TEXAS HYDRAULIC SYSTEM

Dwight Reagan, Texas Highway Department

The Texas hydraulic system (THYSYS) is an integrated system of hydraulically oriented computer routines specifically designed for the solution of highway hydraulic problems. The input and output of the system are geared to the requirements of the Texas Highway Department.

In the past, a number of individual computer routines were available whereby the engineer could solve many individual hydraulic problems. However, a hydraulic design or analysis problem cannot be solved in one step. A group of interrelated calculations is required for the complete solution. This requirement and the need for optimization are the basis for THYSYS. THYSYS was designed to incorporate and use as many existing hydraulic computer routines as possible.

The driver and skeleton of the system are modular; particular routines useful to the Texas Highway Department may be replaced by alternate routines or procedures that might be more useful to another user. The system is documented to the extent that the user need only know what procedure he wishes to use for a particular function. The documentation gives directions pertaining to input and output so that the user may remove the unwanted routine and replace it with one of his own. General documentation is currently available, and detailed documentation will be available in the future.

The input forms present to the user, in familiar terms, all options available (Fig. 1). He merely chooses an option. This method eliminates the need for a high degree of engineering sophistication by the user and allows for broader use by technicians. This style is used in THYSYS in lieu of the command-structured, problem-oriented style used in the Integrated Civil Engineering System.

The computer output is tailored directly to Texas Highway Department needs and requirements. All outputs have been designed in the interest of uniformity and completeness. The output format may be easily adjusted to conform to the needs of any other organization.

THYSYS is composed of a main driver system and 5 basic subsystems (Fig. 2). These 5 subsystems are HYDRO, the discharge determination function; HYDRA, the channel analysis function; CULBRG, the structure analysis and design function; SEWER, the storm sewer analysis and design function; and PUMP, the pump station analysis and design function.

HYDRO, HYDRA, and CULBRG are written so that they may be used in concert (Fig. 3). For instance, without user direction, the discharge may be passed into HYDRA for use in determining a tailwater elevation, and these two items, in turn, may be passed into CULBRG for use in a structure design. A number of other combinations are possible, and each subsystem can be used by itself. SEWER is completely self-contained and is not used in combination with any of the other subsystems.

An extensive data auditing and management scheme is incorporated into the system. All data for a problem are read into the system, and discernible errors are noted. In addition, any assumptions made by the system are noted. An echo print of all input data is generated for each problem.

Figure 4 shows an echo print of input data for a box culvert design, and Figure 5 shows the output for that data indicating the various designs tried and the final accepted design.

Figure 1. Typical input form.

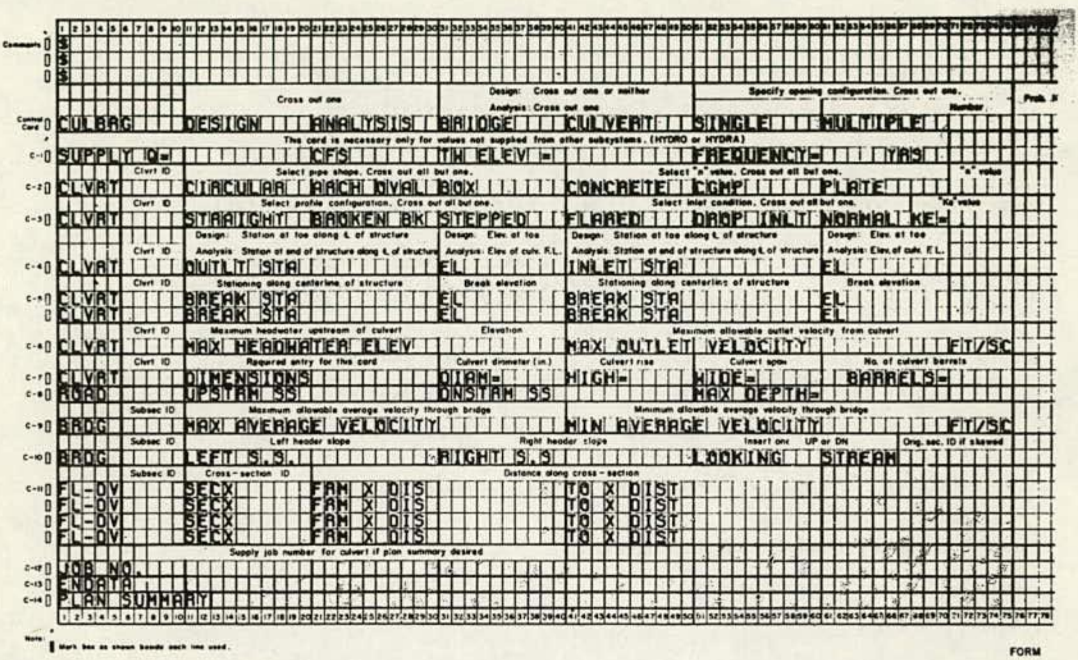


Figure 2. Texas hydraulic system.

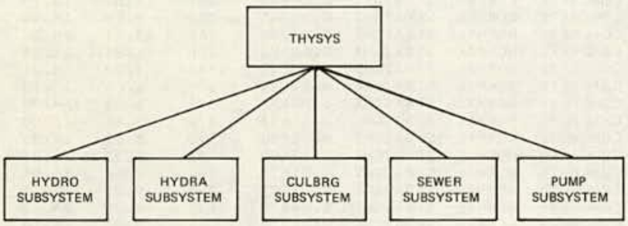


Figure 3. Data exchange paths in THYSYS.

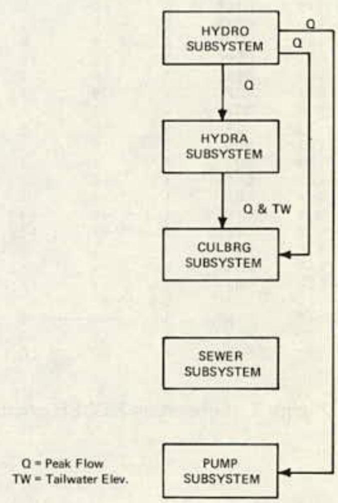


Figure 4. Echo print input.

```
$STA 907+50
$WB LANE
CULBRG     DESIGN                                 CULVERT   SINGLE                      7A567
SUPPLY Q=     1743     CFS          TW ELEV =  2506.04  FREQUENCY=  50 YRS              7A567
CLVRT 907                           BOX        CONCRETE                                 7A567
CLVRT 907 STRAIGHT                                                 NORMAL KE=015·       7A567
CLVRT 907 OUTLT STA          289  EL2499.59 INLET STA       101  EL2500.00              7A567
CLVRT 907 MAX HEADWATER ELEV  2508.00   MAX OUTLET VELOCITY       10     FT/SC7A567
ROAD  907 UPSTRM SS          2  DNSTRM SS          2  MAX DEPTH=        7               7A567
JOB NO.      IPE 567                                                                    7A567
ENDATA                                                                                  7A567
CULVERT FEASIBILITY ROUTINE NOT AVAILABLE
```

Figure 5. Echo print output.

DESIGN SINGLE OPENING CULVERT JOB NUMBER= IPE 567

CULVERT ID = 907

DESIGN FLOW = 1743.0 CFS FREQUENCY = 50 YEAR

TAILWATER ELEVATION = 2506.04

BBLS	DIAM	WIDE	HIGH	LENGTH	ALLOW. HW ELEV	CALC. HW ELEV	CALC. HW	ALLOW. VELOC.	CALC. VELOC.
3	0	9	7	160	2508.00	2508.16	8.19	10.00	10.01
4	0	7	7	160	2508.00	2508.06	8.09	10.00	9.65
3	0	10	7	160	2508.00	2507.75	7.78	10.00	9.01

INLET STATION = 115 ELEVATION = 2499.97

OUTLET STATION = 275 ELEVATION = 2499.62

SLOPE	PROFILE	BARREL MATERIAL	SHAPE	INLET TYPE	KE
0.00218	STRAIGHT	CONCRETE	BOX	NORMAL	0.150

Figure 6. Summary of culvert design and analysis.

SUMMARY OF CULVERT DESIGN/ANALYSIS

JOB NO. IPE 567

CLVRT I.D.	BBL SHAPE	BBLS	WIDE	HIGH	LENGTH	CULVERT MATERIAL	TYPE INLET	PROFILE	SLOPE	Q (CFS)	CALC HW	CALC VELOC
792	BOX	1	9	5	108	CONCRETE	NORMAL	STRAIGHT	0.00874	296	5.06	13.39
792	CIRC	2	60	60	108	CONCRETE	NORMAL	STRAIGHT	0.00874	296	5.24	12.73
792	CIRC	2	60	60	108	CONCRETE	FLARED	STRAIGHT	0.00874	296	5.07	12.73
860	BOX	2	5	3	203	CONCRETE	NORMAL	STRAIGHT	0.05345	162	3.16	19.94
889	BOX	1	9	8	347	CONCRETE	NORMAL	STRAIGHT	0.02092	960	12.22	25.28
901	CIRC	1	42	42	188	CONCRETE	NORMAL	STRAIGHT	0.00426	108	6.88	11.84
907	BOX	3	10	7	160	CONCRETE	NORMAL	STRAIGHT	0.00218	1743	7.78	9.01
941	BOX	1	9	5	115	CONCRETE	NORMAL	STRAIGHT	0.01331	374	6.08	15.73
965	BOX	4	7	3	123	CONCRETE	NORMAL	STRAIGHT	0.03678	572	3.83	17.78
21	BOX	1	5	4	169	CONCRETE	NORMAL	STRAIGHT	0.03821	224	7.46	21.80
102	BOX	5	9	5	379	CONCRETE	NORMAL	STRAIGHT	0.02149	1570	5.27	19.98
120	BOX	4	6	3	370	CONCRETE	NORMAL	STRAIGHT	0.03480	580	4.52	20.35
885	CIRC	1	42	42	261	CONCRETE	NORMAL	STRAIGHT	0.01872	162	9.66	16.94
894	BOX	1	6	3	268	CONCRETE	NORMAL	STRAIGHT	0.01093	249	9.29	16.09
908	CIRC	1	48	48	208	CONCRETE	NORMAL	STRAIGHT	0.04379	171	8.36	23.62
908	CIRC	1	42	42	210	CONCRETE	FLARED	STRAIGHT	0.04379	171	9.00	24.10
936	BOX	3	7	5	99	CONCRETE	NORMAL	STRAIGHT	0.00692	750	5.37	10.03
947	BOX	6	9	7	120	CONCRETE	NORMAL	STRAIGHT	0.00796	3527	8.14	17.70
961	BOX	3	7	3	140	CONCRETE	NORMAL	STRAIGHT	0.00978	594	5.41	13.29
14	CIRC	1	42	42	226	CONCRETE	NORMAL	STRAIGHT	0.00319	87	5.62	10.21
30	BOX	3	5	3	137	CONCRETE	NORMAL	STRAIGHT	0.03815	346	4.31	18.35
58	BOX	1	10	10	256	CONCRETE	NORMAL	STRAIGHT	0.02398	965	10.37	24.92
60	BOX	1	10	10	105	CONCRETE	NORMAL	STRAIGHT	0.00295	993	10.59	14.19

Figure 7. Subsystem SEWER graphic output.

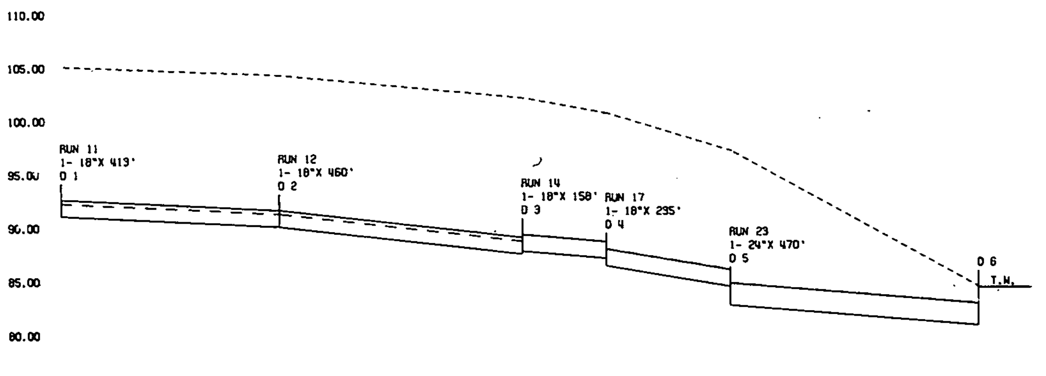
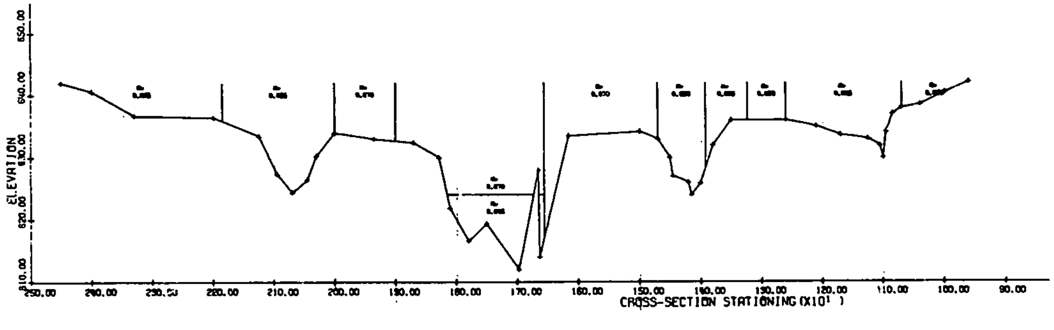


Figure 8. Subsystem HYDRA graphic output.



A feature unique to THYSYS is the "stacking" capability, particularly in the CULBRG subsystem. The first set of input data is submitted in complete form, and a design is the computer output. Then, changes may be made to the original data by reprocessing only those items that change, provided the changed data immediately follow their associated input. A new design is then produced based on the original data and the changes.

CULBRG also has a "plan summary" feature by which basic design data for a computer run are summarized for eventual direct application to the highway plans or for the permanent documentation (Fig. 6). This plan summary is in addition to individual culvert design reports previously generated by the system. This feature provides convenient, uniform, and accurate documentation to the user.

There is an optional graphic output from subsystem SEWER (Fig. 7). Specification may be made for sewer analysis or design and a computer plot of the results. Ordinary computer output accompanies the computer plot. The storm sewer pipe system profile is plotted at standard horizontal and vertical scales, and the computed hydraulic gradient is superimposed on the plot. This graphic output may be applied directly to the plans, with substantial savings in drafting time and expense.

There are many other unique features in THYSYS including the graphic output from subsystem HYDRA as shown in Figure 8. This figure shows a cross section and roughness coefficient boundaries, both vertical and horizontal. (The vertical and horizontal scales may be specified by the user, or a standard set of scales may be used.)

THYSYS has been used extensively in Texas since July 1970 and on a limited test basis for a number of months before that time. The result of this use has been the overwhelming acceptance of the system by field engineers in the Texas Highway Department. Usage leveled out in 1971 to an average of several hundred per month. Particularly heavy use of CULBRG and SEWER has been noted. Because this was expected, emphasis has been directed to completed computation routines pertaining to culvert and storm sewer analysis and design. Obviously, a system of this size cannot be implemented without some problems. THYSYS has been no exception. However, all of the problems encountered to date have been overcome, and development is proceeding. THYSYS now has 70 working subroutines in the system, and important cost analysis routines are to be added in the near future.

A comprehensive user's manual for THYSYS that covers every aspect of required input data has been compiled and distributed. Brief summaries of output and the many possible error messages that may be generated are also discussed. Texas Highway Department personnel have apparently had no major problems in learning to use this system. A self-instructional training manual for the THYSYS computer system has also been compiled, and response to this manual has been very good.

Most of the Texas Highway Department field use of the system is accomplished by mail with the longest delay usually attributable to the U.S. Postal Service. Several urban districts have access to the system through the remote 2,780 terminals. In the near future, these terminals will be located in each of the 25 district offices.