



DEPARTMENT OF MINES

NEW SOUTH WALES

Reference No. C.F. 2

Bellbird Colliery

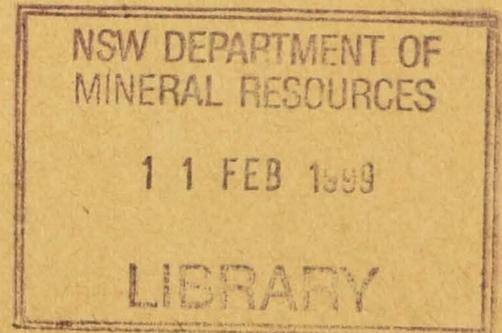
A HISTORY OF THE EVENTS LEADING TO AN
IGNITION OF INFLAMMABLE GASES DURING
THE ATTEMPTED RECOVERY OF A DISTRICT
PREVIOUSLY SEALED BECAUSE OF A
SPONTANEOUS HEATING

BY

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Bellbird Colliery

A history of the events leading to an ignition of inflammable gases during the attempted recovery of a district previously sealed because of a spontaneous heating.

By R. A. MENZIES, Inspector of Collieries

Bellbird Colliery is an extensively worked colliery about 3 miles to the South West of Cessnock in the South Maitland Coalfield. All the workings of the colliery are concentrated in the Greta Seam, which in this general area reaches its optimum development. The Greta seam in this area has, for some reason or other, also become particularly prone to the incidence of spontaneous combustion and Bellbird Colliery is well within the zone popularly known as the "firebelt".

In the 4 West and 6 West districts of Bellbird Colliery in which the events to be related took place, the coal seam is approximately 28 feet thick, but in general the coal was only won to the 18-foot parting because of the high sulphur content of the upper part of the seam. The seam dips at a rate of 1 in 9 in a south-easterly direction.

The attached plan shows the extent to which working had been carried out in the 4 West and 6 West districts of the No. 1 tunnel at the colliery.

The first workings in 4 West and 6 West districts took place in the early life of the mine and have no relation to the events under review.

At some latter stage of the colliery life, the height of the working places was increased to 18 feet and in many cases it appeared that robbing of the pillars took place as the roadways were extremely wide.

About the year 1948, a spontaneous heating was detected in a fall in the bottom level of 6 West district in the approximate position shown on the plan. This heating was contained by the sealing of the entire area comprising 4 West and 6 West districts.

At a later date the area contained within the fire seals was reduced to the two lowermost levels and the area within the faulted zone by the erection of a series of seals between the second bottom level and the one above.

Still later, and before pillar extraction commenced, the whole of 4 West and 6 West districts was again sealed for preservation.

In 1958, 4 West and 6 West districts were re-opened and pillar extraction commenced by hand mining methods.

In March of 1958, some twelve or thirteen pillars of coal were recovered by an operation which resulted in the containing of the original heating on 6 West level by the seals along the line HH shown on the plan.

This recovery operation was completed in 24 hours but notwithstanding the rapidity of the operation the heating was "smoking heavily" within 24 hours, this occurring after the area had been sealed for over 10 years.

Depillaring continued in the area until June, 1959, when a heating was detected in the section and it appeared that the heating was centred in the area indicated on the plan. Unsuccessful attempts were made to isolate this heating and finally the whole area was sealed in July, 1959. This sealing was effected by the line of seals on the inbye side of the West Return (*see* plan) and numbered 1 to 14. Here the position rested until January, 1961, when the area had been closed for some 18 months.

Pipes for withdrawing atmospheric samples were left in seals 1 and 13, and throughout this report samples withdrawn from No. 1 seal will be referred to as 4 West samples, and those from No. 13 seal as 6 West samples.

On the 27th January, 1961, I was served with a notice under Section 37A of the Coal Mines Regulation Act, 1912-60, stating that it was intended to re-enter the area of 4 West and 6 West districts on the 31st January, 1961. The notice also informed me that the writer was "of the opinion that the whole of this work can be conducted under fresh air conditions".

Analyses of two samples taken from the No. 1 seal or 4 West area on the 25th January, 1961, were also appended to this notice and were as follows:—

				<i>No. 1 Sample</i>	<i>No. 2 Sample</i>
CO ₂	..	..	..	3.89 per cent.	3.97 per cent.
O ₂	..	..	..	8.92 per cent.	8.94 per cent.
CO	..	..	..	0.0009 per cent.	0.0012 per cent.
CH ₄	..	..	..	Nil	Nil
N ₂	..	..	..	87.19 per cent.	87.09 per cent.
CO/O ₂ ratio	..	..	..	0.006	0.008

These analyses appeared to indicate that the heating activity had reached a very low ebb and consequently no objections were made to the proposed re-entry and exploration under fresh air conditions.

On the afternoon of the 30th January, 1961, the seals No. 1 and No. 7 were broken to allow fresh air to enter the district by No. 7 seal and leave by No. 1. It is now apparent that too little thought was given to considering the direction in which such air would flow.

When the seals were broken, air immediately coursed through the area and patrols outside the area during the following shift gave no indication of anything untoward happening within the area.

On the morning of the 31st January, 1961, when preparations were being made to re-enter the area, it was discovered that smoke was backing up along the level in which No. 7 seal was located. The area was immediately resealed without incident.

During the following week an air-lock was built at No. 7 seal and preparations made for an inspection to be made by a team wearing self-contained breathing apparatus and this inspection was ultimately made on 11th February, 1961.

The exploration indicated that the air when entering at No. 7 seal had presumably travelled along the level from No. 7 seal, in along No. 11 level or bord, through holes in stoppings at X, Y and Z, over the goaf in which the heating was assumed to exist and from there by devious means to the seal No. 1 at No. 1 level or bord.

After the inspection by the team wearing the self-contained breathing apparatus, it was decided that the next step would be to close the holes in stoppings X, Y and Z, and as this was to be done in fresh-air conditions, a breach would have to be made in the stopping at A to allow the air current to pass to the return.

The breach in the stopping at A was made by the team wearing breathing apparatus and the holes in those at X, Y and Z were bricked up by men working under fresh-air conditions. When the stoppings had been completed, an attempt was made to explore the area to the rise side of No. 11 level through the breach in stopping A, but this proved abortive due to the presence of an extinctive atmosphere as soon as one passed through the hole at A.

An inspection by a team wearing self-contained breathing apparatus on 13th February, 1961, penetrated along No. 11 bord to A, through A and along No. 10 bord on top of the goaf falls. This inspection appeared to show that the only open connection between the area above No. 11 bord (4 West) and the area below No. 11 bord (6 West) was approximately 12 yards wide and 2 to 4 feet high. It appeared at this time that it might be possible to complete a line of temporary seals along the line B, B¹, B², B³, shown by broken line on the attached plan.

On 25th February, 1961, an inspection made under fresh-air conditions tended to substantiate this belief and arrangements were made to erect temporary seals where required along this line. To this end brattice, sand bags, etc., were brought as far as possible into the area under fresh-air conditions.

On the following week-end work commenced on this operation but before long it became apparent that this was doomed to failure and alterations were made in the plan and it was decided to attempt the temporary sealing along the line shown by C, C¹, C², C³, C⁴ and C⁵ shown by dotted line on the attached plan.

During this week-end and others subsequent to this, work carried on in pursuance of this object and in the main this work consisted of directing air to the position required and then erecting temporary seals with the use of pack walls 4 to 6 feet thick, placed on top of falls of stone. The bulk of this work was concentrated in the area between C, C¹ and C².

Although conditions were oppressive and small quantities of CO were present, no undue difficulty was experienced until position L on line CC¹ was reached. It was apparent that this was acting as the main return from that area in which the heating existed. At position L it became obvious that a seal could not be erected in fresh-air conditions.

Up to this time work had proceeded on the erection of brattice ventilation stoppings from A, to direct as much air as possible to the positions where it was required and finally a line of brattice stoppings, some of which were cement washed, was erected to direct all the air to position L. This line of brattice stoppings is shown by the conventional symbol " S " on the plan.

On the 18th March, 1961, twenty-four men capable of wearing self-contained breathing apparatus and adequate numbers of men operating at the fresh-air base attempted to plug this return but chiefly due to high temperature and humidity affecting the work output of men wearing the apparatus, the attempt failed. At this time and place the CO concentration was 0.1 per cent. and the dry and wet bulb temperatures exceeded 93° F. and 92° F. respectively.

As a result of this failure it became obvious that some other means must be found to complete the line of temporary seals and finally it was decided that 6-inch diameter boreholes should be drilled from the surface to the site of the seal and these boreholes used initially to drop sealing material and then used as vent tubes through which air could be forced to the workmen who were placing the material already dropped, in position.

With this end in view the district was again sealed outbye and preparations made to drill the holes, the first of which was completed on the 23rd April, and finally, on the 29th April, five holes had been completed, three of which were in a position to be used pursuant to the objective outlined in the previous paragraph. The position of these five holes is shown by crosses on the plan and the three used in the next operation are numbered 3, 4 and 5.

On the 29th April, 1961, the area was re-opened and an inspection made to determine the exact position of the boreholes. Attempts were also made to take some working tools near to the bottom of the boreholes and at this time two men including an overman, were overcome by Carbon Monoxide by attempting to travel too fast and consequently over-reaching both themselves and the prudence necessary in such conditions. Fortunately neither were seriously affected and both rapidly recovered after the administration of Oxygen from Novitas which were always kept close at hand during the whole of this attempted recovery.

The area was again sealed.

On the 6th May, 1961, the site of boreholes 3, 4 and 5 was reached. Using the boreholes as specified above, work continued on the 6th, 11th, 13th and 17th May with the erection of the seal L and on the last date mentioned, the 17th May, 1961, the seal was completed and was effective to such a degree that the area was left open.

On the 18th May, 1961, the whole of the section on the outside or 4 West side of the dotted line shown on the plan with the exception of No. 1 bord or return was accessible under fresh-air conditions.

During the period the 18th May to the 10th June, 1961, the section remained open during which time some 10,000 to 12,000 cubic feet of air per minute circulated through the area. During this period work was also concentrated on strengthening the temporary seals by doubling up the pack walls and sealing up crevices with loam and ashes which were sent down further boreholes which had been drilled.

Attempts had been made to take samples from a pipe which had been left in stopping Y, but as this stopping was intaking, this proved useless. On the 30th May, 1961, a sample taken in the No. 1 bord return at point "D" gave the following analysis:—

CO ₂	..	..	..	1.08 per cent.
O ₂	..	..	..	18.74 per cent.
CH ₄	..	..	..	0.05 per cent.
H ₂	..	..	..	0.16 per cent.
CO	..	..	..	0.093 per cent.
N ₂	..	..	..	79.78 per cent.
CO/O ₂ ratio	..	..	..	3.9

This analysis, whilst anything but promising, did not indicate any other danger than that to be met with from CO. The small percentages of CH₄ and H₂ did indicate however that Oxygen was reaching the seat of the heating and that distillation was taking place.

At the position this sample was taken, the conditions were humid and hazy, but the fire smell was not particularly strong. It is worthy of note that at this position the P.S. Carbon Monoxide detector gave a reading of 0.1 per cent., whilst the analysis of the atmosphere gave CO as 0.093 per cent.

The seal at L, whilst appearing to be controlling the position, was still relatively weak and in order to strengthen this seal it was decided to sink another borehole to allow loam and ashes to be placed in a more convenient position than was possible with any of the boreholes 3, 4 and 5. It was also decided to place a further two boreholes at the next two seals towards C¹. The latter two boreholes were in a favourable position, but that at L went off line and struck the seal which it partially destroyed.

The area had now been open continuously for approximately four weeks, but as labour was scarce it was decided to reseal until this was more readily available. This labour became available and the seal was replaced on the 19th June, after three days' work.

On the 20th June, a sample taken in the return airway at the same place as that taken on the 30th May gave the following analysis:—

CO ₂	..	..	..	0·81 per cent.
O ₂	..	..	..	19·21 per cent.
CH ₄	..	..	..	0·16 per cent.
CO	..	..	..	0·0918 per cent.
N ₂	..	..	..	79·73 per cent.
CO/O ₂ ratio	..	..	..	4·86

This seemed to indicate a worsening of the position and this was borne out by traces of smoke being detected coming through breaks in the rock rib at point E on the plan.

An investigation at this point indicated that what had been thought to be a normal cut-through driven to the 8-foot parting was, in fact, a cut-through opened to the 18-foot parting and what was thought to be a solid rock rib was, in fact, a mere shell. When this shell was broken smoke poured from the area.

Attempts were made to strengthen this shell but the emission of smoke became so massive that a halt had to be called to the operation. All men were withdrawn from the whole area and the area once again sealed.

As some measure of success had been achieved by using boreholes, it was decided that a borehole should be drilled from the surface so that sealing material could be dropped to a convenient position for sealing this breach in the 6 West sealed area.

This borehole was completed on the 28th June, and in order to fix its position the area was re-opened to fresh air for about 1½ hours and during this short period large volumes of smoke were being given off through the break revealed on the 21st as a result of which the area was resealed.

About 12 yards of ashes and loam were dropped down the drill hole and on the morning of the 1st July, the area was again re-opened to pass fresh air. About 1½ hours after the re-opening men were engaged in building a four-foot thick wall of ashes and loam against the pack wall from which smoke was issuing.

The P.S. detector used at this time showed that only traces of CO were present in the atmosphere where the men were working and no traces could be found of CH₄ by the methods available at that time and place.

An attempted exploration of the 4 West area at 9 o'clock on that morning was impossible because of large quantities of smoke in the general atmosphere of the section.

Work continued throughout the day and at 4 p.m. the amount of smoke issuing had been reduced to a trickle and neither noxious nor inflammable gases could be detected issuing from the seal. An exploration of the 4 West area at this time indicated that the smoke which had been present some hours earlier had been almost entirely cleared out and the atmosphere was gradually clearing up.

Work continued on increasing the thickness of this seal and ramming the loam tightly to attempt to form a completely effective seal until about 8 o'clock that evening whilst some men, including an overman and a deputy, were still at work, tongues of blue flame were seen emanating from the seal near the roof.

This flame was accompanied by neither sound nor violence and in fact had the flame not been seen, the men concerned stated that they would not have been aware of the incident. It may be, however, that any sound which was generated may have been covered by the sound of material which was still being dropped down the borehole.

When the workmen had withdrawn from the seal the overman returned to the position to gather up the tools and as he did so he was aware of flames issuing from the floor. Once again these flames were pale blue in colour and transient in nature.

At this time and for the whole of the period in which the men were employed at this seal, the quantity of air passing the outside of the seal whilst not accurately measured at any time could not have been less than 8,000 to 10,000 cubic feet per minute.

There appears little doubt that the flames which were seen were caused by the ignition of inflammable gas (possibly methane) within the sealed area and that the flames passed through the seal and were finally extinguished when the fuel supply was diluted as the inflammable gases passed through the seal.

Some theories were put forward as to the cause of the ignition but there is little doubt in my mind that the ignition was a result of a sequence of events which may be summarised as follows:—

- (a) The heating which caused the original sealing in 1959 had been revived more or less continuously although possibly at a low rate from the first re-opening on the 31st January, 1961.
- (b) When the area was resealed on the 21st June, 1961, as a result of the massive production of smoke the heating was in an active stage.
- (c) When the area was re-opened on the 1st July, 1961, this active fire was immediately revived and commenced to distil inflammable gases.
- (d) As the sealing at E became more effective these gases were retained within the area until the build up was sufficient to allow them to be ignited by the hot material at the seat of the fire.
- (e) That build up was insufficient to allow an explosive mixture to be produced was in my opinion most fortunate and the fact that the percentage of extinctive gases may have been sufficient to quell the violence even more fortunate.

The area was completely resealed at 11 p.m. on the 1st July, 1961, and has remained so since.

The first sample from the sealed area to be analysed was taken on 5th July, 1961, and gave the following results:—

CO ₂	..	..	..	6.37 per cent.
O ₂	..	..	..	6.91 per cent.
CO	..	..	..	0.891 per cent.
CH ₄	..	..	..	1.43 per cent.
N ₂	..	..	..	84.37 per cent.
CO/O ₂ ratio	..	..	..	5.78

Samples for analysis have been taken regularly from within the area at No. 1 (4 West) and No. 13 (6 West) seals and these together with the relevant analyses are shown in attached appendix (1) and (2).

Although there have been reliable indications that ignitions have occurred in the past when certain heatings were being sealed at this colliery, this is only the second time that flame was actually seen by personnel, the first occasion being reported by a deputy during sealing operations in 10 East on 3rd March, 1956. This clearly points out the possibility of a violent explosive mixture being produced within such an area in this colliery immediately after sealing and it is only too obvious what the result would be on the seals used in this colliery and the probable effect on the ventilation arrangements if such a mixture was ignited.

The analyses shown on the attached appendices indicate that although the activity has decreased to a considerable degree, it is apparent that some activity is still present and that if fresh air was admitted to the area, then a very rapid flare-up in active oxidation could be expected.

It must therefore be concluded that until a position is reached where it can be more or less certain that active oxidation has ceased and the heated material given time to cool down, it would be most unwise to re-open the area for the passage of fresh air.

It appears from the analyses that the two areas in 4 West and 6 West are part of a common sealed area and that any seals between the two parts are more or less ineffective. It will probably be pointed out that there are differences of a considerable magnitude in some of the percentages but a closer study of these will reveal the fact that the percentages of those expected to be high are lower in the area containing the heating (*i.e.*, 6 West) than those in the area assumed to be clear of a heating (*i.e.*, 4 West).

In fact all the analyses seem to indicate that the heating existed in the 4 West area and that some of the gaseous products of the heating are finding their way into the 6 West area whereas in actual fact the reverse is thought to be the case and indeed formed the whole basis upon which the recovery operation was attempted. At no time was a heating suspected in the 4 West area.

It must therefore be assumed that the difference in the composition of the samples obtained from the 4 West and 6 West areas are due to the stratification and separation of gases within a common sealed area.

Although the operation of recovery proved unsuccessful this in no way detracts from the efforts of all personnel who were employed at various times and it was not unusual to find work being carried out in difficult and arduous conditions caused by both the nature of the atmosphere and the temperature thereof.

APPENDIX I

Samples taken at No. 1 Seal (4 West)

Date	CO ₂ per cent.	O ₂ per cent.	CO per cent.	H ₂ per cent.	CH ₄ per cent.	N ₂ per cent.	CO/O ₂ ratio	Remarks
26-1-61	3.89	8.92	0.009	N.D.	N.D.	87.19	0.006	Before re-opening.
30-1-61	2.71	14.33	N.D.	N.D.	N.D.	82.96	..	Before re-opening.
1-2-61	1.08	18.27	0.003	N.D.	N.D.	80.65	0.10	Re-opened 30-1-61, resealed 31-1-61.
3-2-61	4.10	12.89	0.013	N.D.	N.D.	83.01	0.13	.....
6-2-61	3.34	11.22	0.0455	N.D.	0.26	58.13	0.40	.....
8-2-61	4.14	11.39	0.0356	N.D.	N.D.	84.44	0.31	Re-opened 10-2-61.
5-7-61	6.37	6.94	0.891	N.D.	1.43	84.37	5.78	Resealed 1-7-61.
6-7-61	6.14	6.30	0.839	0.67	1.75	84.30	5.24	.....
7-7-61	6.58	5.73	0.839	0.55	1.67	84.63	5.03	.....
10-7-61	6.73	5.10	0.657	0.43	1.64	85.44	3.75	.....
12-7-61	6.94	4.55	0.539	0.26	1.61	86.10	2.95	.....
13-7-61	6.78	4.54	0.539	0.21	1.60	86.33	2.94	.....
25-7-61	7.50	4.41	0.187	0.14	1.08	86.68	1.01	.....
1-8-61	7.06	4.61	0.155	0.04	0.97	87.27	0.83	.....
8-8-61	6.37	4.26	0.128	0.02	0.92	88.30	0.67	.....
15-8-61	7.74	4.24	0.128	N.D.	0.84	87.05	0.68	.....
23-8-61	7.33	4.82	0.135	0.02	0.70	87.00	0.74	.....
30-8-61	7.56	4.70	0.108	0.07	0.69	86.97	0.59	.....
6-9-61	7.42	4.56	0.090	0.05	0.72	87.16	0.49	.....
13-9-61	7.51	4.65	0.100	0.11	0.80	86.83	0.55	.....
27-9-61	7.48	4.23	0.090	N.D.	0.75	87.45	0.48	.....
4-10-61	8.07	3.87	0.072	N.D.	0.75	87.24	0.37	.....
11-10-61	7.99	3.71	0.052	N.D.	0.81	87.43	0.32	.....
18-10-61	8.75	3.51	0.090	0.07	0.71	86.87	0.46	.....
25-10-61	8.33	3.60	0.10	N.D.	0.79	87.18	0.51	.....
2-11-61	8.90	3.04	0.115	0.05	0.82	87.07	0.58	.....
8-11-61	8.40	3.76	0.072	0.09	0.81	86.87	0.37	.....
15-11-61	8.07	4.22	0.064	N.D.	0.85	85.80	0.34	.....

N.B.—In some of the earlier analyses no attempt was made to detect the presence of H₂ and it is possible that the CH₄ percentage also contains some H₂.

N.D. = Not detected.

APPENDIX II

Samples taken at No. 13 Seal (6 West)

Date	CO ₂ per cent.	O ₂ per cent.	CO per cent.	H ₂ per cent.	CH ₄ per cent.	N ₂ per cent.	CO/O ₂ ratio	Remarks
5-7-61	6.98	7.67	0.373	N.D.	0.83	84.15	2.55	Resealed 1-7-61.
6-7-61	6.72	6.04	0.373	0.21	0.87	85.79	2.24	.....
7-7-61	6.75	5.90	0.373	0.11	0.93	85.94	2.21	.....
10-7-61	6.75	5.43	0.373	0.09	1.10	86.26	2.14	.....
12-7-61	6.91	5.22	0.306	0.11	1.14	86.20	1.74	.....
13-7-61	6.70	5.12	0.280	0.09	1.15	86.66	1.57	.....
26-7-61	7.51	4.32	0.0932	0.08	1.03	86.97	0.50	.....
2-8-61	6.99	4.53	0.065	0.02	0.84	87.55	0.35	.....
9-8-61	6.70	4.94	0.0135	0.04	0.70	87.61	0.08	.....
16-8-61	6.95	4.76	0.0104	N.D.	0.65	86.63	0.06	.....
24-8-61	6.81	4.81	0.0675	N.D.	0.58	87.73	0.37	.....
30-8-61	7.10	4.28	0.010	N.D.	0.53	88.08	0.05	.....
6-9-61	7.14	4.40	0.009	N.D.	0.54	87.91	0.05	.....
13-9-61	7.23	4.55	0.010	0.05	0.52	87.64	0.05	.....
27-9-61	7.18	4.94	0.0072	N.D.	0.52	87.35	0.04	.....
4-10-61	7.20	4.99	0.0063	N.D.	0.50	87.30	0.03	.....
11-10-61	7.02	5.24	0.0045	N.D.	0.46	87.28	0.03	.....
18-10-61	6.69	5.39	0.0018	N.D.	0.45	87.47	0.01	.....
25-10-61	7.16	5.09	0.009	N.D.	0.41	87.34	0.05	.....
1-11-61	6.99	5.27	0.0063	N.D.	0.43	87.31	0.04	.....
8-11-61	7.03	5.36	0.0072	N.D.	0.48	87.12	0.04	.....
15-11-61	7.00	5.47	0.0068	N.D.	0.44	87.08	0.04	.....

N.D. = Not detected.

OVERLAND HAULAGE FOR
N°2 TUNNEL

SORD
NUMBER

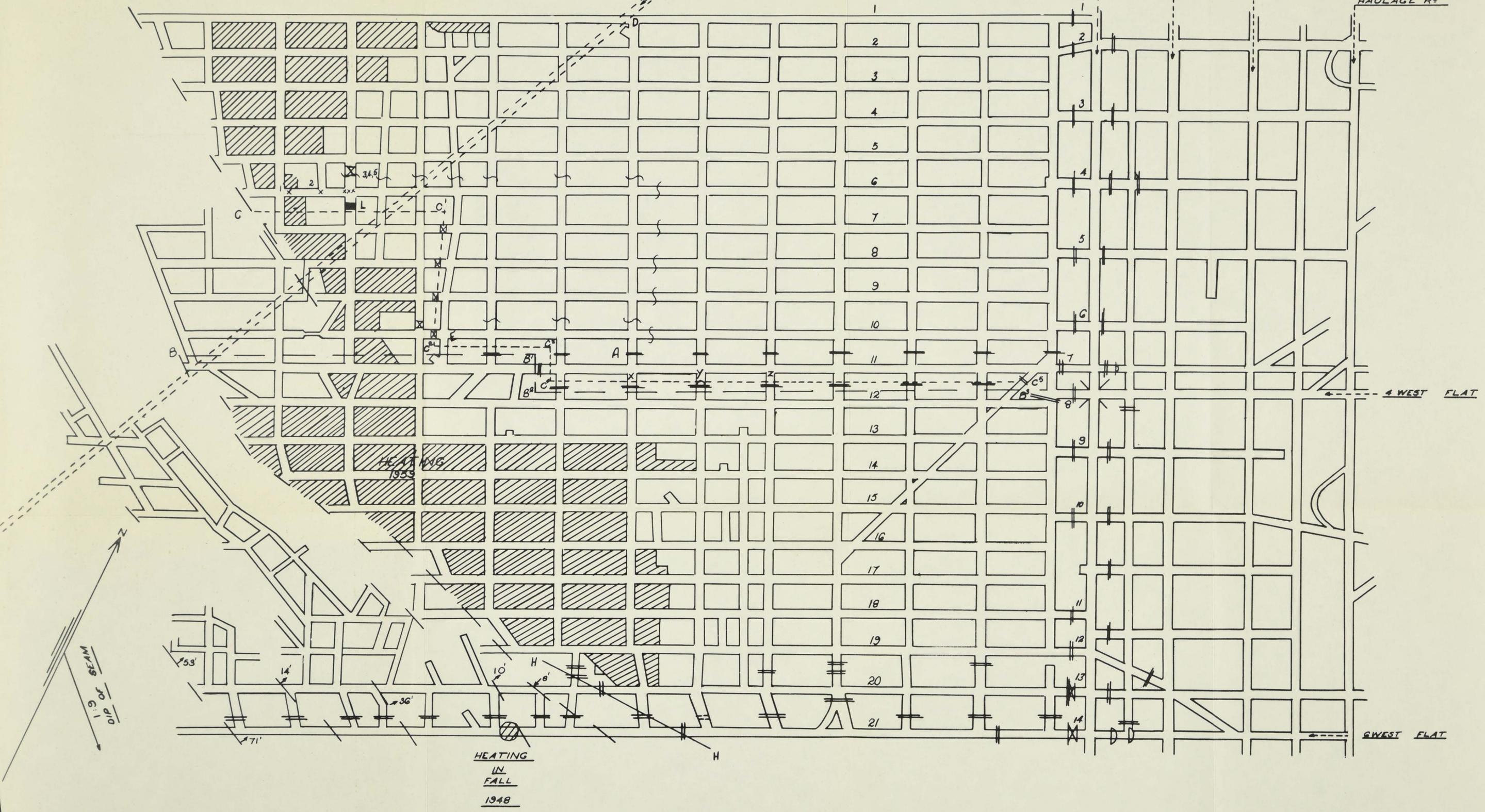
SEAL N°

WEST RETURN

TRAVELLING R°

TRANSPORT R°

HAULAGE R°



1:9
DIP OF SEAM

HEATING
IN
FALL
1948

BELLBIRD COLLIERY
N°4 & N°6 WEST SECTIONS N°1 TUNNEL
SCALE: 2 CHAINS = 1 INCH

