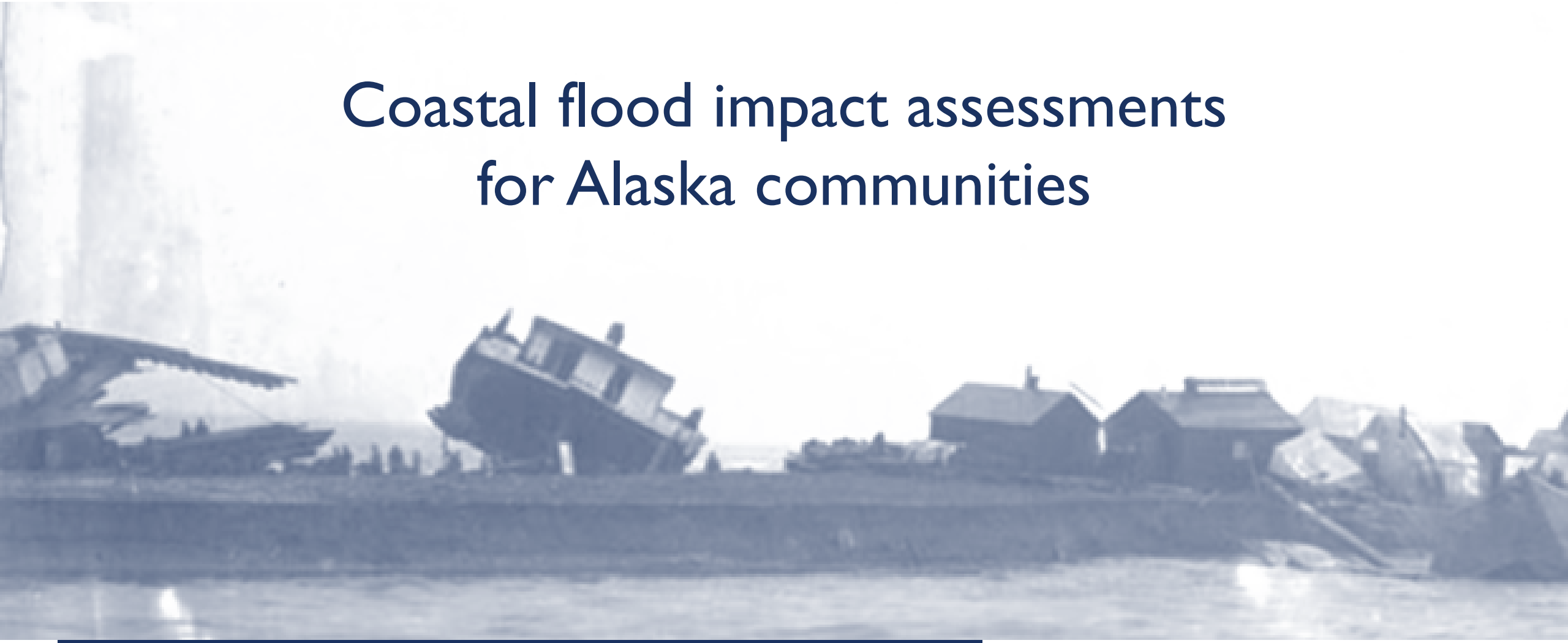
Coastal flood impact assessments for Alaska communities



Presented by Richard Buzard

Collaborators:

Jacquelyn Overbeck, Jonathan Chriest, Karen Endres, and Edward Plumb

THE PROBLEM

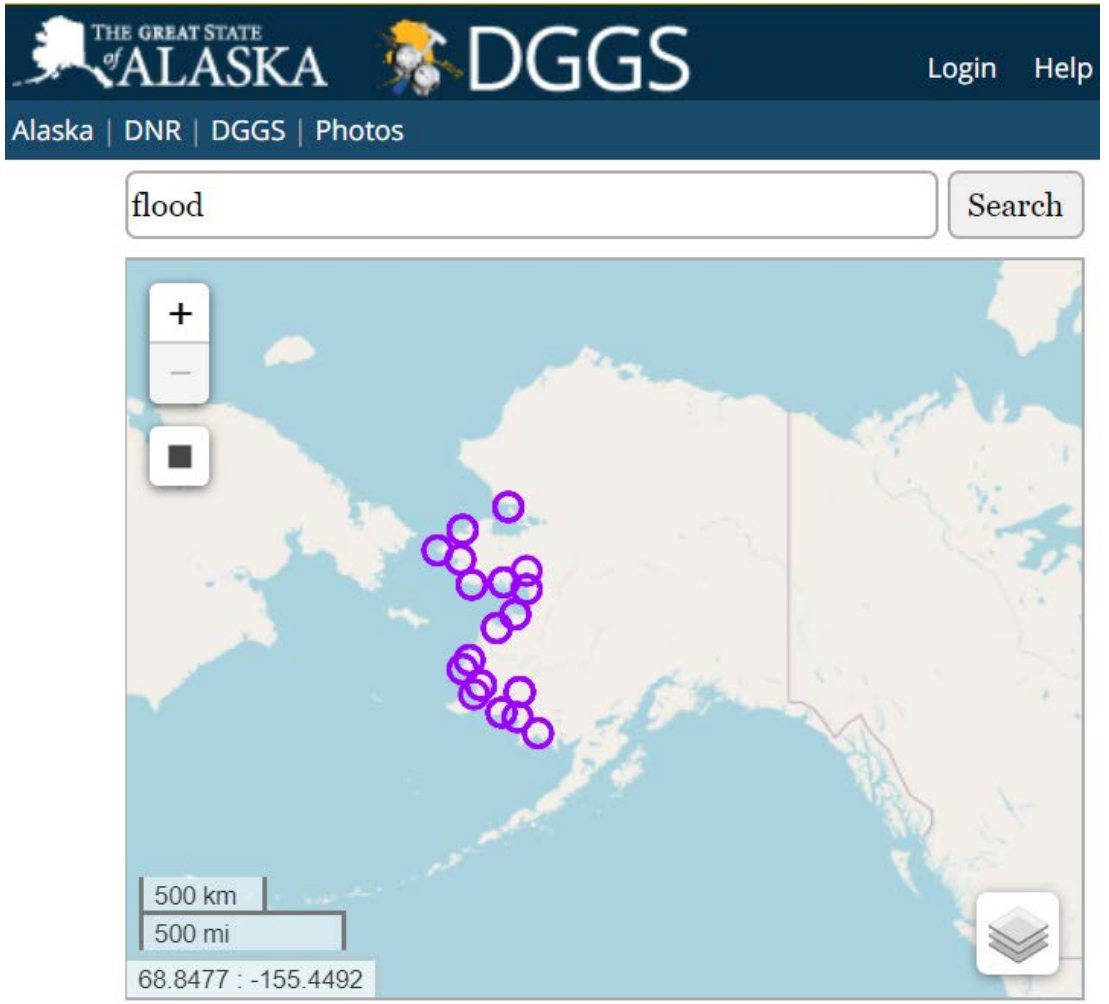
Storm surge flooding affects every coastal community in western Alaska.

The history of flooding in a community is difficult to follow

- **How many** storms have hit?
- **How high** have floods reached?

Knowing the flood history helps inform:

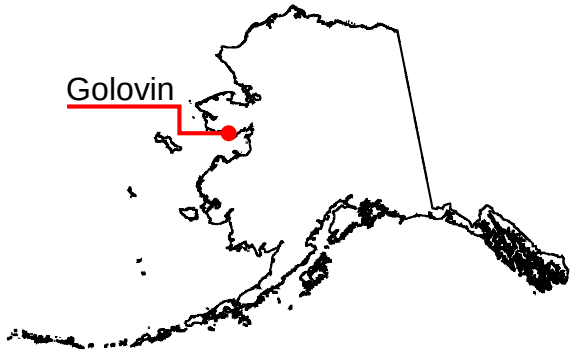
- Forecasters
- Mitigation planners



WHERE CAN I FIND FLOOD INFORMATION?

- Flood resources are **scattered**
- There is no consistent, **full list of floods** for each community
- So, we started putting together a list!

Source	Description
City of Golovin (2015)	Local HMP Update
City of Golovin (2008)	Local HMP
USACE (2017)	Local Flood Report (online)
USACE (2007)	Local Erosion Report
USACE (2000)	Local Flood Report (print)
Wise *et al.* (1981)	State Storm Damage Report
Chapman *et al.* (2009)	Regional Storm Surge Model
Many other sources	Science, news, local reporting



EXAMPLE: STORM HISTORY OF GOLOVIN

Flood is mentioned

Flood is not mentioned

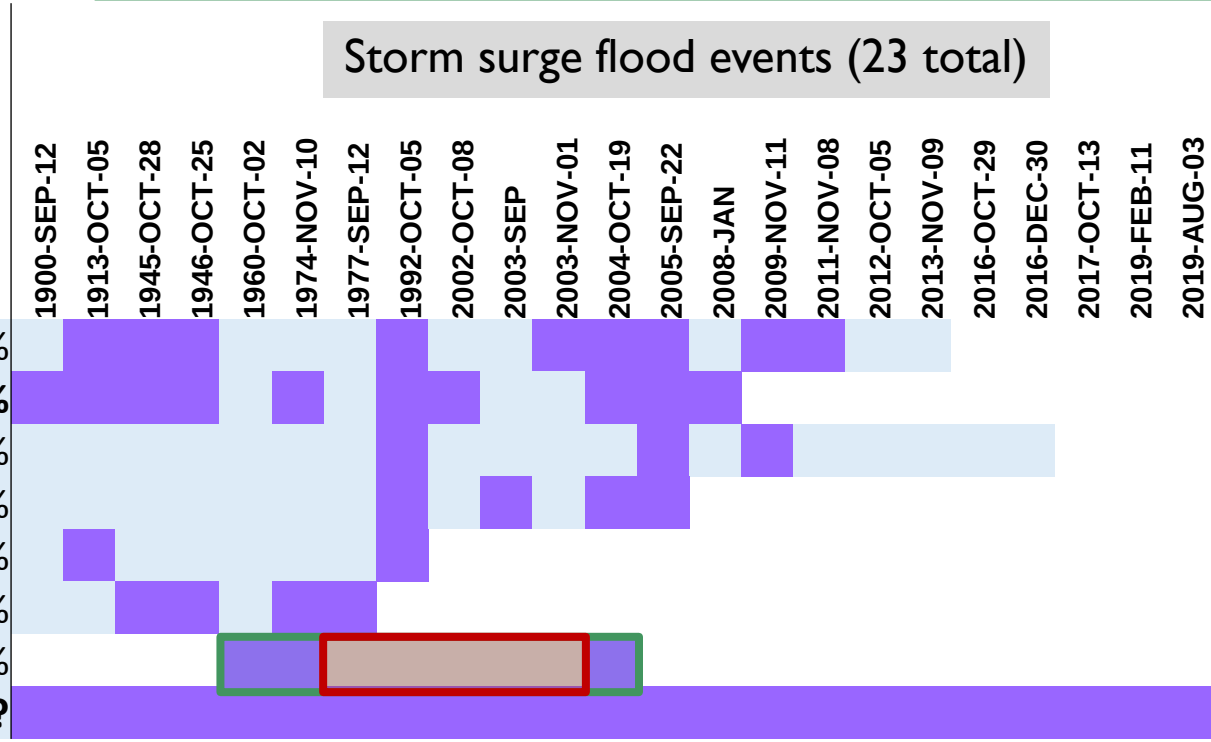
Flood occurred outside time of source

Hazard Mitigation Plan had the most information

No single source is complete, and everything becomes dated, but together they make a long history of storms!

Source	Description	# of storms in report	Percent given time period	Percent of total storms
City of Golovin (2015)	Local HMP Update	9	50%	39%
City of Golovin (2008)	Local HMP	10	**71%**	**43%**
USACE (2017)	Local Flood Report (online)	3	15%	13%
USACE (2007)	Local Erosion Report	4	31%	17%
USACE (2000)	Local Flood Report (print)	2	25%	9%
Wise *et al.* (1981)	State Storm Damage Report	4	57%	17%
Chapman *et al.* (2009)	Regional Storm Surge Model	3	38%	13%
Many other sources	Science, news, local reporting	**23**	**?**	**?**

Storm surge flood events (23 total)



Top 10 Storm surge model caught three big storms

But missed five others

ESTIMATING STORM HEIGHTS (EXAMPLE: NOVEMBER 2013)

- A series of four storms drove water into Norton Sound
- Standing water rose as high as Antone Street, but no significant overtopping occurred

Antone Street

Photo sent from Steve Ivanoff

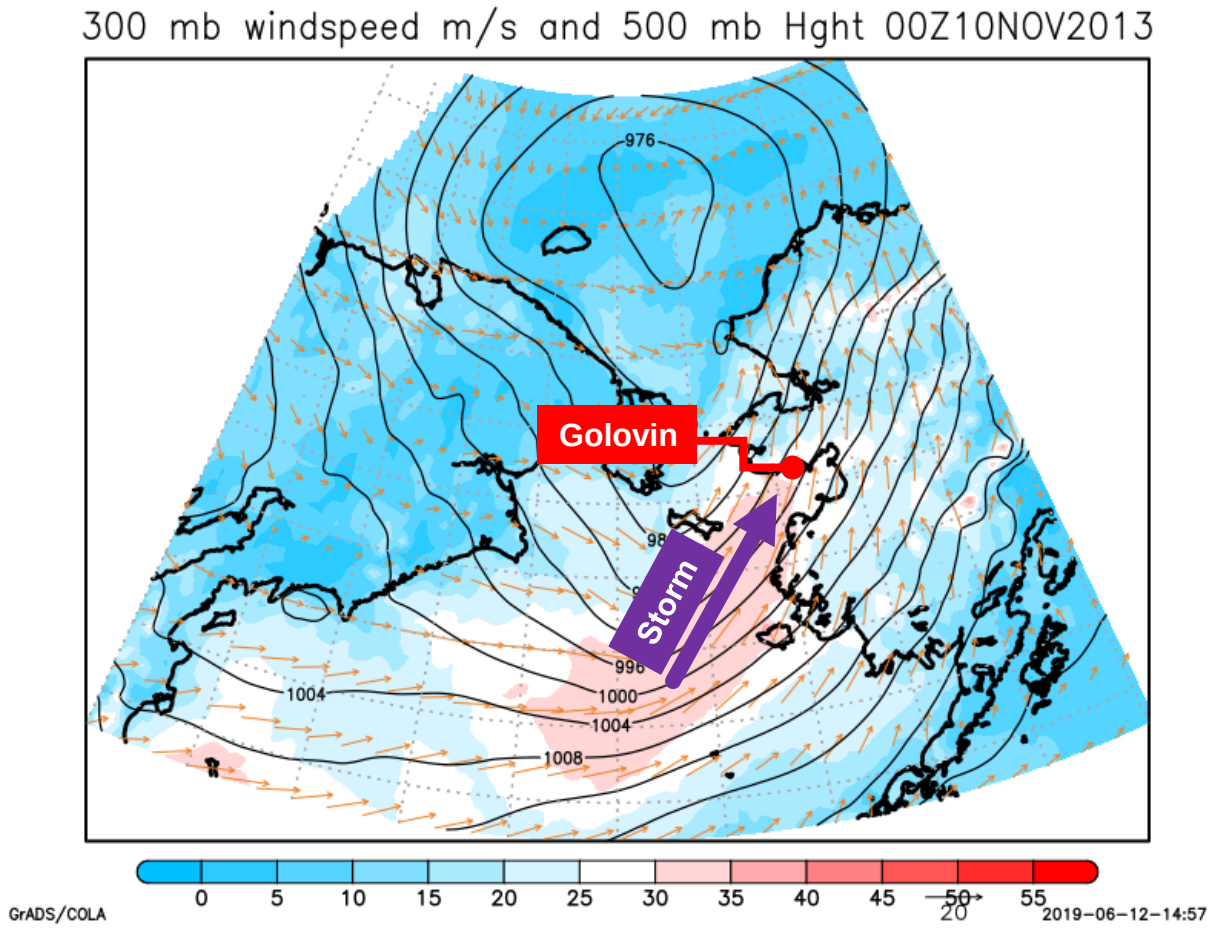


Figure by Emily Niebuhr, NOAA

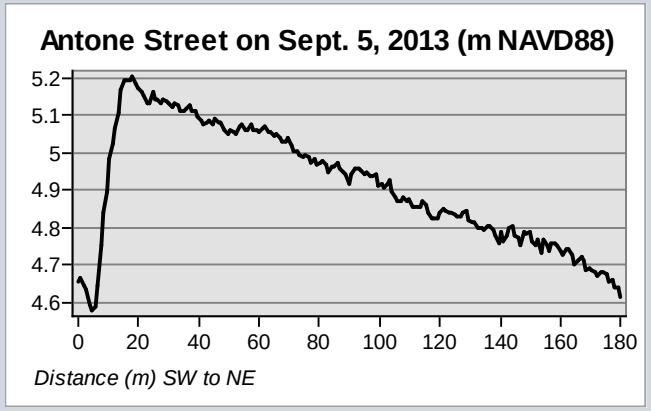
ESTIMATING STORM HEIGHTS (EXAMPLE: NOVEMBER 2013)

- A series of four storms drove water into Norton Sound
- Standing water rose as high as Antone Street, but no significant overtopping occurred

Antone Street

Take storm observation

Use context clues to find location



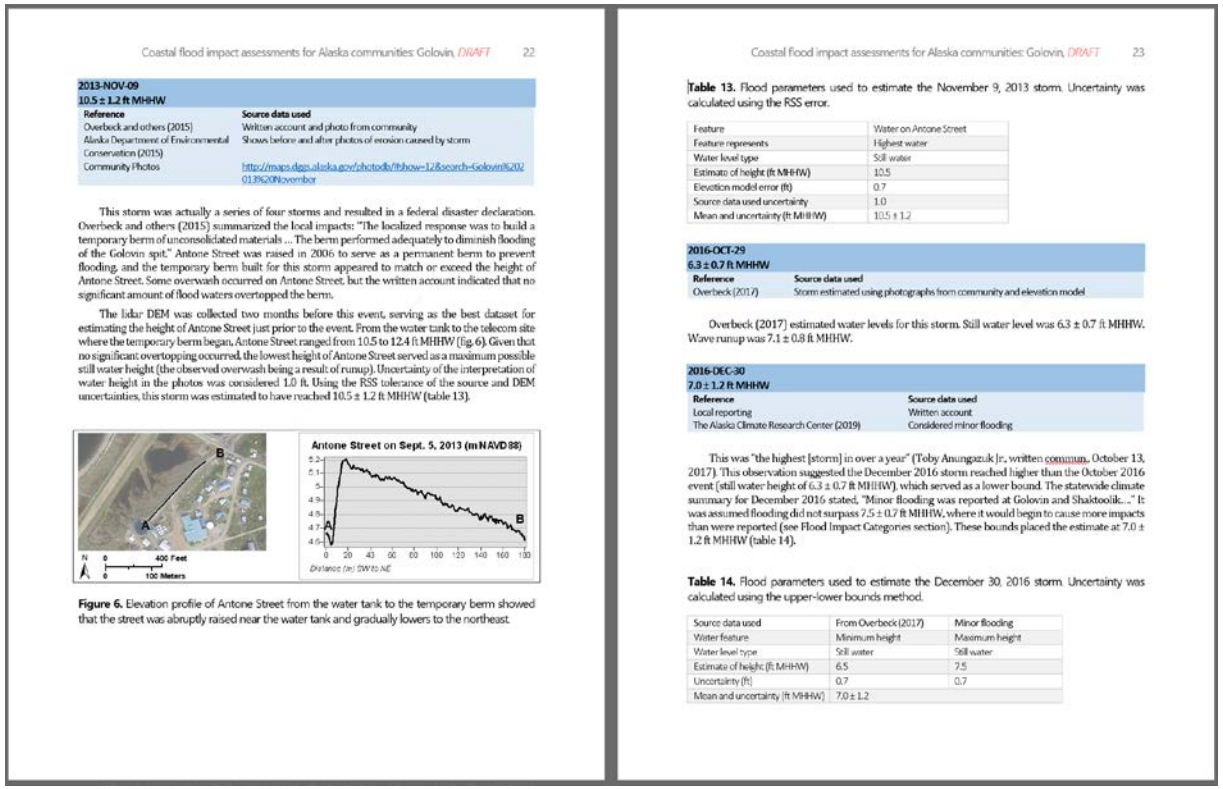
Measure elevation

Feature	Water on Antone Street
Feature represents	Highest water
Water level type	Still water
Estimate of height (ft MHHW)	10.5
Elevation model error (ft)	0.7
Source data used uncertainty	1.0
Mean and uncertainty (ft MHHW)	**10.5 ± 1.2**

Estimate storm height

THOROUGH DOCUMENTATION

Report of Investigations with storm history, height, and estimation method



Coastal flood impact assessments for Alaska communities: Golovin, DRAFT 22

2013-NOV-09
10.5 ± 1.2 ft MHHW

Reference	Source data used
Overbeck and others (2015)	Written account and photo from community
Alaska Department of Environmental Conservation (2015)	Shows before and after photos of erosion caused by storm
Community Photos	http://maps.dggs.alaska.gov/photodb/?show=12&search=Golovin%202013%20November

This storm was actually a series of four storms and resulted in a federal disaster declaration. Overbeck and others (2015) summarized the local impacts: "The localized response was to build a temporary berm of unconsolidated materials ... The berm performed adequately to diminish flooding of the Golovin spit." Antone Street was raised in 2006 to serve as a permanent berm to prevent flooding, and the temporary berm built for this storm appeared to match or exceed the height of Antone Street. Some overwash occurred on Antone Street, but the written account indicated that no significant amount of flood waters overtopped the berm.

The lidar DEM was collected two months before this event, serving as the best dataset for estimating the height of Antone Street just prior to the event. From the water tank to the telecom site where the temporary berm began, Antone Street ranged from 10.5 to 12.4 ft MHHW (fig. 6). Given that no significant overtopping occurred, the lowest height of Antone Street served as a maximum possible still water height (the observed overwash being a result of runup). Uncertainty of the interpretation of water height in the photos was considered 1.0 ft. Using the RSS tolerance of the source and DEM uncertainties, this storm was estimated to have reached 10.5 ± 1.2 ft MHHW (table 13).

Figure 6. Elevation profile of Antone Street from the water tank to the temporary berm showed that the street was abruptly raised near the water tank and gradually lowers to the northeast.

Coastal flood impact assessments for Alaska communities: Golovin, DRAFT 23

Table 13. Flood parameters used to estimate the November 9, 2013 storm. Uncertainty was calculated using the RSS error.

Feature	Water on Antone Street
Feature represents	Highest water
Water level type	Still water
Estimate of height (ft MHHW)	10.5
Elevation model error (ft)	0.7
Source data used uncertainty	1.0
Mean and uncertainty (ft MHHW)	10.5 ± 1.2

2016-OCT-29
6.3 ± 0.7 ft MHHW

Reference	Source data used
Overbeck (2017)	Storm estimated using photographs from community and elevation model

Overbeck (2017) estimated water levels for this storm. Still water level was 6.3 ± 0.7 ft MHHW. Wave runup was 7.1 ± 0.8 ft MHHW.

2016-DEC-30
7.0 ± 1.2 ft MHHW

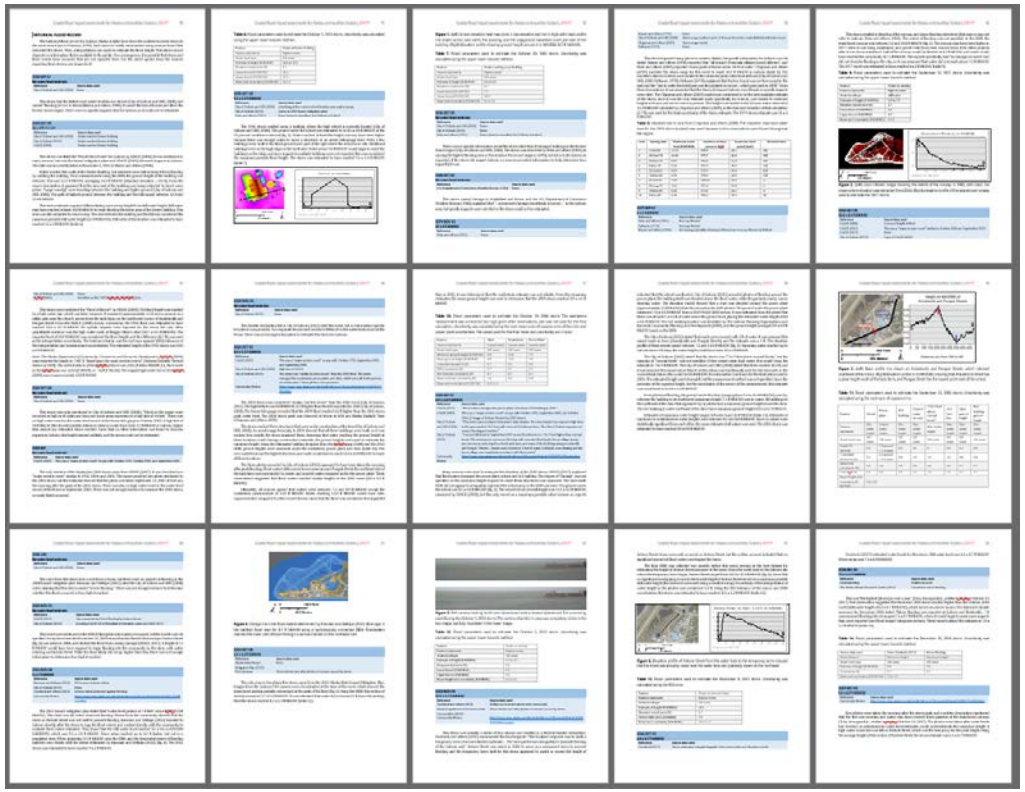
Reference	Source data used
Local reporting	Written account
The Alaska Climate Research Center (2019)	Considered minor flooding

This was "the highest [storm] in over a year" (Toby Anungazuk Jr., written commun., October 13, 2017). This observation suggested the December 2016 storm reached higher than the October 2016 event (still water height of 6.3 ± 0.7 ft MHHW), which served as a lower bound. The statewide climate summary for December 2016 stated, "Minor flooding was reported at Golovin and Shaktoolik..." It was assumed flooding did not surpass 7.5 ± 0.7 ft MHHW, where it would begin to cause more impacts than were reported (see Flood Impact Categories section). These bounds placed the estimate at 7.0 ± 1.2 ft MHHW (table 14).

Table 14. Flood parameters used to estimate the December 30, 2016 storm. Uncertainty was calculated using the upper-lower bounds method.

Source data used	From Overbeck (2017)	Minor flooding
Water feature	Minimum height	Maximum height
Water level type	Still water	Still water
Estimate of height (ft MHHW)	6.5	7.5
Uncertainty (ft)	0.7	0.7
Mean and uncertainty (ft MHHW)	7.0 ± 1.2	

Every storm!



LIST OF STORMS

Rank	Storm	Elevation (ft MHHW)	Vertical Uncertainty (ft)
1	1913-OCT-05	12	2
2	1974-NOV-10	11	3
3	2013-NOV-09	10.5	1.2
4	1992-OCT-05	10.0	0.9
5	1945-OCT-28	9.1	1.4
6	2011-NOV-08	9	2
7	2004-OCT-19	8.9	1.1
8	2005-SEP-22	8.8	0.3
9	2016-DEC-30	7.0	1.2
10	2019-FEB-11	6.5	1.2
11	2016-OCT-29	6.3	0.7
12	1977-SEP-12	6	2
13	2017-OCT-13	5.1	0.7
14	2012-OCT-05	4.2	1.3

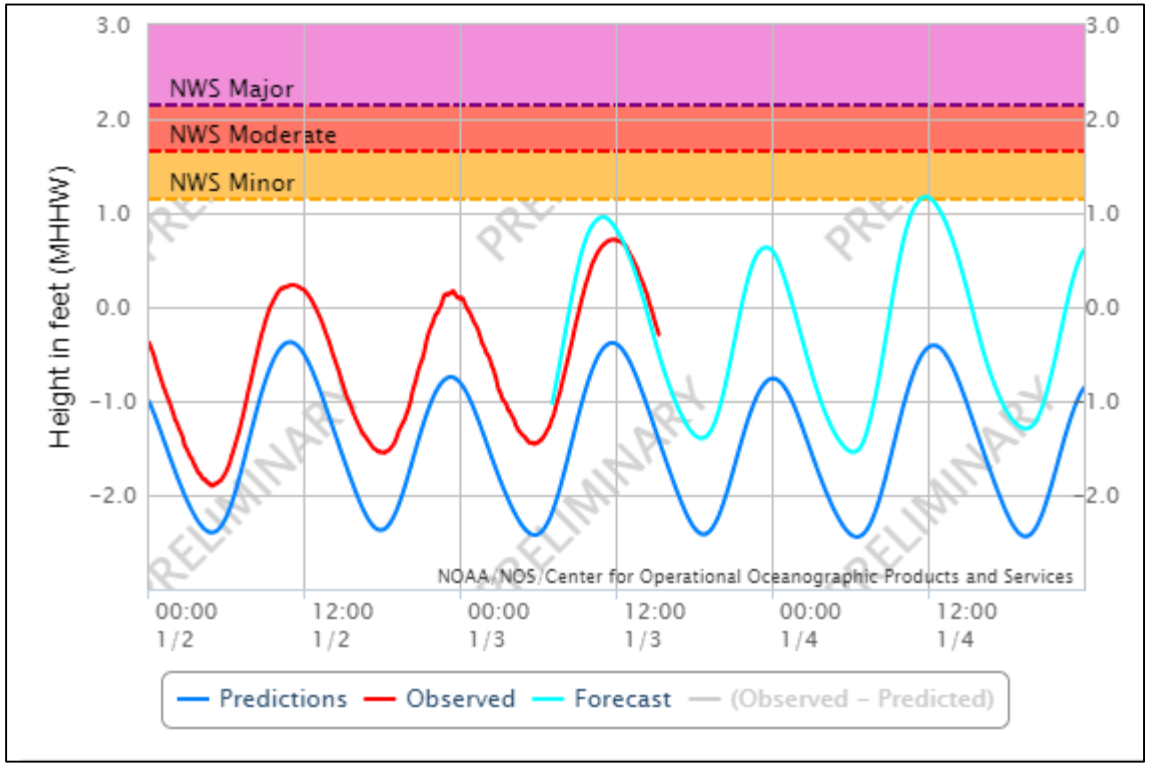
Not enough information
1900-SEP-12
1946-OCT-25
1960-OCT-02
2002-OCT-08
2003-SEP
2003-NOV-01
2008-JAN
2009-NOV-11

Great!

But what does it mean?

COMMUNICATING FLOOD RISK

- Flood Categories are used to communicate general impacts expected by incoming storms



MAJOR: Extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.

MODERATE: Some inundation of structures and roads near stream. Some evacuations of people and/or transfer of property to higher elevations.

MINOR: Minimal or no property damage, but possibly some public threat.

From NWS website:

https://w1.weather.gov/glossary/index.php?word=Flood+Categories

ILLUSTRATING FLOOD CATEGORIES

- Flood categories are based on the height water would have to reach to impact structures and society

Table of infrastructure height

	Elevation Feature	Elevation (ft MHHW)
Major	*Clinic first floor	13.6
	Dexter Roadhouse beach side	13
	Highest recorded storm (still water)	12
	*Recommended building height	12.0
	*High school front door sill	11.1
	Drinking water	10.5
	Several buildings	10.5
	Fuel tanks	10.1
	Major	**10**
Mod.	Lowest residences	8.8
	Roads in town	7.5
	Moderate	**7.5**
Minor	Lowest building	7.0
	Beach property	3.9
	Minor	**3.9**

Table of storms

Storm	Elevation (ft MHHW)	Vertical Uncertainty (ft)
1913-OCT-05	12	2
1974-NOV-10	11	3
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2016-DEC-30	7.0	1.2
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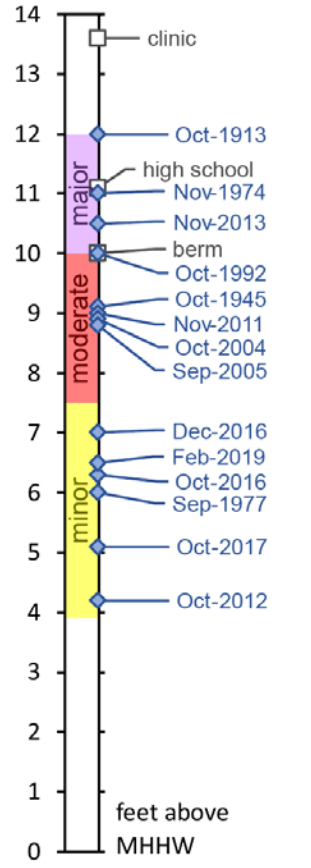

To calculate height above
MLLW: add 1.7 ft
NAVD88: add 4.6 ft

Table of infrastructure height

	Elevation Feature	Elevation (ft MHHW)
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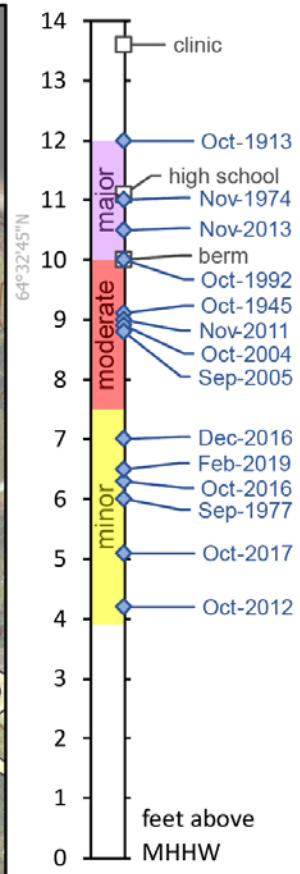
	Roads in town	7.5
	Moderate	**7.5**
Minor	Lowest building	7.0
	Beach property	3.9
	Minor	**3.9**

Map of Flood Categories

DRAFT Coastal Flood Impact
Golovin, Alaska

REPORT OF INVESTIGATIONS 2020-X
Buzard and others, 2020
SHEET GOLOVIN



To calculate height above
MLLW: add 1.7 ft
NAVD88: add 4.6 ft

Projection: NAD 1983 2011 UTM Zone 3N
Orthoimagery available from elevation.alaska.gov
Contours drawn at 20 ft intervals above MHHW
Houses or infrastructure may have moved since DCRA linework was completed

STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

Major Flooding is defined to have extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations are necessary.

Moderate Flooding is defined to have some inundation of structures and roads near the water. Some evacuations of people and/or transfer of property to higher elevations may be necessary.

Minor Flooding is defined to have minimal or no property damage, but possibly some public threat.

This work is a part of the Digital Coast Fellowship project: Bringing Alaska to the Digital Coast. The analysis was paid for by the National Oceanic and Atmospheric Administration Office for Coastal Management, and the State of Alaska.

SOLVING THE PROBLEM

With this resource, you can:

- Quickly see the **history of storms** in a table
- Read about the **storm impacts** in a document
- See how forecasted storms might **impact the community** in a map

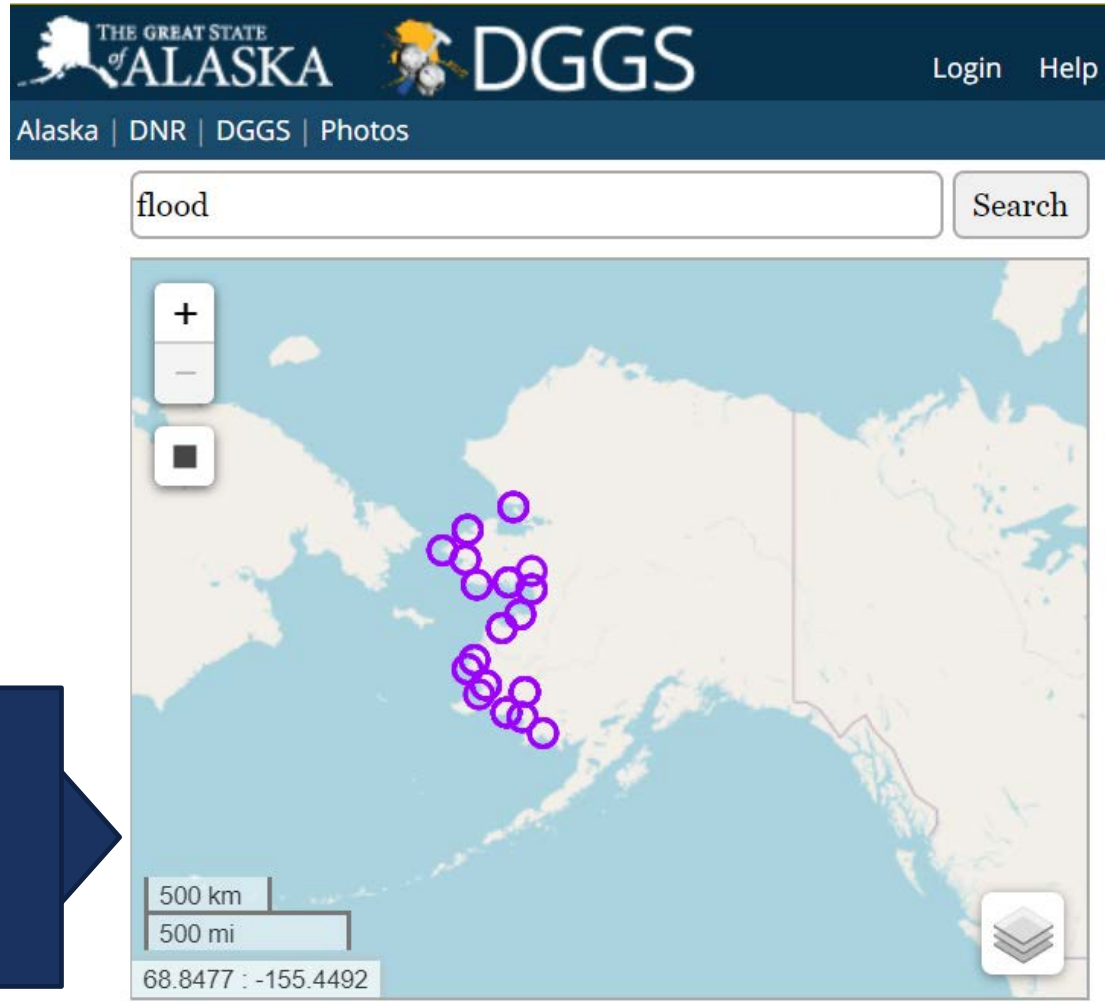
This has only been completed for Golovin and Hooper Bay.

We are working on more locations, but it takes a lot of time to get it right!

You can see pictures of storm impacts for many communities at the DGGS Photo Database:

maps.dggs.alaska.gov/photodb

Search "flood" and explore!



BONUS SLIDES

HOW DID THE USACE MODEL COMPARE TO OBSERVATIONS?

Top 10 surge events between 1954 and 2004 (Chapman *et al.* 2009)

Rank	Starting Date	Maximum Surge (ft MLLW)
1	1960-OCT-01	13.14
2	1974-Nov-10	12.74
3	1970-NOV-26	10.32
4	1978-NOV-26	10.05
5	2004-OCT-15	10.02
6	1966-NOV-14	9.96
7	1996-OCT-25	9.33
8	1975-AUG-25	8.74
9	1965-NOV-12	8.15
10	1985-NOV-06	8.12

Mentioned in other sources, no further details

Estimated: 10.6 ± 1.1 ft MLLW

Not mentioned in any sources

Rank	Storm	Elevation (ft MLLW)	Vertical Uncertainty (ft)
1	1913-OCT-05	13.7	2
2	1974-NOV-10	12.7	3
3	2013-NOV-09	12.2	1.2
4	1992-OCT-05	11.7	0.9
5	1945-OCT-28	10.8	1.4
6	2011-NOV-08	10.7	2
7	2004-OCT-19	10.6	1.1
8	2005-SEP-22	10.5	0.3
9	2016-DEC-30	8.7	1.2
10	2019-FEB-11	8.2	1.2
11	2016-OCT-29	8	0.7
12	1977-SEP-12	7.7	2
13	2017-OCT-13	6.8	0.7
14	2012-OCT-05	5.9	1.3
	1900-SEP-12	-	-
	1946-OCT-25	-	-
	1960-OCT-02	-	-
	2002-OCT-08	-	-
	2003-SEP	-	-
	2003-NOV-01	-	-
	2008-JAN	-	-
	2009-NOV-11	-	-

Using Forecast Tools

The community can build earthen dams to prevent flooding

Golovin, Alaska

Flood impact without barrier

Golovin

Flood impact with barrier

Golovin