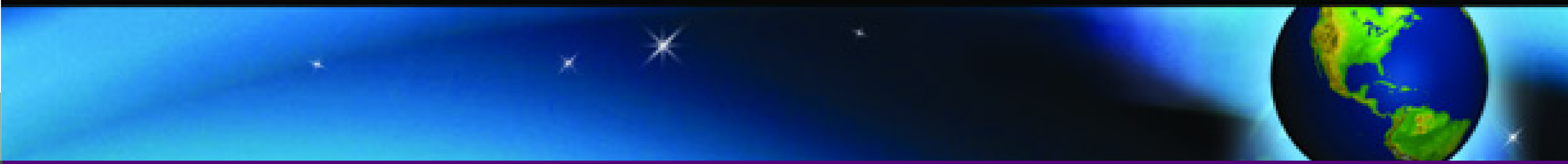

Is Slime The Great Hydraulic Equalizer?

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The proposition - "Slime is the great hydraulic equalizer of sanitary gravity sewer pipe materials" - makes sense. A slime layer builds-up on a sanitary sewer pipe after it has been placed in service. With that being the case, shouldn't all sanitary sewer pipes have the same Manning's n value? After all, aren't we measuring the hydraulic roughness of slime rather than the pipe material underneath?

The logic is sound, but it neglects the fact that the thickness and profile of the resulting slime layer is not the same from pipe material to pipe material. In other words, not all slime is created hydraulically equal.

First: Rougher, more porous pipes are capable of maintaining more slime than smoother, less porous pipe materials. (1, 2, 6, 8)

Second: The surface roughness profiles of slime vary by pipe material. Even a product with micro-porosity demonstrates a magnified surface profile that is jagged and irregular. Conversely, the magnified profile for the PVC slime layer tends to gradually ripple in a regular wavy pattern. (7)

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Table 1
Data on Manning's "n" Values in Small Diameter Sewers with Flow Velocities Below 2.5 ft/sec Concrete Pipe (Reference 6)

State & Line No.	Year Built	Diameter (in.)	Length (ft.)	Test	Velocity (ft/sec)	Manning's "n"
California						
18	1959	12	300	A	1.47	0.0147
				B	1.97	0.0131
Georgia						
38	1960	8	158	A	1.84	0.0195
				B	1.81	0.0190
New York						
60	1956	18	234	A	2.21	0.0156
				B	2.46	0.0145
61	1956	24	427	A	2.06	0.0140
				B	2.03	0.0142
Texas						
74	1962	8	372	A	1.11	0.0230
75	1962	10	362	A	1.65	0.0124
				B	0.90	0.0139
Virginia						
79	1963	15	308	A	2.11	0.0138
Washington						
84	1960	8	358	A	2.01	0.0173
86	1956	8	434	A	1.14	0.0196
				B	1.27	0.0177
Wisconsin						
89	1963	12	326	A	1.27	0.0157
				B	0.81	0.0178

State & Line No.	Year Built	Diameter (in.)	Length (ft.)	Test	Velocity (ft/sec)	Manning's "n"
California						
4	1961	10	398	A	0.87	0.0195
7	1927	15	376	B	2.11	0.0128
9	1958	15	334	B	1.86	0.0091
				C	1.84	0.0089
13	1962	8	325	A	2.05	0.0103
				B	2.24	0.0106
16	1959	8	1,854	A	1.50	0.0146
19	1962	8	316	A	0.98	0.0162
21	1962	12	785	B	1.64	0.0144
24	1963	12	300	A	1.86	0.0122
Delaware						
28	1959	8	509	A	1.32	0.0168
				B	0.97	0.0183
29	1933	10	249	A	1.93	0.0123
				B	1.92	0.0122
Florida						
30	1960	8	398	A	1.69	0.0144
				B	0.64	0.0199
31	1960	8	397	A	1.09	0.0177
35	1960	8	660	A	1.41	0.0151
				B	1.40	0.0150
Georgia						
36	1958	8	285	A	2.32	0.0171
				B	1.62	0.0190
37	1959	12	307	A	1.00	0.0144
				B	0.56	0.0192
Louisiana						
43	1962	12	304	A	1.01	0.0189
				B	1.73	0.0156
45	1963	8	413	A	1.42	0.0149
				B	2.07	0.0132
Massachusetts						
47	1960	8	217	A	2.06	0.0110
51	1958	15	344	A	2.02	0.0101
				B	1.96	0.0100

Table 2
Data on Manning's "n" Values in Small Diameter Sewers with Flow Velocities Below 2.5 ft/sec Clay Pipe (Reference 6)

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To sum up: PVC has no micro-porosity, which results in a significantly thinner slime layer, as well as a slime layer with a smoother profile. This produces a lower Manning's n value for a fully operational PVC sanitary sewer system compared to the n value for more traditional (and porous) materials. (1)

Why Less Slime For PVC?

Cohesive forces between the pipe and the slime try to keep the slime stuck to the pipe wall. Tractive forces from the flow of the wastewater try to rip the slime off the pipe wall. If the cohesive forces are greater than the tractive forces, the slime thickness grows. If the tractive forces are greater than the cohesive forces, the slime layer shrinks.

The cohesive forces for porous pipe materials are greater than the cohesive forces for PVC, which has no porosity - micro, macro, or otherwise. Consequently, the slime is scoured off the PVC pipe wall at a much lower flow velocity (and lower tractive force) compared to more porous pipe materials.

Prove It!

Two assumptions will be made while we prove our case.

• **First Assumption:** The data analyzed will be from field tests rather than lab tests. Field data reflect sanitary system realities that are not simulated in the lab: slime and the build-up of solids.

• **Second Assumption:** The only time that the Manning's n value is of concern is when the system's slope is at or near the minimum slope. Therefore, the data analyzed will be for velocities at or near the typical minimum velocity of 2.0 foot per second. 2.5 foot per second was the cut-off we selected for our analysis. Using data from low flow velocities only will present the "worst case" of the most slime build-up and most solids deposition.

The data for the following analysis is from

Table 2 (cont.)
Data on Manning's "n" Values in Small Diameter Sewers with Flow Velocities Below 2.5 ft/sec Clay Pipe (Reference 6)

State & Line No.	Year Built	Diameter (in.)	Length (ft.)	Test	Velocity (ft/sec)	Manning's "n"
Missouri						
53	1962	12	417	A	1.23	0.0220
				B	0.464	0.0367
New Jersey						
57	1963	8	298	B	1.87	0.0110
New York						
65	1949	8	200	A	2.43	0.0178
North Carolina						
68	1962	8	369	A	1.97	0.0131
				B	1.34	0.0150
Pennsylvania						
69	1962	8	386	A	1.81	0.0090
Texas						
71	1950	10	479	A	0.98	0.0213
				B	1.65	0.0163
73	1960	10	499	A	1.11	0.0270
				B	1.52	0.0202
78	1962	12	458	A	1.19	0.0187
				B	1.22	0.0193
Wisconsin						
91	1960	10	307	A	1.81	0.0110
92	1960	12	979	A	1.57	0.0115

references 1 and 6 since those references meet the field data requirement of our "First Assumption". Tables 1 through 3 list data that meet the "Second Assumption." This means that only data for flows at or below 2.5 foot per second are listed. Analysis of that data reveals the following:

• **Table 1:** This table is for concrete pipe. (More specifically, it is for concrete pipe that was not lined with PVC. PVC is frequently used to protect concrete pipe from hydrogen sulfide corrosion. The PVC liner for concrete is typically referred to as a T-lock liner.) The average n value was 0.0162 with a standard deviation of 0.003. The weighted average, which accounts for the length of pipe tested, was 0.0161.

• **Table 2:** This table is for clay pipe. The average n value was 0.0156 with a standard deviation of 0.005. The weighted average was 0.0160.

• **Table 3:** This table is for the most popular sanitary sewer pipe material, PVC. The average n value was 0.0088 with a standard deviation of 0.0006. The weighted average was 0.0088.

The votes are in and the winner is … PVC! The Manning's n value of 0.013 that is often used for design purposes is un-conservative for concrete and clay and over-conservative for PVC. This points to the danger of using average n values from data for both high and low flow velocities (instead of n values for low flow velocities only). This also shows that much greater efficiencies are available with PVC. The dramatically lower Manning's n value could result in a smaller pipe PVC diameter delivering the same flow capacity as a concrete or clay pipe at the same slope. It is definitely something to keep in mind in these days of shrinking budgets and its accompanying cry of doing more with less.

Remember: Not all pipes are hydraulically equal!

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Table 3

Data on Manning's "n" Values in Small Diameter Sewers with Flow Velocities Below 2.5 ft/sec Polyvinyl Chloride (PVC) Pipe (Reference 1)

State & Line No.	Year Built	Diameter (in.)	Length (ft.)	Velocity (ft/sec)	Manning's "n"
Colorado					
8	1970	8	180	1.86	0.0079
9	1970	8	180	1.00	0.0097
10	1970	8	360	2.22	0.0089
13	1970	8	360	2.26	0.0080
14	1970	8	55	2.07	0.0084
15	1970	8	200	1.97	0.0085
16	1970	8	300	1.93	0.0087
17	1970	8	179	1.67	0.0088
18	1970	8	238	1.60	0.0096
19	1970	8	70	1.45	0.0090
25	1974	8	355	2.22	0.0089