NORTH DAKOTA PETROLEUM COUNCIL

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BKN QUALITY & SAFETY INITIATIVE

NDPC Bakken Crude Characterization Task Force
Presentation of Preliminary Results

Williston Basin Petroleum Conference
Bismarck, North Dakota - May 20, 2014

Key Findings

- Bakken Quality is very consistent
  - Typical Class 3 Flammable Liquid
  - Both well-to-well and throughout the supply chain
  - Little variation throughout entire basin
  - Shows no “spiking” with NGL’s before rail shipment
  - No practical changes in quality during transit
- Produced for over 60 years
  - Recently passed one billion barrel mark
  - Moved by rail, pipeline, truck
  - No corrosion noted by any stakeholder

Key Findings (continued)

- Very desirable to refiners
  - High transportation fuel yield (gasoline, jet fuel and diesel)
  - Low Metals/ConCarbon contents
- PHMSA mandated IBP test (D86) appears not to be the optimal test method for PG determination
  - Significant variability between labs on same sample
  - Not designed for wide boiling range material like crude oil
  - Other groups, including API, are working on recommendations

Why study was initiated?

- Address the following:
  - Volatility?
  - Flammable Liquid or Flammable Gas?
  - Presence of subsidiary hazard?
    - Corrosive?
  - **All Analyses conclude Bakken is properly Classified as a Flammable Liquid**
  - **Three studies all in agreement: NDPC, AFPM and Transport Canada**

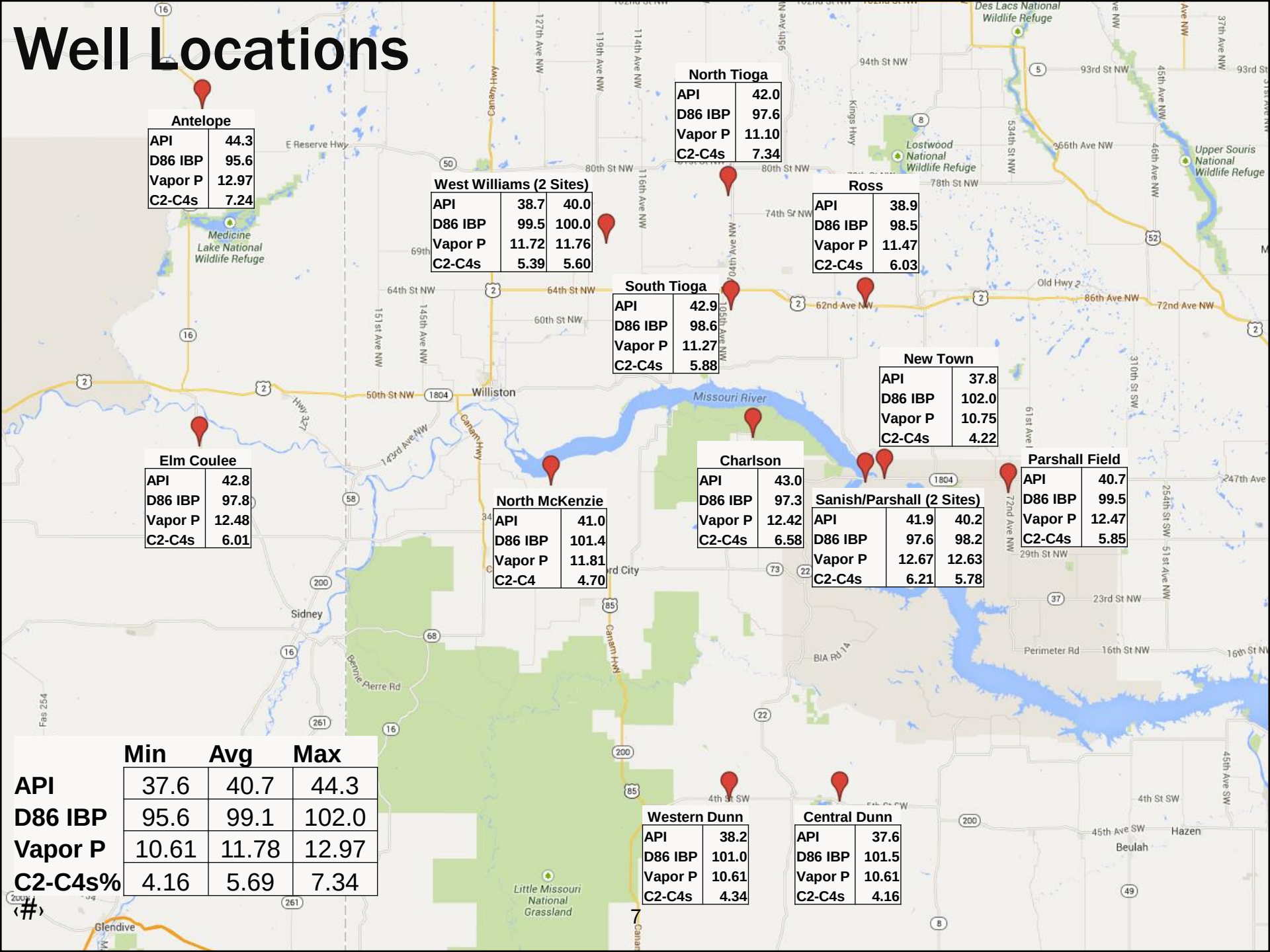
Project Contractors

- Turner, Mason & Company – Overall Project Coordinator
  - Internationally recognized refining consultants
  - 43 years in business
  - TM&C staff supplemented by outside expertise
- SGS - Sampling and Testing Contractor
  - World leading testing and inspection company
  - Over 135 years in business
  - Utilized both local and USGC laboratories
- Overall cost $400,000

Project Overview

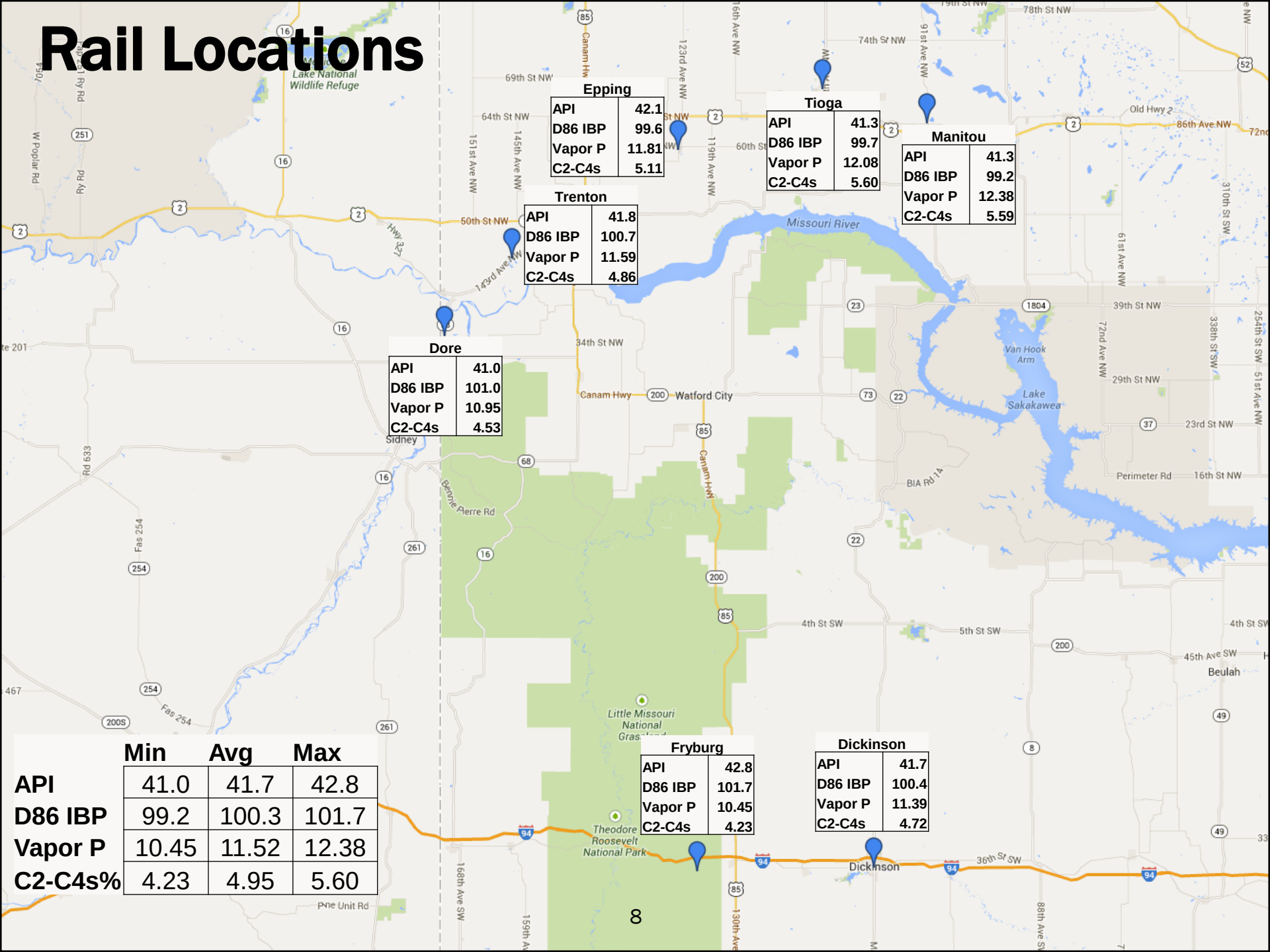
- NDPC commissioned comprehensive sampling and testing program to establish quality baseline
- BKN crude sampled from both well and rail sites
  - 15 well sites and 7 rail-loading terminals
  - Well sites represent producers with over 50% of total ND production
  - Rail sites represent about 50% of total ND rail capacity
  - Significant geographic dispersion for both well and rail sites
- Sampling initiated on 3/25 and completed on 4/24
  - 7 samples at each site
  - Initial samples at well sites included both top and bottom
- Sampling Complete; Testing over 95% complete
  - 152 total samples – 103 from well sites; 49 from rail sites
- Supplemental data provided by member companies

Well Locations



	Min	Avg	Max
API	37.6	40.7	44.3
D86 IBP	95.6	99.1	102.0
Vapor P	10.61	11.78	12.97
C2-C4s%	4.16	5.69	7.34

Rail Locations



	Min	Avg	Max
API	41.0	41.7	42.8
D86 IBP	99.2	100.3	101.7
Vapor P	10.45	11.52	12.38
C2-C4s%	4.23	4.95	5.60

Testing Protocol

- Testing focused on parameters relevant to DOT hazardous material compliance
- The test slate included:
  - API Gravity
  - Flash Point by ASTM D3278
  - Initial Boiling Point (IBP) by ASTM D86
  - Vapor Pressure by ASTM D6377 at 37.8°C (100°F) *
  - Light Ends Analyses by IP344
  - High Temperature Simulated Distillation (HTSD) by ASTM D7169

* Results about 1 psi higher than if D323 RVP test method is used

Class 3 Flammable Liquid, Packing Group I or II

- Defined by Hazardous Materials Regulations (HMR) as having the characteristics:
  - Material is a liquid at 68°F (room temp.)
  - Material has Vapor Pressure <43.5 psig at 122°F
  - Flashpoint <75°F and:
    - Initial boiling point >95°F - Packing Group II
    - Initial boiling point < or =95°F - Packing Group I
  - Bakken = Flammable Liquid, PG I or II

Lab Result Summary

Sample Date Range Total (152 Samples)	3/25 to 4/24/2014 Avg	Min	Max
Ambient Temp (°F)*	34	10	65
API Gravity	41.0	36.7	46.3
Vapor Pressure (PSI)	11.7	8.9	14.4
D86 IBP (°F)	99.5 (PG II)	91.9 (PG I)	106.8 (PG II)
Light Ends (C2-C4s)	5.48	3.52	9.30
Rail (49 Samples)	**Avg**	**Min**	**Max**
Ambient Temp (°F)*	29	10	47
API Gravity	41.7	39.2	44.0
Vapor Pressure (PSI)	11.5	9.6	12.9
D86 IBP (°F)	100.3 (PG II)	96.7 (PG II)	104.1 (PG II)
Light Ends (C2-C4s)	4.95	3.91	6.44
Well (103 Samples)	**Avg**	**Min**	**Max**
Ambient Temp (°F)*	36	11	65
API Gravity	40.6	36.7	46.3
Vapor Pressure (PSI)	11.8	8.9	14.4
D86 IBP (°F)	99.1 (PG II)	91.9 (PG I)	106.8 (PG II)
Light Ends (C2-C4s)	5.76	3.52	9.30

←API/Vapor Pressure Typical For Light Crude

Rail Cars Used Rated For 100 PSI Transport

← Packing Group Crude Currently Categorized/ Transported as Expected

*Some later samples missing Ambient Temp readings, may skew results colder

Bakken Characteristics (Mar-Apr 2014)

- Average API Gravity of 41°
  - Consistent as a light crude oil
- Average Vapor pressure 11.5-11.8 psig
  - 61% below regulatory threshold
- Flashpoint <73°F
  - Consistent for flammable liquid, Packing Group I or II
- Initial Boiling Point midpoint 95°F
  - Consistent for flammable liquid, Packing Group I or II
- Low H2S & Total Acid Number (TAN)
  - No corrosivity

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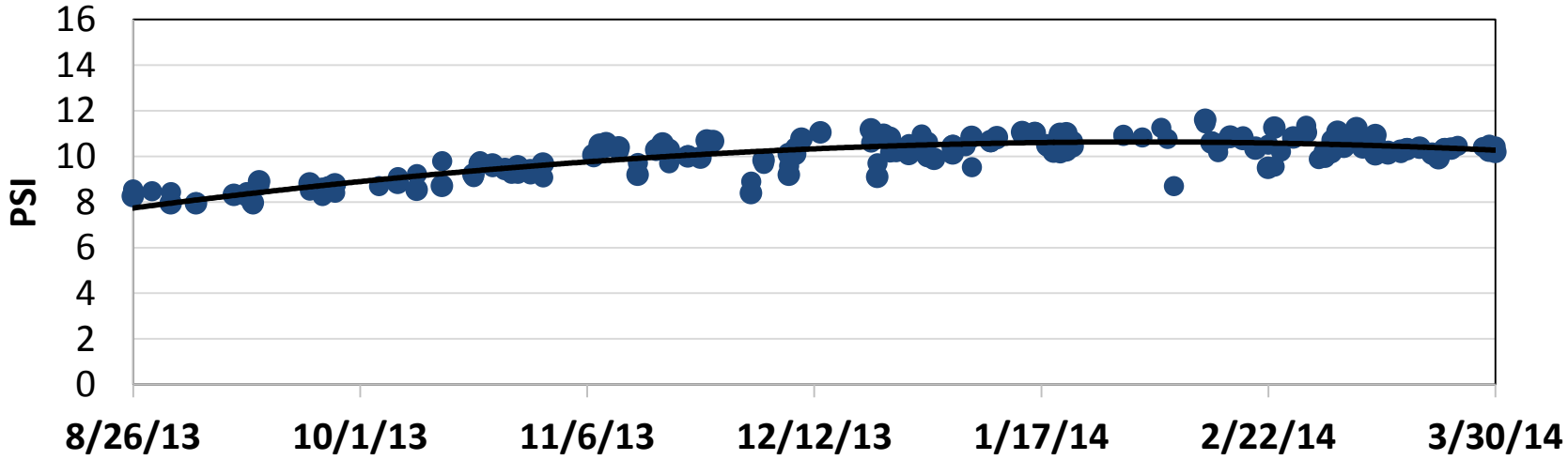
Vapor Pressure

- BKN Average Vapor pressure 11.5-11.8 psig (Mar-Apr)
  - 61% below regulatory threshold
- Seasonality (Rail terminal data outside control data set)



Vapor Pressure Seasonality

- While there is some variability to the data, it shows seasonal variation over a narrow range: 8 psi to 11 psi
- This is exactly as would be expected, with a predictable pattern of higher vapor pressure in the winter and lower vapor pressures in the hotter summer months
- Over this entire 7-month period, there are **no** unusually high values
- This study demonstrates a predictable, consistent crude oil stream

SGS/Intertek Round Robin Testing

- Three labs* tested four identical Bakken crude samples for the following:
  - API Gravity by ASTM D5002
  - Vapor Pressure of Crude at 37.8°C (100°F), 4:1 V/L Ratio, by ASTM D6377
  - Initial Boiling Point (IBP) by ASTM D86 distillation

*Two in North Dakota and one in Louisiana

Round Robin Testing - Summary

- Excellent agreement on API Gravity and Vapor Pressure
  - Supports sample integrity maintained throughout transport and good lab performance
- Poor agreement on D86 IBP
  - Results for the same sample in each case fall on either side of the 95°F level used for PG I/PG II determination
  - Underscores shortcomings of tests required by PHMSA
  - API committee studying this, as well as alternatives

Results – D86 IBP

- All samples fall within Class 3 – Either PG 1 or 2
  - Shipped on same rail cars, same EMS response
- PHMSA prescribed methodology may not be optimal test for crude oil
  - Not designed for wide boiling range materials like crude oil
  - As a result, poor agreement on Packing Group determination

		D86 IBP (°F)			
Sample Location	**Date @ Time**	**Intertek Mandan**	**SGS St. Rose**	**SGS Williston**	**Max Delta**
1	5/1/14 @ 16:30	89.9	95.4	101.8	11.9
2	5/1/14 @ 16:30	83.1	89.1	102.6	19.5
3	4/30/14 @ 16:00	87.8	90.7	105.5	17.7
4	5/1/14 @ 16:30	89.2	94.5	102.2	13.0

Is Bakken corrosive?

- HMR defines corrosive material
  - Corrode steel or aluminum at rate of 0.25 inch per year
  - Bakken average sulfur is <0.10, low TAN
  - Bakken is not corrosive

Consistent Quality – Rail vs. Well

- Quality is consistent between well and rail
- Indicates there is **no spiking** of crudes before shipment

	Well	Rail
API Gravity	40.6	41.7
D86 IBP (°F)	99.1	100.3
Vap P D6330 (PSI)	11.8	11.5
Light Ends %		
Ethane	0.24	0.23
Propane	1.63	1.40
Isobutane	0.66	0.58
n-Butane	3.18	2.75
n-Pentane	2.92	2.72
C2-C4s	5.76	4.95
C2-C5	10.22	9.10

SimDist (°F)	Well	Rail
IBP	<97	<97
5%	107	114
10%	155	166
20%	233	239
30%	312	317
40%	396	397
50%	483	483
60%	574	574
70%	673	672
80%	787	789
90%	936	943
95%	1055	1061
FBP	1271	1278

Loading vs. Destination Testing

- 5 Railcars loaded in North Dakota - Discharged at St. James, Louisiana

Test	Units	Avg. ND Rail Terminal Car Samples	Avg. St. James Rail Terminal Car Samples	Avg. NDPC Data for Same Rail Terminal
VPCR 4 (37.8° C)	psi	10.47	10.61	10.45
IBP	°F	94.7	90.4	101.7
Flash Point	°F	<50	<50	<73
H2S in Vapor Phase	ppm v/v	<1	<1	
C2-C4s	Vol %	4.00	4.08	4.23
C2-C5s	Vol %	8.01	7.89	8.13

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Remaining Work

- Analyze operating conditions/quality data
  - Ambient Temperatures
  - Separator and treater temps and pressures
  - Production rates/last movements out of tank
  - Tank heights
  - Vapor capture status
- Develop field operating standards at well site operations
- Final Report to be issued in late June
- Establish BKN Benchmark

Establish BKN Benchmark

- Define BKN specifications
- Value:
  - Create reference point for buyers and sellers
  - Producers will follow specific field standards to meet BKN specs
  - Ensure proper BKN oil characterization, now and future



Discussion and Questions?