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Data Processing Method Aids Sewer Systems Analysis

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To aid in determining the capability of downstream sewers to handle additional flow, a new method of characterizing sewer systems which utilizes data processing has been developed.

Checking operations are usually simple. However, due to the layout of sewer systems, there is always a chance of error or confusion.

Because of the nature of the problem, data processing is the appropriate technique to solve the problem. A method is proposed here, based on which model will be developed. The proposed method, "Contributing and Receiving Line Method," is based on two basic ideas: line identification and line hierarchy.

Table 1
Program to Compute Flow and Line Capacity Check

Instrument: Texas Instrument SR-52.
Procedures:

1. Enter Hierarchy (H)	Press A
2. Enter Q-Full (Q-Full)	Press B
3. A. For line not end line Enter House connections (HC)	Press C
B. For end-file-line Enter House connections (HC)	Press C and Set Flag 1
C. For end-line Enter House connections (HC)	Press C and set Flag 2

4. Press D, program is halted to give **Cumulative HC**
5. Press RUN, program is halted to give **Loading Status:**
   A. **+ : Under load.**
   B. **−: Over load.**

For the Loading Status computation, HC has to be converted into the same unit as Q-Full. In this program

$$1\ Hc = \frac{3\ Persons \times 350\ GPD/Person}{7.48 \times 3600 \times 24} = 0.00162470\ CFS$$

Note:
This program is developed according to the Flow Computation & Line Capacity Check Flow Chart with some minor modifications. Due to the limited number of addressable registers, this program can only handle a collection system up the HIERARCHY 13:
REGISTER 00: H REGISTER 14:H+1 REGISTER 15:Q-Full
REGISTER 16:HC Register 17:H pre* REGISTER 18:TEMPO
REGISTER 19:ACC REGISTER 01 . . . REGISTER 13: PENDING RECORD TABLE.
*H pre = Previous H.

Line Identification

Under this proposal, each line is described uniquely by its line identification, a number composed of two parts:

1. The number of the map which contains the line; (example map #63) and,
2. The number of the upstream manhole of the line; (example manhole #27).

In each map, manholes are numbered continuously, starting with manhole #1. In the example above, the line is identified as 63-27. If a line stretches over two maps, the map number is the one containing the upstream manhole.

Line Hierarchy

In order to distinguish between receiving and contributing lines a number called "hierarchy" is assigned to each sewer line, according to the following rules:

1. The upstream contributing line has higher hierarchy than the downstream receiving line.
2. Lines between two intersections have the same hierarchy.
3. Individual lines converging on the same manhole have the same hierarchy.

The line hierarchy is based on the concept of contributing and receiving line, but not on the familiar classification (interceptor, trunk, main, submain and lateral).

Data related to each line constitute a record. A line-records file of a sewer system starts with line records of hierarchy 1, then continues upstream to line records of higher hierarchies. At the intersection of many branches, a file is organized for each branch, starting from the

Step	Code	Key	Step	Code	Key	Step	Code	Key	Step	Code	Key	Step	Code	Key	Step	Code	Key	Step	Code	Key
000	46	+LBL		75	—		85	+		00	0		06	6	145	22	INV		02	2
	11	A	030	15	E		43	RCL		00	0		44	SUM		50	+st flg	175	95	=
	42	STO		95	=	060	01	1		01	1		01	1		01	1		81	HLT
	00	0		90	+if ZRO		09	9	090	06	6		09	9		43	RCL		46	+LBL
	00	0		88	+ 2'		95	=		02	2	120	15	E		01	1		15	E
005	81	HLT		15	E		44	SUM		04	4		42	STO	150	06	6		43	RCL
	46	+LBL	035	85	+		01	1		07	7		01	1		81	HLT	180	00	0
	12	B		01	1	065	08	8		00	0		07	7		46	+LBL		00	0
	42	STO		95	=		00	0	095	02	2		22	INV		77	+ 4'		56	+rtn
	01	1		42	STO		49	+Prod		09	9	125	50	+st flg		43	RCL			
010	05	5		01	1		01	1		57	+Fix		02	2	155	01	1			
	81	HLT	040	04	4		09	9		02	2		43	RCL		05	5			
	46	+LBL		36	+IND	070	15	E		95	=		01	1		75	—			
	13	C		43	RCL		42	STO	100	81	HLT		06	6		43	RCL			
	42	STO		01	1		01	1		46	+LBL	130	81	HLT		01	1			
015	01	1		04	4		07	7		87	+ 1'		41	GTO	160	06	6			
	06	6	045	44	SUM		43	RCL		43	RCL		77	+ 4'		65	X			
	81	HLT		01	1	075	01	1		01	1		46	+LBL		93	•			
	46	+LBL		08	8		08	8	105	08	8		89	+ 3'		00	0			
	14	D		36	+IND		81	HLT		36	+IND	135	43	RCL		00	0			
020	60	+if flg		22	INV		43	RCL		44	SUM		01	1	165	01	1			
	01	1	050	44	SUM		01	1		01	1		06	6		06	6			
	89	+ 3'		01	1	080	05	5		07	7		44	SUM		02	2			
	60	+if flg		04	4		75	—	110	00	0		01	1		04	4			
	02	2		46	+LBL		43	RCL		49	+Prod	140	09	9		07	7			
025	87	+ 1'		88	+ 2'		01	1		01	1		15	E	170	00	0			
	43	RCL	055	43	RCL		08	8		08	8		42	STO		02	2			
	01	1		01	1	085	65	X		43	RCL		01	1		09	9			
	07	7		06	6		93	•	115	01	1		07	7		57	+Fix			

Figure 1. Program to Compute Flow and Line Capacity Check.

converging line record to the end line record of the branch. The branch files are filed consecutively.

If in following the branch upstream an intersection is encountered, each sub-branch, starting from the converging line to end line, constitutes a sub-branch file. The sub-branch files are also filed consecutively. Therefore, for a branch which is ramified into two sub-branches, and one of which is further ramified into three sub-sub-branches, for example, the file is organized in the following order: records of the branch up to the intersection; records of any one of the two sub-branches (the sub-branch with three sub-sub-branches for instance); records of the three sub-sub-branches; and, finally, records of the other sub-branch (see example).

Each line record contains the following data: line identification; line hierarchy; type of line; type of manhole; invert elevation and rim elevation, if any, of the manhole; pipe length; pipe size; slope; q-full; number of house connections; pipe material; easement (an easement file can be organized using the line identification as argument); and end line signal (in case of end line).

Once the file is organized, flow computation and line capacity check can be done systematically, provided the following principles are respected:

1. Flow is computed from the most upstream line and from the end of the file backward. Therefore, flow computation starts with the end line record of the end file (end-file-line).

2. In processing the file from the end backward, the flow of the contributing line is added to the flow of the receiving line having the same hierarchy, until a record of different hierarchy is encountered. The record of the different hierarchy encountered should be one hierarchy lower, if it is not an end line record, otherwise the file organization is not correct. The following two cases have to be distinguished (see flowchart).

The record of different hierarchy is an end line record. In this case, the cumulative flow down to the line, whose record is filed next to the end line record, has to be kept pending or set aside in the pending record table. The flow computation is done from the end line record just encountered.

The record of different hierarchy is one hierarchy lower. In this case, the flow of the record one hierarchy lower is the total of three flows: actual flow; cumulative flow of the contributing line one hierarchy higher; and, pending flow one hierarchy higher, if any. In the pending record table, flows of the same hierarchy are added together. Once a pending flow is used, it is crossed out from the pending record table.

3. The flow of each line is checked against the Q-full of the corresponding line.

Whenever an additional flow (or flows) is tentatively to be added to any line (or lines) the following sequences will be observed:

1. Identify the line (or lines) where additional flow or flows are tentatively to be added. Those lines are "breaking lines."

2. Add additional flow or flows to the cumulative flow of the breaking line (see flowchart).

3. Compute downstream flow and check line capacity, as shown in Flow Computation and Line Capacity Check (see flowchart).

The upstream from a line is identified by a system of lines (or a line) whose hierarchies are equal to or greater than the hierarchy of the line from which the upstream is traced. In the file, the upstream ends at an end line, which is filed before a line whose hierarchy is equal to or less than the hierarchy of the line from which upstream is preferably determined.

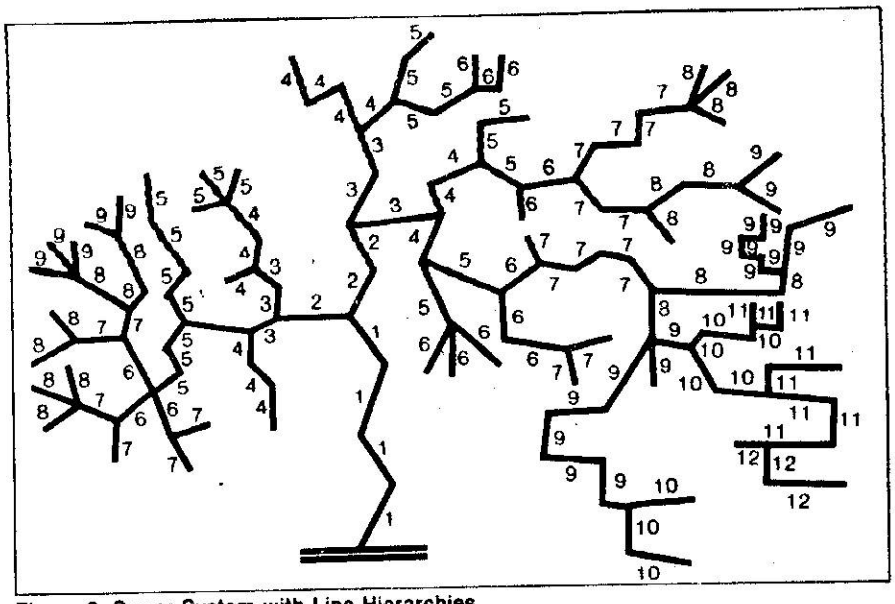

Figure 2. Sewer System with Line Hierarchies.

1(4) 2(2) 3(2) 4(2) [4(1)] 4(1) 5(1) [5(1)] 5(2) [6(1)] 6(1) [6(1)]
3(1) 4(2) 5(1) [5(1)] 5(1) [6(1)] 6(1) 7(4) [8(3)] 7(2) [8(1)]
8(2) [9(2)] 4(1) 5(1) [6(3)] 5(1) 6(2) [7(2)] 6(1) [7(1)]
7(4) 8(2) 9(5) [9(1)] 9(1) [9(1)] 8(1) [9(1)] 9(1) 10(3) [11(1)] 11(1) [11(1)]
10(2) 11(1) [11(1)] 11(3) [12(1)] 12(1) [12(2)] 9(6) [10(1)] 10(1) [10(1)]
2(1) 3(2) [4(1)] 4(2) [5(3)] 3(1) 4(2) [4(1)] 4(1) 5(3) [5(1)] 5(3) 6(1) [7(2)]
6(1) [7(1)] 7(1) [8(3)] 6(1) 7(1) [8(2)] 7(1) 8(1) [9(3)] 8(2) [9(2)]
9(5) = 5 records of hierarchy 9
[ ] = end-record

Figure 3. Line-File Organization.

Whenever a collection system is added to an existing one, the hierarchies of the latter must be updated. This is realized by increasing by one the hierarchies of all the upstream lines, from the line where the new collection system is added. Of course, other data also must be updated if there are any changes, as in the following case:

1. Sewer system with line hierarchies;
2. Line file organization;
3. Flow computation and line capacity check flowchart;
4. Program for Texas Instrument SR-52.

The Contributing and Receiving Line Method is also called the Flow Accounting Method. The sewer map, along with the computer listing showing the actual flow of each line, will constitute a complete accounting book of the collection system. Whenever a subdivision is developed, the sewer map is updated, the hierarchies and flows are recomputed accordingly by computer, and a listing is printed. All this can be done very easily since flow computation, upstream lines identification, and line hierarchy updating are three simple operations. ■

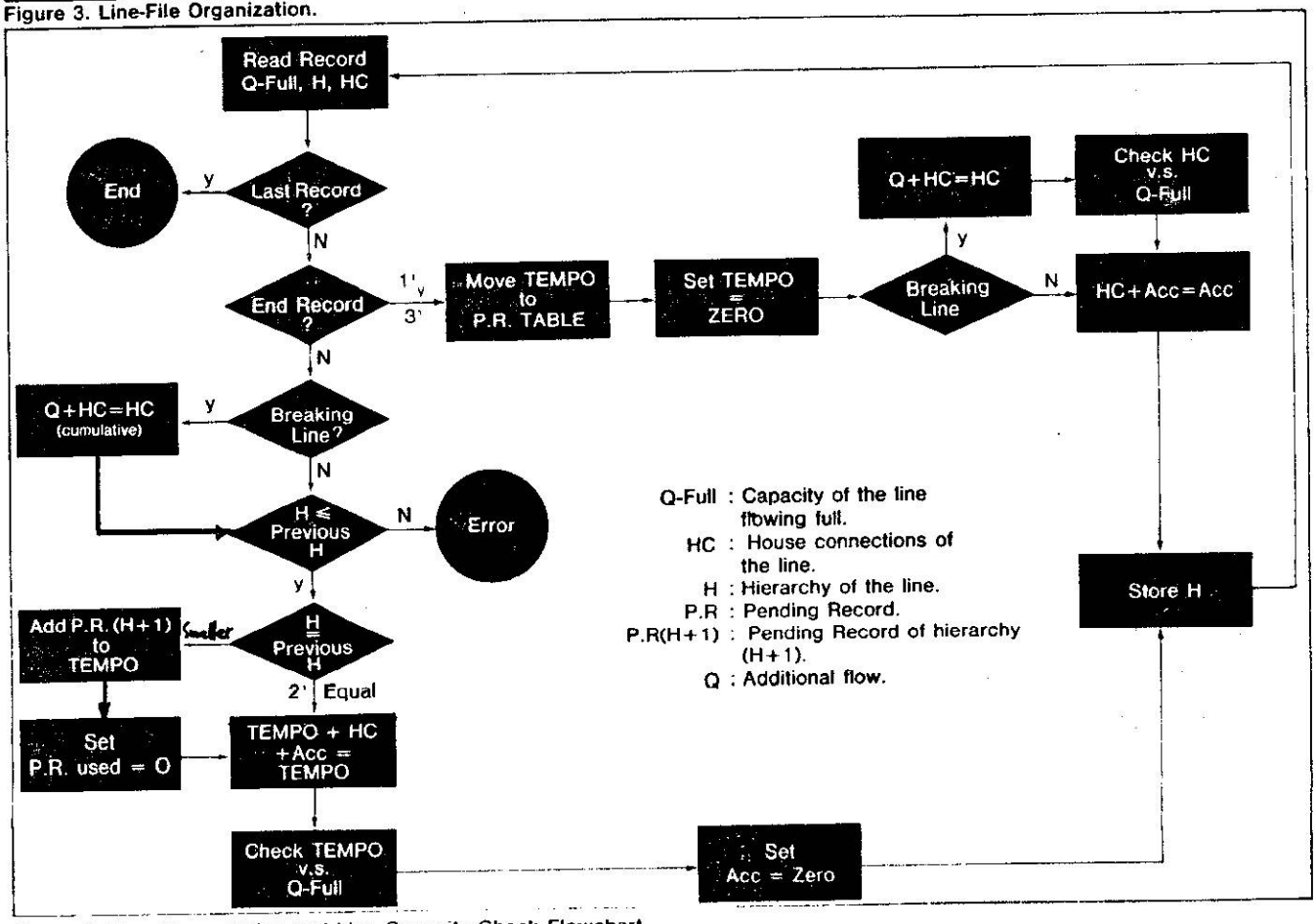

Figure 4. Flow Computation and Line Capacity Check Flowchart.