17 January 1983

Hat Creek Project

Spontaneous Combustion Tests
Update to include S.I.P. 82

By: W.C. Fothergill December 1982

1) Introduction

The report dated 9 December 1977 by D.A. Fawcett was based on the tests and observations conducted during the 1977 Bulk sample program coal excavations and its coal storage piles.

This update is written to add the information of spontaneous combustion occurrences at the conclusion of the S.I.P. 82 A zone coal (Trench D) program to that of the original report by D.A. Fawcett.

2) The S.I.P. 82 - A Zone Coal - Trench D Coal Piles

The Mining, geology, and crushing sampling work is reported in detail in the Trench D report.

Eleven (11) coal sub zone or groups of sub zones samples varying from 500-1200 tons each were put in separate piles uncrushed in the coal yard as depicted in the accompanying plan. The floor of this 1982 coal yard was the levelled off compacted top of the 1977 coal piles, so it is a well compacted coal floor. Selectively mined from each of the 11 sub zone groups in Trench 'D' were samples cut for crushing and blended into a 800 ton pile (#14) for the wash test sample. The old crushed coal piles from the 1977 Bulk sample program were moved to their new position #13 and #15 to make space for the new blend pile.

A new waste coal dump was formed to the East of the old 1977 waste coal dump.

3) Temperature Monitoring of the Coal Piles

All the R.O.M. piles were packed by bulldozers after heaping within the first week after excavation and transporting.

The crushed coal blend pile remained unpacked for a month after the sample shipment, but when temperatures of hot spots had reached 90-100^{o}C indicating ignition of fires was about to start the hot points of the dump were then turned over and the whole dump packed. 3/8" metal pipes (probes) were injected in all piles spaced over the area of the pile and driven down to a depth of 5 feet or more.

Temperature readings using a thermocouple unit in the probes were listed on the attached record sheets which indicate the pile and also ambient conditions. When hot spots were observed in positions not close to the probes, temperatures were checked by thermometer insertion in the coal surface air spaces.

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4) Occurrence of Fires

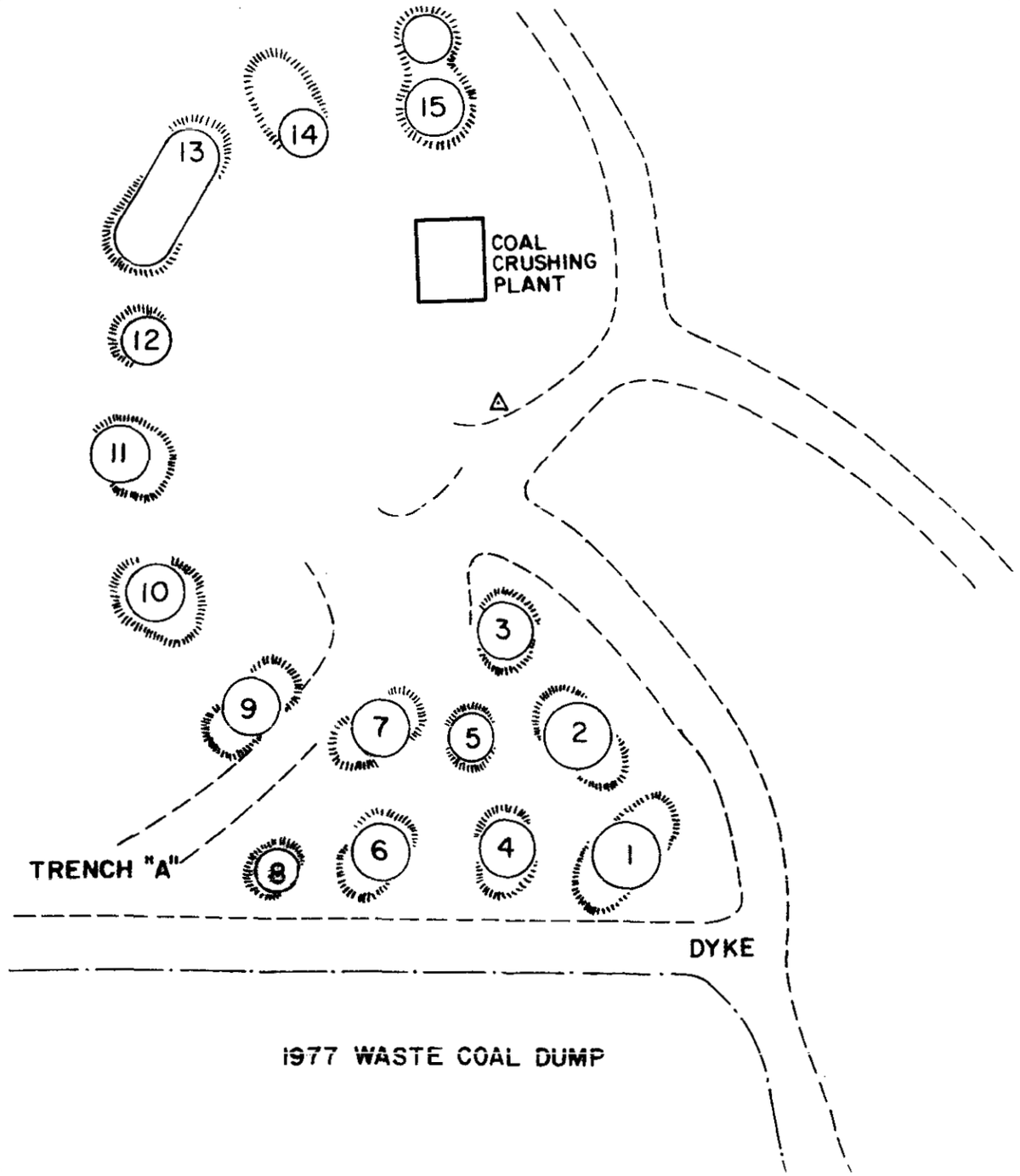
Only two of the coal piles developed spontaneous combustion and heated up to over the basic 40°C to reach burning conditions with steam and smoke, and temperatures of 90-100°C. These two piles (#1-B zone and #14-700 tons crushed blended coal) took approximately 30 days to start heating from time of mining and approximately 60 days to reach temperatures over 65°C where spontaneous ignition could start. The hot spots were deliberately left untouched to observe the consequences. Temperatures appeared to level off but spread through a larger area of the dump for another month. At this time (90 days) the first snowfall and onset of winter temperatures seemed to trigger a flare up of heating to 80-85°C with accompanying steam and smoke in the hot spots of these 2 coal piles. Digging into the pile revealed that the hot areas were confined to shallow depths of 4-5 feet where the moisture of the melting snow had penetrated. Surface packing of these areas seemed to be adequate to reduce temperatures to below 40°C. However, the next snowfalls 2 weeks later (120 days after mining) caused both piles to develope much larger areas of spontaneous combustion (temperatures over 100°C). This time the affected parts of each pile (about 1/2 of each) were dozed out and spread for dissipation of the heat. This extinquished the fires, and temperatures reduced to less than 30°C before repiling and packing was done. A 6" layer of ash was found at the bottom of the B1 coal pile on the south side when it was turned over by the dozer - probably percolating waters reaching to old surface accelerated the oxidation and spontaneous combustion there.

5) Observations

There is no explanation as to why only 2 out of the 13 new coal piles developed spontaneous combustion. All piles received the same amount of packing and treatment when dumped except for the two crushed piles. No visible pyrite or other mineral was found in the hot spots that were dug out and examined.

No spontaneous combustion or heating has been located as yet in either the large waste coal pile which was well packed as the dump was formed and has been covered by topsoil, or in any of the smaller coaly waste piles (clay partings) which were not packed.

The old crushed coal piles that have been standing for 5 years since the 1977 Bulk sample program were moved by bulldozing and loader piling to new positions and repacked there. There is no apparent deterioration of coal quality due to oxidization or spontaneous combustion due to the long storage.



1.	"B" ZONE COAL	RUN-OF-MINE (R.O.M.)
2.	A_4C_7 & A_4C_6	
3.	A_4C_5	
4.	A_5C_2 & A_5C_9	
5.	A_4C_4	
6.	A_5C_4	
7.	$A_3W_1 \sim A_3C_6$	
8.	A_1C_4	
9.	$A_4C_1 \sim A_4C_3$	
10.	$A_2C_2 \sim A_2C_5$	
11.	A_1C_3	
12.	TRENCH "D" "B_1" ZONE 1982	CRUSHED
13.	"B" ZONE TRENCH "A" 1977	
14.	"A" ZONE BLEND PILE 1982	
15.	"D" ZONE TRENCH "B" 1977	

B. C. HYDRO
HAT CREEK PROJECT
MINING FIELD PROGRAM 1982

FIGURE 4

TRENCH D COAL PILES

HAT CREEK

TEMPERATURE OF COAL STOCKPILES

SIP'82 A-ZONE TRENCH D

DATE	TIME	PILE #	LOCATION COAL SECTION	TEMP.	AMBIENT	WEATHER
Aug 24/82	3:22 PM	A1 C4	No1 North	20°	32°	Sunny
"	3:27	" "	No2 East	21°	32°	"
"	3:32	" "	No3 South	26°	32°	"
"	3:37	" "	No4 west	24°	32°	"
"		A4C1-A4C3	No1 North			"
"	3:42	" "	No2 East	23°	32°	"
"	3:49	" "	No3 South	22°	32°	"
"	3:54	" "	No4 west	23	32°	"
"	4:00	CRUSHED LOOSE	No1 west	40	32°	"
"	4:06	" "	No2 South	44°	32°	"
"	4:08	" "	No3 East	32°	32°	"
"	4:10	" "	No4 North East 3f	61°	32°	"
"	4:12	" "	No5 North 3f	34°	32°	"
"	4:14	" "	No6 North West	40°	32°	"

Note: MINING AND DUMPING OF THESE PILES STARTED ON JULY 24th - 82 IN TRENCH D.

MONITORING STARTED AUG 24 - 30 days after mining

HOT SPOTS RECORDED [redacted] SEPT. 24 - 60 days after mining.

HOT SPOTS SURFACE PACKED OCT 24 - 90 days after mining

HOT SPOTS DUG OUT Nov. 16 - 116 days after mining

"B" DUMP and CRUSHED DUMP TURNED OVER AND REPACKED - NOV 28 - 123 days after mining

TEMPERATURE OF COAL STOCKPILE

DATE	TIME	PILE #	LOCATION COAL SECTION	TEMP.	AMBIENT	WEATHER
Aug 24/82	9:30 AM	A4 C5	No 1 North	25°	22°	Sunny
"	9:36	" "	No 2 East Short	25°	22°	"
"	9:40	" "	No 3 South	24°	22°	"
"	9:46	" "	No 4 west	22°	22°	"
"	9:50	A4 C4	No 1 North	25°	23°	"
"	9:55	" "	No 2 East	25°	23°	"
"	10:00	" "	No 3 South	24°	24°	"
"	10:05	" "	No 4 west	24°	24°	"
"	10:12	A3W1-A3C6	No 1 West	20°	24°	"
"	10:17	" "	No 2 North	20°	24°	"
"	10:22	" "	No 3 East	23°	24°	"
"	10:28	" "	No 4 South	28°	24°	"
"	10:34	" "	No 5 South	27°	24°	"
"	10:41	A4C7-A4C8	No 1 North	20°	24°	"
"	10:48	" "	No 2 East	26°	24°	"
"	10:53	" "	No 3 South	24°	24°	"
"	11:00	" "	No 4 west Short	24°	25°	"
"	11:45	B ZONE	No 1 North	26°	25°	"
"	11:50	"	No 2 East	27°	26°	"
"	12:45 PM	"	No 3 South	30°	28°	"
"	12:50	"	No 4 South	38°	28°	"
	12:55	"	No 5 west	42°	28°	"
	1:01	A5C6-A5C9	No 1 North Short	24°	28°	"
"	1:06	" "	No 2 East	25°	28°	"
	1:11	" "	No 3 South	33°	28°	"
	1:16	" "	No 4 west	25°	30°	"
	1:21	A5-C4	No 1 North	20°	30°	"
	1:28	" "	No 2 East	23°	30°	
	2:11	" "	No 3 South	14°	32°	

TEMPERATURE OF COAL STOCKPILES

HAT CREEK – SIP 82 ALONG TRENCH D

DATE	TIME	PILE #	LOCATION COAL SECTION	TEMP.	AMBIENT	WEATHER
AUG 25/82	10:28	A1 C4	No1 North	20°	24°	SUNNY
"	10:29	" "	No2 EAST	24°	24°	"
"	10:34	" "	No3 South	25°	24°	"
"	10:34	" "	No4 west	22°	"	"
"	~~10:35~~	A4C1-A4C3	~~Not used~~	~~22°~~	"	"
"	10:39	" "	No2 EAST	23°	"	"
"	10:42	" "	No3 South	23°	"	"
"	10:44	" "	No4 west	23°	"	"
"	10:51	Crushed Loose	No1 west	40°	"	"
"	10:52	" "	No2 South	45°	"	"
"	10:56	" "	No3 EAST	30°	"	"
"	10:58	" "	No4 North EAST	55°	"	"
"	11:01	" "	No5 North	32°	"	"
"	11:03	" "	No6 North west	42°	"	"

TEMPERATURE OF COAL STOCKPILE

DATE	TIME	LOCATION PILE #	COAL SECTION	TEMP.	AMBIENT	WEATHER
AUG 25/82	8:25 AM	A4 C6	NO1 NORTH	24°	19°	SUNNY
	8:26	" "	NO2 EAST	30°	"	"
	8:30	" "	NO3 SOUTH	25°	"	"
	8:30	" "	NO4 WEST	21°	"	"
	8:35	A4 C4	NO1 NORTH	24°	"	"
	8:35	" "	NO2 EAST	24°	"	"
	8:40	" "	NO3 SOUTH	25°	20°	"
	8:40	" "	NO4 WEST	23	"	"
	8:45	A3W1-A3C6	NO1 NORTH	20°	21°	"
	8:45	" "	NO2 EAST	24°	"	"
	8:46	" "	NO3 SOUTH	26°	"	"
	8:48	" "	NO4 ~~SOUTH~~	27°	"	"
	8:50	" "	NO5 WEST	21°	"	"
	8:55	A4C7 A4C6	NO1 NORTH	21°	"	"
	9:05	" "	NO2 EAST	25°	"	"
	9:08	" "	NO3 SOUTH	21°	22°	"
	9:10	" "	NO4 WEST	23°	"	
	9:16	KB ZONE	~~NORTH NO1~~	25°	"	
	9:20	" "	NO2 EAST	26°	24°	
	9:25	" "	NO3 SOUTH	30°	24°	
	9:25	" "	NO 4 SOUTH	42°	24°	
	9:30	" "	NO 6 WEST	40	24°	
	9:35	A6C6-A6C9	NO1 NORTH	22°	"	
	9:35	" "	NO2 ~~SOUTH~~ EAST	21°	"	
	9:42	" "	NO3 ~~SOUTH~~	30°	"	
	9:43	" "	NO4 WEST	25°	"	
	9:45	A5 C4	NO1 NORTH	20°	"	
	9:50	" "	NO2 EAST	25°	"	
	9:50	" "	NO2 SOUTH	20°	"	

TEMPERATURE OF COAL STOCKPILE

DATE	TIME	PILE #	LOCATION COAL SECTION	TEMP.	AMBIENT	WEATHER
Aug 31	2:00	A1C4	No1 North	21	26°	
	2:00	" "	No2 East	25	"	
	2:05	" "	No3 South	25	"	
	2:05	" "	No4 west	22	"	
	2:10	A4C1-A4C3	No1 North	22	"	
	2:10	" "	No2 East	22	"	
	2:15	" "	No3 South	23	"	
	2:15	" "	No4 West	24	"	
	2:20	A2C2-A2C5	No1 North	23	"	
	2:20	" "	No2 East	25	"	
	2:30	" "	No3 South	25	"	
	2:30	" "	No4 South	26	"	
	2:35	" "	No5 west	23	"	
	2:35	A1-C3	No1 North	24	"	
	2 40	" "	No2 East	25	"	
	2:40	" "	No3 South	25	"	
	2:45	" "	No4 west	22	"	
	2:45	A1 C3	No1 North	26	"	
	2:50	" "	No2 South	27	"	
	2:50	B1 Zone	No1 North	24	"	
	2:55	" "	No2 East	26	"	
	2:55	" "	No3 South	26	"	
	3:00	" "	No4 west	25	"	
	3:00	CRUSHED Loose	No1 west	40	"	
	3:05	" "	No2 South	[illegible]	"	
	3:05	" "	No3 East	30	"	
	3:10	" "	No4 North East 2'	50	"	
	3:10	" "	No5 North East 6'	53	"	
	3:15	" "	No6 North	32	"	

TEMPERATURE OF COAL STOCKPILE

DATE	TIME	PILE #	LOCATION COAL SECTION	TEMP.	AMBIENT	WEATHER
AUG 31	12:45	A4 C5	No1 North	25°	25°	Sunny +
	12:45	" "	No2 East	25	"	Partly Cloudy
	12:50	" "	No3 South	24	"	
	12:50	" "	No4 west	22	"	
	12:55	A4 - C4	No1 North	25	"	
	12:55	" "	No2 East	25	"	
	1:00	" "	No3 South	24	"	
	1:00	" "	No4 west	24	"	
	1:05	A3 W1 - A3 C6	No1 North	21	"	
	1:05	" "	No2 East	20	"	
	1:10	" "	No3 South	23	"	
	1:10	" "	No4 South	30	"	
	1:15	" "	No5 west	28	"	
	1:15	A4C7 - A4C6	No1 North	21	"	
	1:20	" "	No2 East	25	"	
	1:20	" "	No3 South	24	"	
	1:25	" "	No4 west	24	"	
	1:25	B ZONE	No1 North	27	"	
	1:30	" "	No2 East	27	"	
	1:30	" "	No3 South	31	"	
	1:35	" "	No4 South	38	"	
	1:35	" "	No5 west	45	"	
	1:40	A5 C5 - A5 C9	No1 North	22	"	
	1:40	" "	No2 East	22	26°	
	1:45	" "	No3 South	30	"	
	1:45	" "	No4 west	27	"	
	1:50	A5 - C4	No1 North	20	"	
	1:50	" "	No2 East	26	"	
	1:55	" "	No3 South	20	"	

TEMPERATURE OF COAL STOCKPILE

DATE	TIME	PILE #	LOCATION COAL SECTION	TEMP.	AMBIENT	WEATHER
Sept 2	9:00	A4 C6	No1 North	23	17°	
	9:00	" "	No2 EAST	26	"	
	9:05	" "	No3 South	28	"	
	9:05	" "	No4 west	26	"	
	9:10	A4-C4	No1 North	25	"	
	9:10	" "	No2 EAST	25	"	
	9:15	" "	No3 South	30	"	
	9:15	" "	No4 west	25	"	
	9:25	A3W.-A3C6	No1 NORTH	20	"	
	9:25	" "	No2 EAST	25	"	
	9:30	" "	No3 South	30	"	
	9:30	" "	No4 South	30	"	
	9:35	" "	No5 west	20	18	
	9:40	A4C7-A4C6	No1 North	22	"	
	9:40	" "	No2 EAST	24	"	
	9:45	" "	No3 South	24	20	
	9:45	" "	No4 west	19	"	
	9:50	B2 ONE	No1 North	26	"	
	9:50	" "	No2 EAST	28	"	
	9:55	" "	No3 South	33	"	
	9:55	" "	No4 South	42	"	
	10:00	" "	No5 west	26	"	
	10:00	A5C5-A5C9	No1 NORTH	22	"	
	10:05	" "	No2 EAST	24	"	
	10:10	" "	No3 South	35	"	
	10:10	" "	No4 west	26	"	
	10:15	A5-C4	No1 North	20	"	
	10:16	" "	No2 EAST	22	"	
					"	

TEMPERATURE OF COAL STOCKPILE

DATE	TIME	PILE #	LOCATION COAL SECTION	TEMP.	AMBIENT	WEATHER
Sept 2	10:25	A1C4	No1 North	20	20°	Sunny Partly Cloudy
	10:25	" "	No2 EAST	25	"	
	10:30	" "	No3 South	26	"	
	10:35	" "	No4 west	20	"	
	10:35	A4C1-A4C3	No1 North	20	"	
	10:40	" "	No2 EAST	20	"	
	10:40	" "	No3 South	22	"	
	10:45	" "	No4 WEST	22	25	
	10:45	A2C2-A2C5	No1 North	24	"	
	10:50	" "	No2 EAST	24	"	
	10:50	" "	No3 South	23	"	
	10:55	" "	No4 South	23	"	
	10:55	" "	No5 west	24	"	
	11:00	A1-C3	No1 North	21	"	
	11:00	" "	No2 EAST	21	"	
	11:05	" "	No3 South	22	"	
	11:05	" "	No4 west	22	"	
	11:00	A1 C3	No1 North	25	"	
	11:10	" "	No2 South	28	"	
	11:15	B1 Zone	No1 North	30	"	
	11:15	" "	No2 EAST	32	"	
	11 20	" "	No3 South	45	"	
	11:20	" "	No4 west	45	"	
	11:25	CRUSHED Loose	No1 west	39	"	
	11:25	" "	No2 South	52	"	
	11:30	" "	No3 EAST	36	"	
	11:30	" "	No4 North EAST 3	53	"	
	11:35	" "	No5 North EAST 5	57	"	

TEMPERATURE OF COAL STOCKPILE

DATE	TIME	PILE #	LOCATION COAL SECTION	TEMP.	AMBIENT	WEATHER
~~Sept~~	10:22	A1C4	No1 North	17	10	Cloudy
~~Sept~~	10 25	" "	No2 EAST	19	"	QUICK CAST
Sept 24	10:28	" "	No3 South	21	"	"
	10:30	" "	No4 west	20	"	"
	10:32	A4C1-A4C3	No1 North	15	"	"
	10:35	" "	No2 EAST	16	"	"
	10:37	" "	No3 South	20	"	"
	10:40	" "	No4 WEST	20	"	"
	10:43	A2C2-A2C5	No1 North	19	"	"
	10:45	" "	No2 EAST	20	"	"
	10:48	" "	No3 South	22	"	"
	10:50	" "	No4 South	22	10	"
	10:53	" "	No5 west	20	"	"
	10:55	A1-C3	No1 North	19	"	"
	10:58	" "	No2 EAST	17	"	"
	11:00	" "	No3 South	19	"	"
	11:02	" "	No4 west	16	"	"
	11:05	A1 C3	No1 North	23	"	"
	11:08	" "	No2 South	26	"	"
	11:10	B1 Zone	No1 North	30	10	"
	11:12	" "	No2 EAST	26	"	"
	11:15	" "	No3 South	30	"	"
	11:17	" "	No4 west	23	"	"
	11:20	CRUSHED Loose	No1 west	34	"	"
	11:23	" "	No2 South	37	"	"
	11:25	" "	No3 EAST	35	"	"
	—	" "	~~No4 North EAST~~			"
	—	" "	~~No5 North EAST~~			"

TEMPERATURE OF COAL STOCKPILE

DATE	TIME	PILE #	LOCATION COAL SECTION	TEMP.	AMBIENT	WEATHER
Sept 24	9:00	A4 C5	No1 North	12°	10°	Cloudy
	9:02	" "	No2 EAST	15	"	OVER CAST
	9:05	" "	No3 South	16	"	"
	9:08	" "	No4 west	15	"	"
	9:10	A4 - C4	No1 NORTH	14	"	"
	9:13	" "	No2 EAST	18	"	"
	9:15	" "	No3 South	18	"	"
	9:17	" "	No4 west	16	"	"
	9:20	A3 W1 - A3 C6	No1 NORTH	15	"	"
	9:23	" "	No2 EAST	18	"	"
	9:25	" "	No3 South	19	"	"
	9:28	" "	No4 South	19	10	"
	9:31	" "	No5 west	17	"	"
	9:33	A4C7 - A4C6	No1 North	16	"	"
	9:36	" "	No2 EAST	19	"	"
	9:38	" "	No3 South	20	"	"
	9:40	" "	No4 west	17	"	"
	9:43	B2 C NE	No1 North	16	"	"
	9:45	" "	No2 EAST	16	"	"
	9:48	" "	No3 South	26	"	"
	9:50	" "	No4 South	[redacted]50	"	"
	9:51	" "	No5 west	27	"	"
	10:00	A5 C5 - A5 C9	No1 NORTH	15	"	"
	10:03	" "	No2 EAST	18	"	"
	10:05	" "	No3 South	19	"	"
	10:08	" "	No4 west	18	10	"
	10:11	A5 - C4	No1 North	18	"	"
	10:14	" "	No2 EAST	19	"	"
		" "			"	"

HAT CREEK PROJECT

SPONTANEOUS COMBUSTION TESTS

Prepared by: D. A. Fawcett
Date: 9 December 1977

SPONTANEOUS COMBUSTION TESTS

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Appendix

Introduction

Spontaneous combustion is a problem with most low rank coals when exposed to such conditions as wind, heat and moisture in storage stockpiles. Test piles of crushed coal were established and temperature monitoring and observation carried out on these and the raw coal stockpiles to accumulate information on heat build up and occurrence of fires. This report describes the test piles, methods of monitoring, observations and results.

Test Piles

Four piles of crushed coal were specifically built for temperature monitoring; they were:

a. Trench B loose coal pile (approximately 500 tons),

b. Trench B compacted coal pile (approximately 900 tons),

c. Trench A loose coal pile (approximately 750 tons),

d. Trench A compacted coal pile (approximately 700 tons).

These were of sufficient volume and dimensions to allow adequate exposure to the elements as wind and ambient temperatures are important factors influencing rate of oxidation and heat dissipation. When the heat of oxidation exceeds the rate of heat dissipation danger of spontaneous combustion exists.

The Trench B loose pile was built by dumping the coal from as high as possible with the front-end loader and progressively extending the pile in a rectangular shape at maximum height (approximately 10 feet) while avoiding travel on the coal. The Trench A loose pile was similarly built but in a more conical shape with a core of lightly compacted coal where the loader ramped up to achieve sufficient height (approximately 15 feet). The compacted piles were built by spreading the coal in 6 to 12 inch layers then driving over it with the loader. These piles reached a maximum height of about 5 feet due to low slope angles on the piles and space limitations.

In addition to these piles a larger compacted (4000 ton reserve crushed coal pile) was monitored for additional data.

Temperature monitoring was also carried out on the low grade pile, the coaly waste pile and the coal piles at Trench B. The low grade pile was not fully compacted and had stratifications of larger blocky coal that allowed air circulation through large portions of the pile. The coaly waste pile was moderately well compacted.

Plans of the monitored piles showing geometry and probe locations are included in the Appendix.

Methods of Monitoring

The temperature in the coal piles were taken by lowering a thermometer down 3/4 or 3/8 inch I.D. metal pipes (probes) which had been driven into the piles for this purpose. After each test pile was constructed, 3 and 5 foot pipes were driven in at approximately 45° on the sides and vertical on the tops of the piles. The probes were spaced over the entire area of a pile so that representative data of the heat build up could be obtained. Similarly probes were driven into the coaly waste and low grade piles.

In taking a reading the thermometer was left in the pile from three to five minutes depending on temperatures expected, then pulled out as quickly as possible and the reading taken; with hot internal temperatures the mercury would drop several degrees by the time the thermometer was read, but this was within the range of accuracy desired. A complete set of records is being kept on file; a sample sheet has been included in the Appendix.

Later in the program a thermocouple unit was used to take the readings. The unit consisted of a flexible cable attached to a hand held meter. The cable was lowered down the pipe and the reading taken after a brief pause for the thermocouple to stabilize. This unit was introduced to speed up the task of taking the temperatures and worked quite adequately.

An instrument commonly called an "infrared gun" was tested to determine its suitability in detecting areas in the coal piles where heating was occurring. Basically the instrument is pointed at the pile from a distance of approximately 10 feet with the temperature reading obtained from a dial on the instrument. It did not work satisfactorily as the surface temperatures did not exhibit sufficient range for readily detecting changes; the surface temperatures were much lower than the coal below; and by the time the instrument could pick up significant temperature increases, other signs of heating were prevalent (steam coming off the pile above the hot coal and white evaporites on the surface) which indicated that the coal was approaching the danger point for spontaneous ignition.

Occurrence of Fires

Heating within the piles was first observed in the stockpiles of crushed coal prepared for the 7000 ton sample; steam was noticed coming from a bucket load of coal being dumped into a truck for transport to the rail siding at Ashcroft. Temperatures were taken the following day and were found to range from 60 to 70°C in the warmest area. As there was not any prior experience with spontaneous ignition of the Hat Creek coals, the hot coal was dug out and compacted to prevent any further heating. This pile had been exposed for approximately two weeks. Following this occurrence daily observation of the piles was made and a temperature monitoring program established.

Fires began occurring in the uncrushed low grade pile after 50 to 70 days of exposure. These generally occurred around the base of the pile in areas that appeared loose and made up of a high percentage of lumps. This pile was observed to gradually heat over fairly large areas with fires occurring frequently within these zones. The fires and hot coal were dug out when discovered and the hot coal compacted. These fires continued to occur until the pile was sloped and the surface thoroughly compacted by padding a Caterpillar D-6 bulldozer over it.

Fires started occurring in the loose crushed piles after four weeks of exposure and continued to break out until the piles were compacted. Generally these occurred around the base of the pile in zones where the average temperature had risen to 65 to 70°C. These fires may have started sooner but a period of rain and cold weather appeared to cause the daily rise in temperature to level off.

Observations

Five graphs showing the relationship of temperature rise with time were compiled from the temperature monitoring records and are included in the Appendix. These were done with either individual probes, averages of certain probes, or averages for the pile on the crushed coal test piles, the compacted test piles and the low grade pile (in a local area where the heat build up was observed and monitored). The graphs for the crushed loose piles show a rapid temperature rise during the first two weeks with a levelling off for approximately two weeks before fires started occuring. The reason for this levelling off is not known at the present time although the weather may have had some influence as there was a rainy, cooler period coinciding with the levelling off in temperature rise. This same phenomenon also occured in the low grade pile but there was only a brief period of rain when the area had reached the 70 to 75°C range. The heating was not detected in this zone until after the period of rapid temperature rise. Further testing over a longer period of time would be required to produce more complete results.

There was only minor heating in the coaly waste pile and this occured in areas where the pile was not compacted sufficiently. Also this pile contained a large amount of clays which probably helped to seal the pile.

Most of the fires started in the early morning possibly due to heat build up within the pile overnight (no air movement preventing heat dissipation) and then being fanned by early morning breezes.

A report was written during the monitoring program by Brent Noland (a summer student working for Dolmage Campbell Associates who assisted in the temperature monitoring) on "The Effect of Ambient Temperatures on Coal Stockpiles"; it has been included in the Appendix. The report is based upon a brief study of the effects of ambient temperature on the coal pile done on a typical hot day in summer. The study indicates that high ambient temperatures do not significantly affect temperatures within the pile. It should be noted, however, that when the stockpiles are built during a hot day the pile can have a higher initial temperature (up to 30°C) causing more rapid oxidation.

Compaction of the hot and/or burning coal always extinguished the fire and eased the coal to cool off.

Appendix

I Sample Temperature Monitoring Sheet

II Graphs: Temperature Rise vs Time

III Report: "The Effect of Ambient Temperatures on Coal Stockpiles"

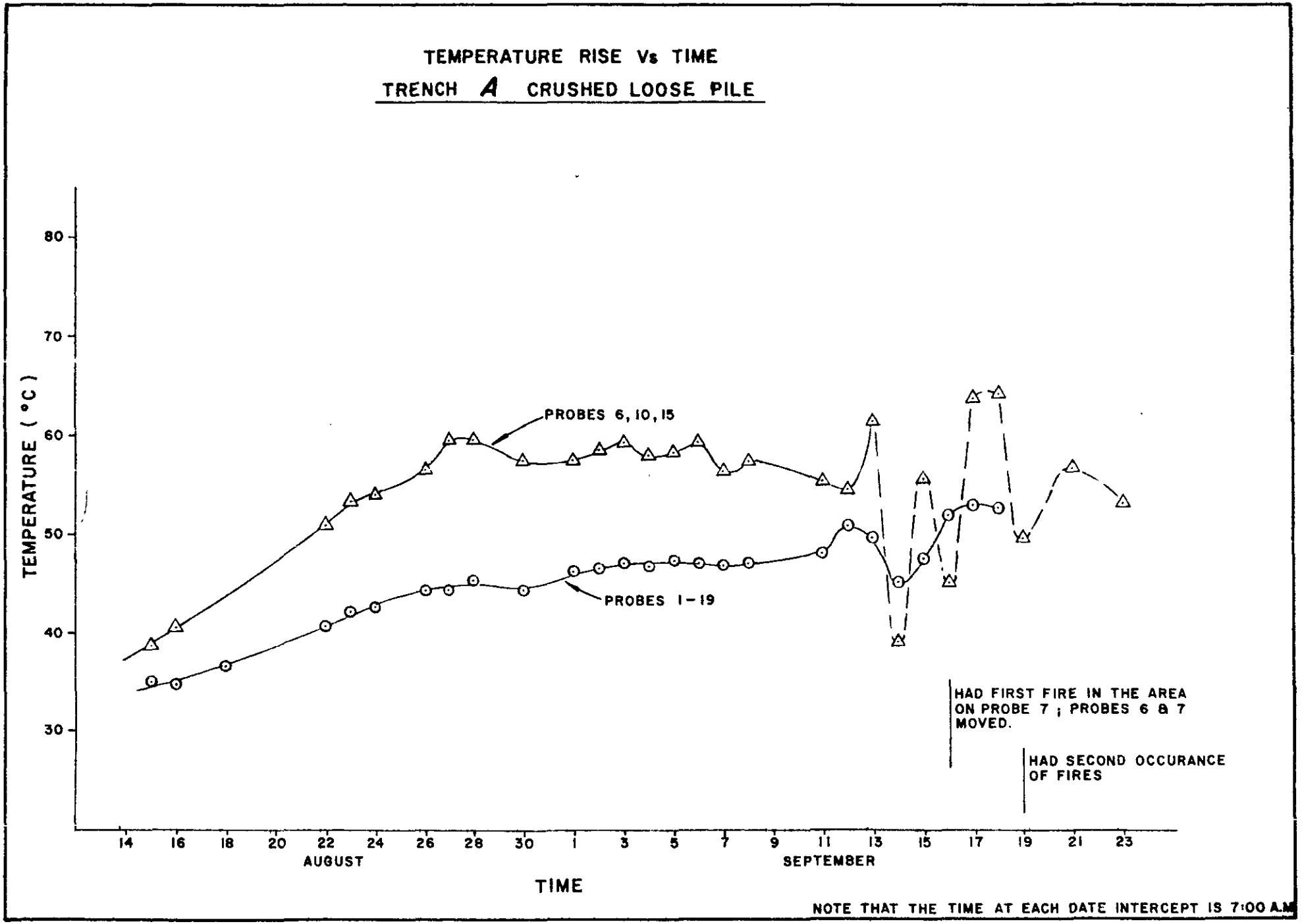
IV Plan of Test Piles

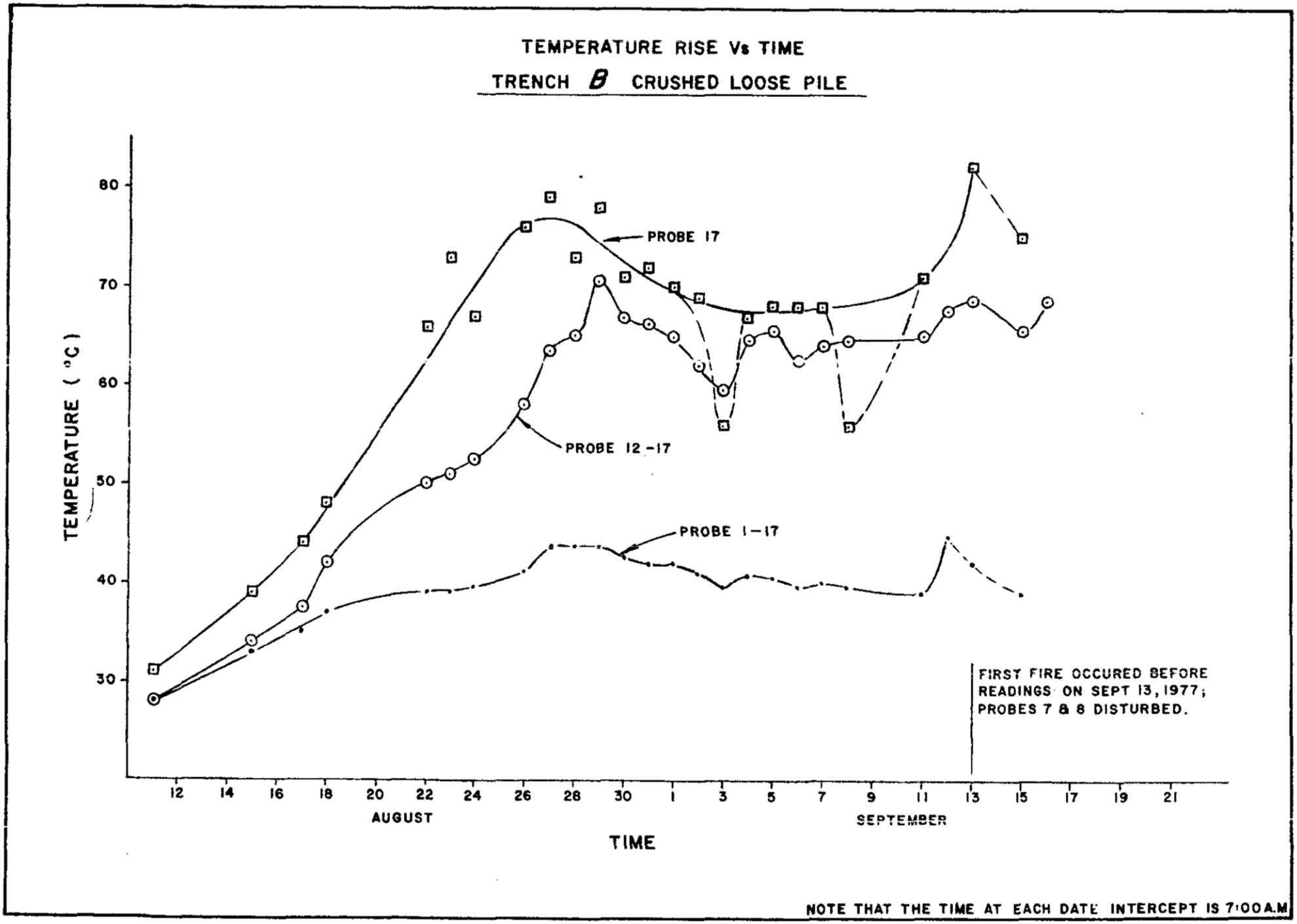
V Photographs

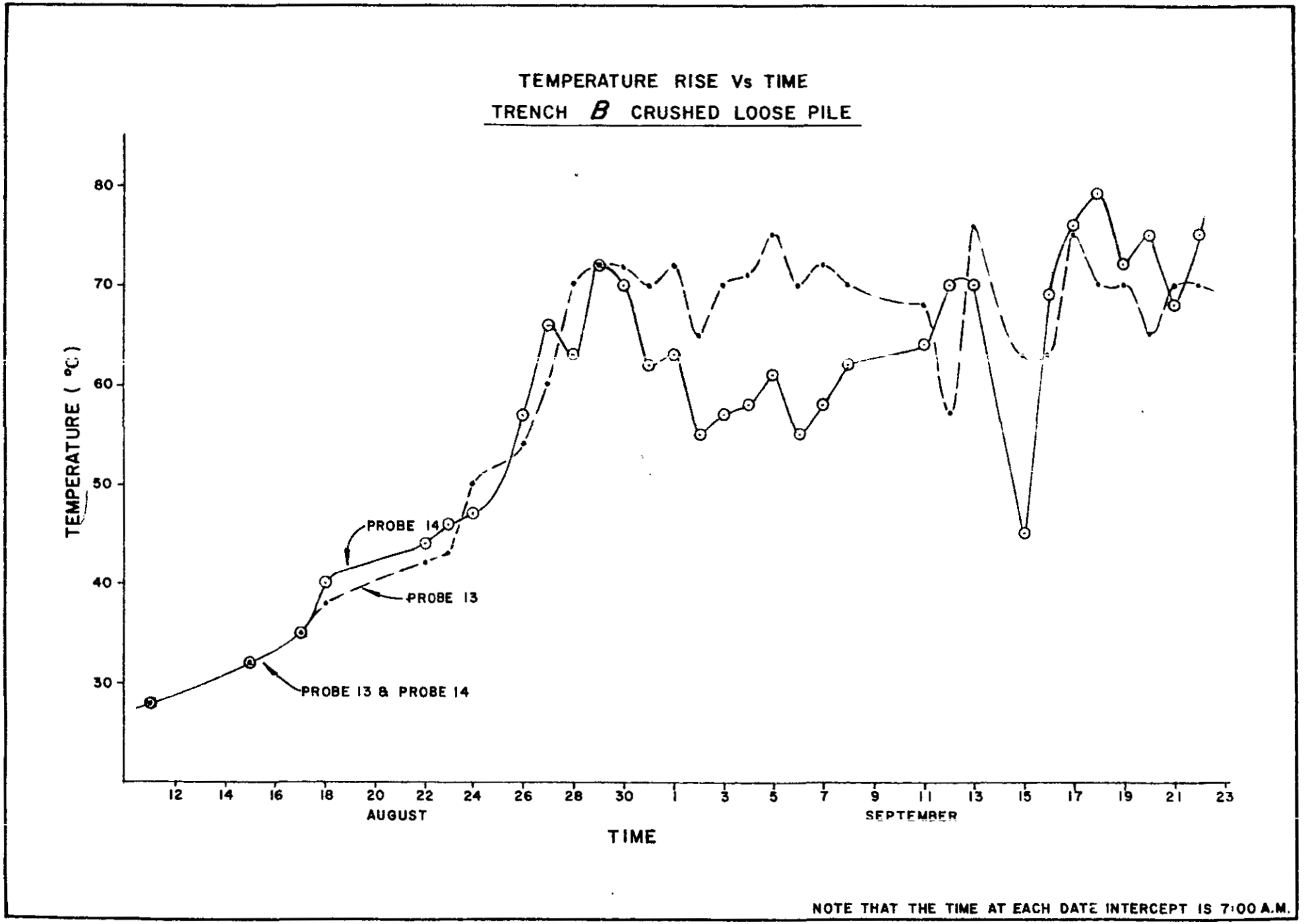
TEMPERATURE MONITORING RECORD

DATE: 24/8/77 PILE: TA Loose

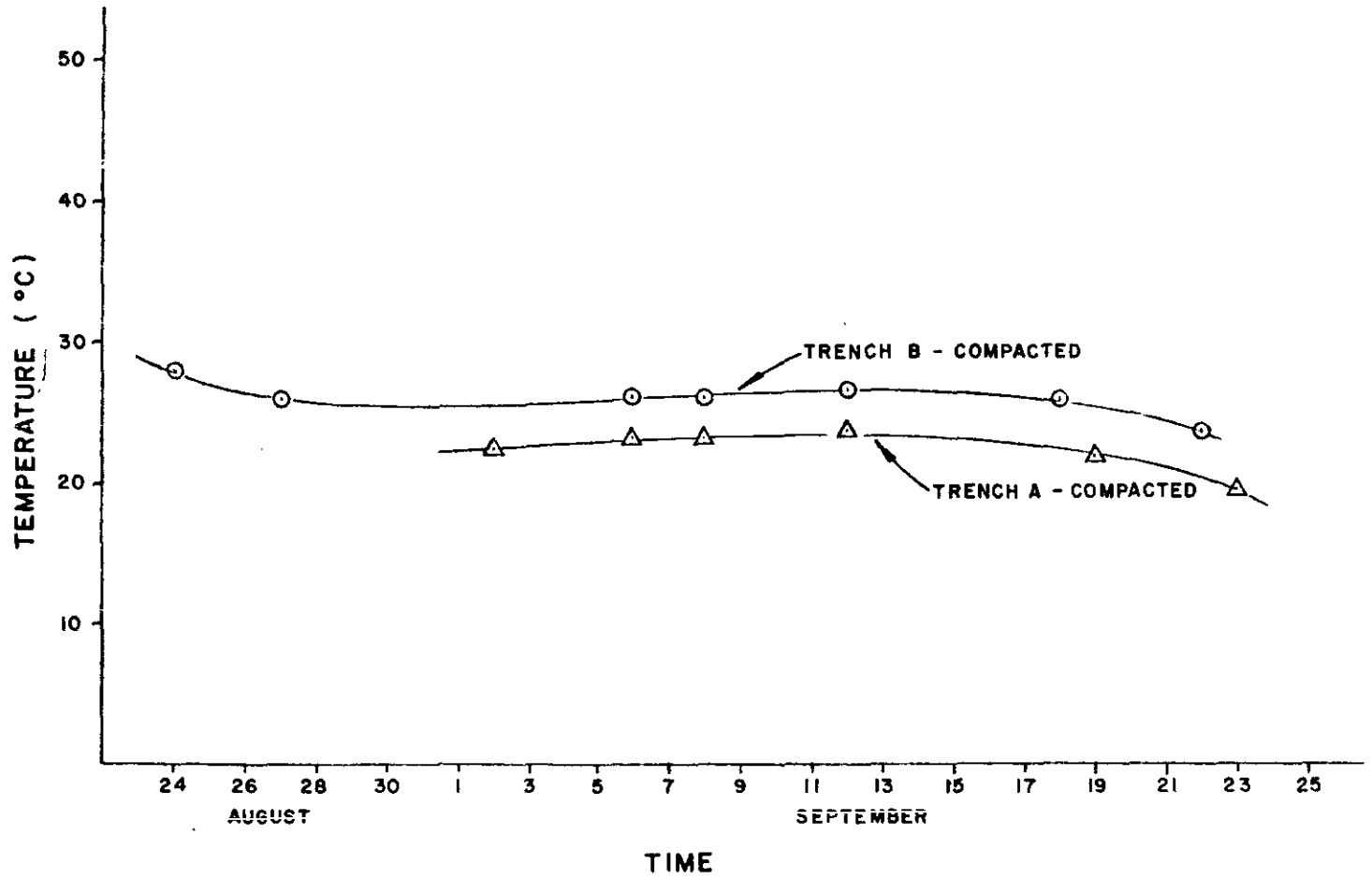
PIPE NUMBER	TIME	AMBIENT TEMPERATURE	TEMPERATURE	REMARKS
A1- 1	7:00 p.m.	15°C	43°C	Overcast, windy.
2		"	42	
3		"	45	
4		"	43	
5		"	45	
6		"	64	Vent above probe.
7		"	39	
8		"	38	
9		"	38	
10		"	54	
11		"	50	
12		"	42	
13		"	44	
14		"	38	
15		"	44	
16		"	34	
17		"	33	
18		"	36	
19		"	36	
				Some venting between 15
				and 17.
				n = 19
				$\bar{X}$ = 42.5
				SD = 7.41


TEMPERATURE RISE Vs TIME
TRENCH A CRUSHED LOOSE PILE
TEMPERATURE (°C)
80
70
60
50
40
30
PROBES 6, 10, 15
PROBES 1-19
HAD FIRST FIRE IN THE AREA ON PROBE 7 ; PROBES 6 & 7 MOVED.
HAD SECOND OCCURANCE OF FIRES
14 16 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 19 21 23
AUGUST
SEPTEMBER
TIME
NOTE THAT THE TIME AT EACH DATE INTERCEPT IS 7:00 A.M.


TEMPERATURE RISE Vs TIME
TRENCH B CRUSHED LOOSE PILE
TEMPERATURE (°C)
80
70
60
50
40
30
PROBE 17
PROBE 12 -17
PROBE 1-17
FIRST FIRE OCCURED BEFORE READINGS ON SEPT 13, 1977; PROBES 7 & 8 DISTURBED.
12
14
16
18
20
22
24
26
28
30
1
3
5
7
9
11
13
15
17
19
21
AUGUST
SEPTEMBER
TIME
NOTE THAT THE TIME AT EACH DATE INTERCEPT IS 7:00 A.M

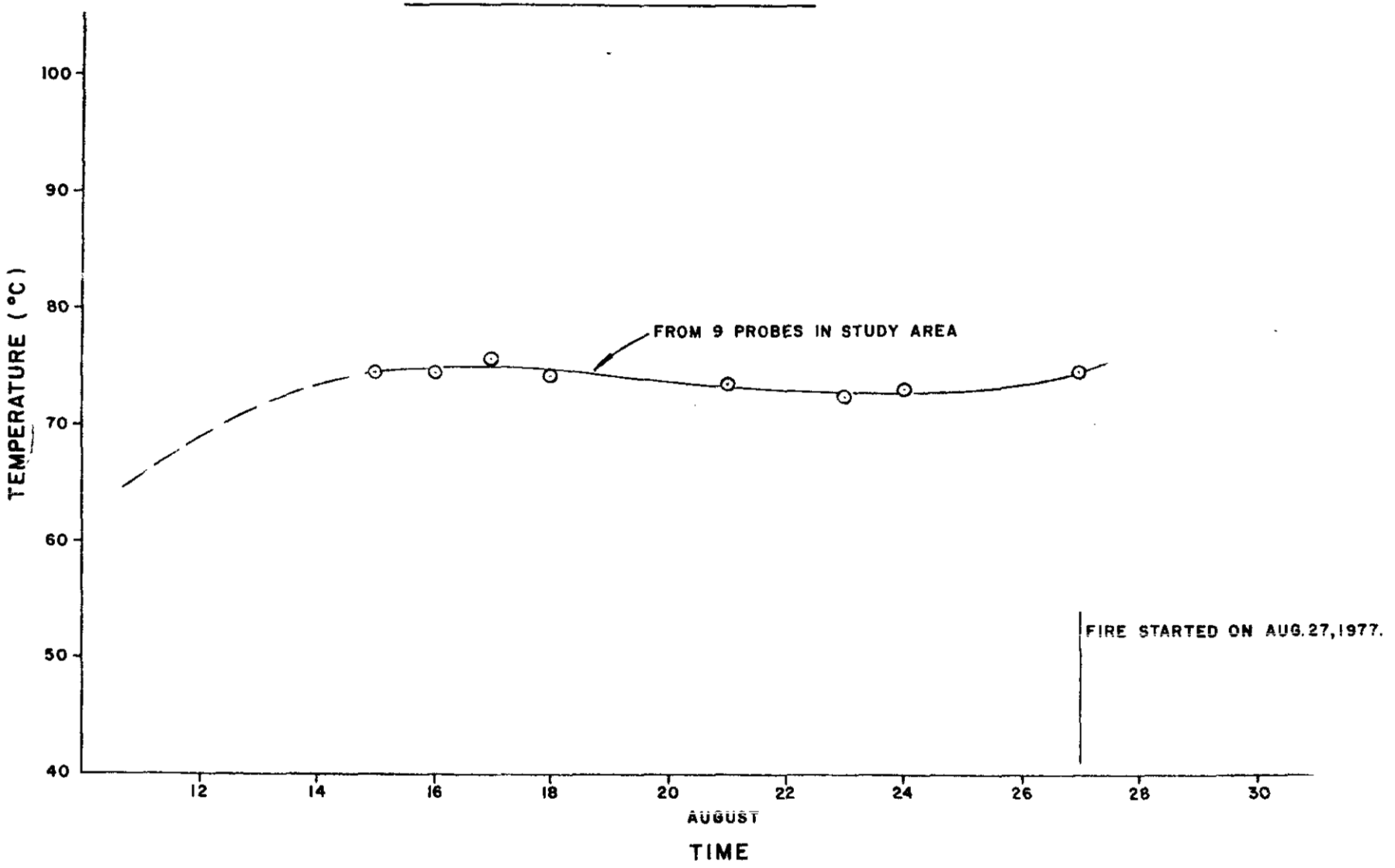

TEMPERATURE RISE Vs TIME
TRENCH B CRUSHED LOOSE PILE
TEMPERATURE (°C)
80
70
60
50
40
30
PROBE 14
PROBE 13
PROBE 13 & PROBE 14
12
14
16
18
20
22
24
26
28
30
1
3
5
7
9
11
13
15
17
19
21
23
AUGUST
SEPTEMBER
TIME
NOTE THAT THE TIME AT EACH DATE INTERCEPT IS 7:00 A.M.

TEMPERATURE RISE Vs TIME
COMPACTED COAL PILES



NOTE THAT THE TIME AT EACH DATE INTERCEPT IS 7:00 A.M.

TEMPERATURE RISE Vs TIME
HOT SPOT IN LOW GRADE PILE



NOTE THAT THE TIME AT EACH DATE INTERCEPT IS 7:00 A.M.

THE EFFECT OF AMBIENT TEMPERATURE ON COAL STOCKPILES

I) Purpose of experiment:

-to determine the effect that ambient air temperature and direct sunlight has on the temperatures of various coal and coaly waste stockpiles at different depths within the piles through a 24 hr. period.

II) Procedure:

-temperatures were measured at a particular "site" for a twenty-four hour period (Aug. 19/77).
-at each site, temperatures were taken at different depths by inserting a metal pipe into the piles and lowering a thermometer down into the probe or, in the near surface observations, the thermometer was inserted directly into the material.
-the thermometers were allowed to reach thermal equilibrium ($\sim$ 5 min) and then read.
Note: The error in measurement is:
i) $\pm$ 0.5°C for near surface temperatures
ii) $\pm$ 1.0°C for temperatures obtained from heat probes.

III) Conditions

-there was a short, but intense, rainstorm the night of the 18th.
-the day and night of the experiment was virtually cloudless.

IV) Hypothesis

-the effect of the ambient temperature fluctuations will have little direct effect on any exothermic activity occuring within the piles at depth.

V) Variables, Results, and Conclusions for Specific Sites

a) Sites 1 and 3

i) Variables:
- these sites are both fine coaly waste material with little or no exothermic activity.
-site 1 faces west (the maximum exposure to direct sunlight), and site 3 faces north (the direction of minimum exposure to sunlight).

ii) Results:
- at the 5' depth, the temperature was virtually constant for both sites.
- at the 3' depth, the temperatures increased $\sim$2°C slowly throughout the day following the ambient temperature but lagging $\sim$5 hours for both sites.
- at the 0.5' depth, the temperature was influenced significantly by the ambient temperature and, at Site 1 by sunlight.
- the increase in near surface temperature at Site 1 shows no lag to the ambient temperature increase while Site 3 exhibits a 2 hr. lag and has a much more subdued increase.

- temperatures at all depths are warmer at Site 1 than at Site 3.

iii) Conclusions:
- both ambient air temperature and direct sunlight effect the internal coaly waste pile temperatures.
- direct sunlight has a more immediate and pronounced effect on the temperatures.
- the effect of the daily fluctuation of these two variables decreases with depth.

b) Site 2

i) Variables:
- this is a low grade stockpile of uncrushed low grade coal consisting of relatively high quality "chunks" surrounded by a fine matrix of coal and clay.
- there is considerable exothermic activity occuring resulting in temperatures of approximately 75°C.
- this site is facing NW.

ii) Results:
- at the seven foot depth the temperature varies considerably with several inflection points and seems to be roughly the mirror image of the ambient temperature curve.
- at the 3' depth the temperature is relatively constant and is consistantly hotter than at 7' with a maximum occuring before the ambient maximum has been reached.
- at the 0.5' depth there was a large amount of variance which seven inflection points.
- from a low in the early morning the near surface temperature increases with the morning sunlight with a 1 hr. lag until the sunlight is no longer directly on it.
- the surface temperature drops until there are two highs in the 2 to 5 p.m. area.
- the curve then drops with the drop in ambient temp.

iii) Conclusions:
- at the 0.5' depth it appears that the ambient temperature and direct sunlight have a gross effect on the overall trend of the curve.
- the variations are explicable by:
  a) the loss of direct sunlight.
  b) venting of trapped heat and steam through the relatively impermeable damp fine material once a certain vapour pressure is reached and/or evaporation increases its permeability.
- this hypothesis is supported by the rise and subsequent fall in temperature at 7' at 2:40 p.m., followed as the heat flows upward, by a rise and fall of temperature at 3' and lastly, by a maximum temperature at the 0.5' level.

- this implies that the gas took about 2 hrs. to rise.
- early in the morning (2 a.m.) the heat is trapped at depth due to the consolidation of the top surface layer which is saturated with dew, as the surface becomes more permeable (i.e. less saturated due to evaporation), the hot gas flows upward.
- the lack of variance at 3' suggests that it is a heat reservoir that is permeable to the hot gases liberated from the active area beneath.
- thus it appears this is a cyclic process with a period of 24 hours.

c) Site 4a and 4b

i) Variables:
- both sites are in the crushed Trench A coal pile with site 4b facing west and 4a facing east.
- there are exothermic reactions taking place resulting in moderately warm temperatures (i.e. 40°C).
- the material seems to be fairly permeable to air due to the large percentage of void space.

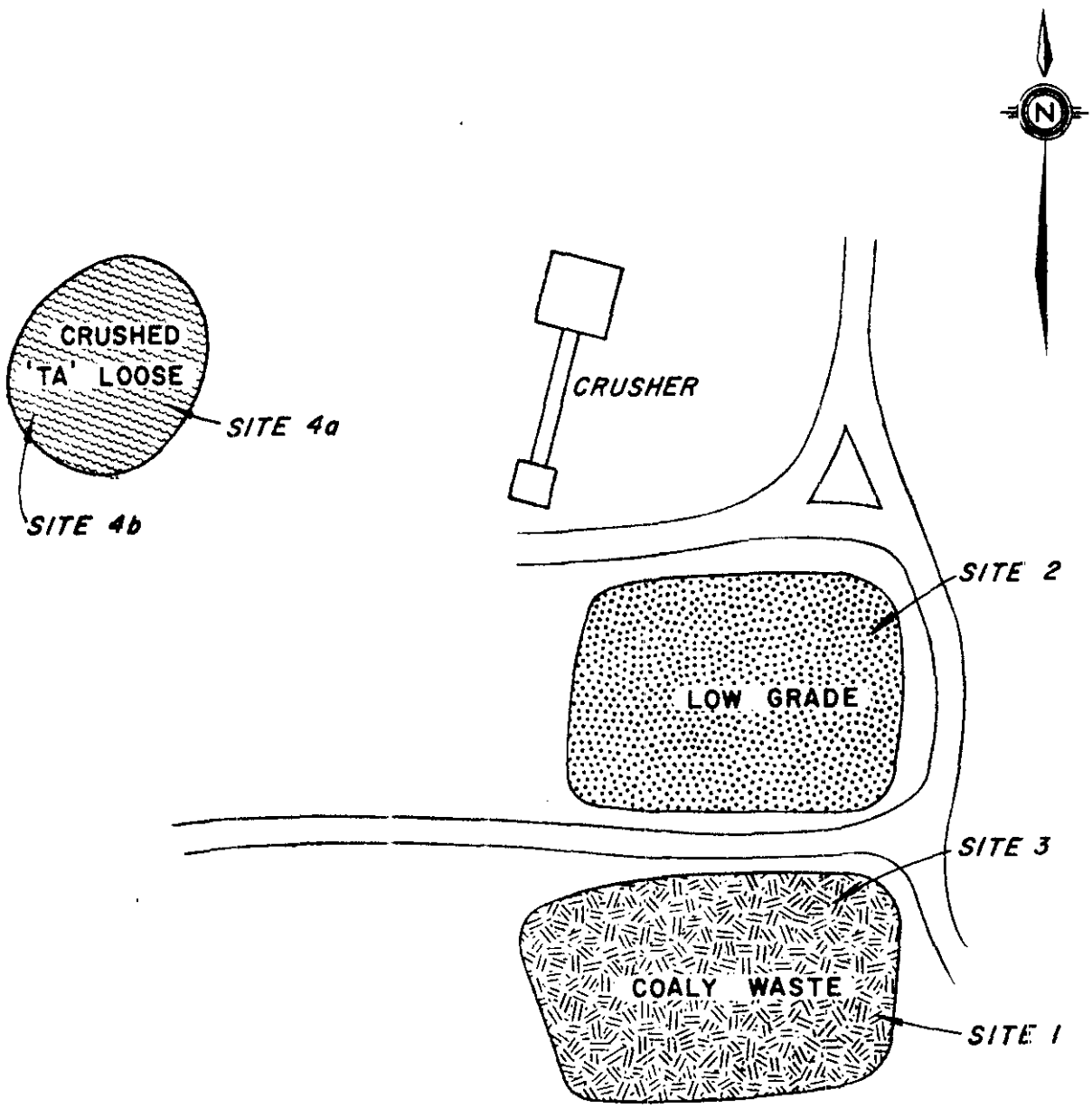
ii) Results:
- both the 3' and 0.5' probes at both sites parallel the ambient temperature to a certain degree.
- the surface of 4b is heated quickly by the direct sunlight while 4a follows a slower less intense increase.
- the 3' temperatures are variable at both sites.

iii) Conclusions:
- the ability of air to flow through the loosely compacted material accounts for the significant influence that ambient air temperature has on the piles at 0.5' and 3' depths even though exothermic reactions are taking place.

VI) General Conclusions

- fluctuations in the ambient temperature and direct sunlight have little effect on temperatures at depth.
- these fluctuations may effect the permeability of the surface material by reducing its moisture content and hence, effect the flow of heat into or out of the pile.
- in piles where heating is occurring, the main method of heat exchange is by hot gases (i.e. convection).
- the mean daily temperature (19.8°C is approximated (minus approximately 5°C) by non-heating material at depth.
- if this temperature (approx. 15°) is sufficient to initiate exothermic reactions then the mean ambient temperature will play a role in spontaneous combustion.

Prepared by Brent Noland
BN:es



REVISION	DATE	DESCRIPTION	DRWN	APP'D

British Columbia Hydro and Power Authority

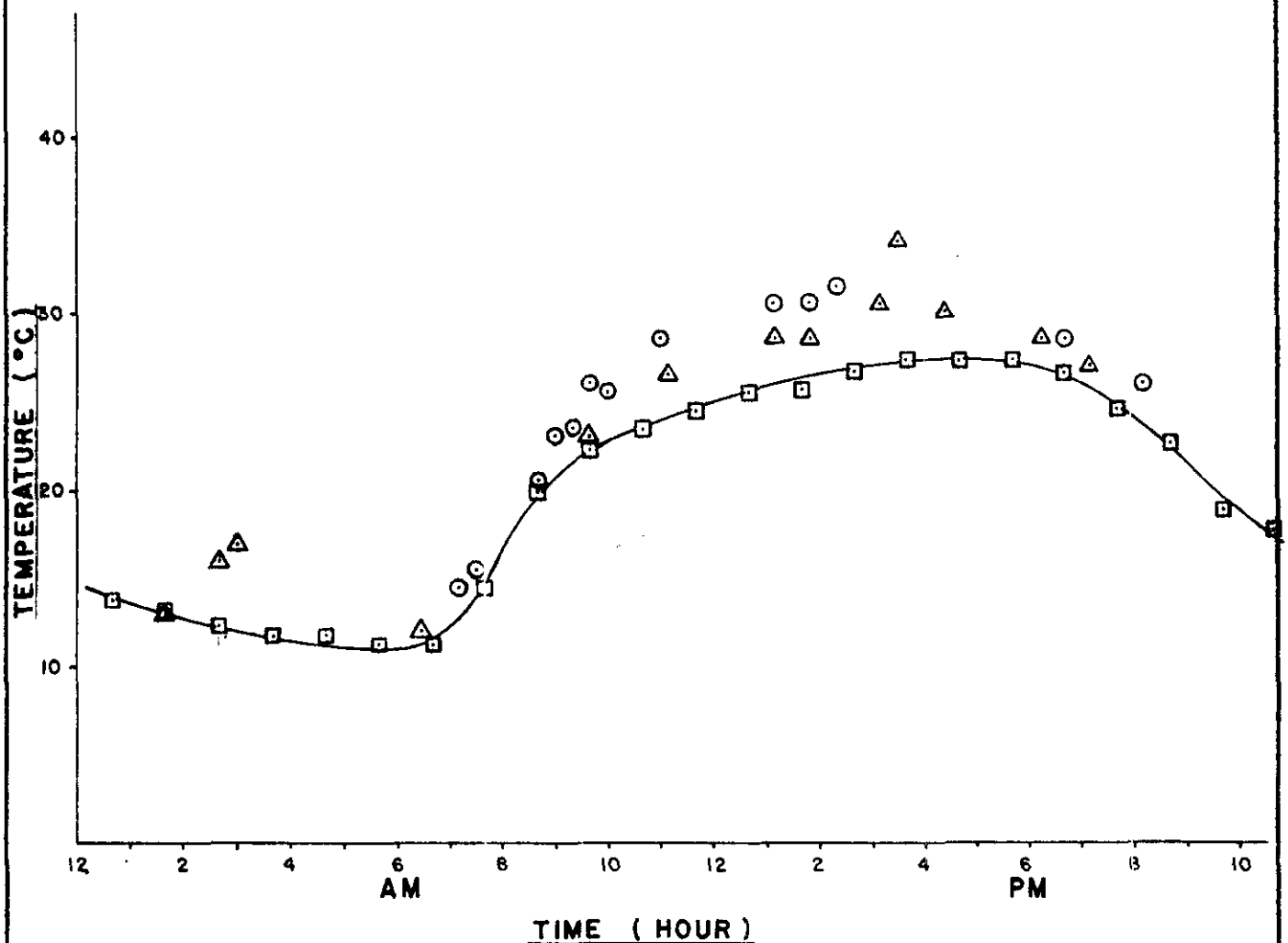
HAT CREEK PROJECT

THE EFFECT OF AMBIENT TEMP. ON COAL STOCKPILES

SITE LOCATION

DATE	APPROVED	DWG No.
1977-12-15	D.F	
DRAWN P.W.	DESIGNED	

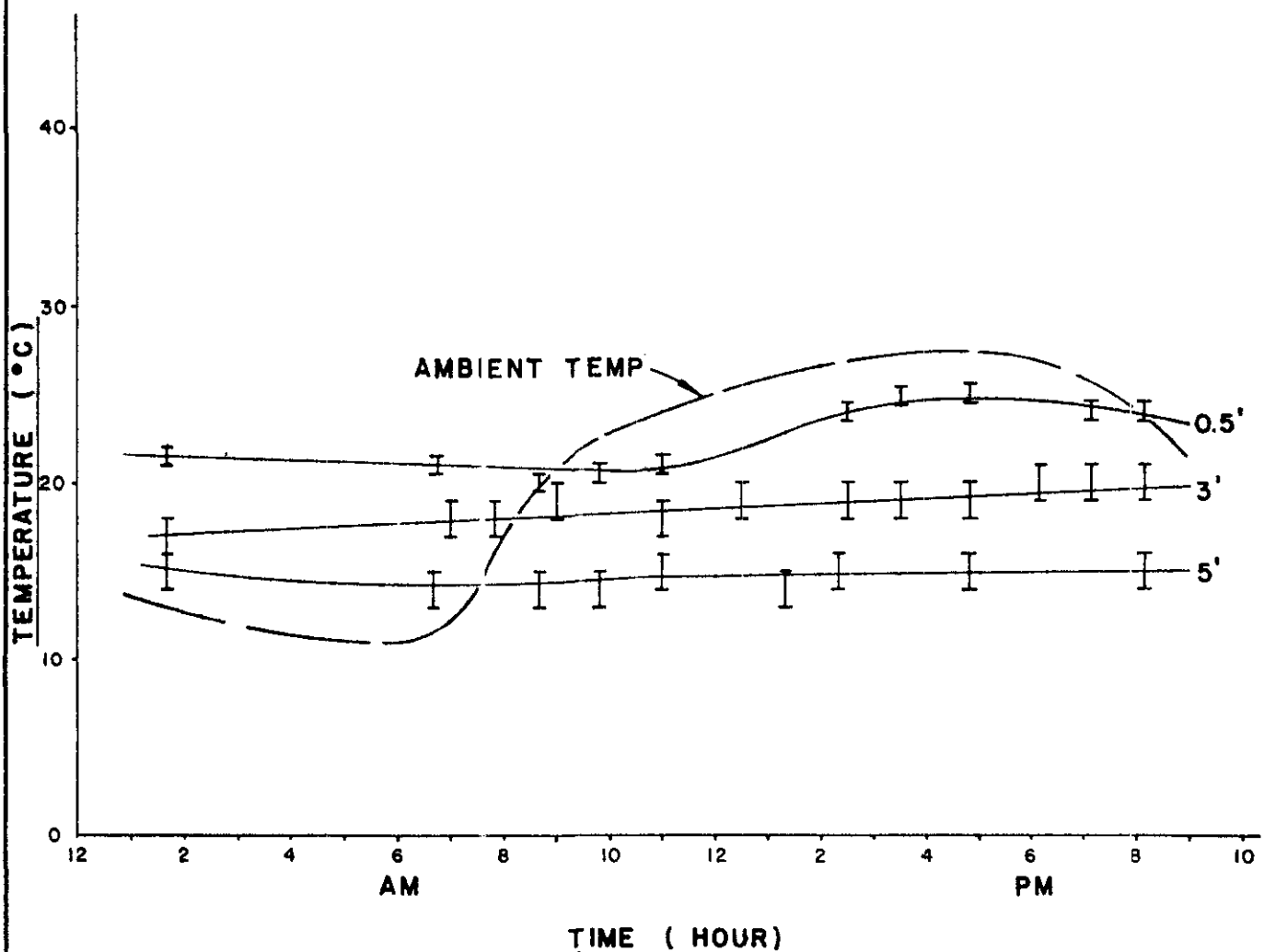
AMBIENT TEMPERATURE Vs TIME



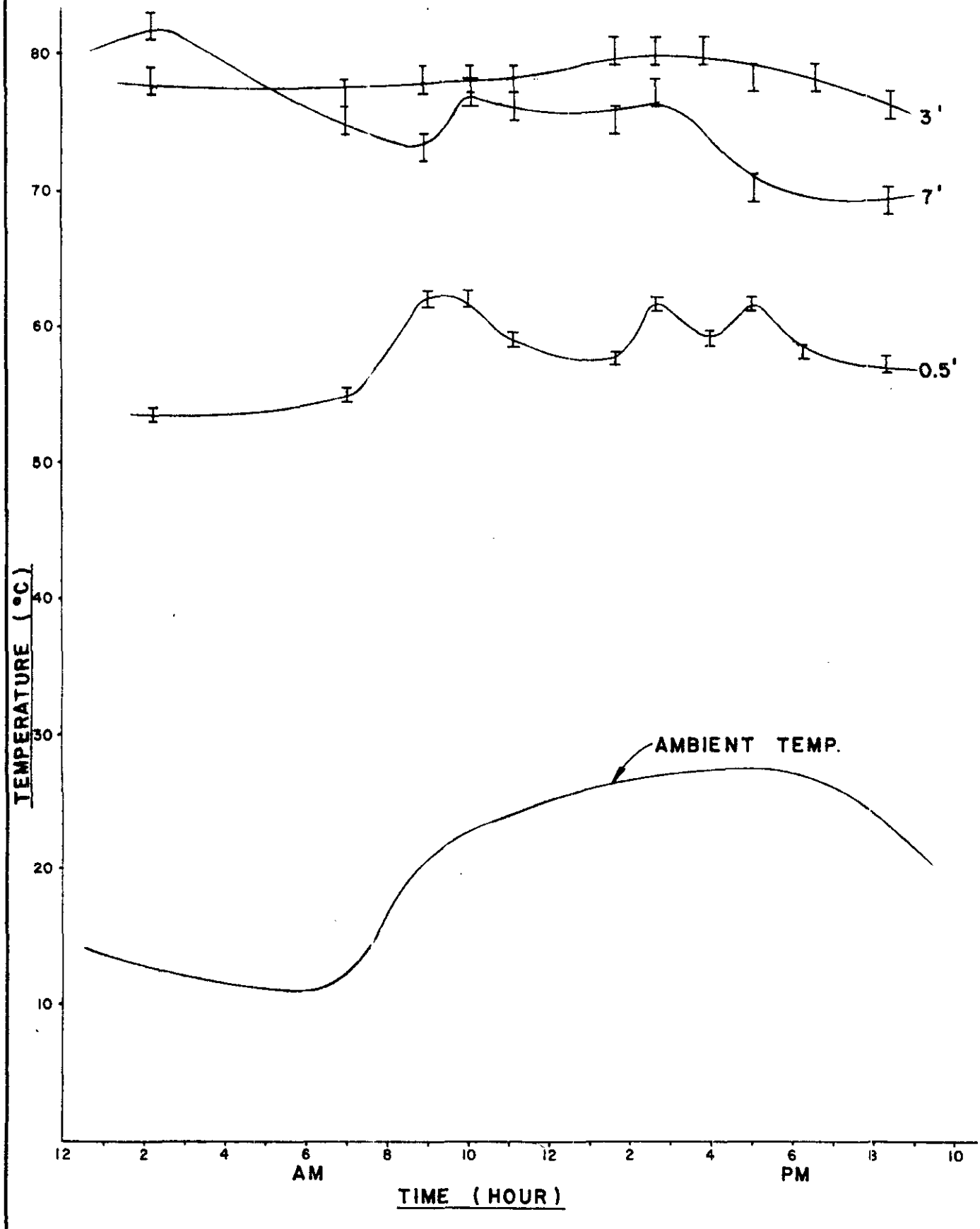
LEGEND :

- ⊙ TEMPERATURE IN DIRECT SUNLIGHT AT COAL STOCKPILE AREA.
- △ TEMPERATURE IN THE SHADE AT COAL STOCKPILE AREA.
- ⊡ TEMPERATURE AT WESTERN RESEARCH'S VALLEY WEATHER STATION (~ 3100' ELEVATION)

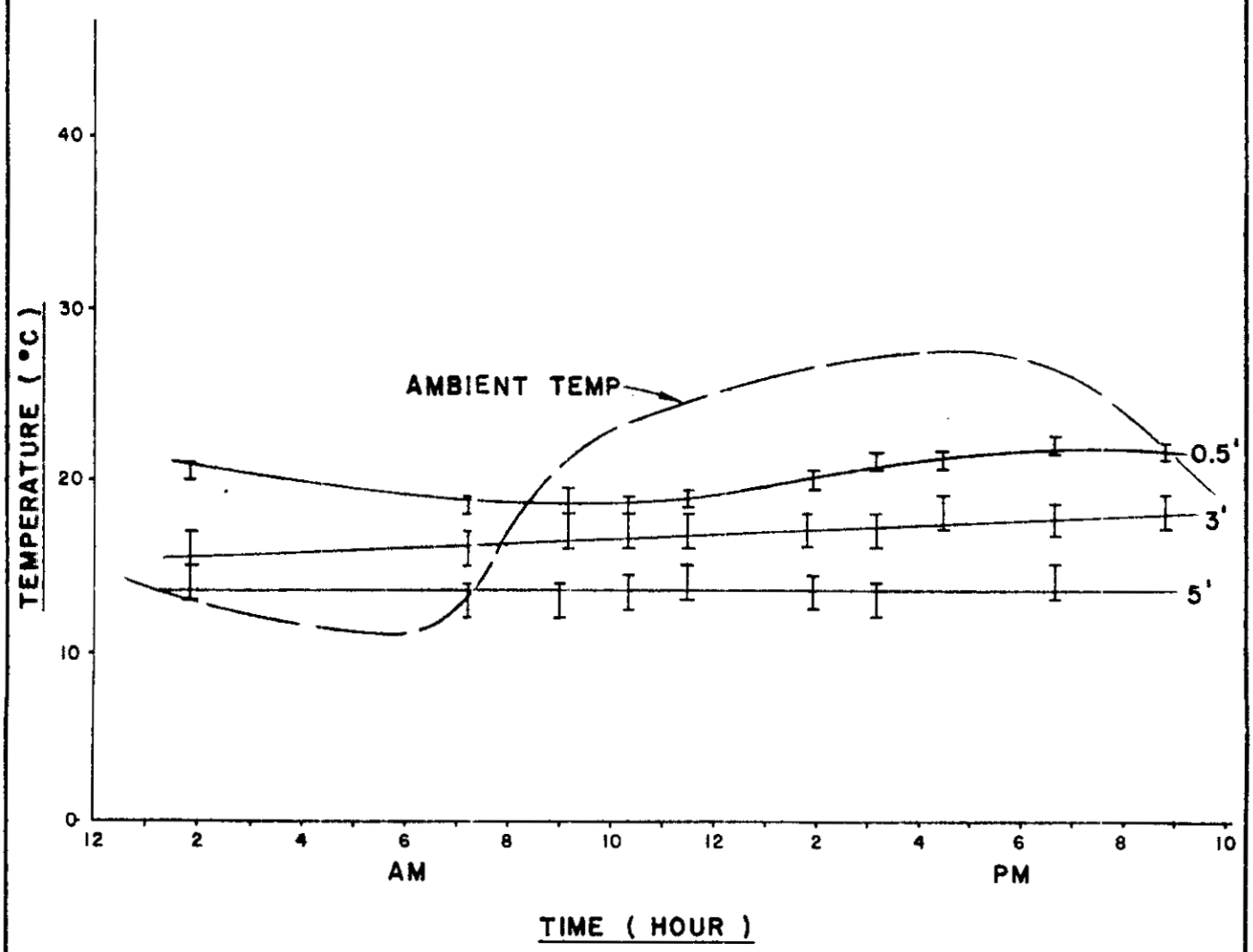
SITE I - TEMPERATURE Vs TIME



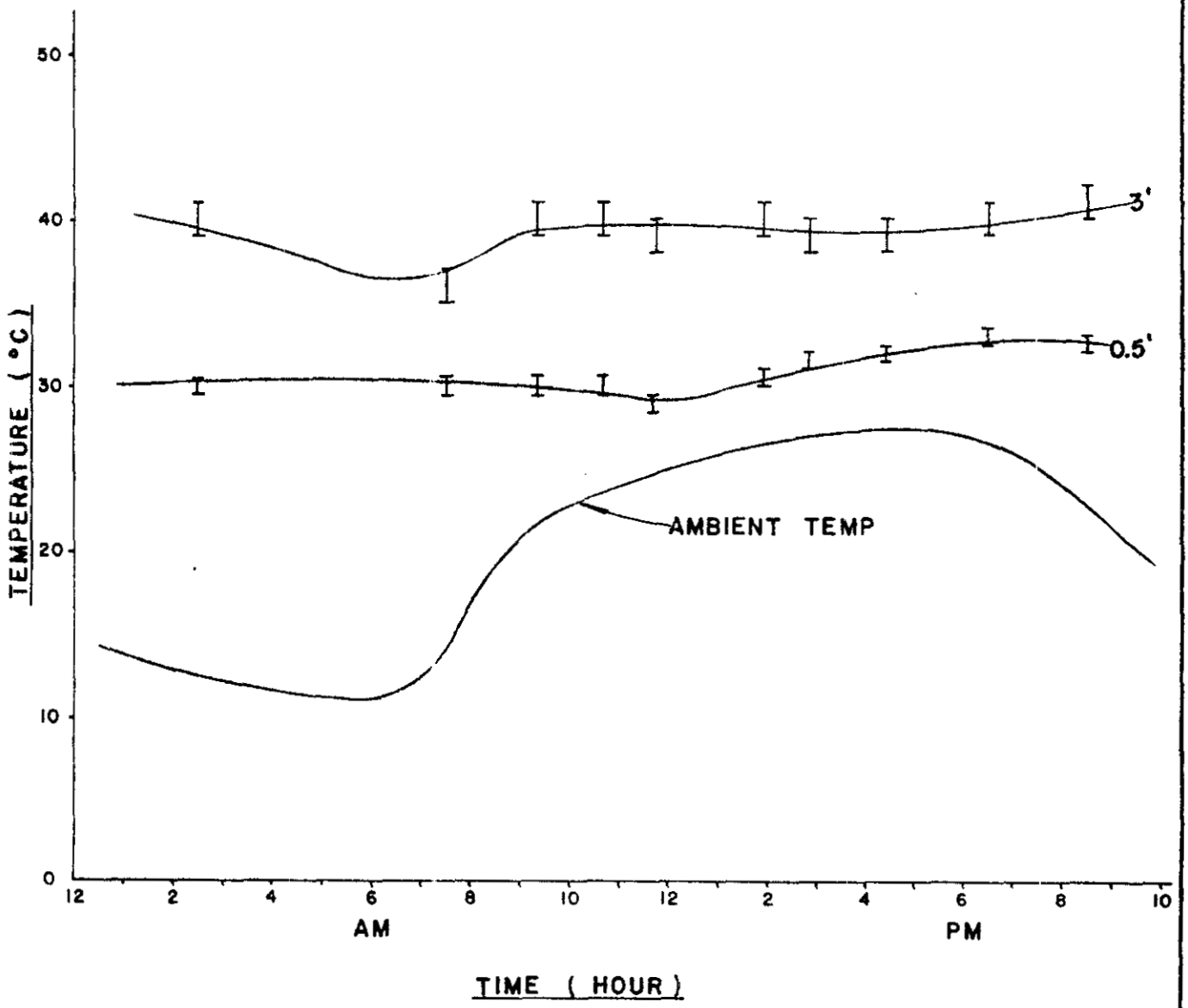
SITE 2 - TEMPERATURE Vs TIME



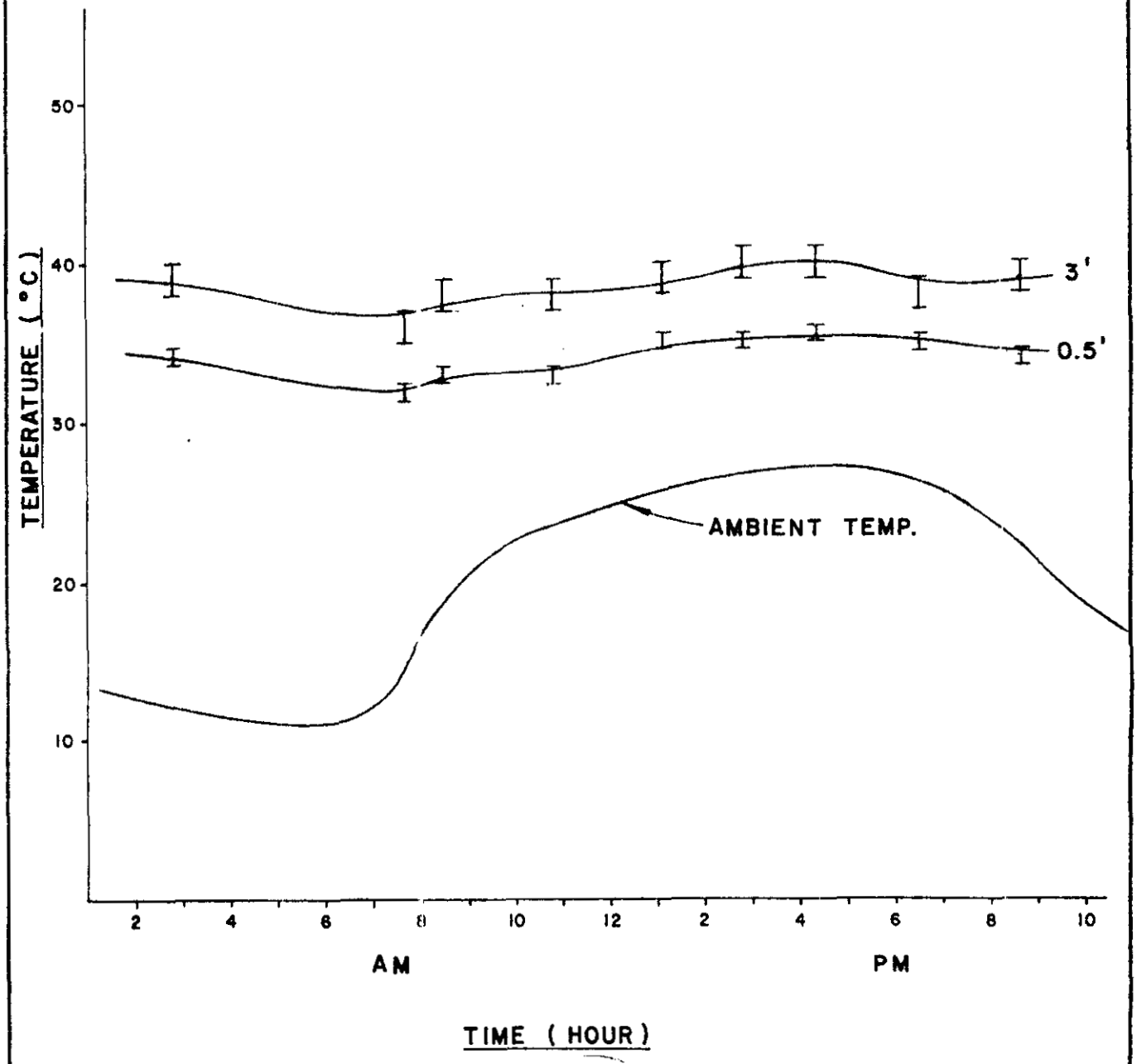
SITE 3 - TEMPERATURE Vs TIME

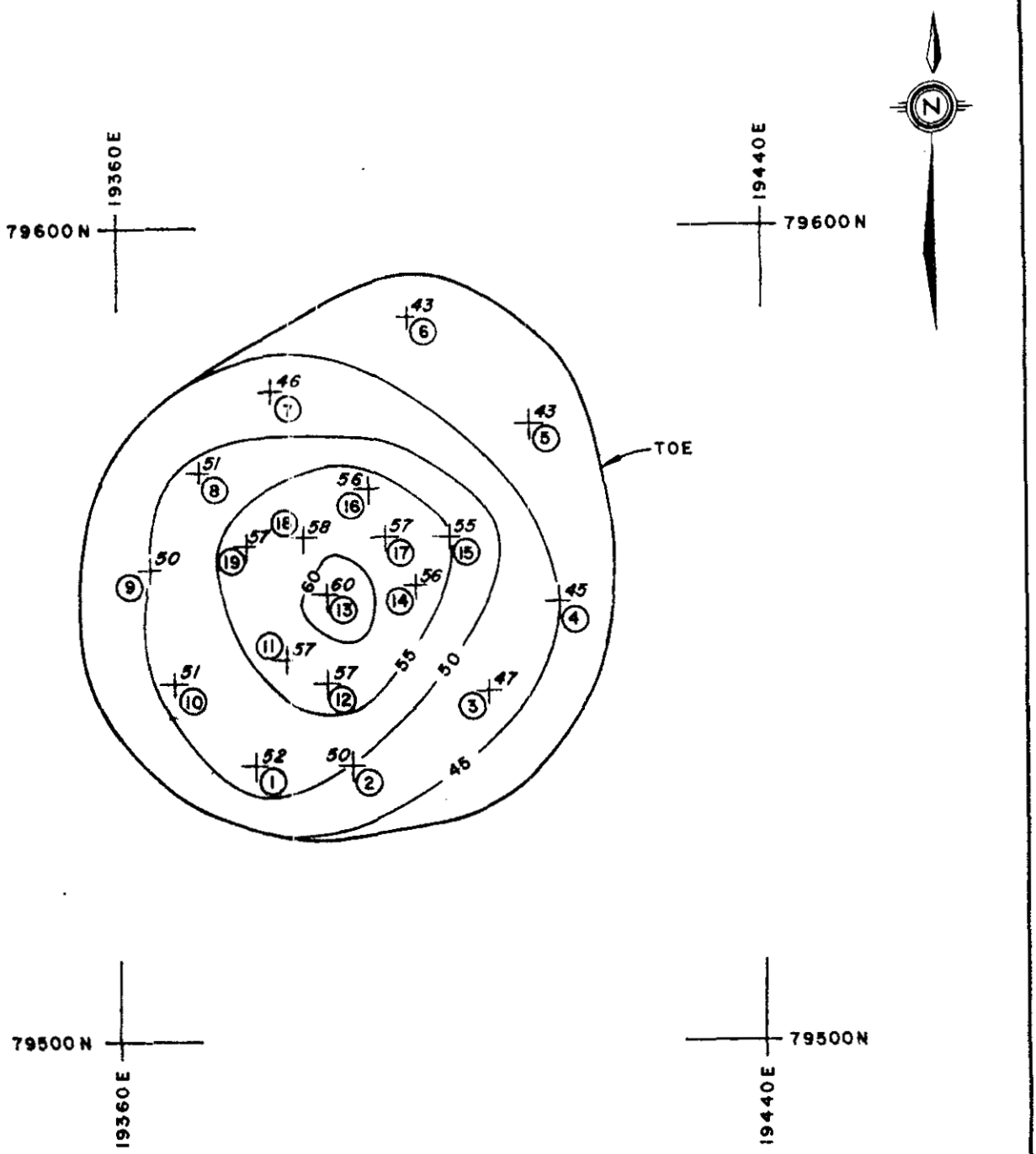


SITE 4a - TEMPERATURE Vs TIME



SITE 4b - TEMPERATURE Vs TIME





SCALE 1" = 20'

LEGEND

⑦ HEAT PROBE

56 SPOT HEIGHT

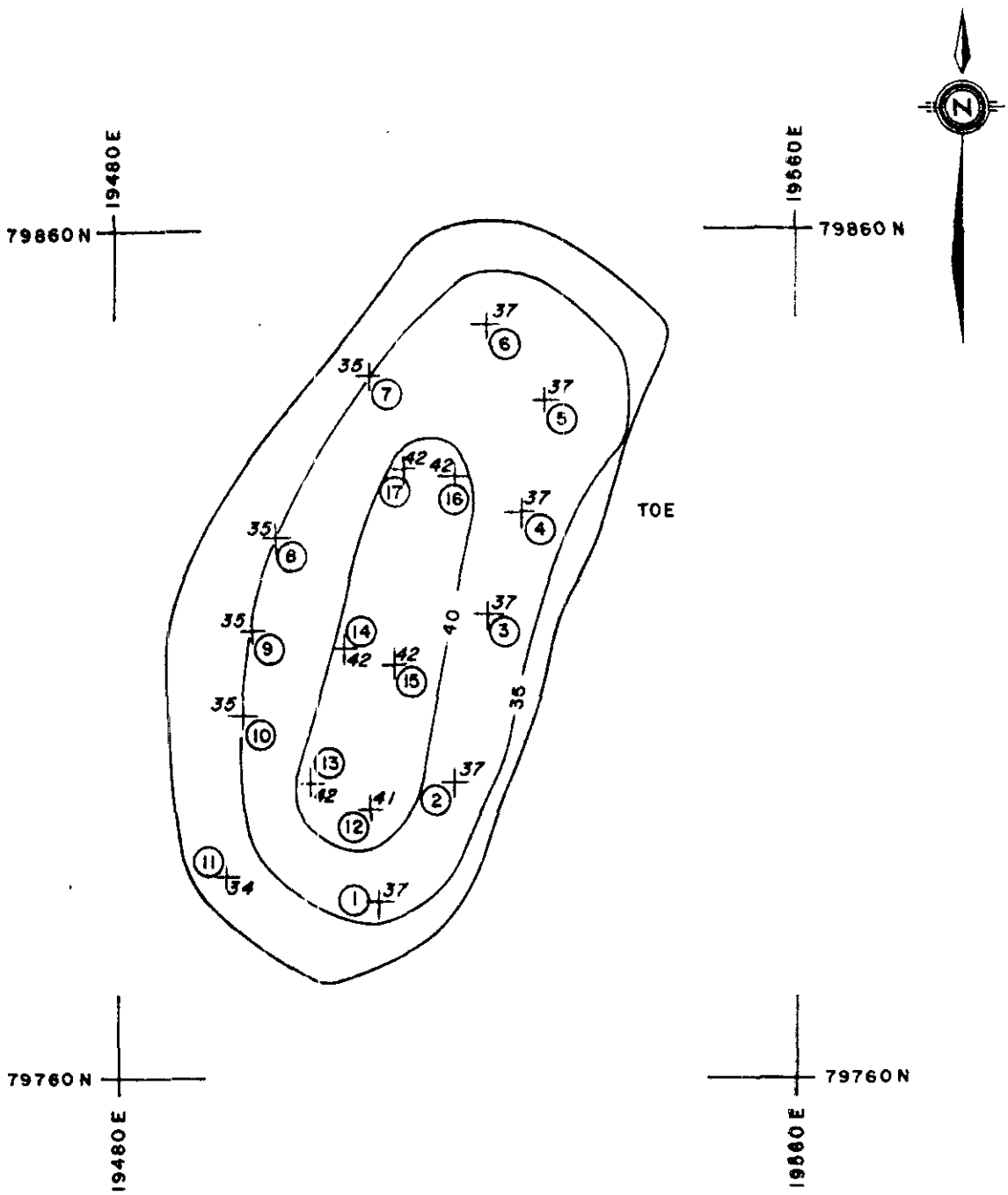
REVISION	DATE	DESCRIPTION	DRWN	APPD

British Columbia Hydro and Power Authority

HAT CREEK PROJECT

SPONTANEOUS COMBUSTION PILE
TRENCH A - CRUSHED LOOSE PILE

DATE	APPROVED	DWG No.
1977-12-15	D.F	
DRAWN P.W.	DESIGNED	



LEGEND

(7) HEAT PROBE

42 SPOT HEIGHT

REVISION	DATE	DESCRIPTION	DRWN	APPD

British Columbia Hydro and Power Authority

HAT CREEK PROJECT

SPONTANEOUS COMBUSTION PILE
TRENCH B - CRUSHED LOOSE PILE

DATE	APPROVED	DWG No.
1977-12-15	D.F	
DRAWN P.W.	DESIGNED	

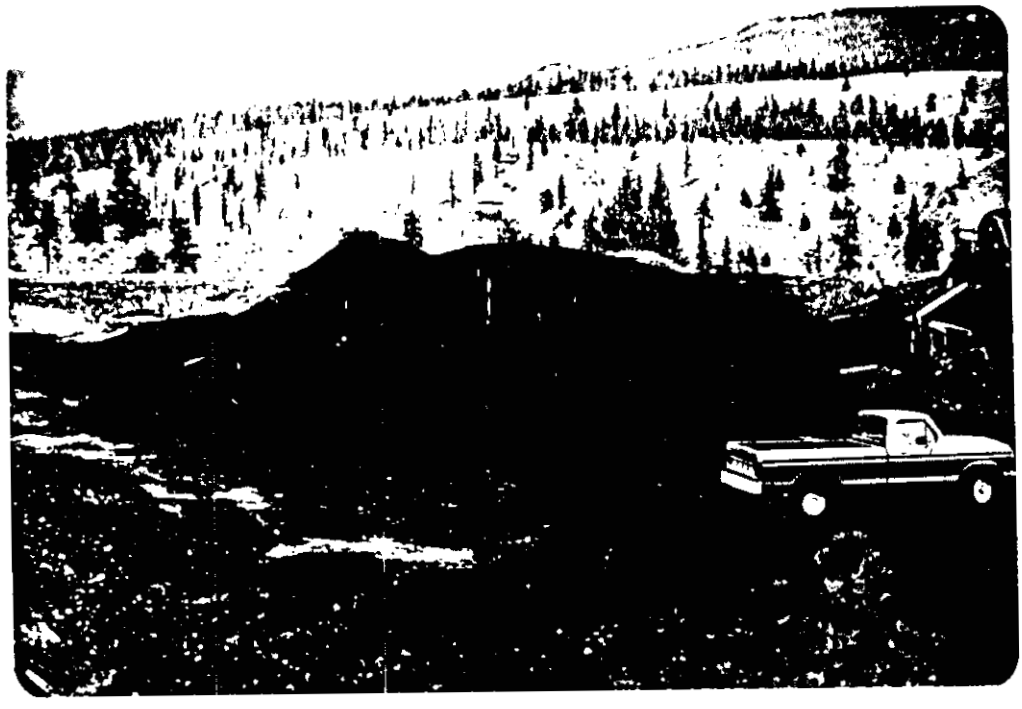
LIST OF PHOTOGRAPHS

1. Trench A loose crushed pile - foreground
   Trench B loose (left) & compacted (right)
   crushed piles - background.

2. Trench B loose crushed pile with steam and
   gases being driven off the hot areas.

3. Fire in uncrushed low grade pile.
   August 27/77

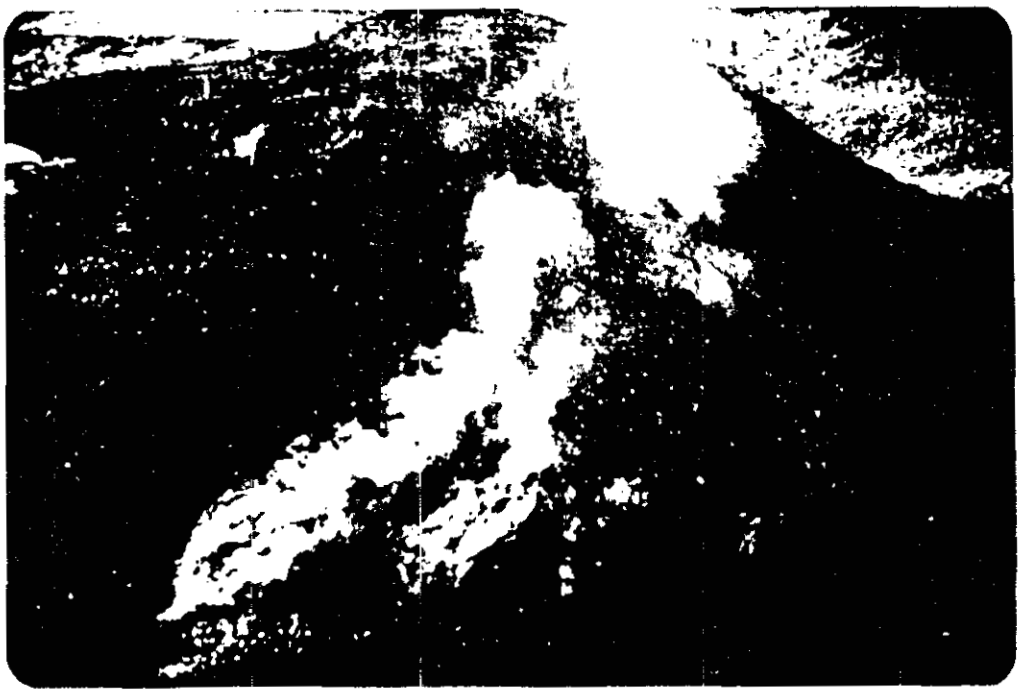
4. Fires in Trench A loose coal pile.



1. Trench A loose crushed pile - foreground
   Trench B loose (left) & compacted (right)
   crushed piles - background.

2. Trench B loose crushed pile with steam and
   gases being driven off the hot areas.

3. Fire in uncrushed low grade pile
August 27/77



4. Fires in Trench A loose coal pile.

40041

B Zone Trench D 1982

	March 1.	March 7	march 14	march 21	march 22
1	40°	37°	40°	43°	43°
2	45°	45°	45°	46°	50°
3	11°	11°	12°	21°	21°
4	14°	12°	12°	19°	20°
5	14°	15°	16°	25°	25°
6	14°	14°	14°	68°	80°
7	39°	35°	35°	75°	80°
8	35°	35°	35°	75°	80°
9	20°	21°	20°	43°	43°