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Hawke's Bay Area Planning Study: Urban capability assessment

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Hawke's Bay Area Planning Study:

Urban capability assessment

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Abstract

As part of the Hawke's Bay Area Planning Study, an urban capability assessment was prepared in August 1979, based on physical limitations to development of eleven urban site options on and adjacent to the Heretaunga Plains.

Physical factors — rock type, soil, slope, terrain, erosion type and degree, drainage, and vegetation — for the site options were mapped at 1:25 000. A four-class urban capability classification was used, grading from negligible to severe physical limitations to urban development. Six sub-classes described the dominant type of limitation within each class.

Each site was described, and assessed for erosion, geotechnical, drainage, and flooding hazards; and an urban land resource inventory and capability given. Sites were then compared.

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Contents

Introduction

As part of the Hawke's Bay Area Planning Study the Hawke's Bay Catchment Board in association with the Water and Soil Division, Ministry of Works and Development (MWD), was requested to consider water and soil interests in and adjacent to the potential growth areas and to prepare a report on these for the Technical Committee of the planning study.

To carry out the study a task force comprising soil conservators and scientists from Catchment Authorities and Water and Soil Division, MWD, was brought together in Napier at the Catchment Board offices for the period 6–16 August 1979 to carry out the field work and map preparation.

Participants were:

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J.H. Lawrence, MWD, Head Office
D.R. Depledge, MWD, Wellington
T.W. Marshall, Waikato Valley Authority
G.N. Thompson, Otago Catchment Board
P.E. Schofield, Hawke's Bay Catchment Board
K.N. Murray, Commission for the Environment

The report was compiled during the remainder of August 1979 by the team leader at the Aokautere Science Centre.

Terms of Reference

The terms of reference for the study were:

1 To consider eleven site options, identified on a 1:25 000 base map provided by Town and Country Planning Division, MWD.

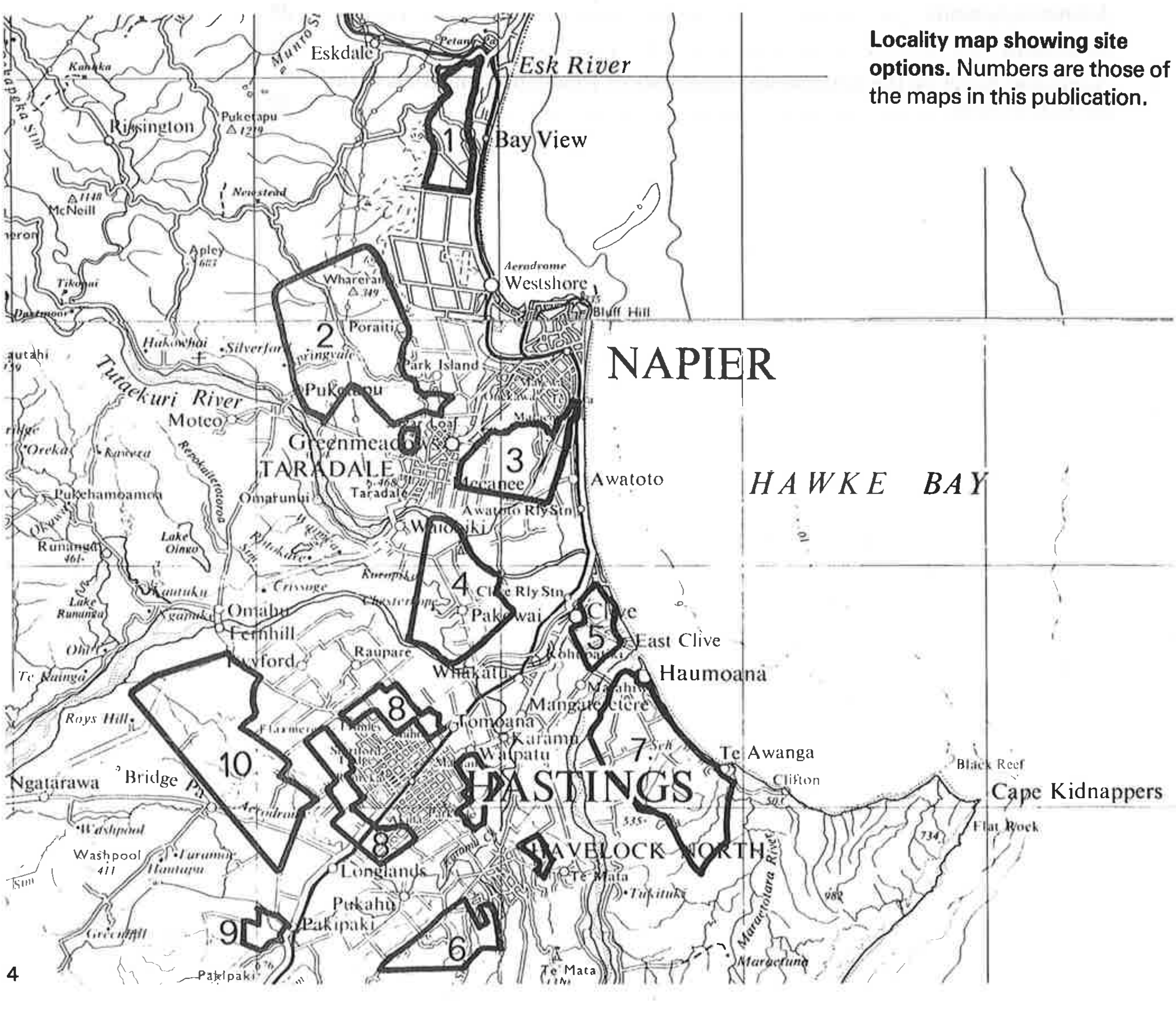
2 To map the following inventory factors at a scale of 1:25 000
— slope and aspect
— rock type
— soils
— erosion
— flooding/wetness
— groundwater.

3 To develop from the inventory factors a hazard prediction rating for urban development.

4 To prepare a comparative ranking of the sites based on their urban capabilities as indicated by 1 and 2 above.

5 To prepare a report on the study including a report on each site together with explanatory maps and explanation of the hazards.

6 Study to commence on 6 August 1979 and to be completed by 31 August 1979.



Locality map showing site options. Numbers are those of the maps in this publication.

Technique

Site location

The Task Force was asked to examine eleven site options, as defined for the Hawke's Bay Planning Study, recorded on prints of 1:25 000 photogrammetric plots. Each site option contained a number of discrete "cells". As these cells had little relationship to landform or other identifiable physical features a boundary was drawn around the outer margins of the cells in each site and the total enclosed area mapped. The mapping of each cell separately at the required scale would have neither allowed an assessment of the whole site option nor provided sufficient detailed information for a cell by cell assessment of the site.

Scale

As the required scale was 1:25 000 and the time limited, the mapping technique was designed accordingly. Aspect could not be recorded, while the physiographic positions of the unit areas could often only be recorded in general terms. Sedimentary rock types frequently had to be grouped. **Thus the investigation can be regarded only as reconnaissance.** Any site option selected for development will require a more detailed investigation of all physical parameters.

Assumptions

The following assumptions were adopted for assessing urban capability:

1 All areas within each site option were to be developed for average subdivision density of single storey residential development (i.e. section size was to be the traditional "small section").

2 The erection of commercial or multi-storey structures was not to be considered in this survey.

3 Development would be accompanied by a minimum of ground disturbance (i.e. the practicability of recontouring with large scale cuts and fills was not considered).

4 Drainage and flood protection works for a 50 year event would be installed.

5 'Downstream' effects of urbanisation were not to be considered.

Survey procedure

The following procedure was followed:

1 Physical resource inventory factors relevant to urban development were mapped for each site option (see the maps of site options, or legends facing).

2 An urban capability was assessed for each inventory area mapped (see the maps of site options, or legends facing).

3 A brief summary of the physical parameters in each site option was prepared together with a description of the capabilities present within that option.

4 A brief description of the physical hazards associated with each site option, including an indication of the feasibility of overcoming them, was prepared.

Data collection

All available existing data relating to the physical resource inventory factors was collated. This was supplemented by field work to assess slopes, vegetation, and erosion, and to fill in gaps in the collated data. Published soil data (DSIR 1939, Pohlen *et al.* 1947) was supplemented by discussions with Soil Bureau staff at Havelock North; subsurface data by information supplied by local MWD (e.g. MWD 1973, 1974) and Hawke's Bay Catchment Board engineers; and flooding and drainage data by information supplied by Hawke's Bay Catchment Board staff.

Urban land resource inventory

A general understanding of the area was obtained from Noble (1976).

The unit area approach to mapping was used with the resource inventory being recorded in code form. The technique used and physical factors mapped were similar to those mapped in New South Wales Soil Conservation Service urban capability studies (e.g. NSW Soil Conservation Service 1978) and to studies carried out by the Northland Catchment Commission (1978) and the Waikato Valley Authority (1978).

The urban inventory code is as follows:

$$\frac{\text{Rock type} - \text{Soil} - \text{Slope} \quad \text{Terrain component}}{\text{Erosion/Potential} - \text{Drainage} - \text{Vegetation}}$$

Within each of the six inventory factors mapped the following subdivisions and rankings were recorded:

Rock type

A basic understanding of the area's geology was obtained from Kingma (1970.) The following lithological classification was devised for the study:

Tp	Taupo pumice alluvium — surface alluvial material composed of redeposited Taupo flow tephra
Pt	Peat
Lo	Loess
Al	Undifferentiated floodplain alluvium consisting of sand, silt and gravels of primarily greywacke origin
Al1	Permeable alluvial deposits consisting primarily of sand and gravel alluvial material
Al2	Relatively impermeable alluvial deposits consisting primarily of silt and clay
Li	Limestone — relatively narrow bands of limestone within a sequence of marine sedimentary rocks. The limestones are well cemented and typically form steep bluffs along valley sides
Up	Undifferentiated marine sedimentary rocks consisting of siltstones, mudstones, calcareous sandstones and greywacke gravels. Surface deposits of loess and colluvial material prevents the differentiation of these lithologies

Wb	Wind blown sand dunes
Gr	Beach gravels

Up to three rock types were recorded in stratigraphic order for each unit area.

Soil

Except where noted in the text, soil types were recorded using published soil survey symbols, as follows:

1 From DSIR 1939

Twyford	1,1B,1C,2,4,5,6
Paki Paki	7,8,9
Havelock	10
Ngatarawa	11
Hastings	13,14,15,16
Pakowhai	17,18
Kaiapo	19
Turamoe	22
Farndon	23,24
Meanee	26,27

2 From Pohlen et al. 1947

Tangoio	15
Crownthorpe	21
Matapiro	28
Okawa	29
Poporangi	32
Twyford	59

Slope

Slope Group		*Slope angle in degrees*
A	Flat to gently undulating	0–3
B	Undulating	4–7
C	Rolling	8–15
D	Strongly rolling	16–20
E	Moderately steep	21–25
F	Steep	26–35
G	Very steep	>35

Terrain component

1	Crest
2	Side slope
3	Foot slope
4	Valley bottom
5	Plain
6	Terrace
7	Fan
8	Ephemeral waterway
9	Beach ridge
10	Sand dunes

Erosion

Only present erosion types were mapped, with present erosion being defined as areas still exhibiting bare ground or evidence of active movement. Both present and potential erosion degree were recorded on a 0–5 scale of severity. Potential was assessed as "under average rural grazing management with no conservation measures applied".

Erosion types

Sh	Sheet
W	Wind
sSl	Soil slip
Su	Slump
eF	Earthflow
R	Rill
G	Gully
T	Tunnel gully
Sb	Stream bank
D	Deposition
C	Coastal

Erosion degree

ϴ	Negligible
1	Slight
2	Moderate
3	Severe
4	Very severe
5	Extreme

Drainage

G1	Water table
G2	Ponding
G3	Overland flow from rivers
G4	Overland flow from adjacent areas
G5	Marine inundation
G6	Springs on hillsides
G7	Unconfined aquifer

A ranking of drainage severity precedes each symbol.

Ranking	*Description*
ϴ	No problem
1	Slight
2	Moderate to severe
3	Extreme

Vegetation

Symbol	*Description*
N1	Native trees
N2	Exotic trees
M	Scrub
P	Pasture
L1	Vineyard
L2	Orchard
L3	Other horticultural crops

An upper case letter was used to record areas with greater than 40% of the area in that vegetation, and a lower case letter for less than 40%.

Urban capability classification

An assessment of the physical capability for urban development of each unit area mapped was made by interpreting the data assembled in the inventory. The urban capability was assessed in terms of an average subdivision density of single storey residential development, excluding large commercial, industrial, or multi-storied buildings.

The classification has two parts; the *class*, describing the general level of physical suitability and the *subclass*, describing the major type of limitation.

Urban capability class

Description

A Land with negligible physical limitations to residential development.

B Land with minor limitations to residential development which may be easily overcome. Such limitations include drainage, topography and slight surface instability.

C Land with moderate to severe limitations to residential development, which may only be overcome by the application of engineering works. Such limitations include poor drainage, steep slopes, and moderate instability. Such areas may be better suited to medium or low density residential development.

D Land with physical limitations of such severity that, although it would be technically possible for them to be overcome, they essentially preclude high density residential use. There will be some areas within this class that will support low density development.

Subclass

The subclass contains up to three symbols (recorded in order of decreasing importance) identifying the major types of physical limitation within the unit area:

Symbol	*Description*
t	Topography (slope and dissection)
s	Slope stability
n	Foundation (settlement and bearing capacity)
d	Drainage
f	Flooding
a	Aquifer (potential hazard to groundwater quality)

A table of per cent and area of each urban capability class within each site option appears on page 8.

Urban capability ranking and site comparisons

Difficulties in ranking

Comparative ranking of the sites based on their urban capability was requested. Where this was not considered possible a brief discussion of site comparisons would be sufficient.

Initially the request for a ranking of sites appeared to be a practical end point of the survey, but on closer examination of the study sites and the results of the survey it has proved impractical to implement. There are three major reasons for this:

1 The sites comprise two very different development situations; the first are the 'ring development' sites i.e. adjacent to existing urban areas in which gradual development can occur; the second are the completely 'new town' sites.

2 The sites vary greatly in size ranging from 160 ha to over 2400 ha.

3 The sites vary markedly in relief, from sites on the plains to sites wholly on the hill country.

These difficulties in comparing sites can be illustrated by considering the Paki Paki and Te Awanga site options:

The Paki Paki site comprises 70% class B and 30% class C while Te Awanga comprises only 60% class B and 10% class C together with 30% class D. However the 60% Te Awanga class B amounts to 1050 ha compared with 113 ha on the Paki Paki site. Thus in total hectares Te Awanga appears a far better option but as a percentage suitability of each site Paki Paki is preferable.

It follows that any ranking depends entirely on the planning requirements of the planners — whole sites versus part sites, individual cell development within sites versus whole sites or groups of cells etc. When these decisions have been made by the planners and the detailed criteria provided, a ranking as requested could be provided.

Site comparisons

Sites can be grouped into two, those on the flat country and those which include significant areas of hill country. Within each of these there is a further breakdown into 'new town' sites and extensions of existing urban areas. The new sites will require a variety of facilities, e.g., shopping, industrial and educational, which require more specific foundation requirements than purely residential (dormitory) sites.

Sites on the flats

are Napier, Pakowhai, Clive, Havelock North (East), Hastings, Paki Paki and Flaxmere. Of these Napier, Hastings, Havelock North (East) and Flaxmere could be considered as extensions of existing large urban areas.

The Hastings site provides the site with the least physical limitations. The two areas on the eastern side have no significant limitations while that along the SW margin has minor limitations due to drainage. This SW area of the Hastings site is similar to the Pakowhai and Napier sites as all are prone to drainage and surface flooding problems which can be overcome quite effectively by Catchment Board schemes.

The Clive site is the lowest lying of the plains sites, requiring considerable flood control works before development. The danger of marine inundation and the receding coastline both constitute limitations difficult to overcome.

The Napier site is limited by its low lying situation, requiring a comprehensive drainage and pumping scheme prior to urban development.

The Pakowhai site has only minor physical limitations needing stopbank improvements and pumping to protect the site. However as this is a 'new town' site the foundation limitations would necessitate the careful design of commercial or high rise buildings.

The Paki Paki site is limited by the peat deposits beneath a portion of the area and by the surface drainage problems. If this site was moved northwards, off the peat and on to the pumice alluvium it would be a much more versatile option.

The Flaxmere site is severely limited by the risk of groundwater pollution in the unconfined aquifer. Due to this, 35% of the site is unsuitable for urbanisation, while a further 28% requires special sewerage and stormwater disposal systems to be designed (NWASCA 1977). The remaining 37% of the site has only minor limitations to urban development. Alternative sites are limited by the presence of the unconfined aquifer; thus no sites west of Bridge Pa should be developed. However the area east of Bridge Pa to the No. 2 State Highway would have only minor limitations to development. This is the same area as the suggested northward extension of Paki Paki and adjoins the SW area of the Hastings site.

The Havelock North (East) site, bounding Arataki Road, has minor surface drainage problems due to a subsurface pan and a need for protection from the Karituwhenua Stream. Both these problems can be overcome, making this a very good site.

Sites having significant area of hills

are Bay view, Wharerangi, Te Awanga and Havelock North (South).

The Bay View site. Two-thirds of the Bay View site is on flat valley bottom or plain areas with only minor limitations to development (these being due to drainage). These problems can be overcome. The remaining third is hill country, mostly rolling loess covered hill crests with steep sides. These areas have moderate to severe limitations but would be very suitable for low density housing. Any development on the hills would require careful control of runoff to protect sites on the valley bottoms.

The Te Awanga site has the greatest degree of physical contrast of all the sites. Approximately half of the area is on flat land, the remainder comprising a mixture of flats, hill country, and rolling country. Adjacent to the coastline are areas of old beach gravels which, if coastal erosion continues at its present rate, could indicate a potential long term (100 year) hazard. Adjacent to the river and towards the mouth is a flood detention area, hence its D classification. The hill areas are not suitable for high density housing but, as part of a separate city, should fit in effectively as areas of low density development.

The presence of surface traces indicating fault lines suggests a severe potential hazard over the whole site. This should be studied in detail before any development decisions are made.

The Havelock North (South) site again provides an interesting series of contrasts. Most (89%) of the site has moderate to severe problems for development. Areas of C capability are frequently loess covered downlands, well suited for medium density housing except for a suspected instability hazard. Time did not allow a detailed subsurface study to define limits of erosion-prone rock types (slump and earthflow potential). A detailed study is essential prior to any development decision.

The steep slopes to the rear of the site could be suitable for low density housing. Extension of the site southwards is probably not warranted, extension onto the plain would be onto very fertile land while extension behind Havelock North is through erosion prone sites. Thus development would need to be within the site.

The Wharerangi site is dominantly hill country with the only areas suitable for high density housing being the wide valleys and the occasional wider ridge crest. The former require intensive drainage. Without re-contouring the surface the site has limited potential for high density residential housing but it does provide excellent sites for low density housing.

Table 1 Areas and percentage of site area of each urban capability class

Site	Site Urban Capability Class								
	A Area		B Area		C Area		D Area		Total Area
	(ha)	%	(ha)	%	(ha)	%	(ha)	%	(ha)
Bay View	--		412	53	104	14	252	33	768
Wharerangi	--		781	32	491	20	1136	48	2,408
Napier	--		1004	100	–	–	–	–	1,004
Pakowhai	--		1100	100	–	–	–	–	1,100
Clive	--		100	30	228	68	5	2	333
Havelock North - East	--		185	100	–	–	–	–	185
Havelock North - South	--		67	11	251	42	279	47	597
Te Awanga	--		1051	60	170	10	529	30	1,750
Hastings	785	56	624	44	–	–	–	–	1,409
Paki Paki	--		113	70	48	30	–	–	161
Flaxmere	--		870	37	650	28	800	35	2,320
									12,035

Site option summaries

Site option 1: Bay View

Map 1

Introduction

The site is approximately 6 km north of Napier City. It comprises two contrasting topographical areas, a flat plain area adjacent to the coast with hill country behind. The hill country comprises a series of narrow undulating to rolling ridges separated by steep sided valleys.

Rock type

The plain area comprises deep alluvial deposits and estuarine sediments. The hill country has a sequence of marine sandstones, siltstones and mudstones with thin limestone strata. Separate thin strata of greywacke pebbles also occur within the sequence. A variable thickness of loess mantles all slopes with depths being greatest on the NW slopes (up to 20 m). This cover makes detailed lithological mapping impossible without drilling. This type of detailed study was not possible in the time available but it is essential prior to any urban development (see below under Erosion and geotechnical hazards).

Soils

On the hill country Matapiro soils (28)[2] are mapped on the loessial deposits and where this has been removed Crownthorpe soils (21)[2] are mapped. These are formed on a variety of materials. Steepland soils, also formed on a variety of materials, are mapped as Tangoio soils (15)[2]. Soils on the fans are Poporangi soils (32)[2] which have a subsoil hardpan and impeded drainage.

Soils on the plains are Twyford silt loams (59)[2] formed on deep silts.

Erosion and geotechnical hazards

Erosion is mainly confined to the loess mantle and to the weathered regolith. Soil slip erosion is common on the steep slopes (i.e. >20°), its occurrence being dependent on infrequent high intensity storm events. Sheet erosion occurs mainly on the NW facing slopes while tunnel gully erosion is common in the loessial soils.

Evidence of the occasional historic slump and the unknown detail of the sedimentary sequence indicates a potential instability hazard to urban development, especially on steep slopes (i.e. >20°). Detailed lithological mapping is required to fully understand the hazard. Foundation conditions on the loessial material are adequate for single storey residential developments, provided care is taken with drainage, compaction of fills, and compaction of backfill around buried service lines — when the addition of traces of lime may be necessary. On the flats foundation conditions are adequate for single storey developments over most of the area.

Drainage/flooding

The plain area is subject to occasional flooding and a high water table is seasonal. The fan areas have subsurface drainage problems due to a perched water table on the subsoil pan. The cost of flood control and drainage of the plain is estimated at $276,000 (Hawke's Bay Catchment Board 1979).

Urban Capability

Class A — No class A land occurs in the site.

Class B — 53% of the site is class B with minor limitations for urban development. These areas are predominantly on the plain area having drainage limitations due to a high water table and surface ponding.

Class C — 14% of the site is class C having moderate to severe limitations. Topography (t) is the major subclass limitation as many areas are the rolling crests which drop off to the steep hill side slopes. The deep loess mantle gives a foundation (n) limitation.

Class D — 33% of the site is class D having very severe physical limitations. The major subclass limitation is slope stability (s) on the steep, unstable, hill side slopes. Small areas have foundation (n) or topography (t) limitations.

Note: Many areas in this class are suitable for low density housing.

[2] from Pohlen *et al.* 1947.

Site option 1: Bay View

Unit Area No.	Urban Land Resource Inventory	Urban Land Use Capability
1	$\frac{\text{Lo/Li+Up-28-C+D}^{1+2}}{\text{1Sh1W/2 - }\theta\text{ - PM}}$	C t.n.
2	$\frac{\text{Lo/Up+Li-15-F+E}^{2}}{\text{1sS11Sh1G/2-1G}_{6}\text{-PM}}$	D s.t.
3	$\frac{\text{Lo/Li+Up-21+28-F+E}^{2}}{\text{2sS11Sh/2- }\theta\text{ - PM}}$	D s.t.n.
4	$\frac{\text{Lo/Li+Up-28+21-E}^{2}}{\text{1Sh/2 - }\theta\text{ - P}}$	D s.t.n.
5	$\frac{\text{A1-59-A}^{5}}{\text{1Wb/1-1G}_{1}\text{1G}_{2}\text{1G}_{3}\text{-L}_{1}\ell_{2}\ell_{3}\text{p}}$	B d.
6	$\frac{\text{Lo+A12-32-B}^{7}}{\theta\text{/1-1G}_{1}\text{1G}_{4}\text{-PL}_{1}}$	B d.n.
7	$\frac{\text{Lo/Up+Li-15-E+F}^{2}}{\text{1sS11Sh/3- }\theta\text{ -PN}_{2}\text{M}}$	D s.t.
8	$\frac{\text{(Lo)/Up+Li-15-E}^{2}}{\text{1sS11Sh/2- }\theta\text{ -PN}_{1}}$	D s.t.

MAP 1

Bay View site option

Introduction

The 1100 ha site lies 5 km west of Napier City. It is hill country, being a series of narrow, undulating ridges separated by steep-sided valleys. A wider central valley contains both swamp and free draining situations.

Rock type

The rock type comprises a sequence of marine fossiliferous sandstones, siltstones and mudstones with thin limestone horizons. Separate thin strata of greywacke pebbles also occur within the sequence. A variable thickness of loess mantles all slopes with depth being greatest on the NW slopes (up to 20 m). This cover makes detailed lithological mapping impossible without drilling. This type of detailed study was not possible in the time available but is essential prior to any urban development.

Soils

Matapiro soils (28)[2] are mapped on the loessial material and where this has been removed Crownthorpe soils (21)[2] have been mapped. Soils from the Okawa series (29)[2] occupy the wetter valley bottoms. All loessial soils have impermeable pans at various depths.

Erosion and geotechnical hazards

Erosion is mainly confined to the loess mantle and to the weathered regolith. Soil slip erosion is common on the steeper slopes, its occurrence being dependent on infrequent high intensity storm events. Sheet erosion occurs mainly on the NW facing slopes while tunnel gully erosion is common in the loessial soils.

Evidence of the occasional historic slump and the unknown detail of the sedimentary sequence indicate a potential instability hazard to urban development, especially on steep slopes (i.e. >20°). Detailed lithological mapping is required to fully understand the hazard. Foundation conditions on the loessial materials are adequate for single storey residential developments provided care is taken with drainage and compaction of fills. Compaction of backfill around buried service lines would probably require addition of traces of lime.

Drainage/flooding

The low lying valley bottom sites are poorly drained with some surface flooding. Adequate drainage is required for urban development. Drainage and flood protection are estimated to cost $740,000 (Hawke's Bay Catchment Board 1979).

Urban capability

Class A — No class A land occurs in the site.

Class B — 32% of the site is class B with minor limitations to urban development. This is mainly confined to the undulating and gently rolling, loess mantled ridge crests and better drained valley bottom areas. Dominant subclass limitations are foundations (n) on the loess, drainage (d) and topography (t).

Class C — 20% of the site is class C with moderate to severe limitations. Dominant subclass limitations are topography (t), slope stability (s) and foundations (n) on the crests and drainage (d) on the lower valley bottoms.

Class D — 48% of the site is class D having very severe limitations. The dominant subclass limitations are topography (t), slope stability (s) and foundations (n).

Note: While classes C and D have major limitations as defined for this study there are extensive areas very suited to low density housing.

[2] from Pohlen *et al.* 1947.

Site option 2: Wharerangi

Unit Area No.	Urban Land Resource Inventory	Urban Land Use Capability
1	Lo/Up-28-E+F^2 2sSl1Sh/2-θ-P	D s.t.n.
2	Lo - 28 - B+C^1 θ/1 - θ - P	B t.s.n.
3	Lo/Up - 28 - C^2 θ/1 - θ - P	C t.s.n.
4	Lo/Li+Up-15-F^2 2sSl1Sh/2-θ-P	D s.t.n.
5	Al - 29 - B^4 θ/θ - 1G$_1$ - P	B d.
6	Lo/Up-28-D+E^2 1Sh1sSl/2-θ-P	D t.s.n.
7	Lo/Up-28-C^{1+2} θ/1 - θ - PL$_2$	B t.s.n.
8	Lo/Up-28-D+C^2 1Sh/2 - θ - P	C t.s.n.
9	Lo/Up-28-D^2 1Sh/2- θ -L$_3$	C t.s.n.
10	Lo/Up+Li-28+21-E+F^2 2Sh2sSl/3 -θ-P	D s.t.n.
11	Lo/Up-28-E^2 1Sh1sSl/2-θ-P	D s.t.n.
12	Lo/Up-28-E+D^2 1sSl1Sh/3-θ-P	D s.t.n.
13	Al-29-A^4 θ/θ-3G$_1$2G$_2$-P M	C d.
14	Lo/Up-28-E^2 2sSl1Sh1R/2-θ-P	D s.t.n.
15	Al-29-A^4 θ/θ-2G$_1$1G$_2$-P	B d.
16	Lo/Up-28-D+C^2 1Sh/2- θ - P	C s.t.n.
17	Lo/Up-28-B+C^{2+3} θ/1 - θ - P	B t.n.s.
18	Up+Li-15-G+F^2 2sSl2Sh/3-θ-PMn2	D t.s.n.
19	Lo/Up-28-E^2 2sSl1Sh/2- θ -P	D s.t.n.
20	Lo/Up-28+21-E^2 3sSl1Sh/2-θ-P	D s.t.n.
21	Lo/Up-28-E+D^2 1Sh1sSl/2- θ -P	D s.t.n.
22	Al-29-A^4 θ/θ-2G$_1$1G$_2$- P	B d.f.
23	Al-29-B^7 θ/θ-1G - P	B d.
24	Lo/Up-28-F+E^2 1sSl1Sh1T/3-θ-Pn$_1$	D s.t.n.
25	Lo/Up-28-D^2 1sSl1Sh/2-θ-P	C t.s.n.
26	Lo/Up-28-E+F^2 1sSl1Sh/2-θ-P	D s.t.n.
27	Al-29-B^4 θ/θ-2G$_1$1G$_2$ -P	B d.
28	Al/29-A^{4+5} θ/θ-1G$_1$1G$_2$- Pℓ$_1$	B d.
29	Lo/Li+Up-28+21-F^2 2sSl1Sh1T/2- θ -P	D s.t.n.
30	Lo/Up-28-C^1 1Sh/1 - θ - P	B t.n.s.
31	Lo/Up-28-E^2 1sSl1Sh/2-θ-P	D s.t.n.
32	Lo/Up+Li-28+21-F+E^2 1sSl1Sh/2-θ-Pn$_1$	D s.t.n.
33	Lo/Up-28-D+C^2 1Sh/2 -θ- P	D s.t.n.
34	Lo/Up-28-E+D^2 1sSl1Sh/2-θ-P	D s.t.n.
35	Lo/Up+Ls-28-E+F^2 1sSl1Sh/2-θ-P	D s.t.n.
36	Lo/Up-28-D+C^2 1Sh1sSl/2-θ-P	C t.s.n.
37	Lo/Up-28-E+D^2 1sSl1Sh/2-θ-P	D s.t.n.
38	Lo/Up-28+21-E^2 2sSl2Sh/2- θ -P	D s.t.n.
39	Lo/Ls+Up-21+28-E+F^2 2sSl1Sh1T/2 - θ -P	D s.t.n.
40	Lo/Ls-28-B+C^1 1W1Sh/1 - θ - P	B t.n.s.
41	Lo/Ls-21+28-F^2 1Sh1sSl/2-θ-P	D s.t.n.
42	Lo/Up-28-D^2 1Sh/2-θ-P	D t.s.n.
43	Al-29-A^{4+5} θ/θ - 2G$_1$G$_2$- P	C d.f.
44	Lo/Up-28-C^2 1Sh1sSl/2-θ-P	B d.
45	Lo/Up-28-C+D^2 1Sh/2 - θ - P	C t.s.n.
46	Lo - 28 - B+C^1 1W/1 - θ - P	B t.n.s.
47	Lo/Up - 28+21-F^2 2sSl1Sh/2-θ- P	D s.t.n.
48	Lo/Up+Ls-28-E+F^2 1sSl1Sh/2 -θ-P	D s.t.n.
49	(Lo)/Ls+Up-21+28-E+F^2 1Sh1sSl/2- θ - P	D s.t.n.
50	Al+Lo-32-B^7 θ/1 - 1G$_1$ - P	B t.n.


MAP 2
Wharerangi site option
N
Scale 1: 25 000


MAP 3
Napier fringe site option
AI - 27 - A5
AI - 24 - A5
Bd

Site option 3: Napier fringe

Map 3

Introduction

The site comprises two areas, the larger being immediately south of Napier city bounded by the 'motorway', Meanee Road and a line east of Riverbend Road, and the second being three small areas on the flats north west of Taradale.

The larger area was a tidal estuary before the 1931 earthquake.

Rock type

Surface deposits are recent alluvium, mainly silt (2–5 m thick) over marine sediments (soft blue clays and sands).

Soils

Heavy soils, the Meanee silt and clay loams (26, 27)[1] have low permeability with indications of saline influence still present. The lighter textured soils, Farndon silt and clay loams (23, 24)[1] are more permeable and have no saline problems.

Erosion

No significant erosion.

[1] from DSIR 1939

Drainage/flooding

The area is low lying and prone to flooding during storm events. Two areas have been separated in the inventory as being more prone to surface flooding than the remainder.

A comprehensive drainage and pumping scheme will be required to protect urban sites from 50 year flood events. This is estimated to cost $1.26 million (Hawke's Bay Catchment Board 1979).

Foundation conditions are adequate for single storey residential developments over most of the area. High rise or commercial buildings would require more detailed site investigation and appropriate design due to the compressible nature of the underlying material.

Urban capability

Class A — No class A occurs on the site.

Class B — 100% of the site is class B. The major subclass limitation is drainage (d) with foundation (n) limitations also occurring throughout the site.

Site option 4: Pakowhai

Map 4

Introduction

The site lies between the Tutaekuri and Ngaruroro rivers centred on Pakowhai between Napier and Hastings.

Rock type

The site is on alluvial materials, mainly silt and sands over gravels.

Soils

Soils are mainly sand and silt loams, fertile and free draining (Twyford fine sandy loam (4), Twyford sandy loam and fine sandy loam (6), Hastings silt loam (14), Hastings silt loam on fine sandy loam (16), Pakowhai silt loam (17))[1]. Finer textured Pakowhai clay loam (18)[1] occurs in small areas. Low dunes occur in the SW of the area adjacent to the Ngaruroro river while small areas of peat can be found. Neither of these are recorded on the map due to scale of mapping.

Erosion

No significant erosion.

[1] from DSIR 1939.

Drainage/flooding

The finer textured soils to the NE of the area will tend to retain surface water, and drainage including pumping will be required for urban use in the area. Improved stopbank protection on the Ngaruroro, Tutaekuri and the Tutaekuri-Waimate Rivers will also be needed. The estimated cost of these measures is $886,000 (Hawke's Bay Catchment Board 1979).

Geotechnical hazards

The area has dominantly low strength foundation soils, poor in places, but improving where more permeable materials are on the surface. Foundation conditions are adequate for single storey residential development over most of the area but high rise or commercial buildings would require more detailed site investigation and appropriate design.

Urban capability

All the area is classified Bd having only minor limitations due to drainage requirements. Areas required for stopbank protection have not been delineated in this study.


MAP 4
Pakowhai site option
N
Scale 1: 25 000
Al-17+25-A5
Θ-IG1 IG3-PL1
Bd
Al-18-A5
Θ-IG2 IG1-L2 L3 P
Bd
Al-4+6-A5
Θ-IG3 IG1-L2 P
Bd
Al-14+16-A5
Θ-IG1-L2 L3 P
Bd
Al-17-A5
Θ-IG3 IG1-P
Bd
Al-3+4-A5
Θ-IG3-P
Bd
Al-4+6-A5
Θ-IG1-L3 L2 P
Bd

MAP 5

Clive site option

Site option 5: Clive

Map 5

Introduction

The site lies between the Tukituki and old Ngaruroro River course from Clive to the coast.

Rock type

Alluvial clays and silts cover the site.

Soils

Soils are mostly heavy textured and slow draining, being formed on sediments deposited by the Tukituki River. North-west of Muddy Creek sediments are formed from Ngaruroro River sediments which are more permeable. Soils are the Farndon silt loam (23)[1] and Hastings silt loam (14)[1] and clay loam (15)[1].

Erosion

Coastal erosion should be considered a risk in the area, especially during storms and exceptionally high tides.

Drainage/flooding

The site is low lying, being lowered by the 1931 earthquake. The low permeability soils and high water table results in a surface flooding potential while marine inundation can also be a problem. Drainage, pumping stations and seawall protection are required for urban protection and are estimated to cost $2.2 million (Hawke's Bay Catchment Board 1979).

[1] from DSIR 1939.

Geotechnical hazards

Foundation conditions are adequate for single storey residential development over most of the area. High rise or commercial buildings would require more detailed site investigations and appropriate design.

Urban capability

Class A — No class A land occurs on the site.

Class B — 30% of the site is class B having minor limitations to residential development. The subclass limitation is drainage (d).

Class C — 68% of the site is class C having moderate to severe limitations. The major subclass limitation is surface flooding (f) due to runoff from adjacent areas or marine inundation.

Class D — 2% of the site is class D with very severe limitations due to flooding (f). This area has been separated out as possibly being required for seawall construction during the next 100 years, assuming present erosion rates continue.

Site option 6: Havelock North – East

Map 6

Introduction

The site covers a gently sloping terrace and fan surface east of Havelock North on both sides of Arataki Road.

Rock type

The rock types on the site comprise loess and fine grained alluvium covering gravels deposited by the Tukituki River.

Soils

Soils are mapped as Ngatarawa and Havelock sandy loams (10 and 11)[1] with most having impermeable pans at 30–40 cm depth. This results in a perched water table and consequent surface wetness.

Erosion

No significant erosion.

[1] from DSIR 1939.

Drainage/flooding

The area is wet in winter, requiring drainage improvement for urban development. Flood protection from the Karituwhenua Stream is also essential. Protection measures will cost approximately $190,000 (Hawke's Bay Catchment Board 1979).

Geotechnical hazards

As the area contains a variety of lithologies foundation strengths vary. However foundation conditions are adequate for single storey residential developments.

Urban capability

Class A — No class A land occurs on the site.

Class B — 100% of the site is mapped as class B. The major subclass limitation are drainage (d) on the eastern side, and drainage and flooding (d.f) on the western side adjacent to the Karituwhenua stream.

Site option 7: Havelock North – South Map 6

Introduction

The site lies on the SW of Havelock North Borough, from Middle Road back to the steep country to the East. Adjacent to Middle Road the topography is gently rolling downlands while to the east slopes get longer and steeper.

Rock types

The site comprises NW dipping marine sediments overlain by a mantle of loess containing thin pumice bands. The marine sediments contain a sequence of mudstone, siltstone, sandstone and limestone but details of relative thicknesses are not known.

Soils

Matapiro sandy loam (28)[2] is mapped on the loessial material and Crownthorpe sandy loam (21)[2] where this has been removed. Okawa heavy sandy loam (29)[2] occupies the wetter valley bottoms.

Erosion and geotechnical hazards

Present erosion is mainly confined to the loess mantle and to the weathered regolith. Soil slip, tunnel gully, slump and stream bank erosion occur, all with only slight severity. *However* evidence of historic slump movement on the site and active earthflows just outside the site indicates a potential instability hazard under urban conditions. A more detailed geological study of this area is therefore required. The combination of loess over gently dipping relatively impervious sediments provides a further potential instability factor. Foundation conditions would be adequate for single storey residential development on the loess material provided care was taken with drainage and compaction and the underlying material proved stable.

[2] from Pohlen *et al.* 1947.

Drainage/flooding

Areas on Matapiro soils will show seasonal wetness. Streams are subject to periodic flooding and require protection and enlarging. Off-site disposal will also be critical. Protection costs are estimated at $317,000 (Hawke's Bay Catchment Board 1979).

Urban capability

Class A — No class A occurs on the site.

Class B — 11% of the site is class B. On this class slopes are relatively low angled. The dominant subclass limitation is drainage (d) caused by slow internal drainage and surface runoff from adjacent areas.

Class C — 42% of the site is class C and occurs mainly on the low crest and side slope topography situations. Slope stability (s) is the dominant subclass limitation and is due to the loess, the angle of dip of the sediments and the rock type. Before any development is carried out, detailed geological investigations will be necessary throughout the class.

Class D — 47% of the site is class D including most slopes over 20° and the drainage systems. The major subclass limitations are slope stability (s) and topography (t).

Site option 7: Havelock North — South

Unit Area No.	Urban Land Resource Inventory	Urban Land Use Capability
1	$\frac{\text{Lo/Up-10-A+B}^{7}}{\theta\text{/1-1G}_{1}\text{ - Pn}_{2}}$	B d.n.
2	$\frac{\text{Al-29-A+E}^{8+9+2}}{\text{1Sb/2-2G}_{1}\text{2G}_{3}\text{ -Pn}_{2}}$	D d.f.
3	$\frac{\text{Lo/Up-28-C}^{2+8}}{\text{1sh/2-1G}_{1}\text{- Pn}_{2}}$	C s.t.n.
4	$\frac{\text{Lo/Up-28-B}^{3+8}}{\text{1sh/2-1G}_{1}\text{-Pn}_{2}}$	B d.s.n.
5	$\frac{\text{Lo/Li-28-D}^{2}}{\text{1Sh/2- }\theta\text{ - Pn}_{2}}$	C s.t.n.
6	$\frac{\text{Lo/Li-21+28-F+E}^{2}}{\text{1Sh 1sSl/2-}\theta\text{-P}}$	D s.t.n.
7	$\frac{\text{Lo/Li-21+28-E+F}^{2}}{\text{2Sh1G1T/2-}\theta\text{-Pn}_{2}}$	D s.t.n.
8	$\frac{\text{Al2+Lo/Li-28-B}^{4}}{\theta\text{/1-1G}_{1}\text{1G}_{4}\text{-Pn}_{2}}$	C d.f.n.
9	$\frac{\text{Al2-28-A+B}^{4}}{\theta\text{/1-2G}_{3}\text{- Pn}_{2}}$	D f.d.
10	$\frac{\text{Lo/Up-28-C}^{1+2}}{\text{1Sh1Su/2-1G}_{1}\text{-Pn}_{2}}$	C s.t.n.
11	$\frac{\text{(Lo)/Up+Li-21+28-F}^{2}}{\text{1Sh1sSl/2-}\theta\text{-P}}$	D s.t.n.
12	$\frac{\text{Al2-28-B}^{4+6}}{\theta\text{/1-2G}_{1}\text{1G}_{2}\text{- P}}$	C d.n.
13	$\frac{\text{Lo/Up+Li-21+28-E}^{2}}{\text{1Sh2Su/2-}\theta\text{-Pn}_{2}}$	D s.t.n.
14	$\frac{\text{Lo/Up-21+28-E+F}^{2}}{\text{1Sh1sSl/1-}\theta\text{-P}}$	D s.t.n.
15	$\frac{\text{Lo/Up-28-B}^{1}}{\theta\text{/1- }\theta\text{ - P}}$	C s.t.d.n.
16	$\frac{\text{Lo/Up-21+28-D+C}^{2+4}}{\text{1Sh/2 - 1G}_{2}\text{- P}}$	C s.t.d.n.


MAP 6
Havelock North site options
Upper: Havelock North – East
Lower: Havelock North – South
N
Scale 1: 25 000
Bd
Bdn 1
Bdn 1
Ddf
Ddf
Cstdn
Cstn
Bdn
Cdfn
Bdsn
Dfd
Cstn 5
Dsn
Cdn
Dstn

MAP 7
Te Awanga site option

Site option 8: Te Awanga

Introduction

The site is adjacent to the coast from the Tukituki River south to behind Te Awanga.

Topography varies from the low river plains and gravel beach ridges, through terrace and rolling country to steep, unstable hill country on the SW boundary.

Rock type

The flatland areas are formed on gravels and alluvium with alluvial and loess fans spreading onto them in places. Gravels, forming beach ridges, lie along the coast while a few low, stable, finger dunes are also found inland on the flats.

The hill country comprises a sequence of marine mudstone, siltstone, sandstone and gravel beds mantled to varying depths by loess. Active faults are common in the area.

Soils

On the plains Hastings silt loam (14)[1] and clay loam (15)[1] and Twyford stony gravel and stony coarse sand (phases 1B, 1C)[1] occur with both the poorly draining clay and rapidly draining silt loams present. The beach ridges contain the poorly developed Awatota gravel soil (Aw)* while the Opoutama sands (Op)* occur on the stable sand dunes.

Fan soils, of the Poporangi Series (32)[2], have subsurface pans and impeded drainage.

On the hills Matapiro soils (28)[2] are mapped on the loessial material and where this has been removed Crownthorpe soils (21)[2] are found. Soils from the Okawa series (29)[2] occupy the wetter valley bottoms. All loessial soils have hard pan horizons at various depths.

Erosion and geotechnical hazard

With erosion rates of 1m/yr (Gibb 1978) along the coastal strip a severe potential problem on the eastern margin exists if erosion continues back to the site area.

Erosion elsewhere is confined to the hill country. Here slips occur mainly in the loess mantle and the weathered regolith. Evidence of the occasional historic slump, the presence of active faults, and the unknown detail of the sedimentary sequence indicate a potential instability hazard to urban development, especially on steeper slopes (i.e. $>20°$). Detailed geological mapping is required to fully understand the hazard.

Foundation conditions are adequate for single storey residential development on the loessial material and on the plains provided care is taken with drainage and compaction.

Drainage/flooding

Low lying areas adjacent to the hills have surface flooding problems while the rolling slopes have impeded drainage causing seasonal wetness. The plains have a surface flooding potential, both from the hills behind and from adjacent rivers requiring stopbanking, drainage and pumping for urban protection. The cost of this and coastal protection is estimated at $3.51 million (Hawke's Bay Catchment Board 1979).

Urban capability

Class A — No class A land occurs on the site.

Class B — 60% of the site is classified class B with minor limitations. The major subclass limitation is drainage (d) and occurs on the flat areas and fans. The coastal gravel bank at distances greater than 100 m from the sea is classed B and needs further consideration before any urban development takes place.

Class C — 10% of the site is class C with moderate to severe limitations. The major subclass limitations are drainage (d) and topography (t).

Class D — 30% of the site is class D with very severe limitations. The major subclass limitations are flooding (f), drainage (d), stability (s) and topography (t). Class D land includes a flood ponding area adjacent to the Tukituki River, another behind a flood detention dam, water courses and confined valley bottoms.

The potential effect of active faults in the area has not been assessed but should be investigated prior to any final development decisions being made.

[1] from DSIR 1939.
[2] from Pohlen *et al.* 1947.
* pers. comm. Mr E. Griffiths, Soil Bureau, DSIR, Havelock North.

Site option 8: Te Awanga

Unit Area No.	Urban Land Resource Inventory	Urban Land Use Capability
1	Al$_2$- 1B - A^5 θ/1 - 2G$_2$ - L$_1$P	D f.d.
2	Al$_2$- 30 - A^5 θ/1-2G$_1$G$_4$1G$_5$-PL$_1$	C d.f.
3	Al$_2$ - 15*-A^5 θ/θ-1G$_1$-Pℓ$_1$	B d.
4	Al$_2$-14*+1c*-A^5 θ/θ-1G$_1$-P l$_1$l$_1$	B d.
5	Al$_2$-14*+15*-A^5 θ/θ-2G$_1$- Pl$_1$	B d.
6	Al$_2$-28-A+B^6 θ/θ-1G$_1$-Pℓ$_3$ℓ$_1$	B d.
7	Lo/Up-28-B+C^{2+1} 1Sh/1-1G$_1$- P	B d.s.n.
8	Lo/Up-28-C+D^{1+2} 1Sh/1 - 1G$_1$- P	C s.d.n.
9	Lo/Up-28-E+C+A^{2+4} 1sSl1G/2-2G$_3$- P	D s.f.n.
10	Al$_2$-28+29-A+B^{4+8} 2Sb2G/2-2G$_3$- P	D f.
11	Al$_2$-32-A+B^{7+8} θ/1-1G$_4$ - P	B d.f.
12	Lo/Up-21+29-F+G^{2+4} 1sSl/2-2G$_1$1G$_3$- P	D s.t.n.
13	Lo/Up-28-D+C^{1+2} 1Sh/1 - 1G$_1$ - P	C s.t.n.
14	Lo/Up-28-B+C^2 θ/1-2G$_1$ - P	C d.n.
15	Al-29-A+B^4 θ/1 - 2G$_1$ - P	B d.
16	Lo/Al-32-B+C^7 θ/θ-2G$_1$1G$_4$- P	B d.n.
17	Lo/Up-28+21+29-D+F^{2+4} 1sSl/2-2G$_1$1G$_3$1G$_6$-P	D s.t.n.
18	Lo/Up-21-F^2 2T1sSl/2-2G$_1$-P	D s.t.n.
19	Lo/Up-29-B^4 θ/1-3G$_1$-P	D d.n.
20	Lo/Al$_2$/UP-30-A+B^6 θ/θ-1G$_1$ - P	B d.n.
21	Al-30+29-A+F^{4+2} 1Sb2sSl/2-2G$_1$2G$_3$-P	D f.d.
22	Al - 29-A^4 θ/θ-2G$_1$3G$_2$-P	D f.
23	Lo/Up-28+29-B+A^{2+4} 2Su/3-3G$_1$2G$_6$-P	D s.t.n.
24	Lo/Up-28-C^2 θ/1 - 2G$_1$ - P	D s.d.n.
25	Lo/Up-21-F+E^2 1sSl/2-2G$_1$1G$_3$-P	D s.t.n.
26	Lo/Up-28-E+D^2 1sSl/1-1G$_1$ - P	D s.t.n.
27	Lo/Up-32-C^7 θ/1-1G$_1$1G$_4$ - P	C d.n.
28	Lo/Up-28+21-C+D^1 θ/1-1G$_1$ - P	C t.s.n.
29	Lo/Up-21-F+G^2 2sSl1G/3-1G$_1$- P	D s.t.n.
30	Al-30+29-A^{4+6} 2Sb/2-2G$_1$2G$_3$- P	D f.d.
31	Al^2-30-A^{5+3} Θ/Θ-2G$_1$2G$_4$- P	B d.
32	Gr-Aw+ - A^9 Θ/1-2G$_4$1G$_5$ -P	B d.
33	Al - 30 - A^5 Θ/Θ-2G$_1$-PL$_1$	B d.
34	Wb-Op+ - C^{10} Θ/1 - Θ - P	B s.
35	Al2-60-A^6 Θ/Θ-1G$_1$- P	B d.

*DSIR 1939.

+E. Griffiths, Soil Bureau, DSIR, Havelock North (pers. comm.).


MAP 8
Hastings fringe
site option
N
Scale 1: 25 000

Site option 9: Hastings fringe

Map 8

Introduction

This site comprises three separate areas adjacent to Hastings City.

Rock type

The rock type comprises alluvial silts, sands and clays over gravels at depth.

Soils

Soils are mainly free-draining and fertile (Hastings clay loam on sand (13) and silt loam (14); Twyford silt loam (5), Twyford sandy loam and fine sandy loam (6))[1] though some have heavier textures and a lower permeability (Kaiapo clay loam (19)[1]).

Erosion

There is no significant erosion.

Drainage/flooding

Sites east of Hastings require only minor drainage improvement for urban development except for one small area which is liable to surface flooding. On the western side of Hastings drainage improvements, including pump stations, are needed. However a portion of this is to ensure adequate off-site control of water. Estimated costs of this protection work are $1.34 million of which over $1 million is on the western side (Hawke's Bay Catchment Board 1979).

[1] from DSIR 1939.

Geotechnical hazards

Foundation conditions are adequate for single storey residential development over most of the area. High rise commercial buildings would require more detailed site investigation due to the compressible nature of the underlying material.

Urban capability

Class A — 56% of the site is Class A land. This covers the eastern sites except for one small area of Bf which has a surface flooding potential.

Class B — 44% of the site is class B land and occurs on the western areas. The major subclass limitation is drainage (d).

Site option 10: Paki Paki

Introduction

The site lies immediately west of Paki Paki at the base of the limestone cuesta and at the mouth of a low lying valley system.

Rock type

The site is underlain by Taupo alluvium (up to 8 m thick) with a cover of peat in the west. Alluvium covers the pumice alluvium on the eastern side of the site.

Soils

Soils comprise Twyford sandy loam and fine sandy loam (6)[1], the Paki Paki series (Paki Paki sand (7), coarse sandy loam (8), clay and clay loam (9))[1], and the Turamoe peats (22, 22a)[1]. The peat soils are on peat up to 4 m in depth and contain many tree stumps.

Erosion

No significant erosion.

Drainage/flooding

The area has a high ground water table level and is prone to surface flooding. The Awanui Stream channel will require upgrading together with pumping stations at an estimated cost of $610,000 (Hawke's Bay Catchment Board 1979). Off site effects of this work will need particular attention, particularly downstream drainage works.

Geotechnical hazards

The development of areas on peat will require special attention to foundations (e.g. piercing the peat zone) and the removal of any stumps.

Areas on pumice alluvium are suitable for urban development — both residential and commercial, while those on the other alluvium are suitable for residential development only.

Urban capability

Class A — No class A land occurs on the site.

Class B — 70% of the site is class B with minor limitations. The dominant subclass limitation is drainage (d) due to the high water table.

Class C — 30% of the site is class C having severe physical limitations. The dominant subclass limitations are drainage (d) and foundations (n), due to high water table levels, the risk of surface flooding and the foundation problems caused by the peat.

[1]from DSIR 1939.

MAP 9
Paki Paki site option

MAP 10
Flaxmere site option
Scale 1: 25 000

Site option 11: Flaxmere Map 10

Introduction

The site comprises 2300 ha west of Flaxmere between SH 50 and the Stortford Lodge — Paki Paki Road.

Rock type

The site contains a variety of rock types which have been deposited by previous courses of the Ngaruroro River.

Coarse greywacke gravels underlie the site, forming the surface deposits to the east. To the west these gravels are covered by pumice alluvium and this in places by varying depths of greywacke alluvium. The gravels form part of the main aquifer system, part of which is unconfined.

Soils

The gravel soil, Twyford stony gravel and stony coarse sand (1)[1], is very infertile and moisture deficient, but where alluvium covers the gravels good quality horticultural soils have formed (Twyford sandy silt loam (2)[1]).

Paki Paki series soils are formed on pumice alluvium, with sandy topsoils (Paki Paki sand (7)[1]) being on coarse alluvium and the coarse sandy loam (8)[1] on shallow greywacke alluvium over the pumice. Surface textures are light and free draining but subsurface bedding inhibits drainage through the profile.

Hastings silt loam (14)[1] and clay loam (15)[1] and Kaiapo clay loam (19)[1] soils are heavy textured with a low permeability.

Erosion

No significant erosion.

[1] from DSIR 1939.

Drainage/flooding

Surface flooding is a potential problem in the south-eastern corner of the site.

Where the surface deposits are gravels of the unconfined aquifer the risk of groundwater pollution is considered to be very severe (NWASCA 1977). The potential is less where fine sediments cover the gravels and is less still on areas over the confined aquifer.

Geotechnical hazard

Most land in this site would provide adequate foundation material for urban development — both residential and commercial. The dominant hazard, severely restricting urbanisation, is the danger of polluting the groundwaters.

Urban capability

Class A — No class A land occurs on the site.

Class B — 37% of the site is class B with only minor limitations to urban development. The subclass limitation is drainage (d).

Class C — 28% of the site is class C with moderate limitations to urban development. Included in this are those areas on the unconfined aquifer with a cover of fine alluvium mapped as subclass (a). Design of sewage and stormwater disposal systems needs to be approved by the Regional Water Board and possible contaminants isolated. Industrial development should be severely restricted.

Class D — 35% of the site is class D having severe physical limitations. The limitations, recorded as subclass (a), are caused by the potential groundwater pollution hazard in areas where the gravels of the unconfined aquifer are on the surface.

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References

DSIR 1939: Land utilization report of the Heretaunga Plains. *DSIR Bulletin 70.* 111p and map.

Pohlen, I.J.; Harris, C.S.; Gibbs, H.S.; Raeside, J.D. 1947: Soils and some related agricultural aspects of mid Hawke's Bay. *DSIR Bulletin 94.* 176 p.

Gibb, J.G. 1978: Rates of coastal erosion and accretion in New Zealand. *NZ Journal of Marine and Freshwater Research 12(4):* 429–56.

Hawke's Bay Catchment Board 1979: Offsite drainage and flood control estimates. Hawke's Bay Urban Study — Urban Site Options. Unpublished report.

Kingma, J.T. 1970: Sheets N134 and N135 "Geological Map of New Zealand 1:63,360." DSIR, Wellington.

MWD 1973: Poraiti-Puketapu Housing Development. Unpublished Engineering Appraisal Report, Napier District.

MWD 1974: Havelock North Borough proposed boundary extensions. Unpublished Engineering Appraisal Report, Napier District.

NWASCA 1977: National Water and Soil Conservation Authority, Minutes of Meeting 2 November 1977, Item No. 11.

Noble, K. 1976: New Zealand land resource inventory worksheets series, Sheets N134 Napier-Hastings, N135 Kidnappers. National Water and Soil Conservation Organisation.

Northland Catchment Commission 1978: Urban capability survey – Hikurangi Town District. Unpublished report.

NSW Soil Conservation Service 1978; Urban capability study. Eglinton. Bathurst Village, Part 4. (Prepared by I.D. Hannam and B.W. Murphy).

Waikato Valley Authority 1978: Ngaruawahia Borough urban land use capability. Unpublished report.

APPENDIX

Notes on the geotechnical properties of foundation materials in the site option areas

Data are derived from *in situ* and laboratory test data obtained from Napier District Laboratory reports and from comparable data from similar materials recorded in general soil mechanics literature.

Geology

The Heretaunga Plains alluvium has been deposited in a fault-angle depression formed mainly by transcurrent movements along lines which are still active.

Bore log data confirms that the Heretaunga Depression has on many occasions been invaded by the sea.

The present surface is covered largely by alluvial deposits which vary in grain size from gravels to clayey silts. Reworked pumice alluvium, mainly of sand and silt-sized material, is found in some areas.

Flanking the plains and forming low hilly areas are folded and faulted blocks of Plio-Pleistocene, mainly marine, soft-rock sequences. These limestones, sandstones, siltstones and mudstones with occasional conglomerate bands, are often in the form of cuestas and ridges capped by the more resistant cemented limestones.

A variable thickness of aeolian soils (loess) with thin bands of volcanic ash is found on these higher areas, representing a periodic post-Pleistocene accumulation of wind-blown, mainly silt-size, sediments.

Foundations and ground stability

For this exercise it has been assumed that only light residential development will take place with minimal earthworks. Average subdivision density of single storey residential development has also had to be assumed for area comparison purposes.

These assumptions could be considered unrealistic both in engineering and economic terms, and also in the belief that council planning officers would not consider uniform density development as either feasible or desirable. However the assumption of uniform average density light residential construction was necessary to provide a uniform base for comparisons.

Most residential developments of the sizes proposed would also require commercial development, school and college facilities, water reticulation including supply reservoirs and other more extensive structures which would require more competent foundation conditions than lightweight single storey domestic dwellings.

Alluvium and water formed soils

Gravels

The gravels found in the Flaxmere area are generally pervious competent materials which should provide adequate foundation conditions for any development. N-values from Standard Penetration Tests are consistently 20+.

Silts

On the flats, stratified fine-grained deposits predominate. The grain size distribution ranges from clayey silts to sandy silts with the silt fraction often exceeding 50%. They are composed generally of quartz and feldspars, with some fragments of muscovite, sericite and clay minerals.

These materials are found in the Napier and Hastings environs and in the Clive and Pakowhai areas in particular.

From shear box data strength parameters range from $\phi = 27°$, c = 10kPa for clayey silts to $\phi = 35°$, c = 0 for sandy silts. These soils generally have low bulk densities in the range 1.6–1.8 Mg/m^3.

N-values from SPT tests are consistently low, in the range 0–10/300 mm and these results are backed up by readings from the highly sensitive electric penetrometer.

Allowable bearing pressures accepted locally for this material are in the order of 50–100 kPa (½–1 t/sf) which is adequate for light structures only.

Settlement below heavier structures can be overcome by preloading and compacting with gravels.

The possibility of differential (non-uniform) settlement where old river channels may have brought more competent materials adjacent to these softer sediments could pose a problem.

The process of liquefaction, which occurs in cohesionless fine-grained soils, particularly fine sands and saturated silts, has been considered to present a potential foundation problem when the ground is subjected to vibrations from seismic activity, but little evidence of the process occurring in the past is available.

Pumice

Reworked pumice deposits are found in the Paki Paki and Flaxmere areas. These are generally silt and fine sand sized sediments with occasional large 'floaters'.

They have low bulk densities (1.0–1.5) and N-values from Standard Penetration Tests of 3–15/300 mm increasing to around 20/300 mm with depth.

The pumice alluvium has a high liquid limit of 60–80% and the *in situ* moisture contents often approach these figures. The layered silts have an unusually low permeability for pumiceous material.

Loess

On the hilly areas examined there are considerable thicknesses of primary loess. Some of this wind-blown material has been washed down into the valleys and plains to be redeposited as secondary loess.

The primary loess is predominantly silt-sized (50%+) and has moderate vertical permeability $k = 10^{-3}$–10^{-4} cm/s. Horizontal permeability is considerably less than this with the ratio k_v/k_h in the order of 15:1.

Bore logs on this loess country often show the presence of hard pans at various depths due to cementation or partial cementation.

The loess is generally a quartzose clastic sediment with some feldspars and has an open fabric. It is of low density (1.5–1.8), making it highly porous.

Loess is regarded as a problematic foundation material unless absolute control of surface water can be achieved. Under a load, loess when wetted can consolidate and settle (hydroconsolidation). However, the material can be remoulded to create a more reliable platform if properly compacted at optimum moisture content.

Excavation is acceptable in loess if the material is kept dry.

The strength characteristics of dry loess are relatively high with ϕ-values of 30–40° and c values of 10–100 kPa. N-values from SPT tests can reach 30/300 mm. When wetted, however, the material loses cohesion and can collapse if saturated.

Gullying and tunnelling can occur on the steeper slopes.

Soft rock

Partially indurated marine sediments underlie the hilly areas. The strata show varying permeabilities depending on the grain size and degree of compaction and cementation of the individual units. The exact structural nature of the formation is unknown but there are definite dips recorded, some relatively steep, and care would be needed in any excavations, for road cuttings for example, involving these materials.

N-values for the siltstones from SPT's have been recorded at 30–50/300 mm with ultimate bearing strengths of about 10 MPa.

The study of the physical suitability of the proposed urban development sites concluded that the flat-lying areas were preferable to the steeper topographical locations. However, should any of the hilly sites appear preferable on other grounds, it is recommended a closer look should be taken at the type and size of development on hillsides.

Any chosen location should have a more comprehensive urban capability study undertaken which should include where applicable 10, 20, 50 and 100 year flood plain maps, relative-stability maps and a comprehensive geotechnical evaluation of the area before the development is designed.

WATER AND SOIL MISCELLANEOUS PUBLICATIONS

1. Rainfalls and floods of Cyclone Alison, March 1975, on the north-eastern Ruahine Range ($1-00)
   P J Grant, N V Hawkins, W Christie — 1978

2. Water quality research in New Zealand 1977 ($2-50)
   compiled by Sally F Davis — 1978

3. Liquid and waterborne wastes research in New Zealand 1977 ($2-00)
   compiled by Sally F Davis — 1978

4. Synthetic detergents working party report ($1-00) — 1978

5. Water quality control committee report ($1-00) — 1978

6. Suggestions for developing flow recommendations for in-stream uses of New Zealand streams ($1-00)
   J C Fraser — 1978

7. Index to hydrological recording stations in New Zealand 1978 ($2-00) — 1978

8. Water rights for the Clyde Dam, Clutha hydro power development ($1-50) — 1979

9. Index to hydrological recording stations in New Zealand 1979 ($2-00) — 1979

10. Water quality research in New Zealand 1978 — in press

11. Liquid and waterborne wastes research in New Zealand 1978 — in press

12. Catchment register for New Zealand. Volume 1 — in press

13. New Zealand Recreational River Survey. Volume 1 Introduction
    G D and J H Egarr — in press

14. New Zealand Recreational River Survey. Volume 2 North Island rivers
    G D and J H Egarr — in press

15. New Zealand Recreational River Survey. Volume 3 South Island rivers
    G D and J H Egarr — in press

16. Waimea East Irrigation Scheme information booklet — 1980

17. Hawke's Bay Area Planning Study: Urban capability assessment
    G O Eyles, J H Lawrence, D R Depledge, T W Marshall, G N Thompson, P E Schofield, K N Murray — 1980

18. Index to hydrological recording stations in New Zealand 1980 — 1980