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A METHOD FOR PRODUCING QUANTITATIVELY
BASED MILITARY GEOGRAPHIC INTELLIGENCE
PRODUCTS FOR AN AIRMOBILE DIVISION

Joseph L. Decell, et al

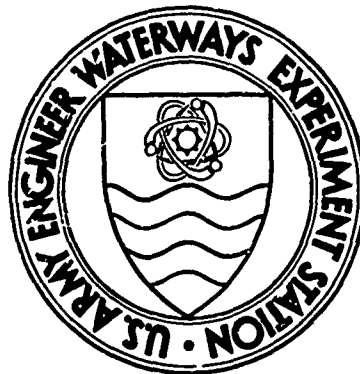
Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

July 1972

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A METHOD FOR PRODUCING QUANTITATIVELY BASED MILITARY GEOGRAPHIC INTELLIGENCE PRODUCTS FOR AN AIRMOBILE DIVISION

by

J. L. Decell, W. E. Grabau, B. O. Benn, J. K. Stoll, B. G. Stinson



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Mobility and Environmental Systems Laboratory
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13. ABSTRACT Seven prototype military geographic intelligence (MGI) products, specifically designed to meet the terrain intelligence needs of an airmobile division in a tactical situation, were developed. The development included five steps: (1) compilation of conceptual models relating the terrain to certain tactical activities; (2) identification of significant terrain factors and assignment of class ranges of their values on the basis of the requirements of the models; (3) construction of factor maps of the selected study area on the basis of the selected terrain factor classes; (4) compilation of a factor complex map for each desired MGI product; and (5) transformation of the factor complex maps to "performance prediction" maps, which were the desired end product. Schematic flow charts of the models are presented, together with lists of significant factors, tables defining classifications of factor values, and the entire array of factor maps, factor complex maps, and MGI products maps.		

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Foreword

This study was part of an effort to design military geographic intelligence (MGI) products to meet specific terrain intelligence needs of an airmobile division. The participation of the U. S. Army Engineer Waterways Experiment Station (WES) in the study was sponsored by the Geographic Applications Branch of the U. S. Army Engineer Topographic Laboratories (ETL). The study was authorized by Intra-Army Order No. MERDC 194-69 under Task 9860032, dated 5 June 1969.

The study was conducted by personnel of the Mobility and Environmental Systems Laboratory, WES, under the general supervision of Messrs. W. G. Shockley, Chief, and S. J. Knight, Assistant Chief, and under the direct supervision of Mr. J. L. Decell formerly of the Vehicle Studies Branch, now of the Terrain Analysis Branch.

Photo interpretation and factor mapping were performed under the supervision of Mr. J. H. Shamburger, Chief, Military Projects Section, Geology Branch, Soils and Pavement Laboratory. The conceptual models used in this study were formulated by Messrs. B. G. Stinson and J. L. Gargaro of the Vehicle Studies Branch. This report was written by Mr. J. L. Decell, with assistance from Messrs. W. E. Grabau, B. O. Benn, J. K. Stoll, and B. G. Stinson.

Directors of WES during the conduct of this study were COL Levi A. Brown, CE, and COL Ernest D. Peixotto, CE. Technical Director was Mr. F. R. Brown.

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Conversion Factors, British to Metric Units of Measurement

British units of measurement used in this report can be converted to metric units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
miles	1.609344	kilometers
pounds per square inch	0.00689476	megapascals (= meganewtons per square meter)

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Summary

Seven prototype military geographic intelligence (MGI) products, specifically designed to meet the terrain intelligence needs of an air-mobile division in a tactical situation, were developed. The development included five steps: (1) compilation of conceptual models relating the terrain to certain tactical activities; (2) identification of significant terrain factors and assignment of class ranges of their values on the basis of the requirements of the models; (3) construction of factor maps of the selected study area on the basis of the selected terrain factor classes; (4) compilation of a factor complex map for each desired MGI product; and (5) transformation of the factor complex maps to "performance prediction" maps, which were the desired end product. Schematic flow charts of the models are presented, together with lists of significant factors, tables defining classifications of factor values, and the entire array of factor maps, factor complex maps, and MGI products maps.

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A METHOD FOR PRODUCING QUANTITATIVELY BASED
MILITARY GEOGRAPHIC INTELLIGENCE PRODUCTS
FOR AN AIRMOBILE DIVISION

Background

1. In the past, military geographic intelligence (MGI) products have generally been designed to meet the needs of numerous potential users. Consequently, they often contain information on more subjects than any specific user needs, but seldom enough information on individual subjects that are critical to a specific user's requirements. A new concept is to produce terrain intelligence products to meet the specific needs of specialized Field Army elements, such as an airmobile division.

Objectives of Study

2. The objectives of the study reported herein were to develop the procedures required to produce a family of MGI products designed to furnish the specific information required by the commander of an airmobile division to plan and conduct certain critical tactical activities, and to produce prototype versions (maps) of these products.

Scope

3. The MGI products selected for the program were cross-country speed for vehicles, cross-country speed for personnel, helicopter landing zone (HLZ) construction effort, concealment characteristics, cover characteristics, airfield construction effort, and bunker construction effort. The prototype MGI product maps were to be constructed to a scale of 1:50,000, and were to cover a small area near Manati, Puerto Rico. For those activities for which no mathematical performance prediction models exist, conceptual models were to be prepared, but no

attempt was to be made to make such models into rigorous mathematical constructions. The emphasis of this program was on the development of new formats and concepts for MGI products, and not on the quantitative reliability of the prototypes.

4. The rationale for developing the proposed new MGI products is based on recognition of the fact that one of the most critical of the tactical commander's information needs is knowledge of the effects of the terrain on his men and equipment. That is, he needs a prediction of their performance in the proposed operational region. In the past, the predictions furnished him by the terrain analysts have been almost entirely subjective and qualitative: "cross-country going is good," "concealment potential is poor," and the like. It seems apparent that an MGI product that provided quantitative answers to the commander's questions concerning terrain impacts would be a significant improvement.

5. The acceptance of the need for quantitative predictions makes it mandatory that the predictions be based on some form of mathematically rigorous procedure. In effect, this means that the first step in the analytical process must be the development of mathematical performance prediction models of military functions to produce objective evaluations of the effects of terrain on the modeled functions. The model identifies the terrain factors that significantly affect the performance of the modeled function; those factors can then be objectively mapped in quantitative terms over the area of interest. The factor maps can then be compiled into a factor complex map that will contain the specific data required by one of the performance prediction models. The map can then be readily transformed into a performance prediction map by using the displayed terrain descriptions as input parameters to the appropriate performance prediction model.* The resulting performance prediction map becomes an invaluable tool for determining the

* W. E. Grabau, J. K. Stoll, and B. G. Stinson, "A Plan for Quantitative Evaluation of the Cross-Country Performance of Prototype Vehicles," Miscellaneous Paper M-70-7, Sep 1970, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

magnitudes of the effects of terrain on tactical functions in any part of the area of interest.

6. The proposed procedure yields objective evaluations of the effects of terrain on military activities, and thus reduces the dependence of the commander on subjective judgments. Even given an adequate description of the terrain, few tactical commanders have the necessary skill to quantitatively evaluate all of the terrain/activity interactions that will affect the operations of his unit. In most cases, the best that can be obtained is scarcely more than a subjective and very general qualitative estimate of such interactions. In modern war, this is no longer adequate.

Approach

Selection of study area

7. The area for which the prototype MGI products were produced was selected on the basis of four considerations. First, it was believed that the area selected should offer a wide variety of terrain characteristics. Second, as much ground-truth data as possible should be available within the area, because most of the actual mapping would have to be done by photo interpretation. Third, it was essential that recent, high quality air photography at a scale of about 1:20,000 be available, so that the factor mapping would be as reliable as possible. Fourth, the area should be reasonably accessible, so that field checks of the mapping could be conducted at some time in the future, if necessary.

8. Several areas were proposed, including small regions in Puerto Rico, the Federal Republic of Germany, Thailand, the Yuma area of Arizona, and the northeastern United States. An analysis of these areas revealed that the Manati area (bounded by $66^{\circ}37'30''$ and $66^{\circ}22'30''$ west longitude and $18^{\circ}15'$ and $18^{\circ}30'$ north latitude), Puerto Rico, would best satisfy all of the requirements. Adequate map and photographic coverage was available, the terrain presented a wide variation in conditions, abundant quantitative ground-truth data were readily

available, and the area was readily accessible.

Selection of prototype MGI products

9. Through a literature search of field manuals and discussions with personnel of airmobile division units, it was determined that, following the selection of the tactical objective, the operational plans for an airmobile division operation are developed sequentially as follows:

- a. Ground Tactical Plan (based on the objective)
- b. Air Landing Plan (based on the Ground Tactical Plan)
- c. Air Movement Plan (based on the Air Landing Plan)
- d. Loading Plan (based on the Air Movement Plan)
- e. Staging Plan (based on the Loading Plan)

Program restrictions were such that prototype MGI products were developed to satisfy only the first three of the operation plans (i.e. items a, b, and c, above).

10. Examination of the three operational plans (i.e. Ground Tactical Plan, Air Landing Plan, and Air Movement Plan), revealed that a major part of their terrain intelligence requirements could be met by the seven MGI products:

- a. Cross-country speed for vehicles
- b. Cross-country speed for personnel
- c. HLZ construction effort
- d. Concealment characteristics
- e. Cover characteristics (weapons effectiveness)
- f. Airfield construction effort
- g. Bunker construction effort

Formulation of models

11. Because the end product of military terrain analysis is ideally a quantitative prediction of the performance of a military activity or item of equipment in the operational environment, it follows that the actual terrain analysis had to be preceded by the compilation of an analytical model for each MGI product. Suitable mathematical models already existed for three of the MGI products: cross-country locomotion of vehicles, HLZ construction effort, and airfield

construction effort (figs. 1, 2, and 3, respectively). Since no mathematical models existed for the other four MGI products, the first effort had to be the compilation of such models. However, because the objective of the program was primarily to develop the formats of the new products and the procedures for constructing them, and not to prepare actual MGI products for tactical use, the four models were brought only to the conceptual stage. That is, they were formulated into reasonably sophisticated flow charts, but no attempt was made to complete them by converting the flow charts into completely quantitative mathematical statements. In consequence, four of the prototype MGI products (cross-country speed for personnel, concealment, cover, and bunker construction effort) are probably not intrinsically reliable, since the map unit values were obtained by somewhat subjective methods, albeit closely guided by their respective conceptual models. The four conceptual models are presented in graphic form (i.e. as flow charts) in figs. 4-7.

Terrain analysis*

12. The performance prediction models are in essence only highly formalized statements describing the interrelations among terrain factors and military activities or items of materiel. Thus, their formulation required the identification and definition of all terrain factors that are significant to the seven models. A total of 24 factors was found to be required to satisfy the input requirements of the seven models. A listing of these factors and their associations with each individual model and resulting products is shown in fig. 8.

13. Once the terrain factors were determined, class ranges were selected for each factor to be mapped. The factor classes were established by weighing several different considerations:

- a. Requirements for accuracy in the predictions. If great accuracy is required, class intervals must be small; if

* U. S. Army Engineer Waterways Experiment Station, CE, "Mobility Environmental Research Study: A Quantitative Method for Describing Terrain for Ground Mobility," Technical Report No. 3-726 (Vols I-VIII), Vicksburg, Miss.

relatively general predictions are acceptable, the class intervals may be large.

- b. Reliability of acquired terrain data. If the terrain data can be obtained with great accuracy, the class intervals may be small, but if the terrain data can only be obtained as estimates, the class limits must be large, and in fact ought to be as large as the "error of estimation" of the factor values.
- c. Significance of the factor to the performance prediction. If the factor plays only a small role in the performance prediction, the class intervals may be large, but if the factor is a major controlling element, then the class interval should be small.

14. It is evident that the actual class intervals were obtained by a trade-off process. The factor classes ultimately selected for the 24 factors mapped in this study are presented in table 1. References and a definition relating to the origin of selected factor classes are presented in table 2.

15. Factor mapping. The general sequence of stages by which a final MGI product map is constructed is shown in fig. 9. After the significant factors have been selected, the relevant data are withdrawn from the data files. These data comprise the available "ground truth" required by the photo interpreters. The ground truth is then plotted on an overlay that can be placed on the available aerial photographs. Then, on the basis of the accuracy of the data and other considerations (as previously noted), the total range of values presented by each factor is subdivided into acceptable classes, designated "factor classes." With the plotted data as guides, the photo interpreter then delineates the areas of occurrence of each factor class, one factor at a time. Thus there are as many "factor maps" as there are significant factors in the problem (in the present instance, 24).

16. When attempts to map the various factors are made, it is quickly discovered that there are two general classes between which the analyst is forced to differentiate because of peculiarities in their occurrence. All of the factors (see fig. 8) relating to substrate characteristics, surface macrogeometry, surface microgeometry, and vegetation structure are such that their expression can be mapped as areal

distributions. The reason for this is that, in general, they tend to occur in homogeneous areas that are large enough to be readily delineated on maps of the selected scale. These factors may thus be designated "areal terrain factors." The remainder of the factors, namely those describing hydrologic geometry, occur for all practical purposes only as linear features too narrow to show as a band on the appropriate maps. The most convenient method of dealing with this problem is to map them with line symbols. These factors may be designated "linear terrain factors." Fortunately, in most analytical processes the two kinds of distributions tend to result in different kinds of effects on military activities, and thus there is no particular reason to attempt to combine the two on the same maps.

17. The 24 factor maps specified as necessary for the seven MGI products were mapped for the entire study area. Small segments of those maps are illustrated in figs. 10-33. Of these, figs. 10-27 incorporate all of the areal terrain factors, and figs. 28-33 incorporate all linear factors.

18. Factor complex map compilation. After all of the individual factor maps have been completed, the array needed as input values for any one MGI product is selected and "stacked" to produce a factor complex map. For example, from the matrix of MGI prototype products versus factors presented in fig. 8, we note that the "Concealment" MGI product will need nine factors in the factor complex map: height of surface microgeometry feature, spacing of surface microgeometry feature, height of tallest plants, number of stems of tallest plants (per 1000 m²), stem diameters of tallest plants, horizontal obscuration, vertical obscuration, bank height of hydrologic geometry feature, and bank angle of hydrologic geometry feature. The process of "stacking" is illustrated in detail in fig. 34.

19. The legends for the factor complex maps may become quite complex. In effect, each map added to the "stack" adds at least one digit to the code describing the factor array in each patch. For example, let it be assumed that Factor A in fig. 34 represents "height of surface microgeometry feature" and Factor B represents "spacing of

surface microgeometry feature." The two-digit code in the patches of the factor complex map (Factors A + B, fig. 34) then represents the specific combination of factor values of the two factors in each patch. That is, the patch identified by a "11" code is characterized by surface microgeometry features 0-30 cm high and spaced at distances of less than 2 m apart. A complete legend is illustrated in fig. 34. It should be noted that the four simple units on the individual factor maps have proliferated into 13 map units on the factor complex map. It can readily be seen that the legend for a factor complex map that incorporates many factor maps may become very complex indeed, since the patch codes will contain at least as many digits as there are factors in the compilation. For example, the areal terrain factor complex map compiled for use with the "cross-country speed of vehicles" model will have a 10-digit code representing each patch, while that for the "helicopter landing zone construction effort" model will have 13.

20. Such arrays of numbers are far too long to be convenient as patch identifiers on the factor complex maps, so the usual technique is to simplify the identification code used on the factor complex maps. The process is illustrated in fig. 35. The identification codes are ranked in numerical order, and a "map unit" number is assigned to each in rigorous numerical sequence. These numbers are then placed in the appropriate patches on the factor complex maps. This procedure has the obvious disadvantage of making legend utilization somewhat more difficult: the user identifies the map unit, uses that number to identify the factor complex identification code, and then uses the digits in that code to establish the relevant factor value classes.

21. Examples of the various factor complex maps produced for this study are presented in figs. 36-44. On the map legends, the columns headed "Complex" contain the factor complex identification code. In every case, the order in which the factor codes are placed in the identification code is the same as the order of listing in fig. 8.

22. Performance prediction maps. Each "patch" (i.e. each delineated area) on the factor complex map represents an area that is essentially homogeneous with respect to the factors included in the

compilation. Thus, the factor values represented by the class codes on one patch on the map can be accepted as input values to the relevant performance prediction model, and one calculation will result in a value that represents the performance prediction for that entire patch. The general procedure is then to calculate the performance prediction for each patch, and then group the resulting values into convenient classes for the final MGI product map. In the normal course of events, some adjacent patches will exhibit closely similar performance values, and thus may fall into the same performance class. In this event, the boundaries between the similar patches are removed from the final MGI product map. The resultant MGI product map (or performance prediction map) may then resemble the example illustrated in fig. 45. In the example, the "model" used to make a "performance prediction" is only a simple algebraic relation, and is for illustrative purposes only.

23. Examples of portions of the performance prediction maps produced for this study are presented in figs. 46-52.

Conclusions and Recommendations

Conclusions

24. The concept and techniques in this study appear to comprise an expedient and economical method of producing quantitatively based MGI products for the field commander. In addition, the procedure seems to be far more objective than previous methods, thus making MGI products produced by different teams of analysts more uniform and less subject to individual bias or preconception.

Recommendations

25. In order to reduce the time required to compile the various MGI products, and to improve the reliability and objectivity of the final products, it is recommended that:

- a. Research be organized to develop the various mathematical performance prediction models that will be required to handle the full spectrum of terrain intelligence needs.

- b. Effort be devoted to the automation of many of the processes that must now be done manually. Of specific importance is the process of compiling the factor complex maps from the factor maps; this process is presently very time consuming and therefore costly, but it is entirely rigorous and could accordingly be accomplished by computer processing.

Table 1
Summary of Terrain Factor Classes Used in Constructing
Terrain Factor Complex Maps

<u>Substrate characteristics</u>	<u>Surface macrogeometry</u>
Soil type:	Slope, deg:
50% stones or rock fragments	0 to 2
Gravel	2 to 10
Sand	10 to 30
Silt	30 to 90
Clay	
Moisture content, cm water/cm soil:	Elevation, m:
0.0 to 0.1	0 to 10
0.1 to 0.3	10 to 500
0.3 to 0.8	500 to 1000
0.8 to 1.0	>1000
Surface strength, RCI:	<u>Surface microgeometry</u>
0 to 20	Height of feature, cm:
20 to 30	0 to 30
30 to 60	30 to 50
>60	50 to 70
Slope of soil strength profile, deg:	>70
0 to 10	Approach angle of feature, deg:
10 to 30	0 to 5
30 to 60	5 to 10
60 to 120	10 to 20
>120	20 to 30
Unconfined compressive strength, psi:*	30 to 90
<300	Spacing of feature, m:
>300	0 to 2
Soil thickness, m:	2 to 4
No soil	4 to 10
<0.2	>10
0.2 to 1.0	<u>Vegetation structure</u>
1.0 to 5.0	Height of tallest plants, m:
>5.0	0.0 to 0.5
Depth to water table, m:	0.5 to 3.0
0.0 to 0.5	3.0 to 8.0
0.5 to 1.5	8.0 to 14.0
1.5 to 4.0	14.0 to 24.0
>4.0	>24.0

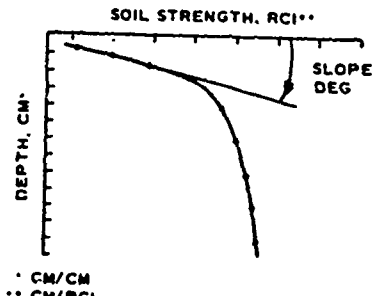
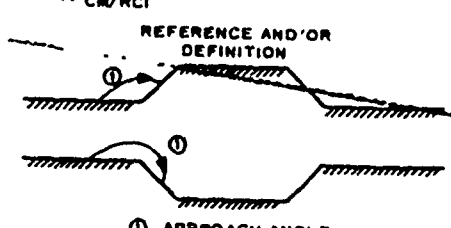
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* A table of factors for converting British units of measurement to metric units is presented on page vii.

Table 1 (Concluded)

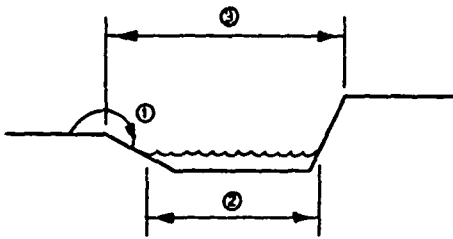
Vegetation structure (continued)	Hydrologic geometry
Number of stems of tallest plants per 1000 m ² :	Bank height, m:
>900	0 to 1
500 to 900	1 to 2
100 to 500	2 to 3
10 to 100	3 to 5
2 to 10	>5
0 to 2	Bank angle, deg:
Stem diameter of tallest plants, cm:	0 to 10
0 to 2	10 to 20
2 to 7	20 to 45
7 to 15	45 to 90
15 to 30	Water width, m:
30 to 60	No water
>60	0 to 9
Specific gravity of green wood:	9 to 15
0.0 to 0.20	15 to 21
0.20 to 0.40	21 to 30
0.40 to 0.60	>30
0.60 to 0.80	Gap width, m:
>0.80	0 to 9
Horizontal obscuration, m:	9 to 15
0 to 5	15 to 21
5 to 10	21 to 30
10 to 20	30 to 50
20 to 50	>50
>50	Water depth, cm:
Vertical obscuration, % covered:	No water
0 to 10	01 to 100
10 to 30	100 to 300
30 to 60	>300
60 to 100	Water current velocity, mps:
	No water
	0 to 1
	1 to 2
	2 to 3
	>3

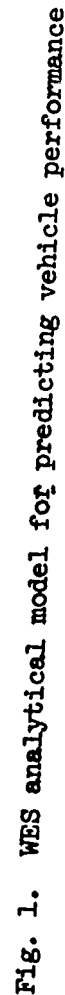
Table 2
References and/or Definitions for Origin of Selected
Factor Classes Found in Table 1

Factor	Class	Reference and/or Definition
Soil type	50% stones or rock fragments	GW, GP } From Unified Soil Classification System GM, GC SM, SC ML, CL MH, CH
	Gravel	
	Sand	
	Silt	
	Clay	
Surface strength	0 to 20 RCI	J. G. Kennedy and E. S. Rush, "Trafficability of Soils; Development of Revised Mobility Index Formula for Self-Propelled Wheeled Vehicles in Fine-Grained Soils," Technical Memorandum No. 3-240, 18th Supplement, Mar 1968, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
	20 to 30 RCI	
	30 to 60 RCI	
	> 60 RCI	
Slope of soil strength profile	0 to 10 deg	
	10 to 30 deg	
	30 to 60 deg	
	60 to 120 deg	
	> 120 deg	
Approach angle of feature	0 to 5 deg	
	5 to 10 deg	
	10 to 20 deg	
	20 to 30 deg	
	30 to 90 deg	
Horizontal obscuration	0 to 5 m	Defined as the distance at which an object of a given size is totally obscured. For this study the objects considered were a man and a jeep. "Visibility Studies I, Instrument and Concepts Development" (in preparation), U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
	5 to 10 m	
	10 to 20 m	
	20 to 50 m	
	> 50 m	

(Continued)

Table 2 (Concluded)

Factor	Class	Reference and/or Definition
Vertical obscuration	0 to 10% covered	Defined as the proportion of a given area that is encompassed when the crowns of all plants are projected vertically downward to the ground. H. T. Odum and R. F. Pigeon, ed., "Tropical Rain Forest; A Study of Irradiation and Ecology at El Verde, Puerto Rico," 1970, Division of Technical Information Extension, U. S. Atomic Energy Commission, Oak Ridge, Tenn.
	10 to 30% covered	
	30 to 60% covered	
	60 to 100% covered	
Bank angle	0 to 10 deg	See below
	10 to 20 deg	
	20 to 45 deg	
	45 to 90 deg	
Water width	No water	 ① BANK ANGLE ② WATER WIDTH ③ GAP WIDTH
	0 to 9 m	
	9 to 15 m	
	15 to 21 m	
	21 to 30 m	
	>30 m	
Gap width	0 to 9 m	See above
	9 to 15 m	
	15 to 21 m	
	21 to 30 m	
	30 to 50 m	
	>50 m	



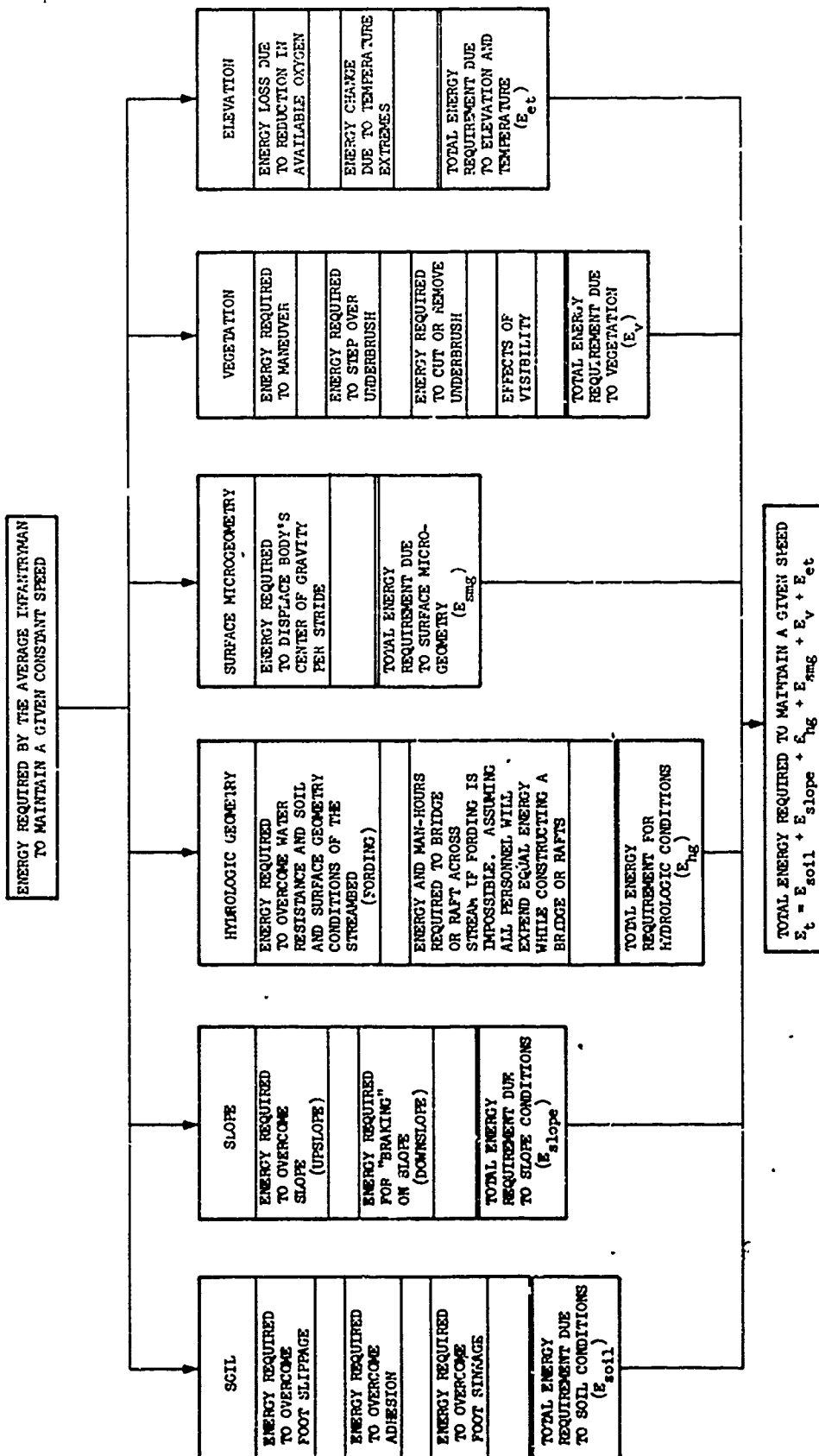


Fig. 2. HLZ construction effort

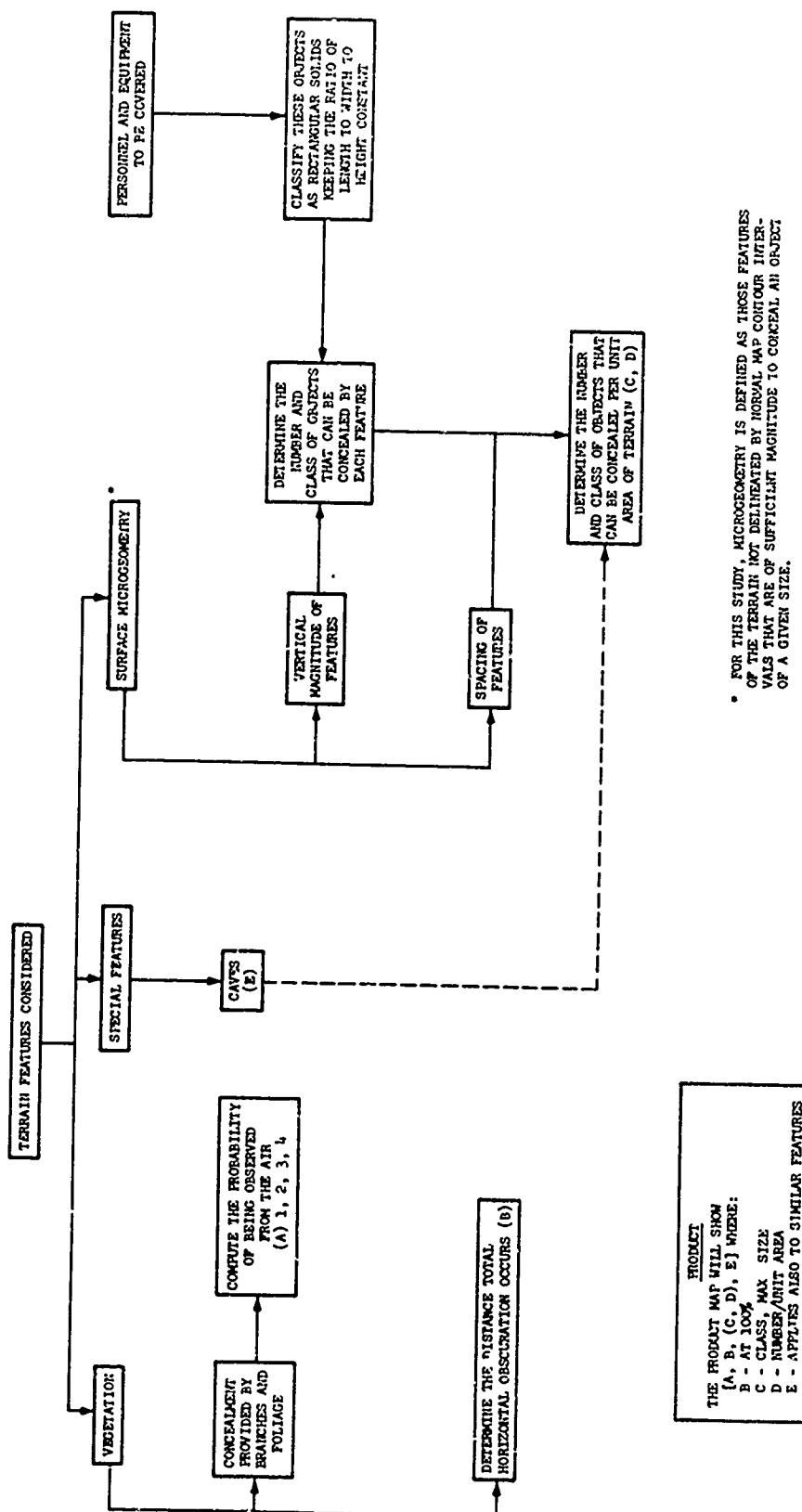


Fig. 4. An analytical model for determining cross-country speed for personnel

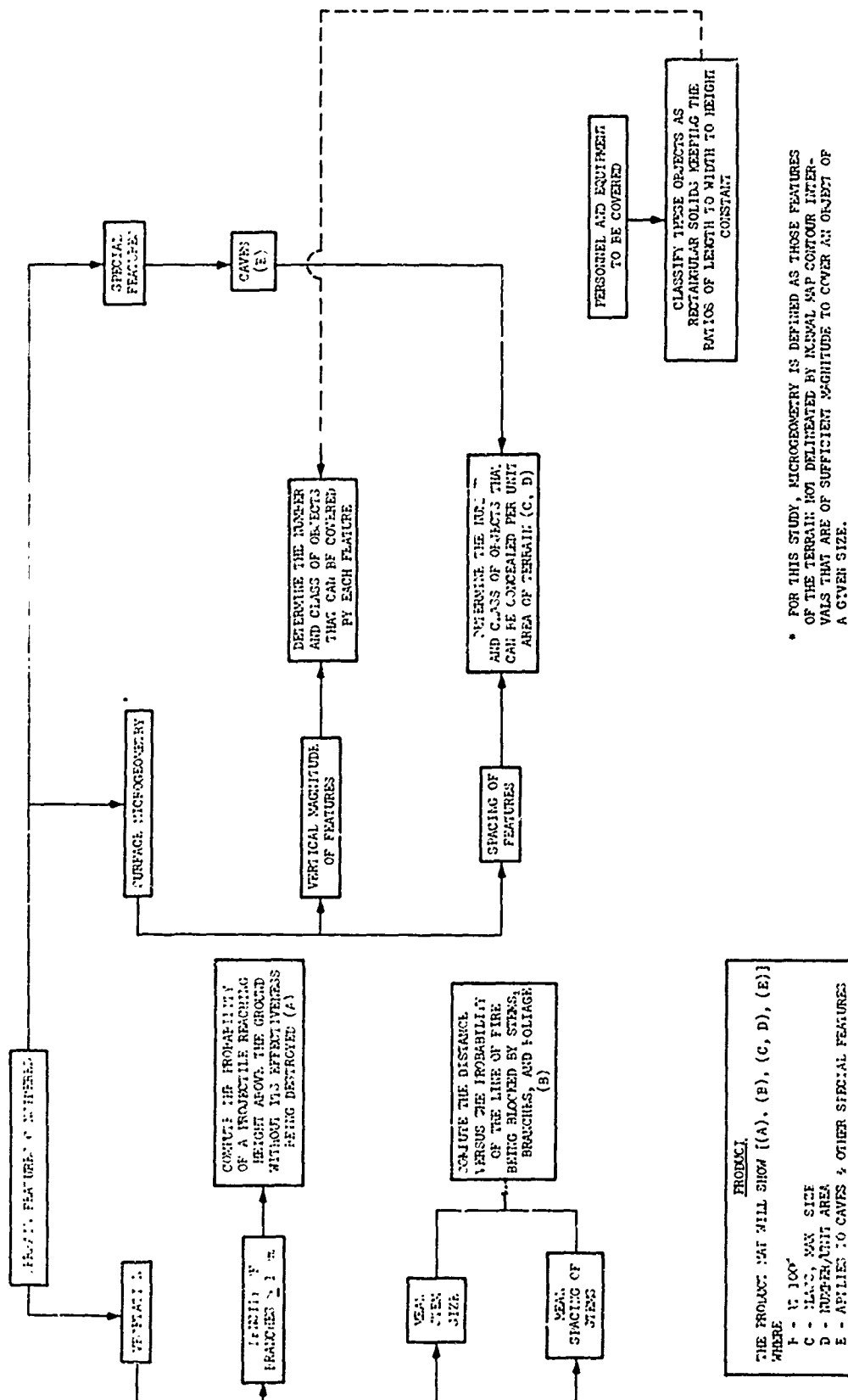


Fig. 5. An analytical model for determining concealment offered by naturally occurring terrain features

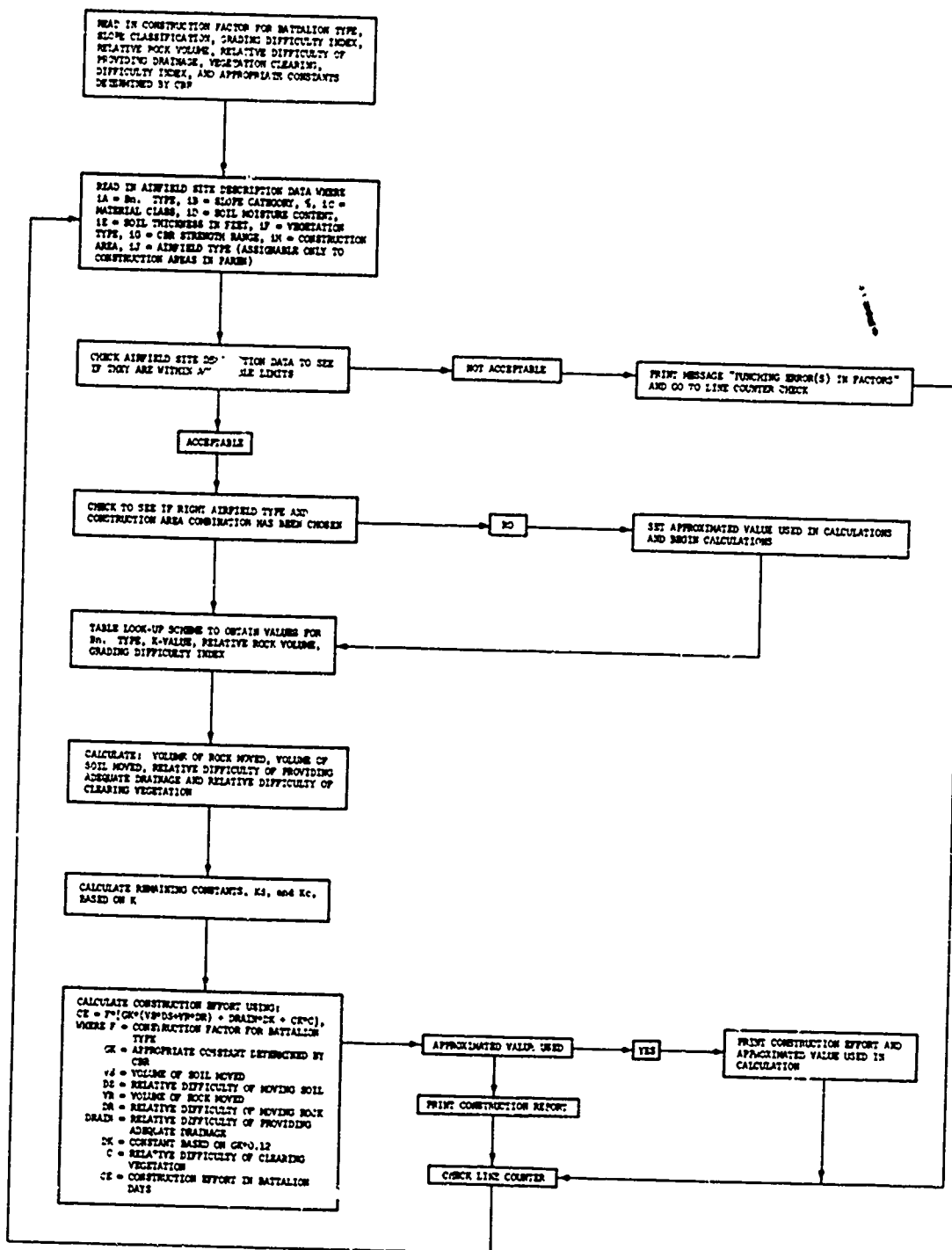


Fig. 6. An analytical method for determining cover offered by naturally occurring terrain features

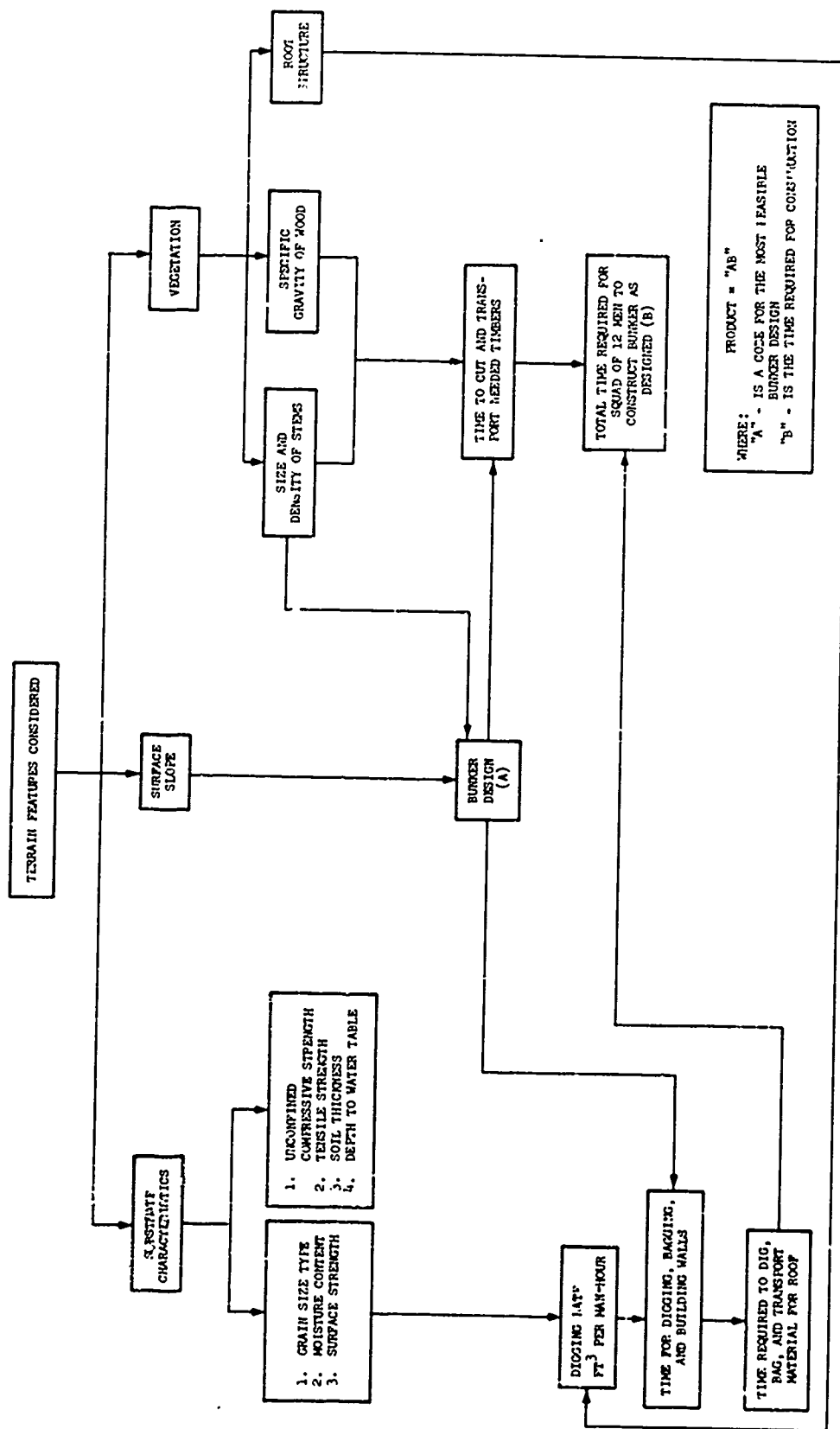


Fig. 7. Analysis of requirements for bunker construction effort relative to pertinent terrain features

PROTOTYPE MG1 PRODUCTS AND MODELS*

FACTORS	CROSS-COUNTRY SPEED FOR VEHICLES	CROSS-COUNTRY SPEED FOR PERSONNEL	HLZ CONSTRUCTION EFFORT	CONCEALMENT CHARACTERISTICS	COVER CHARACTERISTICS	AIRFIELD CONSTRUCTION EFFORT	BUNKER CONSTRUCTION EFFORT
SUBSTRATE CHARACTERISTICS							
SOIL TYPE			X		X	X	X
MOISTURE CONTENT			X			X	X
SURFACE STRENGTH	X	X			X	X	X
SLOPE OF SOIL STRENGTH PROFILE	X				X		
UNCONFINED COMPRESSIVE STRENGTH			X			X	X
SOIL THICKNESS			X			X	X
DEPTH TO WATER TABLE						X	X
SURFACE MACROGEOMETRY							
SLOPE	X	X	X		X	X	X
ELEVATION		X	X				
SURFACE MICROGEOMETRY							
HEIGHT OF FEATURE	X	X	X	X	X		
APPROACH ANGLE OF FEATURE	X		X				
SPACING OF FEATURE	X	X	X	X	X		
VEGETATION STRUCTURE							
HEIGHT OF TALLEST PLANTS		X	X	X	X		
NO OF STEMS OF TALLEST PLANTS/1000 M ²	X	X	X	X	X	X	X
STEM DIAMETER OF TALLEST PLANTS	X	X	X	X	X	X	X
SPECIFIC GRAVITY OF GREEN WOOD	X		X				X
HORIZONTAL OBSCURATION	X	X		X			
VERTICAL OBSCURATION				X			
HYDROLOGIC GEOMETRY							
BANK HEIGHT	X	X		X	X		
BANK ANGLE	X	X		X	X		
WATER WIDTH	X	X					
CAP WIDTH	X	X					
WATER DEPTH	X	X					
WATER CURRENT VELOCITY	X	X					

* THE MODEL IS THE ANALYTICAL PROCESS BY WHICH THE IDENTIFIED FACTORS ARE CONSIDERED, THE RESULT BEING A PRODUCT OF THE SAME NAME.

Fig. 8. Matrix of interrelations among MGI products and factors

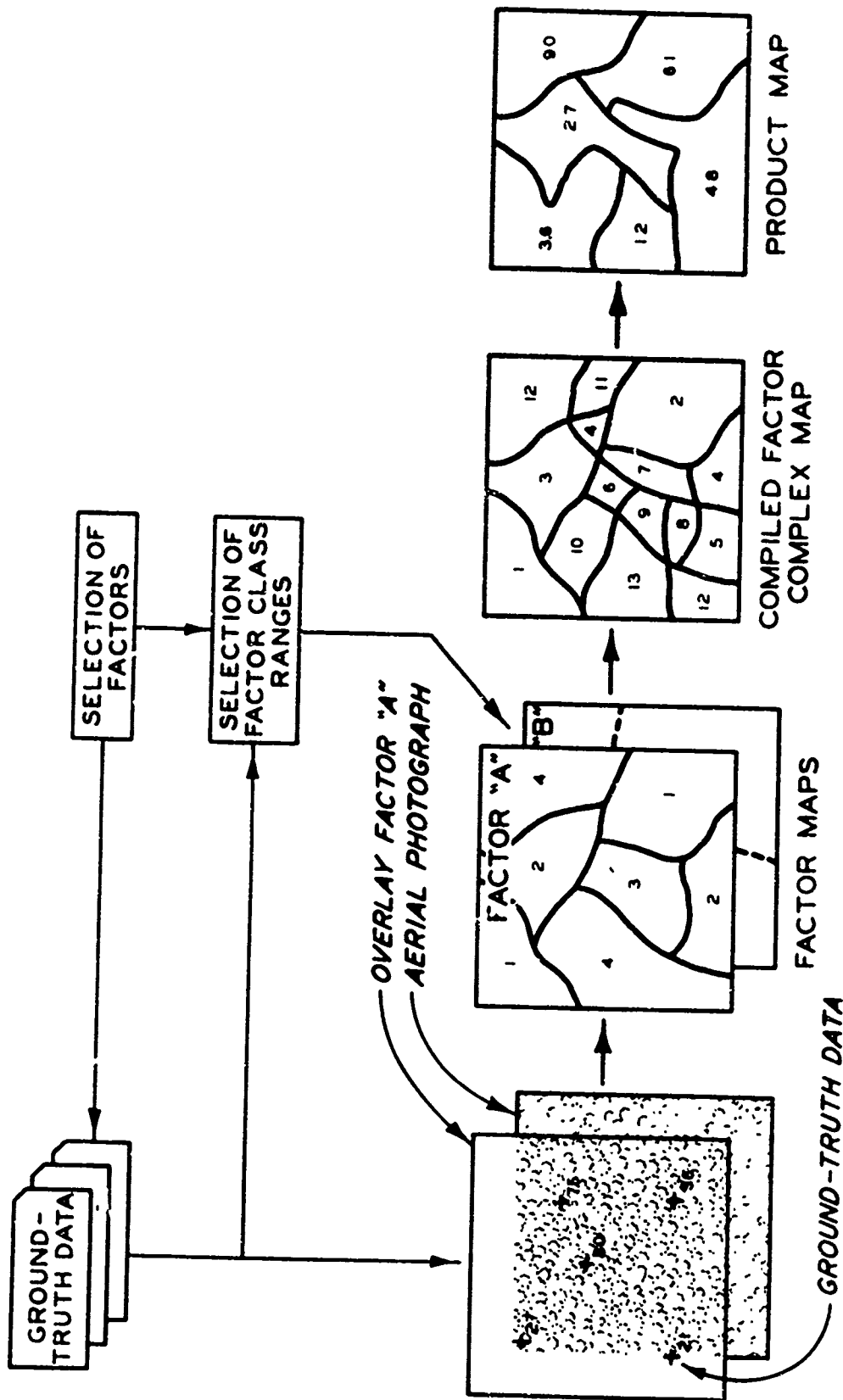


Fig. 9. Sequence of stages in the construction of MGI product map

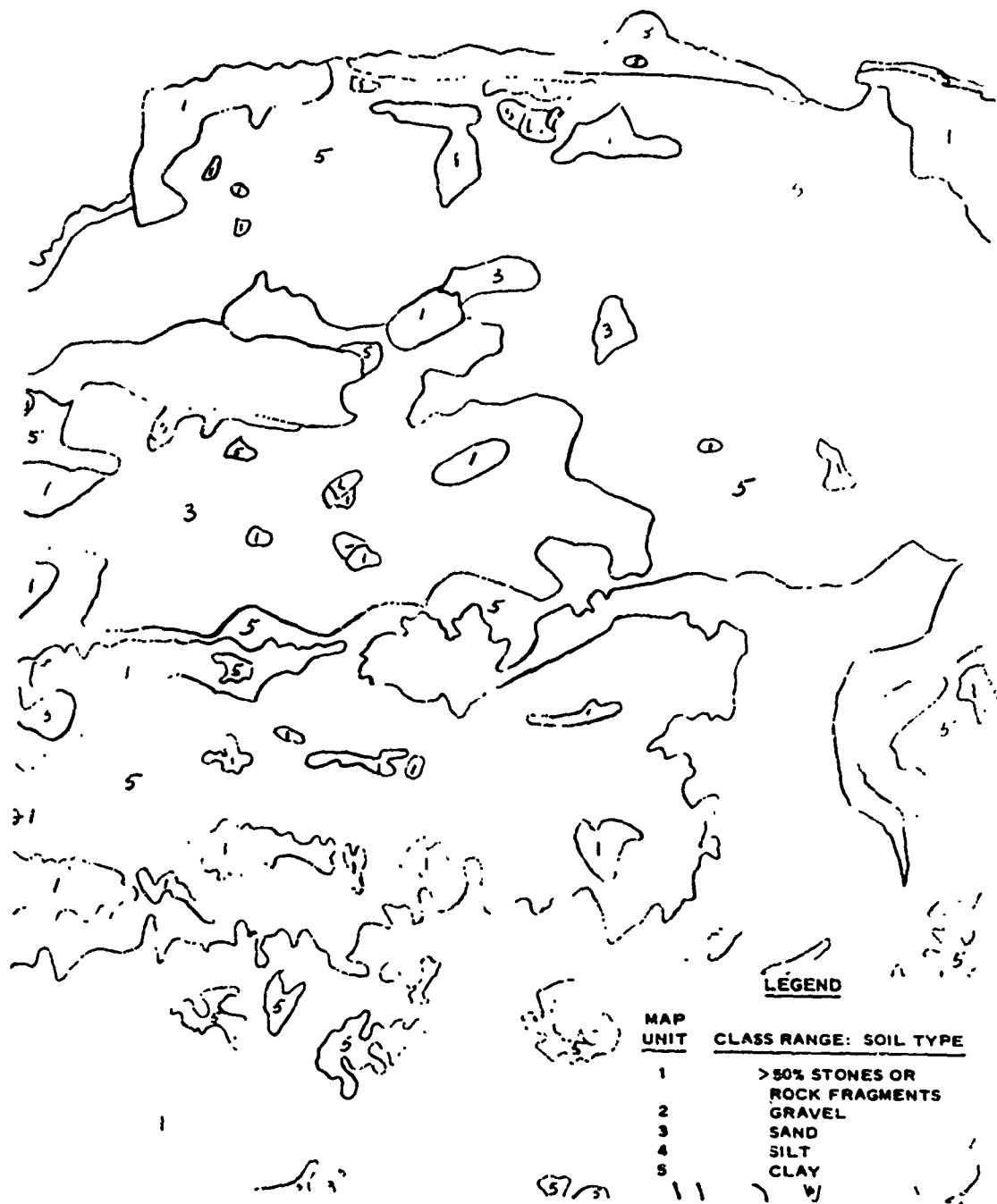


Fig. 10. Factor map. Substrate characteristics: Soil type

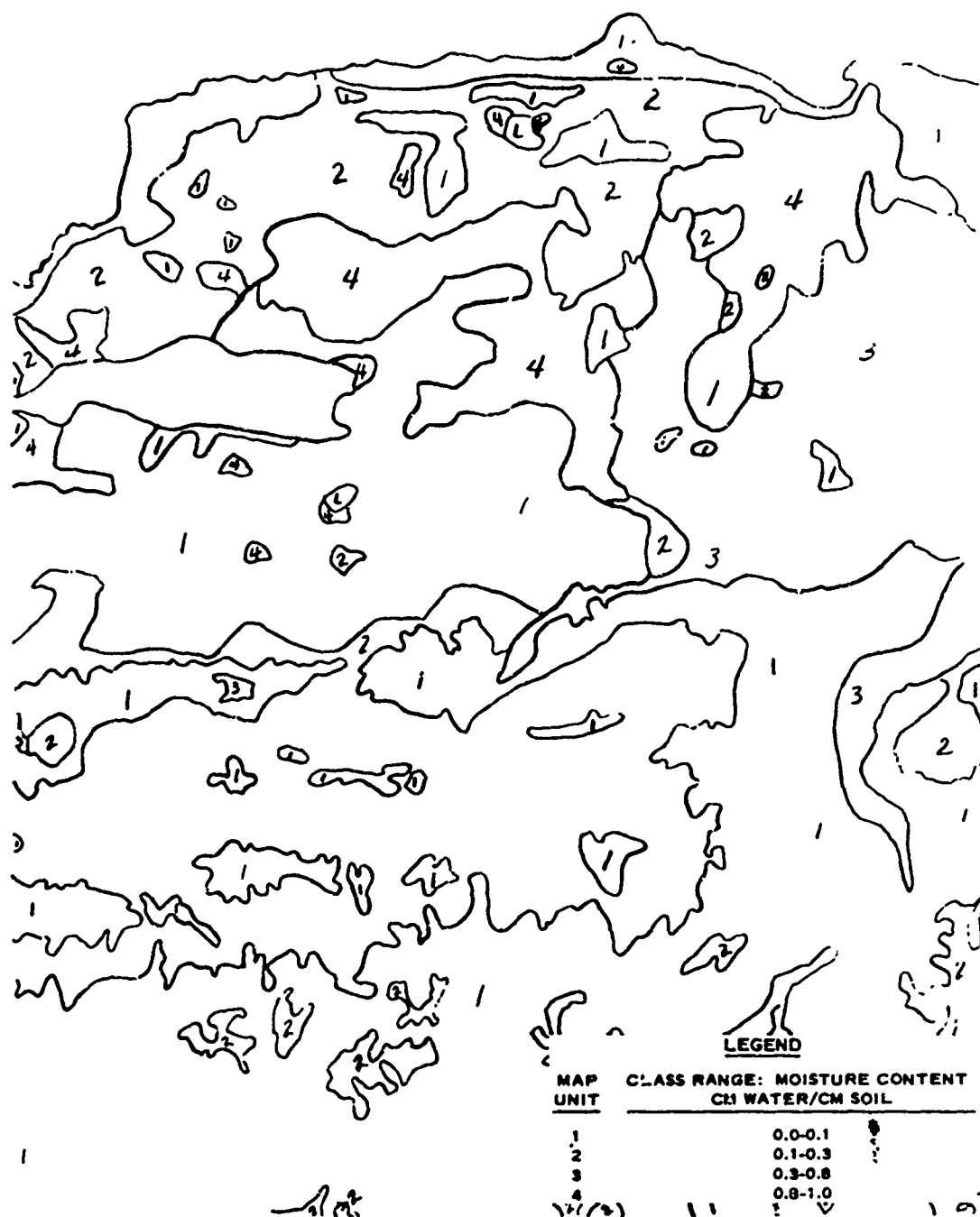


Fig. 11. Factor map. Substrate characteristics: Moisture content

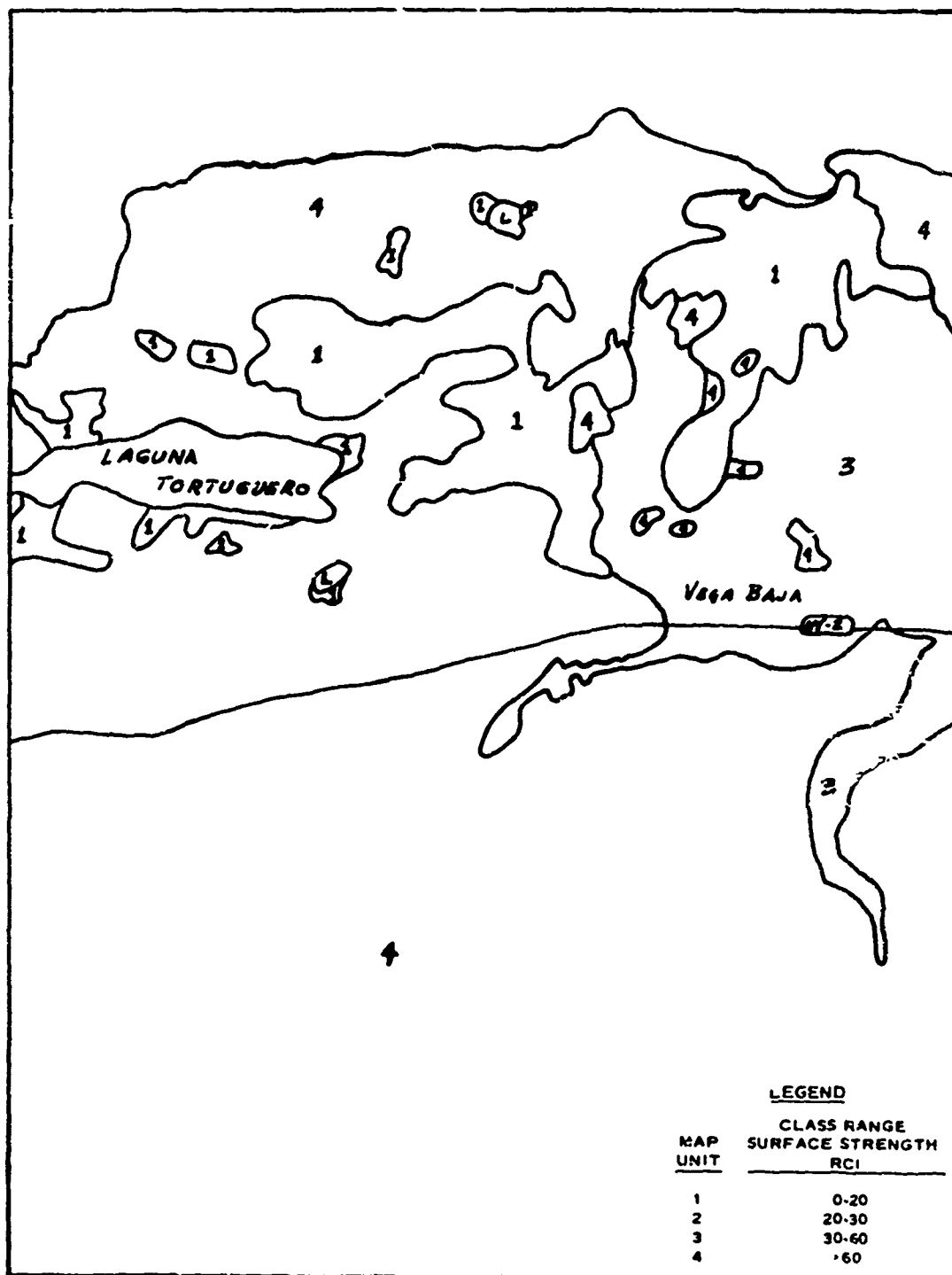


Fig. 12. Factor map. Substrate characteristics: Surface strength

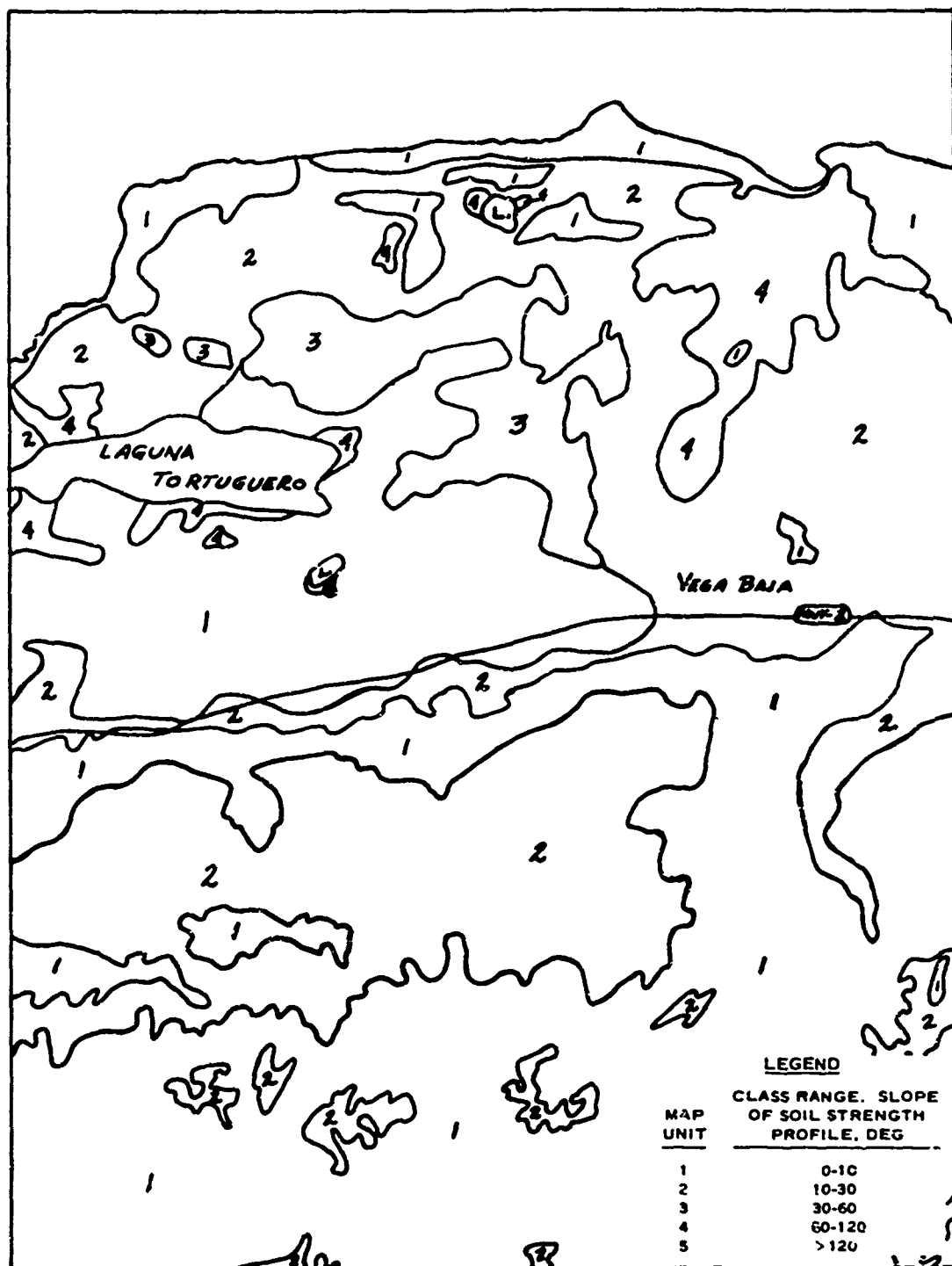


Fig. 13. Factor map. Substrate characteristics: Slope of soil strength profile



2

LEGEND	
MAP UNIT	CLASS RANGE: UNCONFINED COMPRESSIVE STRENGTH, PSI
1	< 300
2	> 300

Fig. 14. Factor map. Substrate characteristics: Unconfined compressive strength

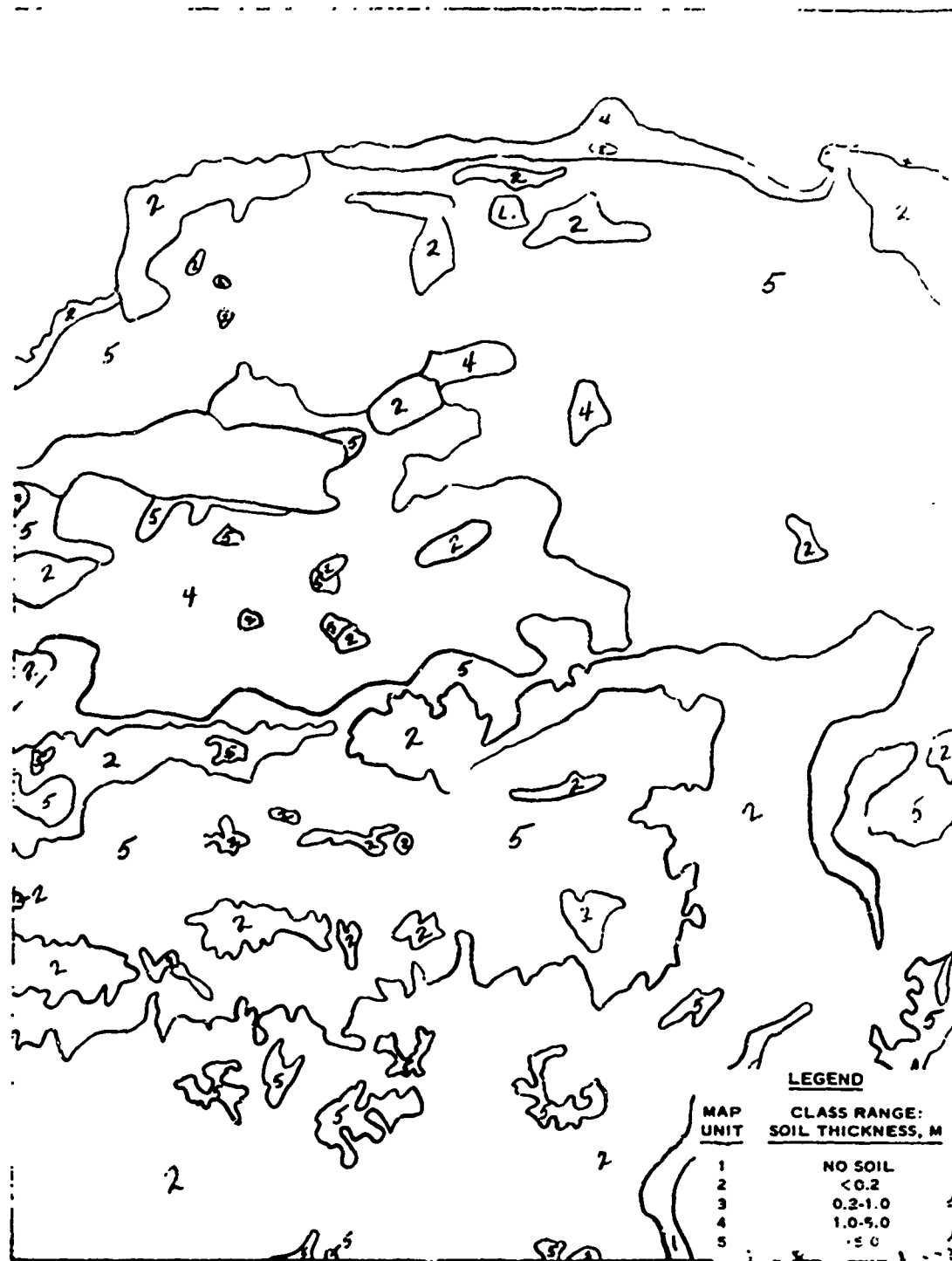


Fig. 15. Factor map. Substrate characteristics: Soil thickness

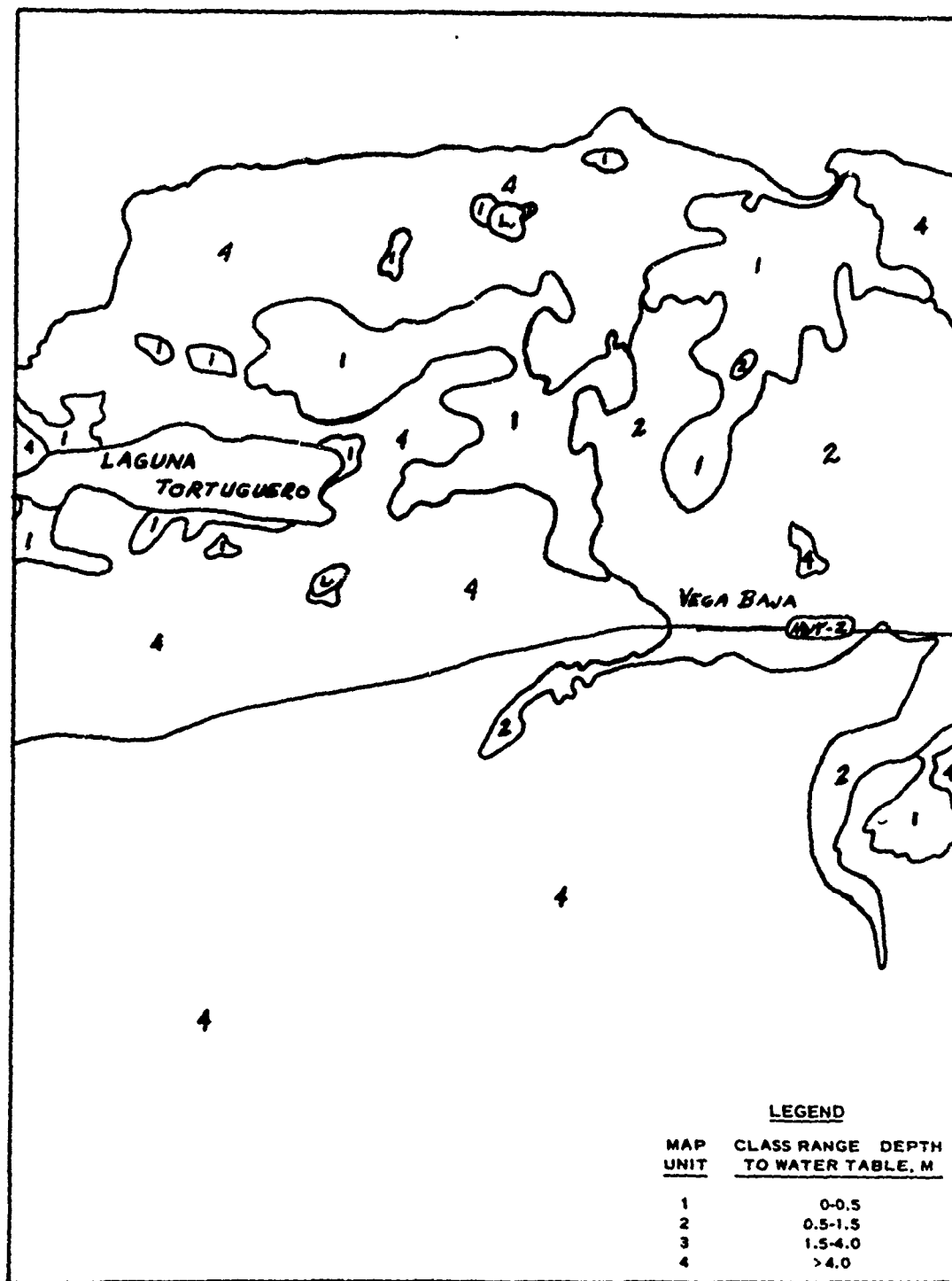


Fig. 16. Factor map. Substrate characteristics: Depth to water table

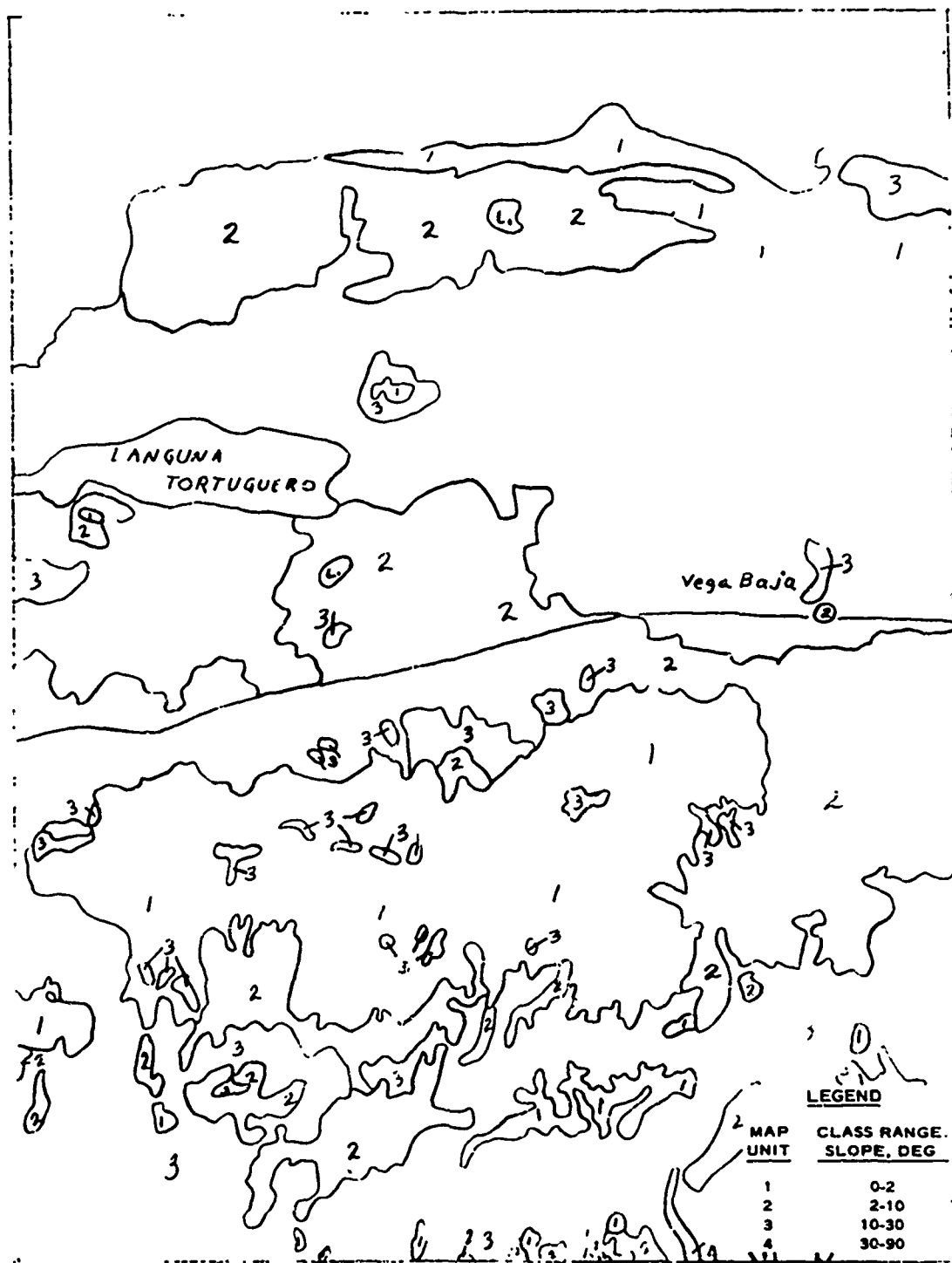
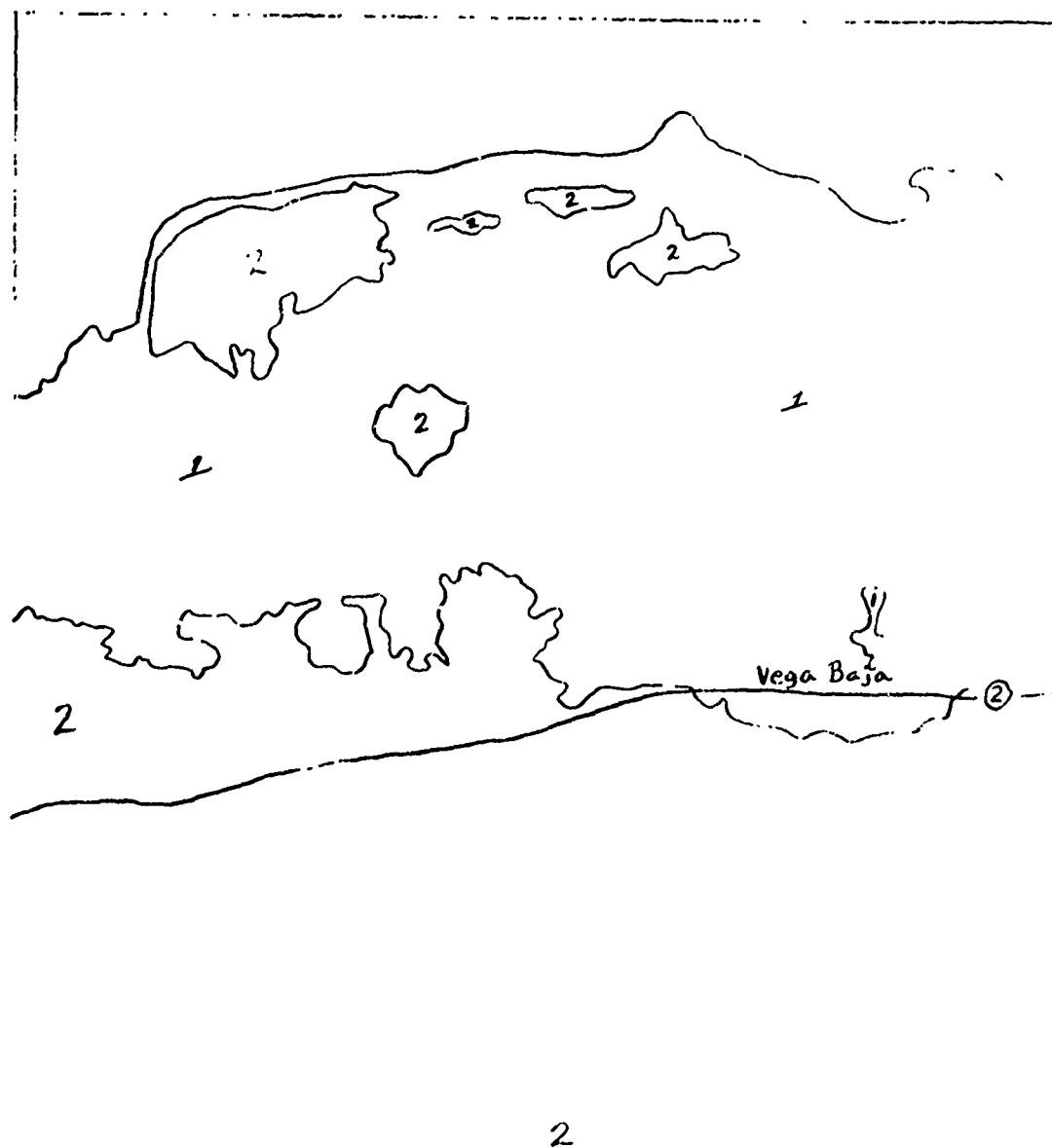


Fig. 17. Factor map. Surface macrogeometry: Slope



LEGEND	
MAP UNIT	CLASS RANGE. ELEVATION, M
1	0-10
2	11-500
3	500-1000
4	>1000

Fig. 18. Factor map. Surface macrogeometry: Elevation



LEGEND	
MAP UNIT	CLASS RANGE: HEIGHT OF FEATURES, CM
1	0-30
2	30-50
3	50-70
4	>70

Fig. 19. Factor map. Surface microgeometry: Height of feature

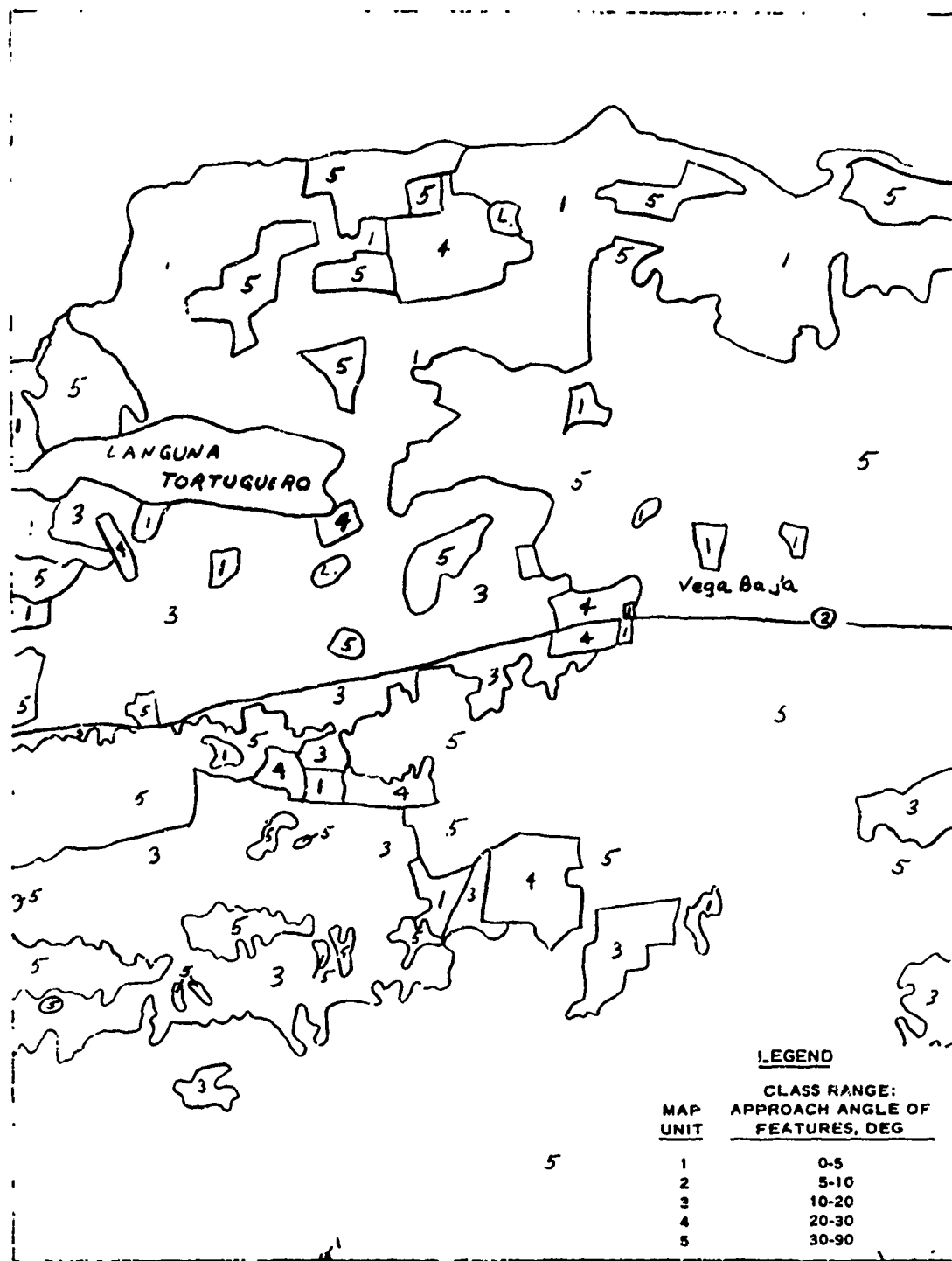


Fig. 20. Factor map. Surface microgeometry: Approach angle of feature

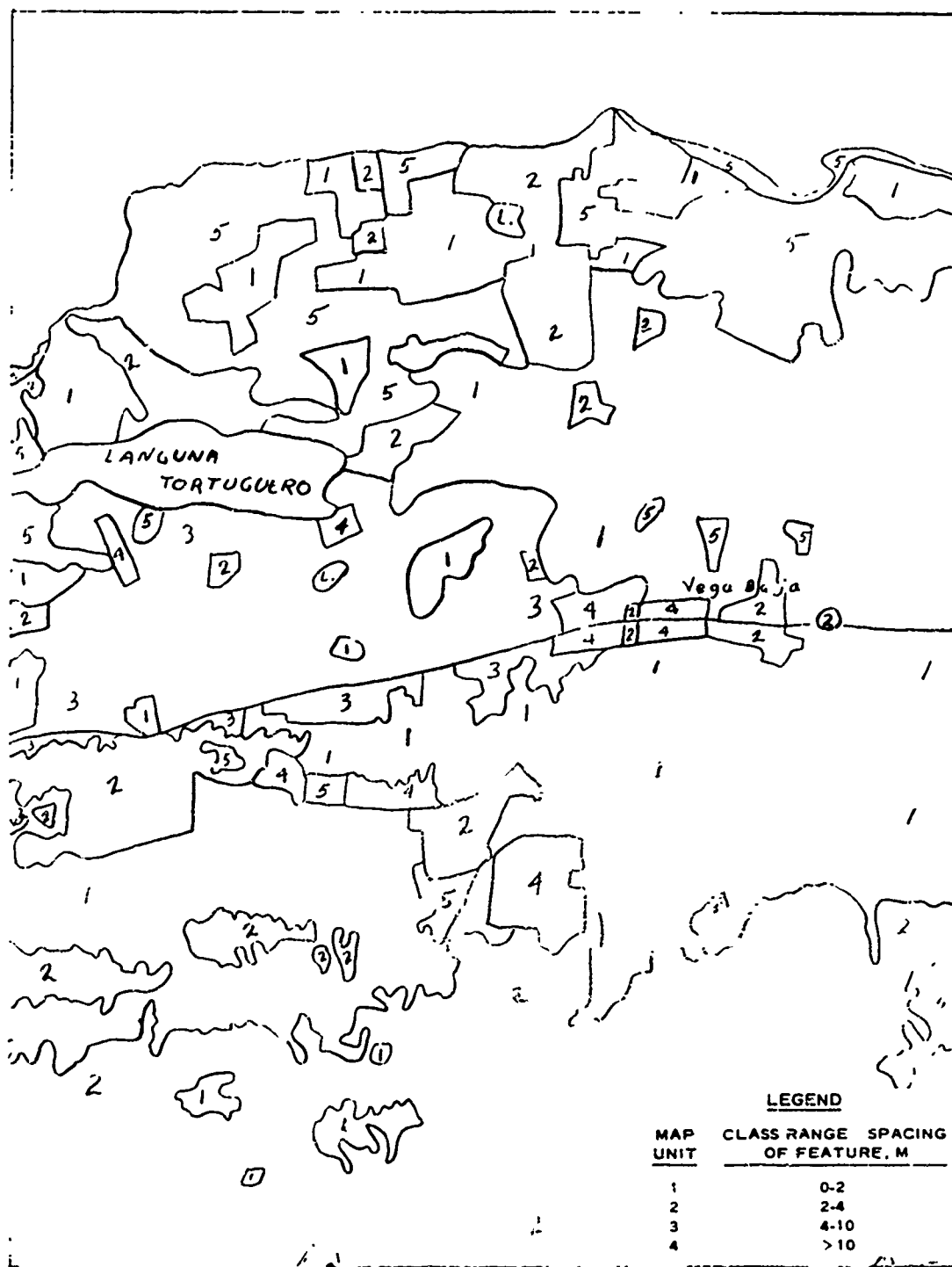


Fig. 21. Factor map. Surface microgeometry: Spacing of feature

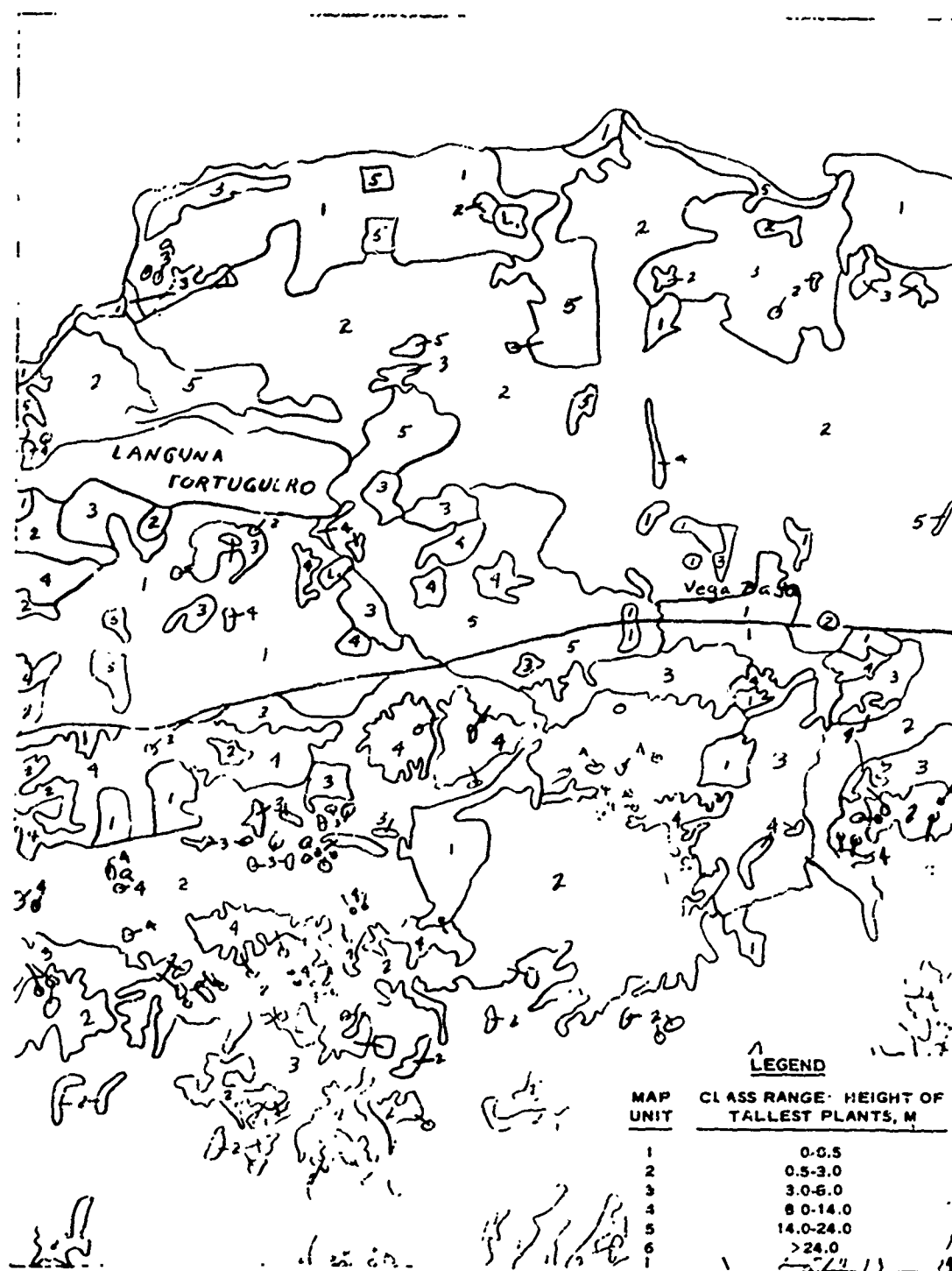


Fig. 22. Factor map. Vegetation structure: Height of tallest plants

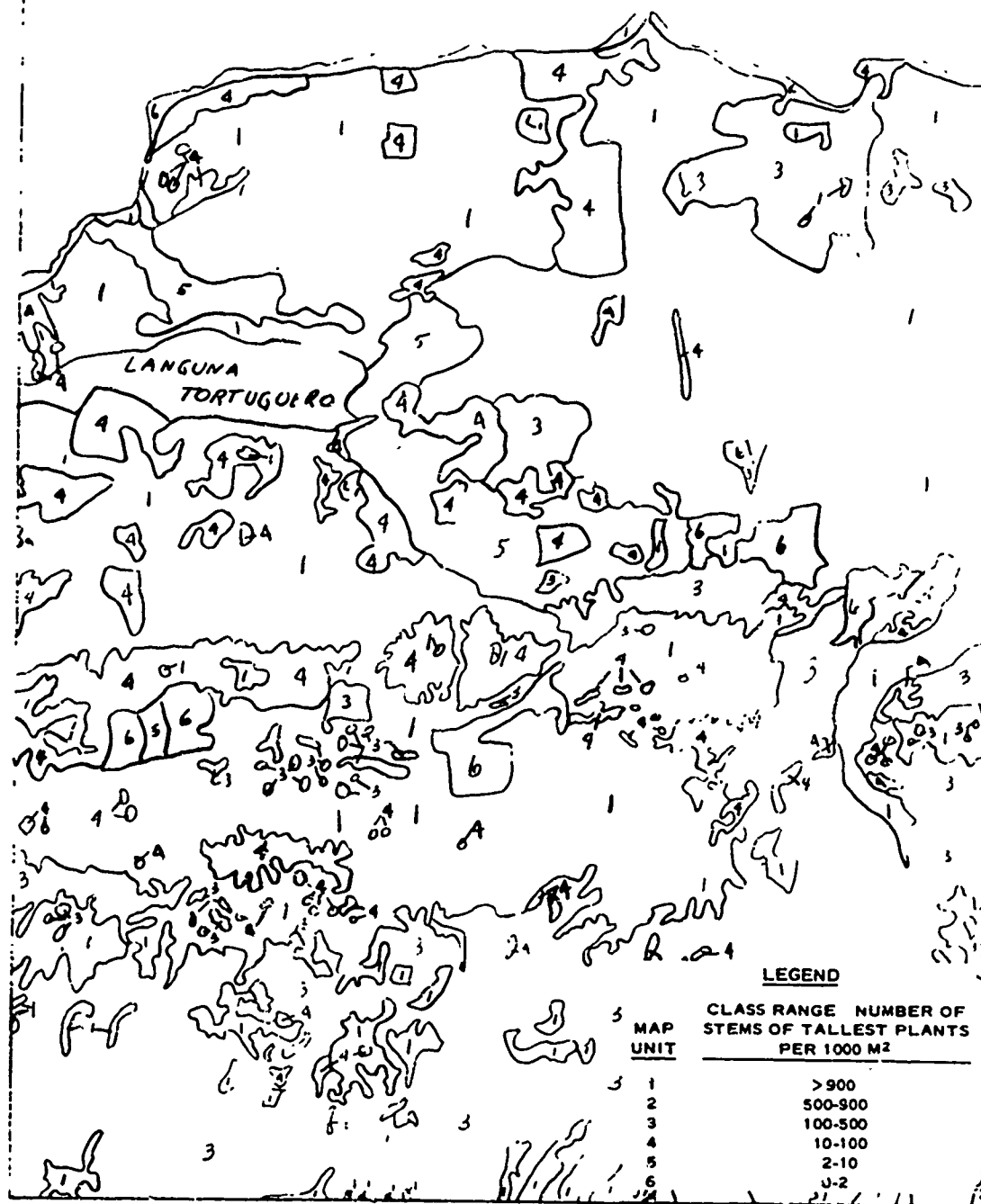


Fig. 23. Factor map. Vegetation structure: Number of stems of tallest plants per 1000 m²

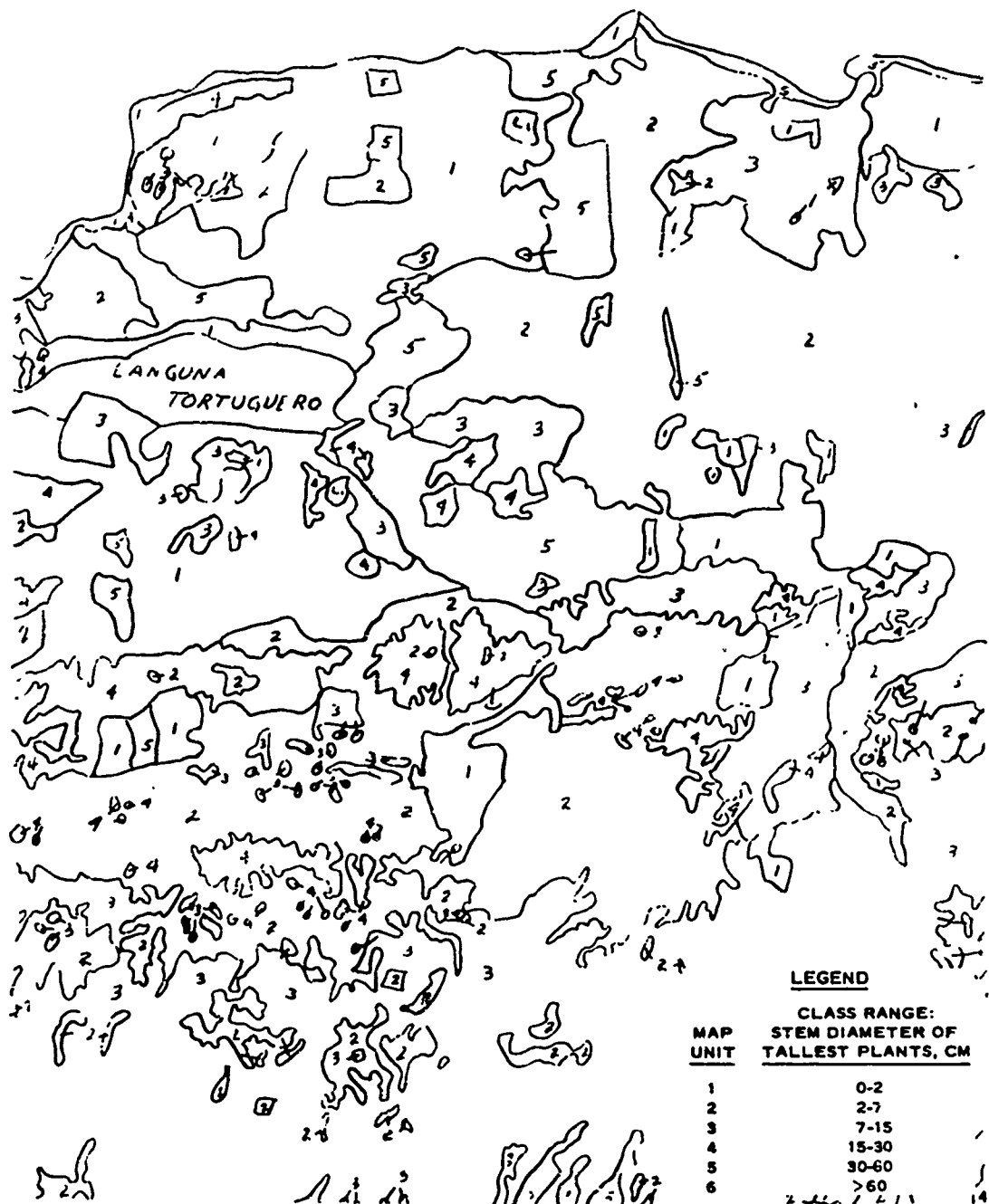


Fig. 24. Factor map. Vegetation structure: Stem diameter of tallest plants

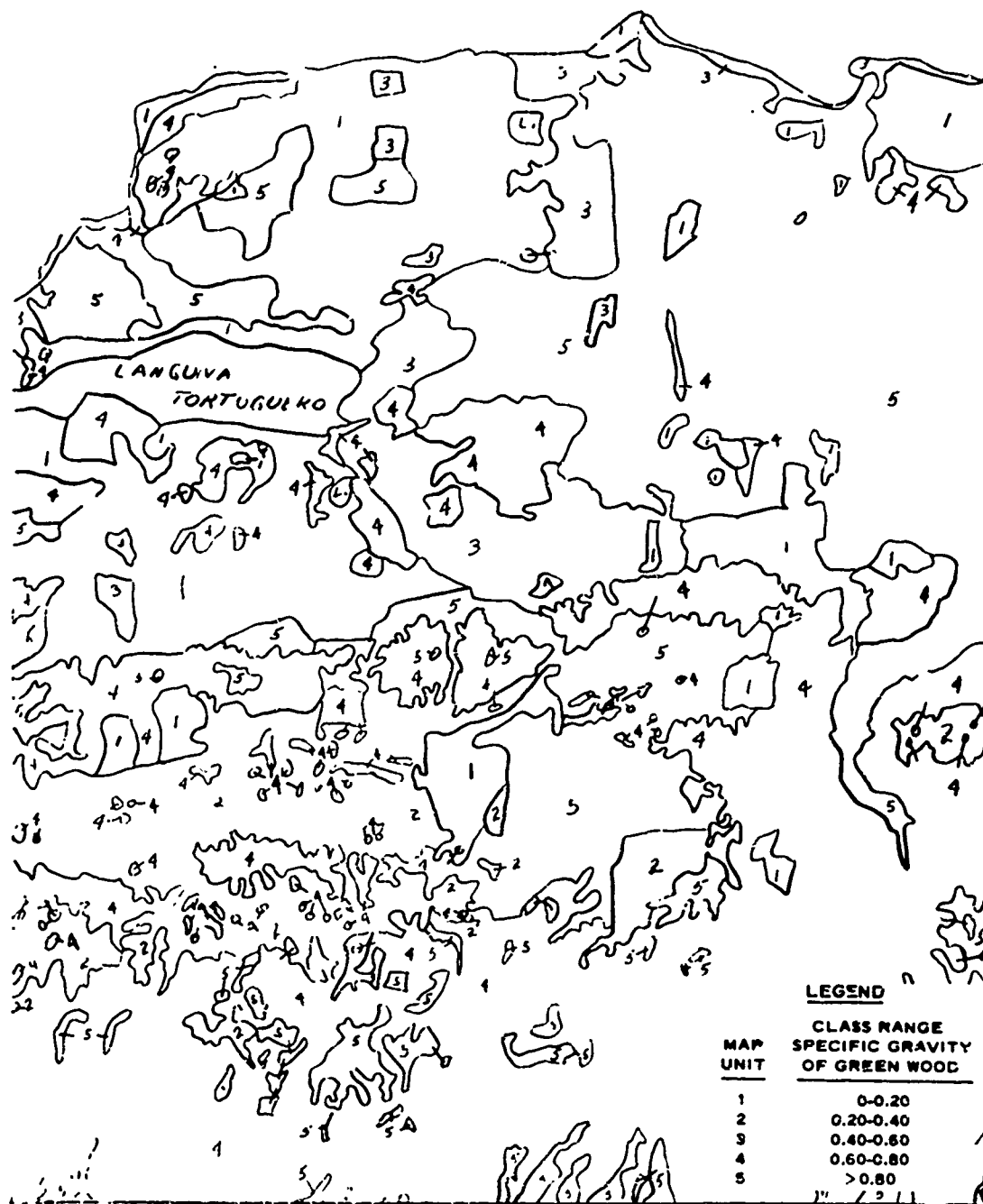


Fig. 25. Factor map. Vegetation structure: Specific gravity of green wood

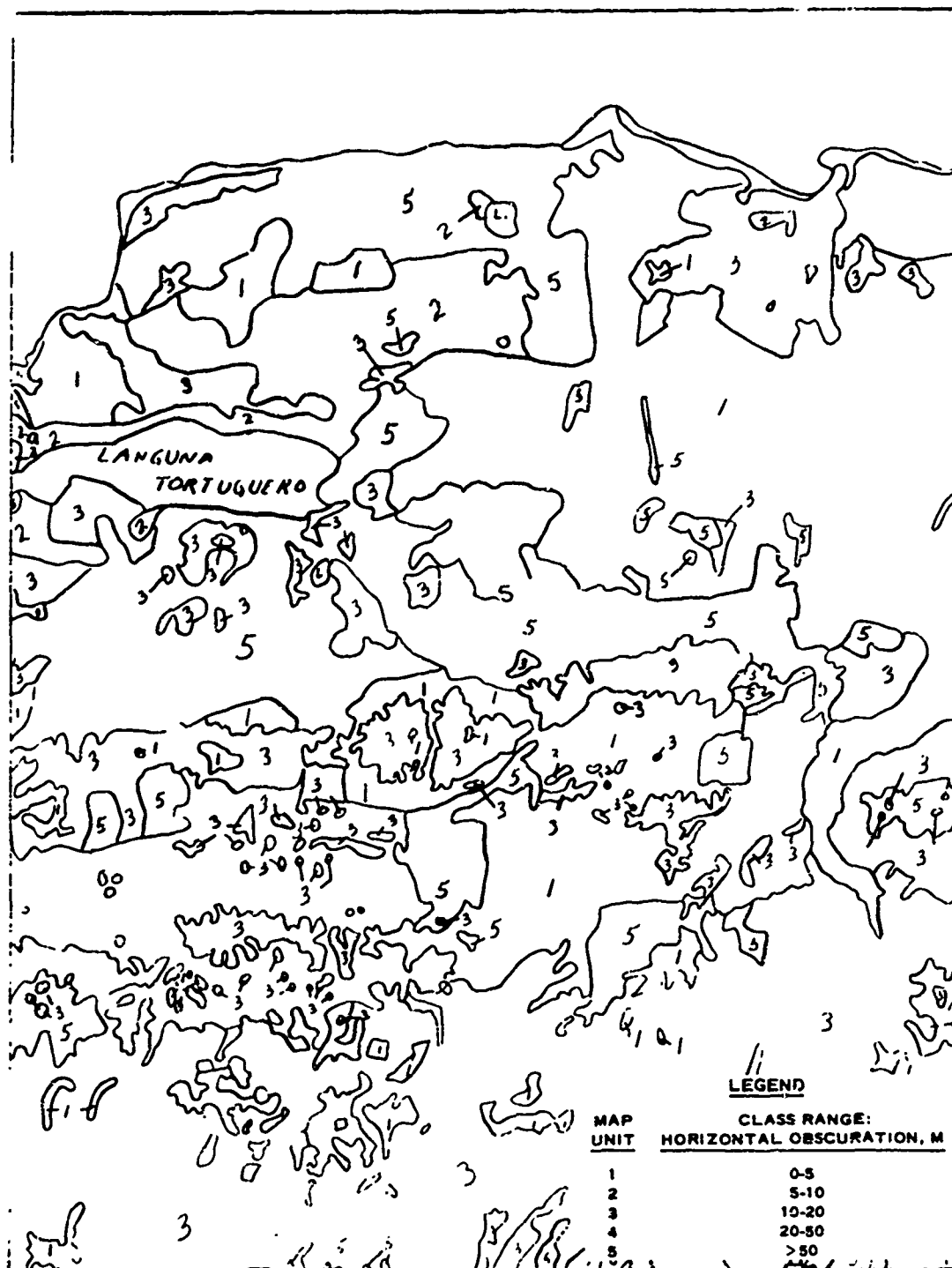


Fig. 26. Factor map. Vegetation structure: Horizontal obscuration

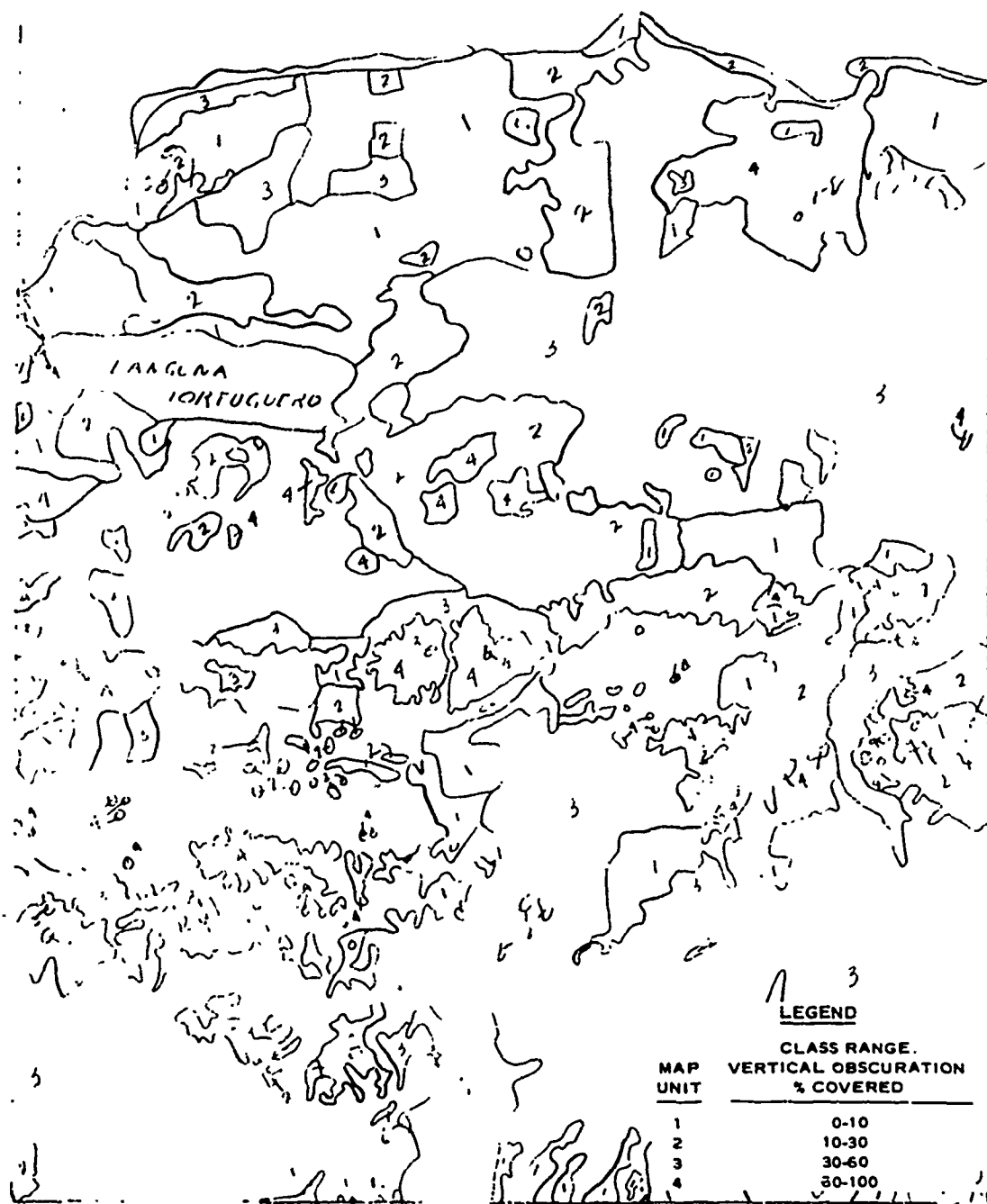


Fig. 27. Factor map. Vegetation structure: Vertical obscuration

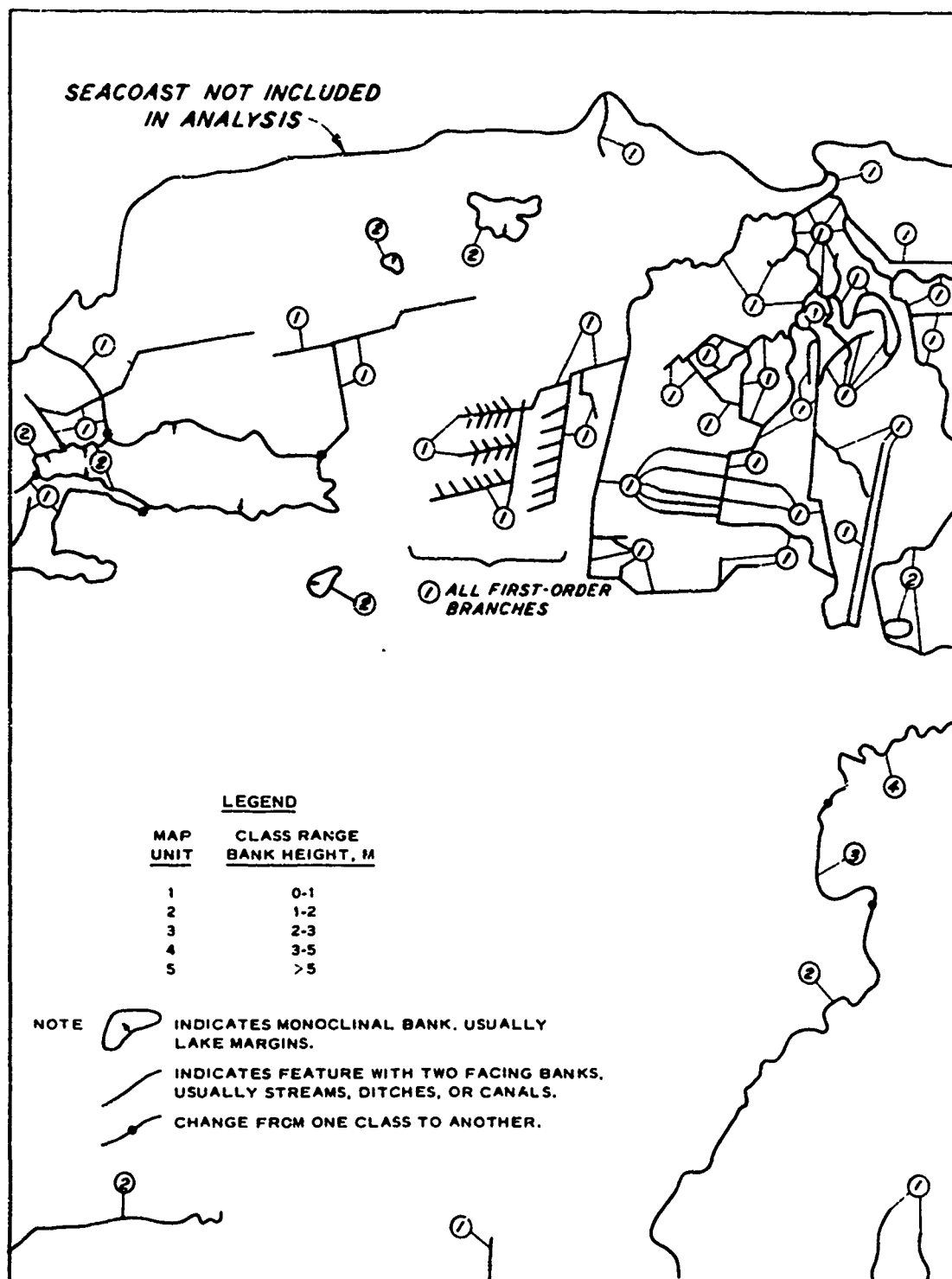


Fig. 28. Factor map. Hydrologic geometry: Bank height

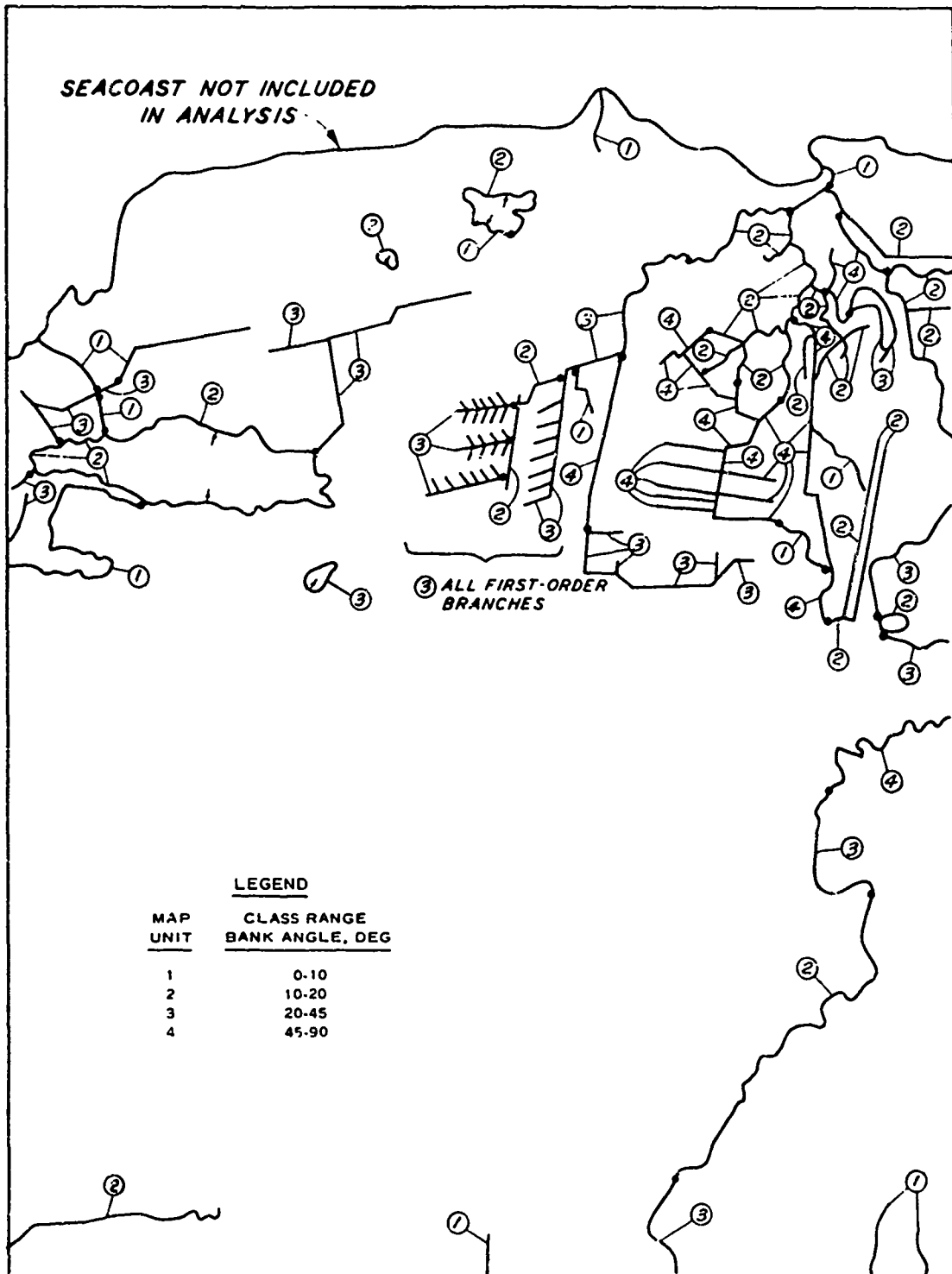


Fig. 29. Factor map. Hydrologic geometry: Bank angle

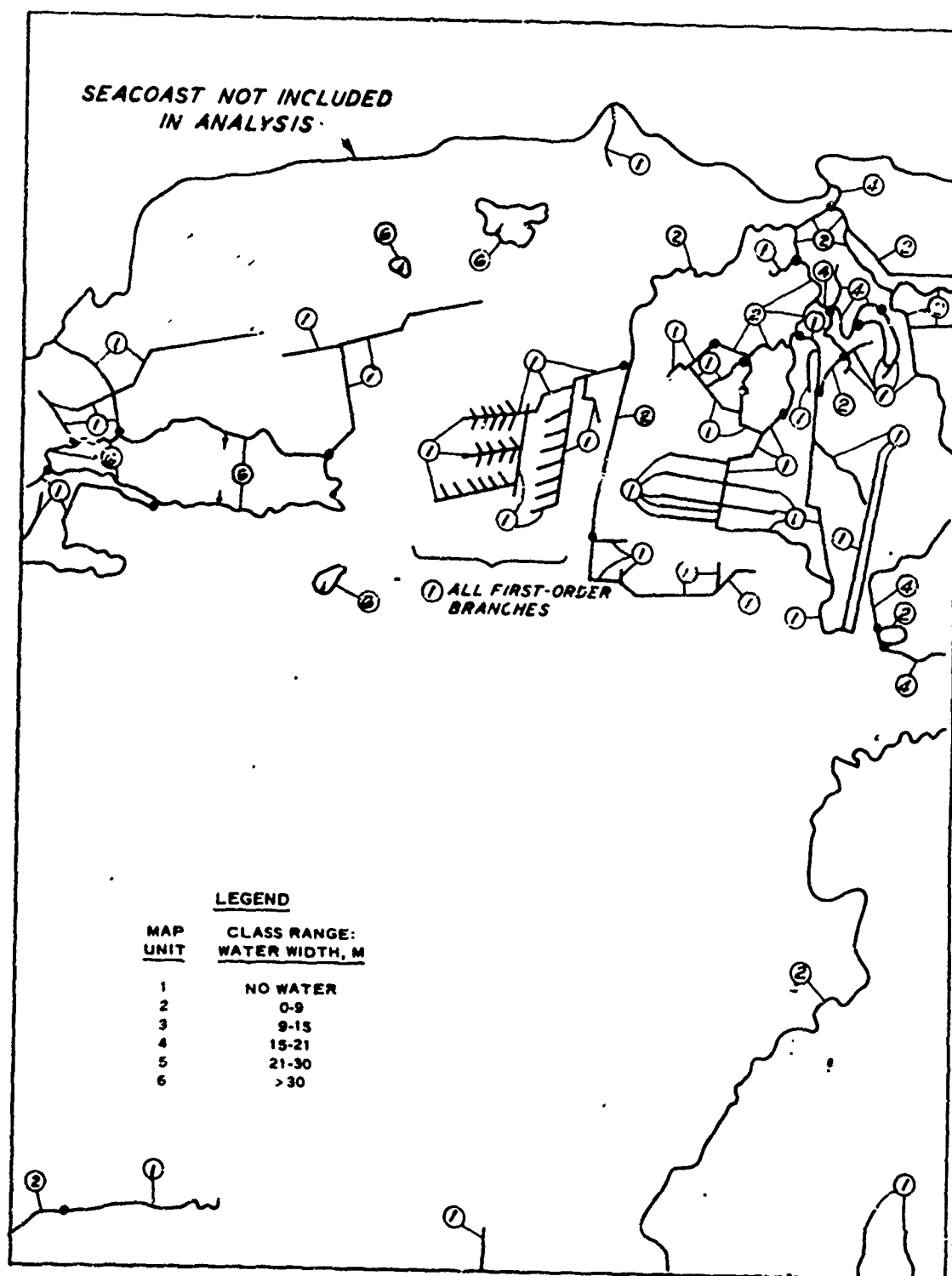


Fig. 30. Factor map. Hydrologic geometry: Water width

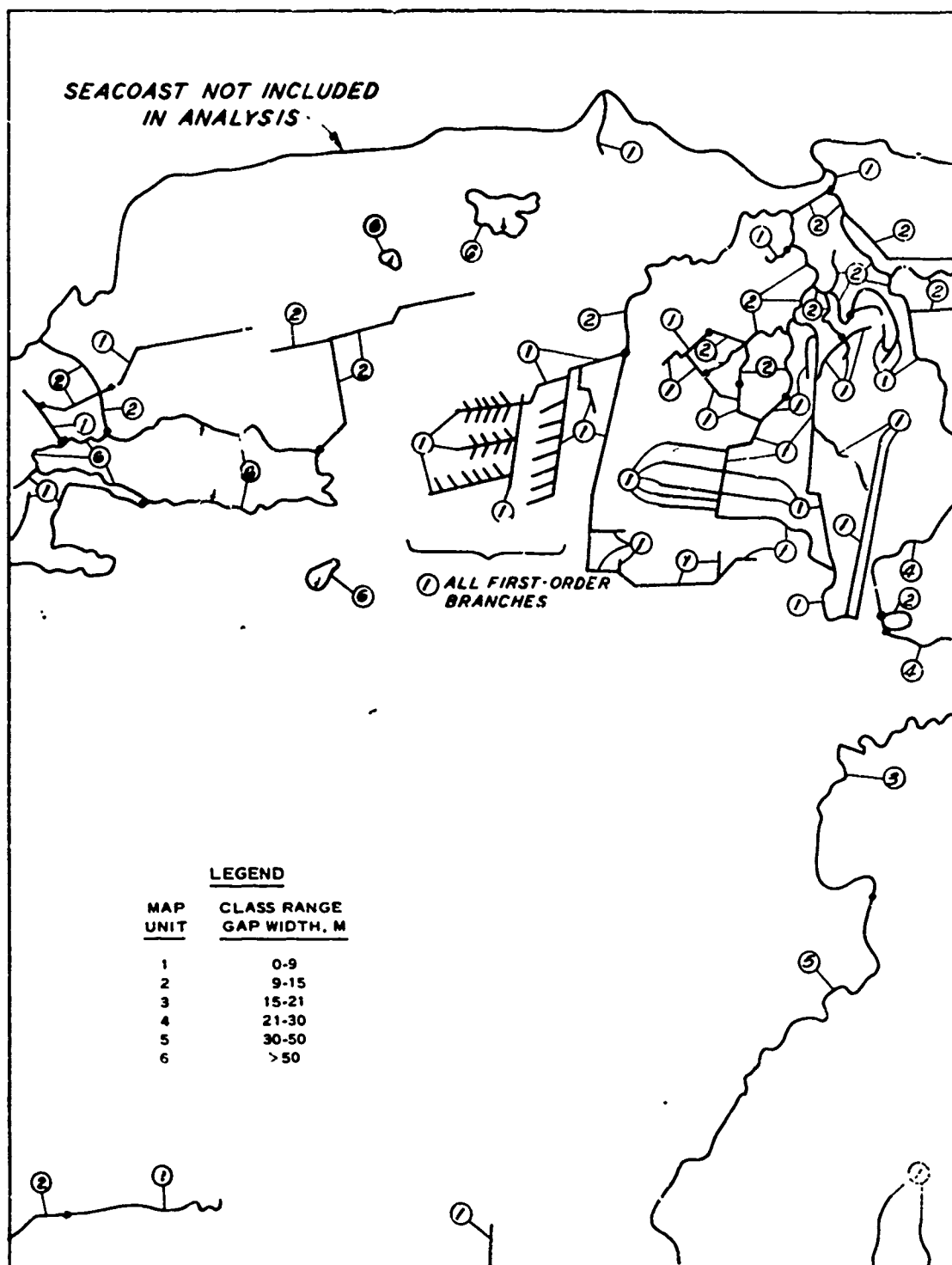


Fig. 31. Factor map. Hydrologic geometry: Gap width

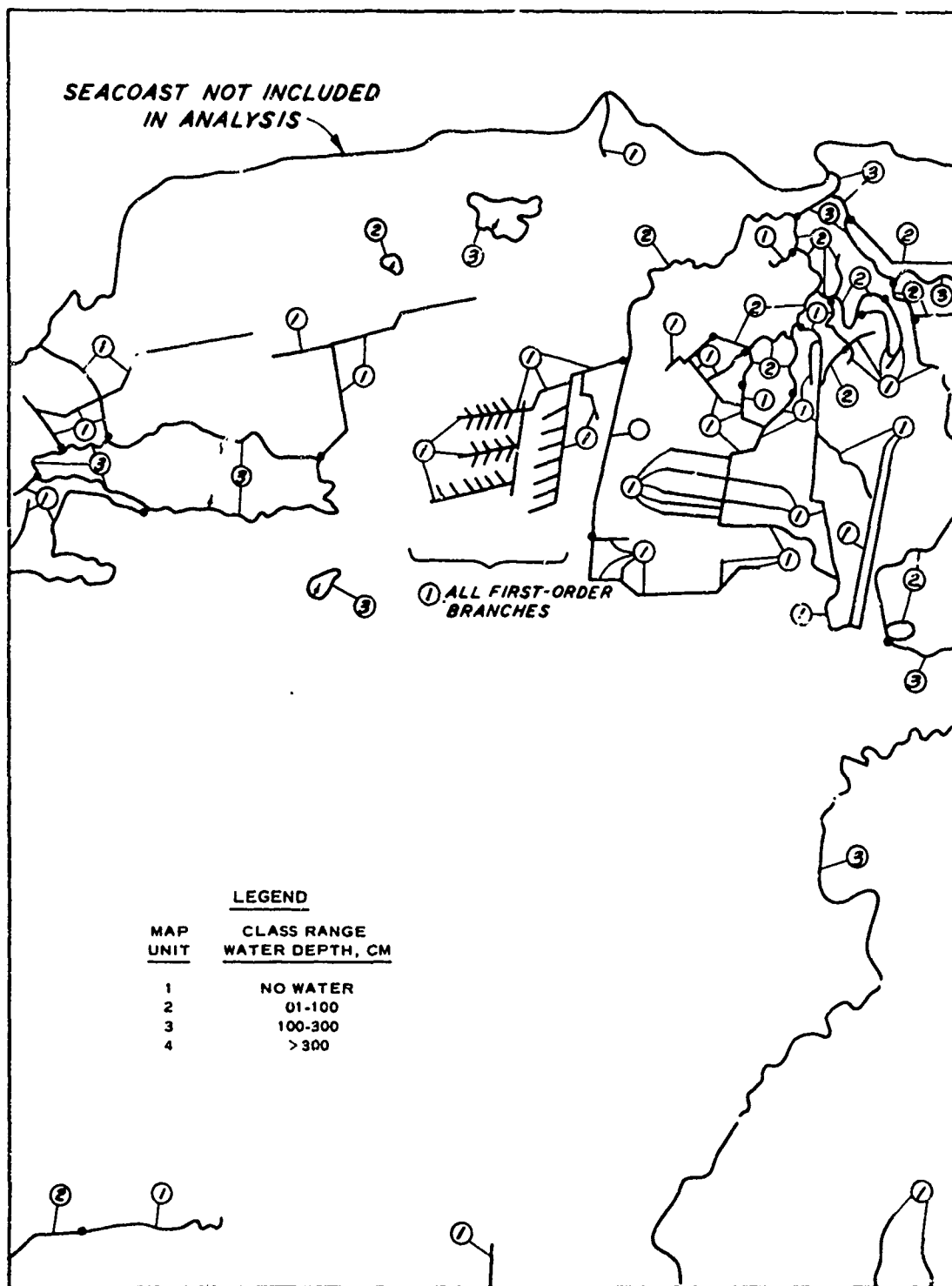


Fig. 32. Factor map. Hydrologic geometry: Water depth

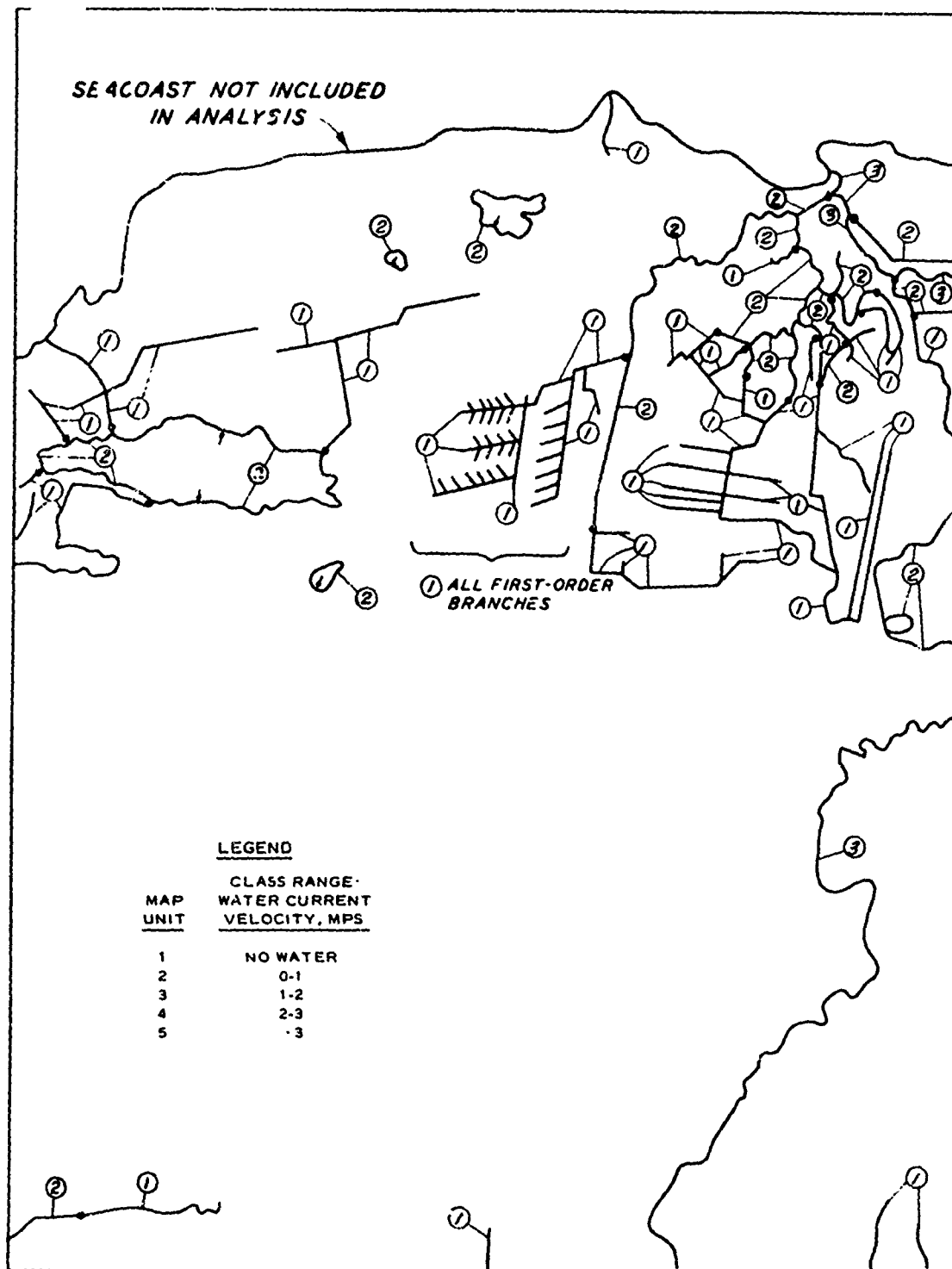


Fig. 33. Factor map. Hydrologic geometry: Water current velocity

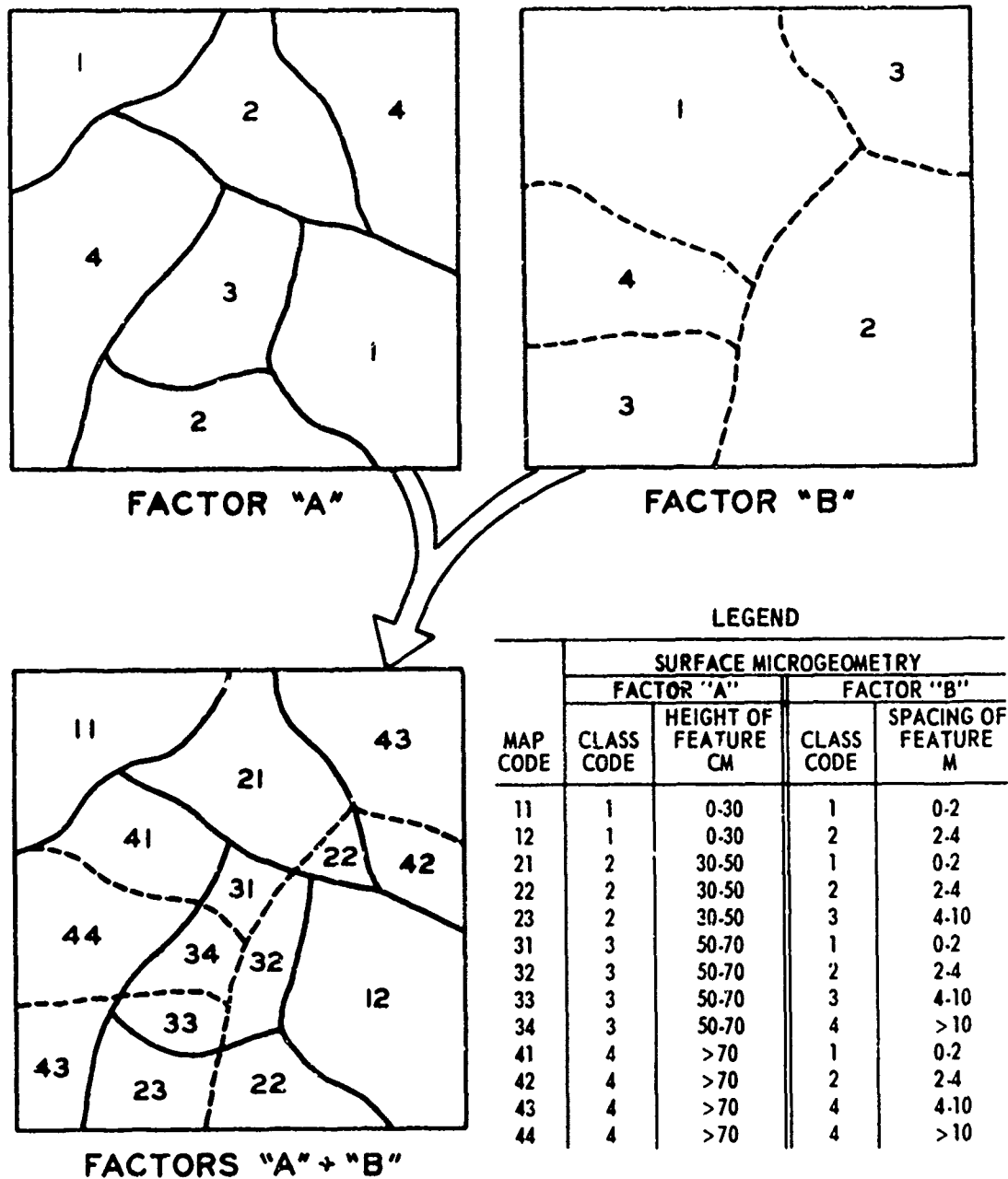
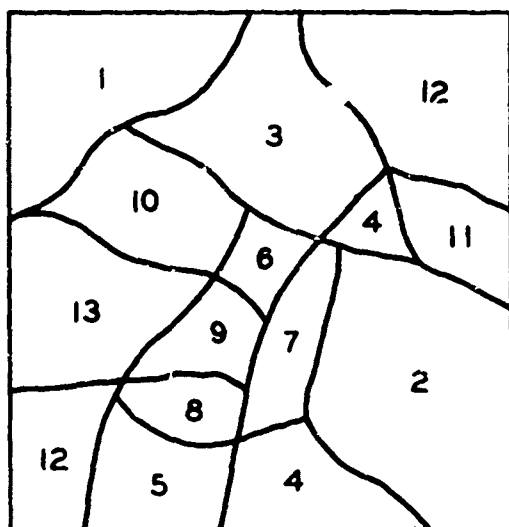


Fig. 34. Method of "stacking" factor maps to create a factor complex map



FACTOR COMPLEX MAP

<u>MAP</u> <u>UNIT</u>	<u>FACTOR COMPLEX</u> <u>IDENTIFICATION CODE</u>
	<u>FACTORS</u>
	<u>"A" "B"</u>
1	11
2	12
3	21
4	22
5	23
6	31
7	32
8	33
9	34
10	41
11	42
12	43
13	44

Fig. 35. Technique for simplification of identification code



Fig. 36. Factor complex map. Areal terrain factor for cross-country speed for vehicles (M151) (sheet 1 of 2)

1969
Cross Country Speed for Vehicles
Factory Complex Map

Map Unit	Complex	Map Unit	Complex	Map Unit	Complex	Map Unit	Complex	Map Unit	Complex	Map Unit	Complex
1	1211143353	100	1312562155	11	4121123363	207	41311463363	305	4211562155	404	4222512155
2	1211143663	101	1312562166	12	4121123563	208	41311463463	306	4211562166	405	4222512166
3	1311125353	102	1312562177	13	4121123663	209	41311463563	307	4211562177	406	4222512177
4	1311125353	103	1312562188	14	4121123763	210	41311463663	308	4211562188	407	4222512188
5	1311125353	104	4111121112	15	4121123863	211	41311463763	309	4211562199	408	4222512199
6	1311121112	105	4111121112	16	4121123963	212	41311463863	310	4211562210	409	4222512210
7	1312151112	106	4111121215	17	4121124063	213	41311463963	311	4211562221	410	4222512221
8	1312512151	107	4111121318	18	4121124163	214	41311464063	312	4211562232	411	4222512232
9	1312512151	108	4111121421	19	4121124263	215	41311464163	313	4211562243	412	4222512243
10	1411123363	109	4111121524	20	4121124363	216	41311464263	314	4211562254	413	4222512254
11	1411123363	110	4111121627	21	4121124463	217	41311464363	315	4211562265	414	4222512265
12	1411123363	111	4111121730	22	4121124563	218	41311464463	316	4211562276	415	4222512276
13	1411123363	112	4111121833	23	4121124663	219	41311464563	317	4211562287	416	4222512287
14	1411123363	113	4111121936	24	4121124763	220	41311464663	318	4211562298	417	4222512298
15	1411123363	114	4111122039	25	4121124863	221	41311464763	319	4211562309	418	4222512309
16	1411123363	115	4111122142	26	4121124963	222	41311464863	320	4211562320	419	4222512320
17	1411123363	116	4111122245	27	4121125063	223	41311464963	321	4211562331	420	4222512331
18	1411123363	117	4111122348	28	4121125163	224	41311465063	322	4211562342	421	4222512342
19	1411123363	118	4111122451	29	4121125263	225	41311465163	323	4211562353	422	4222512353
20	1411123363	119	4111122554	30	4121125363	226	41311465263	324	4211562364	423	4222512364
21	1411123363	120	4111122657	31	4121125463	227	41311465363	325	4211562375	424	4222512375
22	1412511112	121	4111122760	32	4121125563	228	41311465463	326	4211562386	425	4222512386
23	1412511112	122	4111122863	33	4121125663	229	41311465563	327	4211562397	426	4222512397
24	1412511112	123	4111122966	34	4121125763	230	41311465663	328	4211562408	427	4222512408
25	1412511112	124	4111123069	35	4121125863	231	41311465763	329	4211562419	428	4222512419
26	1412511112	125	4111123172	36	4121125963	232	41311465863	330	4211562430	429	4222512430
27	1412511112	126	4111123275	37	4121126063	233	41311465963	331	4211562441	430	4222512441
28	1412511112	127	4111123378	38	4121126163	234	41311466063	332	4211562452	431	4222512452
29	1412511112	128	4111123481	39	4121126263	235	41311466163	333	4211562463	432	4222512463
30	1412511112	129	4111123584	40	4121126363	236	41311466263	334	4211562474	433	4222512474
31	1412511112	130	4111123687	41	4121126463	237	41311466363	335	4211562485	434	4222512485
32	1412511112	131	4111123790	42	4121126563	238	41311466463	336	4211562496	435	4222512496
33	1412511112	132	4111123893	43	4121126663	239	41311466563	337	4211562507	436	4222512507
34	1412511112	133	4111123996	44	4121126763	240	41311466663	338	4211562518	437	4222512518
35	1412511112	134	4111124099	45	4121126863	241	41311466763	339	4211562529	438	4222512529
36	1412511112	135	4111124202	46	4121126963	242	41311466863	340	4211562540	439	4222512540
37	1412511112	136	4111124305	47	4121127063	243	41311466963	341	4211562551	440	4222512551
38	1412511112	137	4111124408	48	4121127163	244	41311467063	342	4211562562	441	4222512562
39	1412511112	138	4111124511	49	4121127263	245	41311467163	343	4211562573	442	4222512573
40	1412511112	139	4111124614	50	4121127363	246	41311467263	344	4211562584	443	4222512584
41	1412511112	140	4111124717	51	4121127463	247	41311467363	345	4211562595	444	4222512595
42	1412511112	141	4111124820	52	4121127563	248	41311467463	346	4211562606	445	4222512606
43	1412511112	142	4111124923	53	4121127663	249	41311467563	347	4211562617	446	4222512617
44	1412511112	143	4111125026	54	4121127763	250	41311467663	348	4211562628	447	4222512628
45	1412511112	144	4111125129	55	4121127863	251	41311467763	349	4211562639	448	4222512639
46	1412511112	145	4111125232	56	4121127963	252	41311467863	350	4211562650	449	4222512650
47	1412511112	146	4111125335	57	4121128063	253	41311467963	351	4211562661	450	4222512661
48	1412511112	147	4111125438	58	4121128163	254	41311468063	352	4211562672	451	4222512672
49	1412511112	148	4111125541	59	4121128263	255	41311468163	353	4211562683	452	4222512683
50	1412511112	149	4111125644	60	4121128363	256	41311468263	354	4211562694	453	4222512694
51	1412511112	150	4111125747	61	4121128463	257	41311468363	355	4211562705	454	4222512705
52	1412511112	151	4111125850	62	4121128563	258	41311468463	356	4211562716	455	4222512716
53	1412511112	152	4111125953	63	4121128663	259	41311468563	357	4211562727	456	4222512727
54	1412511112	153	4111126056	64	4121128763	260	41311468663	358	4211562738	457	4222512738
55	1412511112	154	4111126159	65	4121128863	261	41311468763	359	4211562749	458	4222512749
56	1412511112	155	4111126262	66	4121128963	262	41311468863	360	4211562760	459	4222512760
57	1412511112	156	4111126365	67	4121129063	263	41311468963	361	4211562771	460	4222512771
58	1412511112	157	4111126468	68	4121129163	264	41311469063	362	4211562782	461	4222512782
59	1412511112	158	4111126571	69	4121129263	265	41311469163	363	4211562793	462	4222512793
60	1412511112	159	4111126674	70	4121129363	266	41311469263	364	4211562804	463	4222512804
61	1412511112	160	4111126777	71	4121129463	267	41311469363	365	4211562815	464	4222512815
62	1412511112	161	4111126880	72	4121129563	268	41311469463	366	4211562826	465	4222512826
63	1412511112	162	4111126983	73	4121129663	269	41311469563	367	4211562837	466	4222512837
64	1412511112	163	4111127086	74	4121129763	270	41311469663	368	4211562848	467	4222512848
65	1412511112	164	4111127189	75	4121129863	271	41311469763	369	4211562859	468	4222512859
66	1412511112	165	4111127292	76	4121129963	272	41311469863	370	4211562870	469	4222512870
67	1412511112	166	4111127395	77	4121130063	273	41311469963	371	4211562881	470	4222512881
68	1412511112	167	4111127498	78	4121130163	274	41311470063	372	4211562892	471	4222512892
69	1412511112	168	4111127601	79	4121130263	275	41311470163	373	4211562903	472	4222512903
70	1412511112	169	4111127704	80	4121130363	276	41311470263	374	4211562914	473	4222512914
71	1412511112	170	4111127807	81	4121130463	277	41311470363	375	4211562925	474	4222512925
72	1412511112	171	4111127910	82	4121130563	278	41311470463	376	4211562936	475	4222512936
73	1412511112	172	4111128013	83	4121130663	279	41311470563	377	4211562947	476	4222512947
74	1412511112	173	4111128116	84	4121130763	280	41311470663	378	4211562958	477	4222512958
75	1412511112	174	4111128219	85	4121130863	281	41311470763	379	4211562969	478	4222512969
76	1412511112	175	4111128322	86	4121130963	282	41311470863	380	4211562980	479	4222512980
77	1412511112	176	4111128425	87	4121131063	283	41311470963	381	4211562991	480	4222512991
78	1412511112	177	4111128528	88	4121131163	284	41311471063	382	4211563002	481	4222513002
79	1412511112	178	4111128631	89	4121131263	285	41311471163	383	4211563013	482	4222513013
80	1412511112	179	4111128734	90	4121131363	286	41311471263	384	4211563024	483	4222513024
81	1412511112	180	4111128837	91	4121131463	287	41311471363	385	4211563035	484	4222513035
82	1412511112	181	4111128940	92	4121131563	288	41311471463	386	4211563046	485	4222513046
83	1412511112	182	4111129043	93	4121131663	289	41311471563	387	4211563057	486	4222513057
84	1412511112	183	4111129146	94	4121131763	290	41311471663	388	4211563068	487	4222513068
85	1412511112	184	4111129249	95	4121131863	291	41311471763	389	4211563079	488	4222513079
86	1412511112	185	4111129352	96	4121131963	292	41311471863	390	4211563090	489	4222513090
87	1412511112	186	4111129455	97	4121132063	293	41311471963	391	4211563101	490	4222513101
88	1412511112	187	41111295								

Fig. 36. (sheet 2 of 2)



Fig. 37. Factor complex map. Areal terrain factors for cross-country speed for personnel (sheet 1 of 2)

Cross-Country Movement
of Personnel
Complex Legend

Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.
1	111112711	76	322244423	151	412123332	226	421212211	302	432111115
2	111127115	77	322244434	152	412123333	227	421213332	303	432111165
3	111125545	78	331212211	153	412123443	228	421213333	304	432112211
4	111125555	79	331214434	154	412124433	229	421241115	305	432112215
5	111131115	80	332124423	155	412124434	230	421241165	306	432113332
6	111141115	81	332124434	156	412124435	231	421242211	307	432113333
7	111142112	82	332132215	157	412124436	232	422111115	308	432114423
8	111142311	83	332134434	158	412124443	233	422111165	309	432114434
9	111143333	84	332134423	159	412125545	234	422112211	310	432114443
10	111212112	85	332134434	160	412125555	235	422112215	311	432121115
11	111212211	86	332212215	161	412125555	236	422113332	312	432121165
12	112112211	87	332214423	162	412131115	237	422113333	313	432122211
13	112113333	88	332214434	163	412132211	238	422114333	314	432122215
14	112141115	89	332242215	164	412132215	239	422114334	315	432122215
15	112143343	90	332244423	165	412133343	240	422114443	316	432122215
16	112142112	91	332244434	166	412133443	241	422121115	317	432122215
17	112212211	92	332244443	167	412134433	242	422121165	318	432122215
18	121111115	93	332344423	168	412134435	243	422122211	319	432122215
19	121112211	94	332344434	169	412134443	244	422122215	320	432122215
20	121121115	95	332344443	170	412135545	245	422122215	321	432122215
21	121131115	96	332344443	171	412141115	246	422123333	322	432122215
22	121212211	97	411111165	172	412141165	247	422124333	323	432122215
23	122141115	98	411112112	173	412142211	248	422124334	324	432122215
24	132142112	99	411112211	174	412142215	249	422124335	325	432122215
25	211113115	100	411113332	175	412143333	250	422124423	326	432122215
26	211143333	101	411113333	176	412143343	251	422124434	327	432122215
27	211212211	102	411121115	177	412143443	252	422124443	328	432122215
28	212212211	103	411122112	178	412144333	253	422125545	329	432122215
29	222212211	104	411122211	179	412144355	254	422125555	330	432122215
30	322212211	105	411125545	180	412144423	255	422131115	331	432122215
31	311111115	106	411125555	181	412144434	256	422132211	332	432122215
32	311112112	107	411131115	182	412144443	257	422132215	333	432122215
33	311122111	108	411133333	183	412145545	258	422132215	334	432122215
34	311121115	109	411133343	184	412145555	259	422133332	335	432122215
35	311121165	110	411135555	185	412211115	260	422134334	336	432122215
36	311131115	111	411141115	186	412212211	261	422134423	337	432122215
37	311141115	112	411141165	187	412212215	262	422134434	338	432122215
38	311141165	113	411142112	188	412213332	263	422134443	339	432122215
39	311142211	114	411142211	189	412213333	264	422135545	340	432122215
40	311211115	115	411143333	190	412213443	265	422135555	341	432122215
41	311212211	116	411143443	191	412214333	266	422141115	342	432122215
42	311213333	117	411144443	192	412214423	267	422141165	343	432122215
43	311231115	118	411145545	193	412214443	268	422142211	344	432122215
44	311233443	119	411145555	194	412221115	269	422142215	345	432122215
45	311241115	120	411142115	195	412222211	270	422143332	346	432122215
46	311241165	121	4111421165	196	412223332	271	422143333	347	432122215
47	312121115	122	411212112	197	412223333	272	422143343	348	432122215
48	312124334	123	411212211	198	412223333	273	422143443	349	432122215
49	312131115	124	411213333	199	412223333	274	422144334	350	432122215
50	312132211	125	411213443	200	412242211	275	422144335	351	432122215
51	312212211	126	411215555	201	412242215	276	422144423	352	432122215
52	312244423	127	411221115	202	412244434	277	422144434	353	432122215
53	321212211	128	411222211	203	412244443	278	422144443	354	432122215
54	322112211	129	411225545	204	412244434	279	422145555	355	432122215
55	322114434	130	411233333	205	412244443	280	422211115	356	432122215
56	322114443	131	411235555	206	421111115	281	422212211	357	432122215
57	322121115	132	411241115	207	421112112	282	422212215	358	432122215
58	322122215	133	411241165	208	421112211	283	422213332	359	432122215
59	322124334	134	411242211	209	421113332	284	422213333	360	432122215
60	322124423	135	411243333	210	421114443	285	422214423	361	432122215
61	322124434	136	411311165	211	421121115	286	422214434	362	432122215
62	322132215	137	412111115	212	421124333	287	422214443	363	432122215
63	322134423	138	412111165	213	421131115	288	422222211	364	432122215
64	322135555	139	412112211	214	421133333	289	422223333	365	432122215
65	322141115	140	412112215	215	421133343	290	422232215	366	432122215
66	322142211	141	412113332	216	421134443	291	422234355	367	432122215
67	322142215	142	412113333	217	421135555	292	422242112	368	432122215
68	322144434	143	412114333	218	421141115	293	422242215	369	432122215
69	322212211	144	412114443	219	421141165	294	422244334	370	432122215
70	322212215	145	412115555	220	421142112	295	422244423	371	432122215
71	322214434	146	412121115	221	421142211	296	422244434	372	432122215
72	322224423	147	412121165	222	421143443	297	422244443	373	432122215
73	322231115	148	412122211	223	421145555	298	422244443	374	432122215
74	322232215	149	412122215	224	421211115	299	431142211	375	432122215
75	322242215	150	412122343	225	421211165	300	431211115	376	432122215
						301	431212211	377	432122215

F-10. 37. (sheet 2 of 2)

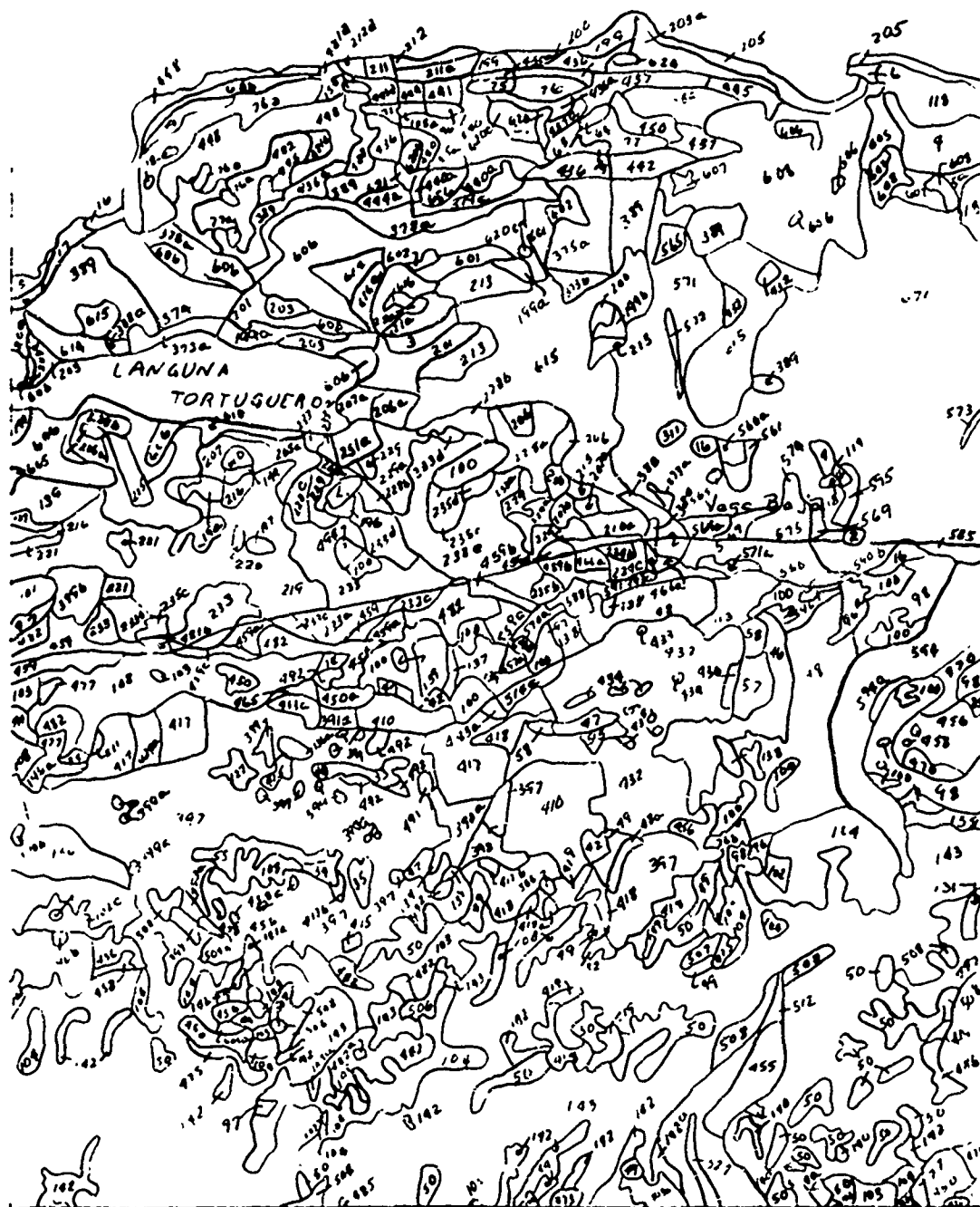


Fig. 38. Factor complex map. Areal terrain factors for
HLZ construction effort (sheet 1 of 2)

[illegible]

Fig. 38. (sheet 2 of 2)



Fig. 39. Factor complex map. Areal terrain factors for concealment characteristics (sheet 1 of 2)

Concealment Legend

Map Unit	Complex No.	Map Unit	Complex No.
1	1111115	42	1411615
2	1122115	43	1421112
3	1122131	44	1422115
4	1133323	45	1422131
5	1133332	46	1433323
6	1133343	47	1433332
7	1144233	48	1433332
8	1144324	49	1433343
9	1144443	50	1434443
10	1211114	51	1443344
11	1211615	52	1443515
12	1221112	53	1444233
13	1222115	54	1444324
14	1222131	55	1444443
15	1223423	56	1455425
16	1233323	57	1455525
17	1233332	58	2111115
18	1233333	59	2111615
19	1233343	60	2121112
20	1234433	61	2122115
21	1243344	62	2122131
22	1243515	63	2133323
23	1244233	64	2133332
24	1244324	65	2134433
25	1244344	66	2144233
26	1244443	67	2144324
27	1245533	68	2144443
28	1255425	69	2145435
29	1255525	70	2155425
30	1311115	71	2222131
31	1322115	72	2311115
32	1322131	73	2322115
33	1333323	74	2343515
34	1333423	75	2322115
35	1334433	76	2443344
36	1343344	77	2444233
37	1343515	78	2444324
38	1344233	79	3211615
39	1344324	80	3222131
40	1355425	81	3233323
41	1411115	82	4422131

Fig. 39. (sheet 2 of 2)

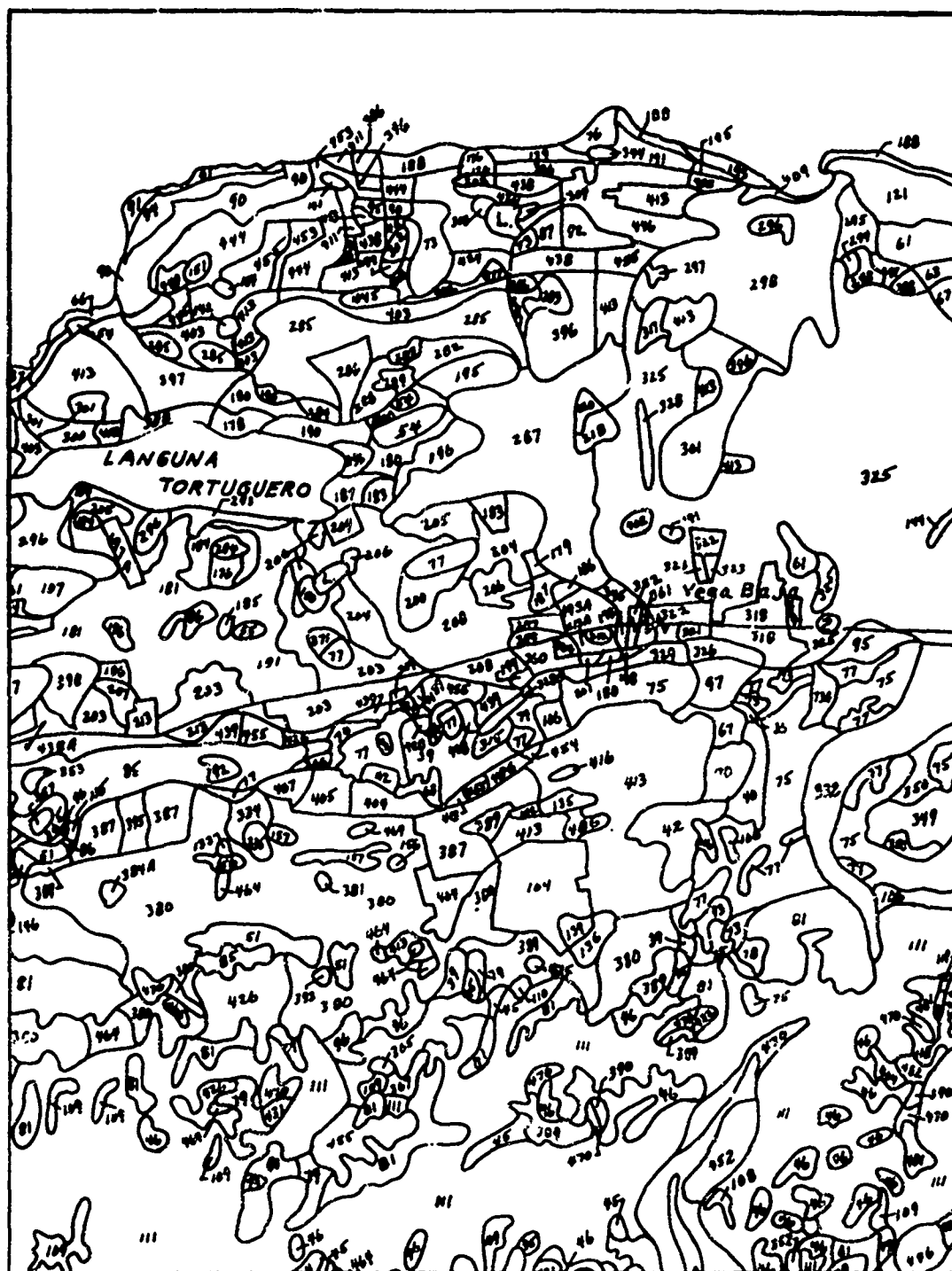


Fig. 40. Factor complex map. Areal terrain factors for cover characteristics (sheet 1 of 2)

Factor Complex Cover
(Various 1-1000000000)

Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.
1	11212111	1078	11112111	202	11112111	301	11112111	400	11112111
2	11212112	1079	11112112	203	11112112	302	11112112	401	11112112
3	11212113	1080	11112113	204	11112113	303	11112113	402	11112113
4	11212114	1081	11112114	205	11112114	304	11112114	403	11112114
5	11212115	1082	11112115	206	11112115	305	11112115	404	11112115
6	11212116	1083	11112116	207	11112116	306	11112116	405	11112116
7	11212117	1084	11112117	208	11112117	307	11112117	406	11112117
8	11212118	1085	11112118	209	11112118	308	11112118	407	11112118
9	11212119	1086	11112119	210	11112119	309	11112119	408	11112119
10	11212120	1087	11112120	211	11112120	310	11112120	409	11112120
11	11212121	1088	11112121	212	11112121	311	11112121	410	11112121
12	11212122	1089	11112122	213	11112122	312	11112122	411	11112122
13	11212123	1090	11112123	214	11112123	313	11112123	412	11112123
14	11212124	1091	11112124	215	11112124	314	11112124	413	11112124
15	11212125	1092	11112125	216	11112125	315	11112125	414	11112125
16	11212126	1093	11112126	217	11112126	316	11112126	415	11112126
17	11212127	1094	11112127	218	11112127	317	11112127	416	11112127
18	11212128	1095	11112128	219	11112128	318	11112128	417	11112128
19	11212129	1096	11112129	220	11112129	319	11112129	418	11112129
20	11212130	1097	11112130	221	11112130	320	11112130	419	11112130
21	11212131	1098	11112131	222	11112131	321	11112131	420	11112131
22	11212132	1099	11112132	223	11112132	322	11112132	421	11112132
23	11212133	1100	11112133	224	11112133	323	11112133	422	11112133
24	11212134	1101	11112134	225	11112134	324	11112134	423	11112134
25	11212135	1102	11112135	226	11112135	325	11112135	424	11112135
26	11212136	1103	11112136	227	11112136	326	11112136	425	11112136
27	11212137	1104	11112137	228	11112137	327	11112137	426	11112137
28	11212138	1105	11112138	229	11112138	328	11112138	427	11112138
29	11212139	1106	11112139	230	11112139	329	11112139	428	11112139
30	11212140	1107	11112140	231	11112140	330	11112140	429	11112140
31	11212141	1108	11112141	232	11112141	331	11112141	430	11112141
32	11212142	1109	11112142	233	11112142	332	11112142	431	11112142
33	11212143	1110	11112143	234	11112143	333	11112143	432	11112143
34	11212144	1111	11112144	235	11112144	334	11112144	433	11112144
35	11212145	1112	11112145	236	11112145	335	11112145	434	11112145
36	11212146	1113	11112146	237	11112146	336	11112146	435	11112146
37	11212147	1114	11112147	238	11112147	337	11112147	436	11112147
38	11212148	1115	11112148	239	11112148	338	11112148	437	11112148
39	11212149	1116	11112149	240	11112149	339	11112149	438	11112149
40	11212150	1117	11112150	241	11112150	340	11112150	439	11112150
41	11212151	1118	11112151	242	11112151	341	11112151	440	11112151
42	11212152	1119	11112152	243	11112152	342	11112152	441	11112152
43	11212153	1120	11112153	244	11112153	343	11112153	442	11112153
44	11212154	1121	11112154	245	11112154	344	11112154	443	11112154
45	11212155	1122	11112155	246	11112155	345	11112155	444	11112155
46	11212156	1123	11112156	247	11112156	346	11112156	445	11112156
47	11212157	1124	11112157	248	11112157	347	11112157	446	11112157
48	11212158	1125	11112158	249	11112158	348	11112158	447	11112158
49	11212159	1126	11112159	250	11112159	349	11112159	448	11112159
50	11212160	1127	11112160	251	11112160	350	11112160	449	11112160
51	11212161	1128	11112161	252	11112161	351	11112161	450	11112161
52	11212162	1129	11112162	253	11112162	352	11112162	451	11112162
53	11212163	1130	11112163	254	11112163	353	11112163	452	11112163
54	11212164	1131	11112164	255	11112164	354	11112164	453	11112164
55	11212165	1132	11112165	256	11112165	355	11112165	454	11112165
56	11212166	1133	11112166	257	11112166	356	11112166	455	11112166
57	11212167	1134	11112167	258	11112167	357	11112167	456	11112167
58	11212168	1135	11112168	259	11112168	358	11112168	457	11112168
59	11212169	1136	11112169	260	11112169	359	11112169	458	11112169
60	11212170	1137	11112170	261	11112170	360	11112170	459	11112170
61	11212171	1138	11112171	262	11112171	361	11112171	460	11112171
62	11212172	1139	11112172	263	11112172	362	11112172	461	11112172
63	11212173	1140	11112173	264	11112173	363	11112173	462	11112173
64	11212174	1141	11112174	265	11112174	364	11112174	463	11112174
65	11212175	1142	11112175	266	11112175	365	11112175	464	11112175
66	11212176	1143	11112176	267	11112176	366	11112176	465	11112176
67	11212177	1144	11112177	268	11112177	367	11112177	466	11112177
68	11212178	1145	11112178	269	11112178	368	11112178	467	11112178
69	11212179	1146	11112179	270	11112179	369	11112179	468	11112179
70	11212180	1147	11112180	271	11112180	370	11112180	469	11112180
71	11212181	1148	11112181	272	11112181	371	11112181	470	11112181
72	11212182	1149	11112182	273	11112182	372	11112182	471	11112182
73	11212183	1150	11112183	274	11112183	373	11112183	472	11112183
74	11212184	1151	11112184	275	11112184	374	11112184	473	11112184
75	11212185	1152	11112185	276	11112185	375	11112185	474	11112185
76	11212186	1153	11112186	277	11112186	376	11112186	475	11112186
77	11212187	1154	11112187	278	11112187	377	11112187	476	11112187
78	11212188	1155	11112188	279	11112188	378	11112188	477	11112188
79	11212189	1156	11112189	280	11112189	379	11112189	478	11112189
80	11212190	1157	11112190	281	11112190	380	11112190	479	11112190
81	11212191	1158	11112191	282	11112191	381	11112191	480	11112191
82	11212192	1159	11112192	283	11112192	382	11112192	481	11112192
83	11212193	1160	11112193	284	11112193	383	11112193	482	11112193
84	11212194	1161	11112194	285	11112194	384	11112194	483	11112194
85	11212195	1162	11112195	286	11112195	385	11112195	484	11112195
86	11212196	1163	11112196	287	11112196	386	11112196	485	11112196
87	11212197	1164	11112197	288	11112197	387	11112197	486	11112197
88	11212198	1165	11112198	289	11112198	388	11112198	487	11112198
89	11212199	1166	11112199	290	11112199	389	11112199	488	11112199
90	11212200	1167	11112200	291	11112200	390	11112200	489	11112200
91	11212201	1168	11112201	292	11112201	391	11112201	490	11112201
92	11212202	1169	11112202	293	11112202	392	11112202	491	11112202
93	11212203	1170	11112203	294	11112203	393	11112203	492	11112203
94	11212204	1171	11112204	295	11112204	394	11112204	493	11112204
95	11212205	1172	11112205	296	11112205	395	11112205	494	11112205
96	11212206	1173	11112206	297	11112206	396	11112206	495	11112206
97	11212207	1174	11112207	298	11112207	397	11112207	496	11112207
98	11212208	1175	11112208	299	11112208	398	11112208	497	11112208
99	11212209	1176	11112209	300	11112209	399	11112209	498	11112209
100	11212210	1177	11112210	301	11112210	400	11112210	499	11112210
101	11212211	1178	11112211	302	11112211	401	11112211	500	11112211
102	11212212	1179	11112212	303	11112212	402	11112212	501	11112212

Fig. 40. (sheet 2 of 2)

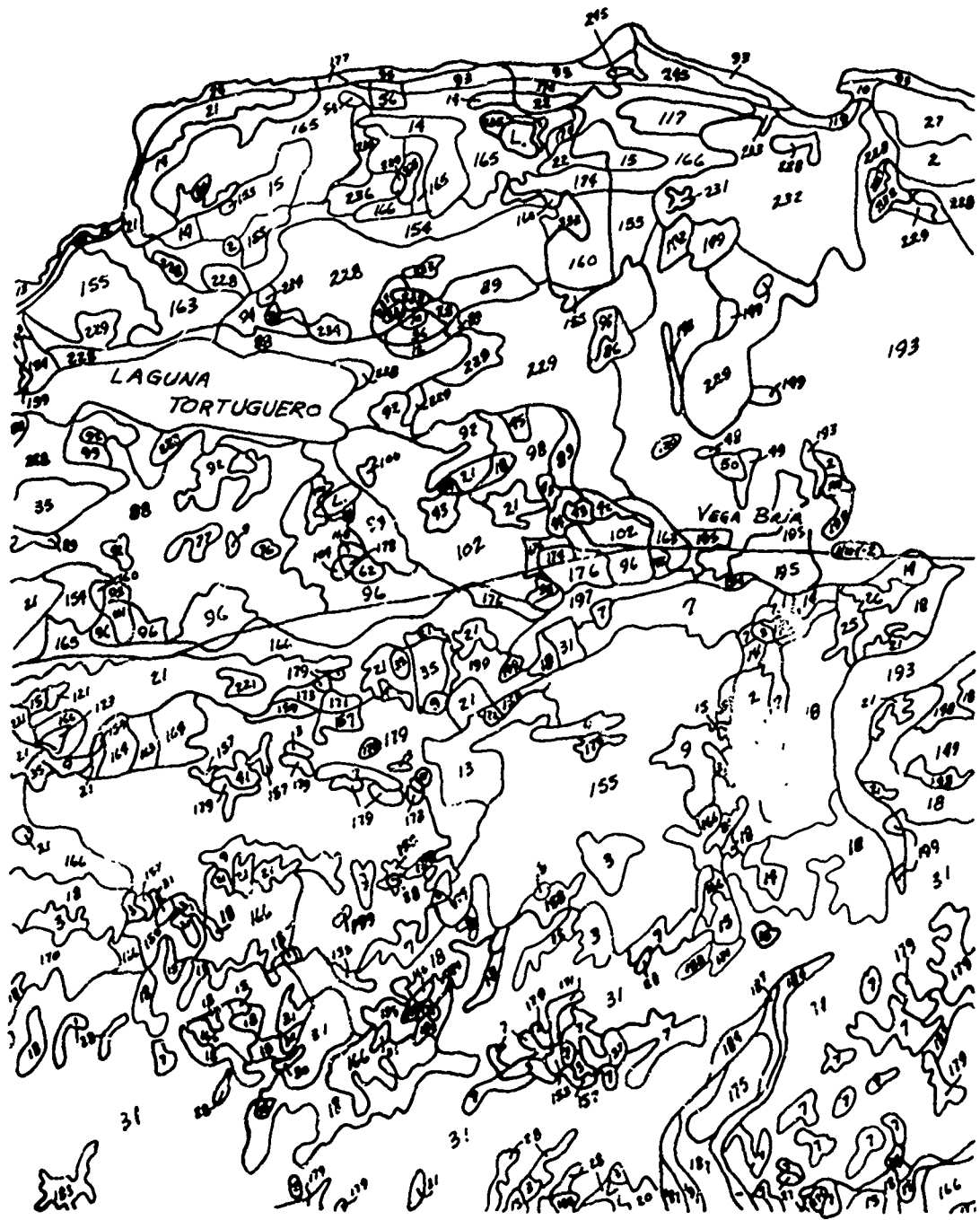


Fig. 41. Factor complex map. Areal terrain factors for airfield construction effort (sheet 1 of 2)

Legend
Airfield Construction
Effort Complex "no"

Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.
1	111224111	53	124234324	125	524224211	187	524254353
2	111224111	64	124244324	126	524224212	188	524254351
3	111224112	65	124244424	127	524224243	189	524254412
4	111224114	66	124254112	128	524224245	190	524254433
5	111224131	67	133153212	129	524224211	191	524254453
6	111224132	68	133153224	130	524224312	192	533252111
7	111224133	69	133153233	131	524224333	193	533252112
8	111224134	70	133153234	132	524234112	194	533252133
9	111224144	71	133153312	133	524234124	195	533252161
10	111224145	72	133153324	134	524234134	196	533252212
11	111224153	73	133153333	135	524234212	197	533252255
12	111224155	74	133153334	136	524234224	198	533252312
13	111224161	75	141151214	137	524234232	199	533252344
14	111224211	76	144224111	138	524234234	200	533254324
15	111224212	77	144224143	139	524234312	201	534224212
16	111224213	78	144224144	140	524234324	202	534234324
17	111224224	79	311141112	141	524234332	203	534234334
18	111224233	80	314224112	142	524234334	204	534234434
19	111224234	81	314224133	143	524234412	205	534244112
20	111224243	82	314224311	144	524234424	206	534244153
21	111224244	83	314224312	145	524234433	207	534244212
22	111224245	84	314224333	146	524234434	208	534244224
23	111224253	85	314224361	147	524244121	209	534244234
24	111224255	86	314224212	148	524251233	210	534244253
25	111224261	87	314224245	149	524252112	211	534244312
26	111224264	88	314244111	150	524252144	212	534244324
27	111224311	89	314244112	151	524252161	213	534244334
28	111224312	90	314244133	152	524252212	214	534244353
29	111224324	91	314244142	153	524253212	215	534244424
30	111224332	92	314244143	154	524254111	216	534254112
31	111224333	93	314244145	155	524254112	217	534254124
32	111224334	94	314244155	156	524254124	218	534254133
33	111224342	95	314244161	157	524254133	219	534254134
34	111224343	96	314244211	158	524254143	220	534254153
35	111224344	97	314244212	159	524254144	221	534254212
36	111224355	98	314244233	160	524254145	222	534254224
37	111224361	99	314244243	161	524254152	223	534254234
38	111224412	100	314244244	162	524254153	224	534254253
39	111224433	101	314244245	163	524254155	225	534254312
40	111224434	102	314244255	164	524254161	226	534254324
41	111224412	103	314244261	165	524254171	227	534254334
42	111244112	104	314244311	166	524254212	228	541151111
43	111244145	105	314244312	167	524254213	229	541151112
44	111244155	106	314254312	168	524254222	230	524151131
45	111244233	107	424244112	169	524254224	231	524151132
46	111244311	108	424244124	170	524254232	232	524151133
47	111244333	109	424244134	171	524254233	233	524151145
48	111252111	110	424244212	172	524254234	234	524151155
49	111252133	111	424244224	173	524254244	235	524151211
50	111252161	112	424244234	174	524254245	236	524151212
51	111254124	113	424244312	175	524254253	237	524151311
52	111254133	114	424244324	176	524254255	238	524151343
53	111254211	115	424244333	177	524254261	239	524251355
54	111254212	116	424244334	178	524254311	240	542151111
55	111254234	117	424254112	179	524254312	241	542151112
56	111254245	118	511151112	180	524254313	242	542151211
57	111254312	119	514244145	181	524254323	243	542151212
58	111254324	120	514252111	182	524254324	244	542151312
59	111254332	121	514254244	183	524254333	245	544251111
60	111254333	122	524141133	184	524254334	246	544254112
61	111254324	123	524224112	185	524254343	247	544254131
62	124224244	124	524224133	186	524254344		

Fig. 41. (sheet 2 of 2)

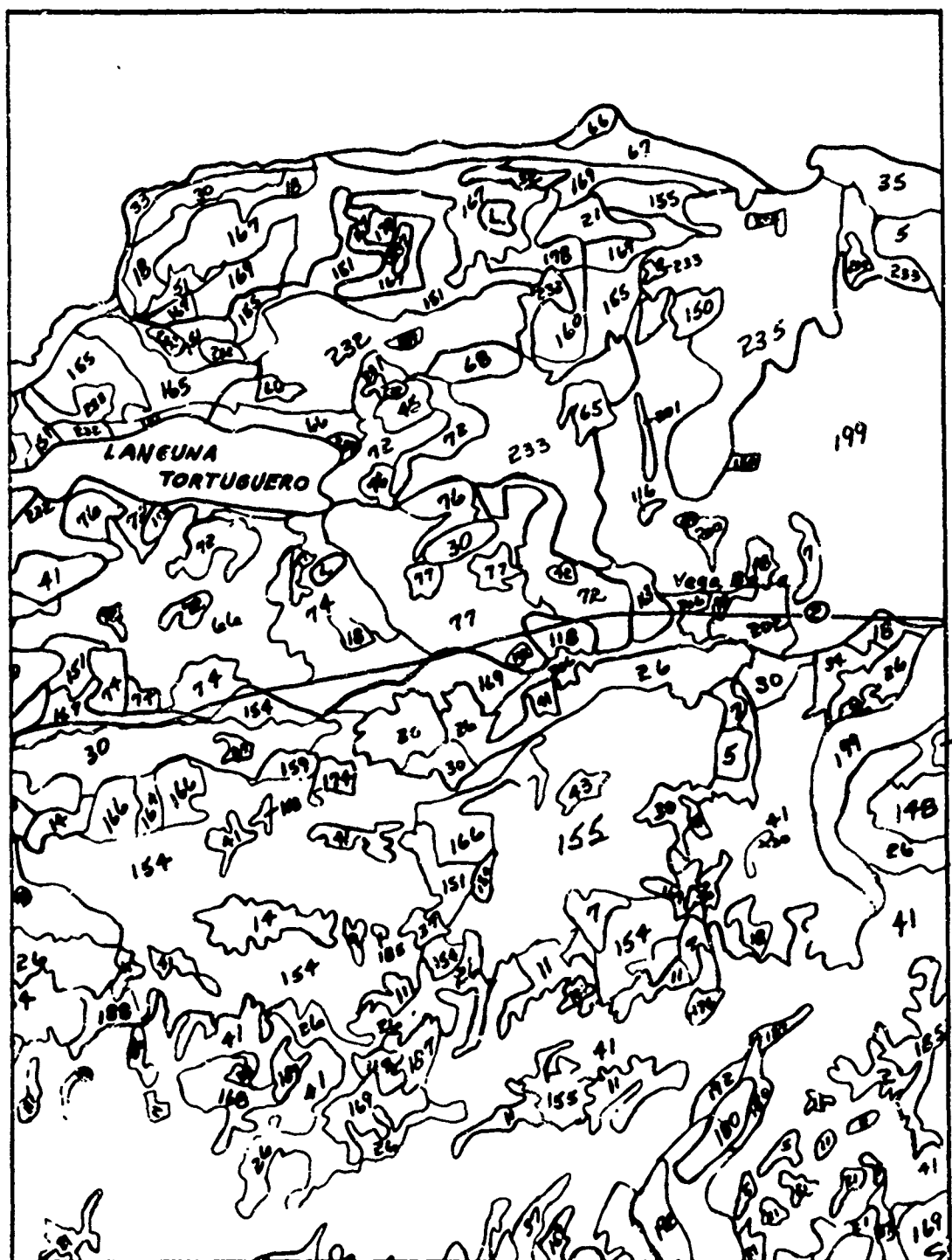


Fig. 42. Factor complex map. Areal terrain factors for bunker construction effort (sheet 1 of 2)

Legend
Baker Construction Factor Complex Map

Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.
1	1112242111	63	1331542244	125	5242541111	187	5242541111
2	1122413344	64	3142241111	126	5242541111	188	5242541111
3	1142224334	65	3142411125	127	5242541111	189	5242541111
4	1142231334	66	3142411111	128	5242541111	190	5242541111
5	1142241111	67	3142411122	129	5242541111	191	5242541111
6	1142241111	68	3142411125	130	5242541111	192	5242541111
7	1142241111	69	3142411234	131	5242541111	193	5242541111
8	1142241134	70	3142441244	132	5242541111	194	5242541111
9	1142241145	71	3142441253	133	5242541111	195	5242541111
10	1142241325	72	3142441553	134	5242541111	196	5242541111
11	1142241334	73	3142441611	135	5242541111	197	5242541111
12	1142241344	74	3142441211	136	5242541111	198	5242541111
13	1142241345	75	3142441212	137	5242541111	199	5242541111
14	1142241444	76	3142441234	138	5242541111	200	5242541111
15	1142241534	77	3142441244	139	5242541111	201	5242541111
16	1142241553	78	3142441261	140	5242541111	202	5242541111
17	1142241611	79	3142441311	141	5242541111	203	5242541111
18	1142242111	80	3142441434	142	5242541111	204	5242541111
19	1142242114	81	3342541125	143	5242541111	205	5242541111
20	1142242122	82	3342541124	144	5242541111	206	5242541111
21	1142242125	83	3342541134	145	5242541111	207	5242541111
22	1142242134	84	3342542125	146	5242541111	208	5242541111
23	1142242225	85	3342542244	147	5242541111	209	5242541111
24	1142242244	86	3342542334	148	5242541111	210	5242541111
25	1142242311	87	3342542344	149	5242541111	211	5242541111
26	1142242334	88	3342543125	150	5242541111	212	5242541111
27	1142242444	89	3342543244	151	5242541111	213	5242541111
28	1142242425	90	3342543334	152	5242541111	214	5242541111
29	1142242435	91	3342543344	153	5242541111	215	5242541111
30	1142242444	92	3422541125	154	5242541111	216	5242541111
31	1142242445	93	3431422325	155	5242541111	217	5242541111
32	1142242453	94	3432323125	156	5242541111	218	5242541111
33	1142242611	95	3432422125	157	5242541111	219	5242541111
34	1142242644	96	3432422244	158	5242541111	220	5242541111
35	1142243111	97	3432423125	159	5242541111	221	5242541111
36	1142243114	98	3442422125	160	5242541111	222	5242541111
37	1142243125	99	3442422344	161	5242541111	223	5242541111
38	1142243244	100	3442423125	162	5242541111	224	5242541111
39	1142243313	101	4232441212	163	5242541111	225	5242541111
40	1142243325	102	4232441312	164	5242541111	226	5242541111
41	1142243334	103	4242343244	165	5242541111	227	5242541111
42	1142243344	104	4242441125	166	5242541111	228	5242541111
43	1142243444	105	4242441134	167	5242541111	229	5242541111
44	1142243534	106	4242442125	168	5242541111	230	5242541111
45	1142243553	107	4242442144	169	5242541111	231	5242541111
46	1142243611	108	4242442244	170	5242541111	232	5242541111
47	1142244334	109	4242442344	171	5242541111	233	5242541111
48	1142411111	110	4242443125	172	5242541111	234	5242541111
49	1142521111	111	4242443244	173	5242541111	235	5242541111
50	1142541125	112	4242443344	174	5242541111	236	5242541111
51	1242541125	113	5111511111	175	5242541111	237	5242541111
52	1331531125	114	5142243334	176	5242541111	238	5242541111
53	1331531125	115	5142241125	177	5242541111	239	5242541111
54	1331531334	116	5142521111	178	5242541111	240	5242541111
55	1331532125	117	5142542334	179	5242541111	241	5242541111
56	1331532244	118	5142542553	180	5242541111	242	5242541111
57	1331532334	119	5211541453	181	5242541111	243	5242541111
58	1331532344	120	5222542125	182	5242541111	244	5242541111
59	1331533125	121	5222542534	183	5242541111	245	5242541111
60	1331533244	122	5222543125	184	5242541111	246	5242541111
61	1331533334	123	5232343125	185	5242541111		
62	1331533344	124	5232343244	186	5242541111		

Fig. 42. (sheet 2 of 2)

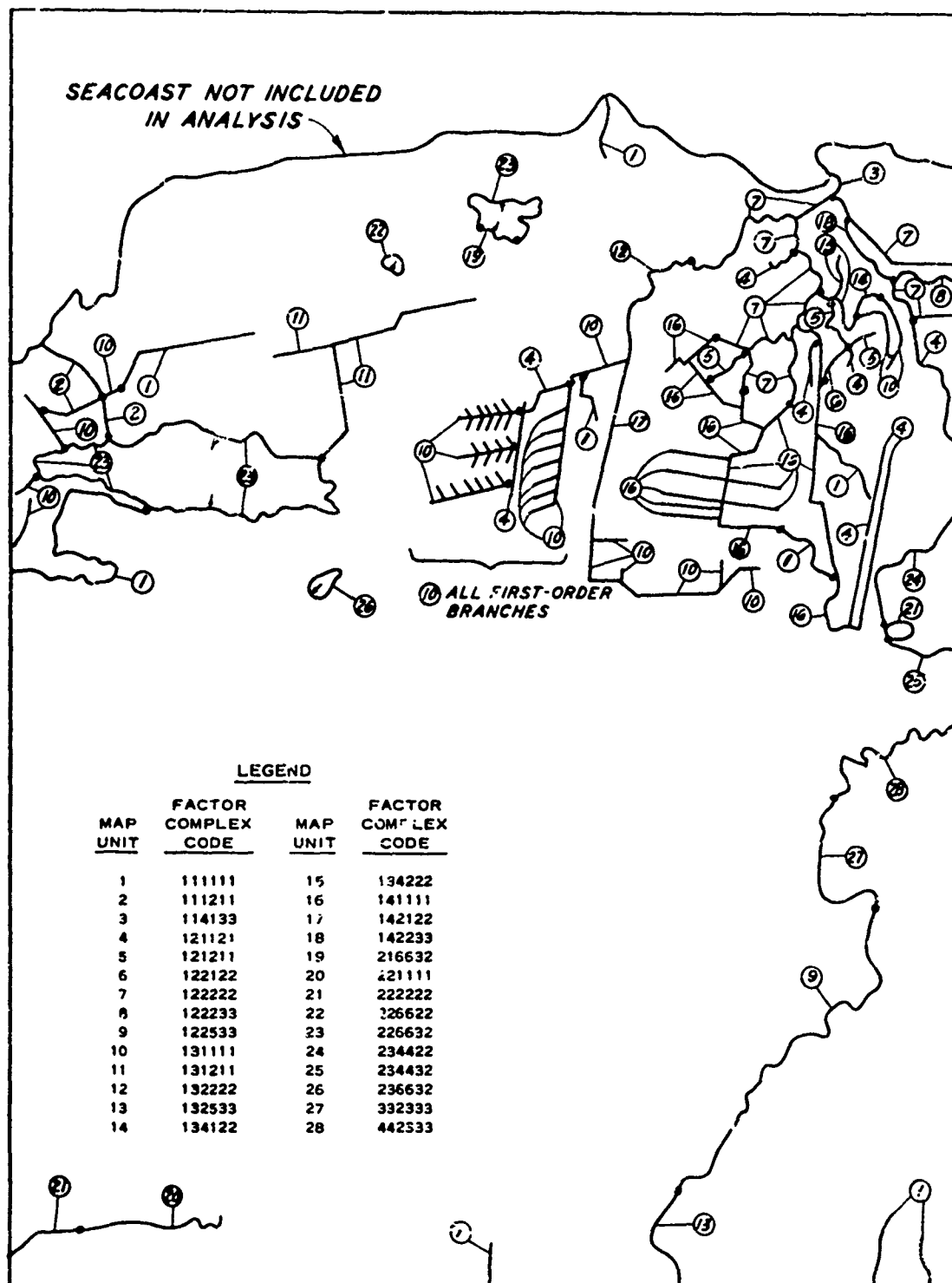


Fig. 43. Factor complex map. Linear features for cross-country speed for vehicles and cross-country speed for personnel.

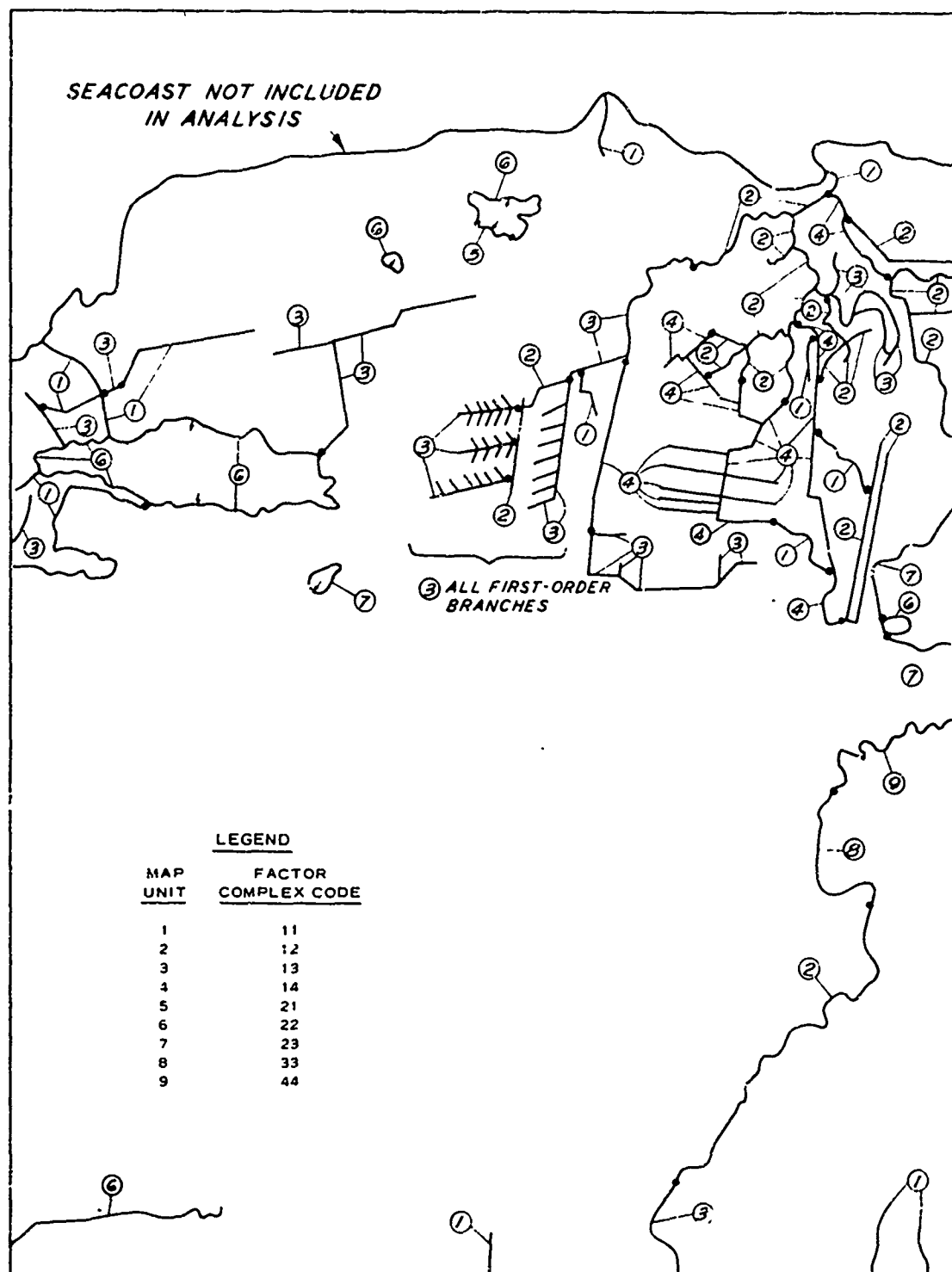
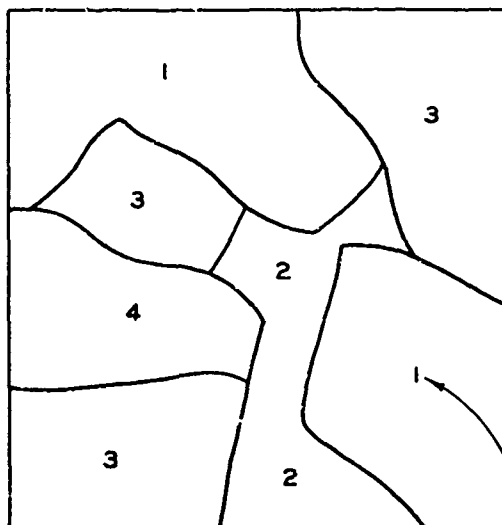


Fig. 44. Factor complex map. Linear features for concealment and cover characteristics

PERFORMANCE PREDICTION MAP



FACTOR COMPLEX MAP UNIT	FACTOR CODE	"MODEL" CALCULATION* (A + 8B = P)	PERFORMANCE CLASS**
1	11	15 + 8.10 = 23	1
2	12	15 + 8.30 = 39	1
3	21	40 + 8.10 = 48	1
4	22	40 + 8.30 = 64	2
5	23	40 + 8.70 = 96	3
6	31	60 + 8.10 = 68	2
7	32	60 + 8.30 = 84	2
8	33	60 + 8.70 = 116	3
9	34	60 + 8.15 = 180	4
10	41	90 + 8.10 = 98	3
11	42	90 + 8.30 = 114	3
12	43	90 + 8.70 = 146	3
13	44	90 + 8.15 = 210	4

* MIDPOINTS OF CLASS RANGES USED FOR CALCULATION.

** PERFORMANCE CLASSES:

CLASS CODE	PERFORMANCE VALUE RANGE
1	20-50
2	51-90
3	91-150
4	151-250

Fig. 45. Preparation of final MGI product map

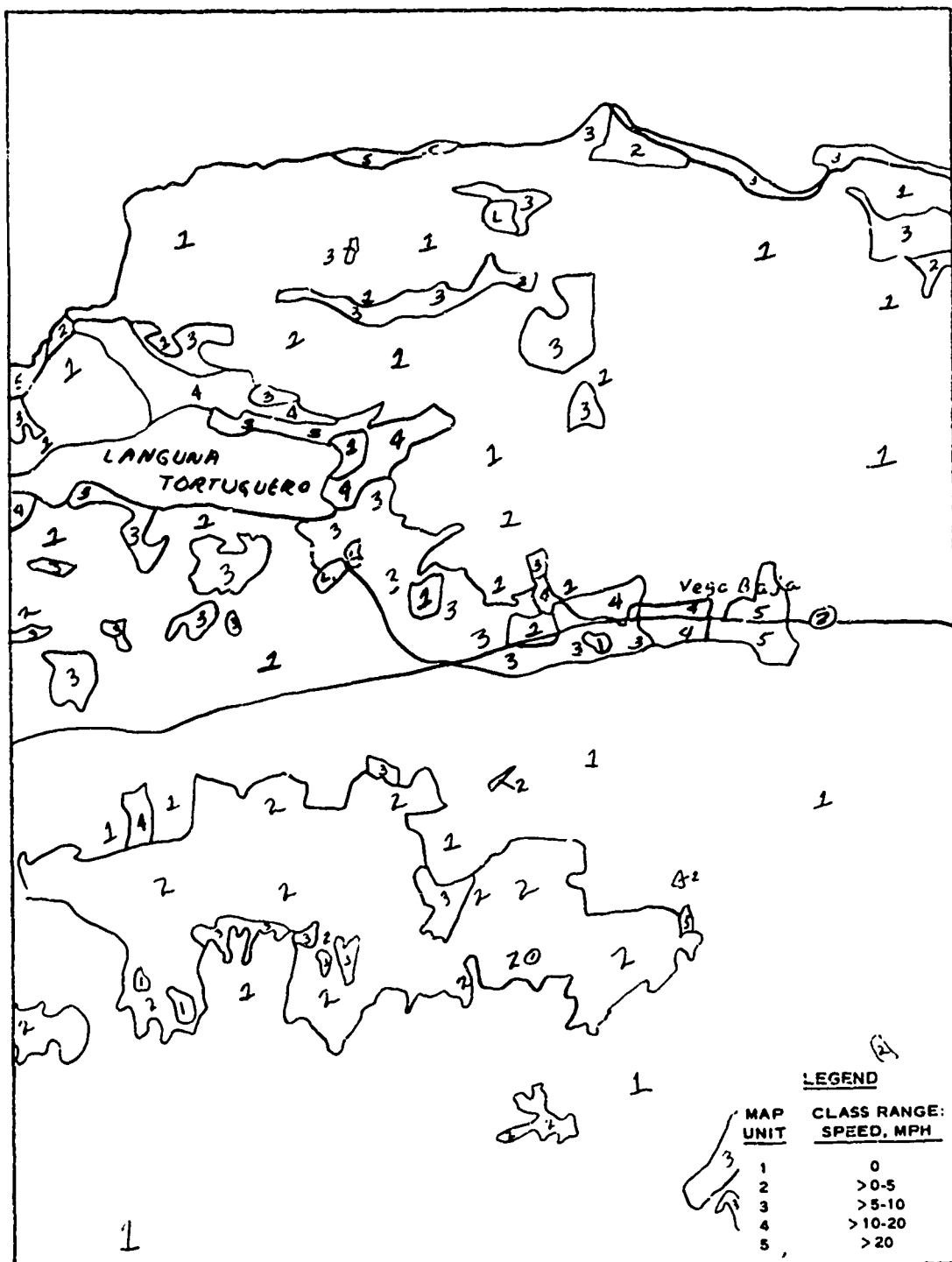


Fig. 46. MGI product map. Cross-country speed for vehicles (M151)

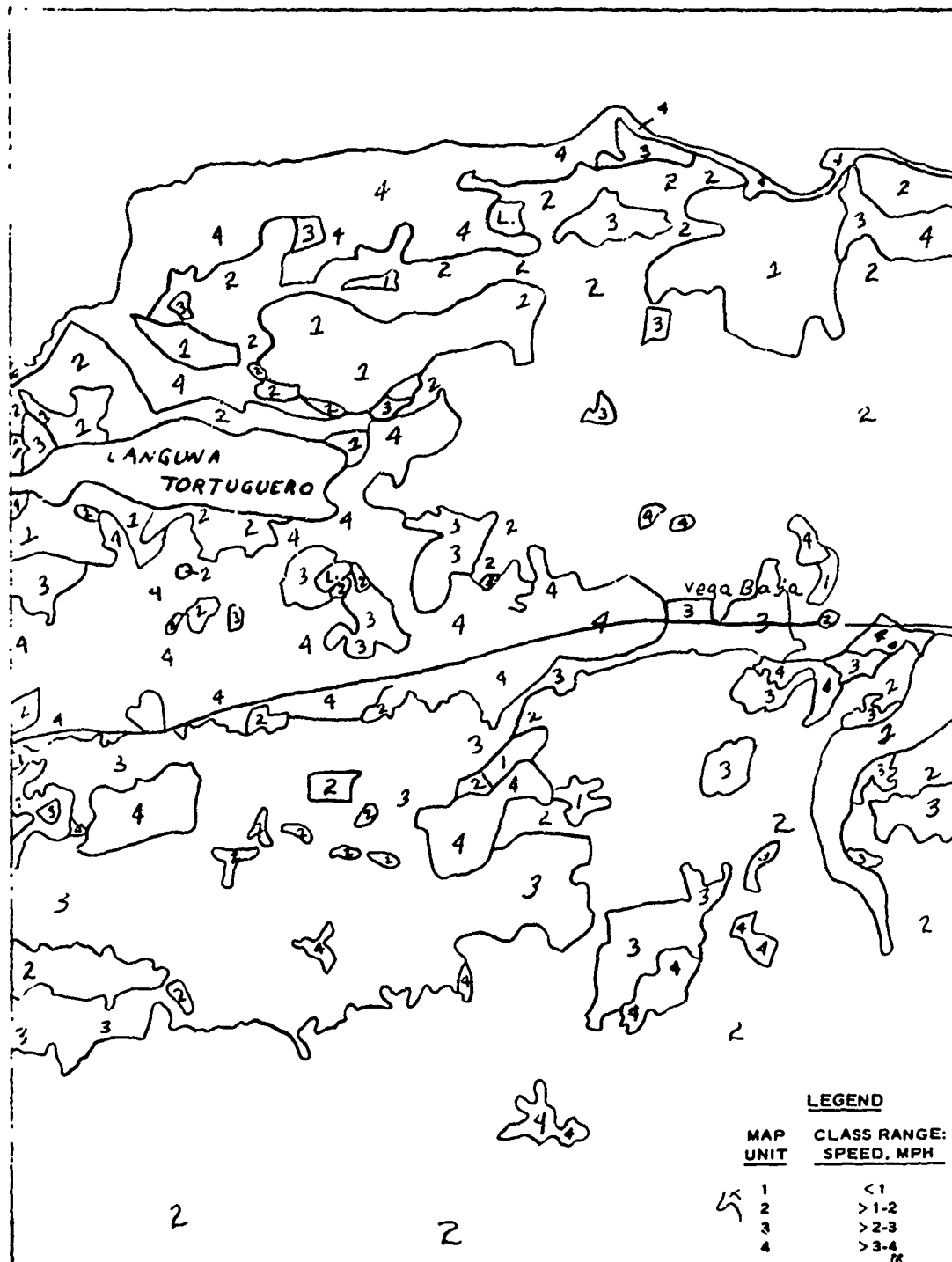


Fig. 47. MGI product map. Cross-country speed for personnel

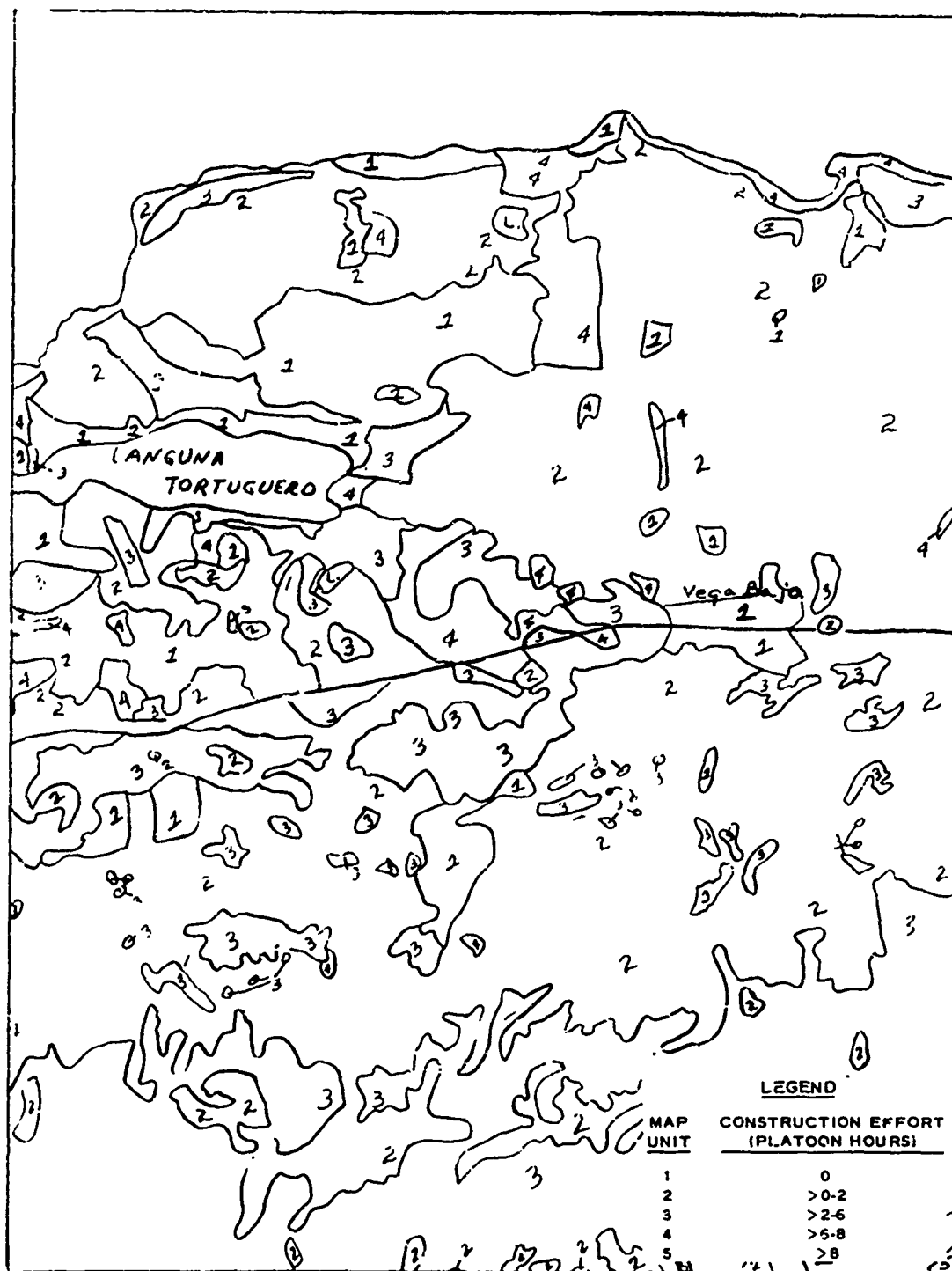


Fig. 48. MGI product map. HLZ construction effort

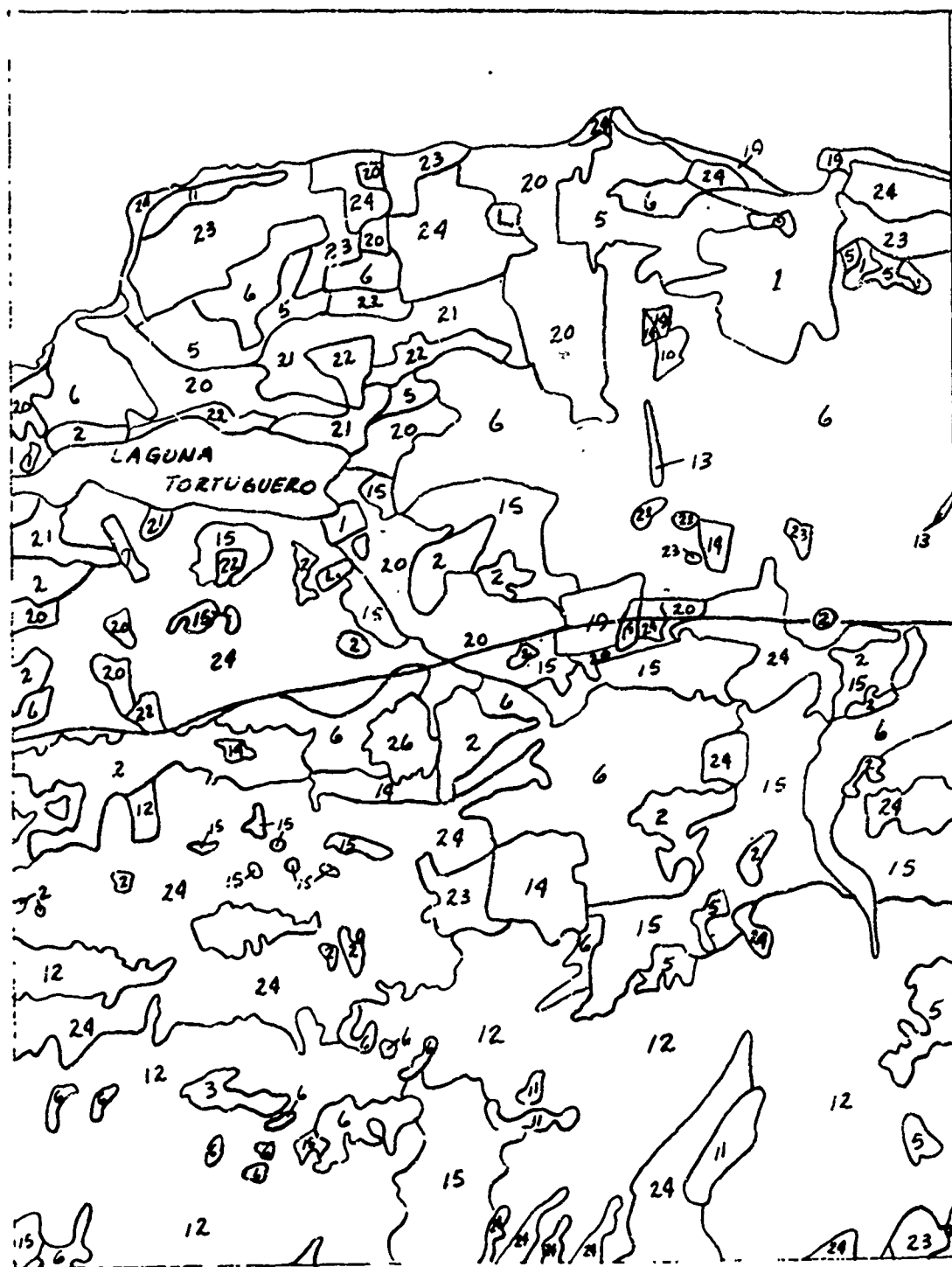


Fig. 49. MGI product map. Concealment characteristics (sheet 1 of 2)

Map Unit	Concealment Code (A)(B)(C)(D)	Map Unit	Concealment Code (A)(B)(C)(D)
1	1311	14	3311
2	1312	15	3312
3	1411	16	3322
4	1412	17	3411
5	2111	18	3412
6	2112	19	3511
7	2121	20	3512
8	2122	21	4211
9	2211	22	4212
10	2212	23	4511
11	2311	24	4512
12	2312	25	4522
13	2512		

Concealment: Parameter Classes and Class Ranges

A. Probability of being observed from the air:

Class	Class Range, %
1	<5
2	>5-10
3	>10-35
4	>35-95

B. Distance at which the line of sight is totally obscured (100% probability):

Class	Class Range, cm
1	0-500
2	500-1000
3	1000-2000
4	2000-5000
5	>5000

C. Largest size of objects to be concealed:

Class	Class Range, m
1	15 x 30 x 200 (man)
2	75 x 150 x 1000 (jeep)

D. Number of objects concealed/1000 m²:

Class	Class Range
1	0-12
2	>12-35

Fig. 49. (sheet 2 of 2)



Fig. 50. MGI product map. Cover characteristics (sheet 1 of 2)

<u>Map Unit</u>	<u>Cover Code</u>		
	<u>(A)</u>	<u>(C)</u>	<u>(D)</u>
1			1211
2			1212
3			1311
4			1312
5			2111
6			2112
7			2121
8			2122
9			2211
10			2212
11			2222
12			2311
13			2312
14			2322

Cover Parameter Classes and Class Ranges

A. Probability of projectile reaching an effective height:

<u>Class</u>	<u>Class Range</u>
1	0-60
2	60-100

B. Distance at which all fire is blocked:

<u>Class</u>	<u>Class Range, m</u>
1	0-20
2	>20-40
3	>40

C. Largest size of objects to be covered:

<u>Class</u>	<u>Class Range, cm</u>
1	15 x 30 x 200 (man)
2	75 x 150 x 1000 (jeep)

D. Number of objects covered/1000 m²:

<u>Class</u>	<u>Class Range</u>
1	0-12
2	>12-35

Fig. 50. (sheet 2 of 2)

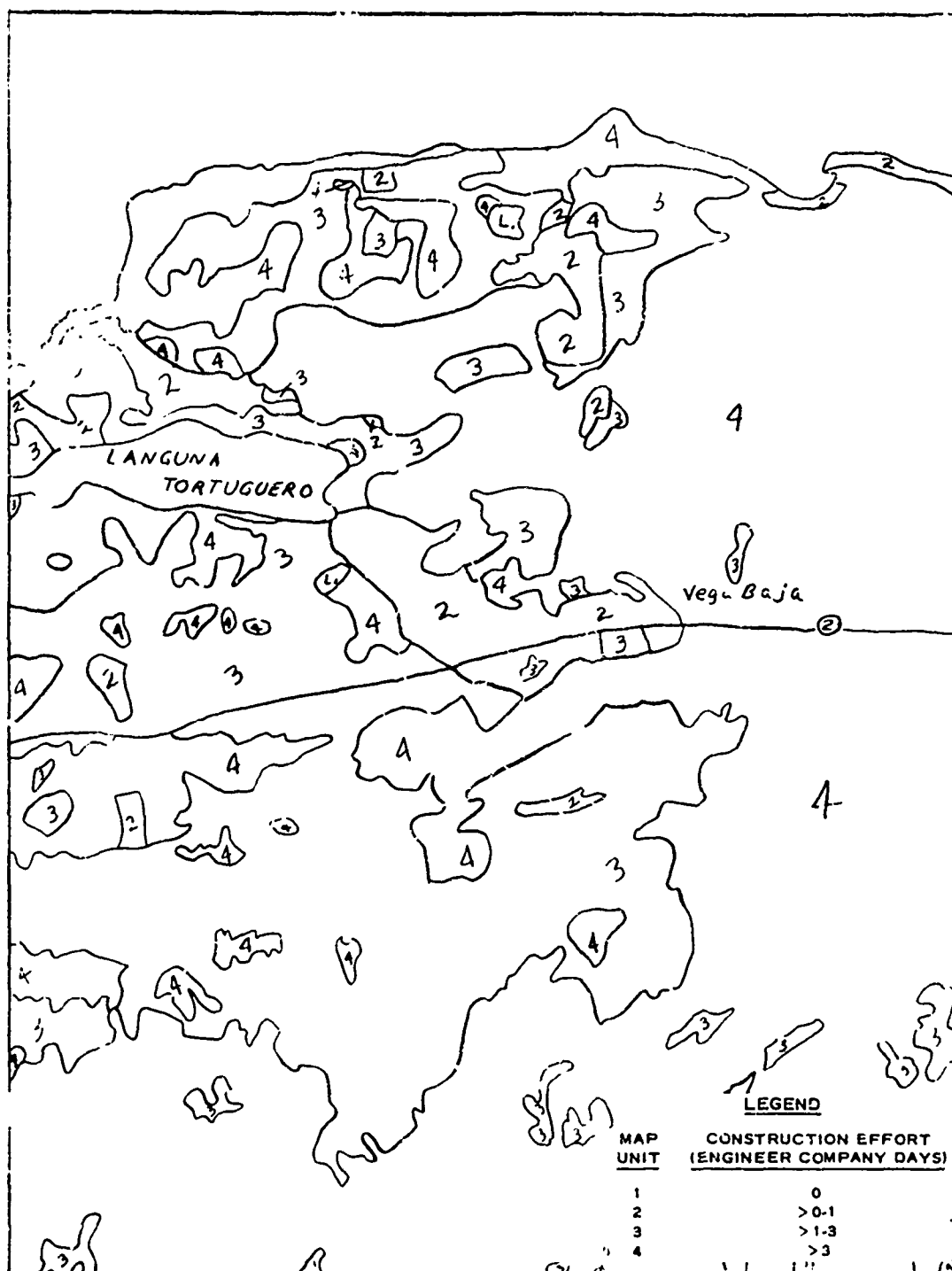


Fig. 51. MGI product map. Airfield construction effort

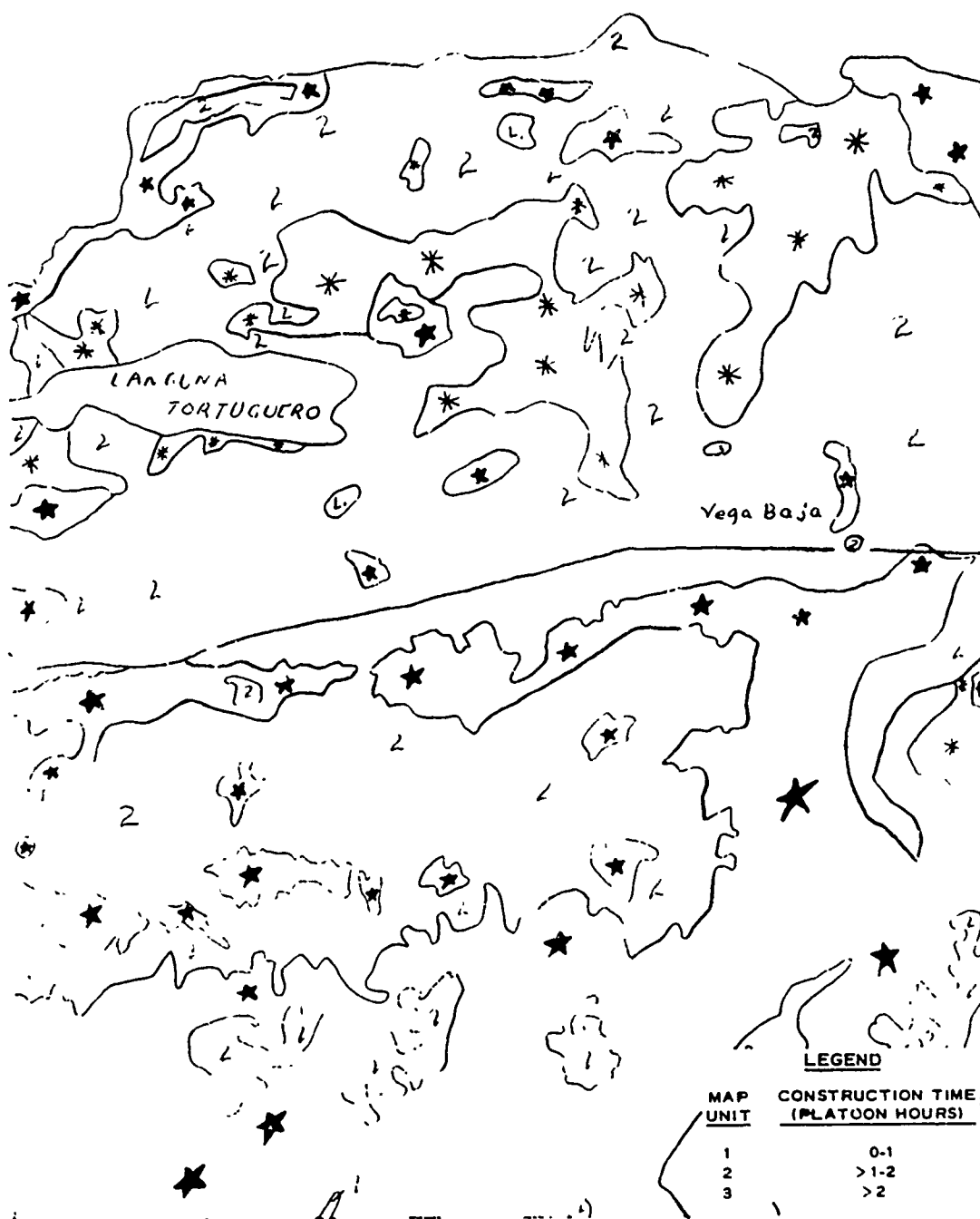


Fig. 52. MGI product map. Bunker construction effort