ASSESSMENT OF U.S. FOREST SERVICE
WATER YIELD INCREASE
ANALYSIS PROCEDURE

by

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PREFACE

Because of the technical nature of this report, the basic content will be of interest mainly to the technically-oriented reader. For those wishing to omit technical details, a review of the following sections will provide a useful summary:

Introduction (p. 1), Water yield increase analysis procedure (p. 1), Watershed response rating system (first paragraph p. 2), Conclusion (p. 9). In essence, there are three major points to recognize in relation to the water yield increase analysis procedure. Firstly, it is a valuable, practical tool for assessing the potential impact of logging on annual water yield and the ability of the stream system to tolerate changes in water yield. Forest hydrology research and experience are brought to bear on a management problem in an objective and straight-forward manner. Secondly, further research and field testing are required to develop appropriate input data for its proper application in British Columbia. Thirdly, the services of a forest hydrologist or team of hydrology and forestry related specialists are needed to ensure that the procedure is used and its results are interpreted correctly.

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ASSESSMENT OF U.S. FOREST SERVICE WATER YIELD INCREASE ANALYSIS PROCEDURE

INTRODUCTION

This report presents an assessment of the water yield increase analysis procedure developed by U.S. Forest Service hydrologists in Idaho and Montana, in relation to its application in British Columbia. The main concern here is with the computer program described by Isaacson (2) and input data required for its successful operation. A Fortran listing of the computer program was obtained from J.A. Isaacson, hydrologist with the Idaho Panhandle National Forests, adopted to run on the PDP-11 computer at the Pacific Forest Research Centre and implemented using U.S. test data. The program was then run using data for upper Arrow Creek watershed, located near Creston, for a comparison of results with those obtained by Hetherington (1) for the same watershed. The results of this analysis plus an assessment of program input data requirements, available data limitations and research and field evaluation needs follow. It should be stressed at the outset that successful application of this water yield increase analysis procedure and interpretation of its results, requires considerable input and direction from a forest hydrologist or a team of hydrology plus forestry-related specialists.

WATER YIELD INCREASE ANALYSIS PROCEDURE

The water yield increase analysis procedure is a fairly comprehensive method for evaluating watershed hydrologic response to man's activity on the land as illustrated by Figure 3, in Appendix 1. It has two basic components: namely, a watershed response rating system which determines an allowable or acceptable water yield increase limit, and a computer program which derives water yield increase amounts for specified treatments (eg. clearcutting) and utilizes the increase limit value to evaluate cutting rates.

This analysis procedure has been designed as a practical tool to assess past, present and future logging effects on annual and monthly water yields from watersheds having snow melt hydrographs. It was intended for application to third-fifth order drainages but there is some indication that it is also applicable to second and possibly first order drainages. It attempts to bridge the gap between forest hydrology research and applied forest management. Some aspects of the system are quite simple, even crude. Complex physical processes and analysis techniques have been condensed to indices or graphs to make the procedure practical and easy to use. Some of the assumptions used were based on the experience of the developers and may be questionnable to those of us without similar experience. However, the real test lies in application and field verification of the method. The U.S. hydrologists who developed the water yield increase analysis procedure are confident that the results are reasonable approximations of reality. At the same time, they recognize that the procedure and its results are only quides which require appropriate and knowledgeable use and interpretation to avoid blind or unreasonable application.

Watershed response rating system

A detailed description of the watershed response rating system is given in Appendix 1. A prime objective of this rating is to develop timber harvesting guidelines related to acceptable water yield increases. The authors stress that guidelines for such increases must be set on an individual watershed basis as each drainage is unique. Ideally, a variety of specialists should generate input to the guidelines such as forest hydrologist, soil scientist, silviculturist, forester and ecologist. Careful field reconnaissance and evaluation should be undertaken for each watershed to be analyzed. Guides for three streamflow parameters are considered; namely, average annual yield, highest average monthly yield (peak flow), and maximum channel impact period. As the calculated volumes of the latter two parameters are dependent on the first, attention is focussed here on changes in annual water yield.

In Idaho, an average of 10% increase in average annual yield for 3rd to 5th order drainages has been used as the basic limiting factor (2, 6). The assumption is that when the average annual flow is exceeded by more than 10%, stream channel damage will begin to occur. This value was derived from on-site inspections for accelerated channel damage and analyses of streamflow records in terms of departures from the mean. In fact, the value of 10% is only an average and calculated increase limits ranging from 5 to 17% have been used depending mainly on stream channel condition and soil stability as described below (2). The watershed response rating system is the process followed to drive an appropriate water yield increase limit.

This process involves field and map inventories to evaluate six criteria which are first combined to give a potential watershed damage rating. This rating is then used to determine a water yield increase limit value. One of the main criteria is stream channel stability. The U.S. Forest Service has developed a Stream Reach Inventory and Channel Stability Evaluation procedure which is used to drive a channel stability rating (3). In British Columbia, the Resource Analysis Branch, Ministry of the Environment, has developed an Aquatic System Inventory procedure which incorporates some of the elements contained in the U.S. approach (5). It would seem logical that the B.C. system should be used to take advantage of data already collected, to permit filing of data in the Provincial data bank and to promote a consistent approach within the Province. To do this requires comparative field evaluations to assess the extent to which the Aquatic System Inventory procedure evaluates

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channel stability and to modify or adapt it as necessary.

Two other important criteria are surface erosion hazard and mass wasting hazard. For some areas in British Columbia, soils maps with these hazard ratings have been prepared as is the case for the Arrow Creek watershed. If such hazard rating information is available it should be suitable for the analysis. From discussions with a soils specialist with the Resource Analysis Branch, it appears as if preliminary hazard interpretations have been completed for most of the West Kootenay area and a small portion of the East Kootenay area.

Two additional criteria are recovery potentials of land and streams, that is, the ability of site or stream to recover to an acceptable condition following treatment. The land recovery potential rating considers both habitat type, to which a risk rating is simply assigned, and microclimate change, the evaluation of which is not clearly described and needs to be clarified. The stream recovery potential rating is based on three criteria: stream channel stability, channel materials-gradient and depth of stream channel material to bedrock. This information would be derived from the field inventory and a risk rating assigned to each category.

The final criterion is a road impact index which is simply the road density (acres of road/watershed area) multiplied by the number of stream crossings. This index is also assigned a risk rating. While type of road is not specified, it would be logical to include all road types (main haul roads and skid roads) plus landings and fire guards in deriving this index.

The ratings for all criteria are combined to give a composite watershed damage rating. Both ON-SITE and OFF-SITE ratings are derived. However, only the OFF-SITE value is used to determine the water yield increase limit from the graph (Fig. 6) presented in Appendix 1. This graph also has provision for using only the stream channel stability rating to determine the water yield increase limit.

Water Yield Computer program

A FORTRAN listing of the water yield computer program as modified to run on the PDP-11 computer is given in Appendix 2. This program will require little further change to run on IBM or other large Provincial government computers. A description of the program and its use is provided by Isaacson (2). The objective here is to briefly describe what the program does, input data requirements and the results of a comparative test.

The program will determine the following information for previous logging activity or watershed disturbance (existing conditions) and/or proposed logging activity for a given watershed or by subdrainages within a watershed:

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1. Existing equivalent clearcut acres (ECA) by habitat type.
2. Annual Water yield increase volume in acre-feet by habitat type plus the total increase.
3. Water yield increase as a percentage of total annual runoff.
4. Monthly distribution of water yield increases.
5. Hydrograph of mean monthly water yields (discharges) for Base, Past Treatment and Post Treatment conditions.
6. Increase in peak monthly flow in percent and acre-feet.
7. Probable allowable acres in equivalent clearcut condition under a certain percent allowable water yield increase (as determined from watershed response rating evaluation).
8. Sustained cutting rates by habitat type based on the given percent allowable water yield increase.
9. For any specified cutting rate (acres/year), the year by habitat type in which the allowable water yield increase limit is met.

The program first accounts for past activities, if any, and then deals with proposed logging. A number of options are available. The simplest case is the computation of water yield increase resulting from logging one area in one year in a given watershed. The maximum impact plus recovery (return to pre-logging water yield) with time can be derived, although the validity of vegetative recovery curves used in the program may be questionnable as noted in the next section of this report. The program will also compute the accumulated water yield increase resulting from logging in a watershed over a number of years, incorporating the effects of vegetative recovery. Computations can be carried out for individual subdrainages and summed to obtain the combined effect on water yield increase from the total main watershed. The Idaho version of the program was modified slightly to allow assessment, without summing, of the maximum effect on water yield increase of a number of different cutting options on the same subdrainage without having to re-enter basic watershed characteristics for each option. This change is described in Appendix 3.

The program is interactive in that it poses questions to be answered by the operator. However, it is simple to use and the operating time is short. On the PDP-11 computer, actual computer operating time to obtain a complete analysis and printout for one set of cutting options on one subdrainage took between 1 - 2 minutes. Once the input parameters and data for the program have been developed by appropriate specialists, the program itself can be run by trained technical staff.

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Input data requirements

1. Name and area of subdrainage and main watershed.
2. Weighted average subdrainage elevation - obtained by planimetering from contour maps.
3. Areas covered by habitat types for which there are 9 classes obtained by planimetering from forest cover maps, forest ecosystem type maps or aerial photographs.
4. The following runoff data, key information which is sadly lacking for smaller and high elevation drainages and represents a major need for field measurements:
   a. Total annual runoff for the subdrainage. The program description specifies mean annual runoff but a value for any given year could be used.
   b. Data which will permit the program to derive a runoff value for any elevation within the subdrainage.
      Either of two options may be used:
      i. The program contains a precipitation-runoff curve developed from data for a range of watershed sizes in the north western States. Annual precipitation totals at the lowest and highest elevations in the subdrainage must be supplied. If this option is employed, the total annual runoff value should be taken from the curve in Isaacson's report (2) using mean basin precipitation.
      ii. A runoff-elevation curve having up to three straight segments and including lowest and highest elevations can be supplied.
   c. Base hydrograph data or monthly distribution of subdrainage streamflow as a percentage of the annual total.

5. Information on past and/or proposed logging activity including type of treatment, mean elevation, aspect, area and habitat type of treated area, year of treatment and percent crown removal.
6. Percent increase limit for average water yield.
7. Year to which watershed status is to be projected and desired cutting rate if option 9 is wanted.

An example of a program run is given in Appendix 4, including input data forms and output results.

Data development needs for British Columbia

To apply the program in British Columbia, it is first necessary to relate forest cover types on provincial forest cover maps or more detailed forest ecosystem types, if available, to the habitat types given by Pfister et al. (4) and hence to hydrologic recovery classes (2, 6).

The next and more significant problem is to derive appropriate precipitation or runoff data for the watershed in question. Option 1 requires actual precipitation (and snow course) measurements at appropriate points within or adjacent to the watershed, or a precipitation-elevation relationship developed from regional data. The Resource Analysis Branch has developed such a relationship based on data from many areas in the province. More local precipitation measurements, particularly at higher elevations,and development of precipitation-elevation curves based on local or regional data are required.

Such curves are only the first step however, as derivation of runoff values is the ultimate objective. A precipitation-runoff curve devloped in the United States in incorporated in the computer program. As noted below, runoff values derived from this curve for Arrow Creek appear to be far too low. Concurrent measurements of runoff from high elevation drainages and precipitation are needed to develop precipitation-runoff and runoff-elevation relationships for British Columbia watersheds. With adequate runoff-elevation data, the use of precipitation data could be bypassed using option 2. In the United States, the Soil Conservation Service produces maps showing isolines of runoff at various elevations, which facilitates extraction of runoff values for use in this computer program.

Measurements of streamflow from higher elevation areas are also needed to obtain representative hydrograph distribution of flow at higher elevations for adequate assessment of logging impact on peak monthly flow.

If the effects of past activity are to be assessed, then some historical file research plus on-site field inspection will be required to determine what took place, when it took place and the actual extent of vegetative recovery.

Finally, the sustained and desired cutting rate program options are based on vegetative or hydrologic recovery curves for each habitat type contained in the program. The option also exists of superimposing a fixed recovery value in terms of percent reduction of original water yield increase. Some research will be required to determine the appropriateness of the recovery curves for British Columbia conditions and to identify or establish hydrologic recovery relationships for the various habitat or ecosystem types in British Columbia.

Comparative test using Arrow Creek data

In a previous report,Hetherington (1) evaluated the effects of harvesting in upper Arrow Creek watershed, a second order drainage near Creston, on water yield using a detailed water balance approach. The harvesting options considered were clearcutting 7.7%, 15% and 25% of the drainage area, 30% and 50% partial cutting of the same percentage areas,

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plus 30% and 50% partial cutting to obtain the same volume of timber as for the clearcutting option. The approach taken was to estimate snowpack redistribution based on research results reported in the literature, apply temperature-index snow melt equations, estimate soil water-holding capacity, evapotranspiration and precipitation, and to do a monthly water balance analysis. The U.S. Forest Service ECA curve was used in the partial cutting calculations (6). For clearcutting, the analysis indicated an on-site increase in water yield of approximately 40%.

In the U.S. Forest Service water yield program, on-site water yield increase calculations for clearcut areas are based mainly on the assumption that the increase varies between 35% and 45% depending on elevation. These percentages, based on research data, were obtained by summing estimated increases due to reduction of transpiration losses redistribution of snow and reduction of interception losses. This approach is much simpler than the detailed water balance analysis, but for Arrow Creek data the resulting on-site water yield increase factors turned out to be very similar in magnitude for both approaches.

Table 1 presents the results of the comparative analysis in terms of computed increased water yield as a percentage of total annual yield for the different harvesting options. Column 2 gives values derived from the arrow Creek water balance analysis (1). Column 3 gives values computed by the water yield program using runoff-elevation data estimated for upper Arrow Creek and supplied to the program. Column 4 gives values computed by the water yield program based on Arrow Creek precipitation-elevation data and the precipitation-runoff curve contained in the program. An example of the computer printout of results for the clearcut 7.7% area cutover using runoff-elevation data for Arrow Creek (Table 1, line 1, column 3) is given in Appendix 4.

For clearcutting, the percentage yield increases derived by the computer program using supplied runoff-elevation data are very close to those determined by the water balance anaylsis. The percentages obtained using precipitation data (column 3) are a little higher but still similar in magnitude. The precipitation-runoff curve in the program gives a considerably lower absolute value for annual runoff (5156 acre-feet versus the actual estimate of 9675 acre-feet). Hence, this curve would not be suitable for providing absolute values of water yield increases for Arrow Creek and possibly for the general surrounding region. However, if the objective is only to obtain a relative estimate of the effects of different harvesting options on water yield, then the percentage values obtained using the precipitation-runoff curve in the program would appear to be suitable for this purpose.

The comparative results for the partial cutting options are a little more variable than for clearcutting, but the percentage values are still close in magnitude. Given the crudeness or uncertainty in the assumptions and in the runoff or precipitation data estimates, the results from both approaches are sufficiently close to consider either equally applicable or representative for both partial and clearcut harvesting.

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TABLE 1

Comparison of water balance and water yield computer program water yield increase percentage values for Upper Arrow Creek Watershed

Harvesting Option (% area cut)	water balance	water yield computer program Runoff[1]	water yield computer program Precip.[2]
Clearcut			
7.7%	2.23	2.27	2.31
15%	4.36	4.63	4.96
25%	7.41	7.57	7.94
30% selection cut - same area as clearcut			
7.7%	0.54	0.51	0.53
15%	0.79	0.86	0.92
25%	1.93	1.25	1.29
50% selection cut - same area as clearcut			
7.7%	0.85	1.05	1.11
15%	1.58	1.99	2.12
25%	3.20	3.14	3.28
30% selection cut - same amount of timber as clearcut			
7.7%	0.93	1.33	1.39
15%	2.01	2.43	2.55
25%	3.16	4.19	4.22
50% selection cut - same amount of timber as clearcut			
7.7%	1.70	2.04	2.12
15%	3.47	3.89	4.07
25%	6.02	6.43	6.74

1 results using supplied runoff-elevation data
2 results using precipitation-runoff curve

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CONCLUSION

The U.S. Forest Service water yield computer program has been successfully tested and adapted to run on the PDP-11 computer. A comparative test has shown that computer program results for upper Arrow Creek are very close to those obtained using a more detailed and time-consuming water balance analysis. With adequate input data and proper interpretation of results, this computer program or, rather, the complete water yield increase analysis procedure constitutes a valuable, practical tool for assessing the potential effects of harvesting an annual runoff or water yield. The next steps will include development of an adequate data base as noted below, and field checks of results of application of the analysis procedure for specific watersheds which have been logged. One should keep in mind, also, that any procedure such as this one should be under continued development to incorporate new research findings and take advantage of experience gained in its use.

In this report several data, research, field evaluation and data development and interpretation needs for proper use of the water yield analysis procedure in British Columbia have been pointed out. In summary these are:

1. The services of a forest hydrologist or team of hydrology and forestry-related specialists are essential. It is important that field evaluations be carried out for each watershed to be assessed.
2. Comparative field evaluation of B.C. Aquatic System Inventory and U.S. Forest Service Stream Reach Inventory and Channel Stability procedures.
3. Development of regionalized runoff-elevation, precipitation-elevation and precipitation-runoff relationships. For this purpose more measurements of precipitation and streamflow at higher elevations are required.
4. Assignment of forest cover types or forest ecosystem types to hydrologic recovery classes comparable to those used in the water yield program.
5. Research to establish hydrologic-vegetative recovery relationships appropriate for British Columbia forest cover, habitat or ecosystem types.

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REFERENCES

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4. Pfister, R.D., B.L. Kovalchuk, S.F. Arno and R.C. Presby. 1977. Forest Habitat Types of Montana. USDA Forest Service. Gen. Tech. Rpt. INT-34, Intermountain Forest and Range Experiment Station. 174pp.

5. Resource Analysis Branch. 1977. Aquatic system inventory and analysis. Ministry of the Environment, Victoria, B.C.

6. U.S. Forest Service. Forest Hydrology Part II. Region One.

<u>Note</u>: Information on references 2, 3 and 6 may be obtained by writing to J.A. Isaacson, Forest Hydrologist, USDA Forest Service, Idaho Panhandle National Forests, Coeur D'Alene, Idaho, U.S.A. 83814.

APPENDIX 1

WATERSHED RESPONSE RATING SYSTEM 1/

INTRODUCTION

The quantity, quality and timing of flow in a watershed is largely dependent upon the summation of the climate, various landforms, stream systems, soils, geology, vegetation patterns and past resource management activity. An analysis of the "hydrologic response" of certain watersheds to climatic events and man's activities on the land can help determine the magnitude of potential changes in the quality and quantity of water produced from these watersheds.

There are numerous factors to be considered in predicting the watershed changes due to timber harvest, road construction, or other related developmental resource management activity. The main objective of this watershed response rating system is to:

1. Determine the risk and magnitude of damage potential for both on-site and off-site watershed conditions.

2. Adjust the allowable water yield increases of various watersheds on the basis of existing watershed conditions, past activity and inherent stability or instability of these drainages.

3. Develop a technique which will provide a systematic, consistant comparison between various land and stream units into an overall "condition" or "response" for first to fourth order drainages.

4. Provide a method to integrate existing resource data such as surface erosion hazard, mass wasting hazard, vegetative recovery potential, stream channel stability, road density, etc., into a risk and potential damage rating.

The principles of the system rely primarily on slope hydrology or the water handling characteristics of a particular landform.

The analysis considers not only the potentials of erosion, mass wasting, etc., but assesses current conditions such as road density, number of stream crossings, and stream channel stability, etc. The evaluation of both the seriousness and magnitude of potential watershed damage on-site and off-site considers resource activities that could affect watershed condition not only from a stream sediment and channel impacts standpoint, but also conditions for on-site changes which could affect long-term productivity of the site.

Equilibrium, or disequilibrium conditions of stream channels are indicative of the downwasting rates of the slopes they incise. However, a systems approach is needed in a watershed evaluation to study the "parts" in order to determine the overall condition.

1/ U.S. Forest Service. Forest Hydrology Part II. Region One (material in this Appendix has been taken directly from this report).

The watershed response rating system was developed to help land managers ascertain the risks involved and the seriousness and magnitude of potential watershed damage both on-site and off-site in relation to proposed resource management activity.

PROCEDURE

The flow diagram in Figure 3 indicates the stepwise progression and the interrelationships of the various field inventories to the analysis procedure.

The subdrainage is first broken into fairly large, homogeneous watershed response units (WRU's). They are stratified by landtypes, vegetation and slope hydrology characteristics. A watershed response rating form is completed for each WRU. (Fig. 4). The form is broken into two main parts - the risk of potential watershed damage and the seriousness or consequence of on-site and off-site damage potential. The six criteria selected for evaluation of risk on the rating form are:

1. Surface erosion hazard
2. Mass wasting hazard
3. Stream channel stability
4. Recovery potential - land
5. Recovery potential - streams
6. Road impact index - (road density x number of stream crossings)

The criteria for evaluating the risk ratings are shown in Table 1.

Upon completion of the risk rating, categories are selected for either high, medium or low seriousness or magnitude of potential watershed damage, both on-site and off-site. The criteria used for this evaluation for each risk criterion (such as erosion hazard, road impact index, etc.) is shown in Table 2. The different weighting values in each column are multiplied by the risk rating factor and each column is summarized for on-site and off-site totals.

Once the on-site and off-site summaries are made, the off-site values are used in conjunction with water quality data and the Regional water yield procedure to determine allowable water yield increase by subdrainage. The general procedure is:

1. Complete the WRRS form for each WRU in the subdrainage.

2. Calculate acreage in each WRU and in subdrainage.

3. Determine weighted-average off-site damage potential by subdrainage.

4. Plot sediment/discharge relationship of subdrainages as in Figure 5 and convert to a 1 - 10 scale. If sediment production data is not available, substitute for the stream channel stability ratings converted to the same 1 - 10 scale as in Table 1, Part III.*

* In analyzing over 32 streams, there appears to be consistent close correlation between sediment production rates and stream channel stability ratings.

5. Determine allowable water yield increase on the basis of weighted average off-site damage potential and sediment/discharge relationship (or stream channel stability) using Figure 6.

6. Compare existing water yield increase in relation to allowable increase and projected timber sale planning. Quantify potential impacts in water quality by plotting water yield increases back on the sediment/discharge curve in Figure 5. Analyze this in relation to the uses of the water, values, etc. (See Flow chart Fig. 3).

7. Selected various alternatives for desynchronization of flows, silvicultural variations, cutting patterns, etc., to modify effects of water yield increases, road construction, etc.

DISCUSSION

The information afforded through the watershed response rating system has many interpretations beyond what initially meets the eye. For example, a high surface erosion hazard on a shallow, droughtly soil could produce on-site changes in long-term productivity or microclimate if erosion was to occur. Thus, the rating would be placed in the "high" on-site category. If the slopes were gentle, with little or no dissection, and on an upper slope position, the chance for this soil material to become steam sediment would be very low. Thus, the low, off-site category would be chosen. In other words, the off-site category indicates sediment production potential and on-site indicates changes in productivity, microclimate, etc.

The factors used for placing the risk into appropriate columns utilizes the key factors in physical features and conditions that appear most responsive to changes through management activities. For example, the effect of roads on water quality is well documented in research. However, the effect of a particular road density on water quality is dependent upon the types of soils, slopes, etc. the road incises. Where the risks are minimal, higher road densities are not a limiting factor for off-site damage potential. The system, hopefully, will enable an overall evaluation to pinpoint areas where maximization of timber harvest, etc., can be made in contrast to areas where very specific, limited activity should be planned.

The weighted values for off-site damage are considerably higher than those for on-site. This is due to the large number of resources being affected "downstream". Thus, the seriousness or magnitude of damage should reflect these conditions.

The system also detects at a quick glance where the "weak links" are that affect either the on-site or off-site values. For example, a particular unit might be put into a "high" potential damage class due to a high road density or numerous drainageway crossings. In order to lessen the impact of a proposed use, the roads could be closed and drainageways restored, thus lowering the magnitude of potential damage from increased water yield, etc.

This system can be used to further refine the regional cutting guide

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procedure - especially in watersheds which have had considerable past disturbance and are in a "tilt" condition.

The system can be used for timber sale planning or other vegetation manipulation activities in order to assist in the evaluation of potential environmental impacts and to depart from treating a variety of landforms with similar types and intensity of development. It can also be used to assist in determining resource allocation through unit area planning, especially in relation to water resource values.

The system lends itself well to computerization to speed up the analysis procedures. It can link with other computer applications for additional analysis breadth. The most important uses it can provide are:

(1). To provide the resource manager with adequate tools to determine watershed change due to the various resource activities and,

(2). To prescribe essential protection prescriptions only where they are needed and to consider alternatives to minimize potential watershed damage - both on-site and off-site.

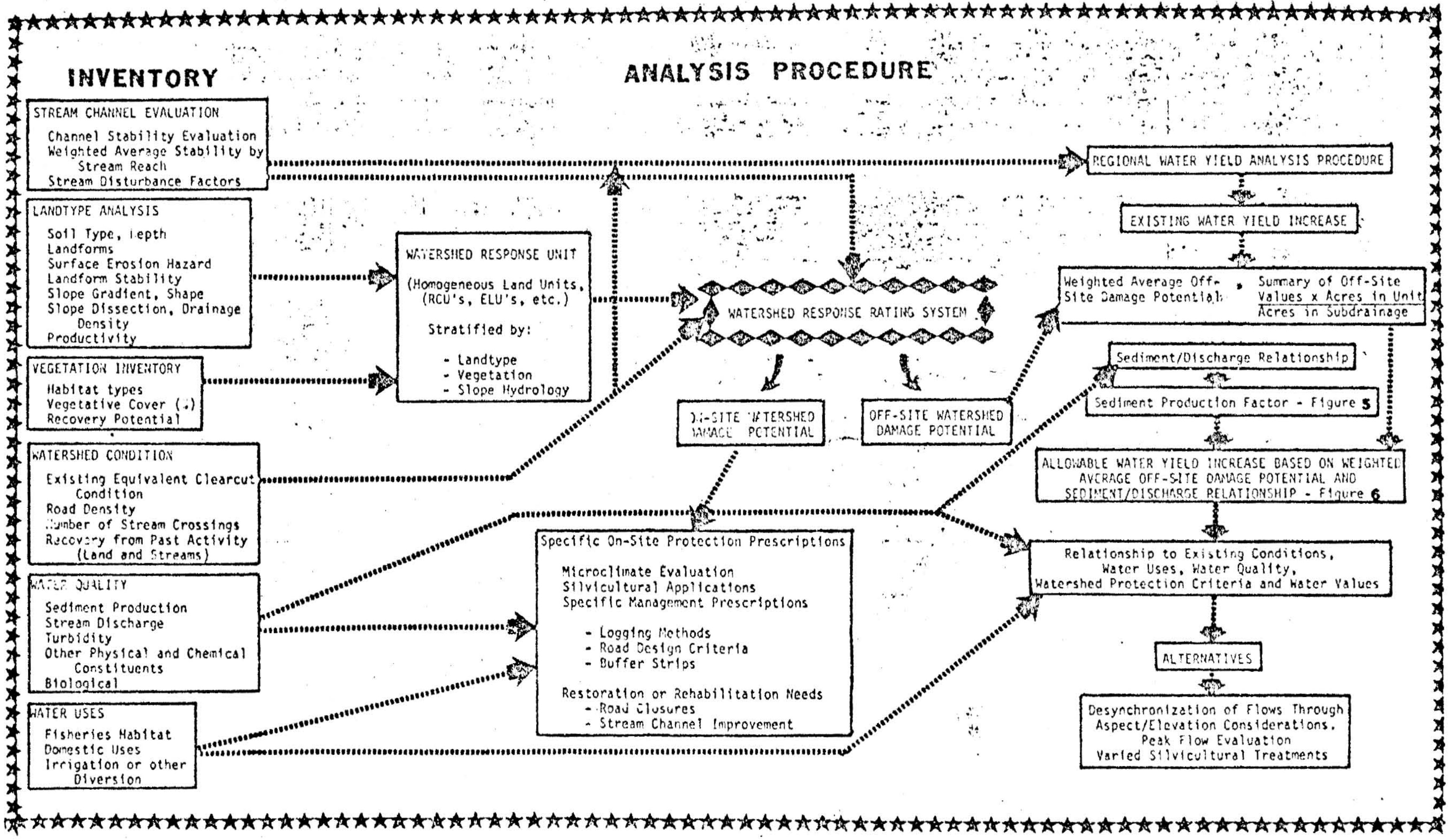


Figure 3. Flow Chart for Watershed Response Evaluation.

Figure 4.

WATERSHED RESPONSE RATING SYSTEM FORM

Magnitude or Seriousness of Potential Damage

Criteria	Criteria Rating (Actual)	Risk Rating (Converted to 1-10 scale)	On-Site High 30	On-Site Med 15	On-Site Low 2	Off-Site High 70	Off-Site Med 30	Off-Site Low 8
Surface Erosion Hazard	____	____	____	____	____	____	____	____
Mass Failure Potential	____	____	____	____	____	____	____	____
Stream Channel Stability	____	____	____	____	____	____	____	____
Recovery Potential — Land	____	____	____	____	____	____	____	____
Recovery Potential — Streams	____	____	____	____	____	____	____	____
Road Impact Index (#Crossings x Road Density)	____	____	____	____	____	____	____	____

Instructions: Multiply risk rating times the weighted values under appropriate column for on-site and off-site damage potential - subtotals are summations of these products.

On-site Sub-total ________

Off-site Sub-total ________

Total ________

WATERSHED RESPONSE-POTENTIAL DAMAGE

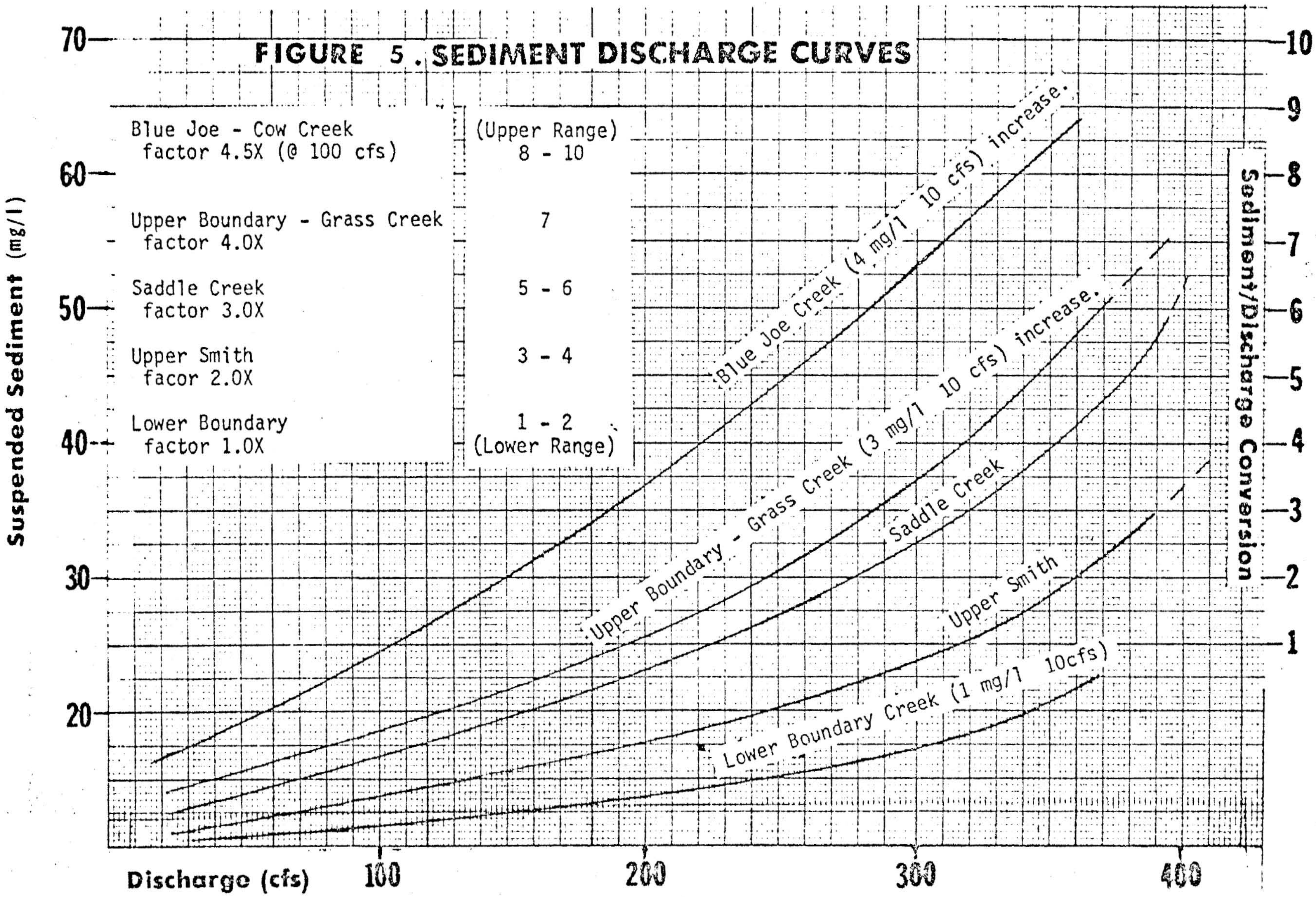
Risk and Potential Watershed Damage Summary

On-Site	Very Low	10-100	
	Low	101-300	
	Moderate	301-500	(Range 12-1800)
	High	501-1000	
	Very High	+1000	
Off-Site	Very Low	48-500	
	Low	501-1000	
	Moderate	1001-1500	(Range 48-4200)
	High	1501-2000	
	Very High	+2000	

Watershed Response: On-Site and Off-Site Composite Rating (Range 60-6000)

Low	60-1300
Moderate	1301-2000
High	2001-3000
Very High	3001-4000
Severe	+4000

FIGURE 5. SEDIMENT DISCHARGE CURVES



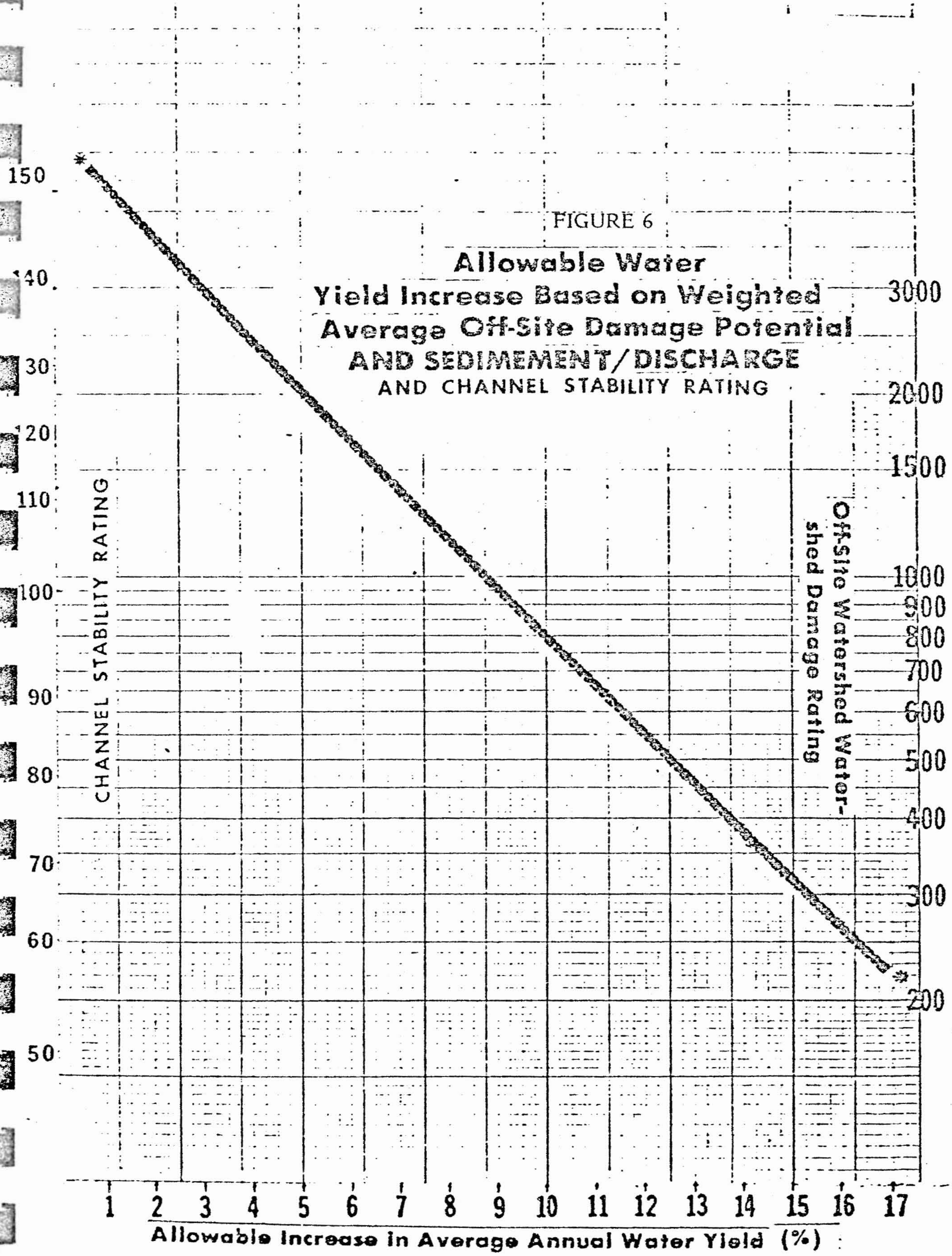


FIGURE 6
Allowable Water
Yield Increase Based on Weighted
Average Off-Site Damage Potential
AND SEDIMEMENT/DISCHARGE
AND CHANNEL STABILITY RATING
CHANNEL STABILITY RATING
150
140
130
120
110
100
90
80
70
60
50
Off-Site Watershed Water-
shed Damage Rating
3000
2000
1500
1000
900
800
700
600
500
400
300
200
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Allowable Increase in Average Annual Water Yield (%)

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TABLE 1 EVALUATION FOR RISK RATING

I. CRITERIA RATING

Surface Erosion Hazard (SEH)

From soil mapping, landtype descriptions, etc., or

Use criteria developed by research, various Regional Guides, SCS or other agencies. Adapt to a 1 - 10 rating scale. Include factors such as:

a. Slope gradient
b. Slope length
c. Soil texture, structure, rock, etc.
d. Storm and snowmelt runoff patterns
e. Plant cover density
f. Water holding characteristics

II. MASS WASTING POTENTIAL

Same as SEH above; include factors such as:

a. Landform
b. Slope position, gradient, length, etc.
c. Soil characteristics
d. Ground water, concentrated sub-surface flow
e. Bedrock Character

III. STREAM CHANNEL STABILITY

Use the revised Regional Procedure (Pfankuch, 1974)

Reach Rating	Risk Rating
48	1
49 - 60	2
61 - 72	3
73 - 85	4
86 - 96	5
97 - 107	6
108 - 120	7
121 - 134	8
135 - 142	9
143 - 152	10

..... 10

IV & V. RECOVERY POTENTIAL - LAND AND STREAMS

Ability of the site or stream to recover to pre-treatment condition or to an acceptable condition following treatment.

LAND RECOVERY CRITERIA

Two-phase recovery potential using habitat types and micro-climate change potential. (Developed 1974 by North Zone Planning, Idaho Panhandle N.F.). An average of the two values will be used to ascertain recovery potential of the land portion.

A. HABITAT TYPE	Risk Rating
Western redcedar/pachistima Western hemlock/pachistima Western redcedar/devilsclub	1
Alpine fir/pachistima	2
Grand fir/pachistima	3
Douglas fir/ninebark Douglas fir/twinflower	4
Douglas fir/snowberry Grand fir/beargrass	5
Alpine fir/menziesia	6
Douglas fir/pinegrass Douglas fir/pinegrass/kinnikinnick phase	7
Alpine fir/grouse whortleberry Alpine fir/beargrass	8
Mountain hemlock/menziesia	9
Mountain hemlock/beargrass Whitebark pine/subalpine fir Alpine fir/alpine larch Douglas fir/bluebunch wheatgrass Ponderosa pine/bitterbrush Ponderosa pine/bluebunch wheatgrass	10

. 11

B. Microclimate Change Potential

Score		Risk Rating
Low	10	1
	15	2
	20	3
	25	4
Moderate	30	5
	35	6
	40	7
High	45	8
	50	9
	55+	10

C. Calculating the Composite Risk Rating

1. Habitat Type ________

2. Microclimate change potential ________

Total - $\frac{\_\_\_\_\_\_\_\_}{2}$

Average ________

V. STREAM RECOVERY CRITERIA

Three categories for recovery potential are presented. A total value for each class will be used to determine final risk rating.

1. Stream channel stability

Excellent	1
Good	2
Fair	3
Poor	4

2. Channel materials - Gradient

Bedrock - Steep or flat or coarse texture - less than 5%	1
Coarse textured - more than 5% difficult to detach	2
Fine textured - less than 5% moderately detached	3
Fine textured - more than 5% easily detached	4

3. Depth of stream channel material to bedrock

Bedrock	1
< 1 foot	2
1-3'	3
3'+	4

Total Count	Risk Rating
3	1
4	2
5	3
6	4
7	5
8	6
9	7
10	8
11	9
12	10

..... 13

VI. ROAD IMPACT INDEX

$$\frac{\text{acres of road}}{\text{watershed area}} \times \text{drainageway crossings}$$

Road Impact Index	Risk Rating
0.6 or less	1
1.0	2
1.4	3
2.5	4
3.5	5
5.6	6
7.0	7
10.0	8
15.0	9
25.0 or more	10

TABLE 2

FACTORS FOR DETERMINING APPROPRIATE CATEGORY
FOR HIGH, MODERATE OR LOW ON-SITE AND OFF-SITE
WATERSHED DAMAGE POTENTIAL

A. Seriousness or Magnitude of Potential Damage

ON-SITE

Criteria	High (30)	Medium (15)	Low (2)
Soil Depth	Shallow soils <20 inches	20 - 140 inches	Deep >140 inches
Top soil	Lack of productive topsoil	Thin topsoil <3 inches	Deep > 3 inches
Slope gradient	Steep slopes 45%+	Slopes 25 - 45%	Slopes <25%
Moisture retention	Poor retention, sandy and coarse loamy soils - droughty - moisture stress limiting.	Moderate retention Coarse silty, fine loamy soils, moisture stress for short durations.	Good soil moisture retention. Fine silty and clay, infrequent soil moisture stress.
Internal drainage	Excessively drained	Moderate to well-drained	Poorly drained
Vegetation Density (%ground cover)	Low plant density <50%	50 - 70%	>70%

B. Seriousness or magnitude of potential damage

Off-Site

Criteria	High (70)	Medium (30)	Low (8)
Slope Dissection	Strongly dissected High drainage density	Moderately dissected Moderate drainage density	Weakly dissected Low drainage density
% of area in low order streams and lateral spacing of drainageways	40%+ <800 feet	20 - 40% 800 - 1600 feet	<20% 1600 feet +
Slope position	Lower slope to middle	Middle to upper 1/3	Upper 1/3
Slope shape	Generally concave	Concave to convex	Generally convex
Water handling characteristics	Rapid response to snowmelt or stormflow runoff. Short time of concentration.	Moderate response, related more to high intense events. Moderate time of concentration.	Slow response to runoff producing events. Long time of concentration
Slope gradient	Steep slopes 45%+	Slopes 25 - 45%	Slopes <25%
Vegetation Density	Low plant density <50%	50 - 70%	>70%
Location and other Physical characteristics	Riparian zones Very close proximity to perennial streams. Deeply entrenched drainageways Sediment/discharge factor 7-10	Associated with intermittent streams (moderate drainage density) Shallow entrenchment Sediment/discharge factor 3-6	Bedrock occupies over 70% of unit. Ridges, terraces benches "rolling" terrain Discontinuous drainageway Sediment discharge factor 0-3
Water uses	High value fisheries Municipal or domestic water use Heavy water-based recreational Use	Fisheries seasonal Very minor irrigation use Very few domestic users Moderate recreational use	Little or no fisheries value. Little consumptive uses of domestic or irrigation

APPENDIX 2

FORTRAN listing of the modified water yield computer program.

```
      SUBROUTINE EG(I,AJ,X)
      IF (I .EQ. 1) X=(ALOG10(AJ)-1.7782)/(-0.017782)
      IF (I.EQ. 2) X=(ALOG10(AJ)-1.8195)/(-0.01673)
      IF (I .EQ. 3) X=(ALOG10(AJ)-1.8751)/(-0.0162)
      IF (I .EQ. 4) X=(ALOG10(AJ)-1.9294)/(-0.01587)
      IF(I .EQ. 5) X=(ALOG10(AJ)-2.07796)/(-0.01547)
      IF (I .EQ. 6) X=(ALOG10(AJ)-1.96848)/(-0.01554)
      IF (I .EQ. 7) X=(ALOG10(AJ)-2.03108)/(-0.01554)
      IF (I .EQ. 8) X=(ALOG10(AJ)-2.1235)/(-0.01554)
      IF (I .EQ. 9) X=(ALOG10(AJ)-2.18365)/(-0.0153)
      IF (X .GT. 100.) X=100.
      IF (X .LT. 0.) X=0.
      RETURN
      END
```

PROGRAM SECTIONS

NAME	SIZE		ATTRIBUTES
$CODE1	000500	160	RW,I,CON,LCL
$PDATA	000100	32	RW,D,CON,LCL

TOTAL SPACE ALLOCATED = 000600 192

```
            SUBROUTINE FEQ(ELEV,AX)
            AX=0.
            IF (ELEV .LT. 1500.) GO TO 8
            AZ=(ELEV/3500.)-1
            IF (ELEV .GE. 3500.)GO TO 6
            AZ=AZ**3
            AZ=AZ-(2.*AZ)
            AP=SQRT(AZ)/.125
            AP=AP-(2.*AP)
            AZ=EXP(AP)
            AX=-0.98+(46.5*AZ)
            RETURN
      6     AP=(AZ/.4)**2
            AP=AP-(2.*AP)
            AX=41.-(.001*ELEV)+(7.5*EXP(AP))
          8 RETURN
            END
```

PROGRAM SECTIONS

NAME	SIZE		ATTRIBUTES
$CODE1	000300	96	RW,I,CON,LCL
$PDATA	000024	10	RW,D,CON,LCL
$VARS	000010	4	RW,D,CON,LCL

TOTAL SPACE ALLOCATED = 000334   110

```
      SUBROUTINE REQ(ELEV,ROF)
      BYTE ITABLE
      COMMON ISW1,SWIT1,FH20(16,2),ANAME(20),BNAME(20),BT(9),IHTA(9),IHT
     1AT(9),SUM3(10),SUM6,EX,NY,SUM1(10),SUM4,TSUM2,TSUM3(10),AII,RUNOF(
     24,2),TSUM4(10),AEP,BEP,IRC,UNIT(50),BV(4,6,8),SUM5(6),ITABLE(51,12
     33),S(6),HGBP(12,3),THGBP(12,3),ICD
      IF (IRC .EQ. 0) GO TO 1
      I=1
      IF (ELEV .LT. RUNOF(1,1)) GO TO 3
      I=IRC
      IF (ELEV.GT.RUNOF(IRC+1,1)) GO TO 3
      DO 2 I=1,IRC
      IF (RUNOF(I,1) .LE.ELEV .AND. ELEV .LE. RUNOF(I+1,1)) GO TO 3
 2    CONTINUE
 3    ROF=((ELEV-RUNOF(I,1))*((RUNOF(I+1,2)-RUNOF(I,2))/(RUNOF(I+1,1)-RU
     1NOF(I,1)))+RUNOF(I,2))/12.
      GO TO 4
 1    Y=(AEP*ELEV)+BEP
      IF (Y .LT. 12.) ROF=0.
      IF (12..LE. Y .AND. Y .LT. 30.) ROF=(.556*Y-6.7)/12.
      IF (30. .LE. Y .AND. Y .LT. 40.)ROF=(.74*Y-12.2)/12.
      IF (40. .LE. Y .AND. Y .LT. 60.) ROF=(.81*Y-15.)/12.
      IF (60. .LE. Y) ROF=(.868*Y-18.5)/12.
    4 RETURN
      END
```

PROGRAM SECTIONS

NAME	SIZE		ATTRIBUTES
$CODE1	000536	175	RW,I,CON,LCL
$PDATA	000030	12	RW,D,CON,LCL
$VARS	000006	3	RW,D,CON,LCL
.$$$$.	004714	1254	RW,D,OVR,GBL

TOTAL SPACE ALLOCATED = 005510   1444

```
0001          SUBROUTINE MDBV
0002          BYTE ITABLE
0003          COMMON ISW1,SWIT1,FH20(16,2),ANAME(20),BNAME(20),BT(9),IHTA(9),IHT
             1AT(9),SUM3(10),SUM6,EX,NY,SUM1(10),SUM4,TSUM2,TSUM3(10),AII,RUNOF(
             24,2),TSUM4(10),AEP,BEP,IRC,UNIT(50),BV(4,6,6),SUM5(6),ITABLE(51,12
             3),S(6),HGBP(12,3),THGBP(12,3),ICD
0004          DATA BV/10.,5.,2*0.,30.,20.,2*5.,2*40.,35.,25.,20.,30.,45.,50.,0.,
             15.,10.,15.,2*0.,2*5.,10.,2.,2*0.,32.5,22.5,7.5,5.,42.5,40.,37.5,30
             2.,15.,27.5,40.,47.5,0.,5.,10.,12.5,2*0.,2*5.,10.,5.,2*0.,35.,25.,1
             30.,5.,45.,2*40.,35.,10.,25.,35.,45.,0.,5.,2*10.,2*0.,2*5.,20.,12.5
             4,5.,0.,37.5,27.5,15.,7.5,35.,40.,2*42.5,7.5,17.5,27.5,35.,0.,2.5,7
             5.5,10.,2*0.,2.5,5.,30.,20.,10.,0.,40.,30.,20.,10.,25.,40.,45.,50.,
             65.,10.,20.,25.,2*0.,5.,10.,3*0.,5.,27.5,17.5,7.5,0.,37.5,27.5,17.5
             7,7.5,30.,40.,45.,47.5,5.,12.5,22.5,32.5,0.,2.5,5.,7.5,2*0.,2.5,5.,
             825.,15.,5.,0.,35.,25.,15.,5.,35.,40.,2*45.,5.,15.,25.,40.,0.,3*5.,
             92*0.,2*5.,17.5,10.,2.5,0.,32.5,22.5,10.,5.,37.5,2*40.,35.,12.5,22.
             A5,35.,45.,0.,5.,7.5,10.,2*0.,2*5./
0005          RETURN
0006          END
```

PROGRAM SECTIONS

NAME	SIZE		ATTRIBUTES
$CODE1	000016	7	RW,I,CON,LCL
.$$$$.	004714	1254	RW,D,OVR,GBL

TOTAL SPACE ALLOCATED = 004732 1261

NO FPP INSTRUCTIONS GENERATED

```
              SUBROUTINE HYDRO
              COMMON ISW1,SWIT1,FH20(16,2),ANAME(20),BNAME(20),BT(9),IHTA(9),IHT
             1AT(9),SUM3(10),SUM6,EX,NY,SUM1(10),SUM4,TSUM2,TSUM3(10),AII,RUNOF(
             24,2),TSUM4(10),AEP,BEP,IRC,UNIT(50),BV(4,6,8),SUM5(6),ITABLE(51,12
             3),S(6),HGBP(12,3),THGBP(12,3),ICD,J1
        C    NEW CODING. 29 DEC/77 ,HUNT
              BYTE J1(9)
              BYTE ITABLE
        C
              J=3
              IF(HGBP(5,3).EQ.HGBP(5,1)) J=2
              IF (HGBP(5,2).EQ.HGBP(5,1)) J=1
              AMAX=HGBP(1,J)
              AMIN=HGBP(1,1)
              BMAX=HGBP(1,1)
              DO 1 I=2,12
              IF (HGBP(I,J) .GT. AMAX) AMAX=HGBP(I,J)
              IF (HGBP(I,1) .LT. AMIN) AMIN=HGBP(I,1)
              IF (HGBP(I,1) .GT. BMAX) BMAX=HGBP(I,1)
        1     CONTINUE
              IF(ICD.EQ.60) AMAX=AMAX-PKF
              DO 13 K=1,51
              DO 13 I=1,12
        13    ITABLE(K,I)=' '
              UNAT=(AMAX-AMIN)/50.
              UNIT(1)=AMAX
              UNIT(51)=AMIN
              DO 2 I=2,49
        2     UNIT(I)=UNIT(I-1)-UNAT
              IF (J.EQ.1) GO TO 6
              IF (J.EQ.2) GO TO 3
              DO 4 I=3,8
              K=((HGBP(I,3)-AMIN)/UNAT)+.5
        4     ITABLE(51-K,I)='-'
        3     DO 5 I=3,8
              K=((HGBP(I,2)-AMIN)/UNAT)+.5
        5     ITABLE(51-K,I)='+'
        6     DO 7 I=1,12
              K=((HGBP(I,1)-AMIN)/UNAT)+.5
        7     ITABLE(51-K,I)='X'
              IF (ICD.EQ.90) GO TO 11
              WRITE(6,9) NY,(ANAME(I),I=1,20),J1
        9     FORMAT(1H1//' HYDROGRAPH YEAR',I5,2X,20A4,' DATE:'9A1//)
              GO TO 23
        11    WRITE(6,9) NY,(BNAME(I),I=1,20),J1
        23    DO 15 I=1,51,2
              WRITE(6,17) UNIT(I),(ITABLE(I,J),J=1,12)
        17    FORMAT (1X,F11.2,4X,11(A1,9X),A1)
              IF (I .EQ. 51) GO TO 20
        15    WRITE (6,18) (ITABLE(I+1,J),J=1,12)
        18    FORMAT (16X,11(A1,9X),A1)
        20    WRITE (6,21) (HGBP(J,1),J=1,12)
        21    FORMAT (/5X,'AC-FT',5X,'JAN',7X,'FEB',7X,'MAR',6X,'APRIL',6X,'MAY'
             1,6X,'JUNE',6X,'JULY',7X,'AUG',7X,'SEPT',6X,'OCT',7X,'NOV',7X,'DEC'
             2//4X,'x  BASE',12F10.2/4X,'+  PAST'/4X,'-  PAST & PROPOSED'/)
              PKF=AMAX-BMAX
```

```
            PPKF=PKF*100./EMAX
            WRITE (6,25) PKF,PPKF
      25    FORMAT (3X,'PEAK FLOW VOLUMES INCREASED BY ',F8.2,' AC-FT OR ',F6.
           12,'%'//)
      600   RETURN
            END
```

PROGRAM SECTIONS

NAME	SIZE		ATTRIBUTES
$CODE1	002010	516	RW,I,CON,LCL
$IDATA	000450	148	RW,D,CON,LCL
$VARS	000036	15	RW,D,CON,LCL
.$$$$.	004726	1259	RW,D,OVR,GBL

TOTAL SPACE ALLOCATED = 007444 1938

```
0001            SUBROUTINE WROUTA(DA,PECA,A)
0002            BYTE ITABLE
0003            COMMON ISW1,SWIT1,FH20(16,2),ANAME(20),BNAME(20),BT(9),IHTA(9),IHT
               1AT(9),SUM3(10),SUM6,EX,NY,SUM1(10),SUM4,TSUM2,TSUM3(10),AII,RUNOF(
               24,2),TSUM4(10),AEP,BEP,IRC,UNIT(50),BV(4,6,8),SUM5(6),ITABLE(51,12
               3),S(6),HGBP(12,3),THGBP(12,3),ICD
0004            DIMENSION IA(9)
0005            SUM4=0.
0006            DO 206 J=1,10
0007      206   SUM4=SUM4+SUM1(J)
0008            YAI=SUM4*100./A
0009            WRITE(6,207) (J,J=1,9),(SUM1(J),J=1,10),SUM4,YAI,PECA
0010      207   FORMAT (/27X,'WATER YIELD INCREASE VOLUME BY HABITAT TYPE'/7X,9I8,
               1'   ROADS    TOTAL'/7X,10F8.2,F10.2,' ACRE-FEET'//2X,'PER CENT OF O
               1RIGINAL WATER YIELD INCREASE'/7X,F7.2,' PER CENT'/2X,'PROBABLE EQU
               1IVALENT CLEARCUT AREA ALLOWABLE '/7X,F9.2,' ACRES'/)
0011      270   WRITE (5,260)
0012      260   FORMAT (' DO YOU WISH TO HAVE THE SUSTAINED CUTTING RATE CALCULATE
               1D? (YES=1. OR NO=-1.)')
0013            READ (5,265) ANS
0014      265   FORMAT (F3.0)
0015            IF (ANS .LE. 0.) GO TO 98
0016            WRITE (6,80) (J,J=1,9)
0017      80    FORMAT (///5X,'SUSTAINED CUTTING RATE IN ACRES/YEAR INCLUDING RECO
               1VERY TO EQUIVALENT'/5X,'CLEARCUT AREA BY YEARS AND FOREST HABITAT
               1TYPES ON AN UNDEVELOPED'/5X,'AREA.'//30X,'HABITAT TYPES'/5X,'YEARS
               1',9I8/)
0018            J=100
0019            CALL CRCALC(J,PECA,DA)
0020      98    WRITE (5,212)
0021      212   FORMAT (' ENTER CUTTING RATE (NONE=0.)')
0022            READ (5,213) CR
0023      213   FORMAT (F8.0)
0024            IF (CR .LT. 0.) GO TO 98
0025            IF (CR .GT. 0.) GO TO 130
0026            CALL HYDRO
0027            RETURN
0028      130   DO 120 I=1,9
0029            AX=IHTA(I)
0030            IF (IHTA(I) .EQ. 0) GO TO 79
0031            AT=CR
0032            AT1=CR
0033            AJ=1.
0034            CX=0.
0035            DO 77 K=1,99
0036            IF (PECA .LE. AT*DA/AX) GO TO 120
0037            AJ=AJ+1.
0038            CALL EQ(I,AJ,X)
0039            X=100.-X-CX
0040            AT2=AT1-X*AT1/100.
0041            AT=AT+AT2
0042            CX=X
0043      77    AT1=AT2
0044      79    AJ=0.
0045      120   BT(I)=AJ
0046            WRITE (6,125) PECA,CR
```

```
      125   FORMAT (5X,'THE ALLOWABLE EQUIVALENT CLEARCUT AREA ',F7.2,'ACRES W
           1ILL BE'/5X,'REACHED AT A CUTTING RATE OF ',F7.0,' ACRES/YEAR'/)
            DO 126 J=1,9
            AX=IHTA(J)
      126   IA(J)=CR*AX/DA
            WRITE (6,127) (J,J=1,9),(IA(J),J=1,9),(BT(J),J=1,9)
      127   FORMAT (//25X,' HABITAT TYPES'//9X,9I7/2X,'ACRES',3X,9I7/2X,'YEAR
           1',4X,9F7.0/)
            GO TO 98
            END
```

ROGRAM SECTIONS

NAME	SIZE		ATTRIBUTES
CODE1	001504	418	RW,I,CON,LCL
IDATA	001330	364	RW,D,CON,LCL
VARS	000100	32	RW,D,CON,LCL
$$$$.	004714	1254	RW,D,OVR,GBL

OTAL SPACE ALLOCATED = 010050 2068

```
           SUBROUTINE WROUTS(DA,A,JPP)
           BYTE ITABLE
           COMMON ISW1,SWIT1,FH20(16,2),ANAME(20),BNAME(20),BT(9),IHTA(9),IHT
          1AT(9),SUM3(10),SUM6,EX,NY,SUM1(10),SUM4,TSUM2,TSUM3(10),AII,RUNOF(
          24,2),TSUM4(10),AEP,BEP,IRC,UNIT(50),BV(4,6,8),SUM5(6),ITABLE(51,12
          3),S(6),HGBP(12,3),THGBP(12,3),ICD
           WRITE (6,15) (SUM5(J),J=1,6)
   15      FORMAT (/' TOTAL MONTHLY DISTRIBUTION OF THE WATER YIELD INCREASE
          1VOLUME',5X,6F10.2)
           SUM6=0.
           DO 17 J=1,10
   17      SUM6=SUM6+SUM3(J)
           WRITE (6,19) (J,J=1,9),(SUM3(J),J=1,10),SUM6
   19      FORMAT (//30X,'EXISTING ECA IN ACRES BY HABITAT TYPE '/7X,9I8,'
          1ROADS    TOTAL'/7X,10F8.2,F10.2,' ACRES')
           CALL FEQ(EX,AX)
           CALL  REQ(EX,ROF)
           PECA=A*AII*100./AX/ROF/100.
           IF (ICD .EQ. 70 .OR. ICD .EQ. 60) JPP=3
           IF (ICD .EQ. 60 .AND. JPP .EQ. 3 .OR. ICD .EQ. 90
          1.AND. JPP .EQ.3) GO TO 5
           DO 13 J=1,6
   13      HGBP(J+2,2)=HGBP(J+2,2)+SUM5(J)
           GO TO 7
   5       DO 25 J=1,6
   25      HGBP(J+2,3)=HGBP(J+2,3)+SUM5(J)
   7       CALL WROUTA(DA,PECA,A)
           IF (ICD .EQ. 60 .OR. 70 .OR. ICD .EQ. 90) GO TO 600
           TSUM2=TSUM2+PECA
           DO 11 J=1,9
           TSUM4(J)=TSUM4(J)+SUM1(J)
           TSUM3(J)=TSUM3(J)+SUM3(J)
   11      IHTAT(J)=IHTAT(J)+IHTA(J)
           TSUM3(10)=TSUM3(10)+SUM3(10)
           TSUM4(10)=TSUM4(10)+SUM1(10)
           DO 21 K=1,12
           IF (JPP .EQ. 2) THGBP(K,3)=THGBP(K,3)+HGBP(K,2)-HGBP(K,1)
           DO 21 I=1,3
   21      THGBP(K,I)=THGBP(K,I)+HGBP(K,I)
     600   RETURN
           END
```

PROGRAM SECTIONS

NAME	SIZE		ATTRIBUTES
$CODE1	001276	351	RW,I,CON,LCL
$IDATA	000260	88	RW,D,CON,LCL
$VARS	000022	9	RW,D,CON,LCL
.$$$$.	004714	1254	RW,D,OVR,GBL

TOTAL SPACE ALLOCATED = 006514   1702

```
0001            SUBROUTINE CRCALC(J,PECA,DA)
0002            BYTE ITABLE
0003            COMMON ISW1,SWIT1,FH20(16,2),ANAME(20),BNAME(20),BT(9),IHTA(9),IHT
               1AT(9),SUM3(10),SUM6,EX,NY,SUM1(10),SUM4,TSUM2,TSUM3(10),AII,RUNOF(
               24,2),TSUM4(10),AEP,BEP,IRC,UNIT(50),BV(4,6,8),SUM5(6),ITABLE(51,12
               3),S(6),HGBP(12,3),THGBP(12,3),ICD
0004            DIMENSION CX(9),AT(9),AT1(9)
0005            IC1=PECA
0006            DO 260 I=1,9
0007            AT(I)=1.
0008            CX(I)=0.
0009      260   AT1(I)=1.
0010            J=J-1
0011            DO 77 K=1,J
0012            AJ=K+1
0013            DO 76 I=1,9
0014            AX=IHTA(I)
0015            CALL EQ(I,AJ,X)
0016            X=100.-X-CX(I)
0017            AT2=AT1(I)-X*AT1(I)/100.
0018            AT(I)=AT(I)+AT2
0019            AT1(I)=AT2
0020            BT(I)=PECA*AX/(AT(I)*DA)
0021            CX(I)=X
0022      76    CONTINUE
0023            IC=BT(1)+BT(2)+BT(3)+BT(4)+BT(5)+BT(6)+BT(7)+BT(8)+BT(9)
0024            IF (IC .LT. IC1) GO TO 97
0025            WRITE (6,210)
0026      210   FORMAT (5X,'MAXIMUM SUSTAINED CUTTING RATE REACHED'/)
0027            GO TO 250
0028      97    WRITE (6,95) K,(BT(J),J=1,9)
0029      95    FORMAT (5X,I3,2X,9F8.2)
0030            IC1=IC
0031      77    CONTINUE
0032      250   RETURN
0033            END
```

PROGRAM SECTIONS

NAME	SIZE		ATTRIBUTES
$CODE1	000642	209	RW,I,CON,LCL
$IDATA	000100	32	RW,D,CON,LCL
$VARS	000204	66	RW,D,CON,LCL
$TEMPS	000002	1	RW,D,CON,LCL
,$$$$,	004714	1254	RW,D,OVR,GBL

TOTAL SPACE ALLOCATED = 006064 1562

```
0001          COMMON ISW1,SWIT1,FH20(16,2),ANAME(20),BNAME(20),BT(9),IHTA(9),IHT
             1AT(9),SUM3(10),SUM6,EX,NY,SUM1(10),SUM4,TSUM2,TSUM3(10),AII,RUNOF(
             24,2),TSUM4(10),AEP,BEP,IRC,UNIT(50),BV(4,6,8),SUM5(6),ITABLE(51,12
             3),S(6),HGBP(12,3),THGBP(12,3),ICD,J1
0002          LOGICAL*1 FILNAM(15)
0003          BYTE ITABLE
0004          BYTE J1(9)
0005          REAL*8 IST1,J2
      C ANAME = SUBDRAINAGE NAME
      C BNAME = DRAINAGE NAME
      C DA = SUBDRAINAGE ACRES
      C A = SUBDRAINAGE RUNOFF
      C EX = SUBDRAINAGE WEIGHTED AVERAGE ELEVATION
      C IHTA = SUBDRAINAGE ACRES BY HABITAT TYPE
      C NY = YEAR PROJECTING WATERSHED STATUS TO
      C AII = % INCREASE LIMIT
      C RUNOF = PRECIPITATION OR RUNOFF DATA BY ELEV
      C HGBP = HYDROGRAPH DATA
      C IST1 = STAND DESCRIPTION
      C ICD = ACTIVITY CODE
      C ELEV = STAND ELEVATION
      C IASP = STAND ASPECT
      C IYR = YEAR CUT OR BURNED
      C PER = % CROWN REMOVAL
      C ACRE = STAND ACRES
      C IHT = HABITAT TYPE
      C S = SUBDRAINAGE TOTAL OF MONTHLY DISTRIBUTION OF WATER YIELD INC. VOL.
      C SUM5 = DRAINAGE TOTAL OF VARIABLE S
      C SUM1 = SUBDRAINAGE TOTAL OF WATER YIELD INC. VOLUME
      C SUM4 = DRAINAGE TOTAL OF VARIABLE SUM1
      C SUM3 = SUBDRAINAGE TOTAL OF EXISTING EQUIVALENT CLEARCUT ACRES
      C SUM6 = TOTAL EECA
      C FH20 = ON-SITE WATER YIELD INC. FACTOR IN %
      C BT = USED IN SUSTAINED CUTTING RATE CALCULATION
      C IHTAT = DRAINAGE ACRES BY HABITAT TYPE
      C AEP = SLOPE OF PRECIPITATION CURVE
      C BEP = Y INTERCEPT OF PRECIPITATION CURVE
      C IRC = CODE FOR PRECIP. OR RUNOFF DATA
      C UNIT = SCALE OF HYDROGRAPH
      C BV = "B" VALUE FOR MONTHLY DISTRIBUTION OF WATER YIELD
      C = ITABLE = HYDROGRAPH
0006          ISW1=0
      C       CALL ERTRAN (9,J1,J2)
      C  ERTRAN IS REPLACED BY CALL DATE AND ASSIGN
0007          CALL DATE(J1)
0008          CALL TIME(J2)
0009          WRITE(5,1717)
0010     1717 FORMAT(' ENTER FILENAME>',$)
0011          READ(5,1818) FILNAM
0012     1818 FORMAT(15A1)
0013          CALL ASSIGN(10,FILNAM,15)
0014          WRITE (6,19)
0015          WRITE (5,19)
0016     19   FORMAT (/30X,'WATER YIELD MODEL - 1977 VERSION (DAVE THORSON MODIF
             1ICATIONS)'/30X,'BE SURE YOUR DATA FOLLOWS THE NEW FORMAT BEFORE PR
             1OCEEDING')
```

```
0017             WRITE(5,1919)
0018        1919 FORMAT(' DO YOU WANT THE WATER YIELD INCREASE VOLUME BY STAND?  (Y
               1ES=1. OR NO=-1.)'$)
0019             READ (5,26) SWIT1
0020        26   FORMAT (F3.0)
0021        212  TSUM2=0.
0022             TDA=0.
0023             TA=0.
0024             CALL MDBV
0025             DO 12 I=1,9
0026             TSUM4(I)=0.
0027             TSUM3(I)=0.
0028        12   IHTAT(I)=0
0029             DO 53 J=1,12
0030             DO 53 K=1,3
0031        53   THGBP(J,K)=0.
0032             TSUM4(10)=0.
0033             TSUM3(10)=0.
0034             WRITE (5,4)
0035        4    FORMAT (' ENTER CURRENT YEAR OR YEAR TO WHICH WATERSHED STATUS IS
               1TO BE PROJECTED, EQ. 1980, NONE=0')
0036             READ (5,6) NY
0037        6    FORMAT (I4)
0038             IF (NY .EQ. 0) GO TO 500
0039             ISW1=ISW1+1
0040             REWIND 10
0041        100  DO 43 I=1,6
0042        43   SUMS(I)=0.
0043             READ(10,11,END=300) (ANAME(I),I=1,20)
0044        11   FORMAT (20A4)
0045        16   READ (10,401,END=300) (BNAME(I),I=1,20),DA,A,EX,(IHTA(J),J=1,9)
0046        401  FORMAT (20A4/F9.0/F9.0/F9.0/9I7)
0047             WRITE (5,5)
0048        5    FORMAT (1H1//' % INC LIMIT FOR AVERAGE WATER YIELD, EQ. 8.0 ? ')
0049             READ (5,150) AII
0050        150  FORMAT (F4.0)
0051             JPP=2
0052             I=0
0053             DO 505 J=1,9
0054        505  I=I+IHTA(J)
0055             IDA=DA
0056             IF (I .EQ. IDA) GO TO 506
0057             WRITE (6,507)
0058             WRITE (5,507)
0059        507  FORMAT (//' ERROR IN HABITAT TYPE ACRES!')
0060             GO TO 500
0061        506  WRITE (6,18) J1,J2,(ANAME(I),I=1,20),NY,(BNAME(J),J=1,20),DA,A
0062          18 FORMAT (/' DATE:',9A1,'  TIME:',A8//15X,'SUBDRAINAGE ',20A4/27X,I4
               1//15X,'DRAINAGE ',20A4/15X,'HAVING TOTAL ACRES OF ',F9.0/15X,'AND
               1TOTAL RUNOFF OF ',F9.0,'ACRE-FEET.'//72X,'MARCH',5X,'APRIL',6X,'MA
               2Y',7X,'JUNE',6X,'JULY',5X,'AUGUST')
0063             DO 15 I=1,2
0064        15   READ (10,10,END=300) (RUNOF(I,J),J=1,2),IRC
0065        10   FORMAT (F5.0,1X,F6.3,I1)
0066             IF (RUNOF(2,1) .NE. RUNOF(1,1) .AND. IRC .EQ. 0) GO TO 69
0067             IF (RUNOF(2,1) .EQ. RUNOF(1,1) .OR. IRC .GT. 3) GO TO 500
```

```
              IF (IRC .EQ. 1) GO TO 21
              IRC=IRC+1
              DO 57 I=3,IRC
        57    READ (10,14,END=300) (RUNOF(I,J),J=1,2)
        14    FORMAT (F5.0,1X,F6.3)
              IRC=IRC-1
              GO TO 21
        69    AEP=(RUNOF(2,2) - RUNOF(1,2))/(RUNOF(2,1) - RUNOF(1,1))
              BEP=RUNOF(1,2) - (AEP*RUNOF(1,1))
        21    DO 3 I=1,10
              SUM1(I)=0.
        3     SUM3(I)=0.
              READ (10,17,END=300) (HGBP(J,1),J=1,12)
        17    FORMAT (12F5.2)
              DO 37 I=1,12
              HGBP(I,1)=HGBP(I,1)*A/100.
              HGBP(I,2)=HGBP(I,1)
        37    HGBP(I,3)=HGBP(I,1)
           22 IF(ICD.NE.60) GO TO 2828
              DO 2727 J=1,6
         2727 SUM5(J)=0.
              DO 2929 I=1,10
              SUM3(I)=0.
         2929 SUM1(I)=0.
         2828 READ (10,23,END=9) IST1,ICD,ELEV,IASP,IYR,PER,ACRE,IHT
        23    FORMAT (A6,I2,F5.0,I2,I4,F3.0,F4.0,I2)
              AJ=NY-IYR
              IF (AJ .LT. 0) GO TO 22
              ICD2=0
              IF (ICD .EQ. 90 .OR. ICD .EQ. 80 .OR. ICD .EQ. 70 .OR. ICD
             1 .EQ. 60) GO TO 9
              CALL FEQ(ELEV,AX)
              CALL REQ(ELEV,ROF)
              EH20Y1=AX*ROF
              ICD1=ICD/10
              ICD2=ICD-(ICD1*10)
              CD=ICD1
              IF (ICD2 .EQ. 1 .OR. ICD2 .EQ. 5 .OR. ICD2 .EQ. 6) GO TO 24
              EECA=ACRE
              IF (ICD1 .EQ. 0 .AND. ICD2 .EQ. 2 .OR. ICD1 .EQ. 0 .AND. ICD2 .EQ.
             1 3 .OR. ICD1 .EQ. 0 .AND. ICD2 .EQ. 4) GO TO 56
              EECA=CD*ACRE/10.
              IF (ICD2 .EQ. 2 .OR. ICD2 .EQ. 3 .OR. ICD2 .EQ.4 .OR. ICD2 .EQ. 7
             1.OR. ICD2 .EQ. 8 .OR. ICD2 .EQ. 9) GO TO 60
              WRITE (6,8) IST1,ICD
              WRITE (5,8) IST1,ICD
        8     FORMAT (' ERROR IN STAND ',A6,' CODE ',I2)
              GO TO 500
        9     CALL WROUTS (DA,A,JPP)
              IF (ICD .EQ. 70 .OR. ICD .EQ. 60) GO TO 22
              TDA=TDA+DA
              TA=TA+A
              IF (ICD .EQ. 80) GO TO 100
              IF (ICD .EQ. 90) GO TO 500
              GO TO 16
        C
```

```
C       **START PARTIAL CUT CALCULATION
C
 24     Y=0.
        IF (17. .LT. PER .AND. PER .LT. 55.) GO TO 25
        IF (55. .LE. PER .AND. PER .LE. 100.) GO TO 27
        IF (PER .LT. 17.) GO TO 28
        Y=100.
        GO TO 28
 25     Y=(0.01*PER+0.5)*PER-11.
        GOTO 28
    27  Y=(-0.02*PER+4.21)*PER-121
 28     EECA=Y*ACRE/100.
 56     IF (ICD .NE. 3) GO TO 59
        IHT=10
        GO TO 60
 59     IF (0 .LT. IHT .AND. IHT .LT. 10) GO TO 35
        WRITE (6,13) IST1,ICD,IHT
        WRITE (5,13) IST1,ICD,IHT
 13     FORMAT (' ERROR IN STAND ',A6,', CODE ',I2,', HABITAT TYPE',I2)
        GO TO 500
 35     IF (AJ .GT. 0) GO TO 36
        GO TO 60
 36     CALL EQ(IHT,AJ,X)
        EECA=X*EECA/100.
 60     SUM1(IHT)=SUM1(IHT)+(EECA*EH20YI)/100.
        SUM3(IHT)=SUM3(IHT)+EECA
        ABC=EECA*EH20YI/100.
        IF (1 .LE. IASP .AND. IASP .LE. 8) GO TO 315
        WRITE (6,413) IST1,ICD,IASP
        WRITE (5,413) IST1,ICD,IASP
 413    FORMAT (' ERROR IN STAND ',A6,', CODE ',I2,', ASPECT',I2)
        GO TO 500
 315    I=1
        IF (ELEV .LT. 3500.) GO TO 45
        I=2
        IF (ELEV .GT. 3499. .AND. ELEV .LT. 4500.) GO TO 45
        I=3
        IF (ELEV .GT. 4499. .AND. ELEV .LT. 6000.) GO TO 45
        I=4
 45     DO 47 J=1,6
        S(J)=ABC*BV(I,J,IASP)/100.
 47     SUM5(J)=SUM5(J)+S(J)
        IF (SWIT1 .LT. 0.) GO TO 22
        WRITE (6,400) IST1,ABC,(S(J),J=1,6)
 400    FORMAT (' STAND:',A6,' WATER YIELD INCREASE VOLUME IS ',F7.2,' ACR
       1E-FEET.',4X,6F10.2)
        GO TO 22
 300    WRITE (6,318) (BNAME(I),I=1,20),NY,TDA,TA
 318    FORMAT (///15X,'DRAINAGE ',20A4/27X,I4/15X,'HAVING TOTAL ACRES OF
       1',F9.0/15X,'AND TOTAL RUNOFF ',F9.0,' ACRE-FEET'//72X,'MARCH',5X,
       2'APRIL',6X,'MAY',7X,'JUNE',6X,'JULY',5X,'AUGUST')
        PECA=TSUM2
        A=TA
        DA=TDA
        DO 320 I=1,9
        SUM1(I)=TSUM4(I)
```

```
               IHTA(I)=IHTAT(I)
        320    SUM3(I)=TSUM3(I)
               SUM3(10)=TSUM3(10)
               SUM1(10)=TSUM4(10)
               DO 51 I=1,12
               DO 51 J=1,3
        51     HGBP(I,J)=THGBP(I,J)
               DO 63 I=1,20
        63     ANAME(I)=BNAME(I)
               L = 2
               IF (HGBP(5,3) .GT. HGBP(5,2)) L=3
               DO 67 J=1,6
        67     SUM5(J)=HGBP(J+2,L)-HGBP(J+2,1)
               WRITE (6,415) (SUM5(J),J=1,6)
        415    FORMAT (/' TOTAL MONTHLY DISTRIBUTION OF THE WATER YIELD INCREASE
              1VOLUME',5X,6F10.2)
               SUM6=0.
               DO 417 J=1,10
        417    SUM6=SUM6+SUM3(J)
               WRITE (6,419) (J,J=1,9),(SUM3(J),J=1,10),SUM6
        419    FORMAT (//30X,'EXISTING ECA IN ACRES BY HABITAT TYPE '/7X,918,'
              1ROADS    TOTAL'/7X,10F8.2,F10.2,' ACRES')
               CALL WROUTA(DA,PECA,A)
               IF (ISW1 .EQ. 6) GO TO 500
               GO TO 212
        500    STOP
                 END
```

PROGRAM SECTIONS

NAME	SIZE		ATTRIBUTES
$CODE1	006342	1649	RW,I,CON,LCL
$PDATA	000050	20	RW,D,CON,LCL
$IDATA	002340	624	RW,D,CON,LCL
$VARS	000172	61	RW,D,CON,LCL
.$$$$.	004726	1259	RW,D,OVR,GBL

TOTAL SPACE ALLOCATED = 016072 3613

LP:=INPF

APPENDIX 3

Selecting computer program options

The instructions for operating the program are given in the report by Isaacson (2). The specific reference here is to the use of data card type 10 for selecting the way in which the program will provide water yield increase values. For a given subdrainage, watershed characteristics are initially entered (card types 1 - 8) and then water yield increases are computed for a series of "treatment" data cards (type 9). Each series of treatment cards (type 9) represents either past or proposed logging activity and is followed by a type 10 data card. This card gives a single code number which determines how the results are processed.

Card type 10A with code 70 is intended to signal the end of a series of past data cards (type 9) and is to be followed by a series of proposed treatment type 9 cards. The effects of past and proposed treatments are accumulated and the sums of changes in water yield and equivalent clearcut area are produced. The first set of type 9 cards could be for future rather than past logging activity. Whatever data are entered, the program will sum the results for the 2 series of type 9 cards or for as many series as desired if code 70 is placed after each series. However, it does not make sense to sum more than post plus one proposed future set of treatments.

Card type 10B with code 80 signals the end of data for a given subdrainage. If calculations for additional subdrainages within the main watershed are desired, then data card types 1 - 8 are repeated for the new subdrainage plus appropriate card types 9 and 10. Once the data for all subdrainages have been entered, the last card type 10B with code 80 is followed by an end of file card. This latter card results in the program computing and printing out combined effects of logging in all subdrainages to give cumulative totals for the entire main watershed. Data for additional watersheds may now be entered or calculations terminated.

Card type 10C with code 90 is used if there is only one subdrainage to be analyzed. Results are computed for a set of past and proposed logging activity or for a single series of treatment type 9 cards and the program is terminated directly without seeking further data.

One minor change was made in the Idaho version of the program. Card type 10D with code 60 has been added to permit assessment of the effects of a number of alternative logging options on the same subdrainage without having to re-enter watershed characteristic data cards 1 - 8 for each option and without having the program sum or accumulate the results for each successive option. Hence, any number of proposed treatments can be easily evaluated by following each series of type 9 cards with a type 10D card. The last treatment option type 9 cards should be followed by a type 10C card with code 90.

APPENDIX 4

Example of computer program run including input data and printout of results.

WATER YIELD DATA FORM I

Subdrainage Name Upper Arrow Creek Tributary to Arrow Creek

Subdrainage Acres 4084 Total Runoff 9675 Acre-feet

Weighted Average Elevation 6000 ft. Subdrainage Acres by Habitat Type:

1 ______	2 ______	3 ______
4 ______	5 694	6 ______
7 2590	8 ______	9 800

Subdrainage Precipitation Data:

	Elevation (Ft.)	Precipitation (In.)
Minimum		
Maximum		

OR Runoff Data:

	Elevation (Ft.)	Runoff (In.)	Code
First point	5000	21.1	3
Second point	5750	24.5	3
Third point	6250	32.6	3
Fourth point	7000	35.9	3

Base Hydrograph Data:

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2.3	1.4	2.2	4.2	40.9	32.5	4.1	2.0	1.6	1.6	3.3	3.9

Do you want the water yield increase volume by stand? Yes.

Year to which watershed status is to be projected? 1979.

Percent increase limit for average water yield? 7 %.

Do you want the sustained cutting rate calculated? Yes.

Cutting rates? 50 acres/year ______ ______ ______ ______ ______.

PAST ______ **ACTIVITY INPUT SHEET** PROPOSED ✓

SUBDRAINAGE NO. 1 SUBDRAINAGE NAME Upper Arrow Creek DATE MARCH 2, 1978

STAND NUMBER						ACT CODE		ELEVATION					ASP CODE		ACTIVITY YEAR				% CROWN REMOVAL			ACRES				HAB TYPE	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
C	L	R	C	T	1		2		5	2	5	0		1	1	9	7	8	1	0	0			4	8		5
C	L	R	C	T	1		2		5	2	5	0		5	1	9	7	8	1	0	0			1	4		5
C	L	R	C	T	1		2		5	2	5	0		7	1	9	7	8	1	0	0			4	0		5
C	L	R	C	T	1		2		5	7	5	0		2	1	9	7	8	1	0	0			7	0		7
C	L	R	C	T	1		2		5	7	5	0		3	1	9	7	8	1	0	0			4	5		7
C	L	R	C	T	1		2		5	7	5	0		5	1	9	7	8	1	0	0			4	7		7
C	L	R	C	T	1		2		5	7	5	0		7	1	9	7	8	1	0	0			5	0		7
						9	0																				

DAT[illegible]-MAR-78 TIME:11:48:53

SUBDRAINAGE UPPER ARROW CREEK
1979

DRAINAGE ARROW CREEK
HAVING TOTAL ACRES OF 4084.
ANDTOTAL RUNOFF OF 9675.ACRE-FEET.

		MARCH	APRIL	MAY	JUNE	JULY	AUGUST
STAND:CLRCT1 WATER YIELD INCREASE VOLUME IS	33.19 ACRE-FEET.	0.00	1.66	11.62	14.94	3.32	1.66
STAND:CLRCT1 WATER YIELD INCREASE VOLUME IS	9.68 ACRE-FEET.	0.97	1.94	4.36	1.94	0.48	0.00
STAND:CLRCT1 WATER YIELD INCREASE VOLUME IS	27.66 ACRE-FEET.	1.38	4.15	12.45	6.91	1.38	1.38
STAND:CLRCT1 WATER YIELD INCREASE VOLUME IS	51.19 ACRE-FEET.	0.00	3.84	19.20	20.48	5.12	2.56
STAND:CLRCT1 WATER YIELD INCREASE VOLUME IS	31.12 ACRE-FEET.	0.00	3.11	12.45	10.89	3.11	1.56
STAND:CLRCT1 WATER YIELD INCREASE VOLUME IS	32.50 ACRE-FEET.	3.25	6.50	14.63	6.50	1.63	0.00
STAND:CLRCT1 WATER YIELD INCREASE VOLUME IS	34.57 ACRE-FEET.	1.73	5.19	15.56	8.64	1.73	1.73
TOTAL MONTHLY DISTRIBUTION OF THE WATER YIELD INCREASEVOLUME		7.33	26.38	90.25	70.30	16.77	8.89

EXISTING ECA IN ACRES BY HABITAT TYPE

1	2	3	4	5	6	7	8	9	ROADS	TOTAL
0.00	0.00	0.00	0.00	102.00	0.00	212.00	0.00	0.00	0.00	314.00 ACRES

WATER YIELD INCREASE VOLUME BY HABITAT TYPE

1	2	3	4	5	6	7	8	9	ROADS	TOTAL
0.00	0.00	0.00	0.00	70.53	0.00	149.38	0.00	0.00	0.00	219.91 ACRE-FEET

PER CENT OF ORIGINAL WATER YIELD INCREASE
2.27 PER CENT
PROBABLE EQUIVALENT CLEARCUT AREA ALLOWABLE
806.19 ACRES

SUSTAINED CUTTING RATE IN ACRES/YEAR INCLUDING RECOVERY TO EQUIVALENT CLEARCUT AREA BY YEARS AND FOREST HABITATTYPES ON AN UNDEVELOPED AREA.

HABITAT TYPES

YEARS	1	2	3	4	5	6	7	8	9
1	0.00	0.00	0.00	0.00	68.50	0.00	255.64	0.00	78.96
2	0.00	0.00	0.00	0.00	45.67	0.00	170.43	0.00	52.64
3	0.00	0.00	0.00	0.00	34.65	0.00	130.44	0.00	39.48
4	0.00	0.00	0.00	0.00	28.26	0.00	106.92	0.00	31.77
5	0.00	0.00	0.00	0.00	24.22	0.00	92.44	0.00	26.31
6	0.00	0.00	0.00	0.00	21.48	0.00	82.45	0.00	23.42
7	0.00	0.00	0.00	0.00	19.56	0.00	75.66	0.00	21.00
8	0.00	0.00	0.00	0.00	18.17	0.00	70.64	0.00	19.23
9	0.00	0.00	0.00	0.00	17.15	0.00	67.08	0.00	17.90
10	0.00	0.00	0.00	0.00	16.38	0.00	64.36	0.00	16.89
11	0.00	0.00	0.00	0.00	15.80	0.00	62.40	0.00	16.11
12	0.00	0.00	0.00	0.00	15.37	0.00	60.89	0.00	15.50
13	0.00	0.00	0.00	0.00	15.04	0.00	59.80	0.00	15.03
14	0.00	0.00	0.00	0.00	14.78	0.00	58.96	0.00	14.67
15	0.00	0.00	0.00	0.00	14.60	0.00	58.35	0.00	14.38
16	0.00	0.00	0.00	0.00	14.45	0.00	57.89	0.00	14.16
17	0.00	0.00	0.00	0.00	14.35	0.00	57.56	0.00	13.99

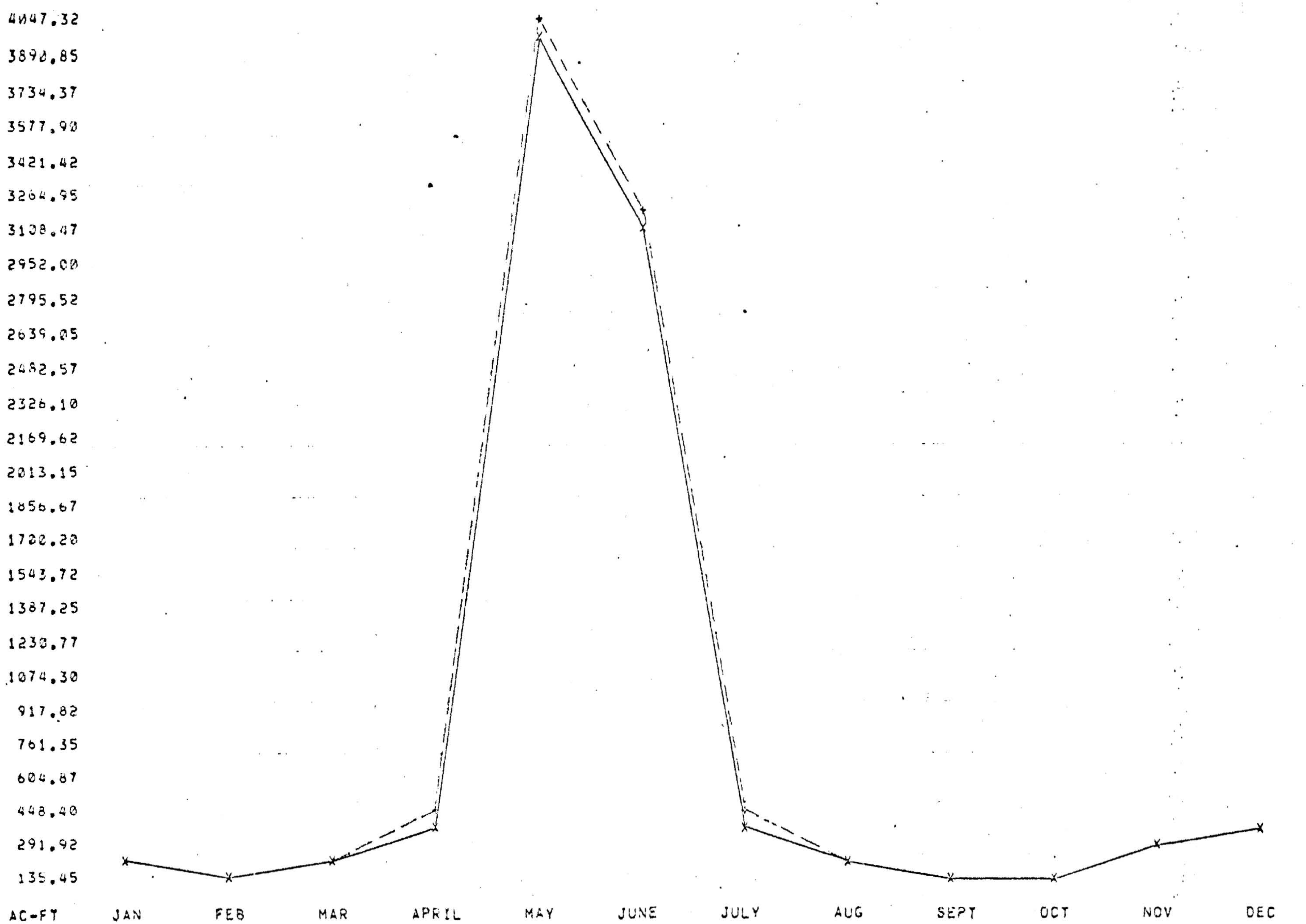
MAXIMUM SUSTAINED CUTTING RATE REACHED

THE ALLOWABLE EQUIVALENT CLEARCUT AREA 806.19ACRES WILL BE REACHED AT A CUTTING RATE OF 50. ACRES/YEAR

HABITAT TYPES

	1	2	3	4	5	6	7	8	9
ACRES	0	0	0	0	8	0	31	0	9

HYDROGRAPH YE[redacted]1979 UPPER ARROW CREEK DATE:02-MAR-78



	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
X BASE	222.52	135.45	212.85	406.35	3957.07	3144.38	396.67	193.50	154.80	154.80	319.27	377.33

\+ PAST
\- PAST & PROPOSED

PEAK FLOW VOLUMES INCREASED BY 90.25 AC-FT OR 2 PCT