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Research Problem Statements in Hydrology, Hydraulics, and Water Quality

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INTRODUCTION

This circular contains thirty-seven research problem statements developed by the Committee on Hydrology, Hydraulics and Water Quality. The statements were screened by subcommittees and the ordering of statements by subject represents the best concensus of priority research needs in that subject. The statements listed under general problems are peripheral to the scope of the committee but are published to indicate two needs impinging on the general problem area.

RESEARCH PROBLEM STATEMENTS

PRIORITY STATEMENTS BY SUBJECT

HYDROLOGY

STATEMENT NUMBER	NAME OF PROBLEM
1	Generalized Flood-Frequency Estimates for Urban Drainage Areas
2	Mixed Population Flood-Frequency Analyses Techniques
3	Flood-Frequency Characteristics from Channel Size
4	The Economics of Flood Data Collection and Culvert Design
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16	Erosion Resistance of New Grasses Used in Highway Drainage Channels
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WATER QUALITY

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1	Effectiveness of Temporary Erosion Control Methods
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5	Restoration of Wetlands As Mitigation for Adverse Impacts Resulting from the Construction of Transportation Facilities
6	Predictive Modeling of the Fate of Highway Runoff Pollutants
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10	Evaluation of Channel Alteration Design to Mitigate Damage to Fish and Wildlife Habitat

GENERAL PROBLEMS

STATEMENT NUMBER	NAME OF PROBLEM
1.	Legalities of Highway Drainage Design
2.	Hazardous and Toxic Materials Spills from Transportation Vehicles and Facilities

HYDROLOGY

PROBLEM NO. 1

I. NAME OF PROBLEM - GENERALIZED FLOOD-FREQUENCY ESTIMATES FOR URBAN DRAINAGE AREAS

II. THE PROBLEM - Knowledge of the magnitude and frequency of storm runoff from urban streams is required for safe and economic design of highway drainage structures. In contrast to sites on rural streams where reliable flow estimating techniques have been defined from an effective data base, no generally acceptable and easily usable estimating techniques have been defined for urban streams. A limited, but growing, data base exists for widely scattered urban areas. Highway drainage designers working in urban areas at present must locate and evaluate any available urban runoff data and then utilize that information in whatever flow estimating technique that they may know about. Flow frequency estimation for urban sites is, therefore, time consuming and expensive, and resulting estimates differ significantly between individuals.

III. OBJECTIVES - Provide an easily usable and widely applicable technique for reliable estimation of the magnitude and frequency of storm runoff at urban stream sites. Technique is to be based upon a consistent nationwide analysis of all currently available urban runoff data and will provide a measure of the reliability of the estimates.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: design floods, urban, frequency analysis.

V. URGENCY - Designs of culverts, bridges, and other drainage facilities will be improved significantly through more realistic and more easily coordinated design criteria. Significant economic benefits will accrue to both highway and non-highway users.

PROBLEM NO. 2

I. NAME OF PROBLEM - MIXED POPULATION FLOOD-FREQUENCY ANALYSES TECHNIQUES

II. THE PROBLEM - Knowledge of the magnitude and frequency of floods is required for safe and economic design of highway drainage structures. General guidelines for estimating magnitude and frequency of future flooding from gaging records have been provided by the Water Resources Council. Existing guidelines only weakly cover the analyses applicable for sites where flooding results from two or more distinct causes such as snowmelt, thunderstorms, hurricanes, and cyclonic storms. Highway drainage designers need additional guidance and/or better techniques for estimating magnitude and frequency of floods in areas where multiple flood causes are experienced.

III. OBJECTIVES - Through study of available flood records and related information propose more detailed and/or alternate guidelines for estimating magnitude and frequency of flooding in mixed population areas. Study will outline how to recognize potential for mixed population flooding and how to evaluate available records. To limit the scope of investigation, the study will concentrate on the east slope of the Rocky Mountains in Colorado to Montana where mixed population floods occur regularly and where existing guidelines are known to be weak. Positive findings from this area should form the basis for more effective studies in other areas.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: floods, design floods, frequency analysis.

C. Related research activities: The U.S. Geological Survey has identified the existence of mixed population floods in parts of Colorado, and U.S. Corps of Engineers has used the concept in the North Atlantic States. No ongoing research known.

V. URGENCY - More reliable estimates of design floods should provide more effective and safe designs of bridges and culverts with substantial economic benefits to non-highway as well as highway users.

PROBLEM NO. 3

I. NAME OF PROBLEM - FLOOD-FREQUENCY CHARACTERISTICS FROM CHANNEL SIZE

II. THE PROBLEM - The hydraulic design of highway stream crossings requires estimates of the flood-frequency characteristics of the streams. Traditional methods of making these estimates include use of rainfall records and basin characteristics. These traditional methods produce estimates inadequate for economical crossing design in arid and semi-arid regions, in regions where precipitation

is highly variable in space, and where geologic controls are dominant. A different method is needed, one that will produce better estimates in problem regions and independent estimates in others, including urban streams.

III. OBJECTIVES

A. Develop a set of relations for estimating flood-frequency characteristics from channel geometry measurements that will provide consistent results over broad geographic areas of the United States. Estimate the reliability of the results. Field measurements of channels at gaged sites will be required where not already available.

B. Develop methods of applying the relations to ungaged sites without field visits, or recommend ways of providing the needed field measurements.

C. Improve the understanding of channel morphology and its relation to flow regime in order to develop better estimating relations.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: hydrology, hydrography, channel morphology, flood frequency.

C. Related research activities: The U.S. Geological Survey has investigated the relationships of flood characteristics to channel width for all or parts of several western States, for Kansas, and for part of the Missouri River basin. The U.S. Geological Survey has also published research reports on channel morphology. Some relations of flood characteristics to channel width have been published by Canadians.

V. URGENCY - More reliable estimates of flood-frequency characteristics at highway crossings would result in more efficient design of culverts and bridges. The savings to the Nation should be substantial. These improved estimates cannot be made until the analyses and data collection described in this statement are made.

PROBLEM NO. 4

I. NAME OF PROBLEM - THE ECONOMICS OF FLOOD DATA COLLECTION AND CULVERT DESIGN

II. THE PROBLEM - Most culverts must be located on streams where flood data are non-existent. The design flood must be estimated on the basis of data from other gaged streams in the vicinity by using best available hydrologic models as the information transfer mechanism. If the procedure used for the hydrologic design is economically valid, as more flood data are collected in the area, the new or replaced culverts in that area will be better designed. However, the procedure for specifying an optimum program of flood data for the design of culverts doesnot currently exist.

III. OBJECTIVES - The objective is to develop a theoretical framework for dealing with the uncertainties in flood-frequency estimates at a highway crossing of a stream and to convert this framework into an operational technique for estimating the design flood at the crossing. This technique will then be applied in estimating the regional requirements of culvert design for flood data.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words: culvert design, flood-frequency analysis, data-collection networks.

C. Many flood-data programs and flood-frequency relations have been accomplished in past research. However, the only one that attempted to mesh the two aspects did not succeed in solving the problem.

V. URGENCY - The collection of flood data requires time, and this study is a prerequisite to the initiation of optimum data programs. Thus, delays in initiating this study prepetuate the current paucity of understanding concerning the sizing of highway culverts.

PROBLEM NO. 5

I. NAME OF PROBLEM - FLOOD-FREQUENCY PREDICTIONS FOR BRIDGE AND CULVERT DESIGN

II. THE PROBLEM - Highway drainage structures are designed for runoff events calculated to recur on the average of once in a certain number of years. As a basis for design, recurrence intervals of 10, 25 and 50 or more years are assigned depending upon the relative importance of the highway and the degree of risk that can be accepted. In order to determine the design capacity needed for a structure for a given recurrence interval, the engineer must either resort to a flood-frequency analysis or use ready-made flood-frequency curves from available sources.

Flood-frequency analysis is a mathematical procedure for predicting the probability of future floods on the basis of past flood events. The prediction procedure is based on records of stream flow which in most instances are too short to have included a maximum flood and which do not give a direct indication of the longer recurrence interval needed for design. The solution is obtained by statistical analysis of a series of the observed maximum floods. Mathematical functions are fitted through short-term records that are plotted on probability paper and extended beyond the data. Such extrapolation for longer recurrence intervals assumes that floods are distributed according to a particular mathematical function.

A number of flood-frequency techniques have gained wide use and acceptance. Examples are the Gumbel and Log-Pearson Type III

methods and their variations. The various techniques can give quite different design discharges. There is a need, then, to compare results and determine which technique, within regions of hydrographic similarity, provides the most reliable and consistent means of predicting design discharges for highway bridges and culverts.

In the aggregate the states in cooperation with the U.S. Geological Survey have spent about $25 million accumulating flood information on about 2,000 small watersheds. A consolidated examination of these observations is warranted to delineate regions of homogeneous flood characteristics. Besides eliminating the artificiality of political boundaries, pooling of data would afford economy of scale in electronic computation. Resultant maps would show which portions of all states are best served by a particular flood-frequency technique.

III. OBJECTIVES

A. To select for comparison those techniques commonly accepted by professional hydrologists and any new promising techniques.

B. To use the maximum of gaged watersheds smaller than 100 square miles for a national comparison of analysis techniques.

C. To recommend the preferred technique region by region, giving consideration to watershed size, physiographic provinces, climatic differences and other factors controlling hydrologic homogeneity.

D. To prepare regional maps of any statistical parameters needed to apply a preferred technique.

E. To present measures of resultant reliability of those techniques selected for comparison.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: flood-frequency analysis, recurrence interval.

C. Related research activities: FHWA Contract Research Studies at Utah State University. WRC Committee on Hydrology sponsored research at the Center for Research in Water Resources, Univerity of Texas.

V. URGENCY - Flood-frequency predictions are basic elements in the design of highway drainage structures. The success or failure of a design is often dependent on the accuracy of such predictions. Engineers have frequently been misled into underdesign or applied factors of safety resulting in overdesign. The consequences have been expensive in either case. For the past 10 to 15 years the U.S. Geological Survey in cooperation with many State highway departments has collected runoff data from a large number of small rural watersheds. These data provide a real opportunity for a study and comparison of flood-frequency techniques. The results of such a study would reduce the risk element in the hydraulic design of bridges and culverts and lead to more uniform practice in the prediction of design discharges for such structures.

PROBLEM NO. 6

I. NAME OF PROBLEM - CRITERIA FOR THE ANALYSIS OF UNUSUAL EVENTS IN ANNUAL FLOOD PEAK SERIES

II. THE PROBLEM - Highway bridges and culverts are designed to pass a flood event of a magnitude that is expected to be exceeded about once in a specified number of years. Statistical probability analysis of annual flood observations commonly is used to establish a relation between flood magnitude and frequency for gaged sites. Techniques have been developed for estimating flood magnitude-frequency relations at ungaged sites where bridge and culvert design criteria are needed, but these estimating techniques usually are based upon transfer of frequency relations defined for gaged sites. Flood-frequency relations for gaged sites therefore are basic elements of highway drainage structure design.

The reliability of any flood magnitude-frequency relation, whether defined by a Log-Pearson Type III probability analysis as recommended by the Water Resources Council or by some other probability analysis, is dependent upon the observed flood record being a representative sample of the floods that can be expected to occur over a very long time period. Records of observed floods are generally of a short duration, yet some contain an observation of one or more very unusual floods. These unusual floods, sometimes called "outliers," may seriously influence the definition of a flood-frequency relation.

III. OBJECTIVES

A. To develop procedures for recognizing those unusual events in a flood record that significantly affect the definition of a flood magnitude-frequency relation.

B. To propose guidelines for defining a flood-frequency relation from a gaging record that contains one or more unusual events.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: outliers, unusual floods, flood-frequency analysis.

C. Related research activities: Research sponsored by the Water Resource Council Hydrology Committee at the Center for Research in Water Resources, University of Texas at Austin.

V. URGENCY - Flood-frequency relations are a basic element of highway drainage structure design. The success of a design is dependent upon accurate frequency information. The proposed study would lead to improved accuracy

of frequency definition and more uniform practices in the hydrologic analysis for design sites.

HYDRAULICS

PROBLEM NO. 1

I. NAME OF PROBLEM - HYDRAULICS OF BRIDGE WATERWAYS

II. THE PROBLEM - Where highways cross waterways water is conveyed through bridges and culverts, and can flow over the embankment. In present procedures for sizing the structures the flow is estimated for each structure as an isolated unit and the resulting discharges are summed and adjusted to make sure that the total is equal to the assumed design flow. Scour caused by a constriction is computed when the estimated flow is known. Sustained high flows will result in an enlarged section and a possible change in the flow distribution. In all of these computations one-dimensional or empirical approximations are used to estimate discharge. In reality flow may be through any or all of several bridges, culverts, or over the road simultaneously while the channel may be degrading or aggrading. Often the flow may be more nearly two- or three-dimensional.

III. OBJECTIVES - The objective is to develop computational procedures to describe this dynamic interactive process. Field or laboratory research could provide insight into the physics of this problem and data to calibrate and verify models. A computerized model using modern graphics would standardize and streamline the design process.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 22 and 25 have not been scanned in preparing this statement.

B. Suggested key words for this problem: bridge and culvert hydraulics, bridge waterways, scour.

C. Related research activities: not known.

V. URGENCY - The results of this study will assist in reducing the size and cost of hydraulic structures by improving the designer's capability to study the alternative drainage schemes. Since attention would be focused on the composite model, research needs would be easily identified as the weak lines in the model.

PROBLEM NO. 2

I. NAME OF PROBLEM - TWO-DIMENSIONAL FINITE-ELEMENT HYDRAULIC MODELING OF BRIDGE CROSSINGS

II. THE PROBLEM - Significant lateral velocities and significant lateral variations in stage are observed in wide flood plains characterized by rapid expansions or contractions, highly variable roughness, or variable topography. The weaknesses of one-dimensional models to describe the hydraulics of constrictions of such flood plains have been noted by numerous investigators. Two-dimensional models can provide information about transverse, as well as longitudinal, water-surface profiles, local velocities near bridge approach embankments, and the lateral flow distribution at a proposed bridge site.

Application of existing two-dimensional finite-element models which were developed primarily as research, not operational tools, to such bridge crossings (for example, the application of the model RMA-2 to the Congaree River) have revealed numerous deficiencies in these models.

III. OBJECTIVES - The objective is to develop an improved two-dimensional finite-element surface-water model for the analysis of complex flood plain bridge sites. The following components of finite-element models need to be tested in a variety of hypothetical and field situations and compared on the basis of stability, accuracy, and economy:

(1) automatic grid renumbering techniques;
(2) element types;
(3) methods of numerical integration;
(4) methods for solving large, sparse, banded matrix equations;
(5) boundary conditions;
(6) roughness coefficients and eddy viscosities.

These components of finite-element models need to be tested in situations that incorporate the particular difficulties arising in flood plain modeling, such as large ground-surface gradients and discontinuities in roughness.

The anticipated result of the research is a stable, accurate, economical two-dimensional model, which can be used by the field engineer in bridge design for wide, complex flood plains.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has not been scanned in preparing this statement.

B. Suggested key words for this problem: finite-element model, bridge site, flood plain model.

C. Several two-dimensional finite-element models, developed as research tools, are available. No attempt has been made to develop a model well-suited to the particular problems of modeling river-flood plain systems.

V. URGENCY - Several current bridge site studies of wide, complex flood plains using the two-dimensional model RMA-2 indicate the need for a two-dimensional model that can be applied by the design engineer to analyze proposed crossings. These studies have also revealed deficiencies in currently available models. The proposed research will develop a tool better suited for such modeling efforts.

PROBLEM NO. 3

I. NAME OF PROBLEM - LONG SPAN CULVERT HYDRAULICS

II. THE PROBLEM - National emphasis on highway safety, bridge replacement, environmental protection and economics have generated an increasing interest in the use of large structural plate corrugated metal structures for highway drainage at stream crossings. The metal pipe industry has responded to these needs and are actively promoting the use of a wide range of sizes and shapes of "long span" structures which are often an alternative to special design and standard bridges.

The size, shape, end treatment and corrugation configurations available from various suppliers offer the designer an array of alternatives; however, only a limited effort has been expended to develop hydraulic analysis and design techniques similar to that available for conventional culvert and bridge design.

III. OBJECTIVES - To expand and/or develop criteria and procedures with design aids to be used for the hydraulic analysis and design of long span corrugated metal structures. This development will include appropriate entrance loss coefficients for various shapes and end treatment designs required by the various structures. Confirmation of friction losses within the barrel where arch structures are utilized with the natural stream bottom should be included in the development process.

The use of step backwater computations appears to be the best approach for establishing the tailwater-headwater relationship for structures of this type; however, present methods of evaluating the various entrance friction and exist losses are not readily adaptable to the water-surface profile computational process.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has not been scanned in preparing this statement.

B. Suggested key words for this problem: long span culverts, hydraulic design, culvert hydraulics.

C. Related research activities: In January 1974 the Federal Highway Administration's Office of Engineering Bridge Division Hydraulics Branch developed a Preliminary Draft of a publication titled "Hydraulic Design of Large Structural Plate Corrugated Metal Culverts."

The information utilized to develop the draft was largely empirical and based on knowledge and experience gained from research for conventional culvert design.

The published draft did not address the hydraulic design of arch structures, which are more environmentally acceptable, and the various design considerations relative to end treatment.

V. URGENCY - Present emphasis on bridge replacement, economics and hydraulic efficiency relative to flood plain management and flood risk require a thorough investigation and documentation of the design for stream crossings.

The analysis and design techniques being utilized should be confirmed and/or improved as necessary in order to assure that the long span culvert will function hydraulically as designed.

PROBLEM NO. 4

I. NAME OF PROBLEM - EFFECT OF VERY HEAVY SEDIMENT LOADS ON FLOW CHARACTERISTICS

II. THE PROBLEM - Intense storms in arid regions can cause floods in watersheds that are normally dry. Many of these watersheds have beds of loose material composed of silt, sand and rocks that are readily picked up by the flowing water. This creates a fluid mixture that moves down the water course.

Conventional flow analysis such as use of the manning equation does not take into account any change in the density or viscosity of this fluid mixture. The normal calculations made such as estimates of velocity, discharge, Froude Number, etc may not be valid if the manning is modified by a change in the fluid density or viscosity. Determinations of flow relative to critical flow are also suspect under these conditions.

Can conventional backwater calculations and manning equation calculations be used when the fluid density and/or viscosity changes?

III. OBJECTIVES - The objective of this research study is to determine the effect of heavy sediment loads on flow characteristics. Estimates of scour potential, slope protection needs, channel capacity, conveyance and hydraulic jump potential are all common hydraulic design problems that are complicated when the fluid no longer acts as clear water.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has not been scanned in preparing this statement.

B. Suggested key words for this problem: sedimentation, flash floods, arid region hydraulics.

V. URGENCY - The problem of insufficient knowledge of how to design for water that may have significant distorted characteristics has been known for some time. Development of more knowledge in this area is needed.

PROBLEM NO. 5

I. NAME OF PROBLEM - METHODS FOR PREVENTING BRIDGE DAMAGE CAUSED BY FLOATING DEBRIS

II. THE PROBLEM - Lodging of debris at bridges is one of the primary causes of bridge failure or need for high maintenance efforts. The types of floating debris causing bridge damage are drift, such as brush and logs, and ice.

Presence of floating debris at a bridge may cause a flow constriction with increased potential for high flow velocities and subsequent scour, impact damage, and lateral displacement of the structure.

Present methods for controlling floating debris include the design of streamlined

pier shapes, increased bridge clearance, physical removal of debris and drift arrestors placed in the stream near the bridge.

III. OBJECTIVES - The objective is to determine the best methods for preventing bridge damage caused by floating debris. The various methods may be categorized as debris prevention, passage improvement and physical removal of debris at the bridge. Specific objectives include:

A. The classification of streams or areas to determine the problem severity and probable type of floating debris.

B. Survey of methods presently used to prevent damage by debris.

C. Effectiveness of methods now in use.

D. Recommendations for new techniques to prevent drift problems.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 22 and 25 have not been scanned in preparing this statement.

B. Suggested key words for this problem: floating debris, bridges, damage prevention.

C. Related research activities: not known.

PROBLEM NO. 6

I. NAME OF PROBLEM - EFFECTS OF INSTREAM MINING ON CHANNEL STABILITY

II. THE PROBLEM - Instream mining activities frequently cause unstable channel conditions and related damage to highway embankments and bridges. Documentation of the actual effects of instream mining and the analysis of hydraulic, geologic and water quality factors associated with resultant channel instability are lacking.

There are many situations where the effect of instream mining activities is becoming more significant on good aggregate-producing channels located near metropolitan areas. Problems associated with instream mining are considered continuous in time as the channel has little opportunity to reach stable conditions.

III. OBJECTIVES - The objective is to document a variety of streams affected by instream mining as a means of determining the significant hydraulic and geologic factors associated with unstable channel conditions. Specific objectives include a survey to determine the extent of the problem, evaluation of factors associated with channel instability and recommended methods to prevent or control channel instability.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has not been scanned in preparing this statement.

B. Instream mining, channel stability.

C. Related research activities: not known.

PROBLEM NO. 7

I. NAME OF PROBLEM - BEHAVIOR OF SUPERCRITICAL SEDIMENT-TRANSPORTING FLOW

II. THE PROBLEM - Streams in which the flow is supercritical probably behave entirely different from the more common subcritical river. There is evidence that culverts can be completely clogged and that deposition may occur at bridges instead of the usual expected scour. However, the flow probably becomes extremely unstable and scour may follow deposition.

III. OBJECTIVES - The objective would be better design of drainage structures for this condition, or, at least, an understanding of what happens, the development of a means for predicting what happens and, therefore, the ability to anticipate and allow for what happens. Preliminary analysis of the problem indicates that little or no obstruction can be tolerated, and this might not be feasible for the highway drainage structure. A different kind of design may be necessary.

IV. CURRENT ACTIVITIES

A. This behavior does not seem to have been recognized previously.

B. Suggested key words for this problem: drainage structures, river behavior, supercritical flow, deposition and scour.

V. URGENCY - This situation is probably more common than generally realized. Conventional design may accommodate what happens in spite of itself, but highway drainage structures are supposed to handle the 50- or 100-year flood--and maybe should be designed for even rarer, and larger, floods. A laboratory study would be needed and might be quite difficult to perform because of the instability of the situation.

A. General estimate of cost to accomplish: $100,000 (or more).

PROBLEM NO. 8

I. NAME OF PROBLEM - FLOW OVER EMBANKMENTS AND GUIDELINES FOR EMBANKMENT PROTECTION

II. THE PROBLEM - The problem can be divided into two parts - the hydraulic part and the erosion part.

A. The Hydraulic Problem - There is a need to develop better bridge routines for existing computer programs being used to compute stream profiles. Computer programs developed by USGS and the Corps of Engineers are widely used for backwater computation and for flood plain boundary delineations. The programs are deficient, however, in algorithms that compute flow through bridges and over embankments. There is a need to experimentally determine how the flow redistributes when it

can flow over the embankment and through the bridge opening.

B. The Erosion Problem - Highway stream crossings are frequently designed so that the embankments are overtopped under some flood conditions. A risk analysis model has been developed to rationally determine what flood conditions should be allowed to overtop an embankment. One of the weak links in the model, however, is the inability to estimate the maintenance costs that will result from scour when overtopping occurs.

Furthermore, the Federal Aid Highway Program Manual states that "all highways . . . shall be designed to permit conveyance of the basic flood (100-year flood) without causing significant damage to the highway, . . .". The problem then is one of establishing guidelines for safeguarding embankments against "significant damage" when overtopping does occur.

III. OBJECTIVES

A. Develop an improved routine for estimating distribution of flow through bridge openings when overtopping occurs.

B. Establish prediction methods for estimating damage related to embankment erosion when no special embankment protection is provided.

C. Establish guidelines for use of protection such as sod, fiberglass, filter cloth, nylon, riprap and flexible pavements on embankments.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress has not yet been scanned for this problem.

B. Suggested key words for this problem: embankment erosion, embankment protection, scour, spillway protection, spillway design, flooding, flood risk analysis.

C. Related research activities:

1. A recent research study of flood risk analysis for design of bridge waterways included a thorough literature review of embankment erosion, but the literature review did not reveal satisfactory methods for predicting highway embankment erosion during overtopping.

2. There are a number of embankment erosion studies that have very limited applicability to this problem because they deal with sheet erosion whereas this problem is more analogous to the erosion that might take place during the overflow of a dam.

3. The Ohio DOT is planning a controlled discharge evaluation of temporary linings in drainage ditches. This study should have some results that will apply to this problem since embankment erosion tends to start as a ditch where overflow concentrates.

V. URGENCY - During the period 1953 to 1973 an average of more than 1000 bridges were built over water per year on the Federal Aid System alone. During approximately the same period 43% of the bridge failures were characterized by washed out approach embankments according to a very limited analysis of FHWA emergency relief files. The large number of bridges that have been built (many of which will be replaced under the bridge replacement program) and the frequency that the embankment is the failure mode is evidence of the urgency for research in this area.

PROBLEM NO. 9

I. NAME OF PROBLEM - DESIGN OF LARGE DETENTION BASINS AND APPURTENANCES

II. THE PROBLEM - Large detention basins, both permanent and temporary, are increasingly being specified for entrapment of floatable and settleable constituents of runoff from highway and non-highway rights-of-way prior to discharge into lakes and streams. There is no rational method available to the designer to estimate efficiency of constituent removal relative to size of basin. In addition information is needed regarding estimating frequency of clean out, design of outlet structures, provisions for maintenance draw down, design of overflow sections, aesthetic and multiple use considerations, methods of predicting quantity and nature of inflow constituents, and skimming methods.

III. OBJECTIVES - To develop a design manual on permanent and temporary detention basin design for transportation facilities. The manual would provide comprehensive guidelines, criteria and recommendations regarding all facets of detention basin design, construction and maintenance considerations. A nationwide review of experience with use of basins should be conducted.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has not been scanned in preparing this statement.

B. Suggested key words for this problem: sediment basins, design manual, water quality, detention basins, spillway design, outlet structures, skimming.

C. Related research activities: NCHRP study on erosion control features; USGS study in North Carolina; HPR studies, Pennsylvania, Milwaukee, Florida.

V. URGENCY - Federal and State laws, rules and regulations have been promulgated that mandate measures to mitigate environmental damage caused by storm water runoff. Detention of runoff appears at this time to be the most cost-effective method available. A design manual is urgently needed in order that use of basins proceeds on a rational basis.

PROBLEM NO. 10

I. NAME OF PROBLEM - SCOUR AT BRIDGES

II. THE PROBLEM - Considerable effort in manpower and money has been spent on the problem of scour at bridges. The problems have been studied using fluid flow theory, laboratory model studies, field data collection programs, empirical correlation of laboratory and field data and field observations resulting in rules-of-thumb. Scour and the effects of scour can still not be quantified with any degree of certainty. This uncertainty is costly not only in bridges lost to scour but in those needlessly (but unknowingly) overdesigned. The location and design of river training works and countermeasures to protect bridge piers and abutments is an empirical process. Furthermore laboratory model studies have been conducted using sand bed channels only. As a result knowledge of scour in other types or mixed bed materials is lacking.

This research has been beneficial however for a lot has been learned about scour. For example local scour depth increases as pier size increases for a given flow. Local scour increases with velocity up to a point. Contraction scour depth increases as the width of the constriction decreases. There are four types of scour; local, contraction, lateral channel migration and general scour. These scour types interact even though they have most often been isolated for study. Their net effect is often considered to be additive.

Recent research has focused on the collection of field data to validate the available formulas. However there were major logistical problems, costly instrumentation packages and difficult data interpretation problems. Much has been learned from these efforts about collecting field scour data, but little usable data have been obtained.

Most researchers have recognized the scour mechanisms, that is, the vortex system at piers and abutments and the contracted streamlines in constrictions. Both mechanisms result in shear stresses at the bed sufficient to erode the bed material. The mechanisms have been studied separately (for example Liu, Brandley and Plate, 1957; Shen, et al, 1969; Schneider, 1968) to simplify the problem, but this previous work is not conclusive. Since flow in the vicinity of the bridge is three-dimensional, further investigations making one- or two-dimensional approximations may not be productive.

III. OBJECTIVES - Several objectives come to mind.

A. Reduce risk and cost in designing new bridges by making more knowledge about scour available.

B. Provide for more efficient countermeasures.

C. Evaluate current design practice to reduce backwater and increase capacity.

The specific objective is to quantify the mechanics of scour in order to learn how the four types of scour interact and how to extrapolate laboratory data to field. This research could be conducted in two ways. Measurement of velocity distribution, bed shear stress, strengths and transport capabilities of the vortex systems and other data as required should be related to constriction ratio, abutment and pier geometries. The measured stresses can then be related to the erodibility of soil other than sand. The shedding characteristics of the vortex systems may be related to the design of riprap as a countermeasure. Shen and Schneider (1970) found that the horseshoe vortex system at a pier could be contained harmlessly at the pier by attaching a trough-like structure to the pier.

In addition a mathematical model which considers the three-dimensional nature of the flow through the constriction should be developed. The laboratory data would be valuable in this effort. Because of the complexity of the problem and the potential computer storage requirements certain cross sections or locations of maximum shear may have to be identified in lieu of a model of the complete flow field.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 22 and 25 have not been scanned in preparing this statement.

B. Suggested key words for this problem: bridge scour, stream erosion.

C. References:

1. Liu, H. K., Brandley, J. N., and Plate, E. J., "Backwater Effects of Piers and Abutments," Colo. St. Univ., Civil Engrg. Section Report No. CER57HKL10, 364 p, 1957.

2. Schneider, V. R., "Mechanics of Local Scour," Ph.D Dissertation, Colorado State Univ., Fort Collins, Colo., 1968.

3. Shen, H. W., Schneider, V. R., and Karaki, S., "Local Scour Around Bridge Piers," Am. Soc. Civil Engineers Proc., Journal of Hydraulics Division, V. 95, No. HY6, pp 1919-1940, 1969.

4. Shen, H. W., and Schneider, V. R., "Effect of Bridge Pier Shape on Local Scour," Preprint Paper No. 1238, Presented to the ASCE Natl. Mtg. on Trans. Eng., Boston, Mass., July 15-17, 1970, 10 p, 1970.

V. URGENCY - This study of scour would result in quantifying the mechanisms of scour. The resulting mathematical model could be used not only to develop design criteria to predict scour but to devise rational methods to reduce and prevent scour and to increase bridge capacity.

PROBLEM NO. 11

I. NAME OF PROBLEM - IMPLEMENTING IMPROVED INLET TECHNOLOGY FOR CULVERTS

II. THE PROBLEM - In spite of considerable research effort to identify and disseminate improved culvert inlet technology there is a national reluctance to implement this new technology. It is believed this reluctance is based in part on inadequate computer

technology, concerns over sediment transport and lack of national industry standards.

III. OBJECTIVES - The objective is to fully identify the reasons for delays in implementing the completed research and then correct the deficiencies through additional research and implementation. In general this is anticipated to consist of:

A. Conduct a national, in-depth inventory of the problems encountered in implementing the completed research and any reasons implementation was not attempted. Identify and evaluate existing computer systems for use with improved inlet culverts. Inventory and evaluate existing industry standards for improved inlets on commercial culverts.

B. Develop a reasonable technology for sediment transport into and through improved inlet culverts so as to preclude sediment from blocking the culvert; incorporate this technology into a computer system for use as a module on existing computer systems.

C. Develop a national industry standard compatible with hydraulics and any existing industry standards.

D. Determine and resolve any other reasons causing delay in implementing the completed research.

E. Develop and distribute an acceptable computer system containing both standard and improved culverts that recognizes the needs of the transportation industry. An advisory panel comprising various users is recommended for this effort.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: culvert, hydraulics, improved, inlet, sediment, standard, systems, computer.

C. Some effort has been made by the FHWA to provide a computer system to design improved inlets, however, this system tends to provide too many design alternatives and excludes consideration of sediment problems and hydrograph routing techniques. The Wyoming Highway Department has completed a culvert system that routes hydrographs through conventional culverts but ignores sediment transport problems and improved inlets. The Corps of Engineers and others have developed computer technology directed at sediment transport in channels (HEC-6) and deposition in large reservoirs which may be analogous to upstream sediment problems encountered by culverts serving transportation systems.

V. URGENCY - The significant savings to be realized by the extensive research completed to date and expensive implementation efforts continue to be unrealized. The forgoing research effort could be accomplished quickly and at a relatively modest cost thereby placing this effort in the immediate need category.

PROBLEM NO. 12

I. NAME OF PROBLEM - GUIDELINES FOR THE USE OF GABIONS

II. THE PROBLEM - Gabions have enjoyed considerable usage in the past. However occasional failures and related problems have caused economic hardships and have diminished gabion use for satisfactory applications. Failures of gabions have resulted from structural, stability, abrasion, corrosion and vandalism problems.

III. OBJECTIVES - To develop guidelines for the design and installation of gabions. Both structural and revetment applications would be included. Emphasis would be on present practice and case histories, rather than theory.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 25 and 62 have not been scanned in preparing this statement.

B. Suggested key words for this problem: gabions, slope mattress, revetment, wire enclosed riprap, retaining structures, erosion control, bank and shore protection.

C. Numerous manuals by manufacturers and governmental agencies have been published. Limitations of applications are poorly defined.

V. URGENCY - Gabions appear to be a viable alternative to riprap, rigid linings, concrete retaining walls and other concrete structures. They are frequently more economical and provide the needed flexibility to withstand any movement of the underlying material. However some engineers are not taking advantage of gabions because they are uncertain of the gabion's capabilities; others are continuing to over extend the gabion's capabilities.

PROBLEM NO. 13

I. NAME OF PROBLEM - A RATIONAL APPROACH TO HYDRAULIC DESIGNS FOR HIGHWAY ENCROACHMENTS ON FLOOD PLAINS

II. THE PROBLEM - Conventional practice in the hydraulic design of highway encroachments on flood plains is to provide for conveyance, with little damage, of the peak discharge of a flood of a selected recurrence interval. Consideration is not usually given to uncertainties in the estimate of the flood peak or to the probability or chance that the design flood will be exceeded. A rational approach is needed for selection of the design flood frequency based on risk and economics.

III. OBJECTIVES - To develop criteria and procedures for incremental cost analysis and decision-making in the selection of design flood frequency for highway flood plain encroachments. The procedure would recognize

the probability that the base design flood will be exceeded during the life of the highway, include techniques for arriving at an optimum design insofar as capital costs and deferred costs are concerned and provide guidance for decision-making in view of budgetary constraints, both for capital investments and deferred costs.

The criteria for the selection of a base flood frequency for the design of a route or route segment would be based on traffic service considerations. The base flood frequency would be dependent upon the availability of alternate routes, the importance of the route or route segment to commerce or national defense, traffic volumes, the need for the route for emergency supply or evacuation in case of a natural disaster and other factors.

The procedure for the design of each encroachment would include an analysis of the risk to life and property, including both the risk of damage to the highway and damage to other property as it would be affected by the presence of the highway; total cost of the highway encroachment, including capital costs for construction and deferred costs for maintenance, repair and reconstruction and for liability to others for damages caused by the highway; costs of traffic interruption; and other factors. It should also provide guidance for decision-making in recognition of budgetary constraints both for capital investment and deferred costs. Inherent in this are methods for evaluating the present worth of probable future costs from floods larger than the design flood and techniques to minimize or mitigate damages caused by the highway from such floods, as by flow over the highway.

The procedure would include consideration of flow duration as well as flood peak in assessing the risk of flood losses.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: design flood, flood plain encroachments, risk, capital cost, deferred costs, hydraulic designs.

C. Related research activities: FHWA Contract research with Water Resources Engineers, Flood Risk Factor in the Design of Box Culverts and Bridges.

V. URGENCY - The Federal Highway Administration annual budget for emergency repair and reconstruction damages to highways on the Federal aid system from natural disasters is $100 million. The States and local jurisdictions undoubtedly spend a like amount for the repair and reconstruction of roads damaged by events which are not widespread enough to be declared an emergency. An additional $40 million is expended annually by the Office of Emergency Preparedness for repair and reconstruction of off-system (non-Federal aid) roads and streets. Much of the costs incurred by local governments for emergency repairs are disallowed by OEP, so the actual costs are much higher than $40 million annually. In addition to these costs courts have held highway agencies liable for flood damages and these costs are not accounted for in the above recital. The bulk of the FHWA $100 million ER funds is expended for flood damage repairs. The $40 million from OEP is for flood damage repair.

In view of annual expenditures nationally on the order of $200 million + for flood damage repairs it is appropriate to take a hard look at design criteria and procedures and to develop procedures for optimizing designs based on the total cost of construction and maintenance.

PROBLEM NO. 14

I. NAME OF PROBLEM - TEST AND EVALUATION OF INVERTED SIPHONS FOR SANITARY, COMBINED AND/OR STORM SEWERS

II. THE PROBLEM - The construction of expressways and subways in urban areas usually necessitates numerous adjustments in existing sanitary, combined and/or storm sewers. While this can sometimes be accomplished by rerouting, occasionally the only alternative is to siphon the sewer beneath the expressway but no thorough evaluation of the performance of inverted siphons has been made. There is a distinct need for good information on design procedures and design details which have proved to be successful.

III. OBJECTIVES

A. To make a state-of-the-art study and define the nature and extent of the problem.

B. To select one or more existing installations for intensive observation.

C. To analyze performance of such installation(s) according to best theory available, including comparison of design and solids transport capacity with actual performance under carefully recorded conditions.

D. To develop a design manual on inverted siphons for sanitary, combined and/or storm sewers specifically related to the types of problems covered by the study.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 22 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: siphons, sewer, inverted siphons, solids transport, combined sewers, sanitary sewers, storm sewers.

C. Related research activities: none known to be ongoing.

V. URGENCY - This study could range from a compilation of design details of a single installation and evaluation of its performance to a comprehensive investigation of many installations. The extent to which good records are available on performance of existing installations will determine the amount of effort required. The short-range objective is to provide information for use by designers

confronted with the problems of getting a sewer line past a new expressway or subway which cuts through its path. The intent is to direct the effort at the situation where an existing line must be disturbed rather than the one where a new sewer line is being designed. In the latter case the head losses and deposition problems inevitably involved with the siphon can be taken into account, whereas for the existing line such losses were not contemplated and therefore their effect on the overall capacity of the line must be calculated.

PROBLEM NO. 15

I. NAME OF PROBLEM - RIVER TRAINING WORKS AS RELATED TO HIGHWAYS

II. THE PROBLEM - The highway engineer is often confronted with the problem of stabilizing channels at highway stream crossings. The task may involve training works associated with either a channel relocation or control of channel shifting and bank erosion. Most river training installations are expensive and many have failed to accomplish desired results. A need exists for information on this subject compiled for ready use by highway engineers. Case histories, design methods and details, costs and materials relating to prediction and control of river meanders and undesirable channel shifting should be studied and presented in a form useful to the highway designer.

III. OBJECTIVES - To prepare a state-of-the-art report on river training works with specific application to the highway river crossing problem. The study and statement should be done with full understanding of river mechanics and alluvial streams.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: river training, channel stabilization, river meanders, alluvial streams.

C. Related research activities: none known to be ongoing.

V. URGENCY - Failure to recognize the need for training works at highway river crossings can result in costly structural failures, some often occurring during or shortly after completion of construction. Guidelines are needed for design and for implementing the hydraulic aspects of the national bridge inspection program.

PROBLEM NO. 16

I. NAME OF PROBLEM - EROSION RESISTANCE OF NEW GRASSES USED IN HIGHWAY DRAINAGE CHANNEL

II. THE PROBLEM - The U.S. Department of Agriculture has performed tests on various grass covers to determine their hydraulic retardance and resistance to erosion and has published the results, mainly during the 1950's. Since that time new types of vegetation such as Crown Vetch and Bahia have come into general use as ground covers and erosion control. New hydraulic and erosion control data are needed on these new types of vegetal cover.

III. OBJECTIVES - To determine the hydraulic retardance and erosion resistance of new grasses and vegetal cover being used along the highway right-of-way. Perform tests similar to those used by the Agriculture Research Service at Stillwater, Oklahoma, using both permissible velocity and tractive force theory. Quality of cover as influenced by climatic and agronomic considerations should be an important variable in this study.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 22 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: vegetation, retardance, erosion, resistance.

C. Related research activities: SCS publication, "Handbook of Channel Design for Soil and Water Conservation"; Mississippi State University tests on sodded channels.

V. URGENCY - New channel design methods presently being developed utilize vegetation as one type of lining. In many instances vegetation is the best lining choice since it retards flow, is self healing and allows infiltration. However design information is not available for many of the grasses being widely used on highways. Proper design and construction of such grass lined channels has the potential of saving many maintenance dollars, and serious safety hazards and esthetic problems can be avoided.

PROBLEM NO. 17

I. NAME OF PROBLEM - ENERGY DISSIPATION AT CULVERT OUTLETS AND STORM DRAIN OUTLETS

II. THE PROBLEM - There is an urgent need to develop criteria for the design and use of simple, practical, economical stilling devices for dissipating the energy of the flow from culverts and storm drain outlets, up to 144-inch diameter or equivalent size. Damaging erosion of drainage channels often results from discharge of high velocity flow from the outlets of culverts and storm drains. Energy dissipators can be effective in reducing the velocity of flow from culverts to a degree that damage to the channel and channel bank will not undermine the culvert or endanger the highway embankment.

III. OBJECTIVES

A. To develop criteria which will provide the designer with a basis for selecting the type of energy dissipator most suited to the conditions.

B. There are several complex types of energy dissipators suitable for the more costly

applications such as for reclamation, flood control or the larger highway drainage structures. For most highway drainage systems, consisting of commercial culverts or storm drains, simpler, more effective and economical devices, including prefabricated modular types, are urgently needed.

C. Designs should be applicable to pipe or box culverts of all shapes operating over a wide range of discharge rates and relations of velocity head to depth of flow at the outlet.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: energy dissipators, stilling basins.

C. Related research activities: no known ongoing research in this area.

V. URGENCY - Inadequate outlet designs result in added maintenance or need for subsequent drainage and erosion control facility replacements and improvements. There is also recurring loss due to overdesigns where the design principles are not clearly established for erosion control structures. Erosion at culvert and storm design outlets is a perennial problem; better guidance and design will help to reduce construction and maintenance costs and enhance safety and esthetics in accord with good engineering practice.

PROBLEM NO. 18

I. NAME OF PROBLEM - TEST AND EVALUATION OF EXPRESSWAY DRAINAGE DESIGN

II. THE PROBLEM - A number of expressway storm drainage systems in Chicago have been designed by the principles outlined in a paper by Tholin and Kiefer, "Transactions," American Society of Civil Engineers, 1960. This is an advanced method of design but it has been used very little, if at all, outside of the Chicago area. The validity of the method should be evaluated.

III. OBJECTIVES

A. To measure the performance of the surface drainage system on selected portions of expressway in the Chicago area under actual storm conditions, measurements to include (1) continuous recording of rainfall over entire drainage area and (2) continuous recording of runoff on subunits of storm drain system for which rates of flow had been computed in the design process.

B. To compute runoff for the observed storms using equations from the design process.

C. To analyze computed vs. observed performance of subunits and of entire watershed.

D. To evaluate the validity of the design method and compare with other computer simulation models such as the EPA model.

E. To recommend improvements in the design method arising from analysis of performance.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: storm sewers, "Chicago" method, hydrograph method.

C. Related research activities: FHWA sponsored research inlet hydrographs at Utah State University.

V. URGENCY - This study is deliberately limited to evaluation of drainage design on expressways by the "Chicago" method. All of the major expressways constructed in Chicago since 1948 have been designed by this method. Evaluation of the method by investigation of the performance of systems so designed would open the way to wider use of the method. The engineer working with urban drainage problems is in urgent need of a more reliable means of designing storm sewers. Verification and/or improvement of the "Chicago" method and adaptation to use elsewhere would be a major advance in storm sewer design procedures.

PROBLEM NO. 19

I. NAME OF PROBLEM - SPUR DIKES AT BRIDGE ABUTMENTS

II. THE PROBLEM - Many highway crossings of major streams have long approach fills on the flood plain to reduce structure costs. These fills block the passage of overbank flow and divert flood plain flow to a bridge opening. Eddies, formed when lateral flow from the flood plain mixes with main channel flow, cause scour at bridge abutments and at adjacent piers and reduce the effectiveness of part of the bridge opening. Spur dikes, projecting upstream from bridge abutments, have been effective in preventing serious problems at these locations, but research data are needed to develop criteria for the design of the spur dikes. Downstream dikes or trailing dikes are sometimes needed to prevent scour by redistribution of flow in the flood plains.

Although existing research data and field observations of existing dikes have been very helpful in the design of spur dikes, additional research information is needed to improve designs and to give engineers more confidence in their performance. Needed research on these structures consists of two parts which can be programmed concurrently. Part one includes extensive laboratory testing of various types and shapes of dikes in both fixed and movable bed models. Part two consists of field observations and measurements of flood conditions at existing dikes.

III. OBJECTIVES

A. To expand present data so that adequate criteria can be developed for the design of spur dikes taking into account various

types, shapes and orientation, flow distribution, bridge opening and vegetal cover.

B. To analyze and evaluate performance of prototype installations in the field during and following flood flow.

C. To define where trailing dikes are needed to inhibit scour at the downstream toe of the abutment fill.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress area 22 has been scanned in preparing this statement.

B. Suggested key words for this problem: spur dikes, bridge abutments.

C. Related research activities: None known to be ongoing.

V. URGENCY - Good design criteria and additional field observations of existing dikes will encourage a wider and better use of these structures. It is estimated that the use of spur dikes in conjunction with new bridge construction and remedial work on existing bridges could approach savings of $3 million annually.

WATER QUALITY

PROBLEM NO. 1

I. NAME OF PROBLEM - EFFECTIVENESS OF TEMPORARY EROSION CONTROL METHODS

II. THE PROBLEM - There has been an increasing emphasis over the past several years on the prevention of water pollution due to highway construction and operation. One of the pollutants of concern is sediment. Probably the greatest emphasis to date has been directed at sediment since the damaging effects of erosion on the highway are readily visible and the concentration of sediment in runoff is higher than that of other pollutants.

The highway system is most vulnerable to erosion damage and sediment runoff during the construction period; thus there have been numerous publications advocating various temporary erosion control measures. In general these measures are to remain in place until vegetation is established or other permanent controls are installed; then they are removed or biodegraded.

While many different temporary erosion control measures have been advocated, few have been evaluated. Most are not designed, but are improvised based on field experience. It appears that some measures may not work, or may create more problems than they solve. Failures of several of the commonly suggested methods are often observed on highway projects.

III. OBJECTIVES - To evaluate the temporary erosion control methods commonly proposed by means of laboratory or field studies in order to determine their efficiency, practicality, ease of construction and durability; and to develop guidelines for the design, construction and maintenance of those measures proven to be effective.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 17 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: water pollution control, erosion, temporary erosion control.

C. Related research activities: EPA has developed, under contract, several recent reports dealing with temporary erosion control methods. Most involve gross estimates of efficiency. A new NCHRP research study has just been initiated on the effectiveness of erosion control methods for roadside development.

V. URGENCY - There is a pressing need to evaluate the performance of the temporary erosion control methods currently being promulgated. If they do not perform as well as expected, their continued use may result in undue sediment pollution of natural waterways and damage to the highway. In fact they may act as placebos curing nothing but providing a false sense of security

PROBLEM NO. 2

I. NAME OF PROBLEM - TOLERABLE TEMPORARY VARIANCES IN WATER QUALITY STANDARDS RELATED TO TOTAL SUSPENDED SOLIDS AND TURBIDITY AS CAUSED BY TRANSPORTATION CONSTRUCTION PROJECTS

II. THE PROBLEM - In the course of constructing transportation facilities it becomes necessary to work in and around streams. This work by necessity will cause a temporary increase in the total sediment discharge and turbidity. Many streams provide a water resource of varying values and susceptibility to damage from such modified sediment regimes. Current water quality standards are based on permanent sediment regime changes in water quality with little flexibility for relatively brief and temporary increases due to construction practices. In order to justify efforts to modify existing water quality standards it becomes necessary to quantify the impact on the water resource of these temporary changes in the sediment regime.

III. OBJECTIVES - The objectives of this research would be national in scope and consist of the following objectives. Quantification identified below should attempt to include such details as sediment concentrations, gradations, particle angularity, sediment nature or origin, duration of change in sediment regime, magnitude of changes in sediment regime and the resulting impact on downstream aquatic biota.

A. A case history of common transportation construction projects completed in the past twenty years should be undertaken to determine if:

1. the sediment discharges have returned to normal, and

2. the temporary increase in sediment discharge occurring during construction resulted in a permanent degradation of the Nation's water resource.

B. Quantifying the tolerance of key aquatic organisms to temporary increases in sediment discharge and turbidity. Research may be necessary to complete the work accomplished to date.

C. Quantifying the acceptable limits of temporary changes in the sediment regime on agricultural, municipal, recreational and industrial uses.

D. Determining seasonal effects of temporary changes in the sediment regime.

E. Well documented case history measurements over time are then needed to verify the research finding (before/during/after construction).

F. Research should include suggested draft revisions to existing federal water quality regulations based on the research findings.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 17 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: water, quality, sediment, temporary, impacts, construction, variances, turbidity.

C. Some completed research regarding the effects of sediment on fisheries, industry, agriculture, recreation and municipal standards for permanent sediment standards are known. However the permanent environmental effect of temporary increases in the sediment discharge is not well defined.

V. URGENCY - There are intensive research efforts that are national in scope being directed at preventing or mitigating temporary increases in sediment discharge arising from construction projects. Additional resources are being directed at designing and constructing facilities to control these temporary increases in the sediment discharges. The forgoing continues to occur without knowledge as to whether temporary increases in sediment discharges from construction projects are permanently degrading the receiving waters.

Regulatory agencies continue to be inflexible about not exceeding water quality standards established for permanent quality levels resulting in delays for needed construction. These delays are costly both in money and loss of life due to untimely replacement of needed transportation facilities.

The forgoing places this research into the immediate need category.

PROBLEM NO. 3

I. NAME OF PROBLEM - NATURAL SYSTEMS TO TREAT HIGHWAY RUNOFF

II. THE PROBLEM - Growing awareness of the potential for environmental damage from the construction and operation of highways and highway drainage systems has resulted in the need to identify and quantify the environmental effects and to develop measures for the protection of the total environment from any adverse effects. Rainfall along highways produces massive amounts of runoff which present significant problems of collection and treatment for contaminant removal by conventional methods. There is a need to develop and evaluate techniques for using the assimilative capacity of natural biological systems that are complementary to highway construction to abate objectionable constituents of highway runoff before discharge into receiving waters. The abatement methodologies must be capable of handling large and variable volumes of runoff in an economical and environmentally compatible manner. Resulting methodologies must be adaptable for application to a variety of site conditions including different soil types, vegetative covers and topographies.

III. OBJECTIVES - The objective is to determine the feasibility of using natural ecological systems to treat highway runoff so as to minimize contaminant loadings to receiving waters. All available information on the potentially feasible systems will be described. Experimentation will be conducted to fill critical information gaps and to develop criteria for establishing reliable abatement systems.

IV. CURRENT ACTIVITIES

A. Highway Research in FHWA FCP Project 3E has been scanned in preparing this statement.

B. Suggested key words for this problem: abatement/treatment, highway runoff, contaminants.

C. Many ongoing projects are monitoring, identifying and quantifying highway runoff constituents. The transport mechanisms of certain contaminants are being determined under Project 3E. The next step will be to develop methods of treating objectionable constituents of highway runoff. Results of related research being conducted by the Corps of Engineers and the Environmental Protection Agency on land treatment of wastewater and the management of leachates and runoff from land disposal of dredged and fill material may have potential application to this problem.

V. URGENCY - This research will develop state-of-the-art knowledge on the feasibility of utilizing natural biological systems to treat massive amounts of highway runoff and therefore is highly urgent. Discussions at the Federal Highway Administration sponsored annual research review of the Federally Coordinated Program of Research and Development in Highway Transportation at Columbus, Ohio on 8 November 1977 indicated that certain states (New Jersey and California) are currently interested in the potential of wetlands and marshes to treat highway runoff as well as the subsequent impact of highway

contaminants on these areas.

PROBLEM NO. 4

I. NAME OF PROBLEM - STRUCTURAL METHODS FOR REMOVAL OF CONSTITUENTS FROM HIGHWAY RUNOFF

II. THE PROBLEM - Much research work is being performed on methods of removing sediment from highway runoff. However it may become necessary, at least at some sites, to remove other constituents from the runoff.

Research is underway on the quality of highway runoff. If this work and other studies on the effects of the materials on plants and animals show that problems exist, it may become necessary to remove certain constituents from the runoff.

Preliminary work indicates that some constituents decay, some are absorbed to sediment and some are lost through ion exchange with soils. These characteristics may lead to some conclusions as to possible removal methods. For example it appears that sediment ponds may be an excellent method of removing contaminants other than sediment, while some oil skimmer designs may be completely unworkable.

III. OBJECTIVES - To derive practical methods of removing problem constituents from highway runoff before such runoff reaches watercourses.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 17 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: highway runoff, pollutants, pollutant removal.

C. Related research activities: FHWA and Washington SHD research on quality of highway runoff. NCHRP study on erosion control methods. Various EPA research studies.

V. URGENCY - If ongoing research defines certain pollutants in highway runoff as being harmful, there will be pressure to quickly derive means of treating the runoff. Some preliminary work along this line should be initiated as soon as possible, so that rash decisions to utilize unworkable treatment methods will not be made.

PROBLEM NO. 5

I. NAME OF PROBLEM - RESTORATION OF WETLANDS AS MITIGATION FOR ADVERSE IMPACTS RESULTING FROM THE CONSTRUCTION OF TRANSPORTATION FACILITIES

II. THE PROBLEM - The location and construction of transportation facilities through wetlands areas cannot always be avoided. Certain unavoidable loss of wetlands usually occurs where this situation does exist. Regulatory agencies are requiring replacement or restoration of wetlands as conditions to approval for permits to construct in such areas.

The transportation agency is often required to restore or replace wetlands without having the proper design criteria or technical guidance required to successfully implement restoration programs. Unsuccessful mitigation attempts by various transportation agencies have lent skepticism to the permit review process and have prevented reasonable "trade-offs" from being a legitimate approach to obtaining necessary environmental permits.

III. OBJECTIVES - Synthesis study and development of guidelines and design criteria for the reconstruction of certain typical wetlands such as marshes (both tidal and freshwater), swamps, submerged vegetation meadows, etc that may be successfully used in wetlands restoration. This would include the gathering of data to understand the physical and chemical requirements of various typical wetlands flora and experimentation in the form of demonstration projects to experimentally produce a variety of wetlands systems.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 17, 22 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: wetlands, fish and wildlife habitat, mitigation, marshes, swamps, restoration.

C. U.S. Corps of Engineers restoration experiments with dredge spoil, various university research activities on marsh and seagrass restoration.

V. URGENCY - The loss of wetlands in the United States has reached critical proportions due to construction and development. There is an urgent need to develop guidelines and criteria for restoration and creation of wetlands lost through construction of transportation facilities.

PROBLEM NO. 6

I. NAME OF PROBLEM - PREDICTIVE MODELING OF THE FATE OF HIGHWAY RUNOFF POLLUTANTS

II. THE PROBLEM - Research in recent years has indicated that numerous constituents transported by highway and street surface runoff may be a serious source of pollution to receiving surface waters. Considerable pressure is being applied to Transportation departments by Regulatory agencies to provide treatment of storm runoff waters on the transportation facility prior to any discharge into receiving waters. In most cases the treatment practices are required without benefit of design criteria for pollutant removal or the desired results of such treatment in terms of resulting impacts on downstream surface waters.

Considerable data now exists which would indicate the types and concentrations of pollutants that might normally be expected in highway surface runoff. There are no satisfactory mathematical tools available however that can predict the fate of these materials (salts, nutrients, heavy metals, etc) as they are transported to receiving waters or the ultimate fate and resultant impact of these materials upon receiving waters and associated aquatic biosystems.

III. OBJECTIVES - To develop a practical computerized predictive model to determine the ultimate concentrations of pollutants in highway and surface runoff that would affect receiving waters to be used as tool to design best treatment practices and determine the effectiveness or need of such practices in project design.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 17 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: highway runoff, pollutants, pollutant removal, storm runoff models.

C. Related research activities: FHWA and various state research on quality of highway runoff. EPA studies on urban runoff and predictive modeling.

V. URGENCY - Section 208 of PL 92-500 presently requires regional water quality management plans by the various states. Non-point sources of pollution (storm runoff) are included in the scope of 208 planning. Water pollution abatement practices by regulatory agencies now are being required on transportation projects often at alarming costs without benefit of any analysis of the need or effectiveness of such practices. Modeling tools are sorely needed so that a more responsible approach to project design can be realized.

PROBLEM NO. 7

I. NAME OF PROBLEM - METHODS OF UPGRADING SEWAGE EFFLUENTS

II. THE PROBLEM - The sewage effluent from many treatment plants will not meet the effluent limitation imposed under Public Law 92-500 or stringent water quality requirements required by the State. Most sewage treatment plants at rest areas are sewage lagoons or extended aeration package plants. These facilities only provide secondary treatment at the best and are upset by the wide fluctuations in loading that occur at a rest area. It is necessary to develop a method of sewage treatment or "treatment train" to meet the requirements.

III. OBJECTIVES

A. To develop a method of sewage treatment that will meet quality standards for new installations.

B. To develop methods of upgrading sewage effluents from lagoons.

C. To develop methods of upgrading sewage effluents from package plants.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 17 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: upgrading, sewage effluents.

C. Related research activities: The extent of research being conducted by other agencies or organizations is not known.

V. URGENCY - Spray irrigation of sewage effluents from safety rest areas appears to be an attractive method of meeting the 1983 effluent quality requirements established under Public Law 92-500. Design criteria must be developed or compiled from other research to determine the suitability of different soils, application rates, schedule of application and amount of storage required. It is urgent that these parameters be determined so that spray irrigation can be used as a possible tool for meeting the new effluent limitations.

PROBLEM NO. 8

I. NAME OF PROBLEM - EVALUATION OF SEPTIC TANK SYSTEM DESIGN

II. THE PROBLEM - Sewage effluent limitations established by Public Law 92-500 will require a greater degree of sewage treatment before effluents can be discharged to a receiving stream. Sewage treatment systems that do not discharge directly into a receiving stream have considerable merit. Since septic tank systems have an absorption field that absorbs the sewage, this method of treating sewage is of considerable interest. Unfortunately the record of septic tank systems for larger installations has been dismal. It would be advantageous to develop design criteria and procedures for using septic tank systems at large installations.

III. OBJECTIVES - To evaluate several septic tank systems that have been designed and constructed with current state-of-the-art knowledge.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 17 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: septic tank, absorption system.

C. Related research activities: It is beleived that there is no ongoing research in this area.

V. URGENCY - Septic tank systems can be useful tools for sewage treatment, particularly at remote locations; however their performance at larger installations has been poor. If the state-of-the-art design procedures can be verified so that an adequate service life is obtainable, septic tanks can be used at low volume rest areas if the proper soil conditions exist.

PROBLEM NO. 9

I. NAME OF PROBLEM - DESIGN CRITERIA FOR SAFETY REST AREAS

II. THE PROBLEM - There is an urgent need for the development of criteria for the design and

construction of safety rest areas. Design criteria must be developed to determine the number of parking spaces required, number of toilet facilities, water consumption, quantity and constituents of the sewage produced and the amount of solid wastes produced. The relationship between these usages and the design ADT must be determined for the various conditions that affect rest area usage.

III. OBJECTIVES

A. To develop criteria that will enable the designer to estimate the number of cars and people that will use a particular rest area site.

B. To develop criteria that will enable the architect to determine the number of toilet facilities required.

C. To develop criteria that will enable the designer to determine the amount of solid waste produced, water consumption and the quantity and constituents of the sewage produced.

D. To develop criteria that will enable the designer to evaluate the various factors (geographical area, distance from last rest area, adjacent service facilities, etc) that affect rest area usage.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 17 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: design criteria, water supply, sewage treatment.

C. Related research activities: FHWA Office of Research and Development Project 3-E1. Improved Design Criteria for Roadside Rest Areas provides ongoing research in this area.

V. URGENCY - Design criteria are needed for the rational design of water supply and sewage treatment facilities at safety rest areas. Several large rest areas have been undersized for water supply either by selecting an improper and inefficient system or underestimating its use. The need for rest areas is becoming greater as the public becomes more aware of their value.

PROBLEM NO. 10

I. NAME OF PROBLEM - EVALUATION OF CHANNEL ALTERATION DESIGN TO MITIGATE DAMAGE TO FISH AND WILDLIFE HABITAT

II. THE PROBLEM - Alterations to natural stream channels are generally not desirable. However some channel alterations will still be required because they are the most feasible and practical alternate for a specific segment of highway location.

The best possible methods for minimizing damage to fish and wildlife habitat, and for preserving or restoring a quality stream channel environment, need to be assembled from existing practice and ongoing or completed studies and published in the form of design criteria and guidelines.

III. OBJECTIVES - To develop a comprehensive set of guidelines and design criteria which will assure highway planners and designers (and others associated with work in this area) that their projects will result in minimum damage to fish and wildlife habitat and the streamside environment.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 17, 22 and 23 have been scanned in preparing this statement.

B. Suggested key words for this problem: stream channel alterations, channel changes, fish and wildlife habitat and design criteria.

C. Related research activities:

1. Montana Fish and Game Department study of stream improvement structures on Prickly Pear Creek and the East Gallatin River.

2. Montana SHD study of channel changes designed to restore fish habitat.

3. Utah SHD study of channel changes on the Weber River.

4. FHWA study to evaluate channel changes in Oregon.

5. University of Idaho's investigation of hydraulic structures used for fishways and the enhancement of fish habitat.

6. Colorado State University study on highway impact on mountain streams.

7. University of Wyoming studies on quantifying fish habitat.

8. Wyoming Game and Fish Commission studies on Rock Creek.

V. URGENCY - A wide range of methods for channel construction have been used in attempts to mitigate damage to fish and wildlife habitat resulting from highway projects. Guidelines and design criteria are needed to identify the best methods to provide possible enhancement or minimum damage and to properly assess environmental impacts.

GENERAL PROBLEMS

PROBLEM NO. 1

I. NAME OF PROBLEM - LEGALITIES OF HIGHWAY DRAINAGE DESIGN

II. THE PROBLEM - The highway industry has progressed well beyond the turn-of-the-century objective of "Getting the Farmer Out of the Mud." Society now demands to know why and where highways are required. In addition the

national interest has focused on upgrading and preserving environmental quality. These facts coupled with the continuing need to provide a safe and adequate transportation system have caused a significant increase in the number of court cases involving highway drainage and the surface-water environment associated with highways.

Historically there appears to be several basic legal concepts from which existing drainage laws have been derived. These concepts are not always in agreement. In addition the application and interpretation of these concepts have been arbitrary and ambiguous. This coupled with the random and indiscriminate case-by-case application of the laws derived from the basic legal concepts has resulted in considerable confusion within the highway industry.

Needed research consists of three general parts. Part one discusses the basic legal concept, categorizes by state the state drainage laws derived from the concepts and summarizes by state any environmental laws related to surface-water. Part two uses the literature review of part one to identify the engineer's responsibility in typical drainage design situations both legally and in light of the inconsistencies that have occurred in the past. Part three would use parts one and two to propose an idealized and integrated system of drainage and environmental laws that protect the surface-water environment and are capable of optimizing highway drainage economics with reasonable protection to adjacent property.

III. OBJECTIVES

A. To conduct a literature review to identify and clarify the basic legal concepts underlying existing highway drainage and surface-water environmental laws.

B. To categorize, identify and interpret existing state laws directed at surface-water environmental protection and typical highway drainage situations to include for each state:

(1) generalized commentary of case history results;
(2) identification of an engineer's apparent legal obligation;
(3) identification of an engineer's obligation considering case history and current trends.

C. To develop draft legislation for an idealized drainage and environmental law and provide accompanying commentary to illustrate the proper legal application to typical highway drainage situations and related surface-water environmental problems.

D. To conduct the research recognizing:

(1) existing engineering terminology and minimizing legal language;
(2) statistical problems inherent in determining flood magnitudes and frequencies;
(3) surface-water environment includes not only water quality and flood zoning considerations, but includes fluvial geomorphology and the biology of lower forms of life inhabiting the stream and flood plains.

IV. CURRENT ACTIVITIES

A. Suggested key words for this problem: drainage, environment, legal, law.

B. Related research activities: AASHTO legal drainage guidelines.

V. URGENCY - A multitude of drainage design decisions are being made each day based on inconsistent and misunderstood laws. These decisions will affect the environment and well being of society for many years hence. Also involved is the economics of a shrinking highway dollar coupled with the increasing amount of litigation being derived from existing facilities. Additional incentive is gained from the need for governmental entities to initiate immediate action culminating in uniform and equitable drainage laws as legislative action often requires several years before enactment. The nature of this research is such that the objectives could be fully met in a relatively short time.

PROBLEM NO. 2

I. NAME OF PROBLEM - HAZARDOUS AND TOXIC MATERIALS SPILLS FROM TRANSPORTATION VEHICLES AND FACILITIES

II. THE PROBLEM - Actual spills, and the potential for spills, of hazardous and toxic materials from transportation vehicles and facilities have produced environmental problems for both the public and private sectors of the transportation industry. The potential for spills of toxic and hazardous materials must be addressed in preparation of environmental impact statements which are required in connection with many transportation facility construction projects. Actual spills create immediate environmental problems for owners and operators of transportation systems, facilities and vehicles with respect to predicting the fate of spilled hazardous and toxic materials so as to facilitate cleanup and removal and to minimize adverse environmental impacts. The prediction of spill potential and fate of spilled material would be aided by development of general predictive techniques which could readily be applied.

III. OBJECTIVES - The objectives are to:

A. Develop a method of predicting frequency of spills and chances of a spill occurring at a given location considering such factors as traffic volumes, traffic patterns, traffic routings, condition of transportation equipment used in hauling toxic and hazardous materials and physical conditions of various transportation arteries.

B. Develop a general method for quickly predicting the fate of spilled toxic and hazardous materials considering such factors as characteristics of the spilled material, hydraulic characteristics of

water bodies receiving spilled materials and geological characteristics of land areas receiving spilled materials.

IV. CURRENT ACTIVITIES

A. Highway Research in Progress areas 17, 23 and 51 have been scanned in preparing this statement.

B. Suggested key words for this problem: environment, toxic and hazardous materials, accidents.

C. Work related to time of travel and dispersion by dye tracing has been done and a number of time of travel studies for specific streams have been completed.

V. URGENCY - Increasingly stringent environmental regulations create an immediate need for predictive methods to be used by transportation planners in addressing spill problems in environmental impact statements and by transportation system owners and operators in spill contingency planning and spill cleanup efforts.