Trans Alaska Pipeline System
Low Flow Overview

October 2017

TAPS Overview

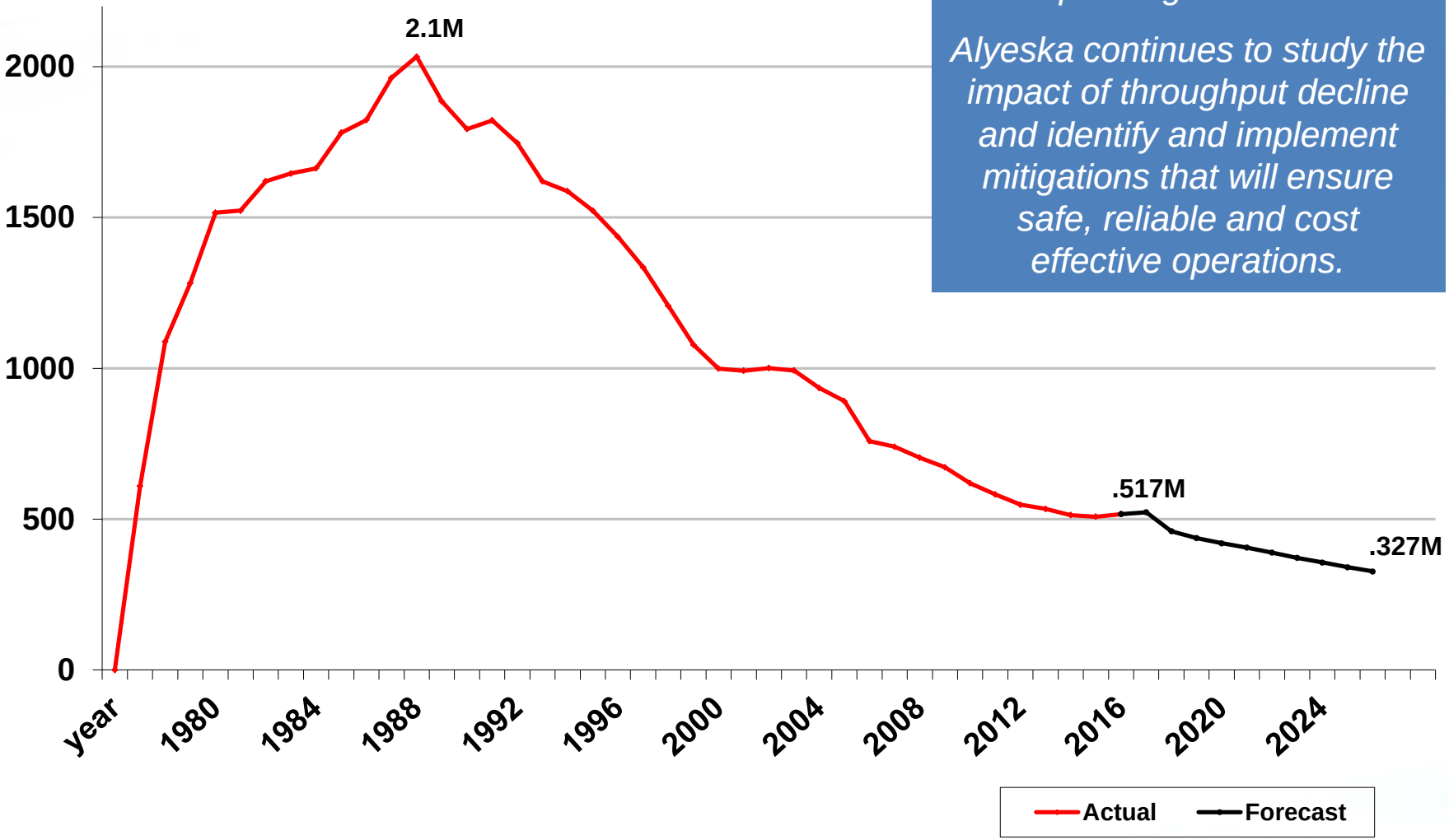
- Alyeska Pipeline Service Company was formed in 1970 to design, construct, operate and maintain the Trans Alaska Pipeline System (TAPS). TAPS began operations in 1977.

- TAPS basics
  - 48-inch diameter carbon steel
  - 800 miles long
    - 420 miles above ground
    - 380 miles below ground
  - 178 mainline valves
  - 78,000 vertical support members
  - Includes Valdez Marine Terminal and Ship Escort/Response Vessel System

TAPS Throughput (MBD)

Throughput has declined since peaking in 1988.

Alyeska continues to study the impact of throughput decline and identify and implement mitigations that will ensure safe, reliable and cost effective operations.



Forecast figures: State of Alaska DOR, Spring 2017 Revenue Sources Book
Actual figures are calendar year; forecast figures are State of Alaska fiscal year

What is “Low Flow”?

“Low Flow” refers to slower oil flow through the pipeline.

- TAPS was designed to move warm crude oil in an Arctic environment.
- As throughput declines, so does the rate at which crude oil flows through TAPS to Valdez.
  - 4.5 day transit time in 1988
  - 18 day transit time in 2016
- Slower flow rates may allow oil and water to separate during transit.
- Oil cools during longer transit times.
- Cooling may lead to potential ice formation and wax accumulation.

Water and Wax

Water and ice issues

- The small volume of water transported through TAPS becomes increasingly problematic as throughput declines.
  - At low velocities, water separates and may create a corrosive environment.
  - Settled water, in conjunction with wax deposition on the pipe wall, increases concern about internal corrosion.
  - During cold weather shutdowns, water can accumulate, freeze and cause problems when flow resumes.
  - During extreme winter operations, without added heat, ice may form in flowing conditions.

Wax issues

- The volume of crude oil solids, or wax, that forms in the oil increases at lower oil temperatures.
- Low crude oil velocity in the pipeline allows wax to settle.
- More frequent use of scraper pigs may be required to manage wax.

Low Flow Research and Study

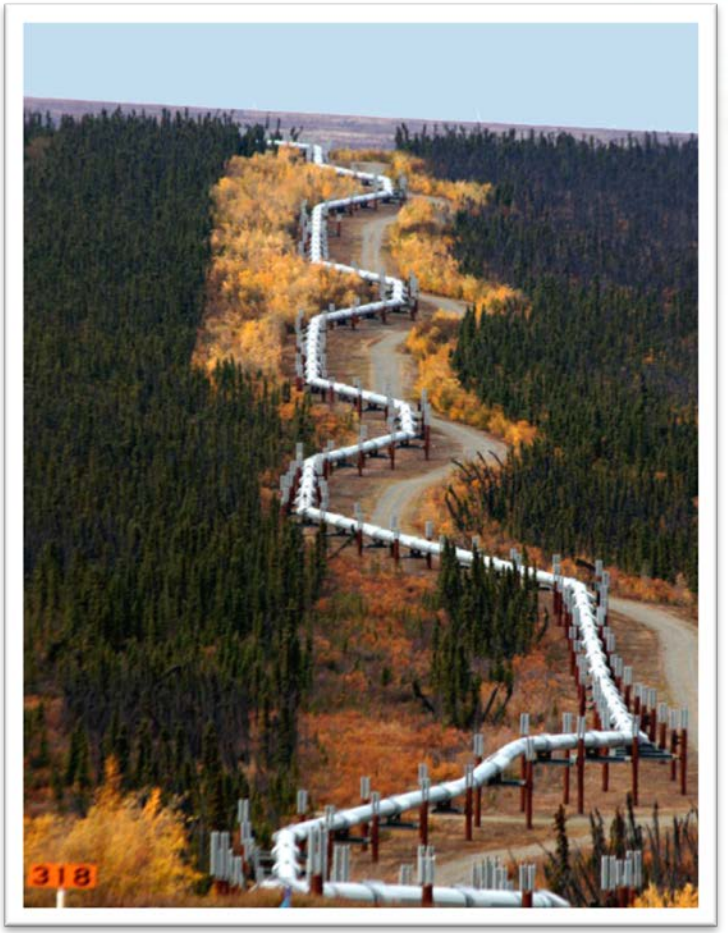
A dedicated team of experts continues to evaluate low throughput challenges and mitigations.

- Recent study work included testing in laboratories and flow loops in Sarnia, Ontario, and University of Tulsa, Oklahoma.
- Research and field testing, including the following, is ongoing.
  - High definition magnifying video cameras inside TAPS to collect data to determine settlement and re-entrainment velocities of wax and water
  - Wax settlement & deposition testing
  - Freeze suppressant testing
  - Pigging technology R&D

High-definition video camera at PS09

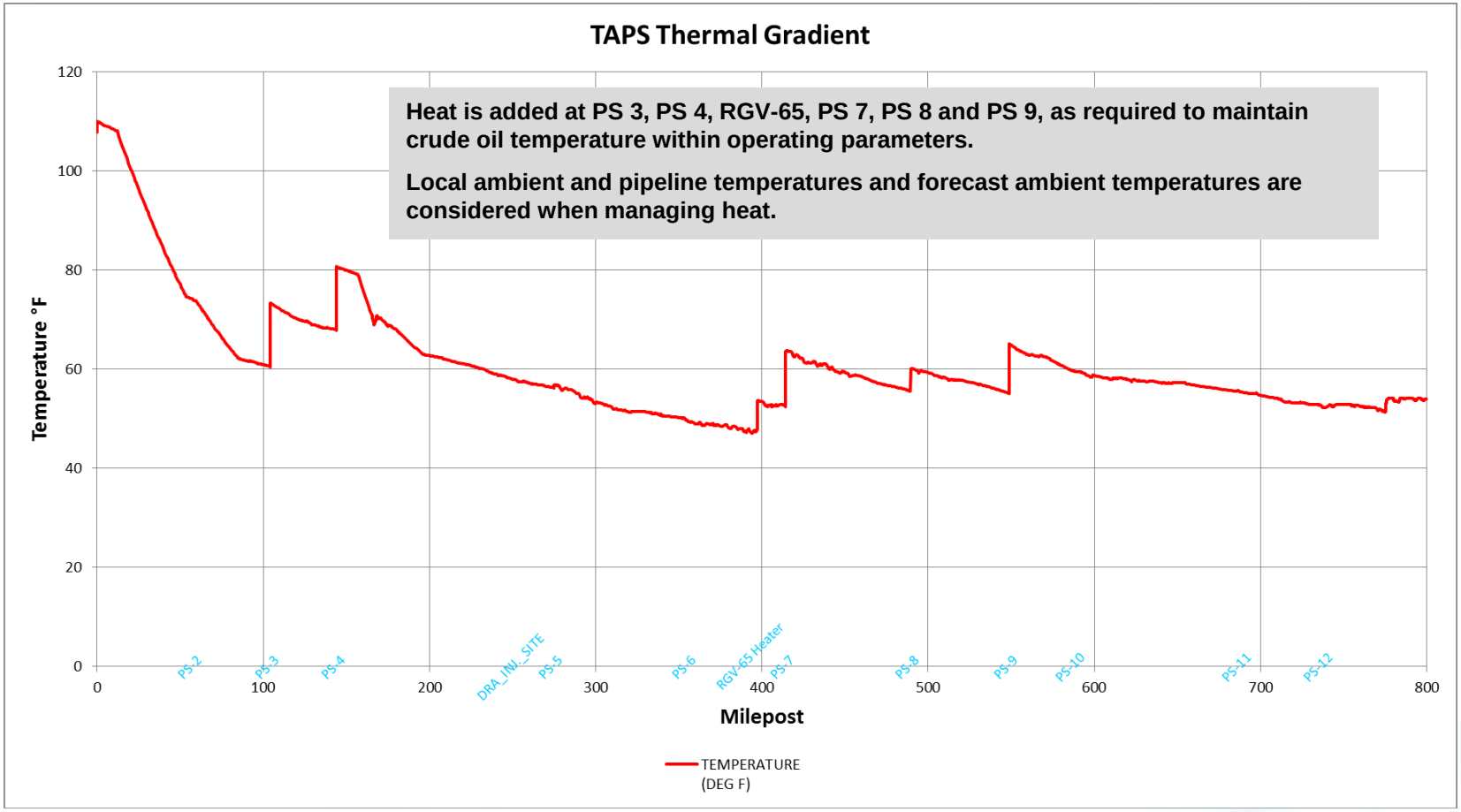
Mitigation Strategies

- Minimize the risk of ice formation.
  - Add heat at key locations
  - Plan for contingency use of freeze point depressants
- Reduce the risk of internal corrosion.
  - Consider extending the use of corrosion inhibitors to the mainline
  - Continue pigging regime and adjust as needed
- Manage wax deposition.
  - Evaluate pigging technologies
  - Install additional pig launchers and receivers
  - Monitor wax and crude oil solids



Temperature Monitoring

Crude oil temperature is monitored to determine the need for mitigations, such as additional heat.



Additional Heat

- Cold crude oil temperatures on TAPS require added heat to keep the oil above minimum operating temperatures.
- Crude oil can be recirculated at Pump Stations 3, 4, 7 and 9 to add frictional heat.
- Supplemental skid mounted, mobile heaters are available at two locations.

Slip Stream Heat Operation

Wax Management

- Alyeska regularly runs scraper pigs to manage wax and water accumulation.
- Research and monitoring inform frequency and pig configuration.
- Pig launcher / receiver facilities are located at Pump Stations 1, 4 and 9 and the Valdez Marine Terminal.

How Low Can TAPS Operate?

- Earlier low flow research examined TAPS operational issues at flow rates above 300 MBD.
  - Based on ongoing research, it is believed that TAPS can safety operate between 300 and 350 MBD with appropriate, identified mitigations.
  - We have developed plans that will help mitigate the operational challenges that occur as throughput declines to the 300 MBD range.
  - Research continues regarding operational issues at rates lower than 300 MBD.
- A dedicated low flow team is evaluating new technologies, alternative operating modes and the feasibility of chemical additives to extend the life of TAPS to lower throughput rates.

The Simple Solution: More Oil

- Arctic oil resources are abundant
- The simplest solution to TAPS' technical challenges is to increase throughput
- More oil in TAPS is possible with
  - Access to resources
  - Streamlined permitting
  - Reasonable regulations
  - Favorable fiscal climate