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Long term sampling and measuring program. Joint report for 1987, 1988 and 1989. Within the project: Fallout studies in the Gideå and Finnsjön areas after the Chernobyl accident in 1986

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LONG TERM SAMPLING AND MEASURING PROGRAM. JOINT REPORT FOR 1987, 1988 AND 1989. WITHIN THE PROJECT: FALLOUT STUDIES IN THE GIDEÅ AND FINNSJÖ AREAS AFTER THE CHERNOBYL ACCIDENT IN 1986

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ABSTRACT

A redistribution and migration study of the Chernobyl fallout begun in 1986. It was realized in an early stage that the fallout from Chernobyl could be used as a large scale tracer study. After one early sampling and measurement it was concluded that at least five of the radioactive nuclides could be used in a long term perspective. The sorption and migration of these elements in geohydrological systems have been investigated during a period of three and a half years and a model of the redistribution is now prepared.

The basis for successful modelling of the redistribution of fallout products within a small catchment area is dependent on accurate input. A repeated sampling of geological materials (and the following determination of the radionuclide concentration), and "direct" measurement of gamma radiation in field, will then be needed.

This report is a summary of the work that has been performed during 1987, 1988 and 1989 within sampling and measurement of radionuclide content in geological materials and surface vegetation. Migration studies and modelling work are other parts of the project that are not presented here.

The collecting of field data is mainly done in an small catchment area (0.74 km^2) c. 30 km N-E of the city of Örnsköldsvik, county of Västernorrland. A minor field study is also done in an area east of Lake Finnsjön, situated c. 50 km north of the city of Uppsala.

The conclusions that can be drawn from the Gideå study site surface measurements are that the gamma radiation in general is decreasing with varying magnitude. But the picture is not all unambiguous. In the subsurface layers of studied soil profiles, an increase can be observed in the upper part of the enriched layer. The outflow of radionuclides with ground water seems to be fairly constant after the peak flow in 1986. Some indications of larger transport and outflow of radionuclides in connection with heavy rain or spring flood is also present.

Results from the Finnsjö area are not yet be complete. Many of the samples are still waiting for their gamma spectra to be analyzed and evaluated.

CONTENTS

1. INTRODUCTION

Large areas of Sweden were exposed to the radioactive fallout from the Chernobyl nuclear reactor accident in 1986. This event started a study of the sorption and migration behaviour of the radioactive elements in biological and geological systems. The study is divided into sampling, migration studies and modelling (Gustafsson et al 1987). The study was performed with funds from SKB and has continued as a collaboration project between SGAB, Studsvik AB and the department of Nuclear Chemistry, Chalmers University of Technology (CTH). It is focused on two small forested areas in Sweden were the radionuclide distribution within an catchment area will be modelled.

The major part of the field study is performed in Gideå, Västernorrland county. To a minor extent field studies are also performed at Lake Finnsjön in Uppland county.

This report is a summary of the results concerning sampling and measurement of radionuclide concentration in various materials within the project **Fallout studies in the Gideå and Finnsjö areas after the Chernobyl accident in 1986.** The report covers the years 1987, 1988 and 1989. The remaining parts of the project, migration studies and modelling, are not presented here.

2. SAMPLING AND MEASUREMENTS WITHIN THE GIDEÅ STUDY SITE

The Gideå site is situated in the northern part of Ångermanland county c. 30 km north-east of the city of Örnsköldsvik. For further geological and geographical information see Gustafsson et al 1987, Ahlbom et al 1983 and Albino et al 1982. The studies in the Gideå area are concentrated to the Orrmyrberget catchment area. In Table 2-1 and in Figures 2-1 to 2-8 all sampling and measurements performed since the project start are presented. The adjacent Gi2 area (c.f. Figure 2-1) is used to some extent, mainly for sampling vegetation and deep groundwater.

In 1987 it was decided that the surveys should concentrate on the Gideå area and that only minor efforts should be placed on the Finnsjö area. This was mainly to concentrate the resources on one site, and because the Finnsjö site is far more complex in its geological and hydrological structure. The aim of the more intense study in the Gideå area is to evaluate models used for the prediction of the redistribution of the fallout radionuclides. Before the calculation of the redistribution can be done it is of utmost importance to have accurate and well defined values of the radionuclide content in various materials within the area. The geological, hydrological and meteorological conditions are also of great importance. This report is a summary of the effort to sample and measure the radionuclide content and to document the hydrological conditions within the area during these years. The measurements performed within the Orrmyrberget and the Gi2 areas in Gideå, 1987- 1989, can be summarized as follows:

Radionuclide concentration measured:

Surface measurements
- γ-spectrometric measurements
- exposure rate measurements
- outcrop (small scale fallout pattern)

Soil measurements
- integrated soil sampling
- soil profile sampling

Vegetation measurements
- trees
- shrubs
- ground vegetation

Water measurements
- surface water
- shallow groundwater
- deep groundwater

Sediment measurements
- fine sediment
- coarse sediment

Hydrologic and meteorologic conditions measured/collected:

Groundwater
- deep groundwater, discharge from artesian boreholes.
- near-surface groundwater
- groundwater level

Surface water
- discharge from study area.

Precipitation

Temperature

2.1 GAMMA SPECTROMETRIC MEASUREMENTS

Gamma spectrometric measurements (Figure 2–1), surface measurements, were performed in May 1987 and in October 1989. Measurements in 1986 (June and November) are presented in Gustafsson et al 1987. The measurements in 1987 were on measuring points G7, G11, G15, G22, G32, G36. During 1989 19 measurements were performed. Each measurement with a duration time of 30 min. The measuring points were G1, G2, G3, G6, G7, G9, G10, G11, G12, G13, G15, G22, G23-24, G32, G36, G50, G51, G52 and G53. The measurements are repeatedly performed at the same measuring point as in the previous years. The measurements of the radioactivity are then compared to see if there is any notable change over the years. Three isotopes were measured, namely, the natural potassium–40 and the fallout fission products cesium–134 and cesium–137. The major part of the gamma radiation, now, a few years after the fallout, comes from these isotopes.

2.2 EXPOSURE RATE MEASUREMENTS

Exposure rate measurements (Figure 2–2), total gamma flux, were made in june 1989 with a portable gamma–meter, in addition to the measurements performed in June and November 1986. The measurements are performed within the study area along a line from G9 to G22 via G12 and G15. Exposure rate were also measured at measuring points G2 and G23-24. Measurements at G12, G15, G22, G32 and G36 were combined with integrating soil sampling. These routes were repeated from the 1986 year measurements. These exposure rate lines are an estimate of the total gamma activity. By repeating these measurements a general picture of the change in the gamma exposure rate can be estimated.

2.3 ROCK AND OUTCROP STUDIES

Rock samples (Figure 2–3) were taken in may 1987 at sampling point G55 and G59. These samples were loose surface rock sampled with hammer. The rock samples are mainly studied by autoradiography. The autoradiographic studies show the small scale distribution of the major gamma ray radionuclides. Samples from 1986 show (compared to Finnsjön) an relatively even blackening cover with an preference to lichen compared to bare rock.

2.4 SOIL

2.4.1 Integrated soil sampling

Integrated soil sampling (Figure 2–4) was made in 1989 at G12, G15, G22, G32 and G36. This technique is used as a complement to the gamma spectrometric measurements and for the exposure rate measurements. At each sampling site 25 samples were taken (5 x 5 samples). They were taken concentrically at different distances from the detector. Five samples were taken at 0–1m, five at 1–2m, 2–4m, 4–7m and 7–10m from the detector. The samples from every distance are put together and five mean values for Cs–137, Cs–134 and K–40 is then obtained for one gammaspectrometric measuring point. The total gamma exposure rate was also measured at these five distances with the portable gamma meter

2.4.2 Soil profile sampling

Soil profiles (Figure 2–5) were sampled, except for the samples taken in Oct 1986 (Gustafsson et al 1987), in May 1987 at G3, G6, G7, G50, G51, G52, G53, G54, G60 and G61. In August 1988 at G2, G3, G6, G62 and G63. And June 1989 at G1, G2, G3 and G64. The sampling is made by cutting out an area of 25x25 cm and then carefully removing layers down to about 40 cm. The top layers are sampled very thin and the bottom layers are thicker. Soil samples are also taken with a plastic tube that is hammered down. The tube sampling has been modified in two ways. The diameter has been increased (from 6.7 cm to 9.4 cm) and also the length of the tube has been increased. These modifications are made for larger samples and also that the radionuclides has penetrated down to a larger depth than expected. Large sample volumes are needed for measuring low radionuclide concentration in deep samples.

2.5 VEGETATION

Vegetation samples (Figure 2–6) were taken in May 1987 at sampling points G50, G55, G58, G59 and in June 1989 at sampling point G1. Mainly ground vegetation were sampled.

2.6 WATER

Water samples (Figure 2–7) in the Gideå area can, due to the radionuclide concentration, be divided into two types of water, namely surface water and ground water, that differ about 100 times in concentration.

Surface water is sampled in the creek at sampling point G40. Samples were taken in February, May 1987 and in April, August 1988 and in June 1989. Surface water was also taken at G3 (fen) in August 1988, G39 (creek) in June 1989, G51 (fen) in May 1987, G62 (fen) in August 1988.

Shallow groundwater were sampled in a well at G31 in February and May 1987, April and August 1988. Shallow groundwater was also sampled in borehole G32 (HGI20) Feb. 1987, April 1988 and Jan. 1989. Deep groundwater is taken at G9 (KGI02), two levels are sampled, 28–96m and 97–106m, 1987; Feb. and May. 1988; April and Aug. 1989; June.

2.7 SEDIMENT

Sediment (Figure 2–8) has been collected in the well, sampling point G31. In 1987 (May) a very good sampling was done with a long PVC tube. The bottom sediment was sampled from its surface (2.5m below ground/water level) down to a depth of 67 cm. The sediment core was divided into 13 samples. In Aug. 1988 and in June 1989 sampling in the well, G31, was also performed.

Coarse sediments in the creek were sampled in May 1987 at sampling point G41.

2.8 HYDROLOGICAL AND METEOROLOGICAL CONDITIONS

The regular monthly collection of meteorological and hydrological data has continued since the start in 1986. The collected hydrological values are the discharge in the creek and ground water levels. Discharge from packed–off sections in artesian boreholes is also measured. The collected hydrological data from Gideå are as follows:
- Discharge from borehole KGI02 at level 28–96m and level 97–106m.
- Discharge from borehole HGI20 at level 0–11.5m and level 12.5–100m.
- Discharge in the creek that drains the catchment area
- Groundwater level in borehole HGI24

Furthermore, these meteorological data are collected:
- Precipitation, presented as monthly sum.
- Temperature, presented as monthly mean.

Precipitation and temperature are collected from the SMHI meteorologic station, at Örnsköldsvik airport, situated 10 km to the south–west of the Gideå study site.

2.9 REMARK

During one week in June 1989 the survey for a detailed surface and soil map was carryed through. The Orrmyrberget catchment area was carefully mapped in over 400 points. The soil material was classified every cm in the uppermost decimeter and there after every 10 cm down to 0.5m. Notes about vegetation and hydrology was also made. As a result of this mapping a calculation of each materials areal cover and also its volume within the uppermost 0.5m was made.

In the same survey pattern, at every third point, one soil sample was taken. These soil samples were then measured and the content of fallout nuclides determined. A map over the distribution of the fallout nuclides within the Orrmyrberget catchment area will then be possibile to construct. This map will show how the radioactive fallout cover within this small area is composed.

Table 2–1 Sampling and in–situ measurements in the Gideå study area 1986 – 1989. Underlined samplings by CTH, the rest by Studsvik AB.

Site	Soil	γ Spectr. in situ	Water	Sediment	Vegetation	Rock
G1	C J	D K			C J	
G2	C E IJ L	D K				
G3	C F IJ L	D K	C I			
G4	C	D				
G5	C					
G6	C F IJ L	D K				
G7	C F L	D G K				
G8	C	D				
G9		A D K	ABC EF HIJ L			
G10		A D K				
G11		A D G K				
G12	J	A D K				
G13		A D K			A	
G14					A	
G15	A D J	A D G K	A			
G16						
G17					A	
G18						
G19						
G20						
G21						
G22	J	A D G K			A	
G23		K				
G24		D K				
G25		D				C
G26					C	C
G27					B	
G28						C
G29			AB	B	B	
G30						
G31			A C EF HI L	F IJ		
G32	J	G K	E H J L			
G33						C
G34					C	C
G35					AB	
G36	A D J	G K				
G37			B			
G38				C		
G39			J	C		
G40			C EF HIJ L			
G41				C F		
G42				C		
G43				C		
G44	C				C	C
G45	A					
G46	A					
G47	A					
G48	B		B			
G49			A			
G50	F				F	
G51	F		F			
G52	F					
G53	F					
G54	F					
G55					F	F
G56						
G57						
G58					F	
G59					F	F
G60	F					
G61	F					
G62	I		I			
G63	I L					
G64	J					
G65		K				
G66		K				
G67		K				
G68		K				

A=25-26	Jun 86
B=7-11	Jul 86
C=18-19	Oct 86
D=4-6	Nov 86
E=17-19	Feb 87
F=4-12	May 87
G=18-19	May 87
H=18-21	Apr 88
I=10-20	Aug 88
J=11-20	Jun 89
K=10-12	Oct 89
L=22-28	Oct 90

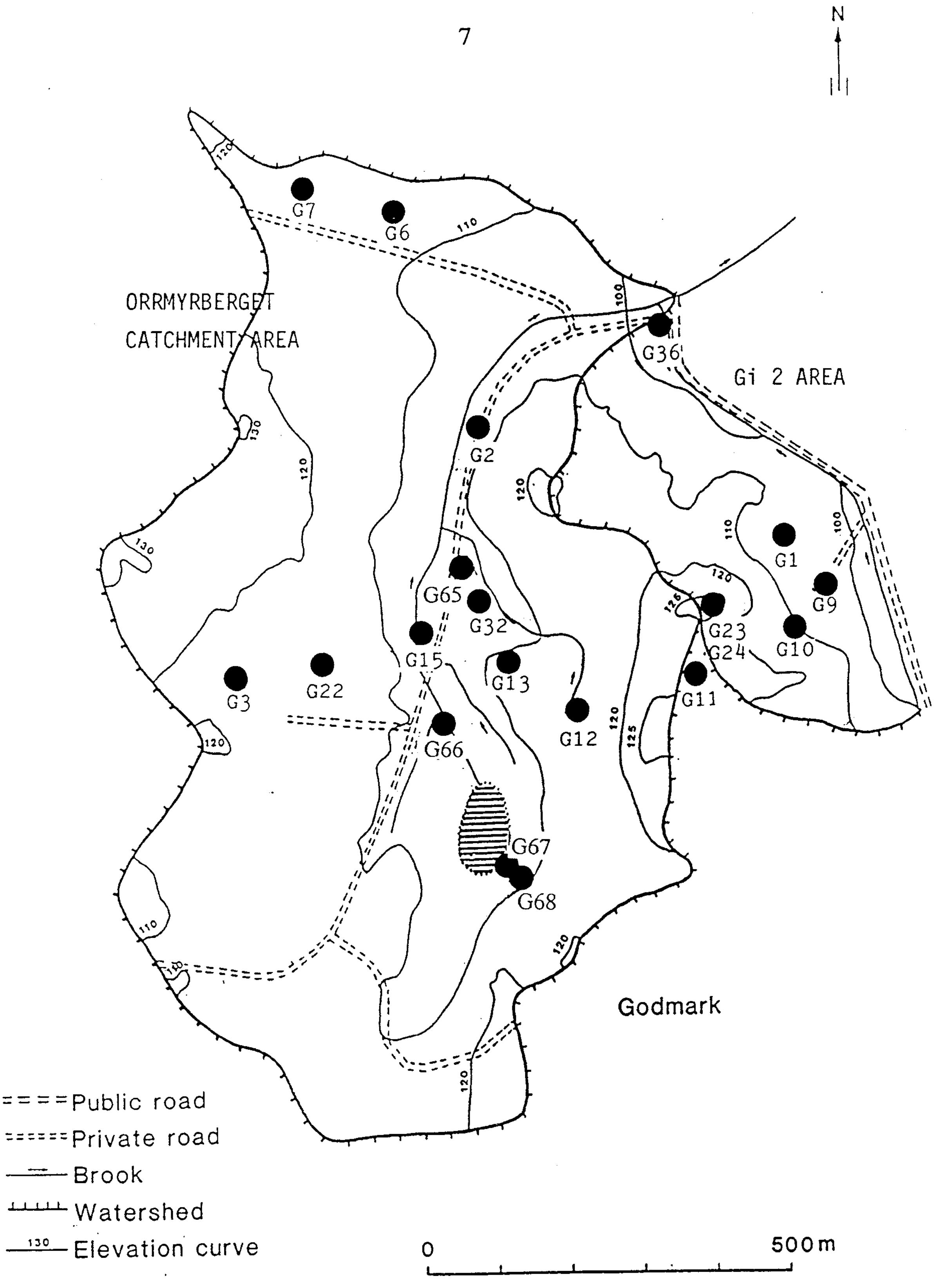

Figure 2–1 Gideå study site. Gamma spectrometric measurements, in situ. c.f. Table 2–1.

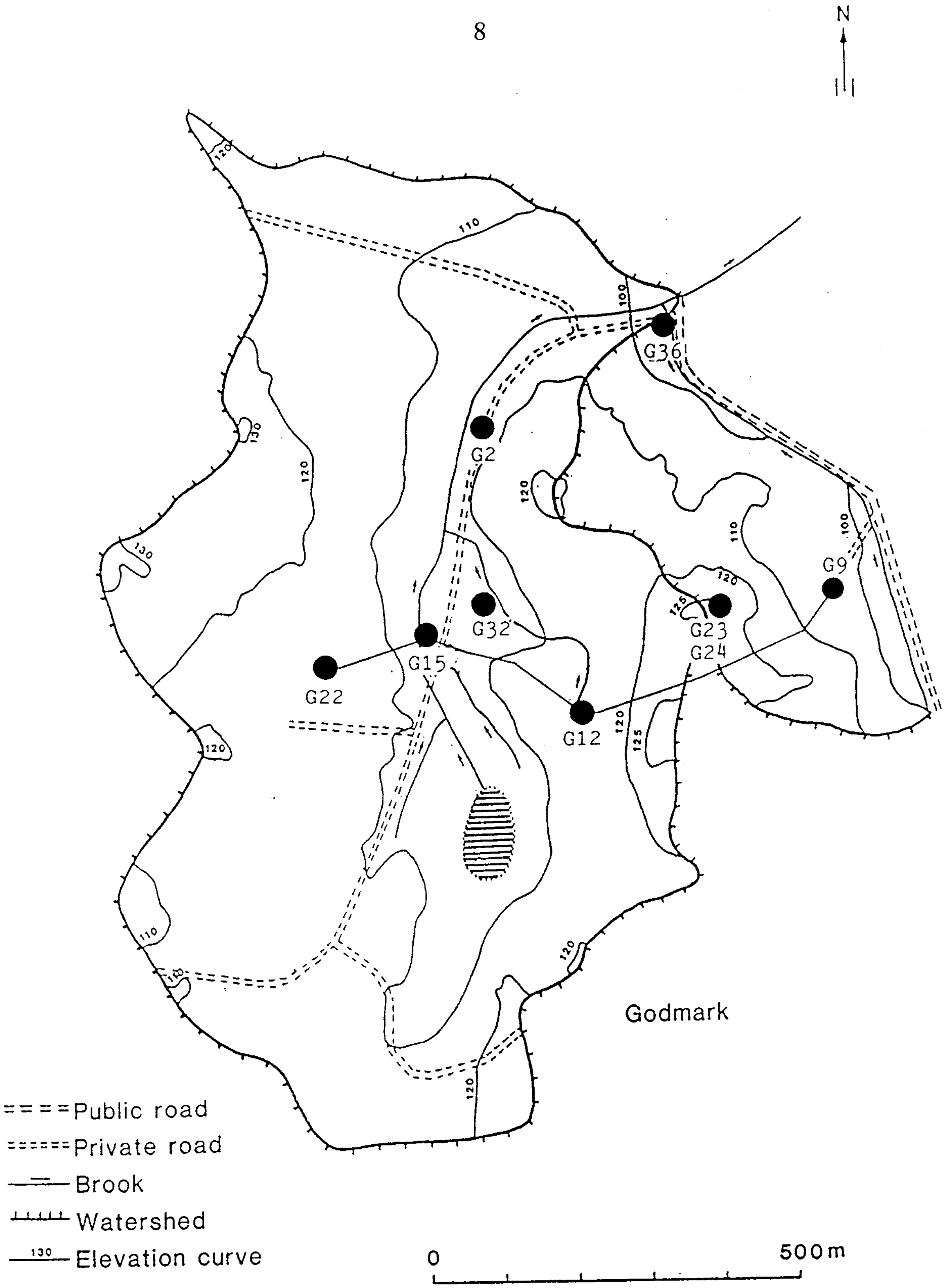

Figure 2–2 Gideå study site. Exposure rate measurements. c.f. Table 2–1.

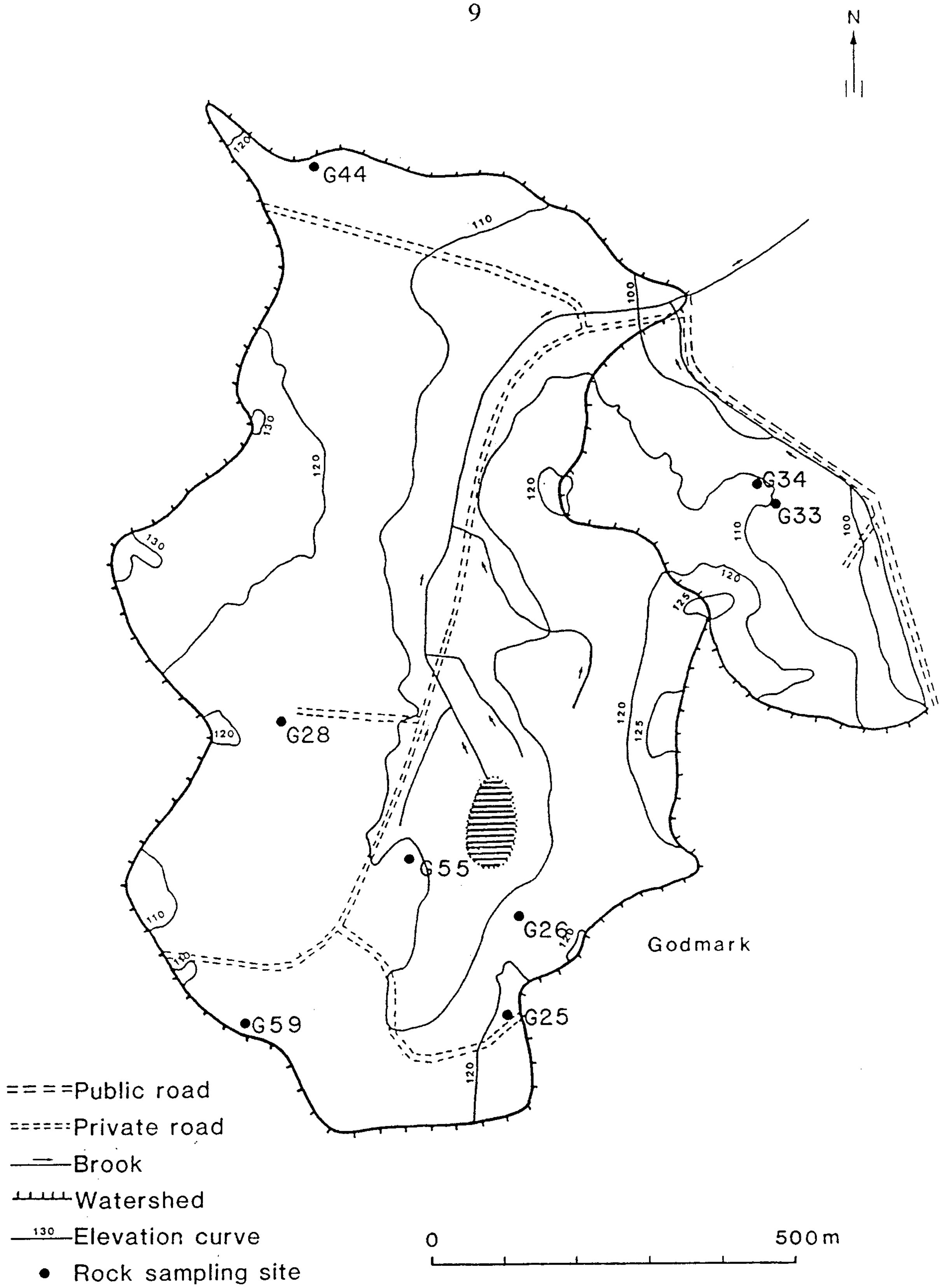

Figure 2–3 Gideå study site. Rock sampling. c.f. Table 2–1.

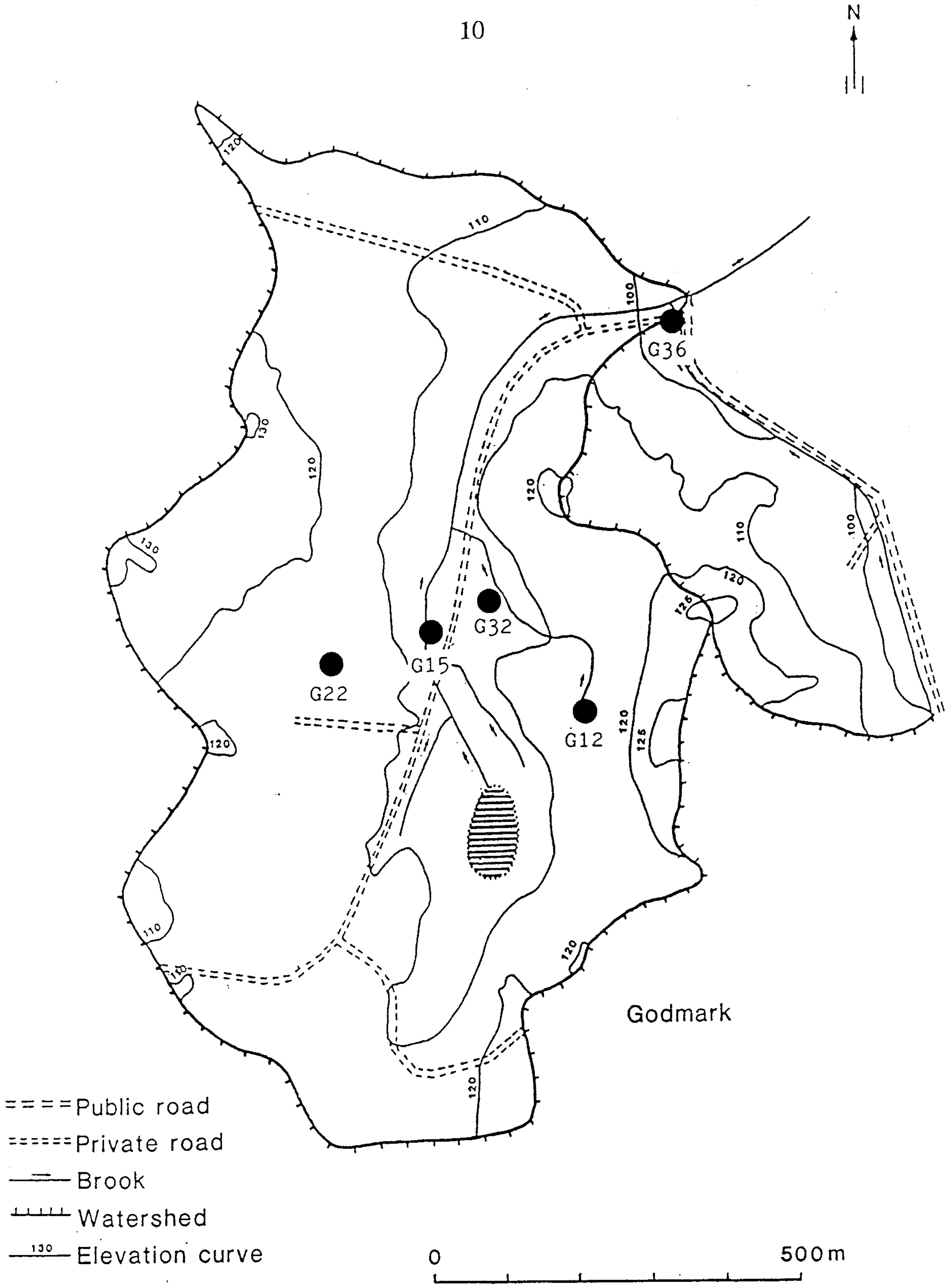

Figure 2–4 Gideå study site. Integrated soil sampling. c.f. Table 2–1.

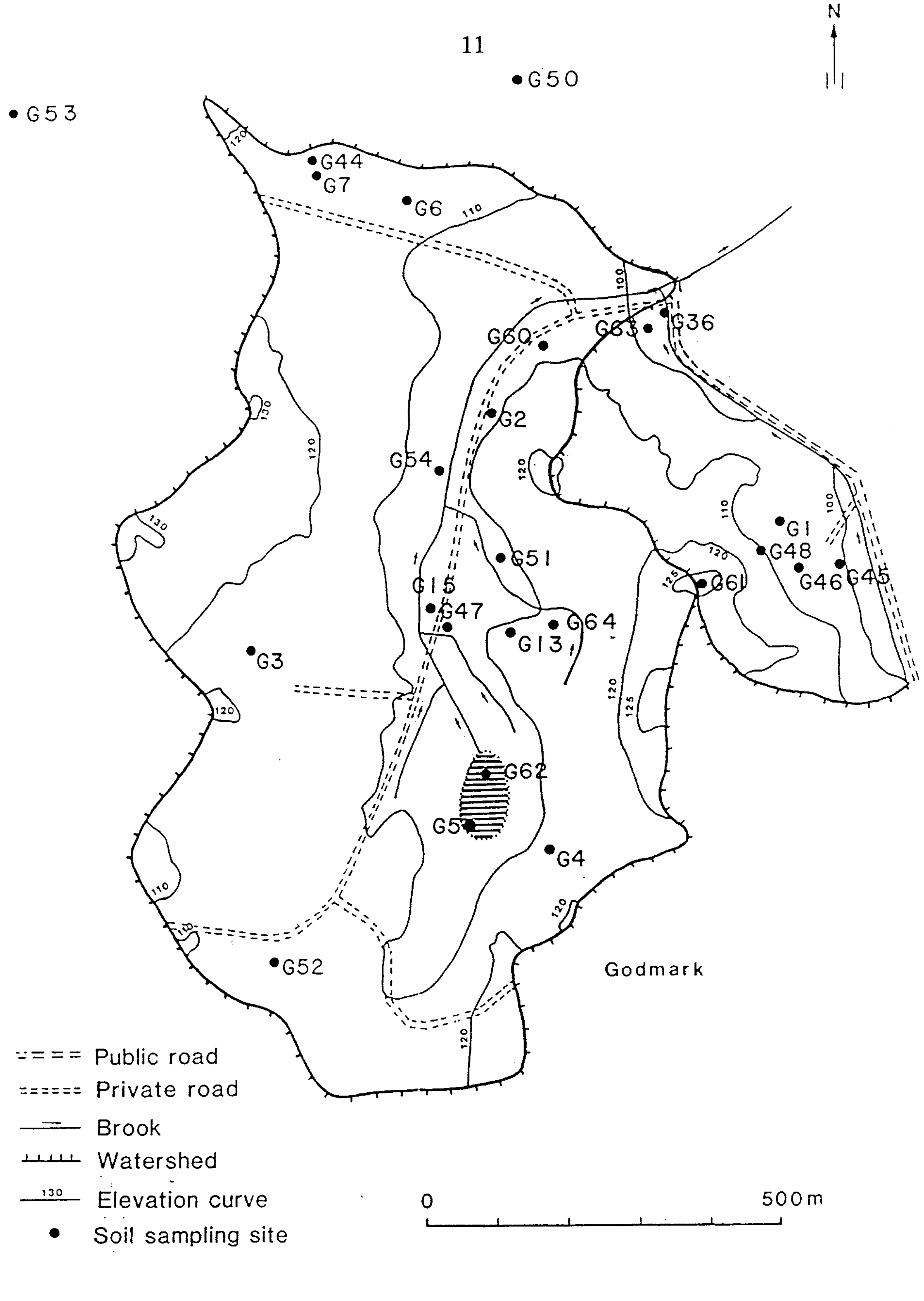

Figure 2–5 Gideå study site. Soil profile sampling. c.f. Table 2–1.

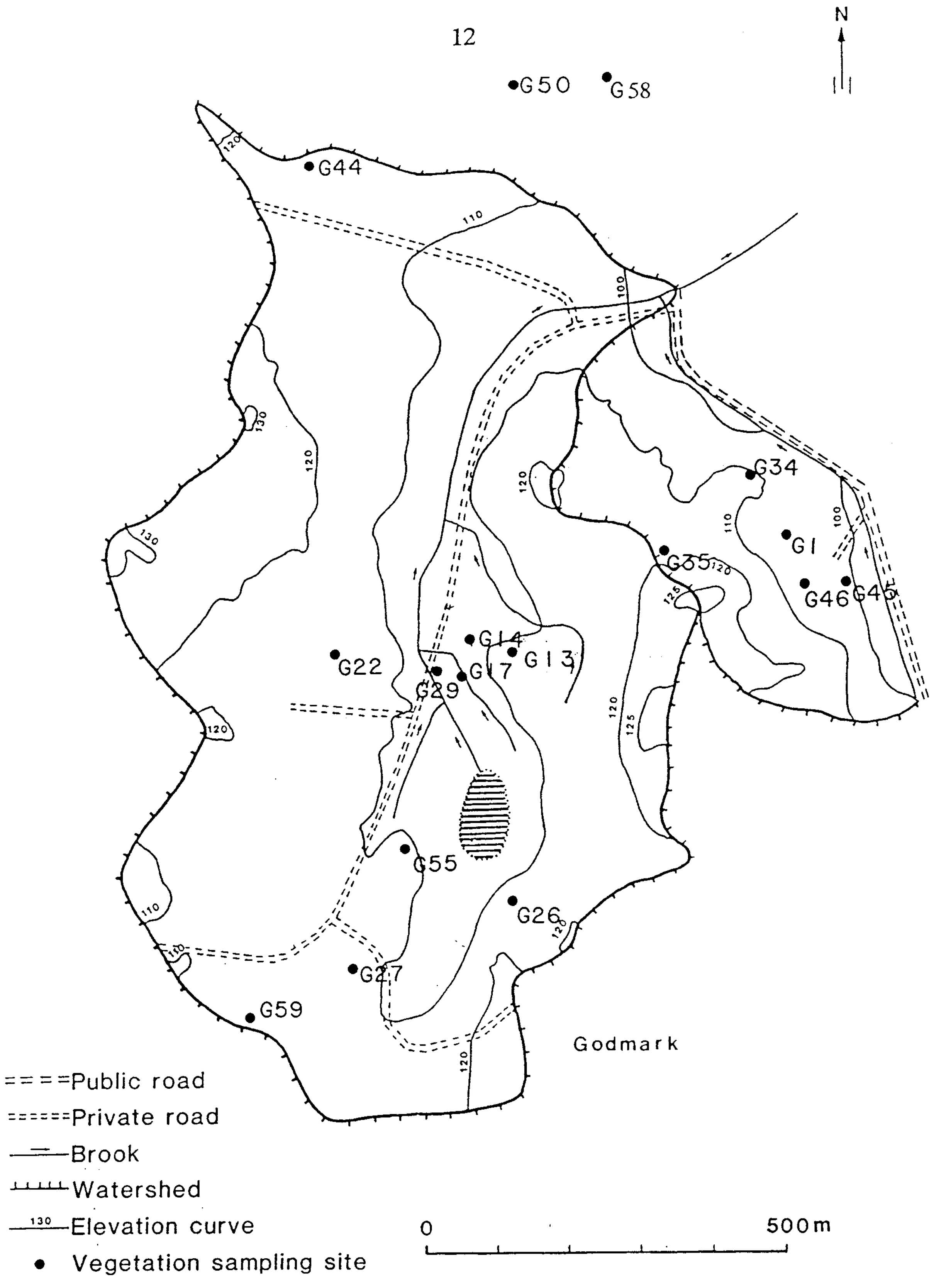

Figure 2–6 Gideå study site. Vegetation sampling. c.f. Table 2–1.

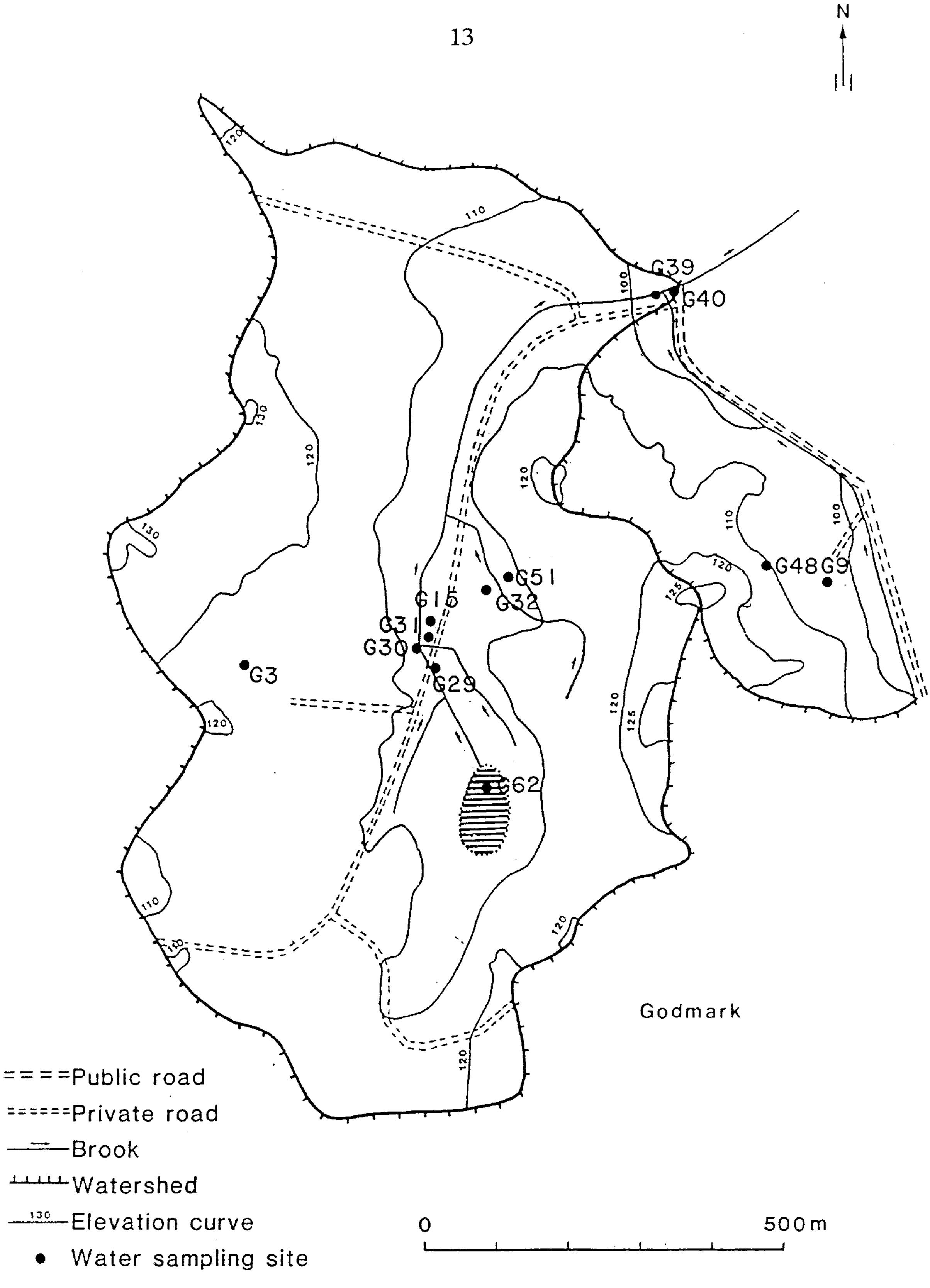

Figure 2–7 Gideå study site. Water sampling. c.f. Table 2–1.

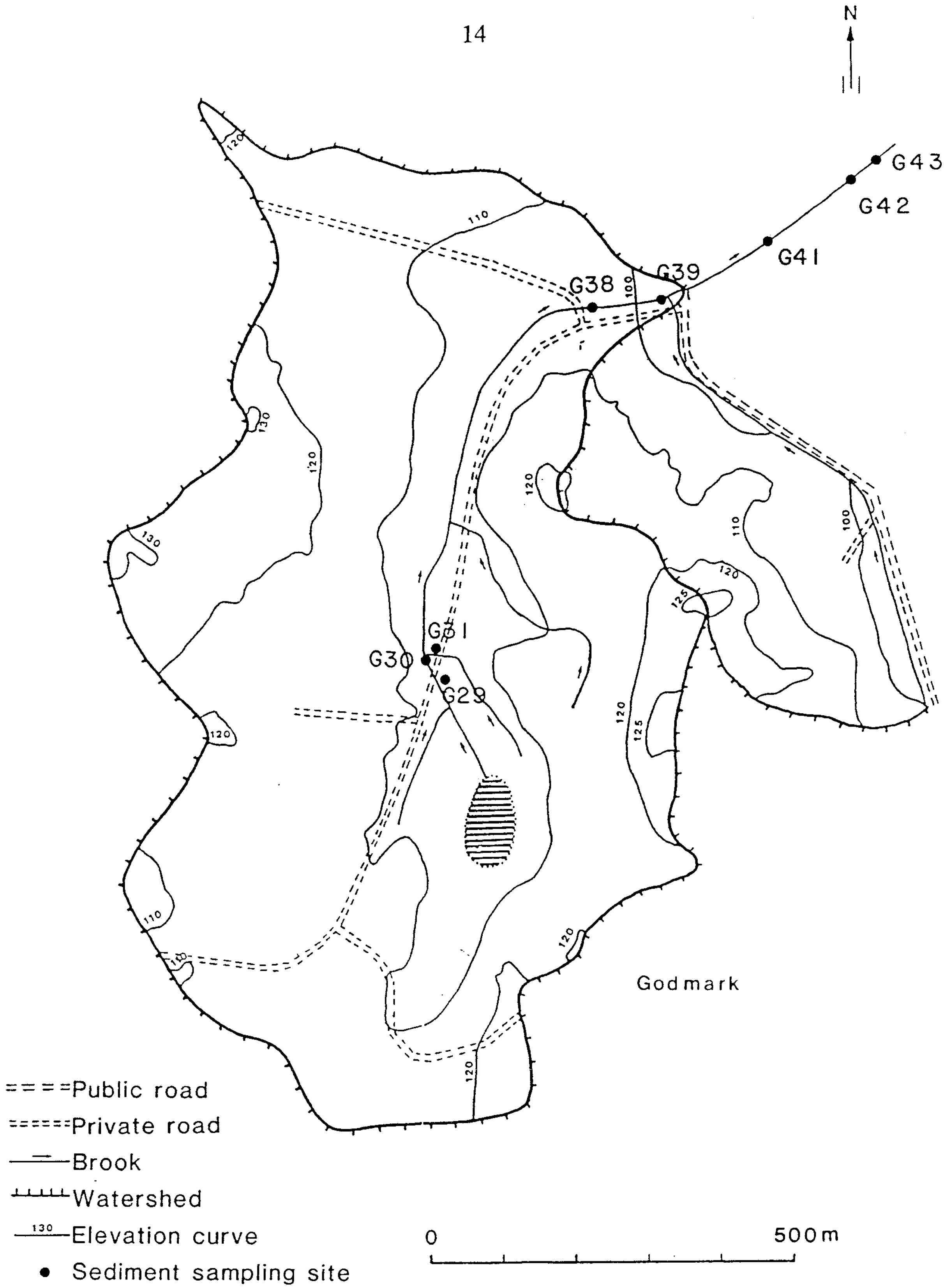

Figure 2–8 Gideå study site. Sediment sampling. c.f. Table 2–1.

3. CONCLUSIONS, GIDEÅ STUDY SITE.

It is of great importance that the long term sampling and measurements within the Gideå area be compiled and compared not only in time but also as a spatial phenomenon. Since the Gideå area is composed of different surface materials the comparation must not be done with a too small angle of incidence, e.g. comparing all soil profiles without reflecting that the materials are different. The comparing should rather be made within the material group than within the same sampling/measurement procedure.

3.1 SURFACE MEASUREMENTS

The γ-spectrometric measurements and the measurements of the exposure rate are spread out to try to cover the area with respect to different surface materials, vegetation and hydrological conditions, thus ensuring data for the forth-coming modelling of the redistribution of the radionuclides within the area. The surface measurements have so far shown that the radionuclide concentration at the surface is decreasing. In the major part of the area the content of radio-cesium in the surface is decreasing with time. The magnitude of this reduction is dependent on both material and hydrology. However, in 3 of the 15 measured points, situated in the west and central part, the radio-cesium content in the surface is increasing. These measuring points are placed upon rock, sand and peat, so the surface material cannot be the guiding factor to this interesting phenomenon.

The exposure rate along the 800m long line between G9 to G22 (Figure 2-2) measured in 1989 (Sundblad et al 1990) can now be compared with the measured values from 1986. In general the measurements from November 1986 show a prickly line which can depend on differences in radionuclide deposition and differences in ground material and the materials with varying shading effect. The low altitudes within the area which usually consists of peat, with higher surface water content, have lower values of total gamma radiation. In contrast to the lower altitudes the intermediate and high altitudes consist of till and rock that are coved by grass, moss, lichen etc, with lower water content in the surface making the ground dryer. Occasionally higher values of the total gamma radiation in the low altitudes can be found on rock surfaces that penetrates the peaty areas. When comparing the results of the measurements of gamma exposure rate from 1989 with 1986, it can generally be described as a decrease with about 8 - 9 μR/h. It seems as if there is no general surface redistribution. The two curves follow each other in rather good agreement. The 1989 curve is more smooth and the sharp peaks are not as significant as in the 1986 measurement. Some of the outcrop areas along the exposure rate line that have radiation peaks 1986, show in the 1989 measurement, a more leveled out profile, more then would be expected from the fall-out decay during these years. This may be interpreted as redistribution.

3.2 SOIL MEASUREMENTS

The results of the measurements of the radionuclide concentration in soil profiles are very much dependent on the material in which the soil profile samples are collected. In the Gideå site the soil profiles are sampled in till, sand and peat. During the sampling period in 1987, 1988 and 1989 all profiles are sampled in recharge areas.

In general the profiles in till and sand have relatively high radionuclide concentration in the surface layers, compared to subsurface layers. A reduction in the surface and an increase in the transfer from leached to enriched layer can be observed with time. This could be due to a combined effect of advective transport down into the soil, radionuclide sorption behaviour and the fact that the fission products were injected as a pulse.

In peat soil profiles the radionuclide concentration are more evenly distributed and the high concentration in the surface that still can be observed in the minerogenic soils, as described above, can not be found. The fluctuating groundwater surface and high water content solutes and redistributes the fission products so that the concentration distribution in the organic soils becomes more evened out.

The measured values from the integrated sampling show agreement with the values that are obtained by the spectrometer measurements.

3.3 VEGETATION MEASUREMENTS

Vegetation is sampled in 1987 and 1989. The sampling in 1989 is more complete and done in about the same extent as in 1986. These samples, when they are measured, will hopefully confirm the idea that cesium is recycled in the growing plants after that they are decomposed and turned into litter and humus.

3.4 WATER MEASUREMENTS

The deep groundwater that has been sampled in the artesian borehole KGI02 (G9), shows, after measurement of the radionuclide concentration, some remarkable results. The measurements from the middle section, 97–106m, have been preliminariey evaluated with a computer based regression method and breaktrough curves have been obtained for the radionuclides cesium-137, ruthenium-106 and cobalt-60. Transport parameters have been roughly estimated. The peak concentration for Ru-106 is deviating from Cs-137 and Co-60 due to its early appearance. This leads to the conclusion that Ru-106 has one water soluble and very mobile chemical form, in contrast to the insoluble form that was for instance detected on surface rocks in Finnsjön 1986. Cobalt is somewhat different to ruthenium and cesium in terms of dispersivity. The wider shape of the breaktrough curve implys a veak sorbing behaviour. (Ittner et al 1990)

The shallow groundwater, represented by the well (G3) water, is advectively transported to the well and this causes, still after four years, about 20–40 mBq/l (Cs-137) in the well. The concentration of Cs-134, Cs-137, Co-60 resembels the values that are measured in the discharging creek at sampling point G 40. On the other hand Ru–106 and Sb–125 has undoubtedly higher values in the creek than in the well. This is interesting due to the fact that the flow/influence area for the creek is much larger than for the well. (Carbol et al 1989)

The outflow of radionuclides from the area seems to bee farily constant after the concentration peak flow in 1986 have passed. The low concentration for the moment has no tendency to decrease any further, on the contrary, for cobalt–60 the concentration seems to increase in the creek water.

3.5 SEDIMENT MEASUREMENTS

So far only one sediment profile has been measured and studied. In the bottom of the well, G31, the sediment core from May 1987 shows that the concentrations of the radionuclides are fairly constant down to 41 cm, the rest down to 67 cm has no measurable values of any fallout radionuclides. The relatively fast migration in the silty clay might be explained by the high pH in the water (pH=8) and to the fast response to any changes in ground water level. (Carbol el al 1989)

3.6 HYDROLOGIC AND METEOROLOGIC CONDITIONS

The hydrological and meteorological monitoring have not shown extreme values. The discharge from the study area corresponds to the precipitation and the groundwater levels in the boreholes. The discharge of the two sections in the artesian borehole KGI02 show no seasonal variation.
The good agreement with the precipitation values from SMHI station, 10 km to the S–W, and the discharge from the study area makes it possibile to use the SMHI values in the forth–coming modelling. (Ittner et al 1989 and 1990)

4. PROPOSAL FOR FURTHER SAMPLING AND MEASUREMENT IN THE GIDEÅ STUDY SITE.

It will be of importance to sum up the experiences before the 1992 year sampling that will be the last to obtain data for the modelling of the radionuclide redistribution of the area within this project. Here the possibility arises to compare values with the previous samplings, and even if this six year peroid probabely will be to short to make a precise prediction for a long term scenario, it will however clearly show the trends in how these elements will be redistributed in the future. It has so far been shown that the velocity of the elemental migration, in general, was highest just after the fall-out and there-after it has decreased logaritmically.

To the high intensity sampling in 1992, new sampling locations of soil profiles have been suggested to try to cover the study area for better accuracy of fallout distribution. Soil profiles should also be placed in discharge areas to study migration behaviour where the advective groundwater flow has the opposite direction. Other types of sampling that will be of current interest is sampling in connection with lysimetric experiments where the chemical form of the migrating species will be studied. For water sampling, one intense study of the radionuclide concentration in the discharging water should be made during one spring flood.

5. SAMPLING AND MEASUREMENTS WITHIN THE FINNSJÖ STUDY SITE

The Finnsjö study site is situated in northern Uppland county, for more geological and geographical information see Gustafsson et al 1987.

In early 1987 it was decided that the Finnsjö area (Figure 5–1) should have low priority and that the studies should concentrate on the Gideå area. Only some limitated surveys would be carried out, this mainly to study fallout elements that were not present in the fallout in northern Sweden. Meterological data could also be collected.

The Finnsjö study site has a more complex build–up of the quaternary geology and quite complex hydrology compared to Gideå, and to simplify a complex area with an computer model for the redistribution of the fallout elements will not justify the study site.

The entire sampling in Finnsjön within the project until the end of 1989 is presented in Table 5–1.

The sampling and collecting of data within the Finnsjö study site during 1987, 1988 and 1989 can be summarised as follows:

Sampling for radionuclide concentration measurements:

Soil measurements
- soil profile sampling

Water measurements
- surface water

Vegetation measurements
- ground vegetation

Surface measurements
- outcrop (small scale fallout pattern)

Meterologic data collected:

Precipitation

Temperature

5.1 SOIL

Soil were sampled as soil profiles (Figure 5–2) in june 1989 at F6 and F7. These two samples, one in till and one in peat, will make it possibile to compare soil profiles from 1986.

5.2 ROCK AND VEGETATION

Rock samples (Figur 5–4) have been collected in May 1987 at F37, F38 and F39. These are loose rock surfaces sampled with hammer. The vegetation samples were taken simultaneously at F37 and F39 in the form of lichen that covers the outcrop surface.

5.3 WATER

Surface water (Figure 5–3), F25 the brook that drains the Brändan area, was sampled in May 1987 and in June 1989. Surface water at F23 and F24 were sampled in June 1989.

5.4 SURFACE MEASUREMENTS

No measurements of the surface cover of radioactivity are planned or measured during this period. Only some rock/lichen samples are taken, partly to study the small scale fallout pattern (c.f. 5.2).

5.5 METEOROLOGIC DATA

The meteorologic data collected are:
- Precipitation. Monthly sum from Lövstabruk and Films kyrkby.
- Temperature. Monthly mean from Films kyrkby.

All data is collected from SMHI. The Lövstabruk meteorological station is situated one kilometer north of the Finnsjö study site and Films kyrkby meteorological station is situated 11 km to the south.

5.6 HYDROLOGIC DATA

No hydrological data were collected within the Finnsjön study site during this period.

Table 5–1 Sampling and measurement in the Finnsjö study area, 1986 – 1989. Underlined samplings performed by CTH, the rest by Studsvik AB.

Site	Soil	γ Spectr. in situ	Water	Sediment	Vegetation	Rock
F1	BCDE	BC E				
F2	D	C				
F3	B DE	BC				
F4	D	E				
F5	D	E				
F6	D J	E				
F7	DE J	E				
F8	B D	C	ABBCD	D	BC	D
F9		BC			B D	D
F10		C			C	
F11	C	C				
F12	C	C				
F13		BC				
F14		C				
F15				E		
F16	BC	BC	C		B	
F17		B E				
F18		C				
F19		E				
F20		E			C	
F21		E				
F22		B	A			
F23			D J	D		
F24			B D J	D		
F25			D G J	D		
F26				E		
F27			ABB		B	
F28			A			
F29			A			
F30	B					
F31	B					
F32	B				B	
F33	B				B	
F34						D
F35						D
F36						
F37					G	G
F38						G
F39					G	G
F40						
F41						
F42						
F43						

A= 29 Apr 86 F=17-19 Feb 87
B=24-28 Jun 86 G= 4-12 May 87
C= 1-2 Oct 86 H=18-21 Apr 88
D=14-15 Oct 86 I=10-20 Aug 88
E= 6-7 Nov 86 J=11-20 Jun 89

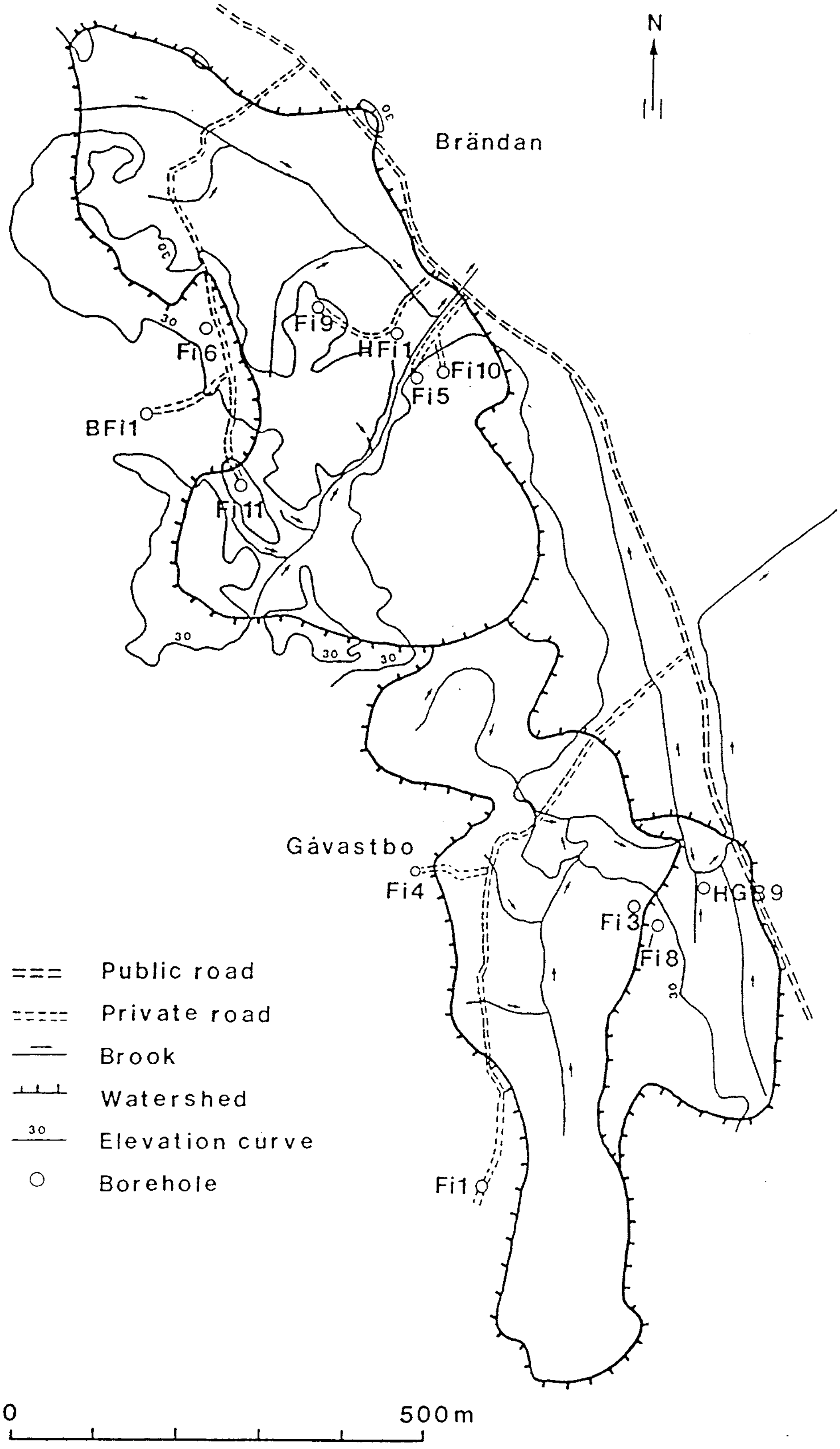

Figure 5–1 Finnsjön study site. Borehole locations.

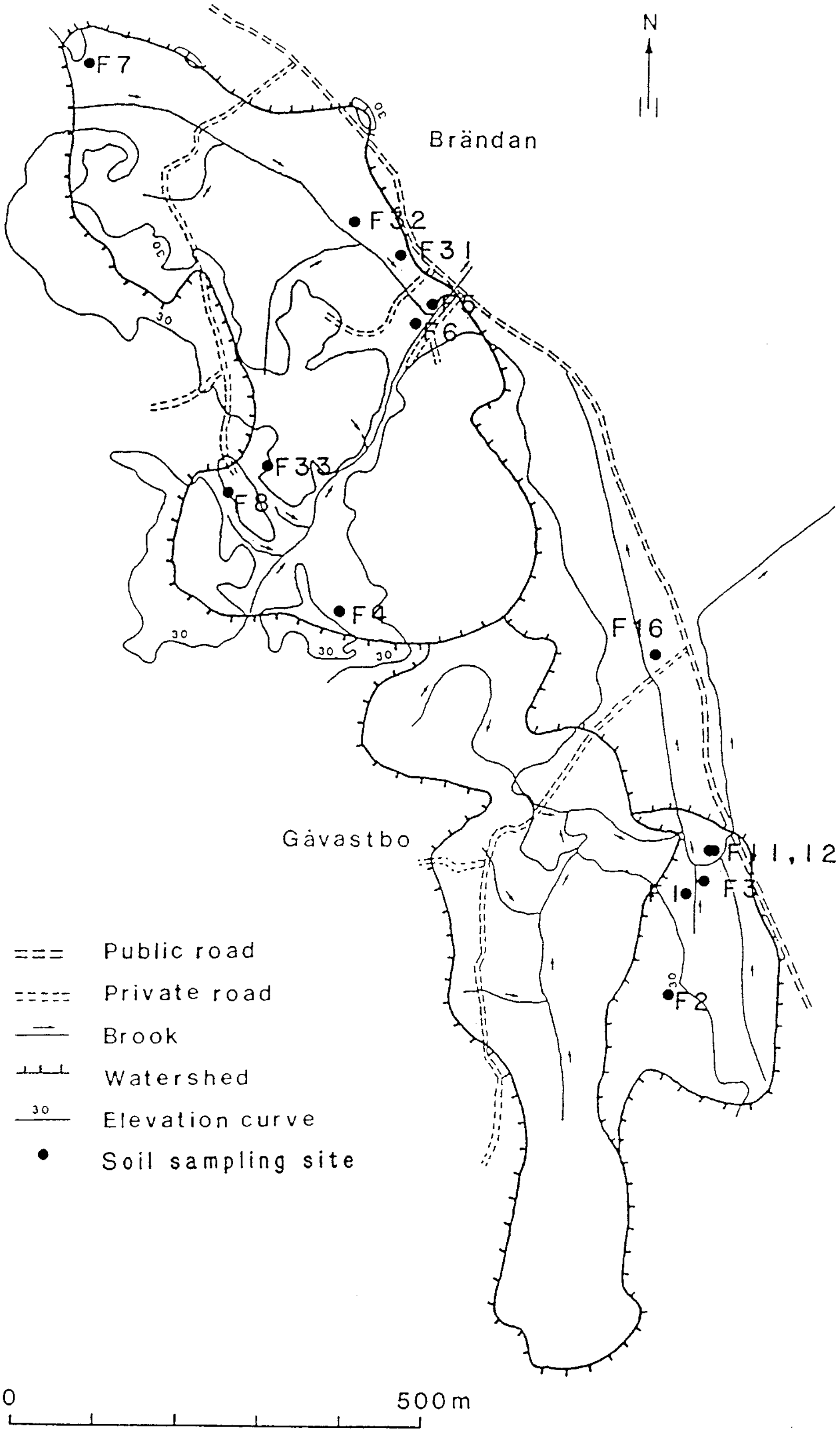

Figure 5-2 Finnsjön study site. Soil sampling. c.f. Table 5-1.

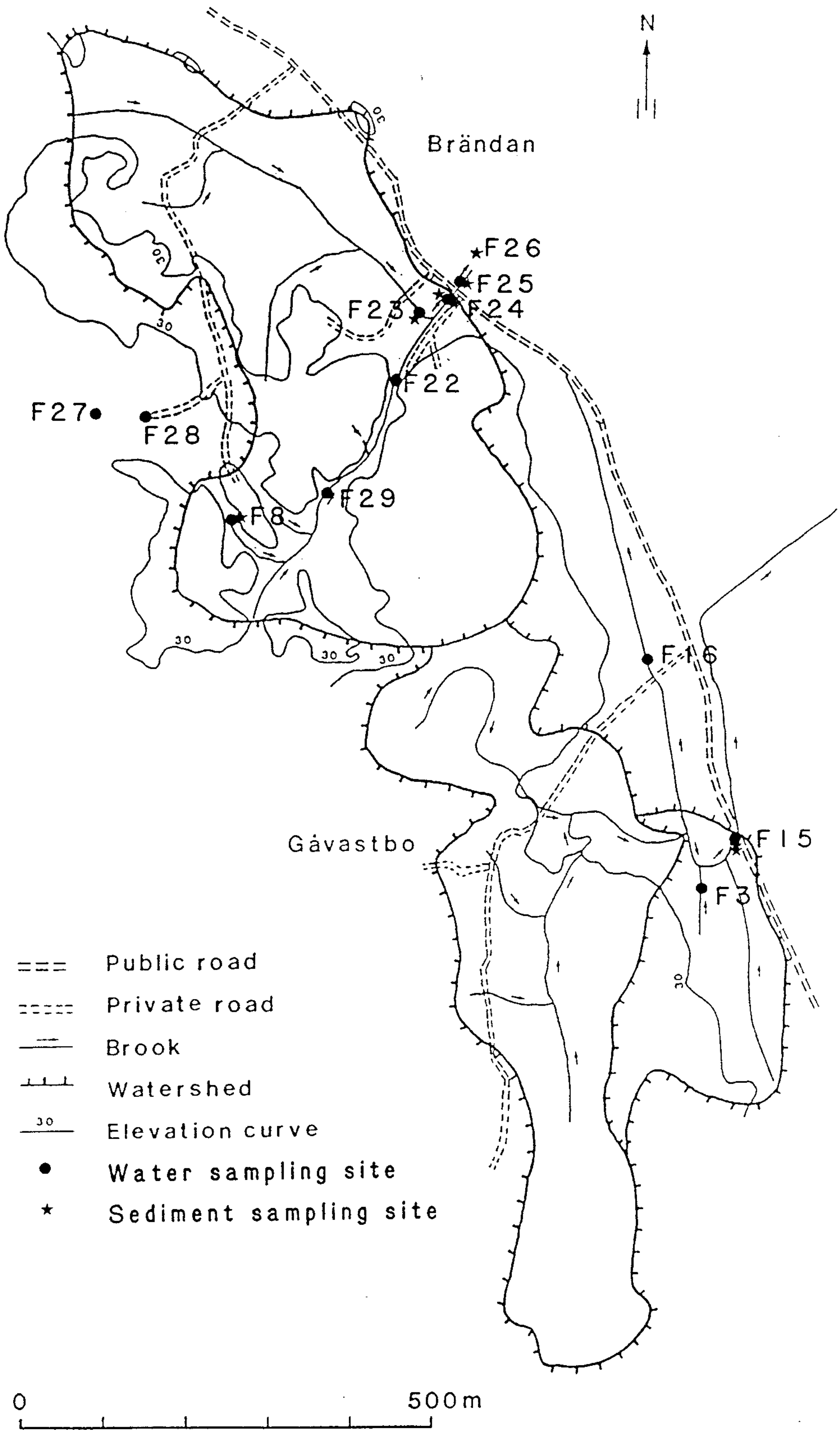

Figure 5-3 Finnsjön study site. Water and sediment sampling. c.f Table 5-1.

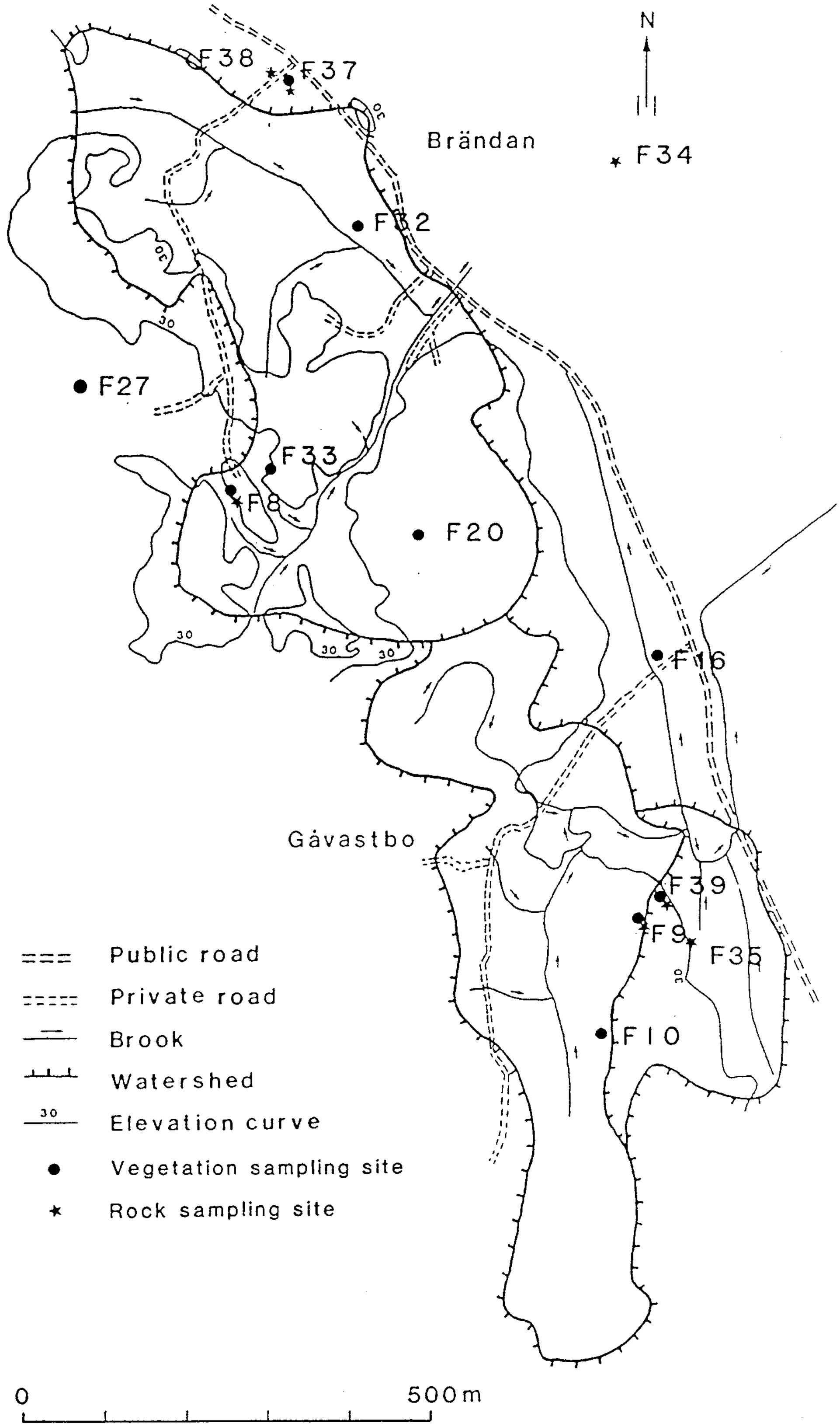

Figure 5–4 Finnsjön study site. Vegetation and rock sampling. c.f. Table 5–1.

6. CONCLUSIONS AND PROPOSAL FOR FURTHER SAMPLING AND MEASUREMENT AT THE FINNSJÖ STUDY SITE.

Conclusions from the sampling and measurement in the Finnsjö study area during 1987, 1988 and 1989 are so far not possible. The samples are not yet measured so no data from the gamma spectra is available for evaluation.

It is however quite obvious, when looking at the data from c.f. the soil profiles, taken in October 1986, that resampling of these profiles probably would result in very good data on radionuclide migration in the soil surface now as the technique and understanding has been worked out at the Gideå site. Even if the Finnsjö area is complex and probably difficult to describe with a simple model of the redistribution of the radionuclides within the area, it will very likely give good results in the small scale, such as studying soil profiles or the change in the surface cover for the fallout nuclides during these six years.

Since the chemical composition of the fallout is different through–out the country it necessitate sampling in Finnsjön to study elements that are not present in Gideå. One example is Cerium–144. Even if Cerium is trivalent and not supposed to migrate to any larger extent, it is still interesting to study its sorption behaviour in soil, vegetation and on rock surfaces.

If the possibility of measuring a large number of samples from Finnsjön exists, then it is advisable to sample in a way that corresponds to the sampling in 1986. The evaluation of these samples is then possible even if this was not included in the original plan from 1988.

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1977-78
TR 121
KBS Technical Reports 1 – 120
Summaries
Stockholm, May 1979

1979
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KBS Technical Reports 79-01 – 79-27
Summaries
Stockholm, March 1980

1980
TR 80-26
The KBS Annual Report 1980
KBS Technical Reports 80-01 – 80-25
Summaries
Stockholm, March 1981

1981
TR 81-17
The KBS Annual Report 1981
KBS Technical Reports 81-01 – 81-16
Summaries
Stockholm, April 1982

1982
TR 82-28
The KBS Annual Report 1982
KBS Technical Reports 82-01 – 82-27
Summaries
Stockholm, July 1983

1983
TR 83-77
The KBS Annual Report 1983
KBS Technical Reports 83-01 – 83-76
Summaries
Stockholm, June 1984

1984
TR 85-01
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Stockholm, June 1985

1985
TR 85-20
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Stockholm, May 1986

1986
TR 86-31
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1987
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List of SKB Technical Reports 1991

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