An Alaskan Challenge: Native Village Sanitation

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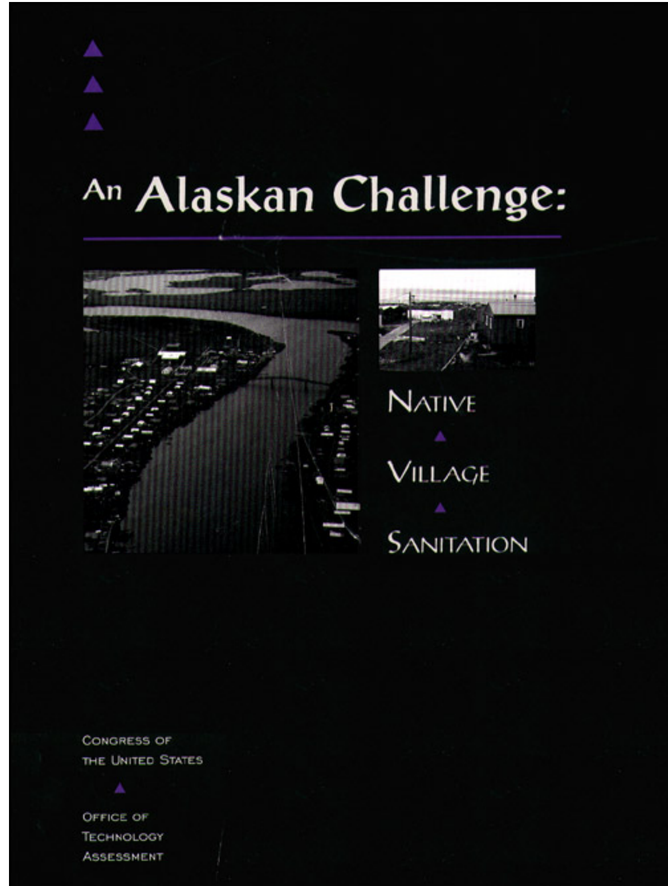

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Foreword

More than 20,()()() rural Native residents in Alaska live in communities without running water and where homes, local government offices, commercial buildings, and even medical clinics use plastic buckets for toilets-euphemistically called “honey buckets.” The waste from these toilets is often spilled in the process of hauling it to disposal sites, and these spillages have led to the outbreak of epidemic diseases such as Hepatitis A.

This OTA assessment, requested by Senator Ted Stevens of Alaska, reviews the status of federal government efforts to provide safe sanitation to Alaskan Natives and the technologies that have been used or proposed for this purpose. Information about similarly relevant efforts by State and Native governments is also provided. A significant portion of this research also focuses on the geographic, social, and economic settings of the Natives and their remote communities. Finally, the work examines the legislative and institutional setting for the waste sanitation problems, and the criteria that need to be applied in selecting and implementing new technologies.

Providing safe water and waste sanitation systems to Alaskan Native villages has been more difficult, expensive, and time consuming than in any other region of the United States—particularly because of the unusual technical constraints. Despite considerable efforts by the Indian Health Services and others, only half of the 191 Native villages have adequate sanitation.

Two major types of measures appear to be needed to support the development and application of cost-effective alternatives in the long-term: 1) a comprehensive Federal research, development, and testing program for innovative sanitation technologies; and 2) increased financial support for operation and maintenance and technical assistance programs.

OTA’s staff received splendid support from Federal, State, and Native organizations and private sector individuals during the preparation of this report. Of special significance is the assistance provided by Native leaders, sanitation experts, and v illage residents during our visit to rural Alaska. Invaluable assistance and guidance was also provided by the Alaska Area Native Health Service, the Village Safe Water, and the University of Alaska-Anchorage.

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ROGER C. HERDMAN
Director

Reviewers

Mike Black
Alaska Department of Community and Regional Affairs

John Bouzoun
U.S. Army Corps of Engineers
Cold Regions Research and Engineering Laboratory

Patrick A. Brown
CHETS International
Seward. Alaska

Greg Capito
Alaska Department of Environmental Conservation

Roger Clark
City of Selawik

Tom Coolidge
Alaska Area Native Health Service

James Crum
Alaska Area Native Health Service

Tudor Davies
U.S. Environmental Protection Agency
Anchorage, Alaska

Chuck Eggener
Chuck Eggener Consulting Engineers
Anchorage, Alaska

J.P. Godfrey
Alaska Science and Technology Foundation

Hollis D. Hall
University of Alaska Fairbanks

Samuel E. Hardin
Farmers Home Administration
Palmer, Alaska

Thomas Joyce
ACTION — Region 10

Julie Kitka
Alaska Federation of Natives

Ed McKiernan
SeaLand Technology, Inc.

Larry Merculief
Alaska Sanitation Task Force

John Olofsson
University of Alaska Anchorage

James Peterson
U.S. Environmental Protection Agency Region 10

Bernhard Richert
Economic Development Administration
Anchorage, Alaska

Randy Romenesko
Alaska Department of Environmental Conservation

John Schaeffer
NANA Corporation

Herb Schroeder
University of Alaska Anchorage

Paul Sherry
Alaska Native Health Board

Dave Shoultz
Yukon Kuskokwim health Corporation

John Spriggs
Maniilaq Association

John W. Sibert
Alaska Science and Technology Foundation

Kathleen Vietch
U.S. Environmental Protection Agency Region 10

Ann Walker
Alaska Native Health Board

Orie Wiliiams
Yukon Kuskokwim Health Corporation

Peter Williams
City of Napaskiak

Preject Staff

Clyde Behney
Assistant Director, OTA
Health, Education, and Environment

Robert W. Niblock
Environment Program Director

GERMAN E. REYES
Project Director

CONTRIBUTORS

Robert Friedman

Peter Johnson

Robert Niblock

CONTRACTORS

John Olofsson and
Jeffrey Schroeder
University of Alaska Anchorage

Florence Poillon
Editor

ADMINISTRATIVE STAFF

Kathleen A. Beil
Office Administrator

Kimberly Holmlund
Administrative Secretary

Sharon Knarvik
Secretary

Barbara Bradley
Secretary

Workshop Participants

Mike Black
Alaska Department of Community and Regional Affairs

Greg Capito
Alaska Department of Environmental Conservation

Tom Coolidge
Alaska Area Native Health Service

James Crum
Alaska Area Native Health Service

Chuck Eggener
Chuck Eggener Consulting Engineers
Anchorage, Alaska

J.P. Godfrey
Alaska Science and Technology Foundation

John Olofsson
University of Alaska Anchorage

Randy Romenesko
Alaska Department of Environmental Conservation

John Schaeffer
NANA Corporation

Herb Schroeder
University of Alaska Anchorage

John W. Sibert
Alaska Science and Technology Foundation

Ann Walker
Alaska Native Health Board

Orie Williams
Yukon Kuskokwim Health Corp.

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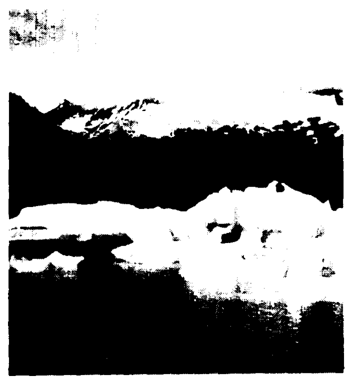
Overview and Findings 1

NATIVE VILLAGES OF RURAL ALASKA: THEIR SETTING AND SANITATION PROBLEMS

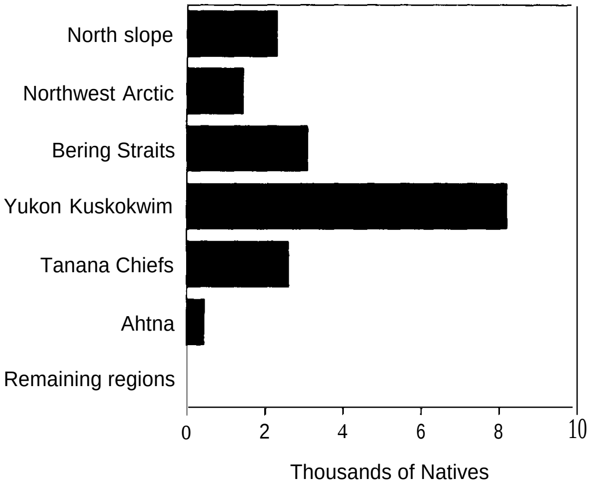
About one-fourth of Alaska’s 86,000 Native residents live without running water and use plastic buckets for toilets+ euphemistically called ‘*honey buckets” (figure l–l). This report examines the status of waste sanitation among Native villages of rural Alaska, identifies the socio-economic factors contributing to sanitation inadequacy, and discusses the technological solutions that have been used and proposed to date. Honey buckets are the predominant means of sanitation for Native residents in 89 villages in the Ahtna, Bering Straits, North Slope, Northwest Arctic, Tanana Chiefs, and Yukon-Kuskokwim regional areas (figure 1-2) (127). [1]

Throughout rural Alaska, but particularly in the Yukon-Kuskokwim Delta and the Northwest Arctic, the outbreak of diseases, including hepatitis A, bronchitis, impetigo, and sometimes meningitis, is believed to be partially attributed to the exposure to human waste caused by inadequate sanitation facilities. Because of the frequent spillage of human waste that occurs on community roads and boardwalks during its transportation to disposal sites or sewage lagoons, the exposure of residents, particularly children,



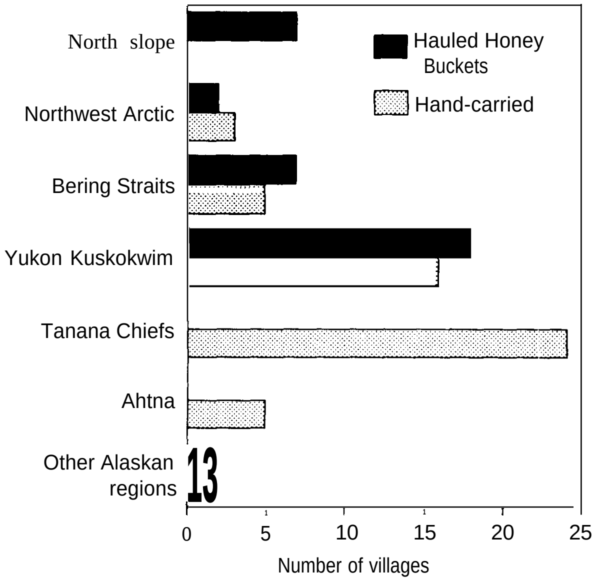
[1] As many as 239 total Alaskan villages have been reported in the past; the actual number, however, is generally difficult to quantify. In its 1992 directory, for example, the Bureau of Indian Affairs, Juneau Area Office, listed a total of219 village governments. For the purpose of this report, OTA focused on only the 191 Native villages on the Indian Health Service’s database.

FIGURE 1-1: Native Population in Alaskan Rural Villages Being Served by Honey Bucket Systems



SOURCE Jim Crum, Director, Diwsion of Sanitation Facilities, Alaska Area Native Health Service, personal cornmunication, November 9, 1993

FIGURE 1-2: Rural Alaskan Native Villages in Which Honey Buckets are the Predominant Waste Sanitation Technology*



* This figure does not include villages (about 13) in which only a few homes use honey buckets

SOURCE Jim Crum, Dirctor, Division of Sanitation Facilities, Alaska Area Native Health Service, personal communication, Nov. 9, 1993

to such waste is frequent. The fact that diseases such as hepatitis A occurs in epidemics has raised questions about both their exact mechanism of transmission and the overall level of disease eradication that can be achieved with sanitation technologies.

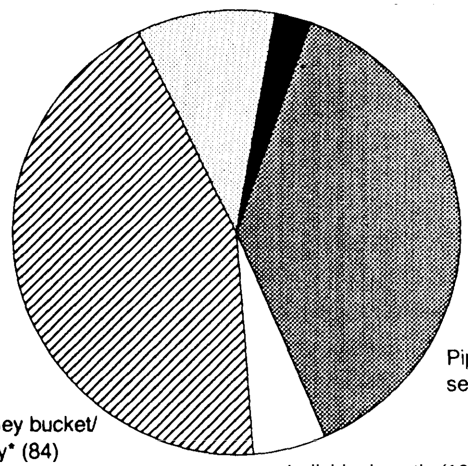
The Native villages with the most frequent outbreaks of disease are those in which running water is difficult to obtain and the principal method of disposal is the honey bucket. In many cases, the honey bucket system consists simply of a 5-gallon plastic bucket lined with a plastic bag, with a toilet seat on top of it. Once filled, the plastic bag is sealed and the bucket is hand carried and emptied into a haul container or sewage lagoon or sometimes dumped at a convenient location. In these communities, honey buckets are used in homes, by local governments, in commercial buildings, and even in medical clinics.

Despite Alaska's abundance of water, it is often extremely difficult to obtain water for drinking and sanitation in rural areas. According to recent estimates, at least 73 of the 191 Native villages comprising the study area of this report have been provided piped water and sewer projects to meet their sanitation needs (figure 1-3). Flush toilets are also found in communities operating truck haul and septic tank systems, which number 10 and 24, respectively. Because in about 95 of the 191 Native villages, piped water systems do not exist inside homes, most of the domestic water used by residents must be hauled by hand from the central watering point, a water well, or a washeteria[2] in the villages. The work involved in hauling water, usually by means of a 5-gallon pail, is burdensome and time consuming; thus, water use in these Native villages tends to be minimal. In the

[2] A building in which people can shower and do their laundry.

Almost all Native villages are geographically isolated from Alaska's major urban centers. Access by road is virtually impossible due to the extensive wetlands found in the region.

FIGURE 1-3: Types of Sanitation Technologies Operating Among the 191 Native Communities of Rural Alaska Identified by the Indian Health Service



* includes 26 honey bucket haul, 19 honey bucket bunkers, and 39 privy systems.

SOURCE Jim Crum, Director, Division of Sanitation Facilities, Alaska Area Native Health Service, personal communication, Nov 9, 1993

winter, ice is often chopped from lakes and rivers, and stored in 30-gallon plastic trash cans. The plastic cans are placed inside the home to melt the chopped ice. Box 1-1 describes briefly some of the difficulties encountered by Native Alaskans in obtaining the water needed to maintain good sanitation and to prevent disease. More details are presented in chapter 3.

The lack of adequate water supplies often increases the risk of disease because it reduces the ability of Natives to maintain good personal hygiene. Because epidemic waves of diseases such as hepatitis A are expected every 15 to 20 years, a great number of casualties might occur if proper measures are not taken in advance. However, prevention of an epidemic does not seem possible unless communities are provided with sufficient water to ensure adequate sanitation, personal hygiene, and safer sewage handling methods. In 1988, more than 70 percent of all hepatitis A cases reported throughout the State of Alaska occurred in Native villages with honey bucket systems.

MISSION AND ACCOMPLISHMENTS OF AGENCIES RESPONSIBLE FOR SANITATION

Federal participation in health care for Native Americans dates as far back as 1802. The formal delineation of this responsibility, which began with the signing of the 1854 treaty with the Rogue River Indians (southwest Oregon), is found today in numerous constitutional documents, historical events, and statutes. Federal funding to support Indian health care activities of the Department of

BOX 1-1: Despite the Large Bodies of Water Throughout Alaska, the Amount of Water Suitable for Drinking and Sanitation in Native Villages is Limited

Alaska is a land of contradiction. When traveling in western Alaska or the North Slope, one is conscious of lakes, tundra ponds, and rivers seemingly without number. However, acquiring water in areas with continuous or discontinuous permafrost can be a challenging proposition.

Permafrost on the North Slope can be several hundred feet deep, effectively preventing or making extremely difficult the drilling of wells. At the same time, permafrost also forms a watertight barrier, which may exist as liquid soil-water in the summer. The upper layers of soil will typically melt seasonally to form what is called the "active layer. " Water that melts in the active layer has essentially no place to go and remains perched above the frozen permafrost layers. This is results in surface water that dissolves a broad range of organic and inorganic materials, and becomes highly colored with a heavy burden of total dissolved solids.

Rivers are often used as sources of water. Unfortunately, Arctic rivers often freeze solid, leaving only a small meandering flow somewhere beneath the ice of the riverbed. Locating this perennial stream beneath the frozen river is often a matter of luck and persistent searching.

River water availability may not even be improved by construction of in-stream impoundments. During spring breakup, ice jamming, high rates of flow, and flooding result in extreme forces from ice moving downstream. Structures designed to withstand such forces would be both expensive and impractical to install.

Seasonal water intakes are often constructed on lakes and rivers for use during the ice-free period and in the winter, Intake lines are frequently floated to an intake point and held in place by an appropriate flotation device. Similarly, after freeze-up in winter, lines are used to pump water through holes cut in the ice. Problems arise because of the decreasing water quality in winter caused by the freeze exclusion of solutes and dramatic increases in the total amount of dissolved solids. Also, subsurface water sources maybe inaccessible for several weeks during the onset of ice cover in the fall and breakup in the spring. More detailed information on Alaska's limited drinking water sources for maintaining good sanitation and preventing disease is provided in chapter 3.

SOURCE John A. Olofsson and H P Schroeder, University of Alaska Anchorage, *Sanitation alternatives For Rura/Alaska,* report prepared for the Congressional Office of Technology Assessment, Washington, DC, Aug. 15, 1993.

the Interior's Bureau of Indian Affairs was first authorized with the passage of the Snyder Act of 1921.[3] In 1955, the responsibility for Indian health care was transferred to the U.S. Department of Health, Education, and Welfare, now the Department of Health and Human Services (248).

As a response to documented health problems among Native communities, and recognizing the need to develop formal solutions to the waste sanitation problem, Congress passed the Indian Sanitation Facilities Act in 1959,[4] giving the Indian Health Service (IHS) the authority to plan, design, and construct water and sewerage projects in Native communities. Since passage of the Act, IHS has provided water and waste sanitation services to more than 182,000 Native residents in the lower 48 States and Alaska, and improved sanitation systems in over 58,000 homes (248).

To further improve the health conditions of American Indian and Alaskan Natives, Congress enacted the Indian Health Care Improvement Act in 1976.[5] Under this Act, IHS is responsible for,

[3] 25 U.S.C. 13.

[4] P.L. 86-1 21; 42 U.S.C. 2004a.

[5] 25 U.S.C. 1601 *et seq.*

Lakes, tundra ponds, and rivers in Alaska are seemingly without number. Despite this abundance, it is often extreme/y difficult for many Native villages to obtain water suitable for drinking and sanitation purposes.

among other things, increasing the number of health professionals serving Native communities, upgrading hospitals and other IHS health facilities including 172 Alaskan village clinics, and building potable water and waste disposal facilities (258). As part of its efforts to improve the overall health of Natives, since 1960 IHS has invested more than $350 million in the construction and upgrade of nearly 700 sanitation projects in roughly 180 Alaskan communities. Currently, IHS is carrying out the construction of 407 new sanitation projects in rural Alaska at a cost of $152 million.[6]

The Indian Sanitation Facilities Construction Act of 1959 and the Indian Health Care Improvement Act of 1976 limited their focus to construction activities. Federal funds were ***not*** authorized for operation and maintenance (O&M) of the facilities that were built. Because Native communities lack outside O&M funding and have poor local economies, many have had extreme difficulties with proper operation and adequate maintenance of these systems. Recognizing this deficiency, Congress amended the Indian Health Care Improvement Act with the Indian Health Amendments of 1992,[7] authorizing IHS to share up to 80 percent of the costs incurred by Native communities in operating, managing, and maintaining safe water and waste sanitation projects. For Native communities with fewer than 1,000 residents, the Act further adds that". . . the non-Federal portion of the costs of operating, managing, and maintaining such facilities may be provided, in part, through cash donations or in kind property, fairly evaluated" (167).

IHS has not sought funds from Congress to carry out the O&M tasks stipulated under this statute because of efforts to first define the nature of congressional intent. Preliminary IHS estimates suggest, however, that an annual contribution of $80 million to $120 million would be needed to implement the mandate of the Act nationwide. Adoption of measures to comply with new waste disposal and drinking water regulations issued by the U.S. Environmental Protection Agency (EPA) could further increase this amount to at least $150 million annually. According to some preliminary estimates, implementation of the 1992 Indian Health Amendments in rural Alaska alone would cost about $15.1 million (122,151 ,204,206,303).

The Village Safe Water (VSW) Program within the Alaska Department of Environmental Conservation (ADEC) is the principal State agency responsible for improving water and sewer systems in Alaskan communities. The VS W program has a small staff (about 12 out of more than 450 ADEC employees). However, as of July 1993, VSW was carrying out projects in almost 60 Native villages throughout rural Alaska. Other agencies with programs relevant to Native communities are discussed in chapter 4.

The Indian Health Service works with VSW in ensuring data reliability, coordinating activities, and sometimes matching funds. When IHS and VSW agree that a proposed sanitation project

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[6] The status of these facilities or projects ranges from just initiated, to partially completed, to fully operational.

[7] P.L. 102-573.

should be undertaken, they cooperate on planning, design, and ultimate construction of the facility. In 1993 alone, the two agencies cooperated on 17 different projects.

To date, efforts by IHS and VSW have provided safe water and adequate waste sanitation service to more than 300 Alaskan urban and rural communities. Of the 191 rural Native village communities relevant to IHS sanitation efforts, more than 70 have already been provided with modern pressurized potable water and gravity sewerage systems. Twenty-six others have received septic or leach field systems, and about a dozen villages (including Galena, Bethel, Barrow, South Point Lake, and Katorik) operate a truck haul system for both potable water delivery and wastewater disposal. A pilot demonstration project of-a small-vehicle haul system is also under way in the village of Mekoryuk. Box 1-2 briefly describes the characteristics of the major waste sanitation systems used in rural Alaska. A more detailed discussion of waste sanitation technologies including the Mekoryuk system is provided in chapter 5.

CAPITAL CONSTRUCTION FOR SANITATION FACILITIES

Despite Federal and State efforts to build water and sewer projects to date, lack of adequate sanitation remains a serious health problem for at least 67 of the 89 Alaskan Native villages operating the most rudimentary sanitation system found in the State: the honey bucket system. Protection of public health is of particular concern because of waste spillage on streets, boardwalks, and backyards that occurs throughout these communities.

Providing safe water and waste sanitation systems to Native villages of Alaska, however, is difficult, expensive, and time consuming. Planning and building such facilities there are more difficult and expensive than in any other region of the United States because of the unusual technical constraints (see ch. 3 and 4) that must be overcome. These constraints include limited drainage; poor soil conditions; extreme variations in temperature; the limited quantity and quality of water; and the high costs of electricity, fuel, and transportation. It is not unusual to find that IHS or VSW must delay project schedules to repair structural damage caused by spring floods or winter ice floes. To avoid some delays, agencies must order supplies up to a year in advance from distant locations, such as Seattle, to fit delivery schedules of barge transport.

Once a final design plan is adopted and supplies are purchased, the pace of construction must be rapid, to take advantage of the short construction season—3 to 4 months-typical of rural Alaska. Building sanitation facilities in rural Alaska seems to some to rank in complexity with a wartime construction project. Fortunately, construction can proceed around the clock in summer as a result of the long days.

This fast pace is sometimes interrupted by the erratic barge schedules typical of the region and the absence of adequate roads in most communities. According to the Governor's Sanitation Task Force,[8] a group of experts convened in January 1992 to develop strategies to improve sanitation in rural Alaska, nearly 100 Native villages lack adequate roads, and at least $100 million will be required to upgrade them. Costly construction delays can also be caused by the slowness and uncertainty of the funding process at both Federal and State levels.

Most communities naturally want the contractor to employ as much local labor as possible when building a new sanitation facility. Training these workers and negotiating mutually acceptable wage scales, working hours, and hirin\firing practices can sometimes delay actual construc-

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[8] The Alaska Sanitation Task Force consisted of 45 experts from 27 organizations assigned to participate in one of 12 separate working groups. Each group was responsible for developing issue-specific strategies to address the sanitation problem; some of these issues included enforcement, education, utility management, operator training, research and development, housing, and subsidies (63). Although a brief working document was issued in October 1992, lack of funds has precluded publication of this important report.

tion. Establishment of labor agreements to ensure employment of local residents (generally known as “force accounts”) has proved a useful tool in addressing these concerns in many Native villages.

The opportunities provided for the Indian Health Service to incorporate these factors satisfactorily in its efforts to deliver sanitation projects to Native communities are limited. One of the major limiting factors is the Federal funding process. Identifying and building sanitation facilities in rural Alaska represents a time-consuming task, sometimes requiring several years. Yet, because Federal funds must be obligated within the same fiscal year (FY) in which they are appropriated, IHS often has difficulty in allowing sufficient time to evaluate project proposals and to involve village officials and residents. Further constraints are imposed by the relatively small staff available to IHS and VSW for this task.

One additional factor hindering IHS from delivering sanitation technologies more rapidly to Native communities is the regulatory framework within which it functions. According to IHS, about 20 percent of the time spent by agency engineers on project construction is devoted to securing environmental review and permits required by existing regulations. In some cases, it has taken IHS up to 39 months to prepare all the documentation needed to obtain a single construction permit from the U.S. Army Corps of Engineers. The time between submission of permit application and permit approval is viewed by many as incongruous with conditions in rural Alaska, as well as unnecessarily costly. According to the Governor’s Sanitation Task Force, additional adverse effects are expected from the recent promulgation of Federal regulations for drinking water and solid waste disposal in Alaska.

Building new sanitation facilities in Native villages will be both time consuming and costly. According to IHS projections, providing piped sanitation systems to all rural Native communities now operating honey buckets will require several decades. The current projection for providing both piped and non-piped systems to all rural Alaskan villages is that $125 million will be required annually for 20 years (204).

Funding an Alaska program at $125 million per year in the future appears to be difficult to achieve, especially since IHS’S FY 1993 national appropriated budget was only about $85 million. Although an additional $40 million is being currently provided by agencies such as VSW ($25 million), EPA ($6 million), and the Farmers Home Administration (about $6 million), future funding appears much more problematic. A long-term budgetary commitment by IHS and other agencies to capital construction projects in rural Alaska remains largely undetermined.

FACTORS CONTRIBUTING TO INADEQUATE OPERATION AND MAINTENANCE OF EXISTING SANITATION FACILITIES

Operation and maintenance of existing and planned sanitation facilities were recently recognized by the Governor’s Sanitation Task Force as the most vital factor in ensuring long-term project success. Under the current system, Native villages are responsible for the operation, maintenance, and management of sanitation projects provided by Federal and State agencies.

Carrying out these responsibilities has been difficult in many Native villages, particularly those in which an adequate economic base does not exist or funds are not available. Although capital funds are essential for constructing new facilities or repairing existing systems, the current Federal—and State—system does not provide funds to maintain the completed facilities. In the past, State agencies sometimes provided financial support for the operation of secondary sewage treatment plants in many Native communities. These efforts, however, were unorganized and modest, generally not exceeding $20,000 per village. Today, this practice has virtually been eliminated. Greater O&M assistance will be required to prevent the water and sanitation projects already built by IHS in small rural Native communities—as

BOX 1-2: Major Existing Waste Sanitation Technologies Considered for Native Villages in Rural Alaska

Piped Systems

Piped sewerage systems include gravity, vacuum, and pressure sewage.

The gravity piped system is the most common type of piped technology employed to deliver water and waste sanitation services to Native villages in rural Alaska to date. It is presently installed in 69 of the 191 Alaskan Native villages identified by the Indian Health Service, primarily in villages of the Aleutians, Kodiak, North Pacific Rim, and Southeast regional corporations In most villages, piped sanitation projects are also equipped with lift stations and force mains.

Building gravity sewer pipes in rural Alaska is not always possible because of the harsh environmental conditions typically found throughout the State. As a consequence, technologies such as pressure and vacuum sewers are considered feasible conventional alternatives for improving waste sanitation in affected communities.

Pressure sewage systems, so called because of their reliance on pressure provided by pumps, are considered highly efficient in removing sewage through smaller pipelines. Although essentially similar to gravity piped systems, the pressure-type technology requires a power source to heat service lines and maintain the pressure needed to ensure transport of sewage through the pipes. The use of specialized plumbing fixtures in homes connected to this type of sewer system is also necessary,

Vacuum sewer collection technology is designed to use a central vacuum to draw raw sewage from connected homes into a central unit or facility. The use of a vacuum environment not only permits the use of smaller water volumes compared to gravity and pressure piped systems, but also enables the placement of service lines on any type of terrain with little concern for slope. The installation and operation of vacuum systems are generally more expensive than for gravity and pressure sewer services. With the exception of a few industrial camps, Noorvik (Northwest Arctic) and Emmonak (Yukon-Kuskokwim) are the only two Native villages of rural Alaska now operating vacuum sewer systems.

Septic Systems

Although they represent the most popularly used waste disposal technology in most rural areas of the world, the installation of septic tanks in rural Alaska is often impractical because of the limited soil drainage, ice-rich soil, and periodic flooding characteristic of these high-latitude regions. According to IHS, only 26 Native villages were operating community or individual septic tank systems in January 1994 to treat the raw sewage discharged from flush toilets in the home. These villages were located almost entirety in the vicinity of the southwestern coastal region of Alaska. Use of septic systems under less favorable conditions has often been associated with, among other problems, frozen or plugged drain fields, high groundwater tables, limited soil percolation, frozen tanks, and overflowing sewage appearing on the surface or discharging into receiving waters.

Truck Haul

Conventional truck haul systems are designed primarily to collect and transport to the community's disposal area, wastewater discharged from flush toilets and stored in tanks outside the home. Under this approach, vehicles are equipped with an insulated tank capable of holding—sometimes under pressure—up to 1,000 gallons of waste at a time, The decreased neec for pipe handling associated with pressure-type truck haul systems often results in an additional reduction in exposure to human waste. Although the initial capital expense is considerably lower for piped sanitation systems, the operation, replacement, and maintenance of the conventional truck approach are often costlier because of the shorter useful life of haul vehicles and the need to ensure road accessibility. Seven of the 10 Alaskan villages operating truck haul systems are located in the North Slope Borough, Two of the remaining three (Galena and Fort Yukon) use the vacuum-type haul system,

A promising small-vehicle haul system, recently developed by Cowater International of Canada, has undergone field testing in Mekoryuk, Alaska. The Cowater technology requires only the use of all-terrain vehicles (ATVS) (during the summer) and snowmobiles (in winter) equipped with a tow trailer and a small vacuum/pressure tank to remove wastewater from home holding tanks (see ch. 5 for more information), Opportunities for future installation in other rural Native communities are being explored by the Department of Environmental Conservation Village Safe Water, Alaska's agency responsible for delivering sanitation services to Native communities in the State,

Honey Bucket System

As of January 1994, nearly 20,000 Natives scattered throughout 89 rural Alaskan villages were operating the *honey bucket system* as their main waste sanitation technology. Consisting only of a 5-gallon plastic bucket lined with a plastic bag and a toilet seat on top, the honey bucket system continues to be the most rudimentary and health threatening means available to Natives for the collection and disposal of human waste. Honey buckets are emptied on the ground, in nearby pit bunkers, on frozen rivers, in the ocean, on tidal plains, in tundra ponds, or in sewage lagoons. Honey bucket waste can also be carried to nearby central collection points called honey bucket bins. These bins are then hauled to the community sewage lagoon by snowmobile, ATV, or truck. Although the latter methods represent an improvement, they have thus far failed to eliminate the potential for direct human contact with the waste. In addition, there are costs associated with the purchase, operation, and maintenance of the equipment needed to make hauling of waste possible. Honey buckets continue to be the waste collection/disposal technology most Iikely to be found among Native communities characterized by having very few economic resources to operate more improved sanitation systems,

Small-Vehicle Haul System

For communities in which the filled plastic bag is disposed in a centrally located plastic collection bin, a transport system based on the use of small ATVS has been designed to improve the disposal of honey bucket wastes. ATV-based systems were developed mainly to minimize the high operational costs of the much larger conventional truck design. In spite of its relatively simple design, relative ease to manage, and ability to operate throughout the year, the ATV-based approach has thus far failed to eilminate the potential for direct human contact with waste.

Comporting Toilets

Certain comporting toilet designs were tried in several rural Alaskan communities with little success for the last 20 years. Common reasons for failure included, among others, offensive odors, overflow, inability of the units to handle liquid overload, and the high energy costs necessary to evaporate accumulated Iiquids Another reason commonly mentioned IS the failure of technology manufacturers and design/project engineers to consult with villagers on the type of improvements needed. This failure to employ a participatory approach contributed to the indifference to, and ultimate rejection of, composting toilets by homeowners Among the villages with firsthand experience in early comporting toilet designs are Selawik, Kivalina, Barrow, and Deeding

(continued)

BOX 1-2: Major Existing Waste Sanitation Technologies Considered for Native Villages in Rural Alaska (cont'd)

Although modern comporting toilets operate on the same basic principle, they incorporate a series of design improvements to avoid the failures of older models. Formal field testing in individual homes has not been accomplished to date, and validated results with which to determine the degree of applicability of comporting toilets in rural Alaska are not available. Several efforts to demonstrate these composting technologies (discussed in ch. 5) are now under way.

SOURCES Arctic Slope Consulting Group, Inc. (ASCG), *Water and Sewer Utilities Master Plan Report Selawik,* Alaska, prepared for Cityof Selawik, Alaska, Jan 1992, Canadian Society for Civil Engineering,*Cold Climate Utility Manual* (Montreal, Canada Beauregard Press Ltd , 1986), Crum, Jim, Alaska Area Native Health Service, Alaska Arctic Cornrnunity Sanitation Construction, document presented at the Environmental Protection Agency Cold Climate Research Seminar, Washington, DC, 1990; Crum, Jim, Director, Division of Sanitation Facilites, Alaska Area Native Health Service, Anchorage, information provided during a briefing of Off Ice Technology Assessment staff, Aug. 3, 1993, Environment Canada, Environmental Protection Service, *Co/d* Climate Utilities De//very Design *Manual,* Report No EPS 3-WP-79-2 (Edmonton, Canada Environment Canada, March 1979), Nelson, Doug, University of Alaska Anchorage, School of Engineering, personal communicatlon, Nov. 23 1993; John A Olofsson and H P Schroeder, Universityof Alaska Anchorage, *Sanitation Alternatives For Rural Alaska,* report prepared for the Congressional Office of Technology Assessment, Washington, DC, Aug. 15, 1993

well as those currently under construction—from failing prematurely due to inadequate maintenance. Figure 1-4 shows the estimated O&M costs associated with each sanitation technology now in operation; the total annual O&M cost for rural Alaska—$] 5.1 million—is also shown.

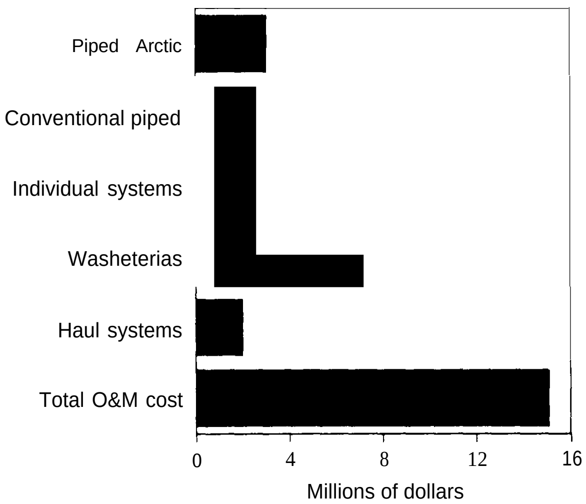
Many communities have employed fund-raising strategies—such as bingo, tax ordinances, and user fees—with varying degrees of success to provide operational support for sewage systems. Operational procedures and disconnection policies have also been instituted by some to make sure that fees are collected. Many Native leaders expect that the current difficulty in obtaining O&M funds can only increase as costs rise and the State economy continues to suffer. As a recent Department of Community and Regional Affairs report (43) concludes, the decline in State revenue sharing programs will have serious adverse economic consequences for small Native villages because these represent their only available source of discretionary funds.

With relatively few exceptions, the inability of remote villages to fund a public works department or hire a full-time, certified water and sewerage operator is often the result of poor local economies. According to the Governor's Sanitation Task Force, sanitation facilities in villages with few resources are often run by part-time operators or volunteers, who are generally ill-trained. As a consequence, the level of oversight is inadequate to respond to system malfunctions.

The frequency of repair needs is expected to increase. Although specific cost figures do not exist, the Governor Sanitation Task Force estimated in its 1992 draft report (63) that the overall toll for repairing all facilities that are inoperative, or are operating with difficulty due to equipment malfunction, will be about $750 million. Although comparisons were not made between the Task Force's one-time cost and the total annual O&M estimate of $15.1 million, many believe that the prompt authorization of O&M funds to IHS would prevent unnecessary expenditures and, would reduce the $750 million figure considerably.

In addition to their poor economy, many Native village governments seem to lack the level of leader-ship required to take on the administrative responsibility for large, complex sanitation projects. Village governments often have little interest in managing sanitation projects and subsequently transfer this responsibility to city managers and facility operators who often lack the authority to

FIGURE 1-4: Estimated Federal Subsidy Needed by Alaskan Native Villages with Fewer Than 1,0000 Residents to Ensure Adequate Operation and Maintenance of Existing Sanitation Projects



SOURCE Jim Crum, Alaska Area Native Health Service, communication with Martha Knight, Department of Housing and Urban Development, Anchorage, AK, May 7, 1993, Jim Crum, Director, Division of Sanitation Facilites, Alaska Area Native Health Service, Anchorage, personal commumication, Nov 9, 1993, John A Olofsson and H P Schroeder, University of Alaska Anchorage, *Sanitation Aternatives For Rural Alaska,* report prepared for the Congressional Off Ice of Technology Assessment, Washington, D C, Aug. 15, 1993 John A Olofsson, University of Alaska Anchorage, School of Engineering, personal communication, Sept. 28, 1993, and Steve Weaver, Indian Health Service, Public Health Service, Rockville MD, personal communication, Jan 24, 1994

set or enforce related policies within the community. According to the Sanitation Task Force, this deficiency has thus far contributed to making the protection of village residents' health and the success of sanitation projects even more problematic. Unfortunately, Federal agencies involved with sanitation projects in rural Alaska have very few programs to strengthen management by local Native governments; a particular exception is the IHS training program, in which technical training services are provided to Natives at an annual cost of about $300,000. The implementation of this IHS program is coordinated with State training efforts.

CONGRESSIONAL OVERSIGHT CONSIDERATIONS OR OPTIONS

Inadequate sanitation facilities in many rural Alaskan Native villages have resulted in a high prevalence of disease caused by a limited potable water supply and the use inefficient technologies such as the honey bucket system. For more than three decades, there has been an insistent demand for the installation of modem, safe facilities. In recent years, Federal and State agencies have built many conventional sanitation systems in roughly half the villages found in Alaska. These systems are costly to build and operate, however, and have unique features designed to meet the harsh environmental conditions typical of the region. Consequently, many villages cannot easily provide the funding needed for proper operation and maintenance of these projects.

Despite the considerable cost—more than $1.3 billion—and the progress made to date in building new sanitation systems, over half of the 191 rural Native villages listed in the Indian Health Service database still lack piped water and waste sanitation service. Addressing the sanitation needs of these communities will take time since the technologies traditionally favored-piped systems—are costly and difficult to build, and face technical constraints not common in other areas of the United States. Unfortunately, the Native villages in rural Alaska operating honey buckets today have almost no basic economy and, in many cases, a relatively limited potential for economic improvement in the future.

Despite the increasing demand for new sanitation projects, the serious economic difficulties faced by many Native villages with existing systems make it necessary to carefully evaluate the installation of similarly complex technologies in communities with few economic or technical resources to operate them. Consequently, to address the waste sanitation problem in Alaska's Native communities, Congress could establish programs to:

- provide safe and healthy alternatives to honey buckets,
- identify and test more cost-effective alternatives to piped systems,
- provide adequate support for O&M-including technical, administrative, operational, and personal hygiene training—to offset the operational costs of sanitation systems.

Interim Option for Improving Sanitation Among Native Villages

Replacing honey buckets under the current system takes time even when the receiving community has a strong local economy. Time is required by Federal and State agencies to coordinate activities and identify available funding among relevant agencies (e.g., Housing and Urban Development, Village Safe Water, Farmer's Home Administration); to develop the community's institutional capability to operate the technology; and to build a system that will solve the sanitation needs within the community's economic reality.

Unfortunately, the majority of Native communities in rural Alaska now operating honey buckets do not have healthy economies. They rely almost completely on transfer payments and subsidies to operate their programs. In fact, per capita income below the State average has been reported in at least half of these communities—particularly in the Northwest Arctic, Bering Straits, and Yukon-Kuskokwim regions. The possible decline in the State's economy might further reduce the revenue sharing funds available to these communities, thus rendering the continued construction of conventional sanitation facilities highly unlikely.

Better interim measures could be adopted by existing Federal and State agencies or programs to reduce the health risk posed by honey buckets, while work to identify more affordable, innovative solutions continues. These interim measures could take various forms, depending on the type of agency program and the community's immediate needs. Measures might involve steps such as improving existing honey bucket systems, delivering existing self-contained sanitation technologies where appropriate, and investing in certain promising technology demonstration projects. The relevant Federal and State agencies could support these measures and incorporate them into their long-term mission and programs.

Improvement of Existing Honey Bucket *Haul Systems*

One measure that could be supported immediately is an improvement program for the existing honey bucket haul systems still used extensively in many Native villages. For communities in which limited funds prevent the installation of a more advanced technology or where such an installation is not immediately feasible, there are many opportunities to improve current haul systems. Examples include improvements in the design of honey bucket trailers and collection bins along with compliance with proper operational procedures (125).

The Indian Health Service plans to continue supporting the use of honey bucket systems in villages with little economic potential to acquire and maintain more sophisticated technologies. Improving the design of honey bucket systems is considered crucial by Indian Health Service to protect public health in these villages and in those for which delivering an improved sanitation system may require several years.

In the view of IHS, new methods are needed for collecting and transporting the waste contained in honey buckets. Improvements to disposal systems might include improved lids and hauling systems, alternatives to plastic bags as honey bucket liners, freeze-resistant containers, and ways to dislodge frozen wastes from haul containers. As the Office of Technology Assessment (OTA) observed during site visits, hauling practices with existing honey bucket collection bins inevitably results in spillage. Human contact with spillage on community boardwalks is also inevitable, particularly because children often play there.

A *honey bucket is simply a 5-gallon plastic bucket lined with* a *plastic bag, with a toilet* seat *on top of it—sometimes they are enclosed in a wooden box for* aesthetic and *venting purposes*

Means to haul sewage in sealed containers by someone other than individual homeowners are also needed. If a limited number of people in a village are involved with sanitary waste collection and transport, exposure to the waste and access to the waste repository will most likely be restricted to a few individuals; establishment of a coordinated community system will require the training of these personnel. Provision of adequate salaries will also be essential.

Interim solutions can give communities additional time to decide on more suitable long-term sanitation options. OTA staff found during their visit to rural Alaska that many villages would like to have advanced waste transport systems, but believed they were not yet ready to manage them. For those communities, improved interim disposal systems other than honey buckets are particularly attractive.

IHS is currently carrying out a project with prototype haul trailers and waste lids in the villages of Kasigluk, Kipnuk, Napakiak, and Nunapitchuk in the Yukon-Kuskokwim region. After thorough testing and evaluation of the information, this improved system will be provided to the nearly 30 Native Alaskan communities currently operating honey bucket haul systems. This small program, however, should not be envisioned as the solution to the sanitation problems of rural Alaska but ***only*** as an interim step while these Native communities identify more appropriate and affordable sanitation technologies. A summary of possible improvements to the honey bucket system is shown in box 1–3.

Coordinating the development and implementation of short-term measures is important. To avoid disrupting their long-term mission, primary agencies, such as the Indian Health Service and Village Safe Water, could also work cooperatively with other institutions in the development or delivery of interim measures. Some of the institutions already involved that might play a larger cooperative role are the University of Alaska Anchorage (research, field demonstrations, educational and training programs), Alaska Science and

Plastic bags facilitate the transport and disposal of waste, but because wastes remain sealed, their degradation is slow, making the sewage disposal area another potential health concern

Technology Foundation (funding of research and demonstration projects), regional native corporations, and Alaska's Native Health Board (technology application, institutional cooperation, and community involvement). Another institution potentially beneficial to this effort is the Federal Field-Alaska Rural Sanitation Work Group being convened by a congressional request to identify and coordinate rural sanitation goals between Federal and State agencies.

Congressional Options for Solving the Waste Sanitation-Problems of Alaskan Natives

For more than three decades, the Federal, State, and local government health care system in rural Alaska has focused on incrementally building complex infrastructure to provide adequate sanitation facilities in each Native village. This emphasis on capital construction, based on legislative authorities, is viewed by some as a barrier to the ability of IHS to support operation and maintenance costs and other direct operational needs.

In addition to capital construction, some believe the historical preference for installing community-wide piped sanitation technologies rather than individual, self-contained ones, has directed attention away from the testing and demonstration of technological alternatives. In the long term, the Federal Government could evaluate the feasibility of the following steps to eliminate the health risks associated with honey bucket use and to improve overall waste sanitation among Alaskan native communities:

OPTION I—Authorize the establishment of a Sanitation Technology Demonstration Work Group to identify recommend, and demonstrate suitable sanitation technologies and improvements

While more affordable, permanent alternatives to piped sanitation systems are developed, Congress could assist Alaskan Native villages that rely on honey buckets by establishing a work group responsible for identifying and recommending suitable, interim sanitation improvements or technologies. Such a program could be established in the Indian Health Service, the Environmental Protection Agency[9], or other appropriate Federal agencies. The work group could be composed of engineers from Federal and State sanitation and construction agencies, maintenance experts, village operators, and representatives of Native corporations and village leaders in communities where honey buckets are still in use.

The work group could be responsible primarily for identifying the type of sanitation improvement most suitable for a particular v ill age and for locat-

9 Section 113 of the Clean Water Act requires EPA to enter into agreement with the State of Alaska, and in coordination with the Department Human Health Services, to carry out demonstration projects *to provide for central community facilities for safe water and elimination or control of pollution in those native villages of Alaska without such facilities.* Expanding this section to include sanitation technologies whose design is home-specific rather than community-wide could support demonstration programs involving alternative technologies to conventional pipe systems. EPA is also instructed to *provide technical, financial and management assistance of such demonstration projects* (Sections 113 (a), (b), and (f); 33 U.S.C. 1263).

ing future technology demonstrations. Programs might start with demonstration projects in a small number of communities, followed by the addition of other villages as the demonstration program grows and new technologies are developed.[10] Areas in which the work group's participation would be highly beneficial to the delivery of 1ong-term Federal sanitation assistance include the following:

- identifying Native villages in which honey bucket systems are currently inadequate due to inappropriate equipment selection,
- working with State and Federal agencies to promote demonstration pilot projects,
- disseminating the results of field tests involving improvements to honey bucket systems, and educating village residents about the benefits of adopting such improvements while a better and more suitable technology is identified and installed;
- ensuring the commitment of local Native governments both to adopt improved honey bucket systems, as a means of reducing the health risk of village residents and to participate actively in efforts to identify better sanitation systems; and
- identifying within a reasonable time the criteria needed for selecting, installing, and operating the next level of waste sanitation service in those communities now operating honey bucket systems.

The IHS estimated that the cost of implementing a Sanitation Technology Demonstration Work Group in at least four Native villages would total about $100,000 annually. Ensuring its funding for a reasonable period of time could help project a sense of stability and commitment among the work group's participants, other State and Federal agencies, and Native community leaders and residents.

OPT/ON 2—Provide operation and maintenance assistance to needed Alaskan Native communities through the implementation of the Indian Health Amendments of 1992 (Section 302), or other relevant federal statute such as the C/can Water Actor the Safe Drinking Water Act.

In the past, Federal and State agencies have not funded direct O&M costs for the piped sanitation systems constructed in Native Alaskan villages. At one time, State agencies supported O&M for sewerage and water utilities in many communities, but this practice, although limited in extent, was virtually eliminated in 1992. As a consequence, communities receive only a small amount of municipal and State revenue sharing for this purpose. These funds are insufficient to support O&M needs, especially for the complex sanitation facilities being operated in many villages. Today, it is not rare to find a multimillion dollar sanitation project in need of preventive maintenance due to improper O&M and limited funding.

[10] Section 201 (g)(5) of the Clean Water Act currently prohibits EPA from making grants to . . . *any State, municipality, or intermunicipal or interstate agency for the erection, building, acquisition, alteration, remodeling, improvement, or extension of treatment works unless the grant applicant has satisfactorily demonstrated* . . . that the particular new or improved method of treating municipal waste is effective in preventing water or other environmental pollution. EPA's participation in technology improvement and demonstration efforts would be helpful in expediting their application or use, particularly because Native villages continue to lack adequate resources to demonstrate alternative technologies as required by the Act. EPA could also assist in studying the effectiveness of alternative technologies as required in Section 517.

BOX 1-3: Possible Improvements to the Honey Bucket Haul System

The honey bucket haul system is still used extensively in many Native villages. For communities in which limited funds prevent the installation of a more advanced technology, or such installation is not immediately feasible, there appear to be many opportunities for improvement in the current haul system. The following are examples of such opportunities, some of which are already being considered by the Indian Health Service (IHS):

- Improved honey *bucket trailers—IHS is* currently developing and testing, with the assistance of a private engineering firm, an improved honey bucket haul trailer.
- Improved lids *on the honey bucket collection* bin—One of the most Immediate needs of the honey bucket haul system is to find a more adequate lid design to prevent further spillage of human waste on village streets or boardwalks during transport.
- An *improved honey bucket collection tub orbin*— Redesign is needed of the more than 800 black plastic tubs[1] used throughout rural Alaska to collect and subsequently transport human waste to disposal locations. These tubs are held in the metal holding frames of the carriage system (four-wheel) and transported to the sewage lagoon for disposal. According to IHS, however, no improvements to the tub system are scheduled at this time.
- Modified *transmission on the transport* system--Human sewage gathered from collection tanks inside the house, or from stationary tubs located at certain points in the village, is carried to a sewage lagoon by a four-wheel vehicle. Vehicles are sometimes unable to prevent spillage of human waste when turning corners or driving over inadequately maintained roads. Modification of the transmission system of all-terrain vehicles to preclude them from traveling at faster speeds to and from dump sites is needed.
- *Providing a water source at the disposal site—One* additional means of helping to reduce the risk of exposure to human waste, and thereby preventing enteric disease, consists of providing a source of water at the disposal site so that operators, at least during the summer, can rinse and remove sewage particles attached to plastic collection tubs, lids, and other parts of the carriage before returning them to the village. Adequate measures should be adopted early in the planning and engineering phases to prevent this water source from becoming a watering point and, therefore, an additional health hazard for the community.

IHS is currently carrying out a project with prototype haul trailers and waste lids in the villages of Kasigluk, Kipnuk, Napaklak, and Nunapitchuk in the Yukon-Kuskokwim region. One of the goals of the IHS effort is to develop and test considerably lighter lids made of aluminum, preferably with a continuous weld around the lid to prevent spillage. Strapping systems (bungie cords, cinch straps, and C-clamps) are also being tested to Identify the strap, or combination of straps, most capable of preventing sewage from seeping out of the waste haul carriage onto streets and boardwalks.

According to an IHS communication of October 5, 1993, tests of the aluminum-made lid in Napakiak were successful in reducing waste spills and identifying better clamp systems. The lids developed as part of this field demonstration project are being sent to the three other communities participating in this research effort for further field evaluation. After the system has been thoroughly tested and the information evaluated, this improved system will be provided to other Native Alaskan communities currently operating honey bucket haul systems.

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[1] Tubs are made of high-denstty polyethylene

SOURCE. U S Public Health Service, Alaska Area Native Health Service, Office of Environmental Health and Engineering, "Updateon Honey Bucket Haul Equipment Improvements," Oct 5, 1993

Recognizing this deficiency, Congress amended the Indian Health Care Improvement Act of 1976[11] by passing the Indian Health Amendments of 1992.[12] Section 302 of the Amendments authorizes the Indian Health Service to fund up to 80 percent of the costs incurred by Native villages and Indian Tribes for the operation, maintenance, and management of their water and sewer systems.[13] One relevant aspect of the Act is that it encourages IHS to help make up the difference, particularly in those Native communities whose O&M costs exceed revenues collected from user fees and taxation, so as to keep the facilities in good operating condition and in compliance with Federal regulations. By providing Native communities with O&M funding, not only can premature wearing out of system components—which now appears routine—be reduced or virtually eliminated, but the installation of sanitation technologies in communities with few resources for maintenance may be more feasible.

To date, no funds have been appropriated under section 302 of the Indian Health Amendments of 1992. The IHS has yet to request funds because of staff and budget constraints, and because of lack of guidance in the legislative intent as to how to implement such a program. Although coverage of the existing level of sanitation services in rural Alaskan Native communities is estimated to cost approximately $15 million annually, current budgetary priorities make funding of these activities under Section 302 extremely difficult or unlikely.

IHS could, however, fund a pilot program to assess O&M needs in a selected number of villages, for example, 25. Funding could also be provided by other relevant Federal agency, such as EPA, with the approval of Congress. A pilot program would require only limited initial funding and would enable IHS and other relevant Federal agencies to determine more clearly implementation plans, procedures, and total needs for future O&M economic assistance. It could also help to develop the criteria by which such assistance might be extended to Native communities not included in the initial pilot program on a priority basis.

OPTION 3—Improve the level of support to technical assistance programs as a means to ensure the proper operation and maintenance of sanitation projects in Alaska's rural Native communities

Another measure that could be adopted is to increase O&M technical assistance funding.[14] The bulk of O&M technical assistance provided to Native communities of Alaska originates with three major agencies: the Indian Health Service, Alaska Department of Environmental Conservation (ADEC), and the Department of Community and Regional Affairs (DCRA). Whereas the major emphasis of the IHS and ADEC programs is to provide operators with the technical skills needed to keep their utilities operational and in compliance with environmental regulations, DCRA focuses on improving government operations and

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11 25 U.S.C. *et seq.*

12 P.L. 102-573, October 29, 1992; 106 STAT. 4526-4592.

13 106 STAT. 4560-61.

14 Examples of instruments Congress could use to increase technical assistance to Native communities include: (1) Section 104 of the Clean Water Act since it requires EPA *to finance pilot programs, in cooperation with State and interstate agencies, municipalities, educational institutions, and other organizations, and individuals, of manpower development and training and retraining of persons in, on entering into, the field of operation and maintenance of treatment works and related activities* (Section 104 (g)(1)); and (2) Section 109 of the Clean Water which directs the EPA to make grants for training or upgrade of waste treatment works operation and maintenance personnel. Additional technical support might also be sought through the Clean Water Act's State Revolving Fund program (Sections601 -603); the Indian Environmental General Assistance Program Act of 1992 (42 U.S.C. 4368b; P.L. 102-497, Oct. 24, 1992; 106 STAT. 3259); the Rural Development Administration's Technical Assistance and Training Grant Program; the Housing Community Development Act of 1974; and the recently introduced Water Quality Act of 1994 (H. R. 3948) and Safe Drinking Water Act Amendments of 1993 (S. 1547).

the financial and managerial skills of utility operators. In complimenting State efforts, IHS also funds several maintenance specialists who deliver O&M assistance and training directly to the villages. Federal support is also provided through the U.S. Environmental Protection Agency (EPA).

Initially tailored primarily to help local utility operators, most O&M technical assistance programs have benefited the entire village by ensuring proper operation of sanitation projects, adequate response to emergencies, and minimization of the adverse effects associated with operator turnover. IHS is currently investing more than $300,000 in technical training services annually; however, this amount is insufficient to support O&M technical assistance to the increasing number of villages that need such support (83,177, 219)

To ensure the availability of this additional technical assistance and to prevent the premature deterioration of existing sanitation projects in rural Alaskan villages, Congress could:

- increase the level of non-construction funds available to Federal agencies such as EPA and IHS for training facility operators and providing O&M technical assistance to Native villages;
- provide EPA and IHS with the necessary funds to coordinate and support State O&M technical assistance programs, such as ADEC'S Remote Maintenance Worker Program and Local Utility Matching Program and DCRA'S Rural Utility Business Advisor Program, as a means of further ensuring proper and safe operation of sanitation projects in rural Alaska; and
- increase the level of funding available to Federal agencies such as IHS to address emergency situations relating to sanitation facilities.

OPTION 4—Establish a research, development, and demonstration program for innovative sanitation technologies

Technology selection decisions to date have been hindered by a capital planning process that focuses on adapting conventional sanitation technologies to a generally unconventional environment, rather than finding novel and appropriate solutions. The current technology selection process does not allow for a comparison of approaches based on total life cycle costs and potential savings to the communities. Only minimal attempts have been made to formally incorporate existing alternative sanitation systems into the technology selection process currently in place.

Many conditions in Alaska's Native villages (i.e., inadequate water supply, poor soil drainage, permafrost, unacceptable topography, high seasonal flooding potential, and weak local economies) appear to favor the application of less costly and complex approaches than piped sanitation systems. However, to date, few alternative methods have benefited from field demonstration tests to determine their actual performance in cold climate regions. Consequently, adopting alternative technologies without first exploring the factors that will make their application in Alaskan Native villages successful appears subject to failure.

Development of a more comprehensive technology evaluation and selection approach capable of supporting demonstration, applied research, and application of innovative technologies is still needed. Congress could facilitate the research, development, and demonstration of innovative sanitation technologies by taking the following steps:

- Directing the Environmental Protection Agency, Indian Health Service, or another appropriate Federal agency to:
  a. establish a program for research, development, and demonstration (RD&D) of innovative sanitation technologies considered potentially appropriate for application in Arctic regions, such as rural Alaska;[15]
  b. advocate the application of those innovative technologies successfully demonstrated under the RD&D program; and
  c. support the establishment of a forum in which cooperative technology research and demonstration activities are carried out with the participation of, among others, Native communities and national and international programs or institutions (e.g., the University of Alaska, Alaska Science and Technology Foundation, U.S. Army's Cold Regions Research Engineering Laboratory, National Aeronautics and Space Administration, National Academy of Sciences' Polar Research Board, and National Science Foundation).
- Providing the Environmental Protection Agency, Indian Health Service, or the Federal agency under which an RD&D program is established, with the necessary funds to successfully carry out the program's objectives. Additional funds might subsequently be sought by requiring other Federal agencies with programs relevant to Native villages to identify funds or funding opportunities that could be utilized to support the RD&D program.
- Establishing a technology advisory group or commission to further enhance and support the RD&D program and policies. Composed of technology experts from state, national, international, and Native governments, as well as private organizations, the advisory group could be beneficial to the agency responsible for the RD&D program in the identification of, for example, priorities and opportunities for research and development.
- Funding, as part of the RD&D program and through a Federal research agency, research and field demonstrations of potentially beneficial engineering systems or concepts that require substantial RD&D before they can be considered for application in Native village homes. One example of this type of system is the Antarctica Analog Project[16] king developed and tested by NASA and the National Science Foundation for use at the South Pole station.

Option 5-Hold oversight hearings on the report on sanitation issues, problems, and solutions to be submitted to the Congress by the Federal Field Work Group led by the U.S. Environment/ Protection Agency. Ho/d

[15] Under Section 104 of the Clean Water Act, for example, Congress requires EPA, in cooperation with other Federal, State, and local agencies, *to conduct and promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, prevention, reduction, and elimination of pollution (Section 104; 33 U.S. C. 1254).* As part of carrying out the objectives of this section, EPA is directed to:

- *develop effective and practical processes, methods, and prototype devices for the prevention, reduction, and elimination of pollution (Sec-*tion 104 (b)(7));
- *develop and demonstrate under varied conditions (including conducting such basic and applied research, studies, and experiments) . . . practicable means of treating municipal sewage, and other waterborne wastes* (Section 104 (d); Section 104 (d)(]));
- *establish, equip, and maintain field labor-awry and research facilities, including . . . one in the State of Alaska, for the conduct of research, investigations, experiments, field demonstrations and studies, and training, relating to the prevention, reduction and elimination of pollu-*//on (Section 104 (e)), and
- *conduct a comprehensive program of research and investigation and pilot project implementation into new and improved methods of preventing, reducing, storing, collecting, treating, or otherwise eliminating pollution from sewage in rural and other areas where collection of sewage in conventional, communitywide sewage collection systems is impractical, uneconomical, or otherwise infeasible, or where soil conditions or other factors preclude the use of septic tank and drainage field systems* (Section 104 (q)(1)). As part of achieving this goal, EPA is allowed to make grants and to encourage the used of improved methods by disseminating relevant information and results *(Section 105 (e)(2)).*

[16] This project involves the use of advanced food production, water recycling methods, and human waste processing technologies.

Although their ideal is to someday have piped sanitation systems in their homes, many Native leaders, in meetings with OTA staff, recognize that this might be economically prohibitive and call for the development of more affordable sanitation alternatives

periodic oversight hearings to review plans *and programs adopted by federal agencies to implement the report's recommendations.*

Problems surrounding sanitation in rural Alaska are complex, and their successful elimination often demands participation by Federal and State agencies. In addition to the Indian Health Service and its State counterpart, Village Safe Water, various Federal and State agencies implement programs that are relevant to Alaskan Native communities. And even though individual agency missions are pursued with vigor and dedication by generally well-qualified and motivated staff, there does not appear to be an overarching rural village policy to coordinate all these agency functions.

Several encouraging efforts by Federal and State agencies to identify better methods for more effectively implementing their programs in rural Alaskan Native villages are now under way. Of great significance is the Federal Field-Alaska Rural Sanitation Work Group convened under congressional mandate to prepare, under the leadership of the U.S. Environmental Protection Agency[17] (253), a report identifying means to improve the coordination of policies and programs among Federal agencies.[18] The participation of State and Native agencies and organizations in the Work Group is also considered highly beneficial.

Starting in May 1993, and building on the work of the Governor's Rural Sanitation Task Force, the Federal Work Group delineated three major tasks: 1) to examine the status of water and waste sanitation projects in operation in rural Alaska; 2) to evaluate all agency programs responsible for delivering sanitation services to Native communities; and 3) to identify barriers that may still impede relevant agencies from providing adequate sanitation to all Native villages of rural Alaska. In

17 In addition to EPA, leadership in the Work Group is shared by representatives of the Alaska Department of Environmental Conservation and Alaska Native Community.

18 Among the Federal agencies participating in the Federal Field-Alaska Rural Sanitation Work Group are the Army Corps of Engineers, Bureau of Indian Affairs, Department of Transportation, Department of Education, Environmental protection Agency, Farmers Home Administration, Department of Energy, Department of Labor, Department of Housing and Urban Development, Indian Health Service, National Oceanographic and Atmospheric Administration, and Soil Conservation Service.

its interim report of January 1994, the Work Group identified several possible recommendations for congressional action (253).[19]

Although the Federal Field-Alaska Rural Sanitation Work Group report identifies opportunities for policy coordination among Federal agencies, the actual level of commitment and support by each agency to the report's recommendations is still unclear. Prior to directing each Federal agency to implement the relevant recommendations of the report, congressional oversight hearings could be held to provide relevant agencies with opportunities to inform the Congress about:

- the process used for gathering and evaluating data, and for formulating the recommendations set forth in the final Work Group report affecting each particular agency;
- the time and type of resources that would be needed by each particular agency to carry out the recommendations of the Work Group report;
- the opportunities for enhancing the agency's mission in case a particular agency cannot carry out a given recommendation because of limited authority; and
- the time within which updates on the progress made in implementing of the Work Group's recommendations should be submitted to Congress and published.

Periodic oversight hearings could be then held in the future to review the plans and programs adopted by relevant Federal agencies to implement the recommendations reported by the Federal Field Work Group.

CONCLUSION

Approximately 20,000 of the estimated 86,000 Natives living in rural Alaska do not have running water in their homes and use plastic buckets-euphemistically called '*honey buckets' '—for toilets. As a result of this inadequate sanitation technology, the outbreak of diseases (e.g., hepatitis A, impetigo, and sometimes meningitis) is frequent among Native villages that employ this system.

To eliminate the prevalence of disease resulting from a limited potable water supply and the use of honey buckets, Federal and State agencies have built sanitation systems capable of withstanding the harsh environmental conditions typical of the region. Because Federal and State agencies fund only capital construction, most Native villages face serious difficulties in raising the funds needed for proper operation and maintenance of these facilities. The only direct source of funding to Natives for O&M expenses is municipal and State revenue sharing—minimal funding that is not always available. As a result, it is not uncommon to find a multi million dollar sanitation project in rural Alaska in need of preventive maintenance.

Despite the considerable progress made to date, nearly half of the 191 Native villages identified by IHS continue to have inadequate sanitation. Because of the inability of many Native villages in which piped systems have already been built to provide proper O&M, serious concerns are being raised about installing similar sanitation technologies in the remaining communities—-the majority of which have few economic and technical resources, as well as a limited potential for economic development. Under existing practices, however, the responsible Federal agencies could continue to implement inappropriate remedies.

OTA's analysis supports the need to adopt both short- and long-term measures to provide adequate sanitation and thus improve the health and well-being of tens of thousands of Alaska Natives living in small, remote villages. In the short-term,

[19] Examples of these preliminary recommendations include: 1) approving a new State Revolving Fund under the Safe Drinking Water Act, capable of setting aside 1.5 percent of annual appropriated funds for direct grants to Alaska Native and Indian tribal communities, 2) increasing the Indian set-aside from 0.5 percent to 1.5 percent of the Wastewater State Revolving Fund; and 3) providing special funds under the Housing and Community Development Act of 1974 to support sanitation activities in rural Alaska.

existing honey bucket systems could be made safer and more effective, and the O&M support required could be provided. In the long-term, the development and application of more cost-effective alternatives could be supported through a directed research and development program. OTA has presented the following actions that Congress and the Administration could take: 1) improve existing honey bucket haul systems while better alternatives are identified or developed; 2) provide O&M funds for special cases in which villages cannot ensure proper operation of sanitation projects; 3) provide additional funds to expand the current O&M technical assistance program so as to prevent premature deterioration of the sanitation facilities now in operation; and 4) establish a comprehensive Federal research, development, and testing program for innovative sanitation technologies. To ensure that these steps are coordinated effectively, Congress could hold oversight hearings on the report requested from the Federal Field-Alaska Rural Sanitation Work Group, and could direct Federal agencies to adopt the report recommendations as a means of coordinating more effectively their functions and activities relating to Native villages in rural Alaska.

Alaskan Native Villages and Their Sanitation Problems 2

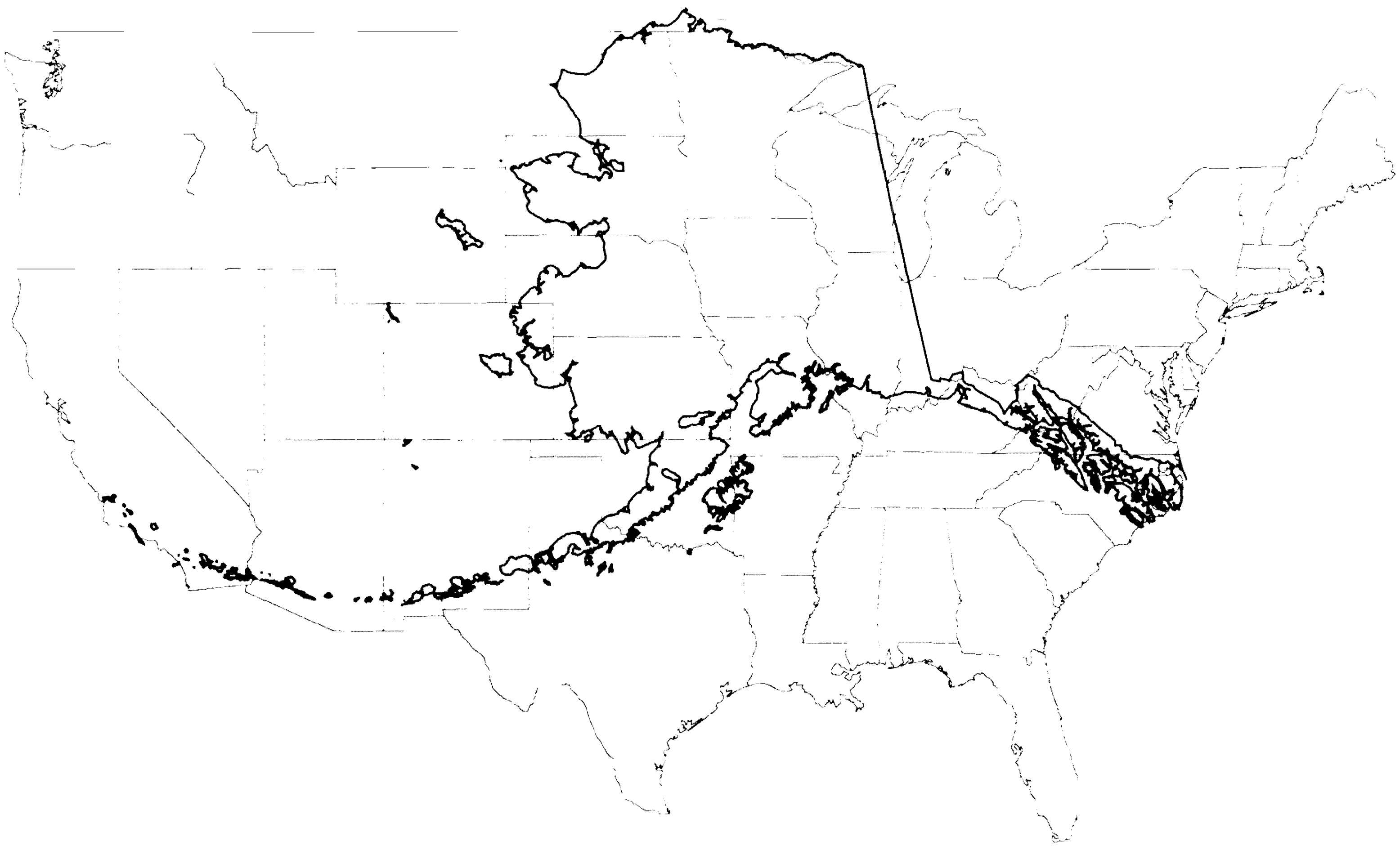
GEOGRAPHIC SETTING

Alaska sweeps across approximately 30 degrees of longitude and covers a total of almost 600,000 square miles. It is the largest State of the United States and is approximately 2.2 times the size of Texas. If Alaska were placed as an overlay on the lower 48, with the western end of the Aleutians matching the southern California coast, Barrow would be found at the U.S.-Canadian border in Minnesota, and the tip of the southeast panhandle would be found near Charleston, South Carolina (figure 2-1). The vastness of this envelope, which is virtually devoid of roads, influences almost every aspect of life in the State.

Diversity is a hallmark of the Alaskan environment, as well as of its people. It has abundant examples of Arctic deserts, northern rain and timber forests, treeless tundra, swamps, and wetlands. It has sand dunes east of Kotzebue, ice fields and glaciers that are larger than some States, the highest mountains in North America, and broad expanses of lowlands. Considerable effort has been devoted to identify and classify the geographical wealth of Alaska technical y; for the purpose of this report, however, only four general areas are arbitrarily considered: southwestern Alaska, western Alaska or the Bering seacoast region, interior Alaska, and the Arctic region.

Southwestern Alaska includes the Alaska Peninsula and the lengthy sweep of the Aleutian Islands, which reach out to the Orient. Of all four regions considered here, southwestern Alaska offers the most startling contrasts, ranging from the lightly wooded hillsides and rugged mountains of the Alaska Peninsula, to the barren, treeless volcanic Aleutian Islands. It also includes the Yukon-Kuskokwim Delta, a geography of meandering rivers and a scattered population dominated by Alaskan Natives. The large

FIGURE 2-1: Comparison of Alaska's Surface Area With That of the Lower 48 States



SOURCE: John A. Olofsson and H. P. Schroeder, University of Alaska Anchorage, *Sanitation Alternatives For Rural Alaska*, report prepared for the Congressional Office of Technology Assessment, Washington, DC, Aug. 15, 1993.

majority of Native villages located in the Yukon-Kuskokwim region are characterized by severe poverty and inadequate sanitation conditions—the latter being the major focus of this report. Box 2-1 briefly describes some of the historical characteristics of the Native groups who settled in this region.

Western Alaska, also referred to as the Bering seacoast region, stretches from Bristol Bay in the south to Norton Sound and the Bering Straits in the north. It is a typically cool, rainy, and foggy area, with summer temperatures of 50 to 70 ‘F and winter temperatures hovering around O ‘F. The significant and sudden changes in ambient temperature caused by the strong local winds generally render this region dangerous for the unprepared.

Much of the Bering seacoast is virtually treeless tundra with underlying areas of continuous and discontinuous permafrost. It also contains uncounted thousands of small lakes, tundra ponds, and rivers that are wide, shallow, and of very low flow velocity. Low-lying areas and their communities are subject to annual flooding caused primarily by low relief and ice jamming during spring breakup. Most local residents often seem to endure this condition as an inevitable feature of life, and even though some have moved to higher ground, a large number still refuse to relocate. Poor sanitation conditions continue to be found among many Western Alaska Native villages.

The Interior Region of Alaska lies between the Alaska Range north of Anchorage and the Brooks Range in the far north. The Continental Divide extends east-west through the Brooks Range, ending at the Chukchi Sea on the Arctic Coast. The region contains the upper reaches of the Yukon, Kuskokwim, and Tanana rivers, although the headwaters of the first two are found deep in the Northwest Territory of Canada. The Yukon is the longest river in Alaska, with a total length of some 1,875 miles.

Temperatures in the interior region often drop to -60 ‘F in winter, producing ice fog that hovers persistently over frigid communities in mercifully still air. Although winters are cold, summers can be hot, with temperatures commonly in the 90s. Although rainfall may only average about 12 inches annually, snowfall can reach 10 feet or higher. Because of the prolonged low winter temperatures, snow tends to be finely divided, fluffy, and easily drifted. Winter melting and loss of snow through sublimation are insignificant, and an entire winter's snowfall is usually preserved until spring. Fairbanks, with a population of 32,000 people, which makes it the second largest city in Alaska, is in the heart of the interior region.

The Arctic region extends from the southern limits of the Brooks Range, which forms a 9,000-foot barrier between the interior and the North Slope. It extends from Kotzebue, just north of the Seward Peninsula, eastward to the Canadian border. The North Slope, which is some 750 miles long from east to west, and about 250 miles wide, consists of vast areas of rolling uplands, mountains, and extensive coastal plains that stretch northward toward the Arctic Ocean. Trees are absent from the entire Arctic Slope region, except for occasional thickets of alders, willow, and Arctic or resin birch, which can be found mostly in river valleys.

The Arctic region is characterized by Summer's midnight sun and sunless winters. Low winter temperatures are moderated by prevailing northerly winds. For example, the average July temperature at Barrow is 40 oF, whereas the average January temperature is -17 oF. A total annual precipitation of some 5 inches renders the area a desert. A historical perspective of the Natives who settled in the Arctic is presented in box 2-1.

The Arctic Slope is where the oil is. Vast deposits of petroleum were discovered in the vicinity of Prudhoe Bay during the late 1960s, along with equally vast deposits of natural gas. The Prudhoe Bay oil fields lie alongside the Sagvanirktok River Delta, about 70 miles west of the Arctic National Wildlife Refuge. These resources have made the North Slope and its few communities some of the wealthiest in the State.

BOX 2–1: Native Peoples of Alaska

The first humans who populated Alaska, and subsequently the Americas, were thought to have migrated from the Siberian Far East. These early nomadic hunters and gatherers probably crossed a land bridge between Asia and North America. Today, some 60 miles of cold ocean exists in place of the now submerged historical route. It is thought that this migration contributed significantly to human occupation of what is now the United States, Canada, Central America, and South America. In modern Alaska, several groupings of Natives can be distinguished. All have seemingly arisen from the original period of migration. The following IS a historical perspective of the major Native groups whose descendants now live in the State

Southeast Coastal People

The coastal Indians comprise three distinct groups, including the Tlingits, Hairdos, and Tsimshians, These people are found in southeastern Alaska and Canada roughly between Yakutat, Alaska, in the north, and Prince Rupert, British Columbia, in the south.

The Tlingits (pronounced "Klink-its")-the most numerous of the three--were scattered throughout the southeast in relatively permanent villages. The historical permanence of Tlingit villages is thought to be due to the relative immobility imposed by the mountainous terrain. These people made a Iiving by fishing and hunting in the moderate climate and generally abundant coastal environment of the southeast,

The Tsimpsians and Haidas (pronounced Sim'-she-ans, and High' -alas, respectively) occupied the Queen Charlotte Islands, the southern part of Prince of Wales Island, and the mainland of southeast Alaska. They collectively represent a small part of the Native population of the southeast. These people are culturally distinct from the Tlingts, but subtly so. It is thought that during the time of the first Russian contact, the Haidas were in the process of displacing the Tlingits northward through periodic warfare, In general, the Natives of the southeast were and are significantly more aggressive than other groups found elsewhere in Alaska.

The indigenous people of the southeast, or Indians as they have come to refer to themselves, are people averaging 5 feet 8 inches in height. They are known to use fish traps, nets, and dip nets for fishing, and harpoons for both hunting of sea mammals and fishing. The surrounding environment, and the proximity to the ocean and inland marine channels, created a strong cultural focus on marine resources that continues today. Until the early 20th century, the Indians utilized large spruce and cedar trees on the immediate shoreline to craft canoes, totem poles, and dwellings, but they never developed inland settlements to any significant degree.

Warfare was a well-developed practice among the Natives of southeast Alaska. Strife was usually directed toward driving out or even exterminating neighboring groups of another matrilineal line. In doing so, the victorious group would acquire all the possessions off the vanquished, including its land, dwellings, and access to traditional resources. This belligerence is in stark contrast to the conciliatory nature of the Natives in the Arctic and western Alaska. In these regions, environmental conditions were thought to be so severe as to require cooperation among nomadic groups to ensure collective survival.

Inland People

The Athapaskan Indians occupied a vast expanse of inland Alaska stretching from the Arctic and subarctic regions along the entire northern perimeter of North America. This region is generally referred to as '(the Interior. " It offers a demanding and harsh environment without easily accessible resources. With no access to the bounty of the ocean and the coastal margin, the Athapaskans turned to the land and rivers for subsistence.

The Athapaskans of the northern interior lived along the Yukon River and its tributaries, ranging from just north of the Yukon Delta westward into Canada to the Mackenzie River. This region is mountainous and IS dominated by a series of small mountain ranges bounded on the north by the Brooks Range The Brooks Range serves as a natural barrier to north-south migration and contains great environmental contrasts, The region is characterized by long cold winters and brief but warm summers, The Athapaskans had Iimited social organization in contrast to the people of the southeast, They generally followed a somewhat mobile lifestyle and Interacted loosely with the various roving bands with whom they had contact They were not generally regarded as a nomadic people. A subsistence lifestyle emerged in which they relied on caribou, moose, migratory salmon and other fish, and berries. In addition, they were adept at trapping fur-bearing mammals both for food and for use as clothing, These people today consider themselves to be true Indians of the north, and are strongly adapted and bonded to an inland life in broad river valleys, mountainous terrain, and forests

Aleutian Islands People

The Aleuts, like other Alaska Natives, adapted themselves superbly to Iife in the unique marine archipeIagic environment of the Aleutian Islands This is a harsh environment of volcanic peaks, almost constant high winds dampness, fog, and moderate temperature. The unique weather found throughout the island chain IS the result of cold Arctic water on the north side of the islands meeting warm northern Pacific waters on the south Primarily because of high winds, the Aleutian Islands are essentially treeless, with vegetation dominated by grasses and low shrubs

The Aleuts, Iiving in a relatively Ice-free marine environment, developed sophisticated open-ocean hunting and fishing techniques that allowed them to harvest sea otters, hair seals, sea lions, and an occasional whale Abundant populations of these animals were found on Kodiak and Unimak, which resulted in a concentration of Aleuts on these two Islands Nevertheless, virtually the entire Aleutian Chain was populated with these indigenous people who are characterized as Inventive, and generally mild and agreeable,

Arctic Coastal People

The Eskimos ranged all along the Arctic Coast of North America from just north of the Seward Peninsula eastward around the pole to Greenland. A great deal of literature has been written about these unique people who have adapted so well to Iife in the Arctic They Inhabit a land of great environmental diversty and, contrary to popular belief, do not generally live amid perpetual ice and snow. Also, Alaskan Eskimos did not I we in ice block houses as some Greenland Eskimos historically have,

It is fair to say the Eskimos in Alaska, and probably elsewhere, are traditional subsistence people with a strong bond to a coastal and marine lifestyle. Although the traditional Eskimo lifestyle and culture have been lost, the hunting of marine mammals and subsistence on the bounty of both the land and the ocean remain vitally Important

Historically, physical survival depended on the ability of individuals and groups to execute successful hunts Even today when the first whales of the season are sighted, entire villages WiIl mobilize to capture them, and all other acivities cease This spirit of cooperation, even to the point of helping one's opponent succeed characterizes modern Eskimos Competitiveness as conceived in Western cultures IS foreign to many Eskimos

The Native peoples of Alaska are many and varied in character, All of them have adapted to the specific demands of distinct regions of Alaska and have succeeded historically in establishing viable lifestyles They came in direct conflict with the Iifestyle of Western explorers, traders, and settlers, who generally tended to be much more aggressive and effective in imposing their culture. The Native people of Alaska, like those in other parts of the world, have suffered the loss of culture, Iifestyle, and identity as a virtually inevitable result of the Introduction of foreign attitudes, values, and practices.

The Native people of modern Alaska represent a people in transition, Traditionally, Natives simply relied on their own resourcefulness, and that of their extended families, to tap the bounty that surrounded them In some cases it took considerable ingenuity to access resources that to the Western eye may have appeared nonexistent Despite the apparent desolation, it was possible to subsist and thrive on available resources as long as a balance was maintained.

(continued)

BOX 2–1: Native Peoples of Alaska (cont'd)

The concept of subsistence as a lifestyle is typically interpreted by Westerners as a condition of bare survival, This is almost diametrically opposite to the Native concept in which subsistence comprises all of the activities associated with living, sometimes quite comfortably and securely, on the resources available from the surrounding environment,

It is Important to realize that subsistence Natives in Alaska generally do not work in the Western sense they subsist. Historically, no need existed for work in the Western, commercial cash-based sense, This significant distinction must be recognized in order to understand Native attitudes,

SOURCE John A. Olofsson and H P. Schroeder, University of Alaska Anchorage, Sanitation *Alternatives For Rural Alaska,* report prepared for the Congressional Off Ice of Technology Assessment, Washington, DC, August 15, 1993

MODERN ALASKA AND EMERGENCE OF NATIVE CORPORATIONS

The five most distinct cultural groups found in Alaska are the Inupiat (Northern Eskimo), Yupik (Southern Eskimo), Aleuts, Athapaskans, and Indians (Tlingit, Tsimpsian, and Haida) (figure 2–2). Throughout most of their history, these indigenous cultures were affected by the climate and geographic characteristics of the region in which they settled. Western contact, which intensified throughout the 20th century, brought about social and cultural changes that were rapid, extensive, and difficult for many of these groups to assimilate.

By the mid- 1900s, the last of the hunters and fishermen had abandoned their nomadic ways of life. Fur trading was usually the entry activity for Alaska Natives into a cash economy. Seasonal wage-paying jobs subsequently became more commonplace. Although nomadic ways were generally abandoned, and "village" lifestyles adopted, many villagers continued to depend on seasonal subsistence hunting and fishing. This tradition continues, and in fact is growing in some areas, as Native peoples select a modified traditional or "subsistence" lifestyle as a compromise with truly Western living.

Originally, the introduction of Western diseases wrought havoc among susceptible Native populations. As the effects of diseases subsided during the first half of the 20th century, they were replaced by a full range of social problems. These included alcoholism, physical abuse, suicide, sexually transmitted diseases, and lately, drug and substance abuse. The aboriginal population, which was estimated to be approximately 80,000 a few years earlier, had declined to a low of 25,000 by 1909.

During the most recent period, two separate and seemingly conflicting movements have emerged among A1aska Natives. One is led by more "assimilated" Natives who are working to administer land and financial resources under the corporate structure mandated by the Alaska Native Claims Settlement Act of 1971.] The second movement began with the more traditional Natives who are seeking to protect their land base and their hunting and fishing lifestyle, as well as to obtain greater control and autonomy over community life. These movements seem to be advocating contradictory "modem" or "traditional" lifestyles. The land claims and tribal movements are discussed in detail in appendix A.

Life in Alaskan villages began to take its current shape by the 1950s. By this time the last of the truly nomadic groups had settled into permanent communities. This ended the transformation that began with the establishment of fur trading cen-

[1] P.L. 92-203, Dec. 18, 1971, 85 STAT. 688 (Title 43, 1601- 1624).

ters, government and missionary schools, and other centers of Western influence. The process was begun by the Russians in the 1780s and advanced by Americans a century later after the purchase of Alaska. Inupiat hunters of the northeastern portion of Alaska were the last of the indigenous people to abandon nomadic lifestyles. New village communities were generally established on sites previous] y occupied as semipermanent camps.

Mechanized means of all-terrain travel and the availability of firearms increased the land area available for harvesting fish, berries, and game, making possible the establishment of permanent settlements. There was no longer a need to travel to the resources on foot or by dogsled when they could be easily reached by snowmobile and four-wheeler. The understandable result is an increase in population density, and a decrease in the intrinsic worth of traditional hunting, fishing, and "country" living skills. A diminished sense of self-value was also created because not every one was needed as a provider. Many social and emotional problems have resulted from these changes.

By 1960, approximately 70 percent of the total Alaskan Native population, numbering about 53,000 individuals, was living in some 178 villages of predominantly Native inhabitants. These villages were scattered across the 600,000 square miles of Alaska and ranged in size from 25 to 2,500 residents. An additional 50 locations were occupied by fewer than 25 inhabitants, usually including one or a few Native families. Only six communities that were predominantly Native had populations of more than 1,000. The median village population was 155, with larger communities serving as regional centers—now sometimes referred to as service centers or air hubs. In western Alaska, these hubs are Bethel, Dillingham, McGrath, Galena, Nome, and Kotzebue.

The remainder of the Native population lived in communities that were predominantly non-Native. The non-Native communities were often established in areas that had traditionally been inhabited by Natives. In the 1950s the migration of Natives from villages in Alaska to urban centers began, and it continues today. An estimated 16,000 Natives now live in Alaska's urban centers.

Anchorage is sometimes referred to as the largest Native village in Alaska because of its estimated population of some 10,000 Native residents. This can be misleading because of the high degree of seasonal migration among the urban Native population. Many urban Native people return to their village seasonally to participate in harvesting activities, such as fishing, whaling, berrying, and hunting, and in this way they preserve elements of a traditional way of living.

Almost all Native villages are geographically isolated from major urban centers. Virtually inaccessible by land during the warmer part of the year due to extensive wetlands, their primary means of extended travel is by air. Overland winter travel is somewhat easier but hazardous, as is travel on rivers, whether frozen or not. Fewer than a dozen villages are accessible on Alaska's limited road system. Access to the majority of the villages is available by airplane, boat, snowmobile, or dogsled. In the last decade, the Alaska Ferry System (the Marine Highway) has been expanded to include several villages in southeastern and southwest Alaska. It is helpful to keep in mind that even Juneau, the capital of Alaska, is not directly accessible by road and is frequently unreachable by airplane due to poor weather.

Communication with the villages is generally by mail, radio, or telephone (since the 1970s), and more recently through the use of communication satellite. Television is available in most villages through the Rural Alaska Television Network, bringing full exposure to world events and entertainment to the most remote parts of the State.

Alaskan aboriginal hunting and gathering economies of the past were independent, autonomous, and truly of the subsistence type—meaning a dependence on traditional activities for 1iving off the land. Modem subsistence hunters and fishermen now require cash to purchase tools, equipment, and supplies. Items such as snowmobiles, outboard motors, fuel, rifles, and ammunition have improved the efficiency of subsistence productivity and have altered many traditional subsistence harvest methods. The elevated level of productivity has resulted in a better standard of living, a greater capacity to support one's family, increasing village populations, and hence, an induced need to sustain the higher level of productivity. High levels of subsistence productivity are possible only with the increased productivity enabled by cash-purchased goods. In this way, Natives have become wedded to cash economies for goods that cannot be manufactured by village resources alone. Today, the term "subsistence" has been adapted to include the mixed economy of true subsistence and cash-based pursuits.

The current nature of the village economy in Alaska is a blend of subsistence and cash, sometimes with a preferred emphasis on subsistence. Cash is infused into the subsistence-based economy from wage employment, the sale of goods produced through subsistence activities, and transfer payments from various governmental sources.

Members of the traditional social groups or extended families will often alternate among themselves between various subsistence activities and wage-paying jobs to ensure that their needs are met. It is not unusual for a wage-earning individual in a village to simply not perform cash work for several days or weeks during the salmon or caribou migration. For Alaskan Natives, this is considered a balanced approach that satisfies both the subsistence need and the need for cash. (Consideration of a village's subsistence practices by Federal and State agencies planning to use the local labor force to build sanitation projects can often help to avoid costly construction delay s.)

This attitude is not unusual in indigenous societies elsewhere in the world where cash is not a primary motivator. For Alaskan Natives, survival (subsistence off the land) has historically been a matter of living through long winters. As in the past, it is still possible to live off the land. But gathering the stores of food needed to survive the long winter without cash may prove difficult for those Natives grown accustomed to purchasing bullets, fuel, nets, and snowmobiles. Even today, this stark reality is made apparent to non-Native visitors in remote Alaska when travel in the "bush" is forcibly interrupted by weather and other natural phenomena. Most prudent winter travelers, even those driving along the highway between Anchorage and Fairbanks, will carry the food and shelter needed to survive a day or two of forced delay.

Certain village members will often contribute cash, or purchase supplies and equipment for the hunters, in exchange for a share of the subsistence harvest. The elderly do this by contributions of various longevity transfer payments and thereby support the subsistence lifestyle. In addition, arts and crafts production for sale in the cities and to local visitors is another source of cash to support subsistence pursuits.

Cash also circulates through the subsistence economy as compensation for special skills and services such as sewing, beading, and preparation of traditional artifacts for ceremonial uses. [individuals may also receive cash as a ceremonial gift in rituals such as the Tlingit and Athapaskan pot-Iatch.

In almost all cases, kinship will dictate membership in a subsistence lifestyle production unit. Generally, households or extended family members comprise the basic production unit. These will often join forces with other such units to form larger groups in the communal pursuits required for hunting bowhead whales, walrus, and beluga whales. It is not unusual for family members living in the cities or even "outside" Alaska to return to the village family in order to participate in seasonal subsistence activities.

The cash economy of a typical rural Alaskan village is dependent largely on the public rather than the private sector. This is likely to be true into the foreseeable future due to the tradition of the people, their desires, the harshness of the climate, and the utter absence of any potential local economy in many village locations. In most rural communities, local, State, and Federal Government expenditures account for fully two-thirds of all earned cash income, the private sector being responsible for the remaining third. The reverse situation characterizes urban Alaska.

Village residents have a per capita income that is considerably lower than that of other Alaskans. The average per capita income for all Alaska is on the order of $18,000 to $20,000, whereas the average per capita income of rural residents is somewhat less than half of this amount. For Native villagers who live outside of regional centers (i.e., hubs and service centers), the average annual per capita income is about $6,000. Most villagers also receive welfare payments (a part of this income) that are about four times that of the average urban Alaskan recipient.

Village economies are dependent on a subsistence-based lifestyle and governmental support, and therefore are fundamental] y different from urban economies. They are extremely sensitive to governmental actions. For instance, decisions to restrict hunting and fishing or to reduce government payments may not affect city dwellers, but these actions can have a severe impact on rural village economies. Among the most essential needs-one that is frequently unavailable to Native villages because of their limited economies—is adequate sanitation.

SANITATION IN NATIVE COMMUNITIES OF RURAL ALASKA

The type of sanitary waste disposal in rural Alaska often varies among native villages; however, the honey bucket system remains the most widespread and least protective of human health in northwest Alaska and the Yukon -Kuskokwim Delta.

The level of sophistication of sanitary waste disposal systems in remote Alaska varies among the 191 Native village communities identified by the Indian Health Service (IHS) for sanitation purposes[2]. As of April 1994, only 102 of these communities were being provided some form of piped sewer service (conventional, circulating, vacuum, gravity, etc.) with flush toilets. In the remaining 89 communities a crude honey bucket is the only sanitation system in operation (figure 2–2).[3] This leads to a high risk of exposure to human waste, poor hygiene, and widespread incidence of disease.

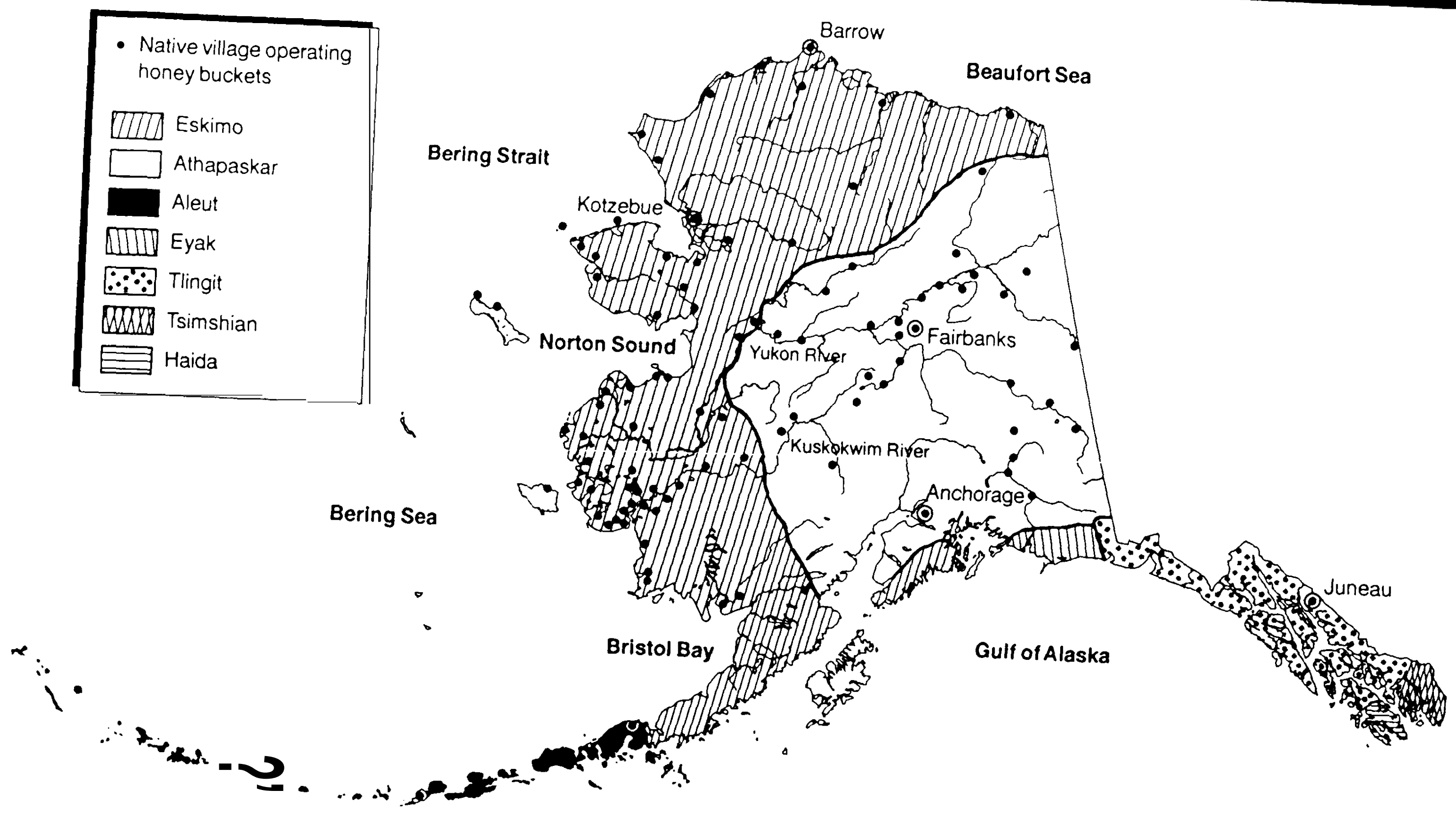
Nearly 20,000 Natives, or about 3.6 percent of the State's entire population, live in these 89 communities that operate only honey buckets. According to II-IS, about 55 of the 89 rural communities, with an estimated population of 8,300 Alaska Natives, have high disease exposure risk because they operate honey bucket systems that require the users to carry untreated wastes to a sewage pond, bunker, or simple privy behind their homes. Lesser risks of human contamination and disease from exposure to human waste appear to exist, IHS officials believe, at the remaining 34 of the 89 Native villages that operate honey buckets because waste is hauled from each house by a truck or all-terrain vehicle. Honey buckets continue to be the most rudimentary sanitation technology in use today by rural Alaska Natives.

Use of a truck-operated system for removing honey bucket wastes is not always a reliable health protection measure. In fact, the management and operation of honey bucket haul systems have been found to vary from village to village: from efficiently operated, well-managed systems, to those in which honey bucket waste is often spilled on streets, boardwalks, or backyards throughout the community. Under the worst-case conditions, the potential for Natives to contract hepatitis A and other diseases is unacceptably high. Such conditions also have a serious effect on village aesthetics and quality of life. About 200,000 physician-patient encounters per year were recently reported in the Yukon -Kuskokwim Delta alone (304). Such statistics help support the impression that current sanitation conditions in many villages of Alaska are no better than those found in developing na-

[2] A considerably higher number of villages are listed in other databases, for example, 317 by the Alaska Department of Environmental Conservation; however, the IHS list is most commonly used when village sanitation issues are being discussed.

[3] The waste technology euphemistically known as a "honey bucket" is simply a S-gallon plastic bucket lined with a plastic bag, with a toilet seat on top of it. When filled, the plastic bag is sealed, and the bucket is hand carried and emptied into a haul container, a sewage lagoon, or sometimes merely any convenient location.

Figure 2-2: General Distribution of Alaska's Major Indigenous Cultures and of Native Villages Operating Honey Buckets



SOURCE: Alaska Department of Community and Regional Affairs, *Community/Borough Map*, 1993; Indian Health Service, Alaska Area Native Health Service, *Alaska Area Native Health Service: Description of the Program* (Anchorage, AK: Indian Health Service, 1979); National Geographic Society, *Alaska*, supplement to *National Geographic*, May 1994; U.S. Federal Field Committee for Development Planning in Alaska, *Alaska Natives & the Land* (Washington, DC: U.S. Government Printing Office, October 1968).

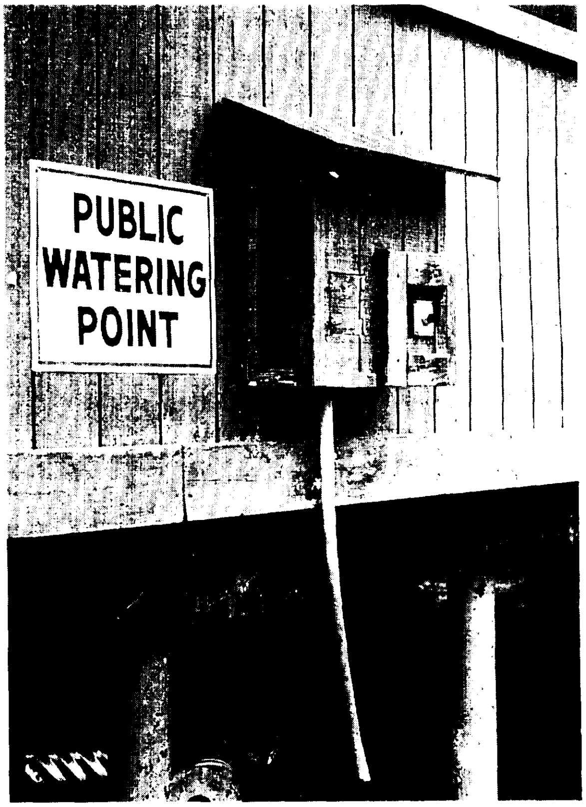
Piped water systems do not exist inside homes in villages that operate honey bucket systems. As a consequence, drinking water must be hauled by hand from a central public watering point

tions. Table 2-1 shows the total number of cases of hepatitis A reported in Alaska for 1987 to 1992. The number of reported cases per individual Native village is listed in appendix B.

Current plans are to replace honey buckets with piped sanitation systems in 10 of the 89 IHS-listed villages. If completed, this will reduce the Native population that depends on this rudimentary sanitation technology from nearly 20,000 to about 16,000. However, most Native villages have little or no local economy and must obtain external financial assistance to build the advanced but costly sanitation technology (i.e., conventional piped systems) traditionally favored by Federal and State agencies. Federal and State agencies have not formally supported the development of alternative sanitation technologies that may be more affordable than conventional piped systems.

9 Health Epidemics and Sanitation Services

The outbreak of epidemics repeatedly experienced by Alaska natives is primarily the result of poor hygienic conditions caused by inadequate sanitation services.



Throughout rural Alaska, but particular] yin the western, southwestern (mostly the Yukon-Kuskokwim Delta), and parts of the Arctic regions, the outbreak of disease is commonly a result of exposure to human waste and deficient personal hygiene. These conditions range from chronic influenza-like symptoms to hepatitis and enteric diseases. Endemic enteric diseases are certainly caused by habitual contact with human waste. Contact occurs on an individual basis, as a matter of casual contact between individuals, particularly through changing diapers or children playing, contact with waste in the open environment, and inadequately protected disposal areas. Because of the spillage of human waste that occurs on community roads and boardwalks during its transportation to the disposal site or lagoon, the exposure of residents, particularly children, is frequent.

TABLE 2-1: Reported Cases of Hepatitis A in Alaska Between 1987 and 1992

Year	1987	1988	1989	1990	1991	1992
Cases	241	596	643	190	96	130

SOURCE John A Olofsson and H P Schroeder, University of Alaska Anchorage, *Sanitation Alternatives For Rural Alaska,* report prepared for the Congressional Off Ice of Technology Assessment, Washington, DC, Aug. 15, 1993

Although the majority of rural Native villages in these regions are provided potable water at a central location, the residents' inability to truck water to their homes limits the amount of water that could or should be available for hand washing and personal hygiene. This, in turn, increases the risk that individuals, especially children, have of contracting diseases from exposure to human waste.

The outbreak of epidemics of otherwise commonly preventable diseases such as hepatitis A, hepatitis B, bronchitis, serious ear infection (otitis media), impetigo, and meningitis in remote Alaskan communities is often attributed to poor sanitary facilities (300). In fact, virtually all sanitation improvement projects for Native villages cite the frequency of disease outbreaks as a major factor justifying the need for such projects.

As part of this Office of Technology Assessment (OTA) study,[4] the 1988 outbreak of hepatitis A was examined to determine the correlation between the level of sewer service and the incidence of disease. Although the spread of this disease is often caused by close contact and person-to-person transmission, as opposed to transmission from the environment directly to the individual, OTA's evaluation showed, as have many similar studies, that the prevalent cause in most epidemic cases of enteric diseases among rural Native villages is a lack of running water to practice good sanitation and maintain good personal hygiene (wash, flush toilets, etc.).

In communities where water is hauled from a watering point, the predominant method of disposal is usually the honey bucket. This conclusion has been supported by previous studies (204) that correlated water supply and sewage systems with the incidence of preventable disease. In fact, OTA's brief evaluation of epidemiological data shows that throughout the State of Alaska, Native villages with honey bucket systems accounted for 72 percent (218 of 301) of the reported cases of hepatitis A in 1988.

Hepatitis A and B cases are most widespread in the Yukon-Kuskokwim Delta region of southwestern Alaska. There, the rate of incidence of hepatitis A and B is, according to local public health experts, one the highest in the United States. Nearly 2,000 people in the region, mostly children, were affected in the last hepatitis outbreak that occurred in the mid- 1980s, whereas the number of cases in areas with adequate water and sewerage was minimal (173). Reviews of the 1988 hepatitis A outbreak data show that village members of the Calista Regional Corp. in the Yukon-Kuskokwim Delta accounted for almost half (46 percent) of the cases reported throughout Alaska that year. Because epidemic waves of these diseases are expected every 15 to 20 years, a greater number of casualties may result in the future if proper sanitation measures are not taken in advance. However, prevention of an epidemic does not seem possible unless communities are provided with sufficient water to practice good sanitation and more adequate means of handling human sewage than the 5-gallon plastic container, euphemistically called a honey bucket, now provides.

Categories of Sanitation Conditions

The Village Safe Water (VSW) program of the Alaska Department of Environmental Conservation is the State agency with primary jurisdiction over sanitation planning and construction issues associated with Native villages. As part of its responsibilities, the VSW has established five lev-

4 Although the OTA analysis was directed at a specific outbreak of hepatitis A in 1988, additional analyses of similar epidemics may well reveal the same results.

els of service to categorize the different methods used by Native communities to dispose of human sewage.

Level a represents the most rudimentary service and consists principally of the use of pit toilets, privies, and honey buckets. Unlike pit toilets and privies where use and disposal are closely related, proper operation of honey buckets requires that residents carry the accumulated wastes out of the house to a disposal site away from the community. More frequently, however, one finds that honey buckets either are emptied on the ground in the immediate vicinity of the residence or carried to nearby pit bunkers by residents of individual households. Alternatively, they are emptied in other convenient locations, including frozen rivers, the ocean, tidal plains, tundra ponds, and sewage lagoons. The rural Native villages currently operating honey bucket systems in Alaska as their only sanitation technology are shown in figure 2–2 and listed in appendix C.

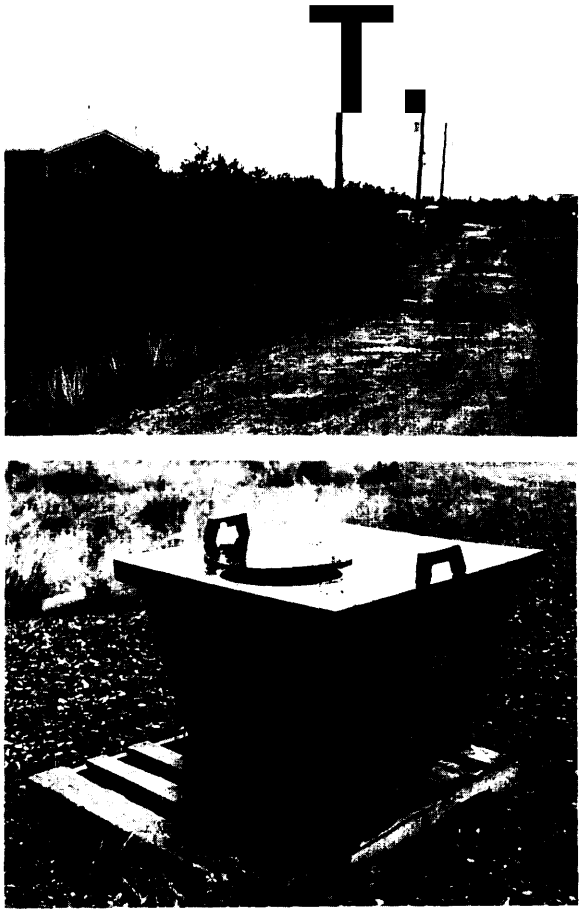
Level b sanitary waste disposal service provides for the hauling of honey bucket wastes by a community employee. Individual residents in these communities haul the waste from their respective households to central collection points known as honey bucket bins. There are more than 800 black plastic bins in use today. When filled, the bins are hauled to the community sewage lagoon by snowmobile, all-terrain vehicle, or truck. Although truck haul represents an improvement over level a sanitation, the inadequate design of certain system components (e.g., lids, trailers, and bins) means that some village residents come in contact with the waste.

In some villages operating levels a and b systems the health risks are lower than others. For example, in the coastal areas of southeast Alaska, small villages might dispose of honey bucket waste directly in the ocean. Although environmental damage is possible, if the populations are small enough the amount of waste disposed in this manner may cause little environmental harm and have little impact on public health. However, improved sanitation services will be needed as the size of these communities increases.

Bagged human wastes are sometimes stored temporarily at a convenient location, perhaps adjacent to the home, prior to their disposal,

Level c encompasses systems with flush toilets, holding tanks for collecting waste, and hauling of wastes to a disposal area by a truck service. Sewage collection tanks can be either large insulated tanks located outside the residence or smaller containers located inside the home. The tanks are emptied periodically by a pump or vacuum collection vehicle operated by the community. Adequate water must be provided for flushing year-round. Although residents provided with this level of sanitation service are ensured minimum contact with the waste, the costs for operating truck haul technologies (operator's salary, truck repairs, road maintenance, etc.) are higher than those incurred by communities with sanitation levels a and b.

Level d systems have flush toilets that discharge to septic tanks and leach fields. About 26 of the 191 villages identified by IHS operate this sys-



In some villages, honey bucket wastes are emptied into haul containers or bins strategically placed along village streets or boardwalks. Bins are periodically hauled and emptied at the village disposal area,

tern. A high degree of community sanitation can be achieved cost-effectively with the use of septic tanks; however, they work only in regions with well-drained soil above the seasonal water table. An adequate water supply for flushing must also be provided year-round. Such requirements preclude the application of level d systems in many remote Alaskan locations, particularly those with riverine delta topography such as the Yukon-Kuskokwim and Northwest Arctic regions. Operation and maintenance costs for villages operating septic tanks (appendix C) are generally lower than those of level c primarily because road maintenance activities, for example, are no longer required.

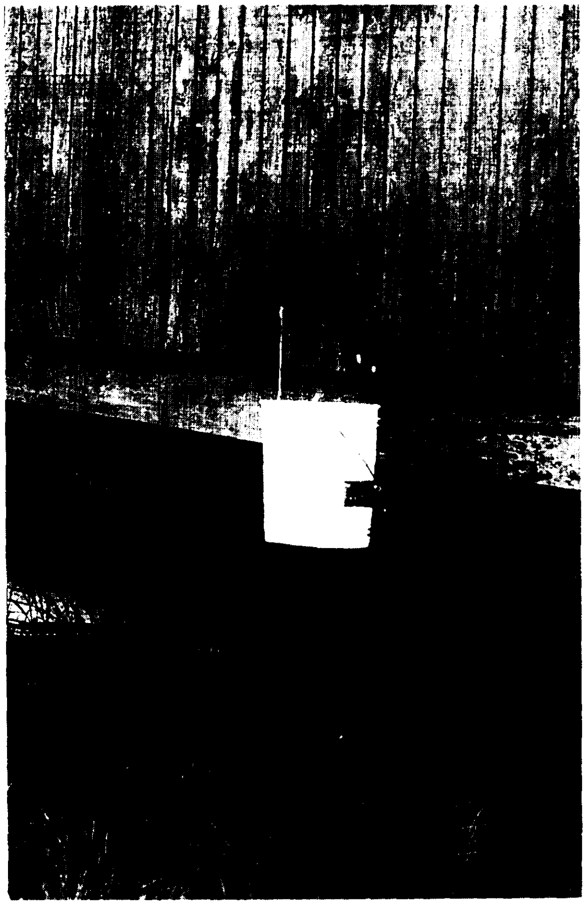
Level e-flush toilets and piped sewerage—represents the highest technical and safety level of wastewater disposal service provided to Native communities of Alaska. Contact with waste is virtually eliminated, provided there is an adequate supply of water to operate the piped technology (including gravity, pressure, or vacuum sytems). To date, 72 of the 191 Alaskan Native villages identified by IHS have been provided with level e piped waste sanitation services (appendix C). However, the construction of these systems has often been difficult and costly because of the harsh environment and remoteness of the villages.

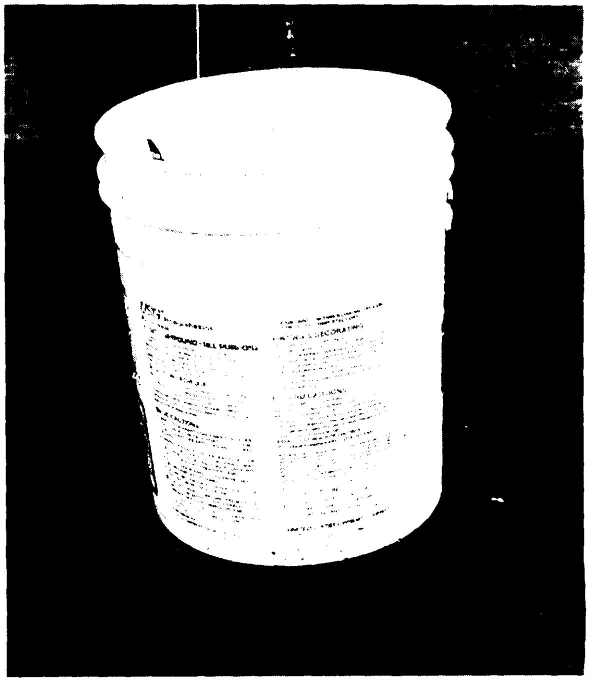
WATER AVAILABILITY AND SANITATION IN RURAL ALASKA

Despite the large bodies of water found throughout the state of Alaska, the water actually available at any time for practicing good sanitation is generally inadequate.

Rural Alaska, particularly the western, Arctic, and interior regions, appears to contain an almost endless number of rivers, lakes, and tundra ponds. Despite this hydrologic abundance, obtaining water for drinking and sanitation on a continuous basis in these areas is often difficult. During the warmer months, for example, water can be collected from surface sources such as rivers and lakes, but treatment is generally required to eliminate glacial silt and other dissolved organic or inorganic materials prior to drinking. The use of gutters or drains to collect rainwater from house roofs, as noticed during a recent visit by OTA staff to rural Alaskan villages, is also popular. Different methods are employed during the winter months, including drilling intake holes through frozen Arctic rivers and lakes, digging wells sometimes 200 to 400 feet under the permafrost, or chopping ice from lakes and rivers (ice chunks are placed in 30-gallon plastic trash cans and brought into the home to melt).

Because of the absence of some means of piping and hauling water to the home, all water consumed and discarded by residents must be hauled by hand. The work involved in hauling water, usu-





The use of gutters or drains to collect rainwater from house roofs for domestic consumption is also popular among many Native villages.

ally by 5-gallon pail, is burdensome and continual. A village watering point may be a hundred yards or more from the point of intended use, thus discouraging increased consumption.

Summer conditions in the interior areas of Alaska with severely limited rainfall include dusty roads, temperatures in the 80s, mosquitoes, subsistence demands,[5] and other factors that conspire to reduce one's willingness to haul water for use and then haul it again for discharge. Under winter conditions of short days, cold temperatures, and blowing snow, the manual hauling of water is an onerous task.

Typically, rural residents will use and reuse water-filled wash basins in the bathroom for personal hygiene. Such basins are frequent] y used until the water becomes visibly contaminated, at which point it is discarded. This is often accomplished by simply tossing it out the back door. Clearly, the opportunity for transmission of disease is increased under such conditions.

The lack of adequate water supplies often increases the risk of disease in Native villages that operate on honey buckets (61). In these communities, honey buckets are used not only in residences but also in local government and commercial buildings, and even medical clinics. When filled, the buckets are generally carried and emptied by hand into the village disposal site. Unfortunately, the community's lack of adequate running water for washing hands after using or disposing of honey bucket contents makes it very difficult to

[5] Subsistence is defined by economic experts as the "household production of goods and services for domestic consumption or sharing. In its ideal form, subsistence is autarkic and precludes extm-local trade or cash markets for goods and labor services" (249).

limit human contact with the raw sewage and avoid disease (300).

Limitations on water availability in rural Native villages also affect the operation and delivery of health care. For instance, 26 out of the 47 villages with clinics utilized by the Yukon-Kuskokwim Health Corporation are without water and sewers, even though nearly 200,000 physician-patient encounters per year were reported recently. Although clinics are the communities' "front line of defense," a respected Native leader recently concluded that the lack of running water precludes either the community or its clinics from having good sanitary conditions (304).

The prevalence of enteric disease in rural Alaska may not be reduced until personal hygiene in the home can be improved. This seems unlikely without sufficient quantities of clean water that can be obtained easily and inexpensively—a difficult prospect to achieve.

CONCLUSION

To telescope history, Western man found in Alaska a fully subsistence-based aboriginal people living nomadically in small groups. Their lives were originally controlled, sometimes severely, by natural events and the requirements of the environment surrounding them. With the advent of improvements in subsistence harvesting, due largely to the availability of cash and the implements it made available, populations were able to increase and the average life span lengthened.

Now, a new composite cash-subsistence lifestyle has emerged that is based not only on subsistence abilities, but also on the vagaries of external economies. Changes in external economies ripple through Native villages and cause their residents to revert to a subsistence lifestyle they have more immediate control over--only to later find that regulations, controls, and the realities of existing village conditions prevent successful reliance on past practices to fulfill all their needs. The most basic of these needs is sanitation, which cannot be provided at adequate levels by local economies alone. Continuing subsidy appears essential if Natives living in rural Alaska are to have adequate water and sewerage facilities.

In spite of these advances, nearly 20,000 Native people living among 89 rural village communities continue to 1ive in conditions created by inadequate sanitation that are highly conducive to contracting hepatitis A, hepatitis B, and other diseases. Children are specially at risk. Concerned individuals and critics commonly refer to the poor sanitary conditions found in Native communities as being no different from those found in developing nations. And, because epidemic waves of these diseases are expected every 15 to 20 years, additional health casualties are expected in the future if sanitation technologies more advanced than the honey bucket are not adopted. Improving village sanitation and preventing possible epidemics appear highly difficult today because conventional technologies are very expensive to build and maintain without outside financial assistance. Developing alternative technologies or methods that are more affordable for communities with 1imited economies is a solution still largely untried by Federal and State sanitation agencies.

Roles and Responsibilities of Alaska Natives 3

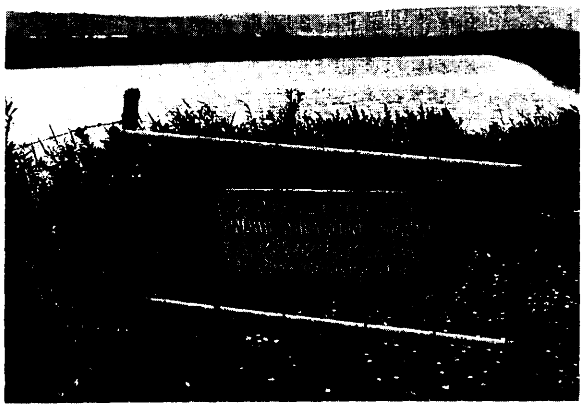
OPERATION AND MAINTENANCE OF EXISTING PIPED SANITATION TECHNOLOGIES

In addition to the harsh climate and geographical constraints typical of the rural Alaska environment, the economic conditions found among Native villagers living in these remote lands also have a direct bearing on the ability of a village to acquire, support, and maintain modern sanitation systems.

The poor economic base in most Native villages in Alaska's southwestern, western, interior, and Arctic regions creates considerable management difficulties for local governments in addressing community needs, including sanitation. Federal and State agencies responsible for building sanitation projects are often forced to recognize these difficulties because sanitation projects require support for operation and maintenance (O&M) at levels that are often beyond the technical and financial capabilities of local villages.

The majority of Native communities in rural Alaska rely almost completely on transfer payments and subsidies to operate basic village programs, including electricity, education, and transportation. Although quantification is difficult, most experts agree that Federal and State subsidies continue to be vital to local village economies.

Because of the extreme economic difficulties experienced by Natives, a subsistence 1ifestyle continues to be the dominant practice in most remote communities. Many personal, social, and cultural values essential to the civilization of Alaskan Native groups are intrinsically embedded in the practice of subsistence living.



Waste collected through piped sewer systems is discharged into sewage lagoons for treatment,

Today, subsistence constitutes a critical continuity with the cultural life of the past.

Several experts and expert groups have recognized that operation and maintenance of existing sanitation projects are vital for protection of the community's health (246). O&M costs are, however, generally high. The shortage of technical assistance from outside agencies and the inadequate training of facility operators contribute to poor O&M. Among the consequences most commonly associated with poor O&M are shortening of the useful life of sanitation projects, system breakdowns, and sometimes, human casualties. Despite insufficient support and capabilities, Native villages continue to be responsible for facility O&M.

The prevalence of disease throughout Alaska is due primarily to a limited potable water supply and the use of inadequate technologies for collecting and disposing of sanitary waste. This has led to an insistent demand for installation of adequate collection and treatment facilities in each Native village.

Even though State and Federal agencies have allocated more than $1.3 billion in the last 30 years (and have been recently spending about $120 million per year), the existing sanitary conditions in many rural Native villages of Alaska indicate that much remains to be done to solve this problem.

Provision of long-term solutions to each community has been the major objective of Federal and State agencies and continues to be so. The most frequent long-term solution is piped sanitation. Attempts to develop and demonstrate short-term or interim promising technologies that might improve sanitary conditions have been limited. Three types of sanitation technologies are used in Alaska: gravity, pressure, and vacuum (see box 3-l).

Although large-scale piped systems continued to be the type of sanitation technology most favored by Federal and State agencies, delivering piped sanitation services takes time and, more importantly, large sums of money for facility construction, operation, and maintenance, which most Native communities now lack. The discussion that follows focuses mainly on the economic health of, and the role played by, Native communities in sanitation projects.

ECONOMIC HEALTH AND CULTURE OF NATIVE VILLAGES

B Role of Subsistence Practices in Village Cost of Living

Subsistence practices among Natives often hide the actual cost of living and economic difficulties of communities, as well as their ability to pay for the construction, maintenance, and operation of new or improved large-scale sanitation projects.

From a distance, cash expenses have traditionally appeared to be the primary means of acquiring food by Native families. A closer look, however, has enabled researchers to conclude more accurately that subsistence practices are as critical to the survival of Natives as food purchased from the local community store. In a 1983 study, subsistence harvests of salmon, for example, were reported to be not only a significant protein source, but also capable of providing up to 55 percent of the food consumed by the average household per year in some localities.

Considerable research on village economics has been carried out since the 1983 study (204). As a result of these efforts, it has been shown that of the regional corporations in Alaska, the Bering

BOX 3-1: Types of Conventional Piped Sanitation Technologies in Rural Alaskan Villages

As of April 1994, gravity piped sewer technology had been Installed in 69 of the 191 Alaskan Native villages identified by the Indian Health Service as needing support for sanitation purposes. Residents of these villages have flush toilets draining to a community collection system that transports human waste to a sewage lagoon for treatment. The majority of communities served by this type of piped sanitation system are found in the Aleutian (8 of 10 villages), Kodiak (all 6 villages), North Pacific Rim (all 4 villages) and Southeast (all 12 villages) regional corporations. All Native villages currently operating gravity sanitation systems are listed in appendix C

Installation of gravity piped sanitation technology is generally dependent on an adequate water supply to transport sewage through the system, the absence of groundwater near the surface where it could infiltrate buried pipes, and proper insulation and heating of system components to prevent winter freeze-up. Although aboveground Installation of gravity piped sewage systems may be used when underground pipes are impractical, it is Inferior to underground installation because of its greater potential for experiencing heat loss (sometimes as much as three times that of underground lines), the likelihood of vandalism, and the adverse effect on community aesthetics. '

Gravity sewer pipes cannot always be installed in rural Alaska because of the harsh soil conditions, permafrost, rocks, and flat surfaces typical of this State, With the exception of Naknek and Iguigig (Bristol Bay) and Aniak (Yukon -Kuskokwim region), where drinking water is obtained from Individual wells, all of the Native villages with gravity sewer systems in rural Alaska are also served by a piped water delivery system

When local environmental conditions make their installation Impractical, pressure piped technology can be substituted for gravity systems Rather than depending on gravity, this type of conventional sewerage system utilizes the pressure provided by pumps to transport human waste through service collection pipes to the disposal area. The possibillity of building a pressure piped sewer system at Nuiqiut and Point Hope is being examined as part of the Indian Health Service effort to deliver piped water and sewer sanitation services to seven Arctic Slope Regional Corp. villages,

The third type of conventional piped technology used in rural Alaskan Native communities is vacuum sewer technology.[2] In addition to the specialized flush toilet Installed inside the home, the vacuum-type system consists of one or more vacuum collection stations situated in a central location in the community, one or more collection tanks for holding incoming sewage, several vacuum pumps for handling sewage flow or discharging sewage into the community's disposal facility; and a network of small service collection pipes. A separate vacuum tank to provide additional capacity and prevent moisture from reaching the vacuum pumps might also be Installed inside the collection station.

The use of a vacuum Instead of gravity allows considerably smaller collection pipes[3] than those employed in gravity and pressure technologies, thus making the installation of vacuum systems possible on almost any type of terrain, with litttle concern for slope. The use of smaller pipes also provides a greater opportunity for

(continued)

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1 Collection lines are generally installed deep in the ground, whenever possible, otherwise additional Protective measures 'ust be taken to prohibit excessive surface loads If underground installation is not possible, collection lines are placed on the surface or on pilings Collection lines can also be installed in "utilidors" along with other utility pipes

2 The three major types of vacuum sewer system in use in the United States are 1) the conventional gravity fixture with exterior vacuum valve, in which collection of sewage is accomplished in a sump located outside the home and maintained by the utility authority (the most common type of vacuum system operated in the lower 48 States), 2) the "two-pipe vacuum sewer system, " which requires the use of two municipal collection lines, one for toilet waste and the other for greywater; and 3) the "vacuum toilets and vacuum sumps with greywater valves" in operation m the villages of Noovik and Emmonak, Alaska

3 Generally between 2 1/2 and 4 inches in diameter

BOX 3–1: Types of Conventional Piped Sanitation Technologies in Rural Alaskan Villages (cont'd)

water conservation, Another advantage of vacuum sewerage systems is their ability to separate blackwater[4] and greywater[5] in the user's home.[6]

Noorvik (Northwest Arctic) and Emmonak (Yukon- Kuskokwim) are the only two Native villages of rural Alaska operating vacuum sewer technology. In Noorvik, the sewage is vacuumed through 2 l/2-inch high-density pipes Inserted in a utilidor[7] into a 7,000-gallon sewage collection tank located within the sanitation facility building. Two discharge pumps are then used to draw sewage out of the tank for disposal through 1,300 feet of 4-inch Insulated sewer force main into a 2.2-acre sewage lagoon for treatment. Heat inside the utilidor is provided by a circulating water distribution system backed up by a glycol heating loop.

Unlike Noorvik's vacuum technology, the vacuum collection pipes and the glycol heating lines of the Emmonak vacuum sewer system are not contained in a utilidor but inside a separate Arctic carrier pipe As a backup heating system, engineers have installed electric thaw cables along the carrier pipe.

The use of the vacuum sewage technology has also been proposed for the City of Selawik in the Northwest Arctic Regional Corp. If sufficient funds are available, two vacuum sewage collection stations[8] Will be Installed as part of the Memorandum of Agreement between local and Federal Government officials to provide water and sanitation services to the city's nearly 600 residents.[9]

4 The term backwater refers to urine, fecal matter, and related debris, such as toilet paper, deposited in a toilet, as well as the water used to transport these materials

5 Greywater is household wastewater without toilet waste, It consists primarily of discharged water from bathtubs, showers, sinks, and appliances such as washing machines and dishwashers

6 In communities where this technology has been Installed, separation is accomplished by dividing the single line that provides vacuum service to the home into two lines: one to serve a specially designed vacuum toilet and the other to serve a vacuum greywater valve To dispose of human waste, the user flushes the vacuum toilet, which in turn causes a vacuum interface valve to open and allows the stored raw sewage to enter the vacuum line connecting the toilet to the vacuum system Once collected, the sewage can be pumped through a force main directly to the community's sewage lagoon or to a lift station from which it is pumped to a lagoon

7 A utilidor is an above- or underground pipe-llke structure des gned to protect the utility services Of the community; it might contain, for example, utility piping (water and sewer pipes), fuel and central heating conduits, and electrical and telephone lines

8 These vacuum sewer stations will be manufactured by AIRVAC Vacuum Sewer Systems

9 The agencies acting on behalf of the Federal Government in ths agreement are the Indian Health Service and the U S Environmental Protection Agency

SOURCES Arctic Slope Consulting Group, Inc (ASCG), *Water and Sewer Utilities Master Plan Report for Selawik,* Alaska, prepared for City of Selawik, Alaska, Jan 1992, Canadian Society for Civil Engineering, *Co/d Climate Utility Manual* (Montreal, Canada Beauregard Press Ltd , 1986), John A Olofsson and H P Schroeder, University of Alaska Anchorage, *Sanitation Alternatives For Rural Alaska,* report prepared for the Congressional Office of Technology Assessment, Washington, DC Aug 15, 1993

Straits, Calista, and Nana areas—located in the southwestern, western, and Arctic regions of the State— are the most economically depressed. The virtual absence of any viable economic base in these areas creates considerable management difficulties for local governments in addressing community needs. Similar difficulties are experienced by those responsible for sanitation facilities in the community because such projects require support for operation and maintenance at levels that are often beyond the technical and financial capabilities of local villages. Attempts by Natives to acquire "matching" capital funding from the village have been largely unsuccessful due to the virtual absence of any self-sustaining economic base.

Villages in the Bering Straits, Calista, and the Nana corporations fall well below the overall average income for the 12 regional corporations and below the overall statewide Alaskan average. The Calista Region, for example, ranked last in the average per capita category and next to last in the average median household income category.

Dismal regional economies and generally low per capita income are exacerbated by the high cost of living in rural areas. Although Anchorage is considered a high cost of living area by most economic experts, the cost of living in areas such as the Calista Region is nearly 40 percent higher than that in Anchorage because of their limited accessibility and the increased shipping costs

A recent comparison between the average annual expenditures reported for Calista Regional Corp. villages and their average annual median household income showed a shortfall of up to $255 (204). An obvious conclusion is that these village households operate at a loss or at a near break-even level. Severe winters with increased heating cost and utility bills, and poor subsistence harvests, are known to place Native residents in these communities in a deficit position. For example, the unprecedentedly low salmon harvest reported to Office of Technology Assessment staff during a visit to the City of Buckland in August 1993 was considered a potentially serious economic concern by community leaders. This was primarily because of the uncertainty about how the community would be able to simultaneously make up for the loss and pay for services during the coming winter months.

Throughout the State of Alaska, the level of sewerage service can be linked directly to the annual average per capita income. Of the 223 Native and non-Native village communities surveyed during the 1990 U.S. Census (53), about 100 did not have a flush toilet inside their homes. Of these, 85 villages (89 percent) fell below the average per capita income, indicating that in addition to geotechnical constraints, economic conditions in remote Alaskan villages limit their ability to support and maintain highly complex and costly sanitation projects, once they have been built.

Any additional monthly payments required for improved water and sewer systems may easily overwhelm the residents' ability to meet their basic living expenses. Because of this, it appears imperative that any proposed technological solutions—particularly those that are large scale in nature—to the waste sanitation problems in Native Alaskan communities need to be based on a detailed analysis of the economic health of each village. Only in this way can its ability to sustain the additional costs for such sanitation systems be determined.

1 Transfer Payments and Subsidized Goods and Services

The ability of most native governments of rural Alaskan villages to provide vital goods and services to their residents, including water and sewer sanitation, is extremely limited without adequate external financial support.

Without subsidies of goods and services by Federal and State agencies, Native village communities throughout rural Alaska are unlikely to survive. Subsidies are also key to the success of large-scale waste sanitation projects. Although quantification is almost impossible, annual subsidies are estimated to be in the range of several thousand dollars per capita. This is a fair assumption, according to most experts, since subsidized goods and services cover a wide range of needs including electric power, education, postal freight service, television and telephone, passenger air service, school lunch programs, and several State loan programs, to name a few. Eligibility y for transfer payments from Federal and State agencies is based on the financial needs of a particular community.

Federal and State subsidies are considered vital to the local economy of most villages, particular y in the Bering Straits, Calista, and Nana regional corporations. Other regional corporations in the western, interior, and Arctic areas of Alaska, where similar problems exist, are Ahtna, Arctic Slope, and Doyon. In 1984, for instance, the average per capita income from transfer payments alone was $5,338 for Calista residents. Federal funding of Native health care, education, and a variety of Native social programs is also included in this figure.

The disturbing conclusion drawn by many experts is that the majority of Native communities of rural Alaska rely almost completely on transfer payments and subsidies to operate their programs. Some view per capita income today as a clear resuit of direct transfer payments. “Villages are no longer self-sufficient,” said a respected Native leader recently (221). Since sustaining the current level of external financial support appears uncertain in light of recent reductions in State oil revenues and Federal Government contributions, the economic potential of Native communities must be evaluated carefully prior to undertaking any large-scale, costly sanitation projects. The relevance of this consideration cannot be neglected in regional corporations such as Ahtna, Arctic Slope, Bering Straits, Calista, Doyon, and Nana, where at least half of the Native villages operating honey buckets have per capita incomes below the State average.

1 Cultural Importance of Subsistence Among Alaska's Native Villages

Although Alaskan Native culture has been affectedly outside forces, it is vital for Federal and State agencies to recognize the importance of subsistence as a cultural factor.

Subsistence is critical to the existence of Alaska Natives. From their beginnings as hunter/gatherers, Alaskan Natives have consistently relied on the land as the source of their most basic needs. Additionally, religious and spiritual ties with nature have long been part of Native culture. As influential as Western culture might be today among rural communities, subsistence continues to be an important factor in defining the cultural fabric of most Natives in the State.

On close inspection of the sociocultural conditions in the southwestern, western, interior, and Arctic regions of Alaska, one finds that without exception, subsistence—not merely economically, but also culturally—is the dominant and largely preferred practice in these regions. More than any other factor, subsistence inspires powerful sentiments, represents significant bonds between family and community members, defines domestic roles and personal identity, represents great cultural achievement, provides critical sustenance and commodities, and demonstrates the persistence of Native culture through time and in the face of adverse conditions.

Therefore, the importance of subsistence as a means of both physical and cultural survival cannot be overemphasized. Although fish wheels and modem technology have thrust Alaskan Natives beyond basic subsistence into a partial cash economy, subsistence salmon fishing, for example, still represents a critical continuity with the cultural life of the past. The importance of subsistence also frequently results in conflicts between periodic summer employment (e.g., cash earnings from sanitation construction projects) versus the need to maximize the salmon catch to survive the winter.

With relatively few exceptions, the economic and sociocultural conditions of most villages in rural Alaska represent significant barriers to planning complex sanitation projects. Examples of this can be found in most villages within the Calista Regional Corp., whose lack of a viable economy reflects their potential inability to support new complex sanitation projects satisfactorily. Furthermore, the lessons learned from previous failures indicate clearly the need for better coordination among Federal, State, and Native governments to create the management base necessary within each village to ensure proper O&M of existing projects. Strong local leadership and community support are also essential for ensuring the success of sanitation projects (221). Similarly, serious consideration must be given to the sociocultural patterns of Alaska Natives early and throughout the planning, construction, and operation of sanitation projects.

| Western Influence and Accessibility of Native Communities

The level of accessibility to external organizations and institutions varies among Native villages.

The cultures and people of Alaska areas different as the many types of land areas found throughout the State. The Native people are ancestrally linked to Eskimo, Aleut, and Indian groups. Each of the Native groups inhabits a specific region of Alaska and is historically related to the people of the Russian Far East to some degree. A major portion of the State's non-Native population has migrated from the rest of the United States or other locations and is generally found in urban areas.

The relationship with the Westerner or "white man" has sometimes been considered tolerable at best. Two factors have been cited as being most disruptive to this relationship: the gold rushes that introduced Eskimos to a variety of Western ways, including intermittent economic opportunities, and the introduction of diseases of epidemic proportions that halved the historical Eskimo population by the early 1900s. The impact of epidemics resulted in a dramatic loss of the elderly. Young Natives frequently lacked the knowledge to continue traditional customs and ceremonies. The remaining Native population was further affected by the introduction of family dwelling units, American political institutions, village schools, trading posts, and post offices, which more gradually, but perhaps also more conclusively, altered the Eskimo lifestyle.

The presence of exploitable resources may also determine the degree of Western exposure that a village has experienced. The gold rush era in the late 1800s and early 1900s, for instance, brought sudden and vast exposure of the Yukon River communities to Western culture. However, the exposure of the Kuskokwim communities was less disruptive, primarily because of the absence of large gold finds along the Kuskokwim River. Additionally, early difficulties in navigating the Kuskokwim further delayed exploration and exploitation of limited resources along the river. Consequently, with much later exposure to Westerners, Kuskokwim communities tend to be more traditional and to favor retaining the old ways of life. A comparative overview of Yukon and Kuskokwim River communities is presented in box 3-2.

Although the intrusion of Western culture has met with resentment, Alaska Natives have occasionally welcomed Western social and economic programs. Many Natives believe that the main source of resentment has emerged primarily from being told by outsiders what to do and how to do it, and rarely being included in the development of solutions to local problems—an obviously understandable response to the worsening economic conditions being experienced by villagers. Some attempts by outside institutions to install sanitation systems unilaterally, and then expect village residents to operate and maintain them, have received little acceptance and consequently have failed.

The misapplication and subsequent abandonment of comporting toilets by Fort Yukon and Galena residents appear to indicate that agencies—in this case, the Farmer's Home Administration—need to evaluate in advance how the technology would perform in a particular community (e.g., through pilot tests), as well as involve potential users in the planning and technology selection process. In the view of many, this is essential for maintaining the agency's credibility. Of the many State and Federal institutions involved with Native communities in rural Alaska, the Indian Health Service (IHS) and the Village Safe Water (VSW) program have been the most successful in encouraging and supporting villagers' participation in the planning, design, and construction of projects. This is extremely important because the degree of project success will ultimately depend on the level of commitment of community leaders and residents.

ROLE OF NATIVE COMMUNITIES IN OPERATION AND MAINTENANCE OF SANITATION PROJECTS

Alaska's rural Native villages are responsible for managing their waste sanitation projects but often lack the financial resources needed to ensure their long-term operation on and maintenance.

The hope of some Native leaders is to see a government program that provides "all Alaskan villages with piped water and sewer systems to serve every home within the village" (300). Others, however, recognize that this might in some cases be economically prohibitive, and they call for the development of more affordable sanitation alternatives. Under the current system, villages are given the responsibility for operating, maintain-

BOX 3-2: Comparative Overview of the Yukon and Kuskokwim Communities

There are several major differences between Yukon and Kuskokwim River communities, including economic, social, and cultural factors. Observation indicates that the downstream villages on either river appear to be in more precarious condition than those upstream. Upstream villages tend to be fewer in number and more viable in almost all respects. From a sanitation perspective, upstream communities have greater access to gravel and permeable soil, and experience fewer waste disposal constraints. They are also generally less assimilated and more traditional in outlook.

There are 10 Calista villages along the Yukon, of which 6 have modern sewage disposal systems. The average per capita income for these Yukon River comrnunities is higher than for the Kuskokwim River and coastal communities in the region. In contrast, only 4 of the 20 Calista communities along the Kuskokwim River operate wastewater disposal systems above the honey bucket level. The remaining 16 have the lowest per capita annual income.

The apparently significant variation in level of sewer service between the Kuskokwlm and the Yukon River communities is generally attributed to the geophysical characteristics of the Yukon River. The SOiI and drainage characteristics of Yukon River villages are usually signficantly better than those of Kuskokwim River communities. In addition, gravel IS more readily available along the Yukon, making infrastructure improvements easier. The seasonal flooding and erosion potential is also much higher along the Kuskokwim than along the Yukon River. All of these factors favor Yukon villages in the successful provision of improved sanitation systems. Permafrost distribution does not significantly favor either region.

Regarding water quality, none of the 10 villages along the Yukon experience problems with iron, manganese, or arsenic However, 15 of the 20 villages along the Kuskokwim report difficulties with high inorganic levels, especially iron, in their drinking water sources. Among the coastal communities in the Yukon -Kuskokwim Delta, 8 of 16 villages recorded high iron concentrations in their drinking water source. From a cost perspective, compliance with water treatment standards for villages along the Yukon require a smaller capital Investment and lower operation and maintenance costs because of generally higher quality source water,

Water availability cannot be compared accurately because of the subjective interpretation of the term “adequate. ” Adequacy of a water source IS relative to the type of water system installed in a given village and the specific Iifestyle of the residents. In general, Yukon River communities are located in an area that is more conducive to cost-effective installation and operation of state-of-the-art piped water and sewer systems.

Socioeconomic Comparison

Historically, the accessibility of a given region to non-Natives has been a major factor in determining the intensity of cultural change, Within the Yukon-Kuskokwlm Delta, Yukon communities, in general, are less traditional than comparable communities on the Kuskokwim River.

Noticeable differences also exist between the average per capita incomes of Yukon and Kuskokwim communities. With Federal and State subsidies identical for both communities, the major difference is attributed to the value of the commercial fishery in each subregion. For a variety of reasons, the Yukon River commercial salmon fishery is larger and more valuable than the Kuskokwim fishery. Prices paid to fishermen are higher along the Yukon than the Kuskokwim, primarily because of well-developed, relatively stable, and more competitive fish processing. Consistently higher value is realized per pound for lower Yukon salmon harvests, compared to similar catches on the Kuskokwim. The Kuskokwim fishery has also been plagued by market instability, the inability of buyers to accept the entire harvest, and an absence of competition among buyers, which have resulted in consistently lower prices.

There IS a significant difference of approximately $800 in annual per capita earnings between Yukon and Kuskokwim communities, For an average household size of 4.9 persons, this translates into a monthly household income of $327 more for Yukon than for Kuskokwim homes. From an income comparison perspective, one might conclude that Yukon households are therefore more financially capable of supporting expenses, Including those associated with municipal infrastructure.

The size of each village should also be considered in terms of operating and maintenance cost dlstribuhon. Simply stated, a larger village would be more able to distribute its costs over a greater population base than a smaller one, if normal economies of scale in the municipal Infrastructure are assumed.

In summary, Yukon River communities, in general, are more capable of Implementing improved sanitation systems than Kuskokwim villages Geophysical conditions along the Yukon are more conducwe to installing and maintaining improved systems, and the quality of source water is higher,

Overall, this comparison between Yukon and Kuskokwim communities supports several general theories expressed by U.S. Public Health Service and Village Safe Water officials, Village attitudes, coupled with an overall readiness and potential to accept improved sanitation systems, are intangible factors, but correlations seem to exist with villager's attitudes. The economic supportability of sanitation systems and the presence of effective local leadership have often been cited as key criteria in ensuring the long-term success of sanitation projects,

SOURCE John A Olofsson and H P Schroeder, University of Alaska Anchorage, Sanitation *Alternatives for Rural Alaska,* report prepared for the Congressional Off Ice of Technology Assessment, Washington, DC, Aug. 15, 1993

ing, and managing sanitation projects, without the funds needed to hire trained, certified operators capable of ensuring that such projects are safely and properly operated (58). One reason villages feel that they should receive adequate support is that other communities in high-altitude regions are supported with O&M funds by their governments. Alaskan sanitation experts have been made aware of this when attending international conferences held in other high-altitude countries, such as Canada, Denmark, Finland, Russia, and Sweden.

Operation and maintenance were recently recognized by the Governor's Sanitation Task Force as the most vital components for ensuring the long-term success of sanitation projects and protecting the health of Alaska Natives. Unfortunately, most communities lack the funds to pay for adequate maintenance (58). This difficulty sometimes results in shortening the useful life of the system, as well as in breakdowns. Inadequate O&M has also been responsible for some human casualties. For instance in 1992, a malfunctioning pump allowed excess fluoride to enter the Hooper Bay water supply, killing one person and causing many other village residents to be ill (300).

According to the Alaska Native Health Board, the State of Alaska spent about $11 million for equipment repair or replacement at sanitation facilities between 1988 and 1991 (58). Many more sanitation projects are expected to require replacement of their mechanical systems in the near future. Although specific figures are difficult to arrive at, the Governor's Sanitation Task Force estimated that the cost of repairing all existing facilities that are inoperative or operating with difficulty due to equipment malfunction will exceed $750 million (67).

Unfortunately, operation and maintenance costs are generally too high for Native communities to afford. Operation of sewer and water systems in remote villages, generally considered the province of local governments, is typically "in the

The inadequate condition of roads in some villages often results in spillage of human waste during its transportation to disposal sites red" or technically bankrupt. The scarcity of Federal or State subsidies makes the operation of sanitation systems at village communities challenging (104). In some cases, State subsidies for electric power, heat, and fuel are helpful, but insufficient to meet the high O&M costs typical of rural Alaska which are several times higher than those in major Alaskan cities.

FACTORS THAT HAMPER SUCCESSFUL OPERATION AND MAINTENANCE IN NATIVE COMMUNITIES

Several factors appear to be hampering the successful operation and maintenance of sewerage facilities in Native communities. These include, for example, a shortage of technical assistance from outside agencies and inadequate training of facility operators. Little change is expected in the near future because Federal and State agencies continue to favor the construction of new capital projects with little direct financial support for O&M of existing sanitation systems.

Other relevant factors hampering successful O&M throughout rural Alaska include the following:

Factor 1—The limited ability of remote villages to hire certified and trained personnel can often result in higher O&M costs. Because a large segment of the rural Native population of communities found in the southwestern, western, interior, and Arctic regions of Alaska falls below the national poverty level, only a few villages can afford to hire an operator on a full-time basis. Where this is not possible, the level of oversight is inadequate and responsible for system malfunctions. Because most communities lack the funds to correct such malfunctions, they often wait until system parts are seriously damaged or inoperative, at which time, their repair or replacement costs are considerably higher and even more difficult to afford. According to Willie Thomas, Vice Mayor of Buckland, a village of 300 residents:

> It is difficult to generate jobs. Some people are trying to develop their own skills. Training would be helpful but once investments are made [by the Native village], there would not be any jobs [in the Village] and trained personnel would go somewhere else (238).

Sanitation facility operators are trained in many technical areas, including water chemistry and treatment, vacuum pumps, operational safety and record keeping.

Factor 2—The small size of the community adversely impacts its ability to pay for O&M because of the inability to develop the economies of scale capable of reducing rate of payments or to support the construction of more advanced, and generally more expensive, sanitation projects.

Factor 3—In addition to the poor economy, lack of roads makes it difficult for communities to acquire spare parts and supplies because of the high costs of freight and fuel (70).

Factor 4—The inability of governments of small villages to fund the O&M of sanitation projects often places an increasing number of operation, maintenance, and management responsibilities on a relatively small number of facility operators. This, in turn, makes the protection of residents' health and the success of sanitation projects problematic (64).

Factor 5—Inadequacies of staffing, planning, and accounting in many small rural villages have resulted in equipment and mechanical failures—many of which are premature in nature. In addition, the lack of consistency and uniformity in fee collection practices results in insufficient funds for O&M expenses and operators' salaries.

Factor 6—Most villages find it difficult to fund a public works department or a full-time, certified sewerage operator. Sanitation facilities are often run by part-time operators, and occasionally volunteers, who are often ill-equipped to deal with the challenges posed to sanitation projects by the harsh climatic and environmental conditions typical of rural Alaska (64).

Factor 7—Some local governments have shown little interest in assuming or sharing responsibility for utility management. Thus, problems relating to utilities are often referred to city managers and facility operators (if they exist) or to other individuals, who do not have the authority required to effect corrective policy within the community.

Factor 8—City clerks and administrators are often left with the responsibility of collecting user fees and keeping records of all financial transactions associated with a waste sanitation facility. The lack of support by local governments, along with low salaries and heavy work loads, has contributed to the high rate of city clerk and/or administrator turnover-ften precluding communities from having skilled clerks and administrators and, therefore, well-managed sanitation facilities (70).

Factor 9—The use of computers is widespread, but the knowledge of software and technical support are highly deficient. Computer systems are generally purchased on the basis of cost, with little attention given to the capability of the software, manuals, and training (227). Unfortunately, the high turnover rate of capable village administrators or city clerks does not allow time for personnel familiar with a computer system to train others in its use.

Factor 10-Many local governments lack the leadership and leadership stability required to ensure the success of a project. Unfortunately, among agencies involved with sanitation projects in rural Alaska, the number of programs to deal with community dysfunctionality is extremely limited.

Factor 11—the lack of meaningful participation in the planning, construction, and management phases of waste sanitation projects leads to community frustration. In addition, the lopsided support by Federal and State agencies for construction, rather than for O&M, often leaves a poor perception among community leaders and members that subsequently may lead to the neglect of the facility (70).

FUNDING OF OPERATION AND MAINTENANCE ACTIVITIES

Although Federal and State agencies have programs to provide essential capital funds for repairing existing facilities and building new ones, the funding for proper O&M of sanitation facilities is not traditionally part of any Federal and State plans. It is not rare to find a recently built multimillion-dollar facility in need of preventive maintenance due to lack of proper operation and adequate local financial support.

Recognizing this deficiency, Congress amended the Indian Health Care Improvement Act of 1976[1] by passing the Indian Health Amendments of 1992,2 and authorizing the Indian Health Service (IHS) to provide, for the first time, up to 80 percent of the O&M funding needed by economically deprived Native communities. Villages with fewer than 1,000 residents, which in-

[1] 25 U.S.C. 1601 et seq.

[2] P.L. 102-573; 106 STAT. 4526-4592.

elude all villages operating honey buckets, could obtain additional funding. To date, IHS has not requested any funding for this purpose. IHS officials have found it dificult to clarify the congressional intent as to how to implement the law, particularly the language of the Act indicating that ". . . the non-Federal portion of the costs of operating, managing, and maintaining such facilities may be provided, in part, through cash donations or in kind property, fairly evaluated."[3] Therefore, Native communities have yet to receive this much-needed help. Under one scenario, it was estimated that if funds are authorized, about $15.1 million would be required to implement the 1992 law throughout rural Alaska (122,204,206).

The need to protect public health often forces local officials to implement programs and activities through which revenues can be obtained to pay for the O&M costs of sanitation facilities. Unfortunately, success has been achieved only in those few communities with the best economies and most effective local leadership. To obtain needed O&M funds, the leaders in these communities have: 1) adopted user fee ordinances and disconnection policies; 2) hooked up and charged industrial-type users such as schools, stores, apartment houses, and businesses; and 3) adopted sales taxes (e.g., 1 percent). Once collected, these funds are used to setup reserve accounts to pay for operational costs and defray residential user charges (104).

Unfortunately, most villages in rural Alaska with fewer than 1,000 residents have almost no basic economy (limited fishing, very limited mining, some tourism), their cash flow is extremely low, and their potential for economic improvement in the future is restricted. All Native villages operating honey buckets as their only means of waste sanitation exhibit these characteristics. The absence of trained managers is also evident among many villages. As a consequence, the difficulty in obtaining funds for O&M activities is expected to increase further in the future.

CONCLUSION

The prevalence of certain diseases in Native Alaskan villages is in large part a direct result of a limited potable water supply and the use of inadequate waste disposal technologies such as honey buckets. Federal and State agencies have provided some villages with more adequate technologies such as gravity, pressure, or vacuum piped systems. These are now installed in more than half of the 191 Native villages identified by the Indian Health Service. However, the continuing inadequate sanitary conditions still found among the remaining communities show that much remains to be done to solve this problem.

Unfortunately, delivering piped sanitation systems takes time and, more important, substantial funds that most Native communities now operating honey buckets lack. In addition, the maintenance and operation of sanitation projects in remote villages—generally considered the province of local governments-are typically unfunded and inadequate. In fact, the virtual absence of a viable economic base among these communities creates considerable management difficulties for local governments in addressing sanitation as well as other important community needs, including electricity, education, and transportation. The almost complete reliance on transfer payments and subsidies forces many experts to conclude that without continued Federal and State subsidies, most Native village communities throughout rural Alaska are unlikely to be able to provide minimally safe and effective sanitation for their people.

[3] 106 STAT. 4561.

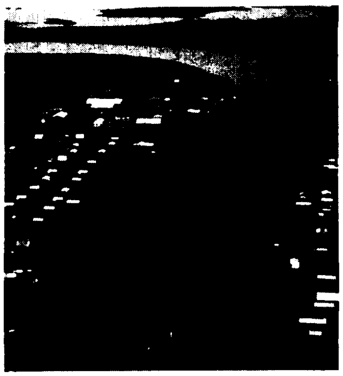
Roles and Responsibilities of Federal and State Agencies 4

INTRODUCTION

With the passage by Congress of the Indian Sanitation Facilities Construction Act in 1959,[1] the Indian Health Service (IHS) became the primary Federal agency directly responsible for planning, designing, and constructing water and sewer projects in Native communities. More than $350 million of the $1.3 billion already spent on sanitation projects in rural Alaska has been provided through IHS to accomplish these objectives. About an equal amount comes from the Village Safe Water (VSW) program within the Alaska Department of Environmental Conservation (IHS'S State counterpart). Coordination of efforts between these agencies often results in successful cooperative ventures for delivering water and sanitation services to Alaska Natives.

The major phases or steps associated with delivering water and waste sanitation are project planning, design, and construction. All of these steps, however, rely on the capital funding provided by Federal and State agencies. Other areas in which participation by these agencies is essential are the training and certification of facility operators, and the provision of technical and financial assistance.

The planning, designing, and construction of sanitation facilities in rural Alaska often face barriers not commonly found in other areas of the United States. Such barriers include, among other factors, limited drainage, ice-rich soils, water scarcity, high fuel



[1]P.L. 86-121.

and shipping prices, limited or inadequate roads, and short construction seasons. Early community involvement is also considered essential to ensuring project success. Many past failures have lacked this involvement.

Considerable political pressure has been placed on IHS and VSW to deliver adequate sanitation services to Native communities in rural Alaska. As a result of efforts to meet this challenge, these agencies have built many piped sanitation systems but with the considerably higher degree of complexity necessary to meet the harsh climatic conditions typical of the region. All of these factors have made sanitation projects among the most demanding and costly capital ventures found throughout rural Native communities of Alaska.

Despite considerable progress, more than half of the 191 rural Native villages identified by IHS still lack adequate or safe water and waste sanitation service. By themselves, these communities lack the resources to build large-scale piped sanitation projects. Moreover, many communities already served with piped sanitation lack the resources to operate them properly. In the future, expected declines in State revenues threaten to affect capital funding availability for new projects and reduce revenue for other municipal assistance, including technical training, to support existing sanitation systems. Many existing systems lack operation and maintenance (O&M). According to IHS, nearly 90 percent of the villages with piped sanitation services were out of compliance with relevant Federal and State regulations.

Although there is a continuing need to build new sanitation projects in Alaskan villages, they must have adequate operation and maintenance support as well. The poor economic conditions in most rural Native communities make system maintenance difficult. Agencies have to avoid installing complex technologies in communities with 1ittle economic and technical resources to operate them. IHS and VSW personnel have recently begun to work with Native communities in the identification and testing of simpler and more cost-effective systems.

INSTITUTIONAL AND REGULATORY FRAMEWORK RELEVANT TO ALASKAN VILLAGE SANITATION

The U.S. Environmental Protection Agency (EPA) and the Alaska Department of Environmental Conservation are the two agencies with major regulatory oversight of sanitation projects and programs in rural Alaska. Permitting decisions by the U.S. Army Corps of Engineers are also relevant to the process in which village sanitation projects are proposed, built, and operated.

Since 1970, the U.S. Environmental Protection Agency has been the principal Federal agency responsible for the promulgation and enforcement of regulations designed to protect the environment and decrease pollution throughout the United States. EPA also coordinates and supports research and antipollution activities carried out by other Federal and State agencies.[2]

The primary focus of the Alaska Department of Environmental Conservation (ADEC) is on the conservation, improvement, and protection of Alaska's natural resources and environment. ADEC is particularly concerned with air, land, and water pollution. Agency responsibility extends to matters affecting the health, safety, economy, and social well-being of people throughout the State. It does so through enforcement of environmental laws, regulations, and quality standards developed in some cases by EPA. One particular function relevant to village sanitation, that of project construction and improvement, is carried out by the Village Safe Water program within ADEC. Less than 3 percent of the more than 450 ADEC employees make up the VSW staff, who until recently were delivering sanitation projects to nearly 60 rural Alaskan Native villages. (The Indian Health Service, discussed throughout this report, is VSW'S Federal counterpart.)

2 40 C.F.R. 1 "Statement of organization and General Information."

The Army Corps of Engineers is the Federal agency responsible under Section 404 of the Clean Water Act[3] for reviewing, approving, or denying permit applications to discharge dredge or fill materials into U.S. waters. All sanitation projects proposed for construction in rural Alaska by IHS and VSW require Corps of Engineers' approval because many of the areas in which such projects are to be built have been designated wetlands. A large portion of the western Alaska region-where many Native communities have experienced disease epidemics from inadequate sanitary conditions-is located on wetlands.

The Corps is also responsible for carrying out projects relating to the development and management of water resources; and for the design, engineering, and O&M of flood control, navigation, and energy-related projects. No economic assistance for waste sanitation projects in rural Alaska is specifically listed in the Corps for fiscal year (FY) 1994 budget.[4]

Until very recently, the level of institutional interaction and coordination among EPA, ADEC, and the Corps of Engineers, or between these agencies and Native village governments, was limited. Some experts at the Office of Technology Assessment (OTA) Workshop on Alaska Village Sanitation held in Anchorage in August 1993 (246), voiced their concern about the lack of flexibility in regulatory programs to recognize the harsh environmental and socioeconomic conditions that prevail in rural Alaska. This concern continues to be evident today.

Native communities are often not in compliance with environmental regulations. In 1991, only 60 of 164 Native villages surveyed were identified as having some variation of a piped system capable of meeting established regulatory requirements. IHS has more recently reported that about 90 percent of the villages it serves operate a water or waste sanitation system that is not in compliance with some aspects of Federal or State regulations. IHS data also show that the large majority of Native residents of rural Alaska do not have any other recourse but to haul water to, and human waste from, their homes (59,61).

The recent promulgation by enforcement agencies of additional regulations for drinking water and waste disposal practices is expected to adversely impact most Native villages with limited economies, particularly because substantial facility upgrades would have to be made to demonstrate compliance. Large expenditures are anticipated by many local Native governments in their efforts to comply with the new surface water treatment, lead, and copper rules (67,246). Providing Native villages with an opportunist y to use less expensive alternative approaches could minimize compliance costs while ensuring relatively similar levels of health and environmental protection.

The regulatory framework applicable to Native villages also affects IHS plans to deliver sanitation projects within a reasonable time frame. According to IHS officials, about 20 percent of the time taken by agency engineers to carry out construction projects is devoted to developing the paperwork required by existing regulations. In some cases, IHS has needed as much as 39 months to prepare all the documentation required to obtain a construction permit from the U.S. Army Corps of Engineers alone. The extremely long time occasionally taken between submission of permit application and permit approval is viewed by many as highly incongruous with current poor sanitation and economic conditions of rural Alaska, as well as unnecessarily costly to Federal, State, and Native governments alike. Examples of some of the Federal and State permits that IHS must have approved are listed in table 4-1.

Several encouraging efforts by Federal and State agencies to identify better methods of more

[3] 33 U.S.C. 1344. See also 33 C.F.R. 323 "Permits for Discharges of Dredged or Fill Materials Into Waters of the United States."

[4] As part of the $3.5 billion budget request for FY 1994, the Corps of Engineers plans to invest $13 million in 21 navigation and flood control projects in Alaska, funding requests for sanitation-related projects are not included (247).

TABLE 4-1: Selected Permit Types To Construct or Upgrade Rural Waste Sanitation Facilities

Permit Grantor	Permit Type
Alaska Department of Environmental Conservation (ADEC)	▪ *Plan Review for Sewerage or Water and Wastewater Works* requires submittal of project design drawings. On approval of the drawings, a Certificate to Construct is issued. ▪ *Wastewater Disposal Permit* is required if construction plans call for discharge of wastewater into State waters, State lands, or a publicly operated sewerage system. ▪ *Plan Review of Public Facilities* refers to the review of plans for public access buildings to ensure adequate ventilation, lighting, etc. ▪ *Certificate to Operate*—within 90 days of completion or sewer system construction, as-built drawings are submitted to ADEC and a Certificate to Operate is granted. Sewer system approval is granted by letter. ▪ *Community Sewer Main Minimum Size Waiver* is required in small communities where it is beneficial to reduce minimum main line diameter sizes from 8 to 6 inches.
Alaska Department of Fish and Game	▪ *Title 16 Permit*—depending on the quality of treated discharge water, a title 16 permit may be required for the discharge of water to certain (e.g., anadromous) fish streams.
Alaska Department of Natural Resources	▪ *Water Rights Permit* documents and reserves water source use by a community.
Alaska Department of Public Safety	▪ *Life and Fire Safety Plan Check for the Construction and Occupancy of Buildings*—fire marshal construction plan review is required for all publicly owned buildings.
Alaska Department of Transportation and Public Facilities	▪ *Notice of Proposed Construction or Alteration*—this form must be completed if construction is to take place within easements established for the community's airport. It applies primarily to height restrictions.
U.S. Department of Defense, Army Corps of Engineers	▪ *Section 404 Permit for the Discharge of Dredged or Fill Material into Water of the United States*--required to build in areas designated as wetlands. Compliance with Section 401 (water quality certification) is required.
U.S. Department of Health and Human Services, Indian Health Service	▪ *Environmental Assessment and Finding of No Significant Impact* is reviewed and signed by the project construction engineer.
U.S. Department of the Interior, Bureau of Indian Affairs (BIA)	▪ *Section 106 Determination, National Historic Preservation Act*—Archaeological survey are to be conducted by archaeologists from the Bureau of Indian Affairs. ▪ *Archaeological Clearance* is coordinated with the State Historic Preservation Officer. ▪ *Lend Lease Authorization (Indian Land)* and *Rights-of-Way (Indian Land)* must be granted by BIA or the association acting on behalf of BIA.
U.S. Environmental Protection Agency	▪ Permit to Discharge into Water (National Pollutant Discharge Elimination System) ▪ *Primary Discharge Waiver*
Notification of the Relevant Regional Corporation	▪ Regional corporations need to be notified of proposed improvements on their lands. In most cases, formal procedures have not been established.
Office of the Governor, Office of Management and Budget, Office of Governmental Coordination	▪ *Coastal Project Questionnaire and Certification Statement* is used for determination of consistency with the Coastal Management Plan of the particular regional corporation.

SOURCE: Arctic Slope Consulting Group, Inc., Water and Sewer Utilities Master Plan Report for Selawik, Alaska, prepared for City of Selawik, Alaska, January 1992.

effectively addressing regulatory enforcement and technology implementation in rural Alaskan Native villages are now under way. Of great relevance is the decision by the Corps of Engineers in 1994 to adopt policies for expediting the review of permit applications proposing the construction of sanitation projects in Native villages. Also significant is the work of the Federal Field-Alaska Rural Sanitation Work Group convened by EPA to identify and coordinate sanitation policy and programs among Federal and State agencies. Some of the agencies participating in this effort are the Bureau of Indian Affairs, Department of Transportation, Department of Education, Farmers Home Administration, Department of Energy, Department of Labor, Department of Housing and Urban Development (HUD), Alaska Department of Environmental Conservation, and Alaska Federation of Natives.

Other examples include EPA's funding of programs designed to provide technical training assistance to Natives (e.g., the Rural Utility Business Advisor (RUBA) and Volunteers In Service To America (VISTA) programs)[5] and the effort led by Bureau of Indian Affairs and other Federal agencies (including IHS, EPA, and HUD) to coordinate future construction and improvement efforts in Native villages and to share costs. In this way, community needs such as housing, roads, and sanitation will be addressed simultaneously.

Despite these efforts, the approach taken is still largely piecemeal, rather than the result of a coherent plan developed by all relevant Federal agencies to ensure adequate sanitation in all Alaskan Native communities. In other words, although individual agency missions are pursued with vigor and dedication by generally well-qualified and motivated staff, overall policy guidance and unity of focus at the highest levels appear to be lacking. Several examples of State and Federal agencies with programs relevant to Native villages are given in box 4-1.

CAPITAL CONSTRUCTION FUNDING

1 Role of Federal Government in Capital Construction

The concern of the U.S. Congress about sanitation issues in rural Alaska spans more than three decades. In recognizing the need to develop formal solutions to this problem, Congress passed the Indian Sanitation Facilities Construction Act in 1959[6], giving the Indian Health Service the authority to plan, design, and construct water and sewer projects in Native communities. Since passage of the Act, IHS has contributed more than $350 million to sanitation projects in rural Alaska.

Setting priorities within the IHS process takes into consideration, among other factors, the overall health of the population; the deficiencies in sanitation systems found in the community in question; and the community's perception of the project (priority, nonpriority). Of great importance to IHS officials is identifying with some certainty the capability of Native villages to finance the operation and maintenance of sanitation projects under consideration for construction (123).

Funds for construction of sewer systems in Native village communities of rural Alaska are provided under the Indian Sanitation Facilities Construction Act and distributed through the Alaska Area Native Health Service. Provision of Federal funds for capital construction, however, requires certain commitments from the receiving communities. For example, IHS will not provide the City of Selawik with capital funds to construct or improve sewer systems unless it is assured of the community's commitment to: 1) pay for operation and maintenance costs; 2) manage it via a

[5] The RUBA program will provide additional capability for improving government, financial, and managerial activities of Native communities. EPA will also contribute about $100,000 to have five VISTA volunteers, already trained by IHS, provide technical planning assistance to Native communities. About 25 VISTA volunteers already operate in Alaska (163).

[6] P.L. 86-121,

BOX 4-1: Additional State and Federal Agencies With Programs Relevant to Alaska's Native Villages

The following are examples of State and Federal agencies with programs that might also be considered relevant for improving overall conditions in rural Alaska Native villages:

- Department of Housing and Urban Development (HUD)—Although the major focus of this Federal agency is to help Native communities meet their housing needs, the agency can also provide funds for improving existing community water and sewer projects that serve HUD-financed homes. Funds provided to local housing authorities for improvements originate from HUD's Comprehensive Improvement Assistance Program and from the Comprehensive Grant Program.
- Farmers Home Administration—The Farmers Home Administration (FmHA) is another Federal agency with the authority to actually fund water and waste sanitation projects in rural areas. Provided in the form of loans or grants, agency funds can be applied to the construction, repair, upgrade, or expansion of sanitation systems in communities with fewer than 1,000 residents. FmHA's financing of sanitation projects has been done primarily in conjunction with Indian Health Service (IHS) since it does not have engineering or construction personnel.
- Bureau of Indian Affairs—The major responsibility of the Bureau of Indian Affairs (BIA) in rural Alaska is to strengthen the development of tribal government infrastructures, as well as coordinate with all Native village governments (State municipal governments, housing authorities, rural electrification authorities, etc.). The involvement of this Federal agency in sanitation projects is relegated to funding the installation of plumbing fixtures inside village homes or connecting homes to the community piped collection system, as part of its housing or road improvement programs. Funding improvements related to sanitation is coordinated with IHS.
- Department of Commerce and Economic Development (DCED)—This State agency serves the dual role of public protection and economic development. As public protector, the Department exercises regulatory authority over financial institutions, securities activities, land development, and the insurance industry in the State. It also supports a number of professional and trade regulatory boards and, through several commissions, monitors activities and ensures compliance in regulated areas such as gas and oil conservation, public utilities, and transportation. To stimulate economic growth, the Department encourages development of the tourist industry, provides loans for purposes generally not fundable by traditional financial institutions, and encourages the development of broad-based economies. These functions can allow DCED to play a pivotal role in identifying and developing local economic potential of the Native villages.
- Department of Community and Regional Affairs (DCRA)—Traditionally a State community development agency, DCRA has recently become one of the key State agencies responsible for working with village governments in finding a solution to their waste sanitation problem. This department is responsible for providing financial, advisory, and management assistance to local governments at both the community and the regional levels. It offers a broad range of planning services, technical training, and financial aid to the State's municipalities, regional planning organizations, and unincorporated communities. This agency has the expertise needed in an overall strategy to assist rural Alaskan Native communities.
- Department of Transportation and Public Facilities—The State's largest department has responsibility for administering State programs for the planning, design, construction, maintenance, and operation of all State-owned buildings and other facilities. It also has specific responsibility for maintaining the Alaska Marine Highway System.

(continued)

- Department of Fish and Game (DF&G)—This State agency is charged with the responsibility for maintenance, development, and enhancement of Alaska's fish and wildlife resources and providing for their sustained optimum use consistent with the social, aesthetic, environmental, and economic needs of the State. Participation of this agency in an overall coordinating strategy is essential because of the significant economic and cultural role that DF&G's decisions play in the quality of life of Native villages.
- Department of Health and Social Services—This State agency administers a broad range of programs to ensure the optimum mental and physical health and well-being of the Alaskan people. It includes family services, public assistance, public health and health care programs, mental health and developmental disability, and alcohol and drug abuse services.
- Alaska Department of Natural Resources (DNR)—DNR manages all the natural resources of the State including, land, water, forests, grass and wetlands, oil, gas, energy, hard rock minerals, parks, historical sites, agriculture, and all related resource development activities. The Department surveys land, surface, and subsurface resources, and offers land for disposal including remote parcels for agriculture and subdivision settlement. It selects land entitled to the State by the Statehood Act, leases oil and gas areas such as Prudhoe Bay, and develops new agricultural resources.
- Department of Transportation and Public Facilities—The State's largest department has responsibility for administering State programs for the planning, design, construction, maintenance, and operation of all State-owned buildings and other facilities. It also has specific responsibility for maintaining the Alaska Marine Highway System.

SOURCES: Arctic Slope Consulting Group, Inc. (ASCG), *Water and Sewer Utilities Master Plan Report for Selawik, Alaska*, prepared for City of Selawik, Alaska, January 1992; John A. Olofsson and H. P. Schroeder, University of Alaska Anchorage, *Sanitation Alternatives For Rural Alaska,* report prepared for the Congressional Office of Technology Assessment, Washington, D. C., August 15, 1993; Michael L. Black, Special Projects Supervisor, Alaska Department of Community and Regional Affairs, Municipal and Regional Assistance Division, information provided at the Office of Technology Assessment workshop on "Waste Sanitation Problems of Rural Alaska," Anchorage, Alaska, Aug. 4, 1993; and Office of Technogy Assessment.

local government structure and provide the expertise required to operate the system; and 3) provide equipment and materials required for successful operation of the system (78). As part of their efforts to meet these requirements, local governments in turn may delegate many of these responsibilities to a Utility Board, a Public Works Manager, or a City Administrator (78). Local government leaders of the City of Selawik in the Nana Regional Corp., for example, have appointed a utility board as a means to assure IHS of their commitment to properly operate the $2.3 million water and waste sanitation project currently planned for construction,

Several approaches are used by IHS to determine overall project funding. They range from performing an engineering analysis, to defining the steps that must be taken to develop a particular level of service, to preparing a feasibility y study or master plan. The high costs of producing a master plan ($1 50,000 in Selawik's case) limit the widespread use of this option. Many of these approaches can: 1) involve coordinating activities and identifying available funding from other agencies (e.g., Housing and Urban Development, Village Safe Water, Farmer's Home Administration); 2) recommend, as for Selawik, that improvements to the "basic utility infrastructure" (e.g., water treatment and sewage disposal) be completed prior to construction of the recommended piped distribution and collection systems (78); or 3) provide IHS and receiving Native villages with the estimated capital and operational funding needed for the project, along with a phased construction schedule.

Feasibility studies and master plans are used by IHS primarily as a means to support decisions and to coordinate and work with community leaders and residents. Through these documents, the IHS discusses how to achieve the following goals:

1) to provide the safe water and sewage disposal needed for improved health; 2) to develop projects that are '*within the economic abilities of the communities;" 3) to improve sanitation service delivery to all village residents; 4) to reduce operation and maintenance costs as a means of ensuring continued support for the project; and 5) to utilize facilities already built in the community to the maximum extent possible (78,1 23).

IHS may also arrange the construction projects contained in feasibility studies, master plans, or other planning documents, into packages. Each package tends to be a stand-alone project that can be built and put in service when demand warrants and funds are available. The master plan for the City of Selawik, for example, consists of several interrelated, intermediate steps planned for the next two decades, culminating with the construction, operation, and maintenance of a piped vacuum sewage collection system. A phased schedule is considered essential by IHS for providing the community with a strategy that is realistic enough to allow it to successfully improve water and sewer service (78,123,127).

1 Role of the State in Capital Construction

The Village Safe Water (VSW) program within the Department of Environmental Conservation is Alaska's main agency responsible for improving water and sewer systems in Native communities of the 49th State. As of July 1993, VSW was carrying out projects in nearly 60 different Native villages throughout rural Alaska.

State funds for construction of sewer systems in Native communities are provided under the Village Safe Water Act. Once funds have been appropriated and an engineering feasibility study is completed, engineers work with communities to select the firm responsible for developing the project design. Potential candidates are invited to visit the community and interview with State and Native village representatives. Once a particular firm is selected, work on investigating geotechnical characteristics and possible technologies begins (104).

To identify the waste sanitation needs of Native communities and secure funds to address them, Village Safe Water ofiicials distribute a questionnaire to each community annually. Returned questionnaires are scored and prioritized according to a capital project ranking methodology that considers factors such as health needs, contamination, local priorities, Federal assistance, and project planning status. If the scoring of the returned questionnaire is sufficiently high to consider the requested project a priority, the VSW program then tries to secure State funding for its construction.

The Alaska Area Native Health Service (AANHS) also reviews the ranking methodology and returned questionnaires to ensure data reliability, check coordination, and sometimes secure matching funds (58). If its review also finds the proposed sanitation project a priority, the AANHS Environmental Health and Engineering Branch participates with Village Safe Water in project planning, design, and ultimate construction. One extremely important result of this interaction is that many construction projects have become cooperative ventures between VSW and IHS.

Alaskan officials have noted a recent decline in State revenues. Many believe this might adversely affect the State's support of sanitation projects in the future (43). One effect anticipated by many is a reduction in funds to support capital construction programs. Another significant effect is the reduction in both revenue sharing and municipal assistance programs, two major funding sources on which the operating budgets of many Native communities now depend (43,87).

1 Community Concerns Regarding Capital Construction in Rural Alaska

According to public health officials working in Native communities of Alaska, the installation of wells and water treatment plants during the 1950s and 1960s constituted a "dramatic step forward" because it virtually eliminated one cause of disease and even death, namely, the drinking of water from lakes and rivers. Prior to that, diarrhea was the cause of death of 1 in 10 children in the Yukon-

Kuskokwim Delta region, for example. Since the 1960s, however, Natives in communities with poor economic potential, such as those found in the Yukon- Kuskokwim Delta, have seen "little viable progress" (173).

In recent years, VSW and IHS have experienced substantial political pressure to deliver sanitation services to Native communities in rural Alaska. To meet this challenge, they have built a considerable number of sanitation projects but with more special features and rugged construction than similar systems built in the lower 48 States—primarily to withstand the harsh conditions typical of rural Alaska. Many concerned individuals, however, have voiced the need for developing a process that refrains from foreing VSW and IHS to build complex water and sewer systems in communities that have neither the financial nor the technical resources to maintain and operate them. Even when communities tax themselves and hold fund-raising activities, the constant increase in O&M costs outpaces their financial capability to manage such sanitation projects proper] y. As pressure for building new sanitation projects continues to increase, it must be understood by all relevant Federal, State, and Native entities that, in time, Native communities will be forced to support these sanitation projects financially with even less revenue sharing.

Concerns about the methodologies employed to set priorities for capital construction projects in terms of cost ceilings applicable to all 50 States have also been raised. These relate in particular to claims by Native leaders that financial assistance to Alaskan villages is unfairly curtailed through the application of cost evaluation formulas that may be applicable to the lower 48 States but are irrelevant to rural Alaska. Leaders argue, for example, that when such formulas are used to compare transportation costs, rural Alaskan communities are at a disadvantage because their transportation costs are incrementally higher than those of communities in the lower 48 States, where roads not only exist but are federally subsidized (300). In their view, the high construction costs in extremely cold areas of rural Alaska render the majority of potential IHS projects in the 49th State "infeasible." In addition to the weighting of capital cost ceilings, these critics point to the lack of uniformity in data collection throughout the State as another adverse factor.

Contrary to critics, IHS officials report the use of higher cost factors when considering potential sanitation projects for rural Alaska. But even with the use of higher cost indices, the agency finds that it is difficult to obtain funding approval because its budgetary process does not allow for the difference in required complexity—and therefore cost —between building a sanitation project in Alaska and one in the lower 48 States. Greater attention to this factor might be warranted since the cost of pipe alone, generally $2 per linear foot in the lower 48 States, may be $30 or more in rural Alaska because of the insulation and heating required to keep it functional, as well as transportation costs.

Critics maintain, however, that the level of service, rather than cost, should be the criterion for providing sanitation services to Native communities. Such is the case for IHS, whose funding recommendations are traditional y based on cost considerations rather than level of service. Since protection of human health is the primary goal, critics claim that ". . . the objective should be to provide uniform basic levels of water and sanitation services to all communities" (300).

In light of the limited economic base of many Native communities, careful planning and periodic reevaluation of projected user fees might become necessary to ensure project success. One example is the City of Selawik in western coastal Alaska. In this community, IHS foresees providing local residents with adequate sanitation services in about 12 years, with work that began in 1993. As part of its plan, every household is expected to pay $100 per month at the initiation of the $2.3 million project and up to $203 by the end of the planning process. However, the expected decline in the State economy might reduce Selawik's projected revenue sharing funds even more, rendering the project infeasible unless subsidies are provided to reduce household payment requirements.

Most concerns relating to capital construction logically originate in communities where such projects do not exist or are in the planning phase. With the increasing limitation of available funding, responsible agencies may also find it necessary to work with communities in which sanitation facilities already exist to ensure their proper operation during the remaining design life of the project. Because the design life of certain components of sanitation facilities does not generally exceed 15 years, a large number of them are expected to require replacement of their mechanical equipment in the near future. Finding the funds necessary for this purpose appears increasingly difficult today.

Factors Affecting Capital Construction Funding

Based on IHS projections and current State and Federal funding rates, many researchers suggest that by adopting nonpiped systems, waste sanitation problems in the areas of greatest concern could be solved within two decades for $2.5 billion, or an estimated annual cost of about $125 million. In light of recent appropriations, however, State and Federal agencies appear unable to meet this funding level. For instance, in FY 1993, the IHS appropriated budget was $40 million less than the estimated $125 million needed annually to meet its schedule. Although the remaining gap in capital expenditures is being filled by agencies such as Village Safe Water ($25 million), the Environmental Protection Agency ($6 million), and the Farmers Home Administration (about $6 million), future increases in IHS appropriated budgets, as well as the long-term budgetary commitment by these agencies to capital construction projects, remain largely undetermined.

Provision of seed money to construct sanitation projects in some cases has been neither sufficient nor expeditious. After the Alaska Legislature appropriated $1.8 million in 1983 to the City of Emmonak, for example, additional funding was requested so that the project could be carried to completion by the Village Safe Water program. The time between requesting and obtaining State money, and the actual start of construction of the Emmonak project, was about 8 years (104).

Under current procedures, the IHS has limited time to work adequately with Natives to identify relevant community needs and arrive at well-thought-out solutions prior to the selection of projects. The limited time allowed for obligating funds can leave the impression that decisions by IHS must also be made in haste; however, once the obligation occurs, IHS can hold funds until the project construction phase is completed. One significant adverse consequence created by the accelerated schedules of the Federal appropriation process is that they place an additional burden on already limited ,IHS resources and personnel to carry out project decisions in a timely manner and with ample community involvement. The recently mandated financial participation by the Farmers Home Administration in sanitation programs ($15 million for FY 1994[7]) is considered highly beneficial to improving the sanitation needed in other villages. Some experts, however, are concerned because this decision might only serve to increase the already accelerated pace of the planning process, particularly since the Farmers' Home Administration role is simply to provide construction funds with little or no personnel or guidance to assist IHS and VSW.

Contrary to the Federal budgetary process, State funding of capital construction projects is conducted on a line-item basis. For this reason, agencies such as Village Safe Water sometimes have a greater opportunity to work with Native communities in advance, to identify the types of

[7] Maintaining this level of support in future years will depend on congressional action (148).

sanitation projects that might be most suitable for them.[8] Considerable attention would have to be given, however, to the implementation of the interagency efforts to fund sanitation projects in rural Alaska as a means to avoid accelerating the funding process and increasing the work load of engineering personnel at IHS and VSW.

PROJECT PLANNING, DESIGN, AND CONSTRUCTION

Planning and designing sanitation facilities in rural Alaska often require taking into consideration physical, social, and economic barriers not commonly found in other areas of the United States. Such barriers may vary from limited drainage and poor soil conditions caused by discontinuous permafrost, to seasonal variations in the quantity and quality of water that is available, to the high costs of electricity and fuel. It is not unusual to find that Federal and State agencies responsible for providing sanitation facilities must delay their project schedules to repair the structural damage caused by spring floods or by ice floes that follow extremely cold winters.

In addition to these factors, agencies must also deal with other rather unique challenges during the critical construction phase. For instance, they must order supplies well in advance, such as toilets, plumbing fixtures, and hundreds of other systems and components, including thousands of feet of specially insulated pipe. Shipping equipment from distant locations, such as Seattle, requires that inspectors visit manufacturing sites to ensure good-quality products prior to shipment and, therefore, avoid unnecessary costs and delays associated with having to store inadequate—and perhaps no longer guaranteed or needed—parts. Without proper planning, the relatively short length of the construction season and erratic barge schedules can result in costly construction delays.[9]

The pace of construction can also be delayed by the slowness and uncertainty of the funding process. The untimely availability of State construction funds, for instance, is a factor that must be carefully considered by agencies involved during the design, planning, and construction phases of a sanitation project. This uncertainty results primarily from the appropriations process of the State Legislature, which calls for allocating funds on a yearly basis. As a consequence, funds do not become available until July or August—the middle of the construction season (104). A notorious case of insufficient and inexpeditious funding practices involves the construction of Emmonak's sanitation project, for which, not only initial funding was inadequate, but more importantly, the time taken between requesting and obtaining State funds to actually start project construction was about 8 years. The adverse consequences of funding uncertainties can be easily prevented in most communities by developing projects that are properly scoped and planned. Multiyear sanitation projects, such as those built by IHS, are not affected by funding uncertainties because funds are appropriated in full before construction starts.

The absence of adequate roads to waste disposal areas is another barrier that makes planning, design, and construction of, for example, truck haul sewage collection projects difficult. During a recent visit to western coastal Alaska, primarily villages in the Calista and Nana regional corporations, the Office of Technology Assessment observed many roads and boardwalks lacking the design and maintenance to ensure safe transport of wastes from collection containers to sewage la-

8 Traditionally, the Alaska State government has dealt not with tribal governments but just with cities and, until recently, with for-profit tribal corporations. Recent State Administration efforts to recognize tribal governments have allowed Village Safe Water to expand its community participation work-up to 2 years in some cases—to increase a community's understanding of, and support for, State-funded sanitation projects.

9 A significant increase in the unreliability of barge schedules, for example, was experienced in several Alaskan communities during clean-up operations of the Exxon *Valdez* oil spill.

goons. Although no evaluation was done, one might also predict that the transport of heavier, larger construction equipment and materials would be similarly problematic. According to the draft report prepared by the Governor's Sanitation Task Force, nearly 100 Native villages in rural Alaska, including many in the areas visited by OTA, lack adequate roads today. Remedying this deficiency, the Task Force estimated, would cost at least $100 million (71)

Another important consideration in planning, designing, and constructing sanitation systems is the number of persons residing in each household, as well as the perception they have about particular sanitation technologies. In Calista Regional Corp. villages, for example, the average household consists of about five persons, the highest ratio for the entire State.[10] Some believe that, with the exception of piped systems, this large household size reduces the number of possible sanitation alternatives that can be built readily to meet such demand. Biological or comporting toilets are assumed by some to be limited in capacity and prone to shock loading, whereas septic and holding tank systems are considered unsuitable under low or inadequate drain field conditions. As an effort to evaluate the actual performance of technological alternatives, the University of Alaska Anchorage is conducting a field demonstration study of comporting toilets in the Northwest Arctic with funds from the Alaska Science and Technology Foundation, and in cooperation with the Nana Regional Corp., the Alaska Department of Environmental Conservation, and IHS.

Opportunities for local employment are also relevant to project planning. Communities naturally want the contractor that is building the new water or sewage facility to use local labor to the greatest extent possible. Sometimes this requires additional time and resources to provide the necessary training and to develop mutually acceptable wage scales, working hours, and hiring or firing practices. IHS and VSW are committed to using local workers on almost all projects. This commitment is often met through the use of "force accounts" or labor agreements that ensure employment to local residents.

Communication begun in the planning phase must be maintained constantly and effectively during the construction phase to eliminate tensions and avoid unnecessary or costly delays (104). Early communication with Emmonak leaders, for example, was crucial in obtaining the community's approval and support, which allowed outside contractors to come in and perform highly specialized electrical work for the project.

The perception by many local Natives that Federal and State agencies have failed to involve them early in the planning process sometimes leads to the erroneous conclusion that sanitation projects built in the past were merely "costly waste sanitation problems" rather than "solutions." In the city of Buckland, for example, some believed that the failure of engineers to consult with city residents was the primary reason for construction of the community sewage lagoon at a site where raw sewage was washed out of the lagoon and down the city streets during spring floods. Information provided by IHS shows that, contrary to this belief, the site selected for the lagoon was based on a sound engineering decision. Unfortunately soon after the facility was built, a catastrophic flood occurred that filled the lagoon and washed the contained waste downtown. To prevent this from recurring, IHS built a steel structure around the lagoon at a cost exceeding $300,000. Efforts by IHS and VSW to work more closely with Native leaders and residents in Buckland and other villages continue to be instrumental in improving communication with Natives.

Failure to involve Natives in the planning, design, and construction of sanitation facilities may also result in the community's perception that it has little ownership of the project. This perception is considered a major roadblock in solving the waste sanitation problems of Alaskan villages.

[9] Alaska averages slightly fewer than four persons per household.

Soliciting community participation early in the planning process and actively responding to the community suggestions and concerns are means by which to institute community ownership (70).

To ensure a positive ownership perception, IHS and VSW have, for several years, adopted Native community participation as an integral part of their programs responsible for building piped sanitation facilities in rural Alaska. One of several IHS strategies to improve the community's perception of ownership involves a two-step process. Step one consists essentially of providing a grant to the community for planning purposes. This is followed, about a year later, by a second grant so that the community can review alternative technologies and develop operation and financial management plans well in advance of actual project construction. Through these types of strategies, community leaders and residents are provided with an opportunity to significantly influence project planning and design decisions, as well as identify economically feasible solutions.

The pressure placed on IHS to build sanitation facilities soon after construction funds have been appropriated often limits its time for working with communities. IHS and VSW regularly find themselves making decisions too quickly. One notable exception is in Emmonak, where the time provided for technical design teams to consult with residents (e.g., explaining details, listening to suggestions, and making changes), and allow community members to modify proposed plans and designs, was largely responsible for the successful completion of the project. The Emmonak success story shows that instilling a sense of ownership requires that Federal and State agencies be provided needed construction funds, as well as sufficient flexibility to work with Native communities in identifying and carrying out solutions that are truly suitable for eliminating their waste sanitation problems.

TRAINING AND CERTIFICATION OF SANITATION FACILITY OPERATORS

Traditionally, funds to support training programs for operators of sanitation projects in Native villages of rural Alaska have been provided through Federal and State training programs. IHS involvement in operator training has existed for more than 17 years (123). The Alaska Department of Environmental Conservation (ADEC) is the State organization with primary responsibility for the certification of sanitation project operators, whereas Village Safe Water, also under ADEC jurisdiction, is responsible for their training. VSW efforts to train operators generally begin during the construction phase of the project. Areas covered in the training of operators include water chemistry and treatment, vacuum pumps, controls, safety, and record keeping. As a result of recent changes in State policy, many operators must now pass State certification prior to running a Native community's sanitation facility (104).

Use of off-the-shelf packaged training programs has not always been successful. The programs and materials are often not relevant to the rural community for which they are intended. As a solution, the Governor's Sanitation Task Force suggested that the State develop culturally sensitive and practical training programs whose main focus is to address realistic village situations. According to the Task Force, "[Operator training] Manuals which require extensive reading skills and [contain] outdated 'canned' programs should not be used. Lectures should be kept to a minimum and real 1ife problems emphasized" (70). In addition, some suggest that training be repeated at periodic intervals to limit the adverse consequences associated with the high rate of operator turnover experienced among Native communities.

Like local funding shortages, training is another critical factor that must be supported if proper operation, maintenance, and management of sanitation facilities are to be achieved in rural Alaska. According to the Alaska Native Health Board. the greater emphasis placed on enforcing regulations rather than supporting training programs has been partially responsible for the deterioration and breakdown of sanitation facilities in various Alaskan villages (58). Others experts, however, point to the limited functionality of local governments as a barrier to training programs.

As the State's inability to fund an expanded training program increases, the suggestion has been made that needed revenues be obtained by setting aside a small fraction of the Federal and State capital budgets. Financial assistance for training programs could also be sought from private organizations and foundations. And although improved funding for training programs is crucial to ensure adequate sanitation in rural Alaska, many firmly believe that complete success will not be attained unless such support emphasizes recruitment of local Native workers (58, 223).

The Governor's Sanitation Task Force, perhaps recognizing the need for training programs to include a business management component, recommends in its unpublished report that once relevant training programs have been assembled, an associates program on '"rural government management and administration" be developed at the University of Alaska Anchorage.[10] Because of the limited funding available at the village level, the Task Force suggested that Federal and State agencies provide the financial support (e.g., scholarships) needed by members of Native villages to participate in the program and learn to manage and operate their sanitation systems (70).

TECHNICAL ASSISTANCE

Technical assistance to Native communities in rural Alaska is provided through various independent programs supported by Federal, State, and Native corporation funds. The most relevant programs today include the Remote Maintenance Worker (RMW) Program and the Rural Utility Business Advisor Program. Another program with potential is the Local Utility Matching Program (LUMP) being tested by Village Safe Water. IHS also funds a Utility Maintenance Specialist program whose four staff members provide a service similar to the RMW program but in areas not served by RMWS (83,127,177). Technical and training assistance is also provided by smaller regional groups.[11]

Remote Maintenance Worker Program

Created by Alaska's Legislature in 1981, the Remote Maintenance Worker Program under the Department of Environmental Conservation provides expert assistance to Native communities on how to maintain their water and sewer systems while complying with environmental regulations (105). In the view of a regional health expert, the crucial role of the RMW program is that it allows villages to become self-sufficient (229).

Individuals in the Native community expected to benefit most directly from the creation of the RMW program were initially thought to be the local utility operators. More recently, however, the entire community has been the benefactor because, in addition to routine operation, maintenance, and emergency response, RMW staff help Native communities to minimize the adverse effects of frequent operator turnover. Since inception of the program, RMWS have become "circuit riders," each serving anywhere between 10 and 15 communities. The State currently funds a program composed of nine RMWS serving rural parts of Alaska (219). The Governor's Sanitation Task Force has termed the success of the RMW program "phenomenal" (65).

Continued provision of technical assistance will be extremely difficult in the future without funding increases for the RMW program. According to the Alaska Native Health Board, the number of RMWS is inadequate to assist the increasing number of remote villages that need to be covered by the program. In 1991, for example, only eight RMWS were available to assist Native nonprofit institutions (58), Recent estimates indicate that more than 100 additional Native villages could

10 Because only a few of its recommendations have actually been implemented to date, many concerned experts would like the Governor's Task Force report to be published and disseminated to all relevant agencies.

11 These include groups such as the Manilaq Association and the Yukon-Kuskokwim Health Corp.

use the assistance of skilled RMW staff. In the view of many members of organizations who deal with RMWS in the field, expansion efforts would be highly beneficial, particularly if the staff added include Alaskan Natives (223).

Rural Utility Business Advisor Program

The activities of the Rural Utility Business Advisor Program, though originally financed by Federal government agencies such as IHS, are now funded by the Environmental Protection Agency and Village Safe Water Program, and carried out by the Alaska Department of Community and Regional Affairs. The program's objectives focus primarily on improving government, financial, and managerial activities in Native communities (89). Although variations might exist among communities, carrying out these objectives frequently requires RUBA staff to develop policies and procedures for effective utility management, including record keeping, accounting, and budgeting. Ensuring continuity when staff turnover occurs and serving as a local information source for Federal and State agencies are also important functions.

Program assistance is available to Native villages now served by water and sewer utilities, as well as those that are planning future sanitation projects. By building close working relationships with village leaders and administrators prior to providing management training, RUBA staff have already contributed to strengthening sanitation programs in at least 10 Native villages. Training provided to key village personnel is "one-on-one, over-the-shoulder" (227). Once training is completed, city administrators become equipped in areas essential to managing their piped sanitation facilities. Included among the areas of training are organizational structure, budgeting, billing and collection procedures, contract negotiations, and accounting. Table 4-2 lists some of the major tasks associated with the program.

From the time of its creation, however, funding for the RUBA program has typically been minimal. For instance, in 1990 the future of the program and its expansion to other villages became doubtful when State funding was near] y depleted. Only when EPA assumed responsibility for providing funds was program stability ensured. Many argue that compared to the more than $1 billion invested in the construction of sanitation facilities in rural villages, or the total that would have to be spent for premature facility repairs and equipment replacement, the amount needed to improve utility management through the RUBA program is negligible: $125,000 per year for every 10 to 15 communities. As a probable solution to this funding shortage, the Alaska Native Health Board has suggested that Federal agencies (e.g., EPA, IHS) work with the Alaska Department of Environmental Conservation to ensure adequate funding and needed expansion of the program-from a staff of 8 to 16 (58). Recognizing the importance of the infusion of Federal funding into RUB A, the Governor's Sanitation Task Force concluded in its draft report that "[RUBA] is possibly the most important program the State could institute to ensure the success of rural sanitation systems" (70).

If future funding permits, RUBA officials plan to provide management and training assistance related to water and waste sanitation utilities to at least 16 additional Native communities during FY 1994. These villages are listed in table 4-3. The most active RUBA participation is planned in low-income villages of the Yukon-Kuskokwim Delta and the community of Gambell (Norton Sound) since most chronic O&M problems are found in these areas (89). To help communities more effective y, RUBA activities will be coordinated with those being carried out by other agencies such as the Indian Health Service and the Environmental Protection Agency (89).

TABLE 4-2: Activities Associated with the Rural Utility Advisor Program in Native Communities of Alaska

Need/problem	Objective	Method of accomplishment	Benefits obtained
Villages do not plan for future replacement or major repairs, and rely on outside agencies (Public Health Service (PHS) and VSW) for assistance in O&M of sanitation uyilities facilitles,	• Develop/revise utility ordinances when they do not exist or are outdated. ▪ Develop office policies and procedures for Implementing local ordinance provisions. • Determine proper rate or fee structures and shutoff policies. • Develop better financial record keeping and reporting tools so community can exercise more effective utility management, ▪ Develop more realistic budgets that reflect needed O&M, as well as reserves for future emergency problems. ▪ Increase village awareness of utility maintenance and budgeting Issues.	▪ Hold meetings with staff and council on developed/revised utility ordinance. ▪ Work with staff to develop policies and procedures for implementing utility ordinances; hold regular meetings with village administrators; and issue brief, periodic newsletters on utilty-related issues relevant to the village, ▪ Work with Remote Maintenance Worker Program staff to ensure that operational concerns are reported to the village council and management	▪ More consistent management policies that can be used by Natives. ▪ Better understanding of O&M obligations and responsibilities of council members during the budgeting process. ▪ Advanced Identification of potentially serious fiscal problem areas ▪ Increased awareness of budgeting and O&M needs among administrators
PHS and VSW programs often need reliable onsite Information about Village management capabilities during the planning of projects	▪ Act as a resource to VSW or PHS personnel to provide current local informahon on village successes and potential problem areas, particularly in relation to economy and management,	▪ Maintain village Information files, Focus on management as well as financial and economic indicators	▪ Increased awareness by other agencies of the community's social and economic realities, particularly during the planning phase of future sanitation projects.
Due to lack of training, village staff do not have adequate training on record keeping, billing, and use of computers for data processing. Maintaining qualified personnel is often difficult	▪ Ensure program continuity when staff turnover occurs. ▪ Help villages in proper record keeping activities such as billmg and receivables.	• Help staff develop written policies and procedures for billlng, budgeting, and handling revenues from water and sewer utilities.	▪ More consistent policies that might be Implemented independently of staff or Council composition. ▪ Better recovery of revenues by villages.

NOTE: PHS= Public Health Service, VSW= Village Safe Water

SOURCE W.B. Smith, RUBA Advisor, letter to Mike Black, Department of Community and Regional Affairs, Feb 18, 1993, W B Smith, RUBA Advisor, letter and informational sources sent to German E. Reyes, Office of Technology Assessment, Aug 5, 1993

TABLE 4-3: Native Communities Receiving and Proposed for RUBA Management Assistance and Training in FY 1994

Area	Native villages receiving RUBA assistance	Native communities to benefit from program expansion
Yukon-Kuskokwlm	Emmonak	Alakanuk[a]
	Kotlik	Chefornak[a]
	Marshall	Eek[a]
	Mt. Village	Hooper Bay[a]
	Pilot Station	Kongiganak[a]
	Pitkas Point	Nunapitchuck[a]
	Sheldon Point	Quinhagak[a]
	Russian Mission	Tuluksak[a]
	St. Mary's	Tununak[a]
Interior region		Chalkyitsik
		Birch Creek
		Rampart
Northwest arctic region		Shungnak
Southeast region		Angoon
Kenai Peninsula		Port Graham
Norton Sound region		Gambell

a Village considered a priorty for RUBA assistance

SOURCE Michael L Black Special Projects Supervisor, Alaska Department of Community and Regional Affairs, Municipal and Regional Assistance Division letter to German E Reyes, Off Ice of Technology Assessment, Aug. 9, 1993

| Local Utility Matching Program

The Local Utility Matching Program (LUMP) is a pilot subsidy program established under Village Safe Water of the Alaska Department of Environmental Conservation. Because of its experimental nature, the LUMP program is being implemented only in 11 Native villages of the Northwest Arctic Borough,[13] at an estimated cost of nearly $500,000 (106). Among the main goals of the program are the creation of incentives to improve O&M within local governments and increasing the amount of revenue available to manage the utility. To achieve these objectives, the program requires communities to collect user fees, promote hiring of qualified facility operators, and establish effective preventive maintenance procedures at each receiving village.

To provide technical assistance more effectively, LUMP staff have very specific areas of expertise, including training and certification of facility operators, O&M budgeting, and compliance with drinking water regulations (51 ,106,152). LUMP has already initiated communication with all villages in the Borough; collected partial data relevant to village qualification for the program; and established monthly collection rates and payroll deductions, facilitating the work of many village administrators. The Village of Noorvik has already met the requirements for receiving LUMP assistance (152).

As a way to supplement the program, LUMP officials require Native communities to match program contributions with revenues collected from local user fees. Many experts consider the functions of this program essential to raising community ownership of sanitation projects (106, 153,1 71). Because of current funding shortages, these experts suggest that an infusion of Federal funds, at least at a matching level, would enable the expansion of the program to other Native communities in need of training in utility management.

12 The communities are Ambler, Buckland, Candle, Deering, Kiana, Kivalina, Kobuk, Kotzebue, Noatak, Noorvik, Selawik, and Shungnak. Of these, Buckland, Kotzebue, Noorvik, and Selawik were visited recently by OTA staff.

Coordination Needs Among Training Programs

The bulk of training and technical assistance provided to Native communities of rural Alaska originates at three major agencies: the Indian Health Service, Alaska Department of Environmental Conservation, and Department of Community and Regional Affairs (DCRA). Whereas the major emphasis of IHS and ADEC training programs is to provide operators with the technical skills needed to keep their utilities operational, DCRA focuses on improving government operations and the financial and managerial skills of utility operators in Native communities.

All training and certification programs developed to ensure that Native communities operate and maintain their water and sewer projects properly were created independent of one another. As a consequence, there has been little interaction among them in the past. This has recently been improved by various coordinated efforts and interagency agreements to streamline training. With the increasing need to protect the health of community residents, and the expected decline in Federal and State funding, continued coordination is an absolute necessity

EXTERNAL SUBSIDIES FOR OPERATION AND MAINTENANCE ACTIVITIES

Sanitation facilities are still among the most demanding and costly capital projects found among Native communities in rural Alaska. Their high cost is associated not merely with their construction but also with high expenditures for electric power, fuel, equipment, training, and labor. In most cases, the more remote the community is, the higher are the costs and the greater is the difficulty encountered in operating the system (69). According to government reports, the greatest need for funding sanitation projects in the United States is still found in Alaska. Of the $633 million in Federal assistance funds estimated by IHS in 1990 as required to build sanitation facilities in U.S. Native areas, nearly 74 percent was needed for Alaska's rural areas (254).

The Indian Health Service is the primary Federal agency responsible for funding the planning, design, and construction of sanitation projects in rural Alaskan Native villages. In the past, IHS evaluated the capital investment needed to provide sewage treatment and collection on the basis of the economic and technical feasibility of construction. Because of the high costs of construction, past IHS criteria often excluded recommendations for piped systems. Today, IHS evaluates capital investment needs in terms of the cost of providing piped indoor systems (254).

Construction funds have essentially been utilized by Federal and State agencies to provide sanitation technologies or systems with a significant degree of advanced engineering. During Alaska's "oil boom," millions of doI1ars were spent to build sanitation projects in rural communities. Not all villages benefited during this period, and in those that did, the overwhelming emphasis was on facility construction, not O&M. Many of these communities are now experiencing facility breakdowns and costly repairs or replacements.

Although IHS funding is also essential for repairing existing facilities, one element not traditionally permitted under existing Federal and State systems is the funding of operation and maintenance of sanitation projects in Native villages. Until 1992, only one State agency supported-in a limited and sporadic fashion—O&M in a few Native communities. The virtual absence of any external contribution to enable local Native governments to properly operate and maintain their piped sanitation projects has forced them to use already-limited municipal and State revenue sharing and entitlements, and local revenues from fund-raising activities, to pay for O&M of sanitation projects.

The majority of rural Alaskan Native communities rely almost completely on transfer payments and subsidies from Federal and State agencies to operate all basic village programs. Quantifying the actual level of external subsidies provided today is difficult. Nonetheless, most experts agree that without this assistance, Native communities would most likely be unable to survive for long. In the villages, a lack of O&M

funding, shortage of technical assistance from outside agencies, and inadequate training of facility operators continue to shorten the useful life of existing sanitation projects, lead to their breakdown, and sometimes even result in human casualties.

As operational costs of sanitation projects increase, so does the need to obtain external O&M assistance. These higher costs, combined with a nearly 50-percent decline in State revenue sharing and municipal assistance, are making the O&M problem even more acute. It is not rare to find a multimillion dollar sanitation project in rural Alaska in need of preventive maintenance because of inadequate O&M and limited funding. Added to this concern is the fact that most 'Native villages do not have, as the Governor's Sanitation Task Force noted in its report, an "equipment replacement account" to ensure facility replacement once existing projects reach the end of their design life (69).

Recognizing these deficiencies, Congress amended the Indian Health Care Improvement Act of 1976[14] by enacting the law commonly known as the Indian Health Amendments of 1992.5 In Section 302 of the new law,[16] Congress authorized the Indian Health Service to fund up to 80 percent of the costs incurred by Native villages and Indian Tribes for the operation, maintenance, and management of their water and sewer systems. This is considered by many experts and Native residents essential not only for avoiding the frequent premature weardown of system components, but also for providing an opportunity for villages with honey buckets to obtain more adequate sanitation technology—an expectation often rejected because of their lack of O&M funds. However, appropriation of funds under the Indian Health Amendments of 1992 to assist Native communities has not yet been requested by the Indian Health Service.

CONCLUSION

As a result of Federal and State mandates to deliver adequate sanitation services to Native communities in rural Alaska, IHS and VSW have built large-scale piped sanitation systems in more than half of the 191 Native villages identified by IHS for sanitation purposes. In addition to project construction, IHS and VSW also support training for operators of sanitation projects and provide technical assistance to Native communities through various programs (e.g., RMW, RUBA, IHS operator training, and LUMP). The high degree of complexity inherent in these systems, however, has made sanitation projects some of the most demanding and costly capital ventures in all of rural Alaska.

Even though funds are provided for project construction and technical support and training programs, one element not provided under the present Federal and State system is O&M subsidies for the villages. In the absence of external financial assistance, local Native governments are often forced to use their limited funds—primarily from municipal and State revenue sharing and entitlements, and from fund-raising activities—to pay for O&M of sanitation projects. Continued dependence on this practice can not ensure proper operation and maintenance of sanitation projects, and most likely will continue to shorten the useful life of existing sanitation projects or cause their breakdown. Recognizing these deficiencies, Congress enacted the Indian Health Amendments of 1992 to assist Native communities with Federal O&M funds. Requests for funds to carry out this congressional mandate have not yet been submitted by the Indian Health Service.

IHS and VSW continue to experience growing pressure to provide improved sanitation projects to villages still operating honey buckets. The increasing economic and O&M-related difficulties

[13] 25 U.S.C. et seq.

[14] P.L. 102-573, October 29, 1992; 106 STAT. 4526-4592.

[15] 106 STAT. 4560-61.

faced by those communities in which sanitation projects have already been built, illustrates the need to avoid installing similarly complex technologies in other communities that appear to have few economic or technical resources to operate them, unless outside support for O&M could be guaranteed. IHS and VSW personnel have recently begun to work with Native communities in the identification and testing of other simpler and less costly systems.[17]

Problems surrounding sanitation in rural Alaska are complex and should demand participation by all potentially relevant Federal and State agencies. In addition to IHS and VSW, a considerable number of Federal and State agencies currently exist with programs that directly or indirect] y support sanitation-related functions in Native communities. A strong framework for cooperation between agencies exists at all levels; however, there does not appear to be an overarching rural village policy to guide agency coordination and concrete action in the field. It appears that throughout the organizational structures of existing agencies, government officials interact with counterparts only in accordance with the demands of their individual responsibilities. And although some success has been achieved by this action-oriented process, greater efficiency of service delivery could be realized with more coordinated interagency policies and guidelines.

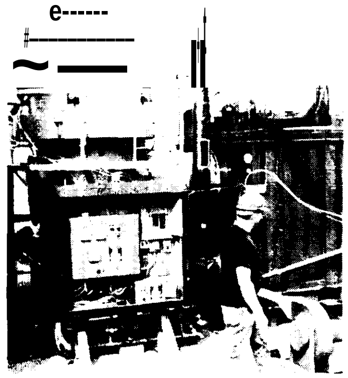
17 Alternative waste sanitation technologies with potential for application in rural Alaska are discussed in ch. 5.

Alternative Sanitation Technologies 5

INTRODUCTION

This chapter discusses a number of new and innovative approaches to providing adequate sanitation systems to Native Alaskan communities. Many approaches have been proposed, but few have been evaluated and tested under realistic conditions. There is, however, a growing need to improve sanitation systems at a realistic cost and with confidence in safe and practical results. For more than three decades, Federal and State efforts to improve waste sanitation among rural Native communities in Alaska have focused on building centralized conventional piped systems. However, these systems have a high initial cost, especially when built in remote regions with harsh cold climates, and because of the environmental extremes, operational maintenance is also difficult and costly. To date, only 72 of the 191 rural Native communities identified by the Indian Health Service have been provided with piped sewerage services. The level of sophistication of waste disposal technologies operating in remote Alaska varies significantly among villages, ranging from complex piped sewerage service with flush toilets to the rudimentary privy and honey bucket systems. Between these two extremes, one finds technologies such as the septic tank and the truck haul approach.

For the most part, the sanitation technologies operating in rural Alaska are merely modifications of approaches designed decades ago for use in more moderate climates. Recently, a modification of the conventional truck haul system tested in the City of Mekuryuk (Nunivak Island, Yukon-Kuskokwim region) is being regarded as a promising alternative to honey buckets. Other systems, such as composting, incinerating, or propane toilets have also been proposed. These alternatives may overcome some of the cold-temperature problems encountered by larger conven-



tional systems and be more effective than honey buckets indisposing of waste and reducing human exposure. The fact that these systems can incorporate low-flush or waterless toilets and eliminate the need for maintaining sewage lagoons is also advantageous. However, because these systems do not require potable water, they defeat, in the view of many, the objective of promoting an ample supply of potable water and thus better sanitation practices in the villages.

Although potentially useful, some of the other innovative technologies discussed in this chapter, such as the National Aeronautic and Space Association (NASA) waste treatment methods, thus far appear either too complex and too expensive for immediate application or are just in their preliminary phase of development. (Current cooperative efforts among Federal and State governments and private organizations to demonstrate NASA's technologies, however, appear to be potentially useful for transferring knowledge and technical experience to remote communities with waste sanitation problems.) Others systems, though already developed, suffer from limited information about their actual full-time performance in treating human waste in areas of harsh climate such as rural Alaska. Finally, an overall mechanism to test and evaluate new systems under actual conditions in these Alaskan villages has yet to be developed. Until this is done, it will be difficult to select a system that is the most cost-effective, safe, and acceptable to the community that must operate it.

FIGURE 5-1: Cowater Sanitation System Showing Water Storage Tank and Toilet Installed Over Indoor Holding Tank

SOURCE Cowater International Inc , Ontario, Canada, Mekoryuk Sewage *Haul System Development Prototype Household Demonstration Final Report,* October 1993

DESCRIPTION OF NEW ADVANCED SYSTEMS CURRENTLY PROPOSED FOR ALASKAN VILLAGES

| Cowater Small-Vehicle Haul System

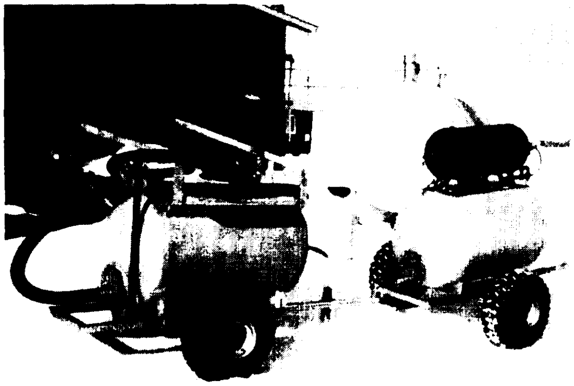
The Cowater small-vehicle haul system, a variation of the larger conventional truck haul system and developed by ***Cowater International*** of Ontario, Canada, is currently being evaluated in the City of Mekuryuk (Nunivak Island, Yukon-Kuskokwim region) as a possible sanitation approach for Alaska (figure 5-1). This technology involves the use of all-terrain vehicles (ATVS; during the summer) and snowmobiles (for winter operations) equipped with a tow trailer and a small vacuum/pressure tank to remove wastewater from house holding tanks (figure 5-2).

Although similar in concept to the truck haul approach, the Cowater system does not require expensive conventional vacuum trucks and is less costly to maintain and operate. In addition, it does not require load-bearing roads and snow removal equipment for its operation. The major elements of this system are: a dual flush toilet, an in-house water storage tank, an outside wastewater holding tank, and a small haul vehicle equipped with a haul tank.

Dual *Flush Toilet*

The dual flush toilet looks like a conventional household toilet, can be connected to a gravity-fed

FIGURE 5–2: Sewage and Water Tanks on Haul Wagons Operated as Part of the Cowater Sanitation System



SOURCE Cowater International Inc Ontario, Canada, *Mekoryuk Sewage Haul System Development Prototype Household Demonstration Flnal Report,* October 1993

water source, and does not require a pressurized water supply. It is designed to control the amount of water consumed, requiring only 1 pint per flush. Sometime in early 1995, one firm expects to begin the large-scale manufacturing of the dual flush toilet (186,1 87,237).

In-House Water Supply System

The in-house system consists of a tank capable of holding up to 150 gallons of potable water. Depending on the desired level of operation, the in-house water supply system can provide water for toilet flushing only; can incorporate a washbasin option in which the water used for hand washing can be recycled as flush water; or can supply water for washing, cooking, and drinking. A small electric pump fitted on the tank provides a constant supply of water whenever needed.

The water stored in the water supply tank is delivered from a small tank mounted on a wagon and drawn by a small haul vehicle. The operator uses the air compressor at the local water treatment plant to draw water from the large storage tanks of the water treatment plant into the haul tank and to fill the small air tank located on the wagon with compressed air. The compressed air is used to force the water from the haul tank into the water supply tank located inside the house.

Wastewater Storage Tanks

Depending on the house's design and the user's needs, the sanitation system may be equipped with either an indoor or an outdoor wastewater holding tank for discharging and storing wastes. Made of a flexible rubber or plastic bladder and aligned by a rigid enclosure, indoor holding tanks can store up to 100 gallons of wastewater. Indoor tanks are evacuated by a blower that pressurizes the tank, pushing the sewage through a pipe into a haul vehicle outside.

Outdoor holding tanks, on the other hand, are heavily insulated and capable of holding larger volumes. These tanks are generally set on skids alongside the house and are connected to the indoor sanitation system by insulated pipes. Outdoor tanks are emptied the same way as indoor tanks. Outdoor holding tanks are preferred to indoor ones because they remove the sewage from the home and eliminate the need to build steps to reach the toilet (120).

Haul Tank and Haul Vehicle

A tank designed for hauling human sewage from the house to the disposal area is made of stainless steel and sized to exceed the capacity of holding tanks.

As shown in figure 5-2, the haul tank can be mounted on a trailer fitted with wheels or skis and hauled by snowmobile, ATV, or a small tractor. With the exception of the pump-evacuated system in which a pump is provided, the system operator is required to use the blower located on the haul vehicle to empty the collected waste into the haul tank. Once the tank is filled, the operator pulls it to the sewage lagoon or disposal area and empties it by gravity. The pump-evacuated system allows the operator to empty the indoor holding tank into the haul vehicle by turning the pump-out switch located on the side of the house.

According to Cowater reports, the field demonstration at Mekuryuk has provided an opportunity for increasing the understanding of the system's engineering and performance, and for successfully working with Native residents in achieving the community's desired level of sanitation and aesthetics (82,1 19,120,1 85).

The "AlasCan" Organic Waste and Wastewater Treatment[1]

The AlasCan is a modular, high-technology, self-contained comporting system designed to handle sanitary and kitchen wastes and greywater(181).[2] The essential components of the AlasCan system are a custom-made comporting tank and a ceramic toilet (consisting of either the fully automatic, computer-operated Nepon Pearl ***foam-flush*** toilet[3] or the pedal-operated ***vacuum*** toilet known as SeaLand VacuFlush). This combination, according to its designers, provides the user the comfort of a flush toilet and the advantage of comporting treatment (97). The AlasCan is also equipped with a kitchen waste disposal system and a greywater treatment tank.[4] To avoid problems experienced with other models in the past (e.g., odor escaping into homes), AlasCan designers built the toilet and compost treatment tank as two separate units (146).

The AlasCan comporting technology has been in use in several facilities in Alaska, Canada, and the lower 48 States. Most of the Alaskan sites, however, are National Guard armories. One particular unit is being used on an oil drilling rig near Prudhoe Bay. Field tests are also being conducted at a few selected locations in the Yukon-Kuskokwim region to evaluate its potential for use in Alaskan Native villages.

Major Components of AlasCan Compost Technology

Comporting Tank

The central component of the AlasCan comporting system is a double-walled "superinsulated" plastic tank containing a fully automated chamber with aerobic bacteria and red worms to decompose sanitary waste or backwater into a safe, fertile humus material similar to garden soil (6,7, 182).5 Wood shavings are added to reduce excess liquid in the tank and to provide the carbon and other minerals needed for effective biodegradation.

The treatment tank is equipped with a series of baffles, air channels, and mixers. A fan is also used to draw warm air into the treatment tank to promote organic decomposition of the waste (figure 5-3). To improve the rate of decomposition, the treatment tank is fitted with two items: automatic churners or agitators capable of mixing the wood shavings, red worms, and waste; and sprinklers, which reincorporate accumulated liquids into the mixture when needed (6,7, 181). The computer-controlled agitators are set to operate for about 20 minutes daily so that recently disposed waste is properly mixed, and the compost pile leveled (6,7). Installation of an auxiliary heating unit may be required in locations where ambient conditions could force the internal temperature of the comporting tank to drop below 60 "F.

The treatment of human waste with the AlasCan comporting technology results in three by-

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[1] This technology is commercially known as the AlasCan Model 10 system.

[2] Greywater is household wastewater without toilet waste. It consists primarily of discharged water from bathtubs, showers, sinks, and appliances such as washing machines and dishwashers.

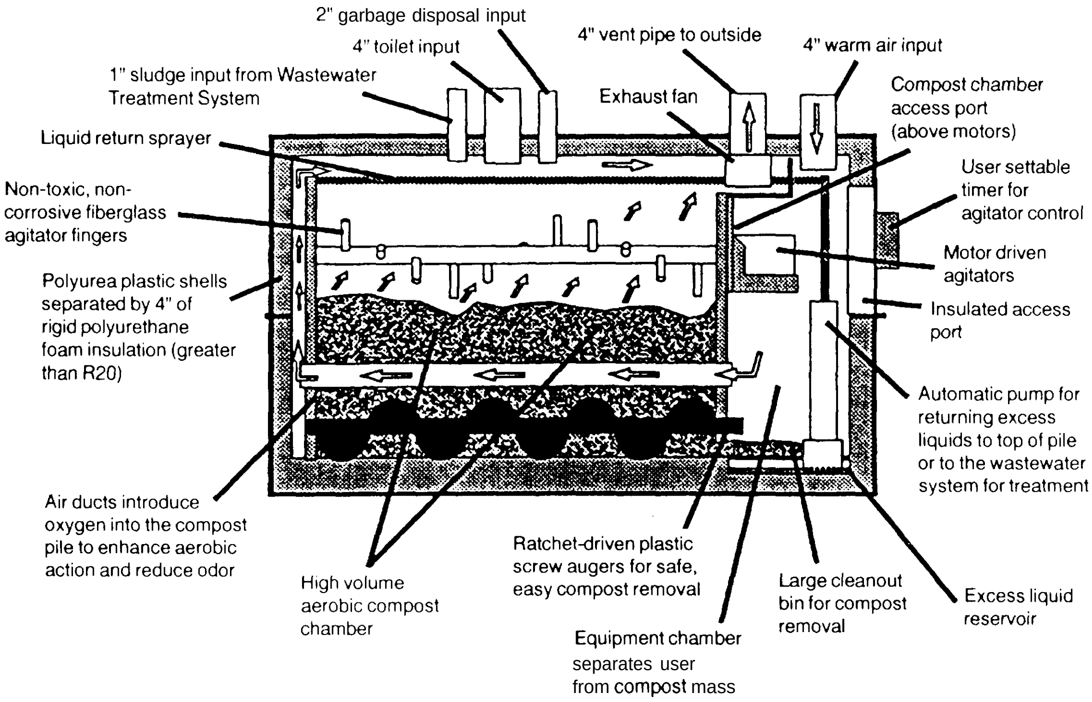
[3] Developed by the Japanese firm Nepon, Inc.

[4] One optional feature offered by the manufacturer of this system is a wall-mounted urinal equipped with the same foam-flush action as the toilet system.

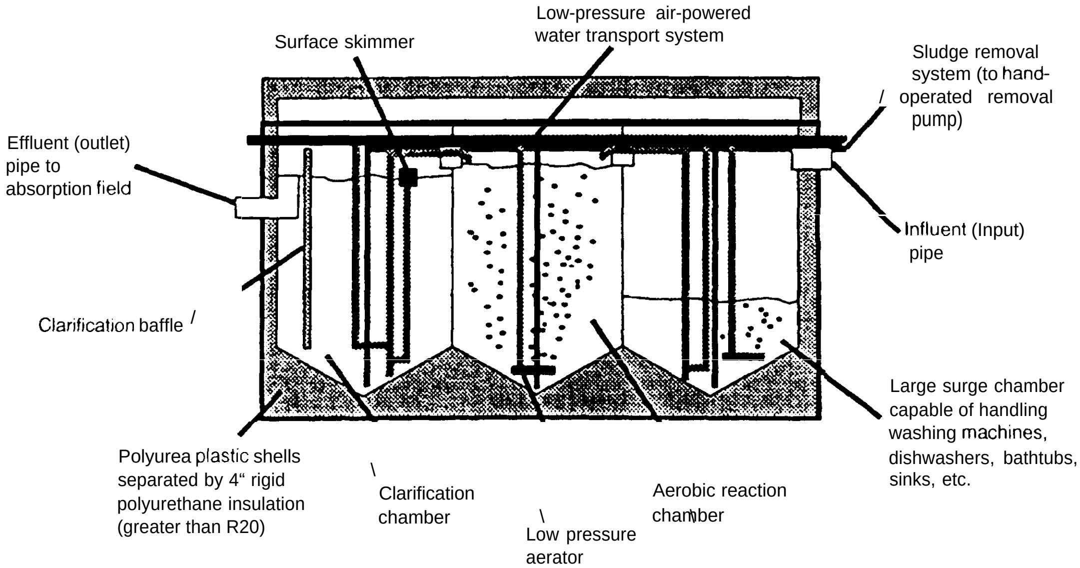
[5] The term backwater refers to the urine, fecal matter, and related debris such as toilet paper deposited in a toilet, as well as the water used to transport these materials

FIGURE 5-3: AlasCan Composting Toilet System

Organic Solid **Waste Treatment System**



Organic Wastewater Treatment System



SOURCE Al Geist, Marketing Director AlasCan Inc Fairbanks Alaska, personal communication, Nov 23, 1993 products: water vapor and carbon dioxide, which are released through an insulated vent installed in the home or building, and humus, which collects in a tray in the lower portion of the tank. The aerobic nature of this technology prevents the generation of malodorous methane gas (181).

Its modular design makes the AlasCan system easy to install and maintain. For homes built on slab floors or with limited crawl space, AlasCan uses a special vacuum flush toilet[6] to lift waste up to the comporting tank. Lifting of greywater into the treatment tank is accomplished by a transfer vacuum pump fitted to a small reservoir (6,7,145). For homes without running water, the bathroom toilet is fitted with a small reservoir or water tank.

Ceramic Toilet

The AlasCan system is an improved design over the internationally known Clivus Multrum comporting toilet.[7] Such improvements include, among others, automation of the comporting process; connection of the comporting tank to a modern foam-flush toilet; and addition of a separate greywater treatment tank unit (181). Toilets may be of a "straight drop" waterless or a foam-flush design. The foam-flush toilet design uses a small air pump, which upon flushing, mixes a soaplike substance stored in the tank with water to produce a soapy foam layer inside the bowl that carries the waste down to the treatment tank with minimal splashing. The use of a biodegradable soap is also advantageous because it minimizes the need for toilet cleaning. When the toilet is flushed, waste is discharged to the insulated treatment tank where it is decomposed by organisms (bacteria and red worms) into organic humus (181).

Kitchen Waste Disposal System

The AlasCan system can also be equipped with a small garbage disposal sink fitted with a sprayer. This device is typically located in the vicinity of the kitchen sink. Garbage, placed in the disposal sink for processing, is subsequently piped to the treatment tank where human waste is also treated (181).

Greywater Treatment Tank

In addition to treating black water, the AlasCan comporting technology can be used to treat greywater (figure 5-3). The treatment of greywater is conducted in a three-chambered tank fitted with a series of baffles and filters. After treatment, the treated water is filtered and released into the ground, while the remaining solids are sent to the comporting tank for further decomposition. According to the manufacturer, treated wastewater can be returned safely to the environment because the AlasCan system removes the majority of pollutants found in it, including nitrites, volatile organic compounds, suspended solids, and organic matter (6,7,170).

Phoenix Comporting Toilet

The Phoenix comporting technology has been designed primarily for indoor installation. Its compact shape results in small tank and maintenance areas. The major components of this technology are a toilet, a kitchen waste inlet (optional), and a comporting tank (figure 5-4). Electricity can be supplied by an independent energy source, such as a photovoltaic system or by the small plug-in alternating current (ac) power plug supplied with the unit.

Use of the Phoenix comporting technology in rural communities of Alaska is limited in comparison to areas in the continental United States and Canada. The School of Environmental Engineering of the University of Alaska Anchorage will soon field-test two Phoenix units as part of an ongoing effort to identify potential alternatives to honey buckets in Native communities (196).

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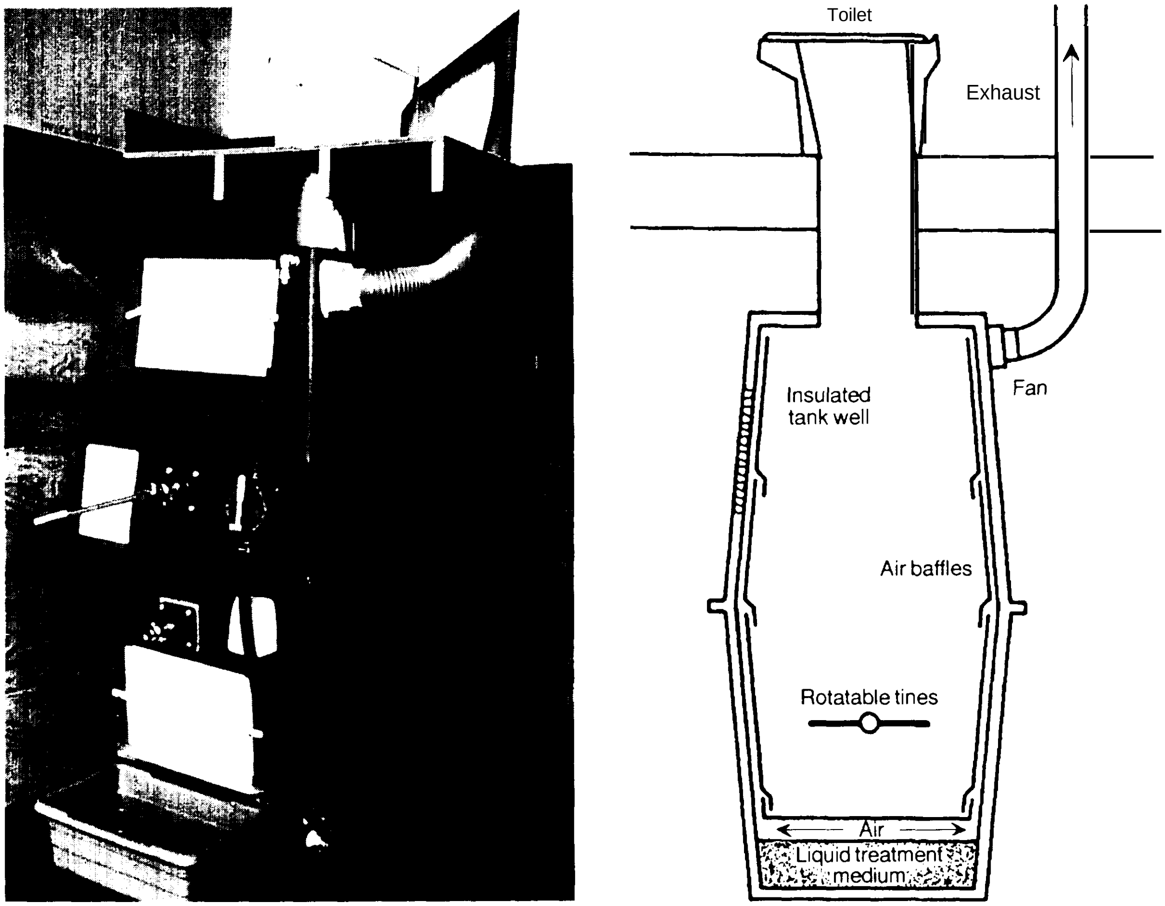
6 Known as the Sealand VacuFlush toilet system

7 The Clivus Multrum system was first developed in Sweden more than 60 years ago with the primary purposes of recycling waste and conserving water and land.

FIGURE 5-4: Phoenix Composting Toilet System



SOURCE Advanced Composting Systems, Whitefish. MT "Testing the Phoenix Composting Toilet," Mar 24, 1991 Advanced Composting Systems, Whitefish MT Evaporation System, " April 1992

Major Components of Phoenix **Toilet** *System*

Toilet System

The toilet provided in the Phoenix comporting system is contemporary in design and made of white plastic. The bowl is attached to the composting tank by a chute and secured with a specially designed connector. According to the manufacturer, certain models allow the connection of up to three toilets (3,197).8

Kitchen Waste Disposal Inlet

Manufacturers of the Phoenix comporting system have built two types of kitchen waste disposal options. One model consists of a stainless steel rim and bowl fitted with a maple chopping block cover for installation in kitchens with counter tops.

[8] If installation of a urinal is desired, the homeowner needs only to mount it on the toilet room wall and connect it to the composting tank with a vinyl hose. Urinals manufactured for the Phoenix system are generally made of steel or porcelain and are trapless in their design (3).

The other is an aluminum access port that can be installed either on countertops or on vertical surfaces (3).

Comporting Tank

The Phoenix operates much like a garden compost pile, requiring adequate food, air, moisture, and temperature to support the breakdown of sanitary and kitchen wastes into a stable humus-like material. Depending on the model, a Phoenix treatment tank is capable of safely comporting the sanitary and kitchen wastes of four full-time users (Model R200) or eight part-time users (R201). Other Phoenix models, such as the R199, have smaller treatment capacity because they are generally intended for cabin use (two people full-time; more if use is intermittent).

The Phoenix comporting system is ventilated by a multiple speed, 12-volt direct current (de), 4-watt fan.[9] The continuous insulation of the walls of the treatment tank seals the ventilation path and allows the air baffles to perform as heat exchangers; this, in turn, promotes heat retention (up to 80 percent) and increased decomposition rates. Aerobic conditions are maintained by air baffles installed on the side walls of the tank to aerate the compost pile and by rotating tines to keep the compost materials from compacting. Use of coarse wood shavings is required as a bulking agent (2,4,5,196,197) .

Transport of composted material through the tank is facilitated, according to the manufacturer, by the vertical and uncomplicated tank design, and by the incorporation of rotating tines. A built-in hand pump allows accumulated liquids to be sprayed back on the compost pile to maintain proper moisture. The sloped design of the internal tank floor helps separate treated liquids from treated solid byproducts. A liquid evaporator equipped with a small storage tank for peak loading is also used to reduce the amount of treated liquid byproduct that must be drained from the Phoenix system to a holding tank or to the outside environment (small leach field, soil bed, etc.) (197). For conditions in which liquid effluents cannot be discharged, the comporting tank is fitted with a highly specialized system (consisting of a 50- to 100-gallon storage tank, an evaporation tower, a pump, a dc fan or ac blower, and controls and sensors) capable of evaporating between 5 and 13 gallons of liquid effluent per day (2,5).

To ensure proper system operation in areas characterized by subfreezing temperatures, however, it is critical that the Phoenix tank be located in a well-heated area and that all vent pipes be insulated to reduce condensation and freezing (1 11,1 12,197).

Maintenance Requirements

The Phoenix treatment tank (approximately 3 feet wide, 5 feet long, and 8 feet high) requires about 5 feet of additional space in front of the tank, and about 1 foot of clearance above the tank, for proper operation and maintenance. The degree of maintenance required by this technology depends hugely on the frequency of use. The manufacturer recommends that bulking agent be added—about 1 gallon for every 100 uses—and thoroughly mixed into the waste pile. A heavily used system requires more frequent attention and care.

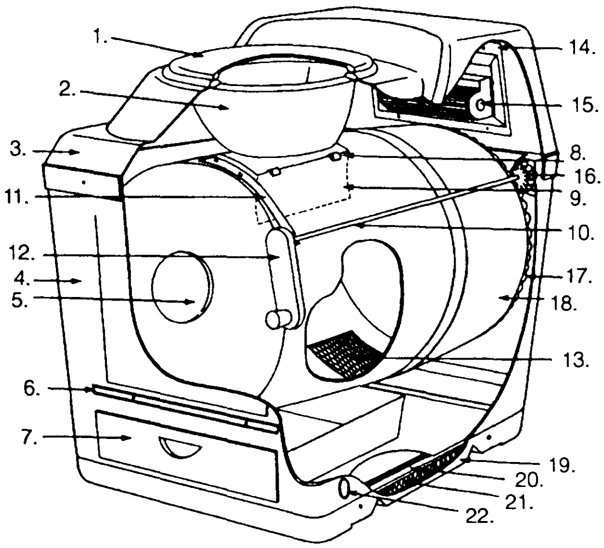
Similarly, the amount and frequency within which by-product materials must be removed depend on the extent of use, the rate of decomposition, and the maintenance of the unit. According to the manufacturer, treated materials should be removed at least once a year, starting after the first year the system has been in operation. It is estimated that about 8 gallons of humus would have to be removed from the tank for every 1,000 uses.

Sun-Mar Comporting Toilets

Sun-Mar Corp. of Ontario, Canada, has developed a series of composting toilets capable of biologically treating human and kitchen wastes, toilet paper, and other organic materials (figure 5-5). Application of the Sun-Mar system in rural

[9] A 24-vtdt dc fan is also available.

FIGURE 5-5: Overview and Schematic Diagram of Sun-Mar Composting Toilet Systems



1. Seat
2. Bowl liner (removable)
3. Toilet top
4. Main shell
5. Drum bearing
6. Step support
7. Compost drawer
8. Drum door hinges
9. Drum door
10. Crank shaft
11. Drum locker
12. Crank handle
13. Drum drain screen
14. Fan mounting plate
15. Fan 30 Watts with speed control
16. Crank sprocket
17. Drum sprocket (moulded into drum)
18. Drum
19. Insulation base
20. Heating element 250 Watts
21. Insulation
22. Vent hole

SOURCE Sun-Mar Corp , Burlington, Canada, "Sun-Mar Cottage Toilets, " undated

communities of Alaska has been limited in the past. The School of Environmental Engineering of the University of Alaska Anchorage plans to conduct a field test of this technology in an effort to evaluate its feasibility as an alternative to honey buckets (197).

System Characteristics

Sun-Mar comporting toilets are available in electric (ac, dc, solar) and nonelectric designs. During operation, waste is transformed into humus by heat from the compost pile or a heating element, oxygen provided by the ventilation system, and organic material (e.g., peat moss) added to the system by the homeowner (236).

The fiberglass and high-grade stainless steel construction, according to the manufacturer, protects Sun-Mar compost toilets from structural damage at freezing temperature. As with most comporting systems, however, temperatures below 60 ‘F will adversely affect the rate at which the Sun-Mar system can degrade waste. For this reason, the manufacturer recommends that the 1 l/2-inch vent pipe provided with the system be insulated adequately.

The use of a 30-watt centrifugal blower fan to provide a negative pressure within the treatment unit prevents back-draft and, with it, the formation and release of offensive odors from the toilet system into the home environment. Rotation of the comporting medium with the mixing system, along with the addition of peat moss, helps achieve rapid, odorless treatment of the waste (77,169,236).

The Sun-Mar models considered most likely to be used in rural Alaska are:

Compact and X-L (EXCEL)

The “Compact” model is a self-contained compost toilet system designed to accommodate low-capacity use (1 to2 people for residential use). The X-L model is recommended for larger demand (2 to 4 people). Both models are available in electric and nonelectric versions.

In addition to the toilet, these units contain three separate chambers for waste comporting, compost finishing, and the evaporation of liquid effluents. Comporting is carried out in a unit or chamber called Bio-Drum in which wastes are tumbled to achieve better mixing, aeration, and higher rate of comporting. Liquids are evaporated by means of a 250-watt electric heating unit with a replaceable thermostat installed at the base, and are drawn out of the system through a vent by a small 30-watt fan. The overall weight of these units is about 45 pounds, and their dimensions are 22 1/2 inches wide; 31 inches high, and 32 inches long (194,236).

Centrex and Water Closet Multrum Models

Sun-Mar Corp. has also developed a comporting toilet system consisting of a specially designed low-flush, ceramic toilet[10] connected by a 3-inch pipe to a comporting unit located some distance underneath the floor on which the toilet has been installed. Weighing nearly 60 pounds, the comporting unit of these models is about 33 inches wide, 25 inches deep, and 26 l/2-inches high. These toilets can accommodate the demand of 3 to 5 full-time users and twice as many under part-time use conditions.

Although the toilet does not have a holding tank, the use of water to flush waste into the comporting unit (less than 1 pint of water per flush) requires that the house be connected to a piped water system. Although a septic field is not required, these comporting systems have been fitted with a drain pipe for situations in which complete evaporation of the liquid cannot be accomplished.

Maintenance Requirements

To maintain the Sun-Mar compost technology in good condition, the homeowner must add one cup of peat moss per person per day plus, if available, organic materials or waste such as vegetable cuttings and greens. Adding warm water is also recommended whenever the compost appears to be too dry. The compost must be mixed and aerated every third day; this is easily done by turning the crank handle on the side of the toilet. Removal of the solid byproduct of comporting (humus) is recommended at least once a year for Sun-Mar systems undergoing residential application; less frequent use requires less maintenance (236).

Incinolet Electric Toilet System

INCINOLET toilets have been designed for a variety of applications, including, homes, cabins, barns, shops, boat docks, houseboats, barges, mobile homes, remote work areas, and laboratories. Most systems are about 15 inches wide, 20 inches high, and 24 inches deep (figure 5-6). Depending on the model, INCINOLET toilets can accommodate up to 10 persons (183,184,199,211).

The INCINOLET toilet is designed to use electric heat to reduce human waste—including urine,

10 Manufactured by SeaLand Technology, Inc., of Big Prairie, Ohio.

FIGURE 5-6: Incinolet Electric Toilet System

SOURCE Research Products/Blankenship Dallas TX, 'Incinolet 'hat Electric Toilet - an installation and maintenance manual 1993

Solids, and toilet paper—-to a small amount of ash, which can then be discarded periodically as trash. Installation of INICINOLET systems involves two steps: installing a pipe through the bathroom wall to vent incineration gases to the outside, and plugging the electric cord supplied with the unit into a nearby outlet (21 1).

Placement of a bowl covering or insert made of polyethylene film prior to each use prevents human waste from contacting the bowl surface and reduces the risks of exposure to users. The purpose of the plastic insert is to capture the incoming waste or urine. Once use is completed, the resident can flush the INCINOLET system by stepping on the toilet's foot pedal, which causes the plastic insert and its contents to drop into the incinerator chamber located at the bottom of the toilet.

Although incineration of waste begins immediately after it enters the chamber, home residents can use the toilet even while the incinerator is running, because combustion heat and vapors are vented to the outside to prevent the surface of the bowl from getting hot. INCINOLET can also allow the accumulation of up to four deposits before flushing (i.e., burning).

CombustiOn of waste at 1,400 °F eliminates bacterial growth, while a platinum-based catalyst, similar to those used in automobile exhaust systems, removes offensive odors from the treated waste or ash.

Because electric toilets are appliances, several features have been incorporated into the INCINOLET system to ensure its safe operation (1 83,2 11). These include an operating timer that limits the heating cycle to 1 hour; a temperature controller to limit heater temperature; and a safety thermostat to prevent overheating of the system m case of blower failure. A second thermostat has also been incorporated into the design to eliminate the extremely high temperatures that may occur following failure of the temperature controller. Even though it appears promising, there are few performance data on the use of INCINOLET in rugged, extremely cold environments such as that of rural Alaska.

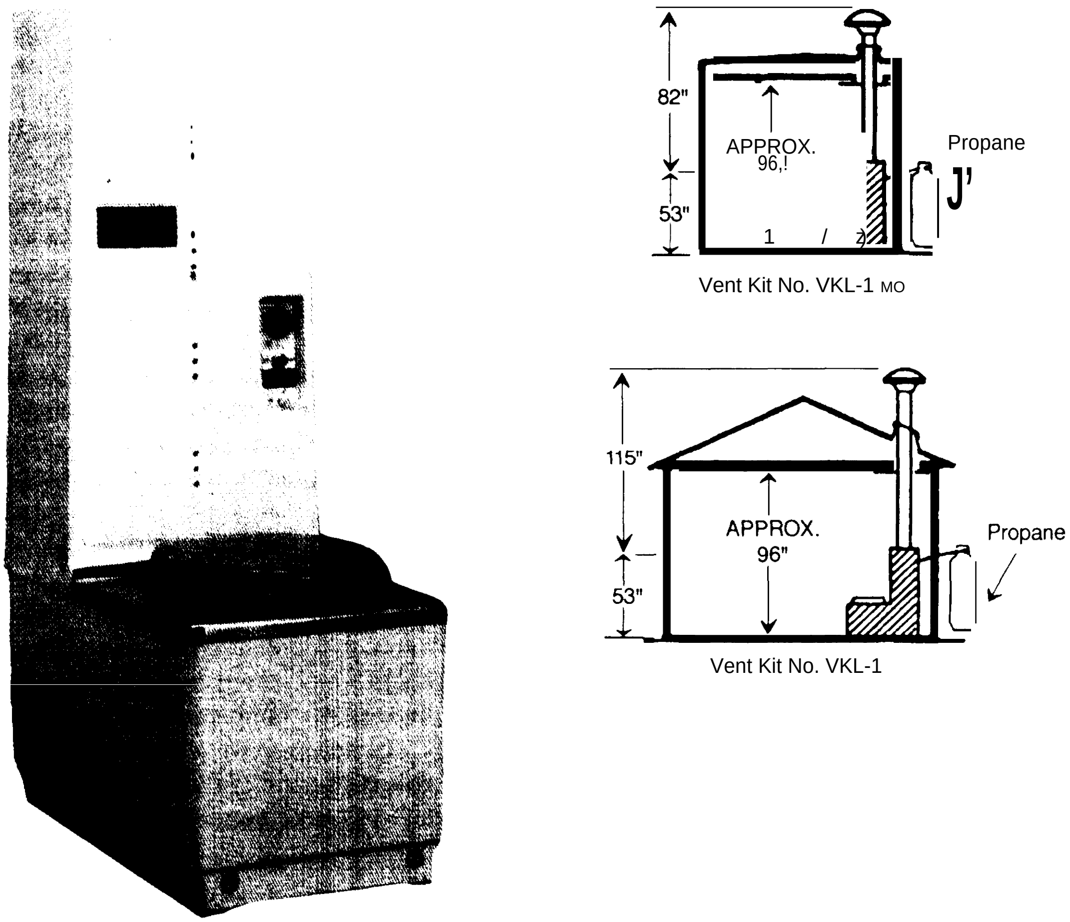
Maintenance Requirements

To ensure proper operation, emptying of the ash is recommended at least twice a week. wiping surfaces with a damp cloth is also suggested for overall cleanliness" The manufacturer advises inspecting the level of the catalyst (white pellets) contained in the incineration chamber every six months (183,21 1).

The Storburn Propane Toilet System

The Storburn technology is a compact, self-contained toilet designed and manufactured by Storbum lntemational, Inc., of Ontario, Canada, to incinerate human waste. Models available can operate with propane or natural gas. Most applications to date are found in cabins, mobile shelter units, and industrial and construction sites. Ac-

FIGURE 5-7: The Self-Contained, Gas-Fired Toilet System Offered by Storburn International



SOURCE Storburn Int , Inc , Ontano, Canada, “Storburn: Pollution-Free Toilet, ” 1993

cording to the manufacturers, about 100 units are already in use in Alaska (144,234).

The Storburn system consists of a toilet made of fiberglass reinforced with plastic material, a stainless steel top deck, and a 3-gallon waste combustion chamber made of cast nickel alloy (figure 5-7). Nearly 4 1/2 feet high and weighing 170 pounds, the entire toilet system covers a floor area of only 18 by 31 inches. A vent and a hookup to a propane or natural gas tank are required for operation.

The Storburn toilet can accommodate between 40 and 60 uses before incineration becomes necessary. Prior to burning of the waste, a chemical powder is added to the toilet system and a special cover is placed on top of the bowl to trip a safety switch, which ignites a pilot light and the burner that heats the combustion chamber. The burner shuts off automatically immediately after all wastes are burned. Depending on the ambient conditions of the area in which it is used, the Storbum toilet system can bum between 10 and 16 maximum-capacity loads (i.e., 600 to 900 uses) with a full 100 pound propane cylinder. The time taken to bum a loaded storage chamber is generally about 4 1/2 hours (234).

According to its manufacturers, the Storburn system is easy to maintain because it has no moving parts and only a few simple electrical controls. The high temperatures reached inside the waste storage chamber sterilize the chamber walls, thus eliminating the generation of foul odors and the need for cleaning the chamber. The only maintenance required is cleaning the burner about once a year (234).

Entech Thermal Oxidation System

Entech, Inc. of Anchorage, Alaska, developed a thermal oxidation process to treat solid waste and sewage from small, remote communities. In addition to incineration treatment of sewage, this technology can be used to treat other wastes and provide some energy as a byproduct.

The Entech thermal treatment system has three basic parts: a primary combustion cell or refractory chamber, where trash and other community wastes are loaded without preprocessing or presorting and are heated—by gas, diesel, or propane torches—to convert them into a combustible gas and other incinerated materials (inert ash, glass, metal, etc.).[11] Removal of treated waste materials from the insulated chamber is required every 6 to 10 cycles.[12] A secondary combustion chamber receives and ignites the gas produced by the primary cell to 2,000 "F to eliminate pollutants and produce a smoke-free, hot air and water vapor emission. According to company literature, "no odor from combustion during the operation of the system is detectable" (134,135,209).

The third major component of this technology is a computerized device called the process logic controller, designed to automatically control the system's operation and reduce the need for hiring highly trained operators. This device monitors the treatment, finishes the cycle, and shuts down the system within a period of 10 to 12 hours after operation was initiated. About 2 or 3 hours after shutdown, the primary cell will be sufficiently cool to allow the next load of waste. Another advantage of the process logic controller is that it permits remote monitoring of performance, and repair diagnosis of the system, by phone from Anchorage to anywhere in the State of Alaska.

Depending on the community's waste disposal needs, schedule of operation, and design preferences, the chambers may vary in size, number, and ability to recycle waste heat. According to its manufacturers, the Entech system can be adapted to operate on a daily, every-other-day, or weekly basis. The configuration of the Entech system can be further designed to collect the radiant heat produced during operation for use in a number of different applications. They may include space heating, water heating, steam production, and refrigerated warehousing—through the use of reverse chillers (135,209).

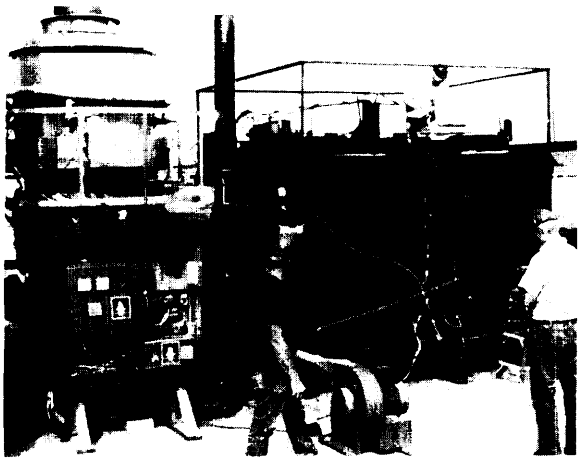
According to company officials, the operation and maintenance (O&M) of the Entech Thermal Oxidation System are relatively simple. An individual who has the capability to read and write at the high-school level, and is familiar with equipment and truck maintenance, is generally qualified to run and service this waste treatment technology. Entech can train operators and supply technical O&M assistance.

Although not specifically designed and built to treat human sewage, the thermal oxidation technology (figure 5-8) could potentially be useful in some communities because it may solve both their honey bucket and their solid waste (trash) disposal problems (208). The initial capital and O&M costs of the Entech technology vary ac -

11 According to company officials, the Entech system can treat, in addition to trash, a number of waste streams including medical waste, tires (with the rims), wood, construction debris, furniture, oil filters, paint, household cleaning and other chemicals, fish net, absorbent booms and pads, ship wastes, honey bucket waste, used oil, tank bottoms, fish cleaning waste, and oily ship waste (bilge water).

12 Testing of ash resulting from the treatment of certain hazardous wastes may be required prior to their disposal.

FIGURE 5-8: Entech Thermal Oxidation System



SOURCE Michael G. Pope, President, Entech, Inc., Anchorage, AK, personal communication, Apr. 7, 1994

cording to the size of the community for which it is being considered. High capital and operational costs might make the application of this technology for treating honey bucket waste difficult in communities with few economic resources. However, expanding its application to other waste streams, such as trash, might make it cost-effective overall. The necessary technical and economic studies of the Entech system for treating solid and sanitary wastes in a rural Alaskan village have not been conducted to date.

NASA's Controlled Ecological Life Support System

The Controlled Ecological Life Support System (CELSS) is one of the cooperative applied research programs of NASA that might be useful in solving future sanitation problems in rural areas of Alaska. The major objective of CELSS is to test advanced technologies to support human life in harsh environments such as the moon, Mars, and remote or isolated regions of Earth (96,192). The program focuses on technologies that, 1) produce and recycle food, air, and water in a way that resembles natural processes; and 2) eliminate the need for frequent resupply, and overcome the harsh environmental conditions.[13] Another portion focuses on developing technologies capable of treating human waste and recycling wastewater in a manner that reduces health and environmental risks of exposure. NASA plans to demonstrate technologies relevant to sewage treatment in two programs: the Antarctic Analog Project and the Life Support Research Testbed in Barrow, Alaska. The possibility for commercialization of the technologies employed in these programs will also be explored. It is too early to evaluate whether these systems could be adapted to solve sanitary problems in Native Alaskan villages.

Currently, several advanced waste processing technologies are being tested by Ames Research Center scientists at Moffett Field, California, for possible application in rural Alaska, Antarctica, and space flight (95,96,308,309). Examples of potential candidates include the following:[14]

Incineration—This approach would involve the thermal treatment of concentrated human waste to produce dry, inorganic ash and gases (e.g., water vapor, carbon dioxide). NASA plans testing to evaluate overall system performance, energy consumption requirements, and level of treatment that may be needed after incineration.

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13 Based on past Pilot demonstrations of minifarrns and fish ponds conducted at the Ames Research Center, NASA personnel have designed and tested the prototype of a special chamber or mini farm for investigating crop growth in highly enclosed environments. The chamber will be used for testing different types of crops along with certain technological devices (lighting and nutrient del ivery systems; and sensor, monitoring, and control devices). According to NASA, previous attempts with this type of technology have produced "world record yields" (192). Several aquiculture tanks are being operated and tested at Ames Research Center for identifying types of fish (e.g., tilapia) and other aquatic animals that can serve as a food source for human consumption, and as processors of inedible biomass into products useful for crops.

14 Other technologies or engineering concepts that NASA might also consider include the Phase Catalytic Ammonia Removal and the Wiped-Film Rotating Disk Evaporator.

- *Pyrolysis-This* commercially available system uses intense heat to treat hazardous waste in the absence of oxygen. To evaluate its potential in controlled ecological life support strategies, NASA plans to test conventional and more advanced pyrolysis technologies (e.g., pyrolysis technology assisted by microwave radiation) by themselves or in combination with incineration.
- *Wet oxidation-Wet* Oxidation, unlike incineration, which requires wastes to be sufficiently dried prior to treatment, involves the combustion of either a dilute or a concentrated waste slurry at high temperature and pressure. In addition to reducing waste volume, wet oxidation allows the recovery of water and nutrient materials. According to NASA, a small prototype for space application already exists.
- *Supercritical water oxidation-This* technology combines high temperature and pressure to create an environment—supercritical—in which organic and inorganic compounds present in wastes become highly soluble, reducing their complex chemical structure to their most basic forms: carbon dioxide, water, and salts. Studies are needed to evaluate means to prevent possible corrosion and clogging of system components prior to the actual deployment of this technology.
- *Electrochemical oxidation—This* technology is designed to treat organic compounds at ambient temperature and pressure with the assistance of electrochemical- and ultraviolet-generated chemicals, such as ozone. Near term use is not possible because the technology is still in its early phase of development.
- *Plasma-arc incineration-This* treatment process involves the passage of waste materials through a thermal plasma field to reduce their chemical compounds to more basic components such as hydrogen, carbon monoxide, and ash. Because the technology is only in its pilot-scale research stage, additional work is required before it can be applied to NASA's field programs in Alaska and Antarctica.
- *Composting or microbial bioprocessing—This* type of technology employs microorganisms to degrade organic waste under near-ambient conditions and in the presence or absence of oxygen. In addition to volume reduction, composting technologies reduce organic wastes to: 1) carbon dioxide, water, and microbial biomass when oxygen is present; or 2) methane gas and generally smaller microbial biomass in oxygen-starved processes. Application of this technology thus far appears limited because of its inability to break down slurries and solid materials completely.

Life Support Research Testbed in Barrow, Alaska

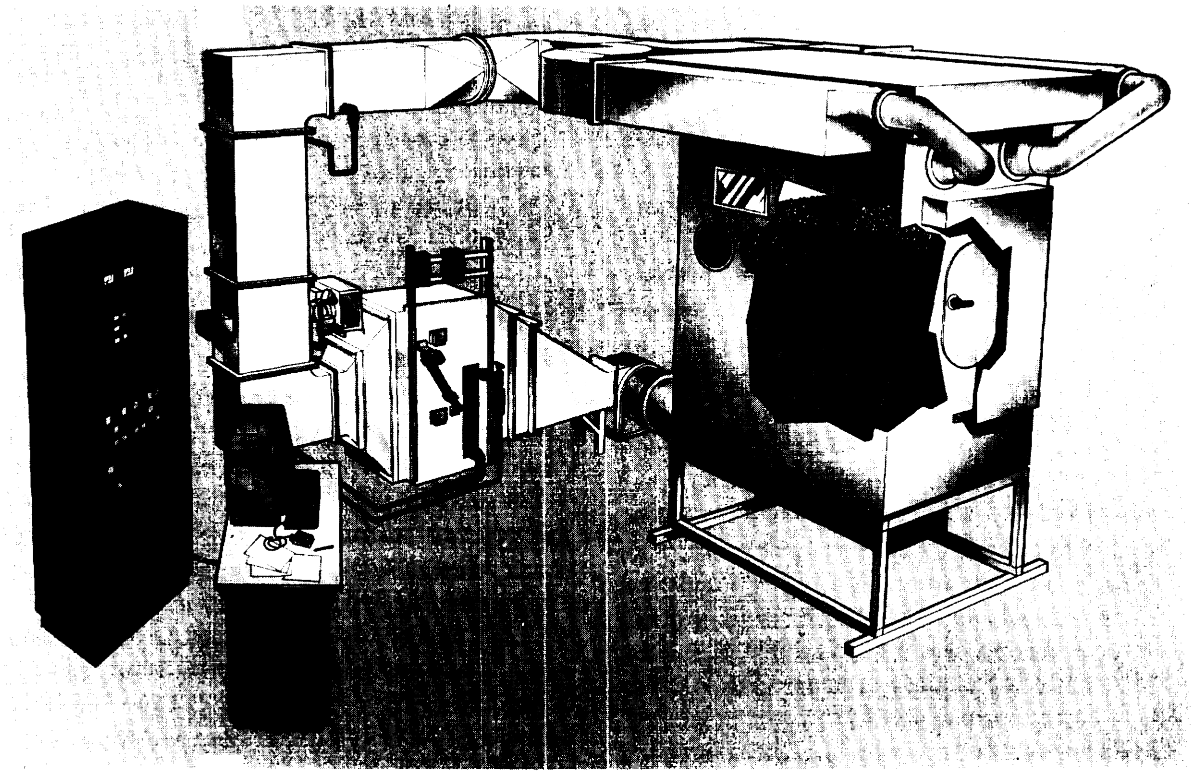
NASA, in cooperation with various Alaskan organizations (i.e., Alaska Science and Technology Foundation, University of Alaska, Native corporations, and the private sector) is planning to test one version of its multi system approach at the National Arctic Research Laboratory in Barrow, Alaska (96,72,196). This test is expected by NASA officials to generate scientific information useful for supporting future use in rural Alaskan villages and other polar regions of the world, as well as for developing an educational outreach program.

Located adjacent to the kitchen of the National Arctic Research Laboratory in Barrow, the testbed is planned to consist of only a modularized crop production chamber equipped with an advanced water recovery system. The capability to process human waste will be added once one of the treatment technologies mentioned above is determined as appropriate for use. Once the entire system is deployed, scientists will have the opportunity to investigate its market potential and adaptability in remote communities where sanitation problems continue to exist.

Antarctica Analog Project

The Antarctica Analog Project is a cooperative effort between NASA and the National Science Foundation to use advanced food production (crop production and aquiculture) systems, water recycling methods, and human waste processing technologies now undergoing development and

FIGURE 5-9: Overview of NASA's Antarctica Analog Project Technology, Which is Being Tested and Scheduled for Deployment at a New South Pole Station by the Year 2,000



SOURCE David Bubenheim, Chief Scientist, CELSS Research and Technology Development, Advanced Life Support Division, NASA Ames Research Center, personal communication, Jan 25, 1994

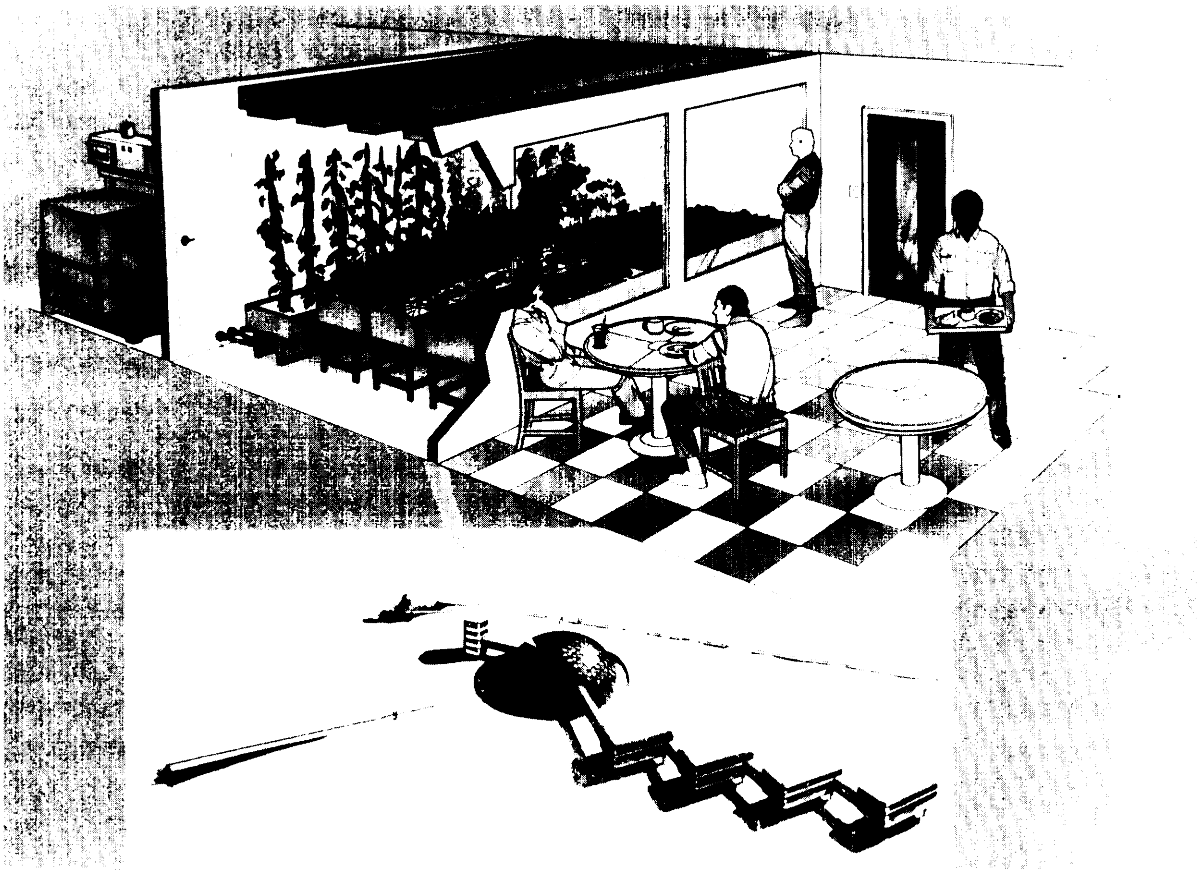
testing. At present, most advanced technologies to support researchers stationed in the South Pole are in their initial stages of project development. NASA researchers are currently identifying all relevant design and performance characteristics associated with crop growth, aquiculture, and waste processing technologies. Evaluation of pilot plant studies is scheduled for sometime in 1995 and 1996 at the South Pole, with deployment of a full-scale system (figure 5-9) by the year 2,000 when construction of a new South Pole station is planned for completion (96,192,235).

When installed, the final Antarctic Analog Project is expected to be fully integrated with the infrastructure of the research station and to consist of a minifarm, a park, a food production system (for growing fish and vegetables), and water recovery and recycling (figure 5-10). Treatment of human waste will be provided by one of the technologies described above once it is successfully demonstrated for use (94, 192, 235). Lessons learned from this research may be applicable in remote areas of Alaska (96,192, 309).

NASA's Space Shuttle Orbiter Waste Management System

The technology used by NASA to collect sanitary waste during space missions is commonly known as the Space Shuttle Orbiter Waste Management System (figure 5-11). The primary purpose of this technology is to safely collect and store urine, hu-

FIGURE 5-10: Artist's Rendition of the Antarctica Analog Project Technology at the Future South Pole Station



SOURCE David Bubenheim, Chief Scientist, CELSS Research and Technology Development, Advanced Life Support Division, NASA Ames Research Center, personal communication, Jan 25, 1994

man waste, and wash water generated during space flight for treatment upon the shuttle's return to earth. The major components of this waste management technology are a urine collection system and a sewage collection-storage system. The system is highly specialized, very costly, and designed for a short-duration, specific mission. Only certain design concepts and unique features may be applicable to the problem of providing adequate sanitation in rural Alaska.

Urine Collection System

To collect urine, air is drawn from the urinal through the piping, and into a fan/pump separator whose rotating and pumping action separates urine from air prior to its storage in a pressurized wastewater tank (90,3 10). Because the lack of gravity prohibits the use of standard urinals, the urinal in the Orbiter waste management system is designed with clear plastic funnels (straight conical design for male use; oval in shape for use by female astronauts) directly connected to the plumbing system (90,3 10).

To avoid the clogging and airflow loss problem caused by drawing debris into the pump/fan separator, which was experienced in early space flights, NASA engineers fitted the base of the urinal with replaceable filtering screens (310). The pumped air used to transport urine through the plumbing is subsequently treated by odor and bacteria filters, and returned to the cabin. Drain water and wash water are stored in a relatively similar fashion (310).

One of the central components of NASA's waste collection and storage technology is the pump/fan separator because it is the system responsible for: 1) providing suction airflow needed for transporting urine and feces; 2) separating wastewater from transport air; and 3) pumping wastewater into the pressurized holding tank.

Sewage Collection/Storage System

NASA's space waste management technology was originally designed to use forced air to push waste into a commode tank where a rotating slinger (a wheel with 10 tines rotating at 1,650 rpm[15]) breaks up and stabilizes the waste before storing it in the commode's tank. After defecation occurs, the user actuates the commode handle to close the slide valve. The fecal material is then stabilized and dried by vacuum action, thus rendering the waste odorless. The air that was used to push waste into the commode tank is filtered by debris, odor, and bacteria filter systems and recirculated to the cabin.

The clogging of filters and loss of airflow caused by fine, dried fecal material experienced during heavy toilet usage in early flights often resulted in poor waste separation, incomplete transport into the storage tank, and inadequate sanitary conditions in the cabin where such fecal particles frequently escaped. The slinger was subsequently removed and replaced with a bag liner that operates like a vacuum cleaner bag: it retains bacteria and waste particles inside it without preventing air from passing through (90).

The rapid filling of the bag liner system with tissue paper as opposed to human waste-caused by the absence of gravity, which, in turn, precludes the separation and dropping of human feces from the body—forced NASA engineers to ultimately replace the bag liner with a feces compactor. By rotating a movable vane located inside the tank, the stretchable fabric material, attached to the movable vane at one end and to a stationary vane on the other, is forced to sweep the interior of the ellipsoidal waste commode and compact the waste. Air drawn through the commode is treated and returned to the cabin. Compaction of waste by this currently used technology is required only every fifth or sixth day of operation.

NASA's Extended Duration Orbiter Waste Management System

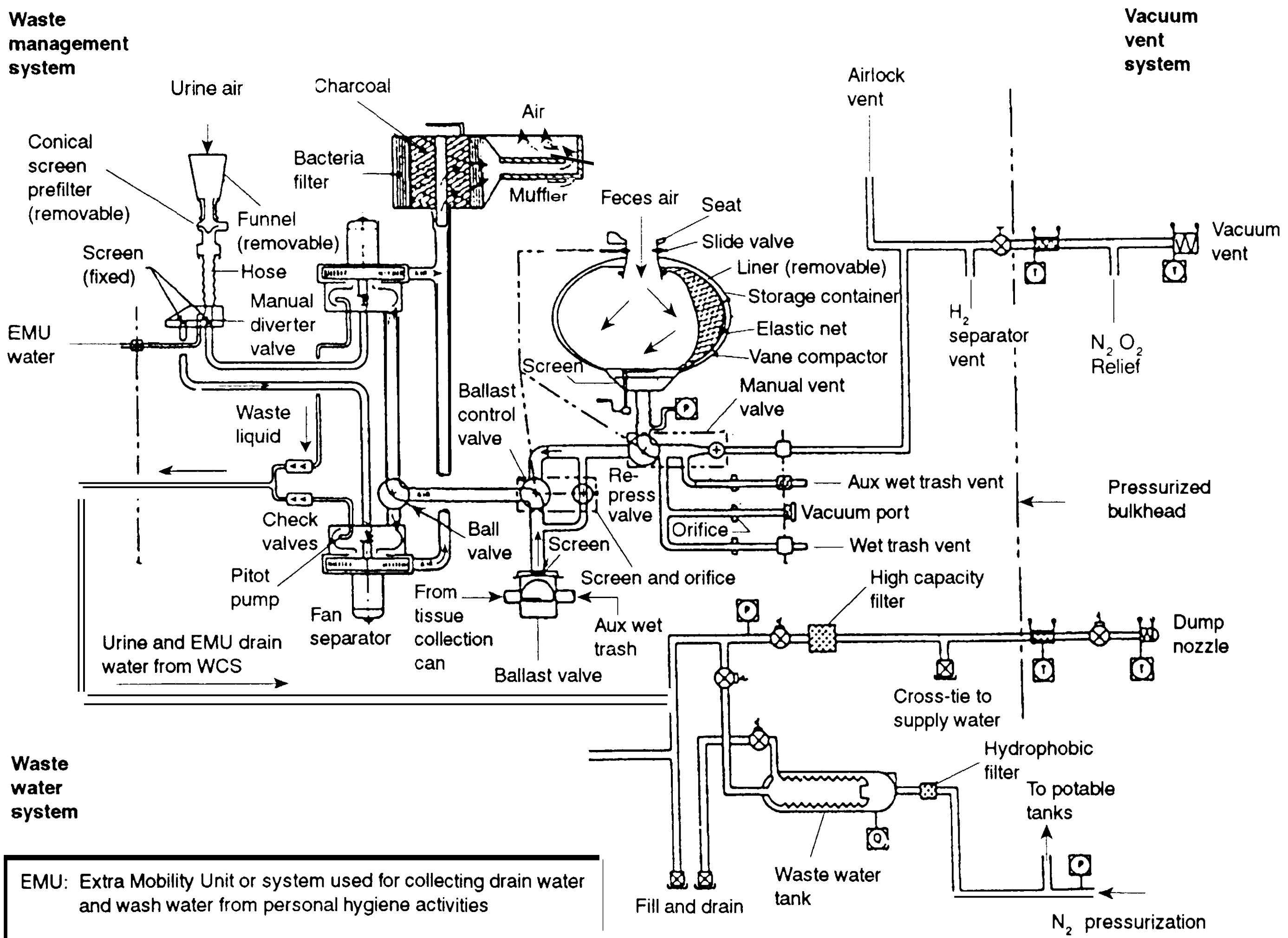
Another very specialized design may be useful for its concepts and unique features. NASA is testing a new waste collection technology known as the Extended Duration Orbiter Waste Management System (figure 5-12) that uses a mechanical piston compactor and disposable bags with plastic lids. Prototypes of this less expensive and easy to maintain waste collection system are being built and scheduled for use in future space flights (90,191 ,239).

The Extended Duration Orbiter waste collection system is designed to be used as a conventional toilet. Its size (12 inches long, 16 inches wide, and 35 inches high), weight (60 pounds), and low power consumption makes this technical approach, according to its developers, one of the most promising for future extended space use (239). One particular advantage of this system over the currently used one is its capability to meet the sanitation needs of up to seven astronauts for a period of 18 to 30 days (90).

During its use, proponents indicate, wastes (including feces, urine, and tissue paper) disposed in the bowl are contained inside a cylindrical bag that permits air to flow through. By applying a load of

15 Revolutions per minute.

FIGURE 5-11: Schematic Diagram of the Sewage Collection/Storage System Installed in NASA's Space Shuttle

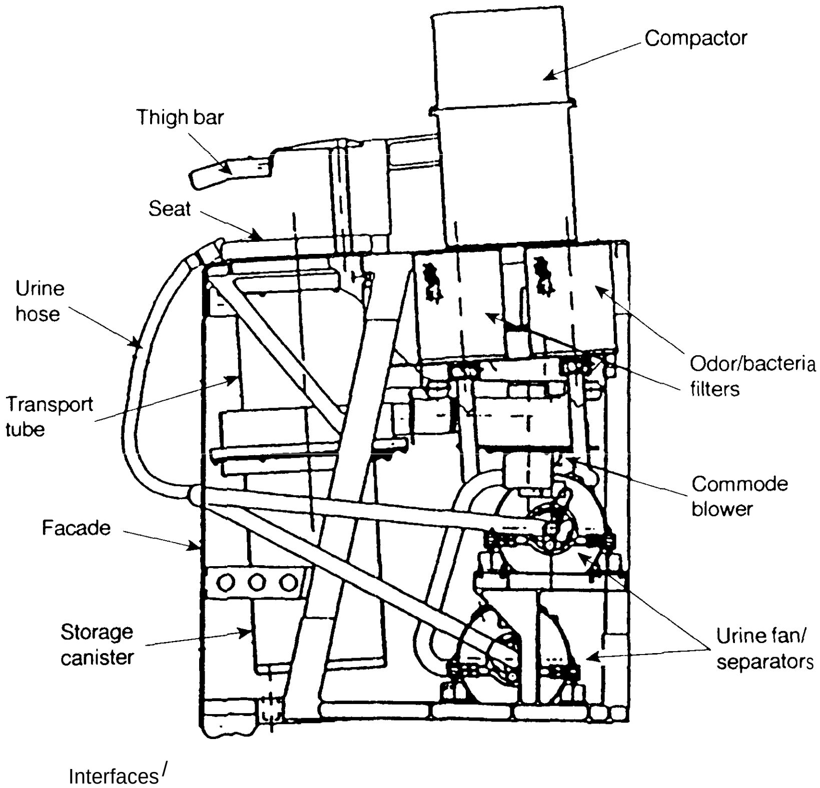


EMU: Extra Mobility Unit or system used for collecting drain water and wash water from personal hygiene activities

WCS: Waste Collection System

SOURCE: H.J. Brasseaux Jr., H.E. Winkler, J.D. North, and S.P. Orlando, "The Extended Duration Orbiter Waste Collection System," *SAE Technical Paper Series*, No. 90 291, 1990.

FIGURE 5–12: Diagram of the Extended Duration Orbiter (EDO) Waste Collection System Planned for Use in NASA's Future Space Flights



SOURCE H J Brasseaux Jr, H E Winkler, J D North, and S P Orlando, "The Extended Duration Orbiter Waste Collection System, " *SAE Technical Paper Series*, No 901291, 1990

about 100 pounds, the compactor travels down the transport tube pushing the waste-containing bag and its lid to the bottom of the collection canister where they are compacted. The rigid collar and wiper-like design of the lid are used to scrape any waste that may have adhered to the walls of the transport tube. The bag is then left behind as part of the stored waste material.

Once the piston returns to its original position. the user places a fresh bag in the toilet for the next user before closing the toilet seat and 1 id. Replacement of collection canisters in the proposed Extended Duration Orbiter system is expected to take place only after an average of 30 uses. Test results from recent space flights show the individual bag collection system to be relatively cleaner than the commode system currently in use by the shuttle (21 2).

The "Self-Contained Home" System

According to its designer, the Self-Contained Home technology has been conceived to address in a cost-effective manner the most basic needs of Natives in rural Alaska: housing, heating, and sanitation. As planned, the technology will consist of an insulated house (36 feet by 38 feet) specially designed for the Arctic environment and served with a heat/cook stove, a self-generated water system, and an Arctic toilet system in which human waste is treated with recycled heat. Made of steel, the heat/cook stove-considered the cornerstone of this system-can be operated with wood, coal, or fuel (92,93).

The Self-Contained Home appears to be potentially useful in addressing more than the waste disposal needs of Native communities in rural Alaska, but because this technology is still in its developmental stage, field studies would have to be undertaken to ascertain the actual applicability of this approach.

SUMMARY OF TECHNOLOGY ISSUES AND NEEDS

All of the alternative technologies described above require some degree of development, testing, and evaluation before they could be chosen as a proven system with satisfactory performance ensured. Identifying and developing appropriate technologies, while meeting safety and reliability standards within cost constraints, constitute the major challenge for designers and developers of any sanitary technology in the Arctic. In years past, most Federal and State agencies provided relatively little support for the basic engineering and environmental research required to produce the data necessary to design and implement specific technologies. This deficiency resulted in a shortage of information in several areas, such as hydrology (e.g., snow surveys), soil (e.g., permafrost), ice research, and climate and natural hazards (8). Considerable progress was achieved in these areas during the 1980s, particularly with the construction of the Alaskan oil pipeline and the installation of piped sanitation systems at major oil industry facilities in Pruhdoe Bay. These advanced piped systems cannot be applied in most villages, however, because of high construction, operation, and maintenance costs.

Very few alternative sanitation methods have benefited from field demonstration tests in rural Alaskan communities in the past. Most of the attempted evaluations failed. The failures were largely the result of limited or inadequate guidance provided to Natives by technology developers. With the exception of certain comporting technologies, the Office of Technology Assessment (OTA) found no long-term effort dedicated to the demonstration of alternative sanitation technologies.

Even today, relatively little information exists on the application of alternative sanitation technologies in environments such as that of rural Alaska. Adopting these systems without first exploring the factors that will make their application in Native villages successful is risky and subject to failure. In many Alaskan villages, there are physical, social, and economic conditions not commonly found in other areas of the United States. Such conditions include limited drainage and poor soil conditions caused by discontinuous permafrost, seasonal variations in the quantity and quality of the water available, and high costs of electricity and fuel. Unfortunately, programs to fund field demonstrations of alternative technologies, to coordinate Federal and State technology programs and policies, and to establish a forum for the advancement of innovative sanitation systems do not exist.

Alternative sanitation technologies must be evaluated prior to their actual use among Native communities and must be designed to accommodate the unique Alaskan environment, including factors such as:

- Permafrost—This is of great importance in the engineering and design of structures and systems, particularly in ice-rich, fine-grained soil, where the ground forms an extremely strong and stable foundation material when frozen but an extremely weak foundation when thawed. The location, depth, and extent of permafrost may preclude the selection of certain sanitation systems due to its influence on local soil conditions, groundwater table, and seasonal flooding.
- Availability of water—Adequate availability of water is a key consideration in the selection of flush toilet systems because without it, sewer, septic tank, and truck haul holding tank systems cannot perform properly. (Water is also extremely important for practicing hygiene.) Piped water is normally incorporated into

piped sewerage projects because the two systems are mutually dependent; however, they also lead to increased water consumption, thus creating a need for additional disposal capacity. The interior region of Alaska is generally supplied with water and contains large areas of wet muskeg and lakes, with significant snowmelt runoff and river drainage. In the Arctic region, however, a myriad of shallow lakes disguise the fact that water supplies are actually very limited for supporting sanitation technologies that consume large amounts of water.

- Household size and design—Identifying the number of persons residing in each house for which use of a particular technology might be planned, as well as recognizing the perception they have about that particular technology, is important in estimating in advance the technology's potential for success. Consideration of household size and design is also important in determining waste volumes to be treated or managed, projecting future system expansions, and estimating costs over extended periods of time.
- Technical training—Training Natives in how to operate sanitation technologies has not always been successful. The reasons for such failure have been primarily the use of inappropriate off-the-shelf packaged training programs and the increasing shortage of technical assistance from Federal and State agencies. To avoid these failures, there is a need to develop programs that are culturally sensitive and practical, and that focus on the realities of the particular village in which the technology will be applied. Examples of these include local limitations in management capability, leadership, and fiscal responsibility. Identifying the extent of the external financial and technical assistance that will be needed once the technology is installed will be also useful.
- Native community involvement—Although the intrusion of Western culture has sometimes met with resentment, many Natives continue to believe that the main source of resentment has emerged primarily from being told by outsiders what to do and how to do it, and rarely being included in the development of solutions to local sanitation problems. Encouraging and supporting continued village participation in the selection and implementation process are extremely important for ensuring a strong perception of community ownership over the project-—an element crucial to the successful application of any technology.
- **Local village economy—The** majority of Native communities of rural Alaska rely almost completely on transfer payments and subsidies from Federal and State agencies to operate basic village programs, including sanitation projects. Despite the increasing demand for new sanitation projects, the serious economic difficulties faced by Native villages with existing systems raises the need to avoid installing similar complex technologies in communities with few economic and technical resources to operate them. Consequently, addressing the waste sanitation problem in Alaska's Native communities requires steps that focus on identifying, demonstrating, and adopting more cost-effective alternatives to honey buckets. Selecting technologies that deliver sanitation with little additional adverse impact on the limited or declining local economies is needed.
- Actual costs to Native village residents--In recent years, Federal and State agencies have focused primarily on providing conventional technologies that require high capital costs and a significant degree of advanced engineering. Their efforts to assist Native villages financially with the operation and maintenance of these projects have been rare. This, and the failure to track community expenses for O&M, have limited the information available today for estimating the actual costs of sanitation projects.

Actual cost data for estimating life cycle costs of complete systems in Alaskan Native communities do not exist. Accurate life cycle cost comparisons of alternative and conventional systems are not possible. Not only does this impair the evaluation of each system's cost-effectiveness but it prohibits agency officials from making valid estimates of the overall economic impact of each technology on the community. There are no data on the potential economic savings by communities that might employ alternative technologies rather than conventional ones. Savings associated with the use of alternative sanitation technologies could include, for example, eliminating local expenses associated with building and maintaining a sewage lagoon, reducing the community water and energy consumption, reducing the need for certified facility operators, and reducing equipment repair or replacement costs. Limited data also prohibit the evaluation of the potential impacts of using alternative systems that do not deliver potable water to the home.

Technology selection decisions to date have been based on a capital planning process that takes into consideration the type and size of the sanitation facility to be installed, the financing process to follow, and the methods by which costs will be recovered. This process, however, is largely limited to the construction of conventional technologies and does not allow for a comparison of conventional and alternative approaches based on total life cycle costs. Only minimal attempts have been made to formally incorporate existing alternative sanitation systems into the technology selection process currently in place.

CONCLUSION

Alternative sanitation technologies, such as comporting, electric, and propane toilets, appear to be an improvement over honey buckets because they reduce the possibility of users coming in contact with human waste and they may reduce overall, long-term costs. Not only do these technologies eliminate the need for a sewage lagoon to hold the wastewater for treatment, as in a conventional piped or haul system, they may also yield a by-product that is generally more environmentally safe or easier to handle. These alternative approaches, however, do not provide the potable water that is needed to practice good sanitation.

Certain of the advanced engineering systems or concepts presented in this chapter appear potentially beneficial. Some, as in the case of NASA's life support systems, still require substantial design modifications, adaptation, or testing before they can actually be considered for waste treatment in Native Alaskan villages. Others, like Entech's thermal oxidation system, might be applicable to treating human waste, but they require testing and evaluation.

Conditions in Native villages (i.e., inadequate water supply, poor soil drainage. permafrost, unacceptable topography, high seasonal flooding potential, and weak local economies) appear to favor the application of less costly and complex systems. With the exception of the limited testing conducted on certain comporting methods, most alternative technologies have not been tested for the treatment of human waste in the harsh environmental conditions typical of rural Alaska. Development of a more comprehensive technology evaluation and selection approach capable of supporting demonstration, applied research, and application of innovative technologies is still necessary.

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Appendix A: The Land Claims and Tribal Movements of Alaska Natives

A

LAND CLAIMS MOVEMENT

The reduction of fur-bearing sea mammals in Alaska and the demands of the Crimean War were among the reasons the Russian Government agreed to sell Alaska to the United States. The general American public believed Alaska to be a land of ice and snow, and quickly labeled the purchase '*Seward's Icebox," "Seward's Folly," and other things, after the Secretary of State who supported its purchase.

Ever since then, Alaska has been a mystery to virtually all who have not experienced conditions in the State on a first-hand basis. It is safe to say that virtually all of the preconceptions that one brings to Alaska will be disproved, and opposite examples encountered, even during a short visit. Alaska is vast and perhaps best described as a land of contrast and contradiction. For example, in spite of its vastness, Alaska is a small community. After an inordinate] y short stay, one begins to realize that even a small network of acquaintances will produce recurring contacts of common interest.

The transfer of Alaska from Russian rule to the United States occurred at Sitka in southeast Alaska on October 18, 1867. The 1867 Treaty of Cession guaranteed that the "uncivilized tribes," which included those groups that had remained independent from Russian domination, would have the same protection of the laws and regulations that applied to other tribes within the United States. The most important of these protections to Native people was a recognition of their right to possess land.

The Tlingit and Haida Indians of southeast Alaska were not allowed to even watch the ceremony in which their land was transferred from one nation to another, an inauspicious beginning from the Native viewpoint. They immediately voiced their objections to the sale and claimed that the land had been sold without their consent. They further claimed that the $7.2 million purchase price should have been paid to them, although their objections were to go unheeded until they brought suit in the courts of the United States.

Although the 1867 Treaty of Cession and the 1884 Organic Act recognized the land rights of Alaska Natives, little was done to restrict non-Native occupation of their lands. The gold rush, followed by the development of lucrative salmon fisheries, commercial whaling, trapping, and the influx of the military, brought a large population of whites to the new territory. Everywhere, Native lands were encroached upon.

In 1935, the Jurisdictional Act was passed by the U. S. Congress, allowing the Tlingit and Haida Indians of southeast Alaska to sue the United States for loss of their lands. Creation of the Tongass National Forest, Glacier Bay National Monument, and the Metlakatla Reservation for the Tsimpsian Indians, who had moved to Alaska from Canada, eroded much of the land base of the southeast Alaska Indians.

The Hydaburg Reservation, which had been created for the Haida Indians, was invalidated by a 1952 court decision. The judge ruled that the reservation had not been validly created. In contrast to earlier judicial decisions, in which Natives had been deemed to be uncivilized, the judge in this case ruled that the Haida Indians had been assimilated (i.e., civilized through assimilation) into the white community surrounding them. It was further reasoned that the 101 ,000-acre reservation would be created at the expense of white people who had nothing to do with the exploitation of the Indians, further increasing discord.

Not until 1968 did the Indian Court of Claims award the Tlingit and Haida a $7.5-million judgment, far short of the $80-million value claimed by the Indians. The award did not provide for a land base, and the remainder of the Tlingit land in the northern region of their territory was to be included in the statewide Native claims.

The Statehood Act of 1958 granted the State of Alaska the right to select 103 million acres. At the same time it recognized the rights of Natives to kinds they traditionally used and occupied. The State's proposed selection of land initiated a series of protests by Alaska Natives. Native people were most concerned that their hunting, fishing, and trapping grounds would be taken by the State. Village after village began to file protests with the Federal Government. In early 1963, nearly 1,000 Natives from 24 villages petitioned the Secretary of the Interior to impose a land freeze to halt all transfer of land ownership until Native land rights had been resolved. The Secretary did not respond to this petition.

The southeast Natives were the first group to organize on a regional basis. The Alaska Native Brotherhood (ANB) was organized as early as 1912, and it claims to be the oldest organization among American Indians. The ANB had attempted to organize local chapters called "camps" in communities outside the southeast, but it met with only partial success. Not until the 1960s were other regional associations formed to advocate for land and political rights of Alaska Natives. In 1963, several of the regional organizations discussed the possibility of organizing a statewide group, but the deep-rooted mistrust that persisted among different cultural groups hindered its formation.

A growing awareness of the need to take concerted action for the protection of Native land ownership finally prompted formation of the Alaska Federation of Natives (AFN) in 1966. The AFN adopted three recommendations relating to land protection: 1) a land freeze until Native claims were resolved, 2) congressional legislation to settle the claims, and 3) congressional consultation with Natives before the enactment of land claims legislation. Before 1966 ended, the Secretary of the Interior had imposed a land freeze until the land claims issue could be resolved. Imagine the leverage this provided when, in a few short years, the State would seek to build an 800-mile pipeline from Prudhoe Bay on the Arctic Coast to the City of Valdez on Prince Will i am Sound on the Gulf of Alaska.

Because of the importance of the AFN as an advocate of Native interests in Alaska, a discussion of its history and current role in these issues is essential to understanding existing Native relationships. The AFN was formed in 1966 when more than 400 Alaska Natives representing 17 organizations gathered for a three-day conference to address the need for a settlement of aboriginal land rights. Natives in different parts of Alaska had worked independently on the land claims issue, but by the mid- 1960s, it had become clear that a united, consolidated effort was needed.

Although different in culture and history, the various Indian, Eskimo, and Aleut groups shared several important concerns. These included a traditional and fundamental reliance on the land and its resources, the welfare and integrity of the community, and a growing concern about Western encroachment on lands on which Natives had relied for millennia.

Between 1966 and 1971, the AFN worked to attain passage of the Alaska Native Claims Settlement Act (ANCSA), which was signed into law on December 18, 1971. With ANCSA in place, the AFN provided technical assistance to Alaska Natives as they began to implement the Act. During the 1970s, the AFN also managed statewide human service programs. However, as Native regional nonprofit associations grew in strength and number, the AFN transferred these human service programs to them.

Since the late 1970s, the AFN has concentrated on lobbying and advocacy efforts on statewide issues, with funding provided by membership fees. The activities of the AFN are oriented mostly toward for-profit corporations. Over the years, the AFN has evolved to meet the changing needs of Alaska Natives and to respond to new challenges as they emerge.

At the State level, AFN plays an active role in the legislative process by promoting laws, policies, and programs benefiting Natives in the areas of health, education, resource development, labor, and government. in the late 1980s, the AFN turned its attention to social, tribal, and economic issues, including the problems surrounding community sanitation.

With formation of the AFN, the legislative land claims battle began in earnest. Native claims to their ancestral lands were adamantly opposed by the State. The Prudhoe Bay oil lease sales on the North Slope brought the State of Alaska some $900 million, and it brought support to the Natives for settlement of the land claims. It was clear that no permit for a pipeline that would carry oil from the North Slope to a southern terminal could be granted until Native claims to their land were settled. The assistance of the oil companies and other business interests ensured the passage of the land claims bill. When ANCSA was signed, Alaska Natives believed that a new and prosperous era was about to begin.

The basic provisions of the Act concerned land, money, and the establishment of Native corporations. Under the terms of the Act, Congress agreed that Alaska Natives would be compensated $962.5 million for the extinguishment of aboriginal title to 330 million acres of land and that they would retain ownership of 44 million acres of land under fee-simple title. Congress also authorized corporations, rather than traditional Native groups or clans, to hold title to the land and assets. The land was to be divided among 12 regional and 200 village corporations. The Act was later amended to allow for the formation of a 13th regional corporation for those Alaska Natives living outside the State.

The regional corporations would hold title to subsurface resources, and village corporations title to surface resources. ANCSA allowed individuals who were alive on December 18, 1971, and who were one-fourth or more Alaskan Native, to enroll as shareholders. Unfortunate y, many eligible Natives did not enroll because of an absence in their culture of any concept of land ownership. Enrollment for ownership in lands they had always used freely seemed pointless and resulted later in resentment, hardship, and seemingly unfair exclusion of title to ancestral lands.

ANCSA appeared to be a landmark legislative act. Alaska Natives were to receive more land than that held in trust for all other American Indians. Compensation for lands surrendered was nearly four times the amount all Indian tribes had won from the Indian Claims Commission over its 25-year history. In the view of many, this was possible only because of the power of the petroleum industry in the State.

The settlement was also a clear departure from previous Indian settlements. Under ANCSA, lands would be held by corporations under fee-simple title rather than as reservations held in trust by the Federal Government. Congress clearly intended that ANCSA would provide the means for economic development and assimilation of Alaska Native peoples.

Alaska Natives were initially elated over the provisions of ANCSA. It did not take long, however, for them to become aware of the complexities and problems associated with the settlement. Corporations would have to wait up to 10 years before they received title to their land, and the cost of implementing the settlement consumed most of their financial award. Natives also came to realize that perpetual ownership of their lands could not be ensured under the corporate structure and that the shareholder system did not allow for the enrollment of those Alaska Natives born after 1971.

The corporations have met with varying degrees of success. Several regional and village corporations have achieved great success, but for the most part, a large number have been less than successful. Several are on the verge of bankruptcy. Alaska Natives have proposed a series of amendments to ANCSA and are hopeful of resolving many of the corporate problems.

TRIBAL MOVEMENT

The tribal movement in Alaska began with Natives who feared that they could lose their ancestral lands, which are held by ANCSA corporations. The concern of tribal Natives is that without their land they will lose their culture, They contend that cultural survival is based on the hunting and gathering of wildlife resources. They also fear that with a growing non-Native population in Alaska, they will lose control over their communities as well. They are concerned that the proliferation of modem institutions in the villages, including the tribal council, city council, corporation, school. and other organizations, has become a source of conflict. They also express opposition to jurisdiction exercised by a State Government and judicial system in which they are not fully represented. They maintain that State agencies enact oppressive laws and regulations, and render decisions that often conflict with their needs and do not always represent their best interest.

A former Canadian Supreme Court Justice, Thomas R. Berger, an internationally recognized advocate of Native rights, was invited by the Inuit Circumpolar Conference (ICC) to head the Alaska Native Review Commission. The ICC is an international organization composed of Alaskan, Canadian, and Greenlandic Inuit dedicated to maintaining their culture. The ICC established the commission to assess the impacts of ANCSA. Judge Berger traveled to more than 60 villages and received testimony from Alaska Natives on ANCSA.

One conclusion was that villagers believed ANCSA represented a cultural encounter between two different societies. They reported that the concept of buying or selling land was alien to Alaska Natives and that land was communally held by a group rather than by individual stockholders. they expressed concern that the 10,000 to 12,000 Alaskan Native children born after the passage of ANCSA were not given automatic membership in the corporation, as they were in traditional social groups or clans by virtue of their birth. They talked about subsistence activities and how the sharing of resources under their traditional customs established social obligations and reinforced bonds among them.

Congress amended the Indian Reorganization Act (IRA) in 1936 to allow Alaskan Native villages to form tribal governments. Seventy v ill ages organized themselves under the IRA council, and many other villages are governed by traditional councils. A common assumption in Alaska is that ANCSA extinguished tribal sovereignty. However, an increasing number of villages, particularly in western Alaska and the interior regions, are beginning to reassert their sovereign rights under their tribal government and judicial councils. Akiachak, which has been at the forefront of the tribal movement, was the first community to dissolve its local government, established under State laws, in favor of tribal government and to organize its own judicial council.

In 1985, a number of tribal governments organized themselves under the Alaska Native Coal it ion (AN C). The ANC was not successful in obtaining an amendment to ANCSA that would have allowed corporations to transfer their lands to tribal governments. A number of tribal governments in southwestern Alaska have united under the Yupiit Nation to further strengthen tribal governments and rights.

The tribal movement also grew in response to increasing concerns over the social problems that plague Native villages. Alcoholism and self-destructive behavior have been a problem in many villages. The suicide rate has been reported to be the highest in the country, particularly among young males. Alienation, loss of family, low income, and alcohol abuse are cited as major factors related to suicide. In an effort to control alcohol abuse, many tribal governments have prohibited the importation of alcohol into their communities.

Cultural resurgence has also been associated with the movement toward self-determination. Communities in which traditional dancing and ceremonies were prohibited by the local churches have reinstituted Native dance and many of the traditional ceremonies. Native leaders and elders have organized cultural camps in which young children can be immersed in Native culture. Children spend a period of time in these camps learning about traditional ways and beliefs. The elders have reasserted their traditional authority in many villages, They participate in formal elder conferences to record traditional knowledge. Continuing political efforts to protect their land bases and subsistence hunting and fishing activities have become the rallying point to protect the survival of Native cultures.

Whether the Inupiat, Yupik, Aleuts, and Athapaskans and the Tlingit, Tsimpsian, or Haida will survive as distinct cultural groups remains to be seen. It is well accepted that Native cultures have changed dramatically y since their first contact with Westerners. However, it is also recognized that they retain elements and values of their traditional cultures that distinguish them from one another and set them apart from non-Natives.

Alaska Natives are on a collision course with non-Natives who oppose the tribal sovereignty movement and their subsistence rights. The ever-increasing numbers of non-Natives, with their expansion into rural communities, create competing uses for wildlife resources. Alaska Natives have become accustomed to, and dependent on, goods and services that can be obtained only from the capital economy, but the prospects for economic development in rural regions of Alaska are uncertain at best and absent at worst. The lack of economic opportunities in rural communities may accelerate the migration to urban centers

Native corporations continue to hold all Native land except two villages that turned over their lands to the tribal government. It is unlikely that the corporations will reconvey their lands to the tribal governments, but Alaska Natives are continuing to pursue amendments to ANCSA that they believe will ensure the continued ownership of Native land. The record is clear that the Native peoples have made a firm commitment to ensure the survival of their cultures.

B Appendix B: Hepatitis A Outbreaks in Alaskan Native Villages, 1988

Village	Population	cases reported	Percentage of population	Level of service[1]
Akiachak	483	1	2,0	b
Alakanuk	544	1	2,0	a
Atmautluak	258	35	0.3	a
Buckland	318	5	0.3	b
Chefornak	320	5	0,3	b
Chevak	598	1	5.9	a
Eek	261	8	1.9	b
Emmonak	642	1	0.8	e
Galena	833	45	0.1	c
Golovin	127	10	6.3	d
Holy Cross	277	9	0.4	e
Hooper Bay	845	1	5.3	b
Kasigluk	425	44	0,5	a
Kipnuk	470	5	0.6	b
Kongiganak	294	2	2.0	b
Kotlik	461	13	9.5	b
Koyuk	231	1	2.2	a
Kwigillingok	278	9	0.7	a
Lower Kalskag	291	1	4,5	d
Marshall	273	1	0,4	e
Mt Village	674	7	1,3	e
Naknek	711	6	0.2	d
Napakiak	318	3	03	b
Napaskiak	328	1	2.1	b
Nenana	393	1	1,5	e
Nunapitchuk	378	10	0.8	b

Village	Population	Cases reported	Percentage of population	Level of service[1]
Oscarville	57	1	1.8	a
Pilot Point	53	1	1,9	d
Pilot Station	463	7	2.2	d
Pitkas Point	135	9	0.7	b
Quinhagak	501	3	0 2	b
Saint Marys	441	15	1 6	e
Saint Michael	295	11	3.0	b
Sand Point	878	1	0.3	e
Scammon Bay	343	1	44	e
Stebbins	400	1	2.8	b
Tanana	345	7	0.3	a
Tetlin	87	1	1,1	a
Tog iak	613	1	0.2	e
Tok	1,256	2	1.0	d
Tuntutuliak	300		03	a
Tununak	316		0.3	a
Upper Kalskag	172		1,2	a

[1] Level **a** represents the most rudimentary service and consists principally of the use of pit toilets, privvies, and honey buckets Level b sanitary waste disposal service provides for the hauling of honey bucket wastes by a community employee Level c encompasses systems with flush toilets, holding tanks for collecting waste, and hauling of wastes loa disposal area by a truck service Level d systems have flush toilets that discharge to septic tanks and leach fields Level e--flush toilets and piped sewerage-represents the highest technical and safety level of wastewater disposal service provided to Native communities of Alaska

SOURCE U S Public Health Service and State of Alaska Department of Environmental Conservation, *Alaska Native Villages Wastewater* Needs, 1989

C

Appendix C: Current Distribution of Sanitation Technologies Among Rural Alaskan Villages and Native Population Served

Community	Population	Regional corporation	Existing potable water system	Existing sewer system
Chitina	49	Athna	Individual wells	Individual privy
Mentasta Lake	96	Athna	Individual wells	Individual privy
Chistochina	60	Athna	None	Individual privy
Gakona	25	Athna	Watering point	Individual privy
Tazlina	247	Athna	Watering point	Individual privy
Cantwell	45	Athna	Individual wells	Individual septic
Copper Center	449	Athna	Individual wells	Individual septic
Guikana	103	Athna	Circulation pipe	Community septic
Akutan	589	Aleutian	Conventional pipe	Piped gravity
Atka	98	Aleutian	Conventional pipe	Piped gravity
False Pass	68	Aleutian	Conventional pipe	Piped gravity
King Cove	451	Aleutian	Conventional pipe	Piped gravity
Saint George	138	Aleutian	Conventional pipe	Piped gravity
Saint Paul	763	Aleutian	Conventional pipe	Piped gravity
Sand Point	878	Aleutian	Conventional pipe	Piped gravity
Unalaska	3,089	Aleutian	Conventional pipe	Piped gravity
Nelson Lagoon	83	Aleutian	Conventional pipe	Individual septic
Nikolski	35	Aleutian	Conventional pipe	Individual septic
Barrow	2,763	North Slope	Circulatlon pipe	Piped gravity
Anaktuvuk Pass	259	North Slope	Washeteria	Truck haul
Atkasook	216	North Slope	Washeteria	Truck haul
Kaktovik	224	North Slope	Washeteria	Truck haul
Nuiqsut	354	North Slope	Washeteria	Truck haul
Point Hope	639	North Slope	Washeteria	Truck haul
Point Lay	139	North Slope	Washeteria	Truck haul
Wainwright	492	North Slope	Washeteria	Truck haul
Diomede	178	Bering Straits	Washeteria	Honey bucket bunker
Gambell	525	Bering Straits	Washeteria	Honey bucket bunker
Golovin	127	Bering Straits	Washeteria	Honey bucket bunker
Koyuk	231	Bering Straits	Washeteria	Honey bucket bunker
Brevig Mission	198	Bering Straits	Washeteria	Honey bucket haul

Community	Population	Regional corporation	Existing potable water system	Existing sewer system
Saint Michael	295	Bering Straits	Washeteria	Honey bucket haul
Savoonga	519	Bering Straits	Washeteria	Honey bucket haul
Shishmaref	456	Bering Straits	Washeteria	Honey bucket haul
Stebbins	400	Bering Straits	Washeteria	Honey bucket haul
Wales	161	Bering Straits	Washeteria	Honey bucket haul
Elim	264	Bering Straits	Circulation pipe	Piped gravity
Nome	3,500	Bering Straits	Circulation pipe	Piped gravity
Unalakleet	714	Bering Straits	Circulation pipe	Piped gravity
White Mountain	180	Bering Straits	Circulation pipe	Piped gravity
Council	8	Bering Straits	Watering point	Individual privvy
Shaktoolik	178	Bering Straits	Circulating pipe	Community septic system
Teller	151	Bering Straits	Washeteria	Truck haul
Portage Creek	5	Bristol Bay	Watering point	Honey bucket bunker
Koliganek	181	Bristol Bay	Circulation pipe	Piped gravity
Manokotak	385	Bristol Bay	Circulation pipe	Piped gravity
New Stuyahok	391	Bristol Bay	Circulation pipe	Piped gravity
Nondalton	178	Bristol Bay	Circulation pipe	Piped gravity
Togiak	613	Bristol Bay	Circulation pipe	Piped gravity
Twin Hills	66	Bristol Bay	Circulation pipe	Piped gravity
Chignik	188	Bristol Bay	Conventional pipe	Piped gravity
Clarks Point	60	Bristol Bay	Conventional pipe	Piped gravity
Egegik	122	Bristol Bay	Conventional pipe	Piped gravity
South Naknek	136	Bristol Bay	Conventional pipe	Piped gravity
Naknek	575	Bristol Bay	Individual wells	Piped gravity
Iglugig	33	Bristol Bay	Washeteria	Piped gravity
Ekwok	77	Bristol Bay	Individual wells	Piped Sewer
Ekuk	3	Bristol Bay	Individual wells	Individual privvy
Kokhonak	152	Bristol Bay	Watering point	Individual privvy
Ivanoff Bay	35	Bristol Bay	Conventional pipe	Individual septic
Perryville	108	Bristol Bay	Conventional pipe	Individual septic
Aleknaqik	185	Bristol Bay	Individual wells	Individual septic
Chignik Lagoon	53	Bristol Bay	Individual wells	Individual septic
Iliamna	94	Bristol Bay	Individual wells	Individual septic
Levelock	105	Bristol Bay	Individual wells	Individual septic
Pedro Bay	42	Bristol Bay	Individual wells	Individual septic
Pilot Point	53	Bristol Bay	Individual wells	Individual septic
Port Helden	119	Bristol Bay	Individual wells	Individual septic
Ugashik	7	Bristol Bay	Individual wells	Individual septic
Chignik Lake	133	Bristol Bay	Washeteria	Individual septic
Newhalen	160	Bristol Bay	Washeteria	Individual septic
Alakanuk	544	Yukon-Kuskokwim	Washeteria	Honey bucket bunker
Atmautluak	258	Yukon-Kuskokwim	Washeteria	Honey bucket bunker
Kwigillingok	278	Yukon-Kuskokwim	Washeteria	Honey bucket bunker
Tuluksak	358	Yukon-Kuskokwim	Washeteria	Honey bucket bunker
Tuntutuliak	300	Yukon-Kuskokwim	Washeteria	Honey bucket bunker
Tununak	316	Yukon-Kuskokwim	Washeteria	Honey bucket bunker
Meroryuk	177	Yukon-Kuskokwim	Watering point	Honey bucket bunker
Newtok	207	Yukon-Kuskokwim	Watering point	Honey bucket bunker
Oscarville	57	Yukon-Kuskokwim	Watering point	Honey bucket bunker
Platinum	64	Yukon-Kuskokwim	Watering point	Honey bucket bunker

Community	Population	Regional corporation	Existing potable water system	Existing sewer system
Upper Kalskag	172	Yukon-Kuskokwim	Watering Point	Honey bucket bunker
Crooked Creek	106	Yukon-Kuskokwim	Individual wells	Honey bucket haul
Akiachak	483	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Chevak	598	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Goodnews Bay	241	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Hooper Bay	845	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Kasigluk	425	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Kongiganak	294	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Kotlik	461	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Kwethluk	558	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Nunapitchuk	378	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Pitkas Point	135	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Quinhagak	501	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Sheldon Point	109	Yukon-Kuskokwim	Washeteria	Honey bucket haul
Chefornak	320	Yukon-Kuskokwim	Watering Point	Honey bucket haul
Chuathbaluk	97	Yukon-Kuskokwim	Watering Point	Honey bucket haul
Kipnuk	470	Yukon-Kuskokwim	Watering Point	Honey bucket haul
Napakiak	318	Yukon-Kuskokwim	Watering Point	Honey bucket haul
Napaskiak	328	Yukon-Kuskokwim	Watering point	Honey bucket haul
Nightmute	153	Yukon-Kuskokwim	Watering point	Honey bucket bunker
Bethel	4,674	Yukon-Kuskokwim	Circulation pipe	Piped gravity
Lower Kalskag	291	Yukon-Kuskokwim	Circulation pipe	Piped gravity
Marshall	273	Yukon-Kuskokwim	Circulation pipe	Piped gravity
Mt. Village	674	Yukon-Kuskokwim	Circulation pipe	Piped gravity
Pilot Station	463	Yukon-Kuskokwim	Circulation pipe	Piped gravity
Russian Mission	246	Yukon-Kuskokwim	Circulation pipe	Piped gravity
Saint Mary's	441	Yukon-Kuskokwim	Circulation pipe	Piped gravity
Scammon Bay	343	Yukon-Kuskokwim	Circulation pipe	Piped gravity
Toksook Bay	420	Yukon-Kuskokwim	Circulation pipe	Piped gravity
Aniak	540	Yukon-Kuskokwim	Individual wells	Piped gravity
Emmonak	642	Yukon-Kuskokwim	Circulation pipe	Piped vacuum
Red Devil	53	Yukon-Kuskokwim	Individual wells	Individual privy
Sleetmute	106	Yukon-Kuskokwim	Individual wells	Individual privy
Stony River	51	Yukon-Kuskokwim	Individual wells	Individual privy
Lime Village	42	Yukon-Kuskokwim	Watering Point	Individual privy
Akiak	285	Yukon-Kuskokwim	individual wells	Individual septic
Chenega	94	North Pacific Rim	Conventional pipe	Piped gravity
English Bay	158	North Pacific; Rim	Conventional pipe	Piped gravity
Port Graham	166	North Pacific Rim	Conventional pipe	Piped gravity
Tatitlek	119	North Pacific Rim	Conventional pipe	Piped gravity
Tyonek	154	Chugach	Conventional pipe	Piped gravity
Eklutna	381	Chugach	Conventional pipe	Individual septic
Chickaloon	147	Chugach	Individual wells	Individual septic
Ninilchick	425	Chugach	Watering point	Individual septic
Grayling	208	Tanana Chiefs	Circulation pipe	Piped gravity
Holy Cross	277	Tanana Chiefs	Circulation pipe	Piped gravity
Kaltag	240	Tanana Chiefs	Circulation pipe	Piped gravity
Ninto	218	Tanana Chiefs	Circulation pipe	Piped gravity
Nenana	393	Tanana Chiefs	Circulation pipe	Piped gravity
Huslia	207	Tanana Chiefs	Washeteria	Piped gravity

Community	Population	Regional corporation	Existing potable water system	Existing sewer system
Nikolai	109	Tanana Chiefs	Washeteria	Piped sewer
Anvik	82	Tanana Chiefs	Individual wells	Individual privy
Allakaket	138	Tanana Chiefs	Washeteria	Individual privy
Arctic Village	96	Tanana Chiefs	Washeteria	Individual privy
Beaver	103	Tanana Chiefs	Washeteria	Individual privy
Birch Creek	42	Tanana Chiefs	Washeteria	Individual privy
Circle	73	Tanana Chiefs	Washeteria	Individual privy
Eagle Village	35	Tanana Chiefs	Washeteria	Individual privy
Hughes	54	Tanana Chiefs	Washeteria	Individual privy
Koyukuk	126	Tanana Chiefs	Washeteria	Individual privy
Nulato	359	Tanana Chiefs	Washeteria	Individual privy
Rampart	68	Tanana Chiefs	Washeteria	Individual privy
Ruby	170	Tanana Chiefs	Washeteria	Individual privy
Shageluk	139	Tanana Chiefs	Washeteria	Individual privy
Takotna	38	Tanana Chiefs	Washeteria	Individual privy
Tanana	345	Tanana Chiefs	Washeteria	Individual privy
Tetlin	87	Tanana Chiefs	Washeteria	Individual privy
Alatna	31	Tanana Chiefs	Watering point	Individual privy
Chalkyitsik	90	Tanana Chiefs	Watering point	Individual privy
Healy Lake	47	Tanana Chiefs	Watering point	Individual privy
Manley Hot Springs	96	Tanana Chiefs	Watering point	Individual privy
Northway	113	Tanana Chiefs	Watering point	Individual privy
Stevens Village	102	Tanana Chiefs	Watering point	Individual privy
Tel Ida	11	Tanana Chiefs	Watering point	Individual privy
Venetie	182	Tanana Chiefs	Watering point	Individual privy
Evansville	7	Tanana Chiefs	None	Individual septic
McGrath	528	Tanana Chiefs	Circulation pipe	Community septic
Tan across	106	Tanana Chiefs	Circulation pipe	Community septic
Dot Lake	53	Tanana Chiefs	Washeteria	Community septic
Fort Yukon	580	Tanana Chiefs	Circulation pipe	Vacuum truck haul
Galena	833	Tanana Chiefs	Washeteria	Vacuum truck haul
Akhiok	77	Kodiak	Conventional pipe	Piped gravity
Karluk	71	Kodiak	Conventional pipe	Piped gravity
Larsen Bay	147	Kodiak	Conventional pipe	Piped gravity
Old Harbor	284	Kodiak	Conventional pipe	Piped gravity
Duzinkie	209	Kodiak	Conventional pipe	Piped gravity
Port Lions	222	Kodiak	Conventional pipe	Piped gravity
Selawik	596	Northwest Arctic	Washeteria	Honey bucket bunker
Kivalina	317	Northwest Arctic	Watering point	Honey bucket bunker
Buckland	318	Northwest Arctic	Washeteria	Honey bucket haul
Deering	157	Northwest Arctic	Washeteria	Honey bucket haul
Ambler	311	Northwest Arctic	Circulation pipe	Piped gravity
Klana	385	Northwest Arctic	Circulation pipe	Piped gravity
Kotzebue	2,751	Northwest Arctic	Circulation pipe	Piped gravity
Noatak	333	Northwest Arctic	Circulatlon pipe	Piped gravity
Shungnak	223	Northwest Arctic	Circulation pipe	Piped gravity
Noorvik	531	Northwest Arctic	Circulatlon pipe	Piped vacuum
Kobuk	69	Northwest Arctic	Washeteria	Individual privy
Angoon	638	Southeast	Conventional pipe	Piped gravity
Annette	40	Southeast	Conventional pipe	Piped gravity

Community	Population	Regional corporation	Existing potable water system	Existing sewer system
Craig	1,260	Southeast	Conventional pipe	Piped gravity
Hoonah	795	Southeast	Conventional pipe	Piped gravity
Hydaburg	384	Southeast	Conventional pipe	Piped gravity
Kake	700	Southeast	Conventional pipe	Piped gravity
Kasaan	54	Southeast	Conventional pipe	Piped gravity
Klawock	722	Southeast	Conventional pipe	Piped gravity
Klukwan	195	Southeast	Conventional pipe	Piped gravity
Metlakatla	1234	Southeast	Conventional pipe	Piped gravity
Saxman	369	Southeast	Conventional pipe	Piped gravity
Yakutat	534	Southeast	Conventional pipe	Piped gravity

NOTES:

Water Supply System Types

Watering point—Single community source available—homes served by hauled water.
Washeteria—Community served by washeteria with Watering point. Homes served with hauled water.
Individual wells—Homes served by conventional wells with piped water.
Conventional pipe—Homes served by conventional piped water distribution system.
Circulation pipe—Homes served by circulating piped water distribution system with added heat features.

Sewer System Types

Individual privy—Homes have individual privy for waste disposal; graywater may or may not have a seepage pit.
Honey bucket bunker—Honey bucket waste is taken by individuals to privy, bunker, or lagoon for disposal.
Honey bucket haul—Individuals take honey bucket waste to a nearby disposal container, which is then hauled by small vehicles to a disposal site.
Truck haul—Individuals carry honey bucket waste to disposal containers which are then hauled to disposal sites by trucks.
Vacuum truck haul—Homes have flush toilets and outside storage tanks. Haul service transports waste from the tank to disposal site, (used in communities with gravel roads).
Individual septic—Homes have flush toilets with Individual septic tanks and drain fields.
Community septic—Homes have flush toilets draining to community collection systems served by a community septic tank and drain field; sewage lift stations may be used.
Piped gravity—Homes have flush toilets draining to a community collection system served by some form of treatment; sewage lift stations may be used.
Piped vacuum—Homes have special flush toilets that discharge to a vacuum sewer system. The vacuum system discharges to a sewage treatment system.

SOURCE: Jim Crum, Division of Sanitation Facilities, Alaska Area Native Health Service, Anchorage, "Waste Disposal in Rural Alaskan Villages: Data Analysis," Nov. 9, 1993.

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