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TECHNICAL REPORT

NORSAR PHASE 2

OPERATION AND MAINTENANCE
1 DEC 68 TO 31 MAY 69

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October 1971

TECHNICAL REPORT

NORSAR (NORWEGIAN SEISMIC ARRAY)
PHASE 2

OPERATION AND MAINTENANCE
1 DECEMBER 1968 TO 31 MAY 1969

NORWEGIAN DEFENCE
RESEARCH ESTABLISHMENT
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INTERN RAPPORT S-57

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FOREWORD

This research project is sponsored and supported by the Advanced Research Projects Agency of the Department of Defense. Technical guidance and direction for Contract No F61052-68-C-0060 has been provided by the Electronic Systems Division (AFSC). Contract support was provided by the European Office of Aerospace Research (EOAR), the R&D Contracts Division of ESD and the Air Force Logistics Command (Contract Management Center Det 16). This O&M report covers the period from 1 December 1968 through May 1969.

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This report has been reviewed and is approved.

Richard A Jedlicka

Richard A Jedlicka, Capt USAF
Technical Project Officer
Oslo Field Office
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NORSAR PHASE 2 - OPERATION AND MAINTENANCE 1 DECEMBER 1968 TO 31 MAY 1969

SUMMARY

This report covers operation and maintenance (O&M) of the NORSAR Phase 2 Seismic System during the period 1 December 1968 to 31 May 1969.

This task comprised continued operation and maintenance of the system installed at subarray 01C (Øyer), and further Long Period (LP) recording on site at subarrays 01A (Nes), 06B (Søndre Land) and 07B (Biri).

1 INTRODUCTION

The system operation at 01C generally was the same as described in Technical Report "Norsar Phase 1 - Operation and Maintenance, 1 Feb to 30 Nov 68 - Intern rapport S-41", later referred to as (1).

LP recording at 06B and 07B was based on relocation of recording equipment (DARTs) and Moelven prefab huts from Falldalen and Trysil, respectively. The recording of LP data at Falldalen ended 2 October 1968. The LP DART was brought to 06B (S Land) and reinstalled in the data hut (DRC), which had been moved from Falldalen 7 November. At Trysil LP recording ceased 21 October. The data hut was transported to 07B (Biri) and the LP DART reinstalled 19 November.

LP recording with DART equipment at 01C (Øyer) terminated 21 October. Equipment was reinstalled in a rented prefab house unit at 01A (Nes). To meet a US proposed suggestion for further local LP recording at 01C (Øyer) for the period 1 December 1968 to 31 May 1969, a number of 887 DC-input amplifiers in the ASTRODATA recording system were modified for connection to the LP seismometers.

1.1 O&M tasks

In general these required personnel to operate data acquisition equipment and maintain it so as to assure continuous 24 hours/day operation, to perform calibrations, quality control checks and routine clerical duties. The subcontractor for the Phase 1 O&M tasks, Noratom - Norcontrol A/S, was also charged with the field O&M for Phase 2.

The need for continuous operation made it necessary to establish an adequate preventive maintenance program. This program provided for the calibration, repair and replacement of field components and items as required. A limited amount of expendable components necessary to meet these requirements was provided as US Government Furnished Equipment (GFE).

1.2 Guidance and assistance from US consultants

US consultant in the relocation and reinstallation of the LP recording systems was Mr Ronning from Philco-Ford.

2 TECHNICAL DESCRIPTION OF THE SYSTEM

The technical installation at 01C (Øyer) was identical to that described in (1) except for the modification mentioned above concerning the LP recording with ASTRODATA equipment.

The LP recording setup at 01A, 06B and 07B was similar to the technical installation discussed in (1) for Falldalen and Trysil.

2.1 Automatic weather station

An automatic weather station (described in (1) section 2.4.3) was associated with the noise study at Falldalen. This station was reinstalled and connected to the DART at 06B (S Land).

2.2 Geographical configuration

The installations were located at three different sites in the south-eastern part of Norway, see Figures 2.1 and 2.2.

2.2.1 The 01C (Øyer) site

The location of this site is described in detail in section 2.1.1 of (1). All technical installations and operation in the Data Recording Center (DRC) remained unchanged throughout the period covered by this report.

2.2.2 The 01A (Nes) site

This site is on the Nes peninsula on the east side of lake Mjøsa, by road about 27 km from the town of Hamar. Being a temporary installation, all signal and power cables between the data hut and the Central Terminal Vault (CTV) were laid on the surface, and the recording equipment was placed in the hut. The site (altitude 420 masl) is accessible by car throughout the year. However, in wintertime the steep and winding road may make access difficult. The site location is shown in Figure 2.3.

2.2.3 The 06B (S Land) site

This site contained the second station of the temporary LP array. It is located at Skogstad farm, some 500 masl, and 35 km SW of Gjøvik town.

As in the case of the other sites, the LP instruments were placed in the Long Period Vault (LPV), while the recording equipment was installed in the data hut, a few

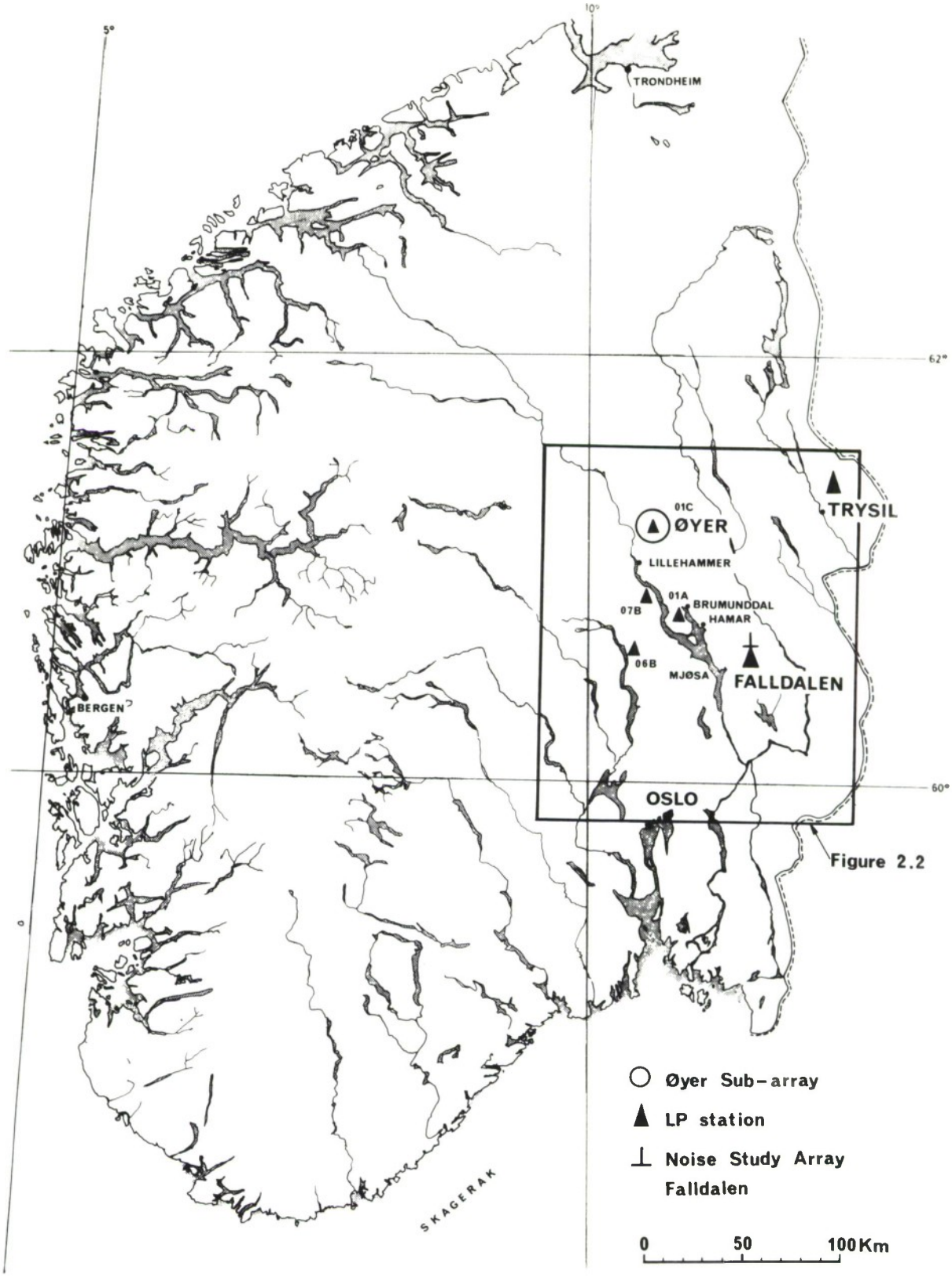
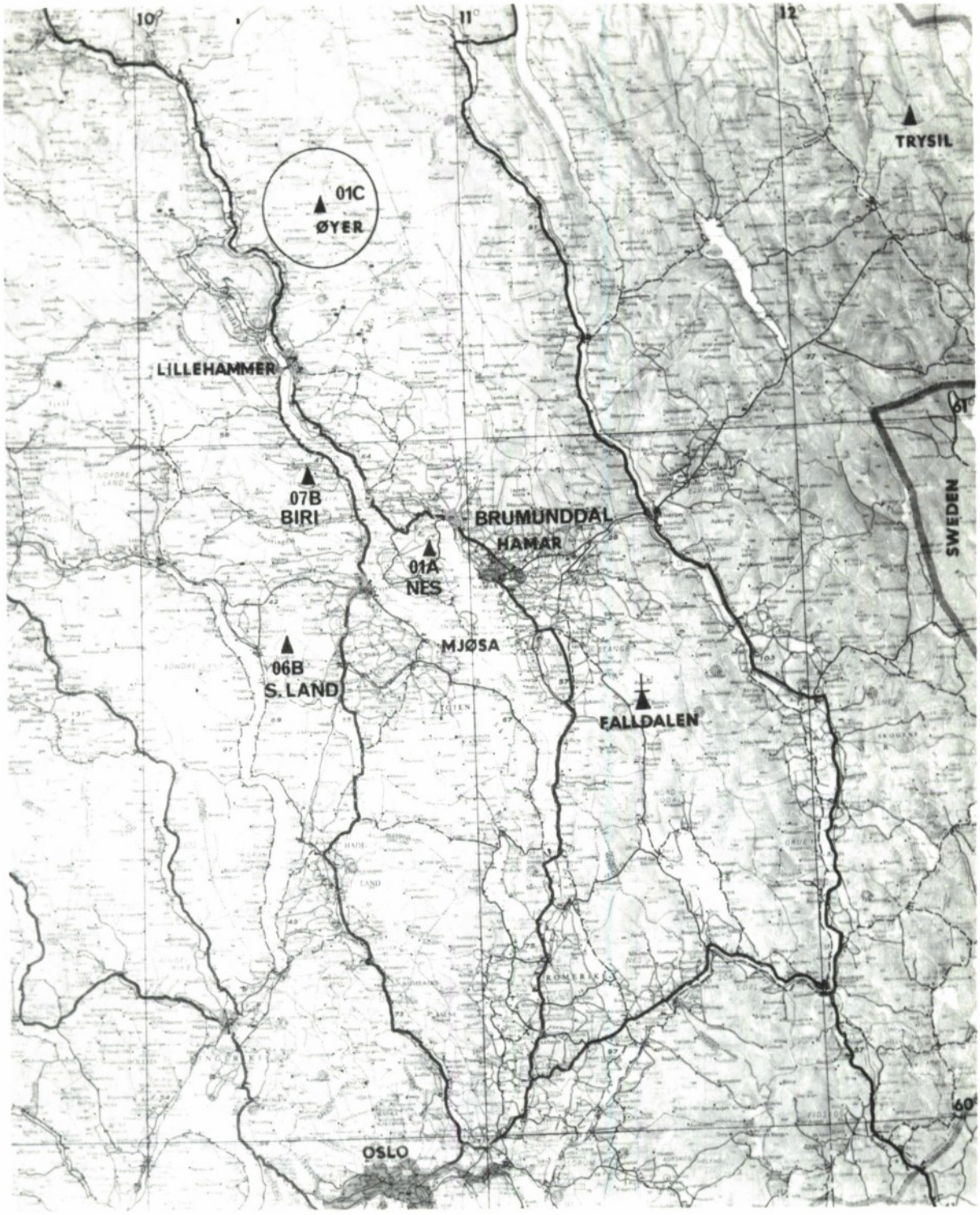


Figure 2.1 Southern Norway
Square indicates general area of interest, shown in detail in Figure 2.2.



0 5 10 20 30 Km

0 5 10 20 Miles

○ Øyer Sub-array

▲ LP station

⊥ Noise Study Array Falldalen

Figure 2.2 Part of south-eastern Norway showing area of operation

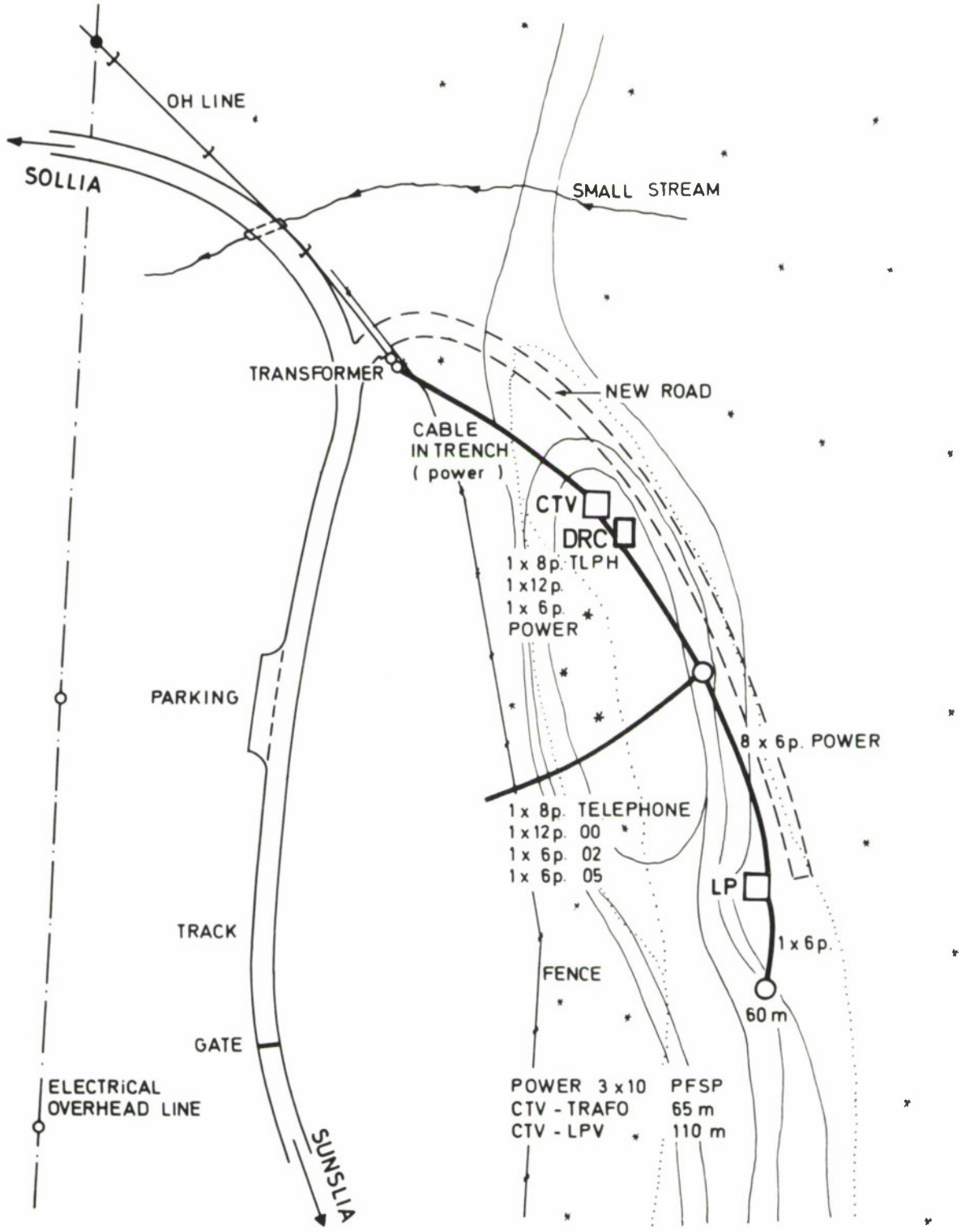


Figure 2.3 01A (Nes) site

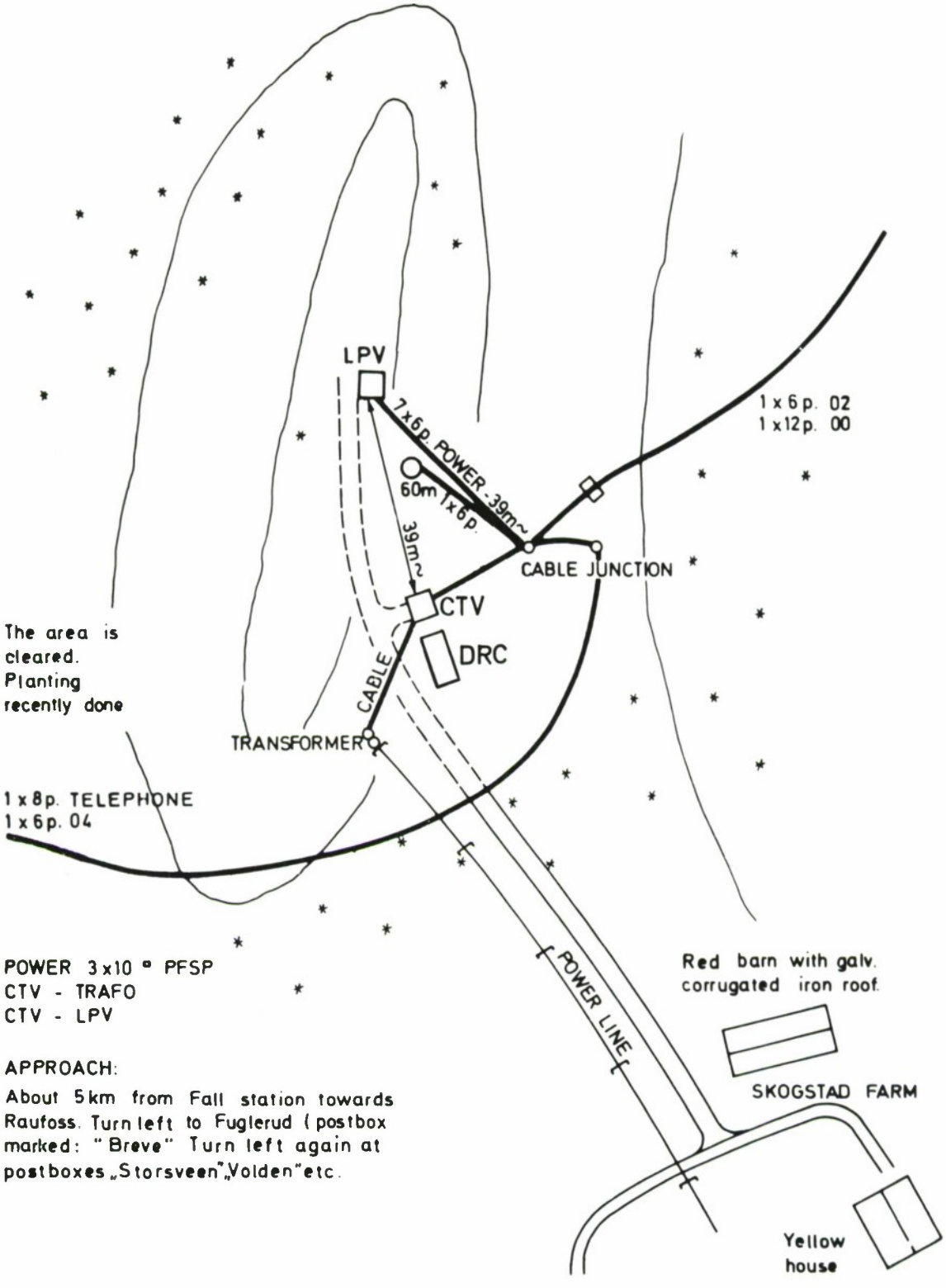


Figure 2.4 06B (S Land) site)

meters away. The weather station aerovane was mounted on a pole on top of the roof. This site can be reached by car all the year round. Its location is shown on the map in Figure 2.4.

2.2.4 The 07B (Biri) site

The third LP station is located at Klomsteinroa, some 500 masl and 30 km north of Gjøvik. It is also accessible by car throughout the year. Its location is shown in Figure 2.5.

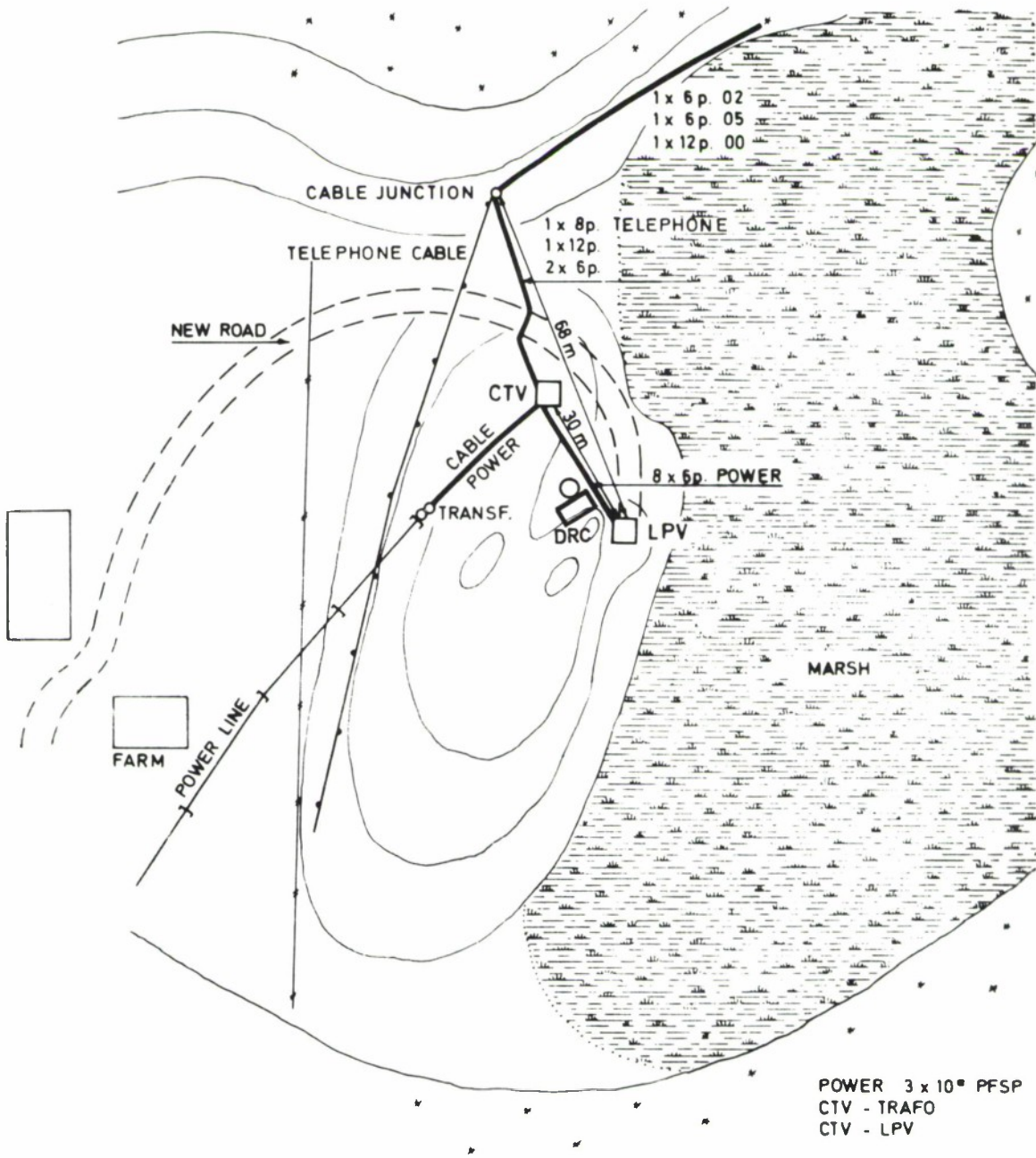


Figure 2.5 07B (Biri) site

3 OPERATION AND PREVENTIVE MAINTENANCE (O&M)

The equipment was installed and connected at all sites by 1 December 1968, but it proved exceedingly difficult to obtain satisfactory recording at all sites simultaneously. A series of component failures (further discussed in section 4.2), most of them caused during transport to the site, prevented useful recording until the end of January 1969. The tasks set forth in the O&M subcontract called for operation and maintenance of stations 01C, 01A, 06B and 07B ensuring a capability for continuous 24 hours/day acquisition of data.

3.1 O&M organization and staff

The duties called for in the O&M contract necessitated a staff of six technicians, supervised by a project leader. As a result of increasing administrative work, it became necessary for the senior technician to act as assistant to the project leader, and an additional technician had to be engaged. This new technician was available from 15 March 1969. At the end of May two members of the staff were sent to LASA Montana, to receive instruction and training mainly on the maintenance of SP-seismometers.

3.1.1 Working schedule, rotation of staff

From 1 December the installation of LP instruments, continued operation at Øyer, LP-recordings at new sites and participation in installation, calibration and check-out of other subarrays made it necessary to adjust the schedule in use. The new 5-week standard roster is shown in Table 3.1. Average working hours were 40 hours a week.

Staff members \ Time	Week no					
	1	2	3	4	5	(1)
1	Ø	Ø	A	L	L	(Ø)
2	L	Ø	Ø	A	L	(L)
3	L	L	Ø	Ø	A	(L)
4	A	L	L	Ø	Ø	(A)
5	Ø	A	L	L	Ø	(Ø)

Table 3.1 Standard schedule for rotation of personnel
Ø - Øyer
A - Off duty (compensation for weekends at Øyer)
L - LP operation/installation and checkout

3.2 Facilities

In addition to huts for accommodation of technical equipment and crew at Øyer and the new LP sites, rooms for a field base were rented and taken into regular use by

the O&M staff during December 1968. This base (see Figure 3.1), located in Birger Langmoensvei 43, Brumunddal, some 15 km north of Hamar, consists of combined work-room/store for field components, approximately 125 m^2, and a garage where snowscooters are stored.

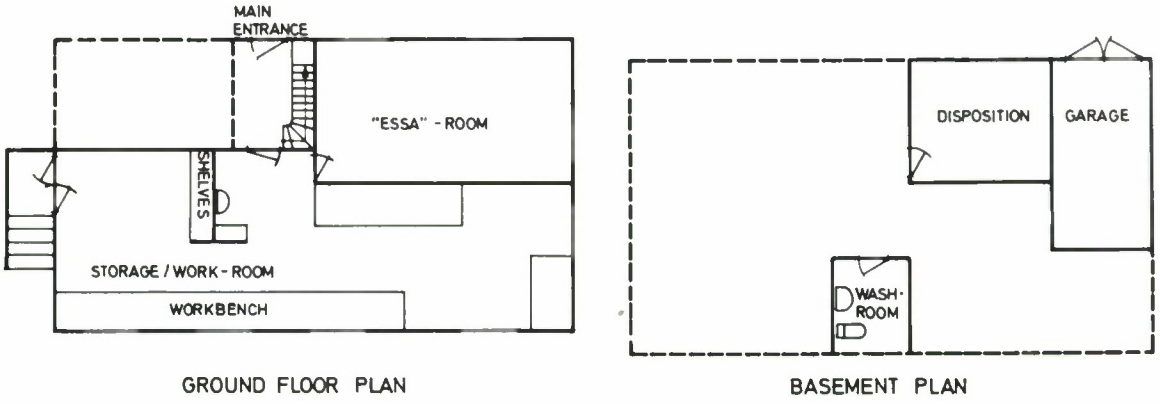


Figure 3.1 Brumunddal storage and field base

Other necessary facilities comprised transportation means to/from and within sites, test equipment and spare units and parts.

3.2.1 Vehicles

Apart from private cars for transportation of crew, the O&M staff had during this period at its disposal four vehicles, viz:

1 Snow-track (type Aktiv Beltetraktor ST4 - make A/B Westerås-maskiner, Sweden) with sledge

2 Snow-scooters (type Evinrude Wide-Track 20) with sledge

1 field vehicle (type Willys 4-wheel drive jeep)

The three first mentioned are US Government Property (GP), purchased by NDRE. The snow-track was used for access to DRC and SP points at Øyer during the winter period. The two snow-scooters were used for the same purpose, both at Øyer and the LP sites. There were some problems with the tracked vehicles at Øyer, and at one time all ordinary transportation means broke down. A snow-scooter had to be rented from Autocenteret, Lillehammer, while the project vehicles were being repaired (2 - 9 May). Preventive maintenance schedule for the GP vehicles is included in (1).

The field vehicle was rented from Norges Automobilforbund, Oslo, during the period 28 April - 16 June, when thaw conditions at the array prohibited access by private car or snow vehicles. The field vehicle performed well and was very useful.

The use of snow-vehicles is undoubtedly essential in the winter season (Oct - May). As it was, during a short period in springtime when snow-melting was severe, the vehicles in present use proved inadequate. Future array operation necessitates continued use of snow-scooters; a type of lighter weight and equipped with a stronger engine is recommended in order to ease the regular transportation and hopefully to overcome the snow-melting problems. The present snow-track at Øyer (01C) will

be of little or no use in the future. It is recommended that this vehicle, along with the old scooters, be traded in for improved type scooters that are now avilable on the market.

In all, 48 000 km were covered by the O&M crew during this reporting period.

3.2.2 Test equipment

The test equipment was the property of Lincoln Laboratory, MIT. A complete inventory is given in Appendix A4.1 of (1).

3.2.3 Spares

Spare parts for the ASTRODATA, DARTs and auxiliary equipment were stored at Øyer. DART parts earlier stored at Falldalen have been moved to Brumunddal.

Major items such as LP/SP seismometers, LP/SP amplifiers etc were also available at Øyer and Brumunddal.

3.3 Routines and schedules

The control of general data handling, record keeping, reproduction and distribution of data to users, etc, called for the establishment of specific routines. These routines also covered stocktaking, inventory control and preventive maintenance.

3.3.1 Preventive maintenance (PM) and calibrations (Cal)

Normal PM and Cal was continued at Øyer. The three LP sites were visited on average twice a week. PM on equipment was performed on each visit, while calibration was done once a week.

3.3.2 Demands for and distribution of data

The general demands for and distribution of data were as follows:

a) Continuous recording at the LP sites and forwarding of all tapes to Lincoln Laboratory (LL)

b) Continuous recording at Øyer (SP and LP) and storing of tape for a minimum of 14 days. Tapes were forwarded on request from the users (University of Bergen and LL). After 14 days, tapes could be degaussed and re-recorded.

3.4 Records

A number of forms had earlier been introduced in order to gather information on data recording as well as on operation and maintenance in general. These forms were also used in this period of the program. For further description of these records reference is made to (1), section 3.4.

4 OPERATIONAL EXPERIENCES, 1 DEC 68 - 31 MAY 69

The main O& M task during this reporting period has been to operate and maintain the equipment described in chapter 2.

The field group also participated in installation and checkout of technical equipment at subarrays installed in 1968, to such an extent as other duties permitted. This work started on 28 February 1969.

4.1 Short chronological narrative

Regular operation of the LP array was considerably delayed, after installation of the DART equipment during the first part of December 1968. This delay was mainly caused by damage to the equipment during transportation and was partly due to installation work of various kinds in the LPVs and CTVs. The systems became fully operational at the end of January 1969

After this, the stations generally performed well. Powerline maintenance, power breaks and malfunctioning of the chronolog clocks (see (1) section 4. 2. 4) caused stops in recording from time to time. At Øyer, operation went fairly well until the spring thaw started. Problems with Datamec recorders (ASTRODATA) occurred throughout the period and caused some downtime. The DART system was used during ASTRODATA breakdowns and performed well.

Starting in February, a frequency response test on all SP seismometers was carried out monthly.

Sensor 1F1 at Øyer was found to be out of operation on 13 March. An attempt was made to replace the seismometer, but ice in the casing tube made this impossible. During the following days several attempts were made to remove the ice. The pipe was cleared to a depth of about 75 cm, but it was still impossible to move the seismometer. It was decided to delay further work until the spring. When finally brought up to the surface, the seismometer proved to be deformed by the high pressure developed below the ice plug.

Figure 4. 1 Details of deformed seismometer at 1F1

Sensors at 1C2, 1D1, 1D2 and 1D3 became inoperative about 20 May due to water in the WHVs. No corrective action could be taken. Water and melting snow rendered further checks of WHVs impracticable; it was impossible to reach them by car or snow-vehicle. Recording at the three LP sites and regular operation at Øyer terminated 31 May. Equipment from the LP sites was

at first transferred to the storage in Brumunddal, and later packed and forwarded to the appropriate US authorities.

The Øyer station was revitalized 16 - 27 June, during a special Scandinavian seismic detonations experiment. This operation, conducted by one man, was combined with an instrumentation front-end inspection and various work connected with the close-down of the station. After this, all equipment was disconnected, packed on site and returned to USA.

4.1.1 Support of noise study group

One part of the Brumunddal storage (see Figure 3.1) was singled out for use by a US noise study group from the Environmental Science Service Administration (ESSA). Approximately 10 man-days of field support were devoted to assisting this group, from 6 January to 10 April 1969.

4.2 Special technical problems

The problems causing most of the equipment downtime are discussed below. A detailed description of problems and downtime in connection with equipment and vehicles is given in Tables 4.1 and 4.2, which are extracts from site logs.

Date	Equipment	Deficiency/Action	Downtime
3 Dec	V2, Snow-scooter	Brake and steering failure, brought to Autocenteret, Lillehammer for repair.	24 h
6 Dec	V1, Snow-track	Punctured tyre. Repaired at Øyer Auto.	60 h
14 Dec	- " -	Engine stopped. Ice removed from fuelpipes, pump and carburettor.	48 h
16 Dec	V2, Snow-scooter	Clutch trouble. Brought to Autocenteret for repair.	182 h
26 Dec	- " -	Drive-gear breakdown.	120 h
29 Dec	V1, Snow-track	Drivebelt torn by a sharp rock. Belt was preliminarily repaired at site.	60 h
2 Jan	- " -	Taken to Øyer Auto to be equipped with new belts. Old ones worn out. Some bushings had to be made as original parts could not be supplied by dealer.	216 h
27 Jan	- " -	Left boggie-wheel broken. Repaired at Øyer Auto.	120 h
24 Feb	V2, V4 Snow-scooters	Minor service work.	20 h
30 Mar	V1, Snow-track	Steering rod broken.	96 h
7 Apr	- " -	Boggie-wheel flat. Replaced.	12 h
2 May	- " -	Chain and chainwheel malfunction.	72 h

Table 4.1 Data concerning corrective maintenance of vehicles

Date	Equipment	Deficiency/Action	Downtime
7 Dec	Recorder 2	Stopped. Worn brushes and rotor changed.	4 h
11 Dec	Recorder 1	Stopped and went into rewind. Vacuum motor clutch adjusted.	15 h
14 Dec	Recorder 2	Rotor windings damaged by loose screw in motorhousing.	39 h
17 Dec	Recorder 2	Stopped. Worn out bearings in motor replaced.	9 h
19 Dec	Recorder 1	Stopped. Bad connection on R3, TTB. Resoldered.	1 h
19 Dec	887 Amplifier	All amplifiers checked and adjusted.	5 h
30 Jan	Recorder 2	Vacuum motor breakdown. Motor replaced.	None
30 Jan	Recorder 2	Sticky roller guide. Bearing changed.	None
7 Feb	DART-01C	Wrong TOD monitored. Metal piece was shorting two pins on clock card.	Unknown
4 Feb	DART-01A	Recorder stopped due to power break.	"
5 Feb	DART-07B	Parity errors, ch 1 & 2. "DART 1 RSS" card replaced.	1 h
19-31 Mar	Recorders 1 & 2	Photosense lamps burnt on both tape stations. Spare lamps were of incorrect type. New ones ordered. Meanwhile, Astrodata was run with manual start/stop during daytime, while DART was run during the night.	152 h
1 Apr	Recorder 1	"End of tape" did not start Recorder 2.	2 h
1 Apr	Recorder 2	Intermittent fault. "Write enable" sometimes caused Recorder 1 to go into rewind. Trouble shooting did not disclose malfunction.	None
1 Apr	DART-01A	High gain on all channels. Adjusted.	1 h
5 Apr	Recorders 1 & 2	Intermittent problems seem to be influenced by temperature changes. Card 2D13 replaced.	4 h
10 Apr	Recorder 1	Check of vacuum motor.	1 h
10 Apr	Recorder 2	Check of playback circuit.	1 h
7 May	Astrodata	According to dump test made in Bergen, LP signals are recorded on ch's 17 and 19 (IF1 and IF4). No irregularities found during trouble shooting.	None
13 May	Astrodata	Above-mentioned problem rechecked. LP signals were induced in MUX, due to bad transistor. Faulty card replaced.	2 h
31 May	Recorder 2	Did not start. Vacuum motor brushes changed. Broken wire on take-up motorbrake repaired.	9 h

Table 4.2 Data concerning corrective maintenance of ASTRODATA/DART equipment

4.2.1 Water in WHVs during spring thaw

The problems encountered in Spring 1968 reappeared in Spring 1969. Water leakage occurred in WHVs 1C2, 1D1, 1D2 and 1D3. The cable entrances sealing had been improved since 1968, but the unfavourable placement in the terrain and insufficient draining of the WHVs still pertained. Weather conditions (snow melting etc) made it very difficult to get to the WHVs for drainage work.

4.2.2 The ASTRODATA

The Datamec recorders continued to be the weak point of the system, especially the vacuum motors. Worn out brushes and bearings and photosense lamps have caused most of the downtime, together with long delivery time of original spares. The ASTRODATA electronics have performed well.

4.2.3 The DART

Downtime on this equipment at the LP sites has mainly been related to the Chronolog clock. In connection with power breaks, irregular recharging of batteries have affected the reliability of the clock. Since these sites were not manned, an estimate of downtime caused by power breaks cannot be given. System grounding was improved at all DARTs. Only two cases of parity errors have occurred after the modification, which was performed by installing ground strips connecting all three cabinets and connecting cabinets to AC ground. DART operation at Øyer has been satisfactory throughout the period.

4.3 Forwarding of data tapes

A total of 176 data tapes were forwarded to LL and the University of Bergen during this reporting period.

5 CONCLUDING REMARKS

Since data evaluation took place elsewhere, only a brief remark on the technical quality of the tape recordings will be made.

Compared with the previous period, great progress has been made towards reducing the data parity errors on DART tapes. Fast feedback of information from tape dumps made at the University of Bergen prevented errors prevailing for any length of time.

Transportation of crew, equipment and materials was also this year rather complicated in the spring thaw and at times in the winter season. At one time the Øyer crew were weather-bound at Lillehammer for two days as a result of severe conditions. Kind assistance from the Norwegian Army made it possible for them to get back to the site.

Experiences gained from SP front end troubles during Phase 1 and this period, mainly caused by water leakages, necessitate reconstruction of WHVs and draining systems.

As a conclusion, it is felt that operation during this reporting period added valuable knowledge of benefit to O&M work in the future.

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(1) - Technical Report, NORSAR Phase 2, Operation and Maintenance, 1 Feb to 30 Nov 68, Intern rapport S-41, Norwegian Defence Research Establishment (1971)

(2) - Interim Technical Report, NORSAR Phase 2, The 1968 Installation Program, Intern rapport S-45, Norwegian Defence Research Establishment (1969)

(3) - Final Technical Report, NORSAR Phase 2, Installations 1969 and 1970, Intern rapport S-51, Norwegian Defence Research Establishment (1971)

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13 ABSTRACT

Project NORSAR concerns installation and operation of a large seismic array in S-E Norway.

This report covers the operation (on site recording) and maintenance in the field during the period 1 December 1968 through 31 May 1969. Assistance rendered by the O & M group to various installation tasks is also reported.

The report does not cover the results of the data processing.

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