Tasmania Department of Mines — Unpublished Report 1988/44

Examination of land at Nobelius Drive, Freshwater Point

by W. L. MATTHEWS and B. D. WELDON

A detailed investigation has been undertaken on Lot 2 (50 Nobelius Drive) at Freshwater Point to examine whether a house could be built on a site favoured by the owner. The investigation has included field examinations, drilling, surveying, laboratory testing of samples and stability analyses.

Surveying

The outline of the northern part of the lot, where development was regarded as possible, has been surveyed, with determination of spot heights allowing approximate contour lines to be drawn. The auger hole positions were surveyed and their positions are marked on Figure 1.

Drilling

Three holes were augered to depths of up to seven metres. Holes 1 and 2 encountered material that could not be drilled at the base of the hole. A number of samples were collected from each hole for laboratory tests. Logs of the three holes are given in Appendix 1.

Laboratory Tests

Atterberg limits, linear shrinkage and moisture contents have been measured on a range of materials from the drill holes (Appendix 2). The clay-rich samples have high liquid limits (and plasticity indices) while linear shrinkages are also high.

X-ray diffraction has been used to determine the composition of the clay fraction of several samples, with kaolinite being the dominant clay mineral present. A small percentage of montmorillonite (an expansive clay mineral) is present in some samples.

Shear strength measurements on two samples have values a little higher than was expected from the Atterberg tests. The shear tests were slow drained tests undertaken in a shear box.

Stability analyses

Stability analyses using Bishop's simplified method have been undertaken. These resulted in a factor of safety calculation (FS). Theoretically a value of 1 or greater for FS indicates the land, under the conditions of the calculation, is stable while in practice a figure of 1.3 is usually used.

Using the first measured residual strength values ($'_r = 19$, $c'_r = 4$) some theoretical slip surfaces were drawn under the slope of the proposed house site. This, as surveyed, has a uniform slope of about 8°. In addition various other strength values were used in separate calculations (namely [11, 4], [19, 0] and [11, 0] for $'_r$ and c'_r respectively). In the Tamar region values of $'_r = 10–11°$ are relatively common in areas affected by landslip and the comparison is useful.

Diagrams of the theoretical slip circles are attached for cases 1, 2 and 3 (Appendix 3). The first series of calculations selects the critical circle radius (Yc), e.g. 100 m, 80 m, 130 m and 110 m for the above strength values respectively for Case 1. Calculations have then been performed using these theoretical slip circles and varying the pore pressure present in the slide mass (R_u) (R_u of 0.5 = complete saturation or a water level at the surface while for $R_u = 0$, the standing water level is below the slip surface). It can be seen in Case 1 that only for $'_r = 11$, $c'_r = 0$ and R_u of greater than about 0.3 are unstable conditions indicated (FS less than 1.3). Similarly for cases 2 and 3 unstable conditions may prevail if pore pressures are high. Stability is indicated in all three cases using the actual measured strength values.

From field observations, the most likely area for unstable conditions to develop would be the area around the steeper slope to the flood plain. Cases A, B, C, D, D (loaded) and E (Appendix 3) deal with various theoretical slip circles as shown on the diagrams. The two sets of measured strength factors have been applied to each of these cases. Again the first set of calculations produce a critical circle and FS is then calculated using varying pore pressures (R_u). In Case C the values of strength factors used in the earlier calculations (cases 1–3) have been included while in Case D (loaded) two Yc values are used. These calculations suggest that instability on the steep slope just above the flood plain is likely under most conditions (cases A and B) while large single movements that include land near and upslope of the house site are possible when high pore pressures prevail.

Conclusions

The most likely location of landslips affecting the block is the steeper slope to the flood plain. Progressive failure on this slope could extend towards the house site under adverse conditions. Large single movements extending from the flood plain to the house site area are possible when pore pressures are high.

It should be possible to build a house at the proposed site with reasonable safety, provided pore pressures remain low. Excellent drainage is essential. Retention of the trees on the steeper southern part of the lot is recommended as this will have a stabilising influence on the area that appears most prone to failure. Progressive failure on this slope is a risk that should be prevented as far as possible.

[31 October 1988]

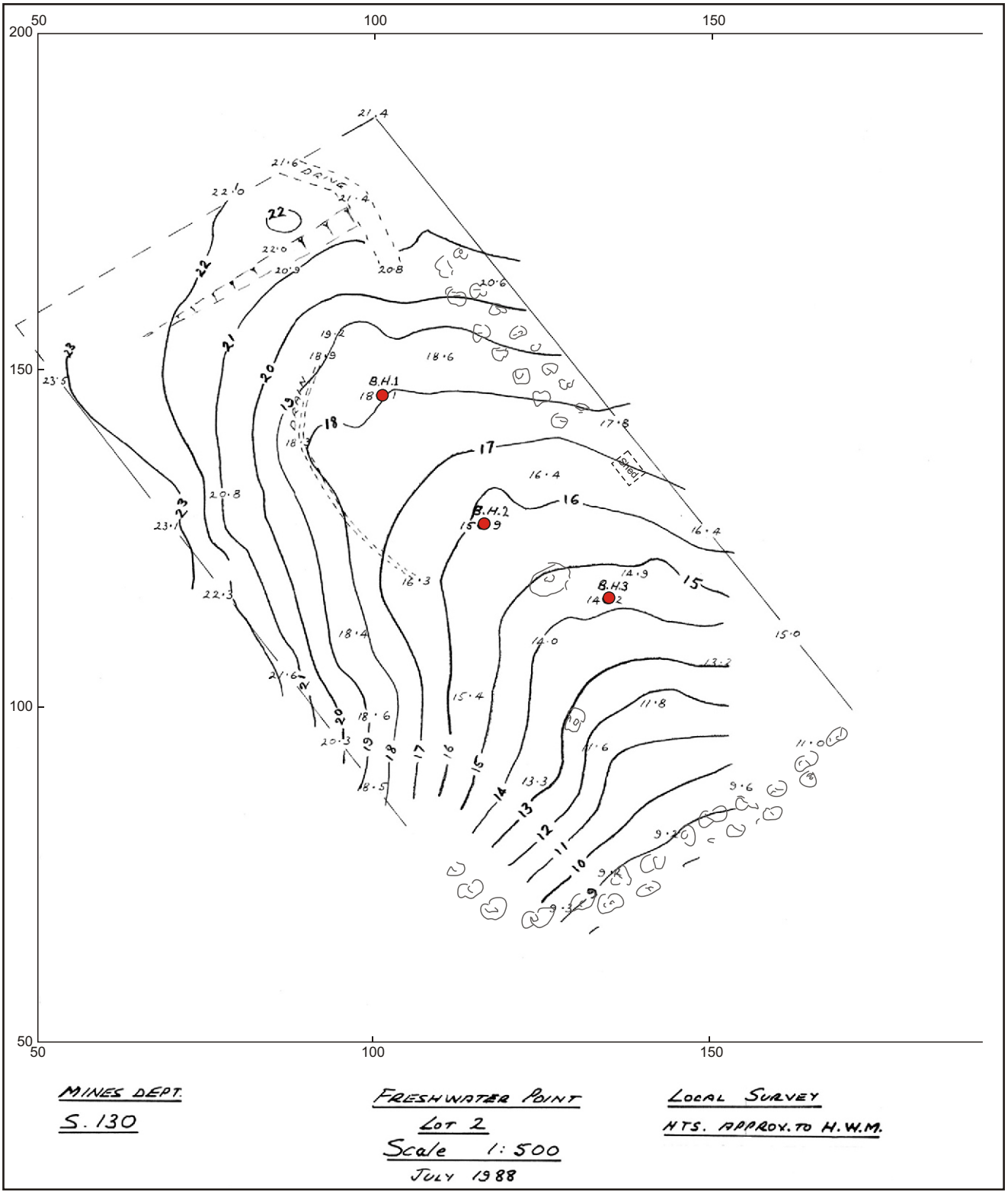

50
100
150
200
150
100
50
B.H.1
B.H.2
B.H.3
MINES DEPT.
S. 130
FRESHWATER POINT
LOT 2
Scale 1:500
JULY 1988
LOCAL SURVEY
NTS. APPROX. TO H.W.M.

Figure 1

APPENDIX 1

Logs of drill holes, Lot 2 Nobelius Drive

Hole 1

0 – 0.95 m Top soil and sandy loam (wet).

0.95 – 1.6 m Sandy light brown clay with pebbles up to 15 mm, rounded (wet).

1.6 – 3.0 m Brown and grey mottled clay, some small pebbles (firm).

3.0 – 3.4 m As above, possibly a little sandier (much wetter).

3.4 – 4.3 m Red and grey mottled clay (water present at 3.4 m) (firm).

4.3 – 5.0 m Brown and grey mottled clay (firm).

5.0 – 5.1 m Iron oxide pan layer, very hard (refusal).

Standing water level 3.80 m.

Hole 2

0 – 0.95 m Topsoil, sandy loam.

0.95 – 1.6 m Grey, red, brown mottled clay (dry).

1.6 – 2.5 m Light brown sandy clay (wet).

2.5 – 3.4 m Reddish brown clay, slightly sandy, iron oxide nodules (wet).

3.4 – 4.2 m Reddish brown sandy clay with 5 mm rounded quartz pebbles (wet).

4.2 – 4.3 m Iron oxide pan layer — refusal (dry).

Standing water level 0.40 m.

Hole 3

0 – 0.2 m Topsoil (wet).

0.2 – 0.95 m Light brown clay, slightly sandy.

0.95 – 1.1 m Red and grey mottled clay.

1.1 – 1.6 m Light brown clay, some hard nodules.

1.6 – 2.5 m As above.

2.5 – 3.4 m As above, no nodules.

3.4 – 4.3 m Darker brown clay (moist).

4.3 – 4.5 m Light grey to brown clay.

4.5 – 5.2 m Dark grey to black clay (moist).

5.2 – 6.1 m As above, some water present (firm).

6.1 – 7.0 m As above.

Standing water level 5.4 m.

All holes drilled and logged by B. Cox, 26 July 1988

APPENDIX 2

Soil testing results, Lot 2, Nobelius Drive

						Clay fraction XRD (%)			
Hole	Depth	MC	LL	PL	LS	Kaol	Goeth	Mont	Gibbs
1	2.5	41	143	37	25	90	5	5	–
1	3.2	62	131	34	26				
2	1.6	39	136	35	24	90	10	–	–
2	2.5	32	57	21	14				
3	1.6	35	104	32	21	65	30	5	–
3	5.2	43	101	34	20	95	–	–	5

MC = moisture content, LL = liquid limit, PL = plastic limit, LS = linear shrinkage, Kaol = kaolinite, Goeth = goethite, Mont = montmorillonite, Gibbs = gibbsite.

Residual shear strength measurements on two samples from hole 1

Depth	$'_r$	c'_r
2.5	15°	8 kPa
3.4	19°	4 kPa

All determinations by R. N. Woolley, Department of Mines

APPENDIX 3

Inputs and assumptions for stability analyses

CASE 1

SLOPE STABILITY ANALYSIS - COMPUTATIONS SHEET 1 OF.....

NAME OF SLIP Lot 2 Wakelin Dr..... MAP REF.....

ANALYSIS BY.....
DATE.....
CHECKED BY.....

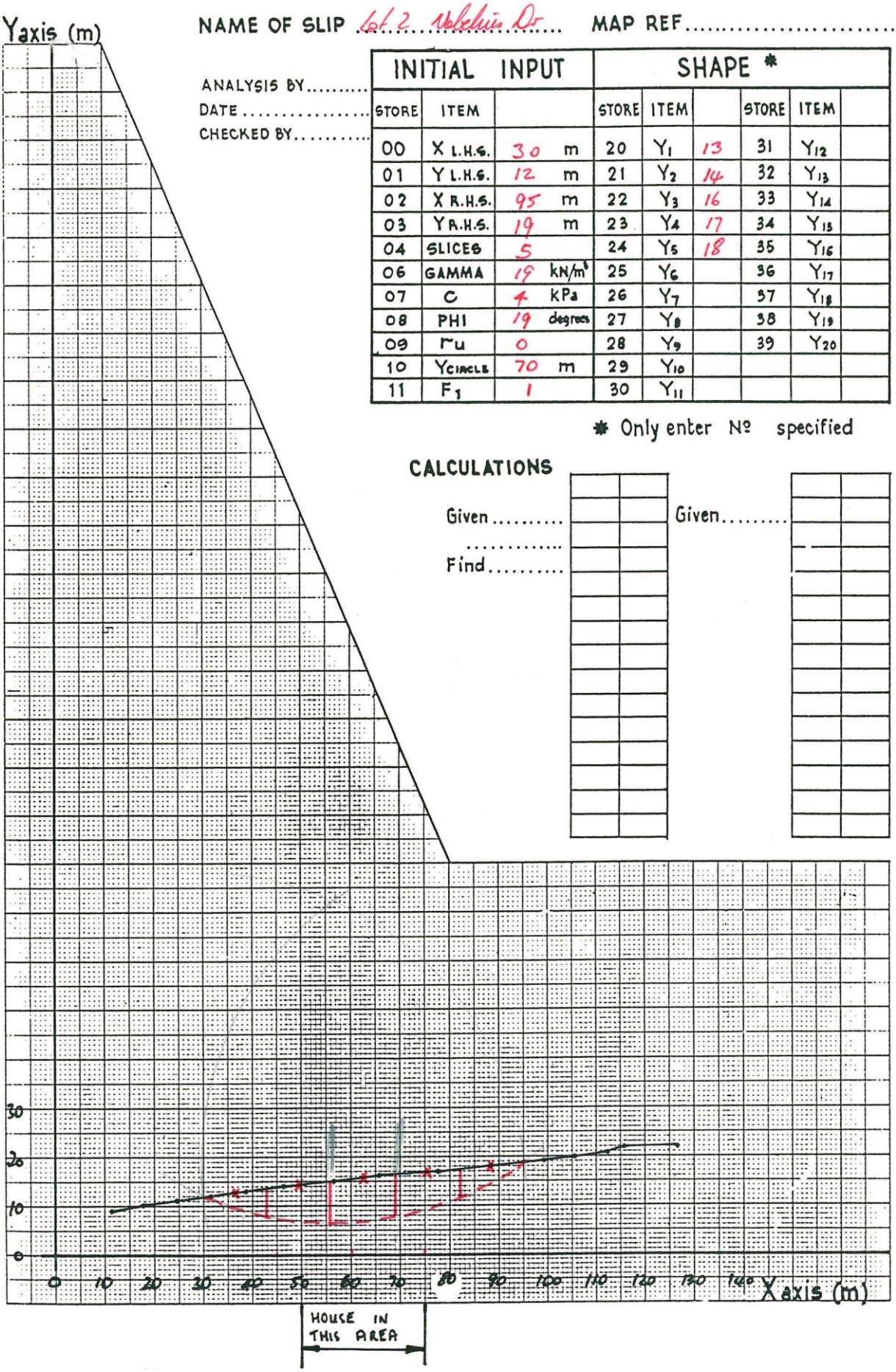
INITIAL INPUT				SHAPE *					
STORE	ITEM			STORE	ITEM		STORE	ITEM	
00	X L.H.S.	30	m	20	Y_1	13	31	Y_{12}	
01	Y L.H.S.	12	m	21	Y_2	14	32	Y_{13}	
02	X R.H.S.	95	m	22	Y_3	16	33	Y_{14}	
03	Y R.H.S.	19	m	23	Y_4	17	34	Y_{15}	
04	SLICES	5		24	Y_5	18	35	Y_{16}	
06	GAMMA	19	kN/m³	25	Y_6		36	Y_{17}	
07	C	4	kPa	26	Y_7		37	Y_{18}	
08	PHI	19	degrees	27	Y_8		38	Y_{19}	
09	ru	0		28	Y_9		39	Y_{20}	
10	Y_{CIRCLE}	70	m	29	Y_{10}				
11	F_1	1		30	Y_{11}				

* Only enter Nº specified

CALCULATIONS

Given.....
.....
Find.....

Given.....



CASE 2

SLOPE STABILITY ANALYSIS - COMPUTATIONS SHEET 1 OF.....

NAME OF SLIP ...Lot 2 Nebelvin Dr... MAP REF.....

ANALYSIS BY.....
DATE .....
CHECKED BY.....

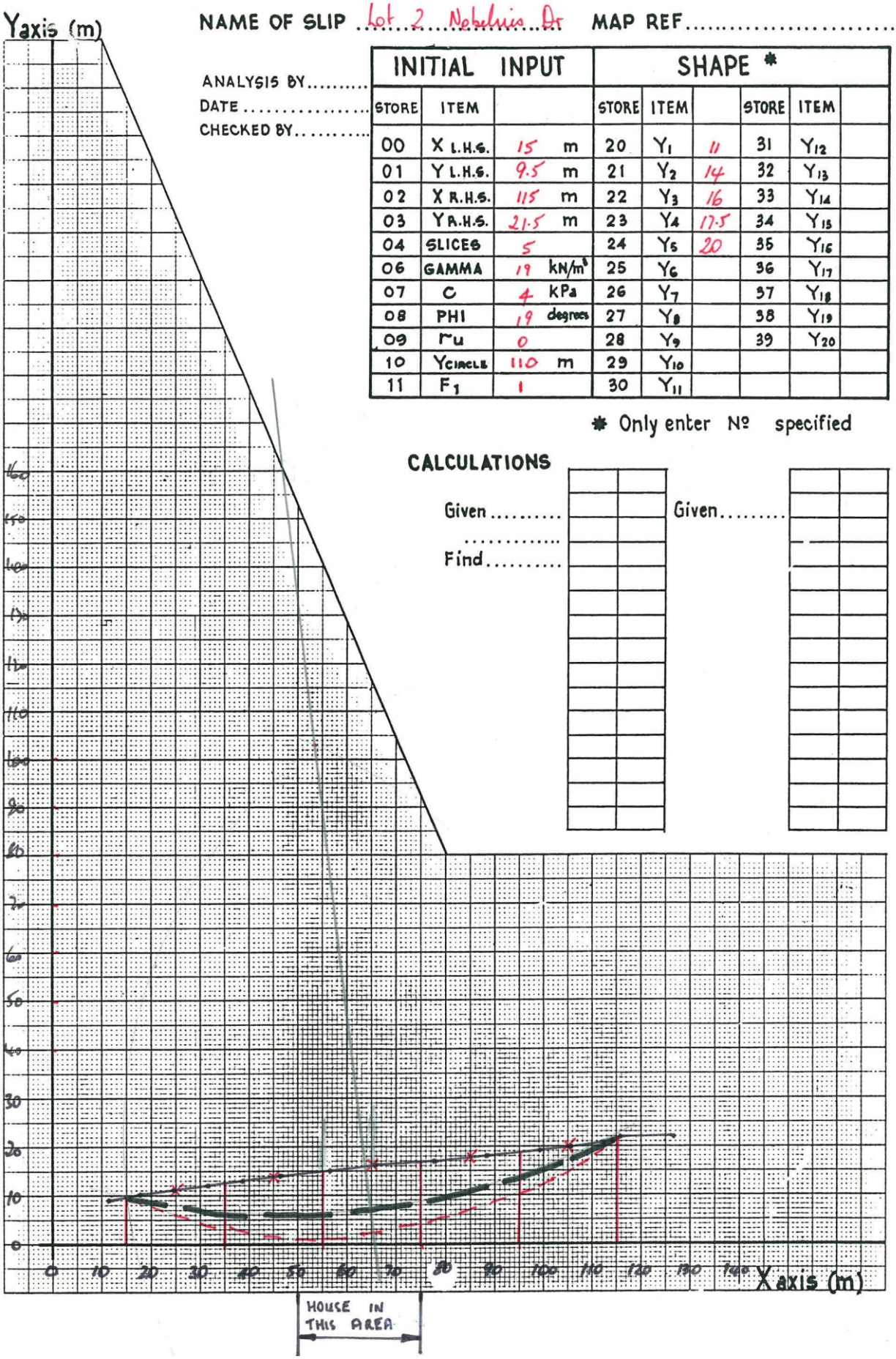
INITIAL INPUT			SHAPE *					
STORE	ITEM		STORE	ITEM		STORE	ITEM	
00	X L.H.S.	15 m	20	Y_1	11	31	Y_{12}	
01	Y L.H.S.	9.5 m	21	Y_2	14	32	Y_{13}	
02	X R.H.S.	115 m	22	Y_3	16	33	Y_{14}	
03	Y R.H.S.	21.5 m	23	Y_4	17.5	34	Y_{15}	
04	SLICES	5	24	Y_5	20	35	Y_{16}	
06	GAMMA	19 kN/m³	25	Y_6		36	Y_{17}	
07	C	4 kPa	26	Y_7		37	Y_{18}	
08	PHI	19 degrees	27	Y_8		38	Y_{19}	
09	ru	0	28	Y_9		39	Y_{20}	
10	Y_{CIRCLE}	110 m	29	Y_{10}				
11	F_1	1	30	Y_{11}				

* Only enter Nº specified

CALCULATIONS

Given .....
.....
Find.....

Given.....



CASE 3

SLOPE STABILITY ANALYSIS - COMPUTATIONS SHEET 1 OF.....

NAME OF SLIP ..... MAP REF.....

ANALYSIS BY.....
DATE .....
CHECKED BY.....

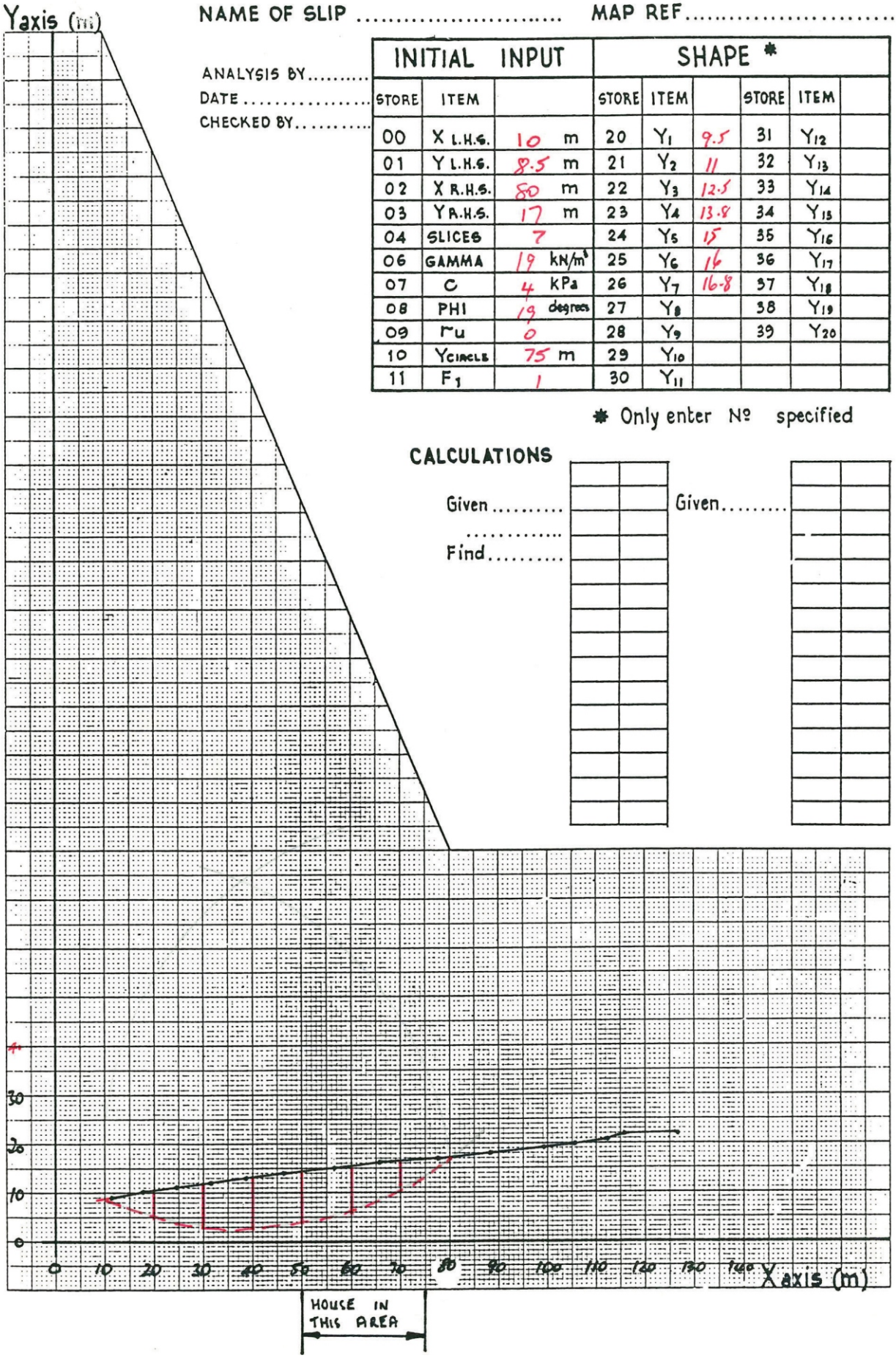
INITIAL INPUT			SHAPE *					
STORE	ITEM		STORE	ITEM		STORE	ITEM	
00	X L.H.S.	10 m	20	Y_1	9.5	31	Y_{12}	
01	Y L.H.S.	8.5 m	21	Y_2	11	32	Y_{13}	
02	X R.H.S.	80 m	22	Y_3	12.5	33	Y_{14}	
03	Y R.H.S.	17 m	23	Y_4	13.8	34	Y_{15}	
04	SLICES	7	24	Y_5	15	35	Y_{16}	
06	GAMMA	19 kN/m³	25	Y_6	16	36	Y_{17}	
07	C	4 kPa	26	Y_7	16.8	37	Y_{18}	
08	PHI	19 degrees	27	Y_8		38	Y_{19}	
09	ru	0	28	Y_9		39	Y_{20}	
10	YCIRCLE	75 m	29	Y_{10}				
11	F_1	1	30	Y_{11}				

* Only enter Nº specified

CALCULATIONS

Given .....
.....
Find.....

Given.....

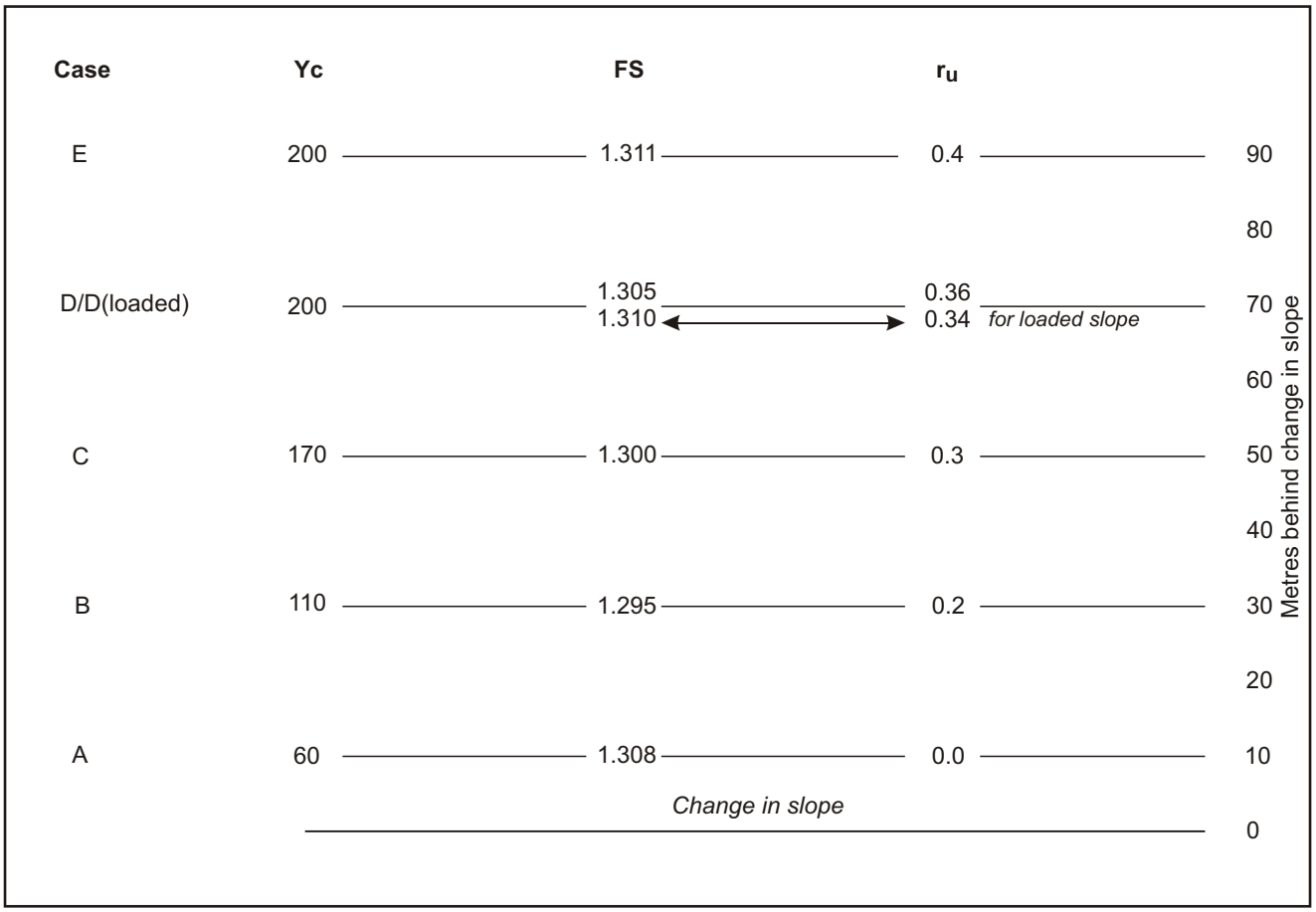


Overall Situation

Assume cohesion (c) = 4 kPa
friction angle ( ) = 19°
density ( ) = 19 kN/m^3
floodplain is flat
terrace slope is 20° over a plan distance of 30 m
terrace surface slopes at 8° over remainder of area

Case Circle		A through toe and 10 m behind change in slope	B through toe and 30 m behind change in slope	C through toe and 50 m behind change in slope
Yc		60	110	170
FS at r_u =	0.0	1.308	1.596	1.811
	0.1	1.185	1.445	1.641
	0.2	1.062	1.295	1.471
	0.3	0.939	1.145	1.300
	0.4	0.816	0.995	1.129
	0.5	0.694	0.846	0.960

FS — Factor of safety
Yc — Y co-ordinate of the slip circle centre
r_u — pore pressure ratio (r_u = 0.0, dry; r_u = 0.5, saturated)



CASE A

SLOPE STABILITY ANALYSIS - COMPUTATIONS SHEET 1 OF.....

NAME OF SLIP Lot 2 Nobeluis Drive MAP REF.....

ANALYSIS BY.....
DATE .....
CHECKED BY.....

INITIAL INPUT			SHAPE *					
STORE	ITEM		STORE	ITEM		STORE	ITEM	
00	X L.H.S.	20 m	20	Y_1	11.5	31	Y_{12}	
01	Y L.H.S.	10 m	21	Y_2	15.5	32	Y_{13}	
02	X R.H.S.	60 m	22	Y_3	19	33	Y_{14}	
03	Y R.H.S.	22.3 m	23	Y_4	21.8	34	Y_{15}	
04	SLICES	4	24	Y_5		35	Y_{16}	
06	GAMMA	19 kN/m³	25	Y_6		36	Y_{17}	
07	C	4 kPa	26	Y_7		37	Y_{18}	
08	PHI	19 degrees	27	Y_8		38	Y_{19}	
09	r_u	0	28	Y_9		39	Y_{20}	
10	Y_{CIRCLE}	50 m	29	Y_{10}				
11	F_1	1	30	Y_{11}				

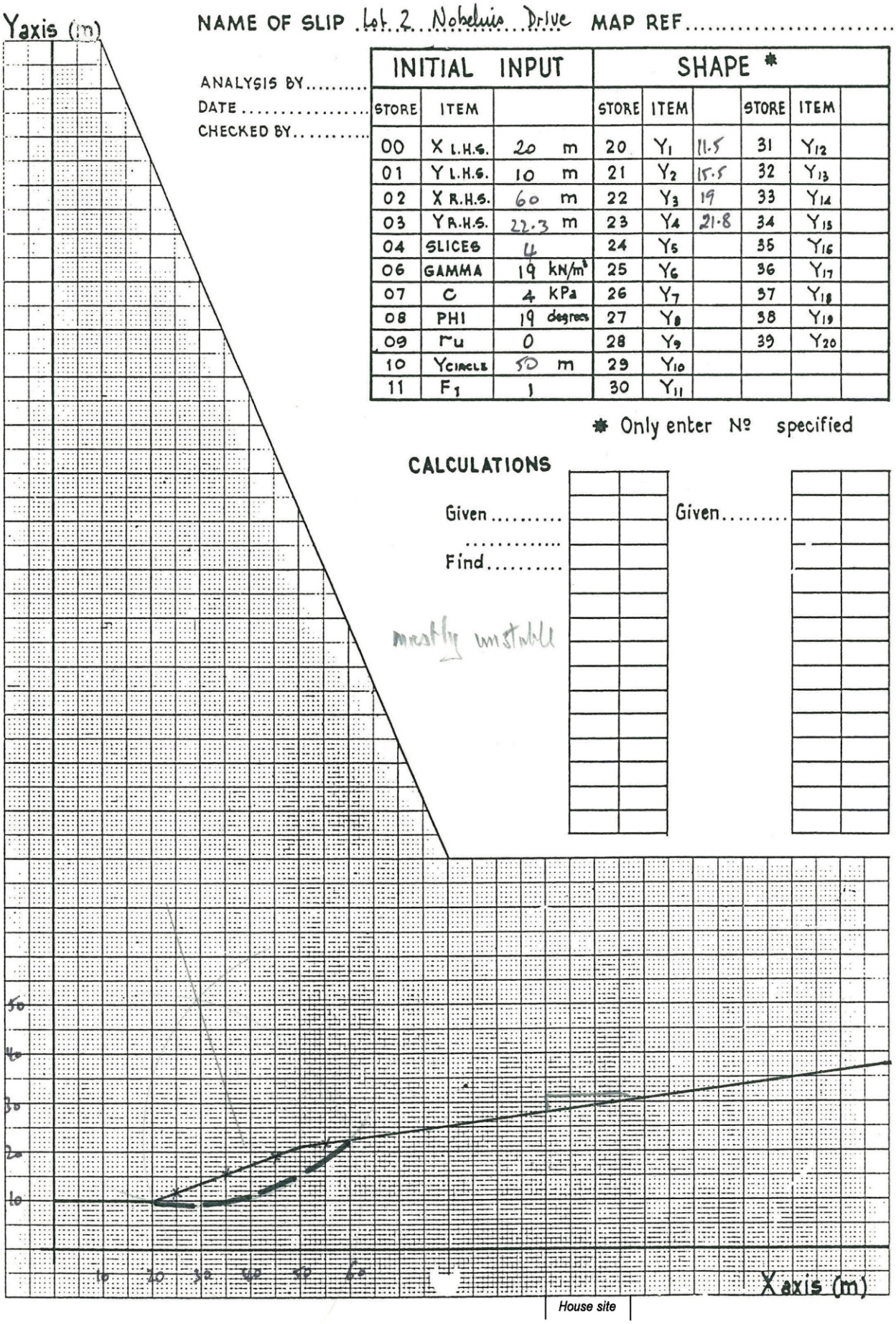
* Only enter Nº specified

CALCULATIONS

Given .....
.....
Find.....

mostly unstable

Given.....



CASE B

SLOPE STABILITY ANALYSIS - COMPUTATIONS SHEET 1 OF.....

NAME OF SLIP Lot 2 Nobelius Drive MAP REF.....

ANALYSIS BY.....
DATE.....
CHECKED BY.....

INITIAL INPUT			SHAPE *					
STORE	ITEM		STORE	ITEM		STORE	ITEM	
00	X L.H.S.	20 m	20	Y_1	11.5	31	Y_{12}	
01	Y L.H.S.	10 m	21	Y_2	15.5	32	Y_{13}	
02	X R.H.S.	80 m	22	Y_3	19	33	Y_{14}	
03	Y R.H.S.	25 m	23	Y_4	21.8	34	Y_{15}	
04	SLICES	6	24	Y_5	23	35	Y_{16}	
06	GAMMA	19 kN/m³	25	Y_6	24.5	36	Y_{17}	
07	C	4 kPa	26	Y_7		37	Y_{18}	
08	PHI	19 degrees	27	Y_8		38	Y_{19}	
09	ru	0	28	Y_9		39	Y_{20}	
10	YCIRCLE	70 m	29	Y_{10}				
11	F_1	1	30	Y_{11}				

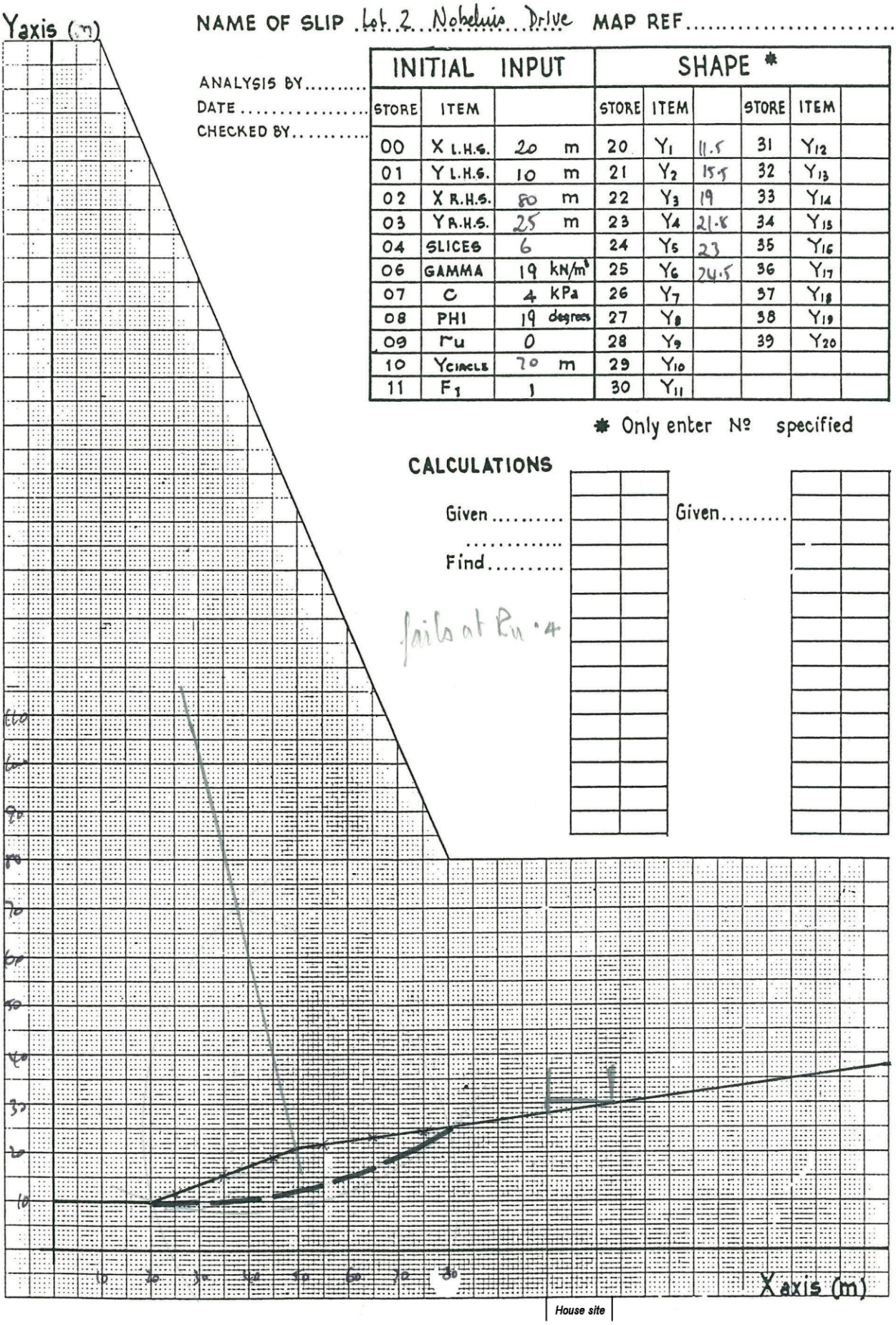
* Only enter Nº specified

CALCULATIONS

Given.....
.....
Find.....

Fails at Ru = 4

Given.....



Case C

SLOPE STABILITY ANALYSIS - COMPUTATIONS SHEET 1 OF.....

NAME OF SLIP Lot 2 Nobelius Drive MAP REF.....

ANALYSIS BY.....
DATE.....
CHECKED BY.....

INITIAL INPUT				SHAPE *					
STORE	ITEM			STORE	ITEM		STORE	ITEM	
00	X L.H.S.	20	m	20	Y_1	11.5	31	Y_{12}	
01	Y L.H.S.	10	m	21	Y_2	15.5	32	Y_{13}	
02	X R.H.S.	100	m	22	Y_3	19	33	Y_{14}	
03	Y R.H.S.	28	m	23	Y_4	21.8	34	Y_{15}	
04	SLICES	8		24	Y_5	23	35	Y_{16}	
06	GAMMA	19	kN/m³	25	Y_6	24.5	36	Y_{17}	
07	C	4	kPa	26	Y_7	26	37	Y_{18}	
08	PHI	19	degrees	27	Y_8	27.2	38	Y_{19}	
09	ru	0		28	Y_9		39	Y_{20}	
10	YCIRCLE	90	m	29	Y_{10}				
11	F_1	1		30	Y_{11}				

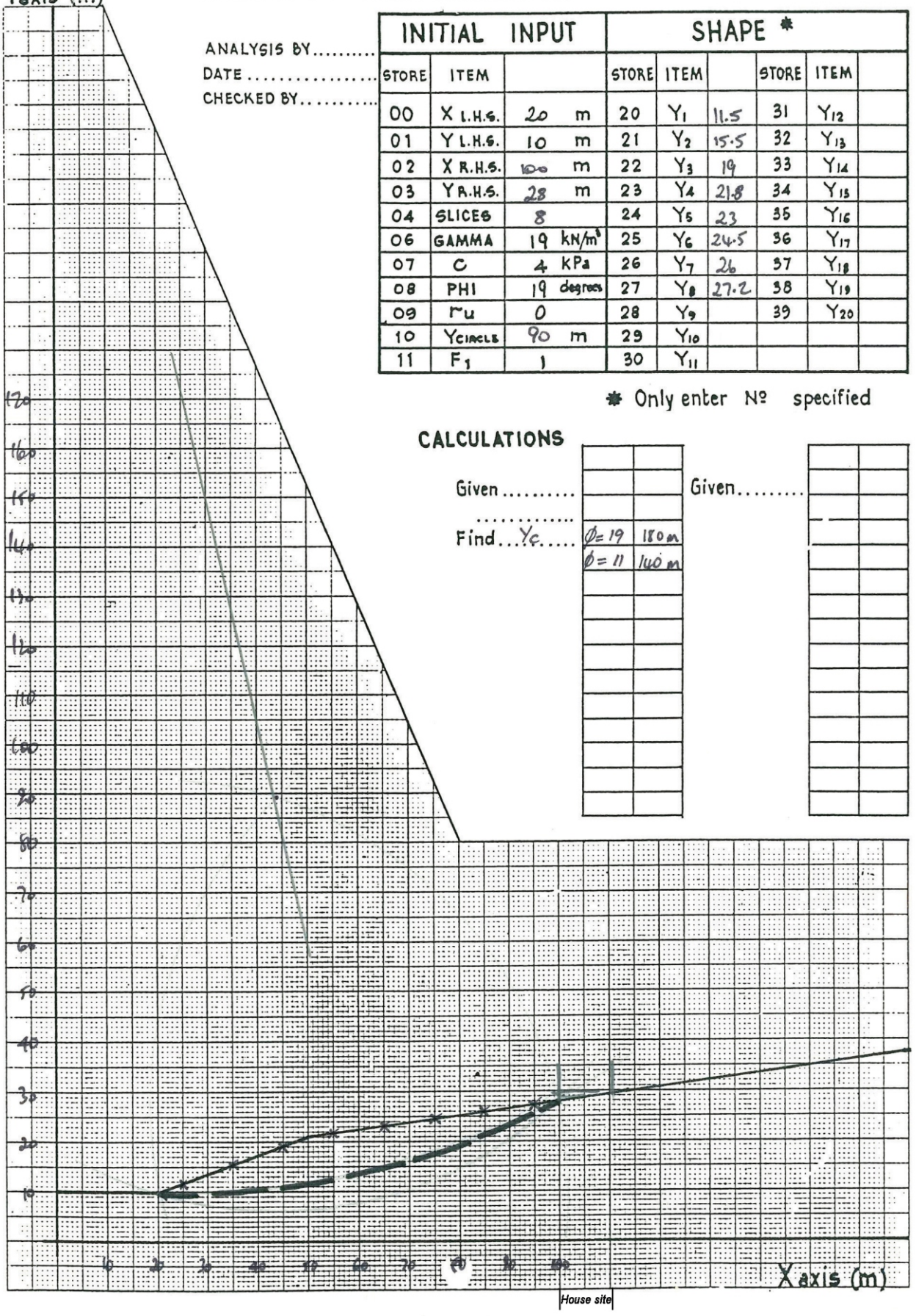
* Only enter Nº specified

CALCULATIONS

Given.....
.....
Find...Yc.....

$\phi = 19$	180 m
$\phi = 11$	140 m

Given.....



Case D

SLOPE STABILITY ANALYSIS - COMPUTATIONS SHEET 1 OF.....

NAME OF SLIP Lot 2 Nobelius Drive MAP REF.....

ANALYSIS BY.....
DATE.....
CHECKED BY.....

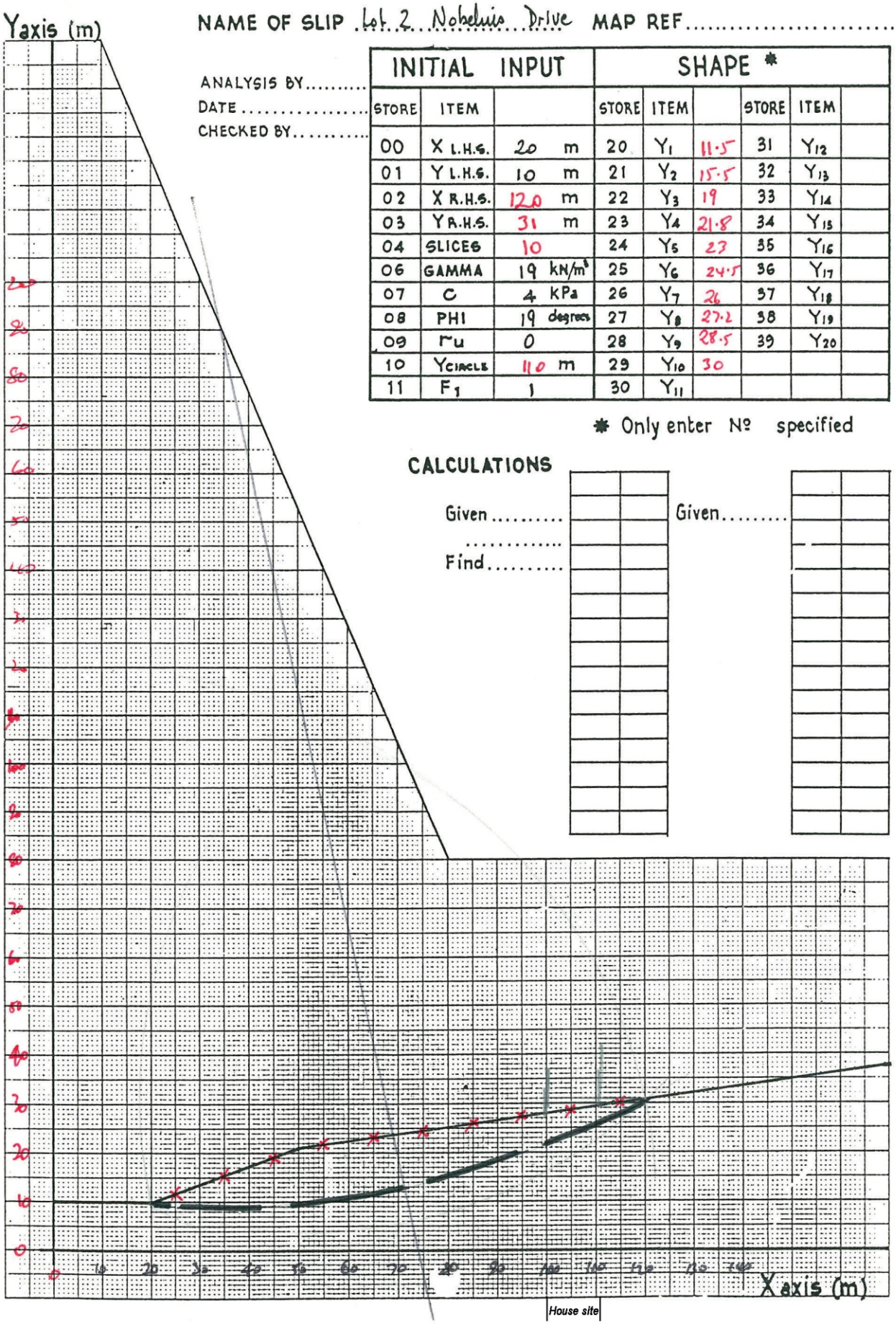
INITIAL INPUT			SHAPE *					
STORE	ITEM		STORE	ITEM		STORE	ITEM	
00	X L.H.S.	20 m	20	Y_1	11.5	31	Y_{12}	
01	Y L.H.S.	10 m	21	Y_2	15.5	32	Y_{13}	
02	X R.H.S.	120 m	22	Y_3	19	33	Y_{14}	
03	Y R.H.S.	31 m	23	Y_4	21.8	34	Y_{15}	
04	SLICES	10	24	Y_5	23	35	Y_{16}	
06	GAMMA	19 kN/m³	25	Y_6	24.5	36	Y_{17}	
07	C	4 kPa	26	Y_7	26	37	Y_{18}	
08	PHI	19 degrees	27	Y_8	27.2	38	Y_{19}	
09	ru	0	28	Y_9	28.5	39	Y_{20}	
10	YCIRCLE	110 m	29	Y_{10}	30			
11	F_1	1	30	Y_{11}				

* Only enter Nº specified

CALCULATIONS

Given.....
.....
Find.....

Given.....



SLOPE STABILITY ANALYSIS - COMPUTATIONS SHEET 1 OF.....

NAME OF SLIP Lot 2 Nobelius Drive MAP REF.....

ANALYSIS BY.....
DATE.....
CHECKED BY.....

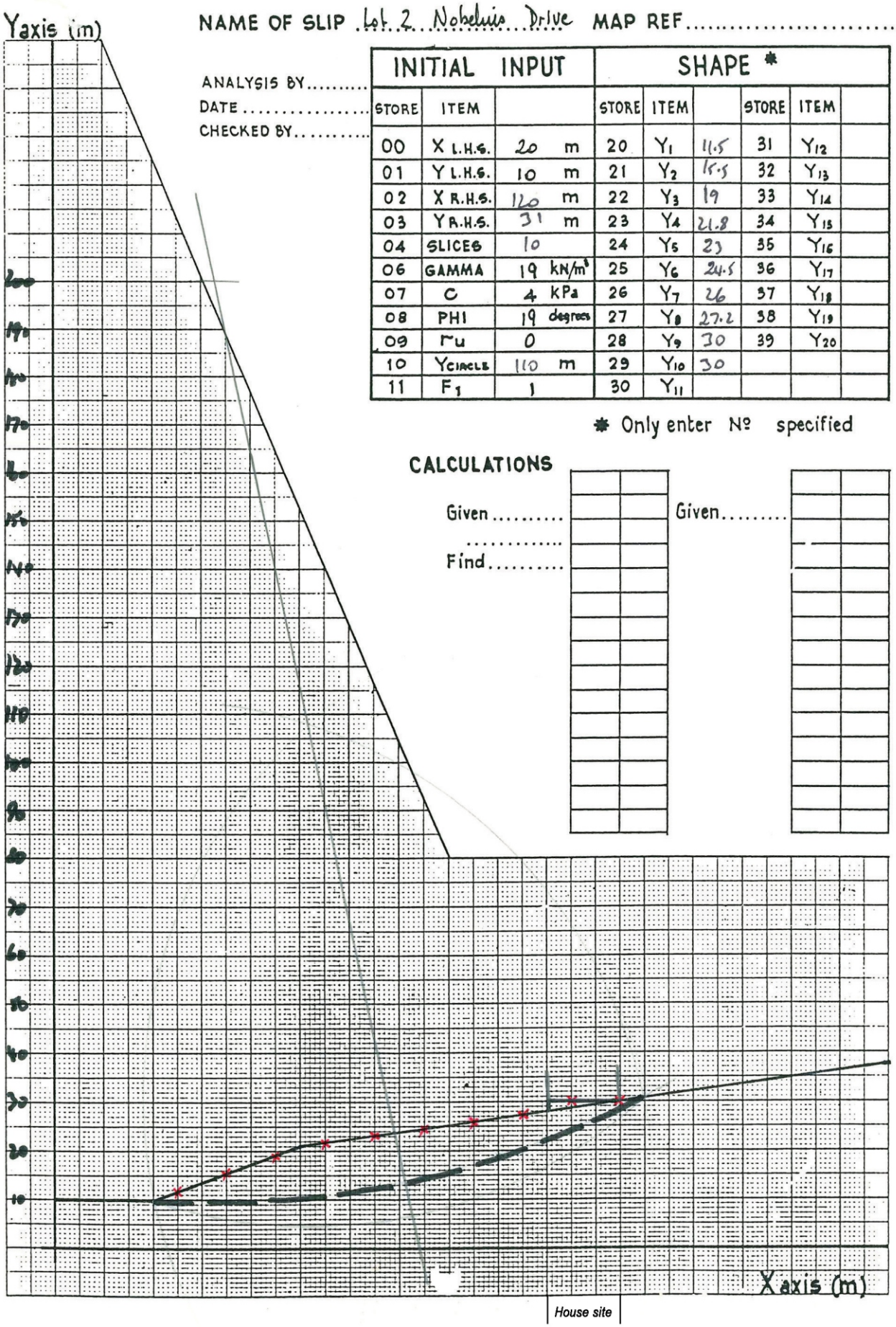
INITIAL INPUT			SHAPE *					
STORE	ITEM		STORE	ITEM		STORE	ITEM	
00	X L.H.S.	20 m	20	Y_1	11.5	31	Y_{12}	
01	Y L.H.S.	10 m	21	Y_2	15.5	32	Y_{13}	
02	X R.H.S.	120 m	22	Y_3	19	33	Y_{14}	
03	Y R.H.S.	31 m	23	Y_4	21.8	34	Y_{15}	
04	SLICES	10	24	Y_5	23	35	Y_{16}	
06	GAMMA	19 kN/m³	25	Y_6	24.5	36	Y_{17}	
07	C	4 kPa	26	Y_7	26	37	Y_{18}	
08	PHI	19 degrees	27	Y_8	27.2	38	Y_{19}	
09	ru	0	28	Y_9	30	39	Y_{20}	
10	Y_{CIRCLE}	110 m	29	Y_{10}	30			
11	F_1	1	30	Y_{11}				

* Only enter Nº specified

CALCULATIONS

Given.....
.....
Find.....

Given.....



Case E

SLOPE STABILITY ANALYSIS - COMPUTATIONS SHEET 1 OF.....

NAME OF SLIP Lot 2 Nobelius Drive MAP REF.....

ANALYSIS BY.....
DATE.....
CHECKED BY.....

INITIAL INPUT			SHAPE *					
STORE	ITEM		STORE	ITEM		STORE	ITEM	
00	X L.H.S.	20 m	20	Y_1	11.5	31	Y_{12}	32.8
01	Y L.H.S.	10 m	21	Y_2	15.5	32	Y_{13}	
02	X R.H.S.	140 m	22	Y_3	19	33	Y_{14}	
03	Y R.H.S.	33.5 m	23	Y_4	21.8	34	Y_{15}	
04	SLICES	12	24	Y_5	23	35	Y_{16}	
06	GAMMA	19 kN/m³	25	Y_6	24.5	36	Y_{17}	
07	C	4 kPa	26	Y_7	26	37	Y_{18}	
08	PHI	19 degrees	27	Y_8	27.2	38	Y_{19}	
09	ru	0	28	Y_9	28.5	39	Y_{20}	
10	YCIRCLE	130 m	29	Y_{10}	30			
11	F_1	1	30	Y_{11}	31.3			

* Only enter Nº specified

CALCULATIONS

Given.....
.....
Find.....

Given.....