

AD617706

AD

TECHNICAL REPORT
ES-16

SOME ENVIRONMENTAL ASPECTS OF THE HUMAN
FACTORS TROPICAL FIELD STUDIES

COPY _____ OF _____	91
WORD COPY	\$. 2.00
MICROFICHE	\$. 0.50

by 32-p

Jack V. Chambers
Earth Sciences Division

May 1965

U. S. Army Materiel Command
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts

DDC
JUL 19 1965

B



NEGATIVE COPY

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

DDC AVAILABILITY NOTICE

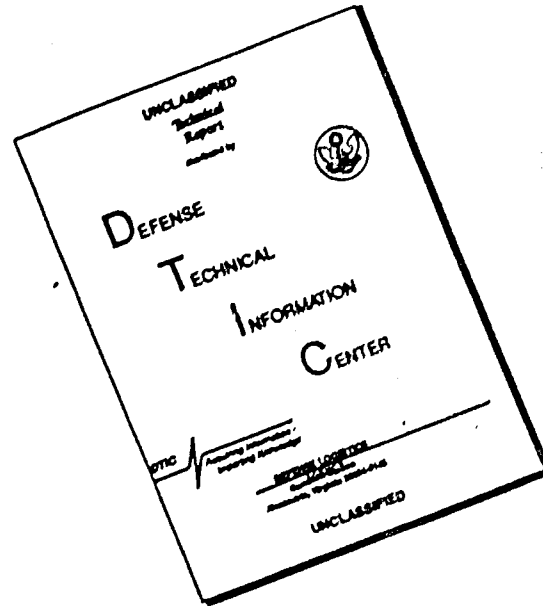
Qualified requesters may obtain copies of this report from Commanding Officer, Defense Documentation Center (DDC) (formerly ASTIA), Cameron Station, Alexandria, Virginia 22314.

Released to the Clearing House for Federal Scientific and Technical Information, Springfield, Virginia 22151, for sale to the public.

DISPOSITION INSTRUCTIONS

Destroy; do not return.

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

**CLEARINGHOUSE FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION, CFSTI
INPUT SECTION 410.11**

AD617706

**LIMITATIONS IN REPRODUCTION QUALITY OF TECHNICAL ABSTRACT BULLETIN
DOCUMENTS, DEFENSE DOCUMENTATION CENTER (DDC)**

- 1. **AVAILABLE ONLY FOR REFERENCE USE AT DDC FIELD SERVICES.
COPY IS NOT AVAILABLE FOR PUBLIC SALE.**
- 2. **AVAILABLE COPY WILL NOT PERMIT FULLY LEGIBLE REPRODUCTION.
REPRODUCTION WILL BE MADE IF REQUESTED BY USERS OF DDC.**
 - A. **COPY IS AVAILABLE FOR PUBLIC SALE.**
 - B. **COPY IS NOT AVAILABLE FOR PUBLIC SALE.**
- 3. **LIMITED NUMBER OF COPIES CONTAINING COLOR OTHER THAN BLACK
AND WHITE ARE AVAILABLE UNTIL STOCK IS EXHAUSTED. REPRODUCTIONS
WILL BE MADE IN BLACK AND WHITE ONLY.**

TSL-121-2/65

DATE PROCESSED: *7/22/65*
PROCESSOR: *A. Sutton*

AD

**TECHNICAL REPORT
ES-16**

**SOME ENVIRONMENTAL ASPECTS OF THE HUMAN FACTORS
TROPICAL FIELD STUDIES**

by

**Jack V. Chambers
Desert and Tropic Laboratory
Earth Sciences Division**

**Project Reference:
1V025001A129**

May 1965

**U. S. Army Materiel Command
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts**

FOREWORD

A comprehensive assessment of the physical environment and operational hardships of the combat soldier operating in the wet-tropics is of vital concern to the U.S. Army. This report describes the environmental factors involved in the first of a series of investigations planned by Pioneering Research Division, NLABS, on the human factors aspect of the soldier operating in the wet tropics. Specific objectives were to determine use and compatibility of equipment, the nature of the tasks performed by the soldier in the field in the execution of assigned missions, and to describe the physical and operational environment in which these assigned missions were performed.

It is well known that knowledge of the environment is essential to successful military operations. The best preparation in advance planning is required to solve problems created by a number of variables such as the commander, the proper time to accomplish the mission, the necessary motivation, the correct size of the unit, the best physical conditioning of the men, the proper skills, the correct tactics, the lightest load and the right food, clothing, and equipment. Even with all of the factors taken care of, it is necessary that the best route be selected and followed according to a fixed timetable. This will depend on the type of environment, namely the terrain, soil, vegetation, and weather conditions likely to be encountered. For these reasons this study of climatic and physical characteristics of some of the field exercises taken at Fort Sherman, Canal Zone, has been made.

PEVERIL MEIGS, Ph.D.
Chief
Earth Sciences Division

Approved:

DALE H. SIELING, Ph.D.
Scientific Director

W. W. VAUGHAN
Brigadier General, USA
Commanding

CONTENTS

	<u>Page</u>
List of Tables	v
List of Figures	v
Abstract	vi
1. The problem: purpose and scope	1
2. Techniques and methods	1
3. Fort Sherman area	3
4. Data from reconnaissance patrols	4
5. Data from the combat patrols	9
6. Data from raids	9
7. Findings and recommendations	10
8. Acknowledgements	11
9. References	12

LIST OF TABLES

<u>Table</u>	<u>Page</u>
I - Mobility rates for field exercises	5
II - Climatic summary of field exercises	6
III - Terrain summary of field exercises	7

LIST OF FIGURES

1. Fort Sherman, Canal Zone, Human Factors Exercise Routes
2. Reconnaissance patrol routes
3. Reconnaissance patrol profiles
4. Combat patrol routes
5. Combat patrol profiles
6. Wet season raid profile
7. Dry season raid profile

ABSTRACT

The purpose of this study was to determine which environmental factors influence the performance (especially mobility rate) of the Quartermaster-equipped soldier in the tropics. The method was for an environmental observer to accompany troops on three types of operational exercises (reconnaissance and combat patrols and raid exercises) during both wet and dry seasons at Fort Sherman, Canal Zone.

Data were recorded showing: weather, movement, terrain, surface conditions and vegetation at regular intervals. Tables are presented summarizing climatic conditions, terrain and mobility rates. Maps and route profiles show vegetation types and surface geology.

The results of the reconnaissance and combat patrols are not such that they could be generalized on or explained by the environment. However, in the raid operations significant differences were found between the data for the two seasons. The slower mobility rate of the wet season is attributed to: (1) the prevalence of mud (the greatest hindrance to movement), (2) the debilitating effects of high humidity (the most significant environmental factor affecting comfort) and (3) a lower visibility than in the dry season. Other factors, significant in both seasons are: frequency of obstacles (streams, gullies and deadfalls), and dense stands of vegetation.

SOME ENVIRONMENTAL ASPECTS OF THE HUMAN FACTORS TROPICAL FIELD STUDIES

1. The problem: purpose and scope

The problem was to develop techniques and methodology for measuring activity and performance capabilities of the Quartermaster-equipped soldier and apply these to military operations in tropical environments. One important purpose was to determine which environmental factors, such as climate, terrain, vegetation, or soil types, influence performance in the tropics by affecting, for example, mobility rates. Finding and determining the specific factors that are significant and the degree of their significance is most important in giving future guidance to tropical research efforts.

First, a literature survey was made, followed by a reconnaissance survey of some tropical and semi-tropical areas under the jurisdiction of the United States or friendly ally. Based on these surveys, Fort Sherman Military Reservation in the Canal Zone was selected as having the largest number of the required environmental characteristics to be investigated. In addition, there were available for observation U.S. soldiers performing in representative tactical and operational exercises in the environmental conditions desired.

2. Techniques and methods

The first step in developing techniques and methodology for recording activity and environmental characteristics was to list and assign working definitions to terms used and for which data were to be gathered. The second step required was to select realistic tactical and operational exercises. A necessary criterion was that each would be representative of simulated combat conditions and yet be observable without interfering with the tactical play itself. Other factors considered were that the exercises be repeatable and that the exercises offer a wide range of tropical environments. Taking into consideration all of the above conditions, the following three types of tactical and operational exercises were selected to be observed: reconnaissance patrol, combat patrol, and raid:

The reconnaissance patrol is a patrol action that departs from a friendly base avoiding contact with the enemy, observes the enemy's position or installation, and returns to a friendly base with certain military information.

The combat patrol varies from the reconnaissance patrol in that it destroys the enemy's position or installation, then rendezvous at a previously arranged point.

The raid is very similar to the combat patrol; the difference is that a larger group of men is involved, and it is longer and more extensive in scope.

The environmental observer positioned himself in the center of the squad of men when it was moving in column, in order to interfere as little as possible with the tactical play. On those occasions when for any reason it was necessary for members of the squad element to separate, the observer followed the maneuvering element.

The data collected by both the environmental observer and the human engineer observers were recorded on a tropicalized wire recorder strapped to the observer's chest with an attached tie clip microphone. In addition, each observer wore a synchronized water-proof wrist watch for recording time of collecting all data. For ready reference, the various categories of environmental criteria to be collected were placed on a water-proof laminated card attached to a cord about the observer's neck. Upon completion of the exercise, the collected data were tabulated or transferred to IBM cards for machine processing.

Using an aspirated psychrometer during the wet season exercises (August) and a sling psychrometer during the dry season exercises (January) climatic observations were taken every hour on the hour or when there was a significant change, such as rain or darkness, recording the time of change. An example of a recording by the environmental observer was: "0900, dry bulb 82°F, wet bulb 78°F, walking level, muddy, sticky, water-covered, scattered, vine covered, thorny, and light." Thus the following were recorded: time, weather, movement, terrain, surface conditions, and vegetation.

From the data collected an estimate of mobility rate for each exercise was made. It is presented in Table I. These rates were calculated on two bases:

- a. $\frac{\text{Map distance}}{\text{Time in movement}} = \text{Mobility rate}$
- b. $\frac{\text{Map distance}}{\text{*Total time of exercise}} = \text{Average speed enroute}$

The map distance of the route followed was used in each case as an estimate of the actual distance traversed.

* Excluding bivouac and temporary encampment time, but including time spent in rest halts and contact with enemy forces.

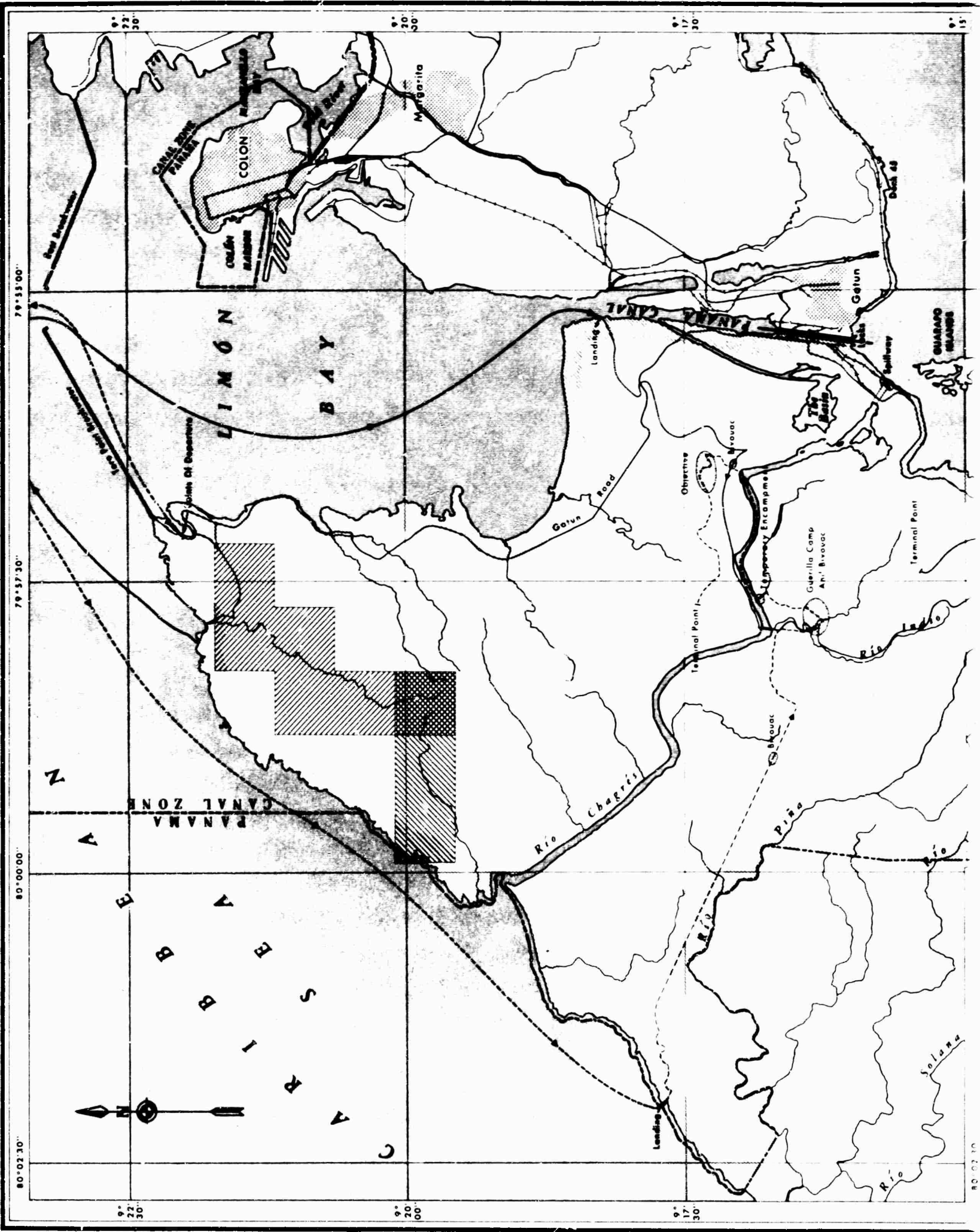


FIGURE 1

A

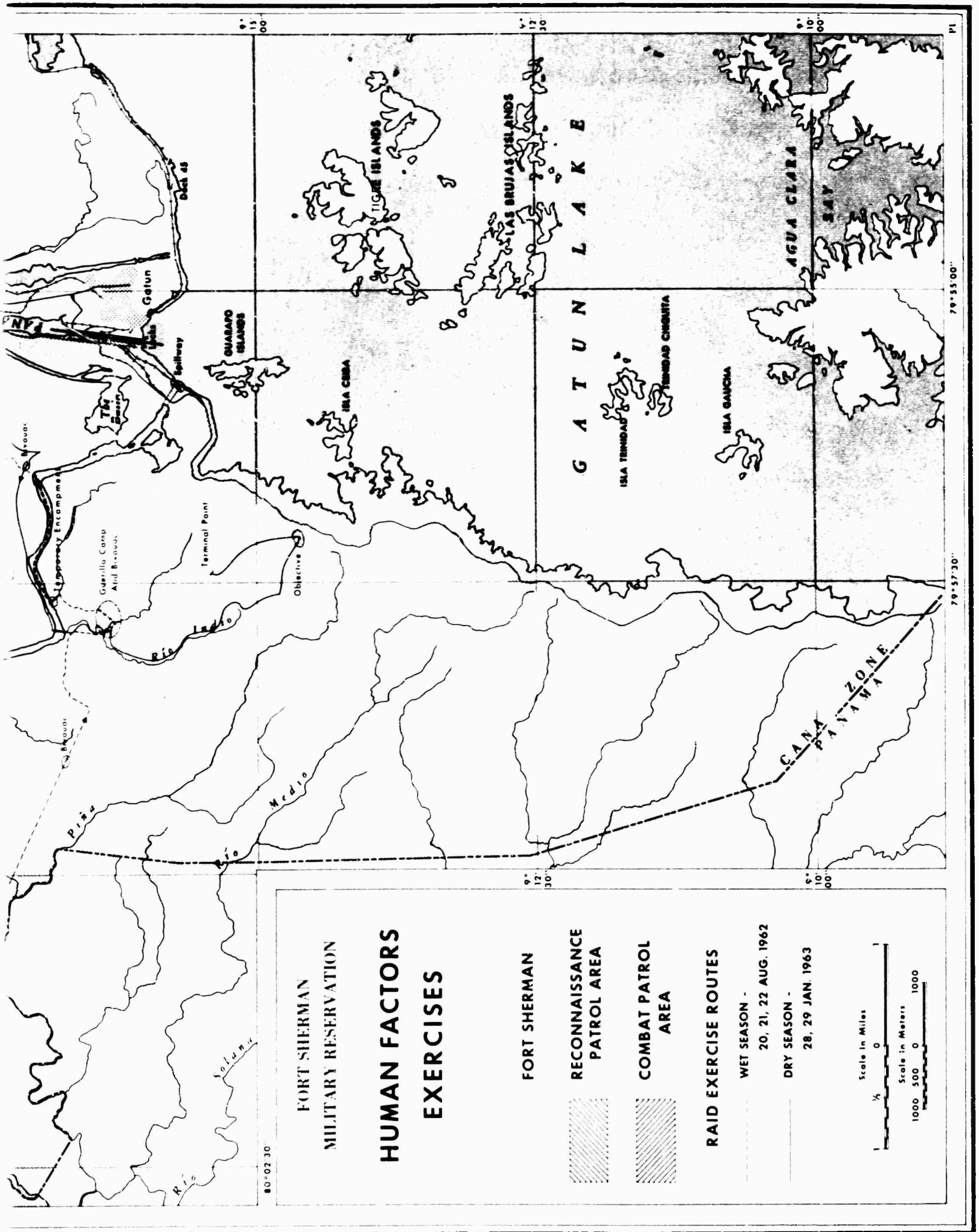


FIGURE 1

B

3. Fort Sherman area

From a climatic and geographical viewpoint, Fort Sherman Military Reservation is the most favorable tropical area for training and testing under the jurisdiction of the United States (Fig. 1). It encompasses major humid-tropic climatic, terrain, vegetation, and soil texture types, and includes natural wildlife hazards and provides the environmental stresses necessary to induce physiological stresses in the troops training there.

The climate is predominantly tropical marine, with no large variations in temperature. The average annual precipitation is about 130 inches, most of which falls during the rainy season from May through December. The mean relative humidity is high, usually about 80 percent. The north-east trade winds blow steadily during much of the year, but like all forested areas, there is little wind, 3 mph or less, within the rain forest.

The terrain varies from flat, low-lying swamplands to low hills with elevations up to 715 feet. The hills have rounded tops, steep slopes, and narrow valleys. Alluvial plains constitute the remaining portion of Fort Sherman. The coast is characterized by coral formations and a series of low, steep cliffs, interspersed with sandy beaches. Tropical mountainous terrain, desired for training and testing, is lacking; however, the cliffs along part of the Rio Chagres are precipitous and are used in training.

Dense stands of vegetation are a dominant feature of the humid tropic environment. At Fort Sherman vegetation falls into two major categories: upland and lowland types.

Based primarily on the total amount and seasonality of rainfall, there are three natural upland types: rain forest, tropical deciduous forest, and savanna grassland. Because man has cut and burned areas within each of these three vegetation types, secondary growth has occurred in each. These upland vegetation types cover 84.6 percent of the Fort Sherman area. In size, this is 28,595 acres or 44.7 square miles. Rain forest is the most common of the three types, covering 35.3 percent of the total area of Fort Sherman.

Five specialized vegetation types are found on the flat alluvial lowlands of Fort Sherman. They are: cativo, coastal thicket, mangrove, manicaria, and raffia palm swamp. Also, secondary growth is found for many of these natural types. These lowland vegetation types cover only 15.4 percent of the Fort Sherman area. In size, this is 5,187 acres or 8.2 square miles. Cativo, the most extensive, is the tallest of the lowland vegetation types. It covers 5.1 percent of the total area of Fort

Sherman. The specialization of lowland vegetation is based primarily on type of drainage or salinity of the water. Most of the types do not occupy clear-cut areas, but tend to merge gradually from one type to another.

The major soil textural types i.e., rock, gravel, sand, silt, clay, and muck, are found at Fort Sherman in sufficient amounts for training and testing purposes.

Fort Sherman is also very rich in many forms of wildlife, including a variety of amphibians, reptiles, mammals, and insects. The reptiles include poisonous snakes, such as bushmaster, fer-de-lance, and coral snake; the mammals include the puma, ocelot, jaguarondi, and many types of monkeys; the insects include the anopheles mosquito, fleas, ticks, bugs, and flies.

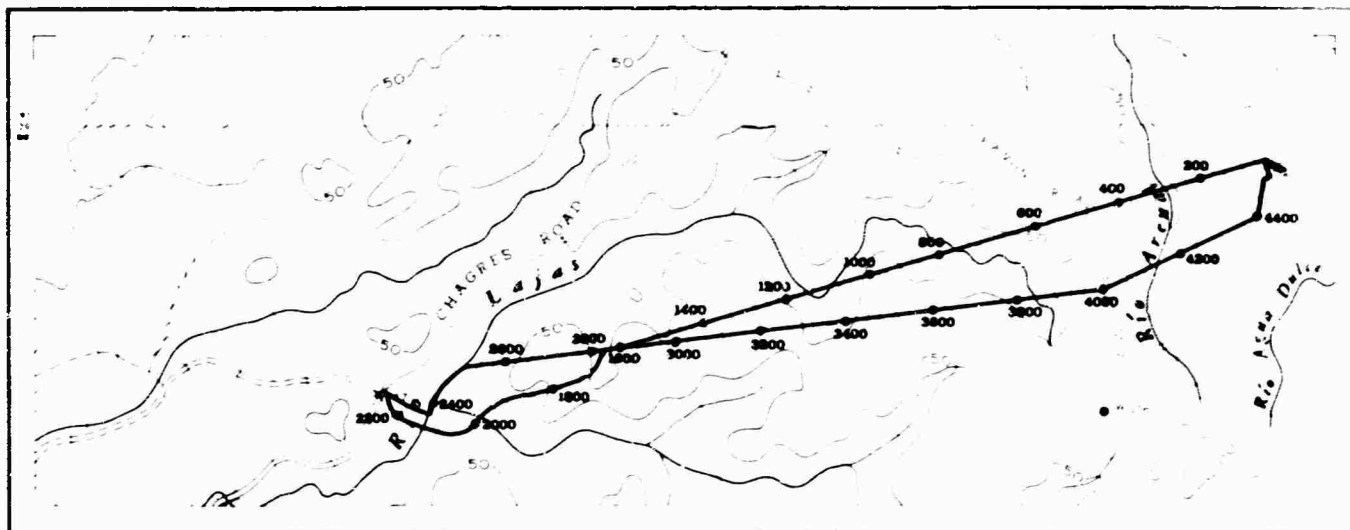
4. Data from reconnaissance patrols

The reconnaissance patrol took place in a hilly rain-forested area of Fort Sherman (Figs. 1, 2, and 3). It was essentially a patrol action that departed from Pavon tower and scouted the road junction S-8 (Chagres Road) and S-8F Road and returned. The total distance was approximately 4,250 meters (2.64 miles) round-trip if a direct route were followed. Environmental data (climate, terrain and mobility rates) were gathered for one patrol during the wet season and for two patrols during the dry season (Tables I-III).

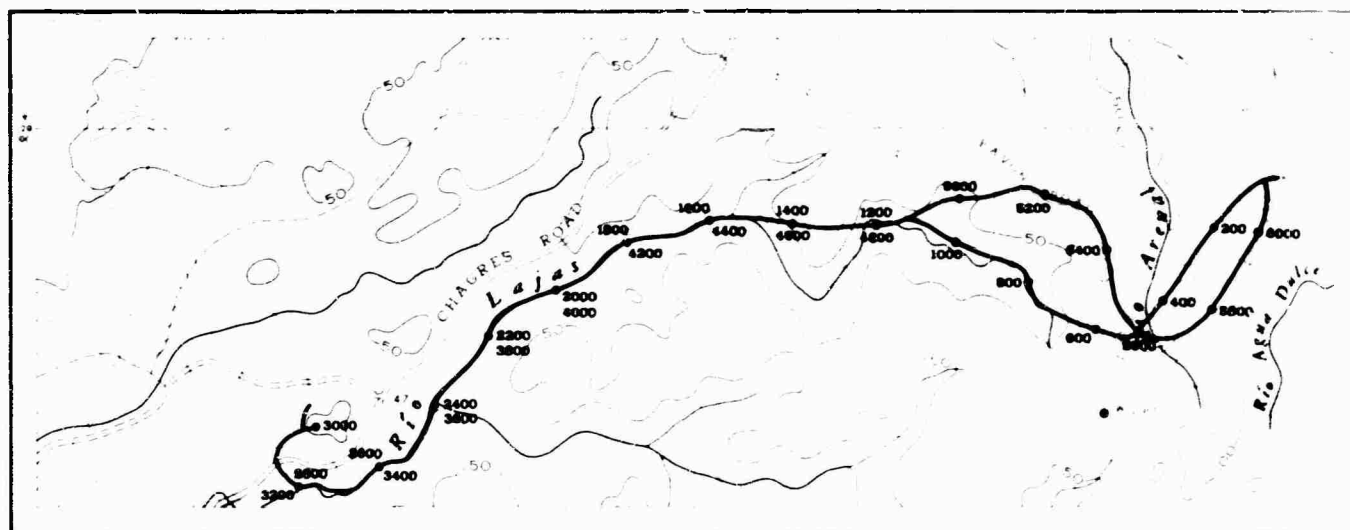
The wet season patrol took a direct compass course to and from the objective, deviating only to circumvent difficult obstacles. In this way their route was the shortest. Their total distance covered was 4,550 meters (2.83 miles) or only 300 meters more than the straight-line distance. Most of the time (93.4%) was traveled in the rain forest and the rest (6.6%) in rain forest secondary growth. A total of 136 direction changes were made because of the frequent obstacles encountered, such as deadfalls, small streams, and gullies (Table I). These obstacles were a very significant factor in slowing down the mobility rate of this particular patrol. Also, 28.6% of the terrain covered required the use of handholds because of the steep and slippery ground surface (Table III). This slippery condition was the result of the early morning rains softening the thin vegetative covered clay soil of the rain forest prior to the mission (Table II). Presumably, these environmental factors, along with the high humidity with high temperatures, had a debilitating effect on the men. The resulting mobility rate was only 996 meters per hour (0.63 mph).

The two dry-season patrols, on the other hand, appeared to have considered the terrain and vegetation in planning their routes to and from the objective.

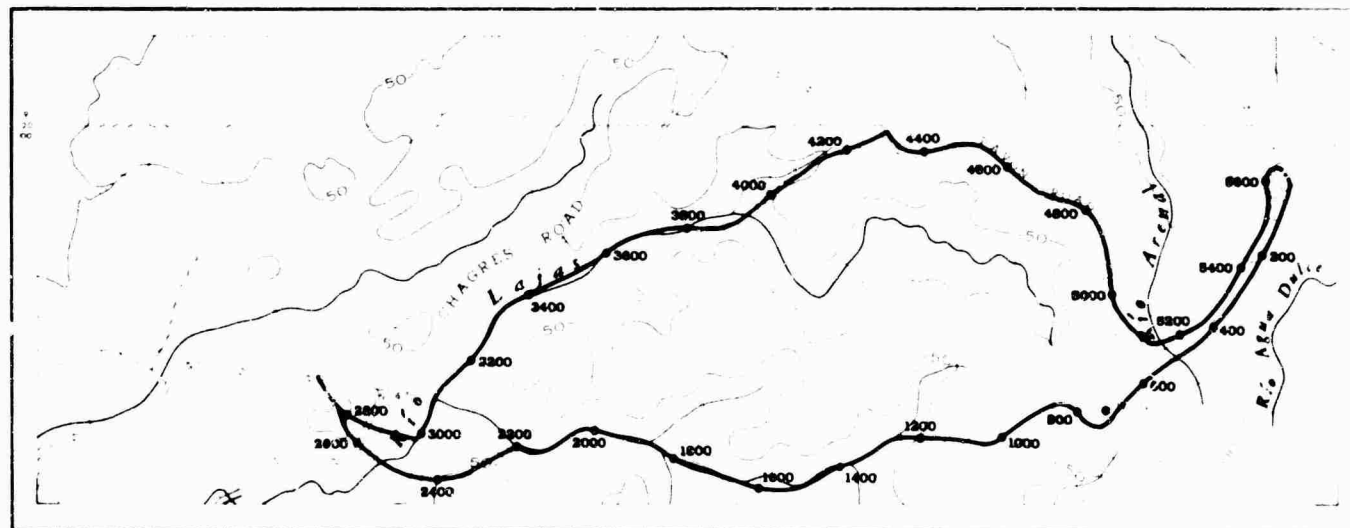
RECONNAISSANCE PATROL EXERCISES



WET SEASON - 15 AUGUST 1962



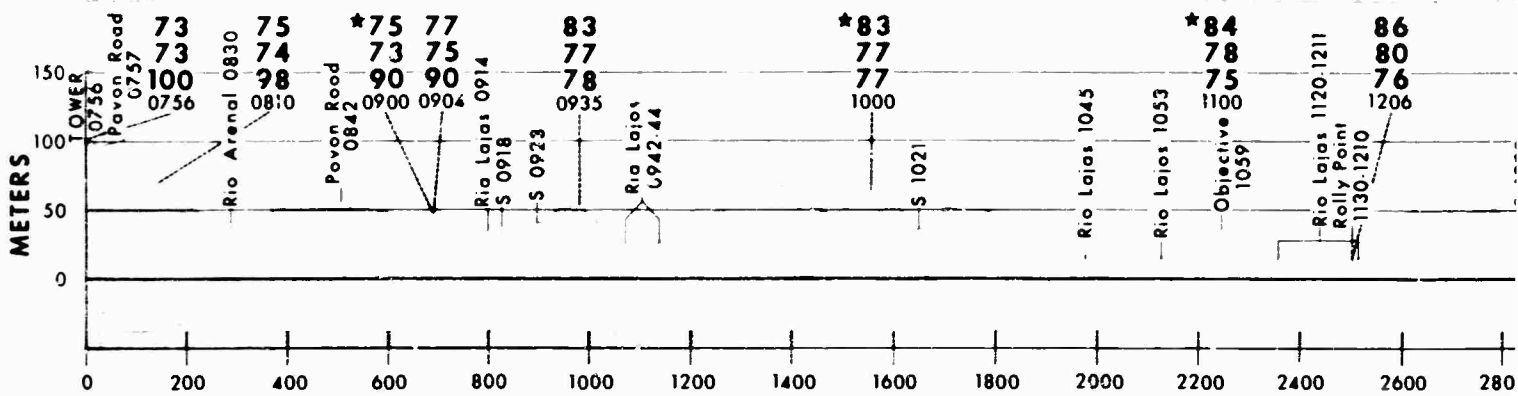
DRY SEASON PATROL I - 23 JANUARY 1963



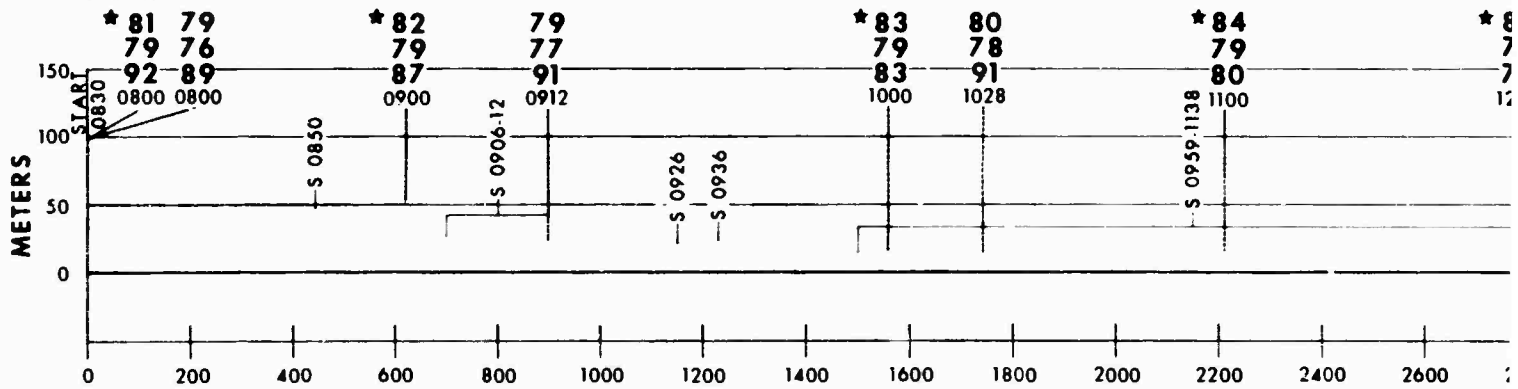
DRY SEASON PATROL II - 23 JANUARY 1963

FIGURE 2

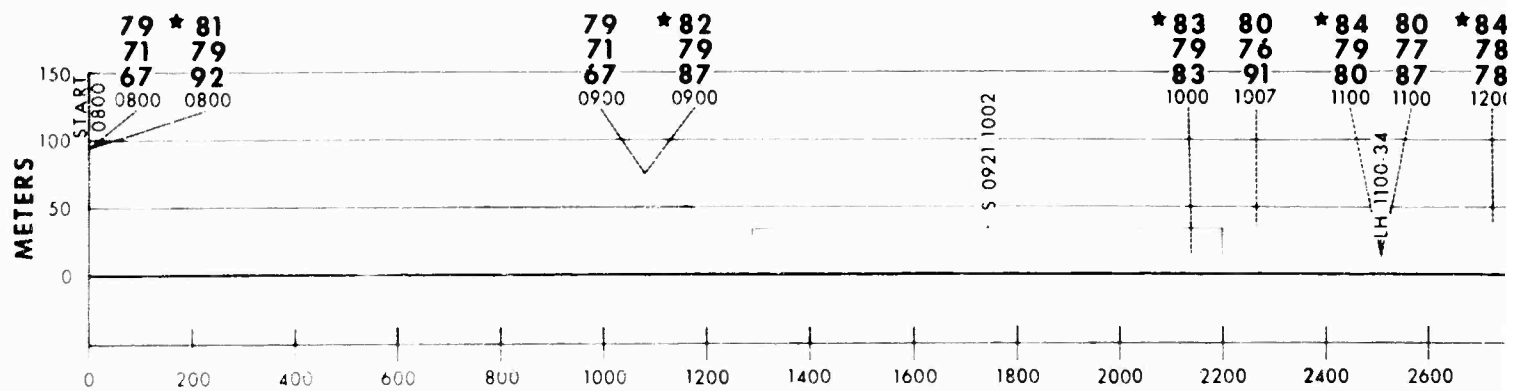
RECO ROUTE PROFILE WITH S



WET SEASON - 1



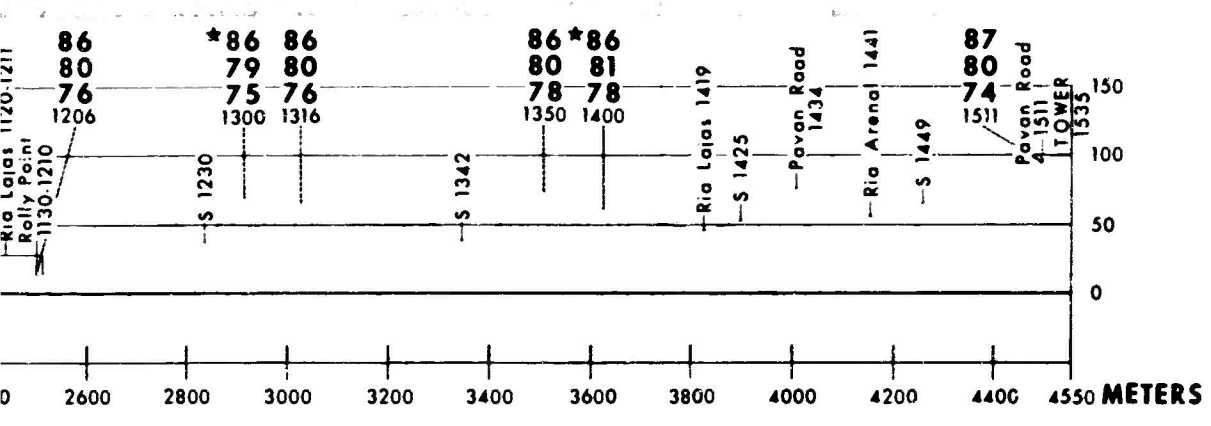
DRY SEASON PAT



DRY SEASON PATRO

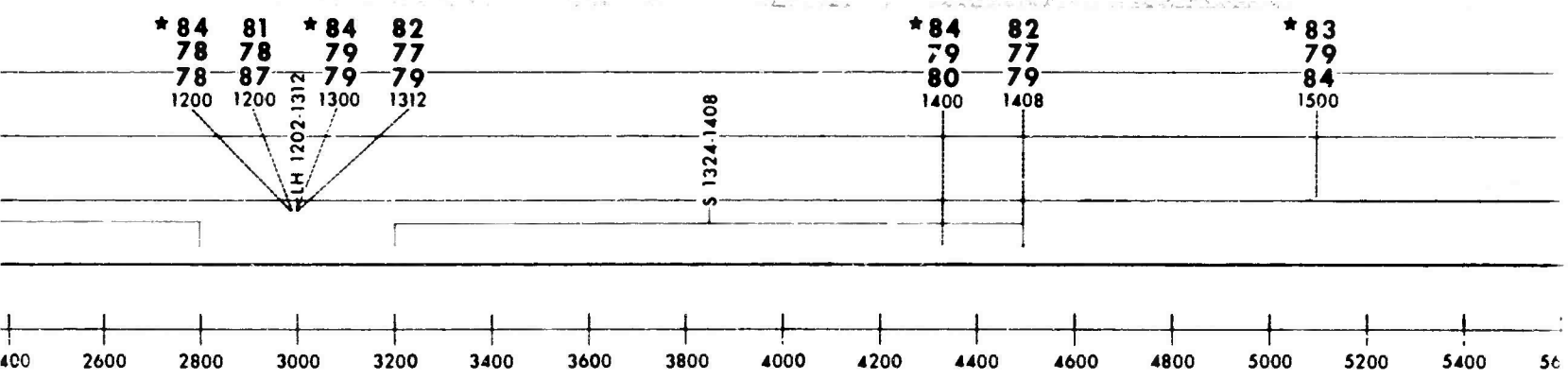
A

RECONNAISSANCE PATROL WITH SURFACE GEOLOGY AND VEGETATION TYPES

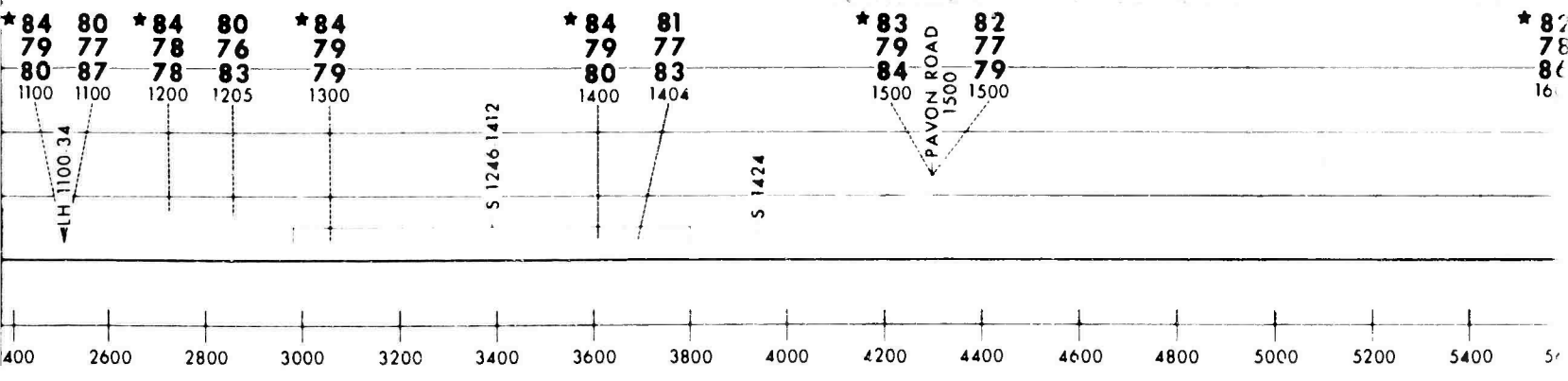


PATROL I - 15 AUGUST 1962

CLIMATE	*84 79 80 131
VEG	
Vertica	
NOTE:	



PATROL I - 23 JANUARY 1963



PATROL II - 23 JANUARY 1963

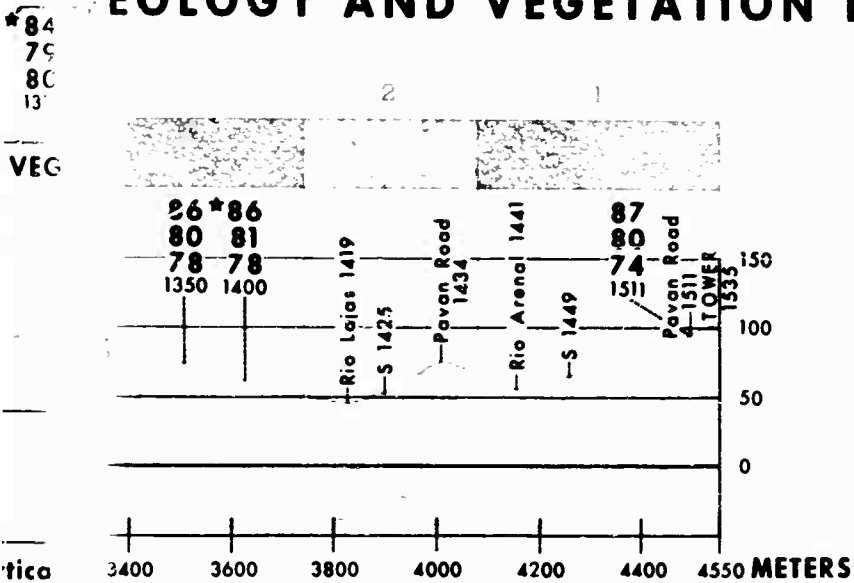
FIGURE 3

B

ANCE PATROL

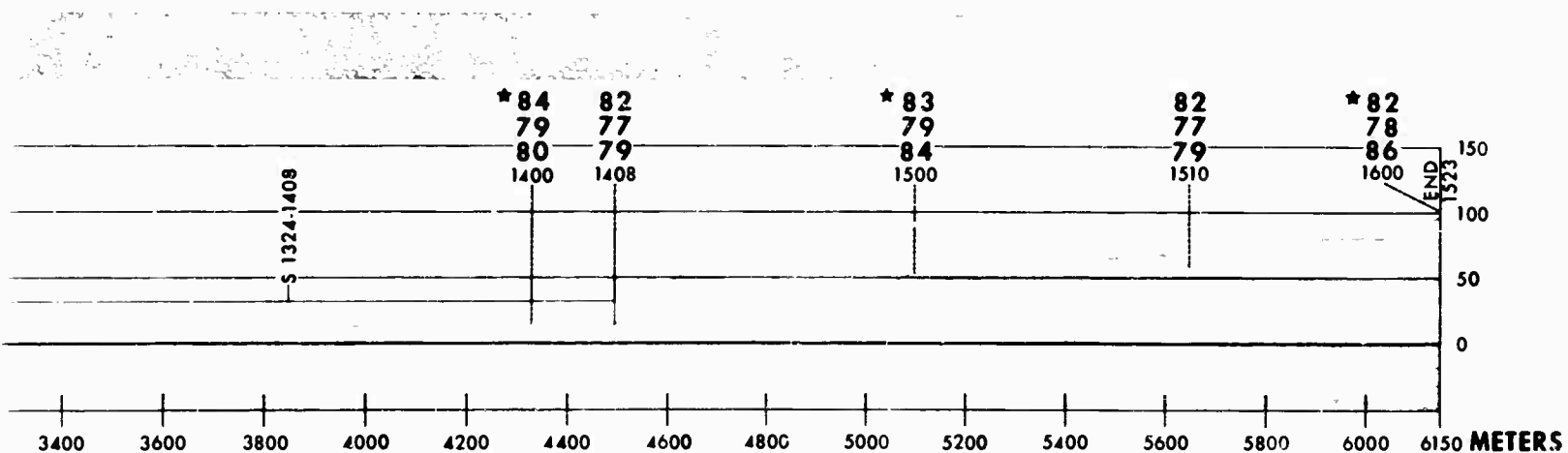
EOLOGY AND VEGETATION TYPES

LEGEND	
CLIMATE	STATION DATA
	*84 DRY BULB TEMPERATURE
	79 WET BULB TEMPERATURE
	80 RELATIVE HUMIDITY
1310 TIME OF OBSERVATION	
VEGETATION TYPES	
RAIN FOREST	
RAIN FOREST - Secondary Growth	
SAVANNA GRASSLAND	
GEOLOGY	
LOWER PLIOCENE CHAGRES SANDSTONE	
Vertical Exaggeration - 1:5	

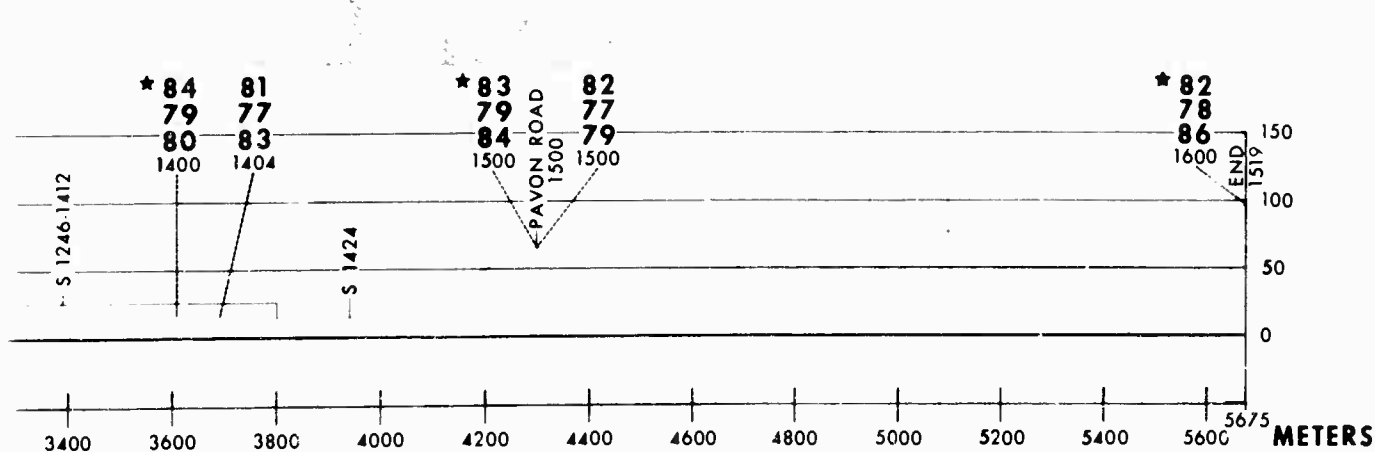


ST 1962

NOTE: S = STREAM
LH = LUNCH HALT



3 JANUARY 1963



ANUARY 1963

C

TABLE I MOBILITY RATES FOR FIELD EXERCISES

Exercise	Season	Map Distance (m)	Time in Movement (min)	Mobility Rate (m/hr)	Number of Stops	Time Stopped (min)	Total Time of Exercise (min)	Avg. Speed Enroute (m/hr)	Direction Changes
Reconnaissance Patrol	Wet	4,550	298	996	10	147	445	613	136
Reconnaissance Patrol #1	Dry	6,150	364	1,013	9	75	439	840	59
Reconnaissance Patrol #2	Dry	5,675	183	1,861	22	230	413	824	57
Combat Patrol	Wet	4,900	186	1,580	28	111	307	958	64
Combat Patrol	Dry	4,550	322	848	10	82	322	848	48
Raid #1	Wet	6,250	676	554	-	64	740	506	96
Raid #2		4,600	525	526	-	314	839	329	35
Raid #3		3,675	248	889	-	168	416	530	13
Raid Total		14,525	1,449	656	-	378	1,995	437	144
			(24h, 9m)	(avg)			(33h, 15m)	(avg)	
Raid #1	Dry	10,575	557	1,134	24	252	809	780	50
Raid #2		6,325	504	752	45	195	609	623	86
Raid Total		16,900	1,061	943	69	447	1,418	702	136
			(17h, 41m)	(avg)			(23h, 38m)	(avg)	

TABLE II CLIMATIC SUMMARY OF FIELD EXERCISES

Exercise	Season	Highest dry bulb temperature (°F)	Lowest dry bulb temperature (°F)	Dry bulb temp. range (°F)	Average dry bulb temperature (°F)	Highest wet bulb temperature (°F)	Lowest wet bulb temperature (°F)	Wet bulb temp. range (°F)	Average wet bulb temperature (°F)	Highest relative humidity (%)	Lowest relative humidity (%)	Relative humidity range (%)	Average relative humidity (%)	Precipitation (in.)
Reconnaissance Patrol 15 August 1962	Wet	87	73	14	81.6	80	74	6	78	100	74	26	84	*0.22
Reconnaissance Patrol #1 23 January 1963	Dry	82	79	3	80.1	77	71	6	75	91	67	24	80	*0.00
Reconnaissance Patrol #2 23 January 1963	Dry	82	79	3	82.1	78	76	2	77	91	79	12	85	*0.00
Combat Patrol 16 August 1962	Wet	87	81	6	83.8	82	78	4	80	90	69	21	82	*0.02
Combat Patrol 24 January 1963	Dry	88	78	10	81.6	78	75	3	76	86	64	22	77	*0.00
Raid #1 20 August 1962	*83	*74	*9	*77.4	77	74	74	3	75	*100	*82	*18	*92	*0.25
Raid #2 21 August 1962	*88	*80	*8	*85.1	*82	*75	*75	*7	*79	*95	*74	*21	*82	*0.02
Raid #3 22 August 1962	*87	*73	*9	*83.2	*83	*75	*75	*8	*78	*90	*74	*16	*82	*0.00
Raid #1 28 January 1963	83	74	9	80.2	78	73	73	5	77	95	80	15	*86	*0.00
Raid #2 29 January 1963	82	76	6	79.0	77	75	75	2	76	95	76	19	86	*0.00

*Fort Sherman shelter station data used.

TABLE III TERRAIN SUMMARY OF FIELD EXERCISES (in percent)

Exercise	Season	Walking Level	Downhill		Uphill		Both Handholds		
			Walking	Handholds	Walking	Handholds		Total	
Reconnaissance Patrol	Wet	12.0	35.2	9.9	45.1	24.2	18.7	42.9	28.6
Reconnaissance Patrol #1	Dry	23.5	34.4	4.3	38.7	37.8	0.0	37.8	4.3
Reconnaissance Patrol #2	Dry	50.6	8.2	8.9	17.1	9.1	23.2	32.3	32.1
Combat Patrol	Wet	20.4	40.8	9.2	50.0	15.3	14.3	29.6	23.5
Combat Patrol	Dry	17.0	44.6	8.2	52.8	23.1	7.1	30.2	15.3
Raid #1	Wet	25.2	14.4	5.6	20.0	42.8	12.0	54.8	17.6
Raid #2		63.4	13.0	5.5	18.5	14.7	3.4	18.1	8.9
Raid #3		54.4	10.9	2.7	13.6	26.6	5.4	32.0	8.1
Raid Average		47.7	12.8	4.6	17.4	28.0	6.9	34.9	11.5
Raid #1	Dry	63.4	14.6	0.1	14.7	21.1	0.8	21.9	0.9
Raid #2		23.9	19.0	18.4	37.4	21.8	16.9	38.7	35.3
Raid Average		43.7	16.8	9.3	26.1	21.5	8.9	30.3	18.1

Dry season patrol #1 selected the longest route, 6,150 meters (3.82 miles) or 1,900 meters more than the straight-line distance. A total of 59 direction changes were made (Table I). The terrain covered was largely made up of slope conditions, 37.8% being uphill slope for the men and 38.7% being downhill slope (Table III). Only 23.5% of the terrain was level and 4.3% was so steep that handholds had to be used. The vegetation was of the "scattered" category more than 98% of the time. Only four obstacles were encountered: one deadfall, and three streams (Fig. 3). Thus, in summary, reconnaissance dry season patrol #1 spent most of the time in passing through scattered vegetation on sloping terrain encountering a deadfall and crossing an occasional small stream. Their total elapsed time was the longest of the three reconnaissance exercises examined, and their mobility rate was 1,013 meters per hour (0.63 mph).

Dry season patrol #2 planned and took the best route by most geographic standards. Their total distance was 5,675 meters (1.07 miles) or 1,425 meters more than the straight-line distance, and their total elapsed time from base camp was shortest, 6 hours and 53 minutes (Table I). They made a total of 22 halts totaling 3 hours and 50 minutes or 44.5% of the time. This would indicate that they rested often but moved rapidly when conditions permitted. They made a total of 57 direction changes. The terrain covered was 50.6% level, 32.3% uphill slope, 17.1% downhill slope; nevertheless, handholds were required 23.2% of the time uphill and 8.9% of the time downhill (Table III). The vegetation was of the "scattered" category 100% of the time. Only five obstacles were encountered: one deadfall and four streams. In summary, dry season patrol #2 spent most of the time in passing through scattered vegetation on level terrain and obstacles that required little time to overcome (Fig. 3). Their total elapsed time was the shortest of the three reconnaissance exercises examined, and their mobility rate was 1,861 meters per hour (1.16 mph) by far the fastest of the three (Table I).

To summarize the three reconnaissance exercises; there were significant differences in the total elapsed time and the mobility rates between the wet season patrol and patrol #1 of the dry season on the one hand and patrol #2 of the dry season on the other hand. Three patrols are too few to provide a basis for sound generalizations. However, the data suggest the following: the route selected and followed is of prime importance, as it determines the number of direction changes and the frequency of obstacles encountered. The visibility, ground condition, weather, vegetation density, and season of the year are all factors which influence mobility rate. Patrol #2 of the dry season points to the importance of resting often but not longer than necessary, and moving as rapidly as the terrain and vegetation permit. However, in many cases the "best" route for foot movement may not be the best route from a tactical standpoint.

5. Data from the combat patrols

The combat patrol described here also departed from Pavon Tower and moved to an objective (Figs. 4 and 5). In this case the objective was only 1,350 meters (0.84 miles) away. The patrol then rendezvoused 3,000 meters (1.86 miles) farther on, near the junction of S-8 (Chagres Road) and Shimney Beach road, making a total directline distance of 4,350 meters (2.7 miles) traveled from Pavon Tower. Data were gathered for one patrol in both wet and dry seasons. The routes selected by the two patrol leaders (Figs. 4 and 5) appear to be very similar to each other in every respect with only minor variations. The wet season patrol took a slightly longer route. Neither was very much longer than the straight-line distance of 4,350 meters (2.7 miles). The total elapsed time from patrol base was 5 hours 7 minutes for the wet season patrol, and 5 hours 22 minutes for the dry season patrol (Table I).

The wet season patrol encountered 64 direction changes, while the dry season patrol had only 48 direction changes. The terrain covered by the wet season group was 50.0% downhill slope, 29.6% uphill slope, and 20.4% level (Table III). Handholds for descending were required 9.2% of the distance and for ascending 14.3% of the distance. The dry season route was 52.8% downhill, 30.2% uphill, and 17.0% level. Handholds for descending were required 8.2% of the distance, and for ascending 7.1% of the distance. The only obstacles were small streams and gullies. For both combat patrol exercises most of the time was spent in passing through scattered vegetation on sloping terrain. In summary, there were significant differences in total time in movement (wet season patrol 3 hours 6 minutes and dry season patrol 5 hours 22 minutes) and mobility rates (wet season patrol 1,580 meters per hour or 0.98 mph and dry season patrol 848 meters per hour or 0.53 mph) not reflected in the total elapsed times (wet season patrol 5 hours 7 minutes and dry season patrol 5 hours 22 minutes). The environmental characteristics encountered by these two groups do not appear to explain this difference. It therefore is probably explained only by the activity of the men other than marching.

6. Data from raids

The raid was unlike the reconnaissance and combat patrol exercises in that the group was company rather than patrol size. Also, on the raid exercises different landing areas, objectives, bivouacs, and rendezvous points were used (Fig. 1). As a result, total distance traveled and length of time varied considerably between the two exercises. Thus, there was no opportunity to compare the effect of environmental conditions. During the wet season, data were gathered for a raid that lasted 2½ days, and during the dry season, data were collected on a raid that lasted 2 days (Figs. 6 and 7).

The wet season raid group covered 14,525 meters (9.03 miles) in a total elapsed time of 30 hours and 27 minutes (Table I and Fig. 6). Their average mobility rate was 656 meters per hour (0.41 mph), and they made a total of 144 direction changes. They traveled on level terrain 47.7% of the distance, 34.9% uphill, and 17.4% downhill (Table III). Handholds were necessary for 11.5% of the distance traveled. Precipitation occurred during the early morning hours of the first two days (Table II), tending to make footing extremely laborious, slippery and hazardous.

The dry season raid group covered 17,075 meters (10.61 miles) in a total elapsed time of 24 hours and 38 minutes (Table I and Fig. 7). Their average mobility rate was 943 meters per hour (0.59 mph), and they made a total of 136 direction changes. They traveled on level terrain 43.7% of the distance, 30.3% uphill, and 26.1% downhill (Table III). Handholds were necessary 18.1% of the distance traveled. The length of the two raid exercises would be very similar if the first 2,500 meter (1.55 miles) march of the dry season group preceding the boarding of the landing craft was discounted. Also, the total number of direction changes is comparable (144, 136) (Table I). The vegetation was of the scattered category more than 95% of the time for both exercises. The number of obstacles was of only minor significance and there were only a few.

To summarize the two raid exercises; there were significant differences in the total elapsed times (wet season 33 hours 15 minutes and dry season 23 hours 38 minutes) and the mobility rates (wet season 656 meters per hour or 0.41 mph and 943 meters per hour or 0.59 mph) (Table I). One explanation is that the muddy condition of the ground caused by the early morning rains of the wet season slowed walking (Table II). The debilitating effects of high humidity with high temperature conditions may have been an added factor in causing early fatigue among these men. Visibility was greater during the dry season since many of the deciduous trees and shrubs had shed their leaves. The streams had less water in them during the dry season and their banks and the banks of gullies were less slippery than during the wet season.

7. Findings and recommendations

In the analysis of the environmental parameters of the human factors field studies performed at Fort Sherman, Canal Zone, the following findings and recommendations are made.

Mobility rates of soldiers operating in various tropical vegetation and terrain types require further investigation. It is not a simple problem, as no single factor determines the difference in mobility rate. Mobility rates are influenced by the interactions of: (1) the man aspects: the decisions of the commander, the time allocated to accomplish the mission, motivation, size of the unit, physical condition of the men.

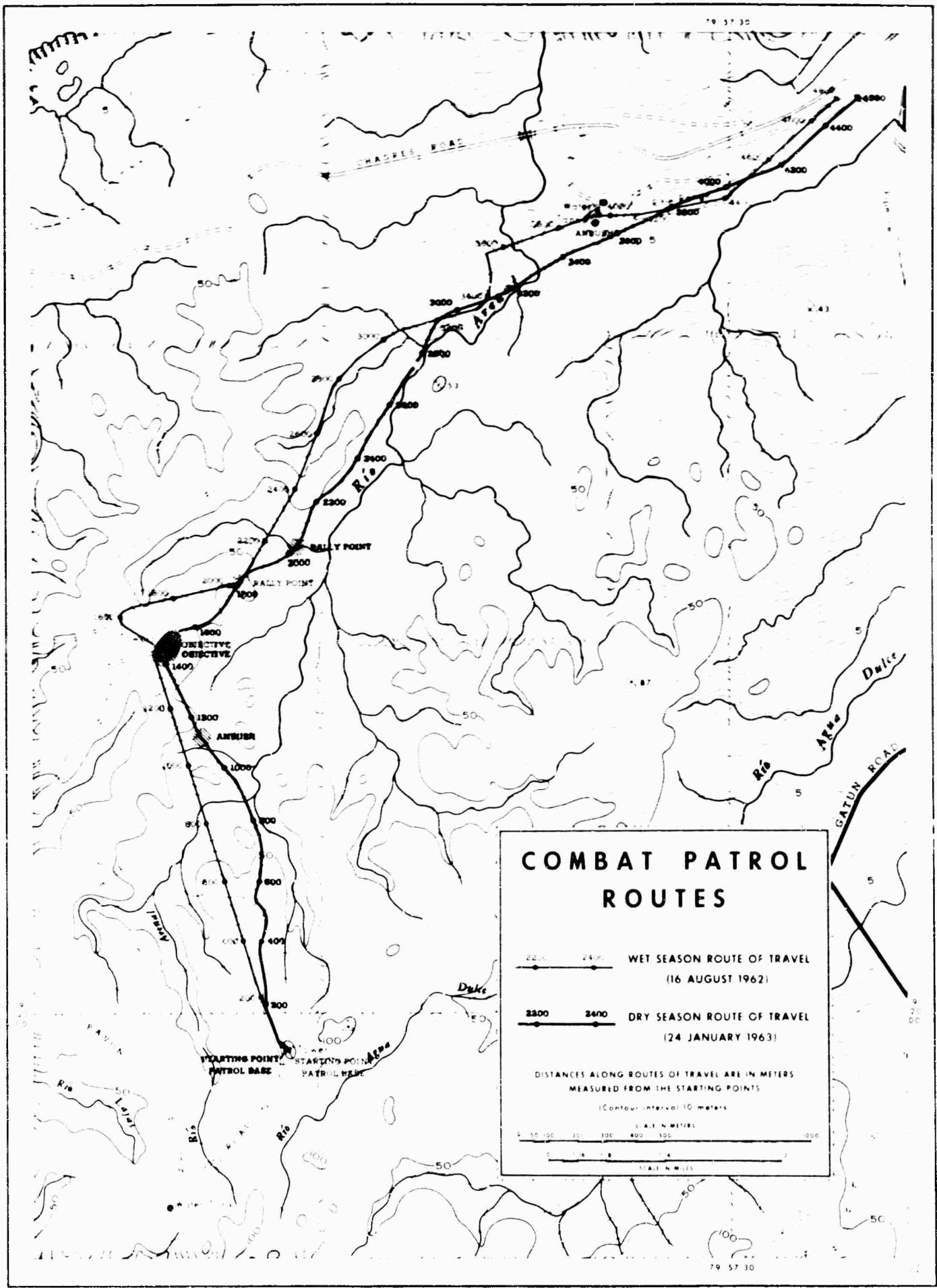
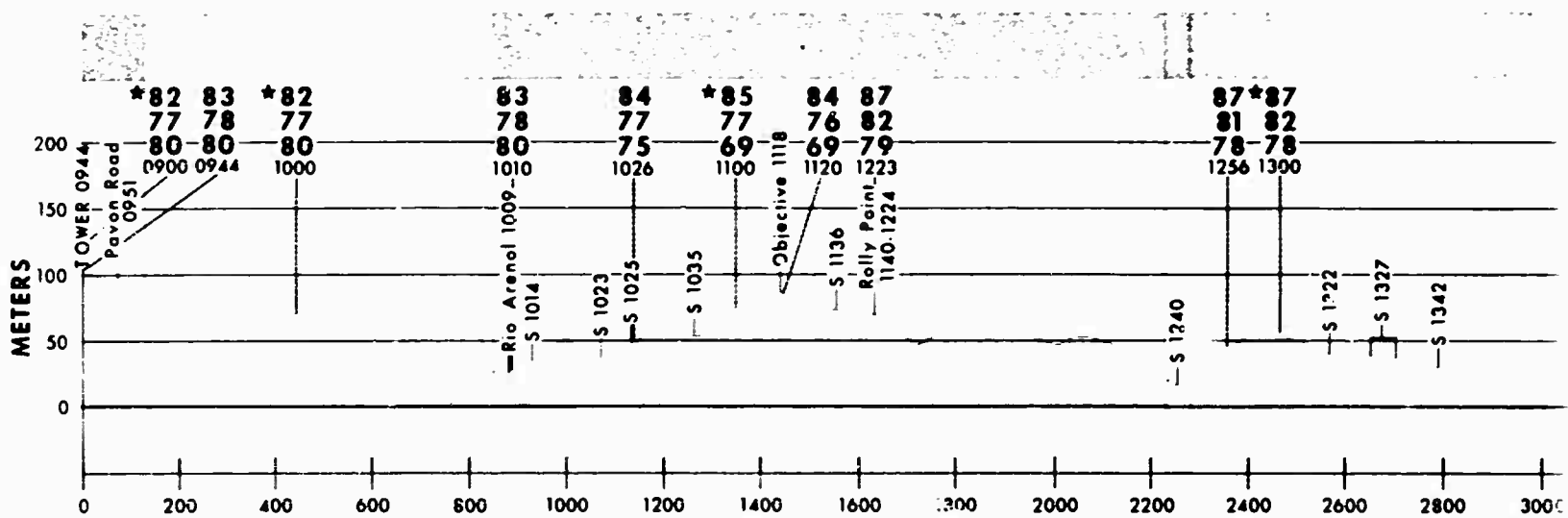
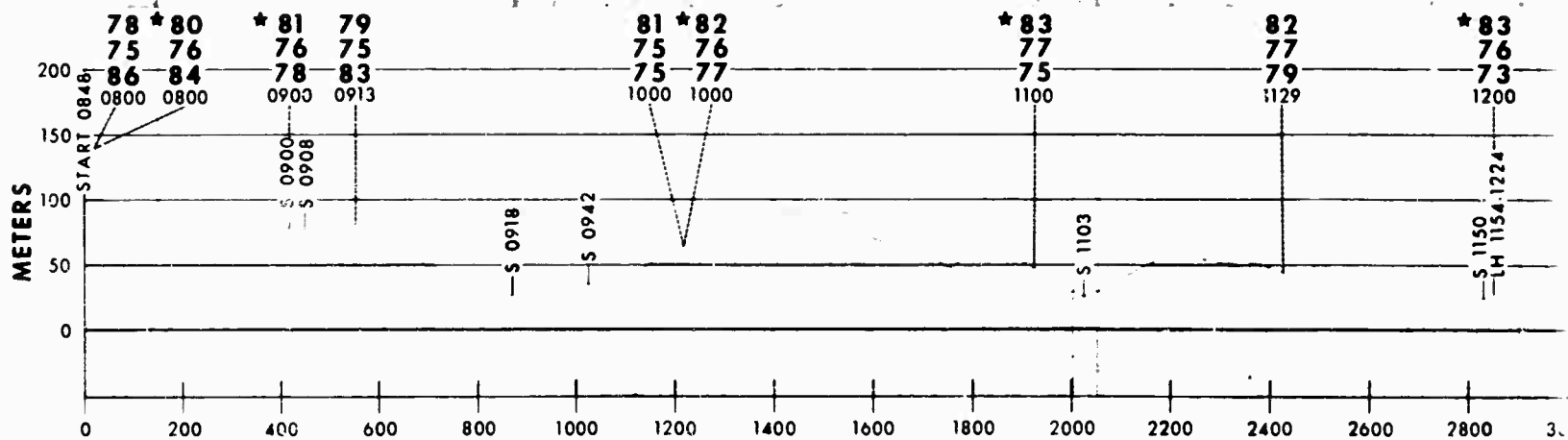


FIGURE 4

COMBAT PATH ROUTE PROFILE WITH SURFACE GEOLOG



WET SEASON - 16 AUGUST



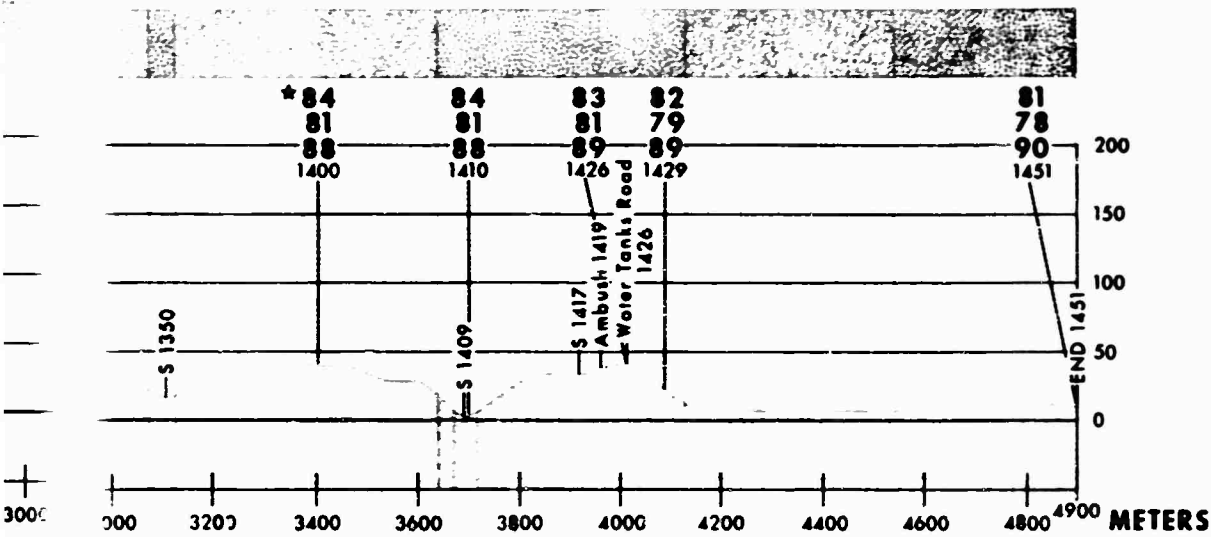
DRY SEASON - 24 JANUARY

FIGURE

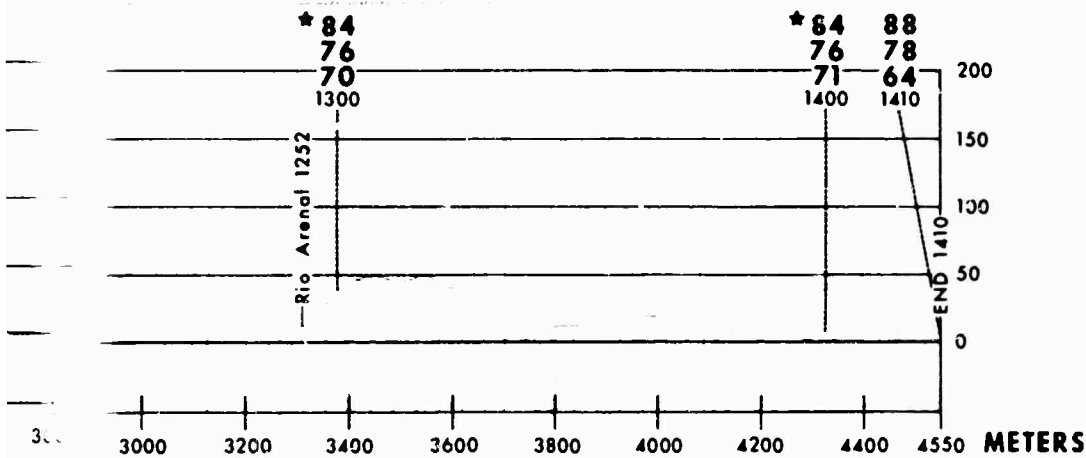
A

CONTROL

GEOLOGY AND VEGETATION TYPES



SI ST 1962



FEBRUARY 1963

JR. FIGURE 5

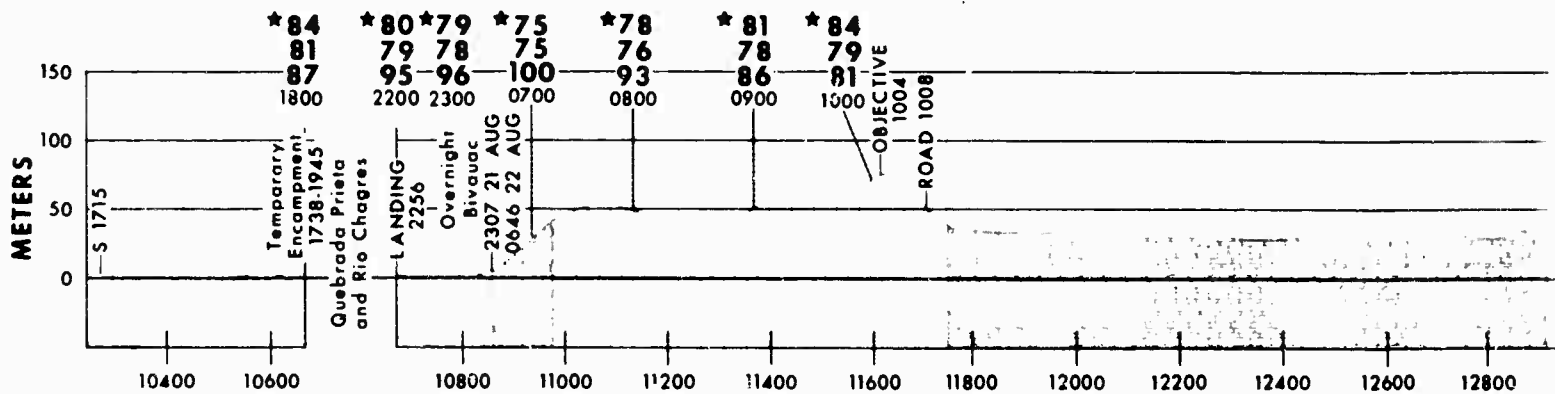
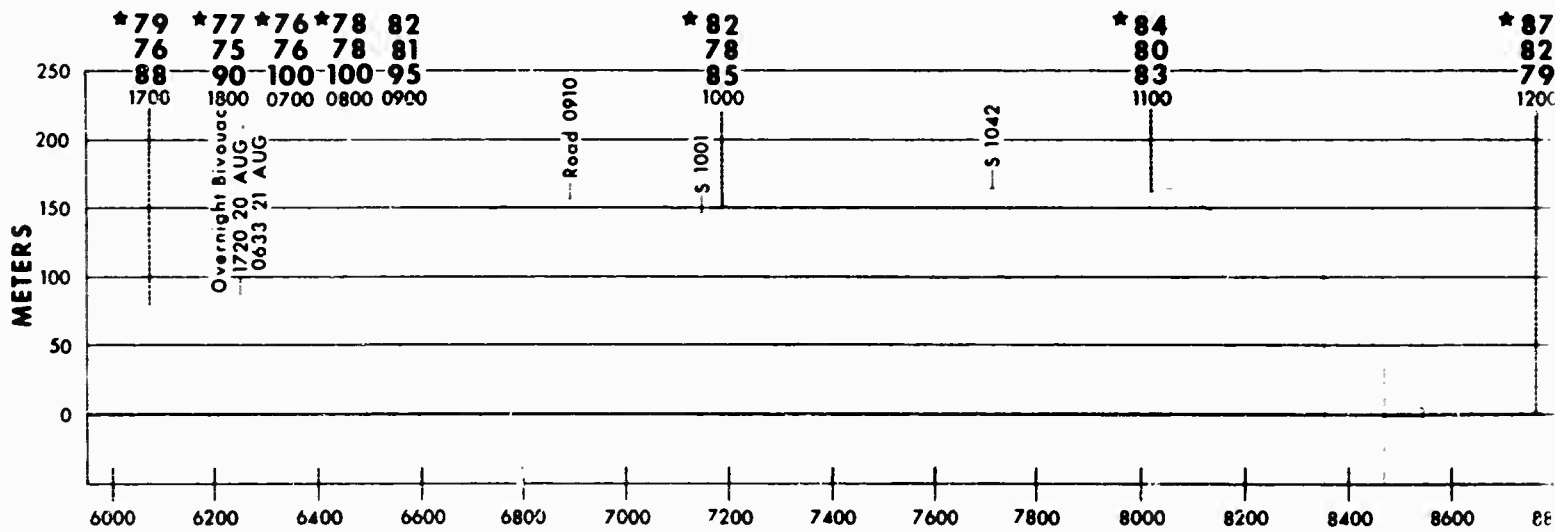
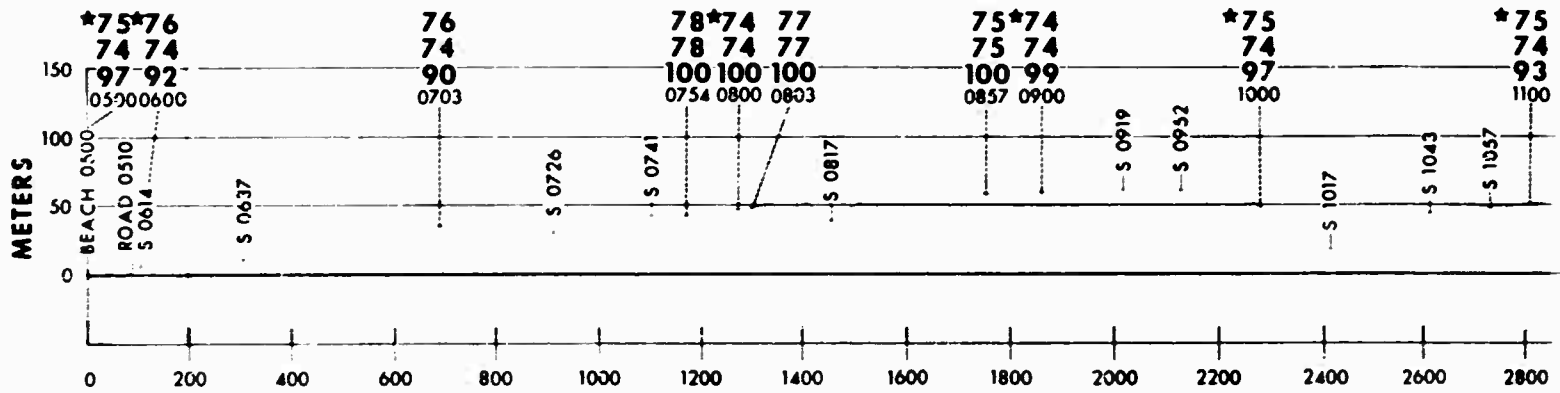
LEGEND	
CLIMATE	STATION DATA
	*84 DRY BULB TEMPERATURE
	79 WET BULB TEMPERATURE
	80 RELATIVE HUMIDITY (%)
	1310 TIME OF OBSERVATION
VEGETATION TYPES	1 RAIN FOREST
	2 RAIN FOREST - Secondary Growth
	3 TROPICAL DECIDUOUS FOREST
	4 SAVANNA
	5 GRASSLAND
GEOLOGIC TYPES	RECENT AND PLEISTOCENE MARINE DEPOSITS AND ALLUVIUM
	CHAGRES SANDSTONE
	TORO LIMESTONE
Vertical Exaggeration - 1:5	

NOTE: S = STREAM
LH = LUNCH HALT

B

WET SEASON RAID EXEC

ROUTE PROFILE WITH SURFACE



A

EXERCISE - 20-22 AUGUST 1962

CLIMATE GEOLOGY AND VEGETATION TYPES

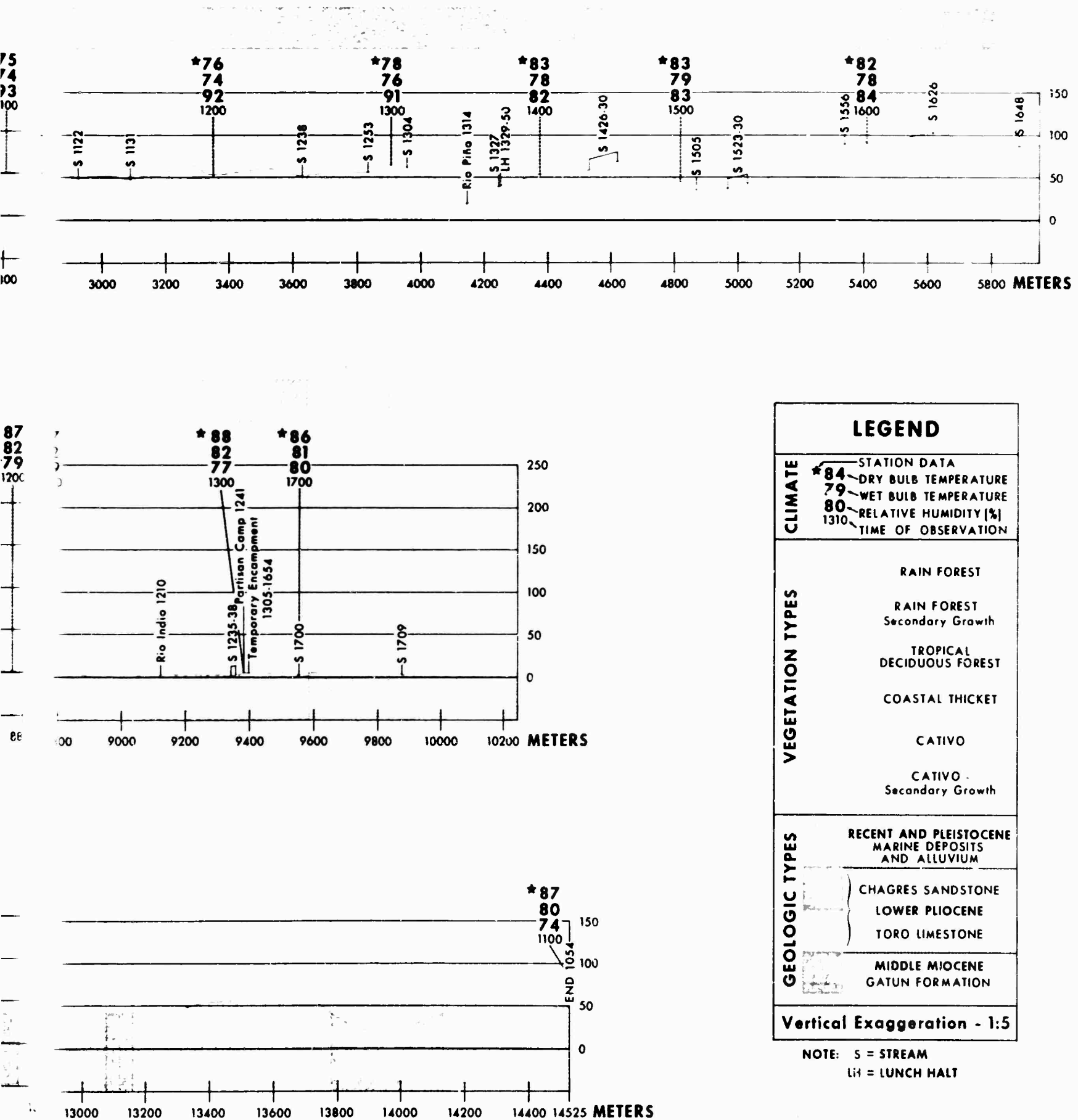
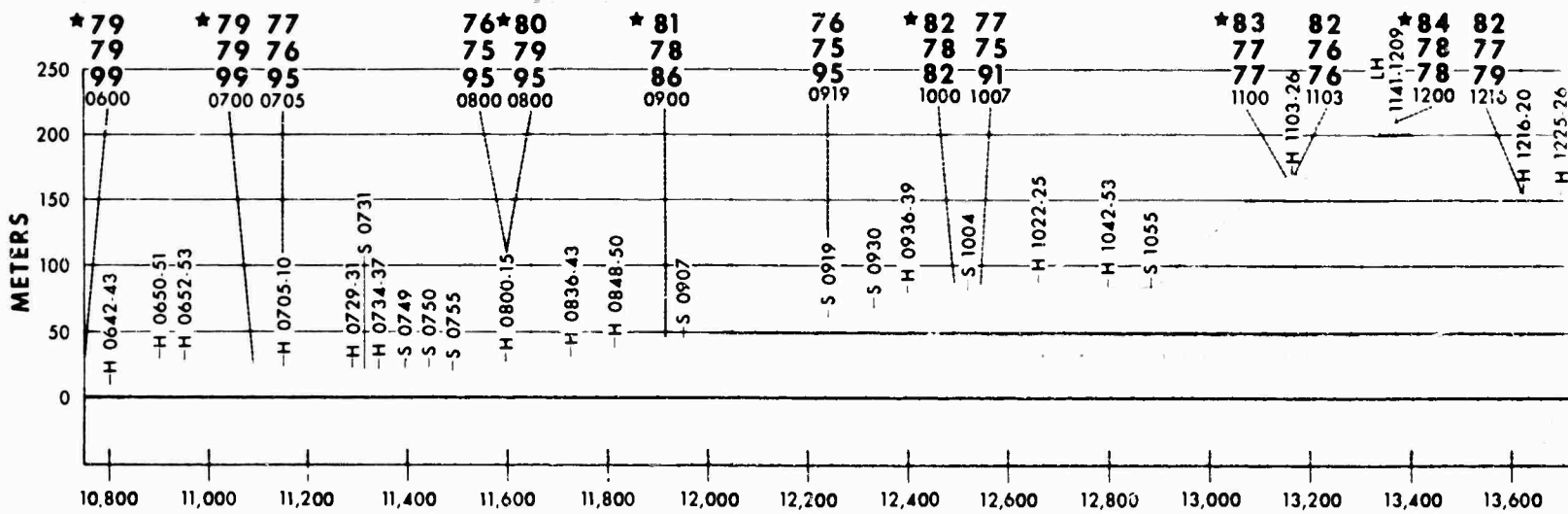
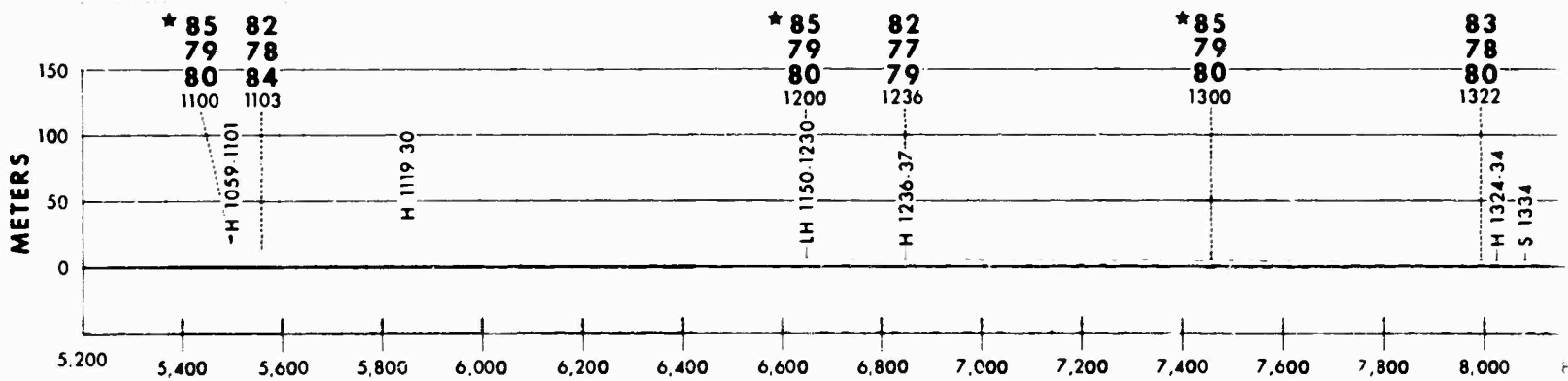
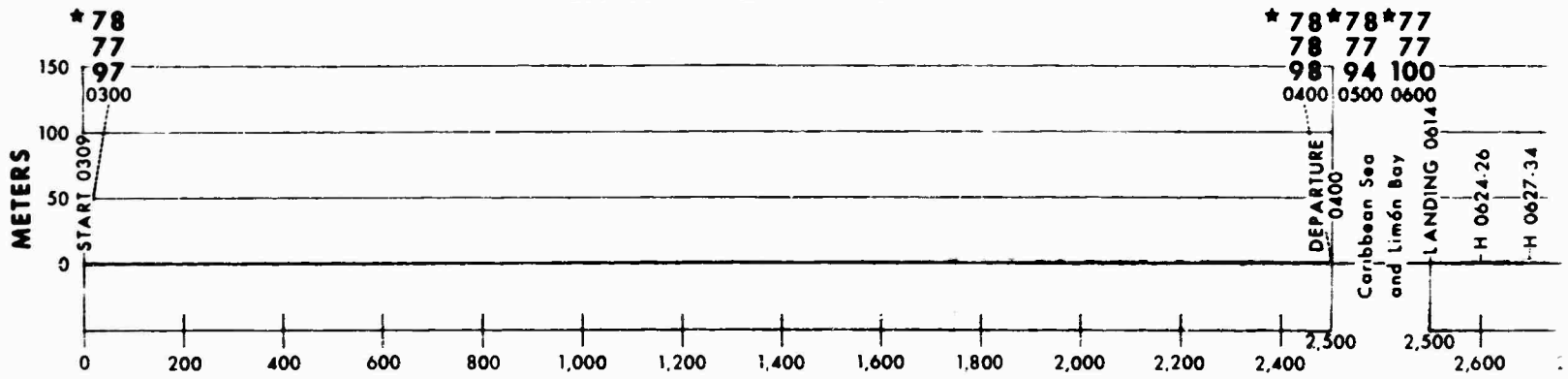


FIGURE 6

B

DRY SEASON RAID EXI

ROUTE PROFILE WITH SURFA



A

WINTER SEASON RAID EXERCISE - 28-29 JANUARY 1963

A PROFILE WITH SURFACE GEOLOGY AND VEGETATION TYPES

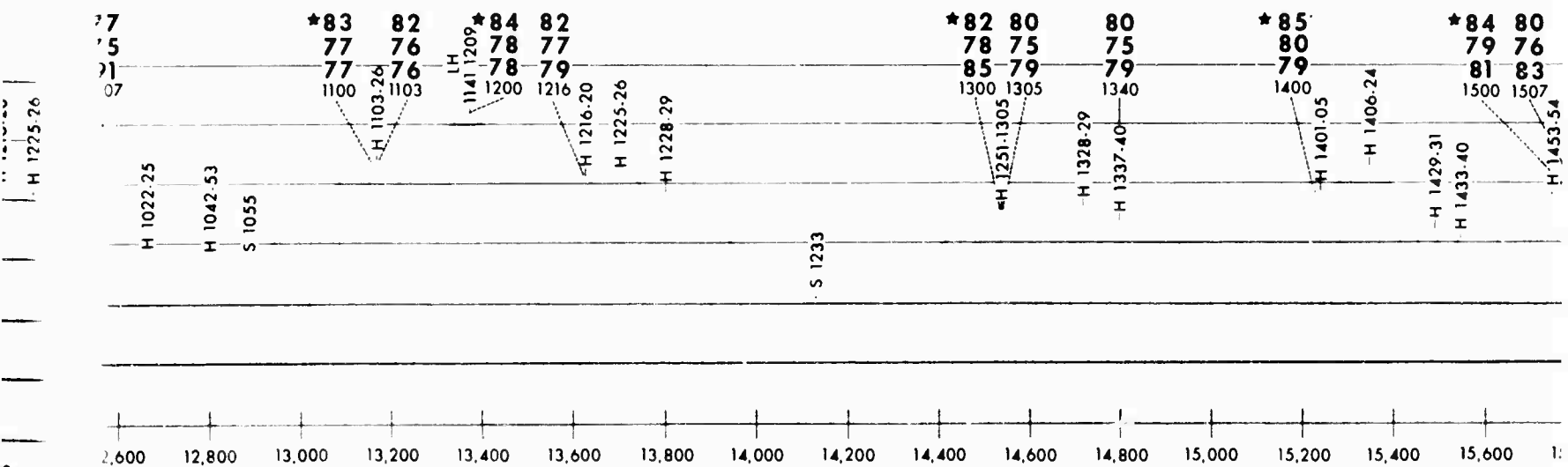
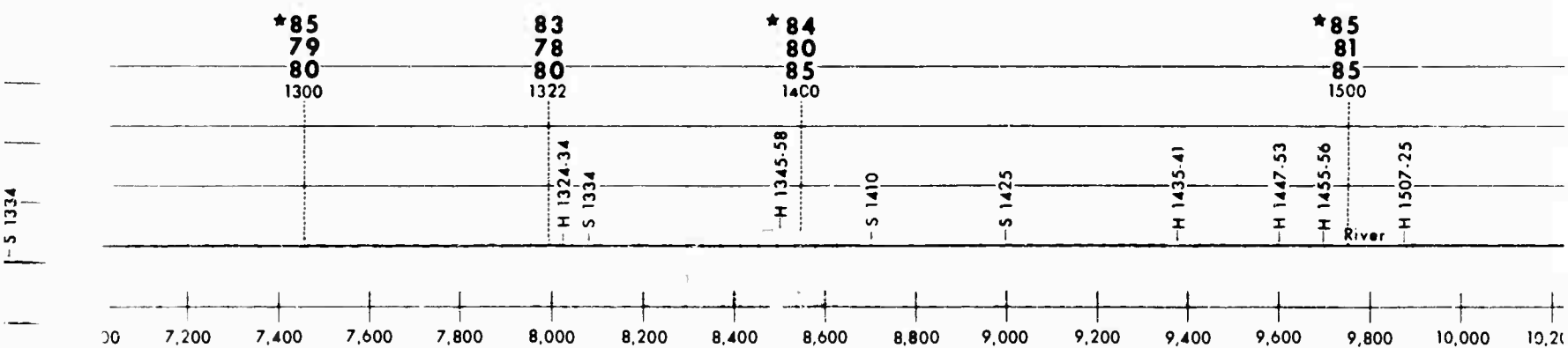
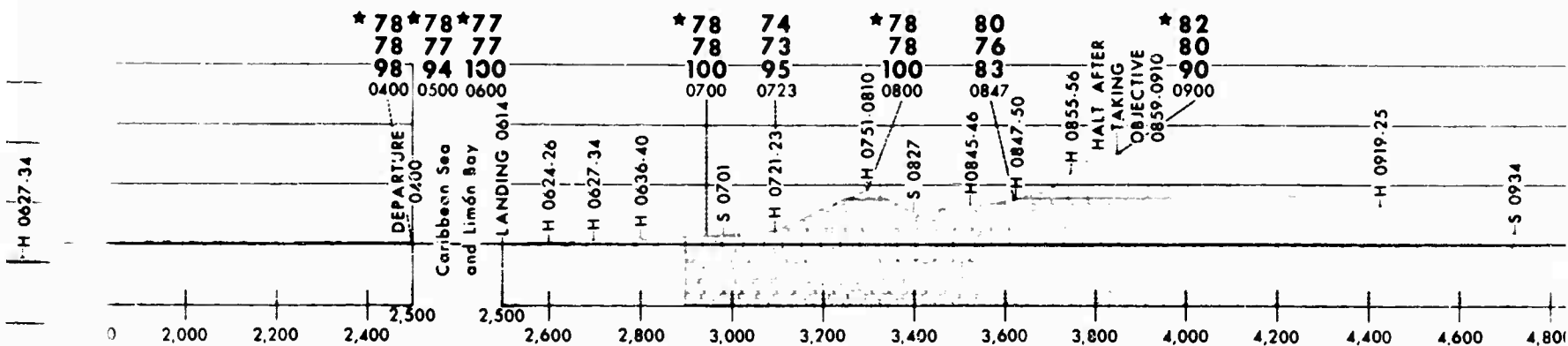
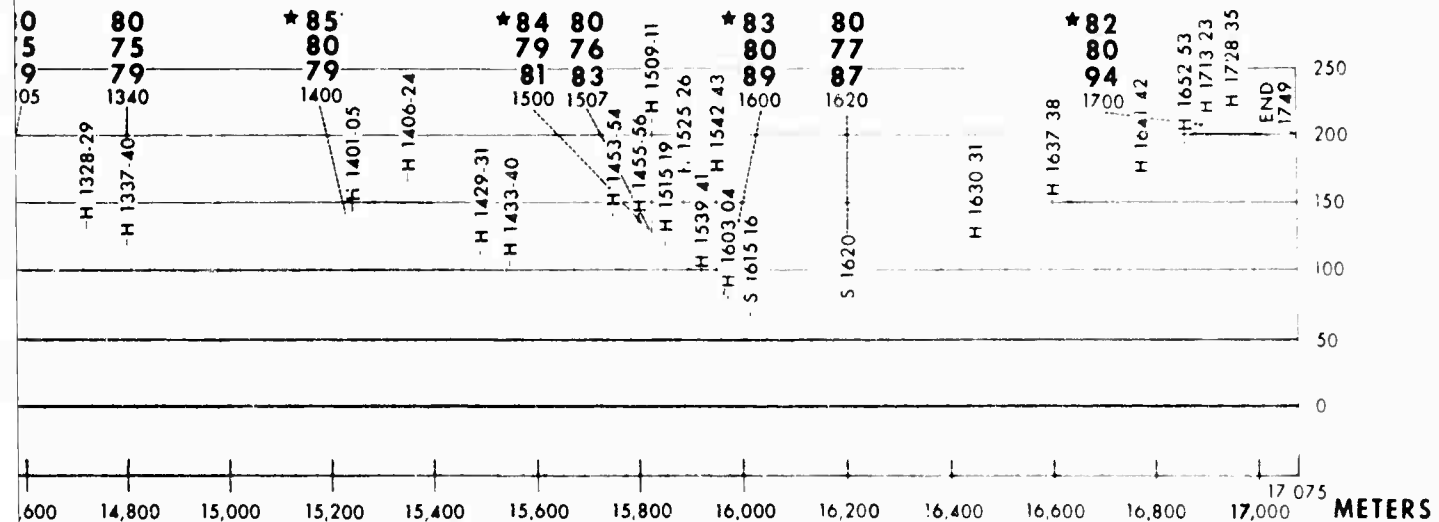
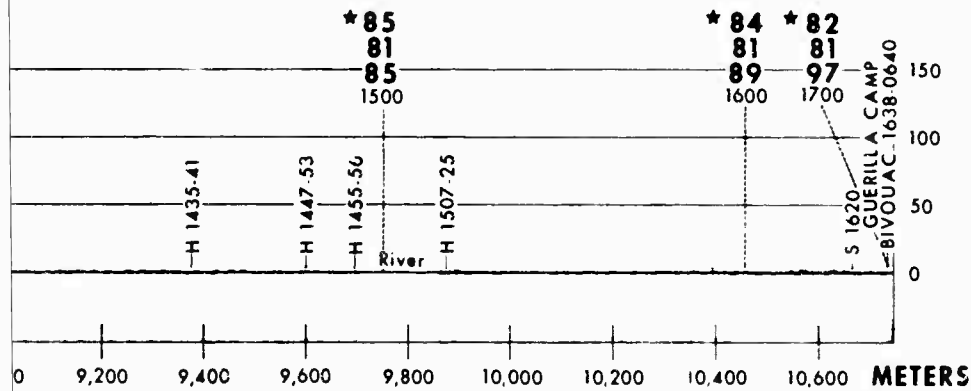
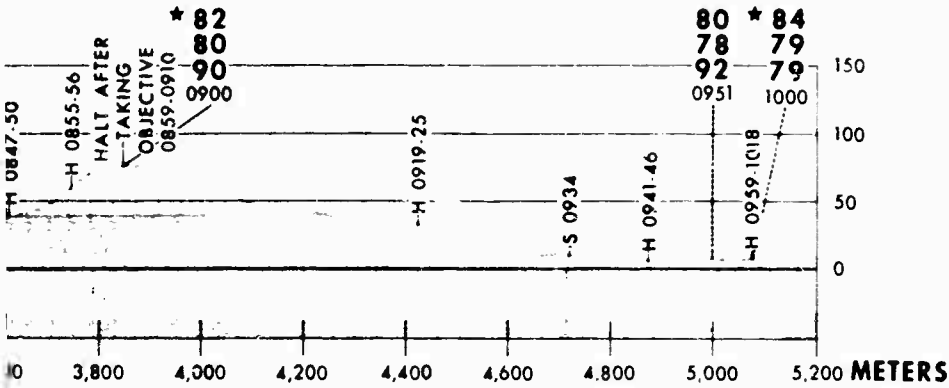


FIGURE 7

B

JANUARY 1963

D VEGETATION TYPES



LEGEND

CLIMATE

★ 84 STATION DATA
 79 DRY BULB TEMPERATURE
 80 WET BULB TEMPERATURE
 80 RELATIVE HUMIDITY (%)
 1310 TIME OF OBSERVATION

VEGETATION TYPES

- RAIN FOREST
- RAIN FOREST
Secondary Growth
- TROPICAL
DECIDUOUS FOREST
- SAVANNA
GRASSLAND
- MANGROVE SWAMP
- COASTAL THICKET
- COASTAL THICKET
Secondary Growth
- CATIVO
- CATIVO
Secondary Growth

GEOLOGIC TYPES

- RECENT AND PLEISTOCENE
MARINE DEPOSITS
AND ALLUVIUM
- CHAGRES SANDSTONE
- LOWER PLIOCENE
- TORO LIMESTONE
- MIDDLE MIOCENE
GATUN FORMATION

Vertical Exaggeration - 1:5

NOTE: S = STREAM H = HALT
 LH = LUNCH HALT

C

tactics, and load, to name a few; and (2) the environmental aspects: temperature, humidity, rainfall, terrain, soil and vegetation types. During the planning stage, leadership can solve many of these man-environment problems by carefully selecting the best route of travel with regard to rate of movement, likely obstacles, weather conditions, and security measures required for a successful mission. Leadership is equally important in determining the degree of success in moving over the planned route, through adjustment of the plan as needed to cope with unforeseen obstacles, accidents, or changes in weather conditions.

In the environment, mud is the greatest hinderance to rapid movement. High humidity with high temperatures, and early morning precipitation are the most significant of all of the weather conditions encountered. Moisture softens the ground surface, with the result that at any given point after repeated passes by groups of men, movement is at first slowed down and eventually is completely bogged down in deep slippery mud.

Frequency of obstacles encountered is next in importance to mud, principally deadfalls, small streams, and gullies, but also the density of tree trunks, branches, and vines which impede physical movement and also vision. All of the dense tropical vegetation types encountered in this study restrict visibility so that a greater number of reference points are required for traversing an area than in other environments.

That observers differ was another finding. Various environmental conditions impress observers differently. As a result, some environmental criteria appear to be reported more frequently than other equally important conditions. In collecting and recording quantitative environmental information using a limited number of samples, this may introduce an unintentional bias into some of the data. By increasing the quantity of observations the quality is also improved. Also, inexperience of observers at the beginning of an exercise or problem in the use of the recording equipment and in the types of environmental data to be observed affects the reliability and quality of the data recorded. Failures occur sometimes because of improper operation of specialized equipment. Therefore the more experience the observer has in using his equipment under field conditions the greater the probability of success. For success in stress-type field problems, reserve or back-up men and equipment are essential.

8. Acknowledgements

Many have given their time and assistance, and their help is gratefully acknowledged. Special thanks are extended to the following: Major Joseph T. Tambe and Captain Filmore L. Ficks, Pioneering Research Division, who led the Human Factors Tropical Field Teams during the wet and dry seasons respectively; Colonel John Goldoni, Commanding Officer, and his staff, Jungle Warfare Training Center, Fort Sherman, Canal Zone;

Sp-4 James Monehan, and Pfc. James Tate, U.S. Army Signal Corps Meteorology Team, Canal Zone, for their able assistance in collecting geographical and meteorological data; Miss Pernel Leuvelink and Mr. Aubrey Greenwald for drafting the route maps and profiles.

9. References

Anstey, Robert L., Visibility in a tropical forest, Earth Sciences Div., Special Report S-3, U.S. Army Natick Laboratories, Natick, Mass., Aug. 1963.

Arctic, Desert, and Tropic Information Center, Living off the America tropics, Informational Bull. No. 10, AF Manual 64-10, Office Asst. Chief Air Staff, Intelligence, New York, Feb. 1944.

Beard, J. S., Climax vegetation in tropical America, Ecology, 25: 127-158 (1944).

-----, The classification of tropical American vegetation-types, Ecology, 36: 89-100 (1955).

Department of the Army, Jungle operations, FM 31-30, Hq., Dept. Army, Washington 25, D.C., Oct. 1960.

Duke, James A., Survival manual I, Pacific Panama, Business Machines, Inc., Durham, N.C., 1963, mimeograph.

McCullough, C. R., I. M. Johnston, J. M. Parker, III, and R. E. Fadum, Terrain study of the Panama Canal Zone with specific reference to the Fort Sherman area and vicinity, Dept. Engineering Res., North Carolina State College, School Eng., Raleigh, N.C., July 1956.

Ramsey, Russell W. and Amos Travis, The common wildlife of Panama, Printing Plant, Mount Hope, Canal Zone, Nov. 1960.

Tambe, Joseph T. and George E. Stenbridge, Human factors aspects of the QM-equipped soldier in jungle operations: an operational approach, Pioneering Research Div., U.S. Army Natick Laboratories, Natick, Mass., manuscript.

Wiley, Selva C., Arthur V. Dodd, and Jack V. Chambers, Environmental handbook of Fort Sherman and Fort Gulick, Panama Canal Zone, Environmental Prot. Div., Tech. Report EP-17, Quartermaster Research and Development Center, Natick, Mass., July 1955.