. "You weren't quite sure what was going to happen one way or another," recalled Jerry Christensen, Section Chief for civil and environmental engineering, "so you spent a lot of time just monitoring and looking at things and seeing what was evolving and developing…." Christensen further explained that "The biggest problem we had was defining what the problem was. It wasn't defining what the solution could be. We had lots of solutions."[13] Three Corps districts – Seattle, Walla Walla, and Portland – were involved in the response effort. Seattle, with assistance from Walla Walla, led damage survey assessment teams and reported on ash cleanup. Portland had three major tasks: clearing the Columbia River channel, restoring the flood-carrying capacity of the Cowlitz and Toutle rivers, and constructing several small debris retaining structures on the north and south forks of the Toutle.[14]

As a water resource agency, the Corps took charge in the effort to provide flood control and navigation on the impacted rivers. The eruption had released large amounts of sediments in the Toutle and Cowlitz rivers, depositing 50 million cubic yards (mcy) of sediment in the Lower Cowlitz River flood plain and another 50 mcy in the Columbia River, including 15 mcy in the navigation channel.[15] Sediments in the Columbia had formed a shoal, large enough to halt ocean vessel traffic, in the river opposite the mouth of the Cowlitz. These deposits substantially reduced the flow capacity of the rivers to a point where normal winter rains could have caused severe flooding. After the mudflows, the District began dredging to reopen channels and initiated construction of levees to reduce potential flooding.[16]

Perhaps the District's most impressive dredging effort occurred on the Columbia. Before the explosion, the Columbia River navigation channel was an important contributor to the regional economy. In fact, the Port of Portland was one of the fastest growing ports in the country and a vital link in the grain export chain. The eruption severed this "economic lifeline," reducing the depth of the normally 40-foot channel to as little as 15 feet. In the days following the event, the District quickly mobilized its dredges, operating its vessels around the clock to clear the sediment. "I don't think anyone will ever again ask why the Port of Portland and the U.S. Army Corps of Engineers are



Dredging on the Columbia at the Port of Portland

Pipeline dredges working on the Cowlitz River

in the dredging business," predicted Dave Neset, Port Director of Marine Services. "Ships couldn't have gotten into or out of Portland as fast as they did, if the *Oregon* and the Corps' three dredges hadn't started digging immediately. You just couldn't expect a private contractor to drop everything and pick up and go like that."[17]

The work was tough, both on the workers and equipment. "What worries me is the strain it's putting on our people," stated Larry Patella manager of the dredge *Oregon*. "The material is murder to handle…just like concrete… and it's tearing up our equipment. Then there's the ash to contend with…. I've commanded three ships – in the Navy 31 years – but I've never seen a bunch with this much dedication." When asked when he had last seen his family, one crewmember responded, "I don't know, maybe a week, I'm a little foggy. We have a daughter 27 and another 8 years old. That spread out should tell you something about family life when you work on the *Oregon*."[18]

Through the intensive efforts of the Corps' dredges, along with dredges from private industries, deep-draft shipping was restored in just five days. This accomplishment was testimony to "remarkable teamwork" and the "quick action and unflagging efforts of the U.S.

Temporary debris dams on the south and north forks of the Toutle River

Army Corps of Engineers." To alert customers that the Port was open and ready for business, the Port of Portland launched a campaign in which it reminded customers that, "If we can move a mountain, we can move your cargo."[19]

In addition to its dredging work on the Columbia, the District also used pipeline dredges on the Cowlitz, which had lost 85 percent of its flow capacity as a result of the eruption. In a massive restoration effort lasting 16 months, the District and its contractors dredged and excavated more than 21 mcy from the Toutle, 54 mcy from the Cowlitz, and another 28 mcy from the Columbia. The District's normal dredging program for Oregon coastal harbors and the Columbia River amounted to about 16 mcy annually.[20]

Dredging was only one component of the District's plan to combat sediments. On the north and south forks of the Toutle, for example, the agency built debris dams. Contractors constructed a 1.5 mile long debris dam immediately downstream of the main mudflow deposit on the north fork and a smaller dam at the lower end of the south fork. The purpose of the structures was to restrain and impound the material eroded from the mudfills upstream, allowing it to be excavated and removed to nearby spoils area. The south fork debris dam also featured a fish trap facility designed to trap and transport steelhead either upriver or to more suitable streams. Workers completed the dams in October 1980, in time for the fall rainy season.[21]

In the days and months and years that followed the eruption of Mount St. Helens the District mobilized a wide variety of resources – both in terms of personnel and equipment. Agency staff worked long hours to meet the challenge of stabilizing the region. "We were working 10 to 12 hour days and six or seven days a week for the first two years," recalled Christensen.[22] By fiscal year 1983, the Corps had spent $327 million on emergency activities, including improvements to levees, construction of two debris dams and excavation of sediment stabilization basins in the Toutle River, dredging of the Columbia River, and pumping at Spirit Lake. Throughout this period, the District demonstrated its ability to utilize its vast engineering expertise to address a range of navigation and flood control issues, in the process expanding its knowledge of how to deal with related emergencies in the future. The agency's efforts were well recognized, and in 1981 the District received an engineering Award of Merit in the Corps of Engineers Design and Environmental Awards program.[23] Reflecting on the 1980 eruption of Mount St. Helens, Senator Slade Gorton expressed appreciation for the Corps' role in the event. "The 1980 eruption unleashed massive destruction on the Pacific Northwest," he observed. "The volcano ejected billions of cubic yards of debris, rock, mud, and ash; but this was only the beginning. The Corps responded immediately to the challenge of maintaining control in an uncontrollable time and region."[24]

While the Mount St. Helens eruption highlighted the agency's strengths, the District recognized that the work was far from over and appreciated the volatility of the situation. "The biggest question mark in the cleanup operation is Mount St. Helens itself," remarked District Commander Terence J. Connell in September 1980. "While it is hoped that the mountain will again become dormant, it is impossible to predict what it might do. In the meantime, it is hoped that good engineering practices and common sense will prevail to permit us to stay one step ahead of being caught by surprise."[25] In the years following the eruption, the District worked to address the long-term consequences of the eruption. In particular, the agency undertook two significant projects – stabilizing Spirit Lake and constructing a sediment retention structure on the Toutle River.

Mount St. Helens

The impacts of the eruption were immediate. Avalanches sent water 20 feet high surging down the Toutle River Valley, uprooting trees and washing out roads and bridges. Elsie Calvert, a resident of the valley, said that she knew it was time to leave her home when she saw a house and several cars floating downstream. "You could hear the river just roaring," she reported. A U.S. Coast Guard helicopter evacuated her, along with her husband and four children. Also rescued was Patrick Killgore, who boarded the helicopter with Josephine, his pet boa constrictor. "I tried to get out by car," he explained, "but trees were blocking the road." Larry Magura, the Corps' Emergency Management Coordinator, described the North Toutle Valley as "a vast panorama of utter devastation – just awesome, mind boggling."

-The Oregonian, May 19, 1980

Stabilizing Spirit Lake

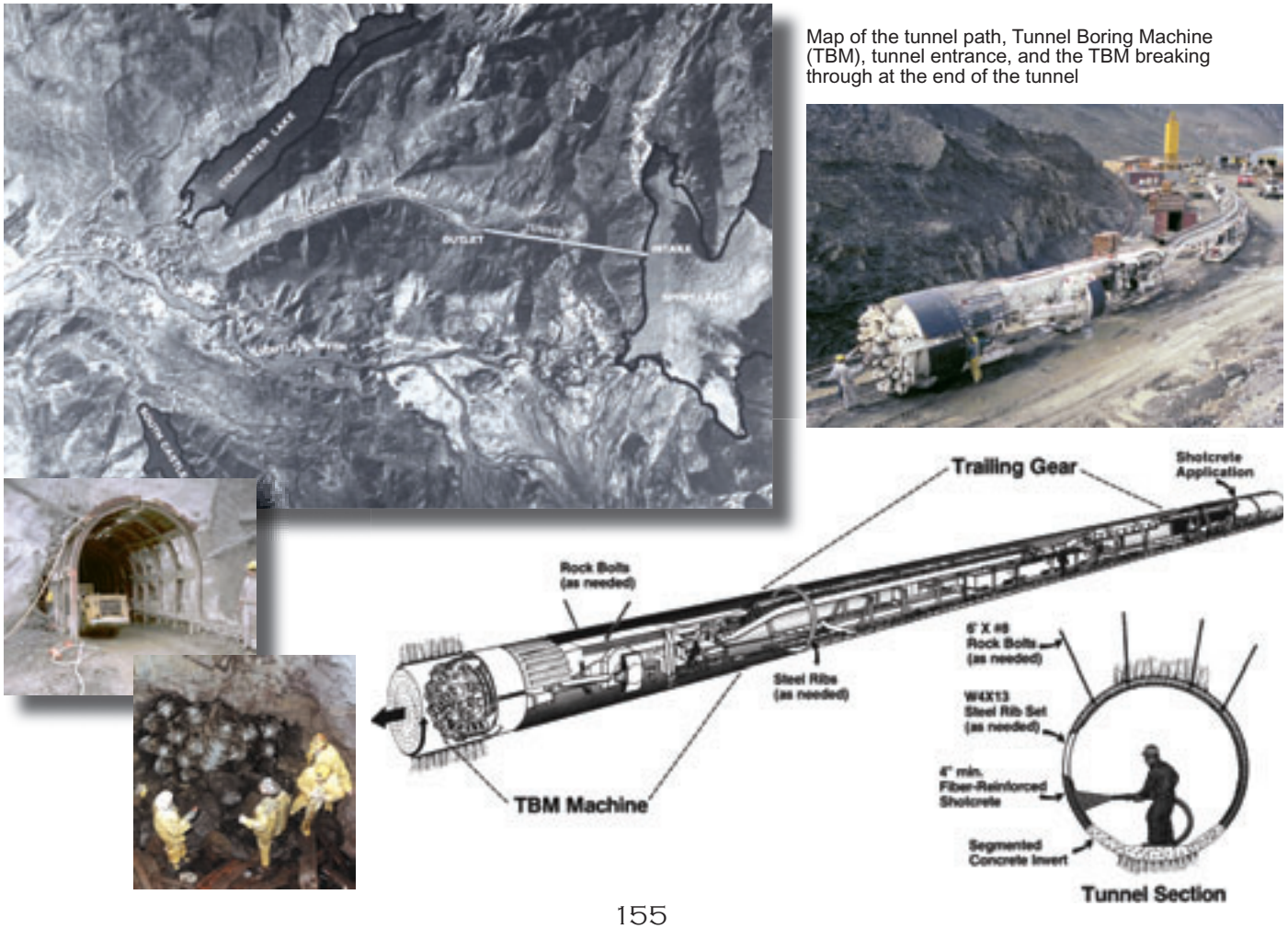
In the period immediately following the eruption, the Corps stabilized the region's waterways through a variety of emergency measures. Agency officials recognized, however, that the continual movement of debris and volcanic sediment posed a long-term threat to existing flood protection measures and had the potential to impair future navigation. In response, in June 1982, President Reagan requested that the Corps prepare a comprehensive plan to address flood control and navigation problems brought about by the huge deposition of sediment from Mount St. Helens. During the planning process, the District considered a number of alternative strategies, evaluating them on the basis of engineering feasibility, economic merit, and environmental sensitivity.[26]

Spirit Lake filled with logs and debris after the eruption

Pump barge maintains the lake level at the debris dam on Spirit Lake

Unlike many Corps projects, planning in the wake of the eruption occurred under crisis conditions with few economic or environmental precedents. Sedimentation and erosion rates and volumes had to be estimated with complex data-gathering and analytical methods. For the first time, the Corps included a "design mudflow" for a large dam. Planning for long-term solutions focused on two major areas: the unstable debris dam that had been formed at Spirit Lake and continuing sedimentation of the Cowlitz River. These problems were connected, in that releasing water from Spirit Lake to avoid dam failure would move more sediment down the Coldwater to the Toutle North Fork and into the Cowlitz. If the dam failed altogether, the situation would be worse.[27]

Spirit Lake is located at the base of Mount St. Helens near the headwaters of the North Fork Toutle River. When the mountain erupted



Map of the tunnel path, Tunnel Boring Machine (TBM), tunnel entrance, and the TBM breaking through at the end of the tunnel

it precipitated a massive debris avalanche that formed a ridge of volcanic material up to 600 feet deep at the lake's outlet to the North Fork Toutle. This material blocked the lake's natural drainage outlet and raised the lake's surface elevation approximately 200 feet. With no outlet the lake could rise until the water overtopped or breached the blockage, causing catastrophic flooding downstream. By 1982 Spirit Lake had risen almost 60 feet higher, increasing the volume of water held back by the debris dam from 126,000 acre-feet to nearly 275,000 acre-feet.[28]

In July of 1982, a United States Forest Service task force report stated that the natural dam barrier at Spirit Lake was unstable and warned of the risk to downstream communities from an uncontrolled breach. In August that year, President Reagan declared a state of emergency, activating FEMA to coordinate a federal response. FEMA requested that the Corps develop an interim solution to stabilize the lake over the winter. The District installed a barge-mounted pumping system that began operating in November of 1982. This system pumped water at a rate of 1,350 gallons per second from the lake through a 3,650-foot-long, five-foot-diameter pipe across the debris plug to a stilling basin, and from there to the North Fork of the Toutle River.[29]

The barge-mounted pumps proved to be only a temporary solution to the problem of sedimentation. In October of 1983, the Corps completed a comprehensive plan for Mount St. Helens that examined six long-term solutions for Spirit Lake. Following a series of technical studies and public debate, the Corps decided in 1984 to provide an outlet for Spirit Lake via a tunnel, which was to be constructed through solid rock.[30] By July of that year, contractor Kiewit-Groves began work on the 8,460-foot tunnel at a cost of $13.5 million. Measuring 11-feet in diameter, the tunnel was created by a tunnel boring machine, often referred to as the "mole."[31] By May of 1985, the tunnel began operating, eventually lowering the lake by about 20 feet to its design elevation of 3,440 feet. As expected, the high flows of the initial drawdown period resulted in significant erosion along South Coldwater Creek. Since that time, the system has operated "flawlessly."[32]

The SRS was created to trap sediment from the water before it could move downstream and cause flooding and impede navigation.

The tunnel at Spirit Lake was a major engineering feat that was accomplished through the cooperation of many agencies and contractors. The 11-foot-diameter tunnel that stretched a mile-and-a-half through solid rock was "created by a modern-day mechanical monster" in "a task that was worthy of the volcano," remarked Chief of Engineers Lieutenant General Elvin R. Heiberg III at the structure's dedication in April of 1985. "It was not the result of the somewhat mysterious forces of nature" that this tunnel was built, he explained, but through "real team work" and by "very real people."[33] Perhaps most importantly, the tunnel was a source of comfort to local residents who feared flooding. "This is something that gives us safety," explained Ethel Mayclin of Longview.[34]

Constructing a Sediment Retention Structure

In addition to discussing alternatives for sediment blockage at Spirit Lake, the Corps' comprehensive plan for Mount St. Helens also proposed five solutions for keeping sedimentation out of the Cowlitz River. In 1984, the agency's feasibility report recommended that the most cost effective solution was a single retention structure, to be built on the North Fork of the Toutle River. Other parts of the sediment prevention project included levee improvements at the town of Kelso and the dredging of the Cowlitz. The following year, Congress authorized the sediment retention structure (SRS), and contractors completed construction by December of 1989 at a cost of $73.2 million.[35]

The SRS was a creative solution to a unique environmental problem. The structure's purpose was to trap sediment from the water before it could move downstream, causing

Completed Sediment Retention Structure (SRS)

flooding and impeding navigation. Essentially, it worked with nature to slow down the flow of water, allowing sediment to drop out and build behind the SRS in a single, large manageable deposit. The facility consisted of an 1,800-foot long embankment that rose 184 feet above the post-eruption streambed, a concrete outlet work, and an unlined spillway at one end. The embankment was made from fractured rock with a tapered core of impervious clay that workers had excavated from the site. The entire structure rested on ancient river gravels, allowing water to pass underneath and rise inside the embankment when lake levels were high. Drainage pipes set into the embankment faced between layers of roller compacted concrete, enabling the water to run back into the lake when the level receded.[36]

Upstream from the SRS, where the North Fork Toutle entered the lake, the stilling action of the impounded water caused sediment to drop to the bottom. The sandbar behind the structure was the natural collection point for the material. Engineers envisioned the bar gradually building downstream toward the embankment as the 3,200-acre lake filled over the 50 year life of the project.[37]

The outlet works consisted of a concrete gravity monolith that featured six rows of five outlet pipes through which water and fish passed into the plunge pool and outlet channel below. The Corps' plan was to close each row of outlet pipes gradually, until the river flowed continuously over the spillway.[38] In 1998, when the last row was closed, the SRS still had room for roughly 190 mcy of sediment to be stored behind it.[39]

The spillway ran along the far north end of the SRS. It was an unlined, ungated structure whose approach channel sloped up from the lake towards the chute, narrowing from about 1,000 feet to 400 feet at the crest. The water was then carried about 2,000 feet down to an exit channel, some 140 feet lower than the crest.[40]

Building the SRS was a challenging task. The entire site was blasted out of solid rock, and during construction the course of the river was changed three times: first, to the north while a diversion pipe was buried at the south side of the valley, then south through the pipe, and then north again through the outlet works. At that point, two years before the project was completed, the SRS began forming a lake and retaining sediment.[41]

One of the Corps' considerations in building the dam was the juvenile and adult fish whose migration would be affected by the structure. As salmon runs declined and many species were threatened or endangered, the agency had to incorporate fish protection measures into every aspect of its work. When dredging the Toutle River, for example, the District had to adapt its methods to accommodate the adult salmon and steelhead that were spawning in tributaries. Specifically, the Corps diverted the river to one side of the channel by means of temporary dikes and prohibited excavation within the fish passage channel.[42] Constructing the SRS also posed challenges in terms of fish passage. With its experience in building fish passage facilities in its dams on the Columbia River [See Chapter Four], the District was technically well prepared to meet this challenge.

Since the mid-1980s, when the Corps began planning the SRS, biologists from state and federal agencies as well as environmental groups expressed concerns about how the project would affect the movement of fish. Specifically, they worried that the sediments behind the SRS would harm the fish and that accumulated debris would impede the downstream passage of juveniles. To address these concerns the District built a trap-and-haul facility downstream from the outlet works. The facility was designed to collect salmon and steelhead and truck them to spawning areas above the dam. The Corps also installed temporary log booms to keep debris away from the structure and enhance fish passage through it.[43]

The trap-and-haul facility was not, however, intended to be a permanent fish passage facility,

according to Jerry Christensen. In fact, the Corps' original plan was for the entire SRS to be a temporary structure; once the pool filled up with enough sediment and the outlet pipes closed, water would flow over the spillway and fish would travel up the spillway and through the system. Eventually, the agency envisioned the spillway naturally eroding, allowing sediment to be slowly released downstream. "We tried to produce a system that was fairly natural, even though it is a dam," Christensen explained. The problem was that once the Corps constructed the SRS, "nobody really wants to let the stuff go, now that it's trapped there," he said. The District therefore retained the trap-and-haul facility into the 21st century, causing concern among proponents of passive fish passage. The Corps, too, recognized the limitations of the current system. "It probably isn't the best for fish," remarked Christensen.[44]

A primary concern for the SRS was the outlet pipes, which carried water and fish. The District began closing the pipes in 1991, shutting down the final row in 1998. Both the National Marine Fisheries Service and Washington Department of Fish and Wildlife supported the closures, believing that migrating juvenile fish were better off traveling over the spillway. A number of environmental groups, including American Rivers and Friends of the Cowlitz, applauded the action. "The continuous release of sediment from a retention dam built to capture debris generated by the eruption of Mount St. Helens has wreaked havoc on Toutle River coho and chinook salmon and steelhead," stated a spokesman for American Rivers. "The heavy sediment loads have killed migrating juvenile and adult fish, and prevented operation of the fish trap that returns adult fish to the upper river to spawn." Closing the pipes on the dam allowed sediment to move downstream on a continual basis, which meant that sediment was transported through the rivers primarily during periods of high flow in the winter and early spring. According to Rob Masonis of American Rivers,

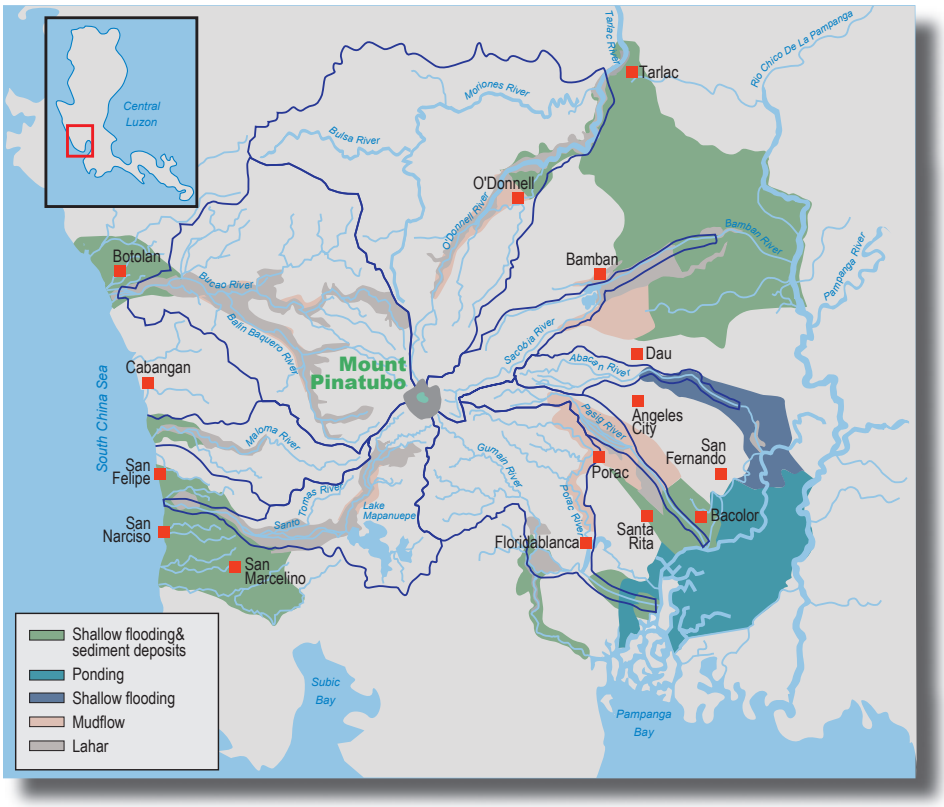
Mt Pinatubo crater and lava flows, 1991

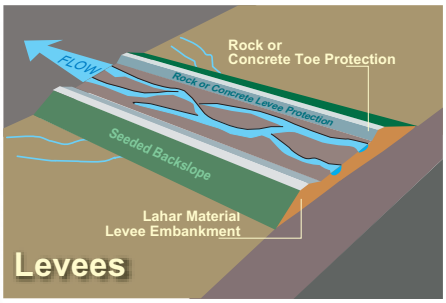
Flooded areas and bridge rebuilding, 1992

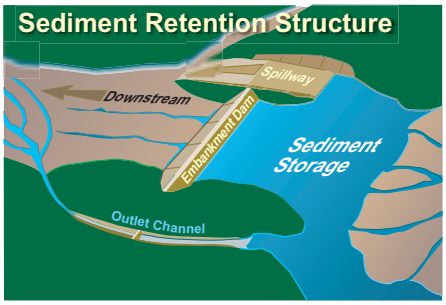
occasional high sediment loads are part of natural river conditions, but the constant turbidity caused by continual sediment loading is not. Both conservation groups credited the District for its response to the problem. "The Corps has responded to our recommendations openly and timely," said Friends of the Cowlitz. "We look forward to working with the Portland District on other habitat restoration projects in the basin."[45]

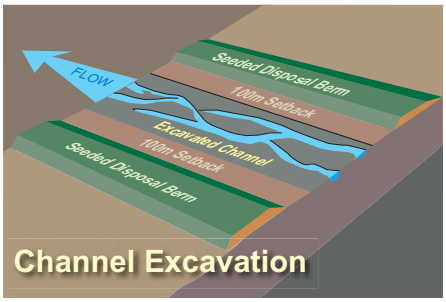
While the SRS posed risks to fish populations, it was an important component of the Corps' plan for meeting the Mount St. Helens emergency. "The sediment retention structure is the final piece of the solution," said Brigadier General Pat M. Stevens, Commander of the Corps' North Pacific Division. Furthermore, both the tunnel at Spirit Lake and the SRS were major engineering accomplishments, winning the national ASCE Outstanding Civil Engineering Achievement Award for 1991.[46] While no one wished for another Mount St. Helens, the eruption provided valuable experience for the District. "Mount St. Helens was truly a unique event," stated Keough. "Ready-made answers did not exist. Answers had to be developed quickly, creatively and diligently in response to immediate and long-term needs. The knowledge and expertise from this response will serve the nation well for generations to come."[47]

Looking back on the eruption of Mount St. Helens and on the District's response to this disaster, Colonel Connell recalled in 2001 that the public generally responded very favorably to the Corps' emergency-operations efforts. "Morale was absolutely phenomenal," he noted. "It was a major team effort in the World Series and we were winning."[48]









Mt. Pinatubo devastation area map and Corps of Engineers recovery plans for sediment retention, channel excavation, and levees

Assisting at Mt. Pinatubo

Through its involvement in the Mount St. Helens recovery work, the District acquired experience in large-scale disaster relief. Eleven years after Mount St. Helens erupted, this knowledge was put to the test at the site of another volcanic eruption – Mt. Pinatubo in the Philippines. When this volcano erupted in the summer of 1991, the State Department requested that the Portland District investigate. Ordinarily, the Corps' Hawaii and Pacific districts would have taken the lead, but Mount St. Helens had made Portland uniquely prepared.[49] "The Portland District was actually requested by the Government of the Philippines to work on it based on our Mount St. Helens experience," recalled Christensen.[50]

Mt. Pinatubo had been silent for nearly 600 years, but in April of 1991 a series of small earthquakes began, emitting steam clouds and bits of ash. This activity continued intermittently until mid-June, with each shake increasing in intensity. Finally, on June 14 and 15, Pinatubo erupted, ejecting huge amounts of volcanic ash, pumice, and pyroclastic flows down its slopes and into the surrounding area. The geographic extent of the volcano was impressive, covering a 40 to 80 kilometer radius. According to Philippine Institute of Volcanology and Seismology officials, "The ejecta covered more extensive areas and were carried by the winds of Typhoon Diding to as far as metro Manila and Palawan to the south and Cambodia to the east."[51]

In September of 1991, the State Department requested a team from the Corps to go to the site to conduct field investigations and prepare a report on the damages. The agency sent four engineers to the scene – two from the Portland District, Steve Stockton and Karl Eriksen, and two from the North Pacific Division Headquarters, John Oliver and Duane Bankofier.[52] During their September trip, the team met with representatives of the U.S. Agency for International Development (USAID), the Philippines Department of Public Works and Highways, and Mt. Pinatubo emergency officials to discuss possible solutions to the threats posed by the eruption. Many of the team members were struck by the devastation they found upon arriving. "It's almost mind boggling, it's so big," said Stockton, Chief, Planning and Engineering Division. "It's really humbling when you look at something like that, you realize how insignificant you are."[53]

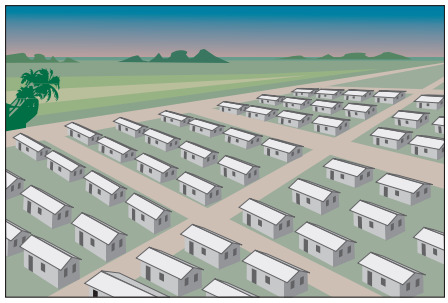


Diagram of flow damage and the Relocation Plan for new homes on safer land areas

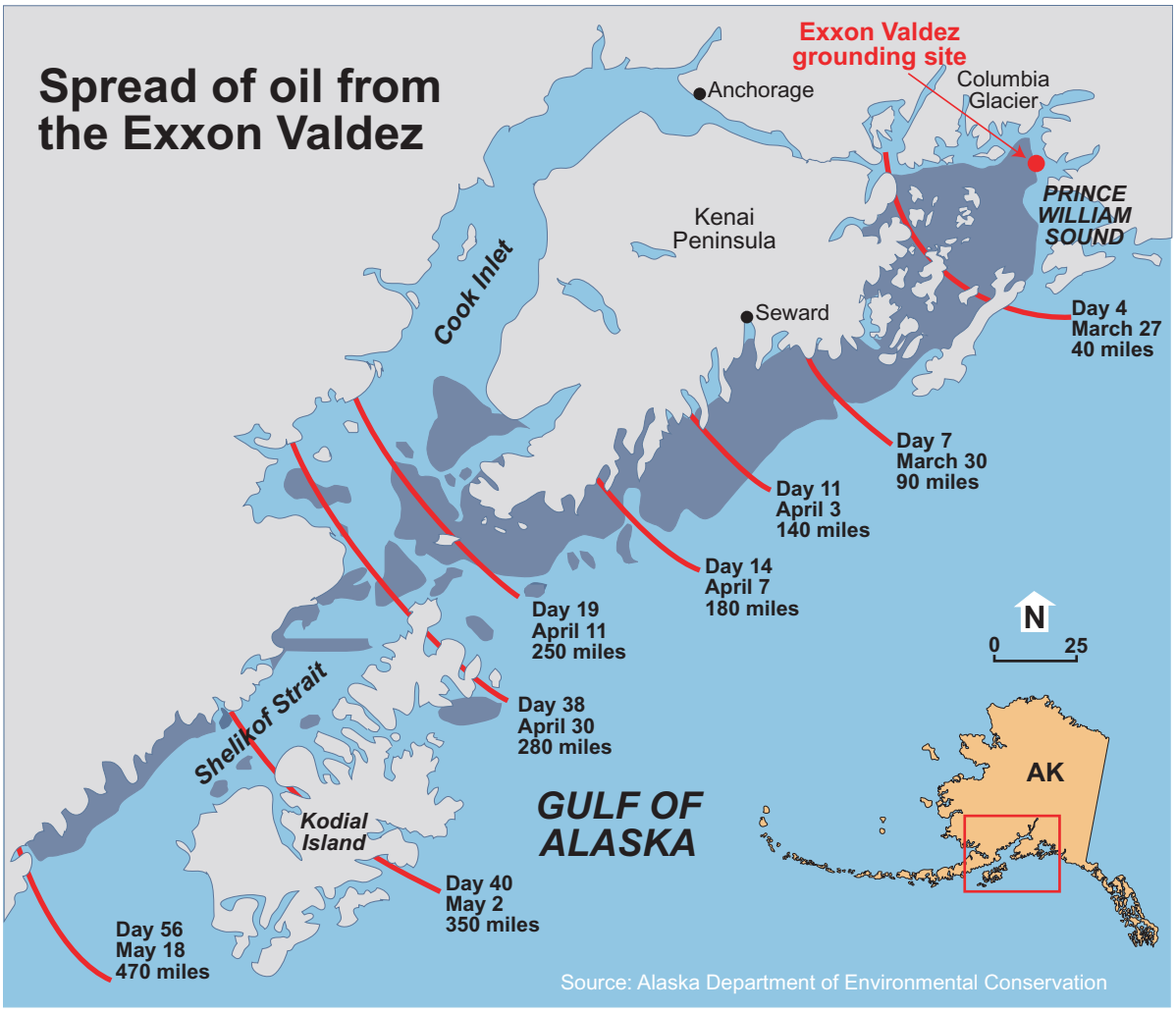
The volcanic eruption took a heavy toll on both people and natural resources in the region. The impacted area was home to more than 500 families of the Aeta tribe, as well as thousands of villagers who lived in the delta land. The eruption, with its accompanying mudflows, displaced thousands of villagers and more than 350 people lost their lives. Many more died in the evacuation centers due to unsanitary conditions. The eruption also created pyroclastic flows, which are extremely hot blasts of volcanic fragments, pebbles, boulders, sand, and hot gases that sweep along the ground at hurricane speed. These pyroclastic flows left deposits all along the slopes of Pinatubo. When rainwater mixed with the deposits and began traveling downhill, it resulted in mudflows with the consistency of cement and left deposits in the river channel, causing them to flood their banks into rice paddies and villages. Overflowing rivers filled with volcanic debris also ruined habitat that supported a considerable fish-rearing industry.[54] These flows were "a nightmare for the farmers out there with their rice crops and the engineers trying to keep the rivers open," observed Duane Bankofier, Chief, Geotechnical and Hazardous, Toxic and Radiological Waste Branch. "It's a monumental task."[55]

The area affected by Mt. Pinatubo's eruption covered nearly 62,000 acres and eight river basins. Although the volcanic ejections and mountain surface of Mt. Pinatubo looked similar to Mount St. Helens, the destruction far exceeded it.[56] "Mount Pinatubo devastated the Philippine countryside much more than Mount St. Helens did," explained Bankofier. "There isn't just one Toutle River … there are six, seven, or eight Toutle rivers." The intensity of the impact was partially due to the fact that unlike the Mount St. Helens eruption, which primarily damaged the northern and western sides of the mountain, Pinatubo "blasted away" at all sides. "In terms of damage, numbers of people killed, acres of land damaged, and other general factors it's many times larger," said Stockton. "The amount of land impacted is not in one area. It is 360 degrees around the mountain, and eight major drainages have been affected by the volcanic sediments. Also, the rainy season in the Philippines has magnified the sedimentation's damage."[57]

In addition to the technical challenges of addressing such a heavily hit area, working with the Philippine government wasn't necessarily easy. "There's a challenge in dealing with a government that does not have an organized emergency management structure in place," explained Mike Roll of the Planning and Engineering Division and technical manager for the Mt. Pinatubo study. "There's also limited money, limited equipment, limited resources." Furthermore, the work could be dangerous. "There's an active volcano over there…. It could spout when you are flying around it or over it," said Roll. "The torrential rains that they get are bad enough, but you throw in 23 typhoons a year and there's always the risk there's going to be a significant mud flow that comes down that hill. Sometimes out walking along the river bank, you can hear the sound of banks caving in – big thumps and booms."[58]

Following their initial visit in September to the Philippines, the Corps team submitted a report to the Department of State, focusing on possible repair measures and the protection of remaining systems.[59] In August of 1992, representatives from the Corps, along with private consultants, left for the Philippines to meet with Filipino engineers and collect material samples to better analyze site conditions and recommend recovery measures. Some of the specific methods considered by the team included building retaining dams, levees, and retaining walls for water and sediment retention. USAID provided six million dollars toward funding these recovery studies.[60]

By the mid-1990s, the Corps had completed a long-term recovery plan for all eight basins impacted by the eruption. The study cost a total of $6 million and outlined procedures to control sediments and protect residents.[61] The report specifically focused on implementing land-use strategies to reduce the level of risk. Due to the relatively inexpensive cost of land in the Philippines, the Corps recommended that the government buy parcels of vulnerable land and relocate people to safer areas.[62] The study was officially managed by the Pacific Ocean Division. Following the completion of the report, the next step was for the Philippine government to initiate recovery efforts. To support that effort, seven representatives from the Philippine government underwent five days of training in a design workshop led by the Portland District's Mt. Pinatubo study team. During the workshop the District went through the alternatives and recommended solutions on a basin-by-basin basis. Participants also went on field trips to Mount St. Helens and other operating units to view some examples of related work firsthand. One member of the visiting group expressed appreciation for the Corps' effort. "I guess the benefit



of the trip is really more than what we actually paid for it," she noted. "I think the Corps has done a great job."[63]

Despite the numerous challenges of the work, for the Corps team involved in the Mt. Pinatubo recovery efforts there were also many rewards. "It's a professional challenge, a prime opportunity to see personally how good they are," said Roll. The personal dimension was also satisfying. "When the helicopter lands in a local school yard and all the kids come out, you really get a feel for who you are responding to. It's their lives, their families, their homes that are going to be potentially impacted by this. If we can do something to alleviate some of the pain or problems that they're going to have, then we're doing what we all wanted to do when we got involved in this career."[64]

Combating the Alaska Oil Spill

Disaster Strikes Alaska

On March 24, 1989, nearly 11 million gallons of crude oil from Prudhoe Bay gushed from the *Exxon Valdez*, causing the worst oil spill in American history and the world's tenth worst oil spill. In an effort to avoid pieces of glacial ice in the outbound lane of the Valdez Narrows in Prince William Sound, the boat's captain changed his route to the inbound lane and then veered three miles off course, hitting Bligh Reef at a speed of over 10 knots and rupturing eight cargo tanks. These tanks began leaking oil at the rate of 1,000 gallons per second, creating black waves measuring three feet high.[65]

Prudhoe Bay, Alaska

Prince William Sound was one of Alaska's most treasured wilderness areas and home to hundreds of thousands of birds, fish, and mammals. The islands of the Sound provided nesting sites

Oil on the water in the sound

for marine birds, such as the black-legged kittewake and tufted and horned puffins. Numerous shore birds used the Sound as a resting and feeding area. Black and brown bear and bald eagles feasted on the rich supply of fish that inhabited the marine and fresh waters. Visitors marveled at the whales, sea otters, porpoises, and seals that they spotted from their boats.[66]

The March 24 oil spill killed more wildlife than any spill in history, including an estimated 100,000 to 300,000 sea birds, thousands of marine mammals, and hundreds of bald eagles. The spill also disrupted the herring and salmon harvests that supported fishing communities in the region, hurt local recreation and tourism businesses, and devastated subsistence hunting, fishing, and gathering in many coastal villages.[67] It was an area rich in natural resources and natural beauty, but its inviting blue green waters were now washed in a wave of thick oil. "I referred to Prince William Sound as one of the most beautiful places on earth," said Don Moore, Cordova city manager, in an appeal to the nation. "I leave it to each of you individually to decide what the other one is. We all have a special Shangri-La in our hearts and minds. Think of yours when you contemplate what has happened to ours."[68] Other citizens were also emotionally affected by the spill. "When you see birds pulling their feathers out until they make holes in their necks and oiled otters that show no resistance when you pick them up, it brings home to you what an oil spill really means," said Dan Lawn of Alaska's Department of Environmental Conservation.[69]

The geographic extent of the spill was staggering. Eventually, oil from the *Valdez* found its way to 2,000 miles of shoreline, and oil patches were sighted in the Shelikof Straits over 300 miles from Bligh Reef.[70] "It's amazing when you look at the tiny spot on the map that is the tanker and think how much it can hold, and then look at how far that tiny amount spread," observed Ted Cooney, an oceanographer at the University of Alaska in Fairbanks.[71]

Part of the reason the oil spill spread so far was the inadequate and confused initial response effort. Alyeska Pipeline Service Company, Exxon, and federal and state agencies lost valuable time trying to mobilize resources and deciding who should take charge of the cleanup. Weather conditions in the first two days following the spill were ideal for mechanical cleanup operations – the wind velocity was less than 5 knots, visibility was excellent, and the seas were calm. Alyeska, whose job it was to contain any spill, failed, however, to mobilize its equipment and crew. Although the company had developed a state-approved oil spill contingency plan, vital components were missing. Much of the necessary equipment, for example, was out of order, buried under deep snow, or simply gone. Alyeska's plan said that containment booms were supposed to go in five hours after a spill, but it took 12 to 17 hours just to deploy the booms. Thirty-six more hours passed before the booms surrounded the Valdez. After 70 hours had passed – the point at which Alyeska's plan had guaranteed that a spill of 200,000 barrels would be picked up – only 3,000 barrels had been recovered.[72]

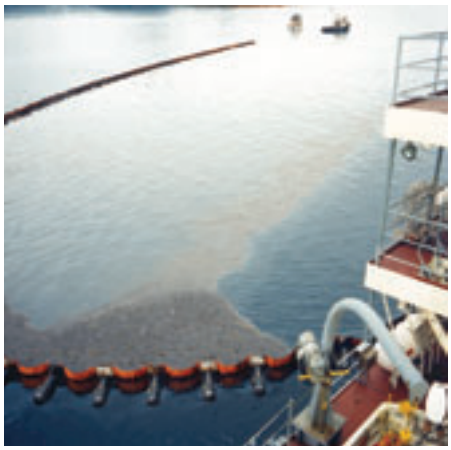
In addition to mechanically collecting the oil, one of the technologies that Alyeska identified in the oil spill contingency plan for Prince William Sound was the use of chemical dispersants. The calm weather of the first few days after the spill limited the use of this treatment, which relied on wave action to mix and distribute the dispersant. Even when the weather began to shift on the third day, however, dispersants didn't substantially contribute to the response, largely because Exxon and Alyeska lacked adequate quantities of dispersant and application equipment.[73] Another procedure used for large spills – the burning of the oil – was also not effectively used in this disaster. Attempts to use fire had failed because, in the days that had lapsed since the spill, volatiles had evaporated and water had diluted the mixture to a point where it would not combust.[74]

Once it was clear that Alyeska's plan was not working, both Exxon and the Coast Guard began to mobilize personnel and equipment to address the spill. From the start of cleanup operations, a lack of clarity about the chain of command and who was in charge hampered the response. Part of the difficulty lay in the number of parties involved: the Clean Water Act had designated the Coast Guard's jurisdiction in the Coastal Zone as part of the National Contingency Plan for serious oil or hazardous material spills; Alyeska was responsible for immediate spill response under the Oil Spill Emergency Response Plan; Exxon was in charge of directing and paying for the cleanup; and the Alaska Department of Environmental Conservation, in conformance with state law, had jurisdiction over water quality and fisheries. "The spill tested the ability of government and industry to cooperate on a scale rarely encountered in the United States and required a tremendous amount of resources," explained one writer who visited the scene.[75]

Also challenging was the relationship between Exxon, as the responsible party and financial backer of cleanup operations, and the Coast Guard, as overseer of the response effort. The Interior Department, the Environmental Protection Agency, and Alaska's congressional delegation all wanted the federal government to assume control. An official from the Alaska Department of Environmental Conservation argued that, "Exxon has not demonstrated an ability to manage a big cleanup properly. They have a lot of people, a lot of equipment, and a lot of oil, but getting them together is a problem. It's very slow, very frustrating, and not very successful."[76] President George H.W. Bush settled the debate when he announced a partial federalization on April 7, in which Exxon would direct operations and the Coast Guard would monitor and supervise all procedures. Furthermore, the plan called for the Defense Department, including the Corps, to assist the Coast Guard and Exxon by providing personnel, equipment, and facilities.[77]

Another obstacle in the cleanup process was the remoteness of the spill, which made logistics and communication difficult. Most of the area targeted for cleanup was uninhabited, with few roads and means of communication. "The logistics to get a man on the beach are awesome," said Allen Smith of the Wilderness Society. "You need a boat to carry men, barges for gas, barges for food, and barges just for garbage. It looks like the logistical support for the invasion of Normandy."[78]

The arrival of the dredge *Yaquina*



While the fishing ships corralled the oil, the dredge drag head was turned over to suction the oil swiftly into the hopper.

Meanwhile, the oil continued to spread. By March 27, the calm weather had ended. Heavy storms blasted the Sound until the morning of the fifth day of the spill, preventing boat operations and grounding aircraft. By the time the storm had passed, the oil covered more than 175 square miles and had been transformed into the consistency of a thick, gelatinous mousse. When calm seas returned, large amounts of oil had polluted the shores of Smith, Green, Knight, Naked, and Eleanor islands. Between March 31 and April 6, currents and winds carried about two million gallons of oil into the Gulf of Alaska, and by mid-May the spill had reached the outer coast of the Kenai Peninsula and was entering

Motor launch pushed the oil boom close to the dredge for oil removal. The cage system for the drag head helped keep large debris away from the suction head. Oil in the hold of the dredge was taken to the dock for transfer to awaiting trucks.

Resurrection Bay. Later the oil flowed into the mouth of Cook Inlet and as far away as Kodiak Island and parts of the Alaska Peninsula.[79]

Corps' Response

The Corps responded to the Alaska oil spill in five key ways: providing and operating dredges for oil recovery, participating in the Department of Defense's contingency planning, providing technical assessment, producing pollution reports and disseminating information, and offering the services of Corps labs in various support capacities. All of these areas were important to fighting the spreading oil, but it was the work of the Portland District dredges Yaquina and Essayons that made the most visible contribution to the remediation effort.

At first, neither Exxon nor the Coast Guard welcomed the arrival of the Corps dredges. The Corps vessels were designed to clear channels in harbors and riverbeds along the Pacific Northwest coast and had never been used in a cleanup capacity. When the Corps offered the dredges to combat the spill, cleanup managers couldn't see any use for them. Almost three weeks passed before the Corps dispatched the *Yaquina* from Oregon on the orders of Brigadier General Patrick J. Kelly, Director of Civil Works. Just a few days later the Corps sent the *Essayons* along as well. Even when the arrival of the *Yaquina* was imminent, cleanup officials in Valdez were still searching for a way to use the dredge. It wasn't until the boat's crew removed 1,500 barrels in only 15 minutes that the critics were silenced.[80]

It was only through the crewmembers' innovative thinking that the Corps dredges were able to remove oil effectively. When the *Yaquina* entered Prince William Sound on April 19, two fishing boats had boomed a circle of oil, measuring 200 feet in diameter and 10 inches thick. Initially, the crew tried both of the small pumps that were aboard the boat, but neither could handle the oil, which had thickened into a mousse-like substance; thus, the dredge pumps were the only option. At first, the dredge crew attempted to use the drag line in its usual position of vacuuming material up from the river bottom. This method did pump some oil, but the percentage of water that came with it was too high. After trying this for a while, the crew decided to modify the drag arm by turning the drag head completely over. Once reversed, the drag head pulled in oil from just beneath the surface, allowing the suction portion to lie above the water line while remaining firmly in the layer of oil. With this change, more oil was being sucked into the hoppers in seconds than had been taken in all day.[81]

The other dredges on the scene, including the *Essayons* and the Russian vessel *Vaydaghubsky*, heeded the *Yaquina's* example and inverted their drag arms as well. Thus, the rest of the dredges' work in Alaska followed a pattern in which fishing boats collected the oil and circled the booms into "donuts" to be picked up by the dredges. Motor launches helped by pushing the boomed oil toward the ship as it was sucked into the hoppers.[82]

One of the challenges in this process was the oil itself. In the weeks that followed the spill, the oil had been transformed from a liquid substance into a material that workers compared to cow patties, peanut butter, and lacquer. "The mousse just lays there in a broad sheet 100 feet square," said Ted Hunt, captain of the *Yaquina*. "You can take a handful of it and flip it over like a fish. It's an amorphous mess – God, what a mess."[83] The oil was so viscous that as the suction pumped it, a hole would be created that the oil would not fill. Therefore the suction had to constantly move around the surface of the oil, a very labor-intensive and physically

demanding task. One crewmember compared it to taking "a piece of chocolate pudding" and scooping "a bite out of it."[84]

In addition to inverting the drag heads, Corps crewmembers came up with other creative solutions to the oil spill work. As they collected the oil, for example, debris and kelp continually clogged the drag heads. Crewmembers therefore designed a cage that fit over the drag head and filtered out large pieces of debris. Another challenge was offloading the oil from the dredges onto trucks that were positioned on barges. Normally, the oil was transported via a pump onto the waiting trucks, but the coagulated oil tended to clog the pump, making the process extremely slow and tedious. In response, crewmembers devised a trough that allowed the oily mass to be directly dumped into the truck. This innovation cut the time involved by 20 percent.[85]

The dredges and their crews worked long hours and covered many nautical miles in their effort to contain the oil. Rather than their usual tour of eight days, some crewmembers worked for two weeks without stopping, and the vessels were operated on a 24-hour basis.[86] The *Essayons* began at Gore Rock and worked as far north as Resurrection Bay to as far south as Sutwik Island in the Shelikof Strait west of Kodiak Island. The *Yaquina* began its work around Knight Island in Prince William Sound and at one point traveled as far south as Kukak Bay. Generally, however, the smaller *Yaquina* remained in more sheltered island areas of the Sound and in the fragile environment of the Kenai Fjords National Park, while the *Essayons* worked in the rougher open waters.[87] The *Essayons* also participated in shoreline cleanup operations, by collecting sacks of contaminated sand and oil.[88]

In addition to removing oil, the dredges assisted the effort in other ways. They provided logistical support services, for example, to fishing and skimming vessels in the area. Fishing boats low on supplies called on the Corps for gas and fresh water. Crewmembers occasionally shared meals with the dredge crews or took hot showers on board.[89]

In late May, cleanup managers decided to withdraw Corps dredges from the cleanup area because the oil was no longer on the open water where the dredges could be of use, greatly diminishing productivity. The dredges were sent to Seward, where contractors cleaned the vessels. The *Essayons* proved particularly difficult to clean because the beach waste and sand had mixed with recovered oil, turning it into asphalt. During the time that they worked the Alaskan waters, the two dredges combined had recovered over 379,720 gallons of oil, proving that hopper dredges could play a crucial role in oil spills.[90]

Wildlife covered with oil

Reaction to the Corps' dredges efforts was overwhelmingly positive. "An Army Corps of Engineers dredge near Katmai National Park has proved to be one of the most effective machines at collecting oil," said John Quinley, Regional Public Affairs Chief, National Park Service.[91] "All of a sudden we were heroes," recalled Miguel Jiminez, captain of the *Yaquina*. The cleanup effort was the vessel's "crowning glory."[92] Yet, despite the excitement generated by their vital contribution, some crewmembers also expressed distress over what they experienced while working in Alaska. "I was awed by the beauty of what I saw," said Ernie Wait of the *Yaquina*. "And I hated to see what was going on up there."[93]

While not every aspect of the Corps' involvement was as visible as the work of the *Yaquina* and *Essayons*, the agency made other important contributions to the cleanup operations. The Alaska District formed a Crisis Management Team (CMT) and opened an Emergency Operations Center (EOC), which stayed open for 65 days, most of that on a 24-hour basis. Part of the CMT responsibilities was planning with Defense Department officials in the event that Exxon failed to continue to meet its obligations. In the 65 days that it operated, the EOC maintained liaisons with state, federal, and local agencies and coordinated support activities for the two dredges.[94]

In addition to providing daily information on the spill and participating in contingency planning, the Corps analyzed Exxon's shoreline cleanup methods and assessed other methods of shoreline restoration at the request of the Joint Task Force. Scientists from the Alaska District, North Pacific Division, and the Waterways Experiment Station in Vicksburg, Mississippi, produced papers on a variety of topics related to shoreline remediation. Alaska District staff also conducted research on incineration techniques, examining different types of incinerators and methods for burning oil-soaked materials.[95]

The effort to clean up contaminated shorelines, however, was ultimately not very successful. By the end of May 1989, almost 9,000 workers had become involved in shoreline cleanup. The most prevalent method pumped vast quantities of cold seawater onto the beaches. This technique failed, however, to remove the oil that had seeped into the rocky crevices. Furthermore, each night brought

tides that usually lifted the oil to the surface or returned oil that had previously been washed off back ashore.[96]

In mid-September, Exxon halted its shoreline operations for the winter. By this point, Coast Guard Commandant Paul Yost had given up hope that the Smith Island beaches could ever be restored by human effort. "I can't see when it will be clean again," he said. "Restoration will have to be done over the next few years by the Lord."[97] Port Graham Village Chief, Walter Megananck expressed his community's distress over the devastation. "Never in the millennium of our tradition have we thought it possible for the water to die," he observed. "But it is true. We walk our beaches. But the snails and barnacles and the chitons are falling off the rocks. Dead. Dead water…. We walk our beaches. But instead of gathering life, we gather death. Dead birds. Dead otters, Dead seaweed…. We are in shock. We need to clean the oil, get it out of our water, bring death back to life. We are intoxicated with desperation."[98]

Despite the heroic efforts of many agencies and individuals, only one-quarter of the oil spilled from the *Exxon Valdez* was directly recovered, leaving 114,000 barrels adrift in Alaska's waters.[99] Perhaps the most obvious lesson from the spill was the need for prevention. The spill also highlighted the need for better spill preparation, more clearly delineated command and control procedures, and more research into increasing the effectiveness of hopper dredges. While no one wanted to experience another such human-caused disaster, the Alaska oil spill demonstrated the Corps' ability to utilize its equipment and personnel in a highly effective manner.

Flooding at Oregon City and south on the Willamette River

Containing the Flood of 1996

As with volcanic eruptions and other natural events, the Corps responded to flooding as part of its disaster relief work. One of the biggest floods the Portland District faced in the late 20th century occurred in February 1996 and caused millions of dollars in damage to the region. The District played a crucial role in combating this flood's impact through a variety of short-term and long-term activities. Once the immediate danger had subsided, the flood prompted environmentalists, concerned citizens, and government agencies to reexamine how human development patterns, such as logging and agriculture, contributed to the intensity of flooding.

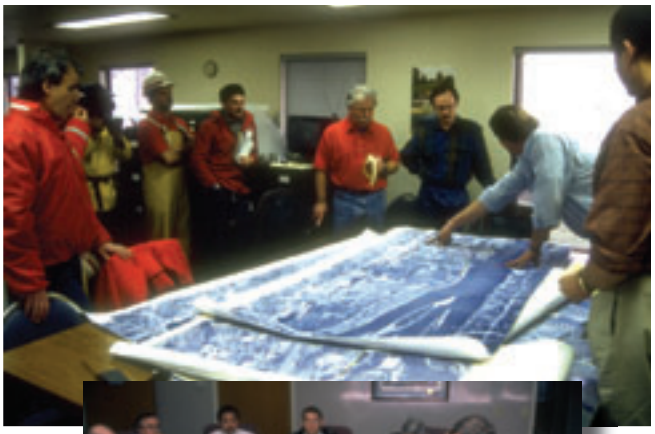
Flooding in the farmlands and residential areas

High water at Willamette Falls Locks

The Pacific Northwest has a history of flooding. Winters in the region sometimes bring a sudden influx of warm westerly winds, referred to locally as chinooks, which rapidly melt the snow pack, causing runoff over the still frozen ground. The first snowmelt, which is often accompanied by warm rain, swells tributaries and major rivers, resulting in floods of various intensities. In the late 19th and early 20th centuries a series of floods transpired on the Willamette and Columbia rivers. More recently, major floods struck western Oregon in 1948 and 1964. Thirty-two years later, another flood of similar intensity struck the region.[100]

The flood of 1996 began in much the same way as previous floods. In the months prior to February, record snowfall had been accumulating, saturating the soil. In January, the snowfall doubled and tripled the snow pack in some locations. Then in early February, a storm began near Java in the western Pacific. This "pineapple express" storm gathered moisture and power as it raced across the subtropical Pacific and veered northward. Typically such storms struck California, but because of La Nina, a powerful west-east jet stream, the storm worked its way northward, across Washington and Oregon. The storm's heavy rains mixed with the snow in the mountains; rainfall in some locations reached half an inch an hour.[101]

Ships in the swollen Columbia River waiting to sail upriver to ports



Portland seawall and Emergency Management strategy meetings

From February fifth through the eighth, heavy rain fell on the Northwest. Combined with melted snow, the rain transformed streams into raging torrents and caused rivers to surge over their banks. "I've never seen anything like this before and I have been in Oregon for 25 years," said a resident of Oregon City. "Last night, the water had not reached the McDonald's parking lot. Now McDonald's looks like it's in the middle of the lake." Flooding hit communities from Puget Sound to central Oregon, killing four people and forcing thousands of others to evacuate. In the countryside, flooding destroyed winter wheat crops in southeastern Washington and damaged many farms and ranches. At least 1,000 dairy cows drowned in Tillamook County, and two farmers lost their entire herds. Rising water and mudslides – more than 100 in the Portland area alone – shut down transportation networks and isolated some towns. Interstate 5 – the north-south artery across Oregon and Washington – was cut off in two places, buried under a landslide and several hundred feet of water. Freight trains in eastern Oregon were backed up, unable to cross through the Columbia Gorge, where a massive slide had buried the railroad tracks and most lanes of the interstate. "This is a very, very damaging flood," Washington Governor Mike Lowry told reporters. "It is way too early to make assessments, but I've seen numerous comments that this might be the worst in 50 years." At the national level, President Clinton issued a federal disaster declaration, clearing the way for providing temporary housing, family grants, and low-interest loans for flood victims.[102]

The Corps took a number of immediate steps to lessen the flood's impact. Before the rain intensified in early February, the Corps had been releasing water from its hydro projects to make room for spring runoff. Once the heavy rains began, it immediately started cutting back flows and storing water in its storage projects. Engineers and technicians at the North Pacific Division Reservoir Control Center (RCC) in Portland worked around the clock to manipulate more than 60 dams in the Columbia River system to minimize flooding. Managing river flows during the flood was a delicate balancing act, according to Cindy Henriksen, Chief of the RCC. "There is a complex system of dams on Northwest rivers and streams," she explained. "But not all of these dams are designed for flood control. Only one dam on the lower Columbia, the John Day, has significant storage capacity."[103]

Despite the challenges in regulating water flow, Corps dams were successful in holding back the flow of water and reducing flooding. Perhaps their most visible success was in downtown Portland, which, because of its location at the confluence of the Columbia and the Willamette, was especially vulnerable. A number of uncontrolled tributaries entered the Willamette upstream of the city, and many experts predicted that the crest would top Portland's floodwall, which protected the downtown area. In response to this threat, Portland's mayor Vera Katz requested technical assistance from the Corps and asked for volunteers to help city crews reinforce the wall. In a matter of hours, the riverfront teemed with people filling sandbags, building a higher plywood wall, and reinforcing the plywood with concrete road slabs.[104] "You essentially had this miniature levee built all along the seawall," explained Jerry Christensen.[105] Crews worked into the night as the river edged up the wall, lapping over it at times. When the crest finally arrived, it was lower than predicted due to waning rainfall, and the city was spared

Sand bagging at Willamette Falls and dike rebuilding in Clatskanie

major flooding. "It could have been a terrible nightmare for Portland if those dams weren't there," said Tom Worden, spokesman for Oregon's state emergency management office.[106] Mayor Katz was also grateful, calling the effort by the Corps and volunteers "a heroic, heroic public works project."[107] *The Oregonian* applauded the District as well, summarizing the effort in a dramatic headline reading, "How They Saved Downtown."[108]

The Corps contributed to the flood relief efforts in other ways as well. At The Dalles-John Day project, for example, the agency distributed more than 100,000 sandbags to outlying communities in four counties. At Mill Creek, Corps' personnel worked to keep the rising waters at bay. When debris began backing up the creek on February 7, crews worked until midnight for many consecutive nights to clear the material. "They were great," exclaimed Kim Fisher of The Dalles Chamber of Commerce. "The guys worked very hard and were soaked from the rain." In addition to directly battling the flood, the Corps also provided less traditional assistance. At the Bonneville project, for example, the District allowed 11 students from a nearby school to use the second powerhouse visitors' theater as a makeshift classroom after a mudslide threatened their own facility. "They're on the project from 8 a.m. until 2 p.m. and we've reserved the gymnasium in the project auditorium for their physical education classes," explained Jim Runkles, park manager.[109]

When the initial threat of flooding was over, the District shifted to recovery work. The agency's primary work involved repairing both federal and non-federal dikes, levees, and flood protection embankments in numerous counties throughout the region. The floods also had produced heavy shoaling in the Columbia River navigation channel, prompting the *Essayons* and its crew to undertake dredging work. Through its immediate response and longer-term efforts, the Corps substantially reduced the economic impact of the flood. Altogether, Corps projects in the Pacific Northwest prevented flood damages totaling more than $3.2 billion, with savings of $1.1 million at Portland.[110]

In addition to impacting human communities, the February floods also affected salmon populations in the Northwest. Raging river currents swept away banks, took out trees, and destroyed streamside vegetation; clear waters became choked with debris. The floods, however, also benefited fish populations by forming new side channels, depositing protective woody debris, scouring out pools, and bringing in new clean gravel. To the general public the flood was a catastrophe, but for fish and other aquatic species, floods are a part of nature's cycle. "These fish have lived with flooding for thousands, even millions of years, and they've done quite well without us," explained Stan Gregory, a professor at Oregon State University. Dave Heller compared floods to forest fires, another natural phenomenon whose role in promoting healthy ecosystems has historically been unappreciated. "Floods are analogous to fire in a forest: It may not be pretty, but it surely plays a critical role," he said.

The Oregonian recognized the Corps' efforts to save the downtown area from the flooding.

In fact, while "postcard-perfect, uncluttered streams" are visually appealing, they offer little food and shelter for fish. By depositing woody debris and creating new deep pools and gravel bars, the floods actually improved the habitat of some streams.[111]

The impact of the 1996 floods on salmon streams was uneven: some suffered extreme damage, while others appeared to be recovering well and even prospering. Some of the disparity could be attributed to differences in terrain and local storm intensity, but the primary factor was the extent of human influences on the landscape. Scientists generally found that areas that were heavily altered by human development suffered more than those that were relatively untouched. Logging, for example, created clearcuts and logging roads, both of which increased the rate of slides. Agricultural development converted wetlands and floodplains, reducing a river's natural flood control system.[112]

The Corps, through its attempts to provide navigation, also contributed to the problem of flooding. In the Willamette River watershed, for example, the agency cut off secondary channels with debris dams, filled in sloughs to increase water volume in the main channel, and performed clearing and snagging activities. Over time, these activities transformed the historic multiple channel configuration of the river to a simplified single channel system that could no longer handle the same volume of water – particularly in an area that had become heavily urbanized.[113]

Prompted by the February flood and several others that followed it, environmentalists, scientists, and government officials in the Pacific Northwest questioned traditional land use practices, seeking a variety of solutions to lessen the impacts of flooding. Despite their success in controlling the water flow, few believed it was feasible or desirable to build new dams. Instead, they pushed to revamp and better enforce land use policies to limit development in flood zones, restrict clear-cutting of forests on steep slopes, and restore wetland areas. "We need long-term changes in policies over the next 40 years," said John Baldwin, a University of Oregon professor and specialist on environmental public policy. "We have to realize that we're looking at problems that building one dam on a river won't change. We need to change the whole way we do business." Later he added, "What we really need to do is develop human systems that recognize the primacy of physical systems." Environmentalists and scientists joined in the debate, arguing for a moratorium on steep-slope logging on both private and public lands until other forest practices could be enacted to reduce the number of landslides. Some environmentalists supported returning the Willamette River to a more "natural" state. "The main thing we can do to alleviate flooding in this valley is to give the flood plain back to the river, to give it room to roam and stay out of its way as best we can," said Phil Wallin of River Networks, a national river conservation group.[114]

In a further step toward river restoration, River Networks proposed restoring flood plain functions through a voluntary wetlands restoration program along the Willamette. The group, who had been exploring the idea prior to the Flood of 1996, released its preliminary report during the February flooding. The River Networks report, along with the support of Congressman Peter DeFazio, led Congress to authorize the Portland District to study the issue. After obtaining study authority, the Corps completed a reconnaissance study and proceeded to begin work on the feasibility study.[115]

President Clinton visited the area to praise the Corps and city for successful prevention and recovery efforts from the flood.

The Corps expects the feasibility study, which generally takes two to three years, to be completed in the early 21st century. The major challenge facing the District at this stage is finding a local sponsor to satisfy the cost-sharing requirements of the project. Identifying an appropriate sponsor will be difficult given the considerable costs of the project, but the Corps remains optimistic about the benefits of this type of voluntary restoration work. "It's clear that the Corps needs to look at new options for flood control in the Willamette Basin," remarked Project Manager Matt Rea. Furthermore, Rea believed that the voluntary nature of the program heightened its potential for success. Much of the land along the Willamette River is privately owned and divided into small parcels. Attempting to implement a mandatory program would likely meet with a great deal of resistance from private landowners, whereas a voluntary program, including tax incentives, easements, and other real estate agreements, would be less politically volatile.[116]

The February 1996 flood brought extensive damages to communities throughout the Pacific Northwest. Using its ability to quickly mobilize, its technical expertise, and its intricate systems of dams, the Corps contributed greatly to relief efforts by lessening the impacts of the flood. The agency's hard work did not go unnoticed; after reviewing flood damages President Clinton stated that he was "very impressed with…the work the Corps of Engineers has done to try to get the water down as much as possible, as quickly as possible."[117] More formal recognition was given in February of 1997, on the one-year anniversary of the flood, when Vice President Gore presented his National Performance Review Hammer Award to the Portland District and the North Pacific Division. The Bonneville Power Administration, Bureau of Reclamation, and City of Portland also received Hammer Awards, which are given to teams of federal, state, and local employees and citizens working together to build a better government.[118]

Yet the story of the flood extended beyond the immediate crisis, prompting environmentalists, scientists, and concerned citizens in the region to reexamine land use practices and beliefs. Logging practices, wetland conversion, and development in flood plains were all called into question in the wake of the event. Not immune to the shifting values, the Corps also reevaluated its position, looking beyond dams to other non-structural approaches to flood control. "The Corps has changed the way it approaches the environment," said Robert Willis, Chief, Environmental Resources Branch. "We used to focus only on flood control and navigation work. Now our emphasis has shifted to include ecosystem restoration and fish and wildlife management."[119]

Participating in Recovery Operations for Hurricanes and Earthquakes

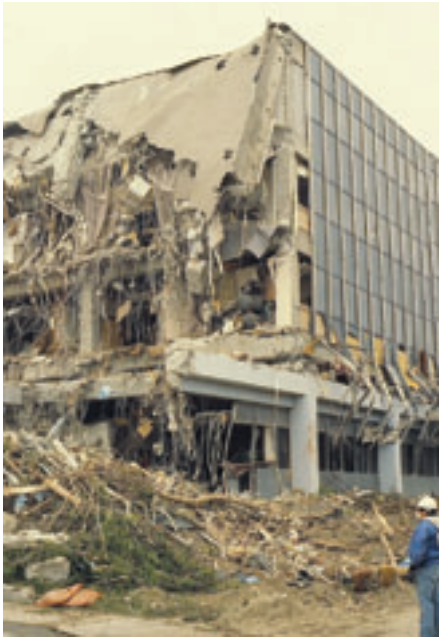
As demonstrated by its role in cleaning up the Alaska oil spill, the District's disaster recovery mission extended beyond its own boundaries to helping other regions with relief work. In the late 20th century, Portland District aided other districts in response to two major events – the California earthquake and Hurricane Andrew. In both of these efforts, Portland employees offered valuable assistance, drawing on their experience with previous disaster work, including the Mount St. Helens recovery work.

California earthquake recovery, 1989

When an earthquake struck central California on October 12, 1989, the Corps was one of the first agencies on the scene. More than 100 people from Portland volunteered to help in the relief work; the 30 selected joined 300 Corps professionals from around the country. Once again, the agency demonstrated its ability to rapidly mobilize. "The fact that 300 people were out there working the next day shows you how quickly you can get out if you need to," said Hank Annus, a civil engineer with the District. "I was very impressed by Sacramento's handling of such a large group of people." Lou Smith, another civil engineer from Portland was also inspired by the Corps' highly organized response. "I arrived in Sacramento on October 22 and by early the 23rd I was in a briefing with 300 people," he recalled. "The Sacramento District Engineer, a very dynamic colonel, was ready to dispatch teams all over the earthquake area."[120]

One of the major tasks of the recovery effort was evaluating damage to residential properties. People whose homes had been impacted by the earthquake submitted special forms to FEMA requesting help. Those forms were then given to the disaster center, where California state emergency management staff members prioritized the requests and dispatched teams to inspect the damage and fill out Damage Report Surveys (DRS). Drawing on their engineering knowledge, many District employees worked on various stages of the DRS. Smith explained his group's role in the process. "We verified [the home] was damaged and the estimated cost to fix it. We looked to see where the cracks were, if the foundation was off," he said. To process the constant stream of applications coming in – in just one day FEMA received more than 800 DRS – Corps members worked six days a week, 10 hours a day.[121]

Many of the District volunteers were surprised by the extent of the earthquake damage and struck by the toll it took on people's lives. "I didn't realize," said Carol Hudson, an emergency operations assistant. "I had seen it previously (on TV) but unless you see it yourself, you never realize how terrible it must have been. People's whole lives were gone, their homes, possessions. It's something I don't ever want to go through."[122]



Despite the shock of the devastation, most District personnel felt that the experience was rewarding as well as beneficial. "I met a bunch of wonderful people, learned about the Corps and learned a new software program," said Jeanette Morden, personnel assistant. Many others agreed that the best aspect of the experience was "working with people." Furthermore, District employees expressed admiration for the tenacious nature of the earthquake victims. "It's amazing how people band together," said Annus. "It's a good feeling to see that people really do care. It's been a positive experience. Every

Hurricane Andrew recovery, 1992

time you go to a disaster there is some positive. You see human suffering but you see people do care."[123]

The Corps was once again called to action when Hurricane Andrew hit South Florida on August 24, 1992. The hurricane damaged $20 billion in property, destroyed or damaged 82,000 businesses, and left 160,000 people homeless. In fact, Hurricane Andrew turned out to be the costliest disaster in American history and the largest disaster recovery effort ever undertaken by the Corps.[124]

More than 1,150 Corps members from all over the country, including the Portland District, traveled to Florida to clean up the ravaged state and help the thousands of victims. "The hundreds of Corps team members deployed to the disaster scene from throughout the Corps are the key to recovery efforts," said Commander Colonel Terrence Salt of the Jacksonville District.[125] Portland sent four people to assist with relief and cleanup and placed 38 emergency response team members on standby. The Portland team was comprised of engineers and specialists in damage assessment, structural inspection, radio and computer communications support, and administrative and logistical support. Furthermore, many of the team members had practical experience working on disasters ranging from Mount St. Helens to floods and hurricanes.[126]

The Corps response effort was comprised of many different tasks. FEMA assigned more than $380 million in recovery missions to the agency, including the following projects: roofing, water supply, providing ice, technical assistance, debris removal, emergency generator and pumps, portable toilets, schools, garbage removal, showers and laundry services, temporary housing, and damage survey reporting. Of these missions, providing temporary roofing and collecting storm debris were the major tasks, utilizing the majority of Corps members engaged in the relief work. Corps contractors and volunteer organizations covered 43,000 damaged roofs with plastic sheeting and collected 11 mcy of storm debris.[127]

Through its dedication and teamwork the Corps greatly contributed to the disaster relief work at Hurricane Andrew. "The performance of all Corps elements in response to Hurricane Andrew has

been simply magnificent," observed Colonel Salt. "Time and time again, Corps elements are singled out for the importance of their contribution and the quality of their response."[128]

Conclusion

Disaster relief is one of the Corps' long-standing missions. The Portland District has responded to many emergencies in the late 20th century, including volcanic eruptions, floods, earthquakes, hurricanes, and oil spills. With its extensive technical knowledge, heavy equipment, and quick response time, the District is prepared to combat a variety of disasters. In addition, District employees have often provided creative techniques to solving serious problems. During the Alaska oil spill, for example, crewmembers of the *Yaquina* inverted the vessel's drag head to suck up oil, providing the first significant success in this area. Disaster relief is one of the Corps' most visible areas of work, and the agency's efforts are generally appreciated throughout the country.

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