Community-based Mitigation and Adaptive Strategies for River Flooding and Erosion in Alaska Native Communities

Kellie Cutsinger and Amelia Wells

Master of Marine Affairs

University of Washington

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I. Introduction

In recent years, Alaska's Yukon-Kuskokwim (Y-K) River Delta has experienced significant environmental change, especially along its river systems where there has been an increase in severe erosion and flooding events throughout the watershed. The Y-K Delta spans 75,000 square miles of lowland river delta and is home to about 23,000 people, a majority of whom are Yup'ik, Cup'ik, and Athabascan. The Yukon and Kuskokwim Rivers flow amongst fifty-eight rural communities, otherwise largely unconnected by roads (Y-K Health Corporation, n.d.). Central Alaskan Yup'ik peoples have lived along the Kuskokwim since time immemorial. Historically, Yupiit have lived semi-nomadic lifestyles, moving seasonally to harvest food, medicine, and materials, which enabled a certain level of adaptive capacity to environmental variation and change (Ayunerak et al., 2014; Wolsko et al., 2006). However, colonization in the early 20th century led to fundamental changes in Indigenous social, political, and economic systems, ultimately resulting in the permanent settlement of Yup'ik communities along the Kuskokwim (Fienup-Riordan, 2020). Today, these communities are facing worsening impacts of flooding, erosion, and river migration, and consequently must work to better adapt within now stationary communities.

A report by the U.S. Army Corps of Engineers (USACE) in 2009 found that nearly 200 Alaska Native (AN) villages across the state were experiencing erosion, 26 of which were identified as "Priority Action Communities" – indicating that they "should be considered for immediate action by either initiating an evaluation of potential solutions or continuing with ongoing efforts to manage erosion" (USACE, 2009, p. ES-1). Akiak Native Community, the village of primary interest to this report, was identified as a "Priority Action Community" in 2009. A decade later, a new report published by University of Alaska Fairbanks (UAF) and USACE, examined a trio of threats to AN communities: erosion, flooding, and permafrost thawing. Akiak was reported to be among the communities under highest threat from both erosion and flooding according to this report (UAF & USACE, 2019). The impacts of flooding and erosion differ among communities depending on their locations, but everything from roads and runways to homes and cultural sites are at risk (Alaska Federation of Natives, 2018; UAF & USACE, 2019).

Highly remote and under-resourced, Yup'ik communities, like other AN communities, face many barriers to addressing concerns related to flooding and erosion. Federal disaster response and recovery efforts are fragmented across many agencies and often

differ in requirements and timelines, making navigation of the system difficult (Government Accountability Office, 2009). The process is further complicated by the fact that the primary threat to many AN communities, erosion, is not considered a 'naturally occurring disaster' in the same way earthquakes or floods are, making it more difficult to receive support from government relief agencies like the Federal Emergency Management Agency (FEMA) in a state of emergency (Alaska Federation of Natives, 2018).

Individual communities along the Kuskokwim have begun developing hazard mitigation and adaptation plans. However, while there exists robust data on coastal erosion in Alaska, there are significant gaps in the understanding of riverine erosion in the Y-K Delta. Due to minimal data and a lack of monitoring equipment, scientists and communities have little information with which to make informed decisions. Therefore, there is an urgent need to identify methods and tools that can help develop adaptive strategies and solutions while also increasing available data.

Starting in 2019, Akiak, which has a population of around 400 people, began experiencing an entirely novel phenomenon, springtime erosion. Massive chunks of land have been sliding into the river within a matter of hours each spring, resulting in the implementation of a managed retreat plan. In 2020, Akiak concluded that the community must collaborate with other villages to better understand the Kuskokwim River changes. To understand what is happening in Akiak, a larger understanding of what is occurring both up and downriver is necessary. In 2021, Akiak approached Tuluksak, Akiachak, and Kwethluk to partner on a hydrologic study of the watershed to begin the collection of data required to appropriately respond to this new threat.

As a part of a two-year National Science Foundation (NSF) Navigating the New Arctic (NNA) planning grant, an interdisciplinary team of researchers from University of Washington (UW) and Iowa State University (ISU) traveled to the Kuskokwim River in August of 2022 to coordinate with local partners from the four villages. Our team was initially invited by collaborator Joel Neimeyer, P.E., a licensed professional engineer who formerly worked with the Denali Commission, and the tribal Chief of Akiak at the time, Michael Williams, Sr. We hosted a community workshop in Bethel and engaged in preliminary data collection and relationship building with village leaders, educators, and planners. The planning grant is the first step toward a long-term goal of developing monitoring tools and engineering interventions to reduce flooding and erosion risks in AN villages in the Y-K Delta region.

Our role as graduate student researchers on the trip was to assist in facilitating the workshop and interview community members to better understand community concerns

and priorities. Prioritizing the incorporation of local knowledge and community priorities in this process is key to ensuring any tools, methods, and adaptive strategies developed adequately address community needs. This report outlines our methodology, findings, and conclusions and is intended to be used by both the Y-K Delta communities we worked with as well as the project's principal investigators (PIs) for future efforts.

II. Methods

This NNA planning grant placed a strong emphasis on collaboration and co-production from the outset. Relationships between researchers and the Indigenous peoples of Alaska are rooted not only in the context of settler-colonialism but an unethical and harmful scientific history (Lanzarotta, 2020; Wilson et al., 2020). In entering AN spaces and communities we aimed to adopt an approach that was not extractive or exploitative in nature and that allowed for partners to co-generate knowledge alongside the research team. Our goal was to foster reciprocity and work in partnership with all involved parties to investigate and address these pressing issues within both historical and cultural contexts.

In the effort to avoid perpetuating extractive paradigms, we purposefully incorporated non-research based activities into the project to engage community members with the research and develop products directly relevant to the community. For example, we co-generated multiple lesson plans, including map making, interviewing techniques, soil erosion experiments, river bathymetry surveying, and photo elicitation for use by the Yupiit School District (YSD). During our stay in Akiak in August of 2022, we worked with students to document both the impacts of erosion as well as the knowledge of cultural practitioners. The recorded video and audio will be used to develop two informational videos, which center the YSD's Culture Camp and community-wide erosion impacts. Both the lesson plans and informational videos will be shared with school administration and faculty to be used as they see fit. To provide context for information collected through the workshop as well as through interviews, both the ISU and UW teams were taken on boat trips along the river to observe erosion first hand. Additionally, those of us from UW spent six days living in the community of Akiak to meet and converse with residents. Other key steps taken toward ensuring ethical research practices and building trust with collaborators included completing the Alaska Area Institutional Review Board (AAIRB) process, maintaining data sovereignty, protecting the privacy of individual participants, and convening an advisory board to review research at all phases.

In researching co-productive methodologies, we sought to determine how we may better develop our research questions around the specific context of the Y-K Delta and

ultimately engage in research that would be beneficial to Y-K Delta communities. Broadly, the literature on co-productive methodologies focuses on creating collaborative, transdisciplinary processes of solution-oriented, actionable knowledge generation grounded in local context (Lang, et al., 2012; Robards et al., 2018; Schuttenberg and Guth, 2015). This concept directed how we approached our eventual interview and workshop methodologies. Specifically centering co-productive research with Indigenous communities, Ellam Yua et al. (2022) explain that, "[the] co-production of knowledge (CPK) [is] a process that brings together Indigenous Peoples' knowledge systems and science to generate new knowledge and understandings of the world that would likely not be achieved through the application of only one knowledge system" (n.p). In the context of our project specifically, the knowledge generated through interviews and workshop sessions will supplement and inform data collection and modeling efforts by our co-researchers. Predictive tools and adaptive strategies developed as a result will therefore incorporate local knowledge and center AN community priorities in future project directions.

A. Interviews

In reviewing the literature on interviewing methodologies, we determined the appropriate interview method to use in this case was the semi-structured interview. Huntington (1998) identifies the semi-structured interview as useful in the context of documenting locally specific knowledge in the way that it allows the participant, rather than the interviewer, to guide the direction, scope, and content of the interview. While the interviewer may provide questions or suggestions of conversation topics, the interests and expertise of the participant are prioritized. Further, semi-structured interviews have been used in a number of similar studies that similarly center AN perspectives, observations, and concerns surrounding environmental change (Herman-Mercer et al., 2016; Herman-Mercer et al., 2019; Huntington et al., 2016; Moerlein & Carothers, 2012). Using semi-structured interviews, these studies identified increased vulnerability of subsistence systems in the Y-K Delta due to social and environmental change (Herman-Mercer et al., 2019), disruptions in subsistence hunting due to sea-ice loss (Huntington et al., 2016), and the impacts of climate change on Inupiaq subsistence fisheries (Moerlein & Carothers, 2012). In our effort to better understand the socio-ecological impacts of erosion and flooding on AN communities on the Kuskokwim River, we therefore employed similar interview methodologies to capture and center community perspectives and knowledge.

In initial conversations with collaborators working in Akiak, we developed three goals for the interviews: 1) to identify place-and time-specific local knowledge on flooding and erosion, 2) to elicit participants' knowledge of impacts to places and cultural practices,

and 3) to determine the efficacy of past erosion control efforts. We conducted interviews with residents of Akiak to develop both a deeper understanding of community member experiences, concerns, and ideas as well as contribute to the larger body of knowledge on river erosion and flooding in western Alaska, especially pertaining to new instances of springtime erosion.

Participants were recruited through our primary contacts in Akiak. Interviews were conducted either in community spaces or homes. We developed an interview guide to help direct conversations, however, we primarily allowed interviewees to freely discuss topics of their interest related to river use, community history, traditional subsistence, environmental change, ecology, erosion, and flooding. We conducted six in-person interviews with residents of Akiak, who ranged in age from about 40 to 90 years old. The interviews were conducted in English and ranged in length from 36 to 64 minutes. Additionally, we provided multiple satellite and aerial images of different segments of the Kuskokwim River watershed for participants to note specific locations of river change events. Interviews were logged and transcribed, then coded for analysis in the Atlas TI software.

B. Workshop

On August 21, 2022, our team facilitated a regional workshop at the Yupiit Piciryarait Cultural Center in Bethel. It was attended by 20 participants, who primarily consisted of community members, elected officials, and planners from Bethel, Akiak, Kwethluk, and Tuluksak. Participants were invited to share concerns about river changes—including effects on housing, infrastructure, transportation, and subsistence and cultural practices. As a part of the NNA planning grant, this workshop also aimed to identify potential partners and collaborators for a full NSF NNA grant that will further explore community-based mitigation and adaptation strategies for river flooding and erosion.

During this community workshop, our team conducted a collaborative mapping session, which involved working with participants to create maps that capture local knowledge about the river. Collaborative mapping is a method that has been used in other systems to document environmental change and risk as well as ecosystem services (Brady & Leichenko, 2020; Burdon et al., 2019). This method "produces a wealth of detail...but also sets in motion a process of affirmation of local people as knowledgeable actors" (Cornwall and Jewkes, 1995, p. 1668). Roles are often reversed in terms of who informs and generates research problems, which allows participants to analyze their own situations and design their own solutions (Cornwall and Jewkes, 1995).

To prompt conversation and elicit place-and time-specific river knowledge, we printed several large and small-scale satellite images of the watershed (from Tuluksak to Bethel) using United States Geological Survey's (USGS) "The National Map Viewer" (TNM Viewer). Using color coded sticky notes, participants noted instances of historical and recent river-changing events they had experienced or heard about. River change events were categorized by erosion, flooding, ice jams, thawing, and sandbars formation. These noted events were then transferred from the physical maps to a single digital map on the Google Earth platform.

Figure Key:
Green: Erosion
Blue: Flood
Orange: Sandbar formation
Yellow: Ice jam
Pink: thawing

Figure 2. *A satellite-aerial map image depicting a particular segment of the Kuskokwim River watershed, which was used during the collaborative mapping activity as well as during individual interviews with Akiak community members. Akiak Native Community can be seen in the center of the image as well as various color coded sticky notes that were used to depict specific river change events by workshop participants. Events identified on this map include erosion along Akiak's river bank, sandbar formation just up river of Akiak, and areas of flooding.*

During the workshop session we also worked to create a timeline of significant events over the past 70 years. The large linear timeline depicted segmented decades ranging

from pre-1950 to 2022. Participants were invited to indicate specific events and note the year(s) in which they occurred. This timeline, as well as the Google Earth product, will be used by our colleagues at ISU to aid in the generation of a more comprehensive history of the changes occurring on the Kuskokwim River.

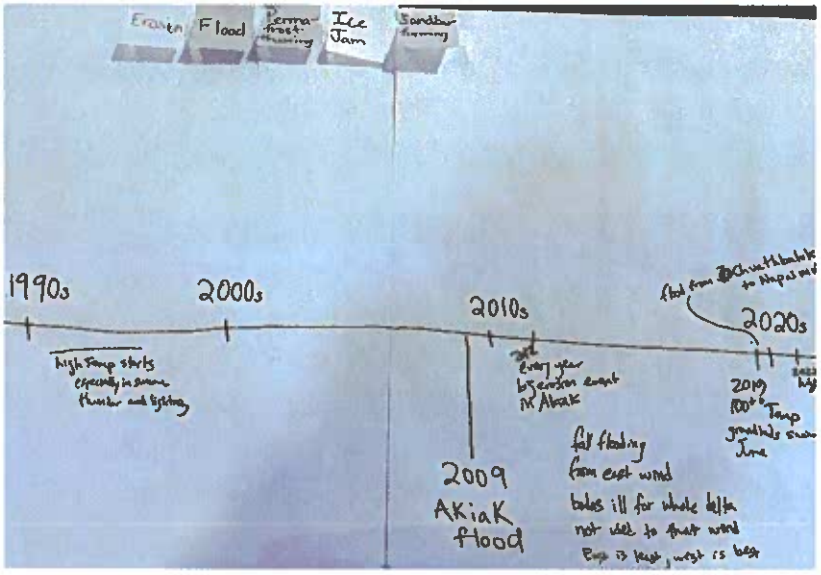

Figure 3. *Image of a segment of the workshop timeline activity that depicts the decades ranging from 1990 to 2020. River change events were noted by perpendicular lines to represent the specific year in which they occurred, note that some events were only recalled within certain decades. Different colored sticky notes are also depicted to indicate specific types of events, which were largely used during the collaborative mapping activity.*

III. Results

A. Interviews

Interviews with residents of Akiak revealed a wealth of local knowledge and information about the history of the area as well as observed changes in the river system and how those changes have impacted life on the Kuskokwim River. The following section will outline the main themes that arose throughout our six formal interviews and six days of community engagement while visiting Akiak and working with local students.

1. Observed Changes in the River System

Interviewees in Akiak had a breadth of historical and current knowledge about the Kuskokwim River, including changes that have occurred over time. A fisherman and boater familiar with the river told us that the "Kuskokwim is always changing," indicating

that change is common and anticipated (001). However, others expressed that the intensity and rate of change is what has become concerning, with a few expressing the opinion that climate change is a factor in that acceleration. Another interviewee who has been heavily involved in the community's response to the erosion said, "Regardless of what we do, I think it will always be eroding; simply because there is [nothing] to hold the ground together" (002). The village of Akiak sits on very sandy ground, and as noted later on by the interviewee, the ground seems to just be sinking into the river. The interviewee references the fact that there is nothing to hold the ground together, indicating that the seasonal patterns of freezing and thawing of the active layer may be changing. When combined with strong wind storms in the fall that churn up the water before shore-bound ice forms, this has resulted in some devastating erosion events in Akiak. Multiple elders interviewed noted that there has been significantly less ice in recent years, especially on the river itself. Thinner ice has a number of implications for residents of villages along the Kuskokwim, primarily in the way it impacts wintertime transportation. What used to be a safe and reliable "ice road," is now more dangerous to travel on.

Five of the six interviewees highlighted the fact that the main channel is constantly moving, resulting in continuous fluctuations of the river structure. These various channel changes have prompted residents to alter their boat transportation routes, and opened up new routes for barges. One interviewee stated "the channel is changing" and estimated the upper portion of the main channel has changed at least five times in the last ten years (002). Just above Akiak, the main channel is in the process of shifting, with much of the river's strength now flowing directly into Akiak's banks. Those who grew up in Akiak remember swimming in the pool that formed between an old sandbar and the river bank, just below Akiak. One such interviewee stated that "always there was a sandbar…[the channel] was never this huge, [the sandbar] is like an island of its own now" (006). Currently, the depth and width of this particular channel has increased enough for boats to pass through.

Multiple interviewees and local community members noted how the river's depth and width has expanded in recent years. One person stated that they used to walk across the river during the winter in the early 1980s and it was far narrower (006). This expansion has contributed to the current state of Akiak's banks, which are now steep cliffs with sharp drop offs. These conditions are dangerous, with an interviewee noting the intensity of the physical hazard especially, "when it's windy…it's very, very choppy [along the bank], which is not good," and often causes extreme wakes up to four feet high (006).

The changes in the river's morphology and the increasing rate of sediment deposition are causing not only extreme erosion events, but increased occurrences of sandbars and islands forming or disappearing. Many individuals explained how channels that were historically used for travel are no longer passable due to the formation of new sandbars and islands. An elder and tribal council member stated that an island disappeared at one point, then reemerged (002), while another person noted how an area that used to be a waterway, has now become a sandbar (004). An indication of these changes was provided by one former Akiak resident who stated that, "growing up in the 80s…a 1/5th of a mile, 1/6th of a mile [of the island] was all willows…which showed me that at one point in time that was a sandbar…they were short willows, maybe 12, 15 feet…you could tell right away that that was new growth" (006). This issue has become especially pronounced around the Tuluksak Native Community, where boat access into the community has become hindered due to the formation of multiple sandbars.

2. *Erosion Observations, Impacts, and Concerns*

The community members of Akiak we interviewed were able to provide us with both current and historical information regarding erosion in the area. A husband and wife agreed that they have observed worsening erosion since the 1960s (005,006), while another interviewee said, "as far as I can remember, it's always been eroding" (002). Although some fluctuation may be expected, erosion events along the Kuskokwim have become increasingly severe, with the most devastating events in recent years occurring in between 2019 and 2022, during which people observed 50 by 50 foot chunks of the bank falling into the river in a matter of hours. During times of high water and strong winds (primarily from the south and east) the risk of erosion has been observed to be especially high. A majority of those we interviewed remarked on the increasing severity and frequency of storms, which appear to be accelerating the rate of erosion, with extreme events happening every year now. Another person noted that erosion is occurring not just from storms, but due to the way in which the strong currents eat away at the sandy bank year round (004). These erosion events are happening all along the river, but our interviewees identified a few locations that they have noticed specifically. One man who spends a lot of time on the river fishing and boating noted that bank areas five miles upriver as well as just south of Akiak below where people park their boats are eroding badly (001). Others pointed out how while sediment is being deposited across the river from Akiak, the banks directly in front of the community continue to erode.

The accumulation of these erosion events has had myriad impacts on communities like Akiak. For one, community spaces have disappeared. Not too long ago there used to be

a gently sloped beach in front of Akiak, where today there are only steep drop offs into the river. Community members kept boats, nets, four-wheelers, and other equipment along the beach, which also made for easy entry and exit by boat (006). One elder remembered swimming, walking, and playing along that beach: "All of this [pointing to the banks of Akiak on a map], no matter where you go, [was] beach. After the erosion, I don't see it no more" (006).

Subsistence practices, especially those related to fishing are also being heavily impacted. The same elder also told us about how erosion has impacted where and how community members process their fish catch. She told us:

> "When we were growing up…all the way alongside the river, everybody had their fish caches, their smokehouses, their drying racks for their fish…up on the embankment, up on the highest part…you would go down to the river and you would see people, their fish hanging out. It just seems like with so much erosion going on down there nobody even wants to take a chance cause you're just going to lose everything" (006).

Now, most people have moved their smokehouses and drying racks to their yards. A fisherman told us about how his family member's smokehouse and hanging rack fell into the river, and explained that he decided to preemptively move his last year (001). Fishing grounds are being impacted as well. The same man explained that he cannot access his usual fishing grounds right now because there are cottonwoods falling into the river and sandbars filling in the area (001). Additionally, some families have had to relocate their seasonal fish camps or move structures further away from the encroaching river bank.

Homes and community infrastructure have also been significantly impacted. Akiak began implementing a managed retreat plan in 2019. Since then, eight homes have been moved, in addition to two structures that have been demolished. Homes that used to be far from the river are now nearing the bank, as one elder recounts, "another house that's moving…the first housing…the river was far, it used to be so far…I was so surprised…that they're gonna have to relocate that house because its in a danger zone area" (006). One related concern is the threat to utilities. One person, who has been very involved in disaster response and planning in the community told us, "I'm so worried about water, sewer, electric lines, and homes. That's the bottom line" (003). The same person feels it is a priority for the community to understand the potential extent and rate of future erosion events in order to help Akiak plan further adaptive efforts.

A final concern that arose in almost every single conversation we had while in Akiak was that of barge activity and gravel dumping. Every person we interviewed mentioned how barges have been getting stuck on a sandbar just above Akiak and dumping huge loads of gravel into the river to get themselves unstuck. One of our interviewees who has been involved in tribal and city leadership, believes the accumulation of gravel over time is contributing to the change being observed in the channels above Akiak and potentially related to the increasing intensity and frequency of erosion events (002).

3. *Solutions*

Akiak has attempted to implement a number of different types of erosion control methods, including sand bags, geo-fabric, and pipes used to reinforce the bank. It was clear from our conversations with community members that nothing has worked. "We might slow it down, but I doubt we will ever stop the erosion," one man said (002). Thus, the community has turned to managed retreat. With equipment purchased using government funding, Akiak can and has been moving homes, the general rule being that once a home is within 200 feet of the river bank, it needs to be moved.

When asked about what they think a potential solution to erosion might be, interviewees provided a number of ideas including constructing log jams, grading the river bank to a gentler slope, and excavating the deposited sediment on the opposite side of the river to relieve pressure on Akiak's bank. Many people we spoke to brought up the idea of a seawall, citing Bethel's success in controlling its erosion with the implementation of a seawall. However, at the same time, there is widespread acknowledgement that seawalls are extremely expensive and therefore might not necessarily be realistic due to the morphology of the river at Akiak's location and given the lack of funds. Indeed, in 2013, the Natural Resources Conservation Service (NRCS) estimated that the installation of a seawall in Akiak would cost $80 million (NRCS, 2013).

4. *Future Actions, Needs, and Considerations*

Looking ahead, the people we interviewed in Akiak identified several strategies they see as key to continuing to adapt to and mitigate erosion in their community. First, is addressing the barrier of funding. One interviewee stated that "there is never any funding for erosion" (002), and as noted above, funding is a significant barrier to implementing solutions. Related to this is the need to educate and seek assistance from the state government. One interviewee with past political involvement told us, "The state of Alaska has a constitution and they have a responsibility to take care of their people. The best way is to educate them…Respectfully discuss things with them…We've got to brief the congressional delegation" (003). More immediately, those in charge of the

managed retreat in Akiak desperately need more information on how far the erosion will go in order to know where they should be moving homes.

Notably, most people we talked to emphasized the importance of approaching this issue in collaboration with the other communities along the Kuskokwim, and to spread awareness and tell the story as a united front:

> "The solution is this, we've got to paint a picture along the Kuskokwim. Other villages are in danger, that's the picture that needs to be drawn…We're not the only ones [struggling with erosion issues]. It's gotta be addressed all the way down [the river]...We've gotta do it together, not sporadically…We're all in this together" (003).

There is a deep awareness of the interconnectedness between communities, and how one village's actions may impact another. Moving forward, any solutions and actions taken need to be approached in a collaborative and inclusive manner to ensure each community on the Kuskokwim is provided with the assistance and support they need.

5. *Flooding*

Although we arrived in Akiak intending to talk about flooding as well as erosion, our interviews revealed to us that flooding is currently less of a concern. One previous resident noted that it used to flood every spring when the water was high, if the ice was backed up the water would come up from behind the village (006). Another interviewee noted that "Old rivers and creeks fill up from the back when the water is high. From the southside [of the village]" (001). While there have been a few severe floods in recent years, the more immediate threat communicated by community members was that of erosion.

B. Workshop

The products generated from data gathered at the August 2022 workshop will inform ISU's engineering study on the development of potential solutions to the issue of erosion in the area. Both the Google Earth product and timeline provide visual representations of recent and historical river change events and their impacts to this area, as well as how quickly these conditions and impacts have worsened. Ultimately, these products allow for the expansion of the historical data available related to these river change events, which may then be applied to predicting potential future conditions and impacts. Additionally, this information will be given back to the community for their own usage and historical knowledge preservation.

1. *Collaborative Mapping: Digital Google Earth map*

Upon seeing the aerial images of the Kuskokwim River watershed, participants immediately began identifying village sites, travel routes, fish camps, and other significant places. Multiple instances of river change events and their specific locations were noted in addition to various channel changes from human activities such as dredging, shortcut formation by the use of dynamite, and gravel dumping by barges. These events are represented in a single digital map compiled using Google Earth which highlights the type of change that has occurred and its specific location along the watershed from Tuluksak to Bethel.

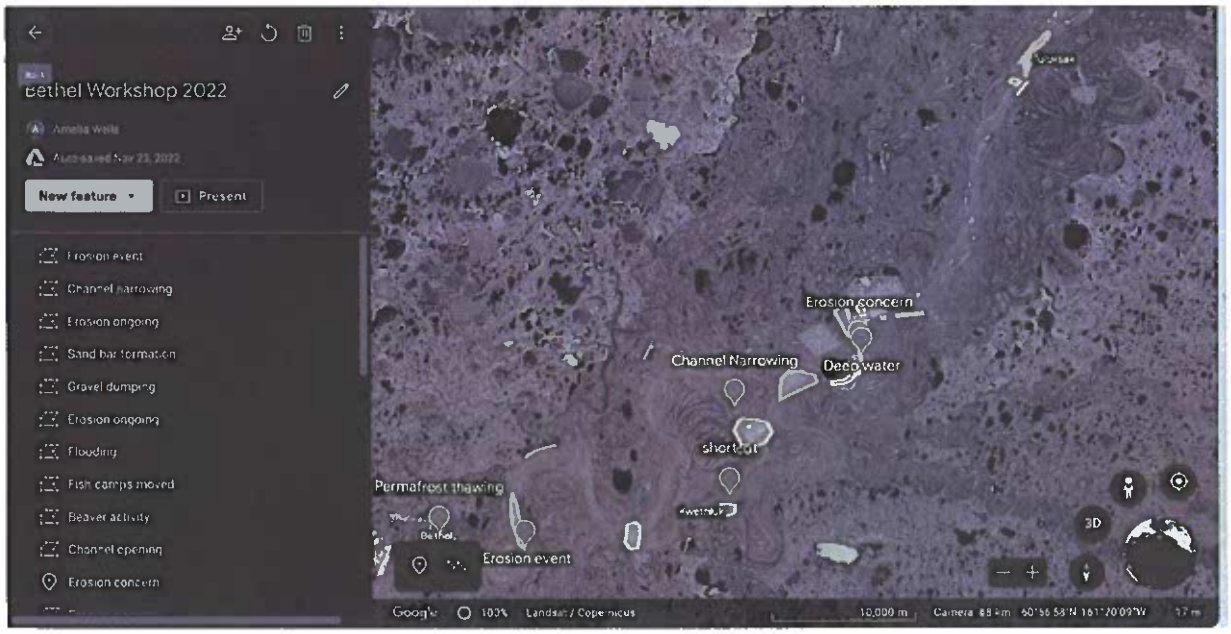

Figure 4. *A screenshot of the compiled digital Google Earth map based on Workshop results. River change events are represented by polygons and location pins. See Appendix A for a link to the map.*

2. *Timeline: Chronological list of historical river events*

During the workshop timeline activity, participants noted not only erosion and flooding events but also significant changes in weather patterns and instances of attempted adaptation and mitigation. Impacts to multiple villages were noted throughout the timeline as well as changes to subsistence practices. The start of dramatic ground thawing was noted in the 1980s, when participants noted many fish camps no longer had ice cellars. Erosion events were explained to be worsening over time with the first severe instance recorded in the 1960s. Communities have since experienced severe

erosion events every year starting in 2012. These events have dramatically changed traditional fishing practices in the area with people having to move their fish camps, boat parking locations, as well as fishing locations. Major flooding events have been declining, potentially due the trend of ice thinning over time. The issue of the river ice increasingly thinning is impacting critical transportation modes and traditional hunting practices since the river acts as an ice road during winter months. Participants also recorded instances of extremely high temperatures and the increased occurrence of high intensity storms.

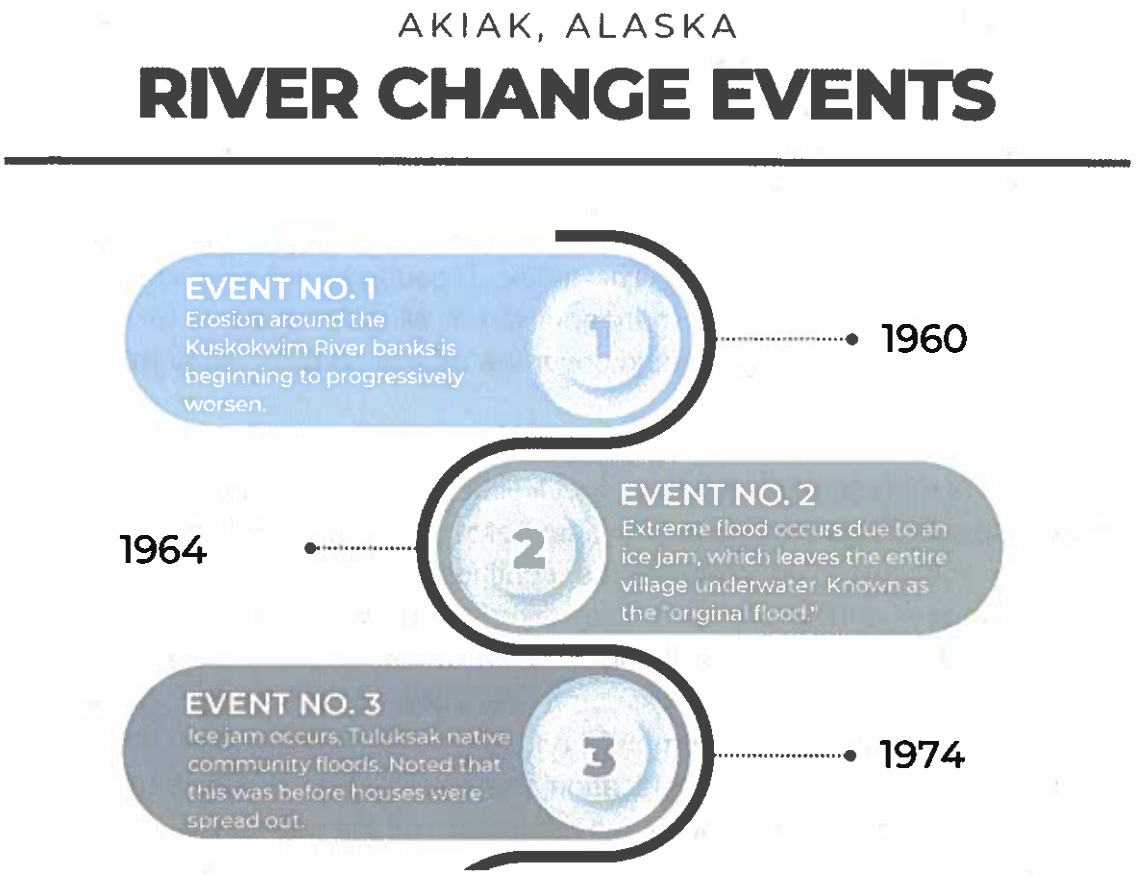

Figure 5. *A selection of timeline events compiled based on the workshop timeline activity. See Appendix B for the full timeline.*

IV. Discussion and Conclusion

As we have outlined in this report, the impacts of erosion on Akiak and surrounding communities are various and extensive. Infrastructure, homes, community spaces, and subsistence-related structures are all at risk. The initial pressing needs communicated by members of these affected communities included increased cooperation and

communication with government representatives and agencies, more funding, further assistance in developing adaptive strategies, and better scientific knowledge on riverine erosion processes. While coastal erosion has received significant attention in recent years, river erosion remains an under-studied issue. While the Alaska Division of Geological & Geophysical Surveys (A-DGGS) is making progress in developing actionable science for the threat of coastal erosion (see Buzard et al., 2021), the scientific data and technical skills required to effectively assess the threat of riverine erosion is lacking. This in turn limits the ability of communities like Akiak to implement adaptive strategies since there is little sense of how erosion will proceed in the future.

A key barrier for most tribal communities to address these issues is funding. While there are state and federal agencies that provide money for these types of issues, grant applications require time and resources. Further, grants tend to be piecemeal, fragmented and involve a number of stipulations–like required matching funds–that are not always feasible for AN communities to fulfill. Still, through great effort and diligence, in the fall of 2022, Akiak was one of five tribal communities to receive federal funding to respond to climate threats (Flavelle, 2022). This influx of resources will no doubt be helpful to the community in their ongoing managed retreat. Michael Williams Sr. was quoted in the New York Times saying it would cover the relocation of 15-20 homes (Flavelle, 2022).

In conjunction with the managed retreat plan, Joel Neimeyer, P.E. and engineers from ISU hope to develop additional strategies to mitigate erosion through additional NSF funding. In order for solutions to be implemented, continued research in these areas is necessary. It will take time and resources to determine appropriate adaptation methods, and these may not be the same for each community in the Y-K Delta. There are a number of potential actions to take, the most commonly adopted and recommended by Alaska's Department of Commerce, Community, and Economic Development (DCCED) being 'protect-in-place', 'migration', and 'relocation' (Alaska DCCED, 2013). Each of these strategies may take different formulations depending on the location and type of erosion occurring. In exploring any solution, attention must be paid to the needs, priorities, and resources of each individual village.

It should be noted that the findings reported here are the result of conversations with only six individuals from one community. Any continued work on the Kuskokwim should aim to engage a broader array of stakeholders from all communities within the study area. While the information gathered through the collaborative mapping process and the timeline activity highlight the key knowledge held by community members, our research products by no means capture everything happening on the Kuskokwim. In the case of future NSF funded research, efforts should be expanded to engage more communities

beyond one workshop. It is our recommendation that workshops be held in each village in the project area to encourage and facilitate greater engagement and participation across the region. We further recommend inviting state or federal officials to participate in these meetings as a way to open the conversation to greater collaboration and further government involvement and support. Additionally, interviews should be conducted with residents of villages other than Akiak to develop a broader understanding of the impacts along the river. Finally, to increase accessibility to information and project planning, we recommend creating a website to provide updates to Kuskokwim residents on research, pilot projects, and funding opportunities. We hope some of the products resulting from this work, especially the timeline and Google Earth map can be converted into editable online resources accessible for Kuskokwim residents to update in real time.

Indigenous scholar, Linda Tuwei Smith (2012) highlights the importance of method or process in community research. She writes,

> In all community approaches, *process* – that is, methodology and method – is highly important. In many projects the process is far more important than the outcome. Processes are expected to be respectful, to enable people, to heal and to educate. They are expected to lead one small step further towards self-determination (p.130).

In the pursuit of further NSF funding, we want to encourage our colleagues to ground their research in processes that support and uplift Kuskokwim communities and continue to develop trusting, reciprocal relationships, which will ultimately result in better outcomes for all involved.

V. Acknowledgements

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VI. Author Statement

The authors of this report acknowledge their positionality as cis-gender, non-indigenous members of a settler colonial academic institution.

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