TA7
W34i
no.H-77-1
c.4

INSTRUCTION REPORT H-77-1

GUIDELINES FOR MONITORING AND REPORTING DEMONSTRATION PROJECTS

SECTION 32 PROGRAM STREAMBANK EROSION CONTROL EVALUATION AND DEMONSTRATION ACT OF 1974

by

Ellis B. Pickett, Bobby J. Brown

Hydraulics Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

September 1977

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

TA7.
W34r
no.H-77-
C.4

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Instruction Report H-77-1

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE *(and Subtitle)*
GUIDELINES FOR MONITORING AND REPORTING DEMONSTRATION PROJECTS; SECTION 32 PROGRAM, STREAMBANK EROSION CONTROL EVALUATION AND DEMONSTRATION ACT OF 1974

5. TYPE OF REPORT & PERIOD COVERED
Final report

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR*(s)*
Ellis B. Pickett
Bobby J. Brown

8. CONTRACT OR GRANT NUMBER*(s)*

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U. S. Army Engineer Waterways Experiment Station
Hydraulics Laboratory
P. O. Box 631, Vicksburg, Mississippi 39180

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

12. REPORT DATE
September 1977

13. NUMBER OF PAGES
52

14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*

15. SECURITY CLASS. *(of this report)*
Unclassified

15*a*. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*
Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*
Bank protection
Demonstration projects
Erosion control
Guidelines

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

These guidelines are to aid in providing brief, thorough, uniform documentation of the data to be collected by field monitoring and reported for the numerous demonstration projects to be conducted under the Streambank Erosion Control Evaluation and Demonstration Act of 1974 (Section 32 of Public Law 93-251).

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
TECHNICAL LIBRARY
P. O. BOX 59
LOUISVILLE, KENTUCKY 40201

THE CONTENTS OF THIS REPORT ARE NOT TO BE USED FOR ADVERTISING, PUBLICATION, OR PROMOTIONAL PURPOSES. CITATION OF TRADE NAMES DOES NOT CONSTITUTE AN OFFICIAL ENDORSEMENT OR APPROVAL OF THE USE OF SUCH COMMERCIAL PRODUCTS.

PREFACE

The guidelines presented herein were prepared in support of work under the Streambank Erosion Control Evaluation and Demonstration Act of 1974 (Section 32 of Public Law 93-251). This program is conducted by the Secretary of the Army, acting through the Office, Chief of Engineers (OCE), and consists of (a) an evaluation of the extent of streambank erosion on navigable rivers and their tributaries; (b) the development of new methods and techniques for bank protection, research on soil stability, and identification of the causes of erosion; (c) a report to the Congress on the results of such studies and the recommendations of the Secretary of the Army on means for the prevention and correction of streambank erosion; and (d) demonstration projects, including bank protection works. All phases of the program are under the general supervision of a steering committee representing each CONUS Division, OCE, and the U. S. Army Engineer Waterways Experiment Station (WES). Mr. J. H. Douma, OCE, is chairman of the steering committee.

The guidelines were prepared during the period June 1976 to June 1977 in the Hydraulics Laboratory of WES under the direction of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory. The work was done by Mr. E. B. Pickett, Chief of the Hydraulic Analysis Division, and Mr. B. J. Brown, Chief of the Analysis Branch, with reviews and comments by the steering committee.

Directors of WES during the preparation and publication of these guidelines were COL G. H. Hilt, CE, and COL John L. Cannon, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

Page

PREFACE 2

PART I: INTRODUCTION 4

- Purpose 4
- Scope 4
- Application 5
- Outline of Needed Data 5
- Visual Observations 5

PART II: OUTLINE OF NEEDED DATA 6

- Historical and Design Data 6
- Construction Data 8
- Performance Data 9

PART III: NOTES ON DATA COLLECTION 10

PART IV: EXAMPLE PLAN AND SPECIFICATIONS 28

PART V: EXAMPLE DEMONSTRATION PROJECT PERFORMANCE REPORT 33

TOPICAL OUTLINE FOR DEMONSTRATION PROJECT REPORTS 41

PHOTOS 1-9

PLATES 1-15

GUIDELINES FOR MONITORING AND REPORTING DEMONSTRATION PROJECTS

Section 32 Program Streambank Erosion Control Evaluation and Demonstration Act of 1974

PART I: INTRODUCTION

PURPOSE

The purpose of these Guidelines is to aid in providing uniform, brief, thorough documentation of the data to be collected by field monitoring and reported for the Section 32 demonstration projects. Field monitoring of Section 32 Program demonstration projects is necessary for proper evaluation of protection methods tested, correlation of field and laboratory studies, and application of results to future streambank erosion control problems. The data collection in this program must provide for evaluation of many protection methods subjected to a wide variety of service conditions. Some of the protection designs may be somewhat "speculative" as to adequacy for permanent protection; therefore, careful observation of the performance and service conditions is very important. The monitoring measurements, observations, and documentation should permit accurate and easy understanding and comparison of protection performance relative to site conditions within each project and among the various projects Corps-wide. Uniformity of each type of data among the projects for whatever monitoring activities are done, combined with brief but thorough documentation of relevant aspects of the success or failure of protection methods investigated, constitutes the objective of these Guidelines.

SCOPE

These Guidelines give recommendations on kinds of data to be obtained and suggestions on possible methods to obtain the data. The Outline of Needed Data (Part II) is nearly all-inclusive to serve as a comprehensive checklist for selection of items appropriate to specific projects among a wide variety of sites and conditions. Data of highest priority for all projects are so identified in the Outline. Specific comments and suggestions on some items in the Outline are referenced and given in the Notes on Data Collection (Part III). One CE Division's proposed plan of measurements and specifications for monitoring by the contractor are given in Part IV. Some such plan should be prepared for each project or group of projects and submitted to the U. S. Army Engineer Waterways Experiment Station (WES) for review through the appropriate CE Division member of the Section 32 Program steering committee. The Example Report (Part V) illustrates how the monitoring observations will be used and the desired scope of subject matter.

APPLICATION

The intent is to obtain the best possible set of data within the available time and capability for each project, balance the ideal goals and practical efforts, and allow flexibility in what is to be monitored at specific sites. Priority of needs, particular project requirements, site conditions, and costs will dictate the actual monitoring measures to be implemented from these Guidelines or other criteria. The frequency and detail of data collection must be adequate but also preclude voluminous data of questionable value.

Performance of protection methods will be evaluated relative to the average ranges of hydrologic and hydraulic conditions that would be considered in their design. Consequently, good data are essential for as much of the full range as possible; and data on any extremely severe conditions are highly desirable for establishing actual upper limits of performance.

District personnel are familiar with most of the measurements and instruments mentioned in the Outline and Notes. WES can assist in specific problems involving specialized equipment. (Such assistance should be coordinated through Mr. E. D. Hart, FTS 542-2258.) Automated systems are costly for single measurements but may be useful in special cases for obtaining simultaneous measurements.

Documentation of historical, design, and construction aspects should be accomplished by the end of the construction phase. Most of the information will be available then as part of normal design and construction activities. This practice will avoid having to become refamiliarized with unorganized and incomplete data a few years later when the project reports are prepared. Wherever possible, data should be presented in graphical or tabular form consistent with conventional practice or with the Example Report (Part V).

OUTLINE OF NEEDED DATA

The types of data in the topical Outline are arranged in a sequential order and subdivided by physical characteristics. Actually, the sequential arrangement is a continuous process from historical through the present into the future, or from preconstruction through construction into the performance observation period. The arrangement also correlates with the proposed organization of the Reports. Physical characteristics concern the general types of data: geometry; geology and soils; climate, hydrology, and hydraulics; streambank protection; and environment.

Historical data (as available) are important in establishing expected rates of erosion for various combinations of bank material and streamflow conditions. Particular note should be made of both natural and man-caused changing conditions (flow, stages, meanders, bank materials, etc.) that may have affected rates of erosion.

VISUAL OBSERVATIONS

Periodic visual inspections are of particular importance in documenting the performance of the protective works and in relating the many interacting variables. Such observations may require follow-up measurements of varying detail. Perhaps an interested local resident or organization could assist in data collection, photography, etc.

PART II: OUTLINE OF NEEDED DATA

A. HISTORICAL AND DESIGN DATA

1. GEOMETRY (Topography, Hydrography)

   **a.* General relief of drainage area and river valley (topography, slopes, land use, etc.) and general characteristics of channel (straight, meandering, braided, etc.; control points, i.e., falls, rapids, dams, encroachments, etc.; a sequence of available aerial photographs may show trend of any changes).

   **b.* Dredging performed in test reach (purpose, limits, disposal area).

   c.* Historical hydrography in test reach (typical successive cross sections of channel, successive bank lines, etc.) and photographs of historical channel and bank conditions in test reach (with descriptive titles, locations, etc.). (Note 1a)

   **d.* Present hydrography in test reach (detailed full channel and bank survey extending upstream and downstream for distances equal to several channel widths to establish an alignment pattern). (Notes 1a, 1b)

   **e.* Detailed survey of present bank line with matching aerial photoprints at same scale. Establish benchmarks at each test reach to reference surface monuments and other measurements. (Notes 1a, 1c)

   **f.* Cross sections along test reach and at site with alongbank and overbank stereophotographs (include cross-section markers in photographs). Establish camera locations and view directions for later photographs (ground level; oblique and controlled-vertical aerial). (Notes 1a, 1d)

   g. Detailed acoustic profiles and side-scan sonar imagery of submerged surfaces and acoustic subbottom profiling of bottom sediment structure at test site if possible. (Note 1a)

2. GEOLOGY AND SOILS (Note 2a)

   **a.* Local area geology (including type and depth of alluvial deposits) with locations, elevations, and types of underlying older formations (bedrock). (Note 2b)

   **b.* Description of rates of erosion, slope stability, etc., problems that occur along the general reach in the vicinity of and including the demonstration site. These may be available from historical records, i.e., maps and aerial photography.

   **c.* Available boring logs and soils testing data obtained in conjunction with these studies.

   **d.* Subsurface investigations at project site (including standard penetration tests) of bank and bed material for erosion and stability analyses (to depths below anticipated maximum scour and failure surfaces, respectively) and foundation analyses of protective works (as required). (Note 2c)

   **e.* Testing of soils at project site for water content, gradation (including hydrometer), Atterberg limits, specific gravity, SCS dispersion test, relative density of cohesionless soils, unconfined compression (erosion analysis), shear strength (slope stability and foundation analyses), and consolidation (as required for foundation analysis). (Note 2c)

   **f.* From available records, determination of changes in groundwater levels (perched conditions, etc.) relative to river stage and season.

   **g.* Installation of piezometers for groundwater level changes relative to river stage and season during planning, construction, and monitoring. (Note 2d)

---

* High priority items.

** Parenthetical notes (Note 1a, etc.) refer to Notes on Data Collection, pages 10-12. Parenthetical letters and numbers (from A1d) or (changes from A1g and B1c) refer to the respective lettered parts of outline.

A. HISTORICAL AND DESIGN DATA (Continued)

3. CLIMATE, HYDROLOGY, AND HYDRAULICS

**a.* Local climatic averages and extremes (air and water temperatures, precipitation, wind) through the year, and design assumptions. (Note 3a)

**b.* River ice conditions in test reach (average freeze-up and break-up dates, ice thickness, movement and jams, etc.), and design assumptions.

**c.* Stage-discharge curve for test site (with any significant historical changes identified). (Note 3b)

**d.* Operating procedures (both normal and emergency) of control works on regulated streams that may affect test site.

**e.* Floods of record and flood frequencies (stages and discharges).

**f.* Typical annual stage hydrograph for test reach (with any significant changes due to control works, etc.), and design assumptions. (Note 3b)

**g.* Water-surface profiles and cross sections at varying flow conditions.

h. Velocity distributions through test reach (including quiet water areas, maximum and secondary currents, and tow or pleasure boat propeller wakes, with any significant historical changes identified), and design assumptions. (Notes 3c, 3d)

i. Sediment conditions through test reach (bed and suspended load; scour, transport, and deposition; bed and suspended material sizes and fall velocities; evidence of largest size of stone moved by floods; change of channel bottom depth and shape during high flows, etc.), and design assumptions. (Note 3g)

**j.* River traffic in test reach (type, amount, significant changes). Propeller wash from river traffic (frequency of occurrence, resulting erosion damage).

**k.* Wave action from wind and traffic in test reach, and design assumptions.

4. STREAMBANK PROTECTION

**a.* Description and performance of previous and existing works in or near test reach.

**b.* Availability of construction materials within economic hauling distance; available information on rock and other materials to be used; determination of freeze-thaw durability for construction rock.

**c.* Specific designs to be tested; design rationale for all general and specific details; estimated costs. (Do not relate costs to economic value of site.) (Notes 4a, 4b)

5. ENVIRONMENT

**a.* General characteristics (cultural, wetlands, water quality, fish, endangered species, etc.); seasonal variations.

**b.* General assessment to appropriate level (consider State and other agency requirements). (Note 5a)

c. Inventory to appropriate detail (acquatic, vegetative, zoological).

d. Water quality (turbidity, chemical content, etc., as appropriate).

B. CONSTRUCTION DATA

1. GEOMETRY

**a.* Any changes (from A1d) in hydrography in test reach. (Note 1b)

**b.* General plan and longitudinal elevation of completed work, plus aerial photograph. (Note 1a)

**c.* Cross sections and alongbank stereophotographs of subsurface grading, filter layers, etc., during construction. (Notes 1a, 1c)

**d.* As constructed cross sections (including crown profiles to thalweg) and alongbank stereophotographs (corresponding to A1f) along test reach and in test site. (Notes 1a, 1c, 1d)

e. Detailed acoustic profiles and side-scan sonar imagery of submerged surfaces and acoustic subbottom profiling of bottom sediment structure at test site (changes from A1g). (Note 1a)

f. Locations and detailed photographs of marked elements subject to displacement. Establishment of permanent aids for continuing visual observations. (Note 1e)

**g.* Measurements and photographs of any special conditions.

2. GEOLOGY AND SOILS

**a.* Observation of groundwater level piezometers for changes relative to river stage, season, or construction activities.

**b.* Installation and observation of instruments (monuments, settlement plates, etc.) to monitor any movement in the slopes.

**c.* Any changes from historical and design conditions.

**d.* Problems or special conditions.

3. CLIMATE, HYDROLOGY, AND HYDRAULICS

**a.* Weather, river stages. (Notes 3a, 3b)

b. Any changes (from A3h) in general and local velocity distributions relative to historical and design conditions. (Notes 3c, 3d)

**c.* Problems or special conditions relative to waves, wakes, etc. Any changes (from A3k) in anticipated wave and tow or pleasure boat wake action relative to historical and design conditions.

**d.* Initial scour and deposition action in vicinity of protection structures and along test reach. (Note 3g)

4. STREAMBANK PROTECTION

**a.* Construction activity log and photographs.

**b.* Material properties "in place" (size, gradation, vegetation, etc.)

**c.* All changes from design.

**d.* Upstream and downstream extension (transition) details.

**e.* Actual costs.

**f.* Development of vegetation during construction period.

**g.* Visual inspections. (Note 1d)

**h.* Problems or special conditions. (Note 4b)

5. ENVIRONMENT

a. Water quality (turbidity, etc.).

**b.* Any changes from preconstruction conditions (habitat, etc.). (Note 5b)

C. PERFORMANCE DATA
(Through Monitoring Period, Including End Condition and Reconstruction)

1. GEOMETRY

**a.* Any changes of hydrography in test reach at varying flows or along with other possible changes of the channel and flow system (comparable to A1d and B1a). (Notes 1a, 1b).

**b.* Dredging performed in test reach (see A1b).

**c.* Aerial photographs, cross sections (to thalweg), and alongbank and overbank stereophotographs made periodically, following high flows, and at any damaged areas (changes from A1f and B1d). (Notes 1a, 1c, 1d).

d. Detailed acoustic profiles and side-scan sonar imagery of submerged surfaces and acoustic subbottom profiling of bottom sediment structure (changes from A1g and B1e). (Note 1a).

e. Movement of marked elements (locations and photographs; see B1f). (Note 1e).

2. GEOLOGY AND SOILS

**a* Observation of groundwater level piezometers and other instruments for changes relative to river stage, season, or other factors.

**b.* Bank caving and active erosion at test site and other locations in test reach.

3. CLIMATE, HYDROLOGY, AND HYDRAULICS

**a.* Weather (air and water temperatures, precipitation, wind). (Note 3a).

**b.* River ice conditions (presence, thickness, movement, jams, etc.).

**c.* Local river stage record. (Note 3b).

d. General and local velocity distributions at varying flows or along with any changing channel and flow conditions (including quiet water, secondary currents, tow or pleasure boat propeller wakes, and any significant velocity fluctuations). (Notes 3c, 3d).

**e.* Water-surface profiles and cross sections at varying flow conditions.

**f.* River traffic in test reach (types, sizes, speeds, sailing lines, amount). (Notes 3e, 3f).

**g.* Wind and traffic-generated wave action (height, period, direction, and runup on bank relative to wind and traffic). (Note 3e).

h. Scour and deposition along test reach, especially in vicinity of protective works. (Note 3g).

4. STREAMBANK PROTECTION

**a.* Damage to protective works, such as toe failure, erosion by water currents, sloughing of cohesive banks, flow slides, erosion from wind waves, erosion from traffic-generated waves, erosion from seepage out of banks, general aggradation-degradation, effects of ice, etc.

**b.* Behavior, quality, and stability of construction materials.

**c.* Development and performance of vegetation. (Note 4c).

**d.* Periodic visual inspections (photographs, measurements, etc; see A1f and B4g). (Note 1d).

**e.* Problems or special conditions. (Note 4b).

**f.* Repair details.

**g.* Reconstruction details.

*5. ENVIRONMENT (Note 5b)

a. Water quality.

b. Vegetation.

c. Fish and wildlife.

PART III: NOTES ON DATA COLLECTION

1. GEOMETRY

   a. (A1c-g; B1b-e; C1 a, c, d)* Consistency of scales and general orientation for plans, sections, photographs, etc., will greatly simplify evaluation. Chronologically successive cross sections and photographs should also be consistent in locations, directions, and scales.

   b. (A1d; B1a; C1a) Test reach channel and streambank details should extend upstream and downstream from the test site for distances equivalent to several channel widths (possibly a full meander) to help define the local streamflow system affecting the relatively small test sites.

   c. (A1e; B1c, d; C1c) Topographic detailing should extend well riverward of the toe and landward to at least the maximum expected high-water elevation, including overbank flow, or possibly to the top of an eroding bluff. A possible scheme for measuring cross sections is given in Figure 1.

   d. (A1f; B1d; B4g; C1c; C4d) Stereophotographs often yield more details in later examination than do single photographs. If a stereo camera is not available, a single camera can be used for "still-life" stereophotographs by making successive photographs with a transverse camera position spacing of about 2 percent of the distance to the middle of the primary subject matter. This camera spacing slightly exaggerates the "depth" effect for near objects, but enhances the viewing of distant objects. Some sample stereophotographs are give in Figure 2. All photographs (and negatives) should be well identified, possibly with small "signboards" within the picture areas.

   e. (B1f; C1e) Elements of the bank protection to be monitored for movement could be marked with paint (or possibly by other methods).**

2. GEOLOGY AND SOILS

   a. (A2) The purposes of the geology and soils investigations are to aid in the selection of test reaches where relatively uniform soil conditions occur throughout the reach (especially important where several different protective methods will be constructed in one test reach), to evaluate the resistance of the bed and bank material of the test reaches to erosive forces, to determine the change in groundwater levels relative to river stage and seasons, and to conduct slope stability analyses and protective works foundation analyses as required.

   b. (A2a) The geology investigation should identify surface and subsurface geological deposits including type, depth, distribution, and depositional environments (point bars, abandoned course, abandoned channel, backswamp, braided stream, natural levee, alluvial apron, etc.) of alluvial deposits. Older underlying formations should be identified. These data should be collected from published reports, aerial photographs, and field investigations. Old slide areas along the test reach should be delineated. Relative ages and geologic history of strata should be determined. In some cases, absolute age dates determined by carbon-14 methods may be useful. Aerial photographs may reveal subsurface features such as buried channels, old river loops, etc.

   c. (A2d, e) The soils investigation should define the index properties of the bank and bed material over the test reach. Pocket penetrometer and Torvane readings should be made in cohesive soils in the field and laboratory for index correlations, field variations, and determination of shear strength. For erosion analysis, unconfined compression tests should be conducted on undisturbed samples of bank and bed material to depths below anticipated scour. The SCS Dispersion Test (procedure given in Figure 3) should be conducted on samples of bank and bed material to depths below anticipated scour. For foundation analysis of protective works, shear strength and consolidation tests should be conducted on undisturbed samples of bank and bed material as required.

---

* Parenthetical numbers correspond to items in outline.

** Butler, P. R., "Movement of Cobbles in a Gravel-Bed Stream During a Flood Season," *Geological Society of America Bulletin*, Vol 88, No. 8, Aug 1977, pp 1072-1074.

d. (A2g) Sufficient piezometers should be installed to define the groundwater regime before and after construction as a function of time. Consideration should be given to including piezometer observations in any automatic data acquisition systems planned for hydraulic data.

3. CLIMATE, HYDROLOGY, AND HYDRAULICS

a. (A3a; B3a; C3a) Weather observations should be obtained close enough to the test site to be reliably representative of conditions at the test site. "Package" weather stations are available commercially (Figure 4). WES has developed an automated environmental data acquisition, handling, and display system (Figure 5) that may be applicable in some of the measuring and recording activities of this project.

b. (A3c, f; B3a; C3c) River stages at the test site possibly can be based on records at existing, not-too-distant gaging stations, if maximum total errors do not exceed 1/2 ft. This scheme can be confirmed by periodic staff gage readings at the test site.

c. (A3h; B3b; C3d) Sufficient data should be collected at each demonstration site for the determination of the average velocity of the flow in the river. If possible, velocity distributions should be obtained in considerable detail to define the flow attack on the protective works. Velocity measurements at two or three characteristic river stages (low, intermediate, high) annually and also in connection with any significant flow events probably would be adequate in most cases to define velocity patterns at a given site. Consideration should be given to extending the reach where velocity profile sections are established some distance beyond the upstream and downstream limits of the protected reach to determine any possible changes in velocity patterns caused by different types of protection. Detailed velocity distributions for the test reach should include a minimum of three directional velocity measurements at the bottom, middle, and surface on each of at least 20 vertical profiles along cross sections spaced at no more than half a channel width. (See example plots in Figure 6, which are from a model study [cofferdam] and a prototype river site [Chain of Rocks Canal]. These prototype data are from the extremely few directional measurements ever obtained anywhere in inland waterways.) Several Districts have direction-indicating current meters similar to the one shown in Figure 6. [Under adverse conditions precluding current meter measurements, consideration should be given to surface velocity measurements by tracking floats with surveying equipment, a succession of low-altitude aerial photographs, or other methods.]

d. (A3h; B3b; C3d) The relation between local velocity near the bank and average velocity may be useful in interpreting limited data obtained during floods and in the design of future similar projects. Local velocity profiles to define boundary shear along the test site could be obtained with small meters allowing detailed velocities to be measured at 0.1-, 0.2-, 0.4-, 0.8-ft, etc., vertical distances from the bottom on profiles at 2-1/2-, 5-, 10-, 20-ft, etc., distances out from the water's edge to the thalweg and at 100-ft spacing along the channel. Details of portable booms that might be used for obtaining velocity measurements along the side of a channel are given in Figure 7. Pygmy meters or small electromagnetic meters mounted below the weights or on wading rods are suggested. Transient variations of local velocities and pressures between a tow and the bank also may be important.

e. (C3f, g) Wave-action data should be sufficient to yield an observed or extrapolated frequency distribution of this type:

Wave Direction (from): _____; Source: _____(wind, traffic, etc.)

Wave Height ft	Occurrence, hr/yr, for Periods, sec, of			
	0-1	1-2	2-3	2-4
3-4	—	—	—	—
2-3	—	—	—	—
1-2	—	—	—	—
0-1	—	—	—	—

The numbers of larger waves in continuous series also may be of importance. Wave action can be measured by electrical gages (surface-piercing, submerged pressure transducers, and other types) or by visual observation (or motion picture records) of a staff gage. The location of the measuring device should be in water of depth equal to about half a wavelength. Wave directions probably will have to be determined visually (or from photographs). Consideration of surges resulting from lockages may be relevant in some areas. See CERC TM30* for more detailed information on wave measurements and gages, including corrections necessary with submerged pressure transducer systems. Assistance in providing a wave recording system can be obtained from WES.

f. (C3f) It may be possible to extrapolate limited wind wave data on the basis of the local wind record and some correlations of observed waves with the wind occurring in the same sample period. Traffic-generated wave data might also be approximated from traffic records at a nearby lock and some detailed observations of typical passages of tows at the test site.**

g. (A3i; B3d; C3h) An estimated annual cost of maintaining a total sediment station on the Ohio River (near a USGS office) is $30,000.

4. STREAMBANK PROTECTION

a. (A4c) The documentation of design rationale should include design criteria or other reasons for selected dimensions, materials, etc.

b. (A4c; B4h; C4e) Although the economic values of specific sites are important in the planning and authorization of protection works, these values will not be used in this physical evaluation of protection methods. However, any significant impacts of the test site work on local land use may be recorded for general information.

c. (C4c) It would be desirable to attempt to quantify and to standardize the performance of vegetation in terms of some appropriately chosen parameters (cover, density, height, health, etc.).†, ††

5. ENVIRONMENT

a. (A5b) A case-by-case approach will be needed relative to expected impacts on the local environment.‡

b. (B5b; C5) The progression of any environmental changes (good as well as bad) through the construction and performance observation periods should be well documented.

---

* Williams, L. C., "CERC Wave Gages," TM 30, Dec 1969, U. S. Army Coastal Engineering Research Center, Washington, D. C.

** See "Implementation of the Performance Monitoring System," EC 335-2-18, 2 Jan 1976 (with Changes 1 and 2), Office, Chief of Engineers, Department of the Army (RCS DAEN-CWO-46), Washington, D. C., for details on the reporting of data on waterway traffic through locks and regulated canals.

† See, for example: "Final Report, Erosion Control Experimentation—Tennessee, Tombigbee Waterway Project, Divide Cut Section," Nov 1975, Mississippi Agricultural and Forestry Experiment Station, Mississippi State University, Mississippi State, Miss.; Conducted for U. S. Army Corps of Engineers, Nashville District, Ohio River Division.

†† U. S. Army Engineer Waterways Experiment Station, CE, "Environmental Data Collection Methods; Volume IV: Vegetation, Instruction Manual 1, Vegetation Structure," Instruction Report No. 10, May 1968, Vicksburg, Miss.

‡ See "Environmental Policies, Objectives, and Guidelines for the Civil Works Program of the Corps of Engineers," EP 1165-2-501, 29 Oct 1976, Office, Chief of Engineers, Department of the Army (DAEN-CWR-P), Washington, D. C.

Test panels shrink in the Wash

Winter storms have caused considerable damage to two out of four rip-rap test panels built on the offshore trial bank in the Wash estuary, providing important data for developing a rip-rap design method. The panels were completed last October as part of CIRIA's research into the design of rip-rap protection for reservoirs, barrages and harbour works.

Stone sizes range from 230mm (panel 1) through 400mm and 500mm to 560mm (panel 4). The first panel failed within three weeks, when a two-day storm on 16/17 November caused the largest waves so far recorded at the offshore bank site. The 0.9m-high waves, battering the panels over four tides almost totally destroyed the lightweight protection, washing away the rip-rap and the underlying course filter material and ripping holes in the three-layer membrane separating the trial panel from the permanent armouring of the trial bank.

Failure was no surprise to the designers. Stone sizes had been chosen so that panel 1 would be likely to fail within a year, with damage to the remaining panels depending on the hydraulic scale effect that CIRIA is aiming to measure.

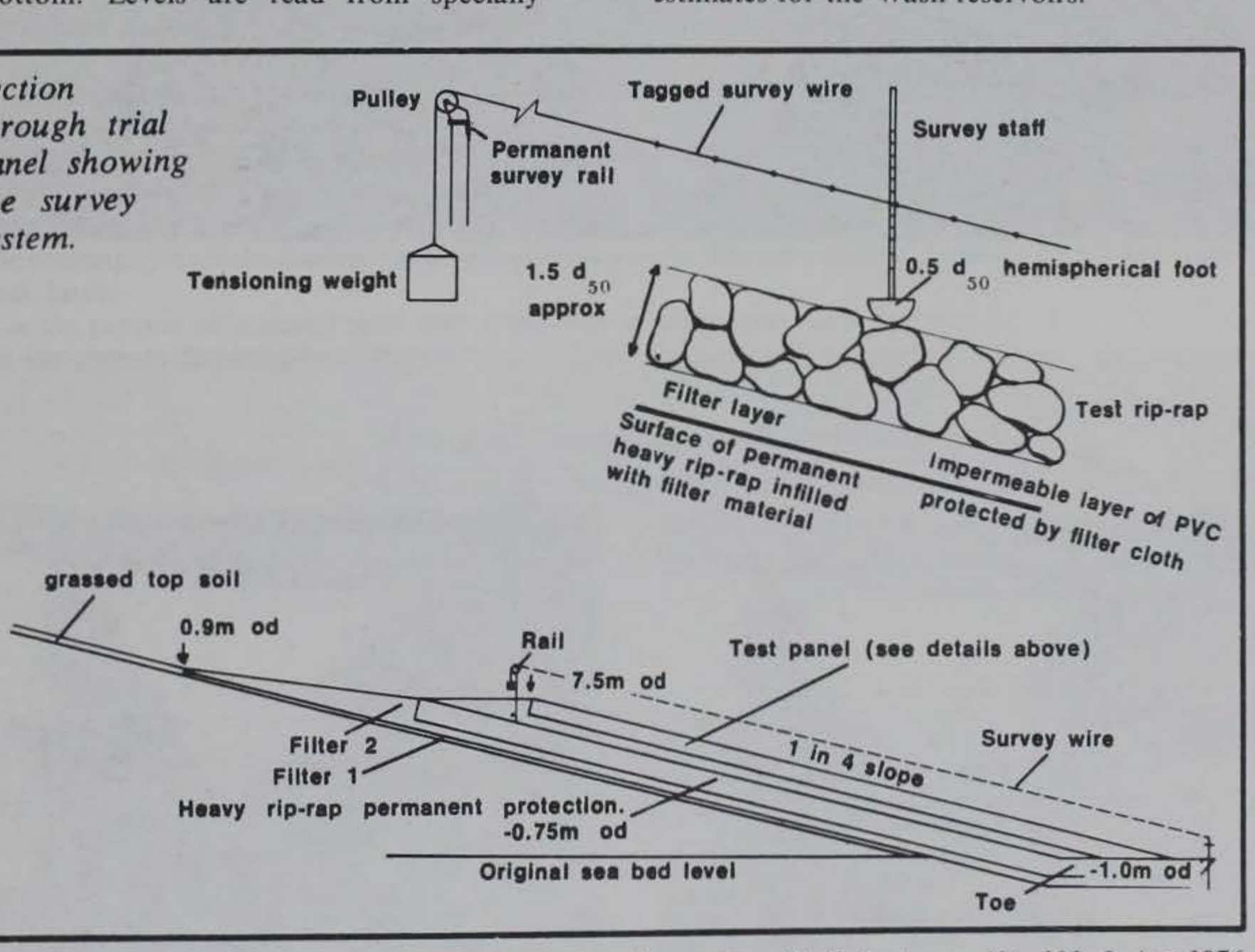
Consultant Binnie & Partners surveys the 6m-wide panels fortnightly, by stretching a pre-tagged piano wire between permanent frames at the top and bottom. Levels are read from specially designed staffs—one for each panel—with a hemispherical foot equal to half the median stone size. A fifth set of readings is taken on a panel of the 690mm main bank rip-rap adjacent to the test panels. Wave, wind and tide measurements from permanent recorders provide storm data against which stone movements will be analysed.

Later storms have damaged the second panel (400mm stone), but the location of the damage—adjacent to panel 1—suggests that failure could be due to removal of edge support. Surprisingly, the January storms, which caused massive damage down the East coast, had little effect on the Wash panels. The north facing tail panels escaped the brunt of the storm, partly because the peak of the storm did not coincide with high water and partly because the winds were mainly from the sheltered west face.

The CIRIA study is due to end in June, when the £57,000 funds run out, but project co-ordinator Bip Desia has not yet decided whether to seek further finance to keep the surveys going. A lot will depend on the results of model tests at the Hydraulics Research Station. HRS has already produced a design method for rip-rap protection, but results from large-scale tests in America suggest that it may be over conservative. CIRIA's aim is to verify the American scale factors in full-scale tests. HRS will now model the actual storms recorded in the Wash and correlate the model results with Binnie's surveys.

Confirmation of the American results could yield considerable savings on future dams and coastal defences. According to Binnie, a switch to the US method would cut more than £1M off cost estimates for the Wash reservoirs.

Section through trial panel showing the survey system.



From New Civil Engineer, No. 188, 8 Apr 1976

Figure 1. A profiling scheme

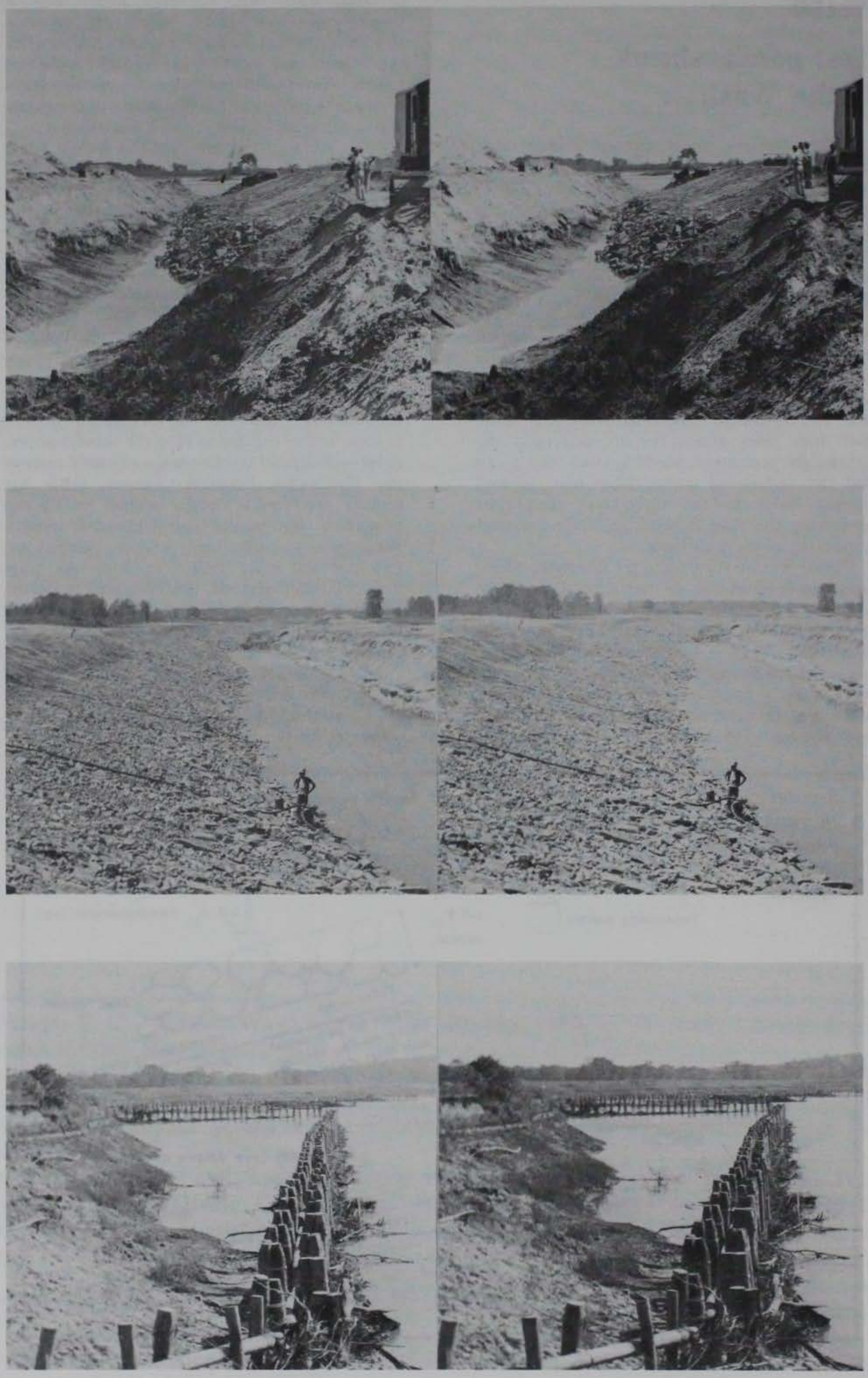


Figure 2. Sample stereophotographs

PROCEDURE FOR SCS LABORATORY DISPERSION TEST

APPENDIX A of

Piping in Earth Dams of Dispersive Clay, James L. Sherard, Roy S. Decker, and Norman L. Ryker (Volume 1—Part 1—Proceedings of the Specialty Conference on PERFORMANCE OF EARTH AND EARTH-SUPPORTED STRUCTURES, June 11-14, 1972 Purdue Unviersity—Lafayette, Indiana. Published by American Society of Civil Engineers.

A. PURPOSE

The dispersion test is a measure of the water stable aggregates in a soil. This test is designed to measure the amount of material finer than 0.005mm size in a soil-water suspension that has been subjected to a minimum of mechanical agitation. The fraction finer than 0.005mm in the soil-water suspension divided by the total fraction finer than 0.005mm, determined from a regular hydrometer analysis × 100, is referred to as % dispersion (see footnotes).

B. APPARATUS AND EQUIPMENT

1. Hydrometer jar calibrated at 1000 ml.
2. Calibrated hydrometer with a specific gravity range from 0.995 to 1.030 and marked in 0.001 subdivisions.
3. 500 ml. filtering flask with side tube and one-hole stopper.
4. Vacuum pump.
5. Balance sensitive to 0.01 grams.
6. Thermometer accurate to 0.5°C.
7. Distilled water.
8. Timer or clock.

C. SAMPLE PREPARATION

The sample is usually shipped to the laboratory in an airtight container to prevent moisture loss, and tested at the natural moisture content. The sample will consist of material passing the No. 10 sieve (2.0mm). The water content of the material finer than the No. 10 sieve is determined.

D. PROCEDURE

1. Place approximately 125 ml. of distilled water in the filtering flask.
2. Weigh the equivalent of 25 grams of dry soil to 0.01 grams and place into the flask with water.
3. Place the rubber stopper into the mouth of the flask and connect to vacuum pump.
4. START PUMP AND APPLY A FULL SUCTION.

⅝. At approximately 3 minutes, 5 minutes, and 8 minutes after pumping has started, swirl the flask several times in a rotating manner to assist in removing entrapped air.

6. After a total pumping time of 10 minutes, disconnect from vacuum.
7. Wash the soil-water suspension into the hydrometer jar and add distilled water to the 1000 ml. mark.
8. Shake the cylinder end over end at the rate of approximately 30 times per minute for one minute and record the time at the end of the shaking. This is the start of the sedimentation period. The time interval between Item 2 and Item 8 should not exceed one hour.
9. Determine the percent of material finer than 0.005 mm in suspension. (See footnote.)
10. Compute the percent dispersion as follows:

$$\text{Percent Dispersion} = \frac{\%\text{ finer than 0.005mm in soil water suspension}}{\%\text{ finer than 0.005mm from hydrometer analysis}} \times 100$$

11. Report as Percent Dispersion. (See footnote.)

The SCS dispersion test is not applicable to soils with the fraction finer than 0.005mm≤12 percent or plasticity index≤4.
The percent dispersion ranges are: 0-35% Nondispersive; 35-50% Intermediate; 50-100% Dispersive.

Figure 3. SCS dispersion test

MRI MECHANICAL WEATHER STATION

by

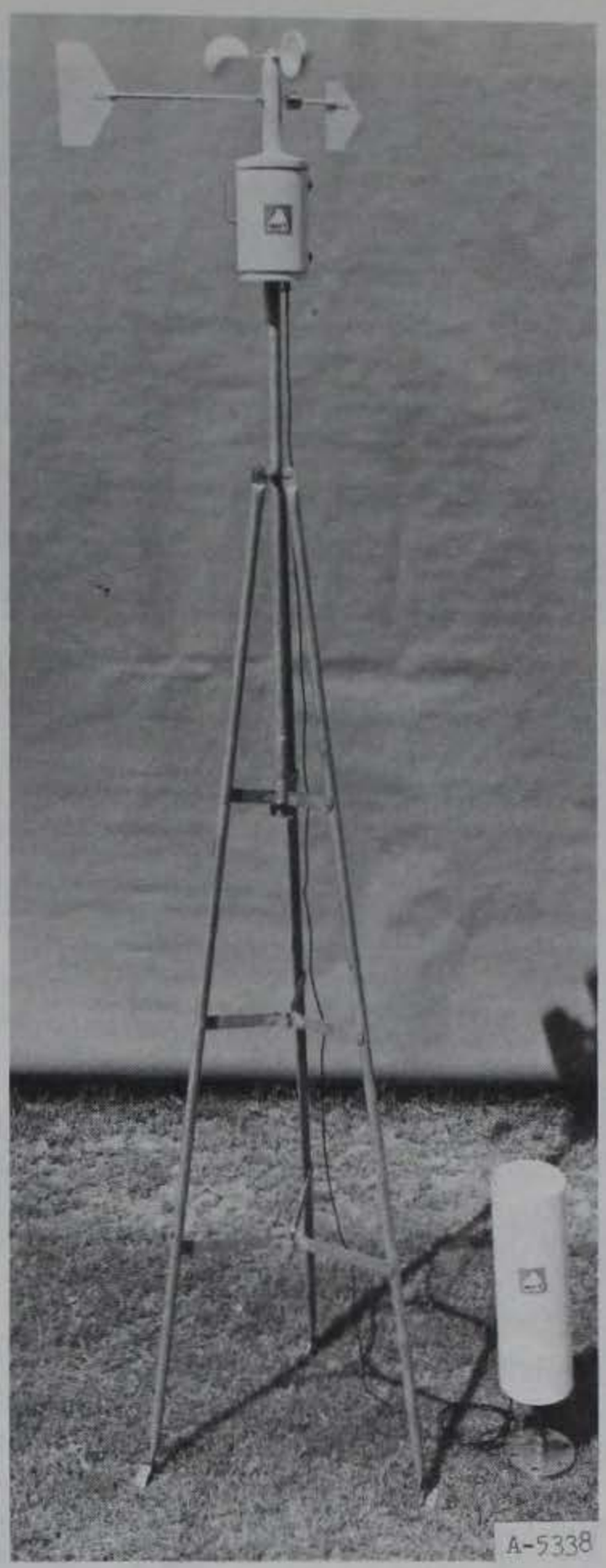
METEOROLOGY RESEARCH, INC.
464 W. Woodburg Road
Box 637
Altadena, CA 91001
(Phone: 213-791-1901)

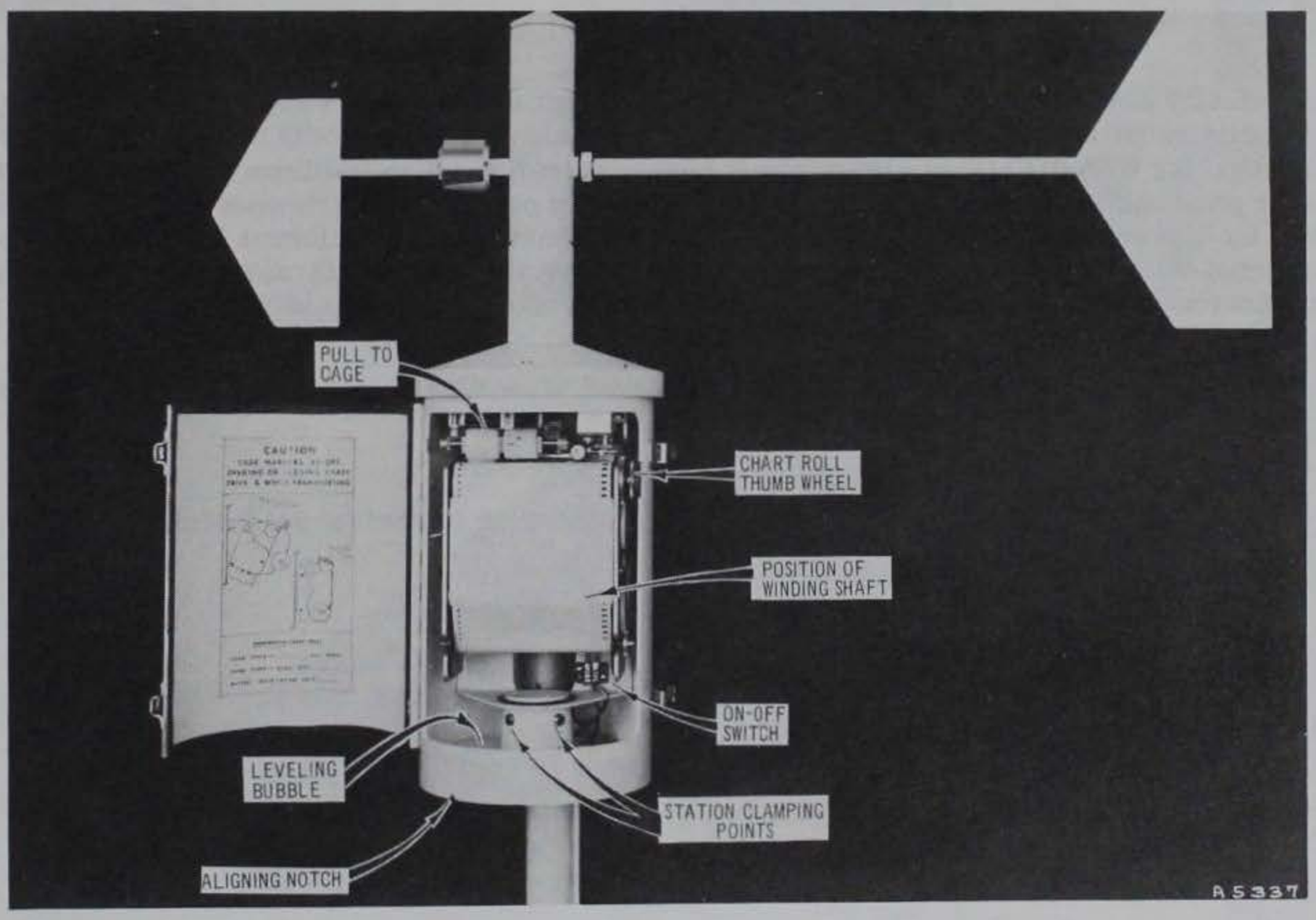
Specifications—Model 1071-1072

Wind Direction Damped 33-1/2 in. aluminum vane	Delay distance = 8 feet (50% recovery) Damping ratio = 0.5 to 0.6 Starting threshold = less than 0.75 mph Overall accuracy = ±1% full scale
Wind Run (Speed) Fast response aluminum cups	Flow coefficient = 7.90 feet/rev Flow per recording traverse = 10 miles Response distance = 18 feet (63% recovery) Starting threshold = less than 0.75 mph Overall accuracy = ±2%
Temperature Shielded bimetal coil sensor	Range L = -90° F to +60° F Range H = -30° F to +120° F Note: Range L or H selectable by field adjustment Absolute accuracy = ±3° F Relative accuracy = ±1° F
Rainfall (Model 1072) Low inertia tipping bucket	7.86 in. I.D. collector, 24 in. high Accuracy: ±1% at 2 in. per hr -2% at 3 in. per hr -10% at 10 in. per hr Resolution = 0.01 in. per recording step 7.95 cc water = one tip
Recorder Precision escapement timed drive	Optional: Hand-wound or battery-wound spring motor Chart paper duration at: 10 mm/hr = 65 days per roll 20 mm/hr = 32 days per roll Chart drive duration: Hand-wound = 35 days—uses 10 mm gears only Battery-wound = 4 months
Batteries Temperature above +20° F Temperature at -20° F Temperature at -40° F	Two "D" size flashlight batteries—approximate life of 65 days Two Eveready E95 run for 4 months Two Eveready E95 run for 3 months Two Eveready E95 run for 2 months

Figure 4. Typical mechanical weather station (sheet 1 of 2)

a. Model 1072





b. Operational view

Figure 4. (sheet 2 of 2)

AUTOMATED SYSTEM FOR DATA ACQUISITION, PROCESSING, AND DISPLAY

An environmental data acquisition, processing, and display system (a) has been designed and developed at the U. S. Army Engineer Waterways Experiment Station (WES). The primary function of the system is the accurate and reliable collection of some types of environmental baseline data in a functional form in both a reasonable cost and time frame. The data acquisition, translation and processing, and analysis and display functions are described briefly below.

AUTOMATIC ACQUISITION

The data acquisition part of the system, a versatile portable field station, consists of a series of sensors and an automatic data recorder. The field station provides for sensing and recording environmental baseline data at sampling rates preselected by the user. Environmental data can be acquired with a variety of presently available sensors providing digital, impedance, or low-level voltaic characteristics. Sensors (b) currently available for establishing environmental baseline conditions include wind speed, wind direction, rainfall, solar radiation (and reflectance), air temperature, soil and water temperature, atmospheric pressure, relative humidity, water stage, water velocity, water depth and the following water-quality parameters: pH, conductivity, dissolved oxygen, and transmissivity.

The heart of the field station is an automatic data recorder (c) that has been designed for use in even very adverse environments. The recorder converts the sensor data into a digital format and stores it on a 6.4-mm magnetic tape cassette. The recorder is capable of data collection at sampling rates varying from 3 min to 4 hr depending upon the nature of the monitoring problem and has an internal power source and can be left unattended for relatively long periods. For example, a 32-channel recorder controlling a mixture of 30 sensors can sample and record data every 30 min for approximately 15 days before the magnetic tape or power source should be replaced. Automatic acquisition data packages are in use at several locations in the United States.

TRANSLATING AND PROCESSING

The translation and processing of the data recorded on the magnetic tape cassette are performed at WES through use of a briefcase-sized device that is used to read the cassette and produce the data on paper tape for input to the WES computers where it is subsequently analyzed. A briefcase-sized cassette reader/translator that will permit transmission of the cassette data directly over telephone lines into the WES PDP 15/30 computer is under development. This device, which will be available in the near future, will permit transmission of the data from any telephone convenient to the field station site.

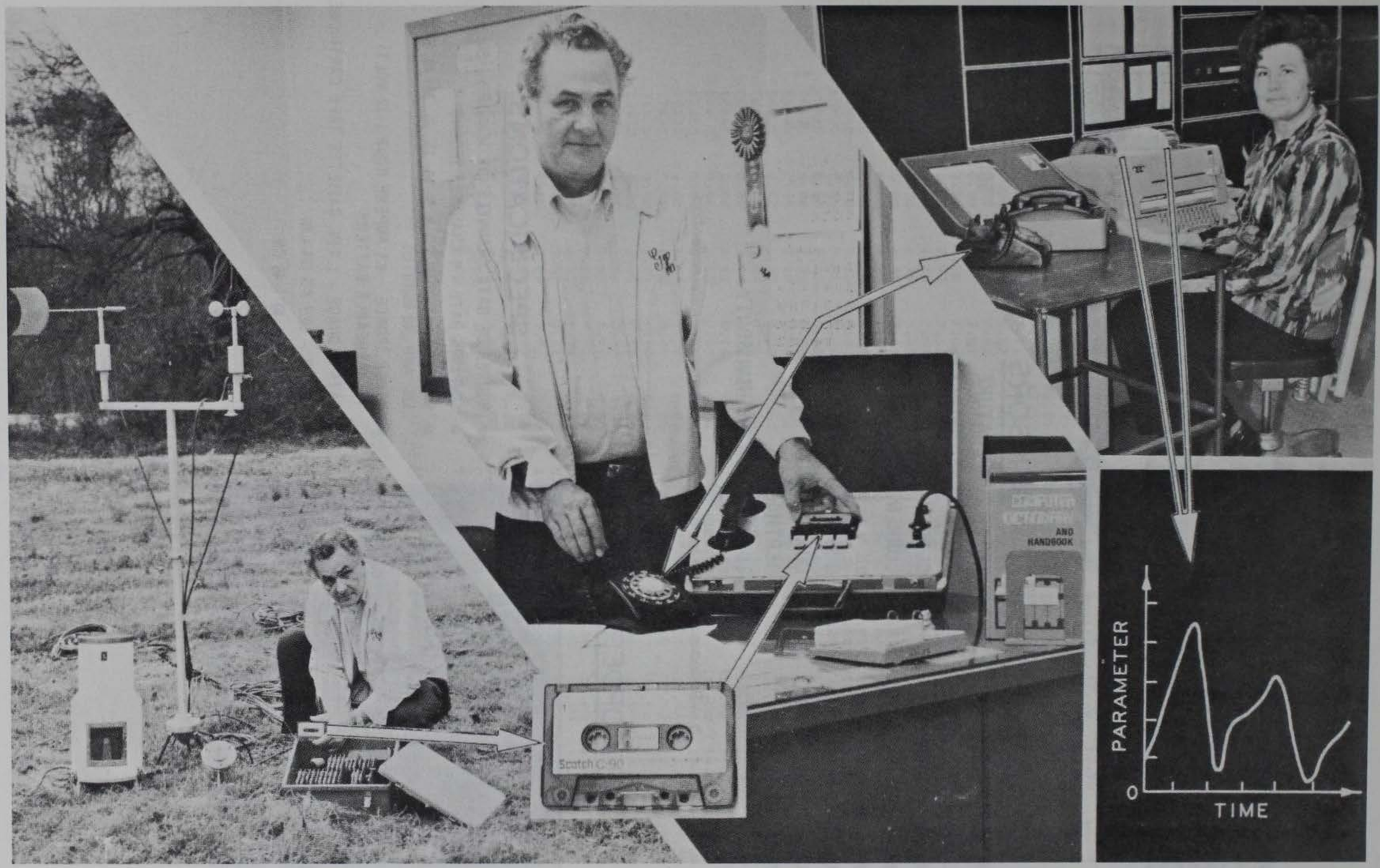
Data translation and processing results in the preparation of a computer stored file of the gathered data.

ANALYSIS AND DISPLAY

Analysis and display of the gathered data are accomplished through use of several computer programs. The computer programs read the data, edit it when required, associate the proper calibration and function with the data from each sensor type, and display the results. The WES PDP 15/30 is the computer primarily used for analysis and display although almost any type of computer could be programmed to perform that function. The computer programs properly associate the data with the type sensor from which the data originated and display the sensor readings in a tabular or graphic format. The computer program user can indicate the format of the tabular or graphic output; examples are given in (d)-(f). The data can also be output onto paper tape or magnetic tape. The time to translate, process, analyze, and display prerecorded cassette data in final form varies from an hour to approximately 3 days depending upon the type data being processed and job priorities.

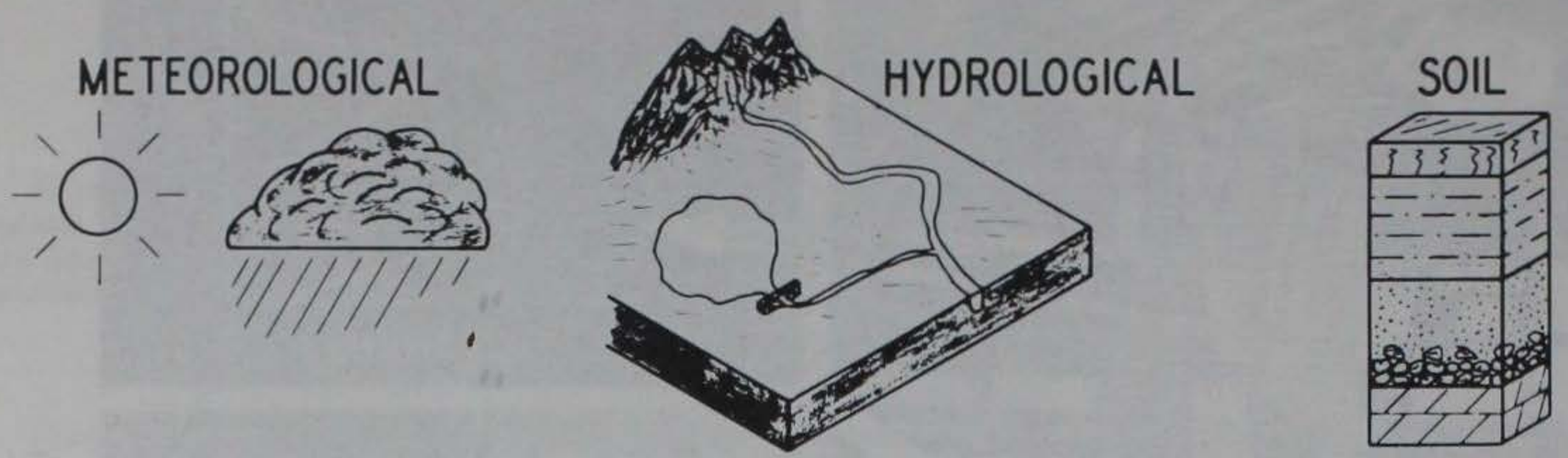
Any inquiries for additional information should be made to Messrs. Wade West or Jack Stoll at commercial telephone 601-636-3111, or FTS telephones 542-2232 or 542-2620, respectively.

Figure 5. Automated environmental data acquisition system (sheet 1 of 5)



a. Components of automatic environmental data acquisition, handling, and display system

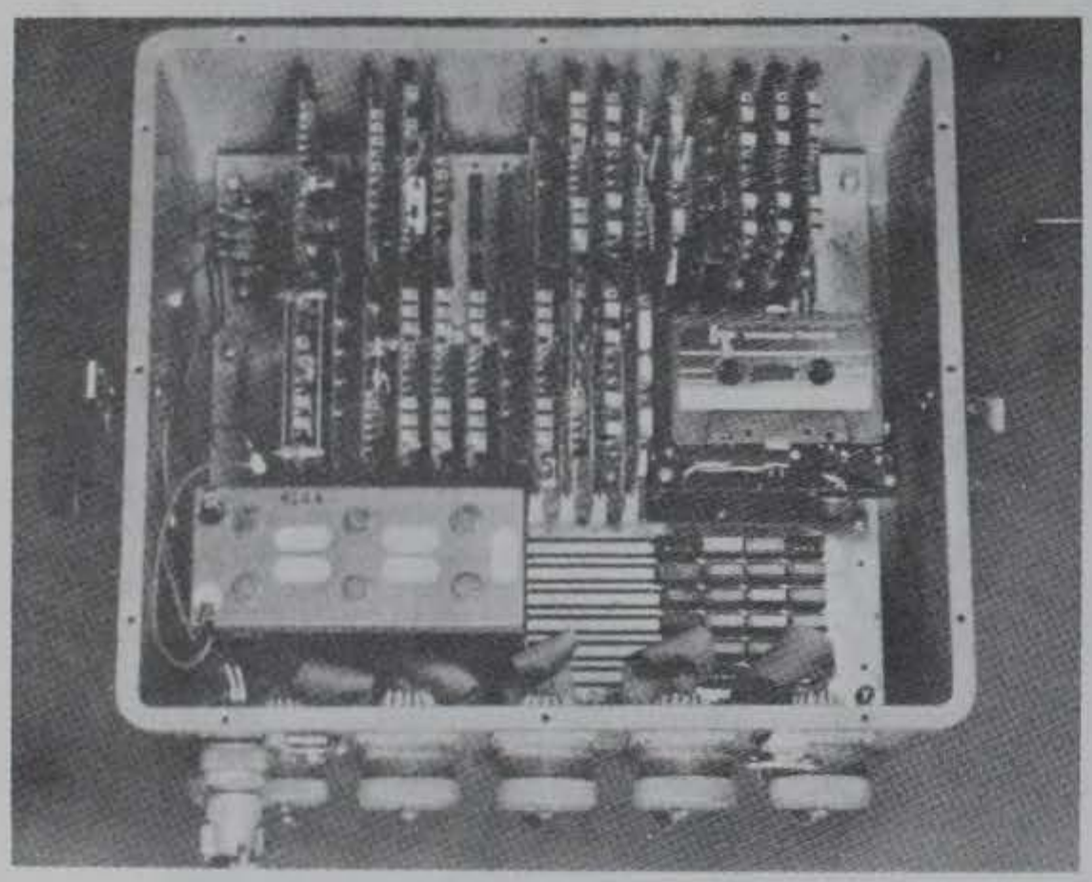
Figure 5. (sheet 2 of 5)



SENSORS	SENSORS	SENSORS
AIR TEMPERATURE	WATER TEMPERATURE	SOIL TEMPERATURE
RELATIVE HUMIDITY	WATER LEVEL (STAGE)	
SOLAR RADIATION	CURRENT VELOCITY	
WIND SPEED	CURRENT DIRECTION	
WIND DIRECTION	pH	
RAINFALL	DISSOLVED OXYGEN	
BAROMETRIC PRESSURE	CONDUCTIVITY	
EVAPORATION	DEPTH	
	TURBIDITY OR TRANSMISSIVITY	

b. Sensors available for automatic environmental data collection

RECORDER



SPECIFICATIONS

- NUMBER OF DATA CHANNELS (OR SENSORS) - 30
- SAMPLING RATE - 8 CHANNELS/SECOND
- SAMPLING INTERVALS - 3, 5, 10, 15, 20, 30, 40, 60, 120, AND 240 MINUTES
- POWER SOURCE - 4.5 AMPERE HOUR (+12 VOLT) RECHARGEABLE BATTERY
- DATA STORAGE - 1/4-IN. CASSETTE TAPE CARTRIDGE
- WEIGHT - 10.9 KG (24 LB)
- SIZE - 20 × 40 × 46 CM

c. Automatic data recorder

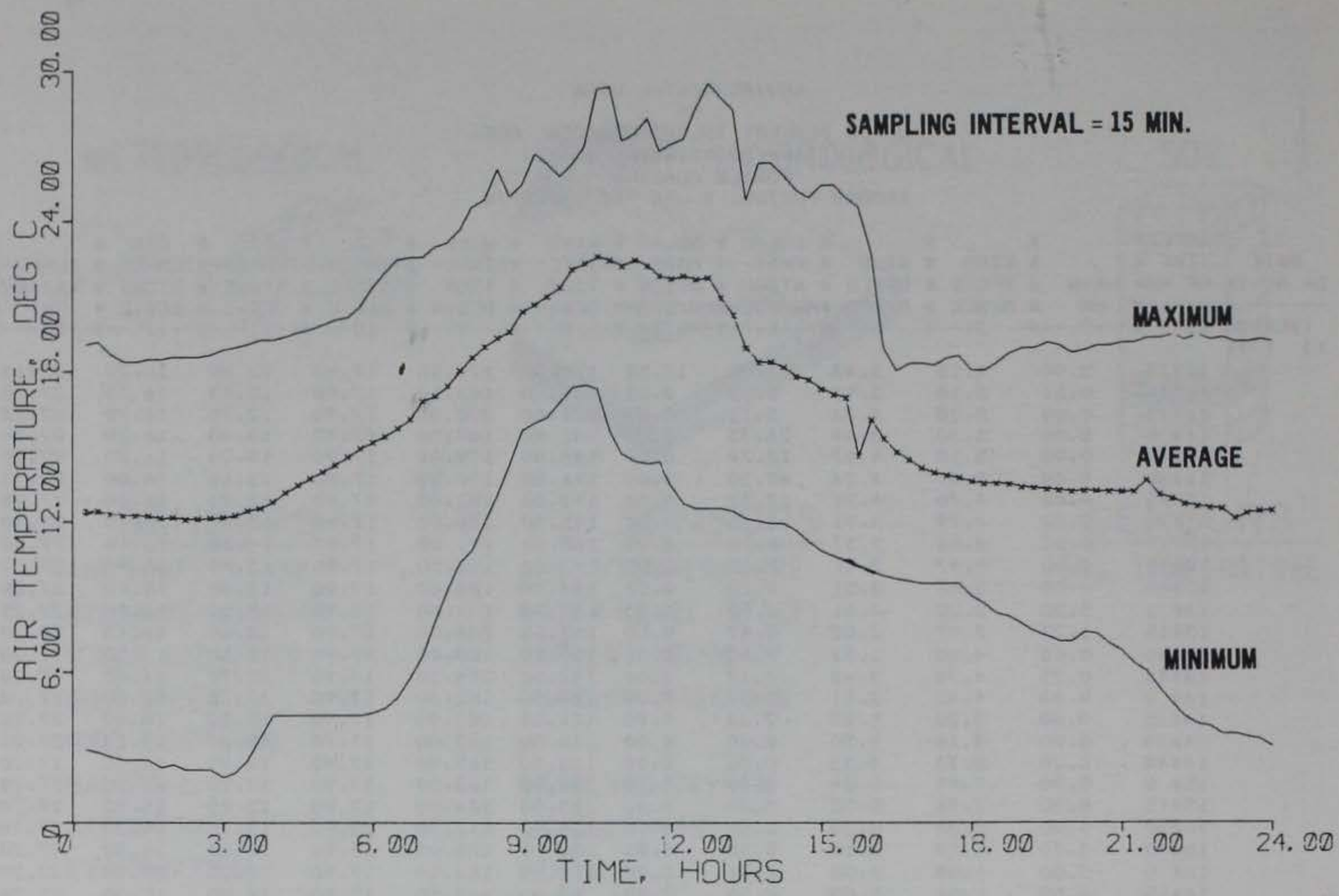
Figure 5. (sheet 3 of 5)

ENVIRONMENTAL DATA
ON
UPPER BLAKLEY ISLAND DISPOSAL AREA
MILITARY COORDINATES 610732
MOBILE ALABAMA
RECORD PERIOD: 9 JAN -15 JAN 1976

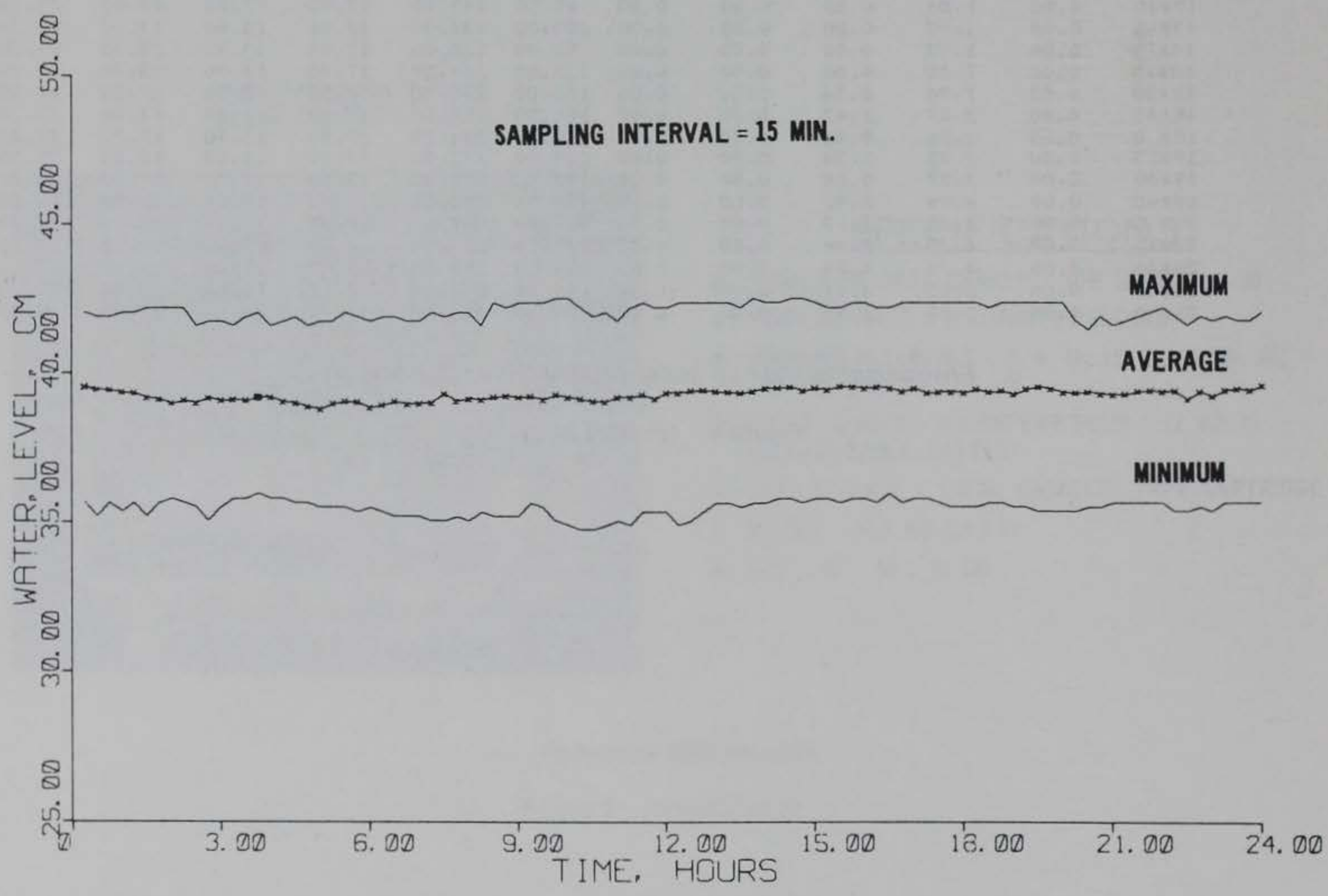
DATE DA MO YR	SAMPLE TIME HR MN	RAIN MM	WIND SPEED M/SEC	WIND SPEED M/SEC	SOLAR RADIATION MW/SQCM	SOLAR RADIATION MW/SQCM	WIND DIRECTION DEG,N	WIND DIRECTION DEG,N	SOIL TEMPERATURE DEG,C	SOIL TEMPERATURE DEG,C	AIR TEMPERATURE DEG,C	EVAPORATION CM
(SENSOR NO.)		2	3	5	6	7	8	9	10	11	12	13
13 1 76												
	10*15	0.00	4.12	2.43	7.76	11.55	157.00	179.50	17.90	12.80	16.20	27.13
	10*30	0.51	5.18	3.92	6.55	0.00	135.50	183.50	17.90	12.80	16.30	27.13
	10*45	0.00	5.28	4.06	5.11	0.00	151.00	202.00	17.90	12.90	16.40	27.13
	11* 0	0.00	5.30	3.69	26.35	0.00	142.00	186.50	17.90	13.00	16.20	27.20
	11*15	0.00	5.16	4.07	13.74	0.00	146.00	179.00	17.90	13.00	16.80	27.20
	11*30	0.00	5.09	4.24	48.20	0.00	136.50	170.50	17.90	13.10	16.80	27.13
	11*45	0.00	4.70	4.58	12.52	0.00	153.00	192.00	17.90	13.20	16.60	27.05
	12* 0	0.00	4.99	3.91	6.06	0.00	145.50	180.00	17.90	13.20	17.10	27.20
	12*15	0.00	4.46	2.37	8.58	0.00	168.00	191.50	17.90	13.30	16.40	27.20
	12*30	0.00	4.47	2.47	7.05	0.00	142.00	181.50	17.90	13.40	16.90	27.13
	12*45	0.00	5.05	3.51	6.18	0.00	143.50	183.00	17.90	13.40	16.70	27.20
	13* 0	0.25	5.28	4.01	0.00	0.00	152.50	187.50	17.90	13.50	16.70	27.28
	13*15	1.27	3.97	2.02	5.47	0.00	153.50	204.00	17.90	13.60	16.40	27.28
	13*30	0.00	4.30	2.57	3.58	0.00	159.50	188.00	17.90	13.60	16.80	27.28
	13*45	0.25	4.78	3.43	7.17	0.00	147.00	204.50	17.90	13.70	16.80	27.20
	14* 0	0.00	4.45	3.11	5.00	0.00	138.50	182.50	17.90	13.70	16.80	27.28
	14*15	0.00	3.20	1.65	2.66	0.00	126.50	185.00	17.90	13.80	16.50	27.28
	14*30	0.00	3.10	1.50	0.00	0.00	144.00	182.00	17.90	13.80	16.20	27.28
	14*45	0.00	2.33	0.33	0.00	0.00	118.50	165.50	17.90	13.80	16.20	27.28
	15* 0	0.00	2.80	0.84	0.00	0.00	133.00	168.00	17.90	13.90	15.90	27.28
	15*15	0.00	2.76	0.88	0.00	0.00	123.00	164.50	17.90	13.90	15.80	27.28
	15*30	0.00	2.38	0.23	0.00	0.00	138.00	162.50	17.90	13.90	15.30	27.28
	15*45	0.00	2.18	0.10	0.00	0.00	138.50	175.00	17.90	14.00	15.80	27.28
	16* 0	0.00	1.59	0.00	0.00	0.00	112.50	163.00	17.90	14.00	15.50	27.28
	16*15	0.00	1.59	0.00	0.00	0.00	97.00	143.50	17.90	14.00	15.00	27.28
	16*30	0.00	2.14	0.14	0.00	0.00	112.00	149.00	17.90	14.00	14.30	27.28
	16*45	0.00	2.12	0.14	0.00	0.00	111.00	148.50	17.90	14.00	13.70	27.28
	17* 0	0.00	2.95	2.48	0.00	0.00	124.50	113.50	17.90	14.00	13.20	27.28
	17*15	0.00	1.48	0.00	0.00	0.00	95.00	142.00	17.90	13.90	13.00	27.28
	17*30	0.00	1.86	0.00	0.00	0.00	89.50	142.50	17.90	13.90	13.20	27.28
	17*45	0.00	1.78	0.00	0.00	0.00	100.00	134.00	17.90	13.90	13.00	27.28
	18* 0	0.00	1.93	0.00	0.00	0.00	90.00	138.00	17.90	13.90	13.00	27.28
	18*15	0.00	1.48	0.00	0.00	0.00	121.00	166.50	17.90	13.90	13.40	27.28
	18*30	0.00	1.96	0.36	0.00	0.00	183.00	235.50	17.90	13.90	17.20	27.28
	18*45	0.00	3.07	1.47	0.00	0.00	101.50	154.50	17.90	13.90	14.00	27.28
	19* 0	0.00	2.26	0.46	0.00	0.00	190.00	236.50	17.90	13.90	17.20	27.28
	19*15	0.00	2.72	1.24	0.00	0.00	129.00	143.00	17.90	13.80	13.60	27.28
	19*30	0.00	2.57	0.64	0.00	0.00	190.00	207.50	17.90	13.80	17.00	27.28
	19*45	0.00	4.09	2.92	0.00	0.00	198.50	223.50	17.90	13.80	17.80	27.28
	20* 0	0.00	4.69	3.17	0.00	0.00	227.00	247.50	17.90	13.80	18.00	27.28
	20*15	0.00	4.78	3.46	0.00	0.00	187.50	239.50	17.90	13.80	17.90	27.20
	20*30	0.00	4.73	4.04	0.00	0.00	233.50	270.00	17.90	13.80	18.20	27.28
	20*45	0.00	5.03	4.11	0.00	0.00	185.50	243.50	17.90	13.90	18.00	27.28
	21* 0	0.00	5.00	3.94	0.00	0.00	196.00	224.50	17.90	13.90	17.70	27.28

d. Environmental data on upper Blakley Island disposal area

Figure 5. (sheet 4 of 5)



e. Air temperature versus time for a period of 14 days



f. Water level versus time for a period of 14 days

Figure 5. (sheet 5 of 5)

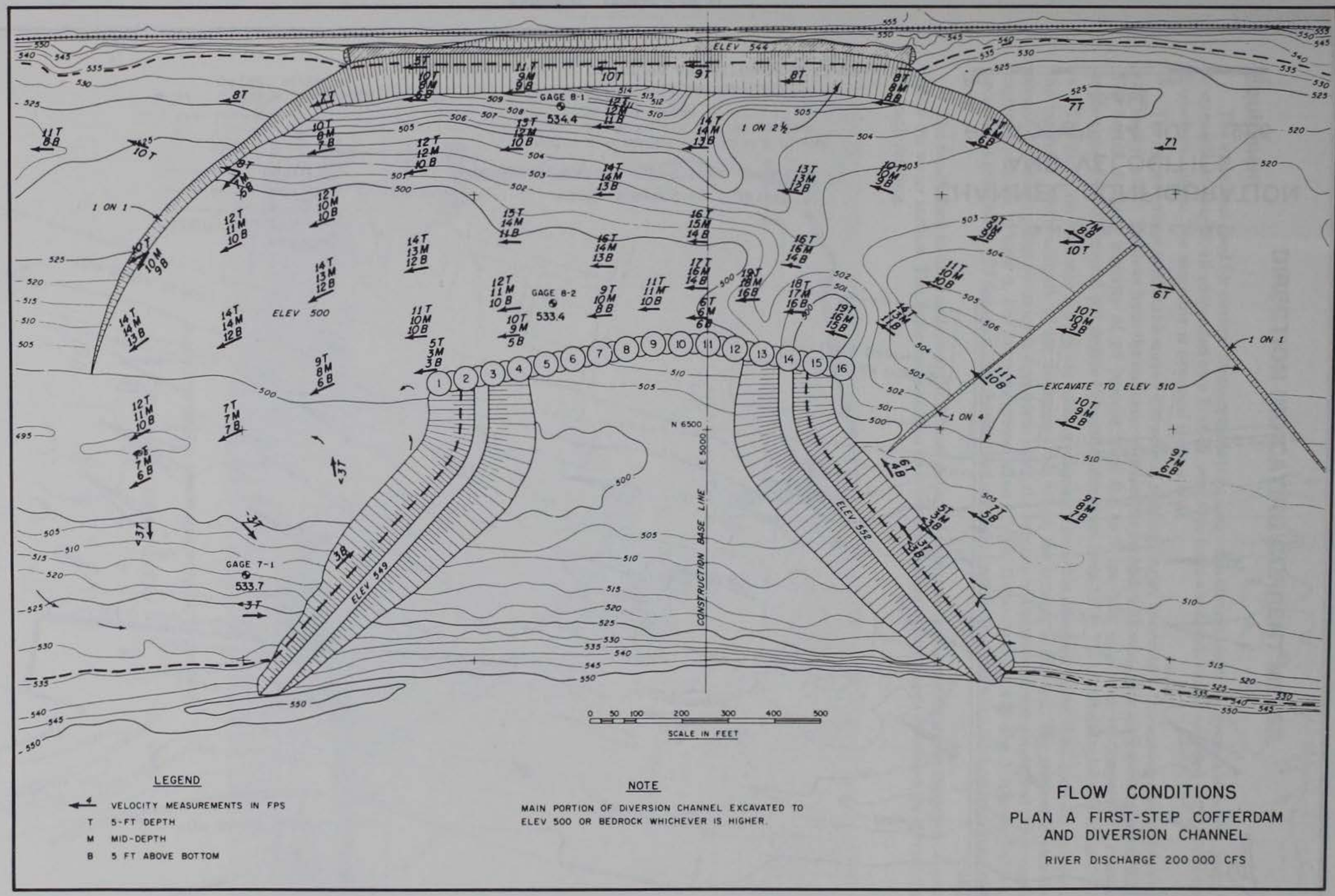
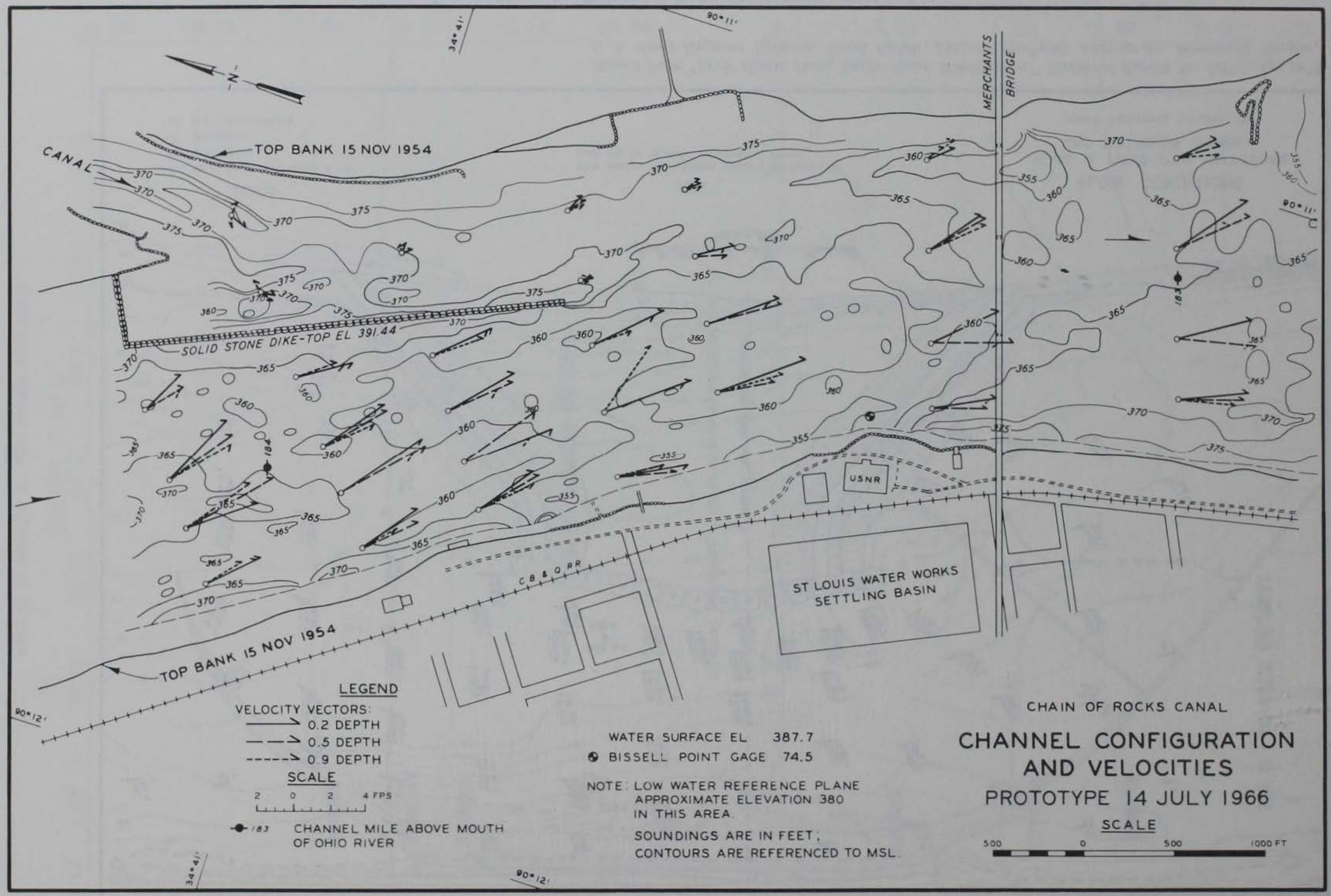


Plate 5 from "Little Goose Dam, Snake River, Washington," Technical Report No. 110-1, Apr 1975, U. S. Army Engineer Division, North Pacific, Division Hydraulic Laboratory, Bonneville, Oregon.

Figure 6. Detailed velocity distributions (sheet 1 of 3)



Unpublished

Figure 6. (sheet 2 of 3)

DIRECTION INDICATING CURRENT METER

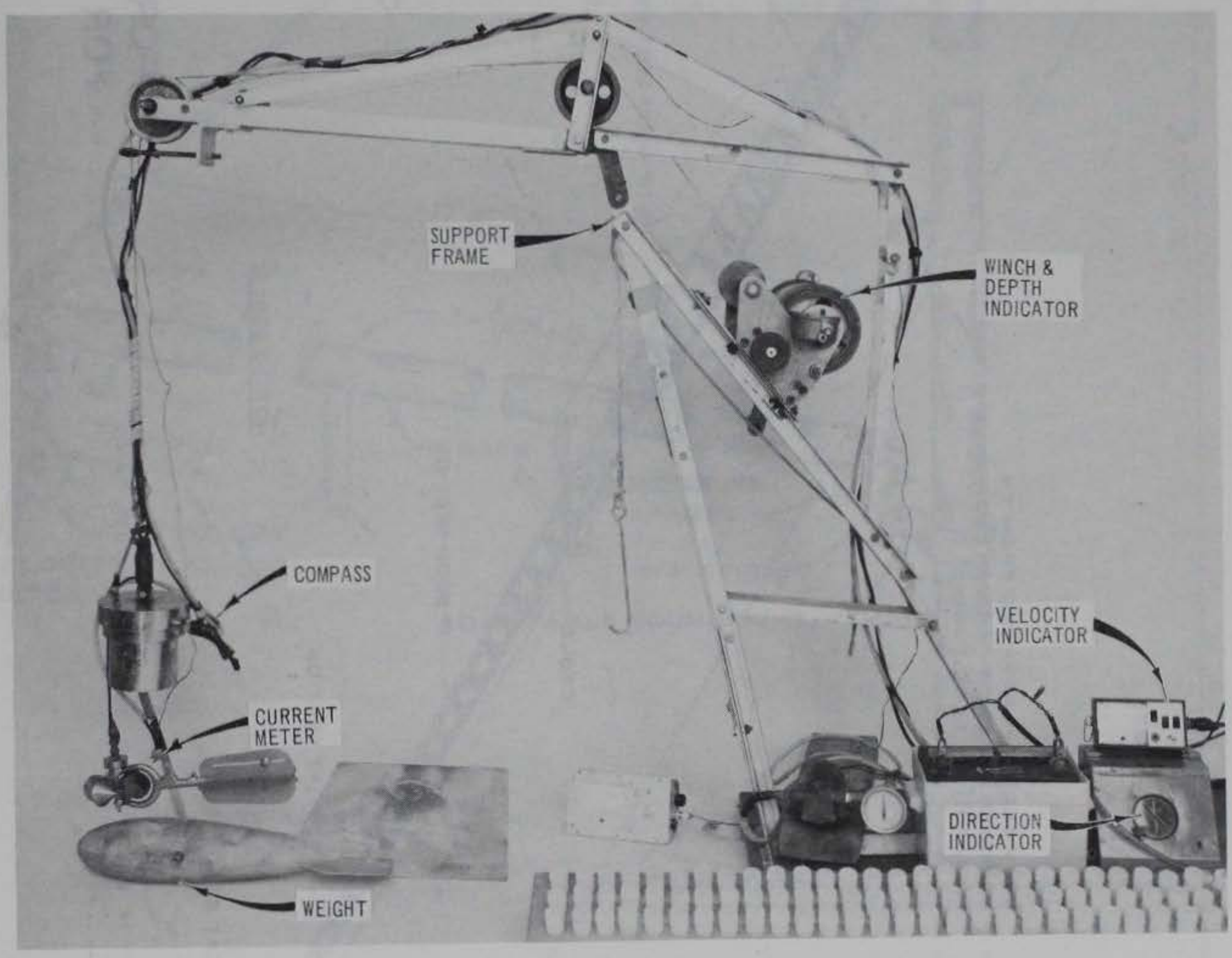
Equipment

The apparatus used for current measurement (a) consists of a current meter, a direction indicator, and a 90-lb streamlined weight, all suspended by a 3/16-in. wire rope from a support frame equipped with pulleys and a drum-type winch. The assembly is operated from a boat.

The current meter used in this survey was a direct reading Gurley Model 665. The sensing unit uses a vertical axis bucket wheel. Readout from the indicator is in feet per second, with minimum scale graduations of 0.2 fps. The meter displays linearity of ±5 percent from 0.2 to 7 fps, and error due to temperature change is approximately 0.05 percent per degree Fahrenheit deviation from 75° F. The threshold velocity is about 0.2 fps.

The direction indicator is a remote reading magnesyn compass designed by the WES such that it indicates the magnetic north azimuth of the direction from which the current is flowing. The readout device has a precision of ±2 deg, but accuracy is dependent upon the balance of the streamlined weight and the strength of current available to turn it. For currents greater than 0.5 fps, the accuracy is ±10 deg. For lower velocities, accuracy is reduced to ±25 deg, particularly when waves cause boat motion and when tidal currents slacken and turn.

The winch used to raise and lower the submerged unit operates an indicator that shows the depth of the unit below the water surface. This indicator is used to measure the total water depth and to position the current meter for each reading.



a. Instrumentation for monitoring tidal currents

Figure 6. (sheet 3 of 3)

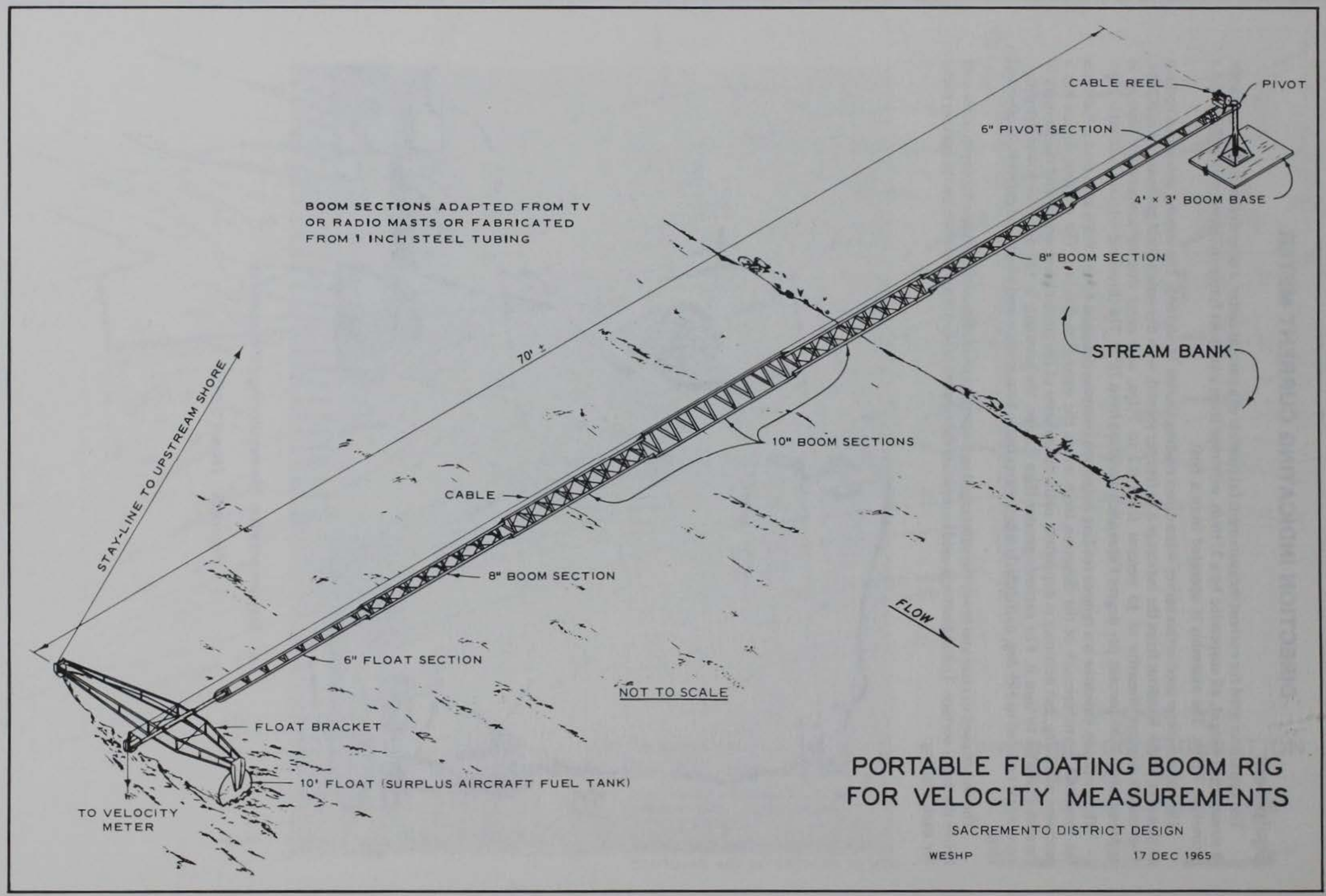


Figure 7. Portable supports for current meters (sheet 1 of 2)

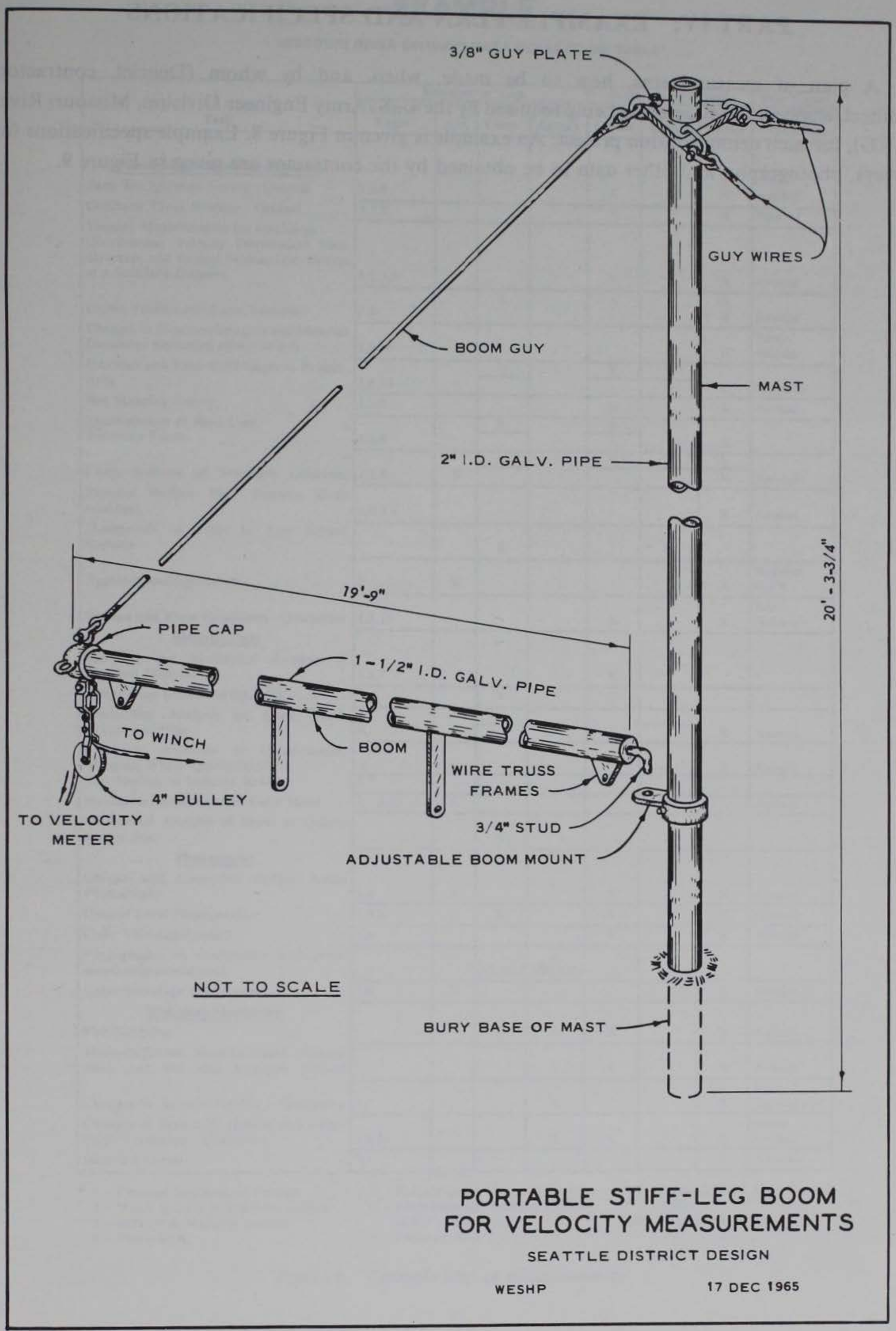


Figure 7. (sheet 2 of 2)

PART IV: EXAMPLE PLAN AND SPECIFICATIONS

A plan of measurements, how to be made, when, and by whom (District, contractor, architect/engineer (A/E), etc.), is being required by the U. S. Army Engineer Division, Missouri River (MRD), for each demonstration project. An example is given in Figure 8. Example specifications for surveys, photographs, and other data to be obtained by the contractor are given in Figure 9.

EXAMPLE

MISSOURI RIVER DIVISION DATA COLLECTION TABLE

Task	Executor of Task				Performance Period			Post Constr
	Corps of Engrs*	A/E	Gen Contr	Other Agency	Before Constr	During Constr	After Constr	Freq Period (Minimum)
Monitoring of Physical Features								
Bank-line Location Survey - General	1,3,8				X		X	Annual
Overbank Cross Sections - General	1,3,8				X		X	Annual
Velocity Measurements for Discharge Distribution, Velocity Distribution Near Structure, and Vertical Velocity Distribution at a Standard Distance	1,2,3,8				X		X	Annual
Crown Profiles and Cross Sections	3,8		X		X	X	X X	Annual
Changes in Structure Integrity and Material Durability (including effects of ice)	1,8,10						X	Semi-Annual
Establish and Read Staff Gages in Project Area	1,8,10		X		X	X	X	Monthly
Bed Mapping Survey	1,3,8				X		X	Annual
Establishment of Bank Line Reference Points	1,3,8		X		X X		X	
Cross Sections of Structure Locations	1,3,8	X	X		X	X	X X	Annual
Physical Surface Flow Patterns (float readings)	1,2,3,8						X	Annual
Dimensions of Trees in Tree Retard Systems			X			X		
Aggradation-Degradation	2	X					X	Regular Cycle
Erosion and River Conditions - Qualitative	1,8,10				X	X	X	Semi-Annual
								Annual
Material Tests								
Sampling and Mechanical Analysis of Riverbed Material	1,2,7				X			
Freeze-thaw Durability for Rock			X			X		
Mechanical Analysis for Rock, Sand, Gravel, and Clay	X	X	X			X	X	Annual
Chemical Analysis of Construction Materials When Appropriate	X	X					X	Annual
Soil Analysis of Exposed Banks	5,7				X			
Mechanical Analysis of In-Place Stone	1,7,8,10	X					X	Annual
Mechanical Analysis of Stone at Quarry and/or Site			X			X		
Photography								
Oblique and Controlled Vertical Aerial Photography	1,4	X			X	X	X	Annual
Ground Level Photography	1,3,8		X		X	X	X	Annual
Color Videotape (aerial)	1,4				X		X	Annual
Photographs (in conjunction with other monitoring procedures)			AS NECESSARY					
Color Videotape (underwater)	1,4	X					X	Annual
Biological Monitoring								
Fish Sampling				X	X		X	Annual
Micro-Organism Samples-Water, Natural Bank and Bed and Structure Surface				X	X		X	Annual
Changes in Aquatic Habitat - Qualitative	1			X			X	Semi-Annual
Changes in Terrestrial Habitat and Upper Slope Vegetation - Qualitative	1,8,10			X	X	X	X	Semi-Annual
Interview Locals	X						X	Annual

* 1 - Channel Stabilization Section
2 - Water Quality & Sediment Section
3 - Surveys & Mapping Section
4 - Photo Unit
5 - Foundation & Materials Branch
6 - Environmental Analysis Branch
7 - MRD Laboratory
8 - Florence Area
9 - Lewis & Clark Lake Project Office
10 - North Dakota Area

Figure 8. Example plan of measurements

EXAMPLE

MRD Specifications for Monitoring by Contractor

SECTION 2J — MONITORING AND DOCUMENTATION

1. SCOPE: This Section covers the special procedures and materials required to adequately monitor and document the experimental and developmental aspects of the various structures.

2. CROSS SECTIONS:

2.1 *General*: Closely spaced and carefully monumented cross sections are required for each structure constructed under this contract. It is anticipated that measurements will be repeated regularly along these sections for a period of at least 5 years. The Contractor is responsible for establishing, documenting, and obtaining initial measurements for these cross sections, as specified below.

2.2 *Locations*: Each cross-section location shall be selected by the Contractor, subject to the approval of the Contracting Officer. Sites shall be selected to provide data of maximum value. For example, sections should be located at structure extremities, and adjacent to and on either side of obvious topographic changes, and on each end of transition zones between structure types. At a minimum, sections shall be located at the following *intervals*:

Hardpoints — root sections, 25 feet or less (3 minimum) oriented perpendicular to the root alignment; and 1 following the structure alignment or center line from the landward end of the root and extending riverward past the terminus.

Composite and Windrow Revetment — 50 feet or less, oriented perpendicular to the riverbank.

Refusals — 50 feet or less, oriented perpendicular to the refusal alignment.

Tree Retard Roots — 1 parallel and 1 perpendicular to the bank line.

Vane Dikes — 1 section along the structure alignment and 3 sections perpendicular to the structure alignment (with 1 at each end and 1 at the midpoint).

2.3 *Extent*:

2.3.1 Cross sections perpendicular to refusal or root alignment shall extend away from the structure only as far as necessary to completely measure the excavation, stone fill, and backfill.

2.3.2 Cross sections perpendicular to the riverbank shall commence as near as possible to the landward side of the structures and shall extend riverward 100 feet from the intersection of the Construction Reference Plane and the structure for composite revetments, hardpoints, or tree retard roots.

2.3.3 Sections for Windrow Revetment shall commence as near as possible to the landward side of the structure and extend riverward 100 feet from the intersection of the CRP and the existing bank.

2.4.4 Vane dike sections, both perpendicular and parallel to the structure alignment, shall extend from the high bank to 100 feet past the structure.

2.4 *Monumentation*:

2.4.1 Controlling points, as described below, for each cross section shall be marked with a wooden or metal post that contains an identifying number or code. The identifying mark must be embossed on the post or may be a metal tag rigidly attached to the post. The bottom of the post shall be buried a minimum of 3 feet and the top shall be a minimum of 2-1/2 feet above the adjacent ground. The post code may be a simple numeric sequence. A log will be kept that indicates, for each post, the pertinent structure number; the position of the post relative to the structure; and the absolute position of the post relative to permanent or semipermanent features in the vicinity, and preferably landward of the post. The positioning method(s) must be adequate to allow simple reestablishment of any or all posts, as necessary, 5 years after construction is completed, and to within 2 feet of the original position.

2.4.2 Posts shall be placed as follows:

2.4.2.1 On each end of each section perpendicular to roots and refusals; or on extensions of such cross-section lines a sufficient distance to prevent damage from construction operations or other identifiable hazards.

2.4.2.2 The landward end and alignment of all cross sections perpendicular to the river and all vane dike sections shall be marked by 2 posts placed 10 feet apart along the selected cross-section line.

2.5 *Survey Procedures*:

2.5.1 The terrestrial portion of the survey can proceed in any suitable manner that will permit accurate measurement of the location along the cross section of visible changes in natural or excavated slopes, and the accurate measurement of relative elevations at each such slope change.

2.5.2 The hydrographic procedure used to complete cross sections across water areas shall include the following features:

— a recording sonic sounder that produces a continuous strip chart recording of the riverbed, and which chart can be marked upon during the sounding operation.

— sufficient instrumentation and methods to assure that the boat stays on the cross-sectional alignment and to determine the distance within 5 feet from the section origin to the boat at any time during the sounding operation.

— in shoal areas, wading techniques may be necessary.

— an accurate measurement of the relative bed elevation shall be obtained every 25 feet or less along the section.

Figure 9. Example specifications for monitoring by contractor (sheet 1 of 3)

2.5.3 The Contractor shall be required to place a single pile in the river at three locations to serve as a base for staff gages. Each pile may be creosoted wood, with 8 in. nominal diameter, or other with the approval of the Contracting Officer. Each pile will be placed at a location designated by the Contracting Officer. The locations shall be in water depths of 5 to 15 feet below CRP. Each pile shall penetrate the riverbed at least 15 feet and shall extend at least 7 feet above CRP. The Government shall be responsible for fabricating the gage and positioning it properly on the Contractor-provided pile. The gage will permit the simple determination, at any time, of the water-surface elevation, msl. This, in turn, will facilitate computation of bank line, structure, and riverbed elevations, msl.

2.5.4 The results of the cross-sectioning shall be furnished to the Contracting Officer as follows:

— a clear, accurate, neat sketch, on graph paper, of the section; scaled to 1″ = 20′ horizontal and 1″ = 5′ vertical. Elevations shall be indicated relative to msl.

— all field notes and sonic sounding charts.

2.6 *Survey Sequence*:

2.6.1 Prior to any excavation or stone placement, at least 1 of the 3 gage piles, requiredabove, must be set or a temporary gage established to monitor water-surface fluctuations.

2.6.2 Prior to any construction activity, except clearing, the cross-section monuments must be established for that structure and a set of complete cross sections taken.

2.6.3 Partial or complete sections will be obtained, as necessary, to accurately document the following phases:

— the lines and grades of all excavations immediately prior to placement of stone or other protective materials.

— the lines and grades immediately after placement of protective materials, including underwater portions of composite revetment toes and hardpoint spurs.

— lines and grades following backfilling and grading.

2.6.4 The remaining 2 gage piles, specified above, will be placed when directed by the Contracting Officer prior to completion of the contract construction requirements.

2.6.5 A complete set of cross sections will be obtained for all sections extending into the river immediately after completion of the contract construction requirements.

2.7 *Submittals*:

2.7.1 The results of cross-sectioning, as specified in paragraph 2.5 above, shall be submitted to the Contracting Officer within 10 working days after the data are obtained.

2.7.2 The log of monuments, specified in paragraph 2.4 above, will be submitted to the Contracting Officer within 10 working days after establishment of the last monument.

2.8 *Measurement and Payment*: There will be no separate measurement for cross sections. All costs shall be included in the contract lump sum price for "Cross Sections," which price shall constitute full compensation for all costs of the labor, equipment, and materials for establishing the monuments, gage pile, and cross-section monuments and obtaining and processing of the cross-section surveys.

3. CONSTRUCTION PROGRESS PHOTOGRAPHS:

3.1 *Scope*: The work covered by this Section consists of construction progress photographs, as specified herein.

3.2 *Type*: All photographs shall be taken in color and shall be sharp, clearly showing detail. The Contractor shall furnish negatives and proof prints of a size not less than 3-1/2″ × 4-3/4″ and an 8″ × 10″ enlargement of each negative. Photos and negatives shall be furnished in individual protective covers to the Contracting Officer, as they are processed.

3.3 *Location and Frequency*:

3.3.1 *Material Acquisition Sites*: Photographs shall be obtained of the rock and gravel when stockpiled for each gradation test, at the quarry site and the jobsite. The photographs shall provide sufficient detail to permit differentiation of the individual particles. The field of view shall include a 1-foot (minimum) interval of a rod, graduated to tenths-of-feet or smaller, for dimensional reference.

3.3.2 *Windrow Revetment*: Photographs shall be obtained of the upstream and downstream ends and at 500-foot intervals for each revetment segment longer than 1000 feet. For revetment segments less than 1000 feet in length, photographs shall be obtained for the upstream and downstream ends and at the midpoint of the segment. All photographs, except at the downstream end, shall be oriented in the downstream direction, and at the downstream end, they shall be oriented upstream. The photographs shall be taken prior to any clearing, excavation, stone placement, and backfilling, and after backfilling and grading.

3.3.3 *Composite Revetment*: The location of photographs for Composite Revetment shall be the same as specified in "Windrow Revetment." The photographs shall be taken before any clearing, before and after excavation of the upper bank slope, and after placement of stone and upper bank paving. A photograph of the upper bank paving shall be obtained at each location with the detail and dimensional reference as specified in "Material Acquisition Sites."

3.3.4 *Hardpoints*: Photographs shall be obtained at each hardpoint location. The photographs shall include the bank line prior to construction; the root trench after excavation; the completed structure, taken along the structure azimuth line; and the structure and downstream bank line, taken parallel to the bank line.

3.3.5 *Tree Retards*: Photographs shall be obtained for each tree retard system. Photos shall include the bank prior to any clearing; each "tree" and root and adjacent bank line immediately after placement; and the retard system and downstream bank line, taken parallel to the bank.

Figure 9. (sheet 2 of 3)

3.3.6 *Vane Dikes*: Photographs shall be obtained for each vane dike and shall include 3 photographs taken along the structure azimuth line in a landward to riverward direction; prior to, during, and after stone placement.

3.4 *Photograph Identification*: Each photograph shall be identified on the backside by date, project name, contract number, structure number, and station, when appropriate.

3.5 *Measurement and Payment*: There will be no separate measurements for photography. All costs shall be included in the contract lump sum price for "Photography," which price shall constitute full compensation for all costs of labor, equipment, and materials for obtaining the required photography.

4. SPECIAL RECORDS:

4.1 *Material Application Rates*:

4.1.1 All material measured and paid "per ton" shall be carefully monitored during placement in structures. The Contractor must maintain a log that records the quantity of material placed in each 50-foot (or shorter) increment of structure length. This special accounting will be accurate to the nearest 1/2 ton for each increment. This log will clearly identify the structure number, the structure stationing, date of material placement, source of material, and quantity.

4.1.2 To facilitate measurement of material placed by floating plant, all barges used to deliver construction material on the jobsite shall conform to the following requirements:

4.1.2.1 Each barge shall be suitably marked with paint of a contrasting color at each of three displacement gaging points along each side of the barge. The marks shall be perpendicular to the edge of the barge, 4 inches wide and 1 foot in length, painted on both the deck and side at three equally spaced points beginning at the rake. The barge name or number shall be affixed to the deck and sides of the barge, both fore and aft, and shall be of sufficient size and legibility so as to be plainly seen and read.

4.1.2.2 *Barge Displacement Tables*: The Contractor shall furnish to the Contracting Officer a barge displacement table not less than 10 working days prior to unloading material from any barge for which displacement tables have not been previously furnished and approved. The table shall be certified accurate by a person or firm, other than the Contractor, accustomed to performing this service and approved by the Contracting Officer. Barge tables furnished shall contain, in parallel columns, the draft of the barge in feet and tenths from zero to the full depth of the barge, and the corresponding gross displacement to the nearest ton. Tables submitted shall show the name or number of the barge, the barge dimensions, the barge owner, the name of the manufacturer, and the certification of the person or firm preparing the table. The Contractor shall furnish with the barge displacement table a drawing or sketch of each barge, dimensioned in sufficient detail to permit checking of the tables. The drawing shall show as a minimum the length, width, and depth of the barge and dimensions of rake or rakes, including radius, origin of radius, and headlog dimensions.

4.2 *Tree Retards*: Special measurements for tree retards will be recorded in a log, as follows:

— the length, width, and depth of the deadman anchor excavation.

— the length, shape, and weight of the deadman.

— the weight of stone placement in each root in the nearest 1/2 ton.

— the source, length, diameter, and relative location of each "tree."

— the approximate length of the horizontal and vertical anchor cables for each retard element.

— the depth of water at the riverward end of each retard element.

4.3 *Submittals*: The above-described logs will be available for review by the Contracting Officer for the duration of the contract and will be submitted to the Contracting Officer upon completion of all construction work. Barge displacement tables shall be submitted to the Contracting Officer not less than 10 working days prior to unloading construction material from barges.

4.4 *Payment*: No separate payment shall be made for maintaining the logs specified in this paragraph. All cost incidental to this work will be included in the applicable contract prices.

Figure 9. (sheet 3 of 3)

PART V: EXAMPLE DEMONSTRATION PROJECT PERFORMANCE REPORT

The purpose of this Example Report is to illustrate the general format and minimum detail of information desired for overall review and evaluation of the many protection methods to be tested at nearly a hundred demonstration projects. The Outline following the Example Report lists information (if available) to be covered in the reports. These reports will be reproduced in appendices to the final report to Congress.

The Example Report has been compiled from excerpts from similar existing reports* and from comments by the Steering Committee on the original working draft. A report on an actual project will be distributed as soon as available to serve as further guidance in preparing project reports. Initial draft reports on all projects as of the end of construction would supply considerable data needed in the laboratory research work and would reduce the problem of lost or forgotten details.

Inasmuch as these many and varied individual reports will be incorporated into the final report, their preparation in accordance with accepted, though perhaps differing, standards and format will minimize later reworking. In the absence of specific Division or District guidance, the following WES Instruction Reports on report preparation are suggested:

a. U. S. Army Engineer Waterways Experiment Station, CE, "Guide for Preparation of Waterways Experiment Station Technical-Information Reports," Instruction Report 0-74-1 (2d ed.), Dec 1975, Vicksburg, Miss.

b. U. S. Army Engineer Waterways Experiment Station, CE, "Guide for Effective Engineering Graphics, Waterways Experiment Station," Instruction Report 0-77-1, Mar 1977, Vicksburg, Miss.

The plates in this Example Report have been reduced in size to conserve space. Full-page plates would be preferred in the actual report.

---

* See, for example: "Report on Measures for Bank Protection, Project CWI 509-b; Salinas and Pajaro Rivers, California," Jun 1954, U. S. Army Engineer District, San Francisco, San Francisco, Calif.

EXAMPLE

Section 32 Program Streambank Erosion Control
Evaluation and Demonstration Act of 1974

SALINAS RIVER AT KING CITY, CALIFORNIA
DEMONSTRATION PROJECT PERFORMANCE REPORT

I. INTRODUCTION

1. Project Name and Location. King City Protection Works, Salinas River - mile 66, King City, California. Plate 1 shows location map.

2. Authority. Streambank Erosion Control Evaluation and Demonstration Act of 1974, Section 32, Public Law 93-251.

3. Purpose and Scope. This report describes a bank erosion problem, the type(s) of bank protection used, and a performance evaluation of a demonstration project on the Salinas River, California, constructed and monitored by the San Francisco District.

4. Problem Résumé. The right bank, upstream of U. S. Highway 101 bridge, was eroding at a rate of 1 to 2 feet per year. The bridge approach was threatened (Plate 2). The high bank land is 40 feet above the streambed and is not subject to inundation. However, it is near the town of King City; and eventually, if urban growth continues, the land could be developed into residential property valued at $2000 per acre (1977 prices).

II. HISTORICAL DESCRIPTION

5. Stream.

a. Topography. The Salinas River drains an area of valley and mountain land situated on the western slopes of the Coast Range of California. The river flows in a northwesterly direction from its source and empties into Monterey Bay. The San Benito River Basin lies east of the Salinas River and is separated from the Salinas by the

Gabilan Mountain Range with elevations to 3000 feet. The Salinas River Basin is separated from the Pacific Ocean by the San Lucia Range which reaches elevations approaching 5000 feet (Plate 1). Between the foothills of the mountain ranges, the river flows through relatively level alluvial valley, which is well suited to agriculture. River slopes of the Salinas River vary between 1.0 to 6.0 feet per mile, and the valley floor ranges in elevation from 10 feet near the mouth to 400 feet near King City (Plate 3).

b. Geology. The study area is a physiographic province of the Salinas River Alluvial Valley and a subprovince of the Pacific Coastal Plain. A number of low meander belt ridges subdivide the delta area into several smaller basins. The land surface, which is generally flat and low lying, is characterized by floodplain and meander belt topography. Alluvial material produced by several depositional environments, underlain at various depths by a sandy alluvial substratum, covers the entire Salinas River Basin. The alluvium is underlain by several formations of Tertiary age. The valley wall and the upland area to the east consist of highly erodible Pleistocene loess and Tertiary deposits which are thoroughly dissected, well drained, and rise abruptly more than 100 feet above the alluvial plain. The topstratum, which forms the topsoil of almost the entire Salinas Basin, consists of clays, silty and sandy clays, sandy silts, and poorly graded, fine-grained, silty and clayey sands. Immense variation in lithology is characteristics of the topstratum because of the many different environments in which the material has been deposited. The topstratum has received extensive study and the types of material associated with the various environments of deposition are fairly well known and mapped. The most common environments of deposition are point bar, backswamp, abandoned channel, abandoned course, natural levee, and braided relict alluvial fan. Typical borings of the alluvial topstratum deposits are given in Plate 4.

c. Hydrologic Characteristics. The Salinas River Valley is in a region of temperate climate with the growing season extending throughout 12 months of the year and freezing temperatures occurring rarely. The seasonal distribution of rainfall typical of Central California causes

the valley to be semiarid. The total annual precipitation is low with the months of May to October being particularly arid. The streams are essentially without flow throughout this six-month summer period and irrigation is required. Average annual precipitation in the Salinas Valley varies from 10.3 inches at King City and 13.0 inches at Salinas to 50 inches or more at the high elevations (Plate 5). Runoff in the Salinas River is characterized by flash-type floods with high-flow durations of 2 to 4 days. In general, all major floods have occurred during the period January through March and all high water has been limited to December through May. Mean annual runoff, as measured at the gaging station near Spreckels, amounted to 1.7 inches during the period of record, 1930-1952. The maximum recorded discharge of 75,000 cfs occurred on 12 February 1938. The hydrograph of this flood and a typical minor flood are shown in Plate 5. Below Spreckels, the stream derives some flow throughout the summer from irrigation, return seepage, and effluents from the Salinas sewage treatment plants. Above Spreckels, the riverbed is arid during the summer. Such flow as may exist in the tributaries disappears into the gravel cones located at the confluence of these streams with Salinas River. This percolation aids recharging the underground water table. Occasionally, a small amount of flow occurs in the upper reaches near King City due to releases from Salinas Dam.

d. Channel Conditions. Moderate flows in the Salinas River cause a braided channel (Photo 1). Moderate flows are contained in multiple, interconnected channels that meander throughout a wide sandy bottom varying in width from one-quarter to three-quarters of a mile. Higher flows completely fill these braided bottoms from bank to bank. High flows inundate the adjoining first-bench areas. The first-bench lowlands are generally brush-covered and are used as scrub pasture or lay idle. In a few cases, the first-bench lands are cultivated. Throughout the period of May to December the riverbed is dry or very nearly dry. During this period prevailing upstream winds form the dry sands into dunes along the river bottom. The dunes sometimes influence the course of streamflow the following winter season. At some locations the

dunes encroach upon cultivated lands.

e. Environmental Considerations. The bank protection plan is not anticipated to result in any losses of forest game habitat within the area. The stabilization program includes vegetative works on top bank areas which are now raw earth. The vegetation is considered beneficial since it improves habitat for wildlife and improves the scenic character of the stream. In addition, the trend toward a stabilized geometry of the alluvial river should result in a deeper channel with more pools which will have a beneficial effect on the fish habitat. Furthermore, the project is not anticipated to affect the water quality in the Salinas River.

6. Demonstration Site - Test Reach.

a. Hydrologic Characteristics. The hydrologic characteristics are as previously stated. The nearest gaging station is located at Spreckels approximately 50 miles downstream. Plate 6 is a table summarizing the natural flow characteristics of the Salinas River at the Spreckels gage.

b. Hydraulic Characteristics. Flood flow velocities in Salinas River range from 4.0 to 4.5 fps at discharges of about 15,000 cfs to 8.0 to 9.0 fps at discharges approaching 75,000 cfs. The velocity ranges are based on the mean cross-sectional velocity as determined from discharge measurements at the Spreckels gaging station, channel cross sections at three locations along the test reach (Plate 7), and high watermarks. Similarly, Plate 6 shows the stage-discharge relation at the downstream section of the test site. Velocity distribution within the channel cross section is unknown.

c. Riverbank Description.

(1) Bank Materials. Materials composing the banks and valley floor of the Salinas River are classified as loams with small deposits of sand and clay. The loams in the vicinity of King City include the Kettleman, Lockwood, Diable, and Rincon series. Some of the lower newly formed banks consist of loose sand with very little cementing. Soil classification for bank material is given in Plate 8. The samples were obtained from auger test borings at the locations indicated in Plate 4.

(2) Normal Bank Vegetation. Vegetation cover on the banks

consists of grasses, willows, baccharis, cottonwood, and various other shrubs and quick-growth trees. Except in a few isolated locations, summer flow in the vicinity of King City is insufficient to encourage or support growth in the streambed.

(3) Bank Erosion Tendencies. The test site (Plate 2) had been eroding at a rate of approximately 1 to 2 feet per year for the past several years. Plate 9 shows the successive bank line as taken from aerial photographs. The flood of record in 1938 caused the most damage with the bank line receding approximately 4 feet during the flood. After, and sometimes during, flood or high water, individual owners have installed revetment works. These revetment works that have been installed over the past three or four decades, have demonstrated a measure of success, and are tabulated in Plate 10.

III. DESIGN AND CONSTRUCTION

7. General. The high bank at the King City site and the threat to the highway bridge approach warrant a heavier type of bank protection than has been previously used by local landowners along the Salinas River. The highway department had used a steel-frame tetrahedron scheme downstream on a similar problem with reasonable success. The scheme consisted of pyramids, fabricated from steel rails, covered with mesh wire, and anchored in place along the riverbank with steel cable.

8. Basis for Design. The primary reasons for selecting the steel frame tetrahedron were its initial low cost and its proven effectiveness for a similar problem. The structural members could be constructed from scrap material that was readily available at a low cost. The use of scrap material, having no fixed specifications, fixed the design on a cut-and-try basis rather than according to standard engineering practices. The intended function of the tetrahedrons was to trap debris carried by the river during floods, thus forming a barrier that would retard or deflect the high-velocity flow away from the riverbank. Furthermore, the structure would serve as a sediment·trap and build up the area between the tetrahedrons and the bank, thus encouraging the growth of trees and other vegetation.

9. Construction Details. The tetrahedrons (Plate 11) were constructed of six 30-foot lengths of used 60-pound steel rail. The rails were bolted together at the ends to form a pyramid with a triangular base. From the midpoint of each upright rail, another section of rail was attached that connected to the midpoint of the opposite base side. The three inside-bracing rails were connected together at the point where they crossed in the center of the tetrahedron. All four faces of the tetrahedron were covered with wire mesh. The tetrahedrons were placed in the desired pattern, and longitudinal cables connecting the apexes and bases of the tetrahedrons were installed. At the King City site, 39 of the tetrahedrons were arranged in one line on 30-foot centers extending upstream from the bridge and parallel to the bank. Plate 12 illustrates the layout of the tetrahedrons while Photos 2, 3, and 4 are views from the bridge (looking upstream) at the site before, during, and after construction, respectively.

10. Cost. The total cost of fabrication and installation of the steel tetrahedrons amounted to $8,400 or approximately $10 per bank-foot. However, if new material had been used, the estimated cost would have been $21,000, or approximately $25 per bank-foot.

IV. PERFORMANCE OF PROTECTION

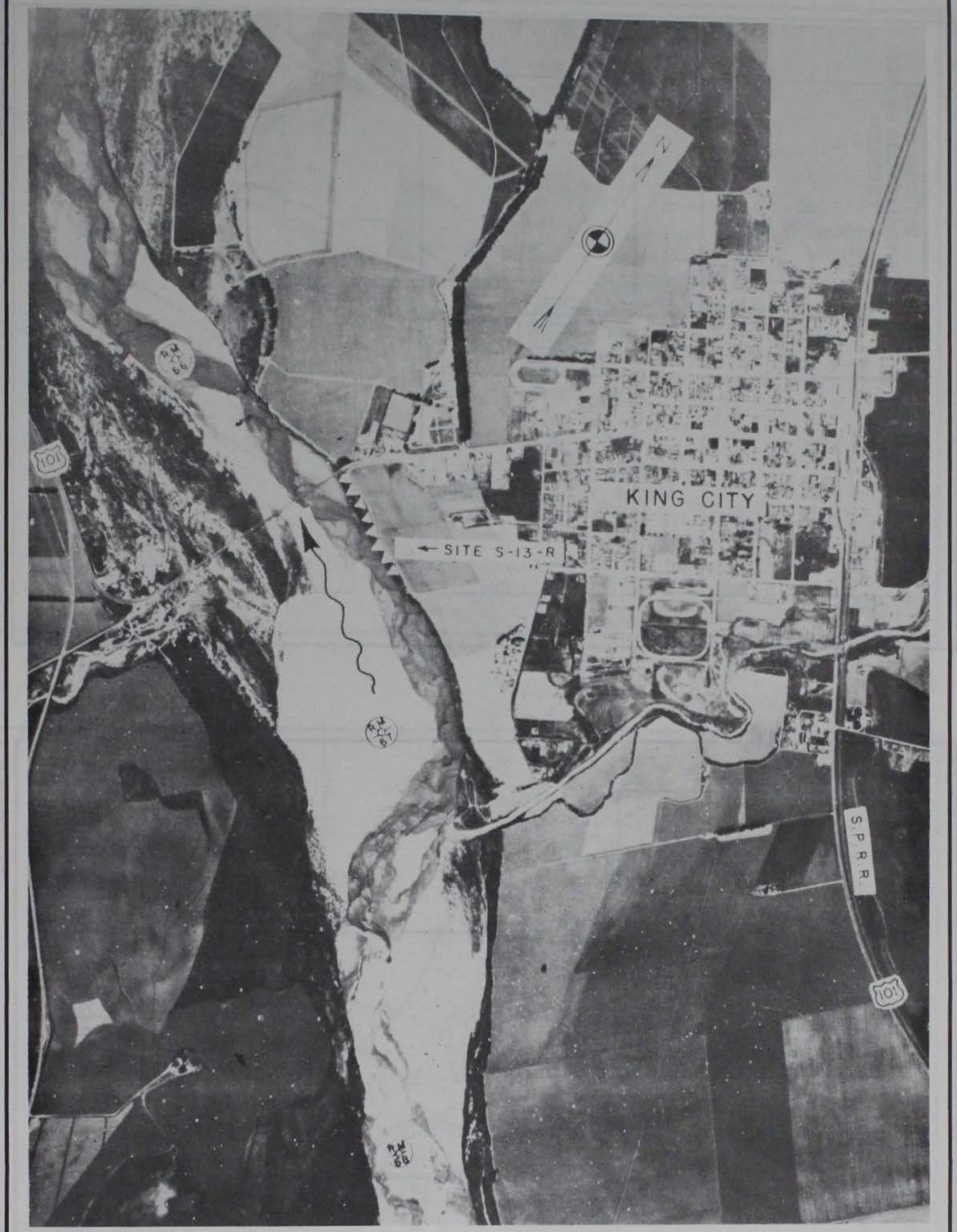
11. Monitoring Program. The elements of the monitoring program are summarized in Plate 13. The site was monitored for three winter seasons. Baseline surveys were made immediately after construction (horizontal and vertical control points established), and subsequent surveys were made in the spring following the high-water period. Plate 14 illustrates the results of these surveys showing the change in the top of bank line and the bank profile of three locations along the test reach. Water-surface elevations of each high-water event during the monitoring period were recorded and these are plotted in Plate 14. The average flow velocity shown in Plate 14 was computed from the recorded discharge at the Spreckels gaging station. The largest event occurred the third year after construction and a field party was organized to collect flow

velocity data during the peak flow. The results of the velocity distribution measurements are shown in Plate 15 and illustrate that the higher velocity flow has been diverted away from the bank, reducing the current velocity attack along the test reach. Ground level photographs were taken during each inspection trip and Photos 5-9 show in chronological order the effectiveness of the protection works. Aerial photographs taken each year after the high-water season indicated that the bank line was stabilized. Material samples were also obtained after each winter season and the results of the mechanical analysis of each sample are given in Plate 8.

12. Evaluation of Protection Performance. The largest flood on record which occurred in February 1973 created the need for the protection described in this report. Subsequent to the 1973 flood and installation of the tetrahedron protection, only one damaging flood (1975) occurred during the monitoring period. The protection has been effective. The opinion that steel-frame tetrahedrons are effective is predicated upon their ability to resist a flood of the magnitude of 1975. Photos 5-9 show that the channel has continued to follow along the bank with no additional erosion and that heavy growth has completely covered the tetrahedrons. The new forming bank, and the original eroded bank, have provided extremely stable bank.

13. Reconstruction. None was required.

14. Conclusion. The effectiveness of the steel-frame tetrahedrons has been demonstrated at the King City site for one moderate flood (frequency of 13 years). An essential feature in bank protection works as set forth by this demonstration project is the value of a protective growth of vegetation. Therefore, subsequent bank protection projects on the Salinas River should include a planting feature in the plans with supplemental irrigation, if needed, to assure successful growth.



SCALE IN FEET

1000 0 1000 2000 3000 4000 5000

PHOTO 1

PHOTO 2. LOOKING UPSTREAM BEFORE CONSTRUCTION
DATE: _____

PHOTO 3. DURING CONSTRUCTION
DATE: _____

PHOTO 4. AFTER CONSTRUCTION
DATE: _____

VIEW OF DEMONSTRATION SITE FROM BRIDGE, LOOKING UPSTREAM

PHOTOS 2-4

PHOTO 5
DATE: _____

PHOTO 6
DATE: _____

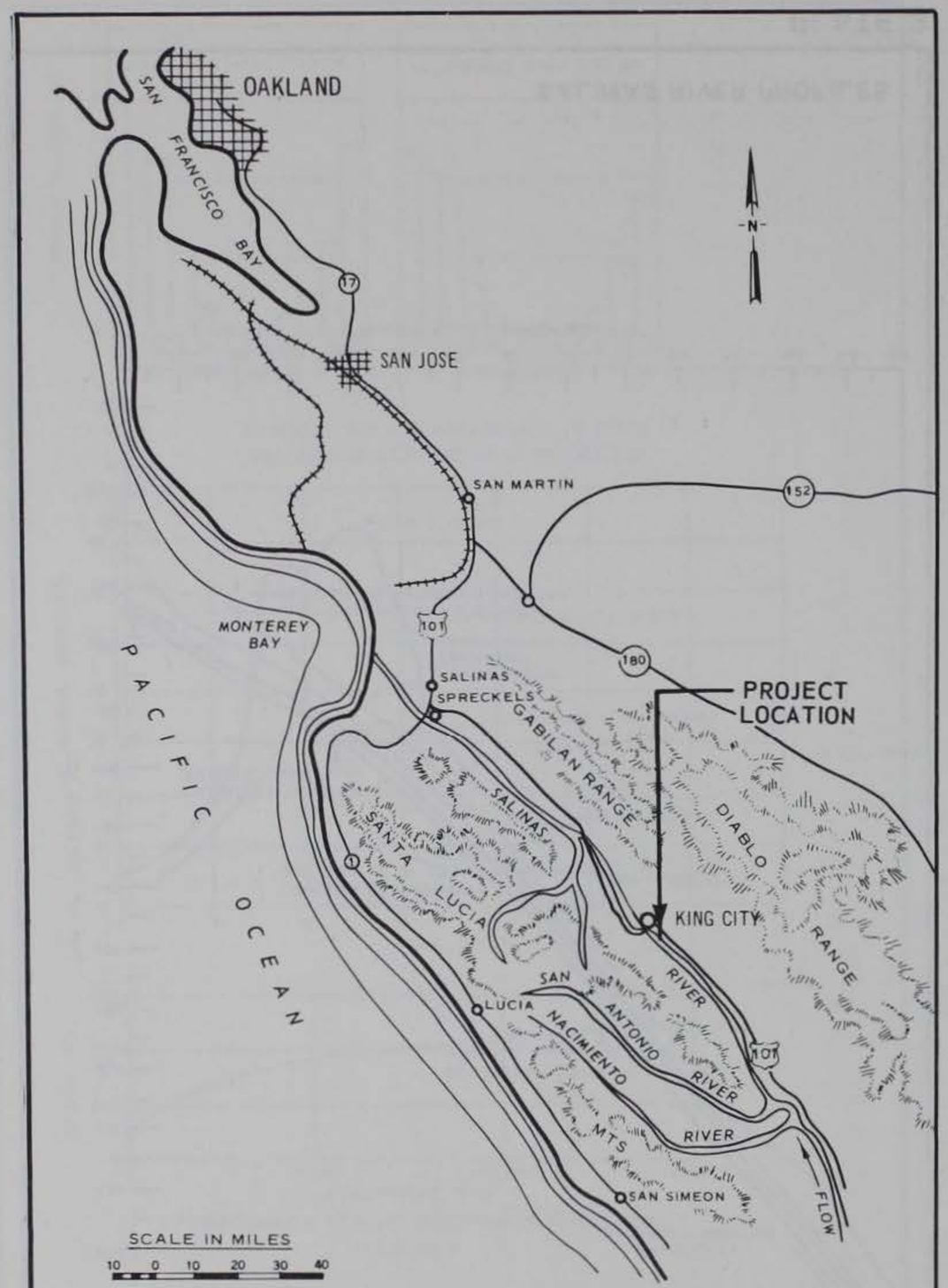
PHOTO 7
DATE: _____

PHOTO 8
DATE: _____

PHOTO 9
DATE: _____

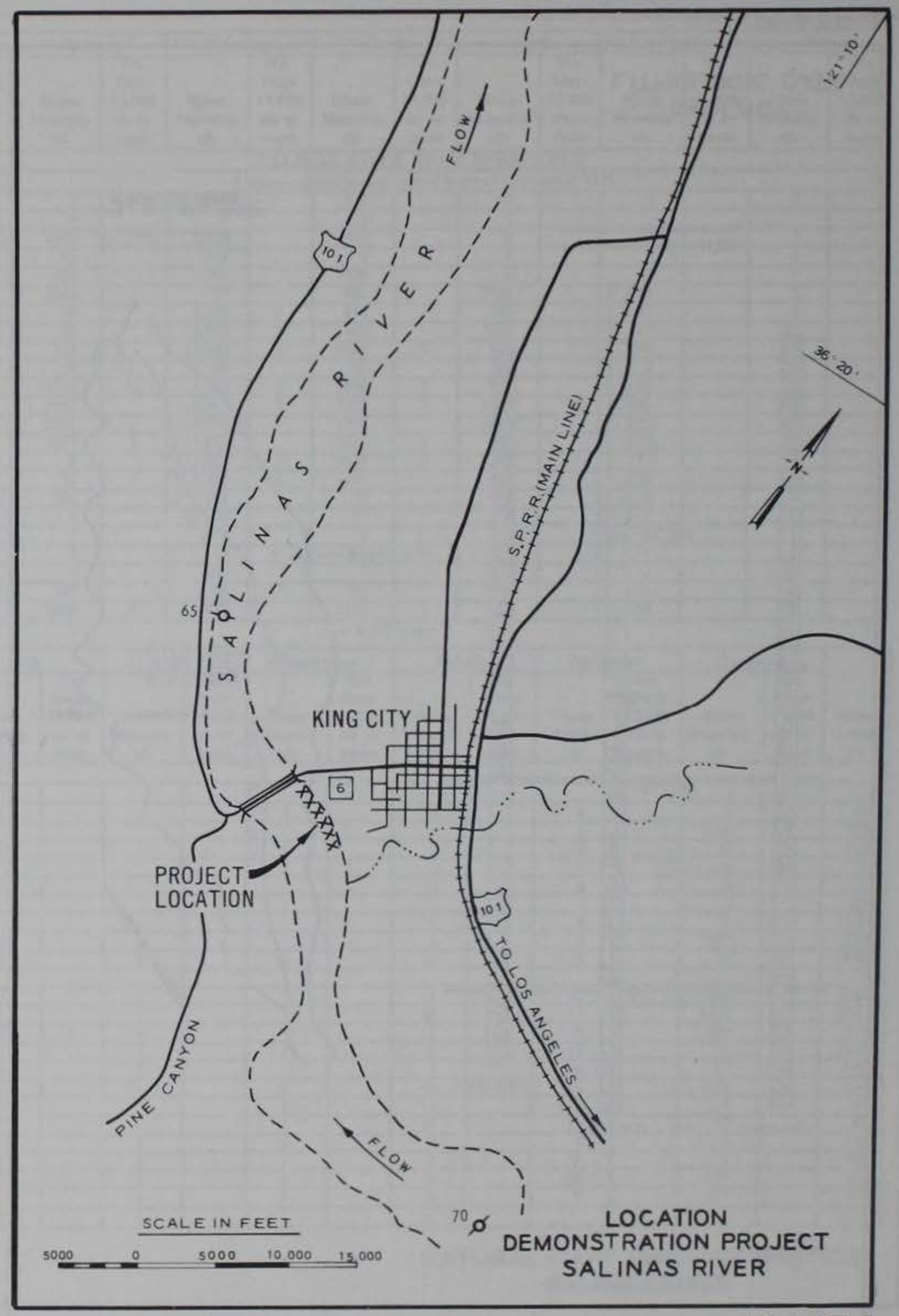
PHOTOS SHOWING EFFECTIVENESS OF PROTECTION

PHOTOS 5-9



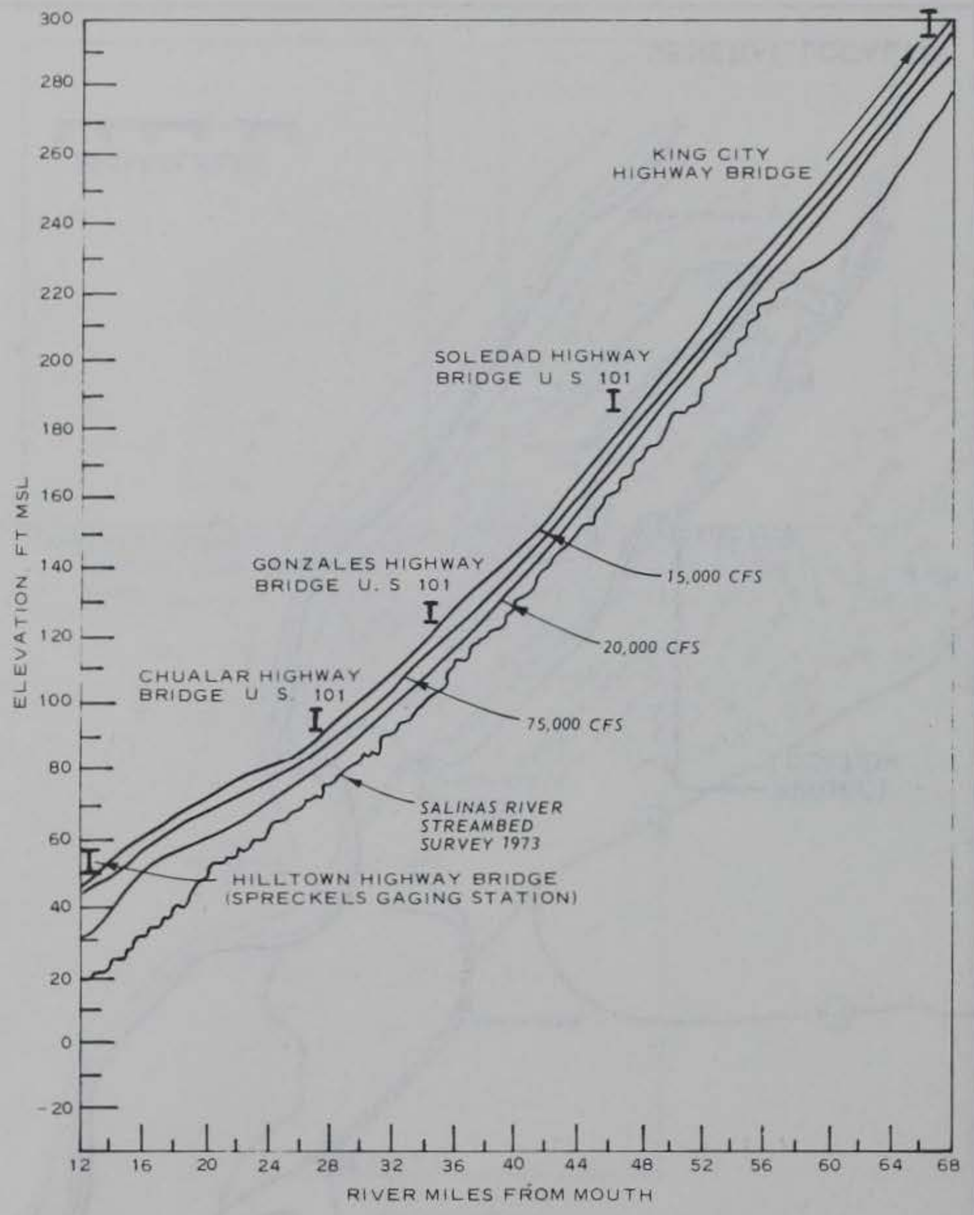
GENERAL LOCALITY

PLATE 1



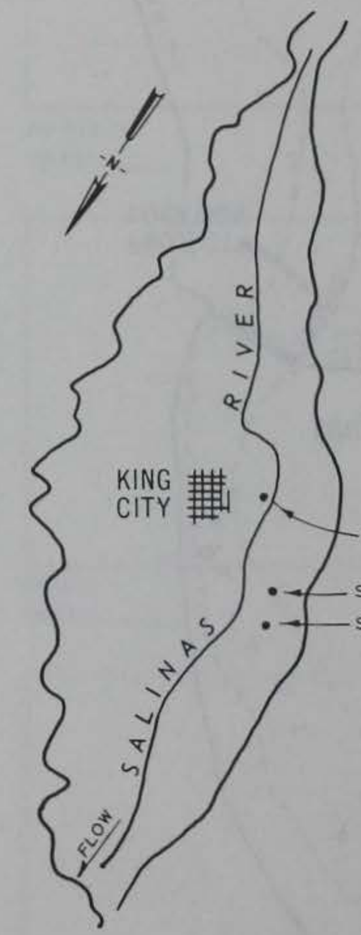
LOCATION
DEMONSTRATION PROJECT
SALINAS RIVER

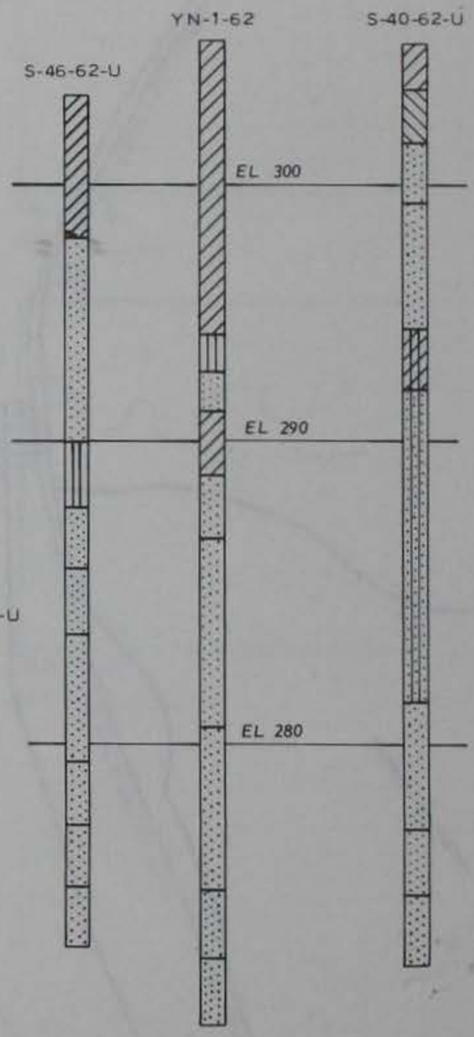
PLATE 2



SALINAS RIVER PROFILES

PLATE 3





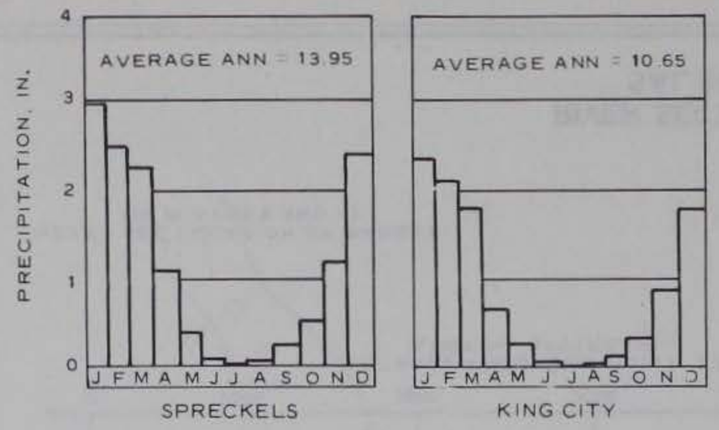
SCALE IN FEET

5000 0 5000 10 000

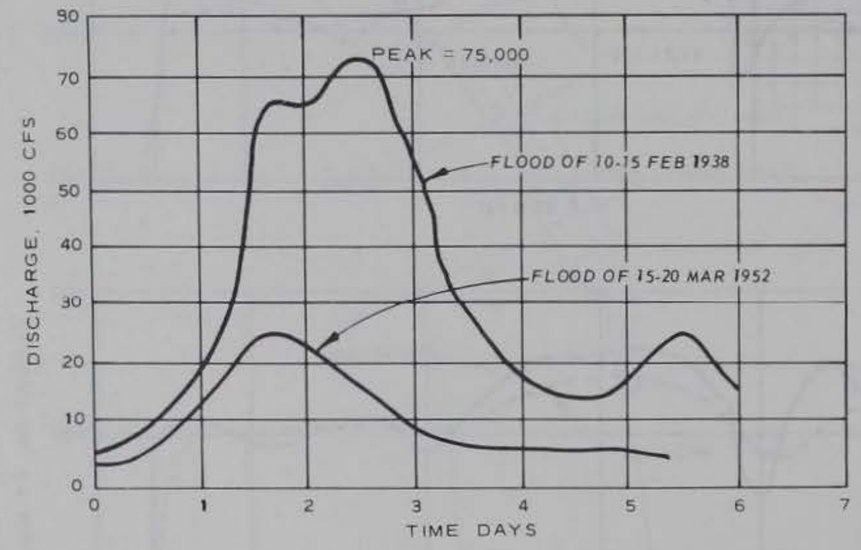
TYPICAL BORINGS

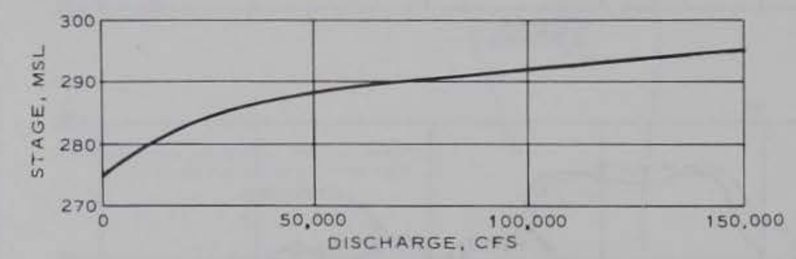
GEOLOGY
LITHOLOGIC DATA

PLATE 4



TYPICAL MAJOR AND MINOR FLOODS
SALINAS RIVER (NEAR SPRECKELS)





APPROXIMATE STAGE–DISCHARGE RELATION
MILE 66.5

HYDROLOGIC CHARACTERISTICS
SALINAS RIVER

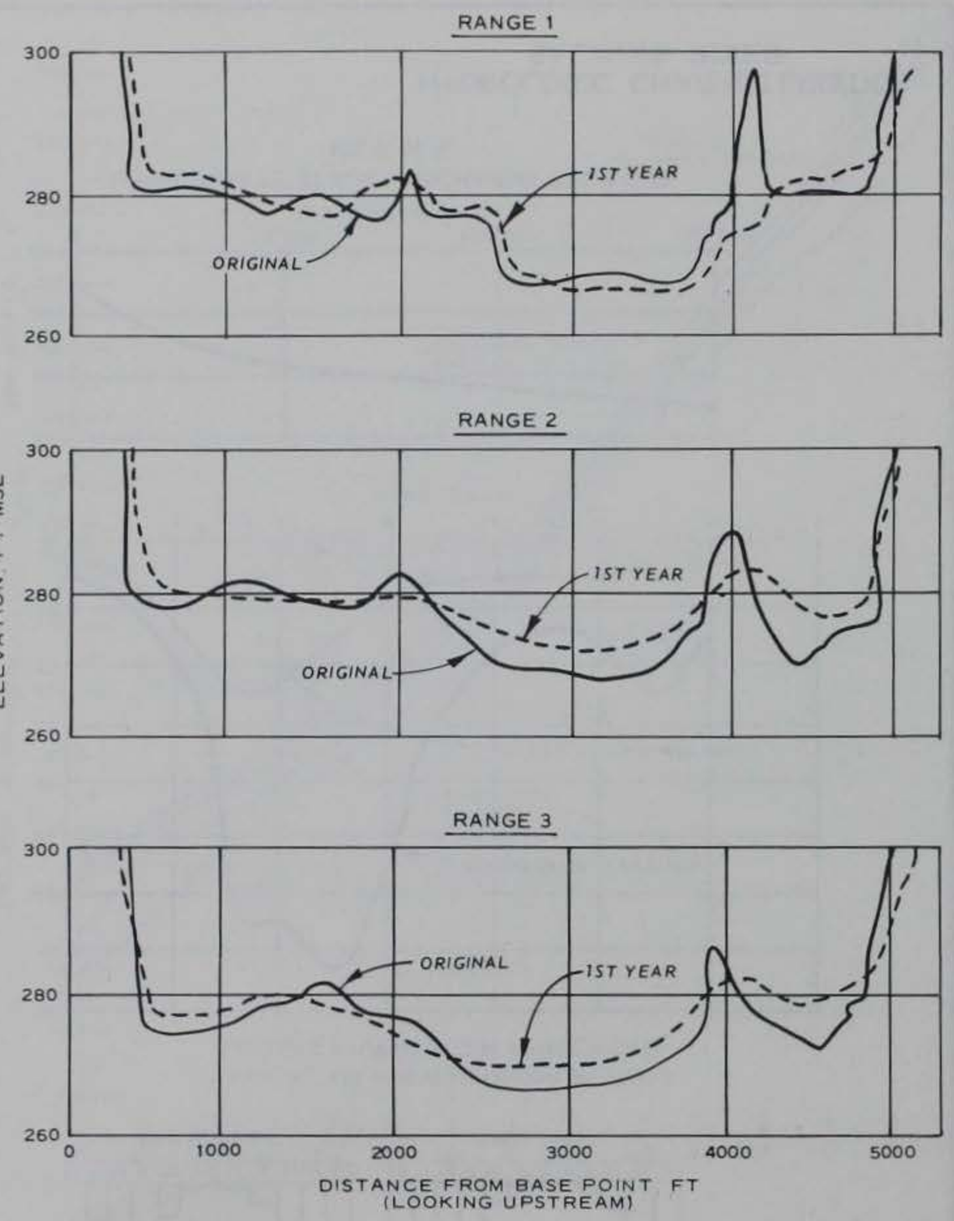
PLATE 5

Year	January Mean Monthly cfs	January No. Days 15,000 cfs or more	February Mean Monthly cfs	February No. Days 15,000 cfs or more	March Mean Monthly cfs	March No. Days 15,000 cfs or more	April Mean Monthly cfs	April No. Days 15,000 cfs or more	May Mean Monthly cfs	May No. Days 15,000 cfs or more	June Mean Monthly cfs	June No. Days 15,000 cfs or more
SALINAS RIVER NEAR SPRECKELS												
1929	Station established and record begins 11 December 1929											
1930	7		65		572		29		3		2	
1931	6		9		4		1					
1932	1580		5,470		415		71		9		3	
1933	85		205		7		4		2		1	
1934	625		392		426		5		1		1	
1935	1044		97		384		2191	1	168		5	
1936	39		5,110	1	814		585		43		3	
1937	89		5,760	3	3442		1101		167		13	
1938	178		11,940	6	9543	5	970		340		49	
1939	10		10		160		20		5		1	
1940	1742		3,782	2	2516	1	911		95		8	
1941	2882		9,311	5	8372	5	7182	3	943		227	
1942	2351	1	1,676		1272		1865		473		67	
1943	3872	3	1,942		5326	2	881		152		15	
1944	8		1,633	1	2849	1	223		77		8	
1945	10		3,823	2	1067		483		30		3	
1946	301		181		69		484		6		1	
1947	4		47		17		3		1		1	
1948	3		1		2		2		1		1	
1949	3		2		786		11		1		1	
1950	3		495		3		2		2		2	
1951	197		58		55		1		1		1	
1952	5610	3	997		3336	1	702		64		3	

July Mean Monthly cfs	July No. Days 15,000 cfs or more	August Mean Monthly cfs	August No. Days 15,000 cfs or more	September Mean Monthly cfs	September No. Days 15,000 cfs or more	October Mean Monthly cfs	October No. Days 15,000 cfs or more	November Mean Monthly cfs	November No. Days 15,000 cfs or more	December Mean Monthly cfs	December No. Days 15,000 cfs or more	Mean Actual cfs
										5		–
1		1		2		3		4		5		58
								2		3220	3	275
1		1		6		7		10		12		612
				2		2		7		16		27
						3		6		4		121
				1		2		3		3		324
						2		5		5		530
2						1		3		877		922
9		5		6		12		12		13		1899
												17
3		1		4		8		12		869		820
45		7		5		10		17		1155		2261
8		4		7		12		16		104		608
5		1		3		8		13		6		1020
2		1		1		7		14		12		400
1		1		4		11		14		1114		524
1		1		2		11		19		9		89
1		1		5		14		18		12		10
1		1		1		2		8		6		8
1		1		1		3		8		6		70
2		2		2		4		124		141		62
1		1		3		6		9		227		47
2		1		1		–		–		–		–

NATURAL FLOW CHARACTERISTICS
SALINAS RIVER

PLATE 6



NOTE: SEE LOCATION OF RANGES ON PLATES 9 AND 12

RIVER SECTION PROFILES
SALINAS RIVER

PLATE 7

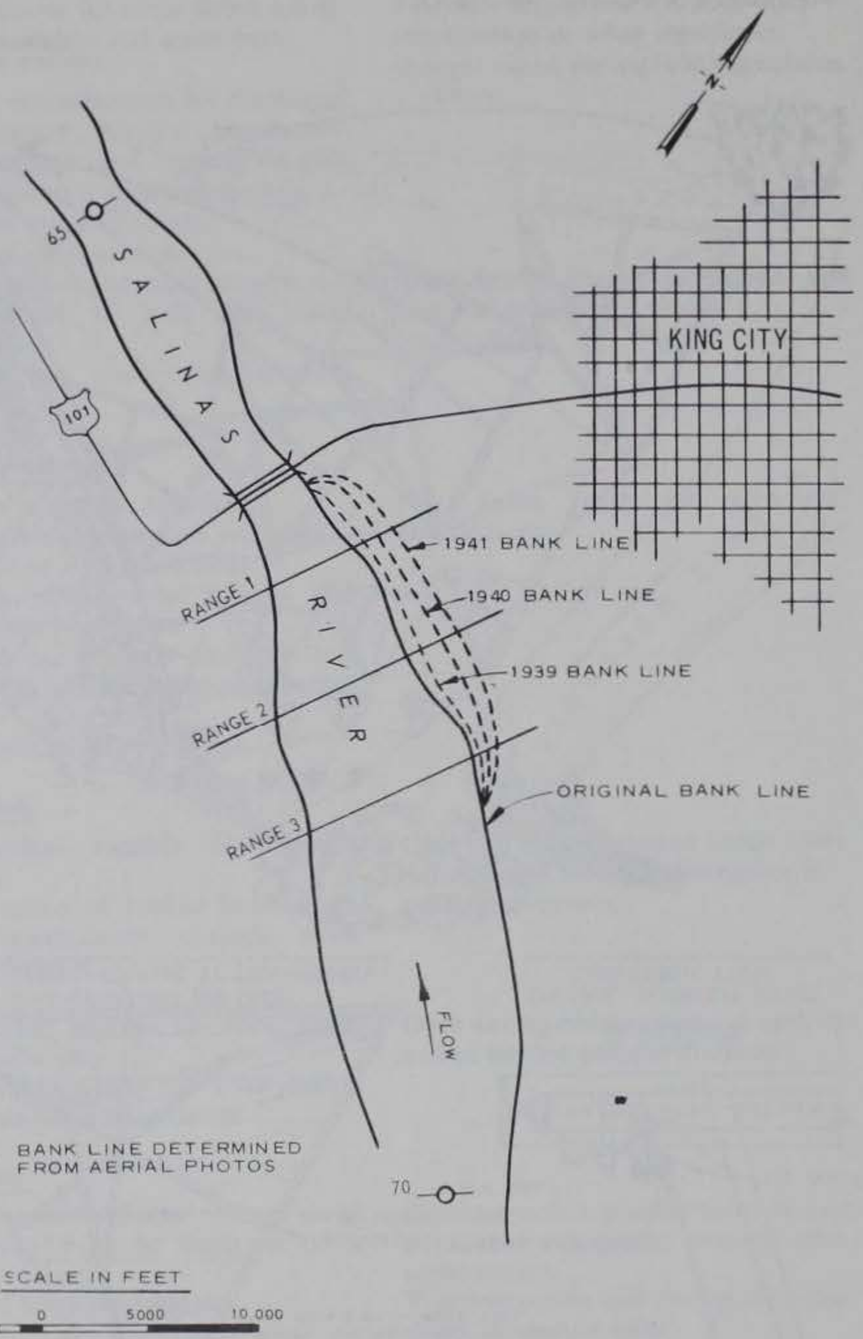
	SALINAS RIVER					
Sample Number	**1**	**2**	**3**	**4**	**5**	**6**
Sampled From:	**Right Bank River Mile 2.6**	**Right Bank River Mile 13.4**	**Left Bank River Mile 21.5**	**Right Bank River Mile 34.2**	**Left Bank River Mile 45.9**	**Right Bank River Mile 66.5**
Percent finer than the sieve size 2″						
1″						
3/4″						
1/2″						
3/8″						
#4						
#10		100				
#40	100	99	100	100	100	100
#100	89	96	85	89	85	92
#200	58	82	48	42	48	69
50 Microns	31	56	19	12	17	38
5 Microns	5	17	2	2	3	8
1 Micron	–	2*	–	–	–	2*
Specific Gravity	2.66	2.63	2.66	2.66	2.66	2.64
Visual Classification	Fine silty sand	Fine clayey sand	Fine silty sand	Fine silty sand	Silty sand	Fine clayey sand

LEGEND

Samples 1 and 2	Before construction
Sample 3	1st year inspection
Sample 4	2nd year inspection

SOIL CLASSIFICATION DATA
SALINAS RIVER

PLATE 8



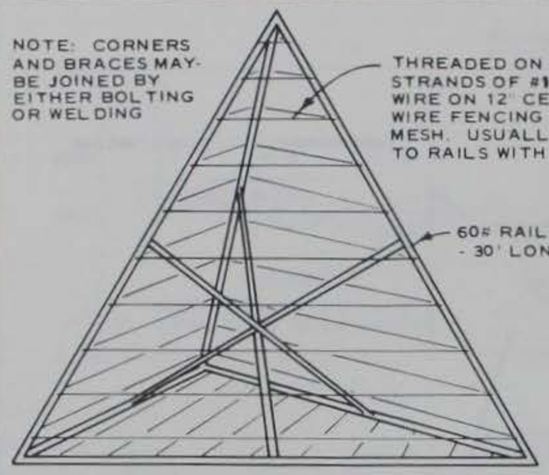
BANK-LINE SURVEYS
SALINAS RIVER

PLATE 9

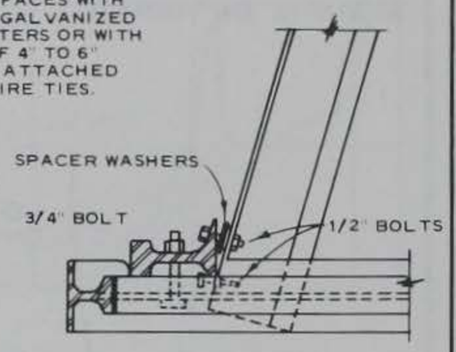
LOCATION OF WORKS		Site No.	Type of Installation	Date of Installation	Installation Made By
River Mile	to River Mile				
2.2	2.6	S-1-R	1600' Steel tetrahedrons	1935-1936	Unknown, probably by property owner (A. J. Molera Estate)
2.8	3.0		1350' Steel tetrahedrons	1941	By property owner under direction of a Civil Engineer (A. J. Molera Estate)
13.2	13.4	S-2-R	1300' Flexible rail and wire fence. Some steel jacks	1945	Cooperative installation by Monterey County and the State of California
14.9	15.3	S-3-L	Channel training works 1700' Floating jacks	1944-1945	Monterey County
15.2	15.3	S-3-L	750' Flexible rail and wire fence	1944-1945	Monterey County
Vicinity of	21.5	S-4-L	700' Steel jacks	1937	Monterey County
			600' Steel jacks	1938	Property owner (Mrs. E. Corey)
23.5	25.2	S-5-R	6400' Steel jacks placed at about double normal spacing	1942-1943	Property owner (Meyers)
25.2	25.3	S-5-R	2000' Steel tetrahedrons	1942-1943	Property Owner (Meyers)
34.3	34.7	S-6-R	2100' Steel jacks, and planting of pepper trees along the banks in back of the jacks	1933	Property owner (C. Orregia)
Vicinity of	35.9		300' Flexible rail and wire fence		
39.5	39.6	S-7-R	700' Steel tetrahedrons (34 units)	1941	Property owner (Maria Field)
39.6	39.7		400' Steel jacks (30 units)		
			4000' Combination of wire mesh and steel jacks	1942	Installed under supervision of Mission Soledad Soil Conservation District and Spreckels Sugar Company
43.2	44.1	S-8-L	800' Steel jacks	1950	
			1000' Steel jacks	1953	
45.9	46.0	S-9-L	1700' Steel tetrahedrons (24-16' tetrahedrons)	1936	State of California Division of Highways

SUMMARY OF PROTECTION WORKS
SALINAS RIVER

PLATE 10

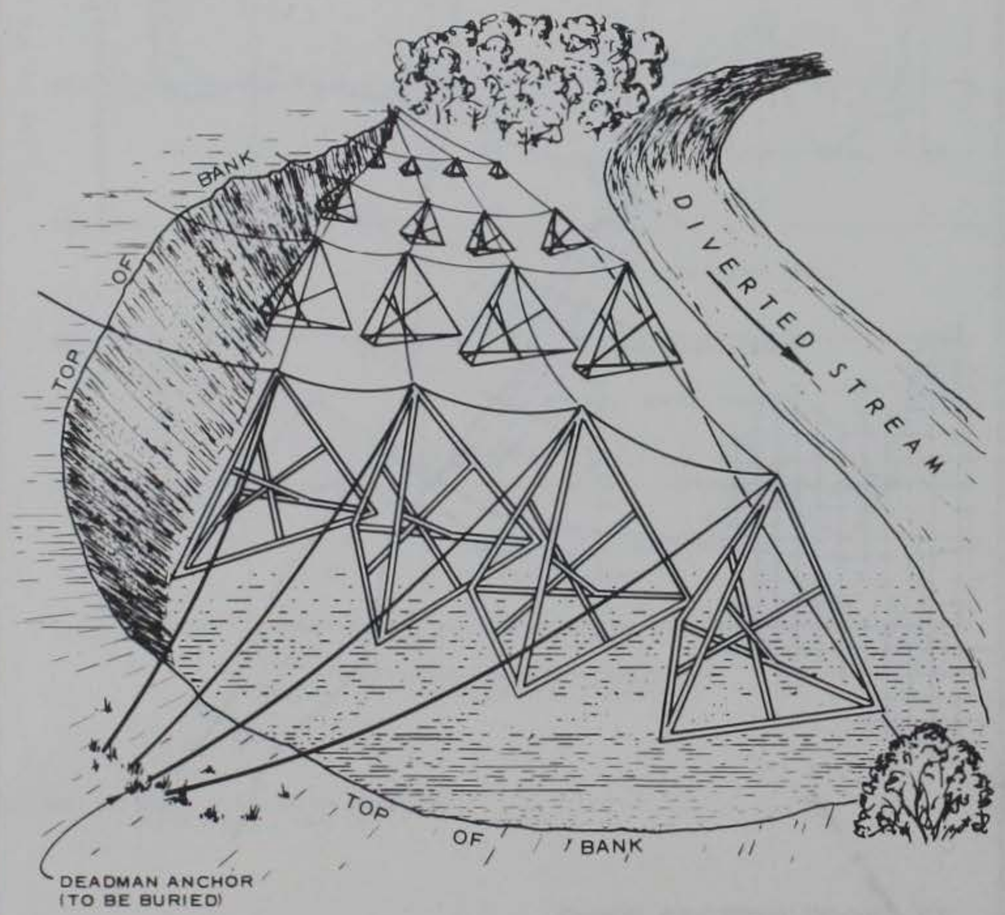


TYPICAL STEEL-FRAME TETRAHEDRON



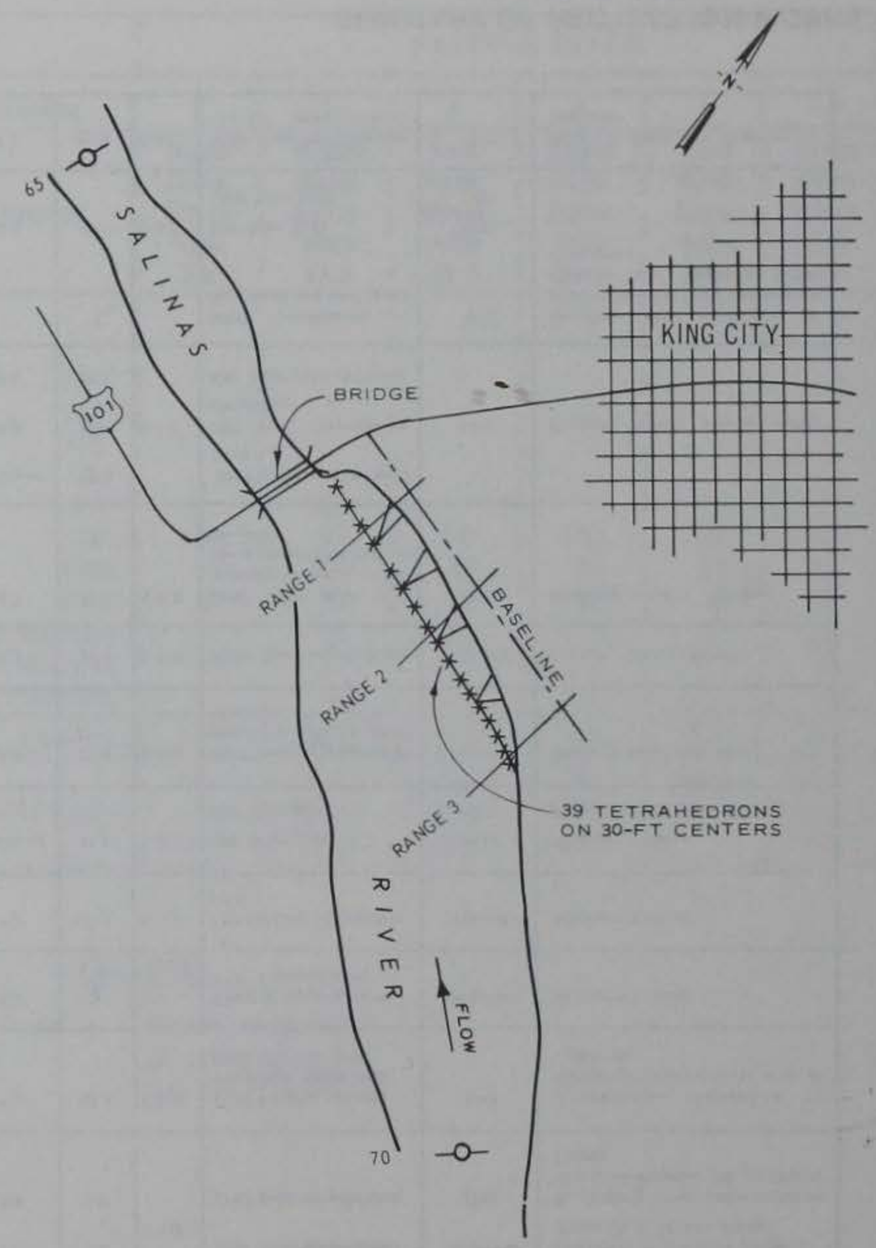
ELEVATION

DETAIL CORNER JOINT CONSTRUCTION



TYPICAL INSTALLATION OF TETRAHEDRONS IN WINGS

PLATE 11



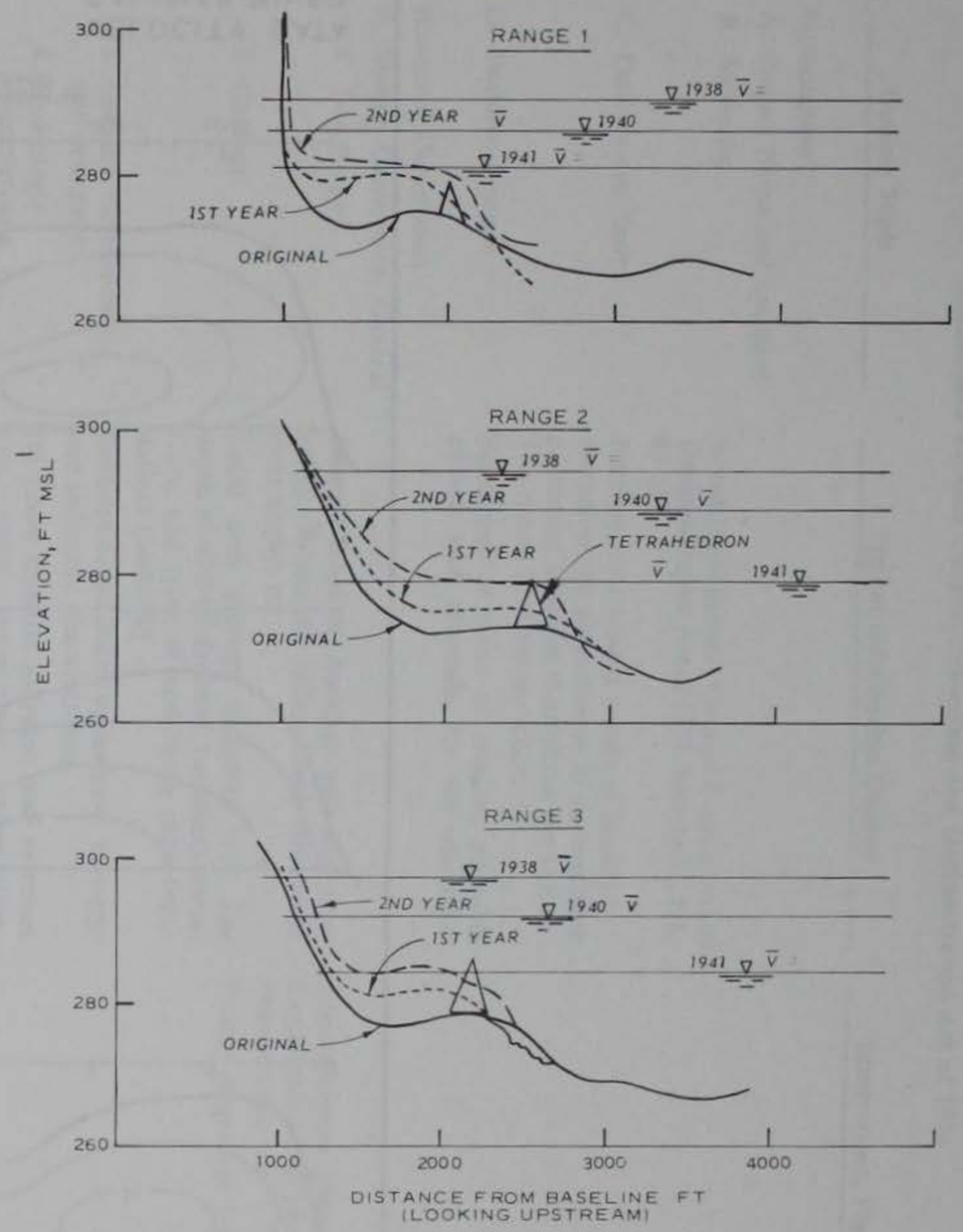
TETRAHEDRON LAYOUT SALINAS RIVER

PLATE 12

Field Data of Physical Features	Frequency
1. Cross sections for scour depth along structure, width, and quiet-water areas.	Preconstruction and annually post-construction or when significant changes noted during field inspections.
2. Velocity measurements for discharge distribution, velocity distribution near structure, and vertical velocity distribution at a standard distance.	
3. Bank-line location survey.	
4. Overbank cross sections.	
5. Crown profiles and cross sections and establishment of aids for visual observations.	Immediately after construction and future dependent on visual observations.
6. Probings for underwater structure locations.	
Visual Observations	
1. Changes in aquatic habitat.	Four times yearly for all visual observations.
2. Aggradation-degradation processes.	
3. Erosion and river conditions.	
4. Changes in terrestrial habitat and upper slope vegetation.	
5. Changes in structure integrity and material durability (including effects of ice).	
6. Surface current flow pattern.	
Material Tests	
1. Mechanical analysis of riverbed material.	Once per source location unless material obtained for wide divergence in geologic structure.
2. Classification of cutting bank material (mechanical analysis when appropriate).	
3. Freeze-thaw durability for rock.	
4. Mechanical analysis for rock, sand, gravel, and clay.	Once during construction for each site and as needed postconstruction.
5. Chemical analysis of construction materials when appropriate.	
Photography	
1. Oblique and controlled vertical aerial photography to be analyzed on a transfer scope.	Preconstruction photography of each site and at a minimum annually after construction.
2. Ground level photography.	Preconstruction and during all subsequent inspection visits.

MONITORING PROGRAM
SALINAS RIVER

PLATE 13



SURVEY OF BANK LINE
AFTER HIGH WATER

PLATE 14

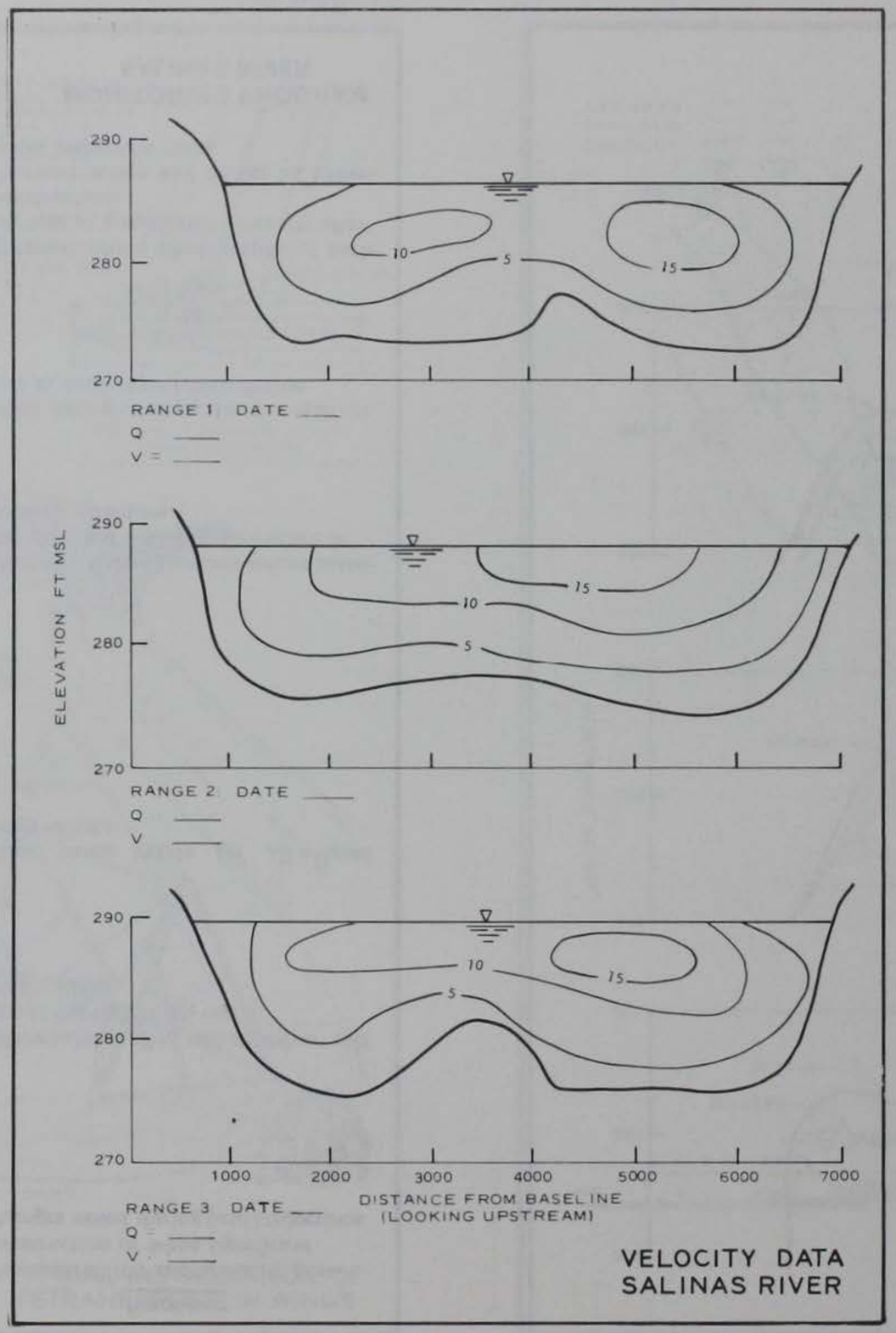

290
280
270
10
5
15
RANGE 1 DATE
Q
V =
ELEVATION FT MSL
RANGE 2 DATE
RANGE 3 DATE
1000
2000
3000
4000
5000
6000
7000
DISTANCE FROM BASELINE
(LOOKING UPSTREAM)
VELOCITY DATA
SALINAS RIVER

PLATE 15

TOPICAL OUTLINE FOR DEMONSTRATION PROJECT REPORTS

Section 32 Program
Streambank Erosion Control Evaluation and Demonstration Act of 1974

Outline Topic	Typical Information Desired	Illustrations, Plates, Tables, Etc.
I. Introduction		
A. Project Name and Location		
B. Authority	Streambank Erosion Control Evaluation and Demonstration Act of 1974, Section 32, P.L. 93-251	
C. Purpose and Scope	Purpose is to present results of studies to determine the performance of various bank protection schemes throughout the U.S.A. The report is of survey scope.	
D. Problem Resume	Statement of types of erosion, probable causes, and rationale for site selections	
II. Historical Description		
A. Stream Description, General		
1. Topography	General relief of drainage area and river valley. Range of valley flood elevations, river slopes, etc.	Location maps, photographs Large-scale aerial photograph with added contour intervals
2. Geology	Local area geology including type and depth of alluvial deposits. Locations, elevations, and types of underlying older foundations (bedrock)	Profile of geologic formations
3. Locality, development, and occupation	Description of local agriculture, forestry, and industrial characteristics	
4. Hydrologic characteristics	(1) Local climatic averages and extremes (air, water, temperature, precipitation, wind) through the year.	
	(2) Flood of record and flood frequencies	Major and minor flood hydrographs
5. Existing channel conditions	(1) General characteristics of channel (straight, meanders, braided, etc.; control points, i.e., falls, rapids, dams, encroachments, etc.)	Aerial photographs or plots showing successive surveys of bank-line and river cross sections
	(2) Stage-discharge relation for test reach (with any significant changes identified)	Stage-discharge plots
6. Environmental considerations	(1) Fish and wildlife (2) Water quality	
B. Demonstration Project (Test Reach)		
1. Hydrologic characteristics	(1) Hydrography in test reach (typical successive cross sections of channel, successive bank lines, etc.). Dredging performed in test reach (purpose, limits, disposal area).	Plots of typical annual hydrograph and successive surveys of bank line and river cross sections. Photographs of progressive erosion, etc.
	(2) River ice conditions in test reach (average freeze-up and break-up dates, ice thickness, movement of jams, etc.)	
2. Hydraulic characteristics	(1) Velocity distributions through test reach (with any significant changes identified; also maximum and secondary current)	Cross sections with velocity measurements (isopleths) superimposed
	(2) Sediment conditions through test reach (bed and suspended load; transport and deposition; evidence of largest size of stone moved by floods; change in bottom depth and shape during high flows, etc.)	Topo maps showing changes in bank-line and channel elevations
	(3) Changes in groundwater levels (perched conditions, etc.) relative to river stage and season.	Tabular data

(Continued)

TOPICAL OUTLINE FOR DEMONSTRATION PROJECT REPORTS (Concluded)

Outline Topic	Typical Information Desired	Illustrations, Plates, Tables, Etc.
B. Demonstration Project (Test Reach) (Cont'd)		
2. Hydraulic characteristics (Cont'd)	(4) Wave action from wind and traffic in test reach; river traffic in test reach (type, amount, significant changes).	Photographs, frequency distributions, tabular data, etc.
	(5) Operating procedures (both normal and emergency) of control works on regulated streams.	
3. Riverbank Description	(1) General characteristics of materials composing the banks; availability of construction material within economic hauling distance, etc.	Available boring logs and soil testing data in conjunction with the borings
	(2) Description of grasses, shrubs, and trees that grow in the test reach	Photographs
	(3) Describe the rates of erosion, slope stability, etc.; problems which occur along the general reach in the vicinity and including the demonstration site. Describe probable causes of erosion, i.e., waves or flow velocity, etc.	
	(4) Descriptions and performance of previous and existing works in or near test reach	Photographs
III. Design and Construction		
A. General	General narrative description of features to be included in the projects	
B. Basis of Design for Each Type of Protection	Selected design conditions for climate, hydrology, water-surface profiles, river cross sections, flow velocities, waves, scour and deposition, groundwater level, etc.	
C. Construction Details for Each Type of Protection	(1) Detailed description of each type protection	As-built drawings showing plan and cross sections at intervals throughout length of test reach
	(2) Description of types of instrumentations installed and parameters to be monitored	Location map of instruments
	(3) Describe unusual climate, hydrology, hydraulic, geology, or soil conditions that caused modification to original design	
	(4) Environmental impact experienced during construction	
D. Costs	Contract cost and modification costs	
IV. Performance of Protection		
A. Monitoring Program	Discuss the monitoring program. List parameters measured, procedures and equipment used, frequency of observations, etc.	Tabular lists, drawings, and plots
B. Evaluation of Protection Performance	(1) Discuss performance of each type of protection	Surveys, photographs, drawings, etc.
	(2) Discuss condition of each type of protection at end of observation period	Surveys, photographs, drawings, etc.
C. Reconstruction	Describe what reconstruction was performed	Photographs, drawings
D. Conclusions	Statements of evaluation for each type of protection and the limits for its satisfactory performance	