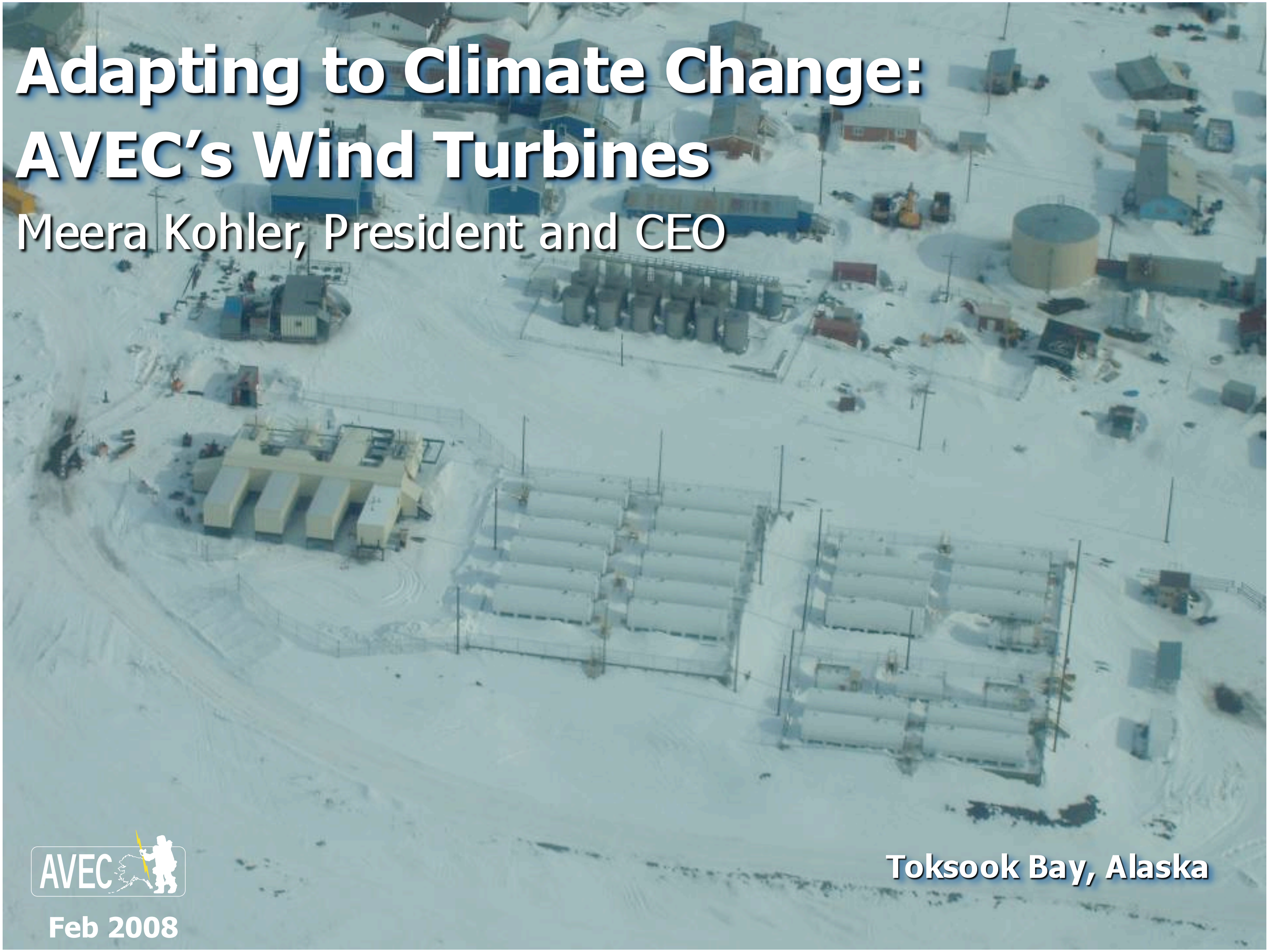
Adapting to Climate Change:
AVEC's Wind Turbines

Meera Kohler, President and CEO



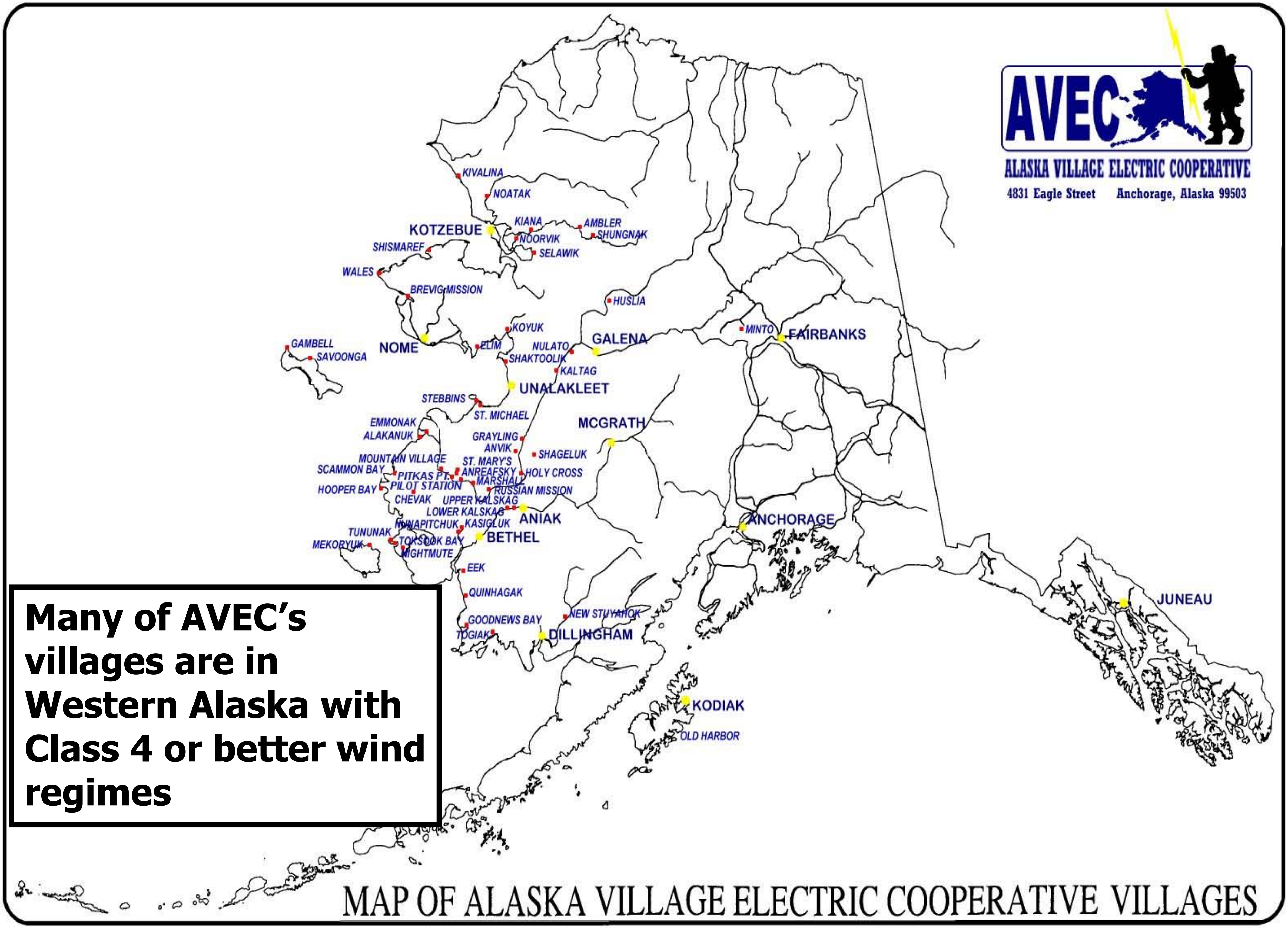
Toksook Bay, Alaska

AVEC

Feb 2008

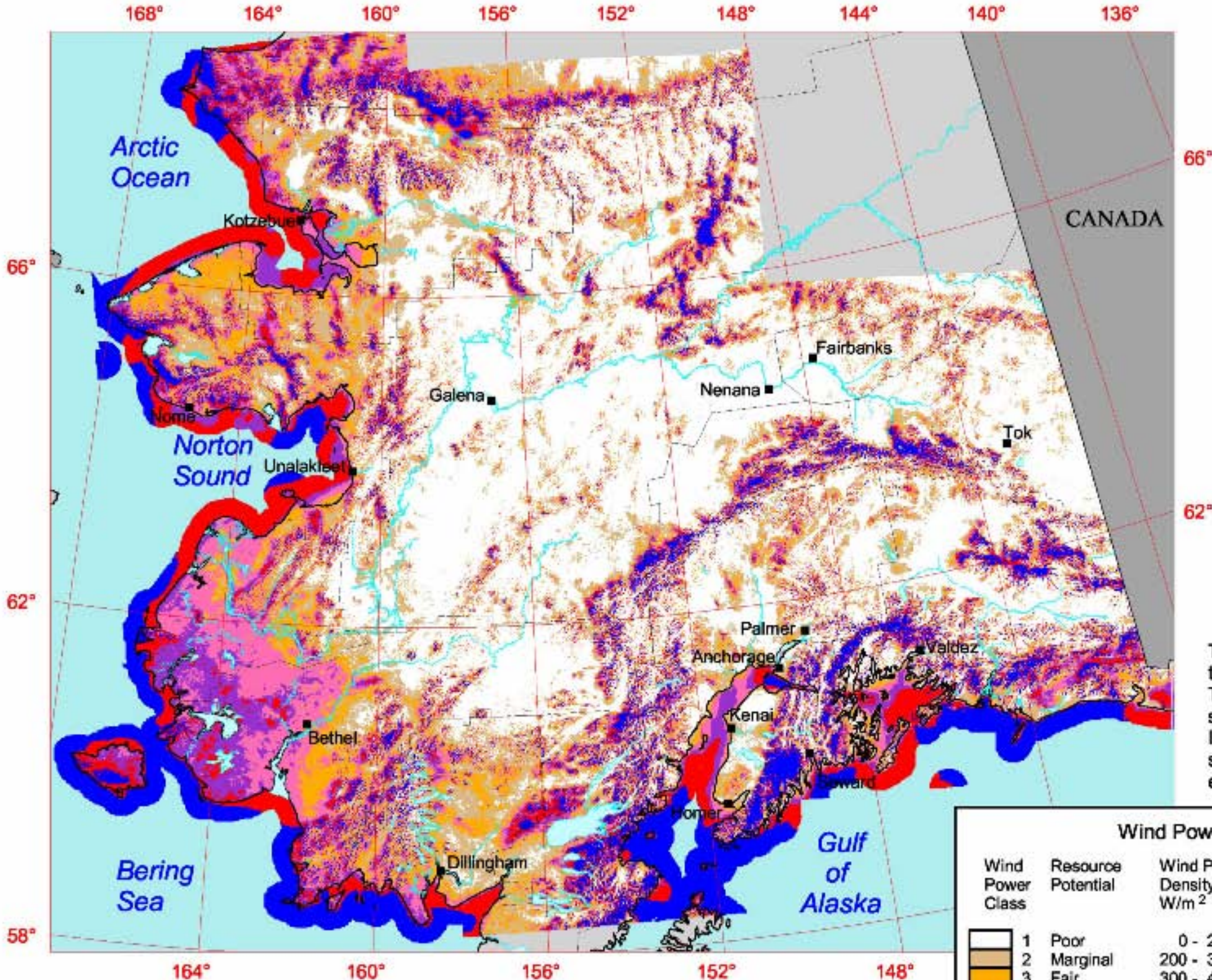
Efficiency Information

- **27 of our 53 villages are in wind regimes of class 4 or better**
- **One NW/100 should be able to produce about 220,000 kWh per year**
- **This would displace 15,700 gallons of diesel fuel used for generation**
- **A wind plot of 3 NW/100s could displace about 47,000 gallons per year**
- **At $3.00 per gallon, savings could total $141,000**



Many of AVEC's villages are in Western Alaska with Class 4 or better wind regimes

Alaska Mainland Regions 50 m Wind Power



The annual wind power estimates for this map were produced by AWS Truewind using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.

Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
1	Poor	0 - 200	0.0 - 5.3	0.0 - 11.9
2	Marginal	200 - 300	5.3 - 6.1	11.9 - 13.7
3	Fair	300 - 400	6.1 - 6.7	13.7 - 15.0
4	Good	400 - 500	6.7 - 7.3	15.0 - 16.4
5	Excellent	500 - 600	7.3 - 7.7	16.4 - 17.2
6	Outstanding	600 - 800	7.7 - 8.5	17.2 - 19.0
7	Superb	> 800	> 8.5	> 19.0

[a] Wind speeds are based on a Weibull k of 1.8. Weibull k values in Alaska vary from 1.4 to 2.0.

100 0 100 200 300 400 Kilometers
50 0 50 100 150 200 250 Miles

U.S. Department of Energy
National Renewable Energy Laboratory

18-JAN-2006 4.1.1

AVEC 2006 Statistics

- 5.2 million gallons of diesel fuel
- 550 fuel storage tanks
- Received fuel in 170 separate deliveries (including 44 by air)
- Only Minto can receive fuel by road
- Continued modest load growth = more fuel purchased and stored

Access to specialty equipment to place foundations and erect turbines is an expensive challenge


Poor roads, water and sewer lines, boardwalks and overhead power and phone lines present challenges
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Above ground water and sewer lines are often crossed with timber bridges that will only support an ATV or snowmachine
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Boardwalks can be easily damaged by heavy equipment or melting permafrost
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Foundations in permafrost are the biggest challenge

- They must not settle, tilt or be uplifted
- 6 - 8 piles may extend 1/3 to 2/3 the height of the tower
- Permafrost conditions are changing

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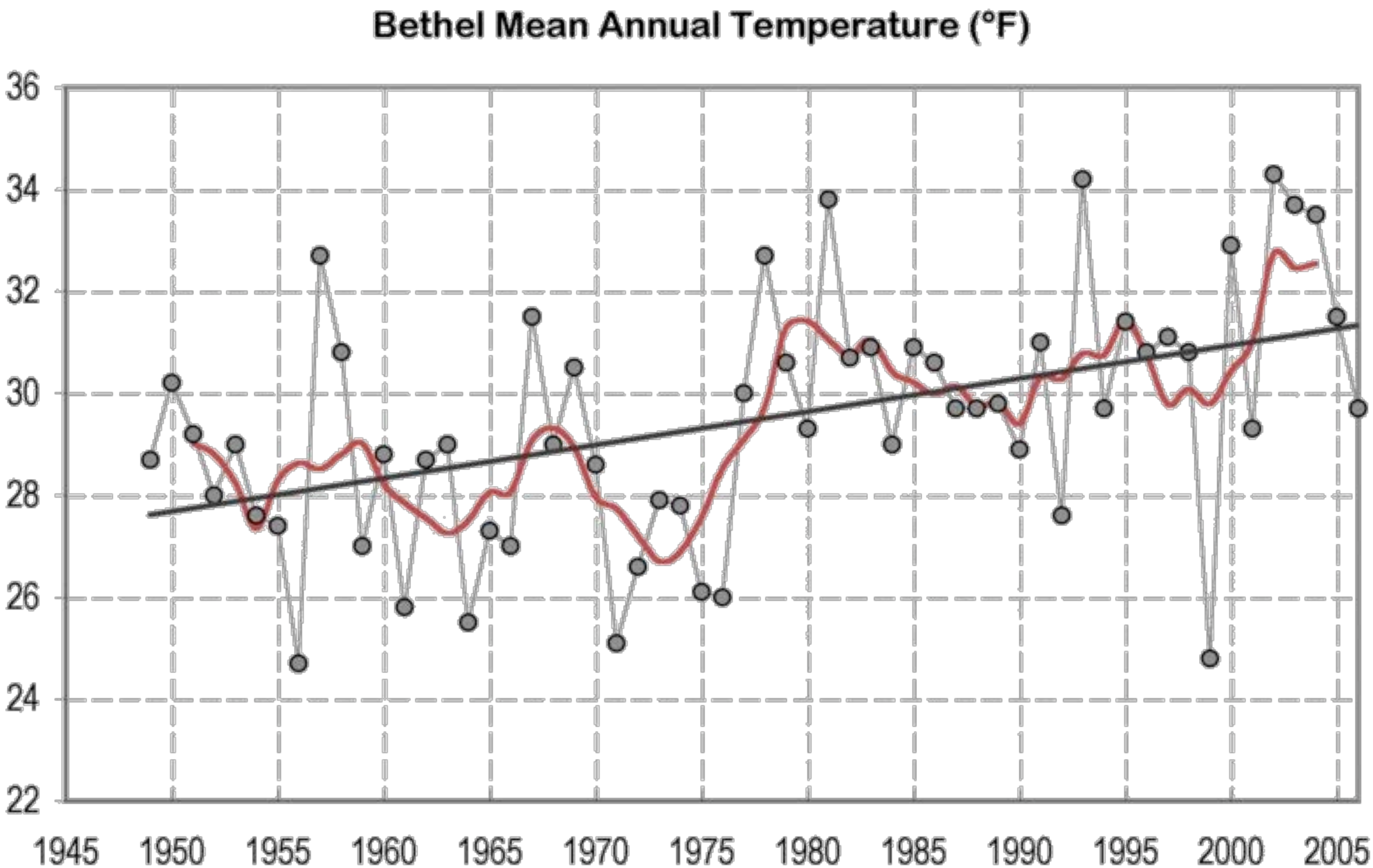
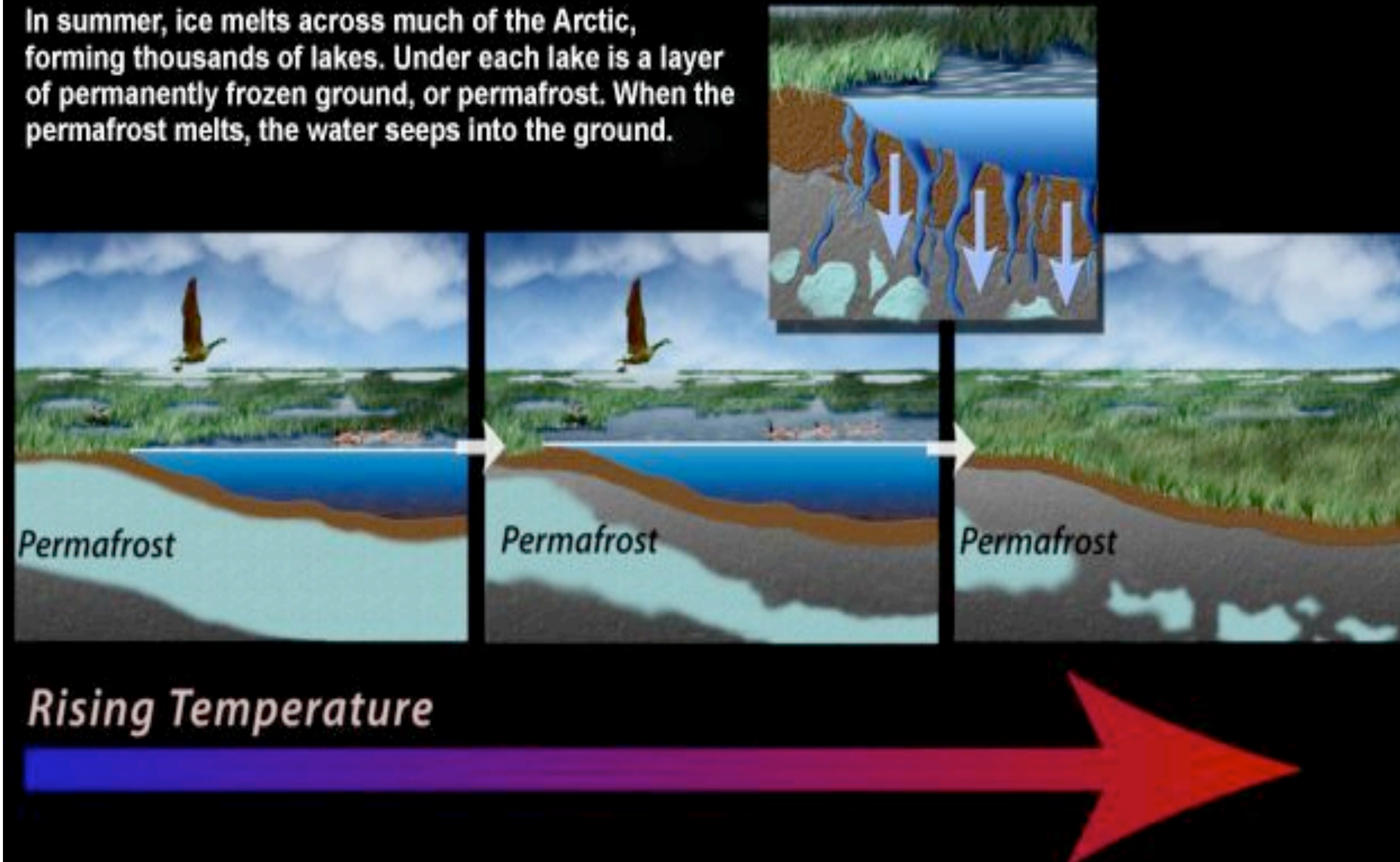


University of Alaska Geophysical Institute Climate Trends

Disappearing Lakes

In summer, ice melts across much of the Arctic, forming thousands of lakes. Under each lake is a layer of permanently frozen ground, or permafrost. When the permafrost melts, the water seeps into the ground.



Credit: Nicolle Rager Fuller, NSF

The Toksook Bay Project

- 2002 – Planning begins
- 2004 – Material mobilization commences
- Permafrost at the site extended 5 to 15 feet deep over a tilted bedrock base.
- Concerns emerged about foundation issues
- 2006 – project energized
- 2007 – achieved 26% wind penetration
- Saved 40,800 gallons diesel

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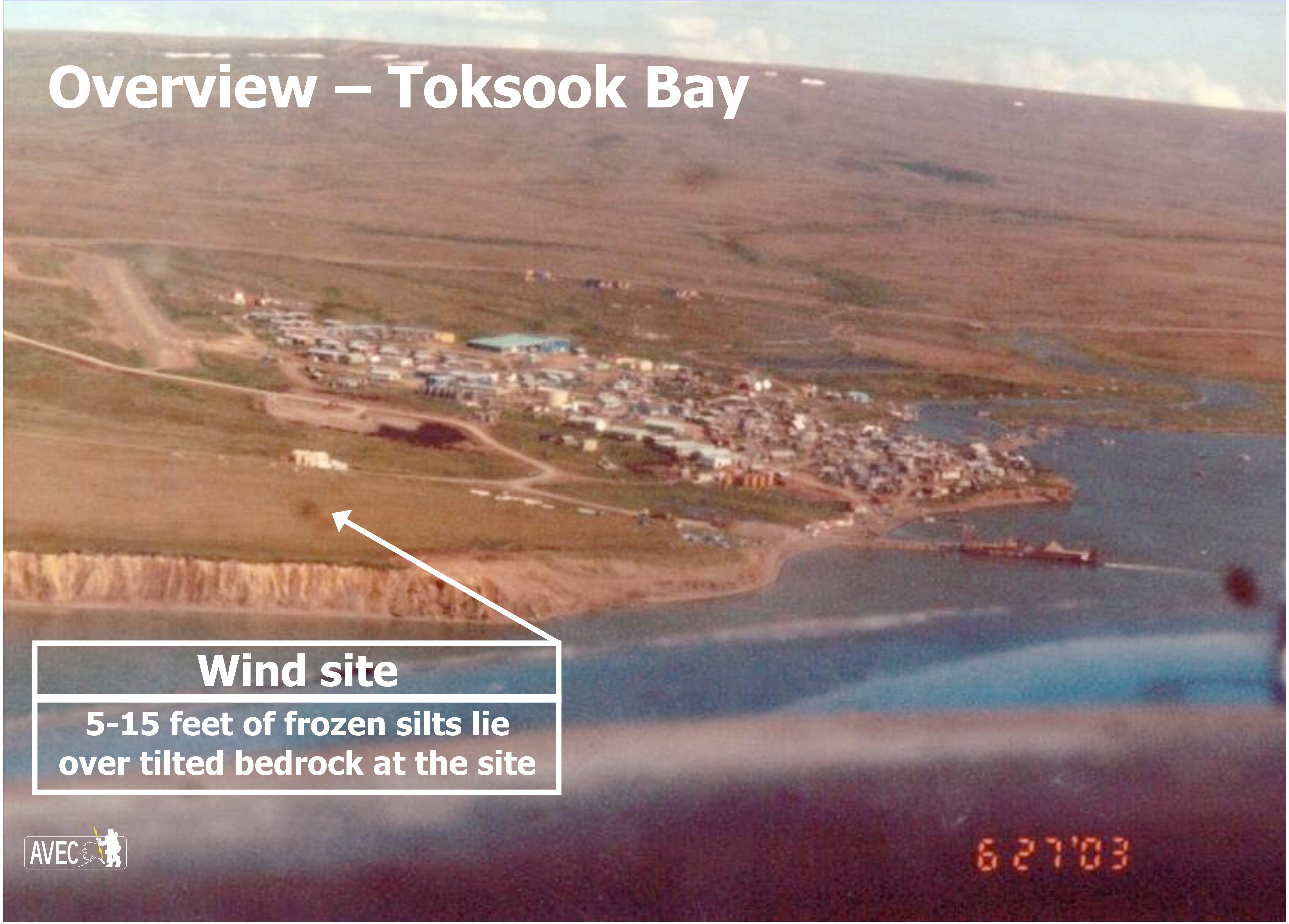
Overview – Toksook Bay



Wind towers on land in most of the world are built with a 'point of fixity' at the base of the tower where it typically rests on a massive concrete foundation

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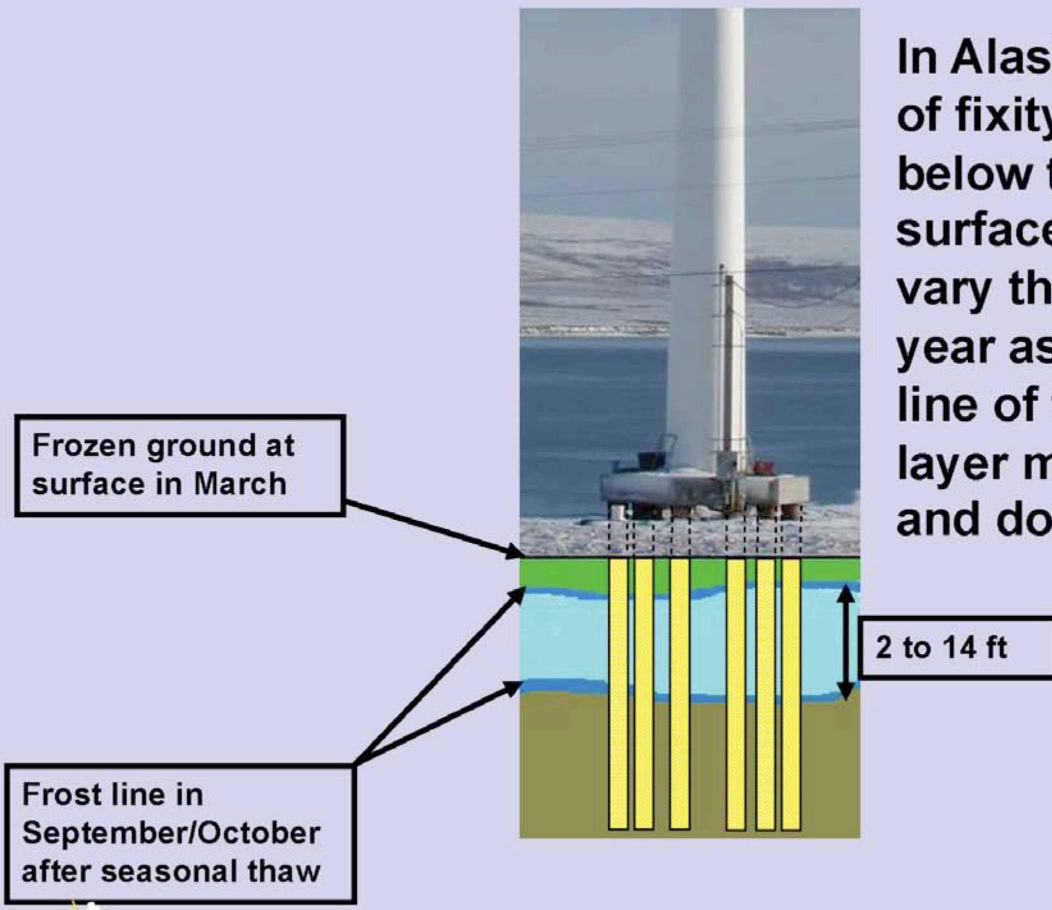
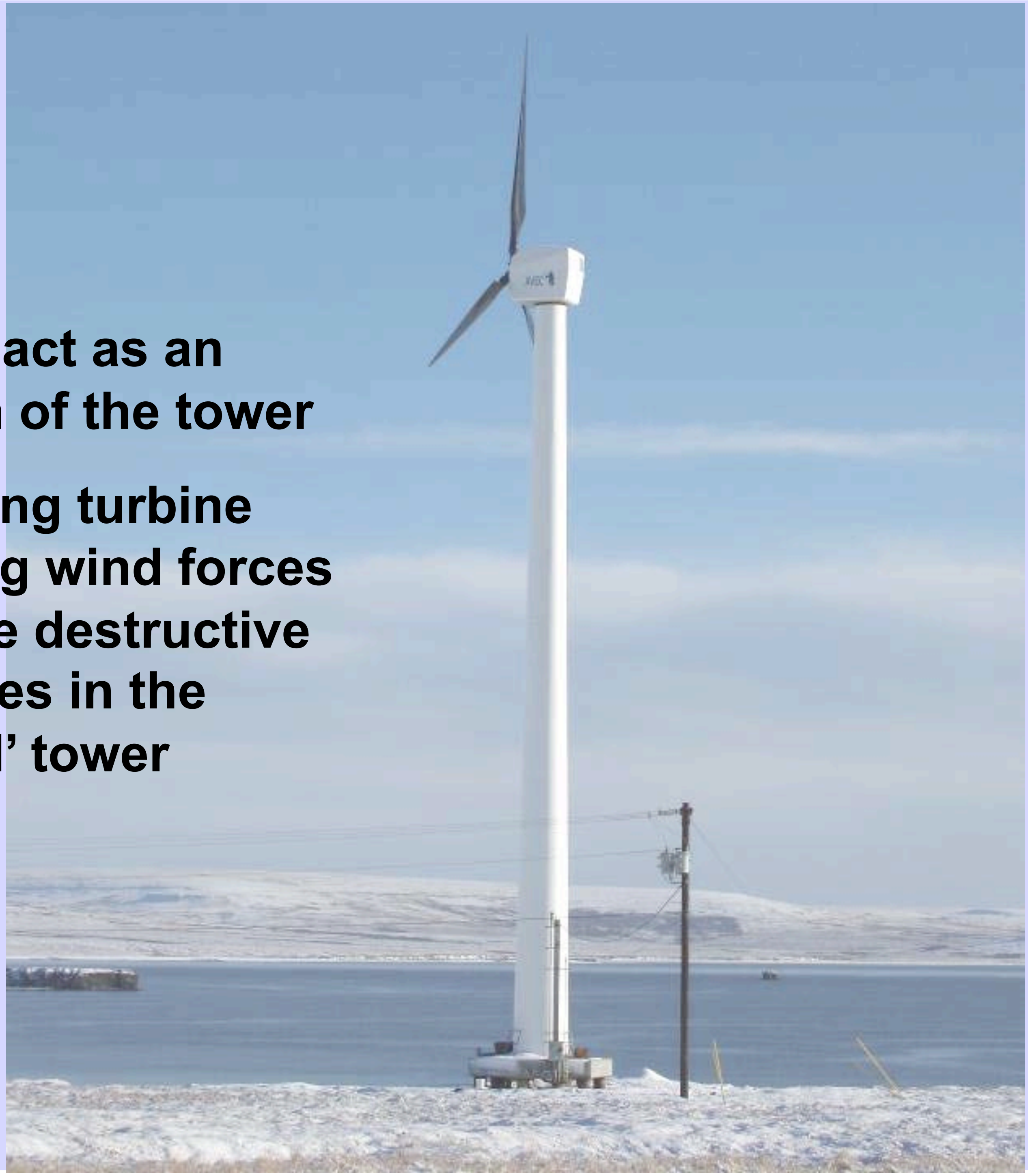
In Alaska, the point of fixity may be below the ground surface and may vary throughout the year as the frost line of the active layer migrates up and down



The piles act as an extension of the tower

The rotating turbine and strong wind forces can create destructive frequencies in the 'extended' tower



Options

- **Slow down the turbine**
  - This approach loses energy and requires complex monitoring of the system operation

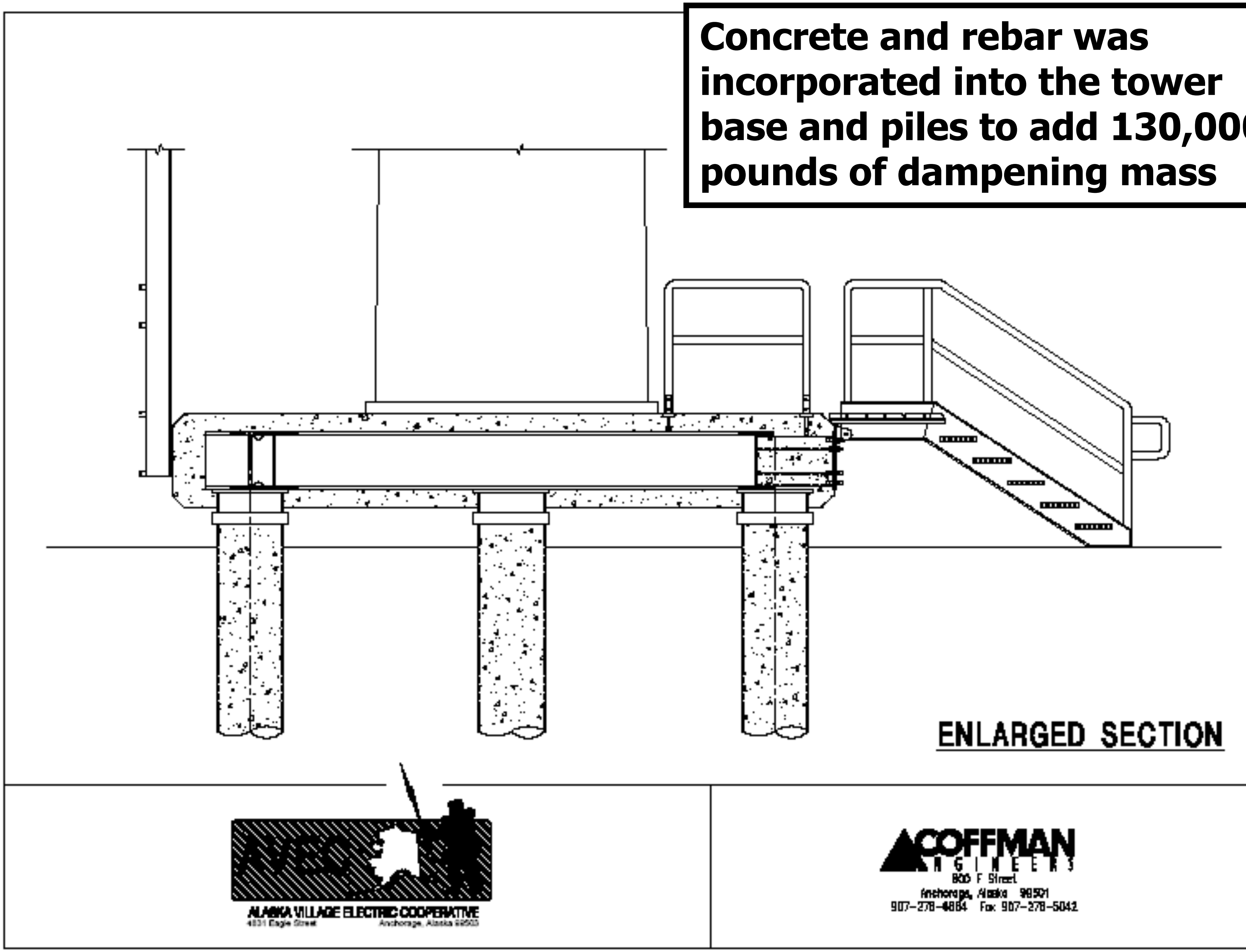
or

- **Stiffen the foundation by adding mass**
  - pile foundations were modified by adding a 130,000 pound concrete and steel mass between the tower base and the piles

- Holes pre-drilled
- Piles driven to refusal
- Piles later cut
- 6 piles per foundation


www.usfc.com
Steel Foundation Star
(Typical of 3)

Concrete and rebar was incorporated into the tower base and piles to add 130,000 pounds of dampening mass




Rebar cage to go
into a pile
F168

Foundation Design Criteria

Design Wind Speed = 130 mph (50 year)

Overturning moment = 1,830,000 ft lb

Total tower/turbine weight = 42,000 lb

The Wind Turbine Controller is placed before the tower is set

Tower/Turbine Dimensions

108 feet from base to center of rotor

Rotor diameter (3 blades) = 61 feet


View from the top!
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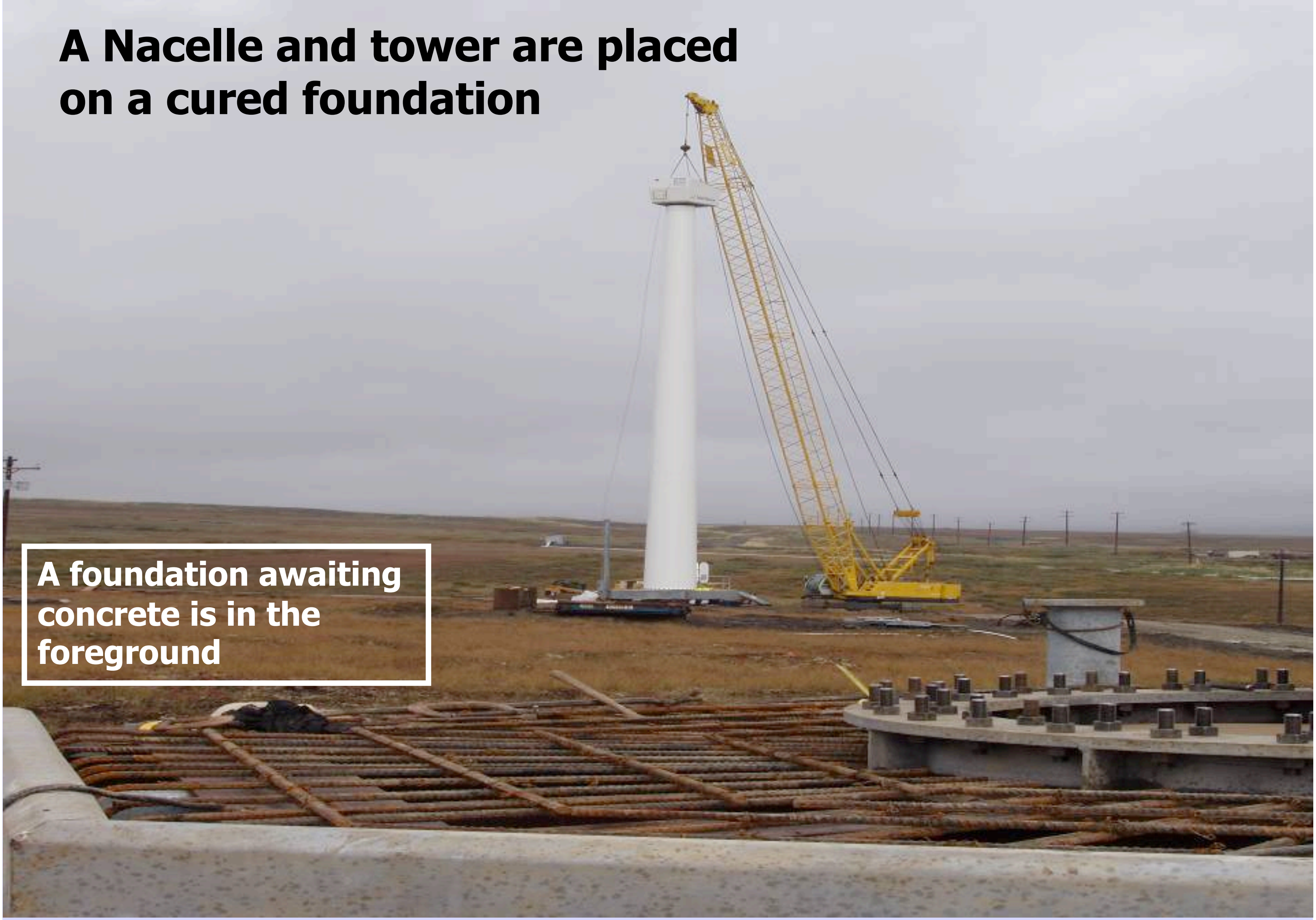
14,000 lb nacelle being prepared for its lift to the top of a 32 meter tower
AVEC
AVEC

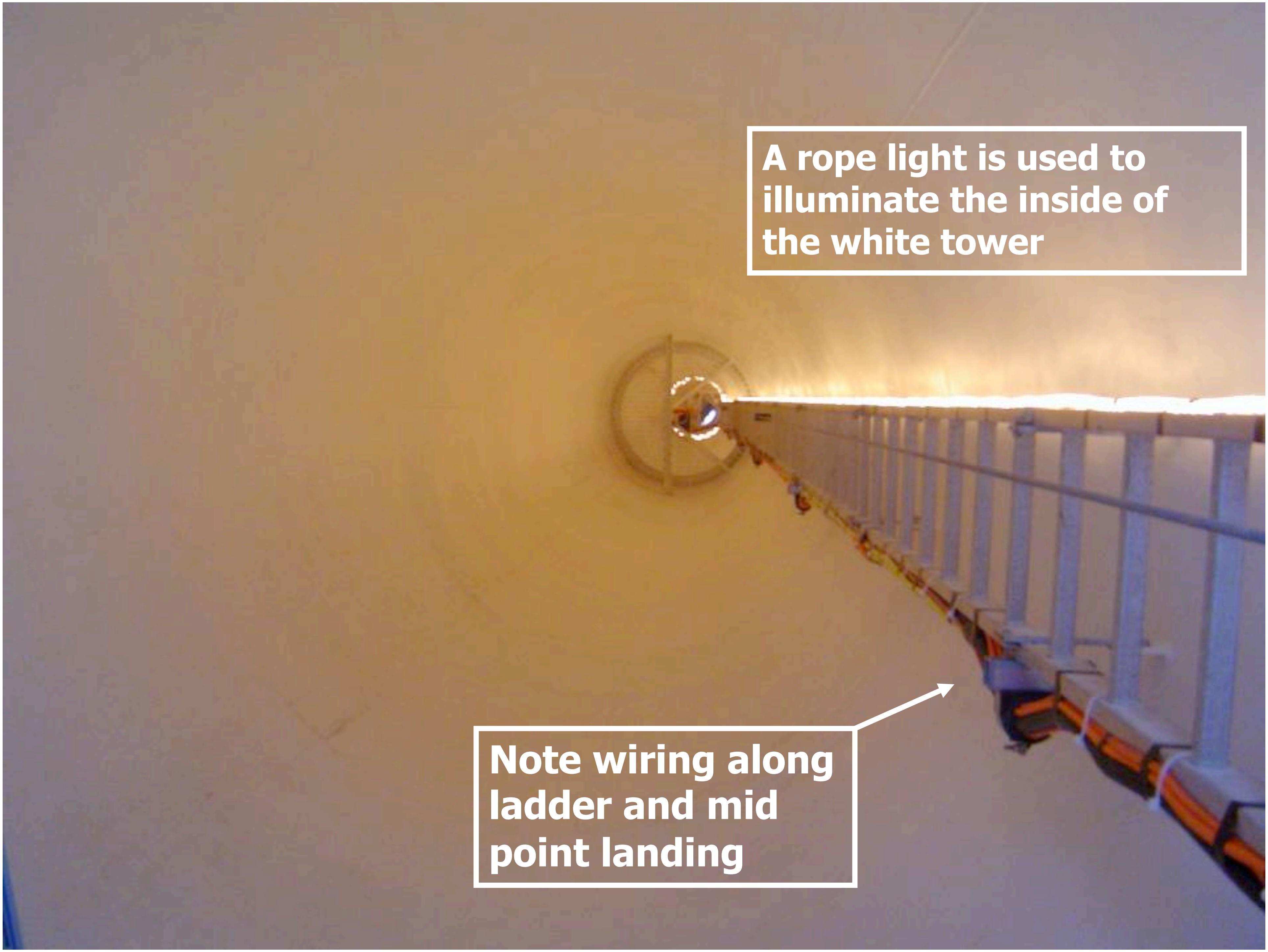

Cleaning the yaw gear teeth prior
to setting it on top of the tower

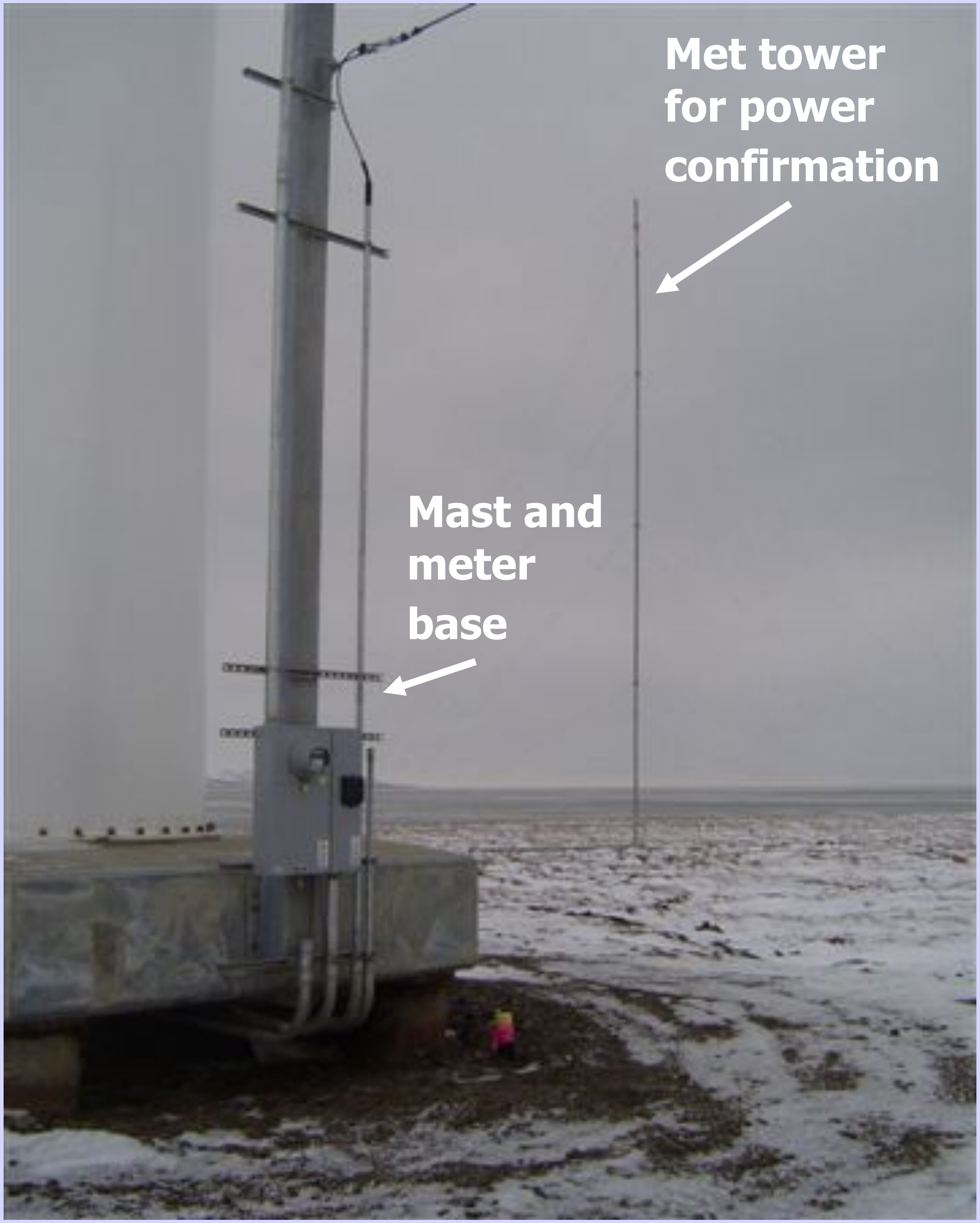
A Nacelle and tower are placed on a cured foundation



A foundation awaiting concrete is in the foreground

Second tower section being put into place


A rope light is used to illuminate the inside of the white tower
Note wiring along ladder and mid point landing



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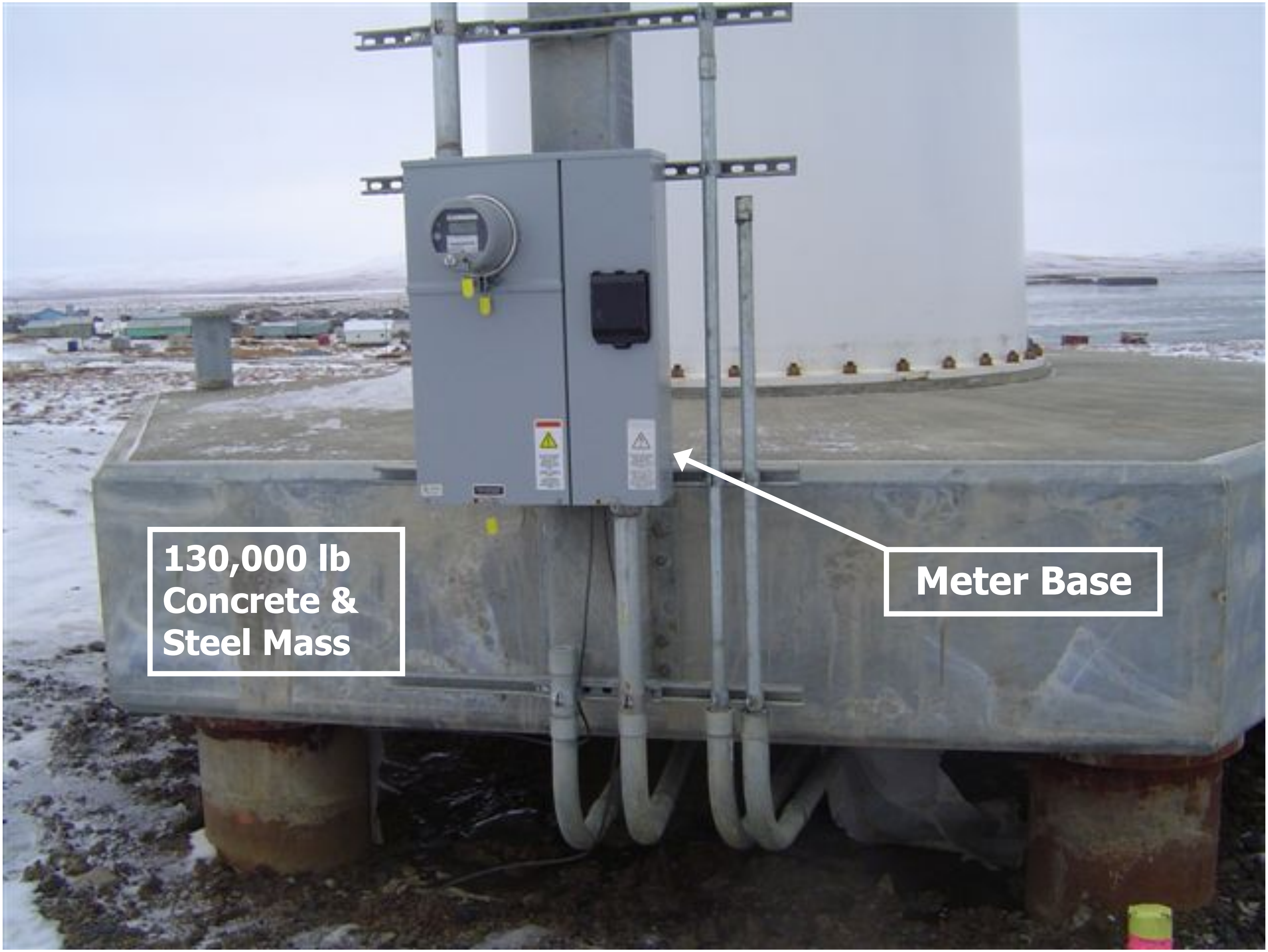
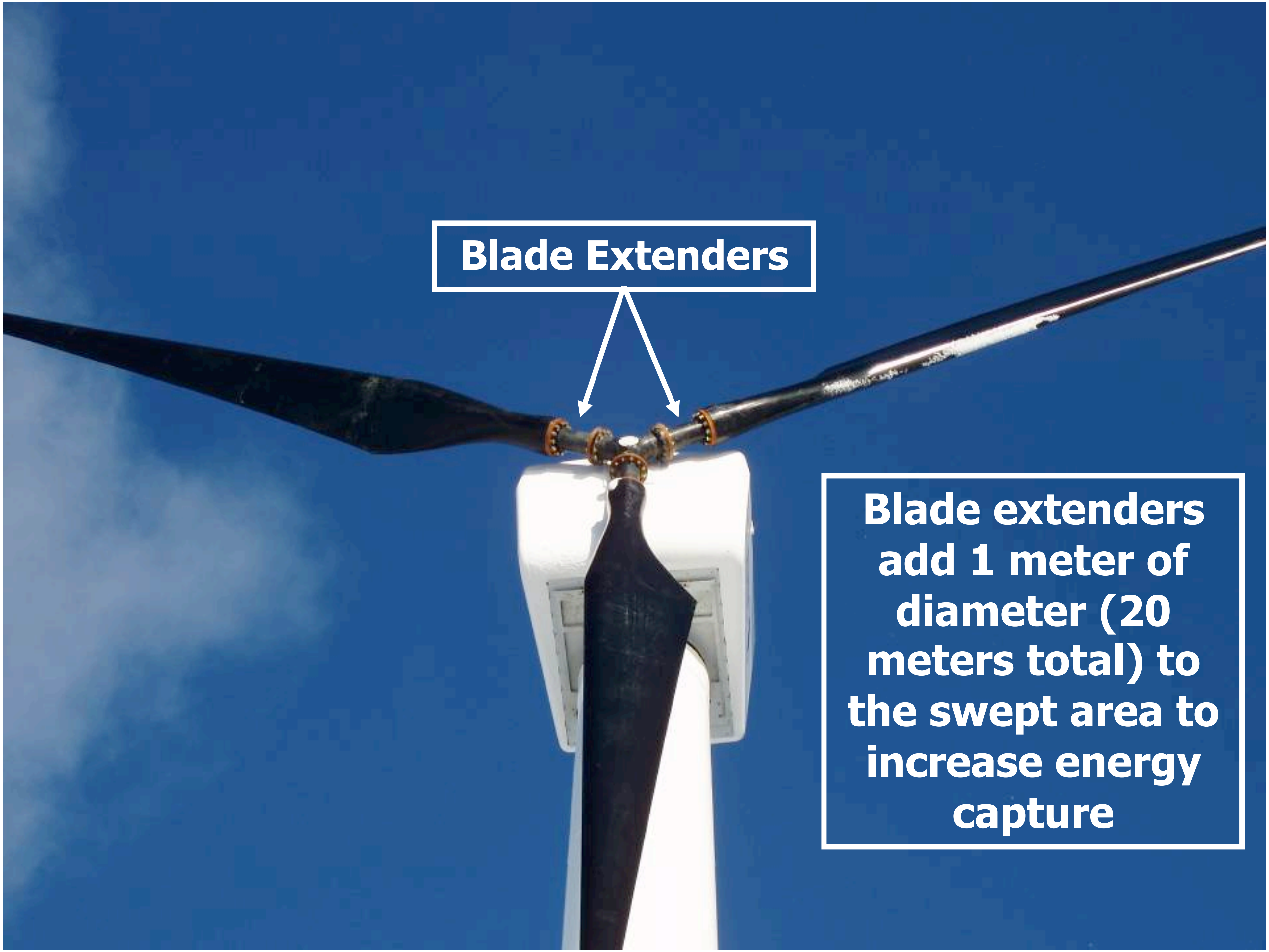
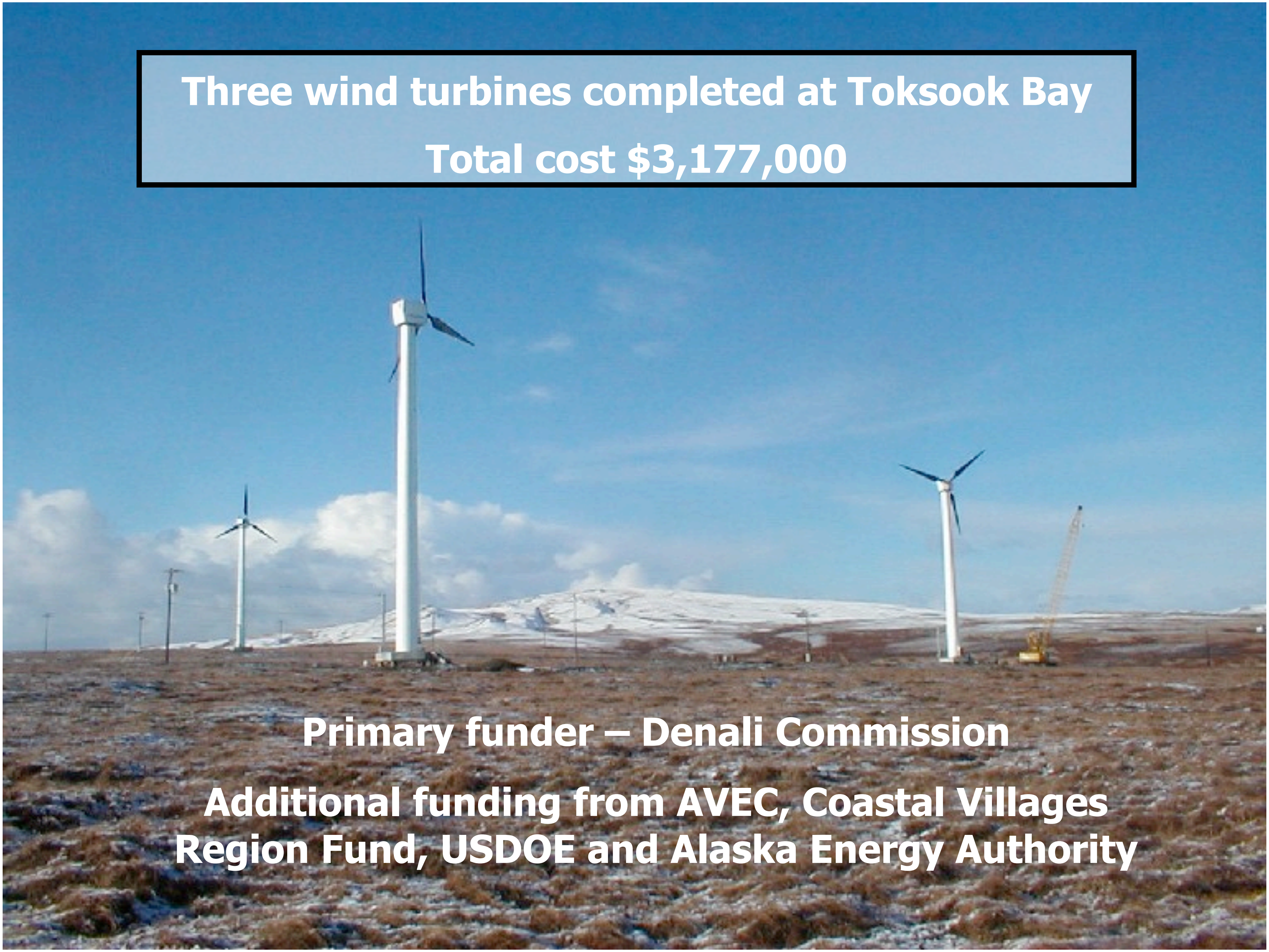

130,000 lb
Concrete &
Steel Mass
Meter Base


Tightening hub to turbine


Blade Extenders
Blade extenders add 1 meter of diameter (20 meters total) to the swept area to increase energy capture


Three wind turbines completed at Toksook Bay
Total cost $3,177,000
Primary funder – Denali Commission
Additional funding from AVEC, Coastal Villages Region Fund, USDOE and Alaska Energy Authority

Quyana

Meera Kohler

Alaska Village Electric Cooperative

AVEC