

1. Introduction

TerraDat (UK) were contracted by Symonds Travers Morgan to carry out geophysical surveys on a SSSI site to complement an overall study of the wetland environment. The aims of the geophysics were as follows:

- Investigate the extent of saline intrusion within the site in relation to tidal influences.
- Identify geological structures of significance.

The survey methods included ground conductivity mapping, electrical resistivity imaging and self potential. The survey data provided conclusions that correlated between the individual methods as well as observations on site from visual inspection and borehole monitoring.

2. Survey Procedure / Data Processing

2.1 Ground Conductivity Survey

The aim of this survey was to characterise lateral changes in conductivity that may be attributable to changes in geology or salinity. The survey was carried out in such a way that the influence on conductivity at the extremes of the tidal cycle could be qualified.

A 250 x 250 metre grid with 10 metre-spaced nodes was established over the site. Measurements of conductivity were collected during three-hour time windows centred on high and low tide. We were fortunate in that the survey was carried out during some of the highest tides, and when high tide occurred during daylight hours. A limitation on the northern extent of this survey was imposed by the overhead high voltage power lines.

A Geonics EM34-3 conductivity instrument was used with a 20m spaced horizontal dipole configuration. This was chosen as this orientation gives the best response to lateral changes in conductivity, and was ideally suited to the depth of the site bearing in mind attenuation due to high conductivities. A detailed description of this method is given in the technical appendix.

The data was processed using the GEOSOFT mapping system to produce colour contour plans of the conductivity data and the differences between the high and low tide datasets.

2.2 Resistivity Imaging Survey

The aim of this survey was to investigate anomalies identified from the conductivity survey, and to produce 2-Dimensional electrical cross sections of the subsurface. A CAMPUS Imager 50 resistivity system was used for the surveys. Details of its operation are given in the technical appendix.

The survey was aided by the very dry ground conditions that reduced signal attenuation, however extensive watering of electrodes was required in order to bring the contact resistance down to a satisfactory level.

The raw field data was processed using the RES2DECO software enabling colour sections of model resistivity versus depth to be produced.

2.3 Self Potential Survey

One traverse down the baseline of the conductivity grid was carried out using porous copper-copper sulphate electrodes.

3. Discussion of Results

3.1 Ground Conductivity Survey

Figure 1 shows a colour contour image of the apparent conductivity data collected at low tide. The scale bar shows the conductivity ranging from 18 to 190 mS.m. The highest values are confined to a zone about 50-55 metres wide immediately adjacent to the sea. This elevation in value is due to the influence of sea water affecting the site and it is likely that this represents the area affected *overall* i.e. by spring tides, water coming over the sea defence and subsurface tidal incursion (see later). The green zone (50-80 m.S.m) is thought to represent areas of the subsurface that are still affected by saline water, but to a lesser extent due to their being further from the sea. There is an

increase in conductivity, but to a lesser extent adjacent to the tidal inlet to the east of the site, again due to the presence of saline water.

The lower conductivity values (18-30 mS.m) represented in blue are interpreted as being closer to the true conductivity of the geology without so much influence of sea water. As would be expected, this area is confined to the middle of the area surveyed.

The data was affected by the presence of a sewer pipeline running approximately north-south. This has been shown on Figure 1, and its effect has been enhanced by the shadow-relief imaging of the data.

The borehole logs show a fairly uniform depth to bedrock (Chalk) beneath the site of around 5 metres b.g.l. The highly variable nature of the material overlying the Chalk is known from the other geophysical surveys and field observations. The influences of this material on the conductivity dataset is minimised by the chosen configuration of the conductivity instrument (i.e. there was more influence from the chalk and seawater than near-surface geology).

Figure 3 shows the same data described above, however it has been presented as a 3D perspective view looking towards Langstone Harbour. The relative amplitudes of the conductivity values are more apparent from this.

Figure 2 shows the difference between the high tide and low tide conductivity datasets. The low tide data was subtracted from the high tide data in order to give positive anomalies in areas that are more conductive at high tide due to the presence of saline water. The conductivity difference is shown on the scale bar which has been adjusted to remove subtle variations in conductivity caused by slightly inaccurate repositioning of the instrument for the second survey. Therefore areas coloured green may be considered not to have any significant influence from tidal changes (during the periods sampled).

As expected, the largest zones of change in conductivity occur adjacent to the sea and the tidal inlet. The area adjacent to the inlet has an average width of 25 metres from

the bank apart from one area that extends up to 70 metres into the site. This anomalous area shows has a raised appearance on the surface, and it possibly represents a trench that has been backfilled and would therefore be more permeable. This is labelled a "1" on the interpretative map. The zone adjacent to the sea shows a less than expected zone of change. There is a large zone centred on 0,100 that coincides with the position of the pipeline and may therefore be due to this feature providing a conduit into the site.

The interpreted position of the pipeline has a series of both positive and negative anomalies associated with it centred on 25,75 / 85,90 / 135,110. These anomalies are interpreted as sea water that has moved up the pipe (either inside or outside) and produced anomalies at joints that are spaced approximately 60 metres apart.

Three negative anomalies (indicating that more sea water is present at *low tide*) are evident at 150,50 / 145,200 and 140,240. These anomalies are labelled "2" on the interpretative map of the site. It can be seen that these are located on the dykes that meander over the site. Sea water was observed to spring up in these locations on the turning tide thus providing an explanation for this initially strange geophysical phenomenon.

The result of the Self-Potential traverse along the 0m baseline is superimposed on Figure 2. Note that areas affected by saline intrusion show highly variable self-potentials, whereas areas without significant sea water activity are more stable.

3.2 Resistivity Survey

The locations of the 8 Imager lines are shown on the A3 diagram which is intended for positioning only; the sections in detail are presented on the pages following the map. Where possible, the same colour scales were used in order to enable correlation between lines. Different scales were used for lines 2 and 8 because the maximum resistivity was much lower than the other traverses. The coloured images represent 2-dimensional sections beneath each line; the horizontal scale referring to metres along the surface, the vertical scale modelled depth below ground level. The highest values

of resistivity are shown in purple and the lowest values in blue. Boundaries have been defined on the basis of cut-off resistivities and where possible geological labels have been applied. These labels are based on the geophysical interpretation. Final interpretation must be based on the on-going correlation of the data with actual physical observations

In general terms, the resistivity survey provided information about the following:

- Extent of saline intrusion laterally and vertically into the site.
- Changes in geology
- Lenses of electrically resistive material associated with a possible erosional channel.
- Anomalies from buried service(s).

Features of interest on the sections have been annotated and also translated onto the final interpretative map. Lines 4,5 and 6 show an undulation in the topography of the chalk which appears to be a channel feature. This is most noticeable on line 5 where the interpreted width of this feature is 50 metres and its depth, around 12 metres. The material infilling this feature becomes less resistive towards the tidal inlet suggesting that this may be due to saline water migrating along it. It is interesting to note the change in shape of the inlet directly opposite the location of this feature (see map). The high resistivity of this feature in line 6 would suggest that it contains quantities of resistive gravel or other dry, unconsolidated material.

The topography of the chalk is represented well on lines 2, 6, 7 and 8. It shows a mean depth of around 5-6 metres below ground level, but shows undulations on line 2. The position of the top of the chalk is complicated on lines with their ends near the areas affected by tidal movement due to the sea. This has the effect of lowering the overall resistivity and blurring the boundary. This does however provide a useful indication of the extent of incursion laterally into the site (such as line 2, 6, 7 and 8). The extent of this zone based on these results agrees with the extent defined by the conductivity survey.

Line 8 has a resistive high anomaly at 144 metres and around 7-9 metres depth. It is interesting to note that this correlates with an area beneath a dyke that shows groundwater activity on the receding tide. It may represent a more porous horizon that facilitates migration.

5. Conclusion

Integrated geophysical surveying at South Moor SSSI has produced information about the geology and hydrogeology of the site that complements the overall study aimed at assessing the impact of these factors on the wetland environment.

Ground conductivity surveying provided information about the extent of saline intrusion into the site, and also provided data suggesting that there is a complex relationship between tidally induced pressure within the site and groundwater movement.

Resistivity surveying yielded data that identified possible geological structures within the site, and also backed up the interpretations derived from the ground conductivity survey.

FOLLOW UP WORK

This survey has achieved its aims, however if required, there remains considerable scope for carrying out further work to obtain additional information about the site. This may include: ground conductivity mapping configured to target the shallow subsurface geology (changes above the chalk); resistivity monitoring with time to investigate the primary flow paths into the site; self potential gridding to investigate abnormal groundwater movement at low tide; seismic refraction to accurately map the topography of the bedrock.

conductivity. This effect is more severe for the vertical dipole mode. For ground conductivities in excess of 700 mmho/m the indicated conductivity in the vertical mode falls to zero, and for greater conductivity becomes negative.

Resistivity Imaging

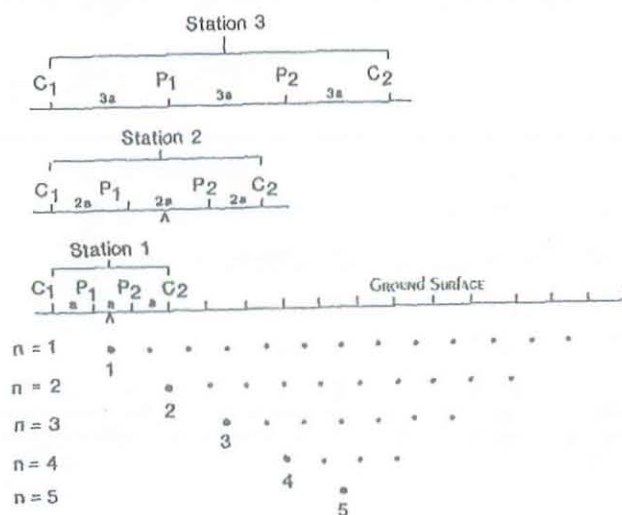
Electrical imaging (tomography) is a survey technique recently developed for the investigation of areas of complex geology where the use of resistivity sounding and other techniques is unsuitable. Electrical imaging involves measuring a series of constant separation profiles with the electrode separation being increased with each successive traverse. Since increasing separation leads to information from greater depth, the measured apparent resistivities may be plotted as a pseudo-section, a contoured section that reflects qualitatively the spatial variation in resistivity in the cross-section. Length of profile, depth penetration and resolution determine the unit electrode spacing which can be anywhere from 1 m to 50m or more.

For electrical imaging with electrode spacings of less than 1m it is convenient to use single multi-core cables such as Campus Imager cables to which all the electrodes are connected at takeouts moulded on at predetermined positions. The cables are connected to a switching module in the GEOPULSE resistivity meter that is controlled by a computer through an RS232 port.

The control software is designed to carry out a series of constant separation traverse along the array, with increasing electrode spacing at each traverse.

Alternatively a 'roll-along' technique may be used. Here, measurement commences at one end of the line using electrodes 1, 2, 3 and 4. The spacing is then doubled without moving on, the active electrodes being 1, 3, 5 and 7. At each measurement, spacing is increased by one unit until the maximum spacing is reached ($n = 6$ for a 20 electrode array), after which the sequence is repeated starting with electrodes 2, 3, 4 and 5. As measurements involving particular reels are completed they can be moved, normally in groups of 3 or 4, to the forward end of the line.

The resulting pseudosection may be modelled using a two-dimensional finite element or finite difference program. Commercially available soft-ware such as RES2DECO enable complex modelling to be carried out on a PC. Alternatively the pseudosection can be inverted automatically to provide an image of true resistivity.



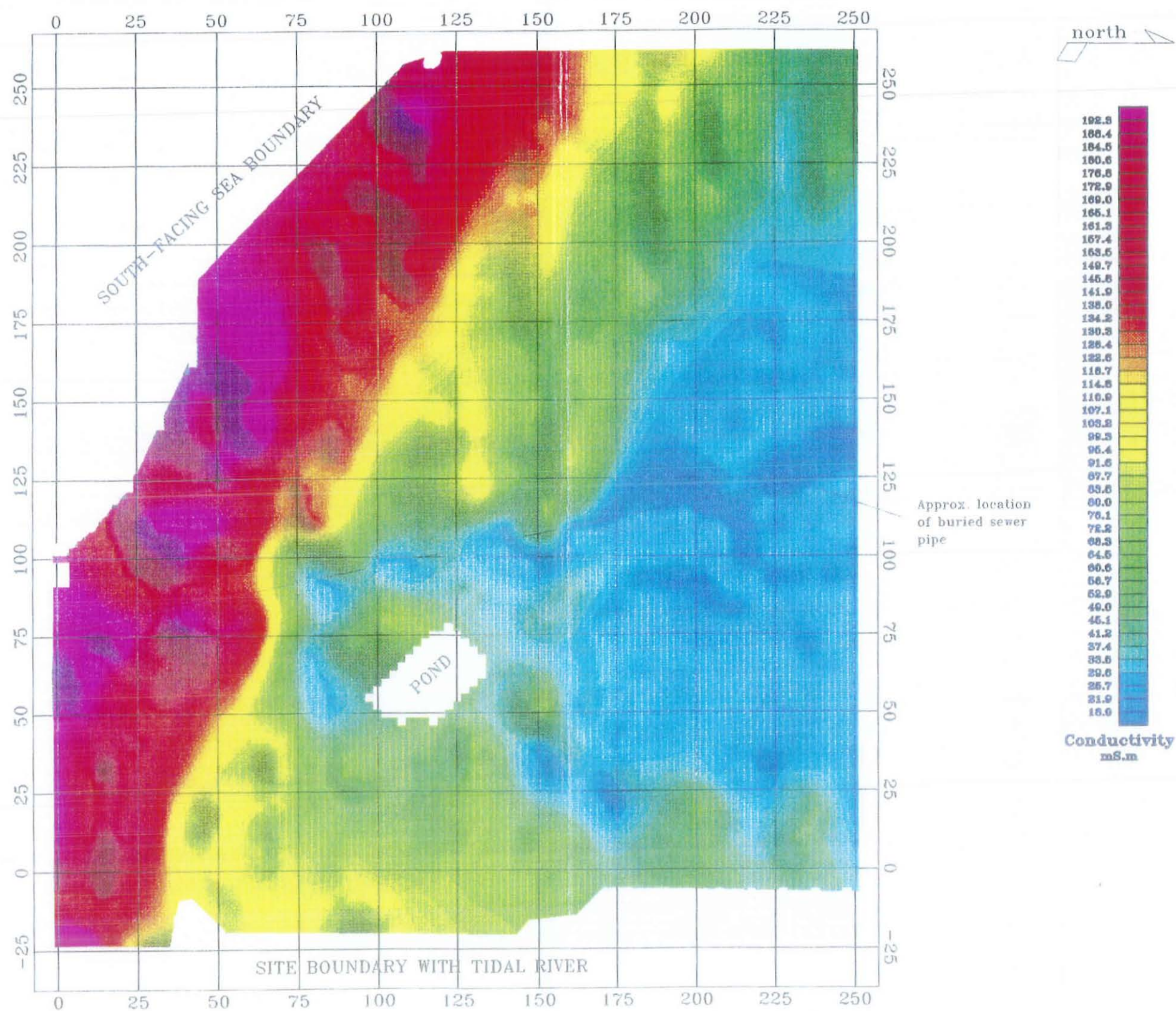


Plan of South Moor SSSI, Havant showing the integrated results of the geophysical surveys. The main features are summarised on the key below:

1. Zone of marine incursion at high tide
2. Areas where more saline water is present at low tide than high tide (more conductive at low tide)
3. Interpreted channel anomaly (based on 3 resistivity lines) - sea water present near tidal inlet
4. Inland extent of land affected by sea water (based on EM34 and resistivity)

Features specific to individual survey / lines are described in main report.

Figure 1.



South Moor SSSI, Havant

Geophysical Survey
EM34 Conductivity
Plan showing conductivity

20m coils, horizontal dipole
August 1995

By: TerraDat (UK) Ltd. - Geophysics

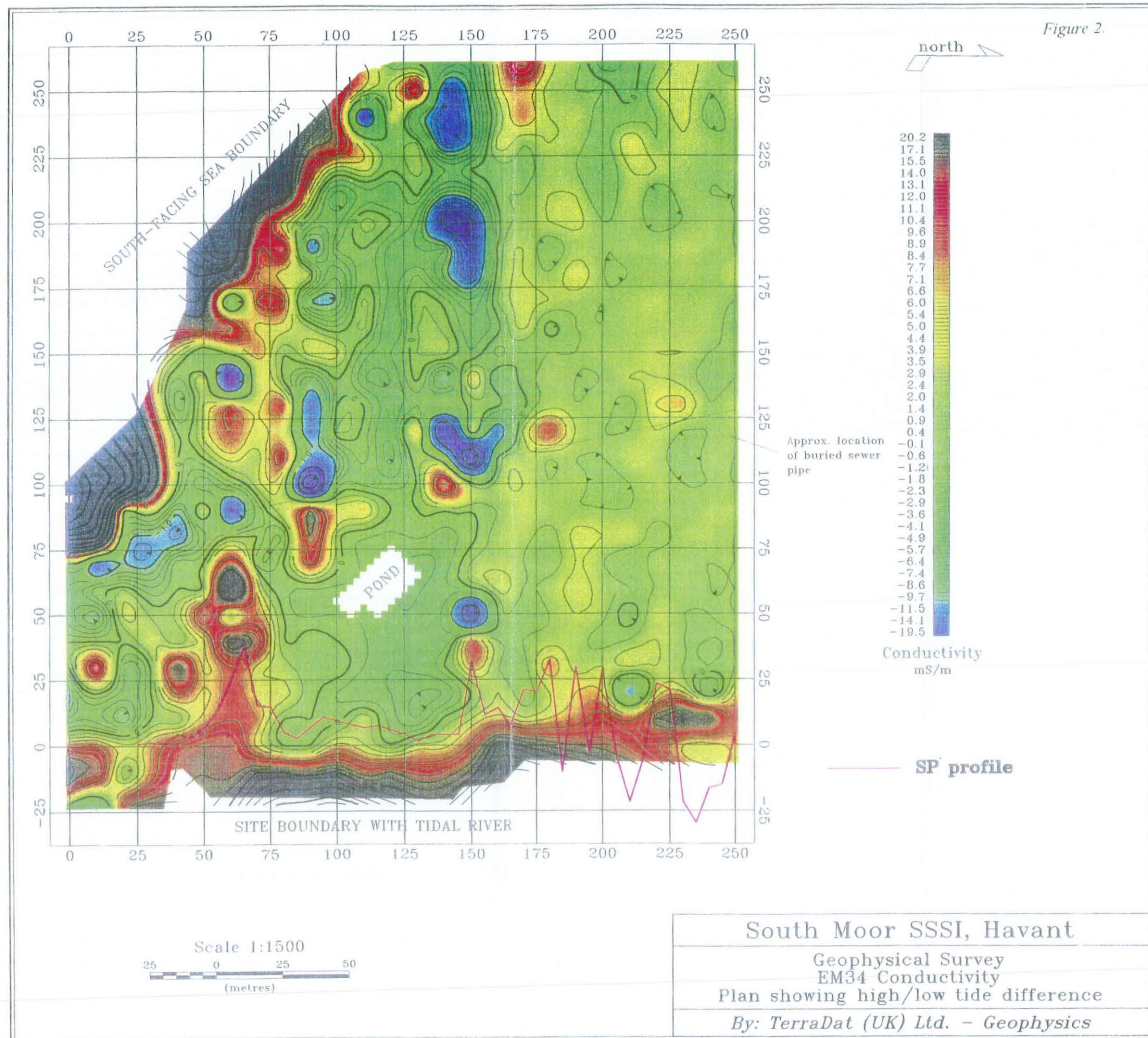
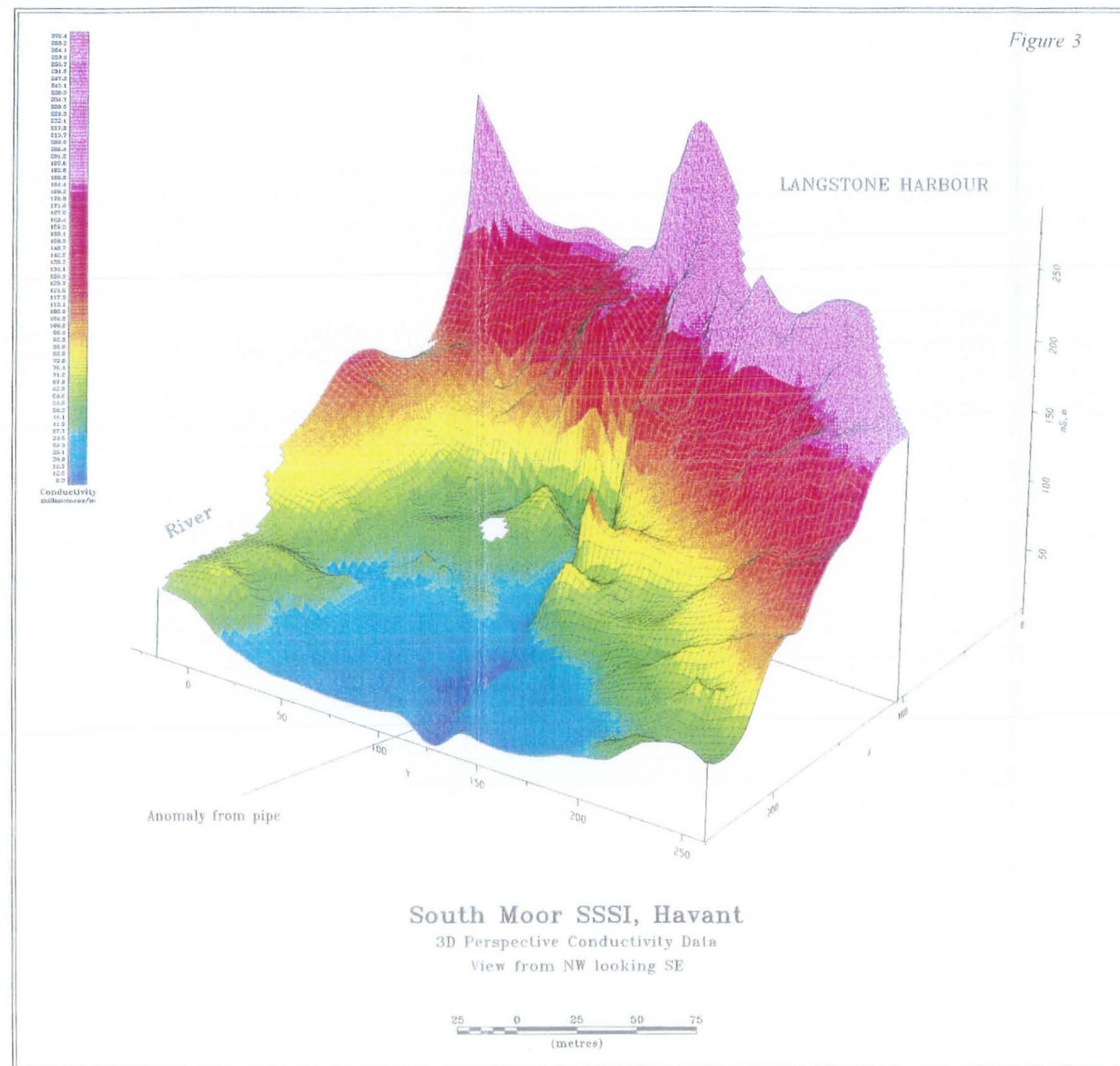
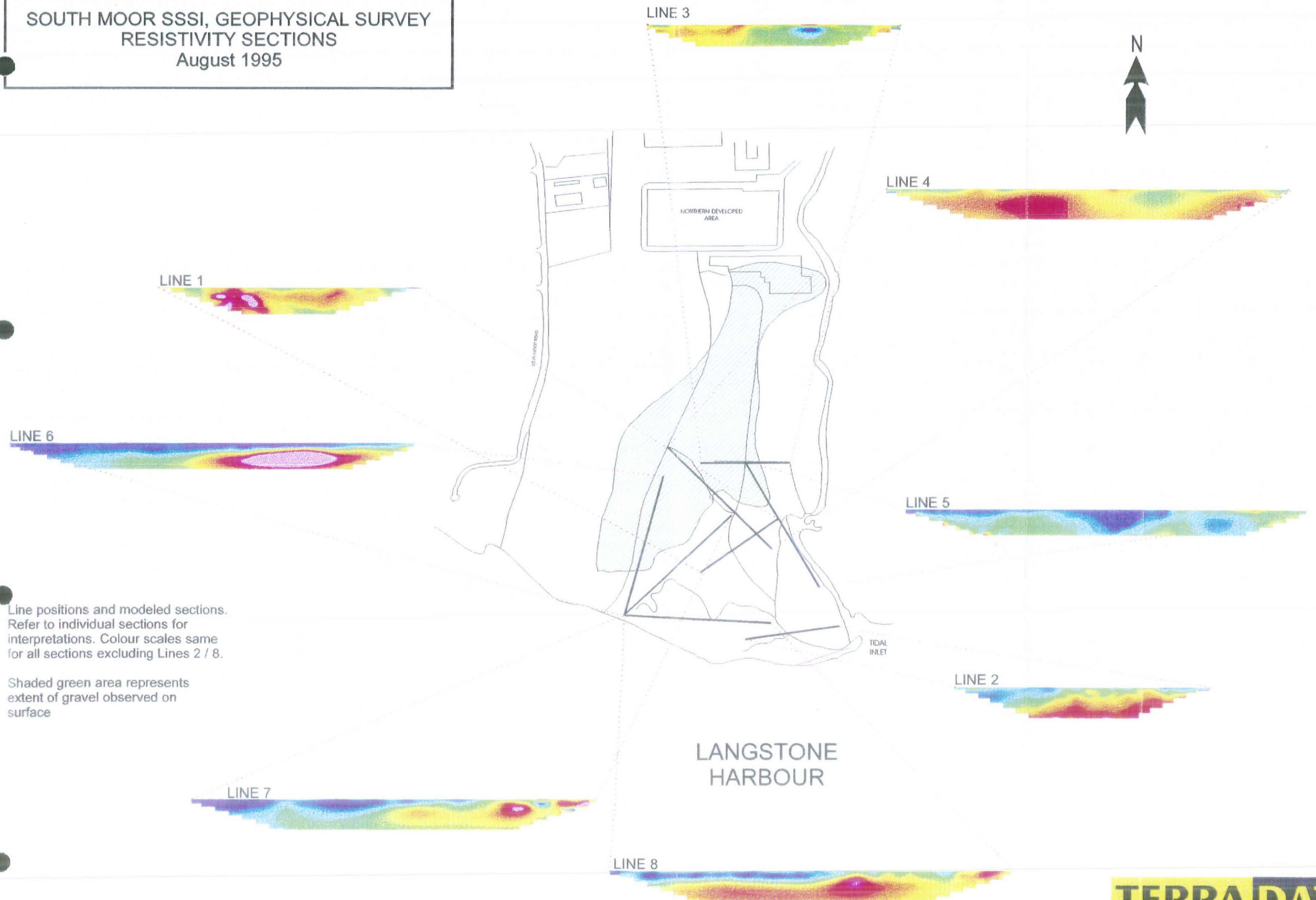


Figure 3



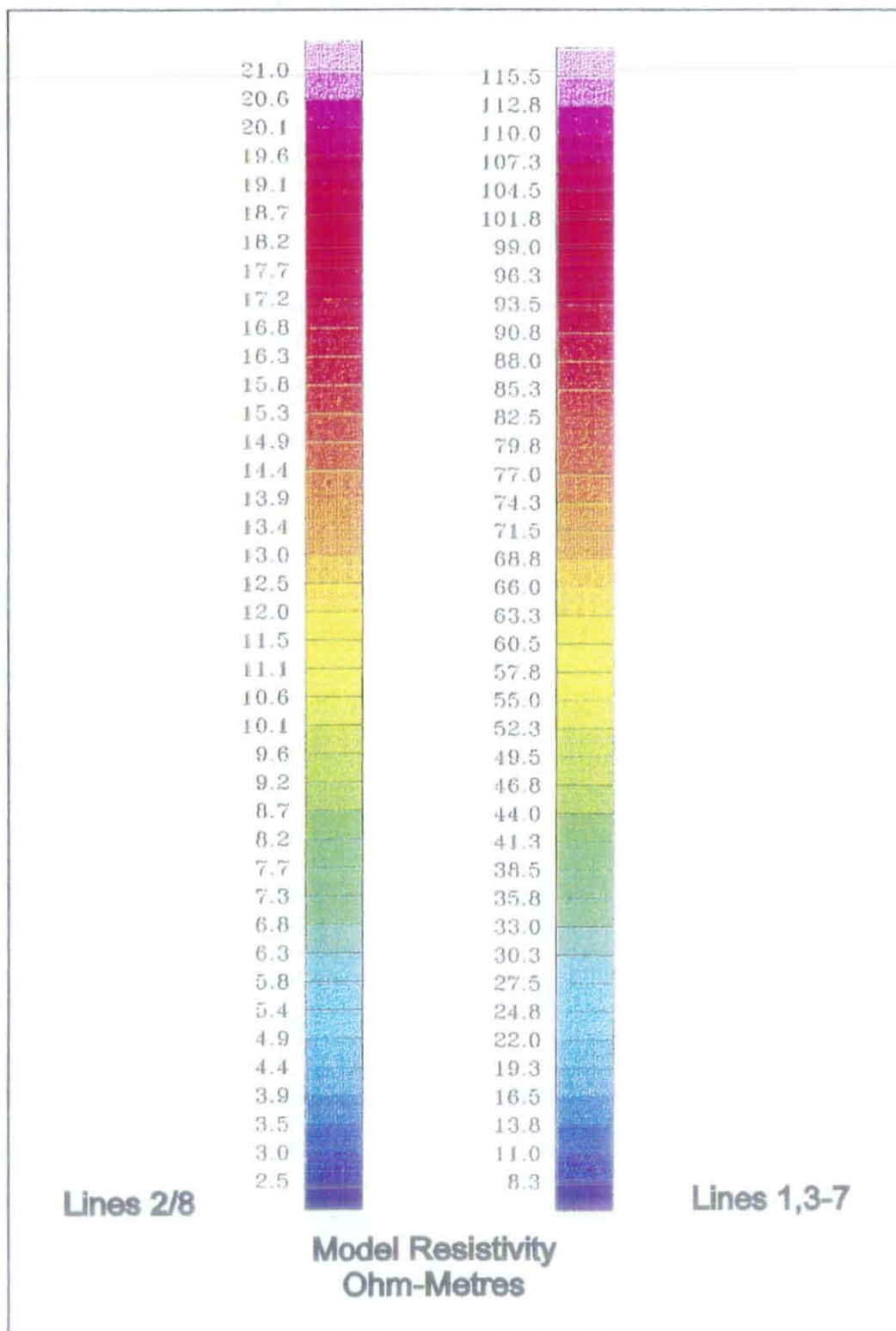
**SOUTH MOOR SSSI, GEOPHYSICAL SURVEY
RESISTIVITY SECTIONS
August 1995**



Line positions and modeled sections.
Refer to individual sections for
interpretations. Colour scales same
for all sections excluding Lines 2 / 8.

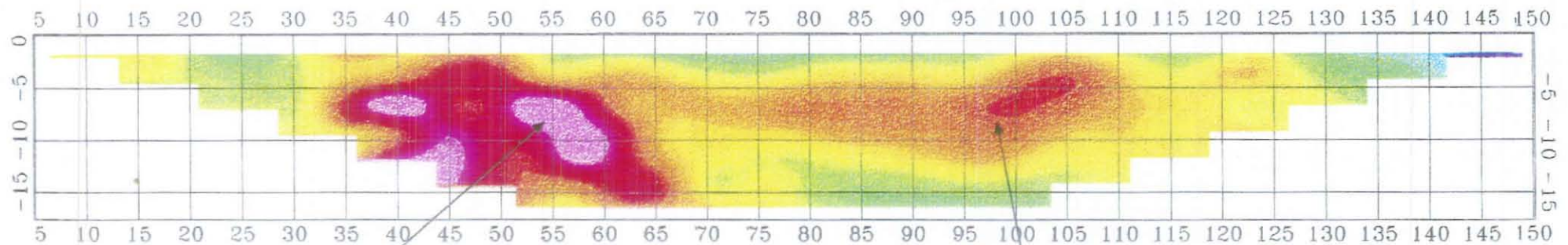
Shaded green area represents
extent of gravel observed on
surface

SOUTH MOOR SSSI **COLOUR SCALE BARS FOR RESISTIVITY SECTIONS**



Resistivities are coloured on the pseudosections according to their values i.e. highest values = purple, lowest = blue. In terms of this site, higher resistivities are attributed to the chalk and gravel in relation to the overlying clay, or sediments that are saturated by saline water which have lower apparent resistivities.

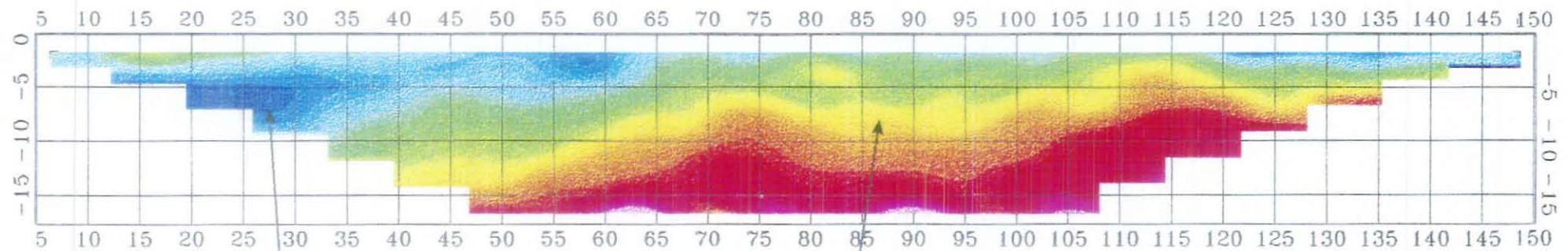
Line 1



Anomalously high resistivities
(buried pipe?)

Intermediate layer of higher
resistivity

Line 2



Low resistivity area due
to presence of sea water

Chalk topography

South Moor SSSI, Havant, Hampshire

Resistivity Imager Sections

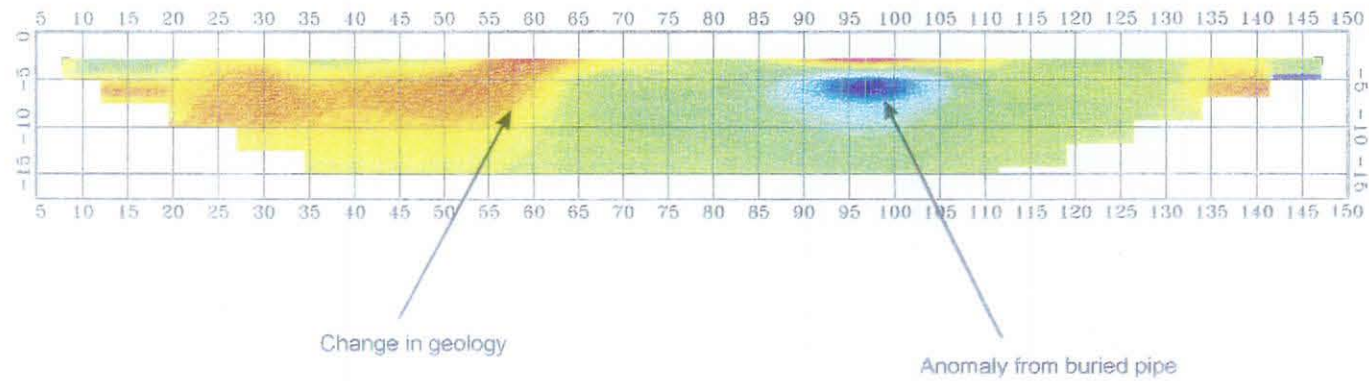
Equipment: Campus Imager 50 and multicore cables

Date: August / September 1995

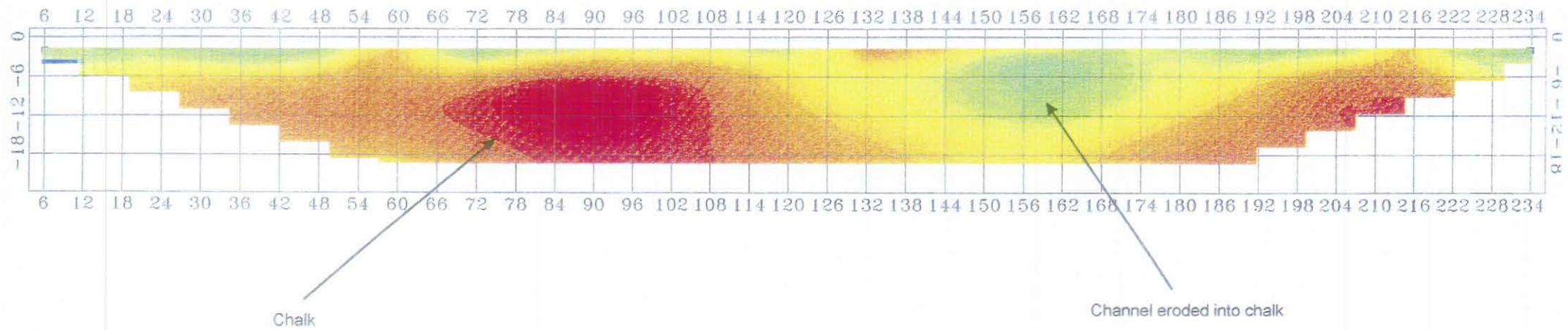
Survey carried out for IBM/Symonds Travers Morgan

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GEOELECTRIC SURVEILLANCE

Line 3

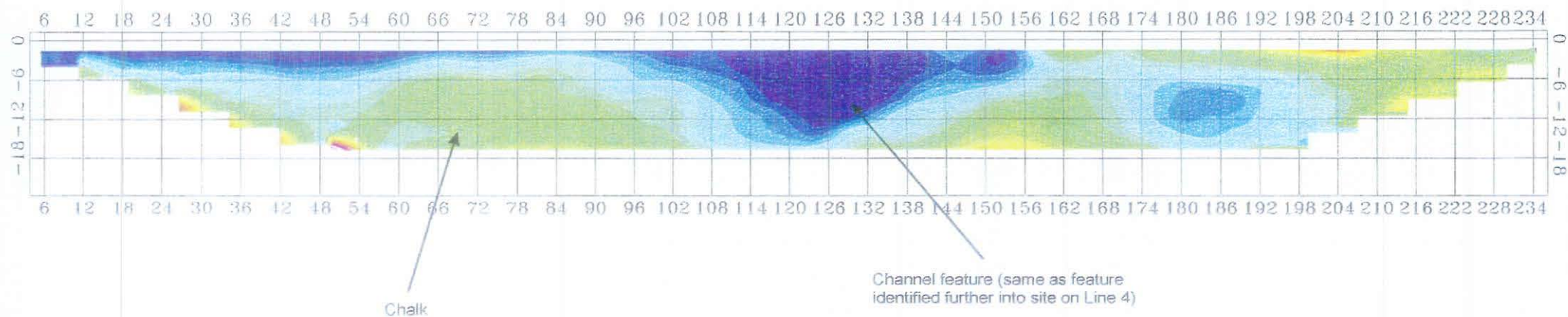


Line 4

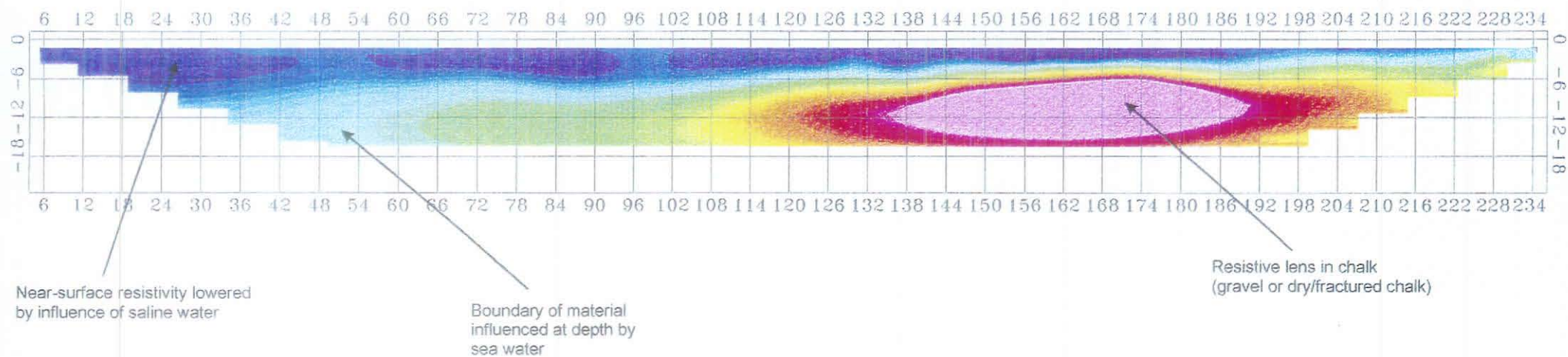


South Moor SSSI, Havant, Hampshire
 Resistivity Imager Sections
 Equipment: Campus Imager 50 and multicore cables
 Date: August / September 1995
TERRADAT

Line 5



Line 6



South Moor SSSI, Havant, Hampshire

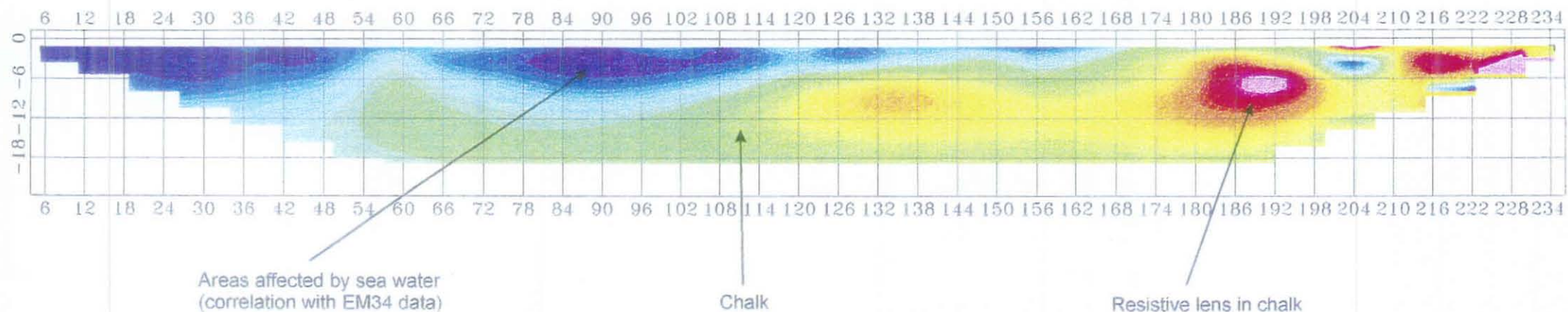
Resistivity Imager Sections

Equipment: Campus Imager 50 and multicore cables

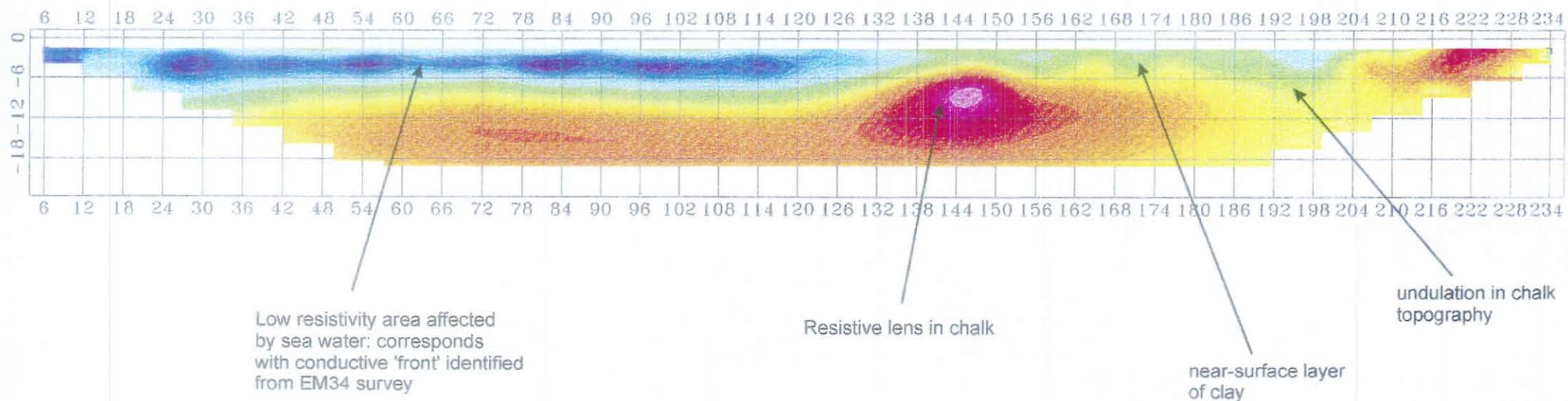
Date: August / September 1995

TERRA DAT

Line 7



Line 8



South Moor SSSI, Havant, Hampshire
Resistivity Imager Sections
Equipment: Campus Imager 50 and multicore cables
Date: August / September 1995

APPENDIX III

Certificate No: SL/95/1246

Date: 9/10/95

ANALYSIS OF SOIL AND WATER SAMPLES

Date received 2/9/95

Client ref 3T40004

Our ref 176-59

SOIL SAMPLES

Determinand	Clint ID Lab ID	LS1SED 45482	LS2SED 45483	DITCH 1SED 45484	DITCH 2SED 45485
Total solids % *		60.2	13.1	75.7	22.0
Volatile solids (LOI) % #		4.6	18.3	10.9	26.7
Sulphide #		130	46	140	570
Sulphate as %SO ₄ #		0.18	0.15	0.52	1.0
Total phosphorus #		830	1300	910	1500
Kjeldahl nitrogen #		1680	5460	2800	7140
Phosphate as P #		37	53	34	25
Iron #		0.62%	0.95%	0.71%	2.21%
Zinc #		140	570	85	120
Copper #		65	150	20	30
Nickel #		15	35	15	20
Lead #		120	460	70	170
Chromium #		35	50	20	20
Cadmium #		3.1	14.9	0.5	1
Manganese #		1.20%	1.30%	1.10%	2.30%
Molybdenum #		8.4	13	13	16
Vanadium #		23	34	36	44
Beryllium #		<1	<1	<1	<1
Barium #		30	10	10	20
Strontium #		30	25	30	25
Mercury #		10.7	<0.10	0.18	<0.10
Arsenic #		8	6	9	10
% Loss on drying		33.5	68.9	44.3	72.9

All concentrations are in mg/Kg unless otherwise stated

Analysis carried out on "air dried" sample

* Analysis carried out on "as received sample"

Certificate No: SL/95/1246

Date: 9/10/95

ANALYSIS OF SOIL AND WATER SAMPLES

Date received 2/9/95

Client ref 3T40004

Our ref 176-59

WATER SAMPLES

Determinand	Client ID Lab ID	BH2 U 45493	BH2 L 45494	BH3 U 45495	BH3 L 45496	BH4 U 45497	BH4 L 45498
Chloride		6080	403	94	24	44	29
Sodium		3855	350	110	18	78	19
Potassium		96	25	3.7	2.1	3.1	2.1
Sulphate		1220	80	70	11	50	13
Bicarbonate		530	280	330	340	390	380
Calcium		120	12	81	110	93	123
Magnesium		241	15	7	2.9	7	3.4
COD		28	11	20	4	21	<4
BOD		-	-	-	-	-	-
Nitrate		<1	<1	<1	3	<1	2
Ammonia		0.6	<0.1	<0.1	<0.1	0.6	<0.1
Phosphate(P)		<0.05	0.10	<0.05	<0.05	<0.05	<0.05
Iron		<0.01	<0.01	3.34	0.04	0.02	0.02
Zinc		<0.01	0.05	0.05	0.03	<0.01	0.02
Copper		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Manganese		0.77	0.74	0.42	0.63	1.74	0.67
Molybdenum		0.08	<0.05	<0.05	<0.05	<0.05	<0.05
Vanadium		0.03	<0.01	<0.01	<0.01	<0.01	<0.01
Beryllium		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Barium		0.08	0.03	0.04	0.07	0.06	0.04
Strontium		0.51	0.34	0.43	0.31	0.30	0.28
Mercury		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

All results are in mg/l

Certificate No: SL/95/1246

Date: 9/10/95

ANALYSIS OF SOIL AND WATER SAMPLES

Date received 2/9/95

Client ref 3T40004

Our ref 176-59

WATER SAMPLES

Determinand	Client ID Lab ID	LS 1 45486	LS 2 45487	DITCH 1 45489	DITCH 2 45490	BH1 U 45491	BH1 L 45492
Chloride		105	18	23400	23800	2831	600
Sodium		71	10	13945	14440	1755	433
Potassium		3.2	1.1	301	345	63	24
Sulphate		20	10	2130	1370	120	93
Bicarbonate		300	260	200	300	440	260
Calcium		94	94	373	403	50	28
Magnesium		7.9	1.9	747	580	114	31
COD		<4	<4	210	200	20	19
BOD		<1	1.6	3.2	9.39	-	-
Nitrate		18	20	<1	<1	<1	<1
Ammonia		<0.1	<0.1	0.4	1.9	0.5	1.2
Phosphate(P)		<0.05	<0.05	0.25	0.95	0.10	0.20
Iron		0.31	1.23	0.94	5.59	<0.01	0.03
Zinc		0.02	0.13	0.02	0.01	0.02	0.04
Copper		<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Nickel		<0.01	<0.01	<0.01	0.02	<0.01	<0.01
Lead		0.01	0.06	0.01	0.02	<0.01	<0.01
Chromium		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Manganese		0.01	0.06	0.03	0.16	1.3	0.85
Molybdenum		<0.05	<0.05	<0.05	0.15	0.05	<0.05
Vanadium		0.02	<0.01	0.07	0.07	0.04	0.03
Beryllium		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Barium		0.01	0.02	<0.01	0.04	0.04	0.04
Strontium		0.38	0.27	0.62	0.65	0.43	0.40
Mercury		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

All results are in mg/l

Certificate No: SL/95/1246

Date: 9/10/95

ANALYSIS OF WATER SAMPLES

Recd date : 02/09/1995

Our Ref : 176-59

Your Ref :

For VOC's By Purge & Trap GC/MS

	SAMPLE ID						
	Client ID	LS1	LS2	DITCH 1	DITCH 2	BH1U	BH1L
	Lab ID	45486	45487	45489	45490	45491	45492
DETERMINAND (ug/l)							
Dichloromethane		<25	<25	<25	<25	<25	<25
Chloroform		<1	<1	<1	<1	<1	<1
1,1,1 - Trichloroethane		<5	<5	<5	<5	<5	<5
Carbon tetrachloride		<1	<1	<1	<1	<1	<1
Benzene		<1	<1	<1	<1	<1	<1
1,2 Dichloroethane		<1	<1	<1	<1	<1	<1
Trichloroethene		<1	2	<1	<1	<1	<1
Bromodichloromethane		<1	<1	<1	<1	<1	<1
Dibromochloromethane		<1	<1	<1	<1	<1	<1
1,1,2,2 - Tetrachloroethane		<1	<1	<1	<1	<1	<1
Freon - 113		<10	<10	<10	<10	<10	<10
Toluene		<1	<1	<1	<1	<1	<1
Tetrachloroethene		<1	<1	<1	<1	<1	<1
Chlorobenzene		<1	<1	<1	<1	<1	<1
Ethylbenzene		<1	<1	<1	<1	<1	<1
m/p Xylenes		<1	<1	<1	<1	<1	<1
o Xylene		<1	<1	<1	<1	<1	<1
Hexachlorobutadiene		<1	<1	<1	<1	<1	<1
4-Chlorotoluene		<1	<1	<1	<1	<1	<1
2-Chlorotoluene		<1	<1	<1	<1	<1	<1
Isopropyl benzene		<1	<1	<1	<1	<1	<1
Bromoform		<1	<1	<1	<1	<1	<1
Styrene		<1	<1	<1	<1	<1	<1
1,3,5 - Trichlorobenzene		<1	<1	<1	<1	<1	<1
1,2,3 - Trichlorobenzene		<1	<1	<1	<1	<1	<1
1,2,4 - Trichlorobenzene		<1	<1	<1	<1	<1	<1
1,2 - Dichlorobenzene		<1	<1	<1	<1	<1	<1
1,3 - Dichlorobenzene		<1	<1	<1	<1	<1	<1
1,4 - Dichlorobenzene		<1	<1	<1	<1	<1	<1
alpha-Methyl Styrene		<1	<1	<1	<1	<1	<1
1,1 - Dichloroethane		<1	<1	<1	<1	<1	<1
1,1,2 - trichloroethane		<1	<1	<1	<1	<1	<1
1,1 - Dichloroethene		<50	<50	<50	<50	<50	<50
trans 1,2 - Dichloroethene		<1	<1	<1	<1	<1	<1
cis 1,2 - Dichloroethene		<1	<1	<1	<1	<1	<1
tert-butyl Methyl Ether		<1	<1	<1	<1	<1	<1

Tetrahydrofuran*

*Non-target, water miscible compound. Quantification would be unreliable due to very low purge efficiency.

Certificate No: SL/95/1525

Date: 7/12/95

ANALYSIS OF WATER SAMPLES

Recd : 7/10/95
 Our ref : 176-62
 Your ref: 3T 40004

	Client ID	BH1 U	BH1 L	BH2 U	BH2 L	BH3 U	BH3 L	BH4 U	BH4 L	DITCH 1	DITCH 2	LS1	DITCH 3
	Lab ID	47441	47442	47443	47444	47445	47446	47447	47448	47449	47450	47451	47452
DETERMINAND													
Sodium		300	1767	328	3650	99	15	20	7.7	13000	1300	6900	75
Potassium		21	68	23	104	4.2	2.2	1.7	2.3	296	42	148	3.7
Calcium		28	53	9.9	116	100	108	106	123	352	267	231	149
Magnesium		29	104	14	258	11	2.7	3.8	3.5	1128	164	571	12
Chloride		382	2940	280	6210	98	25	29	26	22850	2375	11600	174
Sulphate		<20	<20	57	412	39	12	5	12	2833	588	1269	92
Nitrate		<20	<20	<1	<20	<1	<1	<1	<1	<20	<20	<1	<1
Bicarbonate		380	445	435	500	400	320	335	345	160	280	215	290

Concentrations expressed in mg/L (ppm) unless otherwise stated

103

Certificate No: SL/95/1494

Date: 7/12/95

ANALYSIS OF WATER SAMPLES

Recd: 6/11/95
 Our ref: 176 - 64
 Your ref: 3T 40004

Client ID Lab ID	BH1 U 49248	BH1 L 49249	BH2 U 49250	BH2 L 49251	BH3 U 49252	BH3 L 49253	BH4 U 49254	BH4 L 49255	DITCH 1 49256	DITCH 2 49257	LS 1 49258	LS 2 49259
DETERMINAND												
Sodium	1805	266	3930	244	83	16	30	18	8619	4700	113	13
Potassium	78	20	107	23	3.5	2.4	2.2	2.2	261	132	5.1	2.0
Calcium	52	29	119	11	160	112	104	125	344	385	99	105
Magnesium	109	30	263	16	12	2.8	4.9	3.3	1033	549	16	2.3
Sulphate	304	70	1290	51	97	11	7	12	2890	1160	37	12
Chloride	3420	381	5920	262	206	46	49	32	15900	4000	217	43
Bicarbonate	450	250	410	280	300	310	330	380	200	680	260	270
Nitrate	<10	<1	<10	<1	<1	<1	<1	<1	<10	<10	12	5

All concentrations expressed as mg/L unless otherwise stated.

ANALYSIS OF WATER SAMPLES

Recd: 2/12/95

Our ref: 176 - 68

Your ref: 3T 40004

Client ID	BH1 U	BH1 L	BH2 U	BH2 L	BH3 U	BH3 L	BH4 U	BH4 L	DITCH 1	DITCH 2	DITCH 3	LS 1
Lab ID	51559	51560	51561	51562	51563	51564	51565	51566	51567	51568	51569	51570
DETERMINAND												
Chloride	<1	379	5750	270	157	30	30	41	6880	5280	190	150
Sodium												
Potassium												
Sulphate	270	68	1130	64	75	12	3	14	1160	880	87	42
Bicarbonate												
Calcium												
Magnesium												
Nitrate	<1	<10	<10	<10	<1	<1	<1	<1	<1	<10	<1	3

All concentrations expressed as mg/L (ppm) unless otherwise stated.

This data will be subjected
to final QC clearance
before confirmation

ROBERTSON LABORATORIES

ANALYSIS OF WATER SAMPLES

Rec'd : 8/1/96
Our ref : 176-72
Your ref : 3T/40004

DETERMINAND	CLIENT ID LAB ID	BH1 U 53235	BH1 L 53236	BH2 U 53237	BH2 L 53238	BH3 U 53239	BH3 L 53240	BH4 U 53241	BH4 L 53242	DITCH 1 53243	DITCH 2 53244	DITCH 3 53245	DITCH 4 53246
Sodium		1200	367	2900	236	93	19	21	25	8300	815	93	123
Potassium		70	30	139	31	5.7	5.1	4.8	6.7	384	85	10	8.7
Calcium		52	37	92	13	162	109	108	128	386	301	164	152
Magnesium		93	41	216	19	11	2.7	3.5	4.0	1152	247	11	13
Sulphate		270	75	860	46	70	14	4	14	2000	850	100	83
Chloride		2000	515	4400	210	200	25	28	27	15800	1700	145	300
Bicarbonate		200	350	550	390	380	340	360	420	310	430	420	260
Nitrate		<10	<10	<10	<10	<10	<1	<1	<1	<10	<10	10	<10

Concentrations expressed as mg/L (ppm) unless otherwise stated

KJ

ANALYSIS OF WATER SAMPLES

Rec'd : 5/2/96
Our ref : 176-83
Your ref : 3T/40004

DETERMINAND	CLIENT ID LAB ID	BH1 U 56003	BH1 L 56004	BH2 U 56005	BH2 L 56006	BH3 U 56007	BH3 L 56008	BH4 U 56009	BH4 L 56010	DITCH 1 56011	DITCH 2 56012	DITCH 3 56013	DITCH 4 56014
Sodium		1200	240	2840	220	100	17	19	20	1450	2900	89	220
Potassium		92	29	112	30	3.3	2.3	1.7	2.3	52	55	8.7	4.8
Calcium		55	38	81	14	200	110	110	130	190	170	150	210
Magnesium		130	38	190	21	12	2.8	3.9	3.4	180	360	19	21
Sulphate		340	77	850	44	89	22	17	28	440	680	96	130
Chloride		2000	440	4200	190	260	28	30	33	2700	5200	120	460
Bicarbonate		200	160	490	400	380	330	340	380	220	390	460	330
Nitrate		<10	<10	<10	<10	<10	<1	<1	<1	<10	<10	<10	<10

Concentrations expressed as mg/L (ppm) unless otherwise stated

ROBERTSON LABORATORIES

ANALYSIS OF WATER SAMPLES

Rec'd : 4/3/96
Our ref : 176-84
Your ref : 3T/40004

DETERMINAND	CLIENT ID LAB ID	BH1 U 58400	BH1 L 58401	BH2 U 58402	BH2 L 58403	BH3 U 58404	BH3 L 58405	BH4 U 58406	BH4 L 58407	DITCH 1 58408	DITCH 2 58409	DITCH 3 58410	DITCH 4 58411
Sodium		2080	240	2460	250	105	18	18	22	800	1100	79	120
Potassium		105	30	120	32	3.3	2.4	1.1	2.4	35	44	6.4	3.6
Calcium		69	37	88	10	200	120	115	130	150	170	175	150
Magnesium		170	40	230	19	12	2.7	3.4	3.5	110	145	11	8.0
Sulphate		450	67	880	63	72	15	5	18	280	280	75	50
Chloride		3300	430	3700	260	260	30	29	37	1500	2000	98	210
Bicarbonate		550	160	530	310	420	350	360	390	200	430	530	370
Nitrate		<10	<10	<10	<10	<10	<1	<1	3	<10	<10	<10	<10

Concentrations expressed as mg/L (ppm) unless otherwise stated

←

ANALYSIS OF WATER SAMPLES

Rec'd : 22/3/96
Our ref : 176-88
Your ref : 3T/40004/Mon

DETERMINAND	CLIENT ID LAB ID	BH1 U 60160	BH1 L 60161	BH2 U 60162	BH2 L 60163	BH3 U 60164	BH3 L 60165	BH4 U 60166	BH4 L 60167	DITCH 1 60168	DITCH 2 60169	DITCH 3 60170	DITCH 4 60171
Sodium		240	1100	2960	246	110	18	17	22	1730	400	2500	120
Potassium		29	89	112	32	2.8	2.7	1.1	2.6	53	13	77	4.4
Calcium		40	56	91	13	210	125	120	135	140	116	140	107
Magnesium		39	141	225	20	12	3.0	3.3	3.5	168	39	243	16
Sulphate		62	303	951	52	70	15	5	14	470	135	590	52
Chloride		430	2010	4620	235	250	31	29	37	3070	675	4170	260
Bicarbonate		180	190	420	380	450	370	370	410	190	340	350	210
Nitrate		<10	<10	<10	<10	<10	<1	<1	<1	<10	<10	<10	<10

Concentrations expressed as mg/L (ppm) unless otherwise stated

ANALYSIS OF WATER SAMPLES

Rec'd : 12/4/96
Our ref : 176-92
Your ref : Waterloooville

DETERMINAND	CLIENT ID LAB ID	BH1 B 61857	BH1 F 61858	BH2 B 61859	BH2 F 61860	BH3 B 61861	BH3 F 61862	BH4 B 61863	BH4 F 61864	DITCH 1 61865	DITCH 2 61866	DITCH 3 61867
Sodium		246	1240	244	1750	115	18	17	21	690	416	54
Potassium		29	87	31	113	2.9	2.5	1.2	2.5	44	15	2.9
Calcium		38	52	13	88	200	114	113	130	150	134	148
Magnesium		37	120	19	223	12	2.9	3.2	3.4	122	41	6.8
Sulphate		63	322	50	580	76	16	5	20	262	140	63
Chloride		374	2095	235	2970	340	34	40	32	1480	700	64
Bicarbonate		240	190	350	380	320	340	340	390	170	340	430
Nitrate		<10	<10	<10	<10	<10	<1	<1	<1	<10	<10	<10

Concentrations expressed as mg/L (ppm) unless otherwise stated

12 J

ANALYSIS OF WATER SAMPLES

Rec'd : 9/5/96
Our ref : 176-98
Your ref : Waterloooville

DETERMINAND	CLIENT ID LAB ID	BH1 U 63603	BH1 L 63604	BH2 U 63605	BH2 L 63606	BH3 U 63607	BH3 L 63608	BH4 U 63609	BH4 L 63610	DITCH 1 63611	DITCH 2 63612	DITCH 3 63613	LS1 63614
Sodium		1310	300	2560	239	115	18	17	21	7900	3960	55	18
Potassium		81	28	113	31	3.8	2.5	1.1	2.5	170	103	1.9	1.9
Calcium		53	39	90	13	200	115	110	130	240	210	124	104
Magnesium		103	38	214	19	12	2.8	3.1	3.5	578	369	6.8	2.9
Sulphate		380	65	590	56	75	14	5	10	4340	2770	65	14
Chloride		2100	510	4200	230	360	30	26	40	11010	5200	73	26
Bicarbonate		190	250	540	360	300	350	340	380	430	450	340	320
Nitrate		<10	<10	<10	<10	<10	<1	<1	<1	<10	<10	<10	13

Concentrations expressed as mg/L (ppm) unless otherwise stated

ANALYSIS OF WATER SAMPLES

Rec'd : 7/6/96

Our ref : 176-103

Your ref : Langstone Harbour 3T/40004

DETERMINAND	CLIENT ID LAB ID	BH1 U 65676	BH1 L 65677	BH2 U 65678	BH2 L 65679	BH3 U 65680	BH3 L 65681	BH4 U 65682	BH4 L 65683	DITCH 1 65684	DITCH 2 65685	LS1 65686	LS2 65687
Sodium		1550	230	2700	240	65	17	19	17	14000	5400	17	14
Potassium		95	22	120	30	3.5	2.2	1.1	2.0	290	150	1.2	1.1
Calcium		50	43	130	13	150	115	105	120	220	190	90	80
Magnesium		95	38	280	19	11	2.8	3.7	3.6	410	210	3.1	2.5
Sulphate		240	56	927	57	53	12	<1	11	2720	940	9	<1
Chloride		2560	350	4440	224	190	27	29	31	20840	8530	21	18
Bicarbonate		170	280	510	360	280	350	350	370	390	400	270	270
Nitrate		<10	<10	<10	<10	<10	<1	<1	<1	<10	<10	<1	<1

Concentrations expressed as mg/L (ppm) unless otherwise stated

*This data will be subjected
to final QC clearance
before confirmation*

ANALYSIS OF WATER SAMPLES

SITE:- Langstore Harbour

Rec'd: 5-7-96

Our ref:- 176-109

Your ref:- 40004

	CLIENT I.D. LAB ID	BH1U 68019	BH1L 68020	BH2U 68021	BH2L 68022	BH3U 68023	BH3L 68024	BH4U 68025	BH4L 68026	DITCH1 68027	DITCH2 68028	LS1 68029	LS2 68030
DETERMINAND													
Sodium		2200	230	2850	255	113	18	16	23	12000	7500	17	19
Potassium		76	27	116	31	3.2	2.5	1.0	2.3	359	307	1.2	1.4
Calcium		42	40	91	14	177	110	110	118	412	372	101	102
Magnesium		97	37	222	20	9.5	2.8	3.1	3.6	1140	767	2.5	2.6
Sulphate		203	51	875	57	81	17	<1	17	4080	2350	12	14
Chloride		3570	293	4350	217	215	31	29	39	20120	13240	30	28
Bicarbonate		250	400	520	400	400	320	340	350	190	225	290	290
Nitrate		<10	<10	<10	<10	<10	<1	<1	4	<10	<10	9	20

Concentrations expressed as mg/L (ppm) unless otherwise stated

ANALYSIS OF WATER SAMPLES

Rec'd : 20/8/96

Our ref : 176-119

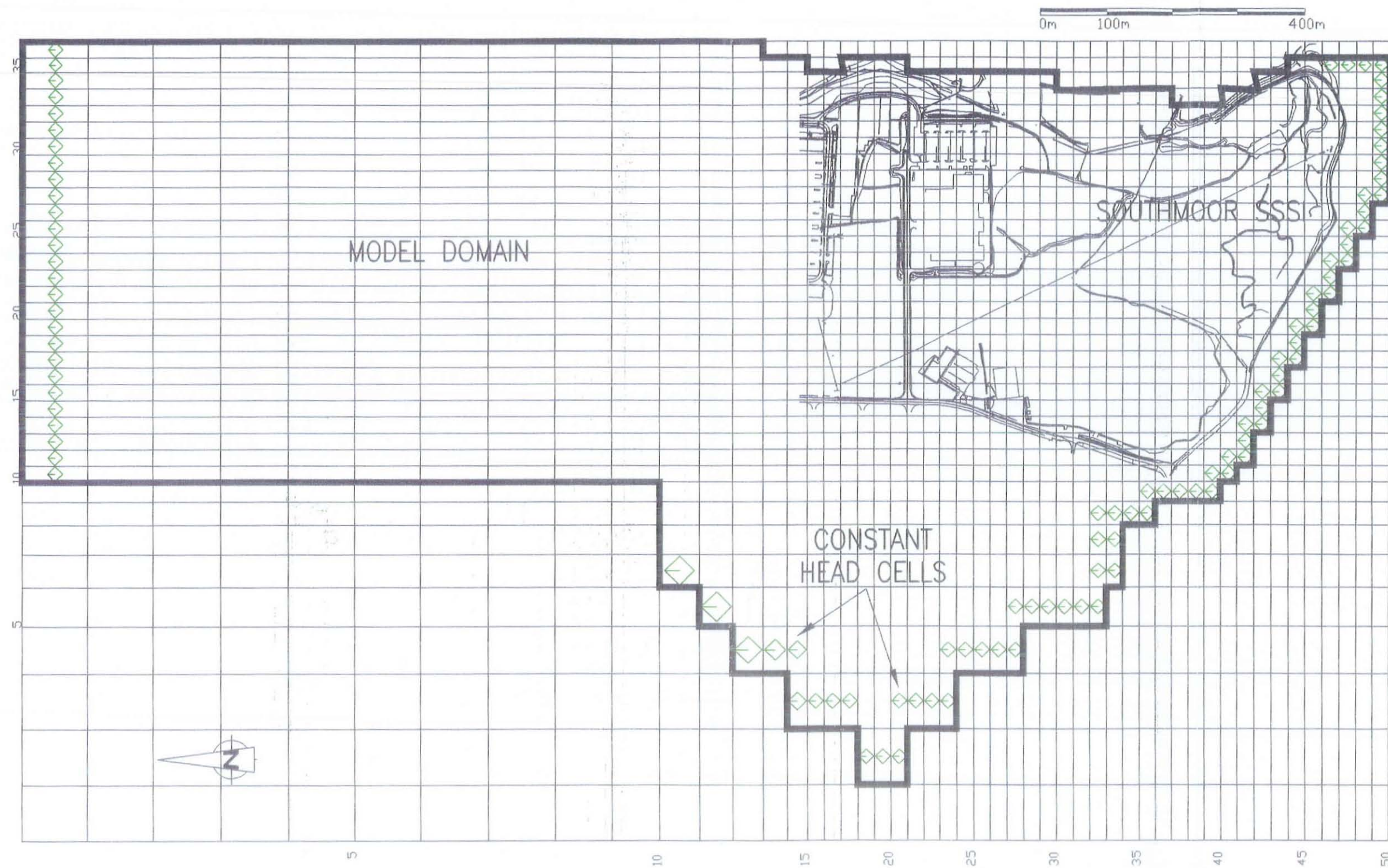
Your ref : Langstone Harbour 40004/KT

DETERMINAND	CLIENT ID LAB ID	BH1 U 70897	BH1 L 70898	BH2 U 70899	BH2 L 70900	BH3 U 70901	BH3 L 70902	BH4 U 70903	BH4 L 70904	DITCH 1 70905	LS1 70906	LS2 70907
Sodium		1210	121	2880	205	70	17	16	24	15000	12	11
Potassium		68	24	114	31	3.1	2.5	1.4	2.4	430	1.6	1.4
Calcium		37	40	88	16	160	105	105	115	400	88	93
Magnesium		85	35	220	21	8.2	2.9	3.1	3.8	1480	2.3	2.2
Sulphate		197	34	920	44	62	14	4	16	3250	7	10
Chloride		1850	160	4360	180	147	28	23	33	26025	19	20
Bicarbonate		480	350	520	410	380	310	330	350	260	260	270
Nitrate		<10	<10	<10	<10	<1	<1	<1	5	<10	14	14

Concentrations expressed as mg/L (ppm) unless otherwise stated

APPENDIX IV

APPENDIX V

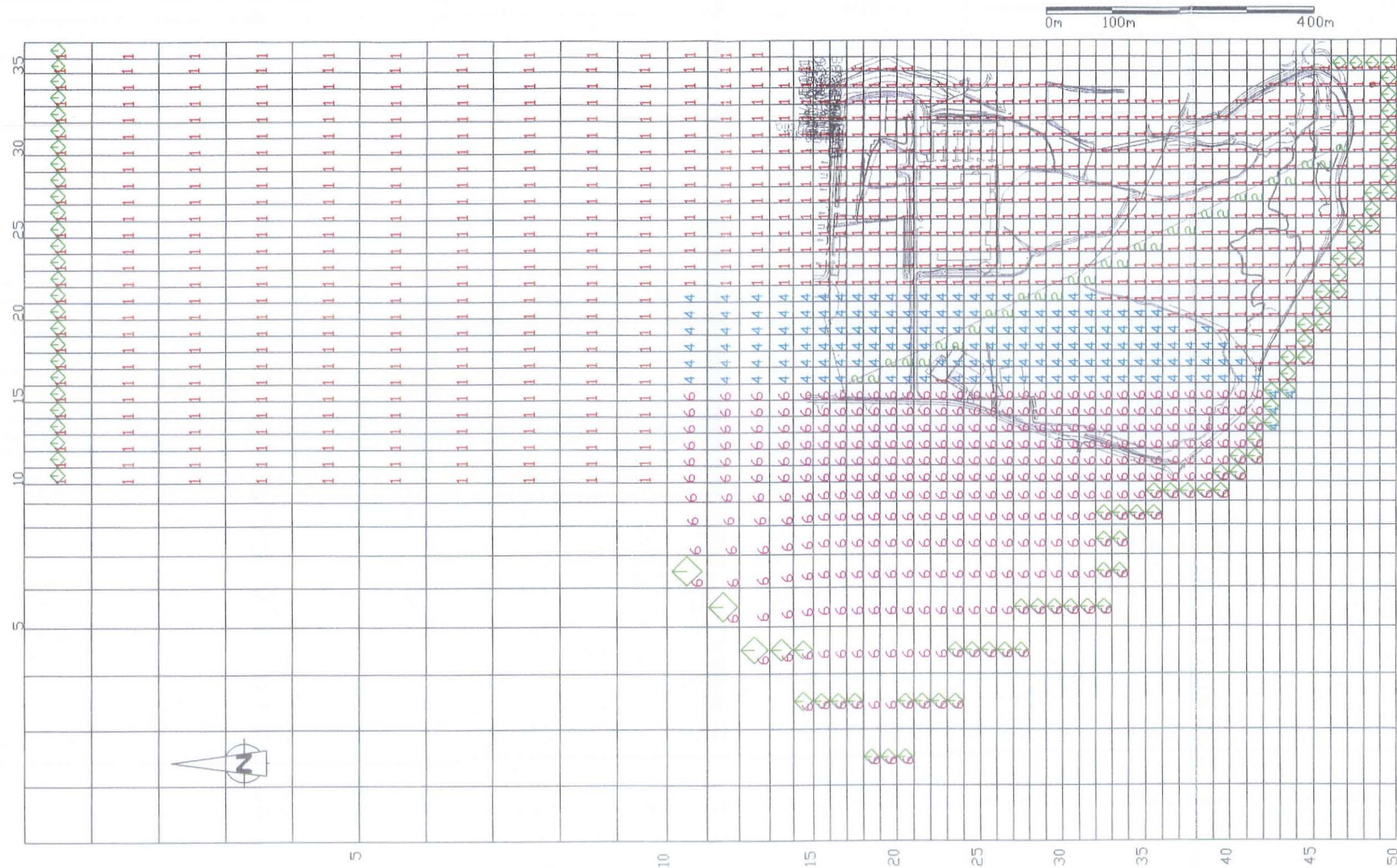


IBM LAND AT SOUTHMOOR, HAVANT

MODELLING PARAMETERS:
MODEL DOMAIN

SYMONDS
TRAVERS MORGAN

DRAWN BY GC	CHECKED BY	PASSED BY	DATE APR'97	SCALE & A3 N.T.S	ISSUING OFFICE E.Grinstead	DRAWING NUMBER	REV 1
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Key to permeability zones

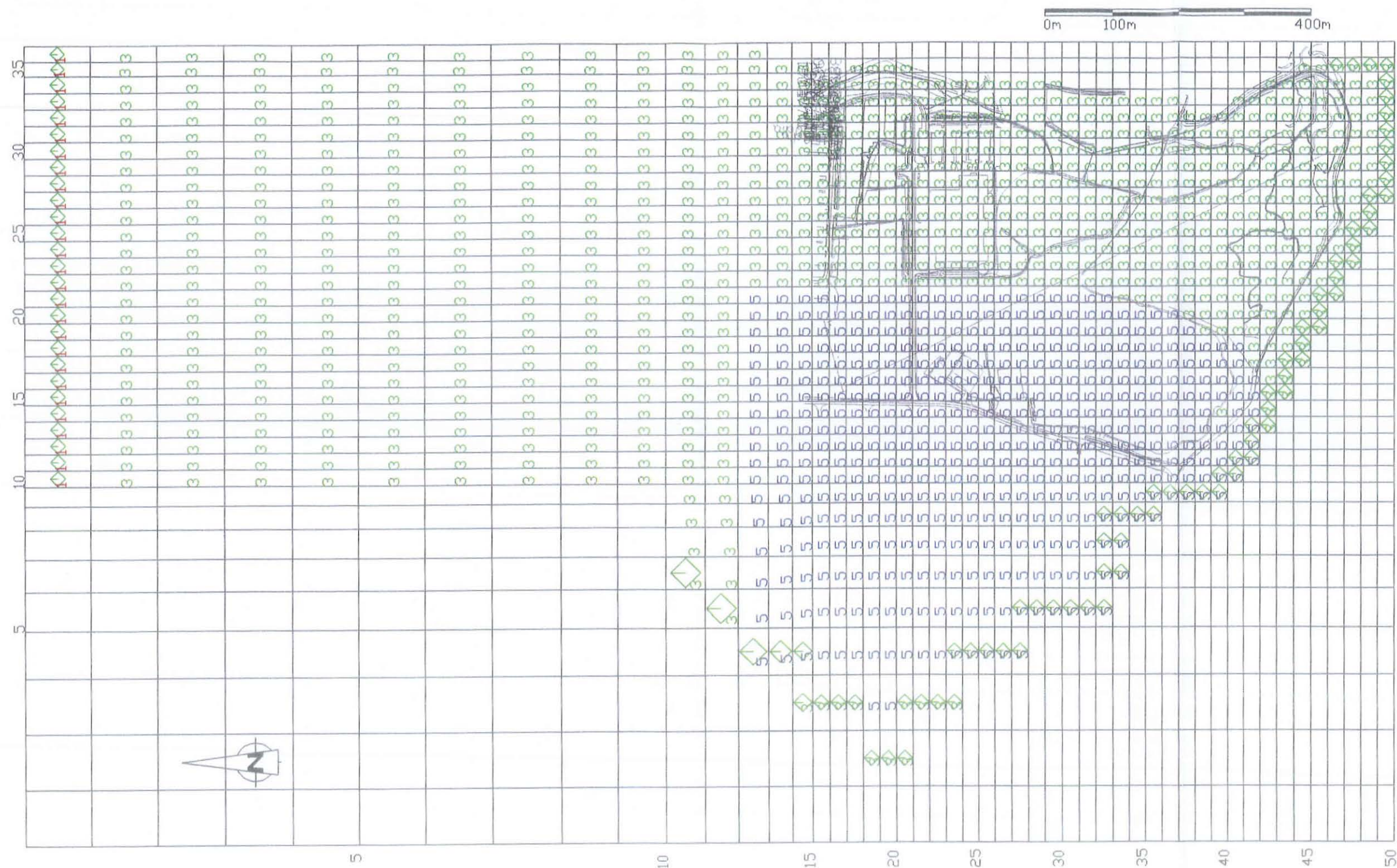
zone	Horizontal Permeability (m/day)	Vertical Permeability (m/day)
1	15	0.015
2	50	5
3	10	0.1
4	15	0.015
5	10	0.1
6	40	0.04

IBM LAND AT SOUTHMOOR, HAVANT

MODELLING PARAMETERS
PERMEABILITY - LAYER 1

SYMONDS
TRAVERS MORGAN

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES	ISSUING OFFICE	DRAWING NUMBER	REV
GC			APR'97	N.T.S.	E.Grinstead		II



Key to permeability zones

zone	Horizontal Permeability (m/day)	Vertical Permeability (m/day)
1	15	0.015
2	50	5
3	10	0.1
4	15	0.015
5	10	0.1
6	40	0.04

IBM LAND AT SOUTHMOOR, HAVANT

MODELLING PARAMETERS PERMEABILITY - LAYER 2

SYMONDS
TRAVERS MORGAN

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES	ISSUING OFFICE	DRAWING NUMBER	REV
GC			APR'97	N.T.S.	E.Grinstead		III

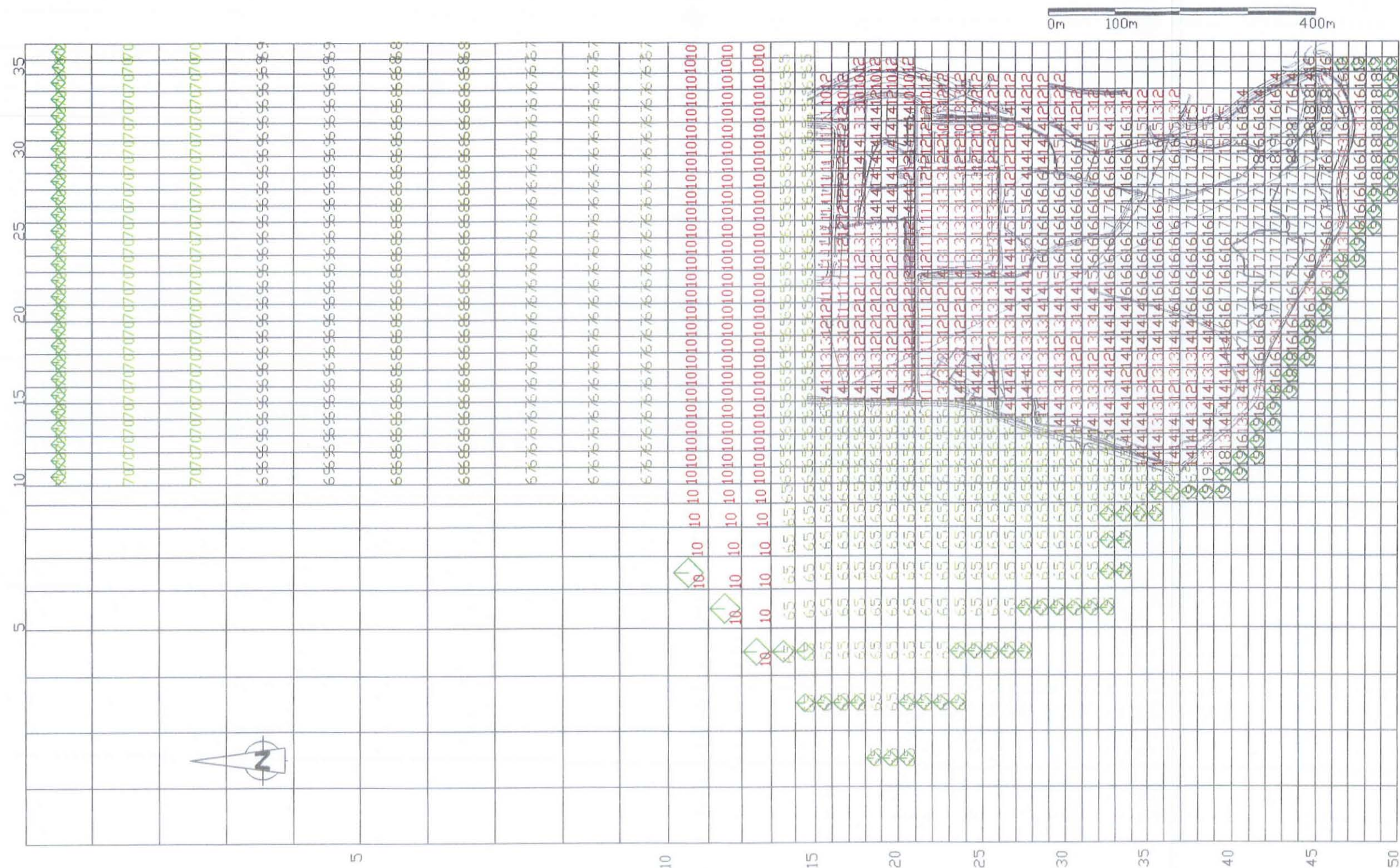
KEY TO ELEVATIONS

Key to elevations (top layer1)

zone	elevation (mAOD)	zone	elevation (mAOD)	zone	elevation (mAOD)	zone	elevation (mAOD)	zone	elevation (mAOD)	zone	elevation (mAOD)	zone	elevation (mAOD)
1	0	11	4.5	21	-0.5	31	-3	41	0	51	-10	61	0
2	0.5	12	4	22	-1	32	-2.9	42	-1.9	52	-9	62	1
3	1	13	3.5	23	-1.5	33	-2.8	43	-1.8	53	-8	63	2
4	1.5	14	3	24	-2	34	-2.7	44	-1.7	54	-7	64	3
5	2	15	2.5	25	-2.5	35	-2.6	45	-1.6	55	-6	65	4
6	2.5	16	2	26	-3	36	-2.5	46	-1.5	56	-5	66	5
7	3	17	1.5	27	-3.5	37	-2.4	47	-1.4	57	-4	67	6
8	3.5	18	1	28	-4	38	-2.3	48	-1.3	58	-3	68	7
9	4	19	0.5	29	-4.5	39	-2.2	49	-1.2	59	-2	69	8
10	5	20	0	30	-5	40	-2.1	50	-2	60	-1	70	9

Key to elevations (bottom layer1)

zone	elevation (mAOD)	zone	elevation (mAOD)	zone	elevation (mAOD)	zone	elevation (mAOD)	zone	elevation (mAOD)	zone	elevation (mAOD)	zone	elevation (mAOD)
1	0	11	4.5	21	-0.5	31	-3	41	0	51	-10	61	0
2	0	12	4	22	-1	32	-2.9	42	-1.9	52	-9	62	1
3	0	13	3.5	23	-1.5	33	-2.8	43	-1.8	53	-8	63	2
4	0	14	3	24	-2	34	-2.7	44	-1.7	54	-7	64	3
5	0	15	2.5	25	-2.5	35	-2.6	45	-1.6	55	-6	65	4
6	0	16	2	26	-3	36	-2.5	46	-1.5	56	-5	66	5
7	0	17	1.5	27	-3.5	37	-2.4	47	-1.4	57	-4	67	6
8	0	18	1	28	-4	38	-2.3	48	-1.3	58	-3	68	7
9	0	19	0.5	29	-4.5	39	-2.2	49	-1.2	59	-2	69	8
10	5	20	0	30	-5	40	-2.1	50	-2	60	-1	70	9

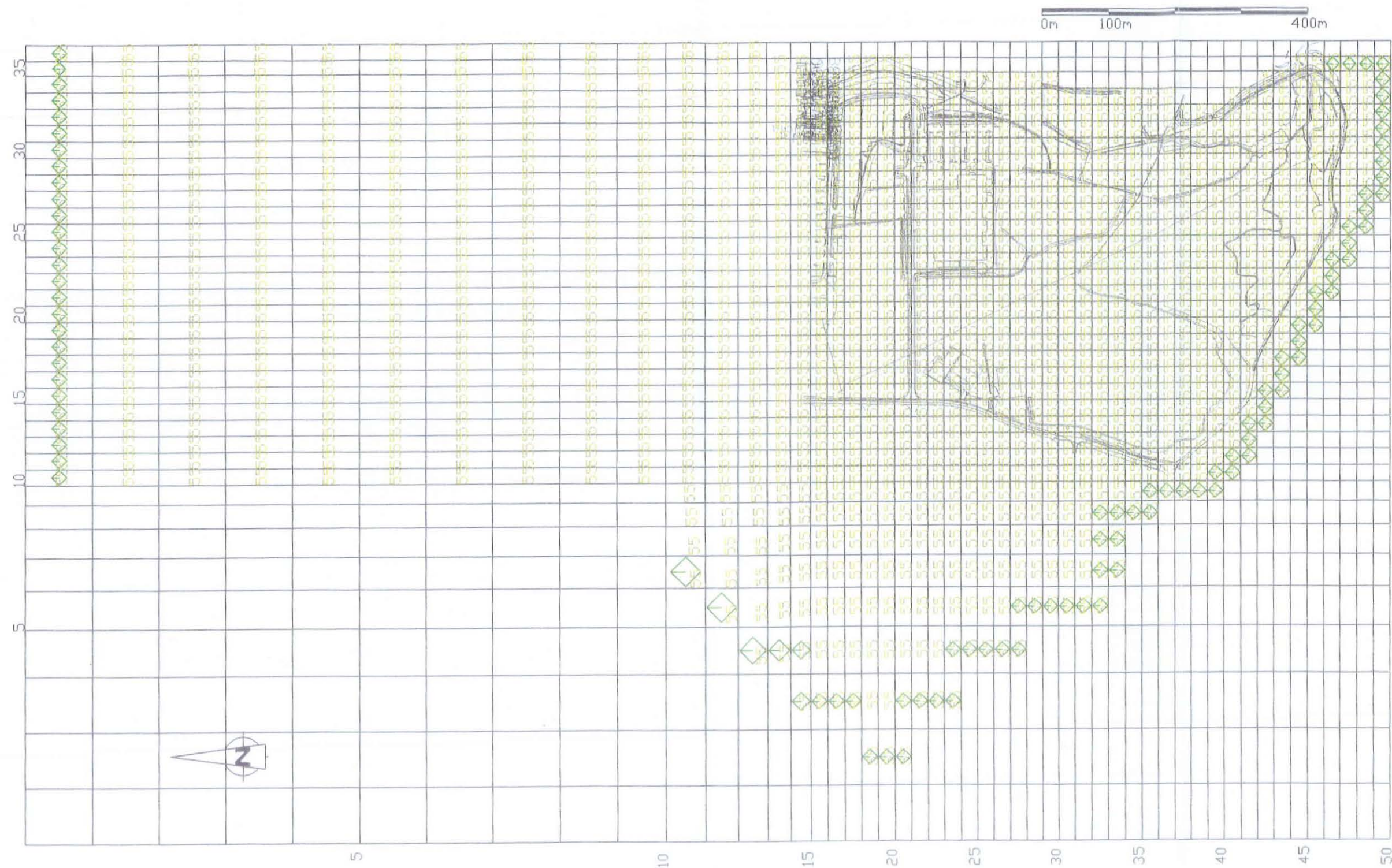


IBM LAND AT HAVANT, SOUTHMOOR

MODELLING PARAMETERS:
TOP ELEVATION OF LAYER 1

SYMONDS
TRAVERS MORGAN

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A3	ISSUING OFFICE	DRAWING NUMBER	REV
GC			APR'97	N.T.S.	E.Grinstead		IV



IBM LAND AT SOUTHMOOR – HAVANT

MODELLING PARAMETERS:
BOTTOM ELEVATION OF
LAYER 2

SYMONDS
TRAVERS MORGAN

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES	ISSUING OFFICE	DRAWING NUMBER	REV
GC			APR'97	N.T.S.	E.Grinstead	APPENDIX VI	

RECHARGE AND EVAPOTRANSPIRATION IN THE TRANSIENT STATE

Key to recharge (m/day) - Transient state (pre development)

zone	Time step	1	2	3	4	5	6	7	8	9	10	11	12
	October	November	December	January	February	march	April	may	June	July	August	September	
1	0.0029	0.0023	0.0029	0.0026	0.0019	0.0021	0.0015	0.0013	0.0014	0.0016	0.0016	0.002	
2	0.000145	0.000115	0.000145	0.00013	0.000095	0.00011	0.000075	0.000065	0.00007	0.00008	0.00008	0.0001	
3	0.0068	0.0058	0.0068	0.0062	0.0051	0.0054	0.0045	0.0042	0.0044	0.0046	0.0046	0.0055	
4	0.0015	0.0012	0.0015	0.0013	0.00095	0.0011	0.00075	0.00065	0.0007	0.0008	0.0008	0.001	

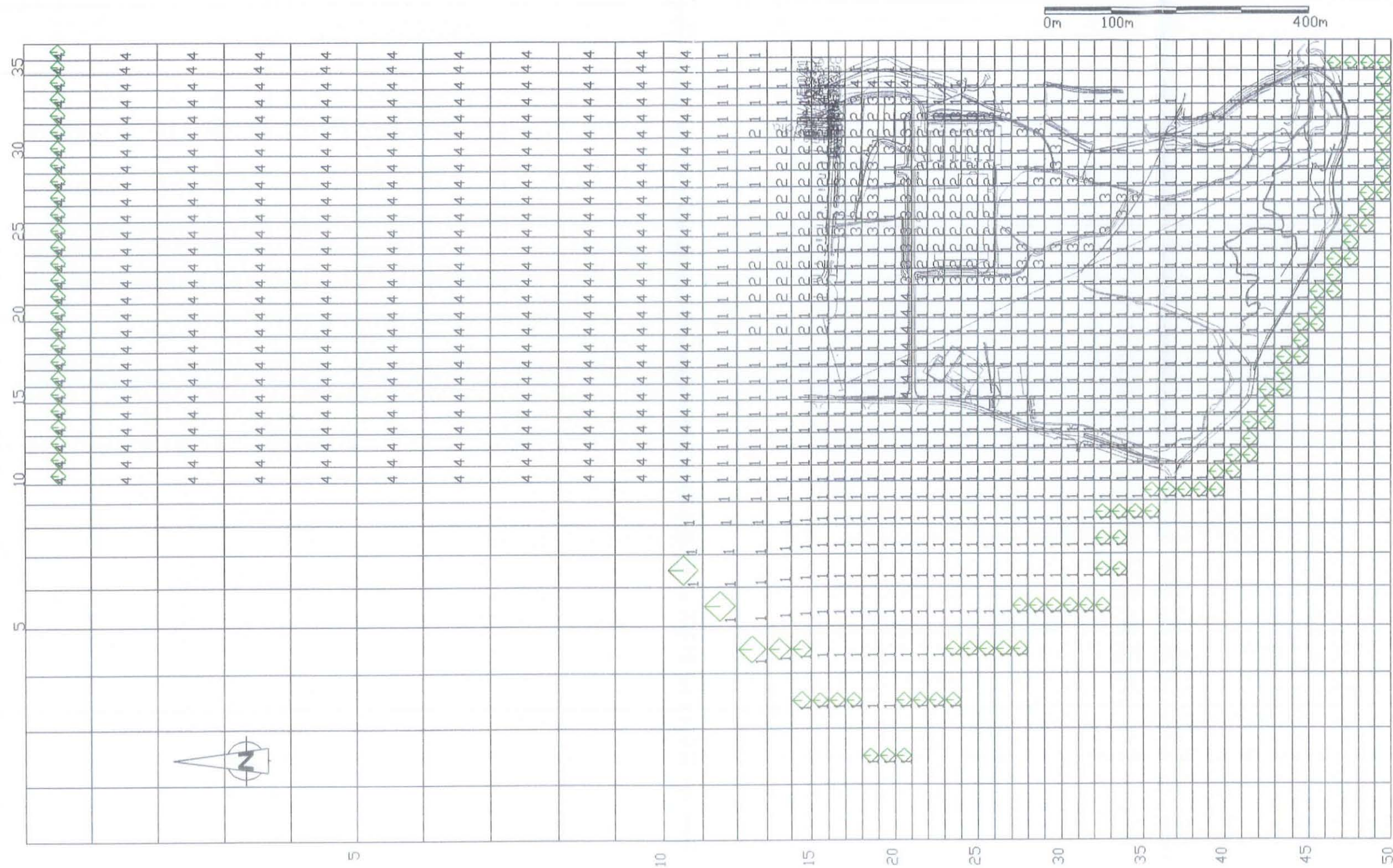
Key to recharge (m/day) - Transient state (post development)

zone	Time step	1	2	3	4	5	6	7	8	9	10	11	12
	October	November	December	January	February	March	April	May	June	July	August	September	
1	0.0029	0.0023	0.0029	0.0026	0.0019	0.0021	0.0015	0.0013	0.0014	0.0016	0.0016	0.002	
2	0.000145	0.000115	0.000145	0.00013	0.000095	0.00011	0.000075	0.000065	0.00007	0.00008	0.00008	0.0001	
3	0.0102	0.0087	0.0102	0.0093	0.00765	0.0081	0.00675	0.0063	0.0066	0.0069	0.0069	0.00825	
4	0.0015	0.0012	0.0015	0.0013	0.00095	0.0011	0.00075	0.00065	0.0007	0.0008	0.0008	0.001	

Key to evapotranspiration (m/day) - Transient state

zone	Time step	1	2	3	4	5	6	7	8	9	10	11	12
	October	November	December	January	February	March	April	May	June	July	August	September	
1	0.0018	0.0063	0.00043	0.00046	0.00059	0.00174	0.00195	0.00284	0.00283	0.00194	0.00169	0.00198	
2	0.0014	0.00105	0.00072	0.00077	0.00098	0.00163	0.00279	0.00355	0.00354	0.00243	0.00211	0.00248	
3	0	0	0	0	0	0	0	0	0	0	0	0	
4	0.00059	0.000315	0.000215	0.00023	0.000295	0.00057	0.000975	0.00142	0.00142	0.00097	0.000845	0.00099	

Note The zonal values of evapotranspiration do not vary between the transient (pre development and post development cases



Key to recharge zones - pre development

zone	Recharge (m/day)
1	0.0019
2	0.000095
3	0.0053
4	0.00095

IBM LAND AT SOUTHMOOR, HAVANT

MODELLING PARAMETERS:
RECHARGE (LAYER 1)

SYMONDS
TRAVERS MORGAN

DRAWN BY
GC

CHECKED BY

PASSED BY

DATE
APR'97

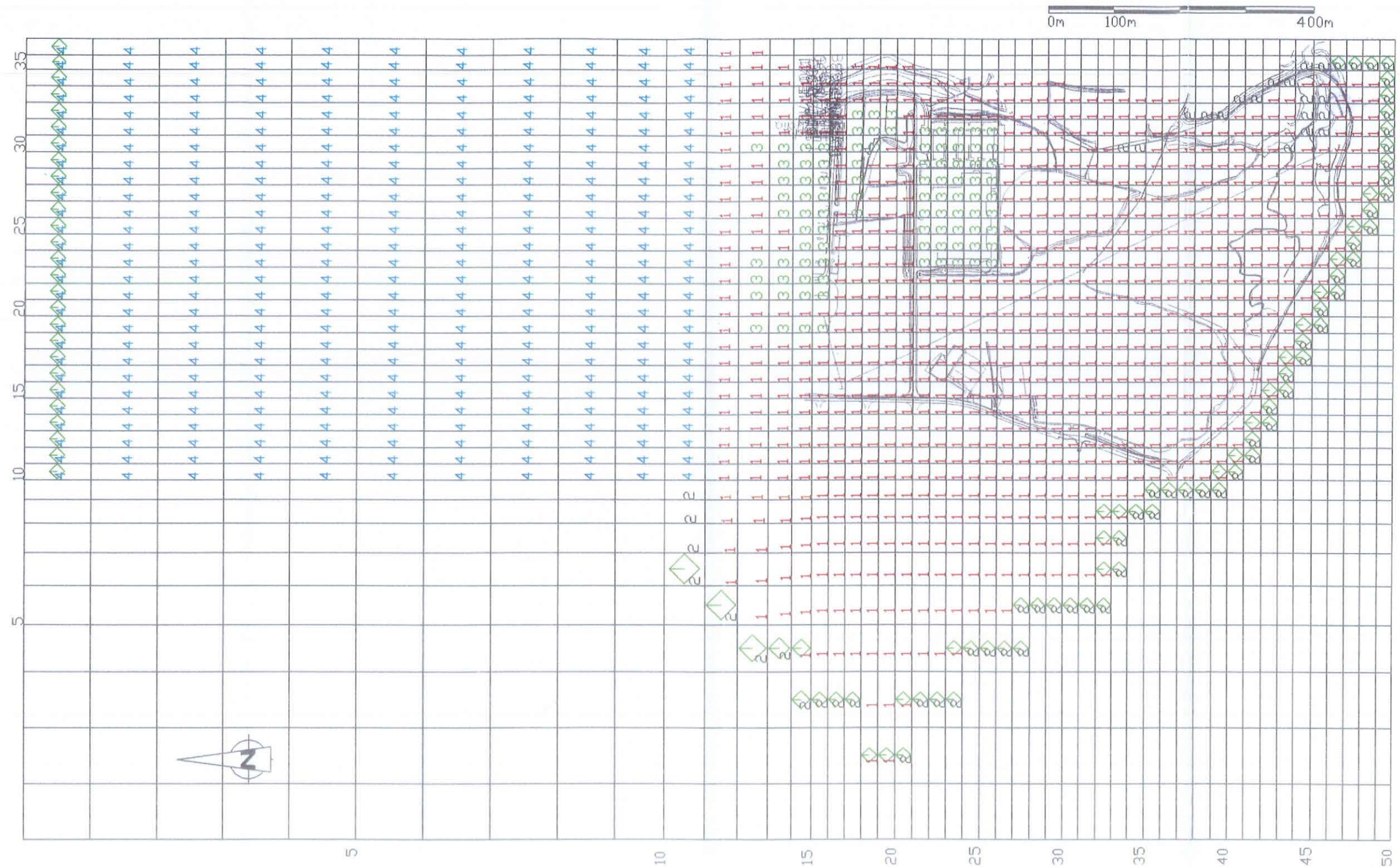
SCALE 1: A3
N.T.S.

ISSUING OFFICE
E.Grinstead

DRAWING NUMBER

VII

REV



Key to evapotranspiration

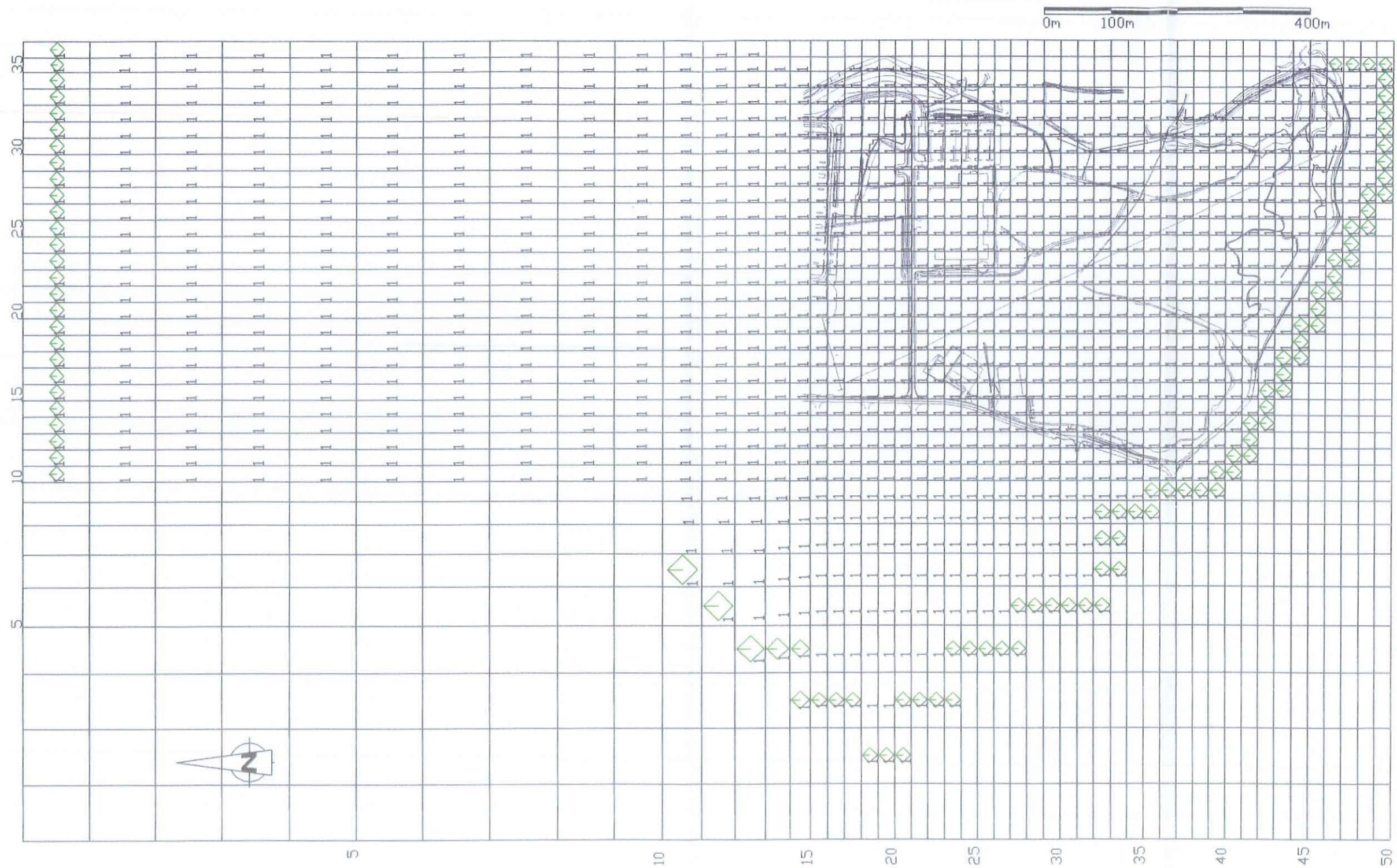
zone	Evapotranspiration (m/day)
1	0.00147
2	0.0021
3	0
4	0.000735

IBM LAND AT SOUTHMOOR, HAVANT

MODELLING PARAMETERS:
EVAPOTRANSPIRATION (LAYER 1)

SYMONDS
TRAVERS MORGAN

DRAWN BY GC	CHECKED BY	PASSED BY	DATE APR'97	SCALE 1/1000 N.T.S.	ISSUING OFFICE E.Grinstead	DRAWING NUMBER	VIII	REV
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zone	storage	porosity
1	0.15	0.2
2	0.01	0.02

IBM LAND AT SOUTHMOOR, HAVANT

MODELLING PARAMETERS:
STORAGE/POROSITY (LAYER 1)

SYMONDS
TRAVERS MORGAN

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALE	ISSUING OFFICE	DRAWING NUMBER	REV
GC			APR'97	N.T.S	E.Grinstead	IX	