File: F-100221

Worker Frozen in Trench

Date of Incident: 1998 09 03
Type of Incident: Fatal

SUMMARY

On September 3, 1998, a worker was found dead in a trench. The worker was one of two individuals monitoring a pipeline freeze plug operation. This was the fatally injured worker's first shift performing this type of work. Between 25 and 45 minutes after the worker entered the trench, he was found frozen by the other worker and a relief crew.

The reason for the worker entering the trench is not known. He was told not to do so. Temperature measurement equipment was found beside the worker. This led investigators to believe that the worker may have entered the trench to measure the freeze plug temperature.

The purpose of the trench was to expose a section of oil pipeline so that it could be tested for leaks. The pipeline was filled with water to prepare for the leak test. Liquid nitrogen was flowing from a nearby bulk truck through a freeze plug jacket surrounding the pipe. The cold liquid nitrogen (-196°C) on the outside of the pipe froze the water inside the pipe, creating a plug of ice. The freeze plug process created an atmosphere cold enough to solidly freeze the soil in the base of the trench. There was no equipment on site at the time of the incident to measure for oxygen deficiency.

The Medical Examiner stated that the cause of death was undetermined. The Alberta Labour investigators concluded that after the worker entered the trench, one of the two following scenarios occurred.

1. <u>If excess nitrogen vapour was present in the trench</u>

   Heavier-than-air cold nitrogen vapour created an oxygen deficient atmosphere in the trench. When the worker moved from one side of the trench to the other, or was in the process of moving, he experienced a deficiency of oxygen that resulted in asphyxia. Upon losing consciousness, the worker collapsed, receiving facial injuries from his head striking the freeze plug jacket or the frozen base of the trench. Rapid freezing of the body then occurred as the worker lay on the frozen ground.

   Alternatively, Worker #1 may have first lost consciousness from an accidental fall within the trench. After the fall, Worker # 1 experienced asphyxia and then froze.

2. If excess nitrogen vapour was not present in the trench
   A worker entered one side of the trench, and after, or in the process of, moving across to the other side, tripped in the trench and suffered a concussion as a result of his head striking the freeze plug jacket or the frozen base of the trench. Unconscious, the worker remained at the base of the trench, where rapid and fatal freezing of the body occurred as he lay on the frozen ground.

The following actions have been taken by the employer, industry and Alberta Labour, to prevent a recurrence of this kind of incident in the future:

- The pipeline service company and prime contractor involved on this project have educated their employees about hazards associated with handling nitrogen; in large quantities and confined areas.

- The pipeline service company has replaced the freeze plug jacket design in use at the time of the incident with one less likely to leak.

- Alberta Labour will issue a bulletin to industry to inform other companies performing freeze plug operations, as well as companies who may use this service.

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Section 2.0 DATE AND TIME OF INCIDENT

2.1 September 3, 1998, 07:00

Section 3.0 DATE AND TIME OF INVESTIGATION

3.1 September 3, 1998, 09:20

Section 4.0 NAME OF INVESTIGATOR(S) (INTERNAL)

4.1 BURNS, Barry
Occupational Health and Safety Officer

4.1.1 WAGNER, Gerry
Occupational Health and Safety Officer

Section 5.0 INCIDENT REPORTED BY

5.1 Royal Canadian Mounted Police
Leduc Detachment

Section 6.0 DATE AND TIME INCIDENT WAS REPORTED

6.1 September 3, 1998, 07:30

Section 7.0 NAME AND ADDRESS OF PRINCIPAL STAKEHOLDER(S)

7.1 **Owner(s)**

7.1.1 Imperial Oil Resources Limited
237 Fourth Avenue S.W.
P.O. Box 2480, Station M
Calgary, Alberta T2P 3M9

7.2 **Prime Contractor**

7.2.1 Probe Exploration Inc.
Box 5479
Devon, Alberta T9G lY2

7.3 **Employer**

7.3.1 Nowsco Well Service Ltd.
9010 – 34th Street
Edmonton, Alberta T6B 2V1

Section 8.0 DESCRIPTION OF PRINCIPAL OWNER(S) OR EMPLOYER(S)

8.1 **Owner**

8.1.1 Imperial Oil Limited owns and operates oil and gas processing, and pipeline holdings within Alberta. This pipeline represents a part of these holdings.

8.2 **Prime Contractor**

8.2.1 Probe Exploration Inc. owns and operates oil production holdings within Alberta. Probe commissioned the work on the pipeline. The results of pipeline pressure tests would be submitted by the Prime Contractor to the Energy Utilities Board with an application to put the pipeline back in service.

8.3 **Employer**

8.3.1 Nowsco Well Service Ltd. is an oil and gas well and pipeline service company.

8.4 At the time of the incident the following contractual relationship was in place between the owner, the prime contractor, other contractors and the employer. Imperial Oil Limited owned the pipeline and allowed Probe Exploration Inc. (Probe), as prime contractor, to perform tests to assess its serviceability. The line had been suspended from service for a few years and Imperial would retain ownership if Probe was successful in putting the pipeline back into service. Probe contracted Colt Engineering Corporation (Colt), to design the integrity check of the pipeline as a part of their overall engineering responsibility on the project. Colt contracted Greenpipe Industries Ltd. (Greenpipe) to oversee the hydrostatic testing and to interpret the pipeline test data. Greenpipe contracted Nowsco to supply, install and monitor the nitrogen freeze plug and to conduct the hydrostatic tests.

Section 9.0 LOCATION OF INCIDENT

9.1 The incident occurred at the southwest corner of the PCL Module Facility, located at 2107 - 4th Street, Nisku, Alberta.

Section 10.0 EQUIPMENT AND MATERIAL INVOLVED

10.1 The incident took place in the southwest corner of the PCL Module Facility. The pipeline being tested passed through this yard and a trench had been dug to expose the pipeline and allow a freeze plug to be installed.

10.2 The trench was about 9 metres long, 4 metres wide, 2.5 metres deep and complied with Alberta regulations. A section of 20 cm pipeline was completely exposed about 0.6 metres above the trench bottom. A freeze plug jacket was installed on the exposed pipeline.

10.3 The two part freeze plug jacket was installed around the pipeline creating a cavity between the pipeline and the walls of the jacket. The ends of the jacket were sealed to the pipeline. The jacket has inlet and outlet fittings which allowed liquid nitrogen to be circulated through hoses from a bulk nitrogen supply to the cavity in the jacket. The liquid nitrogen was released to the atmosphere through the outlet.

10.4 The pipeline was filled with water and then liquid nitrogen at -196°C was circulated through the jacket. The water froze forming a plug of ice in the pipeline. Usually this operation requires two to four hours of circulation to form the ice plug. During the forming of the plug the temperature in the jacket was checked frequently by the workers on site. The temperature was checked by entering the trench and connecting a temperature meter to three thermocouple leads located beside the jacket.

10.5 The freeze plug which was in place at the time of the incident was being used to isolate most of the pipeline for an 8 hour pressure (hydrostatic) test. This particular freeze plug had been initially installed to test for leaks and, when none were found, maintained to perform the hydrostatic test. This plug had been in place for 15 hours at the time of the incident.

10.6 Because of the length of time the plug had been in place, the cold atmosphere near the freeze plug jacket and the liquid nitrogen being released through the outlet, the bottom of the trench in the area of the jacket was frozen solid and slippery with the build up of frost.

10.7 The cold atmosphere in the trench caused a layer of fog to form.

10.8 There was a yard light about 20 metres from the trench which allowed the workers to see during the night. The sun rose at 06:47 and there was twilight about 30 minutes before sunrise.

10.9 The investigators evaluated the possibility of re-creating the conditions at the time of the incident and concluded there were too many variables to allow an accurate re-creation.

Section 11.0 NAMES OF OTHER INVESTIGATORS (EXTERNAL)

11.1 Probe Exploration Inc.

11.2 Nowsco Well Service Ltd.

11.3 Royal Canadian Mounted Police
Leduc Detachment

Section 12.0 NARRATIVE DESCRIPTION OF INCIDENT

12.1 The following is a summary of the events surrounding the installation and use of a freeze plug at the PCL Module Facility in Nisku, that occurred between September 2 at 16:00 and September 3, 1998 at 07:00. The description of events is based on interviews, evidence and observations at the scene.

12.2 Worker #1 (deceased worker) was a cement/acid pumper and driver who was on temporary loan to this job from another department of his employer. He had no freeze plug experience.

12.3 At 08:00 on September 2, 1998, Worker #1 arrived on site and was trained on the first of two nitrogen freeze plugs used that day. It was installed at approximately 10:00 and removed at about 15:00. The second freeze plug was installed at 16:00.

12.4 At approximately 22:00 on September 2, 1998, a decision was made jointly by the representatives of two contractors and the supervisor of Worker #1 and Worker #2 (co-worker), to start an eight hour hydrostatic test and continue it through the night. Worker # 1 and Worker #2 were asked if they would stay through the night to monitor the freeze plug. They agreed to stay.

12.4.1 Workers #1 and #2 were told that they could rest in their vehicles throughout the night while monitoring the flow of nitrogen out of the freeze plug jacket. The fog in the trench made the nitrogen droplets difficult to see, so a hose had been attached to the outlet and run through a nearby fence to improve visibility.

12.4.2 The bulk truck was parked between Workers # 1 and #2, blocking their view of each other.

12.5 Between 22:00 and 22:15 the supervisor and one other employee met with Workers # 1 and #2, who were staying the night. In this meeting, Workers # 1 and #2 were told that they needed to occasionally view the open end of the outlet hose to ensure that liquid nitrogen was dripping out. They were also told to occasionally check the level on the bulk nitrogen truck. At this meeting they were told to not enter the trench during the night and to wait until the relief crew arrived.

12.6 At 00:40 on September 3, 1998, a bulk truck loaded with liquid nitrogen arrived to refill the supply at the site. The driver woke-up Worker #1 and asked if it was necessary to unload immediately. Worker # 1 said there should be enough nitrogen to last through the night. The driver told Worker #1 that he would sleep in his truck and unload at 04:00 on September 3, 1998.

12.7 At 06:00 on September 3, 1998, Worker #1 woke the driver by banging on the outside of the driver's door. The driver stepped outside of his truck at 06:15 and prepared to unload nitrogen into the other bulk truck.

12.8 As the driver was preparing to unload, Worker #2 left his vehicle briefly and saw Worker #1 sitting in the other pickup. Worker #2 concluded that the driver was in no need of assistance and returned to his truck.

12.9 Sometime between 06:15 and 06:40, the driver saw Worker #1 in the trench. He believes that Worker #1 was on the east side of the jacket, bent forward at the waist, facing north and working with his hands beside the jacket.

12.10 The top of the east wall of the trench prevented Worker #2 from seeing down to the level of the freeze plug jacket.

12.11 The driver completed the unloading process at 06:40 and briefly looked for Worker # 1 to sign the receipt for the nitrogen shipment. The driver did not see Worker #1 in his pick-up truck and observed Worker #2 sitting in the driver's seat of his truck. The driver approached Worker #2 and awakened him to sign the receipt. The driver drove away at approximately 06:45.

12.12 A relief crew, (two other workers), arrived at about 07:00 and approached Worker #2 who was still sitting in the driver's seat of the data van. When asked, Worker #2 was unaware of the location of Worker #1. The three men then searched the site for Worker #1.

12.13 At approximately 07:05, Worker #2 discovered Worker #1 laying in the fog, face-down in the base of the trench. Worker #1 was below and to the west of the freeze plug jacket, with his feet situated to the north. The three other workers immediately entered the trench and pulled Worker # 1 out. Worker # 1 was extensively frozen, unconscious and unresponsive. One of the workers immediately called 911 and requested an ambulance. The ambulance and police arrived a short time later.

12.14 Worker # 1 was pronounced dead at the scene.

12.15 No instruments were present at the time of the incident that could determine whether an oxygen deficiency existed.

12.15.1 The flow of nitrogen was stopped immediately after the incident occurred. Stopping the flow of nitrogen allowed the atmosphere to return to normal.

12.16 One of the other contractors hired for the project recorded daily tool box safety meetings. The meeting record for September 1, 1998 cautions site personnel about entering and leaving trenches where freeze plugs are in use. The record states that in the event of a nitrogen leak, "be aware of an oxygen deficiency". Worker #1 was not present at this meeting.

12.16.1 The September 2, 1998 meeting record, as signed by Worker #1, cautions about entering open dig sites and to be aware of nitrogen leaks. A possible oxygen deficiency hazard was not noted on the second record.

Section 13.0 CONCLUSIONS

13.1 Although the exact cause of death remains undetermined, it appears from evidence gathered that one of two possible scenarios occurred.

13.1.1 **If excess nitrogen vapour was present in the trench**

Heavier-than-air cold nitrogen vapour created an oxygen deficient atmosphere in the trench. When Worker # 1 moved from one side of the trench to the other, or was in the process of moving, he experienced a deficiency of oxygen that resulted in asphyxia. Upon losing consciousness, Worker # 1 collapsed, receiving facial injuries from his head striking the freeze plug jacket or the

frozen base of the trench. Rapid freezing of the body then occurred as Worker #1 lay on the frozen ground.

Alternatively, Worker #1 may have first lost consciousness from an accidental fall within the trench. After the fall, Worker # 1 experienced asphyxia and then froze.

13.1.2 **If excess nitrogen vapour was not present in the trench**

Worker #1 entered one side of the trench, and after, or in the process of, moving across to the other side, tripped or slipped and suffered a concussion as a result of his head striking the freeze plug jacket or the frozen base of the trench. Unconscious, Worker # 1 remained at the base of the trench, where rapid and fatal freezing of the body occurred as he lay on the frozen ground.

13.2 There are several factors which may have contributed to this incident:

13.2.1 Within the Chemical Hazards Regulation (393/88), a harmful substance means a substance that by its nature, application or presence creates or could create a danger to the health and safety of any worker who is exposed to it. Nitrogen has the potential to become a harmful substance when used in a trench. Cold nitrogen vapour has the potential to displace air in a trench, creating an oxygen deficient atmosphere. They were aware that there could be an oxygen deficient atmosphere. There were no specific safe work procedures for working with nitrogen in a trench.

13.2.2 September 2, 1998 was the first time that Worker #1 performed this type of work with co-workers. As discussed in Section 10.4, the temperature inside the jacket was checked by entering the trench. However, as discussed in Section 12.5, Worker #1 was instructed not to enter the trench during the night until the day shift relief crew arrived. Worker # 1 failed to observe these instructions to stay out of the trench until the relief crew arrived.

13.2.3 The records of on site tool box safety meetings indicate that Worker #1 did not receive the same degree of information about the hazards of nitrogen as did others. In the September 2, 1998 meeting record, Worker #1 was told to use caution when entering and leaving the trench and to be aware of nitrogen leaks. Worker # 1 was not informed about the hazards of nitrogen in a trench. Although Worker # 1 was told later not to enter the trench, he and other workers had entered routinely earlier in this shift.

13.2.4 The driver observed Worker #1 in the trench but did not recognize the potential hazard. Although the driver routinely handles nitrogen, the driver was not acquainted with the freeze plug process, or its hazards.

13.2.5 Worker # 1 was at the site for 23 consecutive hours; some of this time he was sleeping in the truck.

13.3 The temperature meter was stored outside the trench between readings. Although it cannot be determined why Worker #1 chose to enter the trench, finding the temperature meter beside Worker #1, led investigators to conclude that he entered the trench to check the readings.

13.4 The ground at the base of the trench was covered with overlying frost that had accumulated overnight, creating a potential for slippery footing.

13.5 The thermocouple leads for reading temperatures were bundled and taped directly to the pipe beside the jacket. Taping them to the pipe required the workers to enter the trench every time a set of readings was needed. Extending the leads out of the trench would have made temperature measurement safer and easier.

13.6 Until 20:00 on September 2, 1998, a mixture of nitrogen vapour and droplets of liquid nitrogen, visibly dripped directly out of the open connection on top of the jacket to the ground. No outlet hose was attached to the freeze plug jacket. Between 20:00 and 22:00, the wind decreased, such that the fog was not being carried away. An outlet hose was connected to the top of the jacket and extended to the fence making the nitrogen droplets easier to view.

Section 14.0 FOLLOW-UP/ACTION TAKEN

14.1 Industry

14.1.1 The employer, prime contractor and all other contractors involved on this project have educated their employees about the health and safety hazards associated with nitrogen; both in large quantities and confined areas.

14.1.2 The employer and prime contractor have both recognized that the nitrogen freeze plug process could create an oxygen deficient atmosphere and have developed procedures for freeze plugs. The employer used their existing Confined Space Entry Code of Practice and applied it to the freeze plug procedure. The employer has included in the freeze plug code of practice, a stipulation that temperature checks be conducted by extending the temperature leads to a location away from the potential oxygen deficient atmosphere.

14.1.3 The employer has discontinued the use of the freeze plug jacket design that was in use at the time of the incident. The replacement jacket design is less likely to leak nitrogen than the discontinued one.

14.2 **Alberta Labour**

14.2.1 Alberta Labour is developing a bulletin for issue to industry, referencing this incident, to inform other companies performing freeze plug operations, as well as companies who may use this service.

14.3 **Additional Measures**

14.3.1 In the course of this investigation Alberta Labour has identified two other Alberta employers performing similar processes. After consultation with these companies and reviewing each freeze plug procedure, Alberta Labour is satisfied that the freeze plug procedures of these other employers adequately address the hazards associated with this process. Alberta Labour has reviewed new freeze plug procedures written by the employer and found them to be consistent with the industry standards indicated by the other two employers.

Section 15.0 INJURY SEVERITY

15.1 Fatal

Section 16.0 SIGNATURES

[original signed]

Section 17.0 ATTACHMENTS

Attachment A Photographs
Attachment B Sketch

Photograph #1: **Incident Location:**

Looking north, view of the trench (with fog in base), pipeline, freeze plug jacket, hoses (with frost build-up), nitrogen bulk truck and west fence. The frost line on the west (left hand) side of the trench indicates where the inlet hose was laying at some time prior to the photograph being taken. The red arrow [lower] indicates the location where the fatally injured worker was discovered. The blue arrow [upper] indicates an alteration to this area of the photograph.

Photograph #2: **Incident Location:**

Looking northwest, view of trench, fence, and rear of nitrogen bulk truck. The green arrow [far left] points to the open end of the freeze plug jacket outlet hose. The red arrow [upper right] points to the nitrogen level gauge at the rear of the truck. The blue arrow [centre] indicates an alteration to this area of the photograph.

Photograph #3: **Incident Location:**

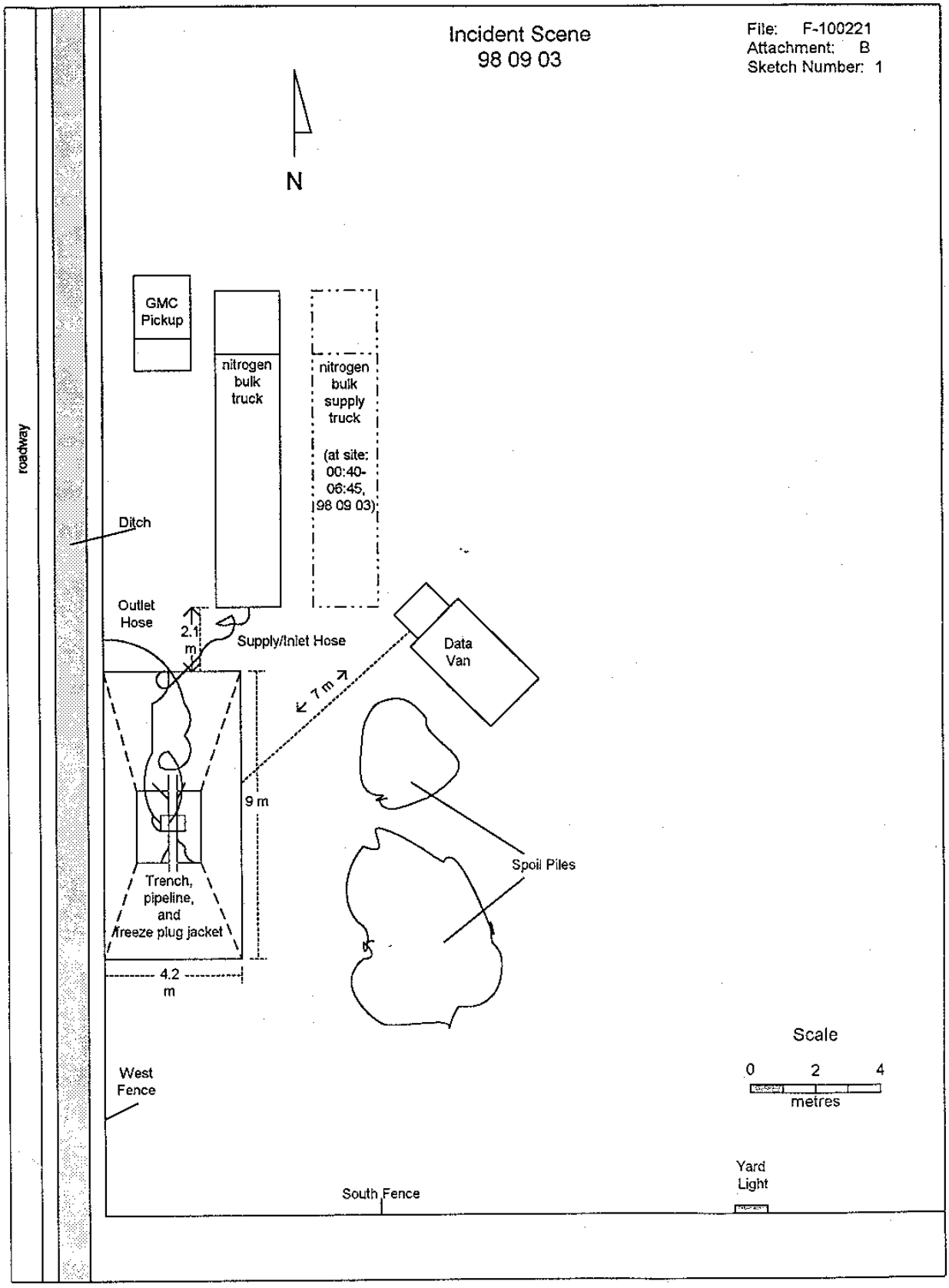
Looking southwest, view of trench by Worker #2 from driver's seat of data van. The hoses are visible extending into the trench. The top of the freeze plug jacket was not visible from the driver's seat. The arrow points to the freeze plug jacket, hidden from view by the east trench wall.

Photograph #4: **Incident Location:**

View of frozen ground in trench base, showing cobble and frozen lumps of clay. The frozen nature of these surfaces made them harder, with the potential to cause a concussion type of injury. No physical evidence was observed at the scene that would confirm whether Worker #1 tripped or was asphyxiated. The red arrow points to the temperature meter.

Photograph #5: **Incident Location:**

Simulation by a model to show where Worker #1 was found. The model's placement of his limbs may not precisely reflect the way Worker #1 was found.


Incident Scene
98 09 03
File: F-100221
Attachment: B
Sketch Number: 1
N
roadway
GMC Pickup
nitrogen bulk truck
nitrogen bulk supply truck
(at site: 00:40-06:45, 98 09 03)
Ditch
Outlet Hose
2.1 m
Supply/Inlet Hose
Data Van
7 m
9 m
Trench, pipeline, and freeze plug jacket
4.2 m
Spoil Piles
Scale
0 2 4
metres
West Fence
South Fence
Yard Light