Pipeline Unplugging Technology Demonstration

Dwayne McDaniel, Amer Awwad, Jose Varona, Rajiv Srivastava, David Roelant

Savannah River/Hanford/Idaho Technical Exchange

October 10, 2007

Technology Need

- At least one cross-site transfers line in Hanford is plugged. Several other pipelines maybe partially plugged.
- Pipeline plugging can and will happen during cross-site slurry pipeline transfers
  - Plugged pipelines are difficult to repair and put back into operation. Usually abandoned and new ones are constructed
    - Schedule delays
    - Increased costs
- Unplugging technologies are needed to remove the blockages in transfer lines

History/Approach

- Demonstrations carried out during FY02 to screen pipeline unplugging technologies for applicability at DOE sites
  - Roto-router, Aqua-Miser, Hydrokinetics, AEAT
- FY07-FY08 Technology Demonstrations
  - NuVision (formerly AEAT)
    - fluidic wave-action methodology
  - AIMM's Hydrokinetics
    - combination of pressure pulse/sonication

Objective

- Assist DOE with pipeline unplugging technology evaluation and qualification
  - Provide understanding of the underlying physics
    - Propagation of pressure pulse
    - Pressure amplification factor
    - Effects of bends and expansion joint
- Determine whether the technology can unplug a pipe at 19,000 ft from the inlet

Test-beds

- The testing parameter (unplugging time, unplugging effectiveness etc.) obtained at three different lengths will be used to predict the corresponding value for a maximum distance to blockage of 19,000 ft.
- Done by fitting a curve on the test data and extrapolating to 19,000 ft.
- Since most of the rheological data is non-linear, L1, L2 and L3 can be selected according to the geometric progression, $L = ar^N$, where N = 1,2,3…Selecting a = 100 ft and r = 1.3, gives for N = 4, L1 = 286 ft, N = 7, L2 = 627 ft, N = 11, L3 = 1792 ft and N = 20, L4 = 19005 ft.

$L=ar^N$

a	r	N	L
100	1.3	3	220
100	1.3	4	286
100	1.3	5	371
100	1.3	6	483
100	1.3	7	627
100	1.3	8	816
100	1.3	9	1060
100	1.3	10	1379
100	1.3	11	1792
100	1.3	12	2330
100	1.3	13	3029
100	1.3	14	3937
100	1.3	15	5119
100	1.3	16	6654
100	1.3	17	8650
100	1.3	18	11246
100	1.3	19	14619
100	1.3	20	19005
100	1.3	21	24706

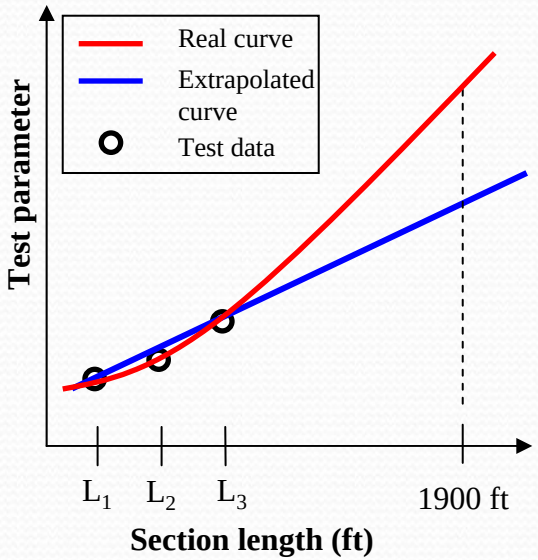
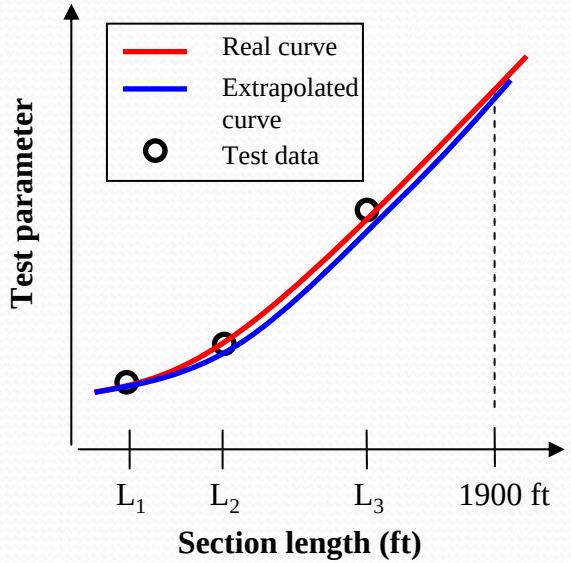
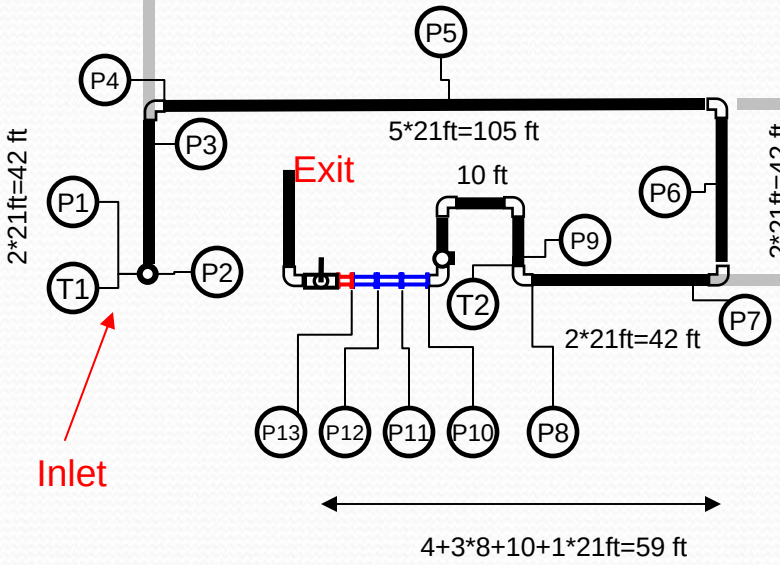


Figure 1. (a) Using equal distance between the section lengths can give an under-prediction of the real behavior of the slurry data.



(b) Using geometric progression for the section lengths will help to predict the data for 1900ft more accurately.

Test-bed #1 (285 ft)



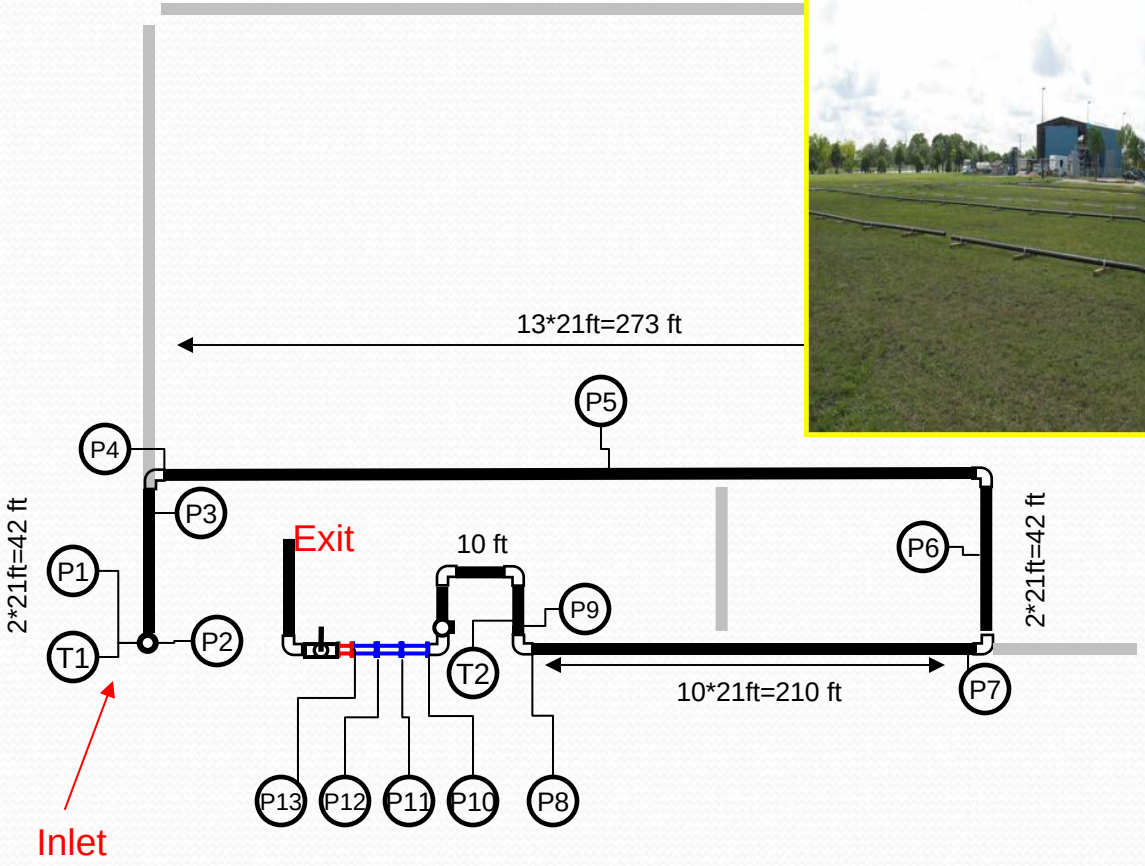
: Ball valve

: Relief valve (150psi)

: 4ft blockage section

: 24ft clear section

Test-bed #2 (621 ft)



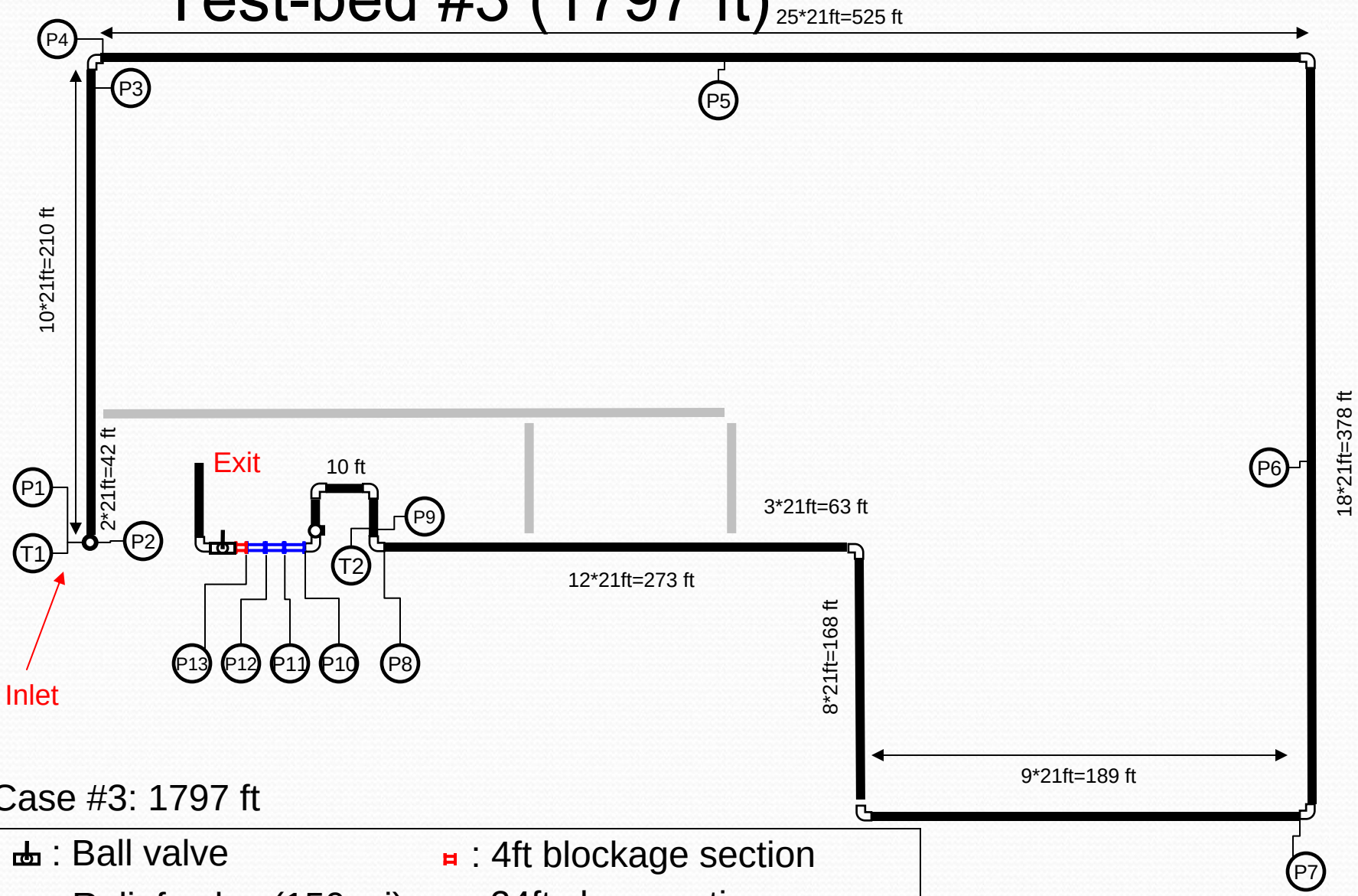
: Ball valve

: Relief valve (150psi)

: 4ft blockage section

: 24ft clear section

Test-bed #3 (1797 ft)



Case #3: 1797 ft

: Ball valve

: Relief valve (150psi)

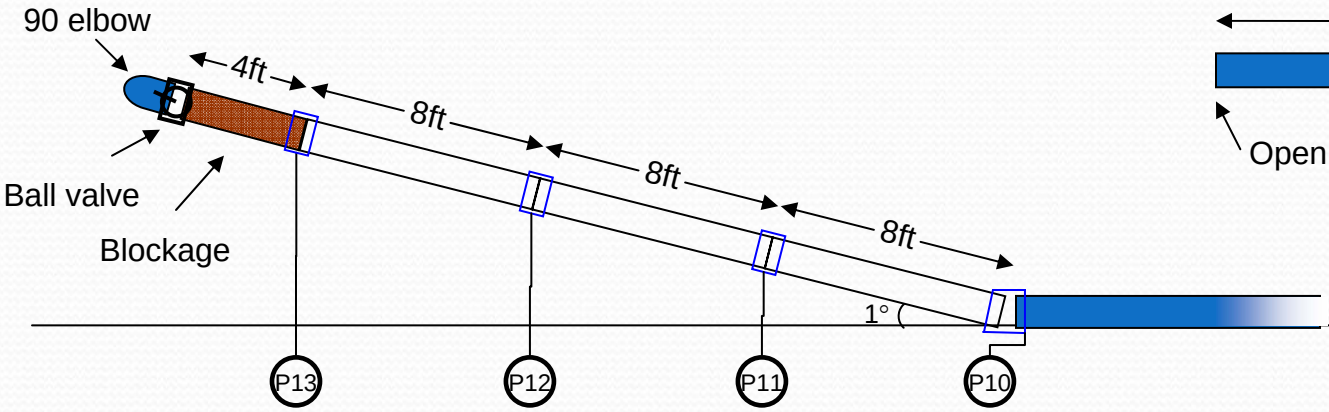
: 4ft blockage section

: 24ft clear section

Test-bed (during fabrication)

Test-bed #3: 1797 ft

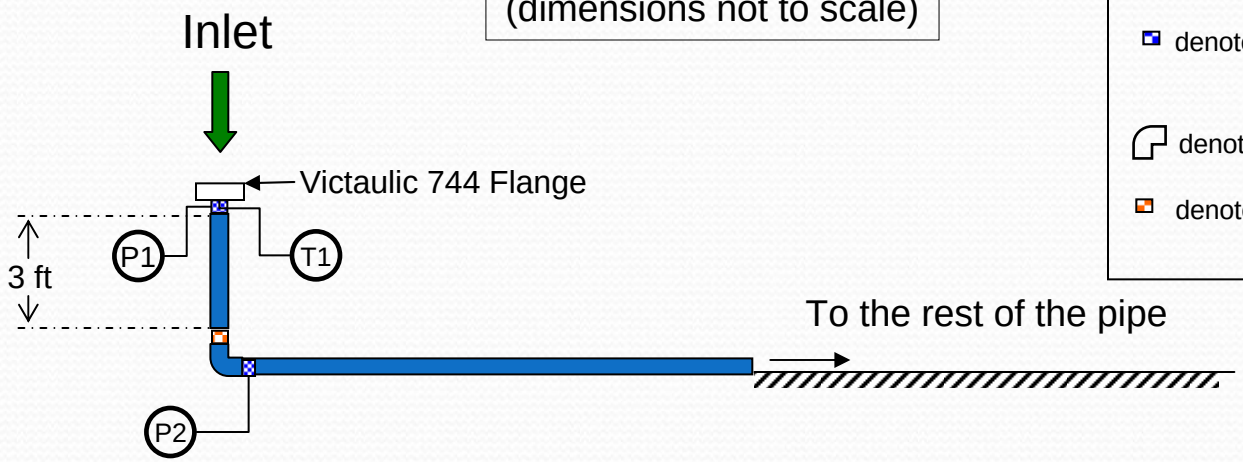
Transparent Inclined Section
(dimensions not to scale)

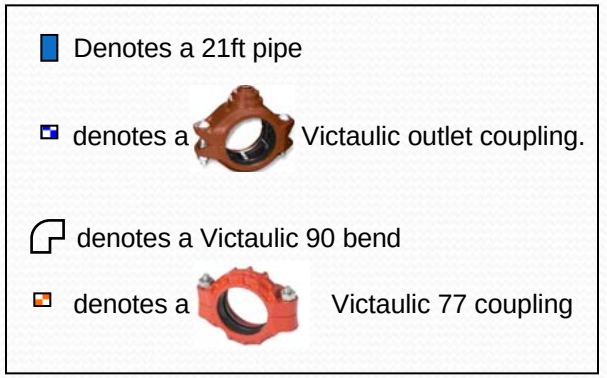


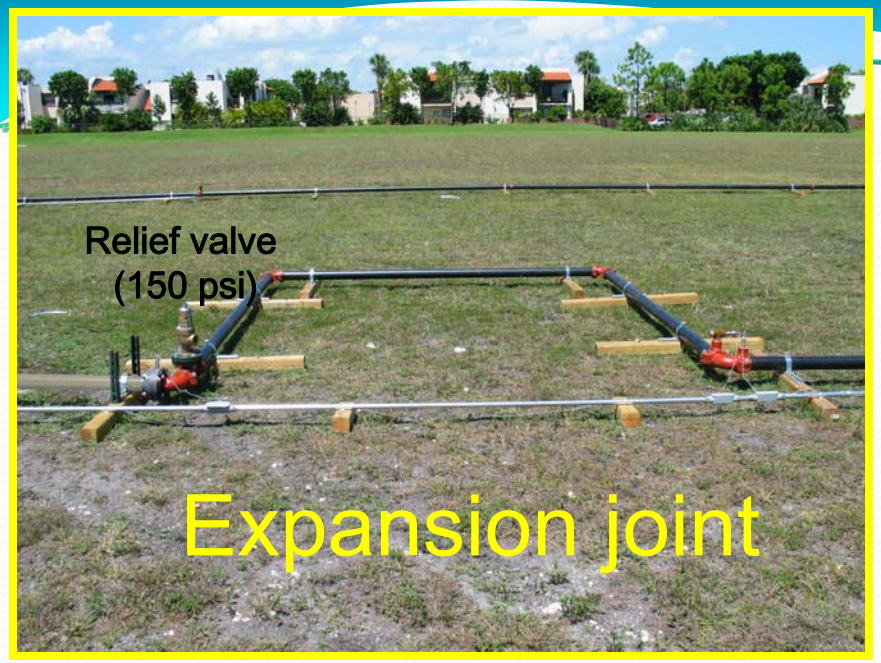
Side view

Front view

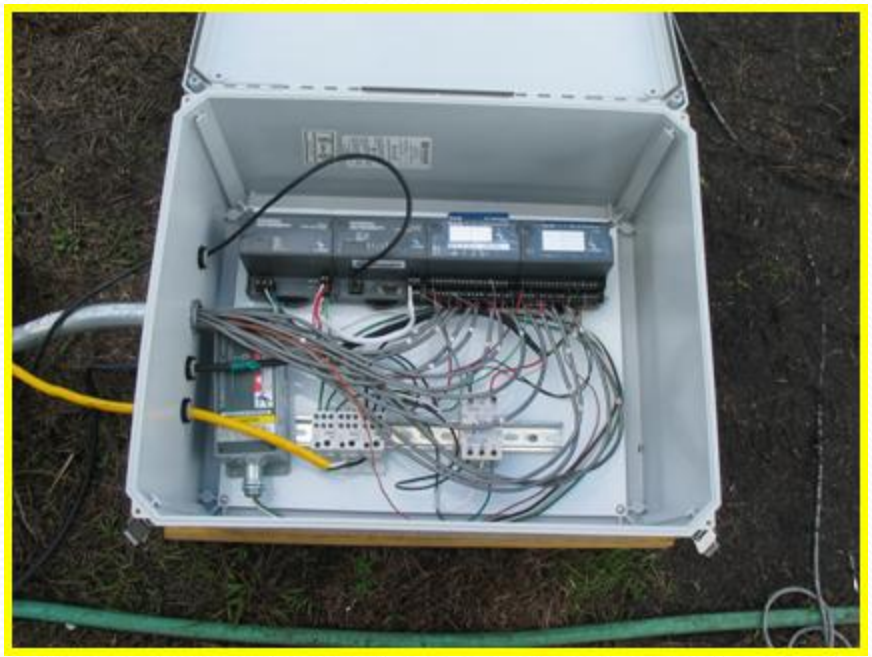
Inlet Section
(dimensions not to scale)






Relief valve
(150 psi)
Expansion joint


3” to 2” Reducer

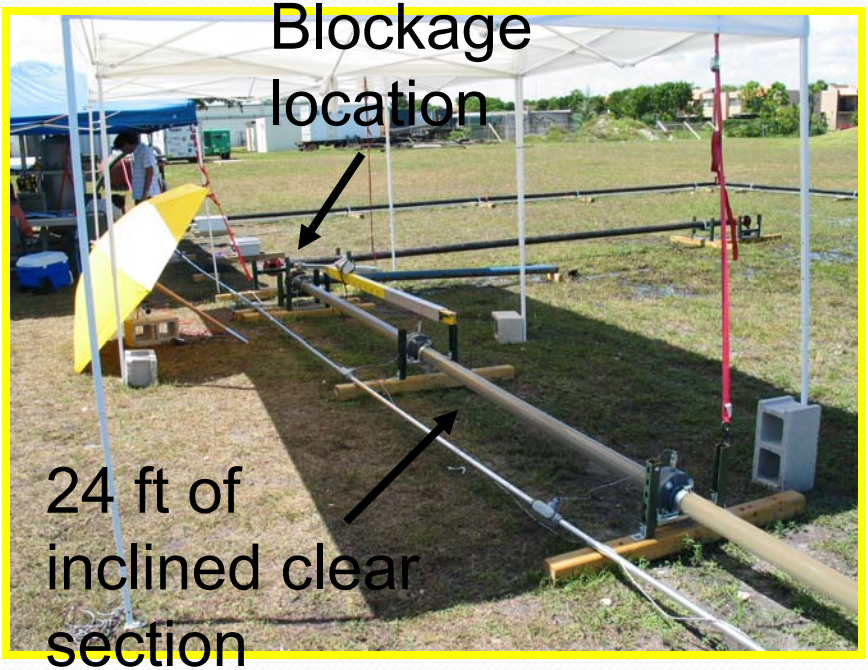


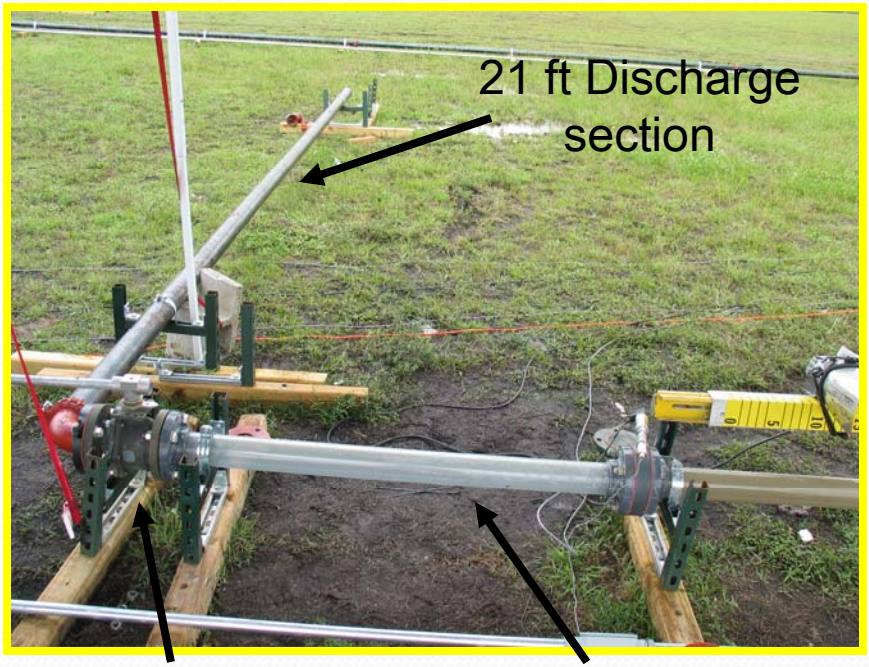
Instrumentation

NuVision and FIU transducers after an elbow

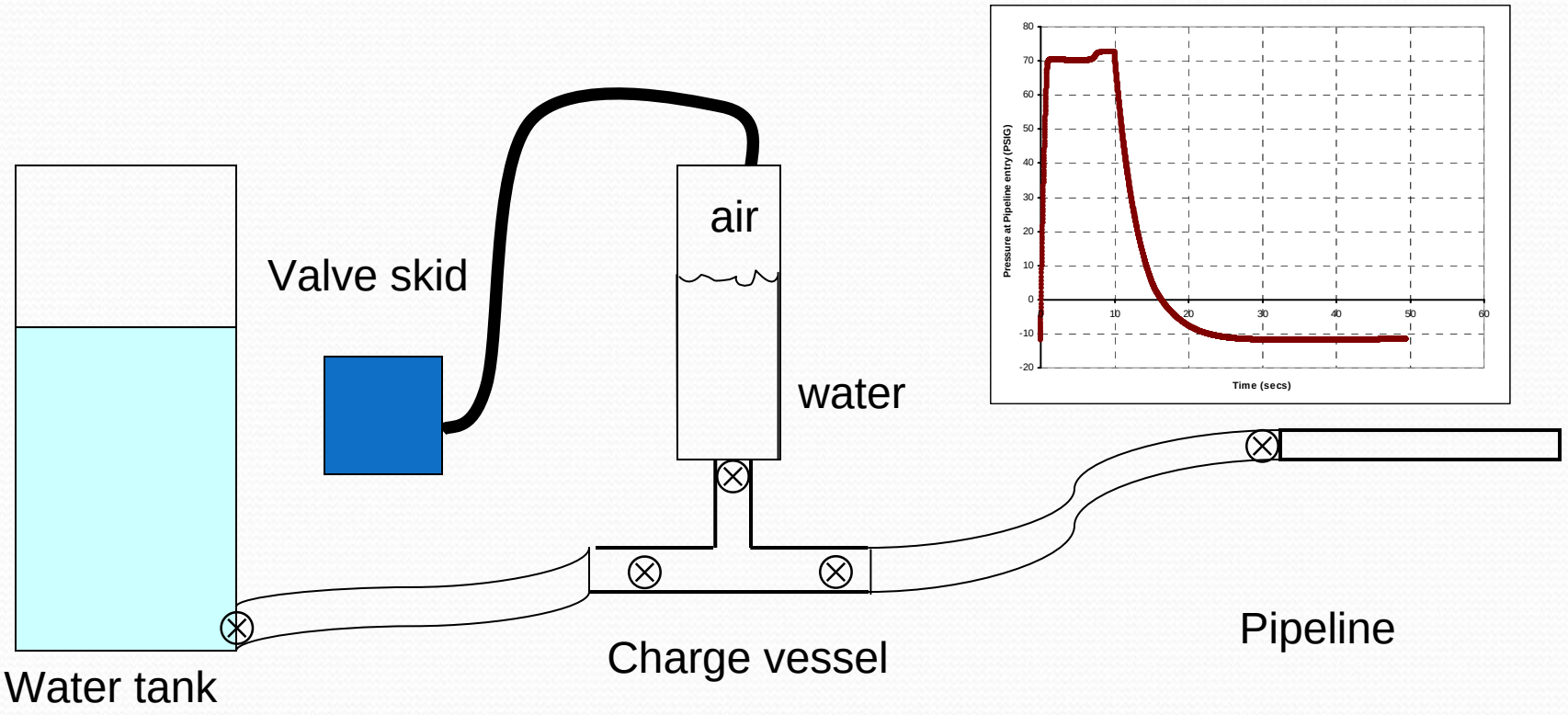
NuVision and FIU transducers at the clear section

Test-bed Clear Section

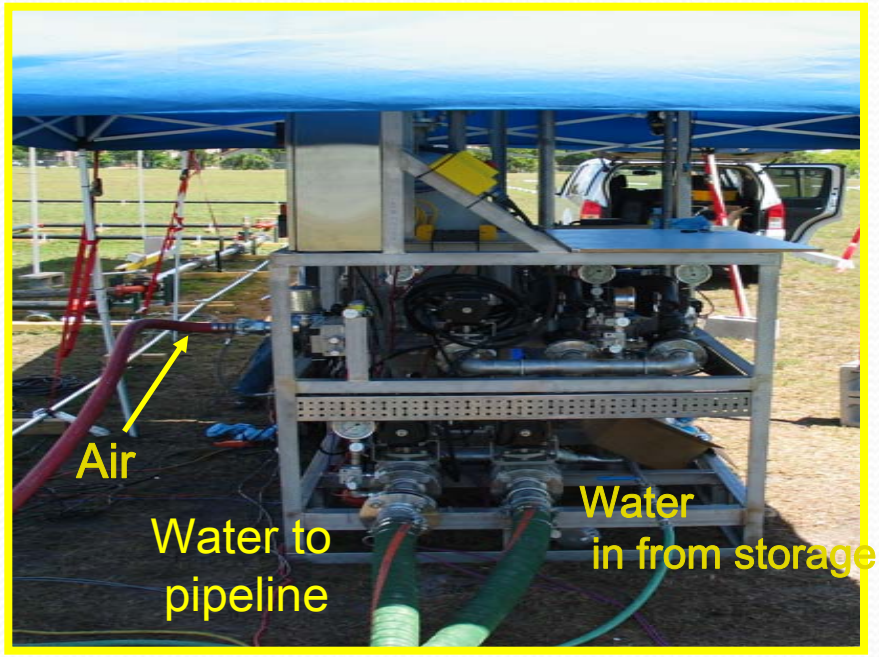


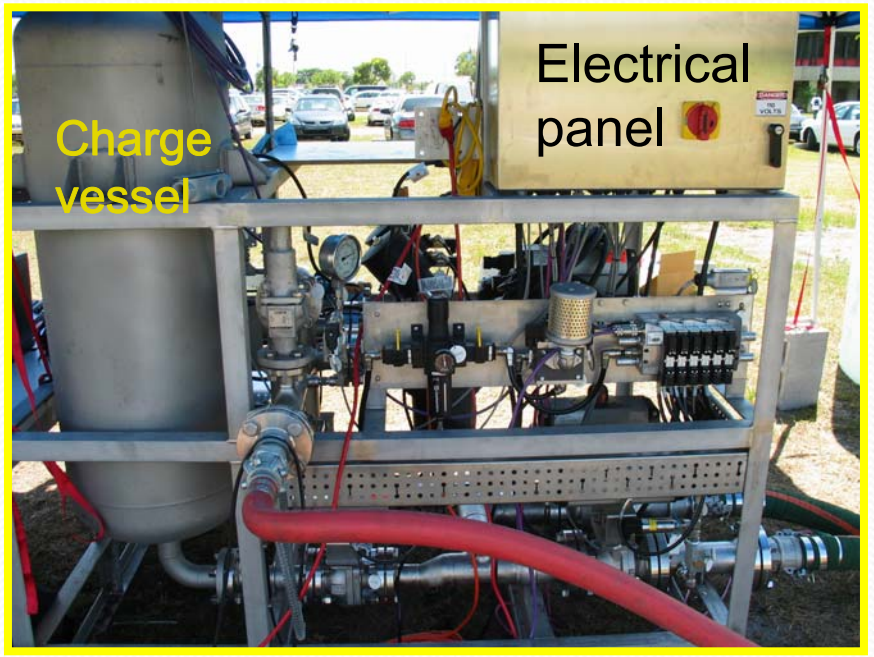


Nu-Vision's Fluidic Wave Action Technology

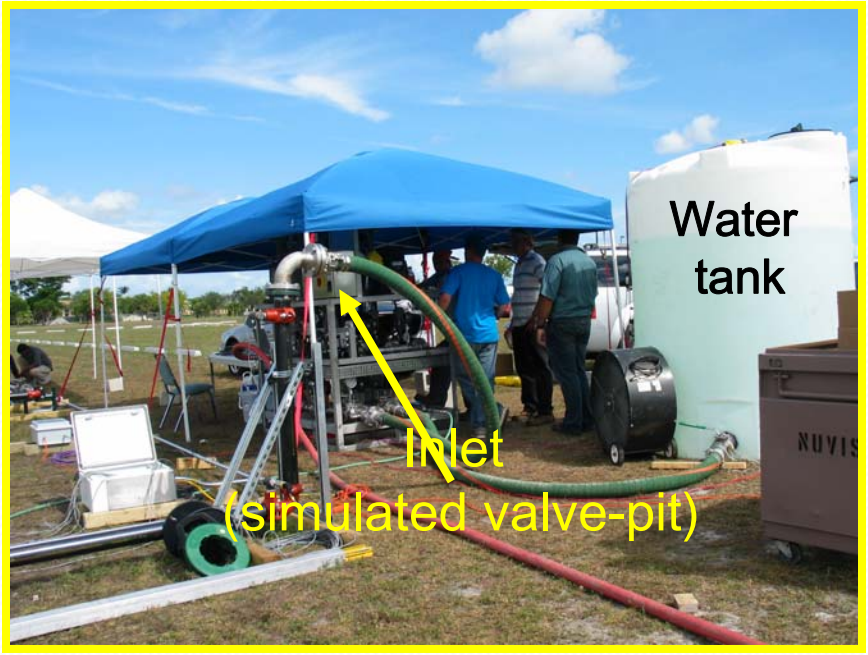


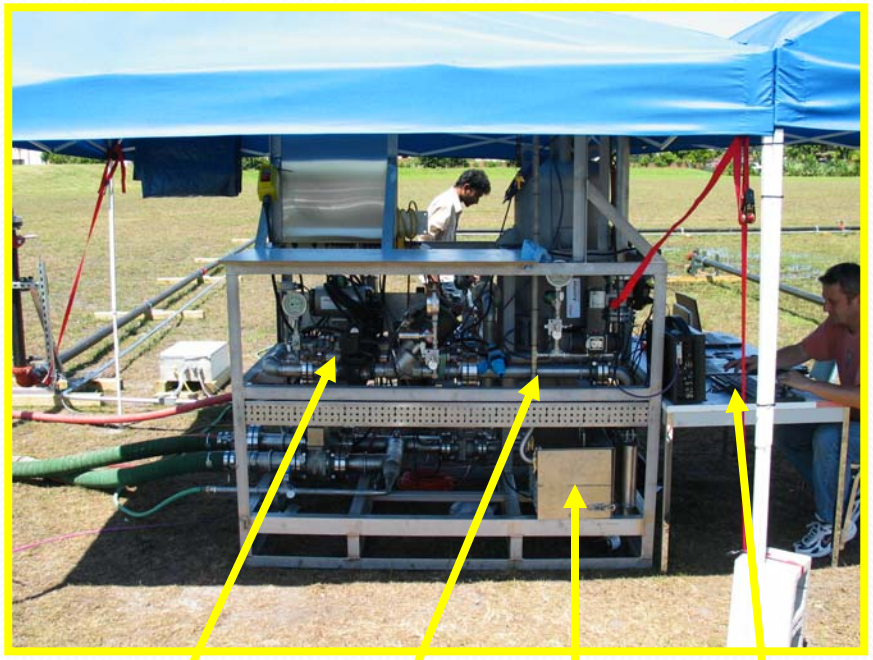
Nu-Vision Equipment



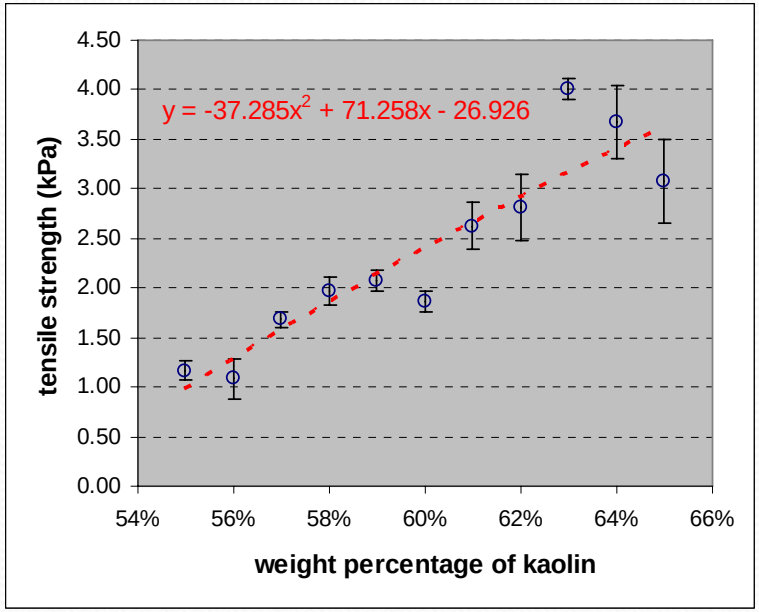


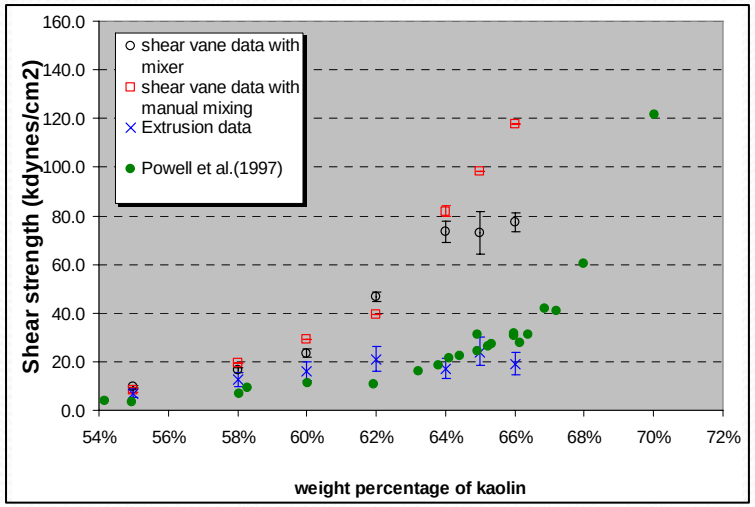
NuVision Equipment (cont)





Kaolin clay plug





Kaolin plugs torqued to 30 ft-lbs

	Mean Particle Diameter µm	Shear Strength kPa	Density g/cm3
Kaolin water mixture (66 wt% kaolin in water)	1.02	3.5	1.65
Tank Sludge	1.2	0 to 5	1 to 2

Aluminum gel plug

- Matrix Solution:
  - 450 ml of distilled water
  - 375 g of Al(NO3)3.9H2O
- Gelling solution:
  - 350 ml of distilled water
  - 120 g of NaOH
  - 53 g of Na2CO3
- Solutions are prepared in separate beakers and the gelling solution is mixed into the matrix solution rapidly.
- 800-850 ml of Al-gel is obtained.

(Media files deleted)

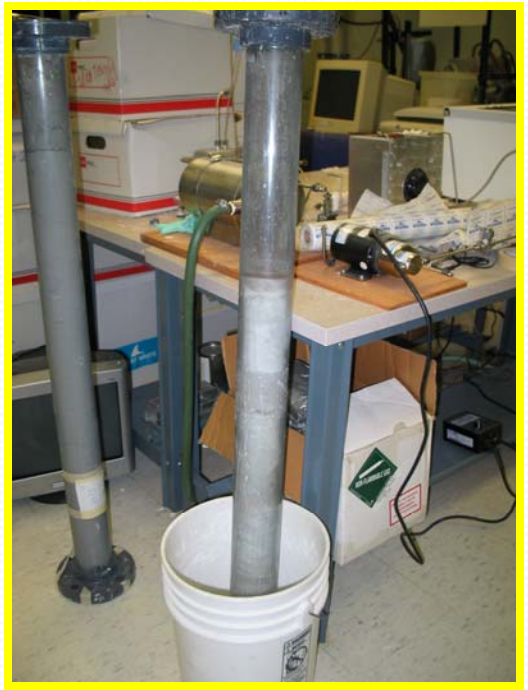
Al-gel in the beaker-video

Al-gel in the 3” tube-video

Phosphate gel plug

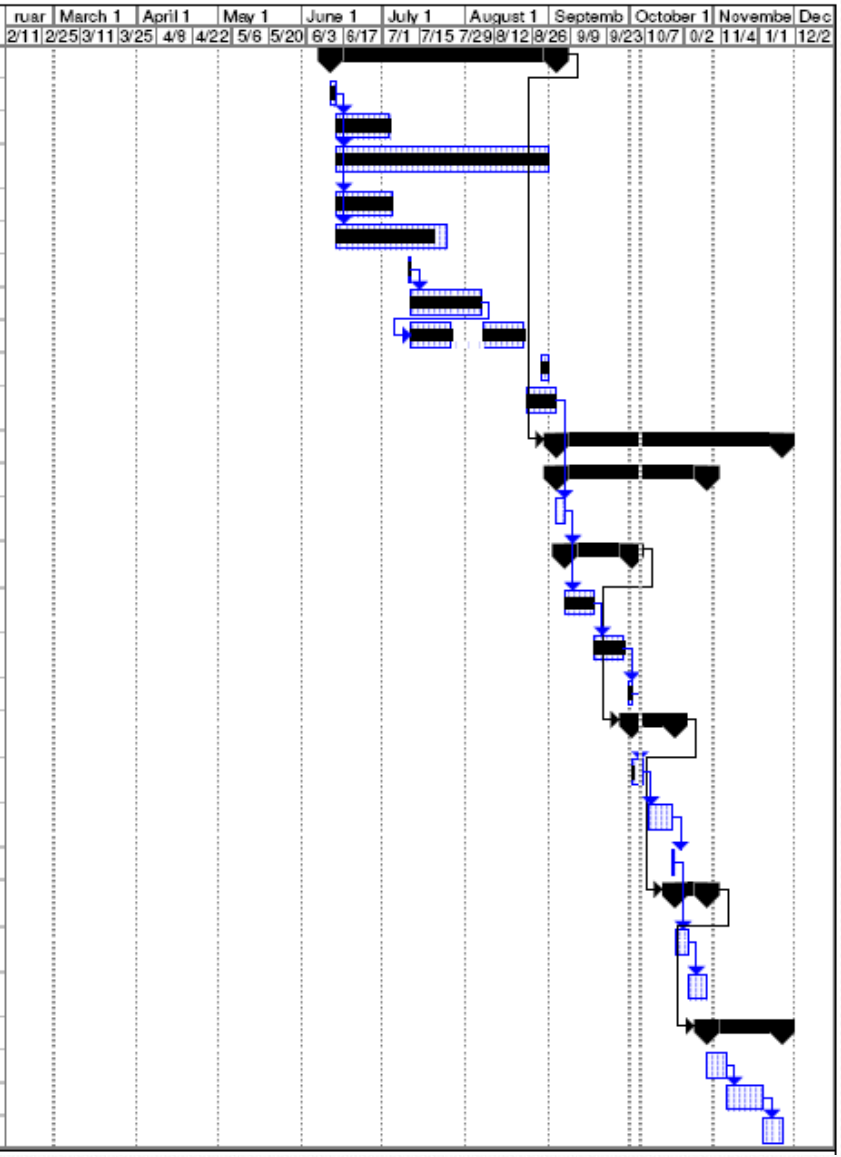
Component	Molarity
$NaAlO_2$	1
NaOH	2
Na_2CO_3	0.1
$NaNO_3$	7
$Na_3PO_4\ 12H_2O$	0.3

- Constituents are mixed in water at 55 - 60°C
- Final solution is cooled down to room temperature rapidly
- Batches of phosphate are kept in fume hood to dry and then placed in the 3” pipe
- More gel is added as the water drains while in the pipe



Project Gantt

ID	Task Name	Duration	Start	Finish
1	**Pre-testing Phase**	**60 days?**	**Tue 6/12/07**	**Mon 9/3/07**
2	Final Design of Test Bed	2 days	Tue 6/12/07	Wed 6/13/07
3	Space Committee Approval	14 days	Thu 6/14/07	Tue 7/3/07
4	Procurement of Test bed Equipments	57 days	Thu 6/14/07	Fri 8/31/07
5	Setup the simulant mixer	15 days	Thu 6/14/07	Wed 7/4/07
6	Preparing the simulants	29 days	Thu 6/14/07	Tue 7/24/07
7	Safety review	1 day	Wed 7/11/07	Wed 7/11/07
8	Safety mitigation	18 days?	Thu 7/12/07	Mon 8/6/07
9	Setup the test bed for case #1	22 days	Thu 7/12/07	Wed 8/22/07
10	Pressure testing and calibration	3 days	Wed 8/29/07	Fri 8/31/07
11	Nuvision ships the complete unit to FIU	7 days	Fri 8/24/07	Mon 9/3/07
12	**Testing Phase**	**60 days**	**Tue 9/4/07**	**Mon 11/26/07**
13	**Unblocking Trials**	**40 days**	**Tue 9/4/07**	**Mon 10/29/07**
14	NuVision Setup/Commisioning	3 days	Tue 9/4/07	Thu 9/6/07
15	**Unplugging tests case #1: 285ft**	**17 days**	**Fri 9/7/07**	**Mon 10/1/07**
16	NuVision establishes equipment parameters	7 days	Fri 9/7/07	Mon 9/17/07
17	Perform unblocking tests per FIU matrix	9 days	Tue 9/18/07	Fri 9/28/07
18	Setup test bed for case #2	1 day	Mon 10/1/07	Mon 10/1/07
19	**Unplugging tests case #2: 621ft**	**12 days**	**Tue 10/2/07**	**Wed 10/17/07**
20	NuVision establishes equipment parameters	4 days	Tue 10/2/07	Fri 10/5/07
21	Perform unblocking tests per FIU matrix	7 days	Mon 10/8/07	Tue 10/16/07
22	Setup test bed for case #3	1 day	Wed 10/17/07	Wed 10/17/07
23	**Unplugging tests case #3: 1797ft**	**8 days**	**Thu 10/18/07**	**Mon 10/29/07**
24	NuVision establishes equipment parameters	3 days	Thu 10/18/07	Mon 10/22/07
25	Perform unblocking tests per FIU matrix	5 days	Tue 10/23/07	Mon 10/29/07
26	**Project Reporting**	**20 days**	**Tue 10/30/07**	**Mon 11/26/07**
27	Draft Final Test Report	5 days	Tue 10/30/07	Mon 11/5/07
28	Review and Comments	10 days	Tue 11/6/07	Mon 11/19/07
29	Final Report	5 days	Tue 11/20/07	Mon 11/26/07



Demonstration Status

Completed

Trial #	Reducer	Elbow at Outlet	Discharge Length	Blockage length	Expansion Joint	Blockage Type	Distance to Blockage
1	0	1	21ft	4ft	1	Kaolin	285ft
2	0	1	21ft	4ft	1	Phosphate	285ft
3	0	1	21ft	4ft	1	Al-gel	285ft
4	1	1	21ft	4ft	1	Kaolin	285ft
5	0	1	21ft	4ft	0	Kaolin	285ft
6	0	1	21ft	4ft	1	Kaolin	621ft
7	0	1	21ft	4ft	1	Phosphate	621ft
8	0	1	21ft	4ft	1	Al-gel	621ft

Current

Trial #	Reducer	Elbow at Outlet	Discharge Length	Blockage length	Expansion Joint	Blockage Type	Distance to Blockage
9	**0**	**1**	**21ft**	**4ft**	**0**	**Kaolin**	**621ft**

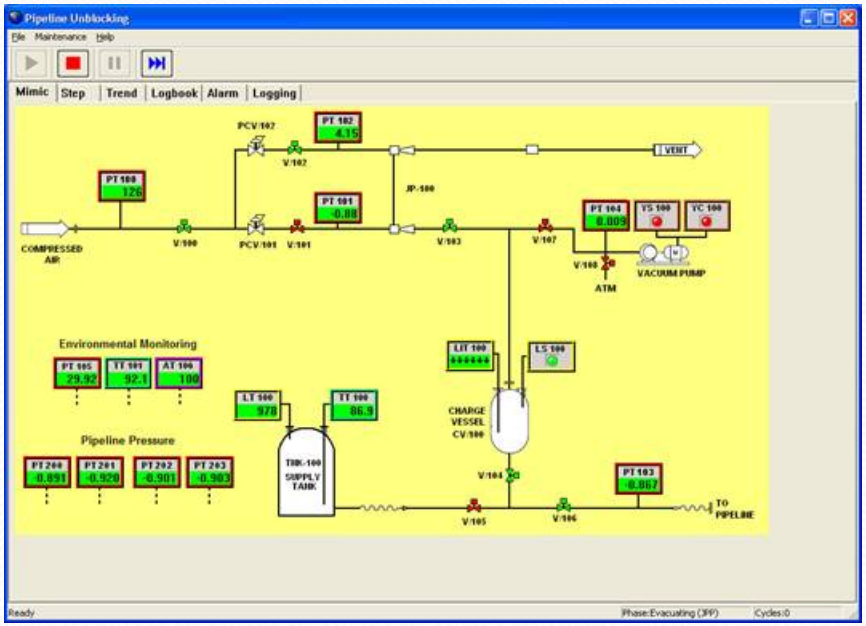
Future

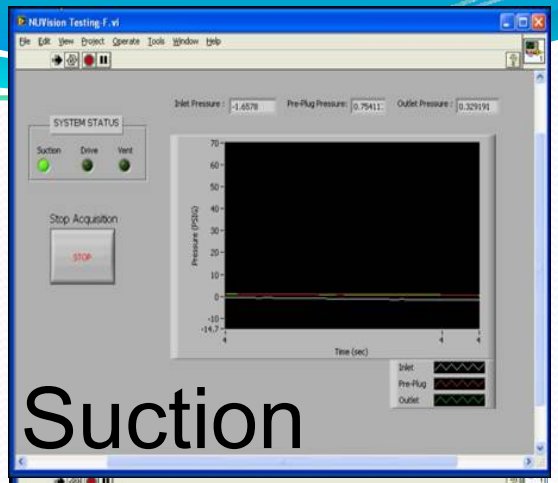
Trial #	Reducer	Elbow at Outlet	Discharge Length	Blockage length	Expansion Joint	Blockage Type	Distance to Blockage
10	0	1	21ft	4ft	1	Clay	1797ft
11	0	1	21ft	4ft	1	Phosphate	1797 ft
12	0	1	21ft	4ft	1	Al-gel	1797 ft
13	0	1	21ft	4ft	0	Kaolin	1797 ft

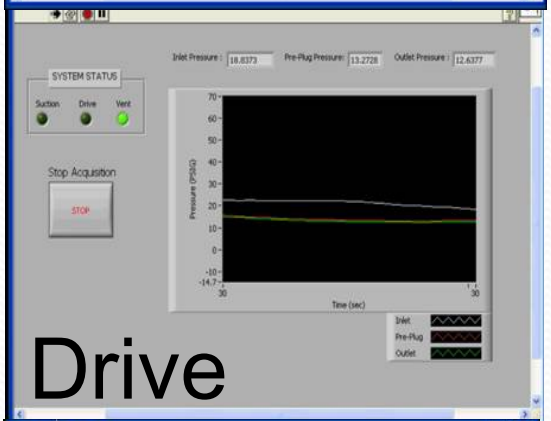
Demonstration Videos

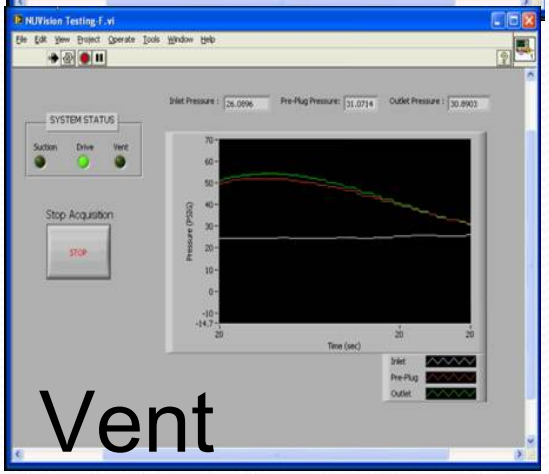
(Media files deleted)

Data Acquisition









Control variables

- Drive pressure
- Suction time
- Drive time
- Vent time
- Vacuum level

Summary

- Completed testing on the 285 ft test-bed; Current testing on the 621 ft test-bed.
- Hanford TFO team engineers will be at FIU to observe the unplugging tests first-hand.
- NuVision's fluidic system benefits
  - short mobilization and demobilization times
  - remote operation; minimal intervention
  - can negotiate numerous elbows, etc.
  - relatively low drive pressures (3 to 4 bar)
  - can be used to deliver chemical solvent to the blockage
  - location of the blockage can be determined by the amount of water required to back-fill the pipeline

Detailed information resulting from the testing will provide the DOE end-user with sufficient data and understanding of the technology, and its limitations so that management decisions can be made whether the technology has a reasonable chance to successfully unplug a pipeline, such as a cross site transfer line or process transfer pipeline at the Waste Treatment Plant.

Acknowledgments

- *Gary Josephson, PNNL*
- *Dennis Hamilton, CH2M*
- *Rick Raymond, CH2M*
- *Blaine Barton, CH2M*
- *Erik Kezler & project team, NuVision*
- *Aruna Arakali, WTP*

- *FIU support staff and students*
  - *Geovanny, Renee, Ranga, Praneeth, Romani*