[205]

Methods of Assessing Instream Flows for Recreation

COOPERATIVE
INSTREAM FLOW
SERVICE GROUP

INSTREAM FLOW INFORMATION PAPER: NO. 6

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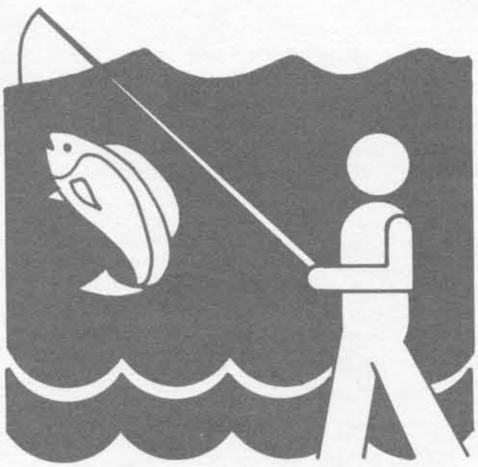

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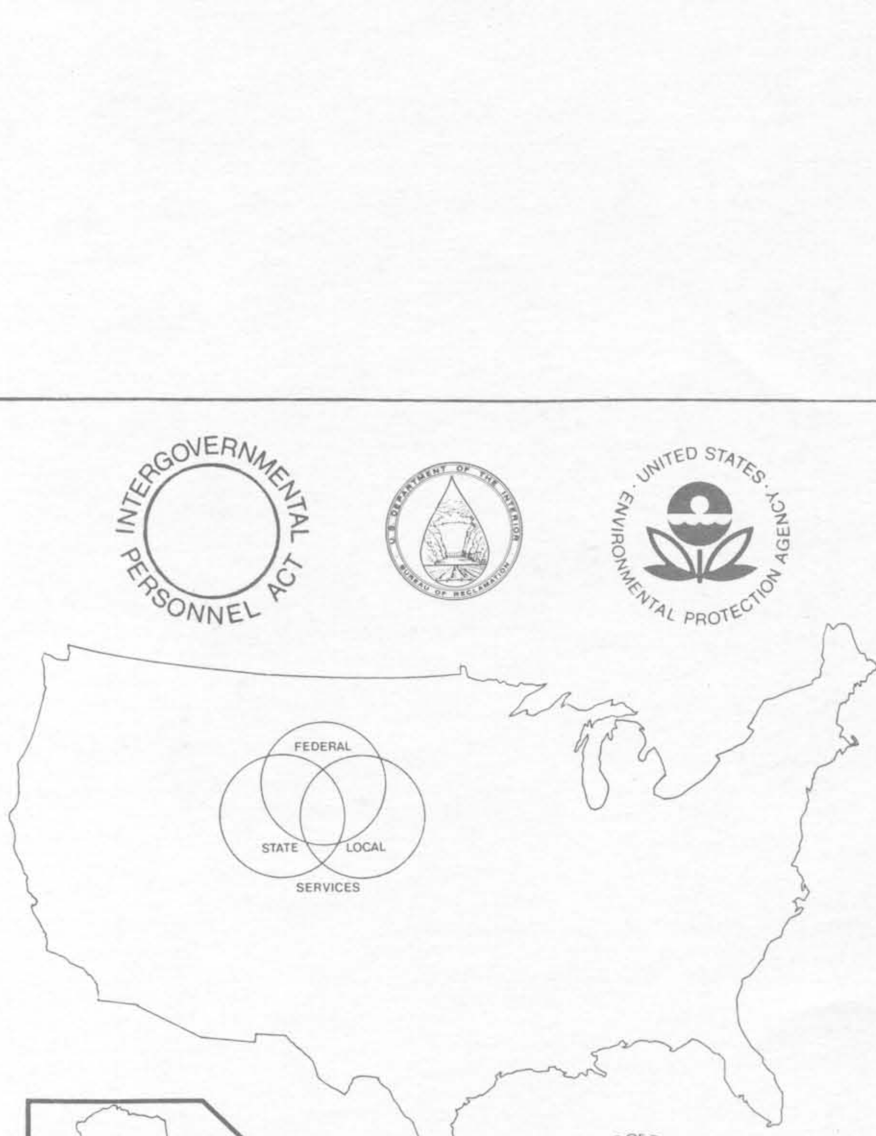

COOPERATIVE INSTREAM FLOW SERVICE GROUP

The Cooperative Instream Flow Service Group was formed in 1976 under the sponsorship of the U.S. Fish and Wildlife Service. Primary funding was provided by the U.S. Environmental Protection Agency. The group operates as a satellite of the Western Energy and Land Use Team. It is a part of the Western Water Allocation Project, Office of Biological Services.

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While the Fish and Wildlife Service is providing the initiative and leadership, the IFG is conceived as a multi-agency, multi-disciplinary program which is to become a "center of activity," providing a focus for the increasing importance of instream flow assessments.

The multi-agency, multi-disciplinary nature of the group is provided through the Intergovernmental Personnel Act transfer of state personnel, and details from other Federal agencies.

Interagency Energy-Environment
Research and Development Program
Office of Research and Development
U.S. Environmental Protection Agency

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METHODS OF ASSESSING INSTREAM FLOWS FOR RECREATION

Instream Flow Information Paper No. 6

by

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[1]Detailed to the Cooperative Instream Flow Service Group from the Heritage Conservation and Recreation Service.

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ABSTRACT

The Instream Flow Group (IFG) has conducted research into methods of quantifying instream flow needs for fish, wildlife, and recreation. This paper describes two techniques developed by IFG for performing recreational instream flow studies. The single cross section method is relatively simple and provides a base flow figure which will provide for the boating activities which make use of the of river. The incremental method is more sophisticated and may be used to develop recommendations regarding streamflows required for various types of recreation, or to provide a recreation analysis of any streamflow. Streamflow suitability criteria for recreation are presented for both methods.

INTRODUCTION

It has been long recognized that there are many competing demands for the use of stream water. Diverting stream water for irrigation, water supply, and energy developments can deplete streamflows to the point where opportunities for recreation and the associated environmental values of the stream are seriously impaired. Numerous water planning studies, both basin-wide and project oriented, have emphasized the need to quantify the amount of water required to support recreation, fish and wildlife resources, and to maintain aesthetic conditions.

The tools and techniques for estimating streamflows required for recreation and aesthetics, and for insuring reasonable consideration of recreation and aesthetics in the allocation of stream water, are currently undergoing study. Instream flow requirements and values for recreation, in the past, have often been based only upon the amount required to maintain a fishery. However, several studies have indicated that recreation and aesthetic requirements, at times, may not be the same as for a fishery.

This paper presents the techniques of assessing instream flows for recreation. These techniques were developed by the Cooperative Instream Flow Service Group and closely parallel techniques used to assess instream flows for fisheries. The data collection procedures, the physical and hydraulic simulation of the stream, and the computer models which analyze the data are the same for both fisheries and recreation. The major difference between the two techniques is the response of the individual fish or recreationist to various physical parameters of stream flow. These responses to stream flow by different user groups are the criteria which are basic to the methods introduced here.

The first method is called the single cross section approach. This method is useful primarily for identifying flows below which a recreation activity is not feasible and results in a so called "minimum" flow recommendation.

The second method is called the incremental method. With this method the recreation planner is able to analyze various flows and determine the recreation potential of a stream at different flows.

This paper is being distributed with four objectives in mind. These are:

1. To bring the problem of preserving instream flows to the attention of recreation agencies and the research community in order to encourage more research in this vital and neglected area.

2. To discuss the development of the recreation probability-of-use curves and of recreation criteria in general, which are necessary for quantifying instream water requirements for recreation.

3. To obtain review and comment on the recreation criteria and probability-of-use curves, and to request data which may be used to test or improve the criteria or curves.

4. To describe the two approaches for assessing stream flows and discuss how various recreation planning processes can be served by their application.

Both methods of instream flow analysis discussed in this paper utilize computer modeling techniques. Both approaches also require that streamflow data be collected. The single cross section approach, as its name implies, requires that information be collected at only one location on the stream. The incremental method requires that data be collected at multiple locations on the stream. In addition to cross sectional data, data relating the streamflow parameters to recreation potential are necessary. These data are termed recreation criteria.

Recreation criteria for instream flow methodologies are the recreation activity information bases necessary to describe a relationship between the quantity of water flowing in a stream, and the quantity and quality of a particular recreation activity which takes place in the stream.

SINGLE CROSS SECTION METHOD

This method requires that only a single cross sectional measurement be taken across a stream. The product of such an approach is a determination of the lowest flow acceptable for recreation. The approach is based on the assumption that a single cross section, properly located, can define a minimum flow requirement. Such a cross section is located at an area displaying the least depth across the entire stream. When this area provides minimum depths for boat passage, the flow at this level may be defined as a minimum acceptable flow. It is assumed that when sufficient water to support boating is available in these critical areas, other areas will have sufficient water to support most of the other instream recreation activities. This approach is best applied to those streams in which flows are expected to be higher than the minimum most of the time.

Criteria for this approach are set forth in Table 1. Criteria have been developed for boating activities only, but for various types of boating craft. Only minimum criteria are presented because this approach provides information on "minimum flows." Criteria are measured in terms of stream depth and width. Velocity is not considered because a minimum velocity is not considered necessary for this approach.

Table 1. Required stream width and depth for various recreation craft as determined by single cross section method.

Recreation Craft	Required depth (ft)	Required width (ft)
Canoe-kayak	0.5	4
Drift boat, row boat-raft	1.0	6
Tube	1.0	4
Power boat	3.0	6
Sail boat	3.0	25

The criteria of Table 1 are minimal and would not provide a satisfactory experience if the entire river was at this level. However, the cross section measured for this method is the shallowest in the stream reach. Therefore, these minimum conditions will only be encountered for a short time during a boating trip, and the remainder of the trip will be over water of greater depths and widths. An important assumption is that all water greater than the minimum is equally useful for the activity (i.e., more is better until bank-full stage).

A computer program (IFG-1) has been developed which predicts width and depth across the transect of any stage (water surface elevation). The output shows discharge and the width with depth equal to or greater than a specific depth. Different water surface elevations may be put into the computer model which are translated into flow in cubic feet per second. When a flow provides the minimum width and depth necessary for an activity, discharge may be considered minimum. Such a minimum indicates that significant losses, if not elimination of this activity, will occur if minimum flow is not equaled or exceeded.

THE INCREMENTAL METHOD

This method, more sophisticated than the single cross section method, describes a relationship between the amount of water in a reach of stream and the associated recreation potential. The incremental method can describe the potential for any recreation activity at any streamflow. A major difference between the methods is that the single cross section method can only be used to identify low flow and cannot be used to assess the recreation potential at any other flow; the incremental method can be used to assess the potential at other flows or to calculate the change in receation potential caused by a change in stream flow.

The incremental method involves a modeling procedure whereby the surface area of a stretch of stream is calculated. In addition to the total surface area of the reach of stream, the area which has certain depths and velocities is calculated. The usable surface area for each activity is then calculated by use of depth and velocity requirements.

It is necessary to make three assumptions regarding the relationship between the quantity of water and the recreation uses of the water: (1) water depth and water velocity are the two streamflow components which are most important in determining whether or not a certain recreation activity may be safely and pleasurably engaged in[1]; (2) there are

[1]Other parameters such as water quality and temperature are also very important in determining the amount of instream recreation use but in many cases are not significantly influenced by flow. Width is also important but is considered outside of the computer model (i.e., width is not a part of the calculation of usable surface area).

certain measures of water depth and water velocity which may be considered minimum, maximum, and optimum for an activity; and (3) the measurement of water surface area which meets certain requirements of depth and velocity is a viable method of describing recreation potential for instream recreation uses.

This method is comprised of four components: (1) computer simulation of a stream reach, (2) determination of the combinations of stream depth and velocity, (3) determination of a composite probability-of-use for each combination of depth and velocity, and (4) calculation of a weighted usable surface area.

1. Simulation of the Stream. The stream reach simulation model utilized in this approach uses several cross sectional transects, each of which is subdivided into subsections. For any stage (water surface elevation) the mean depth and velocity of each subsection is calculated. Typically, a transect would be established across a pool, a riffle, and an intermediate area. Together these cross sectional measurements would represent a stream reach which may extend several miles. In Table 2 a 100 foot length of stream is represented.

Table 2. Depth velocity matrix showing total surface area of stream in square feet.

Depth (ft)	Velocity in feet per second				
	<0.5	0.5-1.0	1.0-1.5	>1.5	Total
<1	500	400	100	0	1,000
1-2	600	700	800	300	2,400
2-3	100	300	500	100	1,000
>3	0	0	100	0	100
Total	1,200	1,400	1,500	400	4,500

2. Distribution of Combinations of Depth and Velocity. The output of the stream reach simulation model is in the form of a matrix showing the surface area of a stream having different combinations of depth and velocity. Table 2 illustrates a depth velocity matrix. The outlined number in the upper left matrix cell refers to 500 square feet per 100 feet of stream having a combination of depth less than 1.0 foot <u>and</u> velocity less than 0.5 foot per second. This figure is the sum of the areas within the stream reach with this combination of depth and velocity.

In order to evaluate the effect of these physical changes upon a streams desirability for recreation, it is necessary to develop an information base for each recreation activity. Such an information base should identify a relationship between depth and velocity of the water, and the desirability of such water for each recreation activity. The information base, called recreation criteria, has been developed and is set forth in the following pages.

3. Composite Probabilities-of-Use. Determination of the probability-of-use for an activity on a certain area of water requires multiplying the probability-of-use for the depth by the probability-of-use for the velocity. For example, from Figure 1 the probability-of-use for the depth of 2.6 feet is 0.9. The probability-of-use for the velocity of 6 feet per second is 0.24. The composite probability-of-use for a depth of 2.6 feet and a velocity of 6 feet per second, is 0.216 (0.9 x 0.24). The probability-of-use is also the weighting factor for calculation of the weighted usable surface area.

4. Weighted Usable Surface Area. The weighted usable surface area equates an area of low desirability to an equivalent area of optimal desirability. For example, if 1,000 square feet of surface area had a composite probability-of-use of 0.216 (see above) it would have a weighted usable surface area of 216 square feet (total surface area times composite probability-of-use). These 1,000 square feet of surface area would be considered to have the same recreation potential as 216 square feet of surface area having optimum depths and velocities.

An example of a matrix is shown in Table 3. In each cell of the matrix, the upper number refers to the surface area of a stream having a depth velocity combination as indicated. The numbers in parentheses refer to the weighted usable surface area.

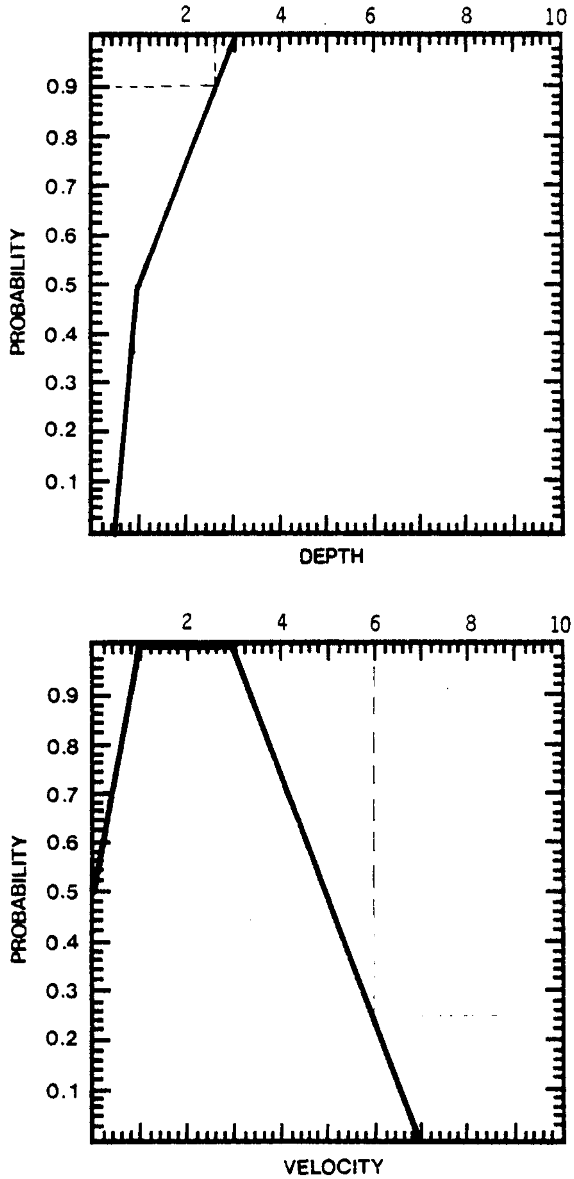

Figure 1. Probability-of-use curve for stream fishing (boat non-power) in relation to depth and velocity.

Table 3. Total surface area of stream and (weighted usable surface area) for a hypothetical recreation activity in square feet.

Depth (ft) and (Probability-of-use)	Velocity in feet per second and (probability-of-use)				
	<0.5 (1.0)	0.5-1.0 (0.8)	1.0-1.5 (0.4)	>1.5 (0)	Total
<1 (0)	500 (0)	400 (0)	100 (0)	0 (0)	1,000 (0)
1-2 (0.3)	600 (180)	700 (168)	800 (96)	300 (0)	2,400 (444)
2-3 (0.8)	100 (80)	300 (192)	500 (160)	100 (0)	1,000 (432)
>3 (1.0)	0 (0)	0 (0)	100 (40)	0 (0)	100 (40)
Totals	1,200 (260)	1,400 (360)	1,500 (296)	400 (0)	4,500 (916)

A separate matrix is required for each recreation activity being considered. A separate matrix is also developed for each of a number of different flows and a different weighted usable surface area is calculated for each flow. Comparison of the matrices provides information on the "best flow" or shows the change in weighted usable surface area due to a change in flow.

RECREATION CRITERIA FOR THE INCREMENTAL METHOD

Recreation activity definitions and a discussion of criteria are presented below.

Minimum and Maximum Criteria

Criteria, as discussed in this section, refer to the parameters of depth and velocity, and deal with the minimum and maximum values. The assumption is made that the recreation activity in question cannot be engaged in outside of the range described by the minimum and maximum values. Optimum values are determined in a somewhat different manner and will be discussed later. Minimum and maximum criteria are of two major types: (1) physical criteria and (2) safety criteria. Regarding physical criteria, recreation activities have certain physical or absolute limits or requirements which must be met (i.e., a boat requires a certain minimum depth of water to float). In the case of safety criteria there are no absolutes; however, it can generally be stated that certain depths or velocities may be unsafe for the average participant. Safety criteria may also be considered a preferred physical limitation.

Optimum Criteria

Minimum and maximum criteria are used to establish the range of depths and velocities which provide a usable surface area for river recreationists. It is also possible to identify a preferred depth or velocity or range of preferred depths and velocities which could be called optimum. Obviously, optimum will not be agreed upon by all recreationists since they represent such a heterogeneous group. However, the total range can be narrowed and a preferred range established. An optimum value of depth or velocity or a preferred range of depths and velocities will be that value or range of values which is usable to the largest number of potential participants.

There are "psychological" criteria that also might be used for selecting optimum depths or velocities. Psychological criteria relate to the quality of the experience. However, in order to evaluate the quality of the experience, one must determine what experience is sought. A number of the recreation activities included in this report have expectations that appear to be unrelated to flow. Therefore, for such activities only the physical and safety criteria need to be considered. Other activities have flow-related expectations and it appears that the experience desired and expected should be a part of the criteria. According to Schreyer and Nelson (1978) the "white water" activities, have an "action-excitement" expectation, and certain types of water are necessary to realize that expectation. Stream depths and/or velocities which produce action-excitement are not easily identified because of the differing skill levels and experience of recreationists. Consequently, psychological criteria, in terms of depth or velocity, are not listed at this time.

The activities which have action and excitement as an expectation are the last four activities listed under boating (below). However, not all of the persons who engage in these activities seek action and excitement. Therefore, a wide range of optimum velocity values is necessary to include the action excitement expectation as well as the other expectations. Each of these four activities may be viewed as two separate activities, one which occurs on tranquil water and one which occurs on non-tranquil water.

Recreation Activities

The stream-oriented recreation activities considered in this report are shown below:

Fishing	Water Contact	Boating
Wading	Swimming	Sailing
Boat, power	Wading	Low power
Boat, nonpower	Water skiing	High power
		Canoeing-Kayaking
		Rowing-rafting-drifting
		Tubing-floating

Definitions

Fishing

- Wading: fishing while walking in the stream.
- Boat power: fishing from a power boat.
- Boat nonpower: fishing from a nonpower boat.

Water Contact

- Swimming: propelling oneself through the water with no, or only occasional, contact with the bottom.
- Wading: walking in the water, including water play.
- Water skiing: being towed behind a boat on skiis.

Boating

- Sailing: wind powered boating.
- Low power: power boating, motor less than 50 horsepower.
- High power: power boating, motor greater than 50 horsepower.
- Canoeing-kayaking: using a canoe or kayak in a river.
- Rowing-rafting-drifting: using a row boat, raft, or drift boat in a river.
- Tubing-floating: floating on a device which is not a full-sized boat or raft. May include inner tubes, small rafts, air mattresses, etc. This activity is also a water contact activity. It is placed here for its similarity to rowing-rafting-drifting.

PROBABILITY-OF-USE CURVES

Development of recreation probability-of-use curves builds upon the recreation criteria discussed in the previous section. Minimum, maximum, and optimum criteria are translated into probablities-of-use and recreation probability curves are developed.

The recreation criteria may be graphed with depth (or velocity) on the X axis and the desirability of certain depths for the recreation activity in question along the Y axis (Figure 2).

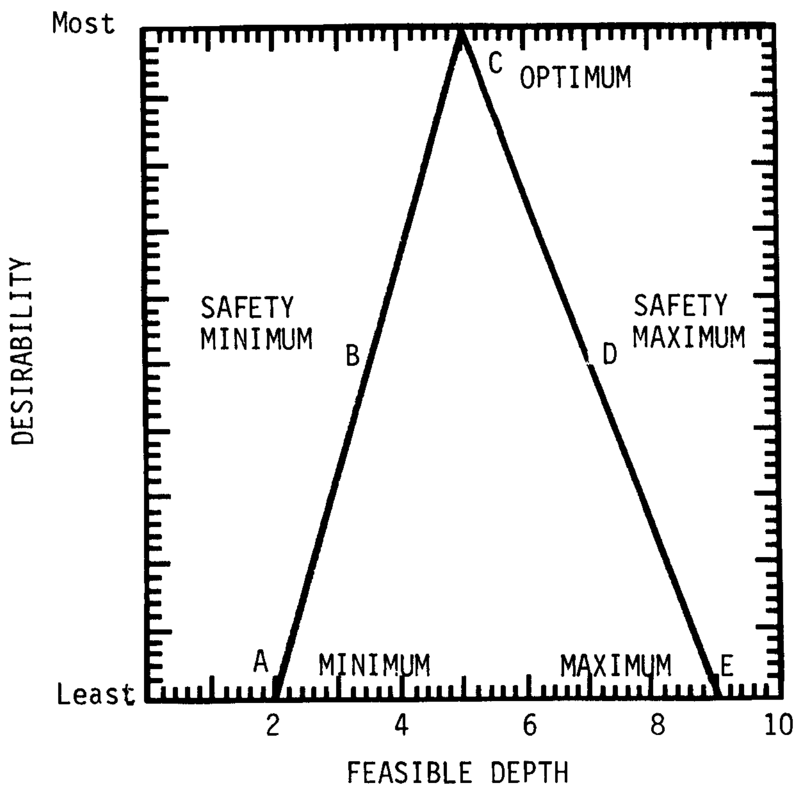

Figure 2. Desirability of stream depth graph for a hypothetical recreation activity.

The physical minimum is shown on the graph as "A" and is the least desirable depth at which the activity is possible. Preferred low flows are the least depth at which the activity can be participated in safely is shown as "B" on the graph. Safety values are somewhat arbitrary because they depend upon experience and skill of the recreationist. In this context, it is assumed that it is an average figure, and that up to 50 percent of the potential participants will find depths between "A" and "B" usable. Point "C" on the graph indicates the most desirable or optimum depth and it is assumed that 100 percent of the potential participants would find such a depth usable. Point "D" indicates the preferred or safety maximum and "E" indicates the physical maximum.

If the Y axis is changed from a desirability scale to a probability scale, with 1.0 on top and 0 on the bottom, the "probability-of-use" may be read off the Y axis.

If Figure 2 represents a probability-of-use curve for an activity in a region where the resource is experiencing capacity use, then the following assumptions can be stated:

1. Areas having depths less than "A" or greater than "E" will have no use.

2. Areas having depths equal to "C" will be experiencing capacity use.

3. Areas having depths equal to "B" and "D" will be experiencing 50 percent of the use of area "C."

Appendix A sets forth the depth and velocity criteria in tabular and graphic forms and defines depths and velocities in terms of desirability as follows:

Optimum	Depth or velocity usable by all; probability-of-use or weighting factor 1.0
Acceptable	Depth or velocity between safety limit and optimum; probability-of-use or weighting factor 0.5-0.99
Marginal	Depth or velocity between physical and safety limits; probability-of-use or weighting factor 0.01-0.49
Unacceptable	Depth or velocity unusable; probability-of-use or weighting factor 0.0

Appendix B shows the probability-of-use curves which are developed from the depth and velocity criteria.

APPLICATION

There are situations where the single cross section method or the incremental method is best suited to do instream flow studies.

The single cross section approach is best suited to situations where:

1. A minimum of time is available.

2. A low flow recommendation is all that is necessary.

3. The low flow recommendation will be exceeded for most of the recreation season.

The incremental method is best suited to situations where:

1. Increments of flow need to be analyzed.

2. The change in streamflow needs to be related to change in recreation potential.

3. The most "exact" answer, available with today's state-of-the-art, is desired.

Opportunities for preserving instream flows for recreation may occur within several programs and processes. Planners did not always take advantage of these opportunities in the past because no method existed by which to quantify the instream flow need.

Opportunities exist within the State water adjudication procedures wherein all water rights will be adjudicated including the Federal reserved rights. When the purpose of the Federal reservation of land includes recreation, the quantity of water necessary to accomplish the purpose must be quantified, and this includes the instream flow required.

Both Federal and State wild and scenic river programs contain language that may be used to preserve instream flows for recreational or aesthetic purposes. The licensing and relicensing procedures of the hydroelectric utility companies call for exhibits to be prepared which describe the recreation resource and the benefits to the public from such a license or project.

Whenever a water project is proposed the impact of the project on recreation is studied. The incremental method will permit the stream portion of such analysis to take its place alongside the reservoir portion.

Use of the incremental method will permit full consideration of recreation by water management agencies as they make decisions about water allocation, conduct hearings for diversion permit requests, or determine low flows.

In general, whenever proposals are made which will change an existing streamflow or flow regime, the impact upon recreation can be determined and be considered in the planning process.

LIMITATIONS

The limitations of the methods discussed in this paper should be understood prior to field testing.

The single cross section is limited to making minimum flow recommendations to accommodate the boating recreation activities. It is less exact than the incremental method and the location of the cross sectional measurement is critical.

The incremental method may be used to describe the impact of a change in flow or used to identify an optimum flow. However, there is no such thing as an optimum flow or flow regime for recreation. Each recreation activity has its own unique flow requirement and frequently flow requirements conflict among activities. For example, a greater flow resulting in higher velocities may benefit the white water boaters, but would all but eliminate fishing while wading. Usually a flow recommendation would be provided in terms of a flow regime. The recommendation of a flow regime would recognize the variable supply of water throughout the year as well as the periods of greatest demand for instream water. A flow regime for recreation would take into account the greater recreation demand during the recreation season, during the weekends, and perhaps even during the daylight hours.

Use of the incremental method can provide only a measure of recreation potential and cannot provide adequate information for developing a recommended flow regime based on the demand for recreation. If such a recommendation is necessary, or if knowledge of a change in recreation use or benefits, due to a change in flow, is desired, a demand-supply study should be undertaken. A demand-supply study would use the output from the incremental method as the supply component.

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APPENDIX A

CRITERIA DEVELOPMENT

Sources of Information Used to Develop the Criteria of Appendix A:

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5. U.S Bureau of Outdoor Recreation. 1977. Resource Requirements for Water Related Recreation. S.E. Regional Office. Draft Report. pp. 15.

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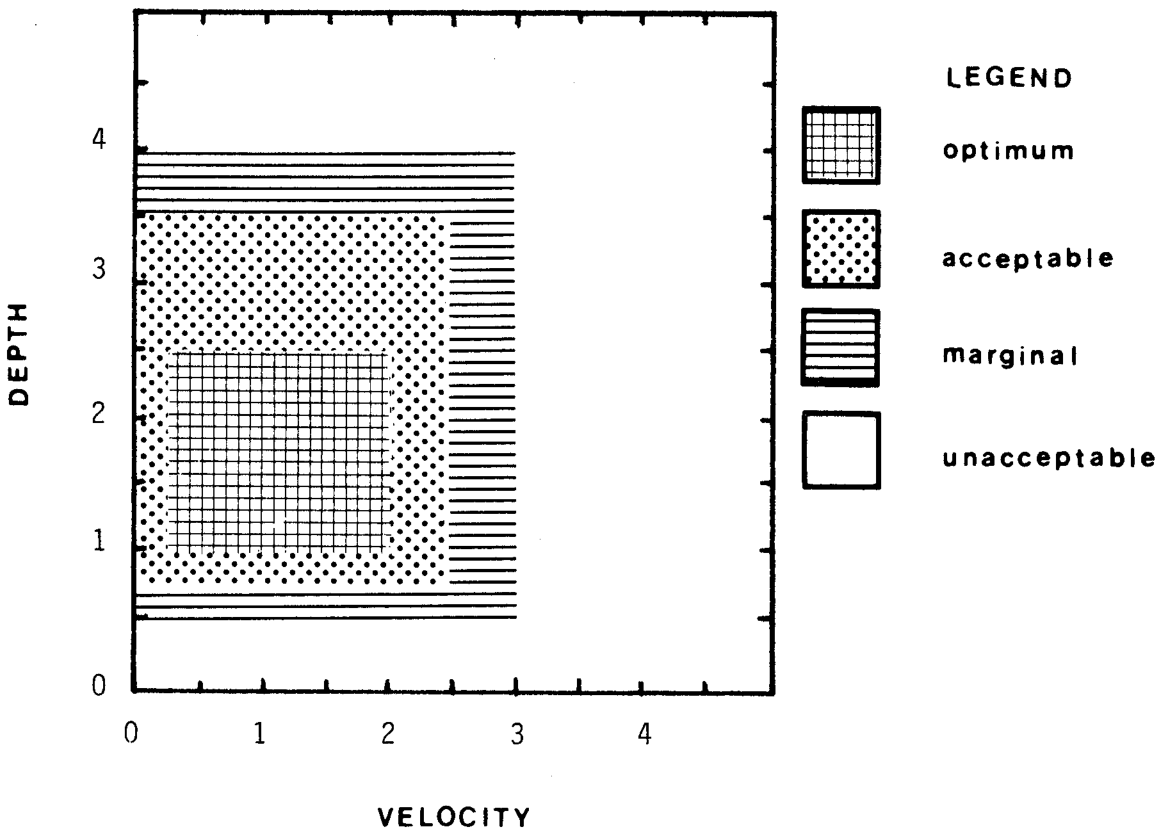
FISHING WADING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			1.0-2.5 ft
minimum	0.5 ft	0.75 ft	
maximum	4.0 ft	3.50 ft	
VELOCITY			0.25-2.0 fps
minimum	0.0 fps	0.0 fps	
maximum	3.0 fps	2.5 fps	

COMMENTS: Depth in ft multiplied by velocity in fps should equal 10 or less. Safety depends upon height and weight of individual as well as substrate type.

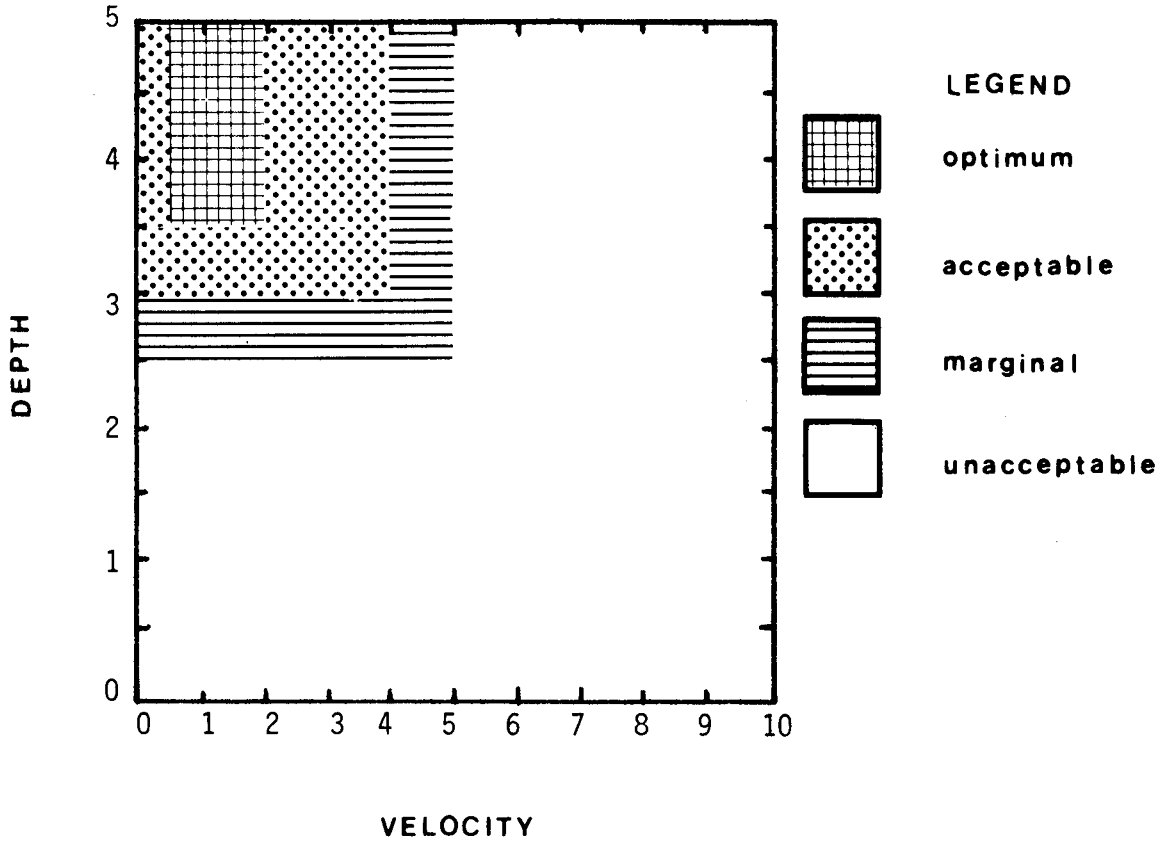


FISHING BOAT POWER

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			3.5 ft +
minimum	2.5 ft	3.0 ft	
maximum	NA	NA	
VELOCITY			0.5-2.0 fps
minimum	0 fps	0 fps	
maximum	5 fps	4 fps	

COMMENTS: Size of boat and motor important. Generally includes boats of low power.

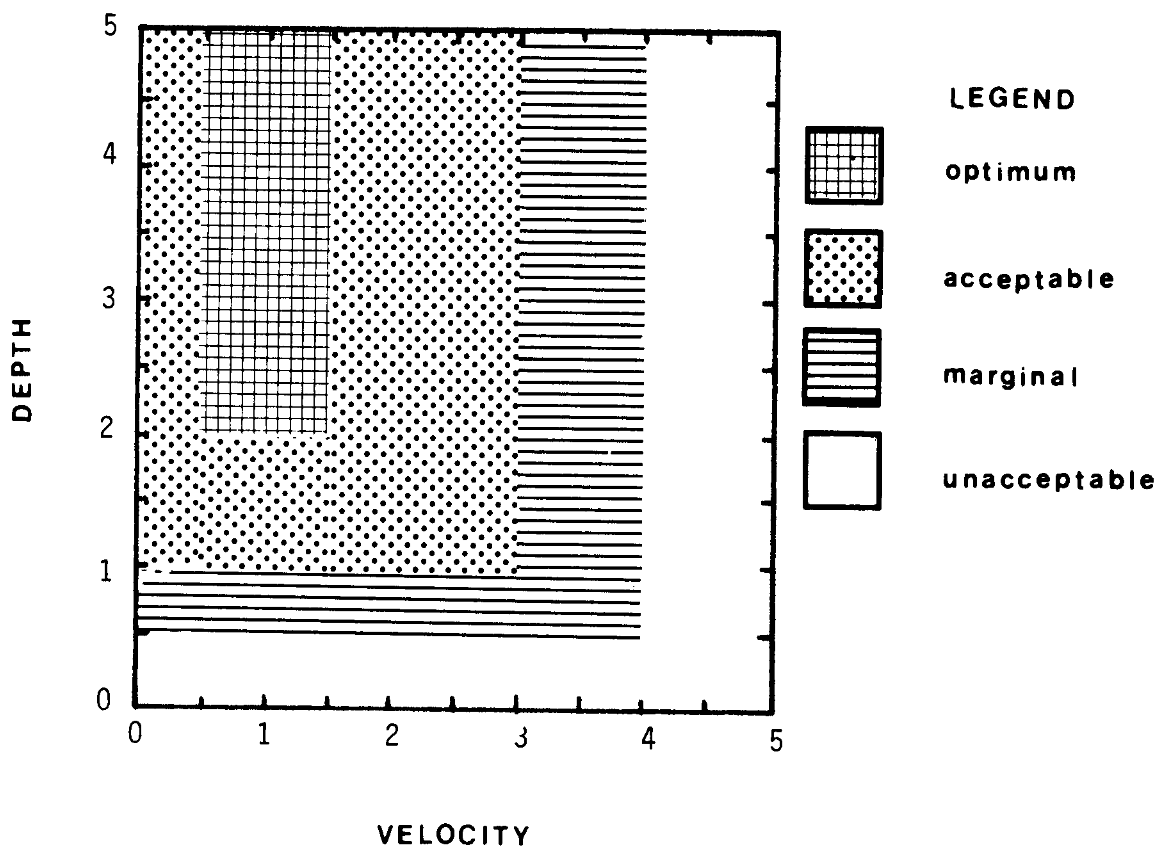


FISHING BOAT NON-POWER

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			2.0 ft +
minimum	0.5 ft	1.0 ft	
maximum	NA	NA	
VELOCITY			0.5-1.5 fps
minimum	0 fps	0 fps	
maximum	4 fps	3 fps	

COMMENTS: Type boat important.

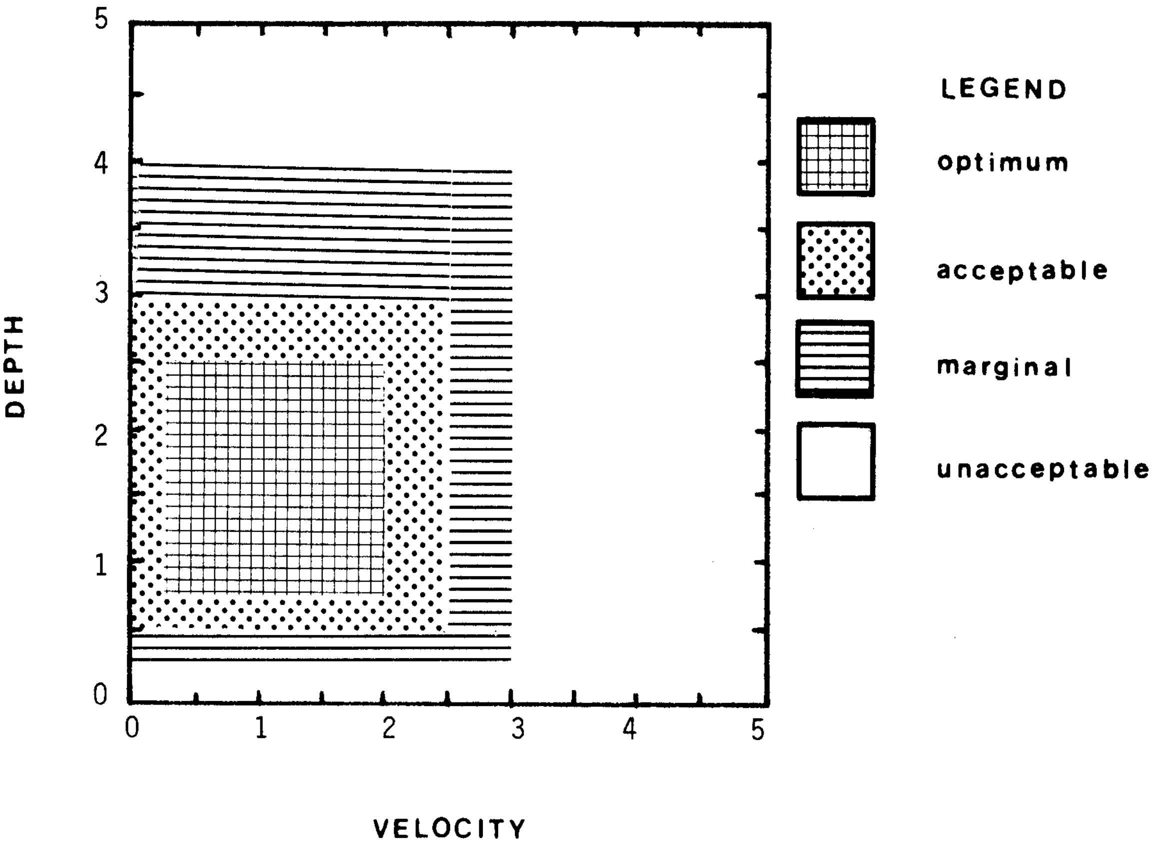


WATER CONTACT WADING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			0.75-2.5 ft
minimum	0.25 ft	0.5 ft	
maximum	4.0 ft	3.0 ft	
VELOCITY			0.25-2.0 fps
minimum	0 fps	0 fps	
maximum	3.0 fps	2.5 fps	

COMMENTS: Depth in feet multiplied by velocity in fps should equal 10 or less. Saftey depends upon height and weight of individual as well as substrate type.

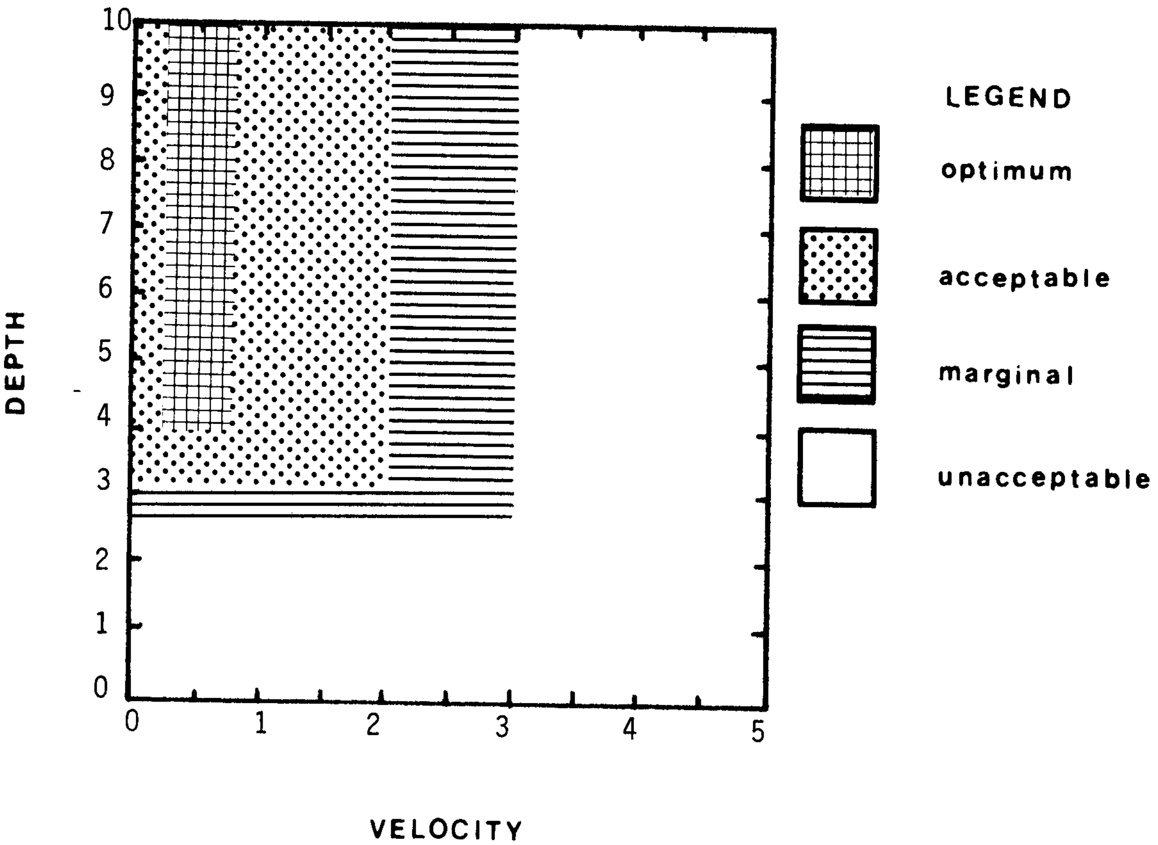


WATER CONTACT SWIMMING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			4 ft +
minimum	2.5 ft	3.0 ft	
maximum	NA	NA	
VELOCITY			0.25-0.75 fps
minimum	0 fps	0 fps	
maximum	3.0 fps	2.0 fps	

COMMENTS: Water quality, temperature, slope of beach, visibility and underwater slope important. Depth safety criteria does not permit diving.

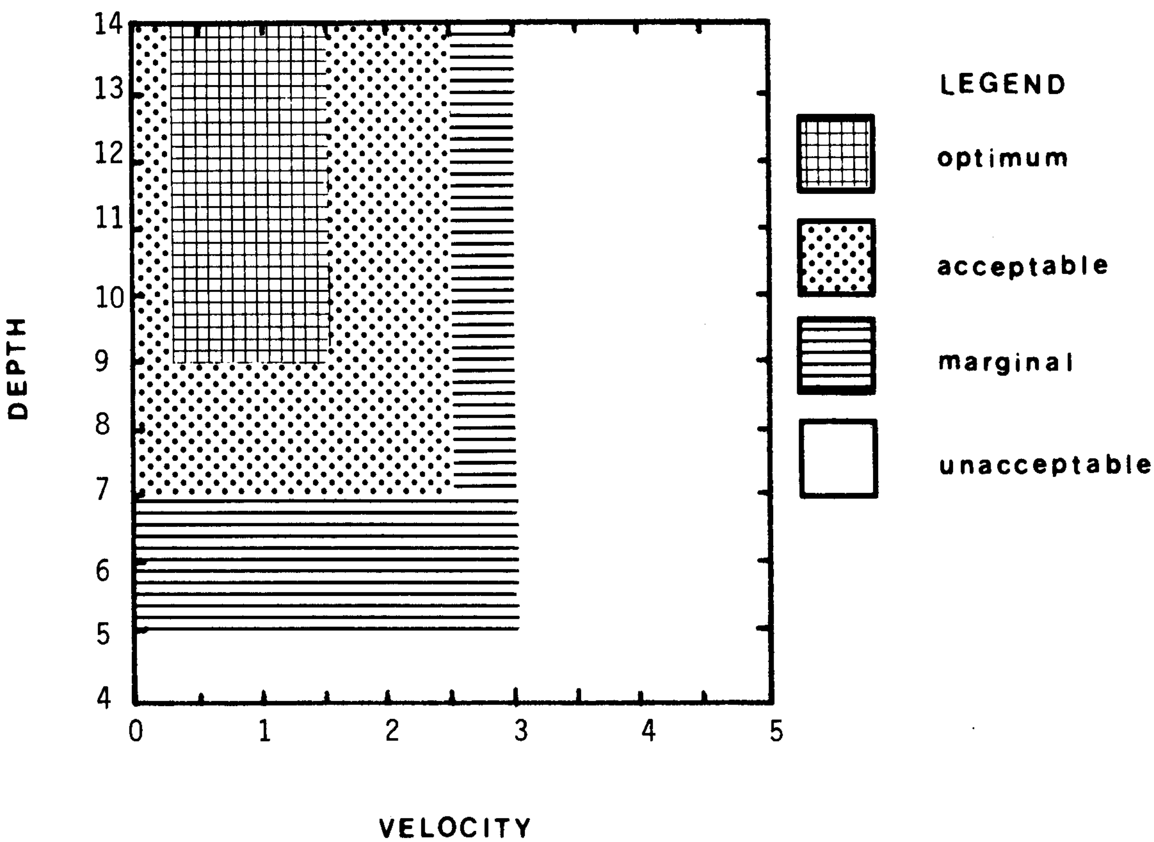


WATER CONTACT WATER SKIING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			9 ft +
minimum	5 ft	7 ft	
maximum	NA	NA	
VELOCITY			0.25-1.5 fps
minimum	0 fps	0 fps	
maximum	3.0 fps	2.5 fps	

COMMENTS: Width is critical also.

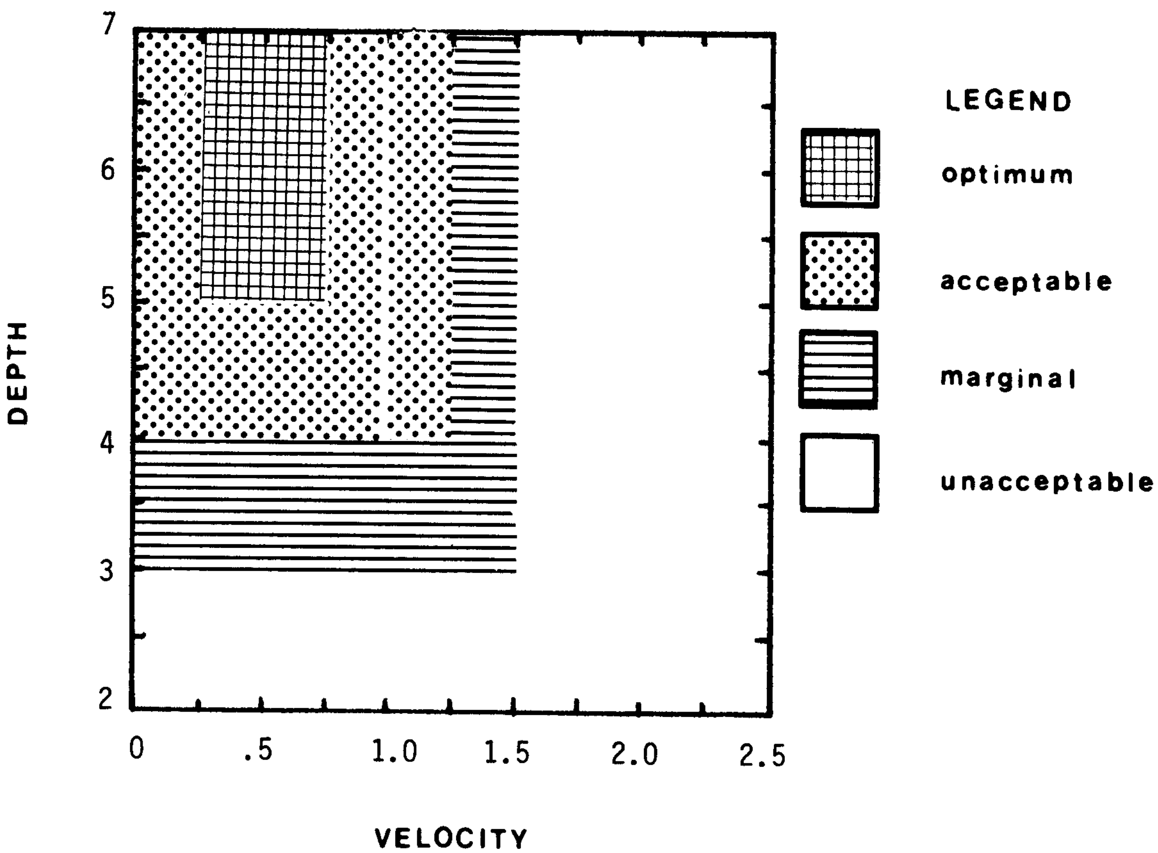


BOATING SAILING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			5 ft +
minimum	3 ft	4 ft	
maximum	NA	NA	
VELOCITY			0.25-0.75 fps
minimum	0 fps	0 fps	
maximum	1.5 fps	1.25 fps	

COMMENTS: Keel or centerboard depth is critical.

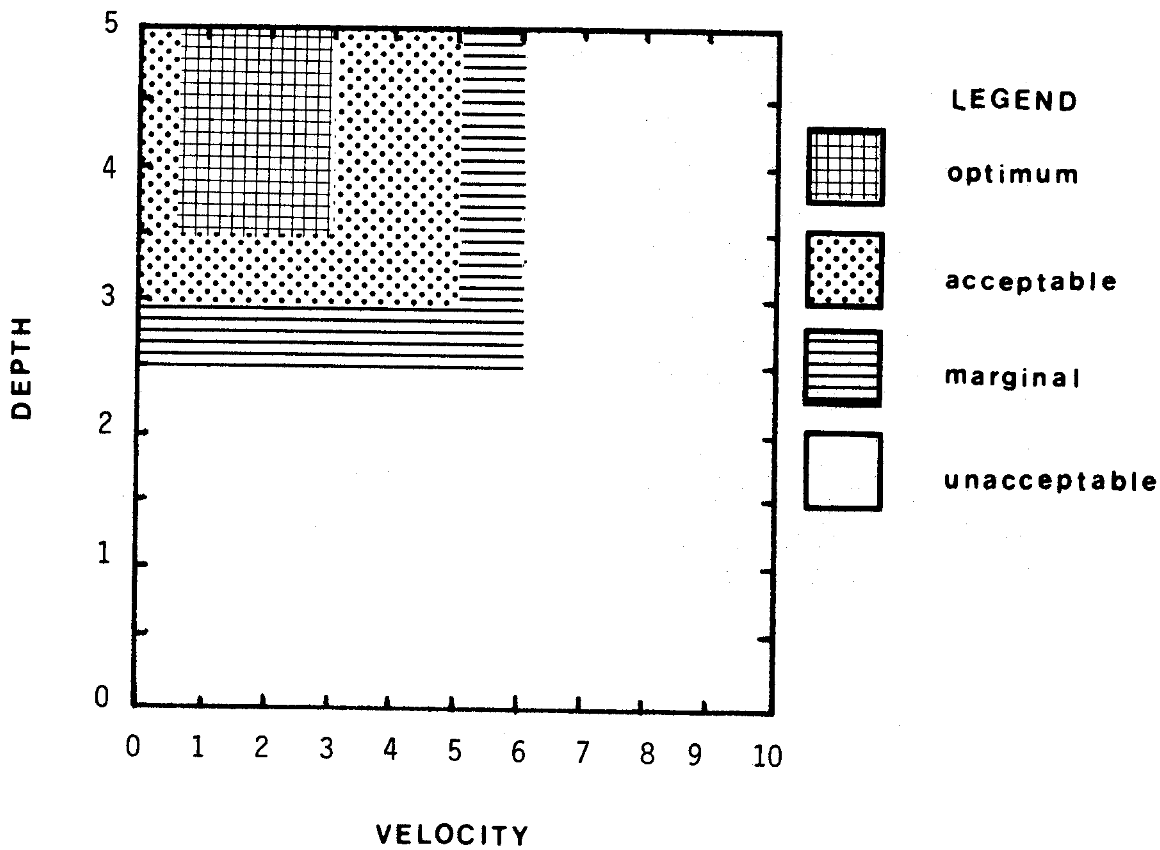


BOATING LOW POWER

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			3.5 ft +
minimum	2.5 ft	3.0 ft	
maximum			
VELOCITY			0.5-3.0 fps
minimum	0 fps	0 fps	
maximum	7 fps	6 fps	

COMMENTS: Low power boats are less than 50 hp.

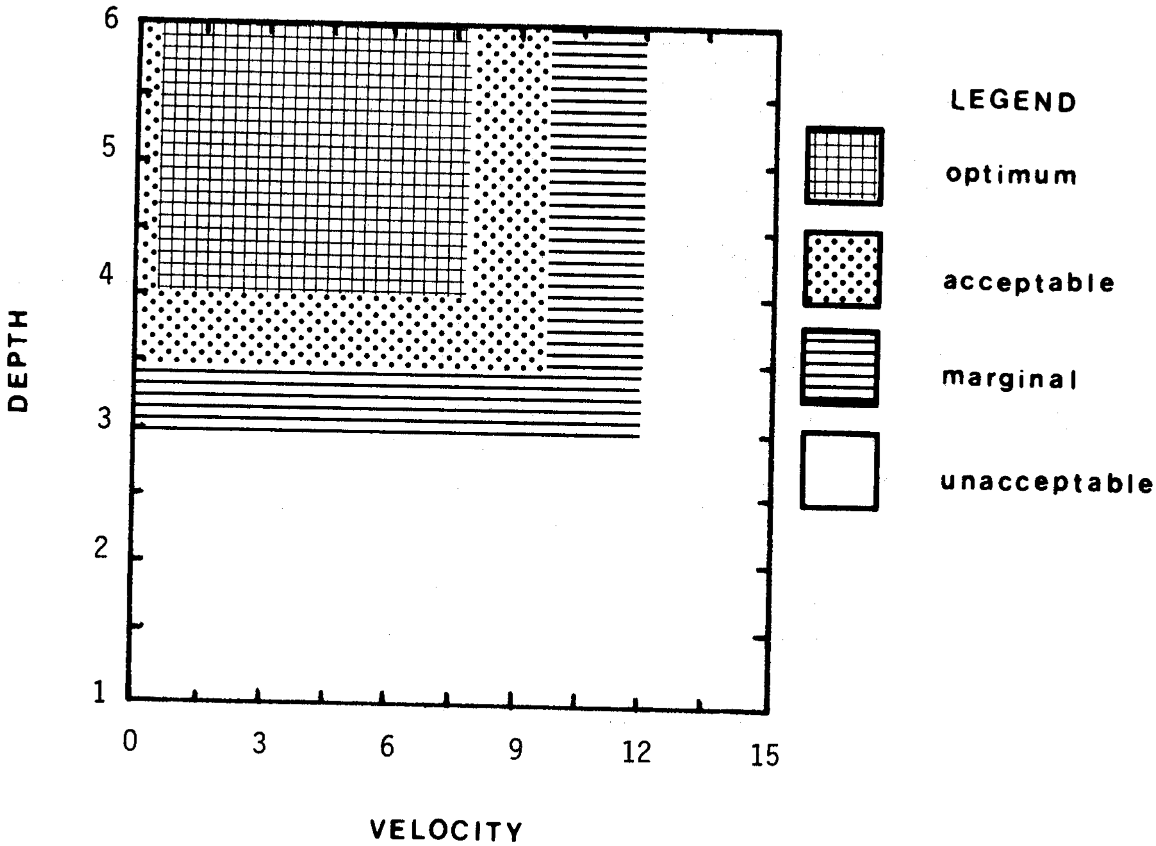


BOATING HIGH POWER

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			4.0 ft +
minimum	3.0 ft	3.5 ft	
maximum	NA	NA	
VELOCITY			0.5-8.0 fps
minimum	0 fps	0 fps	
maximum	12.0 fps	10.0 fps	

COMMENTS: High power is greater than 50 hp. Jet boats or sleds require only 1.0 ft ± water depth. Higher velocities safe only under certain conditions.

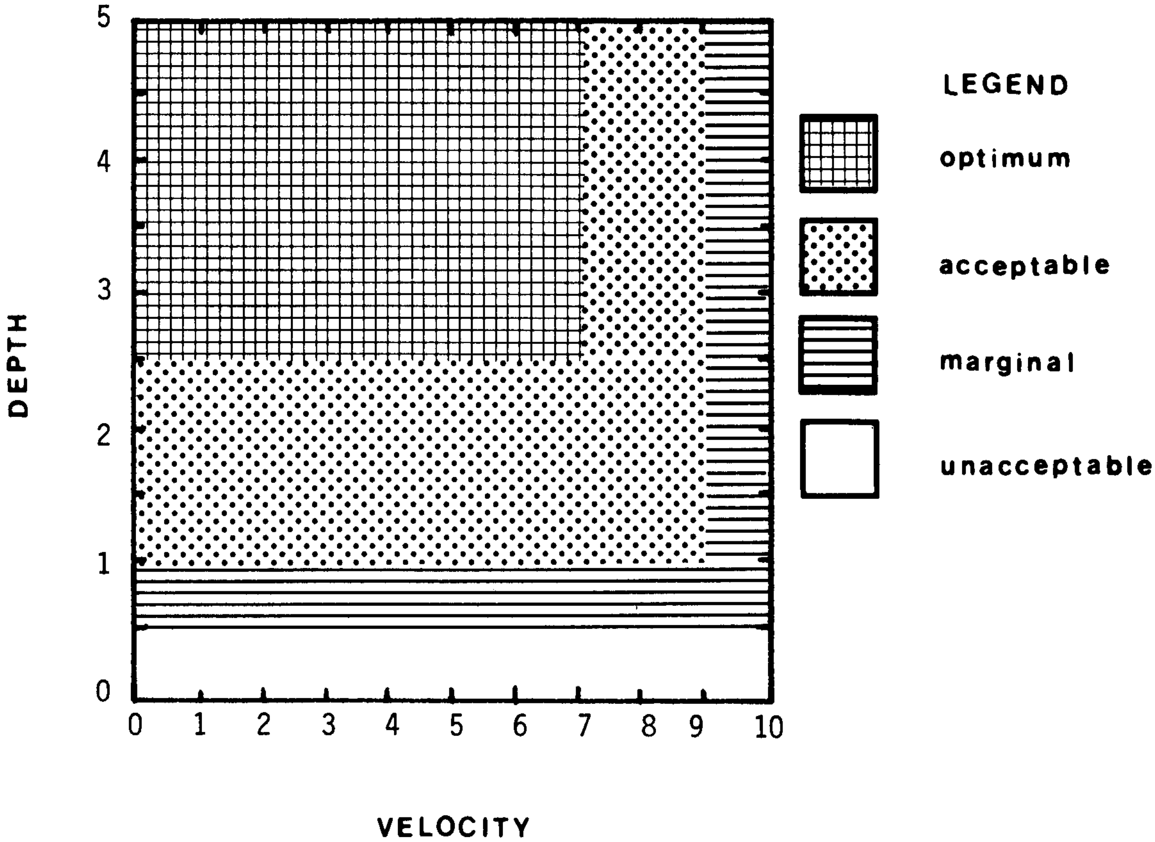


BOATING CANOEING-KAYAKING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			2.5 ft +
minimum	0.5 ft	1.0 ft	
maximum	NA	NA	
VELOCITY			0.5-7.0 fps
minimum	0 fps	0 fps	
maximum	10.0 fps	9.0 fps	

COMMENTS: Higher velocities exclude open canoes. Higher velocities safe only under certain conditions.

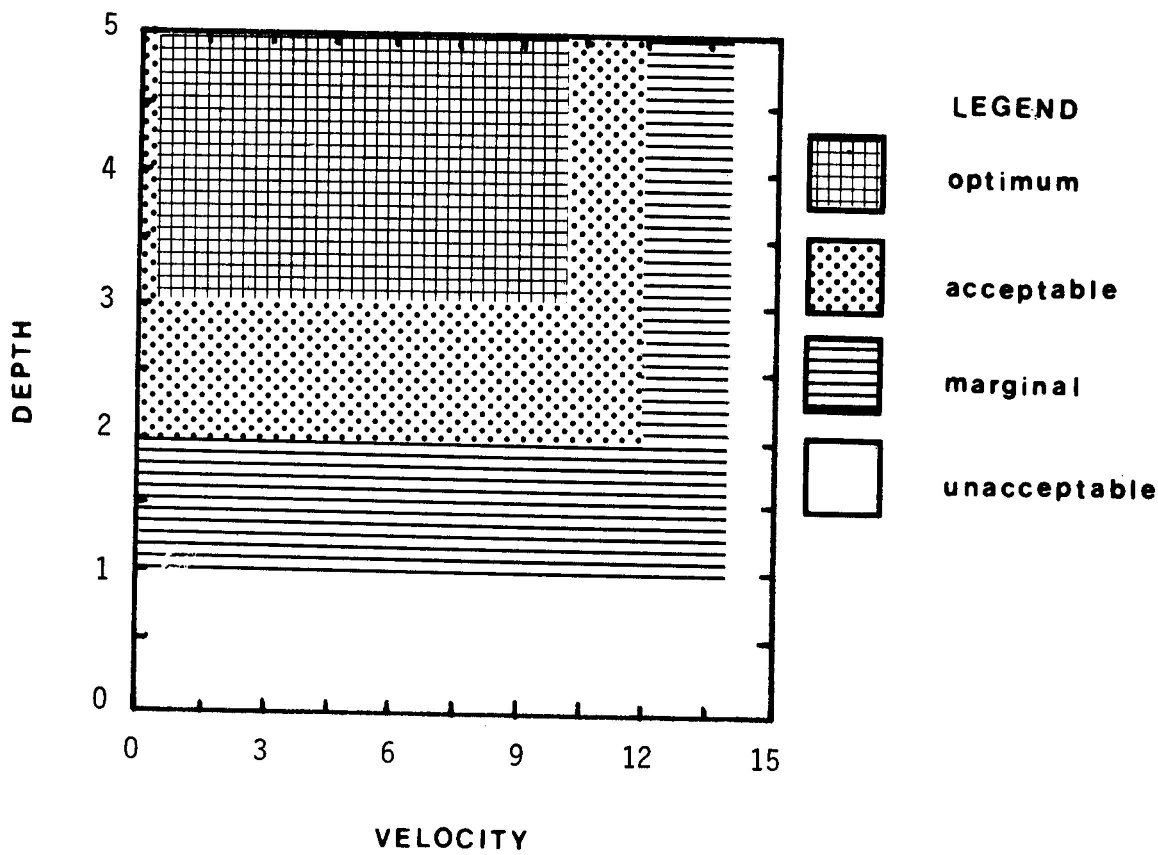


BOATING ROWING-RAFTING-DRIFTING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			3.0 ft +
minimum	1.0 ft	2.0 ft	
maximum	NA	NA	
VELOCITY			1.0-10.0 fps
minimum	0 fps	0 fps	
maximum	14.0 fps	12.0 fps	

COMMENTS: Higher velocities require boats/rafts of a type specifically designed for white water. Higher velocities safe only under certain conditions.

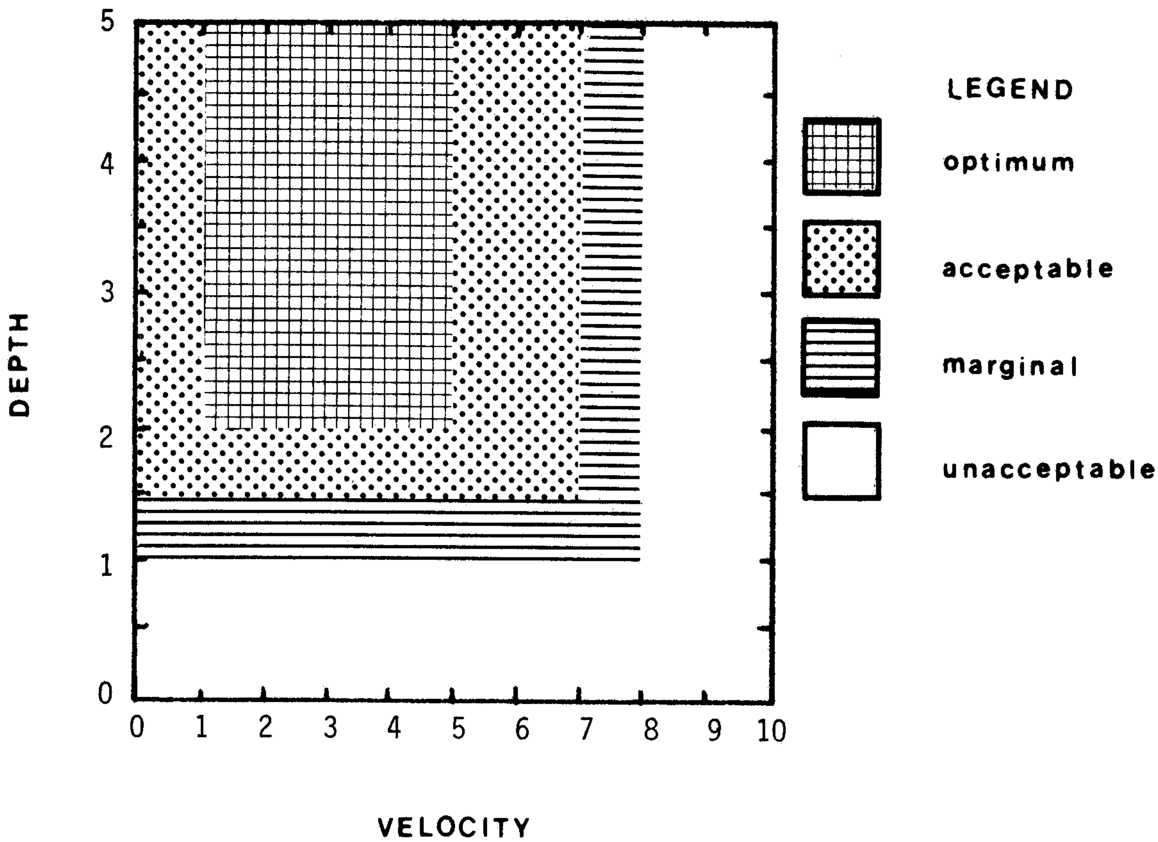


BOATING TUBING-FLOATING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			2.0 ft +
minimum	1.0 ft	1.5 ft	
maximum	NA	NA	
VELOCITY			1.0-5.0 fps
minimum	0 fps	0 fps	
maximum	8.0 fps	7.0 fps	

COMMENTS: Higher velocities safe only under certain conditions.

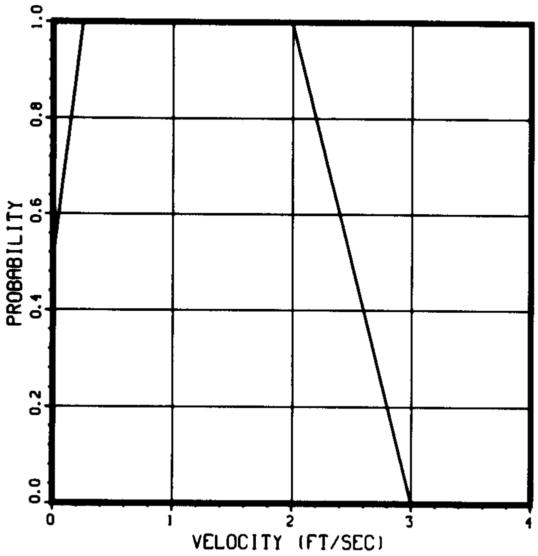


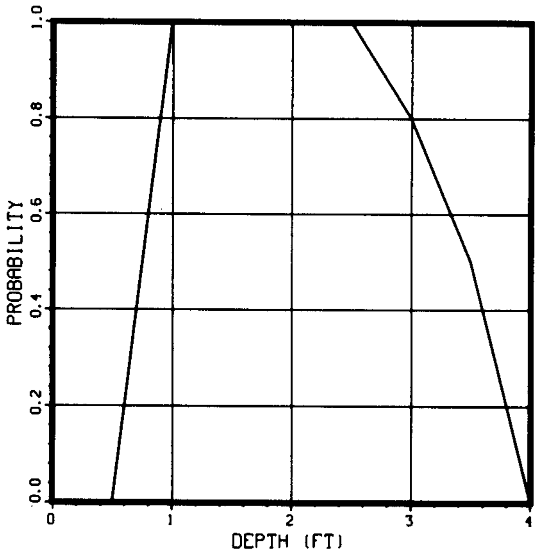
APPENDIX B

PROBABILITY-OF-USE CURVES

FISHING WADING

700000 78/06/26.

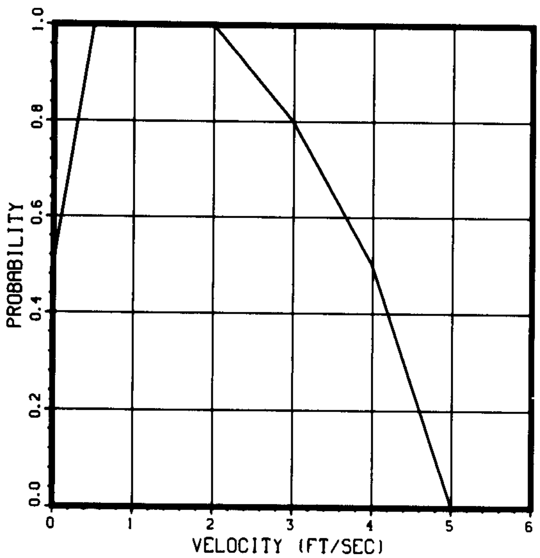


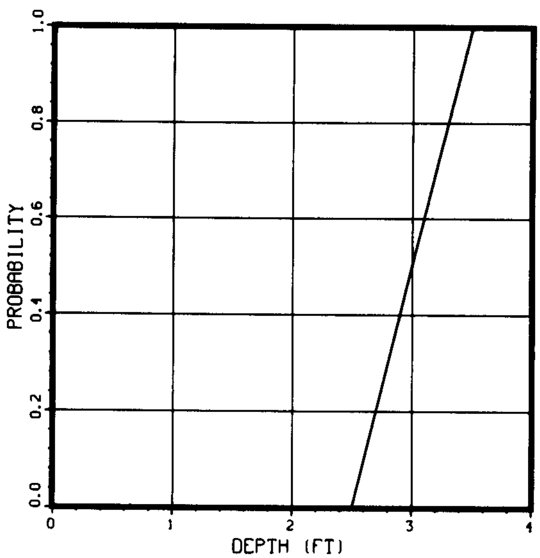


FISHING BOAT POWER

700100

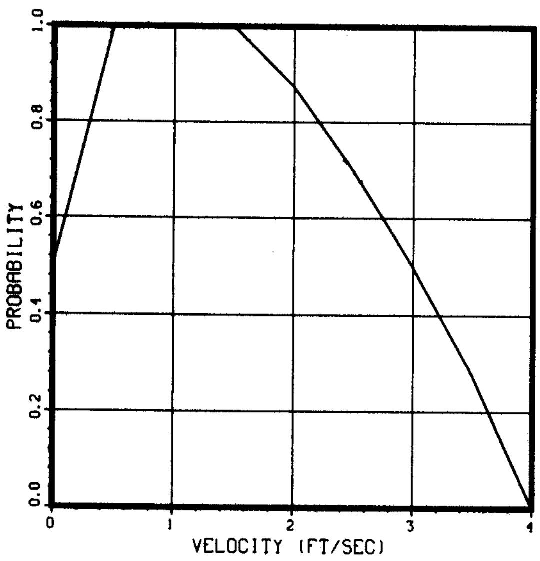
78/06/26.

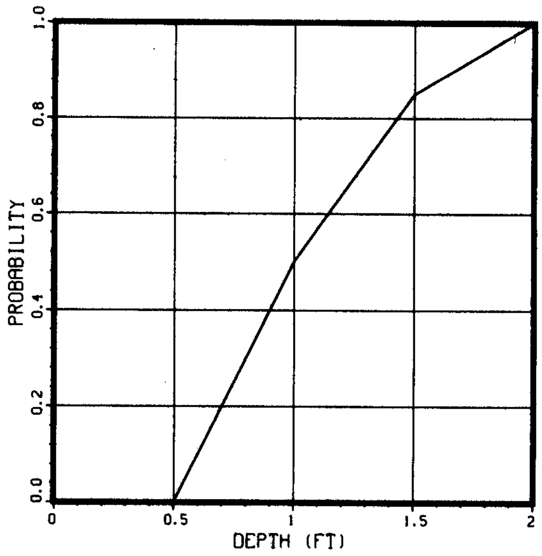




FISHING BOAT NON POWER

700200 78/06/26.

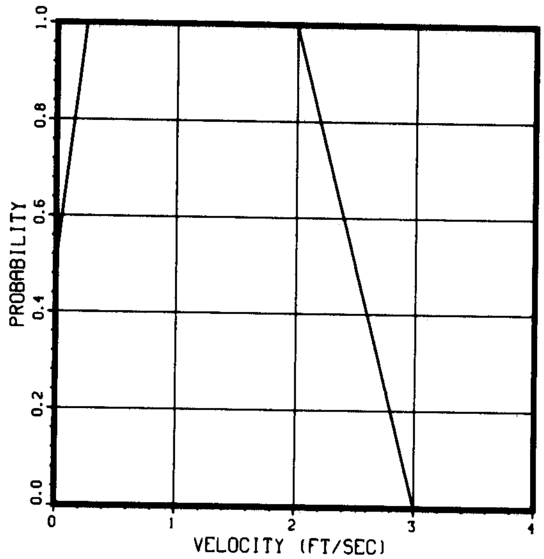


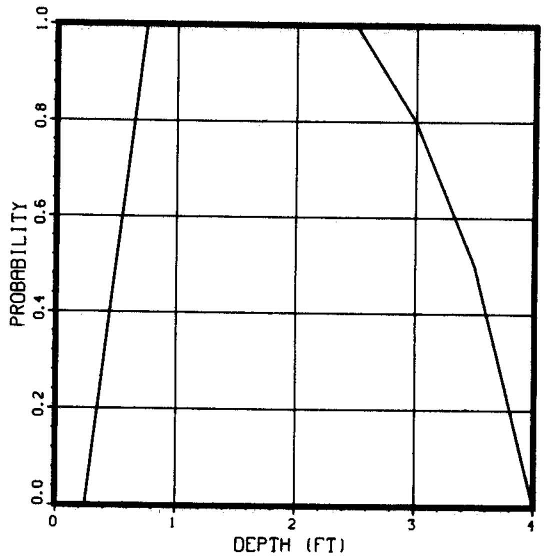


WATER CONTACT WADING

710100

78/06/26.

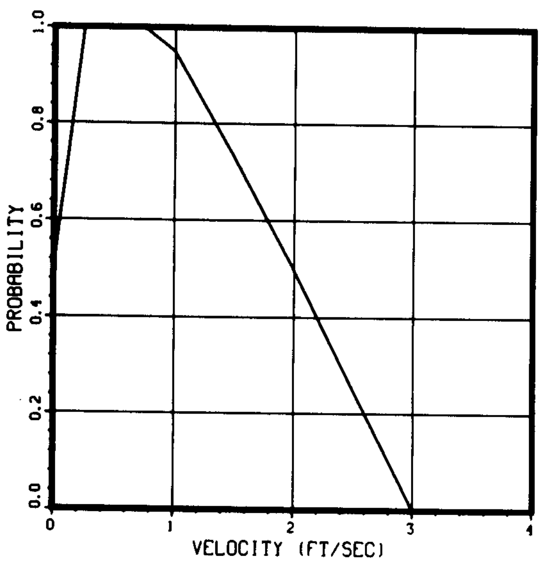


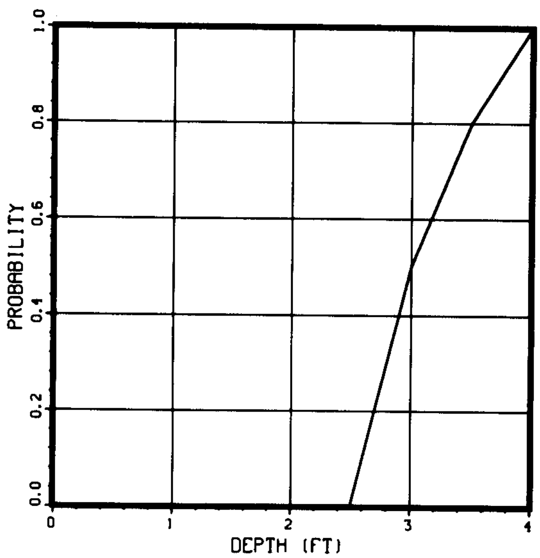


WATER CONTACT SWIMMING

710000

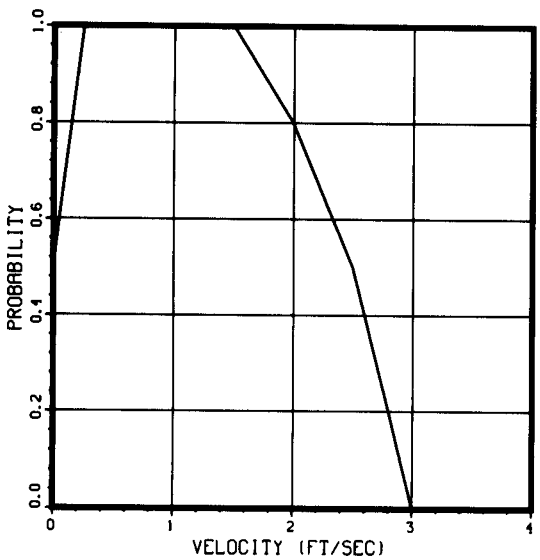
78/06/26.

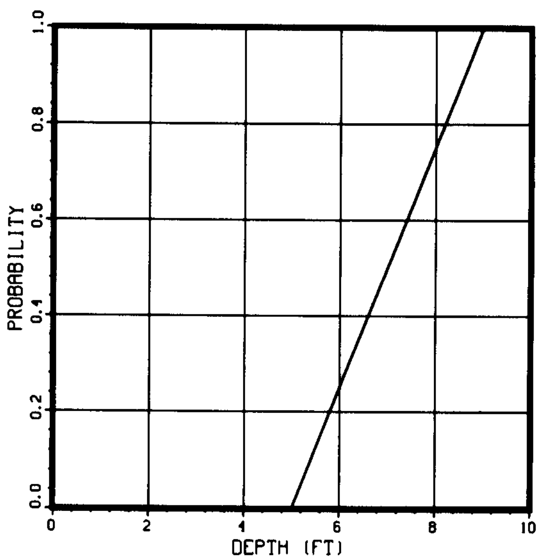




WATER CONTACT WATER SKIING

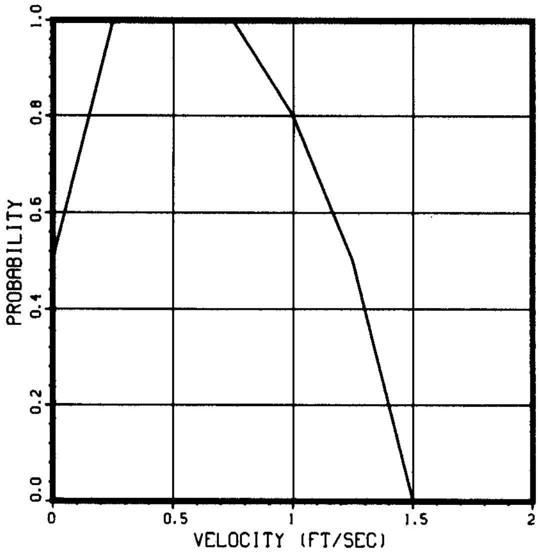
710200 78/06/26.

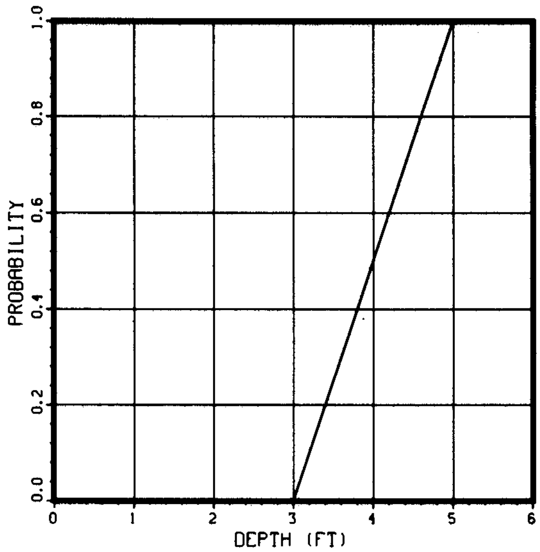




BOATING SAILING

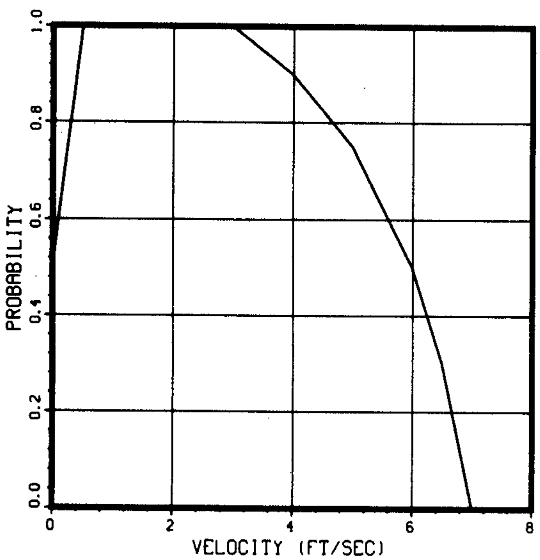
720000 78/06/26.

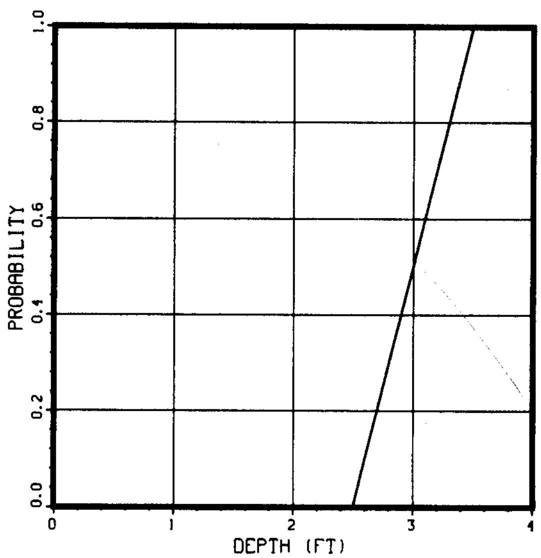




BOATING LOW POWER

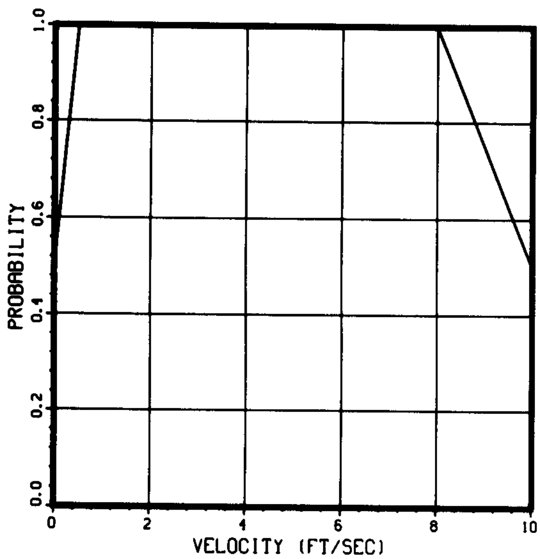
720100 78/06/26.

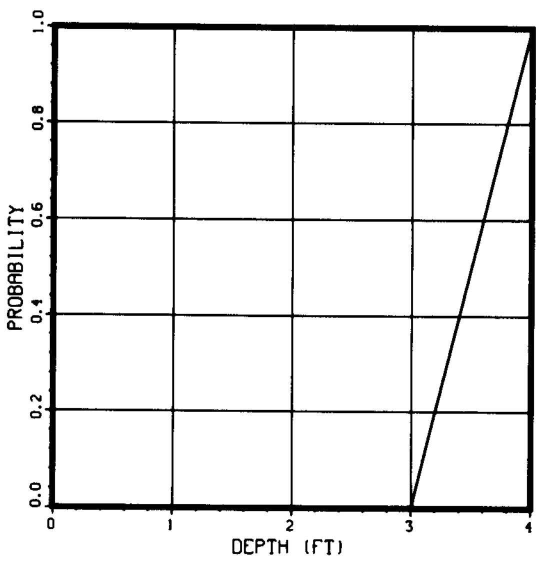




BOATING HIGH POWER

720200 78/06/26.

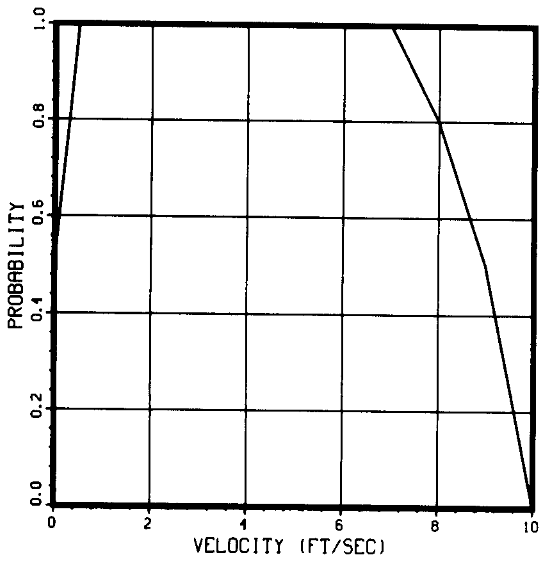


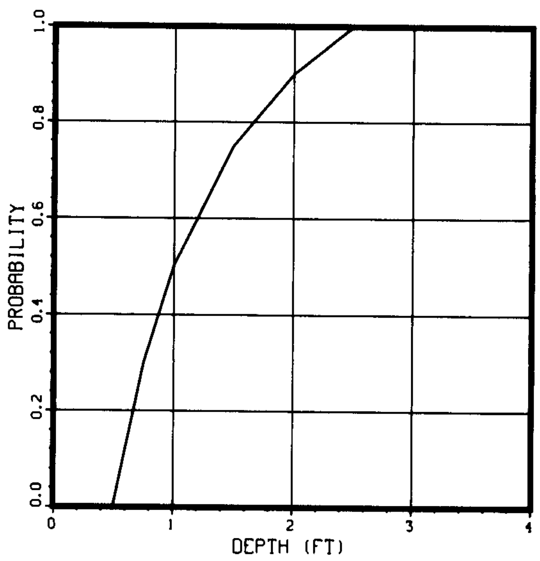


NOTE: Velocity plots have a maximum of 10 fps. The curves for the velocity for this activity reaches a probability of 0.0 at 12 fps.

BOATING CANOEING KAYAKING

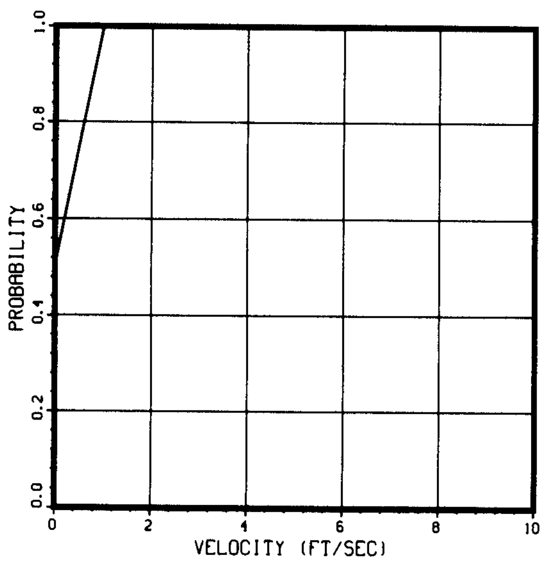
720300 78/06/26.

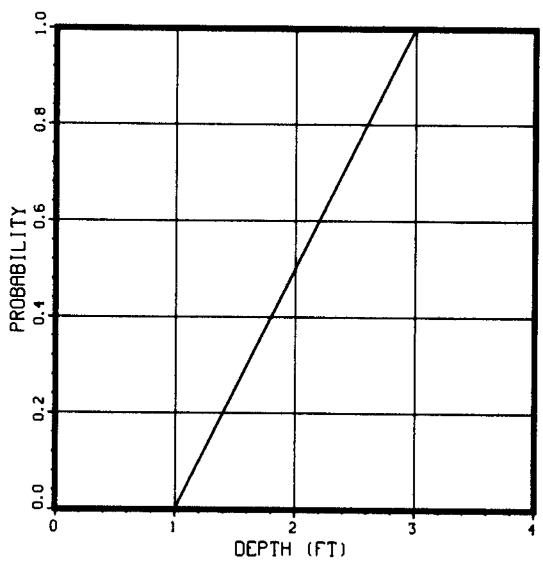




BOATING ROWING RAFTING DRIFTING

720400 78/06/26.

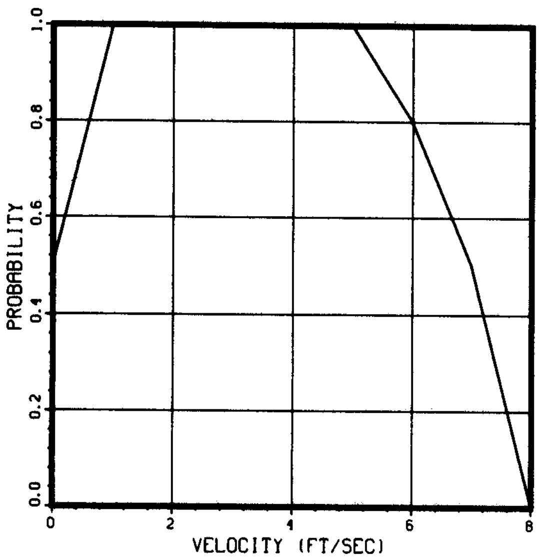


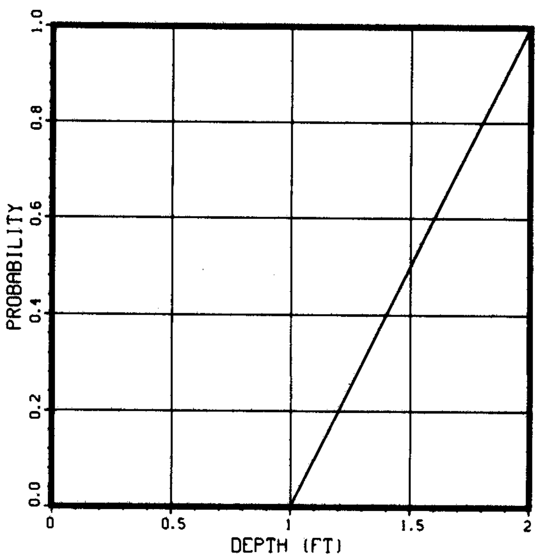


NOTE: Velocity plots have a maximum of 10 fps. The curve for the velocity for this activity is at a probability of 1.0 at 10 fps, a 0.5 probability at 12 fps, and a 0.0 probability at 14 fps.

BOATING TUBING FLOATING

720500 78/06/26.





U. S. Department of the Interior

Fish and Wildlife Service

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.