





**SUPPLEMENTARY  
MATERIAL**  
IN BACK OF BOOK

INVESTIGATION OF THE SANITARY SIDE OF  
THE LANSING SEWERAGE SYSTEM.

A THESIS SUBMITTED TO  
THE FACULTY OF  
THE MICHIGAN AGRICULTURAL COLLEGE.

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BY

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Candidates for the Degree of  
Bachelor of Science.

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THESIS.

## I N T R O D U C T I O N.

To gain the greatest benefits from a college thesis, it is necessary that the investigators undertake a subject that is not beyond their range of vision; one that will interest, as well as instruct.

To this end, we have chosen to investigate a section of the Sewer System installed in the City of Lansing, with special regard to the sanitary system, aiming to suggest remedies for the present unsatisfactory conditions.

We have been guided by text-books on this subject, and have been profited by the advice and help of men who have gained experience and prestige in the engineering world.

We were greatly aided in our work by Metcalf & Eddy's "American Sewerage Practice", Volumes 1 and 2, and, by Folwell's Sewerage, obtaining valuable ideas and formulas.

We wish to thank Mr. Rich, State Sanitary Engineer, Mr. John Gunnell, Assistant City Engineer of Lansing, and, Assistant Professor Gehring, for the courteous treatment and assistance given us.

The city of Lansing, the capital of Michigan, is situated in the mid-central part of the state, and, is almost strictly a manufacturing city. The Grand River flows north through the city, dividing also equally in two parts. The general drainage slope is from the western limits in a general fall to the river.

Owing to the lack of time, we were unable to make our investigation cover the entire City of Lansing, so we confined our efforts to everything west of the Grand River, which district covers practically all the business and about half of the residential district.

The general plan of operation for our work, was as follows:-

- 1.-Determination of people tributary to each manhole.
- 2.-Determination of quantity of sewage flowing from each manhole.
- 3.-Determination of theoritical velocities between each manhole.
- 4.-Determination of the actual velocities between each manhole.
- 5.-Determination of the depth of flow.

Item #1.-

In determining the people tributary to each manhole, we obtained prints of the sewer districts 2, 3, 4 and 5. Our boundaries included all of districts 2 and 3, with part of districts 4 and 5. We counted the houses on both sides of the streets throughout our district, and, made a very thorough survey of the town, allowing five people for each, this being the average number of people in a house.

During this operation, we inspected several manholes, lampholes, and, the outlets. The manholes we inspected were in good shape, and, the outlets we could see were in very good shape. Several of the outlets were submerged, partly on account of high water, and, partly on account of the way they were laid. Practically all the manholes on the streets which were not paved were covered with mud, thus shutting off the ventilation.

Item #2.-

In the determination of the quantity of sewerage flowing into each manhole, we were generally governed by advice and engineering practice. Several books and advices we consulted used different amounts of water per capita, and, we decided to use 125 gallons per capita per day, as the average amount of water used. This seems to be a general average, and, a fair amount in such an estimation.

Item #3.-

The velocities were all taken from diagrams based on Kutter's formula:-

$$V = \left( \frac{41.66 + \frac{1.49}{N} + \frac{0.00281}{S}}{1 + \left( 41.66 + \frac{0.00281}{S} \right) \frac{N}{\sqrt{R}}} \right) \sqrt{RS}$$

Where-

- V-the mean velocity of the water,
- R-Hydraulic mean radius,
- S-Slope of water surface per unit of length,
- N-Coefficient of roughness of the wetted perimeter.



The diagram we used for round pipes flowing full was taken from Metcalf & Eddy, Vol. 1, American Sewerage Practice, page 94. This author recommended .013 as a coefficient N. For egg-shaped brick sewers, running full, we used N=.015. This diagram is found in the same volume. The values of N which we used, are those recommended by the leading Sanitary Engineers in the country. Pages 97-98, Metcalf & Eddy, Vol.1, American Sewerage Practice. The velocities were corrected after we had taken the depth of flow.

Items #4 & #5.-

The total quantity of sewage flowing in the pipe for 24 hours was computed, also the capacity, and, then the depth of flow was taken from tables Nos. 13-14, Pages 53-54, Folwell's Sewage. Folwell asserts that if the depth of flow is less than 2", deposits occur. From these tables, the velocities were also corrected.

| Man<br>Hole<br>num<br>bers | 'peo<br>'ple | 'Quan<br>'tity<br>'of<br>'sewage | ' Grade<br>' between<br>' man-<br>' holes | ' Size of<br>' Pipe | ' Total<br>' Quantity | ' Depth of<br>' flow, in<br>' inches. | ' Cor-<br>' rected<br>' veloc -<br>' ity. |
|----------------------------|--------------|----------------------------------|-------------------------------------------|---------------------|-----------------------|---------------------------------------|-------------------------------------------|
| 1-2                        | 60           | 7500                             | .85                                       | 10"                 | 7500                  | .5                                    | 1.25                                      |
| 2-3                        |              |                                  | .33                                       | 20"                 | 7500                  | .3                                    | .91                                       |
| 4-3                        | 60           | 7500                             | 1.40                                      | 8" I.P.             | 7500                  | .4                                    | 1.33                                      |
| 3-5                        |              |                                  | .33                                       | 24x36 B             | 15000                 | .1                                    | 1.2                                       |
| 6-5                        | 100          | 12500                            | .05                                       | 8" VP               | 12500                 | --                                    | --                                        |
| 5-7                        | 30           | 3750                             | .33                                       | 24x36 B             | 31250                 | 1.44                                  | .95                                       |
| 8-7                        | 110          | 13750                            | .40                                       | 6" VP               | 13750                 | 1.2                                   | 1.3                                       |
| 7-9                        | 10           | 1250                             | .33                                       | 24x36               | 46250                 | 1.8                                   | 1.06                                      |
| 10-9                       | 30           | 3750                             | .50                                       | 9"                  | 3750                  | .6                                    | .06                                       |
| 9-11                       |              |                                  | .33                                       | 24x36               | 50000                 | 1.9                                   | 1.06                                      |
| 12-11                      | 10           | 1250                             | .62                                       | 8"                  | 1250                  | .8                                    | .86                                       |
| 11-13                      | 60           | 7500                             | .79                                       | 24x36               | 58750                 | 1.4                                   | 1.50                                      |
| 13-14                      |              |                                  | .34                                       | 26x39               | 58750                 | 1.6                                   | 1.09                                      |
| 14-15                      | 30           | 3750                             | .34                                       | 26x39               | 64500                 | 1.6                                   | 1.09                                      |
| 20-19                      | 40           | 5000                             | 1.33                                      | 8"                  | 5000                  | .8                                    | 1.3                                       |
| 19-18                      | 40           | 5000                             | .67                                       | 8"                  | 19000                 | 1.2                                   | 1.16                                      |
| 18-16                      | 45           | 5625                             | .22                                       | 32x54               | 15625                 | 1.8                                   | .87                                       |
| 17-16                      | 40           | 5000                             | .35                                       | 9"                  | 20625                 | 1.2                                   | .85                                       |
| 16-15                      | 20           | 2500                             | .22                                       | 32x54               | 34625                 | 1.9                                   | .87                                       |
| 21-15                      | 40           | 5000                             | .50                                       | 10"                 | 5000                  | 1.5                                   | 1.21                                      |
| 15-22                      | 65           | 8125                             | .22                                       | 40x60               | 97750                 | 2.0                                   | 1.01                                      |

| M.H.  | People | Quantity | Grade | Size  | Total Quantity | Depth | Corrected velocity |
|-------|--------|----------|-------|-------|----------------|-------|--------------------|
| 23-22 | 40     | 5000     | .50   | 10"   | 5000           | 1.0   | 1.65               |
| 22-24 | 50     | 6250     | .22   | 40x60 | 109000         | 2.0   | 1.06               |
| 25-24 | 45     | 5625     | .60   | 8"    | 5625           | .8    | 1.87               |
| 27-26 | 115    | 14375    | .40   | 8"    | 14375          | .8    | .72                |
| 26-24 | 105    | 13175    | .37   | 8"    | 27500          | 1.2   | .87                |
| 24-28 | 45     | 5625     | .22   | 40x60 | 147750         | 2.2   | 1.1                |
| 29-30 | 140    | 17500    | .44   | 8"    | 17500          | .8    | .75                |
| 30-28 | 115    | 14375    | .30   | 12"   | 27875          | 1.2   | .83                |
| 28-31 | 24     | 3000     | .20   | 48x72 | 175625         | 2.4   | 1.14               |
| 33-32 | 20     | 2500     | .50   | 8"    | 3500           | .8    | .79                |
| 32-31 | 15     | 1875     | .80   | 12"   | 4375           | .8    | 1.37               |
| 31-34 | 140    | 17500    | .20   | 48x72 | 180000         | 2.4   | 1.14               |
| 35-34 | 85     | 10625    | 1.9   | 8"    | 10625          | .8    | 1.58               |
| 30-34 | 45     | 5625     | 2.33  | 8"    | 5625           | .8    | 1.73               |
| 56-54 | 110    | 13750    | 1.0   | 6"    | 13750          | .6    | .90                |
| 55-54 | 70     | 8750     | 2.12  | 8"    | 23500          | .8    | 1.65               |
| 54-53 | 130    | 16250    | 1.23  | 6"    | 28750          | 1.2   | 1.57               |
| 53-52 | 75     | 9375     | .60   | 8"    | 38125          | 1.2   | 1.20               |
| 52-49 | 85     | 10625    | .45   | 8"    | 48750          | 1.6   | 1.26               |
| 51-50 | 55     | 6875     | .10   | 6"    | 6875           | .6    | .22                |
| 6-50  | 105    | 13125    | .90   | 8"    | 20000          | .8    | 1.08               |
| 50-49 | 65     | 8125     | .40   | 12"   | 28125          | 1.2   | 1.00               |
| 49-48 | 35     | 6525     | .20   | 12"   | 76875          | 2.2   | .95                |
| 48-48 | 110    | 13375    | .66   | 6"    | 13375          | .9    | .80                |



| M.H.  | Peo-<br>ple | Quan-<br>tity | Grade | Size  | Total<br>Quantity | Depth | Correc-<br>ted<br>velocity. |
|-------|-------------|---------------|-------|-------|-------------------|-------|-----------------------------|
| 48-41 | 35          | 4325          | .20   | 15"   | 91940             | 2.25  | .95                         |
| 45-44 | 50          | 6250          | .50   | 6"    | 6250              | .6    | .8                          |
| 8-44  | 115         | 14375         | .40   | 6"    | 14375             | 1.2   | 1.3                         |
| 44-43 | 10          | 1250          | 1.51  | 6"    | 21875             | .8    | 1.0                         |
| 43-41 | 55          | 6875          | .50   | 8"    | 28750             | 1.2   | 1.0                         |
| 41-40 | 40          | 5000          | .20   | 15"   | 123690            | 1.6   | 1.15                        |
| 40-39 | 20          | 2500          | .20   | 15"   | 123190            | 2.0   | 1.15                        |
| 39-38 | 50          | 6250          | .20   | 20"   | 132440            | 2.4   | 1.00                        |
| 38-37 | 55          | 6875          | .20   | 24"   | 139315            | 2.4   | 1.15                        |
| 37-34 |             |               | .20   | 24"   | 139315            | 3.6   | 1.15                        |
| 34-57 | 50          | 6250          | .20   | 48x72 | 335 565           | 1.8   | 1.4                         |
| 59-58 | 60          | 7500          | .50   | 18"   | 7500              | 1.0   | 1.5                         |
| 58-57 | 45          | 5625          | .50   | 10"   | 13125             | 1.0   | .9                          |
| 57-60 | 35          | 4375          | .20   | 48x72 | 353065            | 3.6   | 1.4                         |
| 66-65 |             |               | .50   | 8"    |                   |       |                             |
| 65-64 | 20          | 2500          | .50   | 10"   | 2500              | 1.0   | .97                         |
| 64-61 |             |               | .50   | 12"   | 2500              | 1.2   | 1.11                        |
| 63-62 |             |               | .50   | 8"    |                   |       |                             |
| 62-61 | 20          | 2500          | .50   | 10"   | 2500              | 1.0   | .97                         |
| 61-60 | 100         | 12500         | 1.10  | 15"   | 5000              | 1.5   | 1.55                        |
| 67-68 | 85          | 10625         | 1.6   | 8"    | 10625             | 1.6   | 2.24                        |
| 68-60 |             |               | .50   | 10"   |                   |       |                             |
| 60-69 | 65          | 8375          | .50   | 42x63 | 372060            | 3.3   | 2.1                         |
| 71-70 | 85          | 10625         | .50   | 8"    | 10625             | .8    | .79                         |
| 70-69 |             |               | .50   |       |                   |       |                             |

| M.H.  | Peo-<br>ple | Quan-<br>tity | Grade | Size  | Total<br>Quantity | Correc-<br>ted ve-<br>locity | Depth. |
|-------|-------------|---------------|-------|-------|-------------------|------------------------------|--------|
| 69-72 | 55          | 6875          | .50   | 42x63 | 378560            | 2.1                          | 3.3    |
| 74-73 | 60          | 7500          | 1.0   | 8"    | 7500              | 1.15                         | .8     |
| 75-73 | 60          | 7500          | 1.0   | 8"    | 7500              | 1.15                         | .8     |
| 73-72 | 35          | 1375          | 2.0   | 8"    | 19375             | 1.82                         | 1.2    |
| 76-72 | 50          | 6250          | .70   | 8"    | 6250              | .94                          | .8     |
| 72-77 | 75          | 9375          | .80   | 42x63 | 394185            | 2.70                         | 3.15   |
| 78-77 | 100         | 12500         | .80   | 8"    | 12500             | 1.05                         | .8     |
| 77-79 | 85          | 10625         | .50   | 42x63 | 427310            | 2.10                         | 3.15   |
| 80-79 | 25          | 3125          | .80   | 8"    | 3125              | 1.05                         | .8     |
| 83-81 | 55          | 6875          | 1.00  | 8"    | 6875              | 1.15                         | .8     |
| 82-81 | 25          | 3125          | 2.0   | 8"    | 3125              | 1.66                         | .8     |
| 81-79 | 60          | 7500          | 1.33  | 10"   | 17500             | 1.26                         | 1.0    |
| 79-84 | 80          | 10000         | .50   | 42x63 | 447935            | 2.10                         | 3.15   |
| 87-86 | 35          | 4375          | 1.23  | 8"    | 4375              | 1.26                         | .8     |
| 86-85 | 60          | 7500          | 1.8   | 10"   | 11875             | 1.8                          | 1.0    |
| 95-94 | 60          | 7500          | .41   | 15"   | 7500              | 1.18                         | 1.5    |
| 93-94 | 80          | 10000         | .97   | 8"    | 10000             | 1.15                         | .8     |
| 94-88 | 35          | 4575          | .33   | 18"   | 21875             | 1.70                         | 1.8    |
| 89-88 | 60          | 7500          | .93   | 8"    | 7500              | 1.12                         | .8     |
| 91-90 | 45          | 5625          | .45   | 8"    | 5625              | .76                          | .8     |
| 92-90 | 20          | 2500          | .50   | 8"    | 2500              | .79                          | .8     |
| 90-88 | 45          | 5625          | 1.17  | 10"   | 13850             | 1.48                         | 1.0    |
| 88-85 | 45          | 5625          | .33   | 20"   | 48850             | 1.30                         | 2.0    |
| 85-84 | 35          | 4375          | .25   | 22x33 | 65100             | .71                          | 1.1    |
| 84-96 | 30          | 3750          | .50   | 42x63 | 516785            | 2.20                         | 3.15   |

| M.H.    | Peo-<br>ple. | Quan-<br>tity. | Grade | Size   | Total<br>Quantity | Correc-<br>ted ve-<br>locity | Depth. |
|---------|--------------|----------------|-------|--------|-------------------|------------------------------|--------|
| <hr/>   |              |                |       |        |                   |                              |        |
| 97-96   | 30           | 3750           | .50   | 8"     | 3750              | .79                          | .8     |
| 96-98   | 55           | 6875           | .50   | 42x63  | 527410            | 2.20                         | 3.15   |
| 116-114 | 5            | 625            | 1.60  | 8"     | 625               | 1.44                         | .8     |
| 115-114 | 65           | 8125           | .80   | 8"     | 8125              | 1.00                         | .8     |
| 114-113 | 80           | 10000          | .80   | 8"     | 18750             | 1.00                         | .8     |
| 113-112 | --           | -----          | .80   | 8"     | 18750             | 1.00                         | .8     |
| 112-111 | --           | -----          | .50   | 10"    | 18750             | .97                          | 1.0    |
| 111-110 | 5            | 675            | 1.1   | 15"    | 19375             | 1.91                         | 1.5    |
| 117-110 | 70           | 8750           | 2.8   | 8"     | 8750              | 1.97                         | .8     |
| 119-118 | 30           | 3750           | 1.0   | 8"     | 3750              | 1.15                         | .8     |
| 118-110 | --           | -----          | 3.5   | 8"     | 3750              | 2.16                         | .8     |
| 110-108 | --           | -----          | .40   | 18"    | 31875             | 1.33                         | 1.8    |
| 109-108 | 80           | 10000          | .80   | 8"     | 10000             | 1.00                         | .8     |
| 108-105 | --           | -----          | .40   | 20"    | 41875             | 1.44                         | 2.0    |
| 107-106 | 5            | 625            | 5.5   | 8"     | 625               | 2.70                         | .8     |
| 106-105 | 5            | 625            | .40   | 8"     | 1250              | .72                          | .8     |
| 105-103 | 20           | 2500           | .50   | 24"    | 45625             | 1.84                         | 2.4    |
| 104-103 | 5            | 625            | .45   | 8"     | 625               | .76                          | .8     |
| 103-99  | 70           | 8750           | .45   | 24"    | 55000             | 1.73                         | 2.4    |
| 102-100 | 60           | 7500           | .80   | 8"     | 7500              | 1.00                         | .8     |
| 101-100 | 30           | 3750           | .80   | 8"     | 3750              | 1.00                         | .8     |
| 100-99  | 70           | 8750           | 1.7   | 10"    | 20000             | 1.80                         | 1.0    |
| 99-98   | --           | -----          | .60   | 40x60B | 75000             | 1.72                         | 2.0    |
| 98-120  | 35           | 4375           | .25   | 48x64  | 602410            | 2.65                         | 4.5    |
| 121-120 | 60           | 7500           | .50   | 8"     | 7500              | .79                          | .8     |

| M.H.    | Peo-<br>ple | Quan-<br>tity. | Grade | Size  | Total<br>Quantity | Correc-<br>ted ve-<br>locity. | Depth |
|---------|-------------|----------------|-------|-------|-------------------|-------------------------------|-------|
| 122-120 | 60          | 7500           | 1.90  | 8"    | 7500              | 1.58                          | .8    |
| 120-123 | 50          | 6250           | .25   | 48x64 | 623660            | 2.65                          | 4.5   |
| 125-123 | 55          | 6875           | 1.32  | 8"    | 6875              | 1.3                           | .8    |
| 124-123 | 35          | 4375           | .70   | 12"   | 4375              | 1.3                           | 1.2   |
| 123-126 | 60          | 7500           | .25   | 48x64 | 635910            | 2.66                          | 4.6   |
| 127-126 | 50          | 6250           | .80   | 8"    | 6250              | 1.0                           | .8    |
| 126-128 | 85          | 10825          | .25   | 48x64 | 652785            | 2.66                          | 4.6   |
| 132-131 | 15          | 1875           | .33   | 8"    | 1875              | .7                            | .8    |
| 131-129 | 20          | 2500           | 1.50  | 8"    | 4375              | 1.4                           | .8    |
| 130-129 | 10          | 1250           | 1.0   | 8"    | 1250              | 1.15                          | .8    |
| 129-128 | 45          | 5625           | 1.5   | 10"   | 11250             | 1.65                          | 1.0   |
| 128-133 | 65          | 8125           | 1.92  | 40x60 | 672160            | 4.45                          | 4.62  |
| 138-133 | 65          | 8125           | 1.0   | 15"   | 8125              | 1.4                           | 1.5   |
| 137-135 | 60          | 7500           | 3.5   | 8"    | 7500              | 2.2                           | .8    |
| 136-135 | 60          | 7500           | 2.2   | 8"    | 7500              | 1.7                           | .8    |
| 135-133 | 30          | 3750           | 1.1   | 10"   | 18750             | 1.4                           | 1.0   |
| 133-139 | 50          | 6250           | 1.44  | 40x60 | 703285            | 3.77                          | 4.7   |
| 140-141 | 45          | 5625           | .93   | 6"    | 5625              | .86                           | .6    |
| 142-141 | 45          | 5625           | .50   | 6"    | 5625              | .65                           | .6    |
| 141-143 | 60          | 7500           | .50   | 6"    | 18750             | 1.00                          | .7    |
| 143-144 | 35          | 4375           | 1.5   | 6"    | 13125             | 1.20                          | 2.0   |
| 144-145 | 40          | 5000           | .20   | 6"    | 18000             | .72                           | 2.0   |
| 145     | --          | ----           | .23   | 26x39 | 18000             | .76                           | 1.3   |
| 263-262 | 125         | 15625          | 1.65  | 8"    | 15625             | 1.48                          | .8    |

| M.H.    | Peo-<br>ple | Quan-<br>tity. | Grade | Size | Total<br>Quantity | Correc-<br>ted ve-<br>locity. | Depth. |
|---------|-------------|----------------|-------|------|-------------------|-------------------------------|--------|
| 263-261 | 35          | 4375           | 1.37  | 6"   | 20000             | 1.78                          | 1.0    |
| 261-260 | 80          | 10000          | .4    | 6"   | 30000             | 1.17                          | 1.5    |
| 264-260 | 75          | 9375           | 1.31  | 8"   | 9375              | 1.30                          | .8     |
| 261-260 | 55          | 6875           | .6    | 8"   | 6875              | .72                           | .8     |
| 260-259 | 80          | 10000          | .35   | 8"   | 56250             | 1.24                          | 2.0    |
| 58-259  | 115         | 14375          | .20   | 8"   | 14375             | .51                           | .8     |
| 260-259 | 65          | 8125           | 1.12  | 6"   | 8125              | .94                           | .8     |
| 259-258 | 55          | 6875           | .24   | 8"   | 85625             | 1.16                          | 2.6    |
| 266-267 | 35          | 4375           | .6    | 6"   | 4375              | .72                           | .6     |
| 267-268 | 60          | 7500           | 1.25  | 8"   | 11875             | 1.30                          | .8     |
| 268-269 | 20          | 2500           | .75   | 8"   | 14300             | .97                           | .8     |
| 270-269 | 35          | 4375           | .40   | 8"   | 4375              | .72                           | .8     |
| 264-269 | 50          | 6250           | .26   | 6"   | 6250              | .47                           | .6     |
| 269-271 | 75          | 9375           | .80   | 8"   | 34300             | 1.3                           | 1.2    |
| 274-273 | 35          | 4375           | .75   | 8"   | 4375              | .97                           | .8     |
| 275-273 | 50          | 6250           | .50   | 6"   | 6250              | 1.17                          | .6     |
| 273-272 | 65          | 8125           | .80   | 8"   | 18750             | 1.30                          | .8     |
| 276-272 | 50          | 6250           | .5    | 8"   | 6250              | .79                           | .8     |
| 272-271 | 25          | 3125           | .8    | 8"   | 28125             | 1.2                           | 1.2    |
| 271-258 | 80          | 10000          | .8    | 8"   | 38125             | 1.3                           | 1.2    |
| 258-257 | 60          | 7500           | .46   | 12"  | 123750            | 1.63                          | 2.4    |
| 257-279 | 35          | 4375           | .21   | 30"  | 128125            | 1.48                          | 3.0    |
| 272-277 | 60          | 7500           | .75   | 8"   | 7500              | .97                           | .8     |
| 278-277 | 20          | 2500           | .6    | 8"   | 2500              | .86                           | .8     |
| 277-279 | --          | ----           | .7    | 8"   | 10000             | .94                           | .8     |

| M.H.    | Peo-<br>ple | Quantity | Grade | Size | Total<br>Quantity | Correc-<br>ted ve-<br>locity. | Depth. |
|---------|-------------|----------|-------|------|-------------------|-------------------------------|--------|
| 279-280 | 20          | 2500     | .7    | 8"   | 10000             | .94                           | .8     |
| 282-285 | 65          | 8125     | .83   | 6"   | 8125              | .79                           | .6     |
| 285-284 | 45          | 5625     | .8    | 6"   | 13750             | .79                           | .6     |
| 284-283 | --          | ----     | .84   | 6"   | 13750             | .79                           | .6     |
| 283-282 | 45          | 5625     | 1.35  | 6"   | 19375             | 1.23                          | 1.0    |
| 282-281 | 55          | 6875     | .5    | 8"   | 23250             | .93                           | 1.2    |
| 281-280 | 20          | 2500     | .5    | 6"   | 28750             | 1.08                          | 1.2    |
| 280-290 | 100         | 12500    | .21   | 30"  | 136875            | 2.41                          | 7.5    |
| 252-251 | 165         | 20625    | .67   | 6"   | 20625             | 1.12                          | 1.2    |
| 251-249 | 150         | 18750    | .76   | 8"   | 39375             | 1.25                          | 1.2    |
| 250-249 | 55          | 6875     | .6    | 6"   | 6875              | 1.08                          | .6     |
| 249-248 | 60          | 7500     | .8    | 8"   | 57350             | 1.56                          | 1.6    |
| 248-245 | 50          | 6250     | .8    | 8"   | 60000             | 1.57                          | 1.6    |
| 248-246 | 60          | 7500     | .44   | 8"   | 7500              | .76                           | .8     |
| 247-246 | 55          | 6875     | 1.6   | 6"   | 6875              | 1.15                          | .6     |
| 246-245 | 30          | 3750     | .7    | 8"   | 18125             | .94                           | .8     |
| 245-244 | 90          | 11250    | .20   | 10"  | 78125             | 1.11                          | 2.5    |
| 247-256 | 100         | 12500    | 1.5   | 6"   | 12500             | 1.15                          | .6     |
| 256-253 | 60          | 7500     | .46   | 12"  | 20000             | 1.04                          | 1.2    |
| 254-253 | 65          | 8125     | .5    | 8"   | 8125              | .79                           | .8     |
| 255-253 | 60          | 7500     | .5    | 6"   | 7500              | .65                           | .6     |
| 253-244 | 35          | 4375     | .46   | 12"  | 40000             | 1.04                          | 1.2    |
| 333-288 | 25          | 3125     | 2.7   | 6"   | 3125              | 1.47                          | .6     |
| 287-288 | 35          | 4375     | 1.0   | 8"   | 4375              | 1.15                          | .8     |

| M.H.    | Peo-<br>ple. | Quantity | Grade | Size  | Total<br>Quantity | Correc-<br>ted ve-<br>locity. | Depth. |
|---------|--------------|----------|-------|-------|-------------------|-------------------------------|--------|
| 288-334 | 25           | 3125     | .87   | 8"    | 10625             | 1.05                          | .8     |
| 334-335 | 40           | 5000     | .6    | 8"    | 15625             | .86                           | .8     |
| 335-289 | 20           | 2500     | .6    | 8"    | 18125             | .86                           | .8     |
| 281-289 | 35           | 4375     | .5    | 8"    | 4375              | .79                           | .8     |
| 289-290 | 55           | 6875     | .6    | 8"    | 29375             | .86                           |        |
| 336-290 | 35           | 4375     | .6    | 6"    | 4375              | .72                           | .6     |
| 290-303 | 45           | 5625     | .5    | 24x36 | 206250            | 3.6                           | 9.6    |
| 304-303 | 40           | 5000     | .6    | 8"    | 5000              | .86                           | .8     |
| 305-303 | 40           | 5000     | 1.0   | 8"    | 5000              | 1.15                          | .8     |
| 303-302 | 350          | 43750    | .5    | 24x36 | 260000            | 3.7                           | 12.0   |
| 332-331 | 15           | 1875     | .63   | 6"    | 1875              | .68                           | .6     |
| 331-330 | 35           | 4375     | .75   | 6"    | 5250              | .79                           | .6     |
| 329-330 | 35           | 4325     | .6    | 6"    | 4375              | .72                           | .6     |
| 330-326 | 40           | 5000     | 2.0   | 8"    | 14625             | 1.62                          | .8     |
| 328-326 | 30           | 3750     | .8    | 8"    | 3750              | 1.05                          | .8     |
| 327-326 | 70           | 8750     | .52   | 6"    | 8750              | .68                           | .6     |
| 326-322 | 40           | 5000     | .8    | 8"    | 32125             | 1.18                          | 1.1    |
| 325-323 | 35           | 4375     | 1.15  | 8"    | 4375              | 1.23                          | .8     |
| 324-323 | 30           | 3750     | 1.0   | 6"    | 3750              | .90                           | .6     |
| 323-322 | 55           | 6875     | 1.0   | 6"    | 15000             | .90                           | .6     |
| 322-310 | 50           | 6250     | .38   | 8"    | 47125             | 1.44                          | 1.3    |
| 311-310 | 25           | 3125     | 2.02  | 6"    | 3125              | 1.30                          | .6     |
| 310-308 | 55           | 6875     | .4    | 6"    | 57175             | 1.39                          | 1.8    |
| 309-308 | 20           | 2500     | .5    | 12"   | 250               | 1.12                          | 1.2    |
| 310-313 | 25           | 3125     | 1.0   | 6"    | 3125              | .90                           | .6     |

| M.H.    | People | Quantity | Grade | Size | Total Quantity | Corrected velocity. | Depth. |
|---------|--------|----------|-------|------|----------------|---------------------|--------|
| 313-308 | 45     | 5625     | 1.5   | 6"   | 8750           | 1.15                | .6     |
| 308-306 | 30     | 3750     | .5    | 8"   | 73175          | 1.13                | 2.4    |
| 307-306 | 35     | 4375     | .8    | 6"   | 4375           | .79                 | .6     |
| 321-319 | 55     | 6875     | .5    | 8"   | 6875           | .79                 | .8     |
| 320-319 | 40     | 5000     | 1.4   | 8"   | 5000           | 1.36                | .3     |
| 319-317 | 30     | 3750     | .5    | 8"   | 15625          | .79                 | .8     |
| 318-317 | 55     | 6875     | .87   | 8"   | 6875           | 1.08                | .8     |
| 317-316 | 50     | 6250     | .5    | 12"  | 28750          | 1.15                | 1.2    |
| 314-315 | 20     | 2500     | .8    | 8"   | 2500           | 1.00                | .8     |
| 315-316 | 65     | 8125     | 2.03  | 8"   | 10625          | 1.62                | .8     |
| 316-308 | 65     | 8125     | .3    | 15"  | 47500          | 1.00                | 1.5    |
| 308-302 | 50-    | 6250     | .3    | 15"  | 131300         | 1.29                | 2.5    |
| 302-299 | 175    | 21875    | .54   | 18"  | 413175         | 2.46                | 3.6    |
| 301-300 | 100    | 12500    | .4    | 6"   | 12500          | .57                 | .6     |
| 299-292 | 100    | 12500    | .3    | 18"  | 441300         | 2.27                | 4.5    |
| 300-299 | 125    | 15625    | .4    | 6"   | 28125          | 1.04                | 1.5    |
| 297-296 | 75     | 9375     | 1.5   | 6"   | 9375           | 1.11                | .6     |
| 296-294 | 125    | 15625    | .5    | 8"   | 20000          | .92                 | 1.2    |
| 293-294 | 175    | 21875    | 1.85  | 12"  | 21875          | 2.05                | 1.2    |
| 294-292 | 100    | 12500    | 1.3   | 18"  | 59375          | 2.38                | 1.8    |
| 298-292 | 125    | 15625    | .5    | 8"   | 13625          | .79                 | .8     |
| 292-292 | 100    | 12500    | 1.4   | 8"   | 12500          | 1.36                | .8     |
| 292-225 | 350    | 43750    | .33   | 18"  | 572550         | 2.42                | 5.4    |
| 243-241 | 40     | 5000     | .65   | 6"   | 5000           | .72                 | .6     |
| 243-241 | 60     | 7500     | 1.3   | 6"   | 7500           | 1.22                | .6     |

| M.H.      | People | Quantity | Grade | Size  | Total Quantity | Corrected velocity. | Depth. |
|-----------|--------|----------|-------|-------|----------------|---------------------|--------|
| 241-240   | 50     | 6250     | .96   | 8"    | 18750          | 1.15                | .8     |
| 244-240   | 25     | 3125     | .45   | 12"   | 43125          | 1.05                | 1.2    |
| 242-236   | 30     | 3750     | .5    | 18"   | 234425         | 1.77                | 2.3    |
| 239-238   | 20     | 2500     | .5    | 8"    | 6500           | .79                 | .8     |
| 238-237   | 40     | 5000     | .5    | 6"    | 7500           | .65                 | .6     |
| 237-236   | 35     | 4375     | 1.0   | 6"    | 11875          | .90                 | .6     |
| 236-231   | 50     | 6250     | .5    | 15"   | 252550         | 2.34                | 3.7    |
| 232-231   | 5      | 625      | .7    | 8"    | 625            | .93                 | .7     |
| 233-235   | 65     | 8125     | 1.05  | 6"    | 8125           | .83                 | .6     |
| 234-235   | 90     | 11250    | 1.8   | 6"    | 11250          | 1.22                | .6     |
| 235-231   | 20     | 2500     | .45   | 8"    | 21675          | .88                 | 1.1    |
| 231-230   | 25     | 3125     | .6    | 18"   | 277175         | 1.76                | 2.3    |
| 230-228   | 25     | 3125     | .26   | 18"   | 280300         | 1.68                | 2.6    |
| 229-228   | 100    | 12500    | .7    | 6"    | 13500          | .76                 | .6     |
| 198-197   | 125    | 15625    | 1.4   | 6"    | 15625          | 1.26                | 1.0    |
| 197-199   | 40     | 5000     | .4    | 8"    | 21625          | .67                 | 1.2    |
| 199-228   | 80     | 10000    | .45   | 8"    | 31625          | .95                 | 1.2    |
| 228-228'  | 50     | 6250     | .54   | 18"   | 330675         | 2.43                | 3.6    |
| 228"-228' | 200    | 25000    | .55   | 8"    | 25000          | .97                 | 1.1    |
| 228'-226  | 50     | 6250     | .54   | 18"   | 331925         | 2.45                | 3.6    |
| 291-226   | 100    | 12500    | .67   | 8"    | 12500          | .94                 | .8     |
| 227-226   | 100    | 12500    | .63   | 6"    | 12500          | .72                 | .6     |
| 226-225   | 125    | 15625    | 1.25  | 8"    | 392550         | 3.3                 | 4.0    |
| 225-220   | 125    | 15625    | .25   | 22x33 | 408175         | .55                 | 1.2    |
| 224-220   | 150    | 18750    | 2.20  | 9"    | 18750          | 1.73                | .9     |

| M.H.     | People | Quantity. | Grade | Size  | Total Quantity | Corrected velocity. | Depth. |
|----------|--------|-----------|-------|-------|----------------|---------------------|--------|
| 233-231  | 40     | 5000      | .5    | 9"    | 5000           | .90                 | .9     |
| 222-221  | 150    | 18750     | .5    | 8"    | 18750          | .86                 | 1.0    |
| 221-220  | 50     | 6350      | 1.5   | 9"    | 32000          | 1.53                | .9     |
| 220-191  | 130    | 15000     | .25   | 22x23 | 456925         | 1.11                | 3.6    |
| 219-218  | 70     | 8750      | .6    | 6"    | 8750           | .68                 | .6     |
| 218-215  | 75     | 9375      | 2.06  | 6"    | 18125          | 1.44                | .6     |
| 216-215  | 35     | 4375      | .44   | 6"    | 4375           | .65                 | .6     |
| 217-215  | 60     | 7500      | 1.9   | 6"    | 7500           | 1.26                | .6     |
| 215-213  | 35     | 4375      | .65   | 8"    | 34375          | 1.19                | 1.0    |
| 214-213  | 75     | 9375      | .5    | 8"    | 9375           | .79                 | .8     |
| 213-210  | 20     | 2500      | .4    | 8"    | 46250          | 1.12                | 1.6    |
| 211-210  | 30     | 3750      | 1.3   | 6"    | 3750           | 1.04                | .8     |
| 212-210  | 90     | 11250     | .6    | 8"    | 11250          | .83                 | .8     |
| 210-202  | 30     | 3750      | .4    | 8"    | 65000          | 1.20                | 2.0    |
| 209-208  | 15     | 1875      | .6    | 6"    | 1875           | .72                 | .6     |
| 208-206  | 20     | 2500      | 1.5   | 6"    | 4775           | 1.10                | .6     |
| 207-206  | 25     | 3125      | 1.0   | 8"    | 3125           | 1.16                | .8     |
| 206-204  | 45     | 5625      | .8    | 6"    | 12525          | .88                 | .8     |
| 205-205  | 90     | 11250     | .45   | 6"    | 11250          | .72                 | .8     |
| 205-204  | 30     | 3750      | 1.0   | 6"    | 15000          | 1.06                | .8     |
| 204-203  | 40     | 5000      | .5    | 6"    | 20000          | 1.10                | 1.2    |
| 203'-203 | 40     | 5000      | .6    | 6"    | 5000           | .72                 | .6     |
| 203-202  | 55     | 6875      | .4    | 6"    | 31875          | .96                 | 1.7    |
| 203-200  | 60     | 7500      | .7    | 9"    | 101375         | 1.74                | 2.0    |
| 200-197  | 50     | 6350      | .9    | 9"    | 110625         | 2.10                | 2.0    |

| M <sub>4</sub> H. | People Quantity |       | Grade | Size  | Total Quantity | Corrected velocity. | Depth. |
|-------------------|-----------------|-------|-------|-------|----------------|---------------------|--------|
| 197-196           | 20              | 2500  | 2.0   | 9"    | 13125          | 2.80                | 1.8    |
| 195-196           | 50              | 6250  | .4    | 6"    | 6250           | .58                 | .6     |
| 196-194           | 20              | 2500  | 2.0   | 9"    | 121875         | 2.80                | 1.9    |
| 190-186           | 50              | 6250  | 1.5   | 6"    | 6250           | 1.15                | .6     |
| 186-194           | 50              | 6250  | 4.0   | 6"    | 12500          | 1.80                | .6     |
| 194-192           | --              | ----  | 2.0   | 9"    | 174375         | 2.95                | 1.9    |
| 193-192           | 60              | 7500  | .8    | 6"    | 7500           | .79                 | .6     |
| 192-191           | 50              | 6250  | 2.0   | 9"    | 147925         | 3.00                | 2.0    |
| 191-183           | 175             | 21875 | .20   | 22x13 | 626725         | 2.8                 | 3.8    |
| 189-187           | 60              | 7500  | .6    | 6"    | 7500           | .79                 | .6     |
| 188-187           | 30              | 3750  | .5    | 6"    | 3750           | .65                 | .6     |
| 187-184           | 30              | 3750  | 1.4   | 6"    | 15000          | 1.20                | .8     |
| 185-184           | 50              | 6250  | .4    | 6"    | 6250           | .58                 | .6     |
| 184-183           | 35              | 4375  | 1.16  | 6"    | 25625          | 2.75                | .9     |
| 183-181           | 35              | 4375  | 2.0   | 22x33 | 30000          | 2.16                | 1.1    |
| 182-181           | 50              | 6250  | .8    | 8"    | 6250           | 1.00                | .8     |
| 181-167           | --              | ----  | .2    | 24x33 | 362975         | 1.89                | 3.0    |
| 86-178            | 55              | 6875  | .5    | 8"    | 6875           | .79                 | .8     |
| 180-179           | 20              | 2500  | 1.5   | 6"    | 2500           | 1.15                | .6     |
| 179-178           | 80              | 10000 | 1.5   | 6"    | 13375          | 1.30                | .7     |
| 178-173           | 45              | 5625  | .75   | 8"    | 25000          | 1.12                | .7     |
| 176-175           | 45              | 5625  | .4    | 6"    | 5625           | .58                 | .6     |
| 175-173           | 65              | 8125  | 1.5   | 6"    | 13750          | 1.24                | .7     |
| 173-171           | 25              | 3125  | .3    | 8"    | 41875          | 1.02                | 2.0    |
| 177-175           | 55              | 6875  | .7    | 8"    | 6875           | .94                 | .8     |

| M. H. -  | People | Quantity | Grade | Size  | Total Quantity | Corrected velocity. | Depth. |
|----------|--------|----------|-------|-------|----------------|---------------------|--------|
| 175-174  | 55     | 6875     | .7    | 8"    | 13750          | .94                 | .8     |
| 174-171  | 35     | 4375     | 1.0   | 6"    | 18125          | 1.13                | 1.0    |
| 172-171  | 30     | 3750     | 1.6   | 6"    | 3750           | 1.15                | .6     |
| 171-166  | 30     | 2500     | .3    | 9"    | 63750          | 1.14                | 2.0    |
| 170-169  | 10     | 1250     | .5    | 6"    | 1250           | .65                 | .6     |
| 169-166  | 35     | 4375     | 1.1   | 6"    | 5625           | .94                 | .6     |
| 166-167  | 25     | 3125     | 6.4   | 9"    | 72500          | 3.06                | .9     |
| 167-161  | 10     | 1250     | .20   | 24x36 | 736725         | 1.95                | 8.3    |
| 165-164  | 50     | 6250     | .8    | 6"    | 6250           | .79                 | .6     |
| 164-163  | 60     | 7500     | .4    | 6"    | 13750          | .77                 | 1.4    |
| 163'-163 | 30     | 3750     | .5    | 6"    | 3750           | .65                 | .6     |
| 163-162  | 20     | 2500     | .6    | 8"    | 20000          | .96                 | 1.0    |
| 162'-162 | 30     | 3750     | .6    | 6"    | 3750           | .72                 | .6     |
| 162-161  | 40     | 5000     | .025  | 12"   | 28750          | .17                 | 2.4    |
| 161-157  | 15     | 1875     | .2    | 24x36 | 765475         | 2.01                | 8.7    |
| 159-158  | 20     | 2500     | 1.8   | 6"    | 2500           | 1.22                | .6     |
| 160-158  | 30     | 3750     | .7    | 6"    | 3750           | .76                 | .6     |
| 158-157  | 70     | 8750     | 4.0   | 6"    | 15000          | 2.20                | .8     |
| 157-156  | --     | ----     | 2.0   | 24x36 | 780475         | 5.25                | 7.5    |
| 156-155  | --     | ----     | 2.0   | 24x36 | 780475         | 5.25                | 7.5    |
| 155-148  | --     | ----     | .25   | 24x36 | 780475         | 2.08                | 7.9    |
| 154-153  | 55     | 6875     | 1.3   | 6"    | 6875           | 1.04                | .6     |
| 153-152  | 50     | 6250     | 1.2   | 8"    | 13125          | 1.86                | 1.1    |
| 152-148  | 70     | 8750     | 1.0   | 6"    | 21875          | 1.16                | 1.0    |
| 151-150  | 65     | 8125     | 1.22  | 6"    | 8125           | 1.00                | .6     |

| M.H.    | Peo-<br>ple | Quan-<br>tity | Grade | Size  | Total<br>Quantity | Correc-<br>ted ve-<br>locity. | Depth. |
|---------|-------------|---------------|-------|-------|-------------------|-------------------------------|--------|
| 150-149 | 110         | 13750         | 1.22  | 6"    | 31875             | 1.57                          | 1.2    |
| 149-149 | 50          | 6250          | 1.22  | 6"    | 6250              | 1.04                          | .6     |
| 149-148 | 55          | 6875          | 1.2   | 6"    | 34900             | 1.09                          | 1.3    |
| 148-146 | --          | ----          | .25   | 24x36 | 815375            | 2.07                          | 8.0    |
| 148-145 | --          | ----          | .25   | 24x36 | 815375            | 2.07                          | 8.0    |
| 145-0   | --          | ----          | .25   | 26x39 | 833375            | 2.07                          | 8.6    |

| M.H.          | Peo-<br>ple | Quan-<br>tity | Grade | Size | Total<br>Quantity | Correc-<br>ted ve-<br>locity. | Depth. |
|---------------|-------------|---------------|-------|------|-------------------|-------------------------------|--------|
| 345-345'      | --          | ----          | 4.5   | 8"   | -----             | -----                         | -----  |
| 345-344       | --          | ----          | 1.0   | 10"  | -----             | -----                         | -----  |
| 344-343       | 35          | 4375          | 1.0   | 10"  | 4375              | 1.37                          | 1.0    |
| 343-342       | 35          | 4375          | 3.3   | 10"  | 8750              | 2.38                          | 1.0    |
| 342-338       | --          | ----          | .55   | 12"  | 8750              | 1.15                          | 1.2    |
| 341-340       | --          | ----          | 6.0   | 8"   | -----             | -----                         | ---    |
| 340-339       | 10          | 1250          | 6.0   | 10"  | 1250              | 3.35                          | 1.0    |
| 339-338       | 15          | 1875          | 6.0   | 10"  | 11875             | 3.35                          | 1.0    |
| 338-337       | --          | ----          | .7    | 12"  | 11875             | 1.23                          | 1.2    |
| 337 to outlet |             | ----          | ----  | 12"  | 11875             |                               |        |
| 367-365       | --          | ----          | .2    | 8"   | -----             | -----                         | -----  |
| 366-365       | ---         | ----          | 2.5   | 8"   | -----             | -----                         | -----  |
| 365-363       | 15          | 1875          | .89   | 10"  | 1875              | 1.29                          | .10    |
| 364-363       | --          | ----          | .45   | 8"   | -----             | -----                         | -----  |
| 363-361       | --          | ----          | .53   | 12"  | 1875              | 1.12                          | 1.2    |
| 362-361       | 40          | 5000          | 1.5   | 8"   | 5000              | 1.37                          | .8     |
| 361-360       | --          | ----          | .20   | 12"  | 6875              | .69                           | 1.2    |
| 360-359       | --          | ----          | .20   | 12"  | 6875              | .69                           | 1.2    |
| 359-358       | --          | ----          | 2.2   | 18"  | 6875              | 3.14                          | 1.8    |
| 358-357       | --          | ----          | .20   | 30"  | 6875              | 1.15                          | 3.0    |
| 353-357       | --          | ----          | 1.33  | 8"   | -----             | -----                         | -----  |
| 357-355       | --          | ----          | .8    | 30"  | 6875              | 2.7                           | 3.0    |
| 356-355       | --          | ----          | .37   | 15"  | -----             | -----                         | -----  |

| M.H.          | People | Quantity | Grade | Size | Total Quantity | Corrected velocity. | Depth. |
|---------------|--------|----------|-------|------|----------------|---------------------|--------|
| 355-354       | 25     | 3125     | .67   | 30"  | 10000          | 2.34                | 3.0    |
| 354-353       | 20     | 2500     | .67   | 30"  | 12500          | 2.34                | 3.0    |
| 353-352       | --     | ----     | .41   | 36"  | 12500          | 2.16                | 3.6    |
| 352-351       | --     | ----     | .47   | 36"  | 12500          | 2.34                | 3.6    |
| 351-349       | 10     | 1250     | .47   | 30"  | 13750          | 2.34                | 3.6    |
| 350-349       | 400    | 50000    | .50   | 30"  | 50000          | 2.16                | 3.0    |
| 349-348       | 5      | 625      | 1.10  | 36"  | 64375          | 3.60                | 3.6    |
| 348-347       | 30     | 3750     | 1.10  | 36"  | 68125          | 3.60                | 3.6    |
| 347-346       | 50     | 6250     | 1.20  | 36"  | 74375          | 3.72                | 3.6    |
| 346 to outlet |        |          |       |      | 74375          |                     |        |

Outlet No. 5, District No. 3.

|               |    |      |      |     |       |      |     |
|---------------|----|------|------|-----|-------|------|-----|
| 373-372       | 10 | 1250 | 2.27 | 8"  | 1250  | 1.73 | .8  |
| 372-371       | 20 | 2500 | .8   | 8"  | 3750  | 1.73 | .8  |
| 371-370       | 55 | 6875 | .8   | 10" | 10625 | 1.23 | 1.0 |
| 370-369       | 10 | 1250 | 3.8  | 10" | 11875 | 2.50 | 1.0 |
| 369-368       | 50 | 6250 | .9   | 30" | 18125 | 2.89 | 3.0 |
| 368 to outlet |    |      |      | 20" | 18125 |      |     |

| M.H.          | People | Quantity | Grade | Size | Total Quantity | Corrected velocity | Depth |
|---------------|--------|----------|-------|------|----------------|--------------------|-------|
| 381-380       | 70     | 8750     | .3    | 9"   | 8750           | .68                | .9    |
| 380-378       | 50     | 6250     | .3    | 12"  | 15000          | .86                | 1.2   |
| 379-378       | 100    | 12500    | .75   | 12"  | 12500          | 1.29               | 1.2   |
| 378-375       | 50     | 3125     | 1.0   | 18"  | 30625          | 2.05               | 1.8   |
| 377-376       | 250    | 31250    | .63   | 6"   | 31250          | 1.34               | 1.2   |
| 376-375       | 50     | 6250     | 1.0   | 18"  | 37500          | 2.05               | 1.8   |
| 375-374       | 100    | 12500    | 1.0   | 18"  | 80625          | 2.06               | 1.9   |
| 374 to outlet |        |          |       |      | 80625          |                    |       |
| Outlet 7      |        |          |       |      |                |                    |       |
| 388-386       | 30     | 3750     | .5    | 6"   | 3750           | .65                | .6    |
| 387-386       | 50     | 6250     | 2.5   | 6"   | 6250           | 1.44               | .6    |
| 386-385       | 40     | 5000     | .64   | 8"   | 15000          | .94                | .8    |
| 385-384       | 300    | 37500    | .72   | 8"   | 52500          | 1.57               | 1.6   |
| 384-383       | 65     | 8125     | 2.4   | 8"   | 60635          | 1.02               | 2.0   |
| 383-382       | 55     | 6875     | 3.1   | 8"   | 6875           | 1.08               | .8    |
| 382 to outlet |        |          | 3.5   | 8"   | 67500          | 2.4                | 1.0   |
| Outlet No. 8. |        |          |       |      |                |                    |       |
| 391-390       | 40     | 5000     | 1.09  | 8"   | 5000           | 1.59               | .8    |
| 390-389       | --     | ----     | .6    | 10"  | 5000           | 1.05               | 1.0   |
| 389 outlet    |        |          |       | 10"  | 5000           |                    |       |
| Outlet No. 9. |        |          |       |      |                |                    |       |
| 400-397       | 45     | 5625     | .5    | 8"   | 5625           | .79                | .8    |
| 399-398       | 50     | 6250     | 3.4   | 8"   | 6250           | 2.08               | .8    |
| 398-397       | 50     | 6250     | .34   | 8"   | 12500          | .63                | .8    |
| 397-393       | 70     | 8750     | .23   | 8"   | 26875          | .84                | 1.6   |

| M.H.           | People | Quantity | Grade | Size | Total Quantity | Corrected velocity. | Depth. |
|----------------|--------|----------|-------|------|----------------|---------------------|--------|
| 396-395        | 45     | 5625     | 1.38  | 8"   | 5625           | 1.37                | .8     |
| 395-393        | 35     | 4375     | .5    | 10"  | 10000          | .97                 | 1.0    |
| 394-393        | 75     | 9375     | .5    | 8"   | 9375           | .79                 | .8     |
| 393-392        | 5      | 625      | .5    | 15"  | 46875          | 1.29                | 1.5    |
| 392 to outlet  |        |          |       | 20"  | 46875          |                     |        |
| Outlet No. 10. |        |          |       |      |                |                     |        |
| 1-471          | 115    | 14375    | .50   | 8"   | 14375          | .79                 | .8     |
| 471-466        | 50     | 3250     | .50   | 8"   | 20625          | .88                 | 1.0    |
| 470-469        | 30     | 3750     | .70   | 8"   | 3750           | .94                 | .8     |
| 469-468        | 25     | 3125     | .70   | 8"   | 6875           | .94                 | .8     |
| 468-467        | 30     | 3750     | .70   | 10"  | 10625          | 1.15                | 1.0    |
| 467-466        | 80     | 10000    | .80   | 10"  | 20625          | 1.23                | 1.0    |
| 466-466        | 80     | 7500     | .50   | 6"   | 7500           | .65                 | .6     |
| 466-461        | 60     | 7500     | .30   | 15"  | 56250          | 1.12                | 1.0    |
| 465-464        | 70     | 8750     | 2.0   | 10"  | 8750           | 1.94                | 1.0    |
| 464-463        | 75     | 9375     | .40   | 12"  | 18125          | .97                 | 1.2    |
| 463-461        | 145    | 18125    | .40   | 15"  | 36250          | 1.19                | 1.5    |
| 462-461        | 55     | 6875     | .90   | 8"   | 6875           | 1.08                | .8     |
| 461-456        | 135    | 16875    | .40   | 20"  | 116250         | 1.38                | 2.0    |
| 460-457        | 55     | 6875     | .70   | 6"   | 6875           | .79                 | .6     |
| 459-457        | 55     | 6875     | .50   | 6"   | 6875           | .94                 | .6     |
| 458-457        | 55     | 6875     | 1.5   | 8"   | 6875           | 1.37                | .8     |
| 457-456        | 40     | 5000     | 1.13  | 10"  | 25625          | 1.59                | 1.0    |

| M.H.     | Peo-<br>ple | Quan-<br>tity | Grade | Size | Total<br>Quantity | Correc-<br>ted ve-<br>locity. | Depth. |
|----------|-------------|---------------|-------|------|-------------------|-------------------------------|--------|
| 456'-456 | 55          | 6875          | 1.3   | 8"   | 6875              | 1.70                          | .8     |
| 456-445  | 35          | 3125          | 1.75  | 18"  | 151875            | 2.81                          | 1.8    |
| 455-451  | 115         | 14375         | .45   | 10"  | 14375             | 4.3                           | 1.0    |
| 453-452  | 20          | 2500          | .45   | 8"   | 2500              | .76                           | .8     |
| 451-452  | 85          | 10625         | .45   | 8"   | 10625             | .76                           | .8     |
| 452-451  | 45          | 5625          | .47   | 8"   | 18150             | .79                           | .8     |
| 451-450  | 60          | 7500          | .60   | 10"  | 40625             | 1.16                          | 1.1    |
| 450-448  | 60          | 7500          | 1.25  | 10"  | 48125             | 1.58                          | 1.1    |
| 449-448  | 70          | 8750          | 2.6   | 8"   | 8750              | 1.80                          | .8     |
| 448-447  | 65          | 8125          | 1.25  | 10"  | 65000             | 1.68                          | 1.1    |
| 447-445  | 65          | 8125          | 1.25  | 12"  | 73125             | 1.88                          | 1.2    |
| 446-445  | 60          | 7500          | 1.0   | 8"   | 7500              | 1.15                          | .8     |
| 445-441  | 120         | 15000         | .40   | 24"  | 247500            | 1.66                          | 2.4    |
| 444-442  | 40          | 5000          | 1.0   | 8"   | 5000              | 1.15                          | .8     |
| 443-442  | 35          | 4375          | 1.2   | 8"   | 4375              | 1.23                          | .8     |
| 442-441  | 20          | 2500          | 1.9   | 10"  | 11875             | 1.88                          | 1.0    |
| 441-431  | 25          | 3125          | 1.9   | 20"  | 232500            | 3.06                          | 2.0    |
| 435-434  | 85          | 10625         | 1.65  | 8"   | 10625             | 1.44                          | .8     |
| 434-433  | 80          | 10000         | 3.5   | 8"   | 20625             | 2.16                          | .8     |
| 433-431  | --          | ----          | .70   | 8"   | 20625             | .94                           | .8     |
| 432-431  | 75          | 9375          | .50   | 10"  | 9375              | .97                           | 1.0    |
| 431-429  | 40          | 5000          | 2.4   | 20"  | 297500            | 3.12                          | 2.0    |
| 440'-440 | --          | ----          | 1.3   | 8"   | ----              | ----                          | --     |
| 440-438  | 20          | 2500          | 3.31  | 8"   | 2500              | 2.06                          | .8     |
| 439-438  | 75          | 9375          | 1.04  | 8"   | 9375              | 1.15                          |        |



| M.H.    | People | Quantity | Grade | Size   | Total Quantity | Corrected velocity. | Depth. |
|---------|--------|----------|-------|--------|----------------|---------------------|--------|
| 438-436 | 80     | 10000    | 1.04  | 8"     | 21875          | 1.15                | .8     |
| 437-436 | 15     | 1875     | 2.5   | 8"     | 1875           | 1.80                | .8     |
| 436-429 | 60     | 7500     | 1.95  | 10"    | 31250          | 1.66                | 1.0    |
| 430-429 | 65     | 8125     | 1.0   | 8"     | 8125           | 1.15                | .8     |
| 429-422 | 55     | 6875     | .41   | 24x36  | 313750         | 1.10                | 1.1    |
| 428-426 | 75     | 9375     | 1.5   | 8"     | 9375           | 1.37                | .8     |
| 427-426 | 55     | 6875     | 2.0   | 8"     | 6875           | 1.62                | .3     |
| 426-424 | 70     | 8750     | .53   | 10"    | 25000          | .96                 | 1.0    |
| 425-424 | 70     | 8750     | 1.0   | 8"     | 8750           | 1.15                | .8     |
| 424-423 | 55     | 6875     | 3.5   | 10"    | 40625          | 2.52                | 1.0    |
| 423-422 | --     | ----     | 3.3   | 10"    | 40625          | 2.31                | 1.0    |
| 422-417 | 20     | 2500     | .41   | 28x42  | 386875         | 1.12                | 3.3    |
| 421-419 | 40     | 5000     | 3.0   | 8"     | 5000           | 1.98                | .8     |
| 420-419 | 70     | 8750     | 1.8   | 8"     | 8750           | 1.15                | .8     |
| 419-418 | 25     | 3125     | 1.8   | 10"    | 16875          | 1.80                | 1.0    |
| 418-417 | 20     | 2500     | 1.8   | 10"    | 19375          | 1.80                | 1.0    |
| 417-413 | 10     | 1250     | .41   | 38x42  | 407500         | 1.13                | 3.3    |
| 416-415 | 65     | 8125     | 2.0   | 8"     | 8125           | 1.62                | .8     |
| 415-413 | 30     | 3750     | 2.63  | 8"     | 11875          | 1.80                | .8     |
| 414-413 | 60     | 7500     | .70   | 10"    | 7500           | 1.15                | 1.0    |
| 413-402 | 70     | 8750     | .41   | 30x45B | 435625         | 2.39                | 3.0    |
| 404-403 | --     | ----     | .50   | 8"     | ----           | ----                | ----   |
| 403-402 | 50     | 6250     | .70   | 8"     | 6250           | 1.01                | .8     |
| 412-411 | 25     | 3125     | 4.5   | 8"     | 3125           | 2.42                | .8     |
| 411-408 | 75     | 9375     | .61   | 8"     | 12500          | .87                 | .8     |



| M.H.           | People | Quan-<br>tity | Grade | Size      | Total<br>Quantity | Correc-<br>ted ve-<br>locity | Depth. |
|----------------|--------|---------------|-------|-----------|-------------------|------------------------------|--------|
| 409-408        | 15     | 1875          | 3.0   | 8"        | 1875              | 1.98                         | .8     |
| 410-408        | 60     | 7500          | 1.21  | 8"        | 7500              | 1.26                         | .8     |
| 408-405        | 40     | 5000          | 1.07  | 8"        | 26875             | 2.34                         | .8     |
| 407-405        | 30     | 3750          | 2.8   | 8"        | 3750              | 1.91                         | .8     |
| 406-405        | 35     | 4375          | .60   | 8"        | 4375              | .86                          | .8     |
| 405-402        | 50     | 6250          | 1.44  | 10"       | 41250             | 1.58                         | 1.0    |
| 402-400        | 30     | 3750          | .41   | 30x45     | 486875            | 2.4                          | 3.1    |
| 401-400        | 40     | 5000          | 2.0   | 10"       | 5000              | 1.94                         | 1.0    |
| 400 outlet--   |        | ----          | .41   | 30"       | 491875            | 1.94                         | 3.2    |
| Outlet No. 11. |        |               |       |           |                   |                              |        |
| 400-474        | 20     | 2500          | .30   | 18"       | 2500              | 1.15                         | 1.8    |
| 474-473        | --     | ----          | .33   | 18"       | 2500              | 1.15                         | 1.8    |
| 473-472        | --     | ----          | .33   | 18"       | 2500              | 1.15                         | 1.8    |
| 472 outlet     |        |               |       | Iron Pipe | 2500              | 1.15                         | 1.8    |

-Conclusions drawn from our data sheets.-

Population of district -- 19,629.

Total quantity of sewage--2,453,525 gal. per 24 hrs.

That the pipes are adequate from a sanitary standpoint.

System is made up of vitrified clay pipe, ranging from 6" to 30".

Trunk sewers are brick, with the invert lined with limestone. They range in size from 2'x3' to 4'x6'.

## Conclusions and faults of the system.

The sewer system, as it stands in it's present condition, is practically a replica of the system in any city, where the work is done piece-meal. In a way, this is unavoidable, for, to build for the needs of fifty years hence may be argued unnecessary, because of the change in the methods of doing work, the materials used, the expansion of the city in ways different than that supposed when the system was designed.

However, the system we investigated, is capable of taking care of the domestic and manufacturing wastes, to a certain degree, although, it is not capable of handling both the storm water, and, sanitary wastes.

Metcalf & Eddy, Vol.1, says that in order to avoid deposits in a pipe, the velocity should be one and one-half feet per second, or more. Our data sheets show many velocities lower than one and one-half feet, but, that is due to the fact that our velocities are figures for a steady flow, during the 24 hours. This condition, it can be plainly seen, will not be prevalent, as the house wastes come in spurts, and, it is altogether likely the velocities caused by these wastes spurts are self-cleansing.

The deposition of wastes are lessened by the fact that after any considerable rainfall, the laterals are flowing full, or practically so, so that the deposits are cleaned out, but, this advantage is a disadvantage, in that the pipes are not capable of carrying such a large amount of

water, causing the same to back up, and, flood cellars, thereby destroying property, and, becoming a menace to the health of the occupants.

At the outlet of the big sewer that runs along the Grand River, emptying into the river at the foot of Willow St., North Lansing, the odor of sewer gas was very obnoxious at the time we inspected the outlet. This was the only place that we noticed any presence of sewer gas.

We found there were thirteen outlets into the west side of the Grand River, and, one would think this would be detrimental to public health and a menace, but, taken from good authority, samples of water taken two miles above the city, and, two miles below were identical. The pollution of the river, through the city, amounts to practically nothing, because the outlets which discharge in the city limits on the west side of the river, carry a very small amount of sewage.

The Outlets were all of C.I. pipe, from 10" to 24" in diameter, and, from 50' to 150' long, except numbers 12 and 13, at the foot of Ottawa Street, which outlets empty directly from the retaining wall to the river.

Outlet No. 13 was only noted in our investigation, as it is only a storm water system drainage, a part of the west central part of the city, and, by the way, is not adequate, and, should be enlarged.

From our data, we estimated the population of the city, in our district, to be about twenty-thousand. This is a fair approximation, as the total population of the

city at this time is about 40 or 45,000, and, our district contains about half of the total population. There are no flush tanks and very few lampholes, the sole means of cleansing is by fire-hose, or by self-cleansing velocities.

#### REMEDIES.

In applying a remedy, it should relieve present congested conditions, and, at the same time, provide for the non-occurrence of the condition (work) remedied. It is with this idea in view, that we offer the following remedies and suggestions, which, we believe, if adopted, would be for the betterment of the city, it's inhabitants, and, everyone involved:-

- 1.-A general revision of the entire present system.
- 2.-An overflow vein into the old outlets.
- 3.-The installation of Automatic Flush tanks.
- 4.-The installation of a Disposal Plant.

In the general revision of the system, we suggest a separation of the present combined system, using the present system for the sanitary sewerage, and paralleling the present system, or, as conditions warrant, with the storm sewer.

The present system is entirely adequate for future growth, as a sanitary system, but, not capable of handling an ordinary rainfall, as inquiries and investigations made in different parts of our districts showed that such a rain caused the water to back up, and, flood the cellars.

All pipes and brick sewers are, according to our plan, to empty into an intercepting sewer, which will start at the

corner of Main Street and Grand Avenue, and, run north on Grand Ave., taking the discharge of all storm and sanitary sewers, displacing the numerous present outlets along the river.

This sewer will run along the river bank, after leaving Grand Avenue, intercepting outlets 2, 3, 4 and 5 along the river bank, to a point just west of Roosevelt Avenue.

At the points where outlets 1, 2, 3, 4 and 5 feed in to the trunk sewer, we suggest the placing of over-flow vein, for the purpose of taking care of the immense volume of water, should a condition arise that one trunk sewer is flowing full.

Item #3.-

We suggest the placing of automatic flush tanks at the dead ends of all laterals.

Item #4.-

The installation of a disposal plant.

There is no way, at the present time, to prevent the pollution of the Grand River by emptying sewage into it, and, at some time or other, the City of Lansing is going to be forced to provide against such actions. To better this, to prevent pollution of the stream, we suggest the installation of a disposal plant, to be located on or near the Grand River, just west of Roosevelt Ave., at the end of our proposed trunk sewer.

There are several different methods of treating sewage in successful operation in this country, and, abroad. Each method has its advantages and disadvantages, and, our opin-

ion in the method of treatment is one which provides for a rapid precipitation of solids, followed by a sterilization of the organic matters in the sewage, and, then followed by dispersion and consequent dilution.

We suggest the sedimentation tank, or, Imhoff tank, with an upper and lower compartment. The upper compartment provides for a continuous flow of sewage through it during which time, a large majority of the solids are precipitated, and, pass downward into the lower compartment. They are here digested by biological processes, and, are thus reduced to harmless mineral substances, and, form a muddy substance, called sludge.

At intervals, this is removed by gravity, to sludge beds, upon which it is allowed to free itself of the supernatant water in it, which is discharged into the river, and, the sludge, when dry, is used for fertilizer.

After the sewage passes the Imhoff tank, it flows into a dosing chamber, where hypo chlorite of lime is automatically injected into and mixed with it. A detention chamber is provided for the sewage to flow through, so that the chemical can become thoroughly mixed with the liquid, by which process sterilization is affected, and, the affluent then passes out into the river, with the disease-bearing germs killed, and, the solids removed, so that further putrifaction can take place.

By running the intercepting sewer where we suggested, and, placing the disposal plant just west of Roosevelt Ave.,

all the sewage of our district could be treated, although ,  
if the sewage from the eastern portion of the city was to  
be treated by this aplant, it would have to be pumped across  
the river.

This concludes the work, as we have investigated this  
system, working as we thought best, with the idea of apply-  
ing the knowledge presented to us in our college course.

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