

LOCATION AND ANALYSIS OF HYDROLOGIC SUBCYCLES
ON VANCOUVER ISLAND

by

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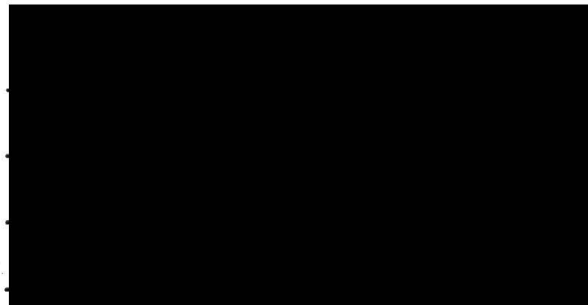
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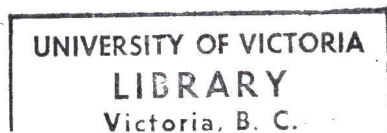
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Abstract

Traditional hydrologic research concerns the runoff characteristics of the individual drainage basin. This study describes the hydrology of Vancouver Island of the months of January and July, on a regional scale, by integrating seven hydrologic factors into fifty-seven hydrologic subcycles. In this study, each of the hydrologic subcycles is located and analyzed, and then discussed in reference to temporal and spatial interaction.

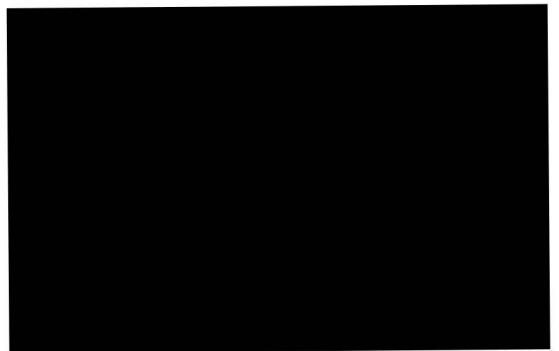


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January Hydrologic Subcycles

July Hydrologic Subcycles

January Precipitation

July Precipitation

January Vegetation

July Vegetation

Soil

January Potential Evaporation Rate

July Potential Evaporation Rate

Slope

Permeability of the Parent Material

January Runoff

July Runoff

January Moisture Supply

July Moisture Supply

Acknowledgement

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Chapter I Introduction

Need and Purpose of the Study

The fundamental base of the science of hydrology is the hydrologic cycle. Hydrologic texts normally discuss the hydrologic cycle in general terms by listing those factors which comprise the basic cycle, with the discussion commonly followed by a chart or diagram (Figure 1). Even those factors which comprise the hydrologic cycle are not readily agreed upon. For example, on a world scale, Barry designates that hydrologic studies are concerned with the exchanges of water in the following stages of the hydrologic cycle: evaporation, moisture transport, condensation, precipitation, and runoff.¹ According to Linsley, Kohler, and Paulhaus, the factors contributing to the hydrologic cycle on a meso-scale are: potential evapotranspiration (amount and time), evaporation, precipitation (amount, time and form), interception, runoff, interflow, soil storage, percolation, and ground water storage.² For micro-scale studies (drainage basins), Wisler and Brater suggest the inclusion of such additional factors as: area of basin, shape of basin, slope, drainage network type, and vegetation (use rate and density).³

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1. R. G. Barry, "The World Hydrologic Cycle", Water, Earth, and Man, R. J. Chorley (ed.), (London: Methuen and Co. LTD., 1969), p. 13.
 2. R. K. Linsley, M. A. Kohler, and J. L. H. Paulhaus, Applied Hydrology, (New York: McGraw Hill, 1949).
 3. C. O. Wisler, and E. F. Brater, Hydrology, (2nd ed.; New York: John Wiley, 1959), pp. 31-32.

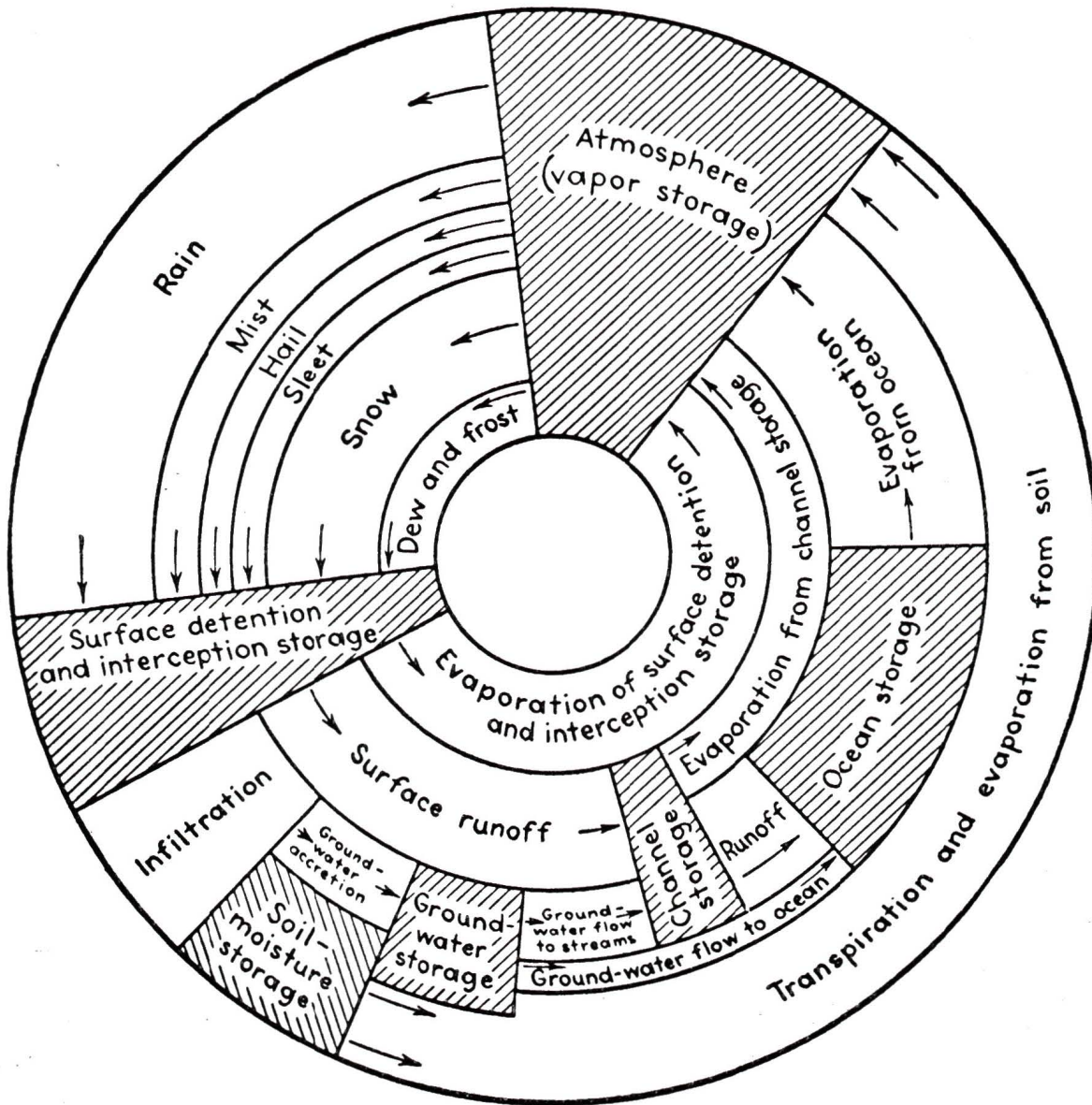


Fig. 1. The hydrologic cycle. Read diagram counterclockwise.

Source: Wisler and Brater, Hydrology, p. 3

The hydrologic cycle has many subcycles depending upon the combination and variation of the contributing factors. Since the hydrologic cycle is the foundation of hydrology, one would assume that determination, classification, and location of these subcycles would be a prerequisite for further hydrologic studies. A regional classification of river regimes, or hydrologic regions has been attempted by Beckinsale, who divides the world's rivers into megathermal regimes, mesothermal regimes, microthermal regimes, and mountain regimes.⁴ This classification of hydrologic regions by Beckinsale, shows a recognition of the relationships between climate, vegetation, soils and rock structure, basin morphometry, and hydraulic geometry; but a closer analysis reveals a simple correlation between climatic regions and hydrologic regions. Others have recognized the many various subcycles which occur throughout the world.⁵ Usually, these discussions briefly describe several regions and then present a typical annual hydrograph for each of the respected regions. Other current research in hydrology involves detailed regional studies, for example, "Grassland Hydrology in a Karstic Region of Southern Australia",⁶ or "Runoff from Small Peatland Watersheds".⁷ The two approaches to regional hydrology mentioned above, that is, presenting brief descriptions from various regions of the

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4. R. P. Beckinsale, "River Regimes", Water, Earth and Man, R. J. Chorley (ed.), (London; Methuen and Co. LTD., 1969), p. 455-471.
 5. J. P. Bruce, and R. H. Clarke, Introduction to Hydrometeorology, (London: Pergamon Press, 1966), p. 50.
 6. J. W. Holmes, and J. S. Colville, "Grassland Hydrology in a Karstic Region of Southern Australia", Journal of Hydrology, X, No. 1 (January, 1970), pp. 28-58.
 7. P. R. Bay, "Runoff from Small Peatland Watersheds", Journal of Hydrology, IX, No. 1 (September, 1969), pp. 90-102.

world or studying a small area in detail, expose a large discontinuity between the two studies: in each approach, only a small number of the possible hydrologic subcycles, which can occur, are discussed.

Other aspects of recent hydrologic research have involved applying sophisticated models to the drainage basin hydrologic cycle. According to More, the drainage basin hydrologic cycle and its relationship to the contributing factors has been "studied in five main ways: by natural analogues, hardware models, synthetic systems, partial systems, and the black-box approach."⁸ In each of the mentioned models there is a need for a greater understanding of the factors which constitute the drainage basin hydrologic cycle. For example, More's conclusion of the "black-box" approach is "because of the complexity of the cycle and the variations of its components from time to time and from area to area it is difficult to find general mathematical expressions relating rainfall and runoff for a given basin ..."⁹ Simply stated, the limiting factor of each of the five models is the lack of information pertaining to the physical features of the drainage basin. In discussing other mathematical models, Huggins and Monke state:

... obviously the overall accuracy of the models depends upon the ability of the functional relationship of hydrologic components to describe their respective phenomena. Unfortunately, hydrologic research has not yet produced reliable, quantitative description of several of the hydrologic components needed for a comprehensive watershed model.¹⁰

It is evident from the above discussion that hydrologists are not satisfied with the present knowledge concerning variations of the hydro-

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8. R.F. More, "The Basin Hydrological Cycle," Water, Earth and Man, R. J. Chorley (ed.), (London: Methuen and Co. LTD., 1969), p. 70.
 9. Ibid., p. 75.
 10. L.F. Huggins, and E.J. Monke, "A Mathematical Model for Simulating the Hydrologic Response of a Watershed," Water Resources Research, IV, No. 2 (June, 1968), pp. 529-539.

logic cycle. Simulative systems and mathematical models demand a greater depth of knowledge about the factors of the hydrologic cycle and their degree of interrelatedness. A holistic approach is needed for a comprehensive knowledge of the hydrologic cycle, and this is partially achieved by knowing which factors vary temporally and spatially. The purpose of this study is to locate and analyze, with the aid of maps, those various hydrologic subcycles which occur on Vancouver Island for the months of January and July.

It is the author's belief that to study the hydrology of a region requires Ackerman's fundamental approach to geography, which he states as, "the difference of the content of space on the earth's surface and the analysis of space relations within the same universe."¹¹ Also this should be considered "fundamental research" in that:

fundamental research need not necessarily be law-giving. An important characteristic would seem to be the capacity, or promise, of such research for furnishing materials with which further advances may become possible.¹²

Before further hydrologic decisions and policies are implemented involving Vancouver Island, the various hydrologic subcycles need to be considered; it is hoped this study can provide such a base.

Methodology

A major part of this study involves the compilation of the first hydrologic subcycle maps of Vancouver Island for the months of January and July. The derivation and classification of the hydrologic subcycles

11. E. A. Ackerman, Geography As a Fundamental Research Discipline, Department of Geography Research Paper No. 53, University of Chicago (Chicago: University of Chicago Press, 1958), p. 8.

12. Ibid., p. 17.

for the maps is based upon the hydrologic typology developed by Juncker.¹³ The basic cycle factors considered are: precipitation, vegetation, soil, potential evaporation, slope, permeability of the parent material, and runoff. Furthermore, each of the components are divided according to assigned values (as they occur on Vancouver Island) in the following manner:

1. Precipitation

- A. Value 1 (no substantial precipitation) represents less than one inch of precipitation recorded for the month.
- B. Value 2 (moderate precipitation) represents between one and eight inches of precipitation, in solid phase, recorded for the month.
- C. Value 3 (moderate precipitation) represents between one and eight inches of precipitation, in liquid phase, recorded for the month.
- D. Value 4 (heavy precipitation) represents over eight inches of precipitation, in solid phase, recorded for the month.
- E. Value 5 (heavy precipitation) represents over eight inches of precipitation, in liquid phase, recorded for the month.

2. Vegetation

- A. Value 1 represents no substantial vegetation which would influence the local hydrology, or stands which are dormant (below 40 F).

13. P. Juncker, "Towards a Hydrologic Typology", (Unpublished manuscript, University of Victoria, 1969).

- B. Value 2 represents shallow rooting vegetation, grass and trees, with light density per unit of area.¹⁴
- C. Value 3 represents shallow rooting trees with heavy density per unit of area.

3. Soils

- A. Value 1 represents no soil.
- B. Value 2 represents shallow soil with low moisture holding capacity and high infiltration rate.
- C. Value 3 represents shallow soil with high moisture holding capacity and low infiltration rate.
- D. Value 4 represents shallow soil with high moisture holding capacity and high infiltration rate.

4. Potential Evaporation Rate

- A. Value 1 represents low potential evaporation rate, which is defined as a mean monthly average temperature below 50 F.
- B. Value 2 represents high potential evaporation rate, which is defined as a mean monthly average temperature of 50 F. or above.

5. Slope

- A. Value 1 represents even to gentle slope, or six percent slope gradient or less (a full discussion on the derivation of this value is presented in chapter two).
- B. Value 2 represents moderate to steep slope, or a slope gradient above six percent.

14. Dr. Fyles, (geologist with the Department of Mines and Petroleum Resources, Victoria, B. C.), in an interview during October, 1969, suggested all soils on Vancouver Island be considered shallow; therefore, all vegetation on Vancouver Island must be considered shallow rooting.

6. Permeability of the Parent Material

- A. Value 1 represents permeable parent material.
- B. Value 2 represents impermeable parent material.

7. Runoff

- A. Value 1 represents no significant runoff; which occurs where there is no precipitation, light precipitation and high potential evaporation rate, or where solid phase precipitation occurs in either light or heavy amounts.
- B. Value 2 represents light runoff, which occurs where there is moderate precipitation and low potential evaporation rate.
- C. Value 3 represents heavy runoff, which occurs where there is high precipitation, in liquid phase, and low potential evaporation rate.

Impossible combinations of factors are those which logically cannot occur in the real world. Table 1, lists those combinations which do not exist on Vancouver Island; although it should be noted these impossible combinations are restricted to Vancouver Island and other regions would have different impossible combinations, for example, steep slope and shallow soil does not occur in the Coast Range of British Columbia.

The compilation of the final hydrologic subcycle maps for January and July involved assessing factor values from basic source maps; then transferring these values to computer cards which were then combined by the university computer into various subcycles. The compilation of the final hydrologic subcycle maps is further discussed in Chapter two, but

Table 1

Impossible Combinations

<u>Component and Assigned Values</u>	<u>Inadmissible Components</u>
No Precipitation (1)	Light Vegetation (2) Heavy Vegetation (3) Light Runoff (2) Heavy Runoff (3)
Light Precipitation (3)	Heavy Vegetation (3) Heavy Runoff (3) Light Vegetation (2), Low Moisture Holding Capacity (2), Low Evaporation (1), Low Slope (1). Light Vegetation (2), Low Moisture Holding Capacity (2), Low Evaporation (1), Medium to High Slope (2), No Runoff (1)
High Precipitation (5)	Low Infiltration Rate (4), Light Runoff (2) Medium to High Slope (2), Light Runoff (2) No Soil (1), Low Slope (1), Permeable Parent Material (1), Heavy Runoff (3)
Solid Phase (2 and 4)	Light Vegetation (2) Heavy Vegetation (3) High Evaporation Rate (2) Light Runoff (2) Heavy Runoff (3)
No Soil (1)	Light Vegetation (2) Heavy Vegetation (3)

it is important to emphasize that this study would have been impractical without the use of a computer.

A Comparison Between the Derived Subcycle Method
and Traditional Hydrologic Studies

The difference between traditional hydrology and the approach taken by this study is emphasized by comparing the resultant information derived from hydrographs to the information obtained from the classification of hydrologic subcycles. The primary tool of the hydrologist is the discharge hydrograph, which may or may not be derived from a digital model.

The discharge hydrograph (Figure 2) expresses graphically, by plotting discharge against time, the sequence of relationships which exist between runoff and the other factors of the water balance, together with their adjustments to the physical characteristics of the basin.¹⁵ Since precipitation is usually irregular in occurrence and intensity, the discharge hydrograph for most rivers is composed of many irregular fluctuations super-imposed on a gently undulating curve. These two sets of curves represent storm runoff and ground water discharge.

The factors which control the hydrograph are permanent or transient in nature. The permanent factors are generally the physical features of the drainage basin, for example, basin area, basin shape, basin elevation, basin slope, and drainage network. Transient factors are

15. J. C. Rodda, "The Flood Hydrograph", Water, Earth and Man, R. J. Chorley (ed.), (London: Methuen and Co. LTD., 1969), p. 405.

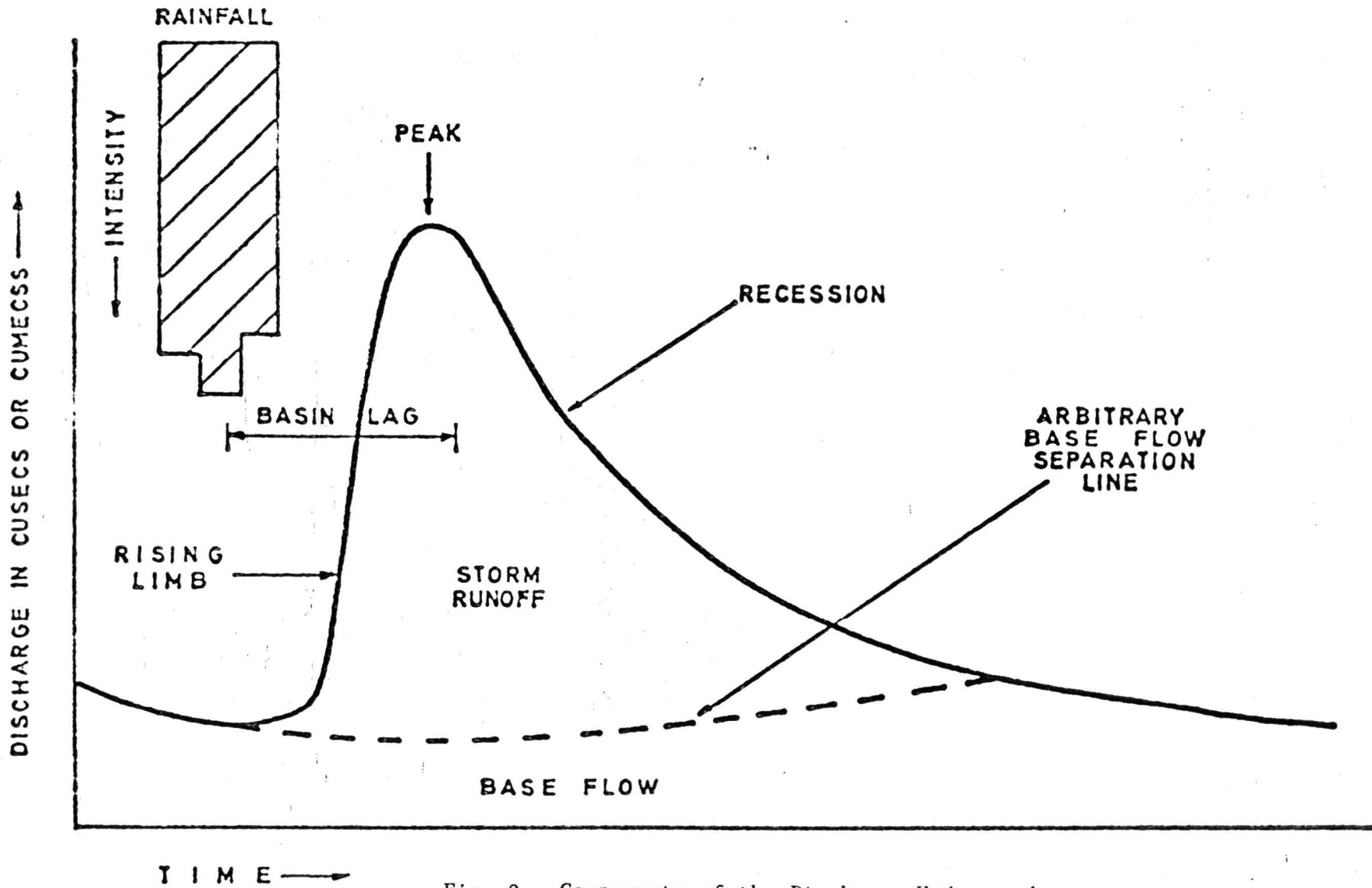


Fig. 2. Components of the Discharge Hydrograph

Source: Chorley (ed.) Water, Earth and Man, p. 415.

climatic factors or factors influenced by climatic conditions, for example, precipitation (time, intensity, and phase), evaporation rate, vegetation, and land use. Although the factors which influence the characteristics of the hydrograph are, for the most part, readily recognizable, Rodda states "relatively few studies have aimed at establishing quantitative relations between the flood and these factors".¹⁶

Many problems are encountered when trying to apply a single term to an easily quantifiable factor of the hydrograph. For example, it is obvious the larger the area of the basin, the greater the amount of rain it intercepts, but it must also be considered that larger basins are usually less steep than smaller ones.¹⁷

Recent research in hydrology has incorporated the use of digital-models for the purpose of runoff prediction (Figure 3). The models differ from the discharge hydrograph, which is limited to a particular aspect of runoff and its control, in that they imitate all the processes involved in the water basin balance by using programs designed to reproduce the factors of the entire physical system. The majority of the models have two functions; to convert rainfall and potential evapotranspiration into runoff, and then to transform runoff volumes into discharge hydrographs.¹⁸ The limitations of the results obtained from the digital-models lies not in the approach or technique used. Instead, it is as Rodda expresses, "like all other approaches that aim at an under-

16. J. C. Rodda, Ibid., p. 406

17. Ibid., p. 409.

18. Ibid., p. 417.

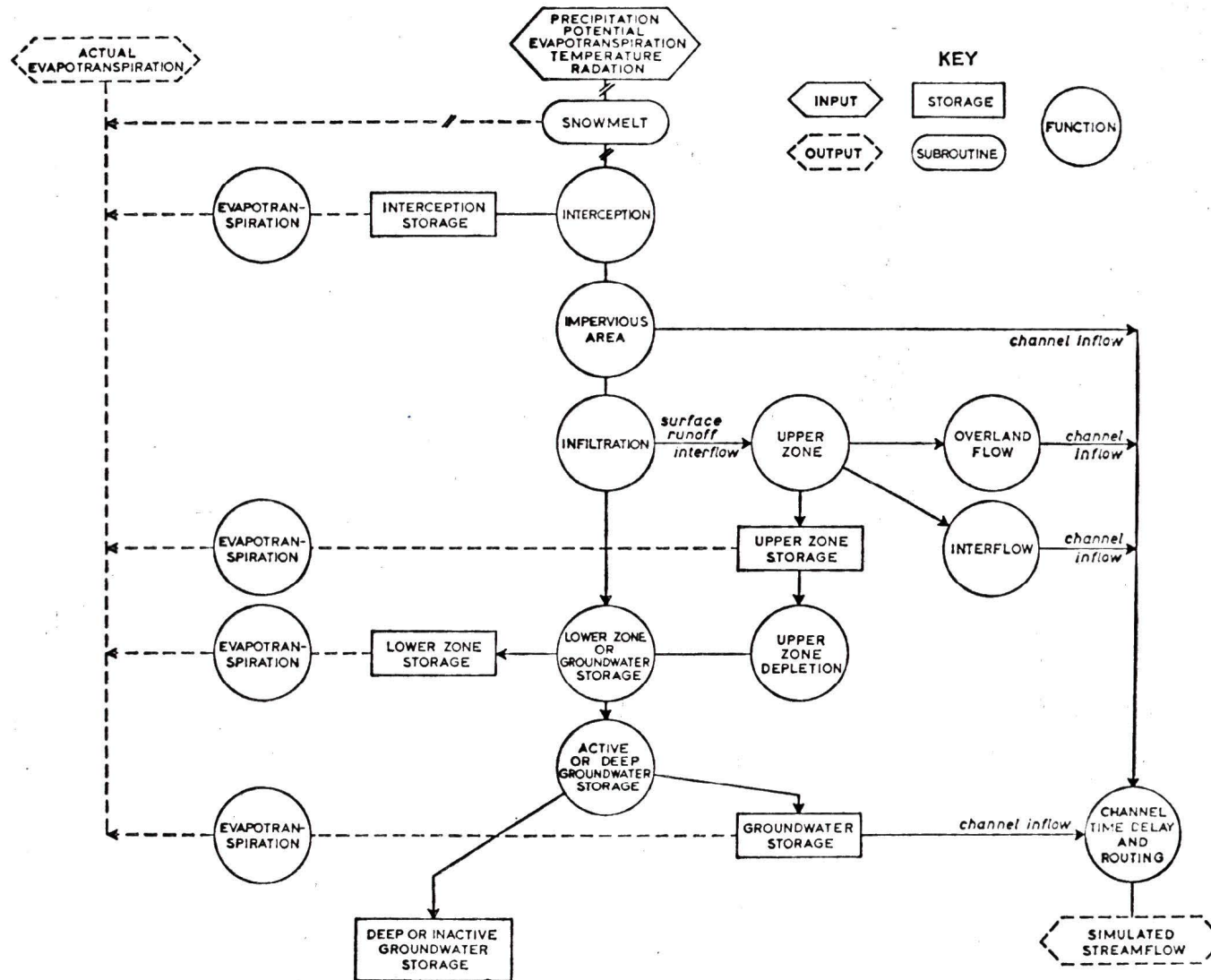


Fig. 3. Stanford Watershed Model IV flowchart (After Crawford and Linsley, 1966).

Source: Chorley (ed.) Water, Earth and Man, p. 416.

standing of the controls of the flood hydrograph, its limitations lie mainly in the veracity of the basic data".¹⁹

In contrast to the discharge hydrograph and digital-models, the classification of hydrologic subcycles does not attempt to explain river discharge and its relationship to drainage basin characteristics with the use of graphs or models. As previously stated, the classification of hydrologic subcycles integrates those factors which contribute to the hydrologic cycle temporally and spatially. One of the most apparent differences between the hydrograph and the subcycle approach is the limited scope of the hydrograph, that is, the discharge from a single river, while the classification of subcycles can be confined to a single drainage basin or encompass an entire continent. Another important advantage deriving from the classification of hydrologic subcycles is the application of the resultant information to disciplines other than hydrology. Because of the nature of the discharge hydrograph, its utility is restricted to mainly hydraulic engineers. While hydraulic engineers can utilize the hydrologic subcycle approach, the information derived from the subcycles can be used by geographers, soil scientists, geologists, agronomists, foresters, etc. The wide spread utility of the hydrologic subcycles is possible because it combines a broad range of the physical features which comprise the earth's land mass.

The foregoing discussion on discharge hydrographs and digital-models reveals that further research is needed to understand the factors of the hydrologic cycle in respect to their location and seasonality.

19. J. C. Rodda, Ibid.

Possibly this study will lead to a clear understanding of those factors which contribute to the hydrology of Vancouver Island, by classifying the factors into subcycles and analyzing their interaction temporally and spatially.

Chapter 2 Compilation of Hydrologic Subcycle Maps

Nature of the Data

Those factors which comprise the hydrologic subcycles are two-fold in nature: soil, slope, and permeability of the parent material are considered to be permanent factors; while precipitation, vegetation, potential evaporation rate, and runoff are considered variable, that is, subject to seasonal change. The data required to compile the hydrologic subcycle was obtained from various source maps representing the physical environment of Vancouver Island. The permanent factors required only one source map, while the variable factors required at least two, one for January and one for July. This chapter explains what source maps were used to obtain the data for each factor and includes a discussion on what decisions were made when discrepancies arose concerning the information depicted by the source maps. The chapter is concluded with a discussion explaining the validity of the data and how it was transferred to the final hydrologic subcycle maps.

Precipitation

The source maps used for precipitation data were the Climatic maps of Canada, published by the Meteorological Branch of the Department of Transportation, in 1967. The map titled, Mean Monthly Amount of Precipitation for January (series 2, sheet 1), discloses that Vancouver Island is divided into two values, according to the classification presented in chapter one, that is, the southeast part of the Vancouver Island receives between one and eight inches of precipitation during

January (value 3), and the remainder of the Island receives over eight inches of precipitation.

To determine the phase of precipitation, the ten inch isoline on the Average Remaining Snow Depth map for April first was used. This map had to be consulted to determine the phase because a map depicting the 32 F. isotherm for January was not available, and a January snow depth map has not yet been compiled. The ten inch isoline of average remaining snow depth for April first, provides a conservative estimate of where only solid phase precipitation occurs during January. With the further division into phase, Vancouver Island, has two more precipitation values for January, that is, moderate precipitation (one to eight inches) in solid phase (value 2), and heavy precipitation (over eight inches) in solid phase (value 4).

Only one source map, Mean Monthly Amount of Precipitation for July (series 2, sheet 4), was needed to determine the precipitation values for July. Approximately ninety percent of the Island, all except the southeast portion, receives between one and eight inches of precipitation in liquid phase during July, and therefore has a value of 3. The extreme southeast portion of Vancouver Island receives less than one inch of precipitation and has a value of 1.

Vegetation

Vegetation values for Vancouver Island were derived from the Forest Inventory summaries of British Columbia, which all of Vancouver Island

is represented by combining the following maps:

Number 1	Index Map 92 B/NW B/SW
Number 2	Index Map 92 C/NW C/NE C/SE
Number 3	Index Map 92 E/NW E/NE E/SE
Number 4	Index Map 92 F/NW F/SW
Number 5	Index Map 92 F/NE F/SE
Number 6	Index Map 92 G/NW G/SW
Number 26	Index Map 92 K/NW K/SW
Number 27	Index Map 92 L/NE L/SE
Number 28	Index Map 92 L/NW L/SW

This series of maps was used because it covers the Island in greater accuracy than other existing vegetation maps of Vancouver Island. Their deficiency is that they are primarily compiled for use by logging companies to determine what stands of timber are mature enough for cutting; therefore, the classification used to describe the vegetation is not necessarily the most desirable for discerning the influence of vegetation on hydrology.

Almost all the vegetation on Vancouver Island is dormant (as determined by the 40 F. isotherm) during January, except for the northwest tip of the Island and a few promontories of the west coast. Vegetation, for July, is assigned to following values as represented by the forest inventory maps: value 1 represents no substantial vegetation, this value is generally reserved for areas over 5,000 feet in elevation;¹ value 2 represents 'not satisfactorily restocked areas, non-productive forests, and non-forested lands'; value 3 represents 'mature timber, immature timber, and non-commercial stands'. Generally, mature timber

1. "At higher elevations this forest gives way to amabilis fir...which in turn merges into alpine tundra and bare rock outcrop at the higher elevations (5,000 to 6,000 feet)." The Vancouver Island Bulletin Area (Department of Lands, Forest and Water Resources, Victoria, B. C., 1967), p. 17.

refers to stands over 120 feet in height, while immature timber refers to stands under 120 feet in height, although the density is considered to be the same;² for this reason, immature timber is assigned a value of 3.

Of the seven factors considered in the hydrologic subcycles, vegetation has been inspected in the closest detail. The careful inspection was due to the forest inventory maps being at a scale of 1:126,720; at this scale it is possible to pick out slight variations in the vegetation pattern and to assign values accordingly. This detailed inspection of the vegetation is readily apparent by comparing the relatively few variations of subcycles on the January hydrologic subcycle map, where vegetation is dormant, to the July hydrologic subcycle map, where the full range of vegetation values repeatedly reappear over the entire Island.

Soil

Information of the soils of Vancouver Island is limited. The only source available for this study was the Soil Survey of Southeast Vancouver Island and Gulf Islands, British Columbia, which is a limited survey covering approximately eight percent of the Island.³ Only four areas, Duncan-Nanaimo, Qualicum-Alberni, Courtenay-Campbell River, and Victoria-Saanich are mapped in detail (at a scale of 1:63,360), while the re-

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2. Personal interview with Mr. G. Harris of the British Columbia Forest Service, Victoria, B. C., October, 1969.
 3. J. H. Day, L. Farstad, and D. G. Laird, Soil Survey of Southeast Vancouver Island and Gulf Islands, British Columbia (Report No. 6 of the British Columbia Survey, 1959), p. 9.

mainder of the Island is unsurveyed.

The unsurveyed soil of the Island, below 5,000 feet, was assigned a value of 2, on the assumption the soil is located on moderate to steep slope, is podzolic in nature, and generally has low moisture holding capacity and high infiltration rate. Areas above 5,000 feet in elevation were assigned a value of 1 (see footnote 1 of this chapter). Appendix 1, summarizes the characteristics of those soil groups which have been mapped. Generally, value 2 was designated to soil groups dominantly consisting of sand and gravel on gentle to steep slope. Value 3, which is characterized by high moisture holding capacity and low infiltration rate, was assigned to soils dominantly consisting of clay or loamy sand on level to gentle slope. Value 4, which is characterized by high moisture holding capacity and high infiltration rate, was assigned to sandy loamy soils on gentle slope.

Potential Evaporation Rate

As previously explained in chapter one, the 50 F. isotherm is used, in this study, as the criterion between high and low potential evaporation rate. Only one source map, Mean January Temperature (map no. 2, British Columbia Snow Survey Bulletin), was needed to determine the potential evaporation rate for January. All of Vancouver Island has a mean January temperature below 50 F., therefore, all the January sub-cycles have a potential evaporation rate of 1.

Two source maps were needed to derive the potential evaporation rate for July. The first map, Mean July Temperature (map no. 4, British Columbia Snow Survey Bulletin), reveals that a large portion

of Vancouver Island, has a mean July temperature of over 56 F. A second source map, a contour map, was used to determine the potential evaporation rate of the mountainous area of the Island, contained within the 56 F. isotherm. A normal lapse rate of 3 F. for every one-thousand feet increase in elevation was taken into consideration for this mountainous area. Using this method a low potential evaporation rate, or a value of 1, was derived for those areas over 3,000 feet in elevation, contained within the 56 F. isotherm. Only a very small area of the Island, less than five percent, is considered to have a low potential evaporation rate in July.

Slope

The values for slope were obtained in the following manner: a topographic map of Vancouver Island at a scale of 1:250,000 and a contour interval of 500 feet was used as the source map; then those areas which are between contour lines, separated by four tenths of an inch or more, were designated as value 1. The areas of low slope, or value 1, have a gradient of less than six percent. According to the Soil Survey of Southeast Vancouver Island and Gulf Islands, British Columbia, six percent is the dividing value between gently sloping (two through five percent) terrain, and moderately sloping (six through nine percent) terrain.⁴

4. J. H. Day, L. Farstad, and D. G. Laird, Ibid., p. 104.

Permeability of the Parent Material

The source map for deriving the permeability of the parent material was titled, "Geologic Sketch Map of Vancouver Island", compiled by J. E. Muller in 1967, at a scale of 1:500,000. An interpretation of the map was made by Dr. James T. Fyles.⁵ Only broad generalizations can be attempted concerning the permeability of the parent material of Vancouver Island. The majority of the permeable parent material is located along the middle third of the east coast of the Island. According to Dr. Fyles, this narrow strip of permeable material is between five and ten miles in width and consists of glacial deposited till over 200 feet in depth. On the west coast of the Island, permeable parent material is restricted to small limestone deposits near lakes, for example, Buttle Lake limestone formation. All the above permeable material was assigned a value of 1, while the remainder of the Island was designated as impermeable, or value 2.

Runoff

To derive the runoff values for the January and July hydrologic subcycles, a comparison was made between the precipitation map and the potential evaporation rate map for each month. Since the potential evaporation rate for January is constantly low, the runoff for areas of high precipitation in liquid phase is heavy, or 3; there is no substantial runoff, or value 1, for areas of either heavy precipitation or

5. Personal interview with Dr. Fyles, a geologist for the Department of Mines and Petroleum Resources, Victoria, B. C., October, 1969.

moderate precipitation occurring in solid phase; while areas of moderate precipitation occurring in liquid phase have a light runoff, or a value of 2.

Only two runoff values, none and light, occur in July. Most of Vancouver Island has a high potential evaporation rate for July, except the mountainous areas of over 3,000 feet in elevation. Those areas of moderate precipitation and high potential evaporation rate have a runoff value of 1, or no substantial runoff; areas of moderate precipitation and low potential evaporation rate have a runoff value of 2, or light runoff; while the area of no precipitation, the extreme southeast portion of the Island, and high potential evaporation rate has a runoff value of 1, or no substantial runoff.

Problems Encountered with the Basic Data

The main problems encountered with the basic data were the difference in scale of the source maps, the form of the data, and the lack of data. In any study, the coordination of the data into useable form is an important consideration. All the source maps had to be reduced or enlarged to a scale of 1:250,000, which was the scale of the base map. This was a major undertaking for such source maps as the four soil maps at a scale of 1:63,360, or the forest cover maps at a scale of 1:126,720. Other maps had to be enlarged, for example, the climatic maps of Canada, at a scale of 1:12,000,000.

The form of the information depicted by the source maps was a ^{cause} ~~course~~ of concern in some cases. All of the source maps were compiled for use other than hydrology. As previously mentioned, the forest cover

maps were compiled for use by logging companies and consequently the classification of the vegetation found on the maps was not the most useful for research in hydrology. For example, a category of non-vegetative areas would have been more useful than merely "non-productive forests and non-forested lands". Other problems in form involved such matters as isoline interval. For example, the nearest isotherm to 50 F. on the mean July temperature map has a value of 56 F., and this created a problem in deciding upon the potential evaporation rate for July.

The availability of basic data concerning the physical environment of Vancouver Island, caused much concern throughout the study. Vegetation, soil, and the permeability of the parent material are the three factors which have the least amount of information available in map form. The forest cover maps are the only maps which completely encompass the entire Island, in a detailed vegetational study. These appear to be the only vegetation maps of Vancouver Island, which depict where forest occurs based on actual field research. Other vegetation maps of Vancouver Island, divide the vegetation into climatic regions; this method of viewing vegetation is based on 'what vegetation should be where' depending upon the climate and does not actually represent what exists in the field.

The only information on the soils of Vancouver Island, is contained in the survey previously mentioned. Only eight percent of the Island has been mapped in detail, and information of the soil of the remainder of the Island is scarce. The lack of information on soil is understand-

able since the survey includes the major arable soils of the Island.⁶

The geologic sketch map compiled by J. E. Muller, is the only complete geologic map of Vancouver Island. Sections of the Island have been surveyed and mapped at a scale of 1:250,000, but the southwestern, central, and extreme northern sections have only scattered geologic information recorded. For this reason, a comprehensive knowledge of the permeability of the parent material is not known.

Validity of the Data

The data is only as valid as the source maps from which it was derived. Some of the source maps were compiled after thirty years of recording climatic conditions. Other source maps are accurate in what they represent; the forest cover maps are accurate, but the information is presented in such a method that it is almost entirely unuseable, in this study, in its present form. The most unreliable data is probably the permeability of the parent material, which was obtained from a sketch map; and that of soil, which for the most part is unsurveyed. From this study, it should be apparent that few comprehensive surveys on the physical environment of Vancouver Island have been conducted, and that such surveys are needed if further research on the hydrology of the Island is to be attempted.

Transfer of Data from the Source Maps to the Hydrologic Maps

The first step in the transfer of the data was to enlarge or reduce all the source maps to a scale of 1:250,000. Then a transparent grid

6. J. H. Day, L. Farstand, and D. G. Laird, op. cit.

(120 rectangles in each row and 287 rectangles in each column, with each rectangle two and one-half tenths of an inch in length by two-tenths of one inch in width) was overlaid on each source map with the grid's length in conjunction with the northwest-southeast orientation of Vancouver Island. Using this approach, each rectangle, which represented eight-tenths of a mile by one mile of the Island's surface, was scrutinized and assigned a value accordingly. The values for each row, or 120 rectangles, were then recorded on 287 computer cards.

Two sets of cards (January and July) were required for the variable factors (precipitation, vegetation, potential evaporation rate, and runoff), while only one set of cards was needed for the permanent factors (soil, slope, permeability of the parent material). To compile a given monthly hydrologic subcycle map, the program control deck was placed with the computer cards recording the values of the seven factors and the computer combined the values recorded for rectangle into a hydrologic subcycle. From the computer printouts, tracings were made to compile the final hydrologic subcycle map for January and July.

Chapter 3 Resultant Subcycles

The resultant hydrologic subcycles of Vancouver Island, for January and July, can be interpreted using many different methods. This chapter analyzes the resultant subcycles by discussing the number and frequency of occurrence of the subcycles and providing a classification and taxonomic key to the subcycles.

Number and Frequency of Occurrence of Subcycles

The total number of hydrologic subcycles occurring on Vancouver Island for the months of January and July, is fifty-seven. Table II, which also serves as a legend for the January and July subcycle maps, lists the assigned number for each subcycle, along with the subcycles' factorial value and frequency of occurrence. Of the fifty-seven subcycles, thirty occur during January, while July has twenty-seven subcycles. Furthermore, each subcycle is exclusive to a single month, that is, no identical subcycle occurs both in January and July. This surprisingly balanced number of subcycles between the two months is due to the equalization of the greater variations of January's precipitation phase (liquid and solid), against July's greater interaction of vegetation with other hydrologic factors. These fifty-seven subcycles are not the total number of possible subcycles which occur on Vancouver Island, but are instead those subcycles which can be derived with the present available information. With more basic information obtained about Vancouver Island, further divisions in the values of the hydrologic factors can be made, leading to a more accurate derivation of subcycles.

Table II

Number of Cycles and Frequency of Occurrence

Cycle	Map	Precip	Veget	Soil	Evap	Slope	Perm	Runoff	Frequency of Occurrence
1	Jan.	5	3	2	1	2	2	3	3
2	Jan.	5	3	2	1	2	1	3	2
3	Jan.	5	3	2	1	1	2	3	4
4	Jan.	5	2	2	1	2	2	3	3
5	Jan.	5	2	2	1	1	2	3	2
6	Jan.	5	1	3	1	1	2	3	2
7	Jan.	5	1	3	1	1	1	3	1
8	Jan.	5	1	2	1	2	2	3	12
9	Jan.	5	1	2	1	2	1	3	6
10	Jan.	5	1	2	1	1	2	3	26
11	Jan.	5	1	2	1	1	1	3	16
12	Jan.	5	1	1	1	2	2	3	1
13	Jan.	4	1	2	1	2	2	1	2
14	Jan.	4	1	2	1	2	1	1	12
15	Jan.	4	1	2	1	1	2	1	2
16	Jan.	4	1	1	1	2	2	1	26
17	Jan.	4	1	1	1	2	1	1	3
18	July	3	3	4	2	1	1	1	1
19	July	3	3	3	2	2	2	1	2
20	July	3	3	3	2	1	2	1	3
21	July	3	3	3	2	1	1	1	10
22	July	3	3	2	2	2	2	1	70
23	July	3	3	2	2	2	1	1	14
24	July	3	3	2	2	1	2	1	43
25	July	3	3	2	2	1	1	1	15
26	July	3	3	2	1	2	2	2	17
27	July	3	3	2	1	2	1	2	1
28	Jan.	3	3	2	1	1	2	2	1
29	July	3	2	3	2	1	1	1	1
30	July	3	2	2	2	2	2	1	100
31	July	3	2	2	2	2	1	1	11
32	July	3	2	2	2	1	2	1	15
33	July	3	2	2	2	1	1	1	7
34	July	3	2	2	1	2	2	2	40
35	July	3	2	2	1	2	1	2	3
36	Jan.	3	1	4	1	1	1	2	1
37	Jan.	3	1	3	1	2	1	2	1
38	Jan.	3	1	3	1	1	2	2	1
39	Jan.	3	1	3	1	1	1	2	7
40	Jan.	3	1	2	1	2	2	2	6
41	Jan.	3	1	2	1	2	1	2	3
42	Jan.	3	1	2	1	1	2	2	9

Cycle	Map	Precip	Veget	Soil	Evap	Slope	Perm	Runoff	Frequency of Occurrence
43	Jan.	3	1	2	1	1	1	2	8
44	July	3	1	1	2	2	2	1	1
45	July	3	1	1	2	2	1	1	2
46	July	3	1	1	1	2	2	2	20
47	July	3	1	1	1	2	1	2	1
48	Jan.	2	1	2	1	2	2	1	1
49	Jan.	2	1	2	1	2	1	1	3
50	Jan.	2	1	2	1	1	2	1	1
51	Jan.	2	1	2	1	1	1	1	1
52	July	1	3	3	2	1	1	1	1
53	July	1	3	2	2	2	2	1	3
54	July	1	3	2	2	1	2	1	4
55	July	1	3	2	2	1	1	1	2
56	July	1	2	2	2	2	2	1	2
57	July	1	2	2	2	1	2	1	4

The frequency of occurrence of a subcycle has little correlation with the amount of area it covers. For example, subcycle 34 occurs in forty different locations during July, but covers less than five percent of the surface of the Island; while subcycle 13 occurs in only two locations during January, but covers approximately forty percent of the surface of the Island. Other subcycles, for example subcycle 12, occur once and cover very little area of the Island, less than one percent. Generally, July subcycles are more frequent in occurrence than January subcycles, because of the many divisions created by light and heavy density of vegetation.

Classification and Grouping of Hydrologic Subcycles

For a more lucid understanding of the derived subcycles, a classification based on the subcycles of January and July, is achieved as follows:

1. (a) For January, four major divisions, heavy precipitation in liquid phase, heavy precipitation in solid phase, moderate precipitation in liquid phase and moderate precipitation in solid phase are formed on the basis of precipitation.
- (b) For July, two major divisions, moderate precipitation in liquid phase and no substantial precipitation, are formed on the basis of precipitation.
2. (a) For January, seven classes are formed depending upon the presence of either heavy density or light density vegetation, and upon the dormancy or absence of vegetation.
- (b) For July, five classes are formed depending upon the presence of either heavy density or light density vegeta-

tion, or the absence of vegetation.

3. (a) For January, twelve orders are formed depending upon the presence of soil with high moisture holding capacity and high infiltration rate, high moisture holding capacity and low infiltration rate, low moisture holding capacity and high infiltration rate, or the absence of soil.
- (b) For July, eight orders are formed depending upon the presence of soil with high moisture holding capacity and high infiltration rate, high moisture holding capacity and low infiltration rate, low moisture holding capacity and high infiltration rate, or the absence of soil.
4. (a) For January, twelve families are formed depending upon either high or low potential evaporation rate. Because of the constant potential evaporation rate in January, there is no difference between the number of orders and families in January.
- (b) For July, eleven families are formed depending upon high or low potential evaporation rate.
5. (a) For January, nineteen categories are formed depending upon the slope being even to gentle, or moderate to steep.
- (b) For July, seventeen categories are formed depending upon the slope being even to gentle, or moderate to steep.
6. (a) For January, thirty types are formed depending upon the permeability or impermeability of the parent material.

- (b) For July, twenty-seven types are formed depending upon the permeability or impermeability of the parent material.
7. (a) The final thirty subcycles for January, are determined by the runoff rate of heavy, light, or none. Because runoff, in this study, is determined by precipitation and potential evaporation rate, the number of types and subcycles remain the same.
- (b) The final twenty-seven subcycles for July, are determined by the runoff rate of light or none.

This classification system is presented and discussed in the following taxonomic key of the individual subcycles of January and July. Each month is presented with an individual taxonomic key. Division III (moderate precipitation in liquid form), occurs in both months; therefore, it is presented in both taxonomic keys with the corresponding subcycles.

Taxonomic Key for the January Subcycles

Division I Heavy Precipitation in Liquid Phase

These are the subcycles of January which have been assigned a precipitation value of 5 for January. These subcycles comprise forty percent of the January subcycles, and approximately forty-five percent of the land surface of the Island. The locations of these subcycles are restricted to the northern eighty-five miles of the Island, an approximately thirty mile strip extending along the west coast of the Island, and 105 mile strip along the east coast beginning at approximately the mid-point of the Island.

Class 1 Shallow Rooting Vegetation with Heavy Density

These January subcycles have an assigned precipitation value of 5 and a vegetation value of 3. These subcycles comprise ten percent of the January subcycles and cover less than five percent of the surface of the Island. The locations of these subcycles is confined to the extreme northwest portion of the Island.

Order 1 Soil with Low Moisture Holding Capacity and High Infiltration Rate

The subcycles occurring in this order have the exact characteristics as Class 1. This means in January, heavy precipitation in liquid phase falling on shallow rooting vegetation with heavy density, occurs on soil which has a low moisture holding capacity and high infiltration rate.

Family 1 Low Potential Evaporation Rate

All of Vancouver Island, in January has a low potential evaporation rate; therefore, these subcycles have the same characteristics as order 2.

Category 1 Moderate to Steep Slope

Type 1 Impermeable Parent Material

Subcycle 1 Heavy Runoff

This subcycle occurs in four locations on the Island which are confined to the northern tip and the northern west coast of the Island.

Type 2 Permeable Parent Material

Subcycle 2 Heavy Runoff

The occurrence of this subcycle is two, which

are confined to the northern west coast of the Island.

Category 2 Even to Gentle Slope

Type 3 Impermeable Parent Material

Subcycle 3 Heavy Runoff

The three locations of this subcycle are restricted to the extreme northern tip of the Island and two interior locations of the northern tip.

Class 2 Shallow Rooting Vegetation with Light Density

This class consist of heavy precipitation in liquid phase and shallow rooting vegetation with low density per unit of area.

These subcycles comprise less than seven percent of the January subcycles and are located on three promontories of the northwest coast.

Order 2 Soil with Low Moisture Holding Capacity and High Infiltration Rate

The subcycles of class 2 are all located in areas where the soil has low moisture holding capacity and high infiltration rate.

Family 2 Low Potential Evaporation Rate

As in family 1, all the January subcycles have low potential evaporation rate.

Category 3 Moderate to Steep Slope

Type 4 Impermeable Parent Material

Subcycle 4 Heavy Runoff

This subcycle occurs in three locations on the Island, all on the northern west coast, and covers less than five percent of the surface of the Island.

Category 4 Even to Gentle SlopeType 5 Impermeable Parent MaterialSubcycle 5 Heavy Runoff

Subcycle 5 occurs in two localities on the northwest coast, and covers less than one percent of the surface of the Island.

Class 3 Dormant or No Vegetation

The dormancy of vegetation accounts for this class. Heavy precipitation and dormant vegetation comprise approximately twenty-three percent of the January subcycles and occupy approximately thirty percent of the surface of the Island.

Order 3 Soil with High Moisture Holding Capacity and Low Infiltration Rate

These cycles are located in small areas where the soil has been given a value of 3.

Family 3 Low Potential Evaporation RateCategory 5 Even to Gentle SlopeType 6 Impermeable SoilSubcycle 6 Heavy Runoff

This subcycle is localized in two small areas of the east coast of the Island where heavy precipitation in liquid phase occurs.

Type 7 Permeable Parent Material

Subcycle 7 Heavy Runoff

This subcycle has a single location on the southwest coast of the Island and covers less than one percent of the Island's surface.

Order 4 Soil with Low Moisture Holding Capacity and High Infiltration Rate

Being the dominant soil type, this order includes more subcycles than Order 3.

Family 4 Low Potential Evaporation Rate

Category 6 Moderate to Steep Slope

Type 8 Impermeable Parent Material

Subcycle 8 Heavy Runoff

The main characteristic of this subcycle is the large extent of area it covers. A large amount of the northern portion and almost the entire western third of the Island, including substantial areas on the east coast and southern part of the Island, are covered by this subcycle.

Type 9 Permeable Parent Material

Subcycle 9 Heavy Runoff

Occurring in six localities over the Island, this subcycle occurs in widely separated locations which are found on the southwest coast to the northeast coast. In comparison to subcycle 8, subcycle 9 covers between six and eight percent of the Island.

Category 7 Even to Gentle Slope

Type 10 Impermeable Parent Material

Subcycle 10 Heavy Runoff

Coastal lowlands, best describes the location of subcycle 10. Having twenty-seven occurrences along the east and west coast makes this one of the most widely dispersed January subcycles. This subcycle covers less area than subcycle 9, even though it has four times as many occurrences.

Type 11 Permeable Parent Material

Subcycle 11 Heavy Runoff

Another coastal subcycle, having less occurrences and covering less area than subcycle 10.

Order 5 No Soil

Family 5 Low Potential Evaporation Rate

Category 8 Moderate to Steep Slope

Type 12 Impermeable Parent Material

Subcycle 12

This is the only subcycle with heavy precipitation in liquid phase and no soil. The location of subcycle 12 is next to the western division of liquid and solid phase heavy precipitation. It covers a minute area, less than one percent of the Island's surface, and hydrologically is insignificant. This is the only subcycle in Division I, which does not have soil.

Division II Heavy Precipitation in Solid Phase

Comprising less than seventeen percent of the January subcycles, these subcycles occur in two large central areas of the Island. The largest of the two areas is centered in the northern portion of the Island and extends to the southeast in an oblong shape approximately 150 miles in length and fifty miles in width. The second area, the smaller of the two areas, is confined to the central section of the southern third of the Island. Together these areas cover approximately thirty-five percent of the surface of the Island.

Class 4 Dormant or No Vegetation

All the subcycles of Division II, have dormant or no vegetation. Occurring where there is heavy precipitation in solid phase it is obvious these subcycles are restricted to areas of high amounts of snowfall.

Order 6 Soil with Low Moisture Holding Capacity and High Infiltration Rate

Being the dominant soil group of the Island, the majority of the subcycles of Division II, have this soil type.

Family 6 Low Potential Evaporation Rate

Category 9 Moderate to Steep Slope

Type 13 Impermeable Parent Material

Subcycle 13 No Substantial Runoff

Because of the solid phase precipitation and low potential evaporation rate, all of the subcycles of Division II have no substantial runoff. This subcycle covers approximately ninety percent of the area of Division II, or approximately

thirty percent of the Island. A majority of the Island's surface is covered by this sub-cycle and subcycle 8, during January.

Type 14 Permeable Parent Material

Subcycle 14 No Substantial Runoff

This subcycle is confined to twelve scattered locations of permeable parent material. The majority of this permeable parent material, is the limestone formations which usually are located near the interior lakes of the Island.

Category 10 Even to Gentle Slope

Type 15 Impermeable Parent Material

Subcycle 15

Occurring in only two localities, subcycle 15 is confined to two valley basins, partially filled by lakes.

Order 7 No Soil

The area of no soil on the Island is generally considered rock outcrops above 5,000 feet in elevation.

Family 7 Low Potential Evaporation Rate

Category 11 Moderate to Steep Slope

Type 16 Impermeable Parent Material

Subcycle 16 No Substantial runoff

A large portion of the central mountainous area above 5,000 feet is comprised of this subcycle. Although this subcycle occurs in twenty-six different locations, it covers less than two

percent of the Island.

Type 17 Permeable Parent Material

Subcycle 17

This subcycle occurs in only three locations and covers less than one percent of the areas of the Island. Its occurrence is always in association with subcycle 14.

Division III Moderate Precipitation in Liquid Phase

These cycles comprise thirty percent of the January subcycles, and covers approximately fifteen percent of the surface of the Island. Moderate precipitation in liquid phase occurs only in the southeastern section of the Island; therefore, the subcycles of this division are all located in this region.

Class 5 Shallow Rooting Vegetation with Heavy Density

This class comprises only three percent of the January subcycles.

Order 8 Soil with Low Moisture Holding Capacity and High Infiltration Rate

Family 8 Low Potential Evaporation Rate

Category 12 Even to Gentle Slope

Type 18 Impermeable Parent Material

Subcycle 28

Restricted to the southern tip of the Island, this subcycle is an anomaly in that it is the only location in the southern half of the Island where the vegetation is not dormant during January. From this subcycle on, a discrepancy

occurs between the type number and the sub-cycle number. This inconsistency is created because of the method of numbering used in this study, which assigns number to subcycles according to the values of the factors.

Class 6 Dormant or No Vegetation

Order 9 Soil with High Moisture Holding Capacity and High Infiltration Rate

This soil group is severely restricted in number of occurrences, having only one, and the area it covers on the Island.

Family 9 Low Potential Evaporation Rate

Category 13 Even to Gentle Slope

Type 19 Permeable Parent Material

Subcycle 36

Restricted to a single, small area near the midpoint of the east coast, this subcycle is unique because of its type of soil.

Order 10 Soil with High Moisture Holding Capacity and Low Infiltration Rate

This is not the dominant soil group of the Island and includes few of the subcycles of this division.

Family 10 Low Potential Evaporation Rate

Category 14 Moderate to Steep Slope

Type 20 Permeable Parent Material

Subcycle 37 Light Runoff

This subcycle occurs only once on a promontory along the southeast coast of the Island.

Category 15 Even to Gentle Slope

Type 21 Impermeable Parent Material

Subcycle 38 Light Runoff

Occupying less than one percent of the Island's surface, this subcycle has its single occurrence six miles south of subcycle 40.

Type 22 Permeable Parent Material

Subcycle 39 Light Runoff

This subcycle is located in seven isolated pockets along the southeast coast and covers approximately one percent of the surface of the Island.

Order 11 Soil with Low Moisture Holding Capacity and High Infiltration Rate

Family 11 Low Potential Evaporation Rate

Category 16 Moderate to Steep Slope

Type 23 Impermeable Parent Material

Subcycle 40 Light Runoff

This subcycle covers approximately twenty-five percent of the area of Division III.

Type 24 Permeable Parent Material

Subcycle 41 Light Runoff

This subcycle occupies those areas of the southeast coast where the parent material is permeable and the slope gradient moderate to steep. The largest area occupied by subcycle 41 is an inland coastal belt, located approximately five

miles from the coast and has a one to nine mile width and a length of fifty-eight miles.

Category 17 Even to Gentle Slope

Type 25 Impermeable Parent Material

Subcycle 42 Light Runoff

This subcycle is generally coastal in location with a few locations inland. The largest area it covers is the entire southern tip of the Island.

Type 26 Permeable Parent Material

Subcycle 43 Light Runoff

Being similar to subcycle 46 except for permeability, this subcycle has a majority of its occurrences directly on the southeast coast of the Island, with the largest inland position occurring three miles north of the head of the Alberni Inlet.

Division IV Moderate Precipitation in Solid Phase

Moderate precipitation occurring in solid phase is limited to the southeastern section of Vancouver Island. The subcycles of this division comprise fourteen percent of the total number of January subcycles, but cover less than five percent of the surface of the Island. This division creates a transition zone between heavy precipitation in solid phase and moderate precipitation in liquid phase.

Class 7 Dormant or No Vegetation

Order 12 Soil with Low Moisture Holding Capacity and High Infiltration Rate

Family 12 Low Potential Evaporation Rate

Category 18 Moderate to Steep Slope

Type 27 Impermeable Parent Material

Subcycle 48 No Runoff

This subcycle covers approximately ninety percent of the area of Division IV. The only difference between this subcycle and subcycle 13, which almost covers the entire central portion of the Island, is that subcycle 13 has heavy precipitation in solid phase, while this subcycle has moderate precipitation in solid phase.

Type 28 Permeable Parent Material

Subcycle 49 No Runoff

Occurring in three scattered locations, this subcycle covers less than one percent of the Island's surface.

Category 19 Even to Gentle Slope

Type 29 Impermeable Parent Material

Subcycle 50 No Runoff

This subcycle occurs in a single location next to the division line of moderate precipitation in liquid phase and moderate precipitation in solid phase.

Type 30 Permeable Parent Material

Subcycle 51 No Runoff

This is another infrequent subcycle with only a single occurrence, occupying approximately one square mile of the Island's surface.

Taxonomic Key for the July Subcycles

Division I Moderate Precipitation in Liquid Phase

The subcycles of this division comprise eighty percent of the July subcycles and cover approximately ninety-five percent of the surface of the Island. The only area not included in this division is the extreme southeast section of the Island.

Class 1 Shallow Rooting Vegetation with Heavy Density

Table I, in the first chapter of this study, presented a list of impossible combinations of which one was that heavy density vegetation could not survive with only moderate precipitation. In this study it is assumed that if a deficit occurs, adequate moisture for heavy density vegetation can easily be maintained through soil moisture and ground water storage. This class comprises thirty-eight percent of the July subcycles and approximately forty percent of the Island's surface.

Order 1 Soil with High Moisture Holding Capacity and High Infiltration Rate

Family 1 High Potential Evaporation Rate

Approximately ninety-five percent of Vancouver Island has high potential evaporation rate during July.

Category 1 Even to Gentle Slope

Type 1 Permeable Parent Material

Subcycle 18 No Runoff

This subcycle has the same location as January subcycle 39. It has only one frequency of occurrence and is an anomaly because of its soil group.

Order 2 Soil with High Moisture Holding Capacity and Low Infiltration Rate

Family 2 High Potential Evaporation Rate

Category 2 Moderate to Steep Slope

Type 2 Impermeable Parent Material

Subcycle 19 No Runoff

The frequency of occurrence of this subcycle is two and both locations are in the middle section of the east coast, and cover less than one percent of the surface of the Island.

Category 3 Even to Gentle Slope

Type 3 Impermeable Parent Material

Subcycle 20 No Runoff

This subcycle has three locations of which two are next to subcycle 19, with the third occurrence six miles to the south. Only one of these is directly on the coast; the other two locations are on the coastal plain approximately ten miles inland.

Type 4 Permeable Parent Material

Subcycle 21 No Runoff

Subcycle 21 has ten scattered locations all on

the southeast coast of the Island. The majority of these locations are directly on the coast and together constitute approximately one percent of the Island's area.

Order 3 Soil with Low Moisture Holding Capacity and High Infiltration Rate

The soil group of this order is the dominant soil of the Island, therefore, this order has more subcycles and covers a much larger extent of area than the previous two orders.

Family 3 High Potential Evaporation Rate

Category 4 Moderate to Steep Slope

Type 5 Impermeable Parent Material

Subcycle 22 No Runoff

Being the second most numerous July subcycle in occurrence, having approximately seventy different locations, this subcycle is located in almost every part of the Island. A rough estimate of the surface of the Island it covers is thirty-five percent.

Type 6 Permeable Parent Material

Subcycle 23 No Runoff

Generally, subcycle 23 is located along the southeast coastal plain. The largest area covered by this subcycle is located along the southeast coastal plain covering an area approximately seven miles in width and 105 miles in length. The remainder of the subcycles are

located south of the strip along the east coast, and a few occupancies are located on the northwest coast.

Category 5 Even to Gentle Slope

Type 7 Impermeable Parent Material

Subcycle 24 No Runoff

The numerous positions of this subcycle are located along both the east and west coasts of the Island. These forty-three locations cover only five percent of the surface of the Island.

Type 8 Permeable Parent Material

Subcycle 25 No Runoff

This subcycle occupies fifteen locations on the southern halves of the east and west coasts.

This subcycle has its largest and its most frequent occurrence on the southeast coast of the Island. The total area of this subcycle's coverage is approximately three percent.

Family 4 Low Potential Evaporation Rate

The subcycles of this family are located in the central mountainous area of the Island, above 3,000 feet.

Category 6 Moderate to Steep Slope

Type 9 Impermeable Parent Material

Subcycle 26 Light Runoff

This subcycle occurs in the central mountainous area between 3,000 and 5,000 feet in elevation. It has a frequency of occurrence of seventeen

and covers less than one percent of the surface of the Island. It differs with the previous July subcycles in that it has light runoff.

Type 10 Permeable Parent Material

Subcycle 27 Light Runoff

The single occurrence of this subcycle is created by the permeability of a limestone formation in the southeast mountainous area of the Island, twenty miles from the coast.

Class 2 Shallow Rooting Vegetation with Light Density

This class comprises twenty-six percent of the July subcycles. The moderate precipitation in liquid phase easily supplies enough moisture to maintain this density of vegetation. Covering approximately forty percent of the Island's surface, this occurs in all areas except the southeast tip of the Island.

Order 4 Soil with High Moisture Holding Capacity and Low Infiltration Rate

Soil of this order occurs infrequently and covers very little area of the Island.

Family 5 High Potential Evaporation Rate

Category 7 Even to Gentle Slope

Type 11 Permeable Parent Material

Subcycle 29 No Runoff

With only a single occurrence, located near the midpoint of the east coast of the Island, this subcycle covers less than one percent of the

Island's surface and is a anomaly among the July subcycles.

Category 8 Moderate to Steep Slope

Type 12 Impermeable Parent Material

Subcycle 30 No Runoff

Being the subcycle with the most frequent occurrence, roughly estimated at 100, this subcycle covers approximately thirty-five percent of the Island's surface. This subcycle can be found in almost every part of the Island except the southeastern tip.

Type 13 Permeable Parent Material

Subcycle 31 No Runoff

Occurring in the mountainous area of the Island, this subcycle has eleven scattered locations which correspond to the interior limestone formations.

Category 9 Even to Gentle Slope

Type 14 Impermeable Parent Material

Subcycle 32 No Runoff

The majority of this subcycle's fifteen locations are along the lowland portion of the west coast. Most of these locations are small in areal extent, therefore this subcycle covers less than two percent of the surface of the Island.

Type 15 Permeable Parent Material

Subcycle 33 No Runoff

Similar to subcycle 32, except having permeable parent material, the majority of this subcycle's locations are along the lowlands of the west coast, with a few positions located in the southeast section of the Island, and covers less than two percent of the surface of the Island.

Family 6 Low Potential Evaporation Rate

The subcycles of this family occur in the central mountainous area of the Island, above 3,000 feet in elevation.

Category 10 Moderate to Steep SlopeType 16 Impermeable Parent MaterialSubcycle 34 Light Runoff

This subcycle approximately occurs in forty locations scattered throughout the central mountainous area. The approximate coverage of the surface of the Island by this subcycle is less than two percent. It differs from the majority of the July subcycles in that it has low potential evaporation rate and light runoff.

Type 17 Permeable Parent MaterialSubcycle 35 Light Runoff

Two of this subcycle's locations are in the central mountainous area and the third location is nineteen miles inland from the southeast coast. Each of these locations is small in area which makes the areal coverage of this subcycle less

than one percent of the Island's surface.

Class 3 No Vegetation

The absence of vegetation in July, occurs only in the mountainous regions above 5,000 feet in elevation. This class comprises only fourteen percent of the total July subcycles and approximately covers only one percent of the surface of the Island.

Order 5 No Soil

Similar to the absence of vegetation, the absence of soil occurs only in the mountainous regions above 5,000 feet. These areas of no soil are usually bare rock outcrops, therefore eliminating the possibility of having an substantial vegetation established in these areas.

Family 7 High Potential Evaporation Rate

The areas of high potential evaporation rate, no soil, and absence of vegetation are located between the 60 F. and 56 F. isotherm; therefore, even with the high elevation these areas do not qualify as having low potential evaporation rate.

Category 11 Moderate to Steep Slope

Type 18 Impermeable Parent Material

Subcycle 44 No Runoff

This subcycle has a single occurrence slightly west of the center of the Island and covers less than one percent of the Island's surface.

Type 19 Permeable Parent Material

Subcycle 45 No Runoff

Both occurrences of this subcycle are located in the high mountainous area surrounding Buttle Lake. The permeability of the parent material is due to limestone formation.

Family 8 Low Potential Evaporation RateCategory 12 Moderate to Steep SlopeType 20 Impermeable Parent MaterialSubcycle 46 Light Runoff

This subcycle has approximately twenty locations, all small in areal extent, in the central mountainous region of the Island.

Type 21 Permeable Parent MaterialSubcycle 47 Light Runoff

The single occurrence of this subcycle is located in the middle of the Island.

Division II No Substantial Precipitation

Only the extreme southeast section of the Island is classified as having less than one inch of precipitation during July, or no substantial precipitation. The subcycles of this division comprise twenty-two percent of the July subcycles and cover only approximately five percent of the surface of the Island.

Class 4 Shallow Rooting Vegetation with Heavy Density

Theoretically, the occurrence of any vegetation and no precipitation is an impossible combination. In this study, no substantial precipitation is less than one inch of precipitation occurring in the month. Soil moisture and ground water storage

is assumed to supply the added moisture to partially alleviate the moisture deficit.

Order 6 Soil with High Moisture Holding Capacity and High Infiltration Rate

Family 9 High Potential Evaporation Rate

Category 13 Even to Gentle Slope

Type 22 Permeable Parent Material

Subcycle 52 No Runoff

This subcycle has a single occurrence located on the northwest coast of Saanich Inlet. The areal extent of this subcycle is small and covers only approximately one percent of Division II.

Order 7 Soil with Low Moisture Holding Capacity and High Infiltration Rate

Family 10 High Potential Evaporation Rate

Category 14 Permeable Parent Material

Type 23 Permeable Parent Material

Subcycle 53 No Runoff

This division covers almost the entire eastern half of Division II, but only approximately two percent of the area of the Island. Of the other two locations of this subcycle, one is on the east coast of the Saanich Inlet, the other is located 3 miles northwest of the Sooke Basin, and both cover very small areas in extent.

Category 15 Even to Gentle Slope

Type 24 Impermeable Parent Material

Subcycle 54 No Runoff

Half of Division II is classified as even to gentle slope; therefore, this subcycle covers a large portion of Division II. This subcycle is located in the central section of Division II, with other locations occurring in the north and in the south of the division.

Type 25 Permeable Parent MaterialSubcycle 55 No Runoff

This subcycle has two occurrences of which both are located in the extreme northern section of Division II.

Class 5 Shallow Rooting Vegetation with Light Density

The same assumptions presented in Class 4 of the division, holds true for this class.

Order 8 Soil with Low Moisture Holding Capacity and High Infiltration RateFamily 11 High Potential Evaporation RateCategory 16 Moderate to Steep SlopeType 26 Impermeable Parent MaterialSubcycle 56 No Runoff

This subcycle has two occurrences, both near the Sooke Basin, in the southwest quarter of Division II. Together, these areas cover approximately seven percent of Division II, and less than one percent of the Island's surface.

Category 17 Even to Gentle Slope

Type 27 Impermeable Parent Material

Subcycle 57 No Runoff

A large portion of the northeast section of Division II is covered by this subcycle. The light density vegetation of this sector is a result of the land use, that is, large areas of residential or agricultural land use.

The taxonomic key of the subcycles fulfills only the requirement of describing the factorial values of each subcycle, and briefly discusses the location and extent of each subcycle. A further discussion, which is provided by the next two chapters, is needed to describe the temporal and spatial interaction of the subcycles.

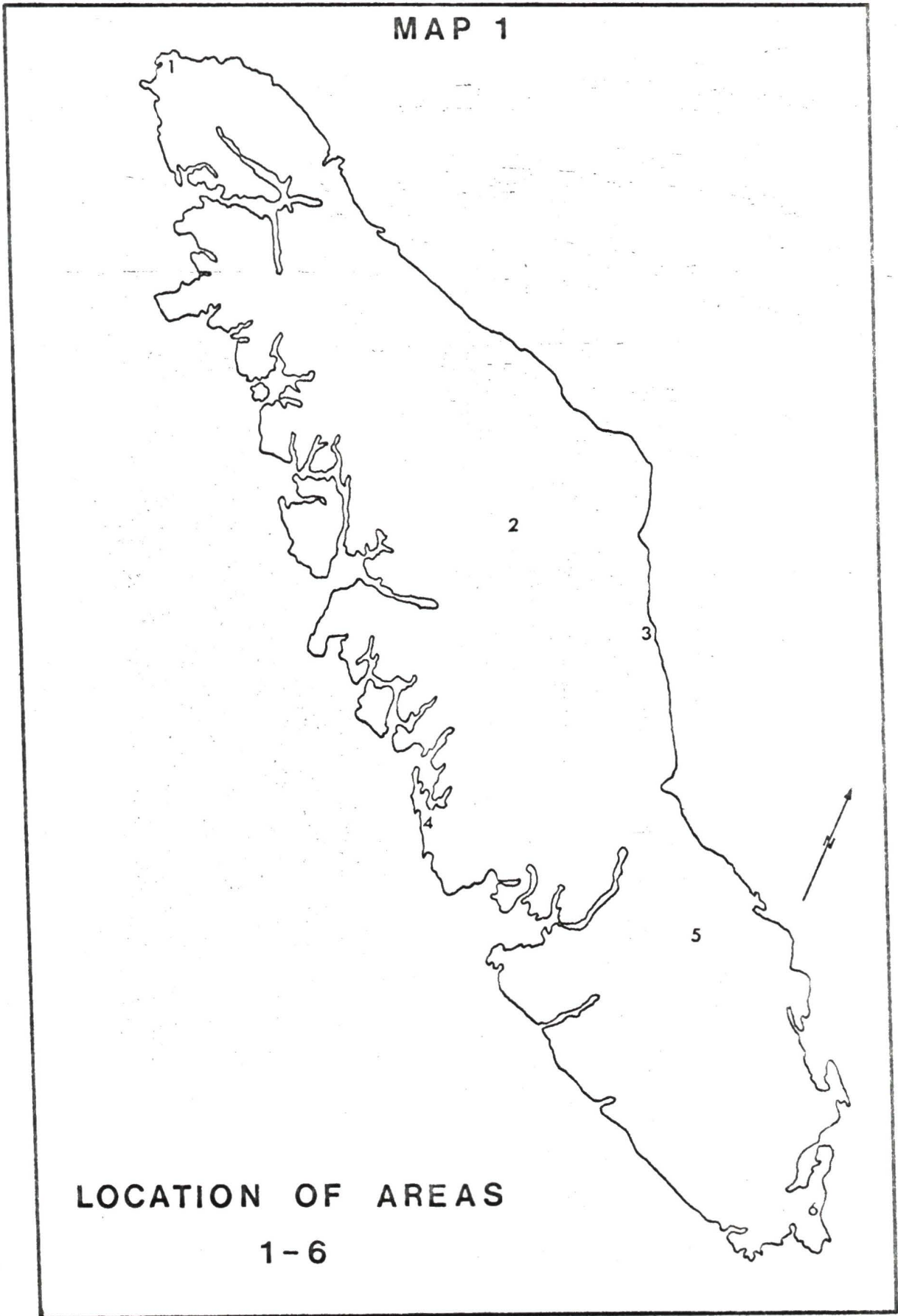
Chapter 4 Temporal Interaction of Subcycles

Temporal interaction refers to those changes which occur in the hydrologic subcycles due to seasonality. Although seasonality usually influences only the variable factors (precipitation, vegetation, potential evaporation rate, and runoff), under certain conditions such permanent factors as the moisture holding capacity and infiltration rate of the soil can also vary throughout the year. For this study, six locations (refer to Map 1) have been selected as examples of temporal interaction, using divisional change as criteria, which occurs on Vancouver Island.

Area 1

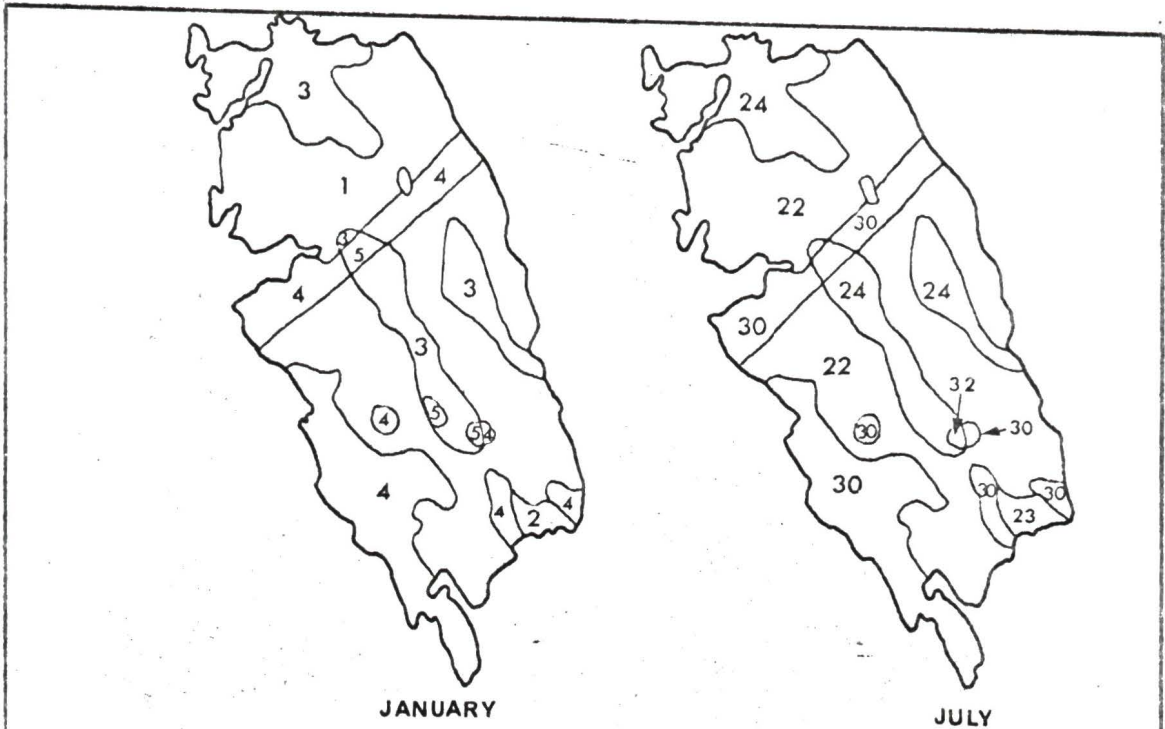
Area 1 is located in the extreme northwest portion of Vancouver Island. Map 2, depicts the subcycles of January and July, which comprise this area, while Graph 1, illustrates the seasonal fluctuations of the variable factors. The three variable factors which change temporally from January to July are: heavy precipitation in liquid phase changes to moderate precipitation in liquid phase, low potential evaporation rate changes to high potential evaporation rate, and heavy runoff changes to no runoff. This is one of the few localities on Vancouver Island, where vegetation does not become dormant during January. This area has a heavy moisture surplus in January, and an adequate moisture supply in July. During July, soil moisture and ground water storage provide enough moisture to maintain vegetation growth.

MAP 1

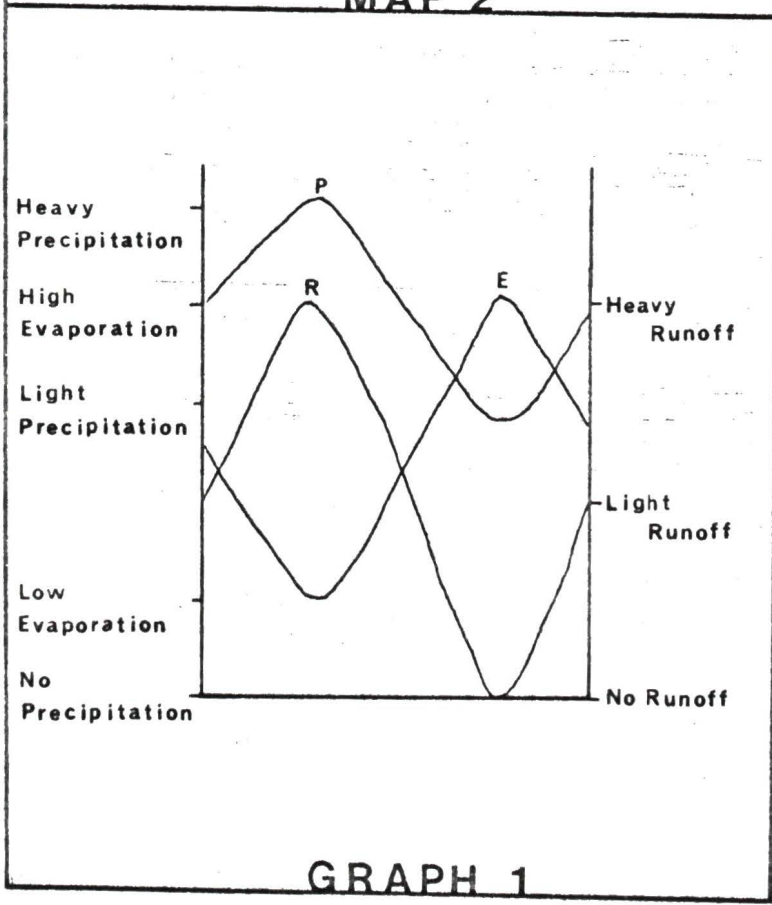


LOCATION OF AREAS

1-6



MAP 2



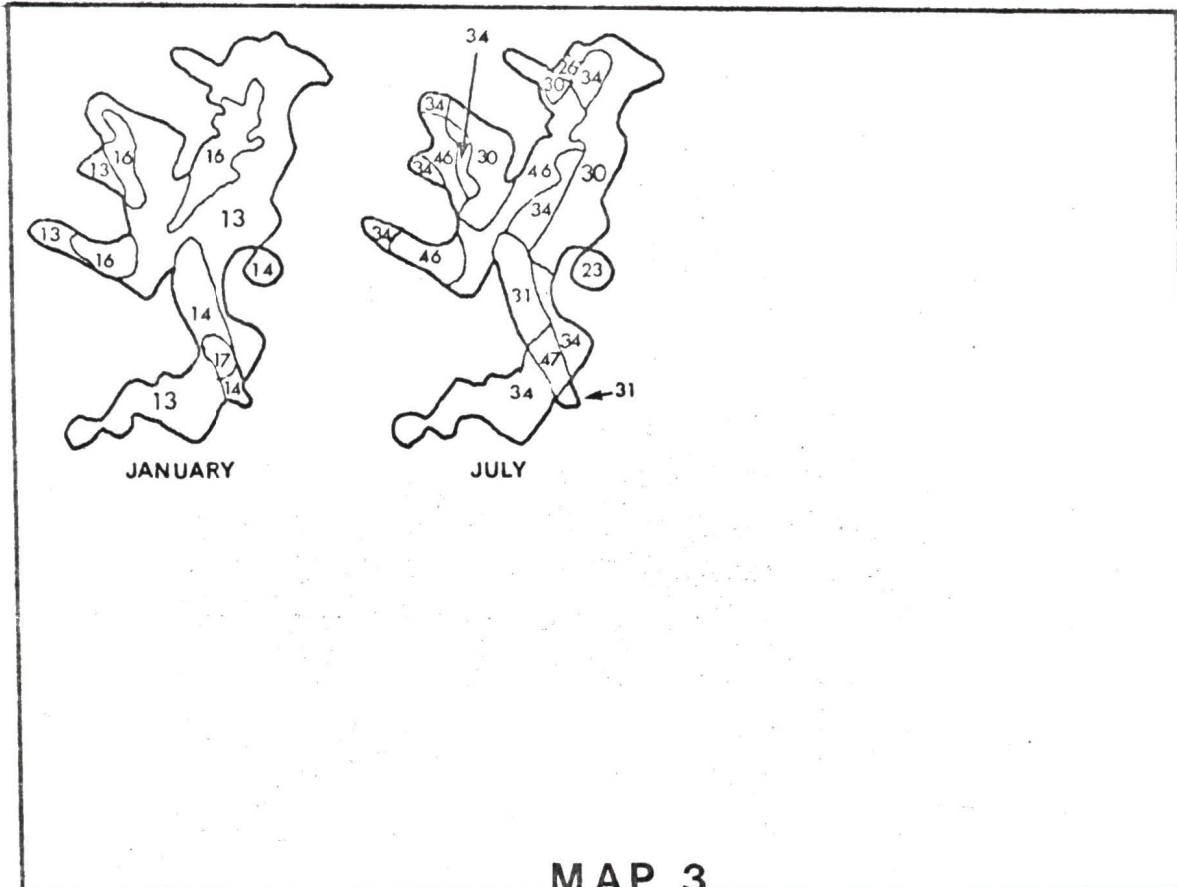
GRAPH 1

Area 2

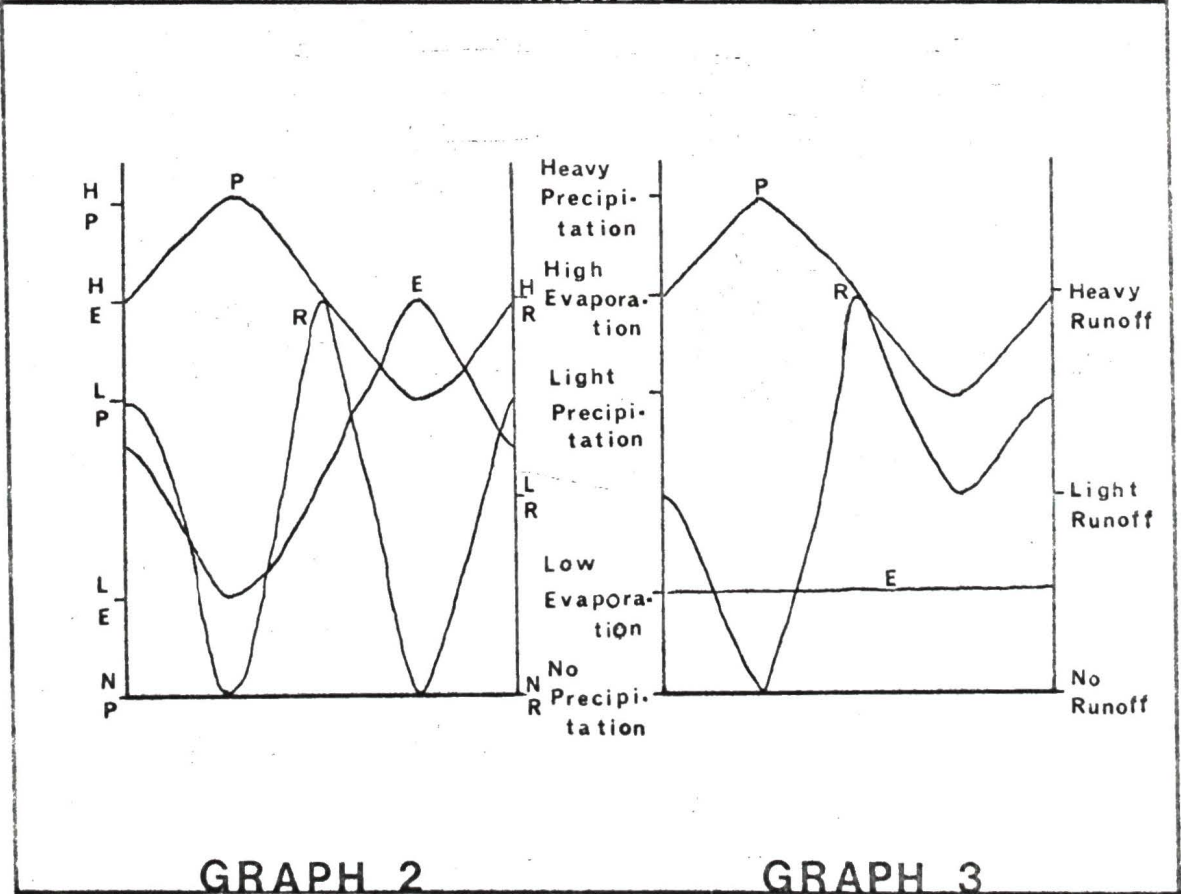
On the July Hydrologic Subcycle map, this area is designated as complex 2. This area is located in the central mountainous region of the Island. Differentiated by only a few subcycles in January, this area divides into many different subcycles in July (refer to Map 3). Graph 2 and 3, illustrate the two variations in potential evaporation rate which occur in complex 2.

Area 2, can be divided conveniently into subcycles which occur below 3,000 feet and subcycles which occur above 3,000 feet in elevation. The variable factors of subcycles below 3,000 feet which change temporally from January to July are: heavy precipitation in solid phase changes to moderate precipitation in liquid phase, dormant vegetation changes to non-dormant vegetation, and low potential evaporation rate changes to high potential evaporation rate. No substantial runoff occurs in these subcycles for either month because in January the precipitation is in solid phase, while during July the high potential evaporation rate evaporates all excess moisture.

The variable factors of subcycles above 3,000 feet which change temporally from January to July are: heavy precipitation in solid phase changes to moderate precipitation in liquid phase, dormant vegetation changes to non-dormant vegetation (if vegetation is present), and no runoff changes to light runoff. In this area, above 3,000 feet the potential evaporation rate remains low all year. Because precipitation has changed phase, from solid to liquid, runoff changes to light during July.



MAP 3

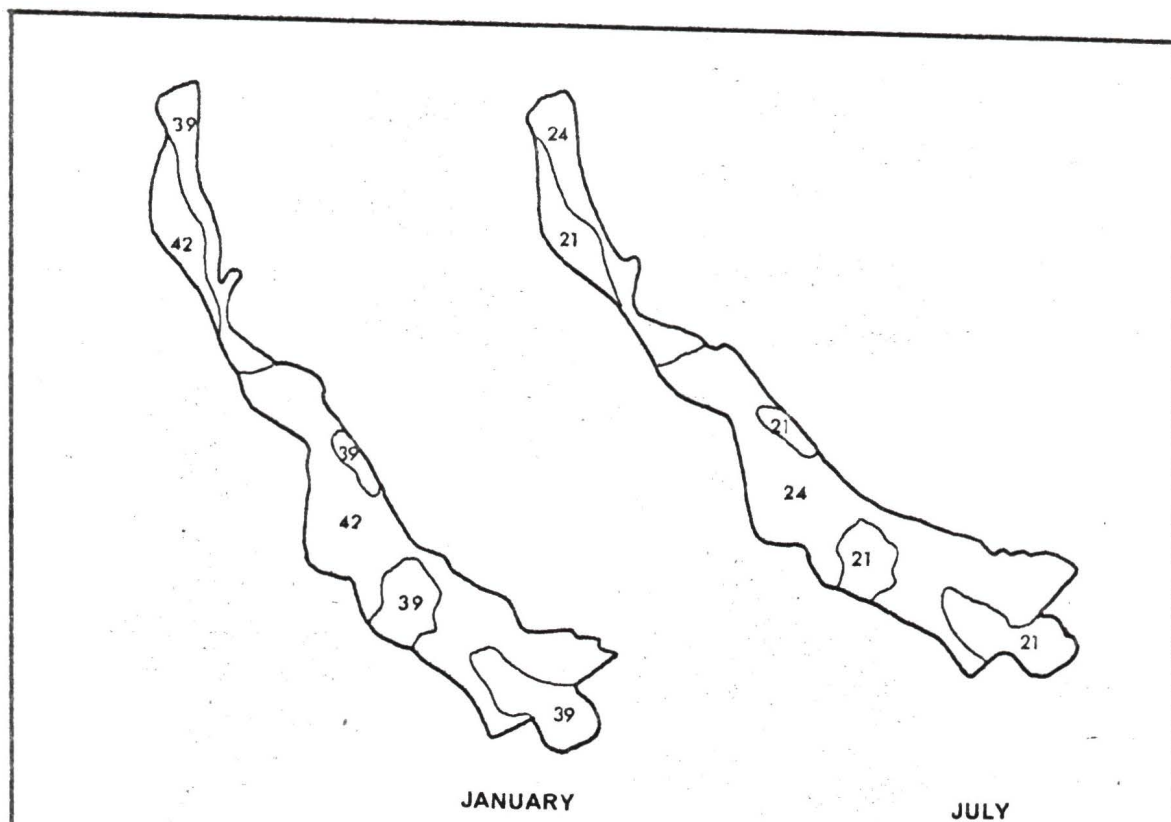


Because precipitation occurs in solid phase in Area 2, time of peak runoff does not coincide with the time of heaviest precipitation. Instead, peak runoff is delayed approximately three months, until April, and coincides with spring melt. Runoff from subcycles below 3000 feet is heavy in the spring, none in the summer, increases in the fall coinciding with the autumn rains, and finally decreases in the winter with the occurrence of solid phase precipitation. Areas above 3,000 feet have the same runoff pattern as areas below 3,000 feet, except runoff during the summer is light due to the low potential evaporation rate of the higher elevation. In reference to moisture surplus and deficit, areas below 3,000 feet have a heavy potential moisture surplus in January, an actual heavy moisture surplus in the spring, an adequate supply in the summer, and a slight surplus in the fall. Subcycles above 3,000 feet have a heavy potential moisture surplus in January, an actual heavy moisture surplus in the spring, a slight surplus in the summer, and a heavy moisture surplus in the fall.

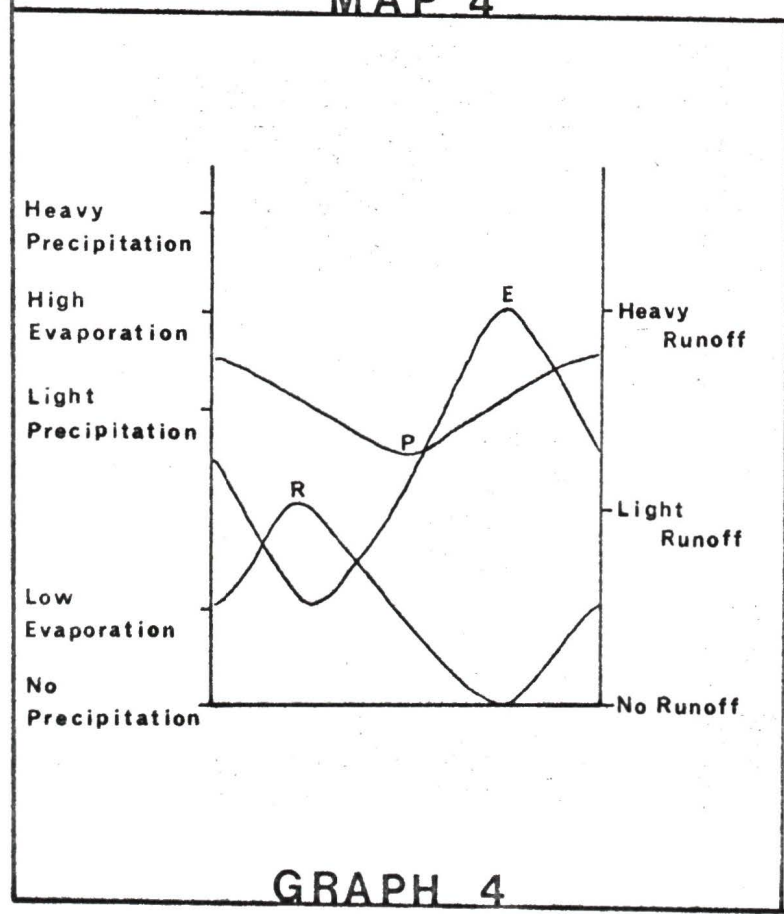
Area 3

This area is located on the southeast coast of the Island, and represents an area where moderate precipitation in liquid phase occurs throughout the year. Map 4, depicts the areal change which occurs in this location from January to July, and Graph 4, illustrates the temporal changes which occur in the variable factors.

Since precipitation remains constant throughout the year, only three variable factors change temporally in Area 3. During January, vegetation is dormant, but as the common vegetation pattern on the Island, it becomes non-dormant in July. This area has low potential



MAP 4



GRAPH 4

evaporation rate during January and high potential evaporation rate during July. Runoff changes from light in January to no substantial runoff in July. This is an area of light moisture surplus in January, and adequate moisture supply during July. Between precipitation, soil moisture, and ground water storage enough moisture is available for vegetation growth during July.

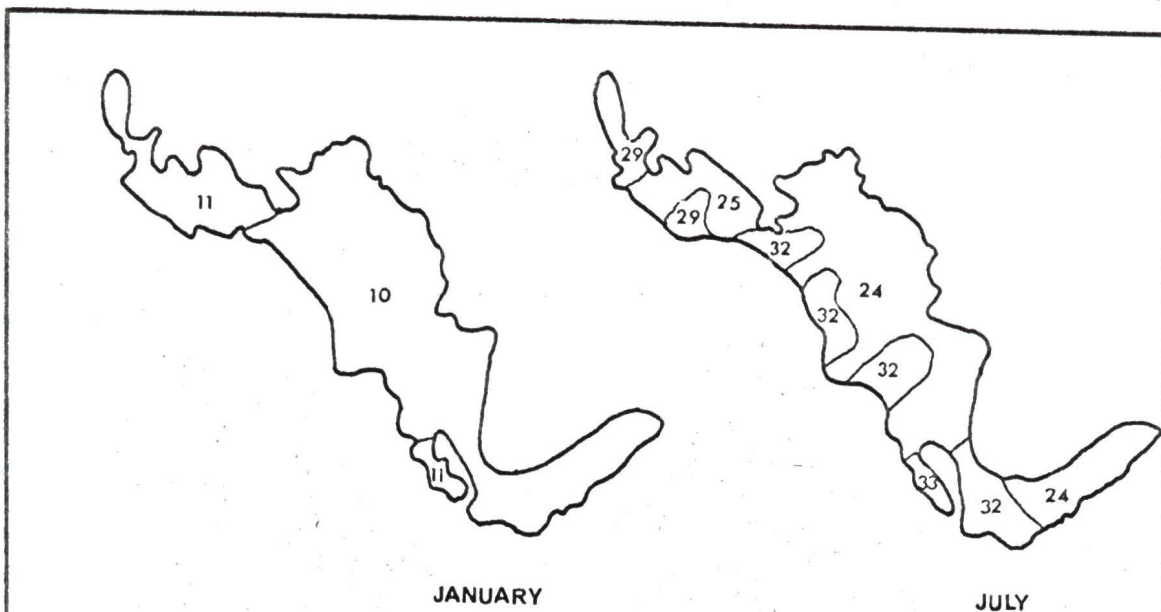
Area 4

Located in the central third of the west coast of the Island, Area 4 represents the areas where precipitation changes from heavy in liquid phase during January, to moderate in liquid phase during July, and where vegetation is dormant in January and non-dormant in July. This is the common pattern of temporal change for almost the entire west coast of the Island, except for the northwest tip where vegetation is non-dormant all year.

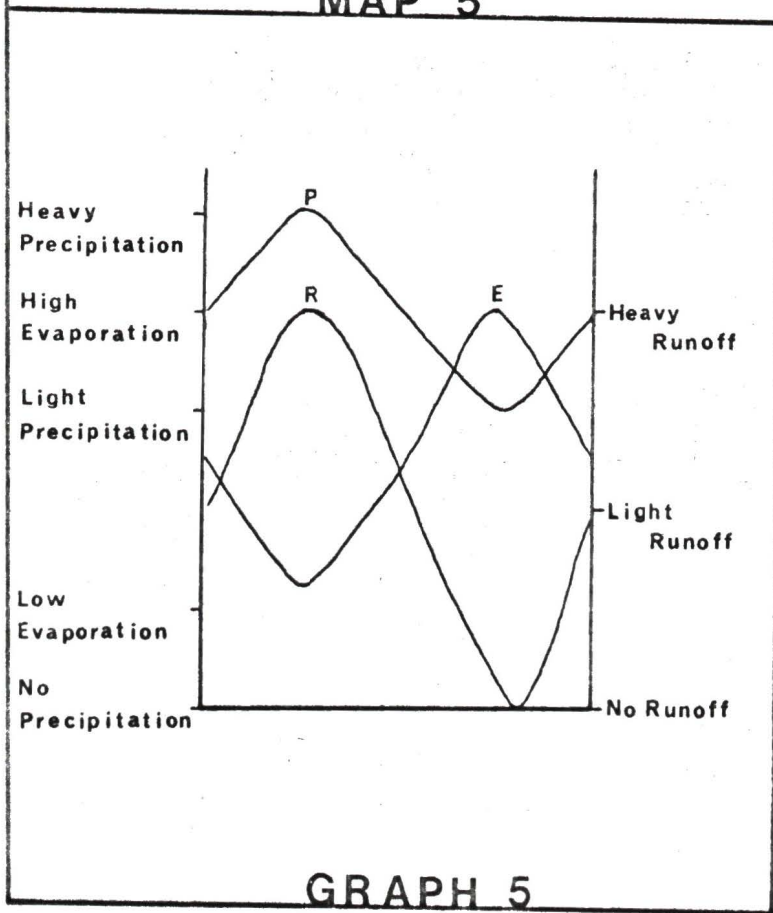
Map 5, and Graph 5, illustrate the areal temporal change and the temporal change of the variable factors, respectively. Potential evaporation rate, in this area, changes from low during January to high during July, while runoff changes from heavy during January, to no substantial runoff during July. Area 4 has a heavy moisture surplus during January, and an adequate moisture supply during July.

Area 5

This area is located in the central highlands of the southern half of the Island, and is representative of that portion of the Island which receives moderate precipitation in solid phase during January, and moderate precipitation in liquid phase during July. Map 6, depicts the



MAP 5



GRAPH 5

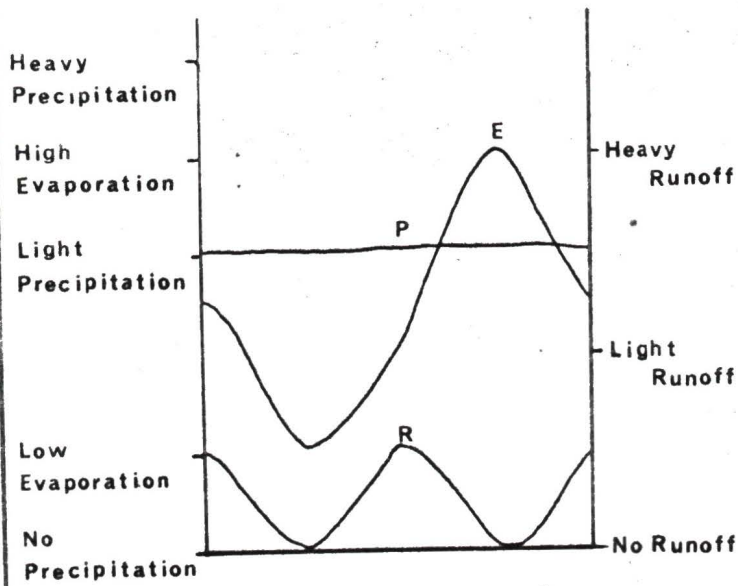


JANUARY



JULY

MAP 6



GRAPH 6

January and July subcycles which occur in this area and Graph 6 illustrates the temporal interaction of the variable factors.

Vegetation, in this area, is dormant during January, and non-dormant during July. Potential evaporation rate changes from low during January, to high in July. As in Area 2, there is no substantial runoff in January, due to the phase of the precipitation, and light runoff, occurs during spring melt. During July, there is no substantial runoff, while light runoff occurs in the fall with a lowering of the potential evaporation rate and precipitation occurs in liquid phase. This area has a light potential moisture surplus in January, achieves an actual light moisture surplus with spring melt, has an adequate moisture supply during July, and again has a light moisture surplus in the fall.

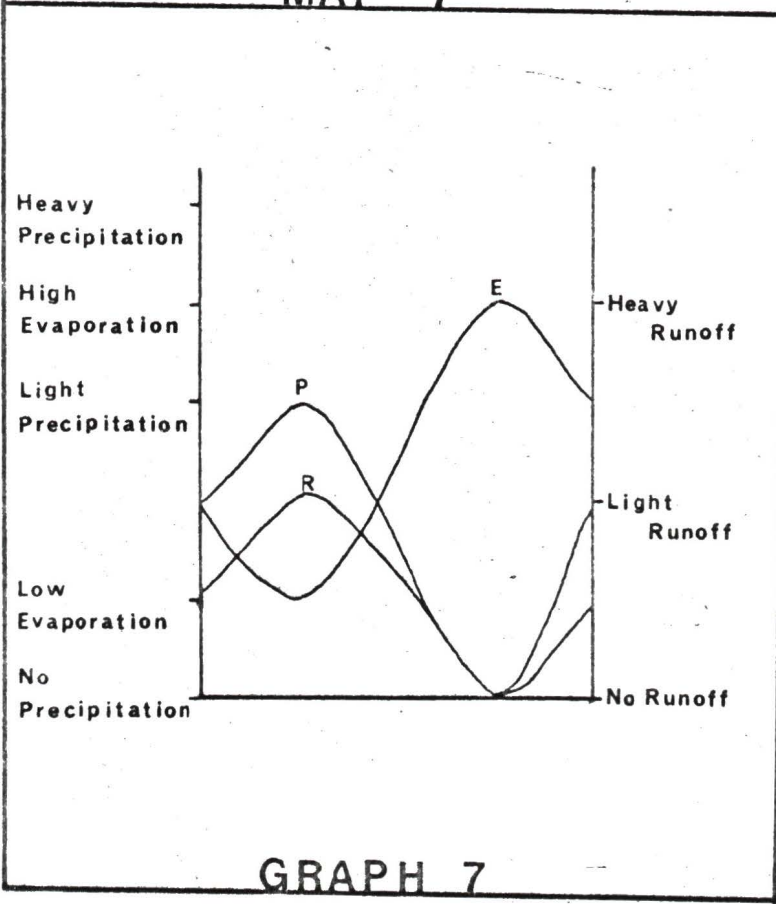
Area 6

Located in the extreme southeast portion of Vancouver Island, this area represents the region of moderate precipitation in liquid phase during January, and no substantial precipitation during July. Map 7, depicts the January and July subcycles which occur in this area, and Graph 7, illustrates the temporal interaction of the variable factors.

Except for the extreme southern tip where vegetation is non-dormant all year, vegetation in this area is dormant during January and non-dormant during July. Potential evaporation rate varies from low during January, to none in July. During January, there is a light moisture surplus, while July has a moisture deficit owing to the lack



MAP 7



GRAPH 7

water storage to support a heavy density of vegetation. The moisture deficit occurring in this area is not alleviated naturally by obtaining moisture from other areas, since the bordering area does not produce runoff, and the drainage network is not arranged in a pattern which allows moisture to be easily transported into this area even if moisture was available from other areas (refer to July Moisture Supply map). Irrigation is needed in this area for vegetation not adapted to periods of moisture deficit, such as commercial crops.

Chapter 5 Spatial Interaction of Hydrologic Subcycles

Spatial interaction of subcycles refers to the spatial distribution of subcycles with different moisture supply characteristics and the interaction, if any, of these subcycles. This chapter explains the spatial interaction of subcycles for January and July, by discussing the spatial relationship between areas of moisture surplus and deficit, for each of the months. The January Moisture Supply Map and July Moisture Supply Map, depict areas of different moisture characteristics, superimposed upon the drainage pattern of Vancouver Island.

January Spatial Interaction

According to the criteria used in this study, January has four areas of different moisture supply characteristics (see January Moisture Supply map). Heavy moisture surplus occurs along the west coast and the northern section of the Island. This moisture surplus is derived from heavy precipitation in liquid phase and low potential evaporation rate, which results in heavy runoff. The majority of this heavy surplus drains towards the west coast, into the Pacific Ocean.

Heavy potential moisture surplus occurs in the same two large areas as does heavy precipitation in solid phase. This potential moisture surplus is derived from heavy precipitation in solid phase and low potential evaporation rate. The solid phase of the precipitation results in no substantial runoff at this time. During spring melt, this potential moisture surplus becomes actual moisture surplus, draining towards both the east and west coast of the Island, adding to

the moisture supply of the area it passes through.

Light moisture surplus occurs along the southeast coast of Vancouver Island, during January. This surplus is derived from moderate precipitation in liquid phase and low potential evaporation rate, which results in light runoff. All of this moisture surplus drains directly into the Strait of Georgia, without passing through any other moisture area.

Light potential moisture surplus is the smallest in area of the January moisture surplus areas and occurs in the same two locations as light precipitation in solid phase does. Light potential moisture surplus is derived from light precipitation in solid phase and low potential evaporation rate, which results in no substantial runoff at this time. Light runoff occurs from this area during spring melt, and drains towards the southeast coast, adding to the moisture supply of the area it passes through.

In summary, all locations on Vancouver Island during January, have a moisture surplus or a potential moisture surplus. Except for the movement of moisture from higher elevation to the coast within the same moisture surplus area, little spatial interaction of subcycles occurs at this time. A large portion of the movement of moisture from higher elevation, is delayed until the spring when the rise in temperature changes the phase of precipitation from solid to liquid phase and changes potential evaporation rate from low to high, which melts the potential moisture surplus.

July Spatial Interaction

The only moisture surplus of Vancouver Island during July, occurs in isolated locations in the central mountainous area. This light moisture surplus is derived from moderate precipitation in liquid phase and low potential evaporation rate, which results in light runoff. Runoff is rapid in these locations since most areas lack soil and vegetation to intercept runoff. This moisture surplus drains both to the Pacific Ocean, towards the west, and the Strait of Georgia, towards the east. Only a portion of this moisture surplus actually reaches the coast since it must pass through an area of moderate precipitation in liquid phase with high potential evaporation rate.

Approximately ninety percent of Vancouver Island during July, has adequate moisture supply. Adequate moisture supply is defined in this study as moderate precipitation in liquid phase and high potential evaporation rate, which results in no substantial runoff. The lack of runoff does not mean the moisture supply of this area cannot fulfill the needs of vegetation and other biotic communities. The forest cover maps demonstrate that soil moisture and ground water storage is adequate to maintain vegetation growth at this time. Also, a small amount of additional moisture is derived through runoff from the light moisture surplus areas.

The extreme southeast portion of Vancouver Island is the only area of moisture deficit during July. This area receives no substantial precipitation and has high potential evaporation rate, which results in no runoff. Most of this area has light density vegetation, possibly resulting from the incapability of soil moisture and ground

of precipitation and the high potential evaporation rate. Most trees can obtain enough moisture from soil moisture and ground water storage to survive this period of moisture deficit, while other types of vegetation (commercial crops) rely on irrigation for the needed moisture.

The above discussion of temporal interaction of hydrologic sub-cycles on Vancouver Island, explains briefly the full range of possible interactions which occur on the Island. With the acquisition of detailed information on the physical environment of Vancouver Island, a more accurate summary of temporal interaction can be presented. For example, it is important to define how much of the moisture surplus or deficit, exists in an area, and to further investigate the relationship between precipitation, vegetation, soil, potential evaporation rate, and runoff.

Chapter 6 Conclusion

Although the purpose of this study was not oriented towards providing a solution to a specific problem, certain conclusions can be ascertained by reviewing those trends which repeatedly occurred throughout the study. This chapter summarizes the recurring trends by discussing the deficiencies and contributions of the study.

Deficiencies of the Study

The inadequacy of many of the source maps, used to derive the basic data, is the most serious deficiency of the study. The basic data for precipitation, vegetation, potential evaporation, and slope is accurate, while the data for soil and permeability of the parent material is limited in accuracy. Because information concerning some of the factors is limited, this does not mean the entire study is inaccurate. Instead, it means further research is needed to derive more accurate data for those factors where information is limited, and then this data can be incorporated into the existing study. For example, where feasible, the use of air photographs for the determination of the presence or absence of vegetation may contribute to the already existing source of basic data.

Classifying the subcycles of only two months, January and July, is another limitation of this study. A clearer understanding of the temporal and spatial interaction of subcycles would have been achieved if the subcycles occurring in all twelve months were classified. Because the subcycles of only two months have been derived and classified, only assumptions can be made concerning the interaction of subcycles

between these months.

A recurring problem of the study was the attempt to explain the relationship of the interaction of factors. For example, actual runoff is more complex than simply the interaction between precipitation and the potential evaporation rate. For a more accurate account of runoff, vegetation, soil characteristics, and the permeability of the parent material should be considered. The relation of these factors to runoff was not considered in this study, because of the limited data on each of these factors, and the exact effect these factors have on runoff is not yet clearly understood.

Contributions of the Study

The major contribution of this study is the location and analysis of those factors which comprise the hydrologic cycle. This approach to the hydrology of Vancouver Island has not been attempted in the past. Furthermore, the discussion on temporal interaction explains how the subcycles change with seasonality, while the discussion on spatial interaction provides a base for a moisture surplus-deficit classification of Vancouver Island.

This study provides a holistic approach to hydrology, that is, all the hydrologic factors are considered to be inseparably inter-related. Each factor is given equal weight, and a change in the value of any one factor changes the entire subcycle. Approaching hydrology holistically, a further understanding of Man's interaction with the hydrology of Vancouver Island can be achieved. For example, the removal of vegetation by logging instantly creates different sub-

cycles in comparison to non-logged areas.

Recently, water resource decisions have been made on a scale larger than the drainage basin, while traditional hydrologists continue to conduct research on the drainage basin scale. This study approaches hydrology on a regional scale, or the same scale at which water resource decisions are being made. Water resource decisions must be made only after careful consideration of all the hydrologic factors; it is hoped this study can provide a base for the decisions being made concerning Vancouver Island.

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Appendix I

Soil Group #2

	Series & Type	Soil Group	Drainage	Dominant Topography	Stoniness	Description of Virgin Soil
Ca	CASSIDY Gravelly loamy sand, Loamy sand, Sandy loam	Alluvial	Variable drainage	Level to gently sloping	Stone free to moderately stony	2 to 4 inches of dark brown, granular gravelly loamy sand, * sandy loam, or loamy sand (A ₁); over brownish grey very permeable gravelly alluvium (C)
CB	COASTAL BEACH Sand and gravel		Variable drainage	Gently sloping	Few to many stones	shore washed sand, gravel, and stone
D	DASHWOOD Loamy sand, Gravelly loamy sand	Brown Podzolic	Well to moderately well drained	Sloping to gently sloping	Frequently cobbly and stony	25 to 30 inches of yellowish brown, loose, permeable gravelly loamy sand or loamy sand, (B), over grey, often mottled, very slowly permeable, gravelly sandy loam till, or marine clay (D)
Er	ERODED LAND Variety of soil materials		Variable drainage	Very steeply sloping	Few to many stones	Escarpments, beach bluffs, etc., variable soil mantle
Ky	KYE Loamy sand, Gravelly loamy sand	Podzols	Well drained	Level to gently sloping	Stone free	2 to 3 inches of light grey to white loamy sand (A ₂), over 13 to 16 inches of yellowish brown highly permeable loamy sand and gravelly loamy sand that grades through 12 to 14 inches of weakly iron cemented sand (B), over mottled loose sand and gravel (C)

* Letters in parentheses refer to soil horizon.

Soil Group #2

Series & Type	Soil Group	Drainage	Dominant Topography	Stoniness	Description of Virgin Soil
La LAZO Loamy sand, Sand loam, Loam	Acid Dark Brown Forest	Well drained	Sloping to gently sloping	Few to many stones	10 to 12 inches of very dark brown, very permeable loamy sand, sandy loam or loam (A ₁); over 10 to 12 inches of yellowish brown highly permeable loamy sand or loam, often gravelly or stony (B); over grey very slowly permeable gravelly sandy loam till (D)
N NEPTUNE Gravelly loamy sand and sandy loam	Rendzina	Well drained	Gently sloping	Few stones	12 to 24 inches of blade granular or loose gravelly loamy sand or sandy loam with occasional shells over gravel, sand, shells, and organic debris (kitchen midden)
Q QUALICUM Loamy sand Gravelly loamy sand	Brown Podzolic	Rapidly drained	Level to gently sloping	Few to excessively cobble and stony	36 to 44 inches of yellowish brown grading to pale brown loose very permeable loamy sand or gravelly loamy sand (B), over pale brown or grey loose sand or gravel
Qn QUINSAM Gravelly sandy loam	Podzol	Well drained	Undulating to steeply sloping	Moderate to very stony	1 to 2 inches of grey platy sandy loam (A ₂) over 18 to 20 inches of reddish brown to yellowish brown permeable gravelly sandy loam (B), over pale brown to greyish compact and very slowly permeable gravelly sandy loam till (C)

Soil Group #2

	Series & Type	Soil Group	Drainage	Dominant Topography	Stoniness	Description of Virgin Soil
Rm	ROUGH MOUNTAINOUS LAND Variety of rocks		Variable drainage	Mountainous	Very Stony	Bedrock with thin soil or soil material, much bare rock
Rs	ROUGH STONY LAND Variety of rock materials		Variable drainage	Gently to very steeply sloping	Very stony	Thinly mantled bare rock
R	ROYSTON Gravelly loam	Brown Podzolic	Well drained	Undulating to steeply sloping	Moderately to very stony	18 to 20 inches of dark yellowish brown to yellow brown gravelly loam; with weak block structure and few concretions, very permeable (B), overlying a compact, grey brown and very slowly permeable, clay loam till (C)
Sk	SANDWICK Gravelly loam	Acid Dark Brown Forest	Well drained	Undulating to steeply sloping	Moderately to very stony	8 to 12 inches of dark brown to black loam, well developed granular structure and very permeable (A ₁) over 10 to 13 inches of dark brown to light yellow brown permeable gravelly loam (B). The clay loam till is grey brown, compact and very slowly permeable.

Soil Group #2

	Series & Type	Soil Group	Drainage	Dominant Topography	Stoniness	Description of Virgin Soil
Sy	SAYWARD Loamy sand	Podzol	Imperfectly drained	Gently sloping	Stone free	1 inch of grey leached loamy sand (A ₂); over 18 to 20 inches dark reddish brown and reddish brown very permeable loamy sand, containing iron cemented clods (B); over 20 to 30 inches of dark grey brown permeable sand, showing iron cementation at lower limits; over very slowly permeable, gravelly sandy loam till or marine clay (D)
S	SHAWNIGAN Gravelly sandy loam	Brown Podzolic	Well drained	Undulating to steeply sloping	Moderately to very stony	18 to 20 inches of pale brown and light yellowish brown permeable granular gravelly sandy loam containing concretionary formations (B) over a grey compact and very slowly permeable gravelly sandy loam till (C)
So	SOMASS Loamy sand, Gravelly loamy sand	Concretionary Brown	Well drained	Level to gently sloping	Few cobbles and stones	26 to 36 inches of yellowish red to strong brown very permeable loamy sand or gravelly loamy sand (B), over grey loose sand or gravel (C). The profile often contains concretion or iron cemented clods.

Soil Group #2

Series & Type	Soil Group	Drainage	Dominant Topography	Stoniness	Description of Virgin Soil
Sp SPROAT Gravelly sandy loam	Concretionary Brown	Well drained	Undulating to steeply sloping	Moderately to very stony	18 to 20 inches of reddish brown to yellowish brown, permeable, subangular blocky gravelly sandy loam, few concretionary forms (B), over grey compact massive, very slowly permeable gravelly sandy loam till (C)
Sm STAMP Gravelly loam	Concretionary Brown	Well drained	Undulating to steeply sloping	Moderately to very stony	10 to 12 inches of uniform yellowish red gravelly loam with many concretionary forms and very permeable, overlying 12 to 14 inches of yellowish brown gravelly loam with weak blocky structure and very high permeability (B). The clay loam till is grey brown compact and very slowly permeable (C)
TF TIDAL FIATS Sand and muck		Poorly Drained	Level	Few to many stones	Coastal breach, organic mineral deposits, within saturation limits of high tide.

Soil Group #3

Series & Type	Soil Group	Drainage	Dominant Topography	Stoniness	Description of Virgin Soil
A ALBERNI Clay	Concretionary Brown	Well drained	Gently sloping	Few to stone free	12 to 15 inches of yellowish red to reddish brown highly concretionary, very permeable, strongly aggregated clay; over 6 to 8 inches of yellowish brown to strong brown, subangular blocky slightly permeable clay (B), over mottled yellowish brown and black very slowly permeable marine clay (C)
Ar ARROWSMITH Peat	Peat	Poorly drained	Depres- sional	Stone free	Undecomposed moss and woody accumulations over 36 inches deep
B BOWSER Loamy sand	Brown Podzolic	Imperfectly drained	Gently sloping	Stone free	20 to 30 inches of reddish brown loamy sand containing many iron cemented clods; over 4 to 6 inches of yellowish brown to reddish brown strongly cemented ortstein (B), over very slowly permeable gravelly sandy loam till or marine clay (D)
Cd CADBORO Gravelly sandy loam	Black	Well drained	Undulating to steeply sloping	Moderately to very stony	8 to 10 inches of dark greyish brown permeable granular sandy loam (A ₁) over 10 to 12 inches of yellowish brown, compact gravelly sandy loam (B), over compact and very slowly permeable gravelly sand loam till (C)

Soil Group #3

	Series & Type	Soil Group	Drainage	Dominant Topography	Stoniness	Description of Virgin Soil
Ch	CHEMAINUS Fine sandy loam to loam, Silt loam to clay loam	Alluvial	Variable drainage	Level to gently sloping	Stone free	3 to 6 inches of dark brown granular permeable fine sandy loam to clay loam (A ₁); over grey brown permeable stratified alluvium (C)
C	COWICHAN Clay loam	Dark Grey Gleisolic	Poorly drained	Level to depressional	Stone free	6 to 8 inches of dark grey brown to black granular clay loam (A ₁), over 4 to 6 inches of very pale brown, slowly permeable subangular blocky clay (A ₂), over pale brown mottled highly plastic and very slowly marine clay (C)
Cu	CUSTER Loamy sand	Podzol	Imperfectly drained	Level to gently sloping	Stone free	4 to 7 inches of light grey, loamy sand (A ₂), over 5 to 6 inches of red brown strongly iron cemented and very slowly permeable loamy sand or sandy loam over greyish brown and grey loose mottled loamy sand (C)
F	FAIRBRIDGE Silt loam to silty clay loam	Concretionary Brown	Well drained	Gently sloping	Few to stone free	10 to 12 inches of brown to light yellowish brown highly concretionary and very permeable silty clay loam, over 7 to 10 inches of pale brown, blocky permeable silty clay loam(B), over pale yellow, somewhat mottled, coarse blocky very slowly permeable marine silty clay loam (C)

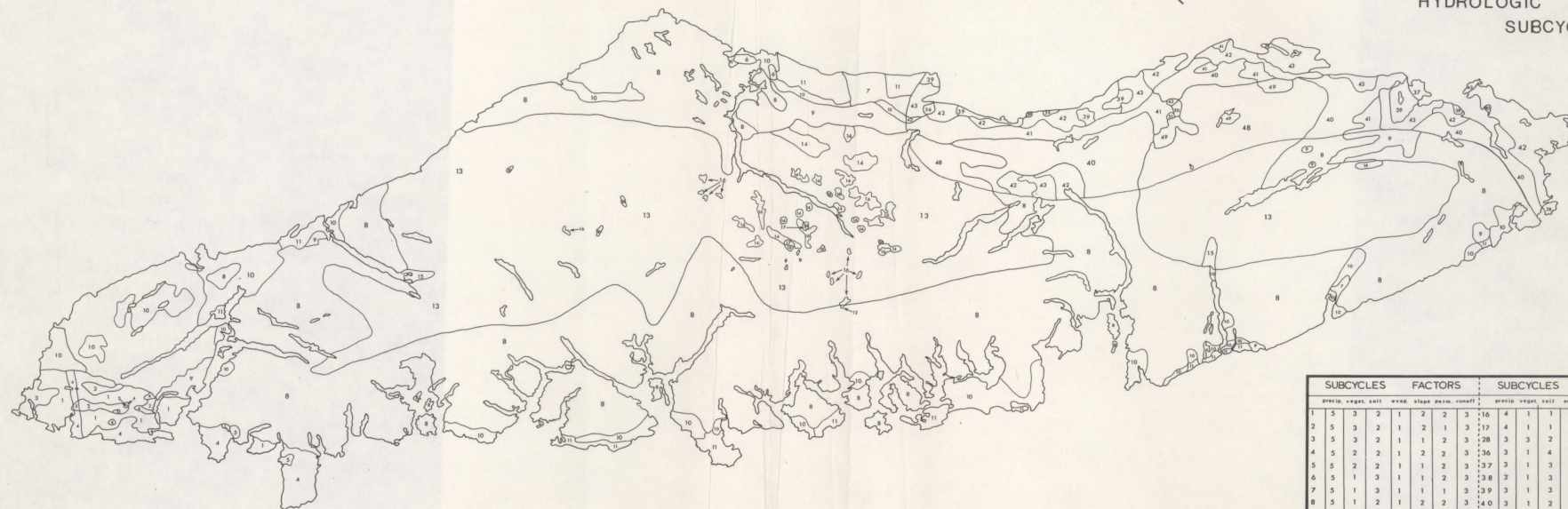
Soil Group #3

	Series & Type	Soil Group	Drainage	Dominant Topography	Stoniness	Description of Virgin Soil
Me	MEMEKAY Clay loam	Podzol	Well drained	Gently sloping	Few to stone free	1 to 2 inches of light grey platy clay loam (A ₂), over 18 to 22 inches of pale yellow brown to pale yellow, subangular blocky and blocky permeable clay (B), over mottled very slowly permeable massive marine clay (C)
M	MERVILLE Loam Sandy loam	Acid Dark Brown Forest	Moderately well drained	Gently sloping	Few stones	6 to 10 inches of dark brown granular permeable sandy loam or loam (A ₁); over brown granular to subangular blocky and very permeable loam (B); over grey slowly permeable, and highly plastic marine clay (D)
T	TOLMIE Fine sandy loam, Sandy loam, Loam, Sandy clay loam	Dark Grey Gleisolic	Poorly drained	Level to depressional	Stone free	6 to 9 inches of very dark brown to black granular and permeable fine sandy loam to sandy clay loam (A ₁); over 4 inches of grey to grey brown slowly permeable, subangular blocky sand clay loam (AB); over 8 to 10 inches of reddish brown to yellowish brown highly mottled and slowly permeable sandy clay (Bg), over grey, compact very slowly permeable marine clay (D)

Soil Group #4

	Series & Type	Soil Group	Drainage	Dominant Topography	Stoniness	Description of Virgin Soil
H	HASLAM	Brown Podzolic	Well drained	Gently sloping to steeply sloping	Moderately stony	2 inches of dark brown granular shaly loam (A ₁), over 6 to 10 inches of yellowish brown subangular blocky very permeable shaly loam (B), over fractured, moderately permeable shale or sandstone (C)
Pa	PARKSVILLE Sandy loam	Dark Grey Gleisolic	Poorly drained	Level	Stone free	5 to 6 inches of dark grey brown to very dark grey brown, very permeable granular sandy loam (A ₁); over 4 to 5 inches of brown permeable loamy sand (B); over 14 to 16 inches of yellowish brown, red brown, mottled, firm loamy sand or gravelly loamy sand (Bg); over light brown, very compact and slowly permeable gravelly sandy loam till or marine clay (D)
Pu	PUNTLEDGE Fine sandy loam	Concretionary Brown	Moderately well to imperfectly drained	Gently sloping	Stone free	15 to 18 inches of yellowish red to yellowish brown, granular to subangular blocky, very permeable fine sandy loam (B); over grey highly mottled plastic and very slowly permeable marine clay (D)

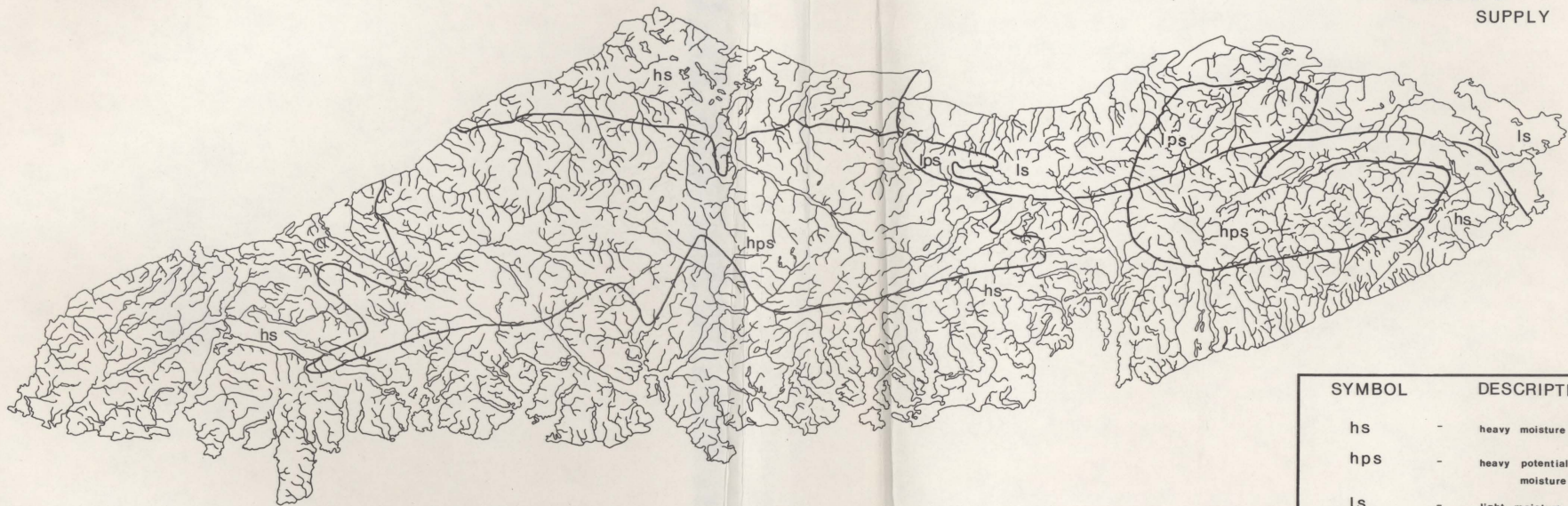
JANUARY
HYDROLOGIC
SUBCYCLES



Scale 1:1,317,888

	SUBCYCLES					FACTORS						SUBCYCLES					FACTORS				
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2	5	3	2	1	2	1	3	17	4	1	1	1	2	1	1						
3	5	3	2	1	1	2	3	28	3	3	2	1	1	2	2						
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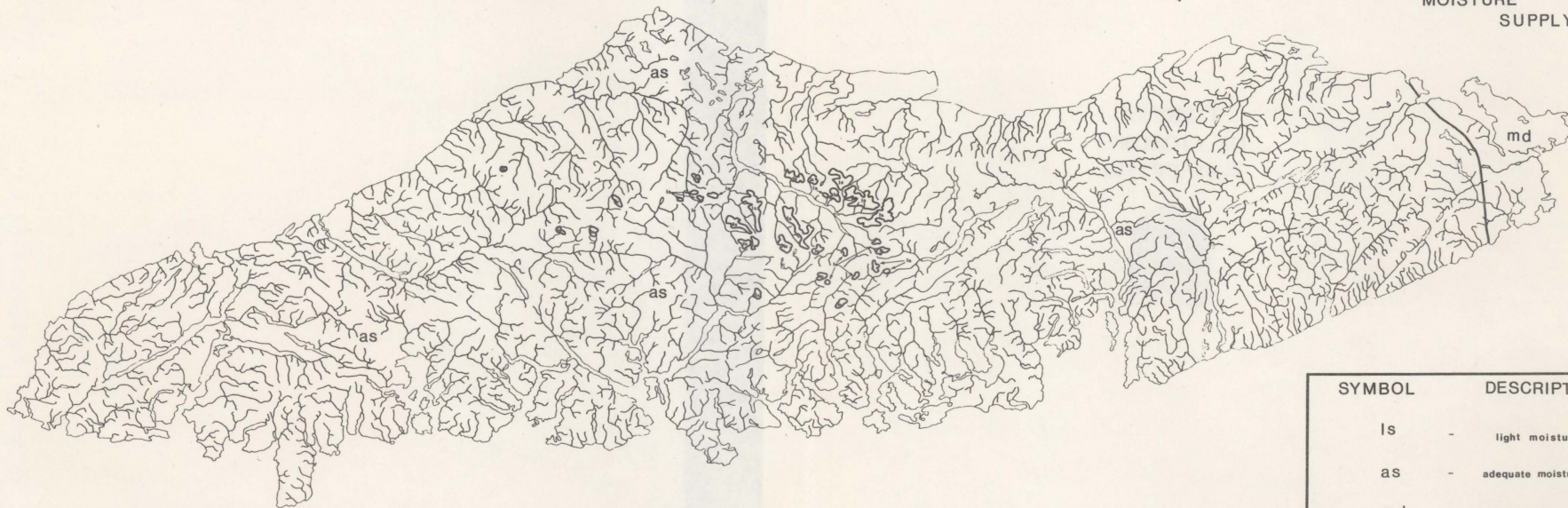
JANUARY
MOISTURE
SUPPLY



Scale 1:1,317,888

SYMBOL	DESCRIPTION
hs	- heavy moisture surplus
hps	- heavy potential moisture surplus
ls	- light moisture surplus
lps	- light potential moisture surplus

JULY
MOISTURE
SUPPLY



SYMBOL	DESCRIPTION
ls	- light moisture supply
as	- adequate moisture supply
md	- moisture deficit

Scale 1:1,317,888

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