2. DEVELOPMENT OF SPREADSHEETS

2.1. Selection of the Base Spreadsheet Program

Several surveys have been done regarding the variety of microcomputer hardware available in the 99 Iowa counties. Those surveys and the survey work of the project staff in the preproject stage convinced the project staff that the most appropriate spreadsheet program to use was Multiplan by Microsoft Corporation. This was based on the fact that it was available in versions that operated on the widest variety of hardware brands and models, and that, it was moderately priced for counties just beginning to acquire software. High cost software places a temptation to acquire pirate software or places an undue burden on the budget to make a trial installation. Multiplan seemed to offer the greatest potential to be low cost, widely implementable and flexible enough in structure to accomodate the range of computational needs. Subsequent research by the project staff identified that Multiplan had the most powerful equation capability which was critical in some of the hydraulic engineering spreadsheets.

2.2. Development Sources

Sources used as the basis of developing these spreadsheets were those that are either expected to be in most engineering offices desiring to use the particular spreadsheet or be readily available in a cooperating office. The highway engineering computation spreadsheets utilized equation relationships and table lookup materials from two primary sources:

* A Policy on Geometric Design of Highways and Streets, 1984, American Association of State Highway and Transportation Officials.
* Route Location and Design, Fifth Edition, Thomas F. Hickerson, McGraw-Hill, 1964.

The hydraulic engineering spreadsheets were based on a variety of sources. Among those were:

* Hydraulic Design of Highway Culverts, Report FHWA-IP-85-15, Federal Highway Administration, September 1985.
* VAL program on DOT T50, Iowa Department of Transportation.
* Open Channel Hydraulics, Ven Te Chow, McGraw-Hill, Inc., New York, 1959, pp 27-28, 249-289.
* "Federal Highway Administration Calculator Series for Hydraulics for the TI-55" equation was used for the critical depth for outlet control for culverts

Other sources include consultations with Mr. Phillip Thompson of the Federal Highway Administration in

Washington, DC, and staff personnel of the Iowa Department of Transportation Office of Preliminary Bridge Design.

NOTE: For culvert design and analysis, full flow was assumed in all cases with velocity defined by the ratio of flow to cross-sectional area of a culvert.

2.3. Development Process

The spreadsheets were developed by first laying out the computational process an engineer typically uses with a paper-pencil-calculator method. Then information was organized into an input screen which became a home base for the spreadsheet. The required computations were organized in a linear flow pattern since a spreadsheet calculates down and to the right unless special instructions are included. Then an output screen was organized into which the computational answers were placed. Testing with a known result example then followed. Modifications to the spreadsheet to enhance user understanding, add flexibility in use, and clarify results created several versions for some spreadsheets.

2.4. System Compatibility Difficulties

It was determined after testing thoroughly that

Multiplan versions were available for almost all microcomputers in use. One exception is the Hewlett-Packard 80 series. Furthermore, consultation with the Iowa State University Microcomputer Products Center and the Engineering Research Institute Electronics Laboratory resulted in a combined hardware-software method for transfering spreadsheets between MS-DOS based hardware and the various Apple microcomputers. One problem never fully resolved was the difficulty of interacting with the Burroughs B-20 series microcomputers.

2.5 Computer to Computer Communication Solution

With the assistance of the Iowa State University Computation Center Microcomputer Products Center it was determined that by connecting between two serial ports on any two computers for which a valid Multiplan program exists, it was possible to transmit spreadsheets between the two computers. A software communication program must exist in common for both computers. KERMIT is a public domain program to public agencies so that ISU can furnish a copy to a public agency (it can be purchased for $40 by for profit organizations). KERMIT is available for a wide range of microcomputers. Using KERMIT permits the transmission of a Multiplan spreadsheet in the SYMBOLIC format code between, for example, IBM computers and APPLE

computers. Similarly, a county engineering office with a modem can use such a communication program to transmit a Multiplan spreadsheet to another office having a modem on a microcomputer. Interchange of spreadsheets can be made in this fashion between computer systems which cannot directly read each others disks.

2.6. Spreadsheets Developed

The following spreadsheets were developed to assist in highway engineering computations:

A. HORIZCRV is a spreadsheet to permit entry of basic roadway design parameters for width of pavement and related facts, entry of PI station, the DELTA angle at the PI, and the design degree of curvature and the spreadsheet will compute the necessary information to locate the curve on the ground. It will also provide the typical design detail information to be included on a plan and profile sheet.

B. VERTCURV is a spreadsheet to permit entry of vertical profile design information such as the VPI station and elevation, the grade entering and leaving the VPI and the distance between desired elevations along a vertical curve to compute vertical curve elevations. AASHTO criteria is used to determine the required length of vertical curve to be input. The spreadsheet will then calculate the vertical profile elevations.

A separate portion of the spreadsheet allows calculations at odd stations for driveways or similar points requiring profile elevations.

C. SUPERE is a spreadsheet to utilize AASHTO criteria to define the centerline, left and right edge of pavement profile for a superelevation transition to a circular curve. The transition can be either tangent or spiral curve. If other than AASHTO criteria are desired, those can be specified.

D. MAXTANG is a spreadsheet to permit an engineer to define a maximum length of tangent that can be accepted in a curve relocation as curve design control. The spreadsheet will then compute the curve which can be placed in the restricted geometry.

E. EARTHWKS is a spreadsheet to permit entering cut and fill data from a series of cross-sections and then compute the mass diagram ordinates. It was hoped that this approach could lead to a quick method for entering limited cross section information resulting in a calculation of the cut and fill, definition of the mass diagram and a character plot of a mass diagram for preliminary adjustment of the design gradeline. This effort was not very successful.

F. SIGNINV and MAINTREC are two spreadsheets included in this project report which were completed under a student special topic effort rather than this contract

effort. The student effort was coordinated with this project so that the inclusion of these two can be provided as an illustration of how a spreadsheet program can be used to perform an inventory and record keeping function. Some offices may not be interested in devoting the time needed to learn a microcomputer data base, which is better suited to this type task, and may find these spreadsheets a useful aid in developing other similar applications.

The following hydraulic engineering spreadsheets were developed:

A. DITCHFL is a spreadsheet to compute flow in a regular section (trapezoid, V-bottom, rectangular, etc.) ditch from Manning's equation. The computation is often used for trapezoidal cross section roadside ditches and for lined channels were the depth of flow is not critical.

B. RUNOFF is a spreadsheet developed to calculate the runoff flow from an Iowa watershed drainage area to yield a design flow for hydraulic structures. The hydrologic bases of this spreadsheet are the Iowa runoff chart and the current version of Bulletin 11. Bulletin 11 is being updated as of this report date. When the new version of Bulletin 11, upon which this spreadsheet was partially based, is issued, the spreadsheet can be updated to reflect any changes and a new spreadsheet revision issued.

C. WSGEOM is a spreadsheet developed to calculate the water surface profile along a section of a trapezoidal channel. If the trapezoid is defined with a zero bottom width it becomes a V-bottom ditch. This is for use in estimating the backwater effects due to ponding by a culvert under the roadway at a downstream location.

D. CULVERT is a spreadsheet developed to perform the necessary steps to size a culvert at a site. The program is less data intensive than the FHWA program and focuses on parameters with which county engineers are expected to be more familiar. The significant advantage of this spreadsheet over the FHWA program is that in the FHWA program all initial data must be reentered each time a single design trial revision is made. In the spreadsheet, only the design parameters the engineer wishes to change are modified to develop a new or alternate solution.

E. XSECT is a spreadsheet developed to permit entry of elevations and distances across the natural reach of a stream to obtain the stage discharge curve. It was created and tested to conform to the Iowa Department of Transportation VAL program for the DOT T50. It provides a useful illustration of the degree to which computational activities can be made to reproduce a high level computer language program in a microcomputer spreadsheet.

F. WSNAT-1 and WSNAT-2 are two spreadsheets which compute the water surface profile for natural cross section channels much like WSGEOM does for a geometric cross section channel. Because of the complexity of the computation layout for the natural cross section channel, only three cross sections can be computed along the channel in WSNAT-1 (plus a data transfer cell area). If the channel under consideration requires more than three cross sections, then the Multiplan "external copy" function can transfer the transitional information to WSNAT-2 to continue computations for three more cross sections. If more cross sections are anticipated, the engineer can create multiple copies of WSNAT-2 under the names of WSNAT-3, WSNAT-4, etc., and continue using the "external copy" function to extend the computation as far as needed. The project staff did not expect most county engineering applications to require such analysis for an extensive distance due to the nature of most county projects.

2.7 Recommendations for Further Developments and Refinements

The project staff is of the professional opinion that coordination of interests in refinements and additional developments using Multiplan (or Lotus 1-2-3 for that