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Resilient Communities

Alaskans Building for Climate Change

PREPARED FOR

The Nature Conservancy

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Executive Summary

This briefing paper summarizes the opportunity for investment in community infrastructure in rural Alaska. With climate change already impacting infrastructure especially in rural Alaska, it is critical to invest in more resilient systems and facilities. Investment in this infrastructure in rural Alaska is timely and especially important for several compelling reasons:

- Rural Alaska communities are on the **front lines of climate change**. Coastal erosion, flooding, permafrost degradation, and wildfires are already damaging community infrastructure and forcing community relocation.
- Infrastructure in rural Alaska is generally **underdeveloped, aging, and inefficient**. Residents and communities face high maintenance and operating costs for these systems and buildings.
- Due to poorly developed infrastructure, there is stark **inequity** between the standard of living in rural Alaska and that enjoyed across the U.S. This inequity has complicated the response to the COVID-19 pandemic, especially in rural communities with limited or no access to clean water.
- Mitigating the impacts of climate change and constructing more resilient infrastructure in rural Alaska are important in the effort to ensure **environmental justice** – where all citizens have the same protections from environmental hazards.

Infrastructure Investment

Hundreds of millions of dollars in public and private funding are spent each year to repair, replace, or construct infrastructure in rural Alaska. Funding for these improvements varies in scale and source. An independent federal agency, the Denali Commission is at the nexus of many of these efforts, acting in partnership with organizations such as the Alaska Native Tribal Health Consortium, Alaska Energy Authority, the Alaska Department of Environmental Conservation, and many others.

Infrastructure investments collectively support jobs in rural Alaska where employment opportunities are often scarce. Similar to construction and major maintenance across the state, these efforts support jobs at a rate of **10 to 20 jobs per million spent**. Investment in measures such as erosion control and wildfire prevention also preserve existing infrastructure that would cost billions of dollars to replace.

Opportunities

An estimated 144 rural Alaska communities are facing infrastructure damage from erosion, flooding, and permafrost thawing. Proactively mitigating this damage will help preserve billions of dollars in existing community infrastructure and must be a top priority. An estimated $4.3 billion in funding is needed for mitigation work over the next decade. Mitigating these impacts in rural Alaska is essential to advancing environmental justice, ensuring all citizens have equal protection from the mounting environmental hazards wrought by climate change. Several factors will be critical to this effort:

- Establishing a **lead funding agency** to address climate change-related infrastructure damage mitigation efforts is a critical step to reducing regulatory barriers and improving equitable access to these badly needed resources.
- Work to create **comprehensive policy** to address these mitigation efforts. Community relocation must include meaningful participation by indigenous communities to ensure equitable access to resources.
- **Federal infrastructure legislation** currently under consideration provides a pivotal opportunity to fill the substantial investment gap in resilient infrastructure in rural Alaska.

Beyond mitigating the impacts of climate change, vast opportunity exists to reduce inequities in infrastructure development between rural Alaska and the rest of the United States. Substantial new investment in infrastructure repair, rehabilitation, and construction will be required to increase community resilience and sustainability in the face of climate change.

- 32 rural Alaska communities still lack a piped **water/sewer system**, and many more contend with aging, inefficient infrastructure. An estimated $1.8 billion will be required to close the gap in rural Alaska's sanitation systems.
- An estimated 10% of rural, Class III **landfills** in Alaska are not permitted, limiting access to funding for improvements. Permitted, resilient landfill infrastructure is critical to mitigating health and safety risks from erosion, flooding, and other impacts.
- **Schools** provide much more than education in rural Alaska. An annual gap of $197 million exists between current facility funding and that needed to construct and maintain energy efficient, quality school infrastructure in Alaska.
- Aging, **carbon-intensive energy infrastructure** in rural Alaska places high cost burdens on residents. More than $300 million in investments will be required to upgrade this aging infrastructure, and additional investment will be required to transition systems towards Alaska's vast renewable resources.
- Community-led efforts to improve **transportation** to and within rural communities can reduce the high cost of living and costs of climate change-mitigation efforts across Alaska.
- An estimated 10,000 buildings in rural Alaska. including **tribal halls, government offices, youth centers**, and more need comprehensive energy-efficiency services to reduce intense energy use and costs.

Introduction

Infrastructure in much of rural Alaska is aging, underdeveloped, and inefficient. Climate change is exacerbating the inequities in the quality of infrastructure in these rural communities and elsewhere in the United States. Melting permafrost, coastal erosion, flooding, and wildfires have already impacted the basic utilities and facilities necessary for community life. While millions of state, federal, local and tribal government dollars, as well as private resources, are spent annually to construct and maintain these systems, funding needs continue to outpace availability.

This paper describes rural Alaska's community infrastructure, gives examples of investments made to improve that infrastructure over the past several years, and describes opportunities for further investments.

What is community infrastructure?

Community infrastructure includes the utility systems and facilities that provide basic services to residents. These include water/sewer systems, electric utilities, school facilities, tribal halls, landfills, ports and transportation facilities, and other facilities. In rural Alaska, this community infrastructure may include a "washateria," a public building offering public showers, laundry facilities, and flush toilets in the absence of water/sewer systems.

Special thanks to the following organizations, which provided data and information for this research:

- Alaska Department of Education and Early Development, Facilities
- Alaska Department of Environmental Conservation, Division of Water
- Alaska Department of Environmental Conservation, Division of Environmental Health, Solid Waste Program
- Alaska Energy Authority
- Alaska Native Tribal Health Consortium, Center for Environmentally Threatened Communities
- Alaska Native Tribal Health Consortium, Rural Energy Program
- Denali Commission
- North Slope Borough

Front cover photo credits: Department of Commerce, Community and Economic Development; Division of Community and Regional Affairs' Community Photo Library. Atmautluak Sewer Line, 2006.

Rural Community Infrastructure

Spread over a vast geography, rural Alaska is characterized by small, isolated communities with limited transportation connections. Building and maintaining basic infrastructure across more than 280 communities spread over 663,000 square miles is a primary challenge for the state, and one that is increasingly impacted by climate change.

In general, Alaska's infrastructure is:

Underdeveloped

Rural Alaska is substantially underdeveloped, and many communities lack basic infrastructure – such as indoor plumbing – considered essential in urban Alaska and across the country. For those communities with infrastructure in place, systems and facilities are aging, inefficient, and vulnerable to climate change. Alaska's Infrastructure Report Card, developed by the American Society of Civil Engineers (ASCE) Alaska Section, assigned a grade of C- (on an A through F scale) to the state's overall infrastructure, reflecting the lack of and poor condition of the state's transportation, utilities, and other infrastructure. Given the influence of urban infrastructure in this scoring and lack of systems in many communities, even this grade overstates conditions in rural Alaska.

As an example of this infrastructure gap, 32 Alaska villages have no central water/sewer system, leaving 3,300 rural homes without running water or a flush toilet.[1] Even in communities with water and wastewater systems, many homes may not be connected to these utilities. In 75 rural Alaska communities, 55% or fewer homes are served by existing water and wastewater systems.[2] This lack of infrastructure disproportionately impacts Alaska Native households. As of 2017, nearly one-quarter (23%) of Alaska Native households lacked complete plumbing, compared to 4% statewide.[3]

[1] Alaska Department of Environmental Conservation, Division of Water. *Alaska Water and Sewer Challenge*.
[2] American Society of Civil Engineers – Alaska. *Alaska Infrastructure Report Card*. 2017.
[3] American Society of Civil Engineers – Alaska. *Alaska Infrastructure Report Card*. 2017; US Census Bureau, American Community Survey 2015-2019 5-Year Estimates

Inequitable

Indigenous communities in Alaska at once contend with aging, inefficient infrastructure and pay high costs for services such as electricity, water, and garbage disposal (in places where these services exist at all).

In the most extreme cases, villages have no services whatsoever. In the 32 villages with no piped water/wastewater systems, residents are forced to haul fresh water to their homes and use "honey buckets" in place of flush toilets. Many communities continue to have unpermitted landfills, where open burning comes with health and safety risks. The inequity between this standard of living and that enjoyed across the U.S. is stark.

These inequities have further complicated the response to the COVID-19 pandemic in rural Alaska. Simple health measures such as hand washing are not a given in remote communities that have limited access to clean water and wastewater systems.

Aging

Much of rural Alaska's infrastructure was built in the 1970s and 1980s and is beyond its useful life. In some instances, designs and construction materials used in that era were ill-suited to Alaska's harsh climate, leaving many systems at risk of failure.[4] Infrastructure such as rural electric utility systems and water/wastewater systems that have reached their useful life now have mounting repair and upgrade needs.

Isolated

More than 200 communities in rural Alaska are not connected to the road system and are far from a regional hub, forcing residents to rely on air and water transportation. Even for coastal communities, short shipping seasons and lack of port or harbor infrastructure limits waterborne transportation. Remote geographies and lack of transportation options contribute to complex supply chains, driving up the cost of living for families across the state.

Isolated communities in rural Alaska have limited opportunity to achieve economies of scale in utility operations. For example, the state's rural energy infrastructure is characterized by more than 150 islanded microgrids, another result of these vast geographic expanses. The small scale of each power plant, reliance on diesel generation, and limited transportation infrastructure all drive high energy costs in rural Alaska, where electricity consumers pay more than double the U.S. average price per kilowatt hour (kWh).[5] Municipal waste systems offer another example of

[4] American Society of Civil Engineers – Alaska. *Alaska Infrastructure Report Card*. 2017.
[5] U.S. Energy Information Administration. *State Energy Data System 1960-2018*.

the limits to economies of scale in rural Alaska; due to lack of road connections, communities cannot rely on shared landfill infrastructure.

Complex

To accommodate varied landscapes and low populations, infrastructure in rural Alaska is often complex. For example, the presence of permafrost (permanently frozen ground) necessitates construction of above-ground water/sewer systems. Landfill operations too are impacted by these atypical conditions. Across Alaska, 184 communities use a "Class III" landfill (less than five tons of waste disposal per day), a category not used elsewhere in the United States. Nearly all rural Alaska communities use open waste disposal sites, and in some communities, pads on permafrost serve as the local landfill.[6]

Impacted by Climate Change

Climate change is already impacting communities across Alaska. Permafrost melt threatens the structural integrity of utility infrastructure and building foundations and can cause structures to sink into the ground. Reduced sea ice has been linked to greater wave exposure in coastal communities, accelerating erosion. River communities also face increasing erosion. In both cases, erosion can lead to buildings and other infrastructure collapsing, or leave the community more vulnerable to flooding. Permafrost melt, erosion, and flooding can all disturb waste disposal sites, risking exposure of hazardous substances and garbage. These effects of climate change have also impacted rural communities' limited transportation infrastructure, washing out roads and boardwalks.

A 2019 U.S. Army Corps of Engineers report evaluated the severity of climate change impacts to rural Alaska communities. The report identified 29 communities with imminent threats from erosion, 38 with imminent flooding danger, and 35 with high risk of damage due to thawing permafrost.[7] Communities facing these immediate threats are generally remote, and many have predominantly Alaska Native populations.

Rising temperatures and drought conditions related to climate change have been linked to intensified wildfire seasons in Alaska.[8] With an estimated 80% of Alaskans living in areas at risk of wildfire, these intense fires come with catastrophic risks: loss of life and injury, infrastructure damage, and adverse health impacts.

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[6] American Society of Civil Engineers – Alaska. *Alaska Infrastructure Report Card*. 2017.
[7] U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory. *Statewide Threat Assessment: Identification of Threats from Erosion, Flooding, and Thawing Permafrost in Remote Alaska Communities*. November 2019.
[8] Grabinski, Z. & H.R. McFarland. *Alaska's changing wildfire environment*. Alaska Fire Science Consortium, International Arctic Research Center, University of Alaska Fairbanks. 2020.

The impacts of climate change on Alaska's infrastructure are disproportionately felt in rural, predominately Alaska Native communities across the state. Mitigating the impacts of climate change and constructing more resilient infrastructure are important in the effort to ensure environmental justice – meaning that all citizens have the same degree of protection from environmental hazards.

Village Relocation

As of 2019, at least 12 communities facing imminent threats from climate change were exploring relocation. The Denali Commission is designated as the lead coordinating agency for federal, state, and tribal resources to address climate change impacts. The Commission operates the Village Infrastructure Protection (VIP) program to assist rural Alaska communities threatened by erosion, flooding, and permafrost degradation. The Commission has deployed nearly $100 million in funding through the VIP program, yet much more will be required to address community relocation needs. As of 2017, the U.S. Department of the Interior was coordinating an effort to develop an Adaptive Village Relocation Framework for Alaska to define a relocation process more clearly; to date, no framework has been published.

Energy Intensive

On a per capita basis, Alaska ranks fifth highest in the nation in commercial energy consumption, with service-providing facilities and equipment consuming about 40% more energy per capita than the national average.[9] The state's cold climate drives this high energy intensity. Heating degree day metrics provide a measure of days per year that space heating is generally required. In Alaska, average heating degree days per year range from 7,000 in Southeast Alaska to 20,000 on the North Slope, compared to the national average of 9,000 to 12,600 for all very cold climates across the country.[10]

Environmental considerations, such as construction on permafrost, also contribute to high energy intensity. For example, many communities in Alaska have above-ground water/sewer systems due to permafrost conditions, and these systems require additional heat to prevent freezing of the water and sewer mains. Aging infrastructure and deferred maintenance also contribute to energy inefficiency in utility systems and public buildings throughout rural Alaska.

At the same time climate change threatens the structural integrity of community infrastructure, community assets such as water/sewer systems and schools continue to rely heavily on carbon-

[9] U.S. Energy Information Administration. *State Energy Data 2019*.
[10] Alaska Housing Finance Corporation. *Alaska Housing Assessment*. 2018.

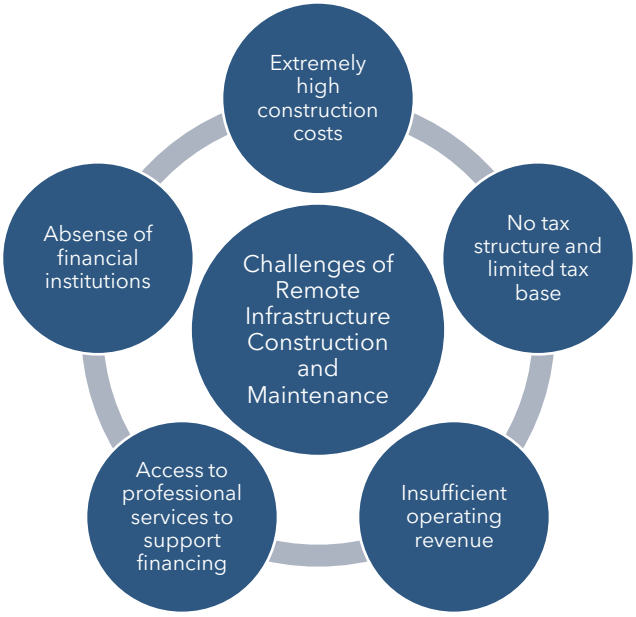
intensive fossil fuels for energy generation. High fuel costs borne by utility operators are often passed on to consumers, contributing to high cost of living for families in rural Alaska and the high cost of operating public facilities such as schools. These fuel sources are carbon-intensive not only in the fuel source itself, but also along the supply chain required to bring fuel to remote communities.

Expensive to Construct, Maintain, and Operate

Logistics and costs related to infrastructure construction, replacement, or major maintenance can be starkly different between Alaska's urban communities and rural, remote, and oftentimes very small communities. Communities with no road connections face multifaceted challenges such as very expensive materials and construction costs, limited access to construction professionals, and limited access to construction equipment. The challenges of engineering and construction in arctic environments with conditions such as permafrost exacerbate these costs.

Many utility system operators have limited revenue, lack access to financing, or do not have a tax base able to support system upgrades or replacement. Programs designed to facilitate efficiency or energy conversion investments in facilities, such as Commercial Property Assessed Clean Energy (C-PACE) programs, hold little opportunity for these rural communities that lack a property tax structure or sufficient tax base, or for which most community buildings are publicly owned.[11] These factors make federal and state investment in community infrastructure critical to rural Alaska.

Figure 1. Barriers to Infrastructure Improvements in Rural Alaska



[11] Vermont Energy Investment Corporation. *Alaska Energy Authority Energy Efficiency Program Evaluation and Financing Needs Assessment*. July 2016.

Infrastructure Investment

While it is outside this paper's scope to detail the investment already devoted to reducing the impact of climate change and increasing energy efficiency of community infrastructure, hundreds of millions of dollars have certainly been spent over the last decade for improvements across the state. Not all infrastructure investment has been related to the accelerating impacts of climate change. Yet design and construction professionals have had to contend with a changing environment and consider energy best practices as new infrastructure has been built.

While not comprehensive, the programs and funding described below illustrate the level of infrastructure investment made across Alaska in the last decade. In many instances, these public funding sources have leveraged private funding to achieve infrastructure improvements. In addition to these federal and state funding sources, local and borough governments, tribal organizations, and others spend millions of dollars annually on infrastructure improvements.

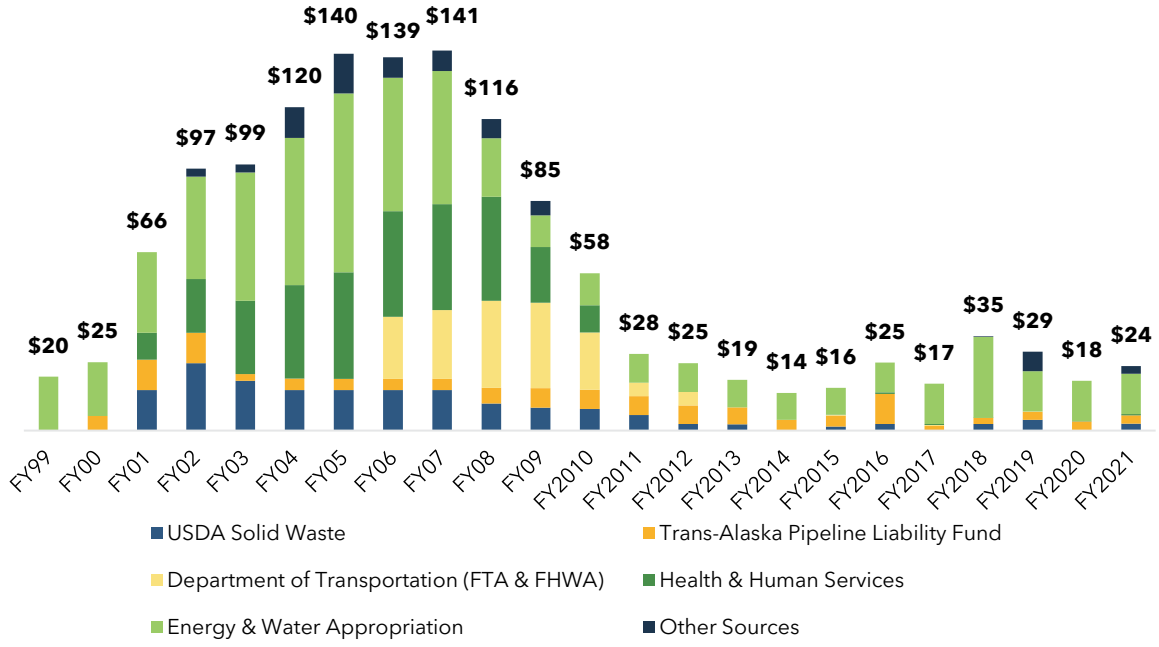
Denali Commission

Established by federal legislation in 1998, the Denali Commission is an independent federal agency whose mission is to provide critical utilities, infrastructure, and economic support in rural Alaska. The Commission plays a key role in funding infrastructure improvements through partnerships with organizations such as the Alaska Energy Authority (AEA), the Alaska Native Tribal Health Consortium (ANTHC), and others.

Over the Commission's 20-year history, the organization has funded several categories of infrastructure: bulk fuel storage, rural power systems, transportation systems, health care facilities, housing, and sanitation systems. In some instances, programs initiated by the Denali Commission have since been transferred to other agencies, as in the case of the Alaska Energy Authority assuming responsibility for the Renewable Energy Fund, or funding has been discontinued. Since a high of $141 million in FY2007, funding allocated to the Denali Commission from various sources has decreased precipitously.

(See chart on next page)

Figure 2. Denali Commission Funding Sources, FFY1999-FFY2021 ($millions)



Source: Denali Commission

The last several years of Denali Commission Work Plans describe the level of funding allocated to various programs. Energy Reliability and Security programs such as improvements to diesel power plants, support for renewables integration, and rural power system programs have been among those with the highest funding over the last several years, followed by bulk fuel safety and security work.

Table 1. Denali Commission Work Plan by Program, FY2016-FY2021 ($millions)

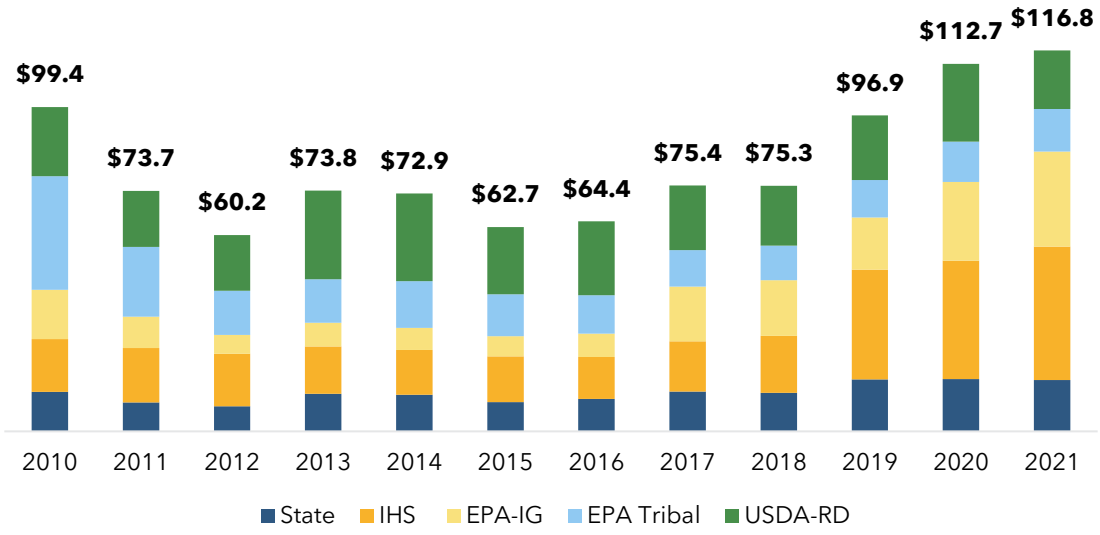
Program	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021
Energy Reliability and Security	$3.8	$6.8	$6.8	$6.8	$6.5	$4.9
Bulk Fuel Safety and Security	$4.9	$3.6	$1.9	$1.9	$2.2	$2.2
Workforce and Economic Development	-	-	-	-	$2.1	$1.7
Sanitation (Village Water & Wastewater, Solid Waste)	-	-	-	-	$2.0	$1.5
Transportation	$7.2	-	$1.2	-	$1.0	$1.0
Broadband	-	-	-	-	$1.0	$0.8
Health Facilities	-	-	-	-	$1.0	$0.8
Housing	-	-	-	-	$0.5	$0.5
Village Infrastructure Protection	$6.7	$5.0	$5.0	$5.0	$1.0	$0.5
Total	**$22.5**	**$15.4**	**$14.9**	**$13.7**	**$17.3**	**$13.8**

Source: Denali Commission

Water/Sewer Systems

With many communities contending with aging water/wastewater infrastructure, the state Village Safe Water (VSW) program and the Alaska Native Tribal Health Consortium (ANTHC) have facilitated millions of dollars in investments over the last decade to install and improve these systems in rural Alaska. Between FY2010 and FY2021, the state and federal government appropriated nearly $1 billion in water/wastewater system funding. Annual funding has increased over the last five fiscal years due to increases in Indian Health Service (IHS) and Environmental Protection Agency (EPA) funding for these improvements.

Figure 3. Rural Alaska Water/Wastewater Infrastructure Improvement Funding, SFY2010-SFY2021 ($millions)



Source: Alaska Department of Environmental Conservation, Division of Water

Landfills

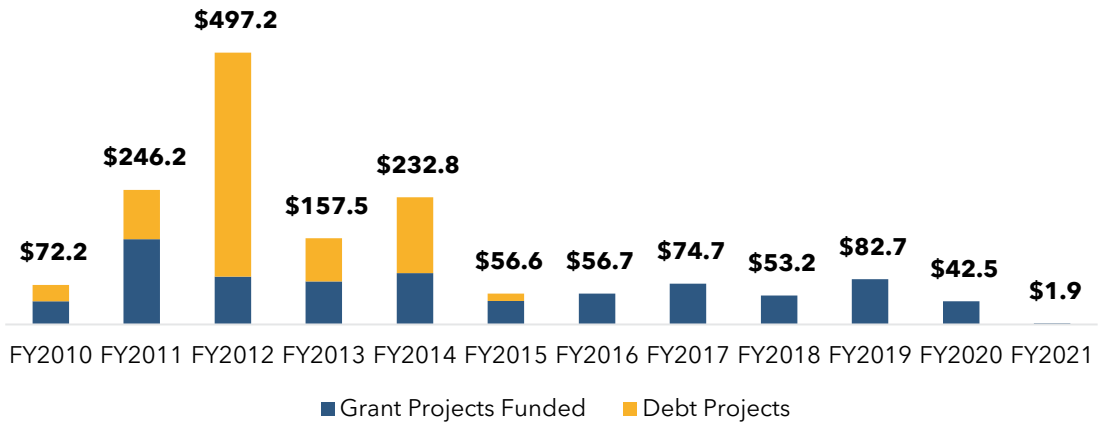
Landfills are the unsung heroes of many communities, ensuring community health and protecting natural resources from contamination. Across the varied landscapes of rural Alaska, landfills must be designed and constructed carefully. Finding a dry site on high ground can be a challenge and in areas of permafrost or wetlands, creating a gravel barrier can be a necessary part of these efforts. Due to the decentralized nature of landfill operations in Alaska, the overall level of funding for construction or major maintenance of these sites is unknown. Federal funding through the U.S. Department of Agriculture (USDA) Rural Development, Indian Health Service, and the Environmental Protection Agency all contribute to funding landfill construction and improvements in Alaska.

School Construction and Major Maintenance

Alaska has more than 500 K-12 school buildings spread over an expansive geography.[12] Due to the vast distances and limited transportation connections between communities, maintaining school facilities in each community is a vital component in ensuring equity in educational opportunities in rural Alaska. Especially in small villages, school buildings serve more than an educational purpose and are often a center of community life. They also may be one of the only buildings in the community with running water. The State of Alaska recognizes this by funding construction and major maintenance projects across the state. Districts are required to provide a local match based on the value of district property and number of students. In FY2022, these local match percentages ranged from lows of 2% in many rural districts up to 35% in urban areas such as Anchorage.[13]

Between FY2010 and FY2020, the state directly provided $813 million in grants to school districts for construction and major maintenance, and an additional $760 million in school bond debt reimbursement. Annual funding has decreased as the state's financial position has changed, and in 2015 the legislature placed a moratorium on new bond debt reimbursement projects until 2025.

Figure 4. State of Alaska School Construction and Major Maintenance Spending, FY2010-FY2020 (in millions)



Source: Alaska Department of Education and Early Development

School building energy efficiency is important in reducing the intense use of energy in rural Alaska. Funding for construction and major maintenance is a critical part of maintaining energy efficient infrastructure. Since 2013, the Alaska Department of Education and Early Development (DEED) has required school construction and renovation projects to meet energy efficiency

[12] 21st Century School Fund, Inc. *State of Our Schools: America's K-12 Facilities*. 2016.
[13] Alaska Department of Education and Early Development. *FY2022 Participating Share Requirements*. 2020.

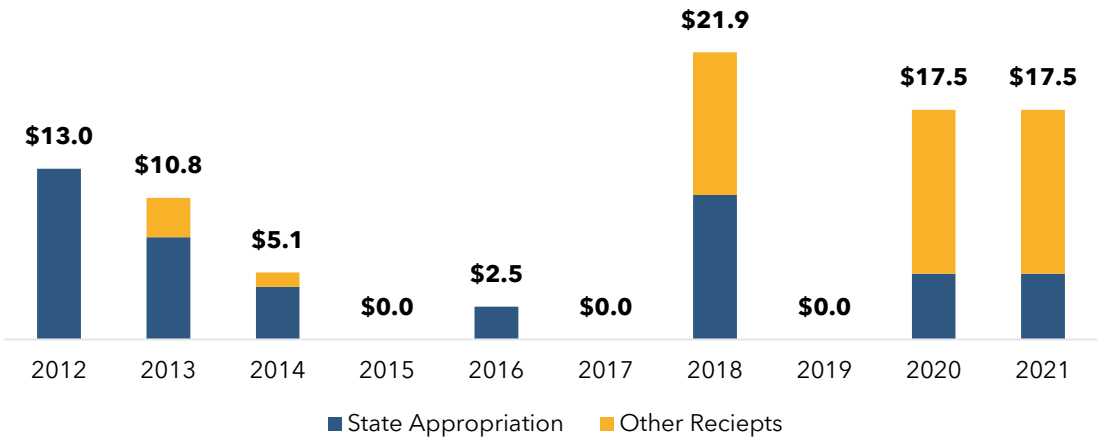
standards to receive state funding. The Department is currently working towards implementation of school facility building standards and guidelines which have been used elsewhere in the United States to ensure educational equity and efficiency measures.

Energy Systems

Energy utility operators invest considerably in plants and equipment, yet the small scale of many utilities in rural Alaska often leaves little revenue for needed maintenance or upgrades. Using state and federal funding, the Alaska Energy Authority (AEA) is a key funder of energy system upgrade and conversion in rural Alaska.

AEA's Rural Power Systems Upgrade (RPSU) program is one way communities can leverage public dollars to fund needed efficiency improvements, powerhouse upgrades or repairs, heat recovery, repairs to generator and distribution systems, and others. To be eligible, communities must have 2,000 residents or fewer and not be connected to the Railbelt or other major hydroelectric power grids. AEA prioritizes projects based on several criteria, which include the potential risk of flooding or erosion and potential efficiency improvements. State appropriations for the RPSU program have been variable over the last decade but have increased along with federal and other funding sources in FY2020 and FY2021.

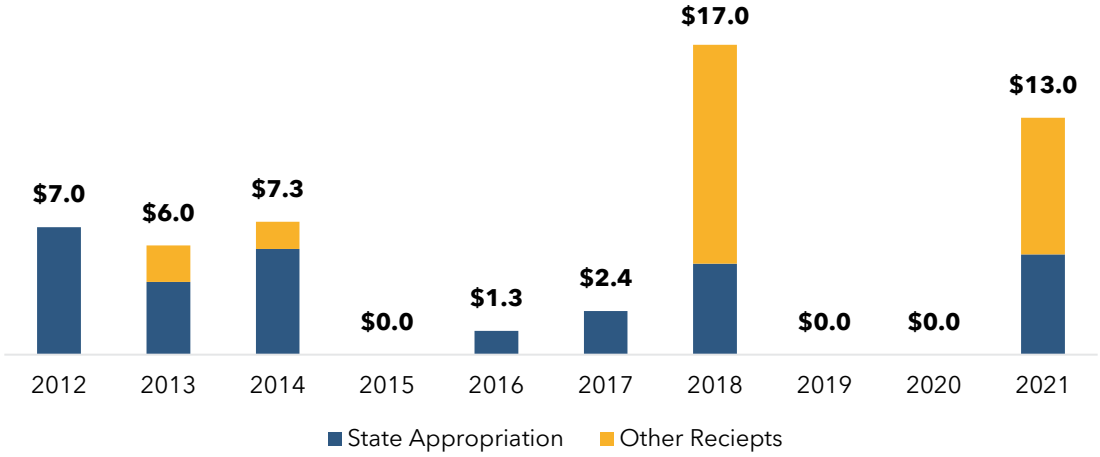
Figure 5. Rural Power Systems Upgrade Program Funding, SFY2012-SFY2021 ($million)



Source: Alaska Energy Authority

Bulk fuel facilities are important to rural communities' ability to achieve cost savings on diesel and other fuel purchases and, in some communities, minimize transportation costs associated with frequent, expensive air shipments.

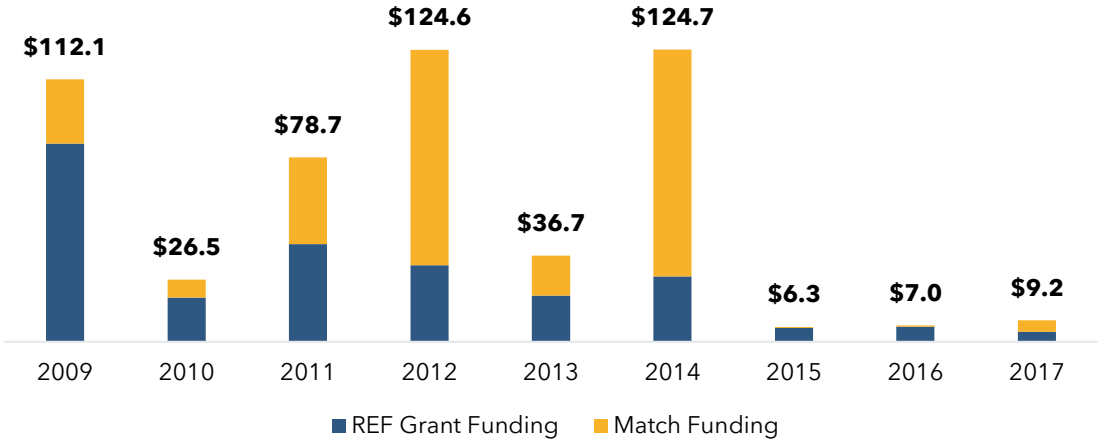
Figure 6. Bulk Fuel Upgrade Program Funding, SFY2012-SFY2021 ($millions)



Source: Alaska Energy Authority

The Authority also contributes to energy conversions through the Renewable Energy Fund (REF), which provides grant assistance for feasibility studies, design, and construction of renewable energy systems. Established in 2008, $242 million in REF grant funding and $306 million in match funding has been spent through the program.[14] The program is currently authorized by the Alaska State Legislature through 2022.

Figure 7. Renewable Energy Fund Grant and Match Funding by Award Year, SFY2009-SFY2017 ($millions)



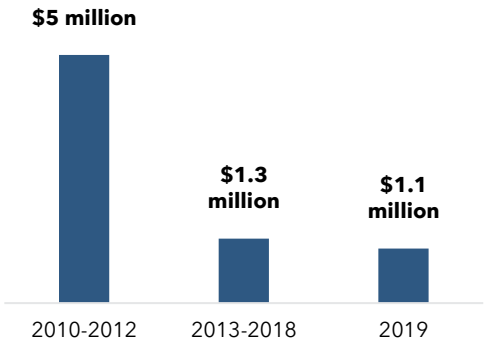
Source: Alaska Energy Authority

[14] Alaska Energy Authority. *Renewable Energy Fund Projects Round 1-12*. Accessed August 2021.

Other Community Buildings

Outside of the systems and infrastructure already described, nonresidential buildings can also be high consumers of energy in rural Alaska. Public buildings including tribal halls, city or tribal council offices, youth centers, and others can often achieve higher energy efficiency through upgrades to lighting, upgrades to water heaters and boilers, and weatherization efforts. AEA's Village Energy Efficiency Program (VEEP) has been one funding source available intermittently to communities to fund these types of energy-savings improvements. Originally implemented in 2005, the program aimed to provide "whole village" retrofits. Due to changing funding sources, the program offered only outdoor lighting retrofits in 2019 and 2020.

Figure 8. AEA Village Energy Efficiency Program Funding by Phase



Source: Alaska Energy Authority

Economic Impacts

Infrastructure investment in rural Alaska serves several purposes: providing a basic standard of living for residents, reducing household cost burdens, unlocking economic opportunities, and preserving infrastructure in places where the impacts of climate change are intensifying. Along with these impacts, investment supports construction and major maintenance-related employment in rural Alaska. These jobs can be particularly important in Alaska's remote communities where employment opportunities are scare. Funding also positively impacts employment in the state's business and professional services sector which are often involved in project design, planning, and execution.

The number of jobs and materials required to complete these infrastructure projects varies widely by project type and location. For example, transportation costs may represent a higher proportion of project costs for communities accessible only by air compared to those with barge service. Overall, infrastructure-related major maintenance and construction spending supports jobs at a rate of 10 to 20 jobs per million dollars invested, typical for construction projects in Alaska. Every $100 million in infrastructure investment supports about 1,000 to 2,000 jobs, including those directly employed in construction and indirect and induced employment supported as firms contract with others for goods and services and construction employees spend their wages in Alaska.

In addition to construction and major maintenance-related employment, efforts to mitigate the impacts of climate change on infrastructure come with important job opportunities. Crews

stationed in rural Alaska to prevent and curtail wildfire damage provide stable job opportunities in communities with limited employment opportunities.

Resilient Infrastructure

For communities and infrastructure already threatened by climate change impacts, investment in measures such as erosion control are critical to increasing the resiliency of utility systems, transportation assets, and buildings already constructed in rural Alaska. While some of this threatened infrastructure may be aged, in many instances these assets still have many years of useful life. Investing in mitigation efforts avoids the costs that would be necessary to replace this infrastructure before its regular end-of-life.

Community Sustainability

Increasing efficiency of utility systems in rural Alaska has been an important component of infrastructure funding over the last decade. Utility system inefficiencies often lead to high household bills and community cost burdens. For example, aging water and sewer systems often use energy inefficiently and rely on expensive fossil fuel-generated electricity, leading to monthly utility fees above $150 in some communities. Energy and other utility subsidies are often vital to combat the disproportionately high cost-burdens rural residents face compared to urban Alaska residents. Yet these subsidies face real fiscal constraints. Improving the efficiency of rural Alaska's infrastructure, and in some cases converting power generation to renewable resources, can provide a path toward more sustainable communities in the face of these high costs.

Training and Technical Assistance

Training and technical assistance programs are important to provide operators and administrators with the skills, experience, and support needed to avoid system failures and maximize infrastructure design life. Various programs in Alaska provide assistance specific to each type of infrastructure. Examples include AEA's rural power plant, bulk fuel, and biomass operator training and the state Department of Environmental Conservation's solid waste service training and technical assistance.

The longstanding Remote Maintenance Worker (RMW) program is one example of a program creating jobs in rural Alaska while providing local water/wastewater utilities preventative maintenance assistance and training vital to the health of these systems. The program combines state and regional health corporation funding to station RMWs in regional hubs such as Dillingham, Bethel, and Kotzebue to provide timely assistance in rural Alaska. In addition to on-site and classroom assistance and training, these workers are often the first to assist operators in case of emergency.

The importance of training and technical assistance extends to the administrative functions required by these utilities. Operated by the Alaska Department of Commerce, Community, and Economic Development (DCCED), the Rural Utility Business Advisor (RUBA) program provides managerial and financial training to rural utility operators.

Case Studies

The following are case studies illustrating how communities and systems are impacted by climate change and efforts to mitigate these impacts.

Wildfire

Over the last decade, numerous fires have threatened Alaska communities. Ignited in August 2019, the McKinley Fire illustrates the high costs of infrastructure damage by these events. The 3,753-acre fire burned in the Matanuska-Susitna Valley between Willow and Talkeetna, just north of the borough's population centers of Wasilla and Palmer.[1] Fire destroyed tens of millions of dollars in property, including more than 50 homes, three businesses, 84 outbuildings, and an electrical power line.[1]

In addition to the direct cost of replacing damaged structures and utilities, the impact of fires is felt by residents in other ways. In 2019, Homer Electric Association (HEA) found 15 miles of electric transmission line exposed to the Swan Lake fire, which burned on the Kenai Peninsula. The line is a vital link between electricity generated by the Bradley Lake dam and population centers along Alaska's railbelt. Affordable hydroelectric power is an important component of power consumption in Southcentral Alaska, and damage or disruptions to this transmission line increase consumer costs as providers are forced to shift towards higher-cost fuel substitutes such as natural gas. In total, Southcentral and Interior ratepayers incurred an estimated $10.4 million in additional costs due to transmission line damage from the Swan Lake fire.[1]

Beyond the costs of infrastructure replacement, wildfire suppression comes with significant expense: efforts to suppress wildfires across Alaska in 2019 cost an estimated $300 million.[1]

Several state and federal agencies and tribal organizations are involved in wildfire fighting efforts in Alaska, and work is coordinated by the Alaska Wildland Fire Coordinating Group (AWFCG) and the Alaska Interagency Coordination Center (AICC). Seasonal wildland firefighters from rural communities play a critical role in fighting fires, protecting towns and infrastructure. The federal Bureau of Land Management (BLM) Alaska Fire Service has six active contracts with crews stationed throughout rural Alaska to provide rapid response in remote regions. Additional crews across rural Alaska are hired on an as-needed basis. Contracting with organizations to assemble crews in villages such as Anvik (population 79) and Mountain Village (population 753) come with the additional economic benefit of providing employment opportunities in communities with limited jobs.

Water & Wastewater Systems

Isolated community water/wastewater systems in rural areas must be designed strategically to contend with Alaska's varied environmental conditions. Systems are often built above ground to avoid permafrost thaw. Yet these systems often come with their own challenges, such as the need to continuously heat the system to avoid freezing in above ground and, in some cases, in-ground systems. These systems can represent as much as one-third of a community's energy use in rural Alaska, and energy costs on average represent 39% of total water/wastewater utility operating costs.[1]

Rural communities often have limited cash economies and small tax bases to fund high-cost systems. This contributes to high user fees and, for many utilities, high arrearages as households struggle to pay these costs. In addition to high energy intensity of the systems, water/wastewater utilities in rural Alaska are being impacted by the effects of climate change. Melting permafrost and frost heaving are among the causes of this damage.[1]

Alaska's Village Safe Water (VSW) and the Alaska Native Tribal Health Consortium's (ANTHC's) Division of Environmental Health and Engineering (DEHE) programs combine federal and state funding to provide and improve sanitation in rural Alaska. These agencies work in tandem to administer funding for sanitation improvements by installing new water/wastewater systems and rehabilitating older systems. ANTHC also operates the Rural Energy Program which provides energy solutions for these energy-intensive utilities.

Tackling water/wastewater system energy efficiency and employing alternative sources are both important methods for reducing this high intensity. Applying energy efficiency retrofits such as upgrading lighting, boiler replacement or maintenance, and others can have immediate impacts to energy use and community costs. For example, ANTHC's efficiency work in Pilot Station saved the community an estimated $11,090 annually in fuel oil and electricity costs, which included an estimated $8,750 savings to the state Power Cost Equalization (PCE) program, which subsidizes electricity rates in rural Alaska.[1]

In many instances, adding renewable energy generation can also offset high operating costs. Installing technology like wood-fired boilers, solar panels, wind turbines, or heat pumps reduces reliance on carbon-intensive diesel fuel or heating oil used to generate power in these remote communities. Heat recovery systems have also been implemented with great success. These systems capture excess heat generated by the local power plant and use that wasted energy to heat the water plant. In 2014, the village of Savoonga, an island community off the coast of western Alaska, installed a heat recovery system capturing waste heat from the local power plant to heat the water treatment plant, resulting in an estimated annual $40,000 in fuel savings to the community. Power plant operator Alaska Village Electric Cooperative (AVEC) is a critical partner in this system.

Erosion Control

Accelerating erosion is threatening infrastructure across many of Alaska's coastal and riverine communities. Decreased sea ice cover and frequent storms have increased erosion and flooding in Utqiagvik, the United States' northernmost community and home to about 5,000 residents. These climate change-related impacts currently threaten more than $1 billion in critical infrastructure in Utqiagvik, including water and sewer mains and the utilidor system, which provides access to the system. One particular area of concern is a gravity-fed sewage pump station at the lowest point of Utqiagvik's sewer system. Inundation of this pump station could lead to the loss of water and sewer service for a significant part of the community. Other infrastructure at risk includes electrical conduit and communications cables and private homes, some of which are precipitously close to the bluff. The community's raw sewage lagoon, freshwater lagoon, and landfill are also vulnerable to erosion, and inundation resulting from a storm event could cause hazardous contamination from these sites or contamination of freshwater resources. Projections also indicate the airport could be impacted by erosion in the next 25 years.[1]

Nearly two-thirds of Utqiagvik's residents are Inupiat Inupiaq, and subsistence practices are of vital cultural and economic importance to the community. The area most impacted by erosion and flooding includes access to the only boat launch in Utqiagvik, which is used for subsistence practices such as whale, seal, and walrus hunts.

The community has traditionally managed erosion by constructing temporary "beach berms" made of sand, dirt, rocks, and other materials to hold back storm surges. These berms are built over a nearly four-mile stretch of beach and are truly temporary. Once hit by large waves, the construction materials wash out. These temporary efforts cost the North Slope Borough millions of dollars annually. In addition to being costly, construction of these temporary berms requires nearly all local gravel supply, resulting in building material shortages for other housing and infrastructure projects in the community.

Utqiagvik would benefit greatly from more permanent infrastructure to reduce erosion and prevent flooding. In 2019, the U.S. Army Corps of Engineers (USACE) published a feasibility study that recommended permanent construction projects to mitigate coastal erosion and reduce the risk of property loss and hazardous contamination. The preferred alternative includes construction of revetments and a raised road, with a total construction cost of $328.6 million and operations and maintenance (O&M) costs of $1.7 million annually. Federal funding of the construction project would require a 35% local match by the North Slope Borough. Community members emphasized the importance of beach and subsistence area access throughout the USACE feasibility process, underscoring the need for community-led efforts and consultation in response to climate change impacts in rural Alaska. The USACE is currently in the design phase of this project.

Opportunities for Further Investment

Rural Alaska communities will continue to require investment to ensure access to basic utilities, roads, and community buildings. Bringing this infrastructure into parity with urban Alaska and the Lower 48 will require millions, if not billions, in additional funding, and is necessary to stem the impacts of climate change, preserve billions of dollars of infrastructure already constructed, and improve the standard of living in rural Alaska.

Federal legislation currently under consideration would support investments in key systems and facilities. Proposed new funding for infrastructure including resilient water and power systems would help fill the gap in investment in rural Alaska. Working through state and local governments, this new investment provides a pivotal opportunity to increase the climate-resiliency of infrastructure critical to life in rural Alaska.

Water/Sewer Systems

With 32 rural Alaska communities lacking piped water and wastewater systems and many more contending with aging, energy-intense infrastructure, the state has immediate need for additional investment in this basic utility infrastructure. An estimated $1.8 billion will be required to close the gap in rural Alaska's sanitation systems, including $1.2 billion to install service in communities without these utilities.[15] This need could grow as the effects of climate change continue to affect systems and may not account for the potential of renewable energy integration with these systems.

Program administrators are working to find new ways to account for the impacts of climate change within project prioritization. In 2021, a new category was added to the state VSW project scoring criteria to account for work needed to protect or replace system components threatened by erosion or thawing permafrost. This is an important first step to more proactive planning for these systems.

The high costs of ongoing water/wastewater system operations and maintenance are a long-time challenge for communities in maintaining efficient infrastructure. Efforts to reduce energy use through retrofits, heat recovery systems, or integrating renewable energy resources provide great opportunity for additional investment with immediate cost savings. Reducing consumer costs can trigger a virtuous cycle – when customers can pay their bills and arrearages fall, system

[15] Alaska Department of Environmental Conservation, Division of Water. *Rural Alaska Sanitation Funding Need 2021*. Accessed August 2021.

operators have new revenue to afford more routine maintenance, reducing risk of failure and keeping end-use costs manageable.

Landfills

Over the last decade, the percentage of Alaska's Class III landfills permitted through the state Department of Environmental Conservation (DEC) jumped from 20% to 90% thanks to concerted efforts by the Department to work with communities. For the remaining 10%, their unpermitted landfill status can prove a real barrier to accessing necessary repair or replacement funding. Without access to this funding, some of these landfills may continue to be ineligible for permitting – a cycle that leaves communities, in some cases, with unsafe garbage disposal sites. Continued support for DEC's important work with these communities is critical to moving towards safe, sanitary landfills across rural Alaska.

Given the decentralized nature of Alaska's landfill operations, it is difficult to estimate the level of funding needed to improve the state's solid waste infrastructure and protect these facilities from heightened climate concerns such as erosion, flooding, and wildfire. These facilities face significant sustainability concerns due to limited ability of residents to pay for service. Important technical assistance programs provided by the state and other organizations are of great importance to helping communities maintain and administer these sites.

The high cost of transportation across rural Alaska also leaves communities with limited approaches to more effectively managing waste. Because these communities are isolated, regionalization efforts tackling all rural waste are generally financially infeasible, and high transportation costs and lack of service mean backhaul solutions are often unavailable outside Southeast Alaska or parts of the Aleutians where barge service is available. Yet efforts to target the most hazardous materials for backhaul could provide a model for reducing the use of rural landfills for waste such as batteries, solvents, and electronics. Led by the Solid Waste Alaska Taskforce, Backhaul Alaska operates a pilot program to remove these materials from 26 villages. Continued support for this and other pilot efforts will be important to reducing contamination risk amid increasing environmental concerns.

School Buildings

The need for additional school facility funding is a matter of efficiency and equity. DEED and school districts have devoted billions of dollars to construction and major maintenance over the last decade. Yet, an estimated annual $197 million gap exists between current funding and that needed to construct and maintain quality school infrastructure in Alaska.[16]

[16] 21st Century School Fund, Inc. *State of Our Schools: America's K-12 Facilities*. 2016.

Great opportunity exists to increase school facility energy efficiency, and in some cases, convert energy use to renewable resources. Reliance on expensive, carbon-intensive energy sources also impacts school district budgets. Reducing this intense use could provide an opportunity to shift funding from energy to other programs. Efficiency standards required for state school construction aid, and forthcoming school facility standards, are important steps already taken to ensure building efficiency. Schools such as the Tok School, which transitioned to biomass heat in 2010, show the real potential to implement renewable energy systems in these educational settings.

As with other community infrastructure, school buildings are vulnerable to the effects of climate change. With an estimated replacement value of $8 billion, any efforts to mitigate climate change impacts on schools will also serve to protect the investments Alaska and individual school districts have already made in quality, efficient educational infrastructure.[17]

Energy/Power Systems

Underinvestment in upgrading and maintaining rural Alaska energy systems has led to high inefficiency in many communities, increasing the energy intensity of these primarily diesel-fueled plants. An estimated 75 rural power system upgrade projects are still required, and deferred maintenance costs related to rural power system upgrades has been estimated at more than $300 million.[18] Much more investment will likely be required to upgrade this aging infrastructure. Yet these necessary improvements have potential to reduce the high cost of living in remote, rural Alaska communities. In addition to upgrading existing infrastructure, adding technology such as heat recovery systems provides further opportunity to reduce energy costs and consumption.

With vast renewable resources, a proven record of integrating these resources with traditional diesel-generation systems, Alaska has nearly unbounded opportunity to reduce the use of carbon-intensive fossil fuels. Hundreds of millions in public and private investment in renewable energy systems and integration will be required to increase renewable energy as a share of Alaska's energy generation. The dividends from such investments could be large: reduced cost of living, more sustainable communities, and new jobs in communities with limited employment opportunities.

Transportation

Given the high level of community isolation and large geographic distances, it is nearly impossible to quantify the needed investment in transportation infrastructure across rural Alaska. More than 200 communities are unconnected by a road system, making air and water

[17] 21st Century School Fund, Inc. *State of Our Schools: America's K-12 Facilities*. 2016.
[18] Curtis Thayer. *Alaska Energy Authority is committed to our rural neighbors*. Anchorage Daily News. February 4, 2021.

transportation infrastructure vital community assets. Roads and boardwalks within communities are also important components of village infrastructure. Community-led efforts to identify desired and feasible transportation projects will be an important component of improving access and reducing the high cost of living and construction in rural Alaska. Improving transportation access could positively impact other infrastructure projects and protections needed in rural Alaska through reduced energy and construction costs.

Other Nonresidential Buildings

Across rural Alaska, an estimated 10,000 nonresidential community buildings have not received comprehensive energy-efficiency services.[19] These tribal halls, government offices, youth centers, and others are vital to rural community life. An estimated $416 million in funding would be needed over the next decade to provide the weatherization services these facilities require.[20] Based on recommendations developed in the *Alaska Energy Authority Energy Efficiency Program Evaluation and Financing Needs Assessment*, this direct funding would best be directed at market-based "upstream" initiatives and supply channel initiatives to make energy-efficient lighting and heating equipment available in rural Alaska.[21] This level of weatherization funding would translate to more than $71 million in benefits from reduced energy costs.

Community Relocation and Mitigation Infrastructure

About 144 rural Alaska Native communities face imminent infrastructure threats from erosion, flooding, and permafrost thaw.[22] In some cases, communities have opted to relocate entirely as conditions in the village cite deteriorate. No comprehensive federal or state policy currently addresses village relocation, and no comprehensive funding for such efforts is available. With limited funding to address first-time construction and major maintenance of existing infrastructure, funding sources are generally not designed to provide communities assistance at the scale needed to address village relocation, and no relocation framework or process has been published.

Comprehensive policy and funding sources to address infrastructure needs related to community relocation will be increasingly important as the impacts of climate change unfold. Development of any comprehensive policy or framework to address village relocation should

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[19] Vermont Energy Investment Corporation. *Alaska Energy Authority Energy Efficiency Program Evaluation and Financing Needs Assessment*. July 2016.
[20] Ibid. Estimated costs are the net present value costs to provide energy efficiency services to non-residential buildings and water/wastewater facilities.
[21] Vermont Energy Investment Corporation. *Alaska Energy Authority Energy Efficiency Program Evaluation and Financing Needs Assessment*. July 2016.
[22] State of Alaska Division of Community and Regional Affairs, Association of Village Council Presidents, Alaska Native Tribal Health Consortium, Aleutian Pribilof Islands Association, Bristol Bay Native Association, Native Village of Buckland. *Unmet Needs of Environmentally Threatened Alaska Native Villages: Assessment and Recommendations – Draft Report*. 2021.

include Alaska Native representation at the development stage to ensure outcomes are culturally appropriate and community directed. Construction of right-sized, efficient, sustainable infrastructure from the start of community relocation will be key to community sustainability and reducing future needs for major maintenance.

In other instances, communities have an opportunity to reduce these impacts while preserving costly infrastructure in place. An estimated $4.3 billion will be needed over the next decade to mitigate climate change-related damage to existing infrastructure, leaving an $80 million annual funding gap.[23]

In Utqiagvik alone, the seawall construction necessary to preserve more than $1 billion in infrastructure is expected to cost about $330 million. Much more will be required to prevent damage in the other communities choosing to remain at their current location. These efforts will collectively preserve billions of dollars in infrastructure.

Mitigation work related to managing climate change impacts should continue to be community driven to ensure design is consistent with local values such as access to subsistence resources. As in the case of crews employed in wildfire prevention and mitigation efforts, other mitigation efforts provide significant opportunity to increase jobs in rural Alaska while benefiting from traditional ecological knowledge of these Alaska Native communities.

Other Considerations

Inequitable Regulatory Barriers

The Denali Commission is the lead federal agency for addressing climate impacts in rural Alaska. Yet there is no lead federal funding agency dedicated to mitigating the damage caused to infrastructure by the impacts of climate change. When seeking infrastructure funding to mitigate damages or address climate risk, these communities are faced with complex regulations and requirements that vary from agency to agency, and sometimes grant to grant. The complex regulations and limited local capacity often mean rural Alaska communities most impacted by climate change also face the greatest challenges in accessing resources to mitigate those impacts.

Designating a lead federal funding agency to coordinate resources to address infrastructure damage caused by erosion, flooding, and permafrost thaw is an important first step to improving access to resources. Regardless of having a lead federal funding agency, program design and regulation must be reexamined to reduce inequitable regulatory barriers that disadvantage rural

[23] Ibid.

Alaska communities. Programs and policies should be designed with meaningful input from Alaska Native communities to ensure they are culturally appropriate and achievable.

Renewable Energy and Heat Recovery

Over the last decade, Alaska utilities have developed a proven track record of integrating renewable energy sources with existing diesel-generation electricity plants and systems such as water treatment plants. The state's vast renewable resources, enhanced battery storage technology, and cost reductions in some technologies provide exciting new opportunities to reduce carbon-intensive energy use of Alaska's community infrastructure. Installing these units shows great promise in reducing costs to residents.

Rural Alaska communities also have a proven record of implementing heat recovery technology in community buildings to reduce energy costs. Units harnessing waste heat from power plants for use in schools, water treatment plants, and others reduce energy consumption and can provide new revenue for electric utilities. Ratepayers and the state's PCE program can reap the benefit of lower energy consumption.

Continued funding for these system enhancements is critical to improving the energy efficiency of Alaska's infrastructure.

Applied Research

Applied research in systems and building design and construction will continue to be critical in improving the resiliency of rural Alaska's infrastructure to the impacts of climate change, especially amid an evolving environment. Engineers, contractors, and others have long been considering the state's harsh climate and distinct environmental conditions as they work in rural Alaska. Organizations such as the Cold Climate Housing Research Center (CCHRC), which has incorporated small-scale water treatment and energy generation into prototype housing design, are an important part of demonstrating new possibilities. Continued applied research in community infrastructure design provides the best opportunity to support these advances. At the same time, collaboratively designing new buildings and systems with community members in rural Alaska will continue to increase the impact and efficacy of applied research and development.

Training and Technical Support

Training and technical support programs, such as the Remote Maintenance Worker program designed to provide timely support and capacity to rural utility systems, have enjoyed great success across rural Alaska. Continuing these programs is vital to ensuring appropriate operations and maintenance of existing infrastructure and extending its useful life. The training provided also offers the opportunity for rural Alaska to harness important job opportunities presented through infrastructure development.

Closing Comments

Hundreds of millions of dollars in private and public resources have been spent over the last decade to improve rural Alaska's aging, underdeveloped, and inefficient community infrastructure. Even with all this previous investment, major deficits exist in rural Alaska infrastructure compared to the rest of the United States. As the impacts of climate change – erosion, flooding, permafrost thaw, wildfire – are experienced across the state, substantial investments will be required to reduce these impacts and improve the resiliency of community infrastructure. Alaska has an enormous opportunity to improve the quality of life in rural areas through improved water/wastewater systems, more efficient and less costly energy generation, well-maintained schools, permitted landfills that protect community health, and many other systems and facilities vital to these communities. With this renewed investment will come increased employment opportunities in villages where jobs can be scarce. What ties these opportunities together is the broader opportunity to advance environmental justice at the far reaches of the United States, ensuring that all citizens are afforded equal protection from the mounting environmental hazards wrought by climate change.

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