*Coastal flooding in Golovin, Alaska (Toby Anungazuk, November 2011)*

# Color-indexed elevation maps for flood-vulnerable coastal communities in western Alaska

AOOS
Alaska Ocean Observing System

NATIONAL WEATHER SERVICE

ALASKA GEOLOGICAL & GEOPHYSICAL SURVEYS

*A <u>pilot project</u> to facilitate real-time discussions between communities and NWS about potential storm-induced flood impacts*

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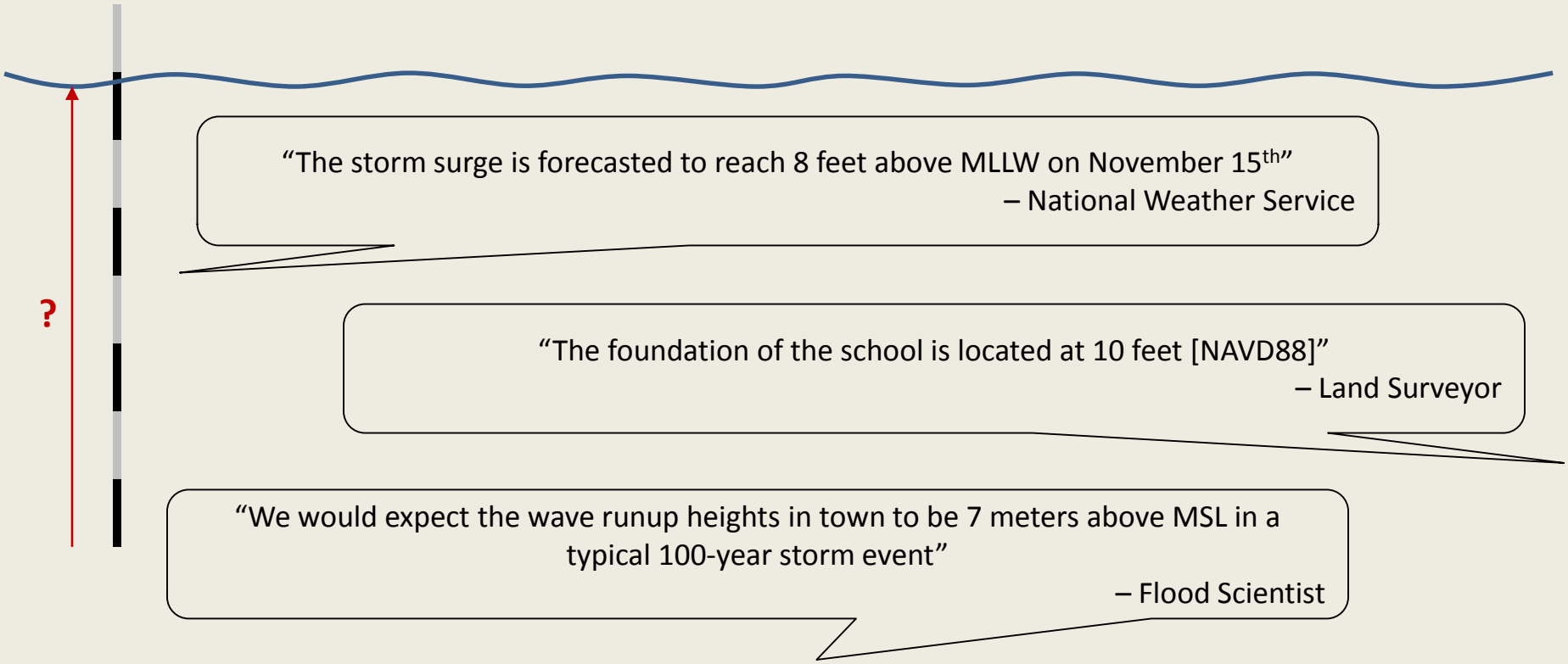
# Motivation

When an extreme event is forecast, there needs to be reliable and efficient 2-way communication between local decision-makers and NWS

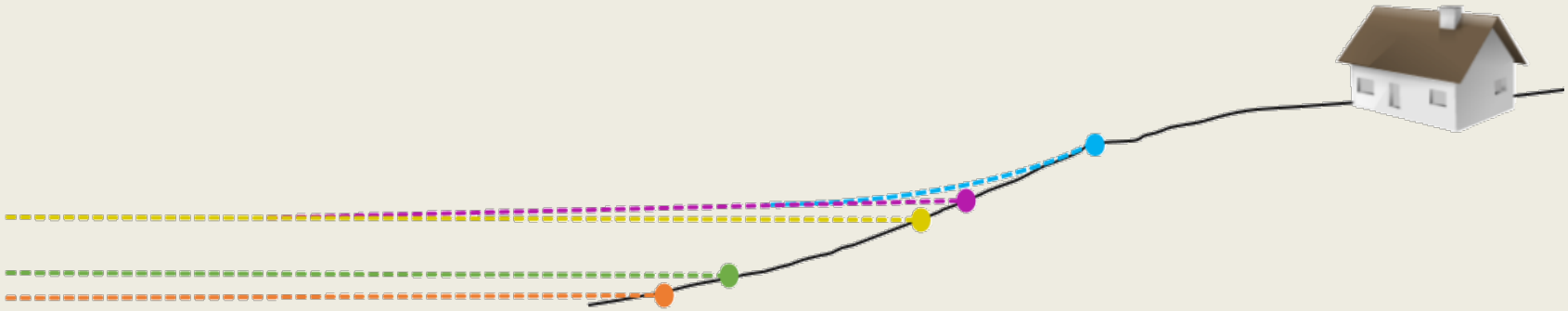
- Where are flood impacts most likely to occur?
- What infrastructure is potentially at risk?
- How will this storm differ from past events at the local level?

# So many reference frames to describe water levels!




| Vertical Reference Frames | Easy Definition | Typical Units | Commonly used… |
|---|---|---|---|
| Mean Lower Low Water<br>**MLLW** | The average height of the lowest water levels in a local area | Feet | 1. by NWS forecasters<br>2. on NOAA nautical charts (depths)<br>3. to define the landward edge of United States waters |
| Mean Sea Level<br>**MSL** | The average height of all water levels in a local area | Feet<br>Meters | 1. to report NOAA tide predictions<br>2. by coastal scientists and modelers |
| North American Vertical Datum of 1988<br>**NAVD88** | The standard for land elevations in the United States | Feet<br>Meters | 1. on topographic maps<br>2. by land surveyors and engineers |

# So many types of water levels in a storm!



| Coastal Storm Water Level Components | | | Full Definition | How determined | Easy Explanation |
|---|---|---|---|---|---|
| Mean Sea Level | | | The average height of all water levels in a local area under normal conditions | Tide Gauge | This is where the water level is usually located |
| Tide Level | Storm Tide Level | Total Water Level | Regular variation in the water level caused by sun/moon gravitational forces and the earth's rotation | Tidal Predictions modeled by NOAA | This includes both high and low tide levels under normal weather conditions |
| Storm Surge | | | Elevated ocean levels that arise from a combination of onshore-directed wind stresses and reduced atmospheric pressure | Forecasted by regional NWS ocean models | This is the overall rise in the water level due to storm conditions |
| Nearshore Setup | | | An increase in water level due to waves and the shoreward transport of water | Calculated or modeled based on local conditions and typical storm characteristics | An additional rise in the water level along open coastlines during a storm as waves 'pile up' against the shore |
| Wave Runup | | | The maximum height to which breaking waves can reach on a shoreface | Calculated or modeled based on local conditions and typical storm characteristics | Breaking waves have extra energy that can cause the water to rush up even higher in some locations. This is an elevation where your feet may be splashed but you are not standing in water. |

# Concept

Community Maps

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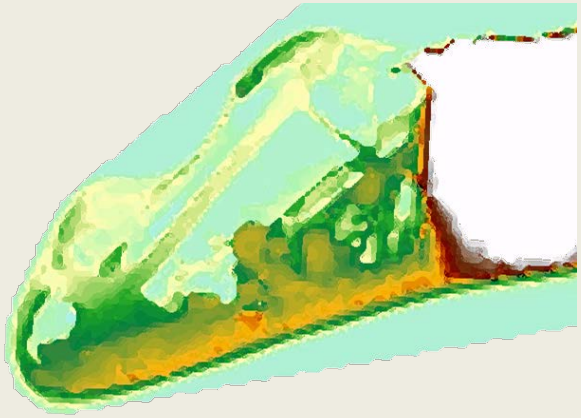
Best available elevation information



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Locations of critical/vulnerable infrastructure

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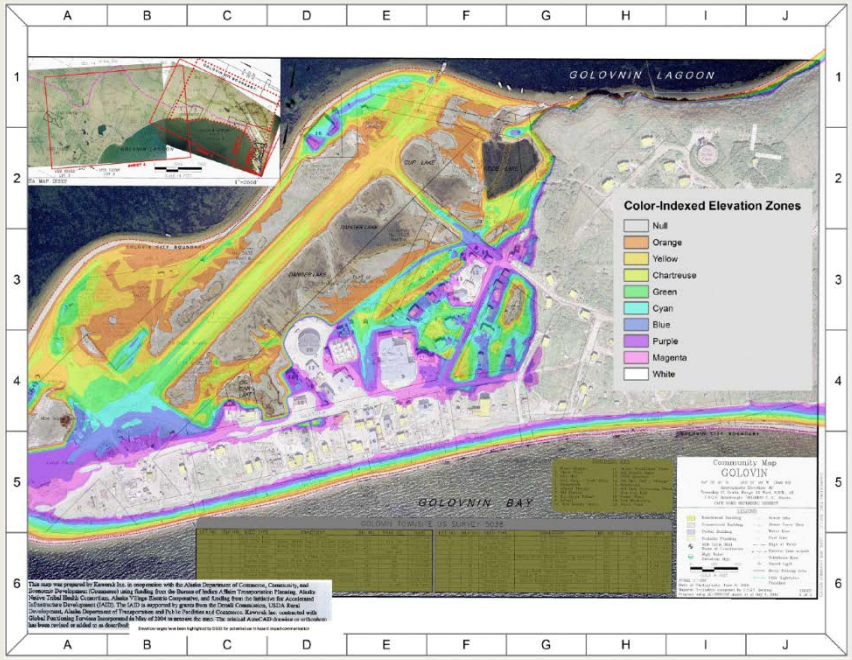
## Color-Indexed Elevation Map



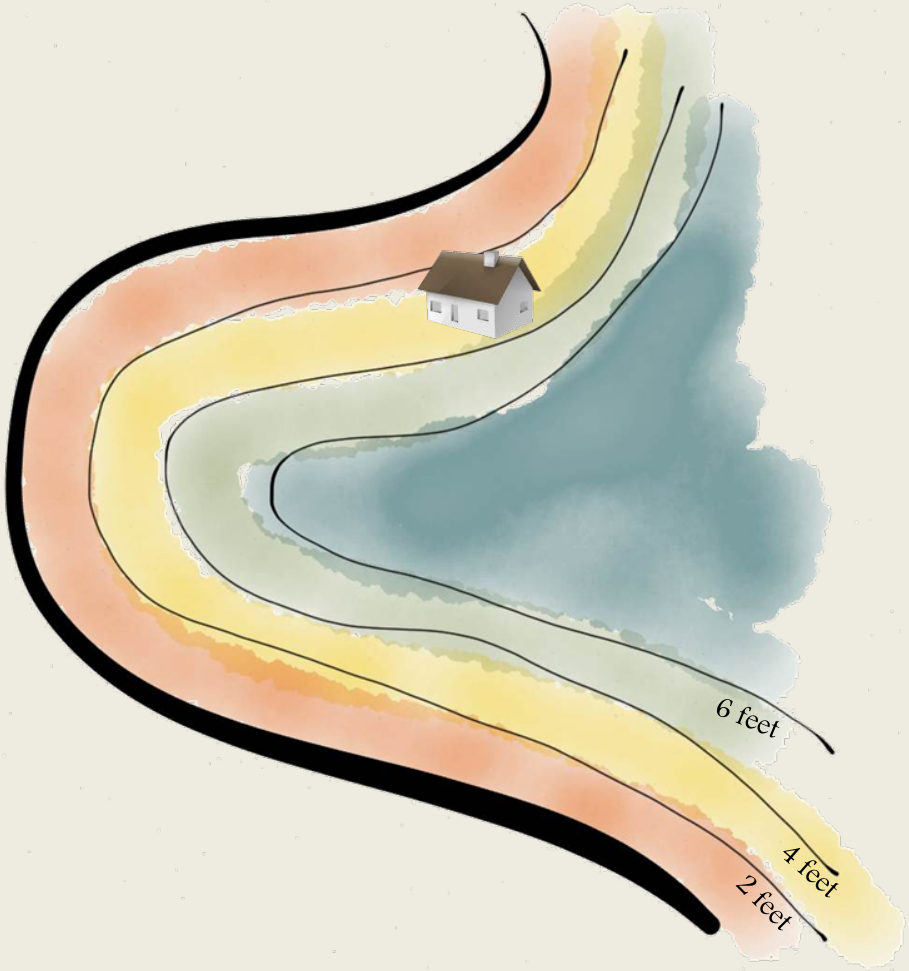

- Colors correspond to land elevations (not flood zones)
- Numerical elevations are linked to different reference frames (*ex. MSL*), but in an emergency, conversation can be limited to just colors

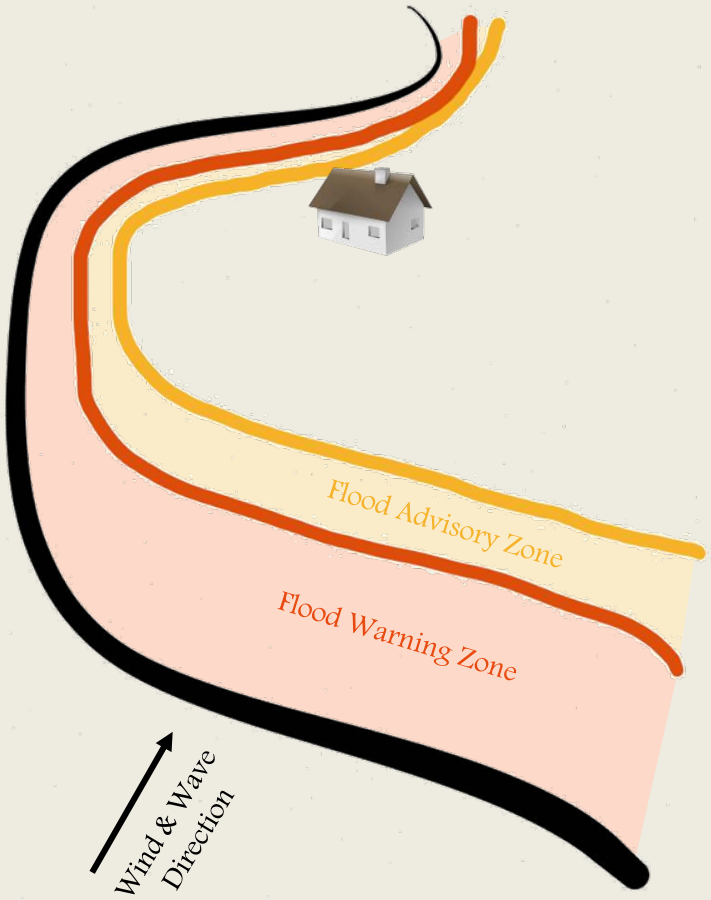
Golovin – Version 1.2 Last Updated Jan. 10, 2014
*Best available local datum offsets as computed by Jacquelyn Smith, UAF

| Map Color-Index | NAVD88 Elevation | Local MLLW* | Local MSL* |
|---|---|---|---|
| Red-Orange | 0.0 – 1.0 | -1.1 – -0.1 | -1.3 – -0.3 |
| Orange | 1.0 – 2.0 | -0.1 – 0.9 | -0.3 – 0.7 |
| Yellow | 2.0 – 3.0 | 0.9 – 1.9 | 0.7 – 1.7 |
| Chartreuse | 3.0 – 4.0 | 1.9 – 2.9 | 1.7 – 2.7 |
| Green | 4.0 – 5.0 | 2.9 – 3.9 | 2.7 – 3.7 |
| Cyan | 5.0 – 6.0 | 3.9 – 4.9 | 3.7 – 4.7 |
| Blue | 6.0 – 7.0 | 4.9 – 5.9 | 4.7 – 5.7 |
| Purple | 7.0 – 8.0 | 5.9 – 6.9 | 5.7 – 6.7 |
| Magenta | 8.0 – 9.0 | 6.9 – 7.9 | 6.7 – 7.7 |
| Pink | 9.0 – 10.0 | 7.9 – 8.9 | 7.7 – 8.7 |

- Critical areas can be highlighted for easy identification by non-residents

# Color-Indexed Elevation Maps vs. Flood Inundation Maps




- Highlights elevations by color
- Colors do no not directly correspond to flood zones
- A temporary tool for areas where data is limited

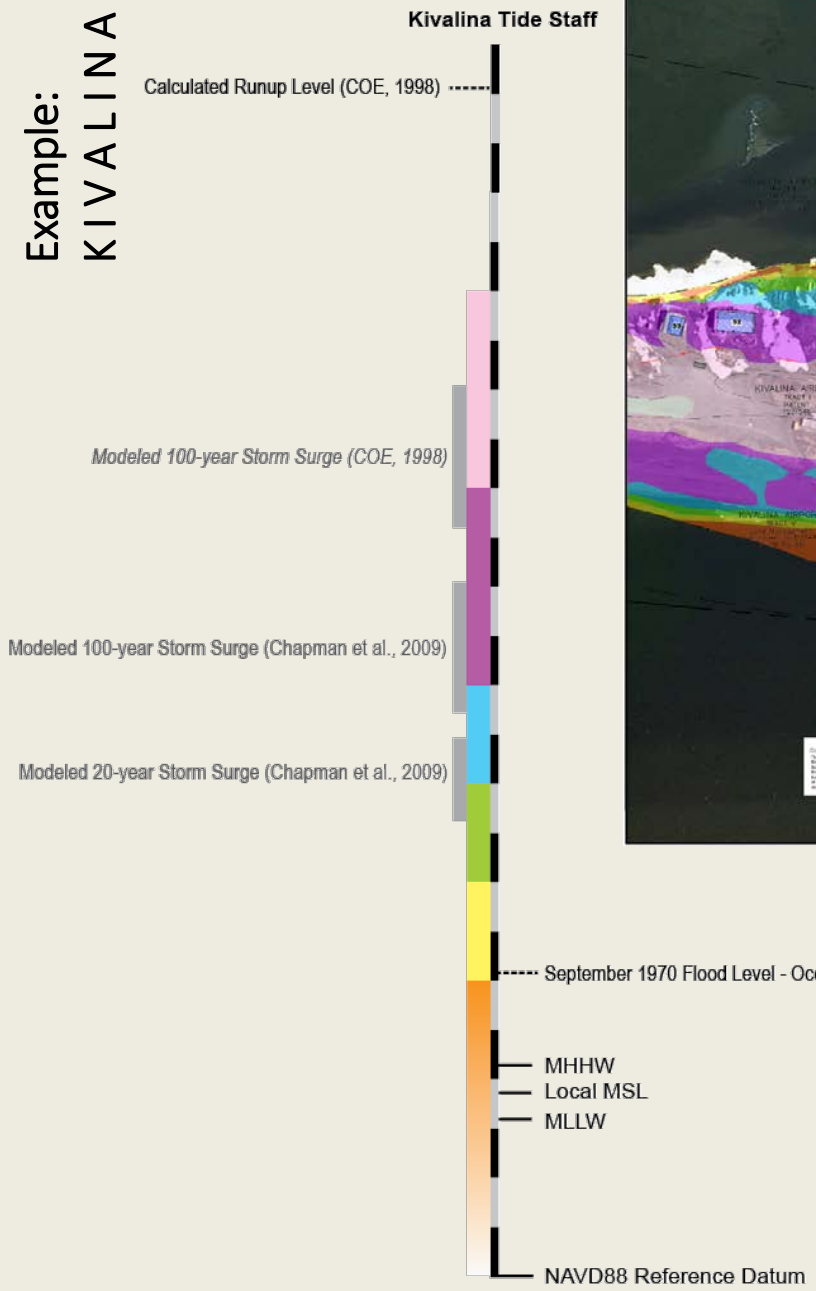
- Flood zones are based on extensive modeling of where water will go in various event scenarios
- These maps can be used to make rigorous planning decisions

# Community Selection for Pilot Project

- Demonstrated Need (documented flood events)
- Established Local Hazard Mitigation Plan
- Availability of existing data required to compile these maps
  - Imagery and linework (DCRA maps)
  - Elevation model
  - Tide levels and storm surge guidance

| Community | Kivalina | Shishmaref | Golovin | Shaktoolik | Unalakleet |
|---|---|---|---|---|---|
| DCRA Map | 1999 | 2004 | 2004 | 2004 | 2004 |
| DCRA Imagery | 2013 | 2004 | 2004 | 2004 | 2004 |
| Elevation Model | 2004 lidar | 2004 lidar | 2013 lidar | 2004 model | 2005 lidar |
| Tidal Predictions | Yes | Yes | No | Yes | Yes |
| Tidal Datum | Est. 1985-86 | Est. 2003 | Approx. 2012 | Est. 2010 | Est. 2011 |
| Surge Guidance | Limited | Yes | Yes | Yes | Yes |
| Local Hazard Mitigation Plan | 2007 | 2010 | 2008 | 2009 | 2008 |
| Existing flood map tools | No | FEMA Flood Insurance Study (2009) | No | COE Coastal Flooding Analysis Maps (2011) | NRCS Floodplain Management Map (2003) |

# Example: KIVALINA

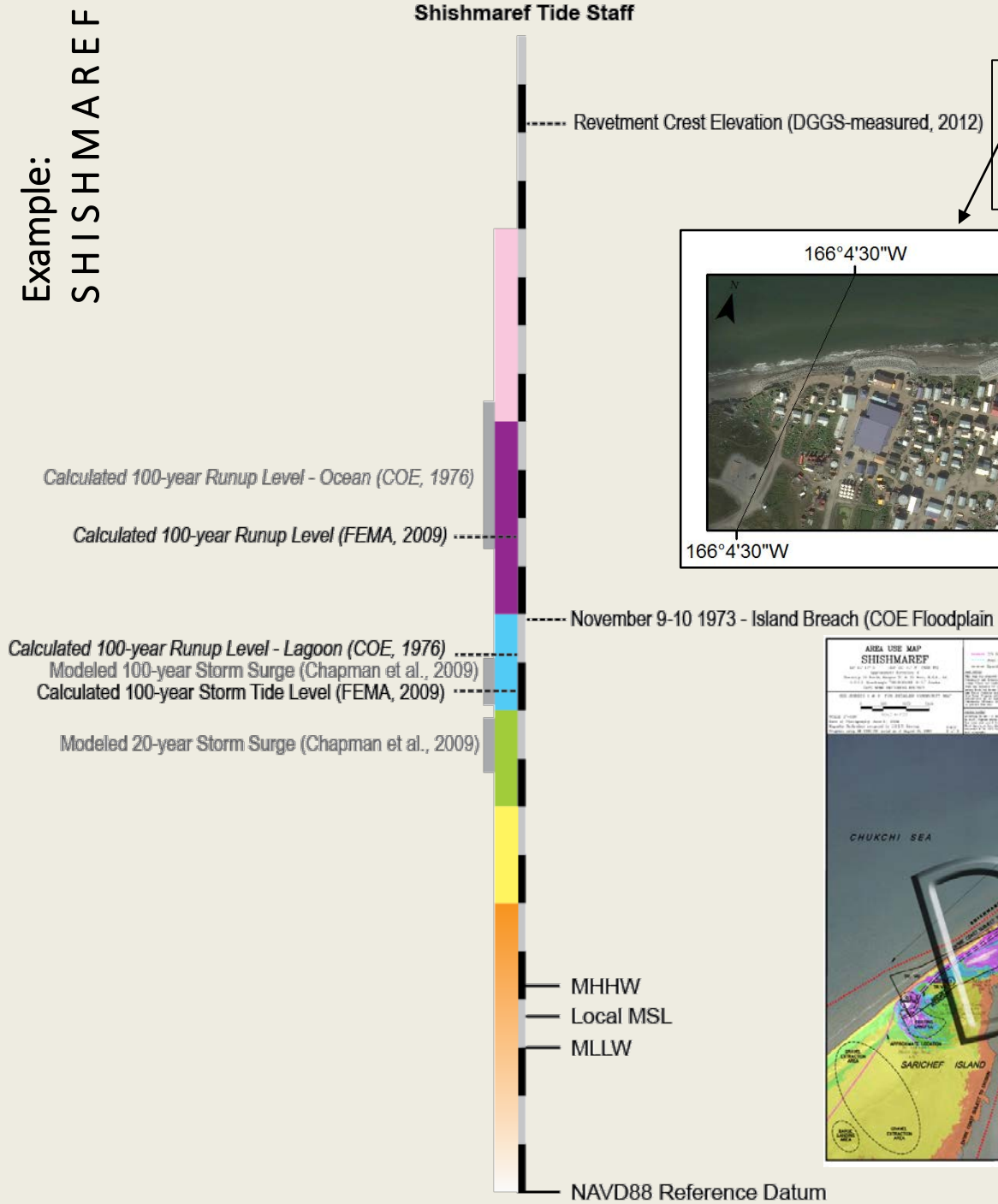


*+1 area-scale map*

Notes:

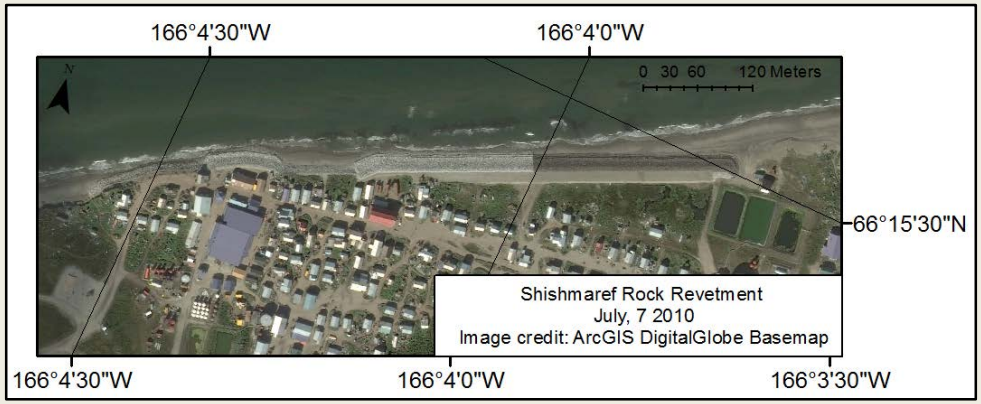
- New 2013 base imagery shows revetment location inland of elevation model
- The spit at the inlet changes shape regularly
- Buildings have moved since the 1999 DCRA map (new community maps are in production)
- 2004 lidar contains some errors and offsets
- Very few past flood events have been well-measured

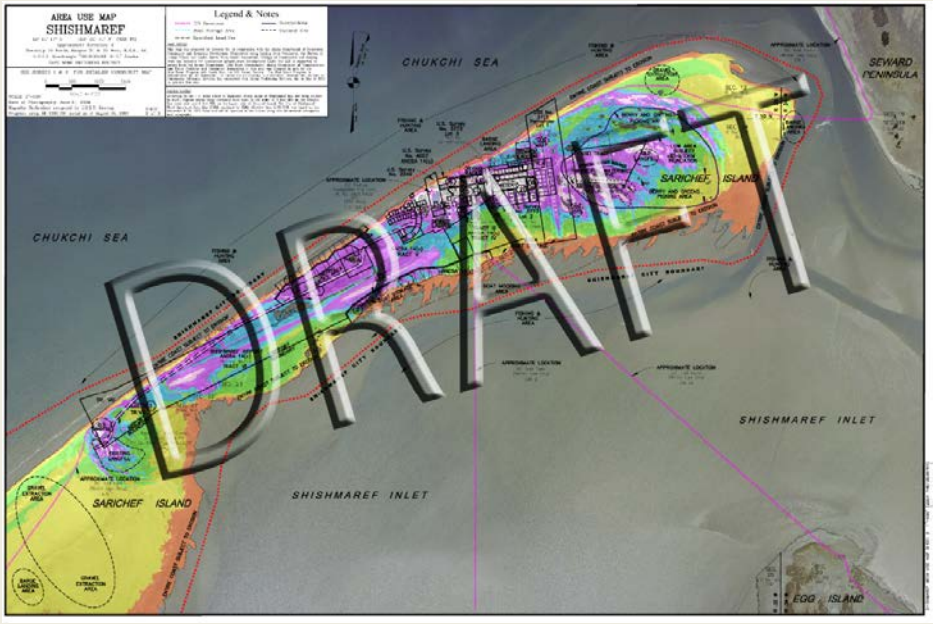
Example:
SHISHMAREF




Notes:

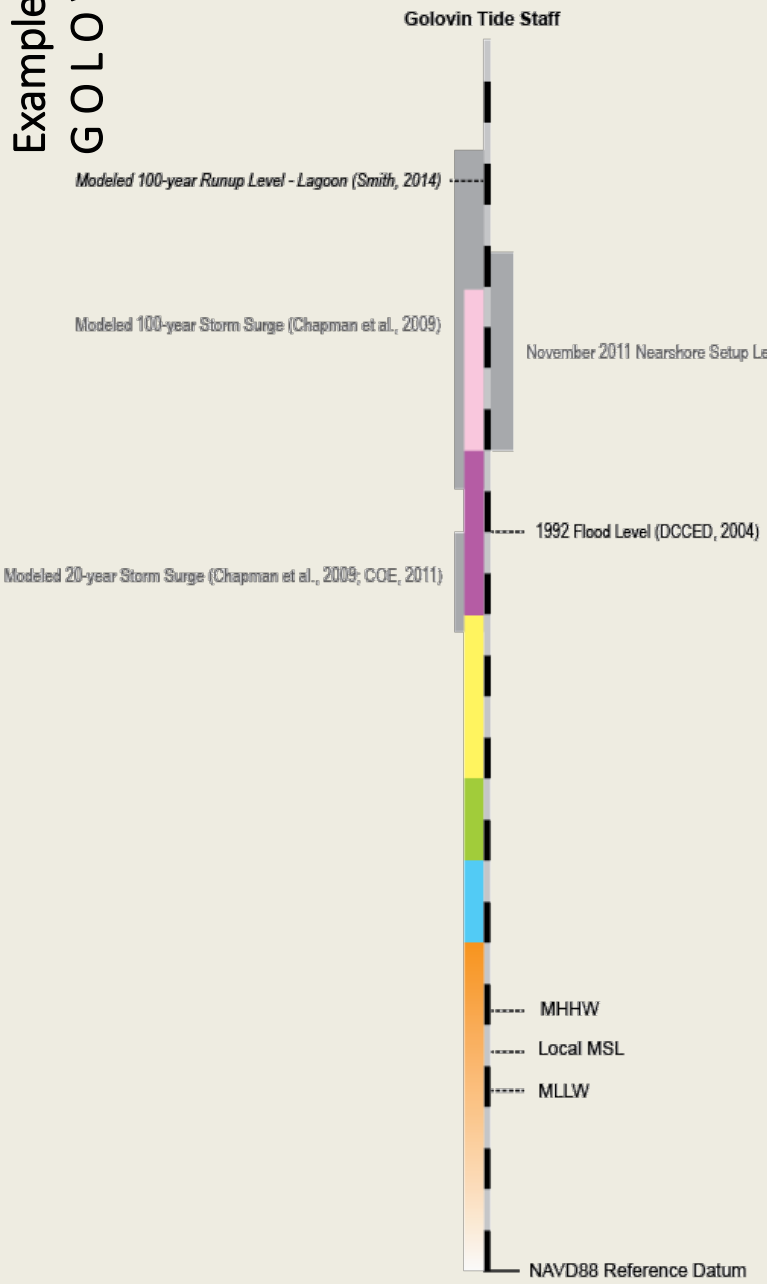
- 2004 lidar pre-dates the 2008/10 revetment
- 2004 lidar contains some errors and offsets
- Few past flood events have been well-measured



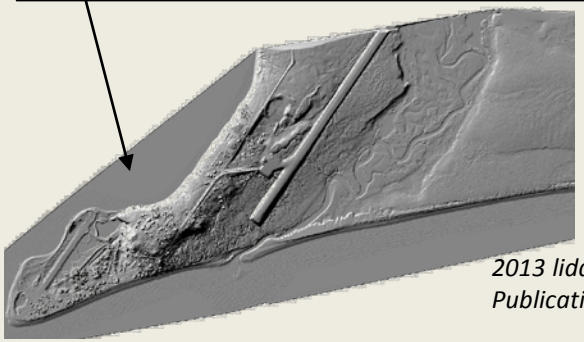

*+2 "zoomed-in" maps*

# Example: GOLOVIN




Notes:

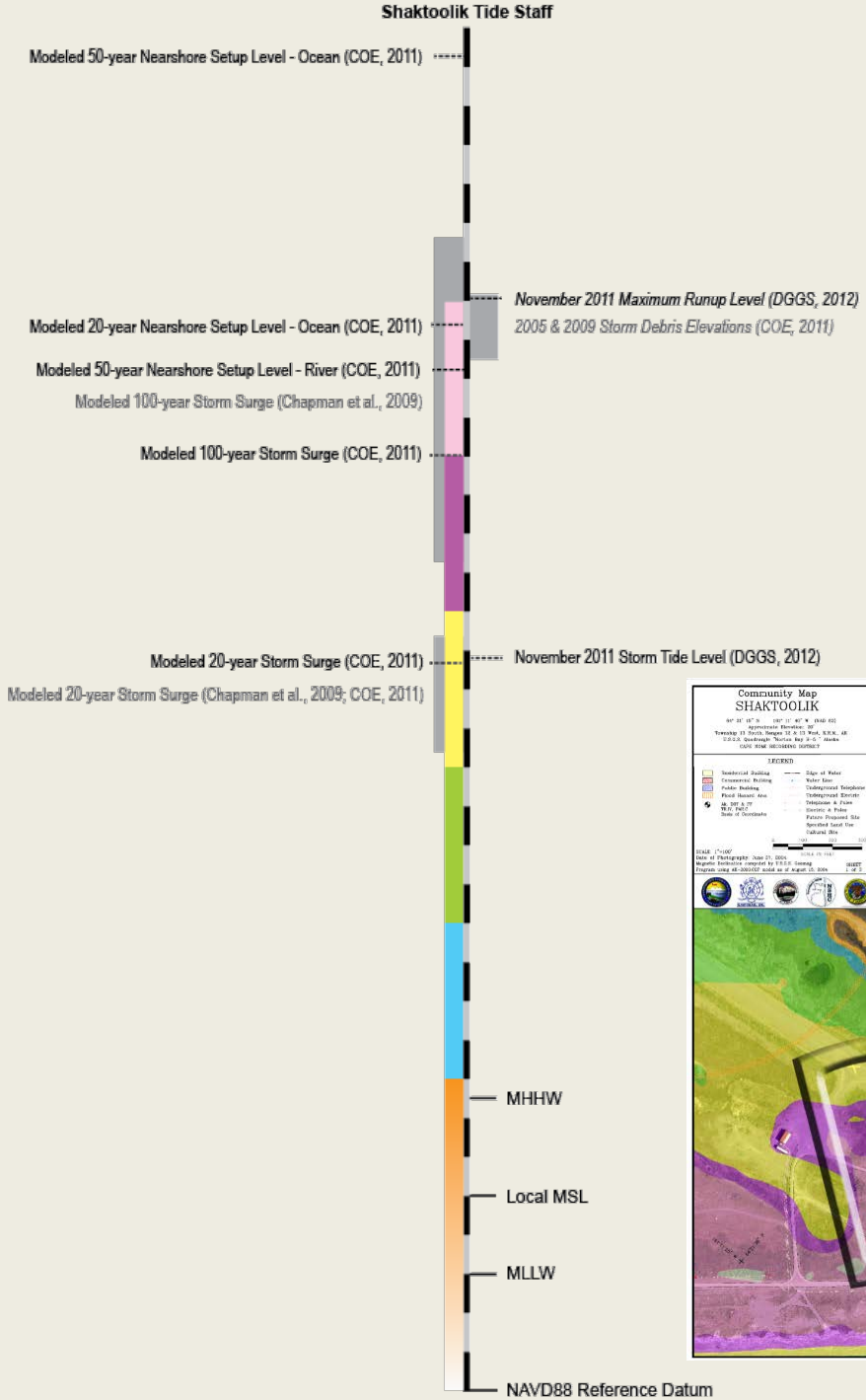
- New 2013 lidar – before or after local levee project?
- The tidal datum is not well constrained in Golovin, location is approximate based on short-term 2012 measurements



*2013 lidar received at DGGS Sept. 4, 2014*
*Publication of data planned by Oct. 2014*

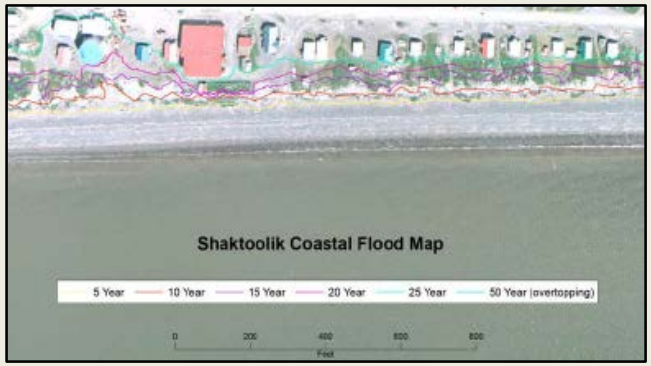
*+1 area-scale map and 1 "zoomed-in" map*

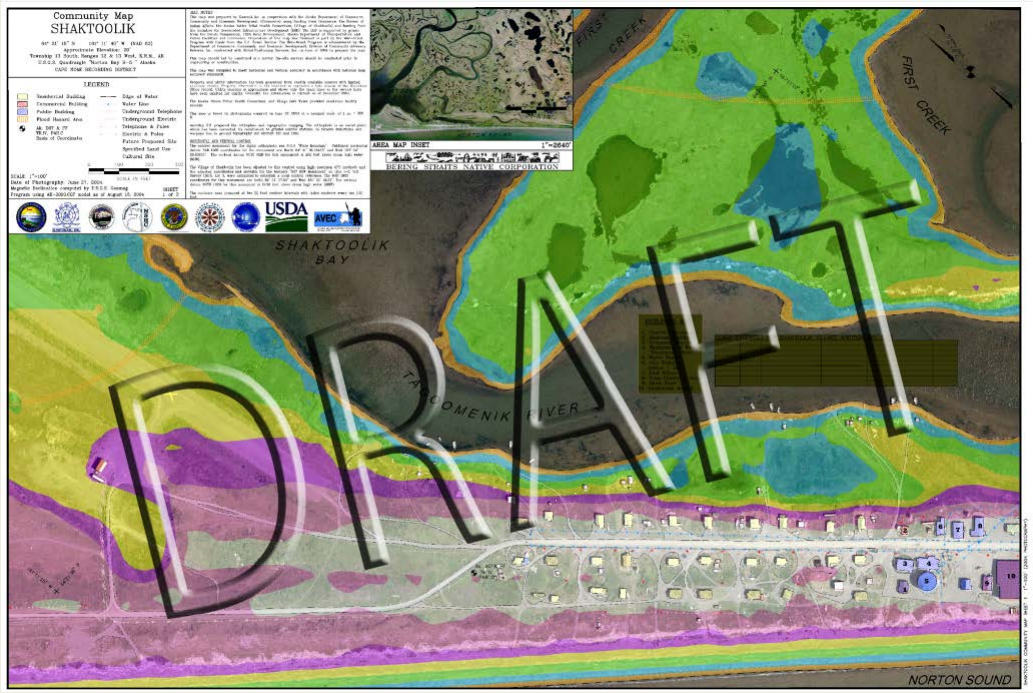
Example:
SHAKTOOLIK




Notes:

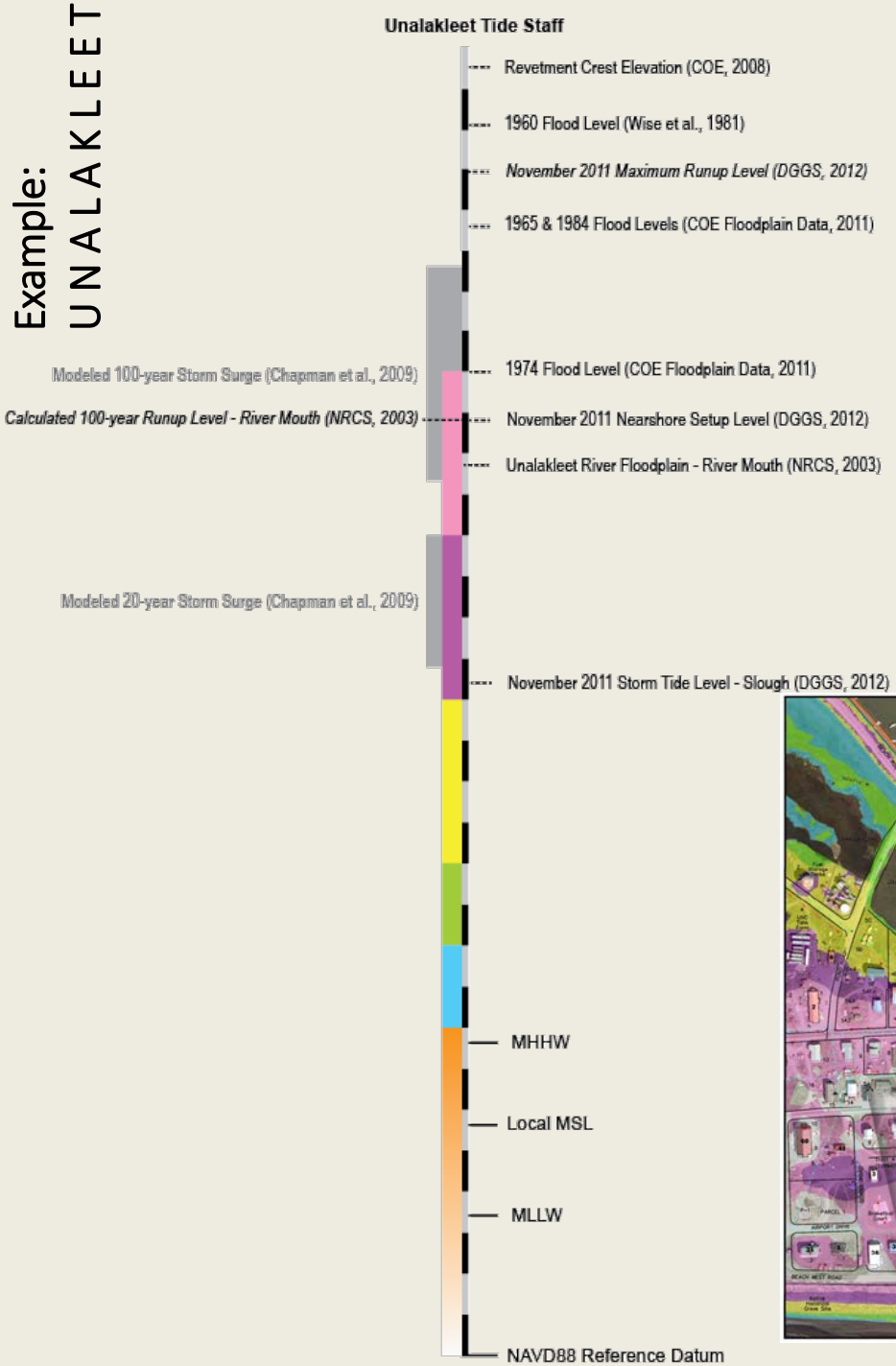
- No high-resolution/lidar DEM is currently available
- 2011 COE Coastal Flooding Analysis contains advanced flood mapping



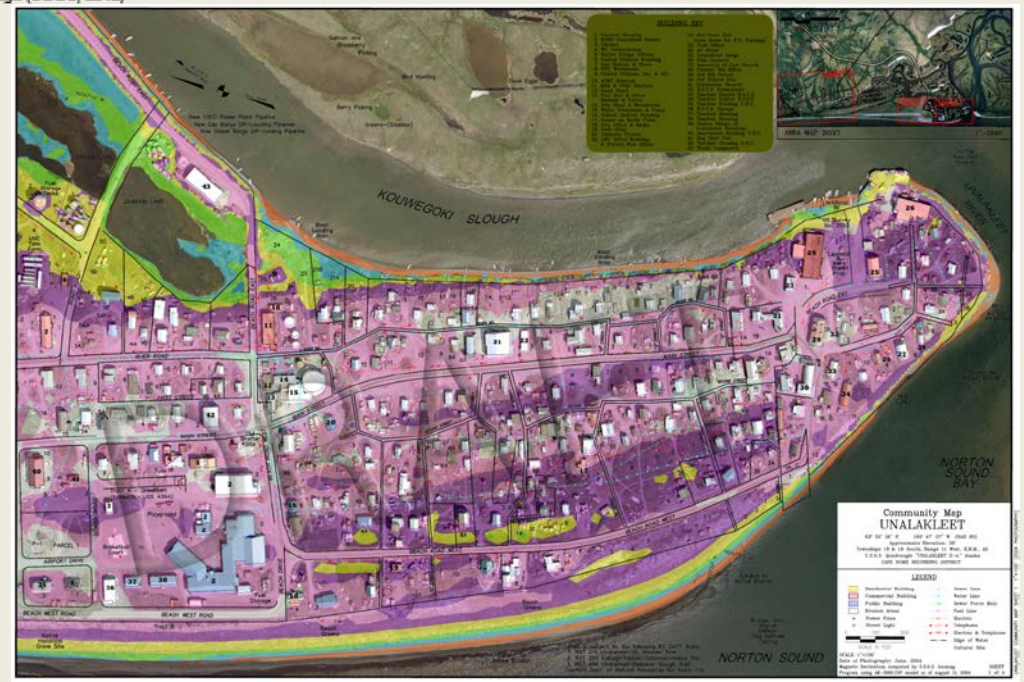

*+1 area map and 1 other "zoomed-in" map*

# Example: UNALAKLEET




Notes:

- 2005 lidar predates the 2010 revetment
- 2005 lidar predates dynamic engineered beach project near the airport
- Past flood event documentation exhibits considerable variation, likely due to setup dynamics and increased flow at the mouth of the Unalakleet River




*+1 area map and 2 other "zoomed-in" maps*

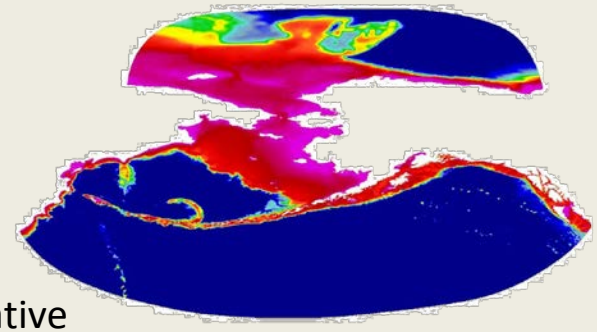
# Proposed Project Timeline

GOAL: Functional Color-Indexed Maps for 5 communities (w/ full documentation) in preparation for 2014 storm season

To succeed:

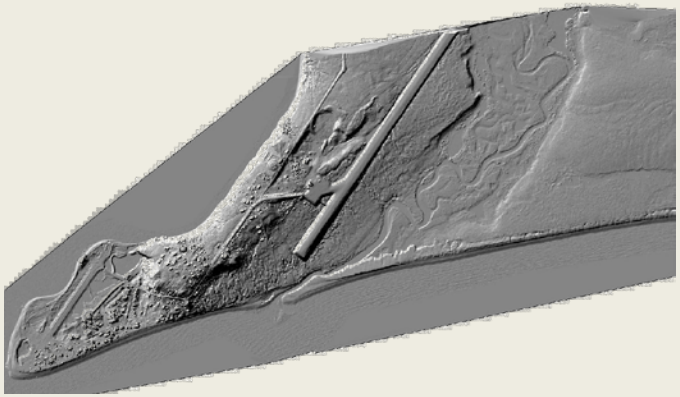
- Need critiques and feedback from local leadership
- Need to finalize format and style
- Report will undergo expedited State of Alaska review for publication
- Want to follow-up in 2015 to consider if project should be expanded

# What is happening to create real Flood Maps in western Alaska?



New storm surge and water level modeling:

- NOAA
- University of Alaska, Anchorage (Tom Ravens)
- USGS Pacific Coastal and Marine Science Center
- Western Alaska Landscape Conservation Cooperative



Baseline data collection at the local level:

- Alaska Division of Community and Regional Affairs
- New Federal/State partnerships for updated elevation and bathymetry data

Improved documentation of Wave, Wind and Water Levels during Storms:

- Alaska Ocean Observing System
- DGGS Rapid-Response Measurement Teams
- Alaska Department of Transportation and Public Facilities
- FEMA and the Army Corps of Engineers