Alaska

MHFAC Meeting, April 4, 2017

Doe-BPXA-USGS Mt Elbert Test Site, Milne Point Unit, 2007. Photo by R. Boswell

Gas Hydrate Production Technology

Depressurization will be the basis of initial scientific field experiments

Thermal

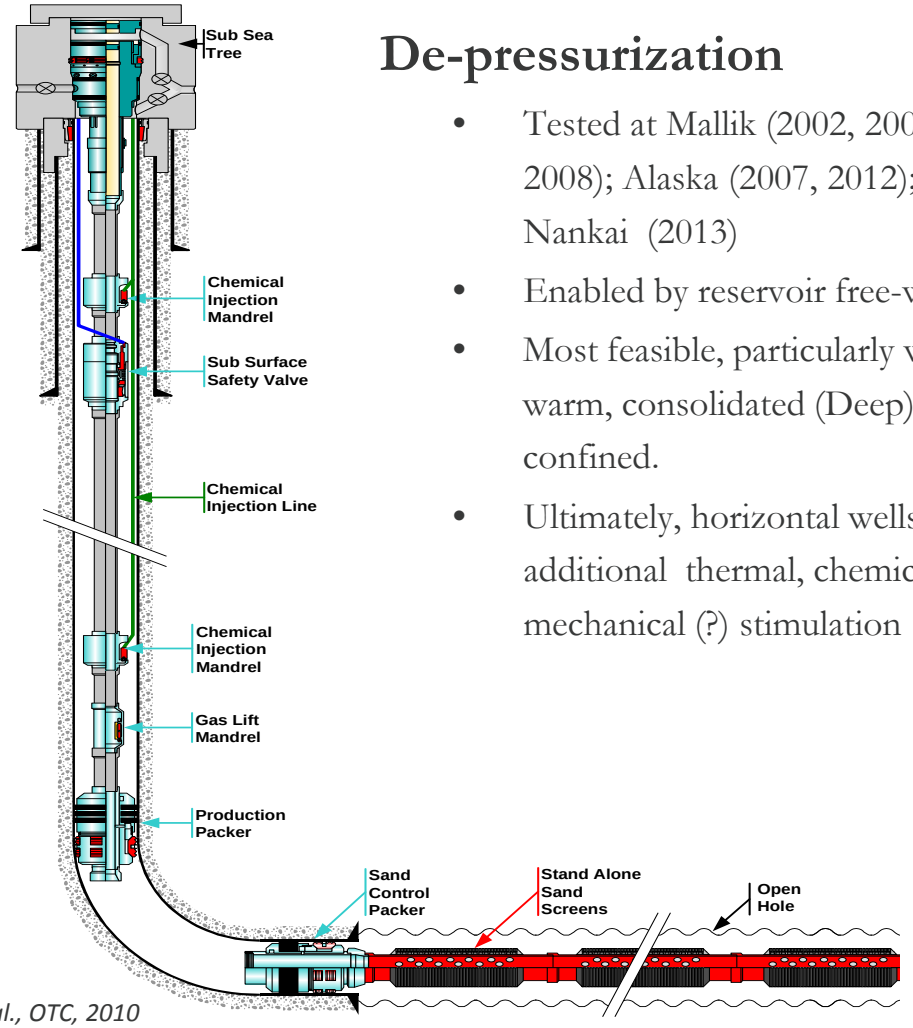
- Tested at Mallik (2002)
- Tests and Modeling → Not feasible
- Near-well bore maintenance/stimulation

Chemical

- Injection: Costly? Ineffective?
- CO_2-CH_4 exchange – challenge of free-water; limited permeability; complex thermodynamics
- Stimulation/mechanical stability?

Mining

- Not being pursued in the US



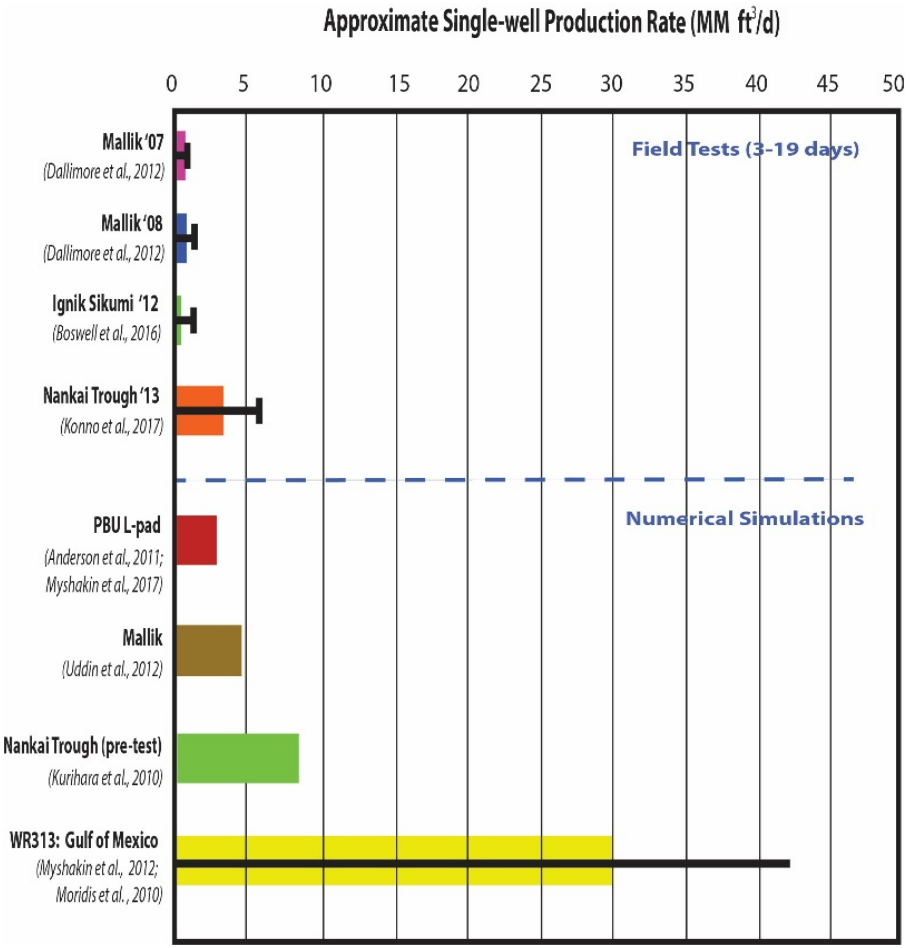
Hancock et al., OTC, 2010

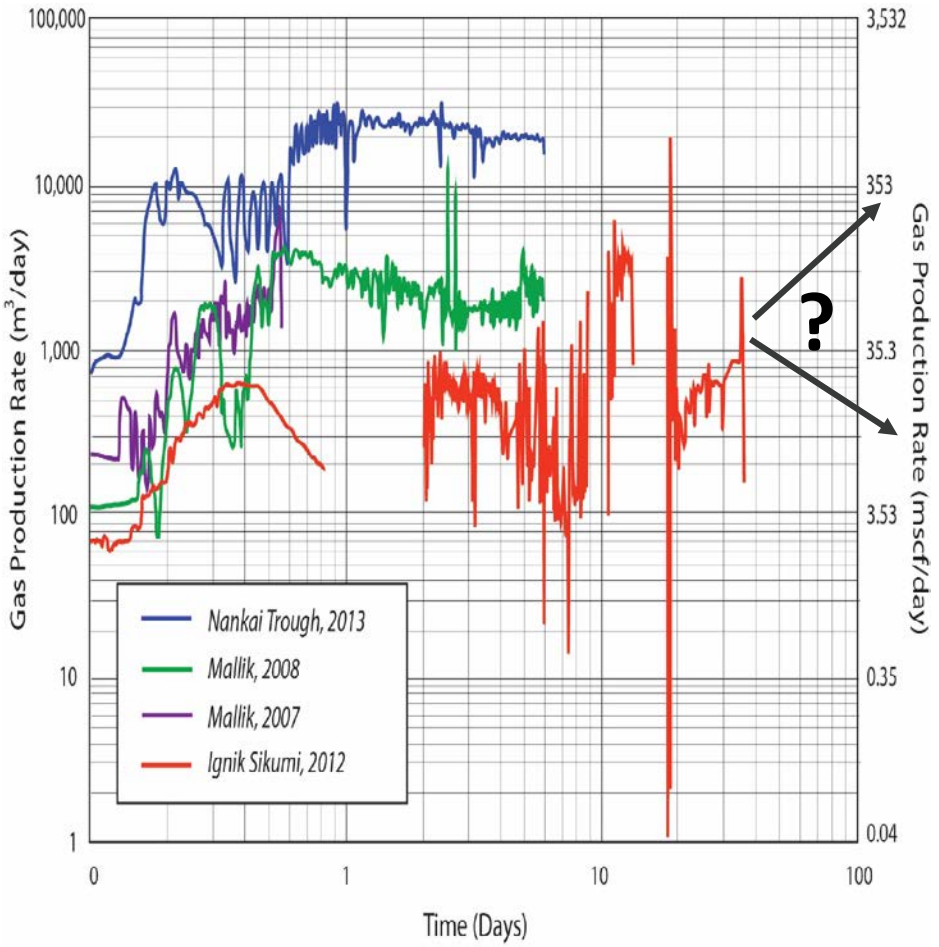
De-pressurization

- Tested at Mallik (2002, 2007, 2008); Alaska (2007, 2012); Nankai (2013)
- Enabled by reservoir free-water
- Most feasible, particularly when warm, consolidated (Deep), and confined.
- Ultimately, horizontal wells w/ additional thermal, chemical, mechanical (?) stimulation

Observed and Modeled Gas Flow Rates

Depressurization-based





Gas Hydrate Potential

Insights From Numerical Simulation

Early 2000s (pessimism)

- Low rates, long lag times, large cumulatives but very long gas flow profiles

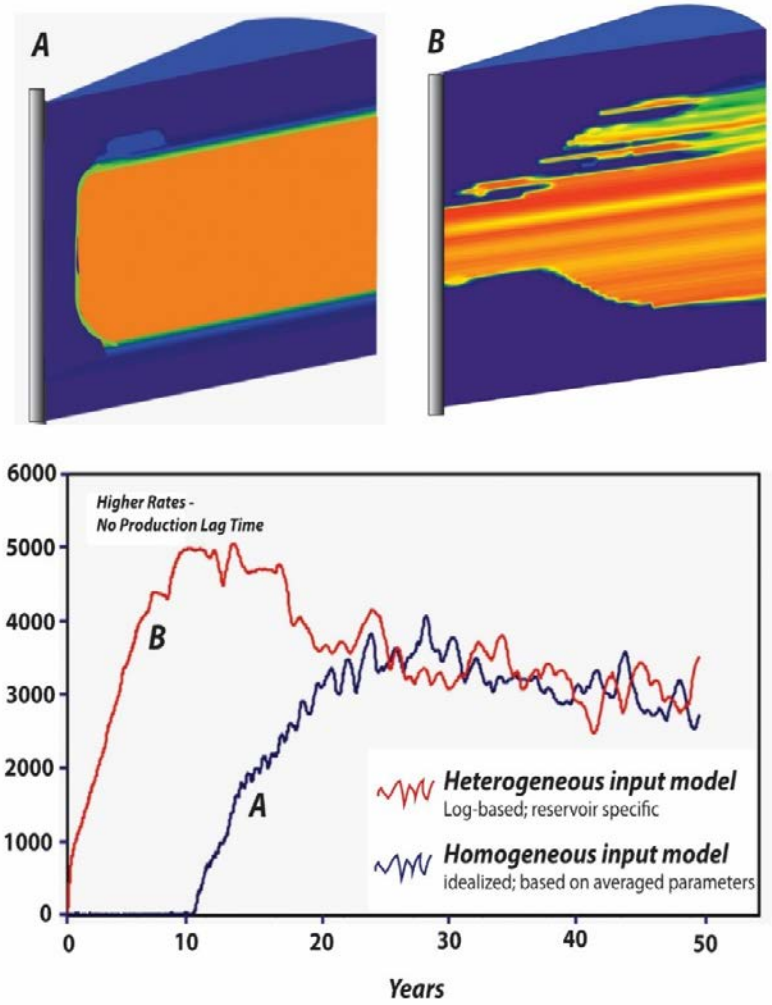
At present (cautious optimism)

- Incorporation of vertical geologic heterogeneity shows potential to eliminate lag, increase peak, and accelerate peak.

Challenges & Current Topics

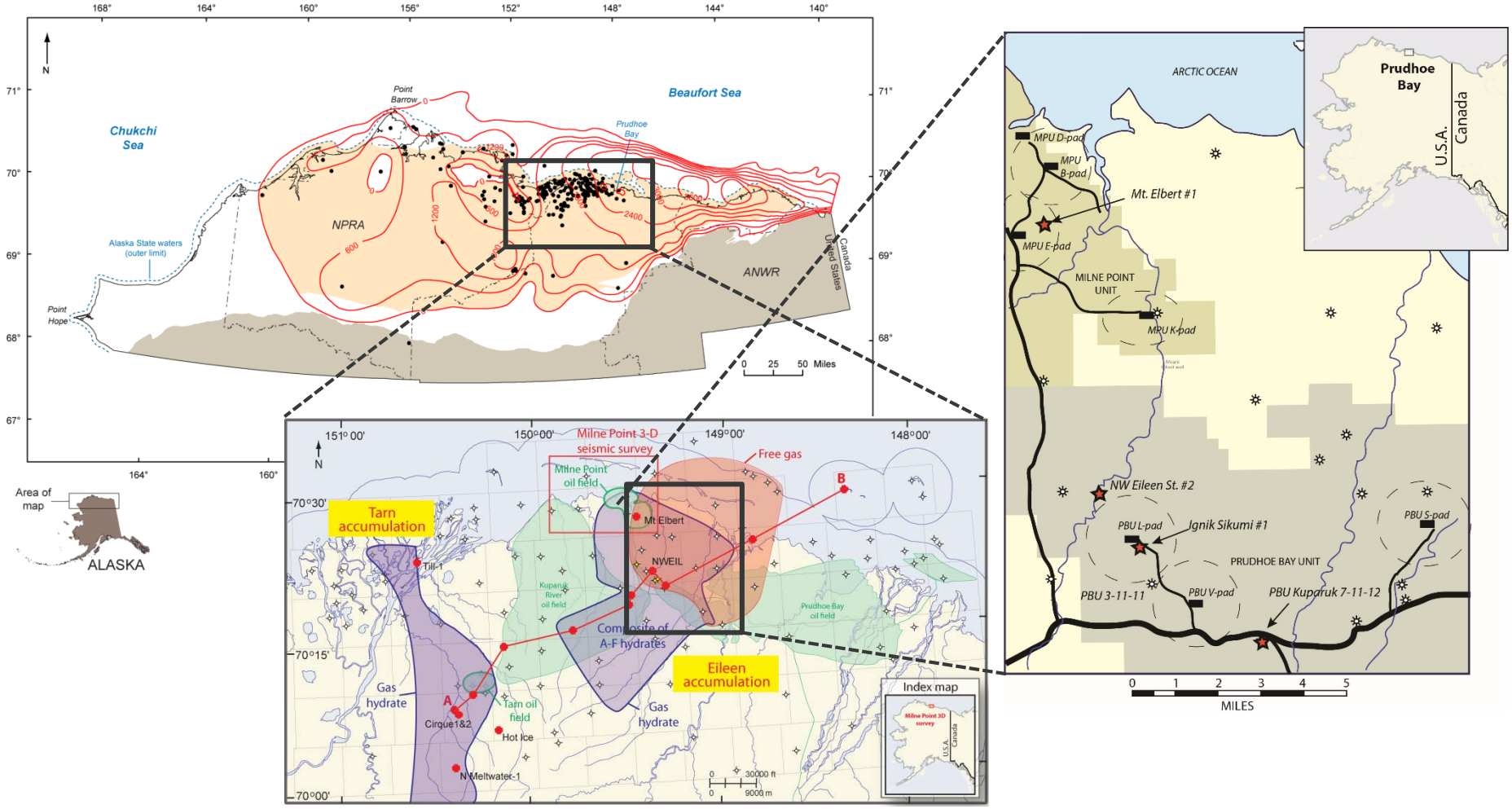
- Impact of permeable boundaries (vertical and lateral) are a major challenge
- Initial permeability poorly known: first assessed as low but recent data suggest it may be much higher
- Permeability evolution with dissociation is uncertain
- Integration of geomechanical effects is a major priority
- Thin bed effects: internal heat transfer
- Fines migration in changing geochemical environments

Continued lack of field validation data remains the major R&D challenge. Longer duration scientific field experiments required in a range of geologic settings



Alaska North Slope Gas Hydrates

Most Promising Accumulation in the Westend Prudhoe Bay Unit, Greater PBU Infrastructure Area



Prior Alaska Field Programs

Conducted in Partnership with Industry and Academia

"Hot Ice" (2004)

- Drilling failed to encounter Gas Hydrate

"Mt. Elbert" (2007) Safe and efficient scientific field program within area of active industry operations

- Confirmed GH exploration methodology
- USGS 2008 GH Tech Recoverable Assessment of 85 tcf recoverable in AK.
- Pressure test data enabled Int'l Code Comparison
- Science Program: 54 scientists from 24 different organizations.

"Iġnik Sikumi" (2011-2012)

- Successful short term (days) field test of CO_2 injection
- Demonstration of mechanical stability maintenance through engineering controls.
- Evaluation of CO_2-CH_4 exchange technology.
- Confirmation of formation of complex mixed hydrates upon injection.
- Confirmation of the ability to effect limited, bulk exchange of CH_4 for CO_2.
- Confirmation of the superiority of depressurization with respect to production rate.

Production Test Site Selection Criteria

2007-2010 Effort with BPXA and CPAI

Geology

- Geologically well-characterized (complimented as needed by project strat/sci test wells)
- Hydraulic isolation (away from sources of free gas or water)
- Sufficient reservoir temperature (at least 5C) and intrinsic reservoir quality
- Multiple reservoir zones – operational risk mitigation and expanded science options

Logistics

- Well location that allows continual operations of 6 mo (minimum); optimally18-24 mo.
- Location that minimizes interference with ongoing operations
- Non-disruptive gas/water handling
- Minimal complexity – avoid use of unproven technologies

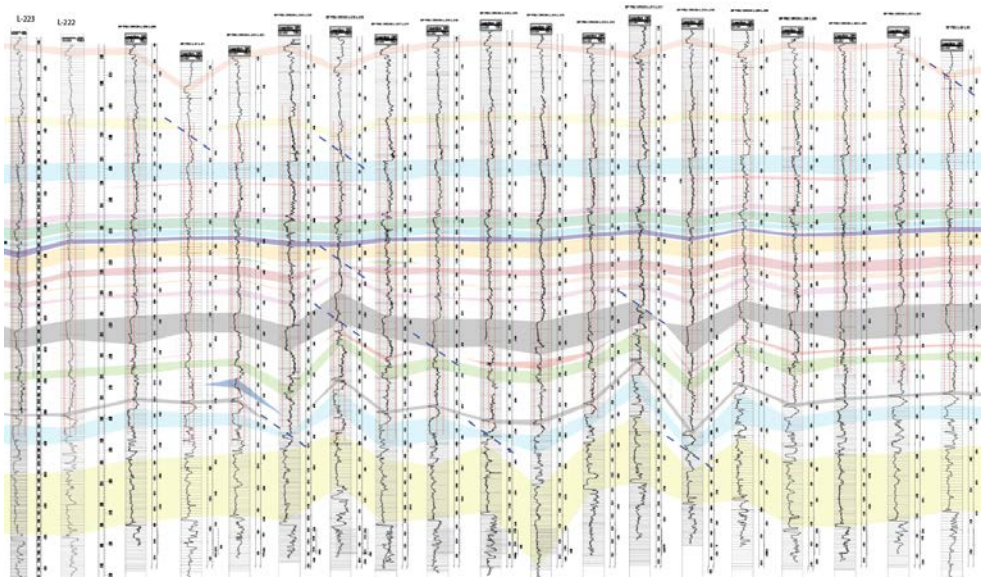
Components

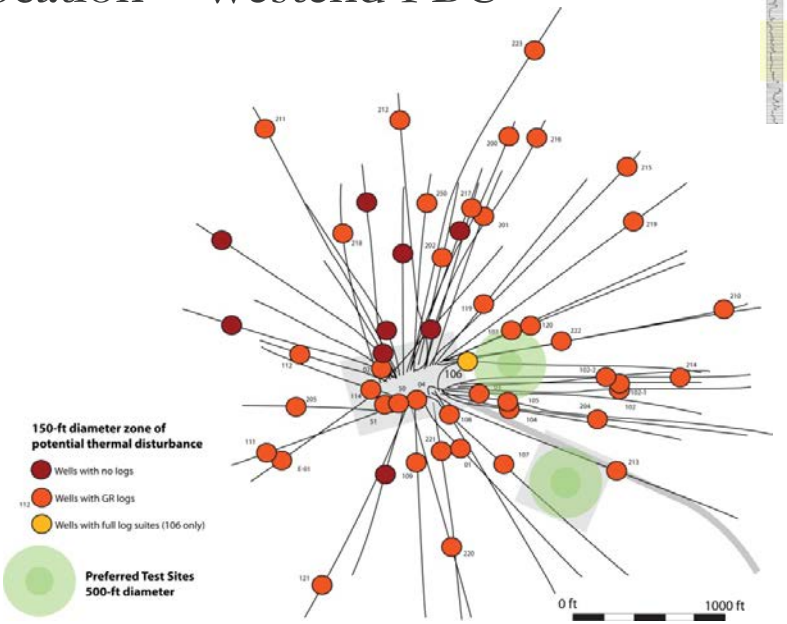
- Depressurization – obtain pre-set or steady rates - scale to commercial applications
- Flow assurance - ability to maintain wellbore during likely interruptions
- Sand control; robust ESPs
- P/T monitoring and DTS; offset monitoring wells
- Surface and reservoir subsidence monitoring; methane migration monitoring; 4-D seismic?
- Progressive well stimulation available – thermal, mechanical, chemical
- Science plan flexibility – ability to "listen to" and respond appropriately to reservoir

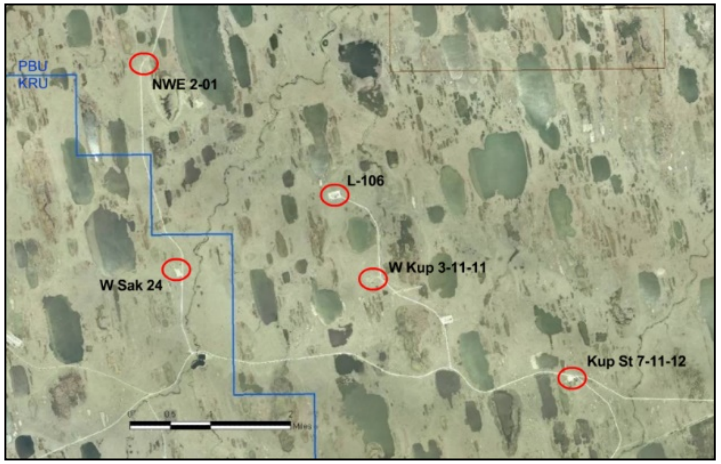
Post Mt. Elbert Effort with BPXA

2007-2011

- Agreement on Need for Long-term Experimental Field Site
- Agreement on Most Viable Location – Westend PBU







2011/2012 Iġnik Sikumi Program

Program Proceeded off Temporary Ice-pad following 2010 Withdrawal of L-pad Site

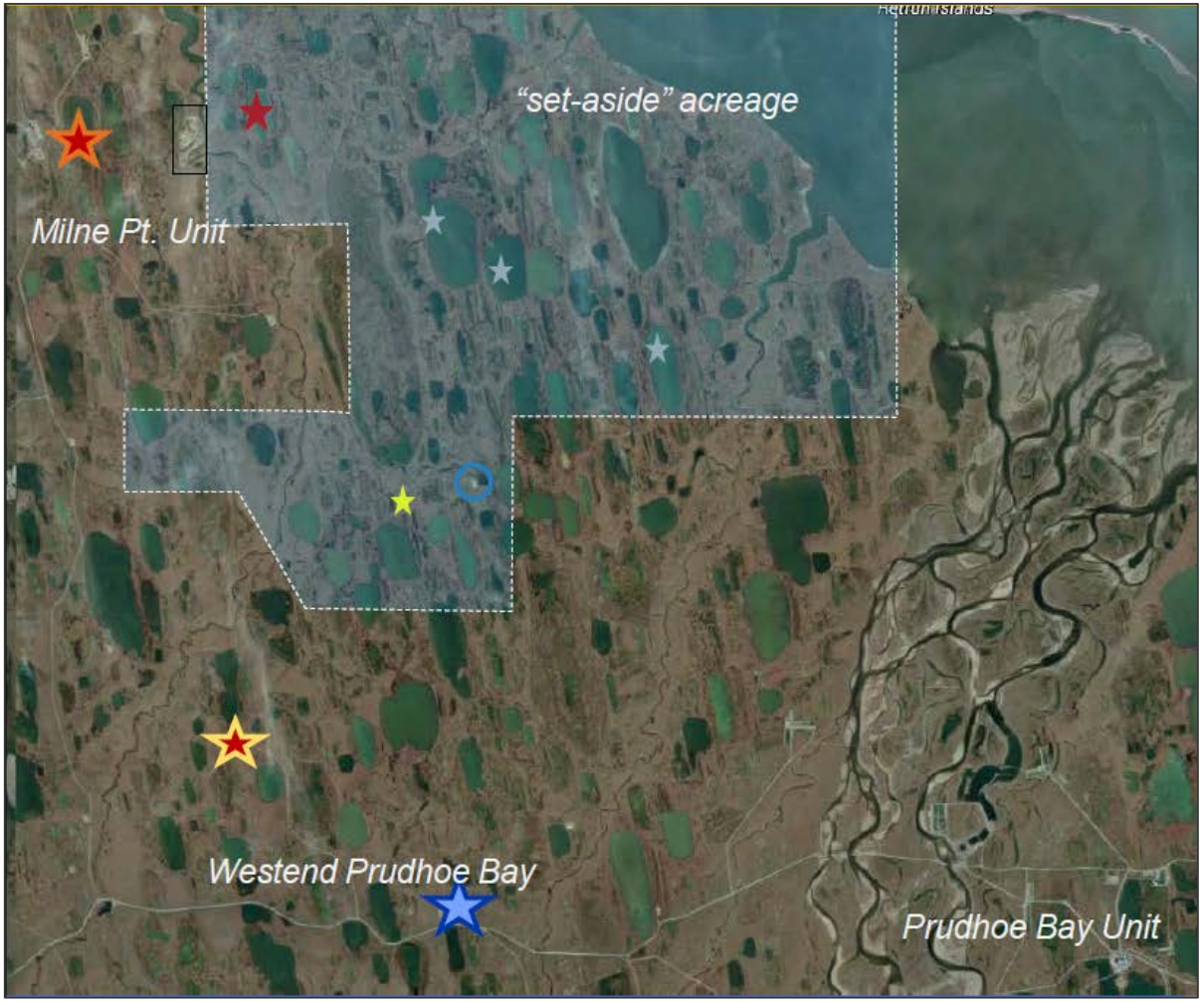
PBU L-pad.
Site of 42 existing oil wells and planned, international, long-term (2 yr) reservoir response field experiment

Ignik Sikumi Ice Pad
Site of 2011/2012 scientific field experiments.

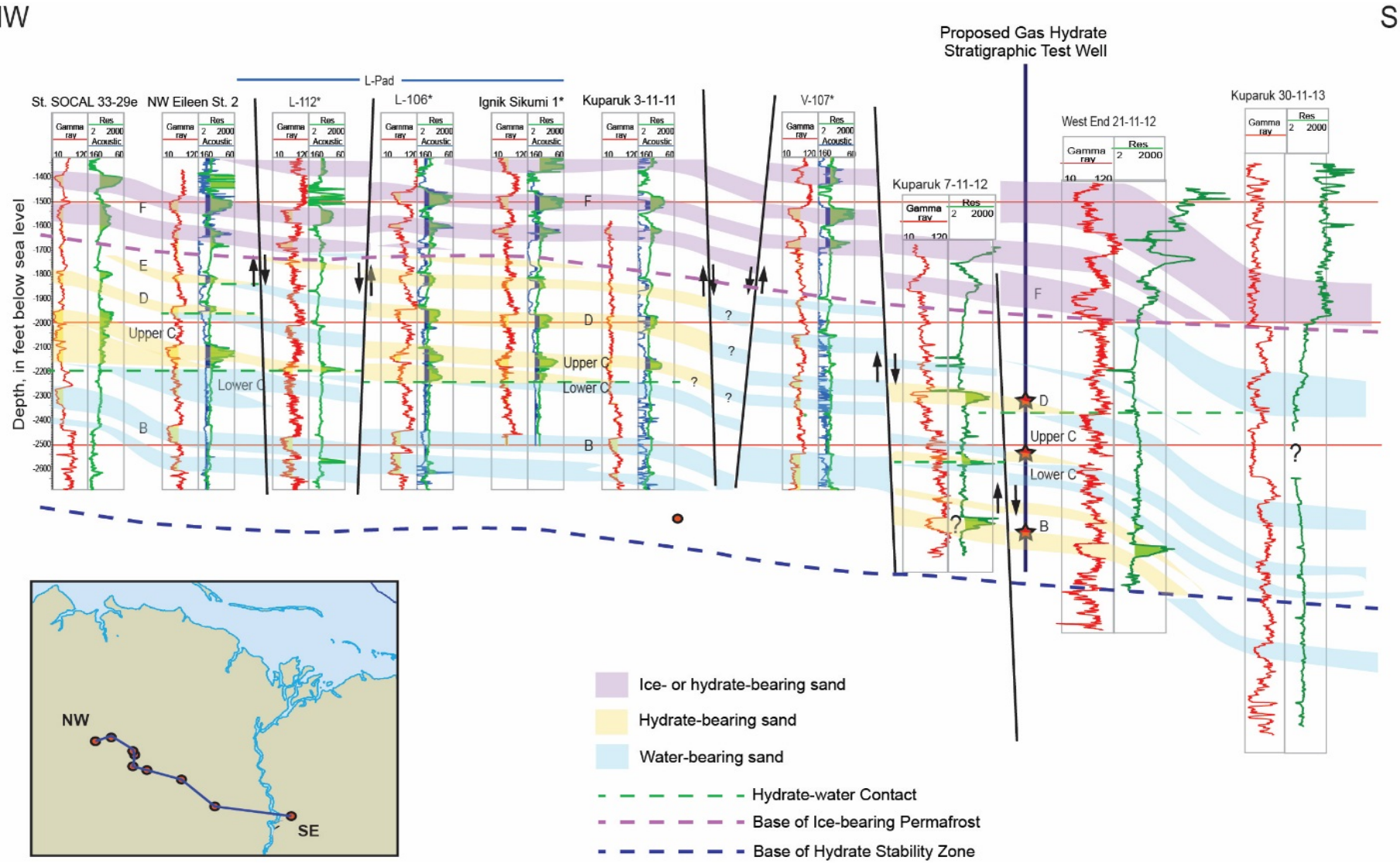
Review of Sites on Unleased Land

Potential Recognized, but....

- **Remote:** High logistics cost (roads, pads)
- **Remote:** High operational risk (lack of infrastructure)
- **Unleased:** Uncertain regulatory environment.
- **Undrilled**: High geologic risk; (limited indications of GH and free gas)
- Who would operate?



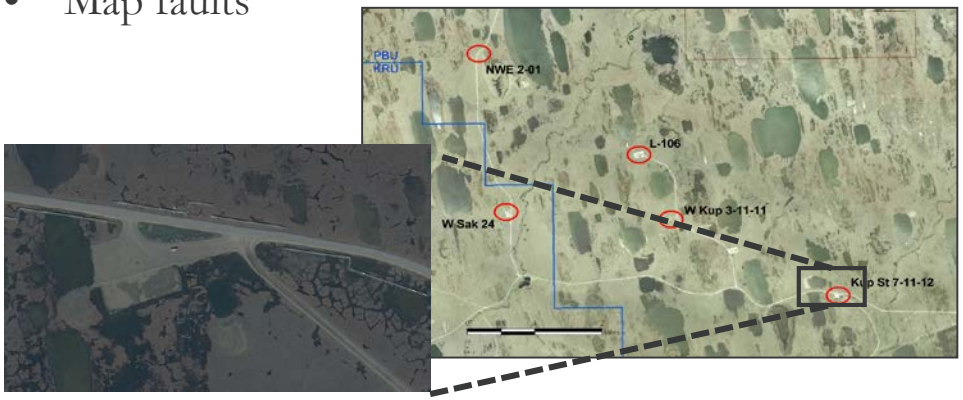
Review of Sites: Westend PBU

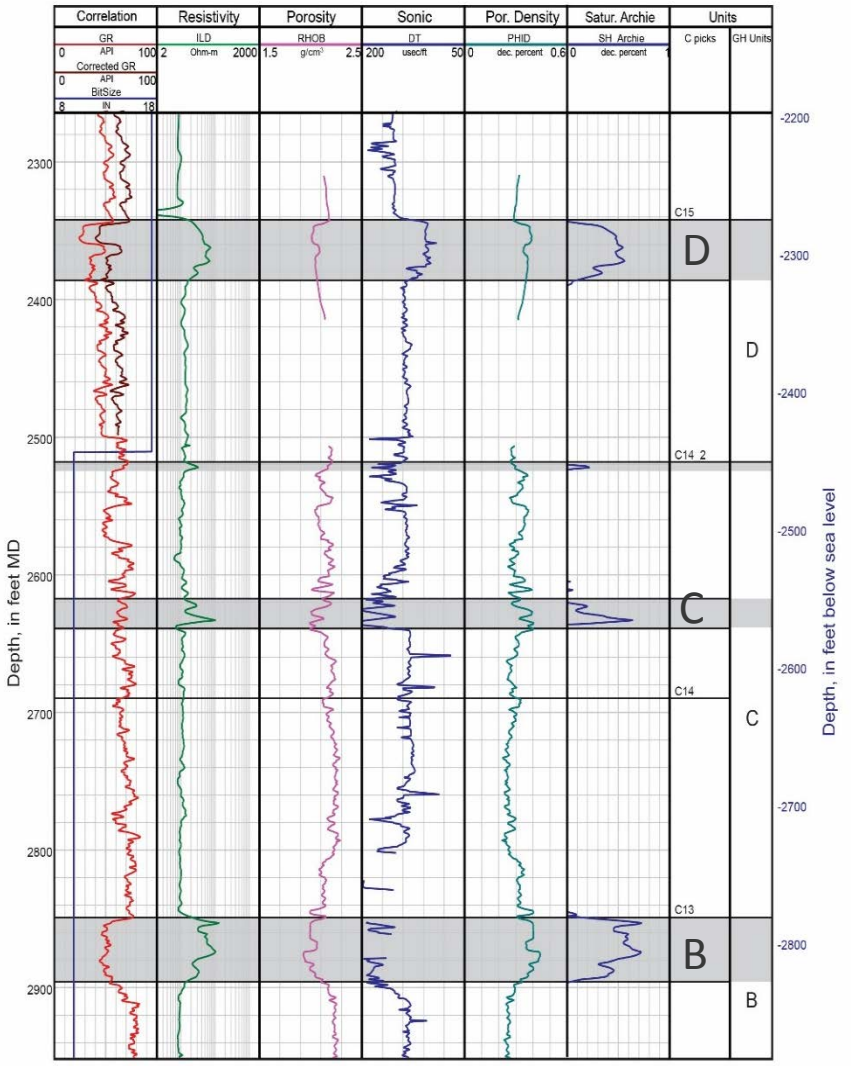


Kuparuk 7-11-12 Well Site (PBU)

- Two exploration wells from pad: One log suite
- D-sand: low geologic risk
- C-sand: limited charge.
- B-sand: HC-charge but poor log quality
- Drilling-disturbed?

- Site BHL away from old boreholes
- Assess potential for nearby free-gas or water
- Assess phase of B-sand
- Map faults

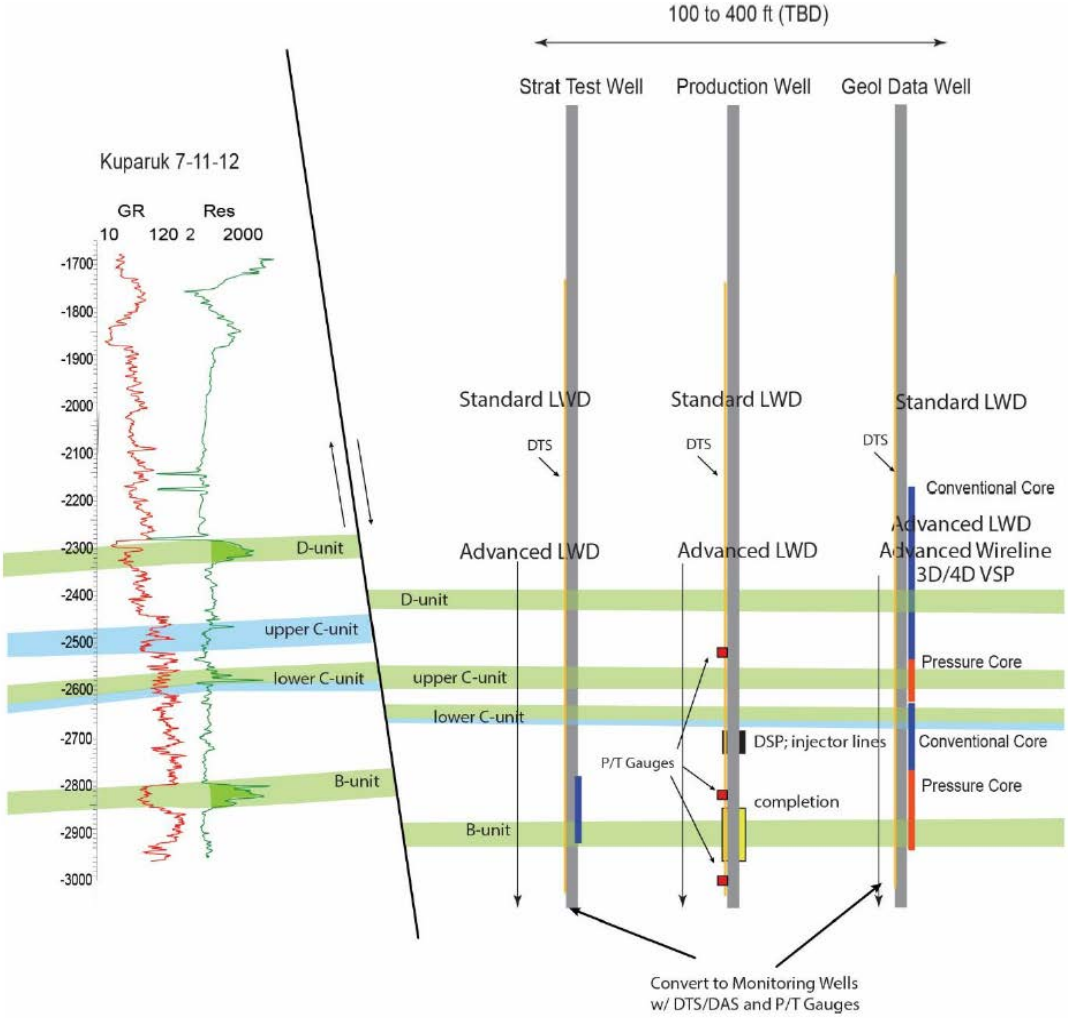




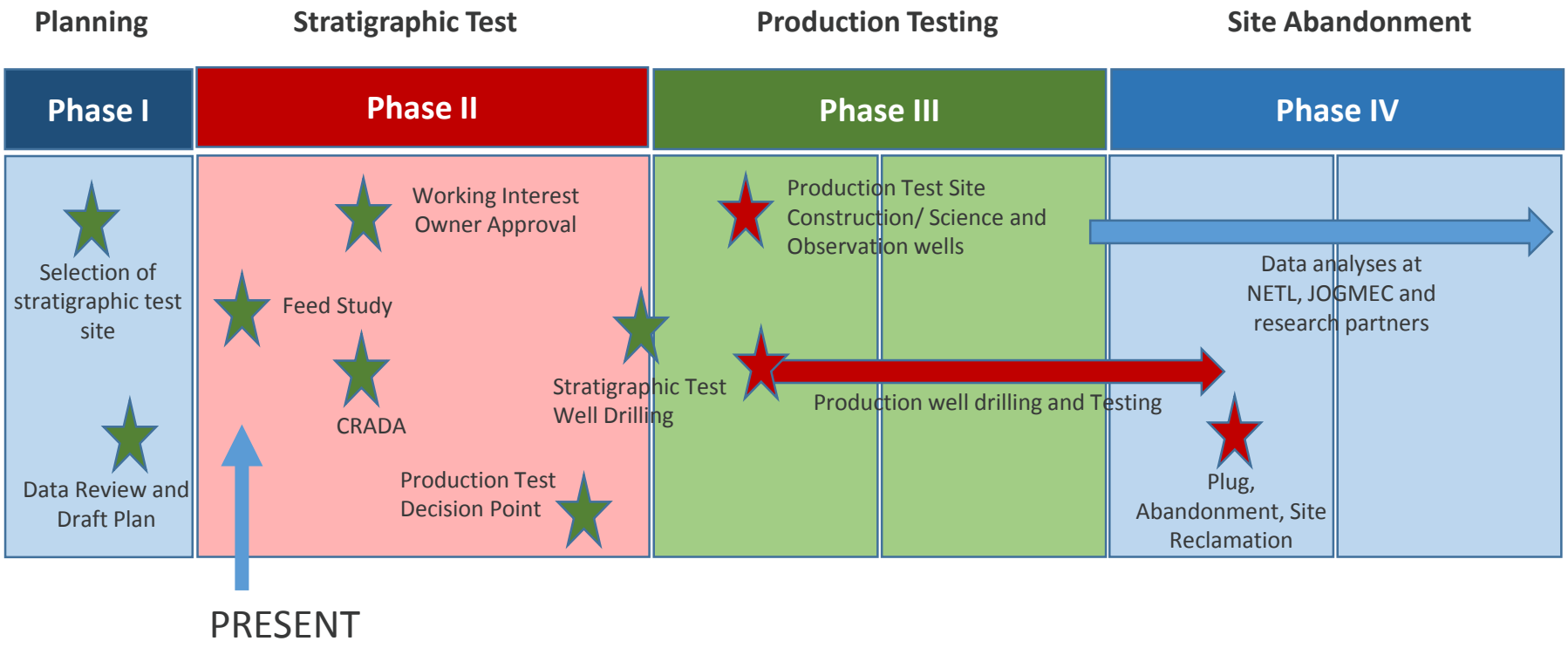
Seismic Data Review (2016)

Enabled by AK DNR under Non-Disclosure Agreement with BPXA

- Preferred BHL identified.
- Geologic risk in B-sand assessed.
- Prospectivity of D-unit confirmed.
- Three-Well/Two Phase Program developed
  - Phase 1: Conduct stratigraphic test → complete as monitoring well
  - Phase 2: Establish facilities; drill and instrument science well; drill, complete and conduct scientific reservoir response experiment.



Nominal Project Timeline



Summary

Ongoing effort to conduct Long-term Gas Hydrate Production Test

- **DOE leads a National R&D program in Gas Hydrate Science and Technology**
  - enabled by the Methane Hydrate R&D Act of 2000. Funded every year other than 2011.
  - collaboration/coordination with 6 agencies (USGS, BLM, BOEM, NSF, NRL, NOAA)
  - extensive and active international engagements (Japan, Korea, India, New Zealand, others)
- **Alaska North Slope (ANS) is a "natural laboratory"**
  - FOAs led to three CAs w/ Industry that conducted scientific drilling programs in 2004, 2007, and 2011/12.
  - DOE and USGS have strong reputations for technical excellence within the ANS Industry
- **Long-term scientific field experiments remain a #1 priority in global gas hydrate science.**
  - Strong partnership with Japan
  - Long-term testing program requires permanent infrastructure at a site with known hydrates
  - The Greater Prudhoe Bay area is the only place on Earth that meets these requirements.
- **Current Effort is a Collaboration designed to develop a Project**
  - Partners are USGS, JOGMEC, State of Alaska, and Petrotechnical Resources, Alaska
  - Initial focus evaluated unleased acreage. The sites have elevated costs and risks.
  - PBU partners are receptive to considering scientific drilling concepts at select sites.