Trans Alaska Pipeline System Flow Assurance Overview

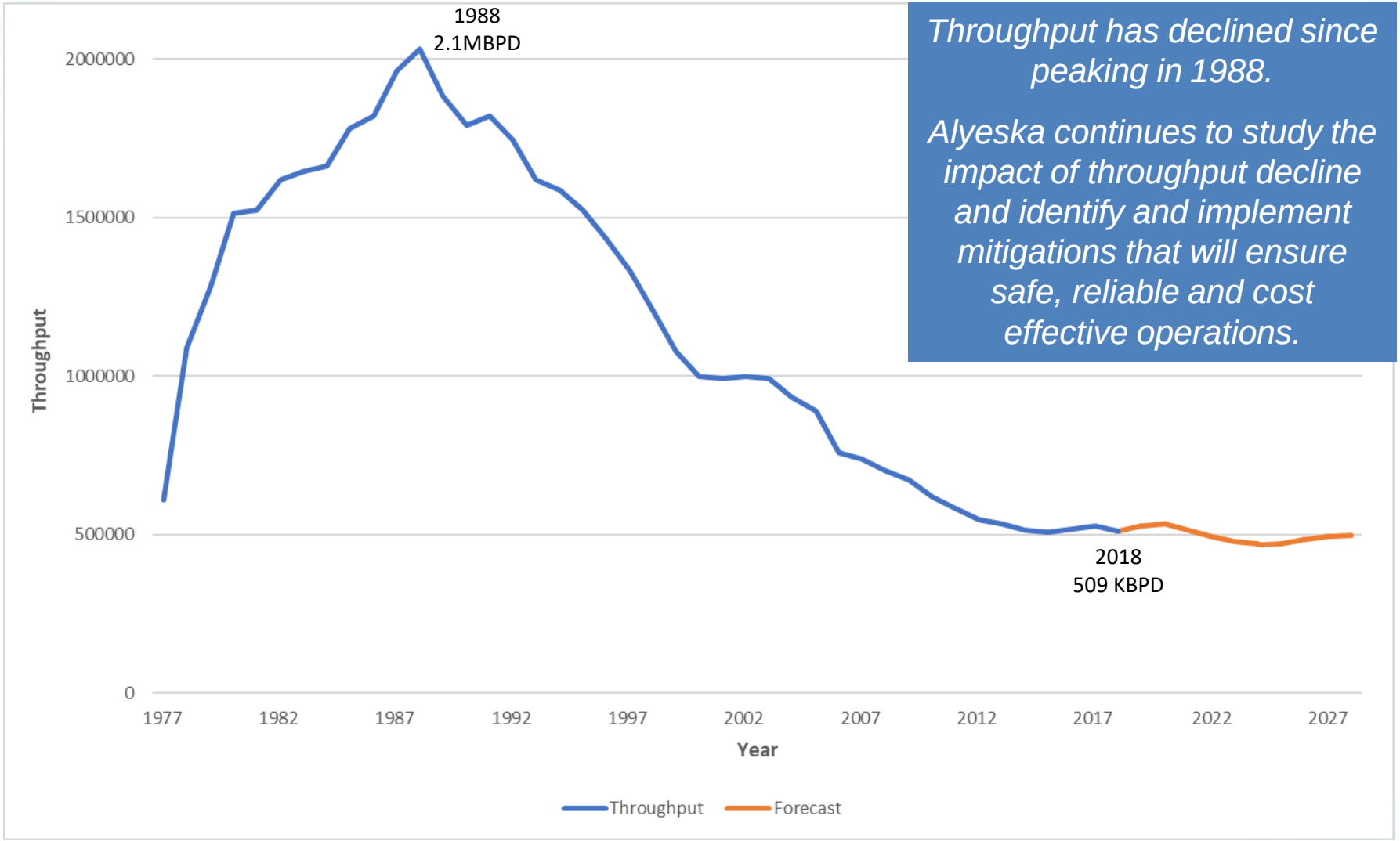
January 2019

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 pipe
  - 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, Fall 2018 Revenue Sources Book
Actual figures are calendar year; forecast figures are State of Alaska fiscal year

What is the impact of low throughput?

Low throughput results in 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 2018
- 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 additional 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 from the oil 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 as the crude oil cools.
- Low crude oil velocity in the pipeline may allow wax to settle.
- Significant wax deposition creates additional challenges with cleaning pig operations.

Flow Assurance Research and Study

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

- Research and field testing is ongoing.
  - High definition video cameras view crude oil, collecting data to determine settlement and entrainment velocities of wax and water.
  - Wax and water settlement and deposition testing.
  - Developing pig technology to identify specific locations of wax concern in the pipeline.
  - Developing transient pipeline model to optimize operations.

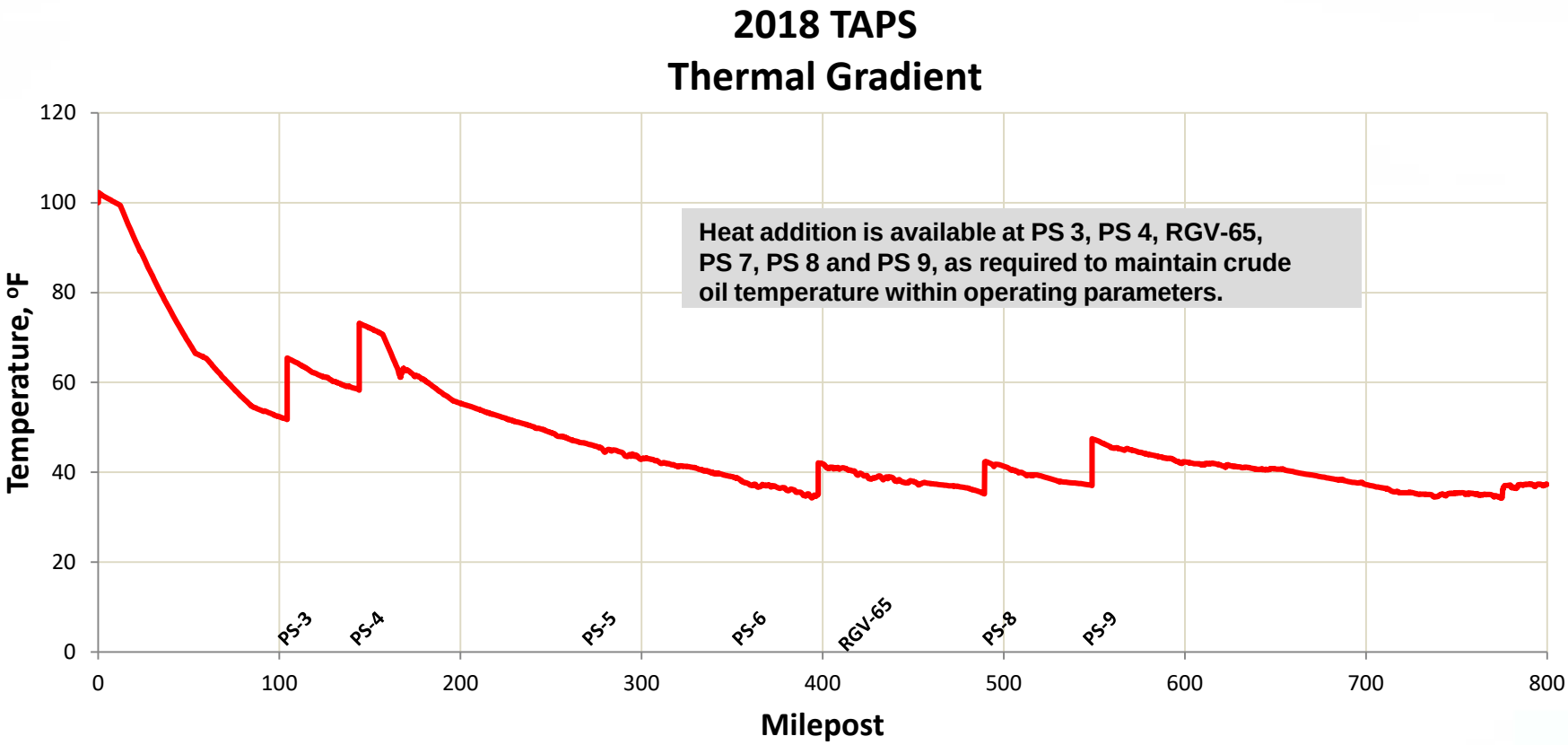
High-definition video camera at PS09

Mitigation Strategies

- Minimize the risk of ice formation.
  - Add heat at key locations.
  - Plan for contingency use of freeze 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.
  - Improve pig design to reduce risk of plugging.
  - Install additional wax management facilities.
  - Monitor wax and crude oil solids.
- Deploy new technologies to collect predictive data.

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.
- Work is on-going to optimize the heat addition locations in order to improve long-term efficiency and reduce operational cost and risk.

Slip Stream Heat Operation

Wax Management

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

How Low Can TAPS Operate?

- Earlier flow assurance research examined TAPS operational issues at flow rates above 300 MBD.
  - Research continues regarding operational issues at rates lower than 300 MBD.
  - Data analysis to date suggests that with additional investment it may be technically possible to safely operate down to annualized throughput rates as low as 200 MBD.
- A dedicated flow assurance team is evaluating new technologies and alternative operating modes to build confidence that TAPS can operate at lower volumes.
- Technical capability does not necessarily equate to economic viability; the long-term sustainability of TAPS may ultimately be limited by per barrel transportation costs.

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 and stable fiscal climate.