Update on NIOSH Silica Exposure Assessment Field Work

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Outline

- Review of respirable crystalline research 2010-2012
- 2019 site visits
  - April ND two hydraulic fracturing locations. Sandstorm used
  - August TX, hydraulic fracturing location. Sandbox used

Early Respirable Crystalline Silica Exposure Research

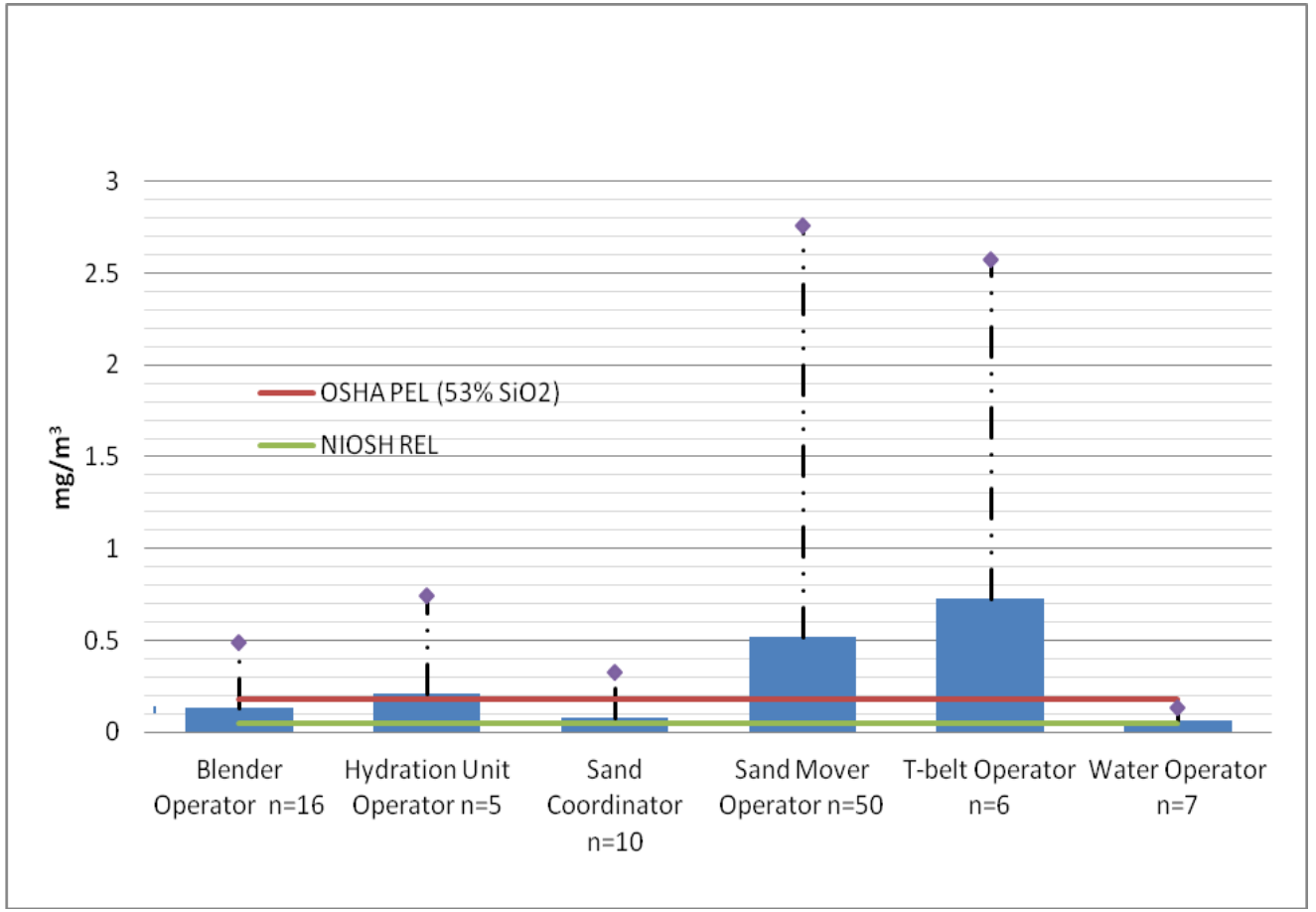
- Work conducted 2010-2012
- All locations used Sandchiefs with pneumatic loading
- 11 Sites in 5 states
- 111 personal breathing zone samples, 15 different job titles

Occupational exposures to respirable crystalline silica during hydraulic fracturing. Esswein EJ; Breitenstein M; Snawder J; Kiefer M; Sieber WK. J Occup Environ Hyg 2013 Jul; 10(7):347-356

Data Summary

Site	ACGIH TLV	NIOSH REL	OSHA PEL	Total No. Samples
Fayetteville, Ark.	24 (92.3%)	19 (73.1%)	14 (53.9%)	26
DJ Basin 1, Colo.	16 (84.2%)	14 (73.7%)	12 (63.2%)	19
Eagle Ford, Texas	5 (62.5%)	5 (62.5%)	4 (50.0%)	8
DJ Basin 2, Colo.	19 (90.5%)	14 (66.7%)	9 (42.9%)	21
Marcellus, Pa.	25 (92.6%)	23 (85.2%)	18 (66.7%)	27
Bakken, N.D.	4 (40%)	1 (10%)	0	10
Totals	93 (83.8%)	76 (68.5%)	57 (51.4%)	111

Exposure comparisons by job title 2010-2012



Eight (8) primary points of dust release or generation from completions equipment or workplace operations

1) Dusts ejected from thief hatches on top of the sand movers during refilling operations

2) Dust ejected and pulsed through side fill ports on the sand movers during refilling operations

3) Dust generated by on-site truck vehicle traffic including sand trucks and crew trucks, the release of air brakes on sand trucks, and by winds

4) Dust released from the transfer belt under the sand movers

5) Dusts created as sand drops into, or is agitated in the blender hopper and on transfer belts

6) Dust released from operations of transfer belts between the sand mover and the blender

7) Dust released from the top of the dragon's tail on sand movers

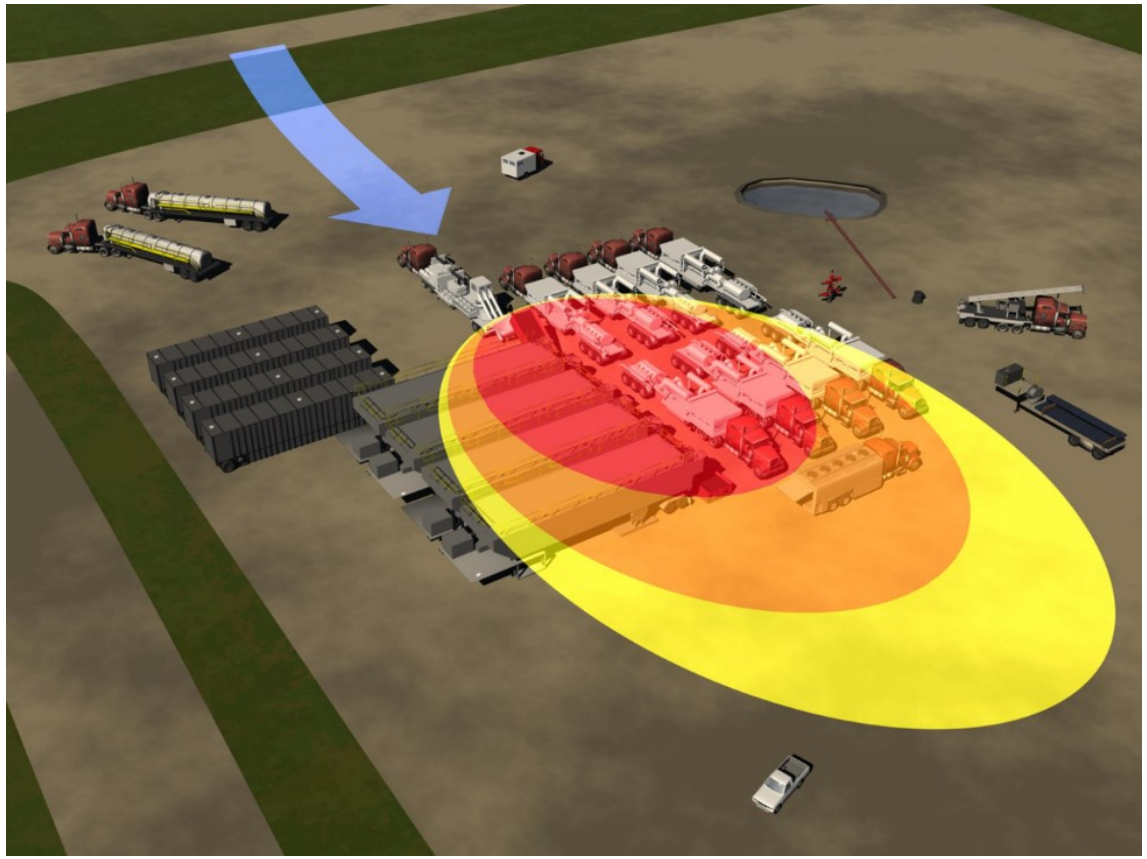
8) Dust deposited on and released from workers coveralls







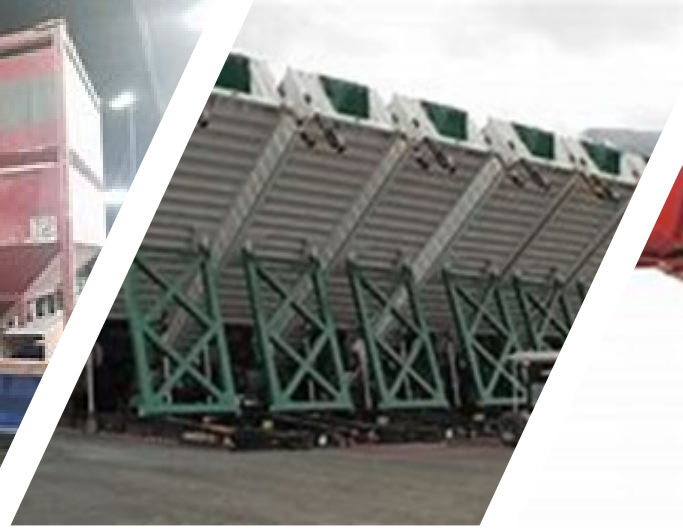
Respirable Silica Exposure Zones



Maximum respiratory protection

Moderate respiratory protection

Avoid area during sand transfers and pumping

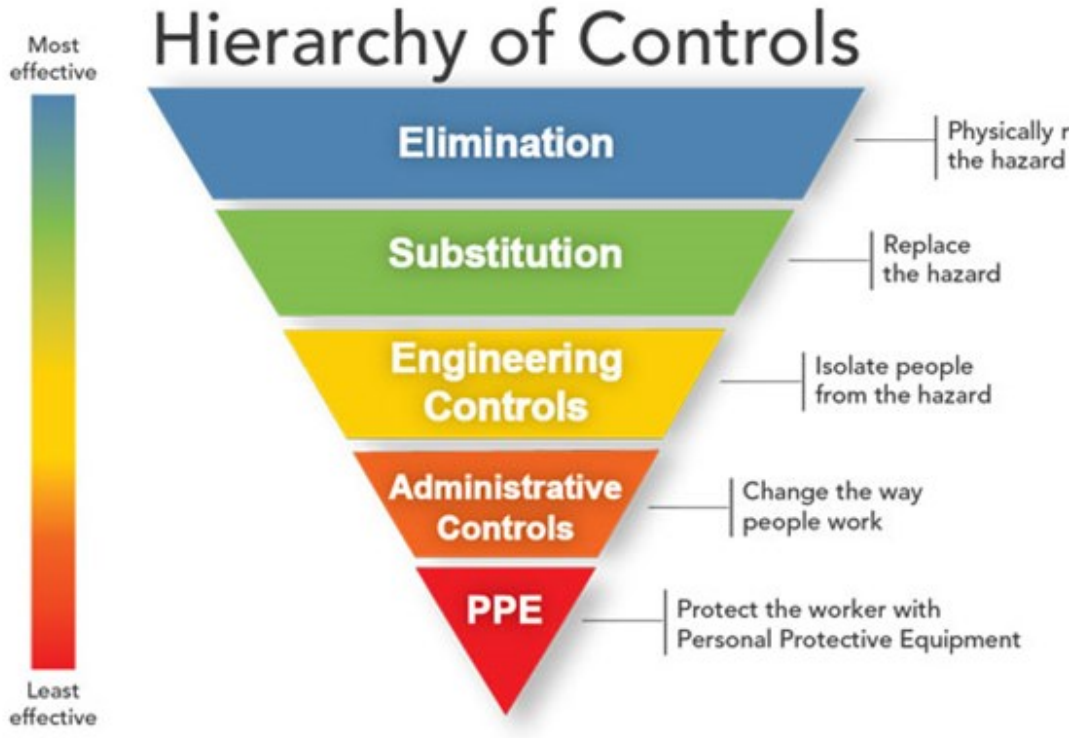


Proppant Handling Today

- Sand Movers/Sand Chief
- Containerized Sand
- Silos
- Vertical Bins

Hierarchy of Controls

- Controlling exposures to occupational hazards is the fundamental method of protecting workers.
- Traditionally, a hierarchy of controls has been used as a means of determining how to implement feasible and effective control solutions.
- The idea behind this hierarchy is that the control methods at the top of graphic are potentially more effective and protective than those at the bottom.
- Following this hierarchy normally leads to the implementation of inherently safer systems, where the risk of illness or injury has been substantially reduced.



Elimination and Substitution

- Stimulate the Well Without Silica Proppant
- Complete elimination of proppant is not possible in all formations
- Manufactured proppants limit generation of respirable silica:
  - Ceramic beads
  - Sintered bauxite

Engineering Controls

Chemical treatment of silica sand reduces dust generation

Use of “wet” sand

Elimination of pneumatic sand transfer from transport trucks

- Silos, Containerized sand, Elevators

Vacuum collection of dust from emission sources

Equipment designed to prevent dust generation

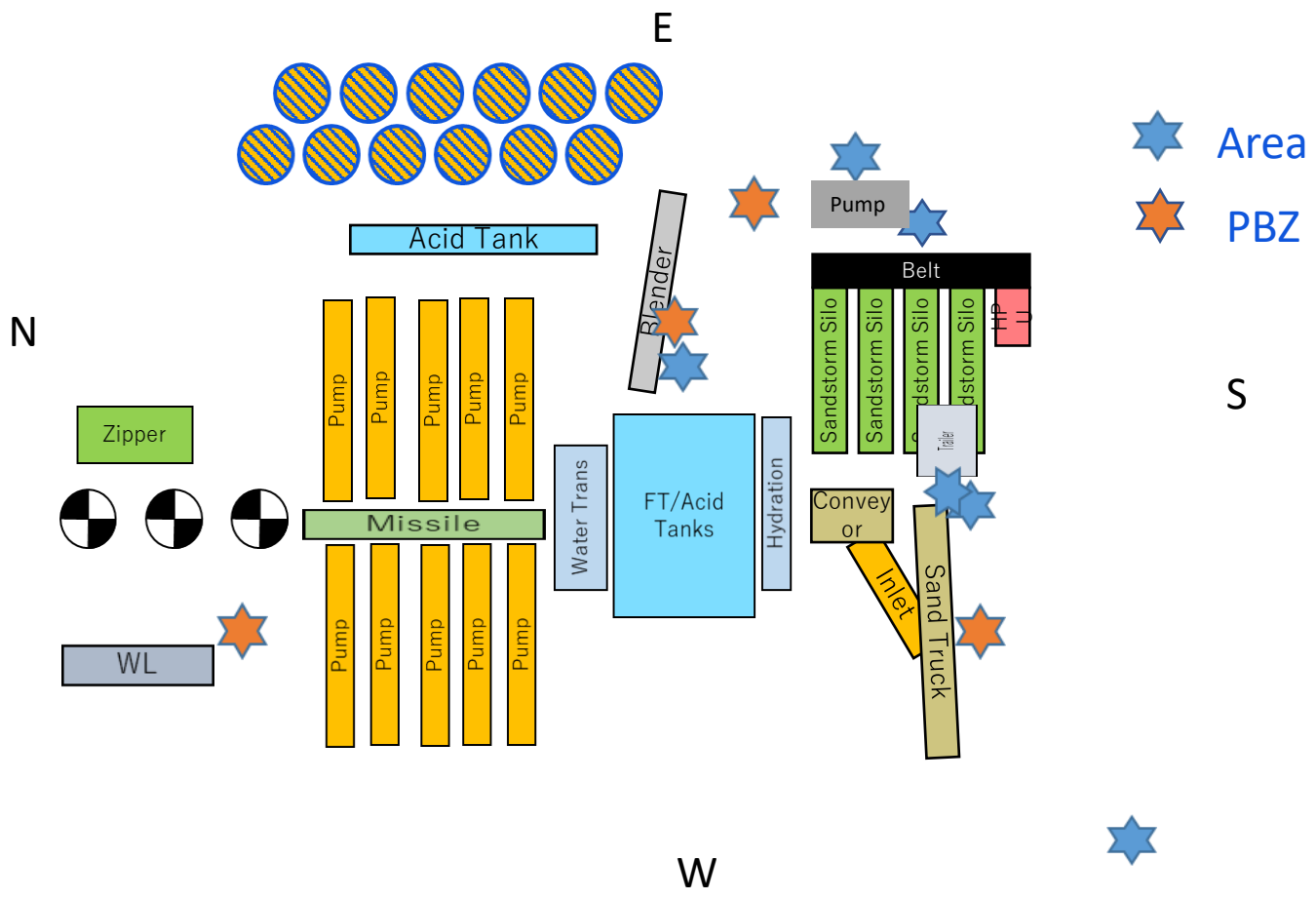
Retrofit existing equipment with controls

April 2019 Hydraulic Fracturing North Dakota

- Sampled 2 well pads, 2 generations of Vertical Bin technology
- Sampled Area and Personal Samples for:
  - Total Respirable Particulate (NMAM 600)
  - Respirable Silica (NMAM 7500)
  - Diesel Particulate (NMAM 5400)
  - Volatile Acids (NMAM 7903)
- Direct Reading:
  - Nanozen 8899 Personal Particle Monitor (post-shift analysis by Raman)
  - SidePak AM510 Personal Aerosol Monitor
  - FLIR AirTec Diesel Particulate Monitor

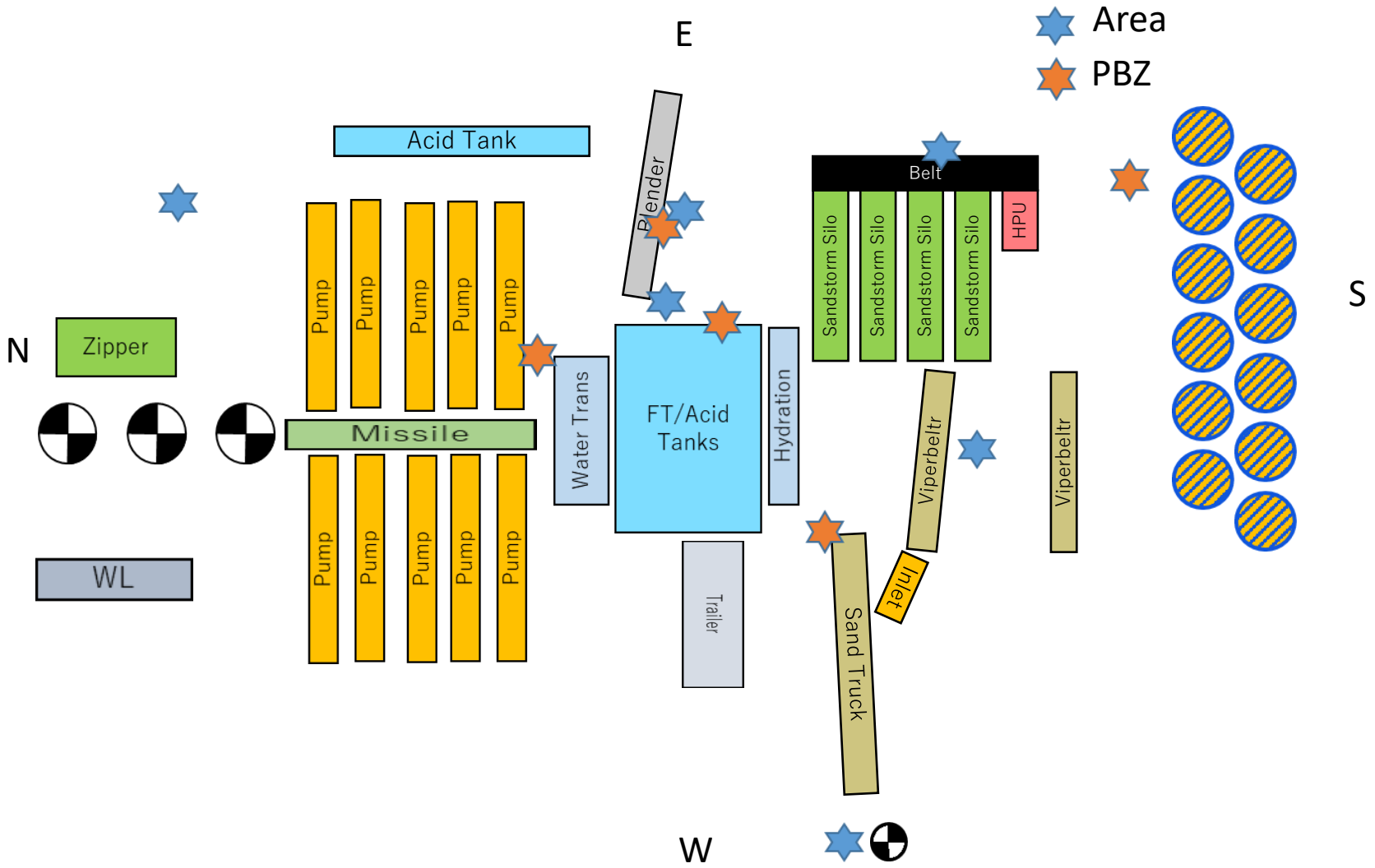
Respirable Silica North Dakota Site 1 April 15-16 2019

Sample Description	Date	Respirable Silica (µg/m³)
PBZ, Wireline	4/15/2019	0.00
	4/16/2019	0.00
PBZ, Sand and Chemical Hand	4/15/2019	0.00
	4/16/2019	7.10
PBZ, Blender Operator	4/15/2019	6.07
	4/16/2019	11.40
PBZ, Sand Operator	4/15/2019	2.18
	4/16/2019	12.82
PBZ, Fueler	4/15/2019	0.00
	4/16/2019	0.00
Area Telebelt	4/15/2019	0.00
	4/16/2019	0.00
Area Light post near Telebelt	4/15/2019	0.00
	4/16/2019	3.53
Area Trailer Gravity Box	4/15/2019	0.00
	4/16/2019	0.00
Area Back of Gravity Box	4/15/2019	10.45
	4/16/2019	47.12
Area Hopper	4/15/2019	19.78
	4/16/2019	48.62

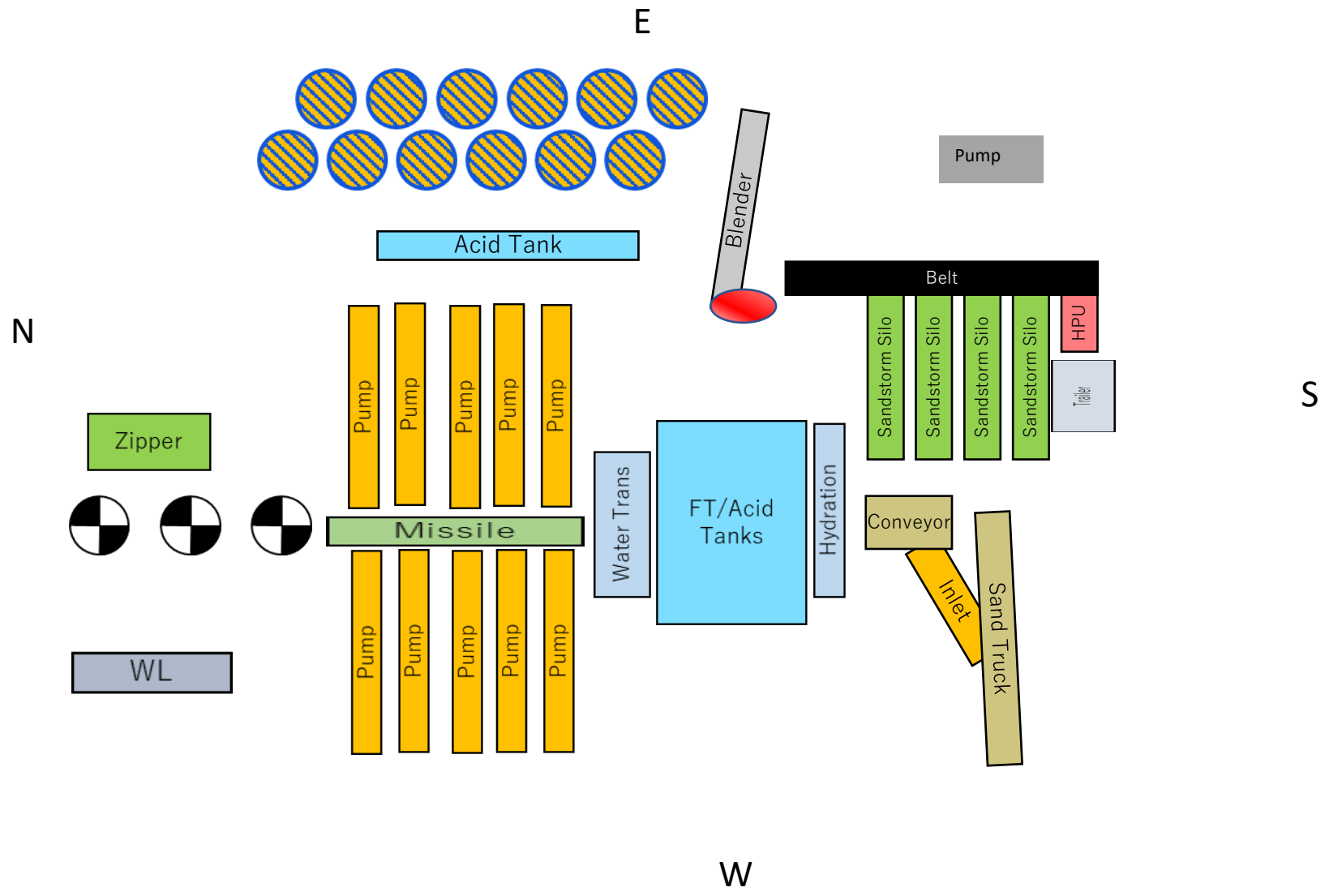


Respirable Silica North Dakota Site 2 April 18-19 2019

Arthur Pad Dunn Center, ND Sample Description	Date	Respirable Silica (µg/m³)
PBZ, Blender Operator	4/18/2019	4.04
	4/19/2019	0.00
PBZ, Chemical Hand	4/18/2019	4.71
	4/19/2019	154.08
PBZ, Iron	4/18/2019	0.00
	4/19/2019	0.00
PBZ, Sand Operator	4/18/2019	2.81
PBZ, Water Operator	4/18/2019	0.00
	4/19/2019	0.00
Area, Sand Truck Transfer	4/19/2019	3.69
Area Behind Gravity Box	4/18/2019	54.32
	4/19/2019	4.11
Area Hopper	4/18/2019	785.47
	4/19/2019	563.01
Area, HazDust	4/18/2019	0.00
	4/19/2019	0.00
Area Idol Viperbelt	4/18/2019	0.00
	4/19/2019	0.00
Area Inside Tent Blender	4/18/2019	30.89
	4/19/2019	18.64
Area Light Post	4/18/2019	19.21
	4/19/2019	0.00
Area Trailer in Front of Hopper	4/18/2019	10.59
	4/19/2019	0.00



Respirable Silica Exposure Zones -Today



August 2019 Hydraulic Fracturing Texas

Hydraulic fracturing using Containerized Sand System

Sampled Area and Personal Samples for:

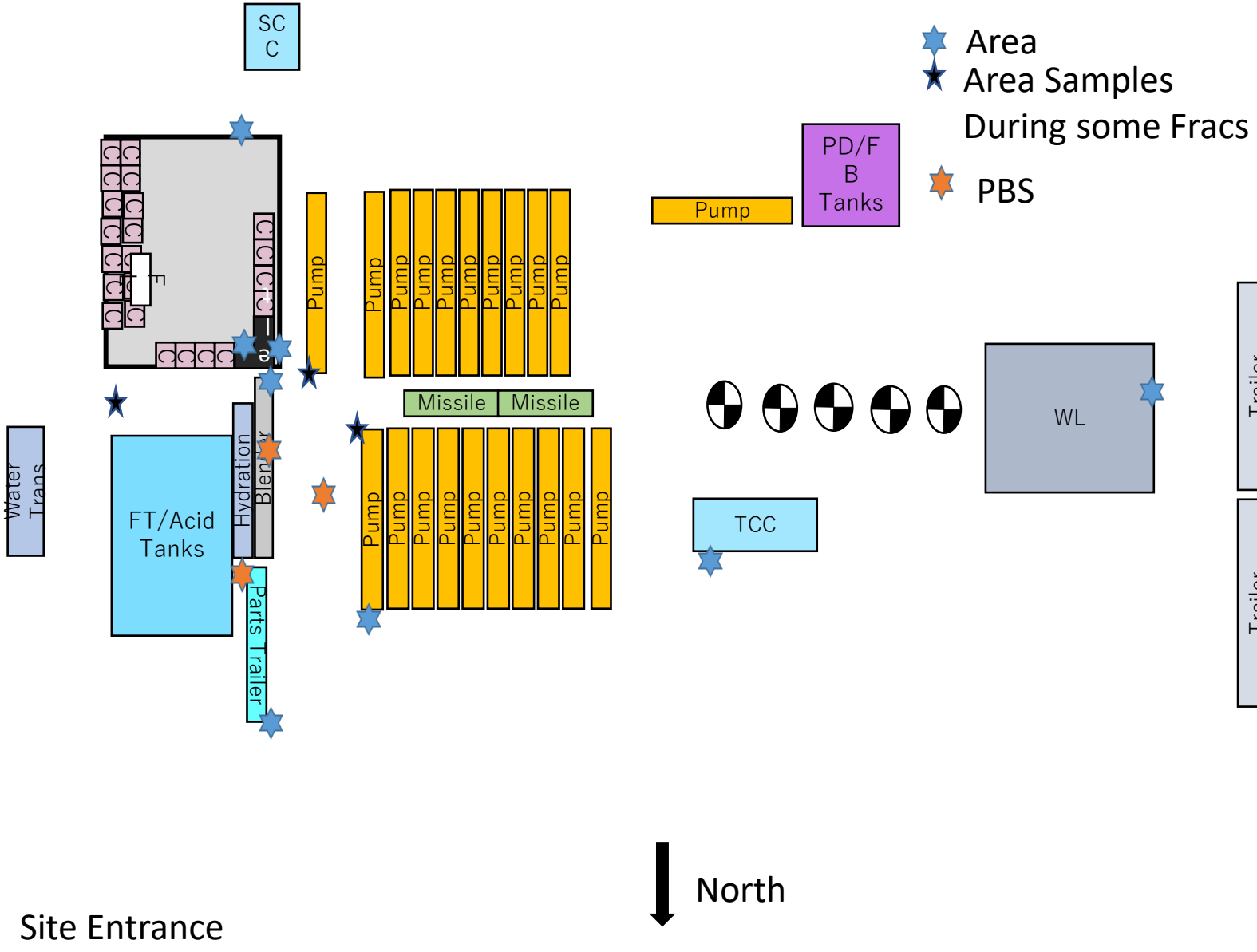
- Total Respirable Particulate (NMAM 600)
- Respirable Silica (NMAM 7500)
- Diesel Particulate (NMAM 5400 and Raman)

Direct Reading:

- Nanozen 8899 Personal Particle Monitor (post-shift analysis by Raman)
- SidePak AM510 Personal Aerosol Monitor
- FLIR AirTec Diesel Particulate Monitor

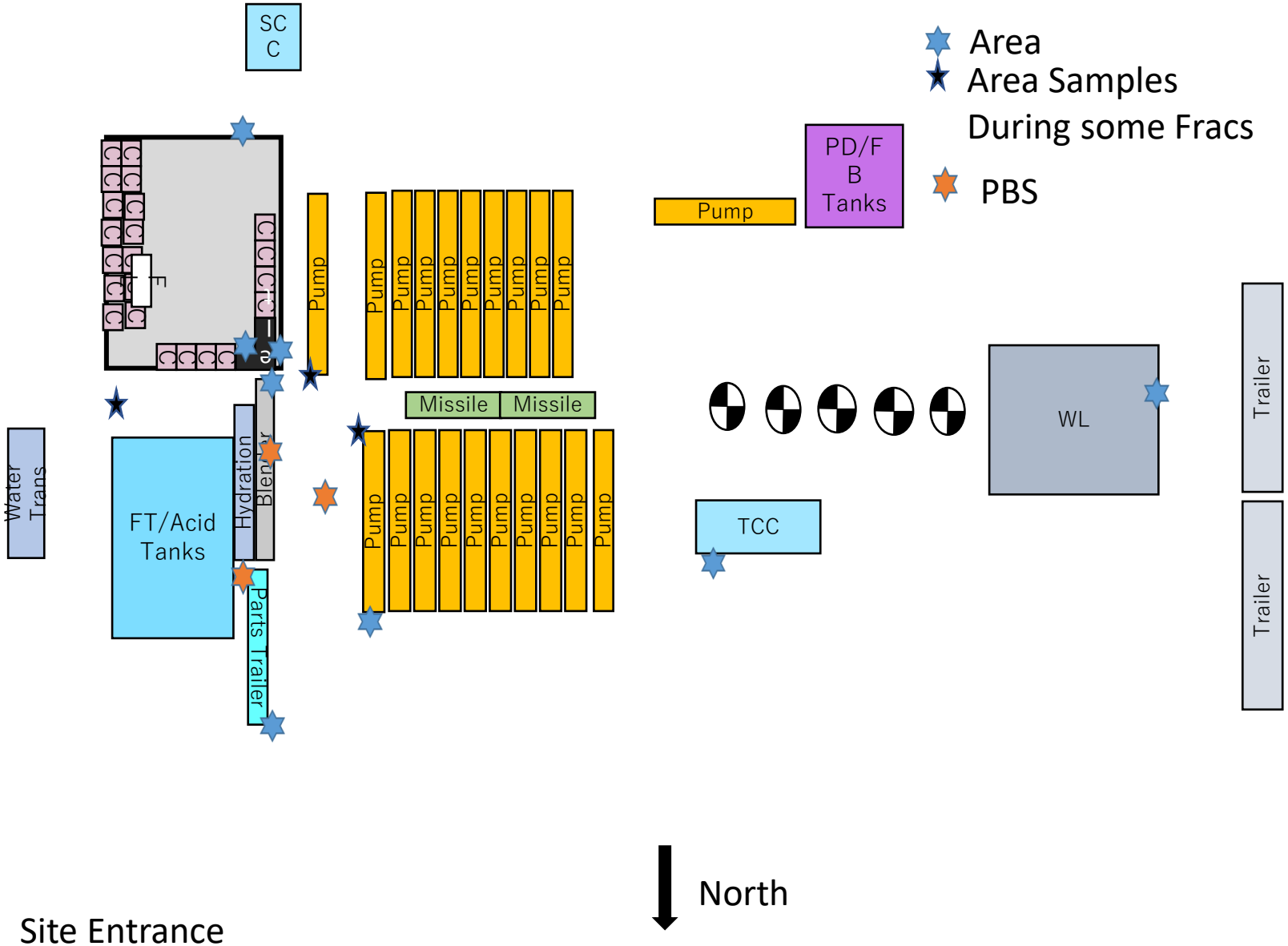
PBZ Texas Site, August 19-22, 2019

Sample Description	Date	Respirable Silica (µg/m³)
PBZ, Blender Operator	**8/19/2019**	**8.41**
	8/20/2019	**32.41**
	8/21/2019	**91.02**
	8/22/2019	**7.63**
PBZ, Chemical Hand	**8/19/2019**	**0.00**
	8/20/2019	**0.00**
	8/21/2019	**0.00**
	8/22/2019	**1.90**
PBZ, Iron	**8/19/2019**	**5.33**
	8/20/2019	**11.57**
	8/21/2019	**25.76**
	8/22/2019	**3.46**

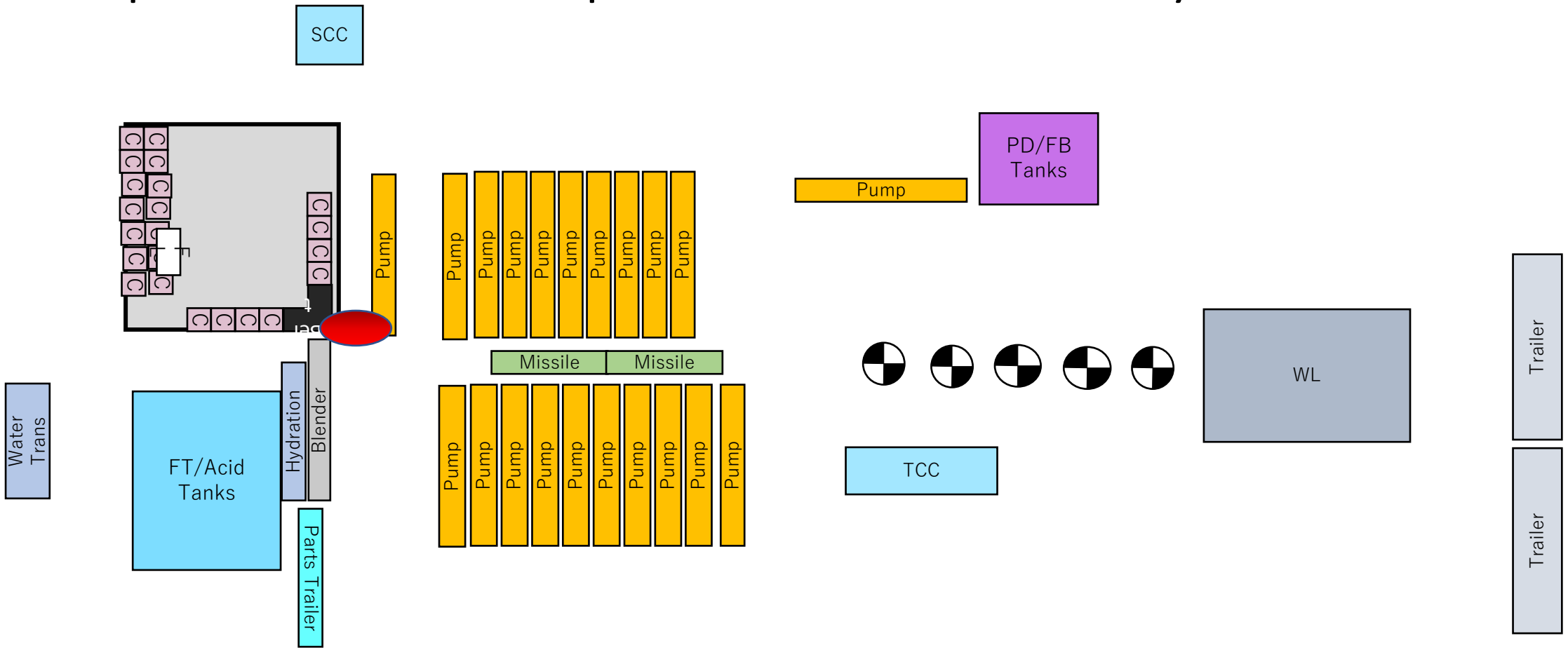


Area Respirable Silica Texas 1, August 19-22, 2019

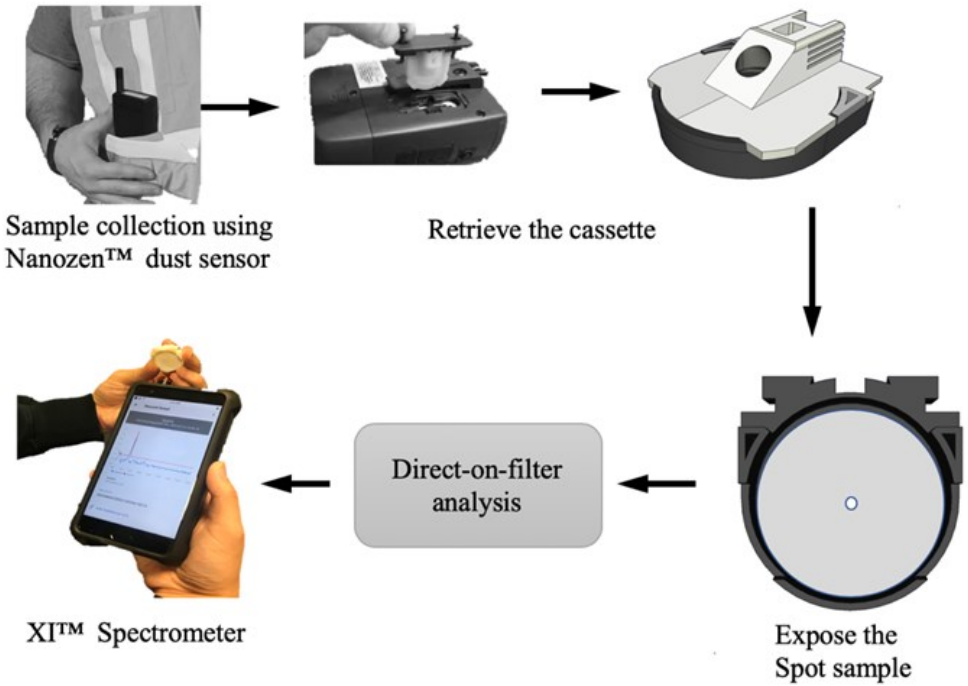
Medina-Hoffman Kenner, TX Sample Description	Date	Respirable Silica (µg/m³)
Area, Data Van Platform Railing	8/19/2019	2.79
	8/20/2019	14.75
	8/21/2019	3.99
	8/22/2019	0.00
Area, Inside Dance Floor	8/19/2019	4.38
	8/20/2019	4.47
	8/21/2019	2.19
	8/22/2019	5.86
Area, Outside Dance Floor	8/19/2019	0.00
	8/20/2019	0.00
	8/21/2019	0.00
	8/22/2019	4.84
Area, Pumper closet to hopper	8/21/2019	191.12
	8/22/2019	129.31
Area, Sandbox close to hopper	8/19/2019	6.13
	8/20/2019	2.59
	8/21/2019	3.82
	8/22/2019	8.74
Area, Trailer Hitch	8/19/2019	4.29
	8/20/2019	0.00
	8/21/2019	0.00
	8/22/2019	14.04
Area, Wireline	8/19/2019	0.00
	8/20/2019	0.00
	8/21/2019	0.00
	8/22/2019	0.00

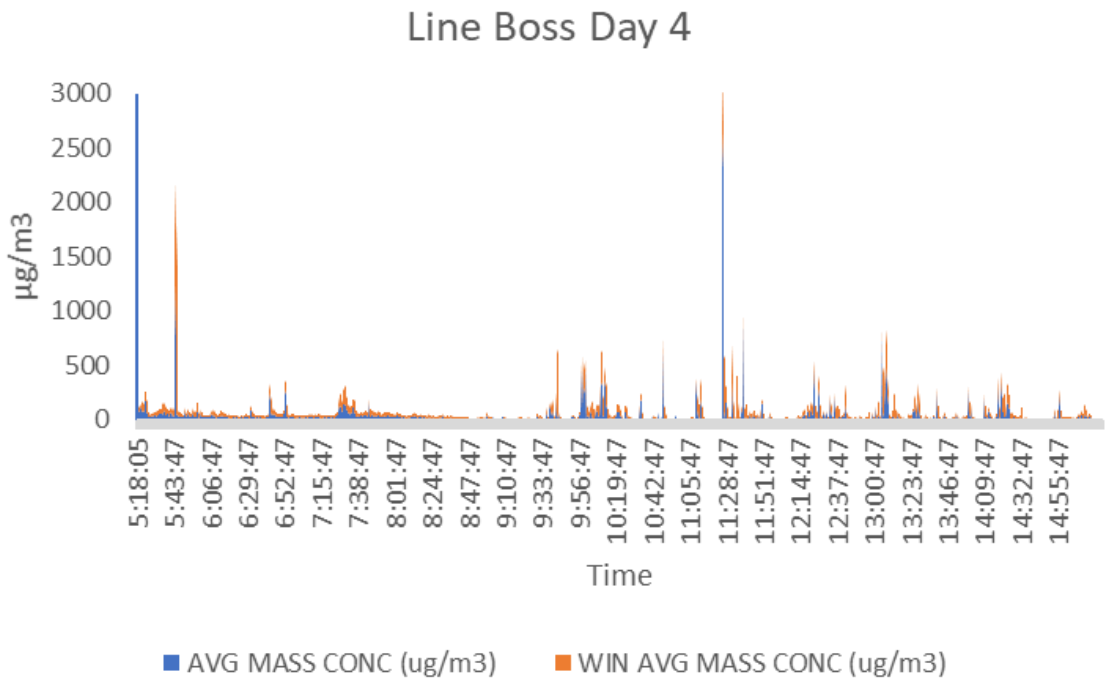


Respirable Silica Exposure Zones -Today



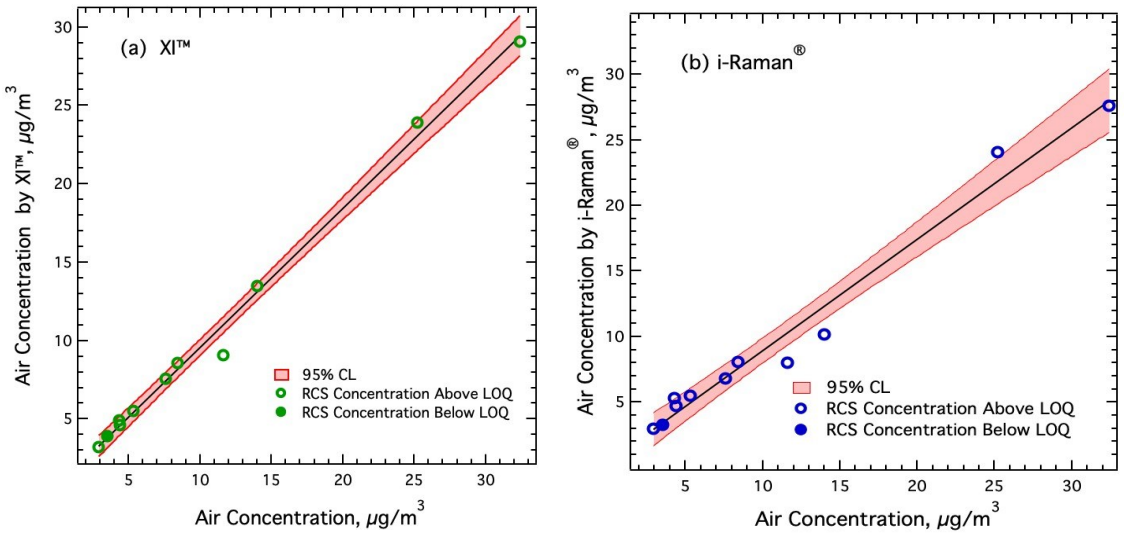
Direct Reading Methods





Direct Reading Methods

Nanozen Personal Dust Monitor with on-filter RCS measurement by Raman



Results of crystalline silica concentration in workplace aerosol collected at a hydraulic manufacturing site: (a) comparison of XI™ and XRD; (b) comparison of i-Raman® and XRD. XRD samples were analyzed by NIOSH 7500 method. Filled symbols indicate samples measured below LOQ of the XRD method.

Personal breathing zone (PBZ) and area exposure concentrations of RCS at a hydraulic fracturing worksite measured by Raman and XRD method.

SAMPLE / LOCATION	Sample type	Collection time (min)	RCS Concentration, μg/m³			Total Dust Concentration, μg/m³	RCS content, %
			i-Raman®	XI™	XRD		
LINE BOSS	PBZ	580	5.5	5.5	5.3	65.6	8.1
	PBZ	678	8.0	9.1	11.6	84.2	13.8
	PBZ	685	3.3	3.9	3.5*	90.0	3.9
	PBZ	548	24.1	23.9	25.2	89.4	28.2
HYDRO-ACID WORKER	PBZ	442	8.1	8.6	8.4	75.3	11.2
	PBZ	675	27.6	29.1	32.4	168.5	19.2
	PBZ	719	6.8	7.6	7.6	59.7	12.7
TRAILER HITCH	Area	146	5.3	4.9	4.3	50.7	8.5
	Area	226	10.2	3.5	14.0	40.6	3.4
INSIDE DANCE FLOOR	Area	190	4.7	4.6	4.4	70.8	6.2
DATA VAN	Area	190	3.0	3.2	2.9	74	4.0

Takeaways from RCS Exposure Assessments

- Vertical Bins and Containerized Sand greatly reduce the number of workers in “silica restricted spaces”
- Vertical Bins and Containerized Sand eliminate multiple sources of RCS exposure associated with sand chiefs/pneumatic bulk trucks
  - ~~Dusts ejected from thief hatches on top of the Sand movers during refilling operations~~
  - ~~Dust ejected and pulsed through side fill ports on the sand movers during refilling operations~~
  - *Dust generated by on-site truck vehicle traffic including sand trucks and crew trucks, the release of air brakes on sand trucks, and by winds*
  - ~~Dust released from the transfer belt under the sand movers~~
  - Dusts created as sand drops into, or is agitated in the blender hopper and on transfer belts
  - ~~Dust released from operations of transfer belts between the sand mover and the blender~~
  - ~~Dust released from the top of the dragon’s tail on sand movers~~
  - Dust deposited on and released from workers coveralls
- Delivery of sand to the hopper remains the primary source of RCS on sites using Vertical Bins and Containerized Sand. Minimize drop height to reduce potential release
  - Engineering controls-shrouding, LEV or vacuum dust collection
  - Dust suppression hopper or chute that reduces width of sand-stream into blender
- Real-time Instruments with direct on-filter Raman analysis are valuable tools to assess exposure

NIOSH Project Researchers

- Barbara Alexander
- Marissa Alexander-Scott
- Mike Breitenstein
- Yousef Elmashae
- Eric Esswein
- Belinda Johnson
- Bradley King

Thanks…Questions?