USEFUL INFORMATION

FOR

STREAM POLLUTION SURVEYS AND EVALUATIONS

Compiled

by

A. W. West

Public Health Engineer

U. S. Department of Health, Education, and Welfare

Federal Water Pollution Control Administration

Robert A. Taft Sanitary Engineering Center

CINCINNATI, OHIO

JANUARY 1966

ENVIRONMENTAL PROTECTION AGENCY

USEFUL INFORMATION
FOR
STREAM SURVEYS & EVALUATIONS

CONVERSION FACTORS

1 cfs = 449 gpm = 0.646 mgd

1 mgd = 695 gpm = 1.547 cfs

1 cfs for 24 hours = 1.98 acre feet

1 ft/sec approximates 2/3 mph (0.682)

1 mph approximates 1-1/2 ft/sec (1.47)

CONVERSION TO MASS OR TOTAL NUMBERS

Q in cfs x concentration in ppm x 5.4 = lbs/day

Q in mgd x concentration in ppm ÷ 0.12 = lbs/day

Q in cfs x MPN/100 ml x 24.6×10^6 = No. of coli./day

Q in mgd x MPN/100 ml x 37.8×10^6 = No. of coli./day

POPULATION EQUIVALENTS

1.0 BOD_5 Population Equivalent	= 1/6 lbs BOD_5/day
1.0 Susp. Solids " "	= 1/5 lbs S.S./day
1.0 Bacterial " "	= 400 billion coliforms/day
Total Phosphorus	= 3 lbs/cap/year
Total Nitrogen (Organic & Inorgan.)	= 9 lbs/cap/year

ESTIMATED PERCENT BOD_5 REMOVALS BY SEWAGE TREATMENT

	Probable Range	Use for Estimating
Primary Sedimentation	30-40	33%
High Rate Trickling Filters	60-90	80%
Standard Rate Trickling Filters	80-90	85%
High Rate Activated Sludge	65-85	75%
Standard Rate Activated Sludge	85-95+	90%

TOTAL COLIFORM BACTERIA

Human feces may contain 2 billion coliform B./capita

SUMMER - (Water temperatures 15° C. or above)

Raw sewage - 57 to 114 billion coli./cap.

Raw sewage - 15-30 million MPN/100 ml

Raw sewage - Use 21,000,000 MPN/100 ml for calcs.

Coliform bacteria multiply about 5 times in about 12 ± hours, from sewer to peak.

BPE at peak = 400 billion coliform bacteria/day.

→ BPE = Q in cfs x MPN/100 ml x 61 x 10^{-6} (at peak)

→ $\text{MPN/100 ml} = \frac{\text{BPE} \times 16{,}400}{\text{Q in cfs}}$ (at peak)

WINTER - (Water temperature = 15° C. or below)

Raw sewage - 19 to 38 billion coli./cap

Raw sewage - 5 to 10 million MPN/100 ml

BPE at peak = 125 billion coliform bacteria/day

BPE = Q in cfs x MPN/100 ml x 194 x 10^{-6} (at peak)

$\text{MPN/100 ml} = \frac{\text{BPE} \times 5{,}150}{\text{Q in cfs}}$ (at peak)

PROBABLE COLIFORM DIE-OFF (After reaching peak)

Approximate % of coliform remaining after flow time
(from die-off curve with 2,000,000 MPN/100 ml at peak)

1/2 day	= 40%	5 days	= 0.5%
1 day	= 17%	6 days	= 0.27%
2 days	= 5%	7 days	= 0.15%
3 days	= 2%	8 days	= 0.08%
4 days	= 1%		

ESTIMATED BACTERIAL REMOVAL EFFICIENCIES
(Imhoff & Fair pg. 6 used as a guide)

	% Reduction Probable range according to Imhoff & Fair	% Remaining Use this value for calculating estimated bacterial loads
A. NOMINAL FACILITIES & CONTROL.		
Plain Sedimentation	25-75	50%
Secondary Treatment (unspecified type)	-	10%
Hi Rate Trickling Filter	80-95	12-1/2%
Hi Rate Activated Sludge	80-95	12-1/2%
Lo Rate Trickling Filter	90-95	7-1/2%
Standard Rate Activated Sludge	90-98	6%
Oxidation Ponds	-	3%
Chlorinated raw sewage	90-95	10%
Chlorinated settled sewage	90-95	5%
Chlorinated biologically treated sewage	98-99	1%
B. WHERE EXCEPTIONALLY EFFECTIVE CHLORINATION CONTROL HAS BEEN DEMONSTRATED.		
Prechlorination of settled sewage	-	0.5%
Two-stage (pre- and post-) chlorination of settled sewage	-	0.01%
Post-chlorination of biologically treated sewage	-	0.01%

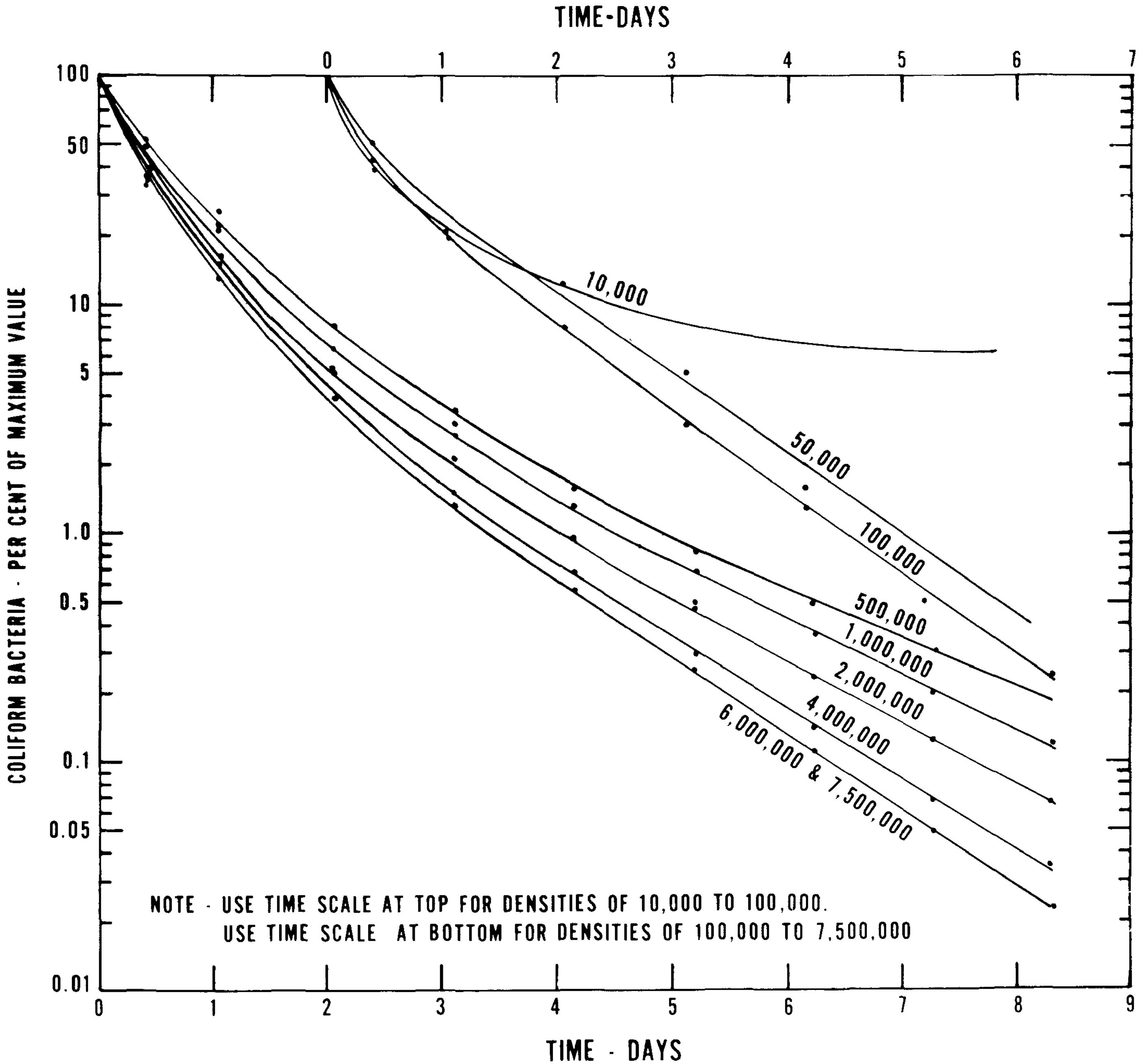
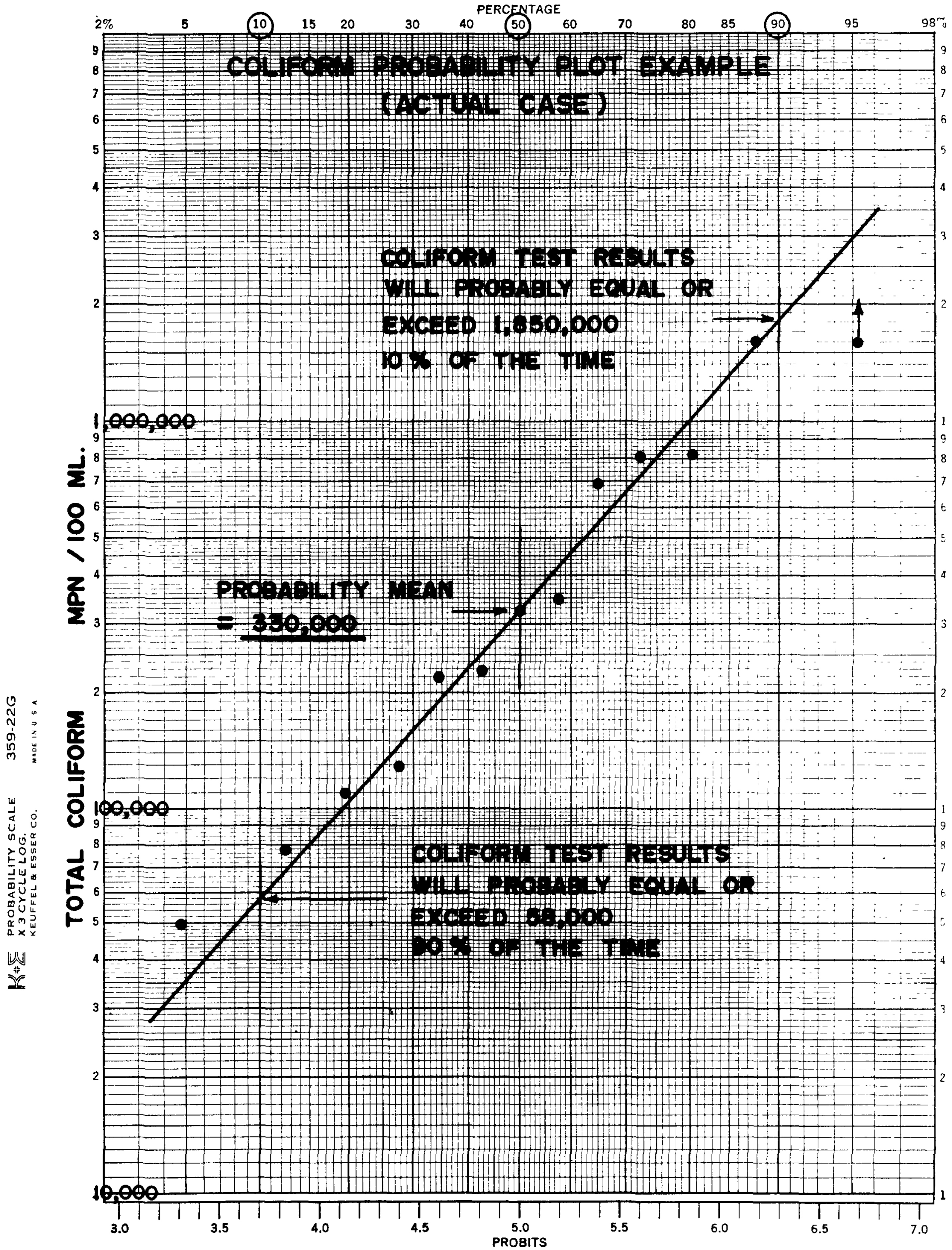


FIG. 5 - EFFECT OF INITIAL DENSITIES OF COLIFORM BACTERIA ON SUMMER RATES OF DECREASE.


COLIFORM PROBABILITY PLOT EXAMPLE
(ACTUAL CASE)
PERCENTAGE
2% 5 10 15 20 30 40 50 60 70 80 85 90 95 98%
COLIFORM TEST RESULTS WILL PROBABLY EQUAL OR EXCEED 1,850,000 10 % OF THE TIME
PROBABILITY MEAN = 330,000
COLIFORM TEST RESULTS WILL PROBABLY EQUAL OR EXCEED 58,000 90 % OF THE TIME
TOTAL COLIFORM MPN / 100 ML.
1,000,000
100,000
10,000
3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0
PROBITS
PROBABILITY SCALE X 3 CYCLE LOG.
KEUFFEL & ESSER CO.
359-22G
MADE IN U.S.A.

COLIFORM PROBABILITY PLOT EXAMPLE

Observed Coliform Density MPN/100 ml	"Exact" Plotting Position N = 13
50,000	4.8
78,000	12.2
110,000	19.8
130,000	27.3
220,000	34.9
230,000	42.5
330,000	50.0
350,000	57.5
700,000	65.1
820,000	72.7
820,000	80.2
1,600,000	87.8
> 1,600,000	95.2

NOTE: 541,000 = Arithmetic Mean

330,000 = Probability Mean (See Example Plot)

PLOTTING POSITIONS FOR NORMAL PROBABILITY PAPER

Sample Size

Ordinal No.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	28.6	19.9	15.2	12.2	10.3	8.8	7.7	6.9	6.2	5.6	5.2	4.8	4.4	4.1	3.9
2	71.4	50.0	38.3	31.0	26.0	22.5	19.7	17.6	15.8	14.4	13.2	12.2	11.4	10.6	9.9
3		80.1	61.7	50.0	42.0	36.2	31.8	28.4	25.6	23.3	21.4	19.8	18.4	17.2	16.1
4			84.8	69.0	58.0	50.0	43.9	39.2	35.3	32.2	29.6	27.3	25.4	23.7	22.3
5				87.8	74.0	63.8	56.1	50.0	45.1	41.1	37.8	34.9	32.4	30.3	28.4
6					89.7	77.5	68.2	60.8	54.9	50.0	45.9	42.5	39.5	36.9	34.6
7						91.2	80.3	71.6	64.7	58.9	54.1	50.0	46.5	43.4	40.7
8							92.3	82.4	74.4	67.8	62.2	57.5	53.5	50.0	46.9
9								93.1	84.2	76.7	70.4	65.1	60.5	56.6	53.1
10									93.8	85.6	78.6	72.7	67.6	63.1	59.3
11										94.4	86.8	80.2	74.6	69.7	65.4
12											94.8	87.8	81.6	76.3	71.6
13												95.2	88.6	82.8	77.7
14													95.6	89.4	83.9
15														95.9	90.1
16															96.1

Ordinal No.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Ordinal No.
1	3.6	3.4	3.3	3.1	2.9	2.8	2.7	2.6	2.4	2.4	2.3	2.2	2.1	2.1	2.0	1
2	9.4	8.9	8.4	8.0	7.7	7.2	6.8	6.7	6.4	6.2	5.9	5.7	5.5	5.3	5.2	2
3	15.2	14.3	13.6	12.9	12.3	11.7	11.3	10.7	10.4	9.9	9.5	9.2	8.9	8.7	8.4	3
4	21.0	19.8	18.8	17.9	17.1	16.4	15.6	14.9	14.2	13.8	13.3	12.7	12.3	11.9	11.5	4
5	26.8	25.3	24.0	22.8	21.8	20.6	19.8	18.9	18.1	17.6	16.9	16.4	15.9	15.2	4.7	5
6	32.6	30.8	29.2	27.8	26.4	25.1	24.2	23.3	22.4	21.5	20.6	19.8	19.2	18.7	7.9	6
7	38.4	36.3	34.4	32.7	31.2	29.8	28.4	27.4	26.1	25.1	24.2	23.3	22.7	21.8	21.2	7
8	44.2	41.8	39.6	37.6	35.9	34.1	32.6	31.6	30.2	29.1	28.1	27.1	26.1	25.1	24.6	8
9	50.0	47.2	44.8	42.6	40.5	38.6	37.1	35.6	34.1	33.0	31.6	30.5	29.5	28.4	27.4	9
10	55.8	52.8	50.0	47.5	45.2	43.3	41.3	39.7	38.2	36.7	35.2	34.1	33.0	31.9	0.9	10
11	61.6	58.2	55.2	52.5	50.0	47.6	45.6	43.6	42.1	40.5	39.0	37.4	36.3	35.2	34.1	11
12	67.4	63.7	60.4	57.4	54.8	52.4	50.0	48.0	46.0	44.4	42.5	41.3	39.7	38.6	37.1	12
13	73.2	69.2	65.6	62.4	59.5	56.7	54.4	52.0	50.0	48.0	46.4	44.8	43.3	41.7	40.5	13
14	79.0	74.7	70.8	67.3	64.1	61.4	58.7	56.4	54.0	52.0	50.0	48.4	46.4	45.2	43.6	14
15	84.8	80.2	76.0	72.2	68.8	65.9	62.9	60.3	57.9	55.6	53.6	51.6	50.0	48.4	46.8	15
16	90.6	85.7	81.2	77.2	73.6	70.2	67.4	64.4	61.8	59.5	57.5	55.2	53.6	51.6	50.0	16
17	96.4	91.1	86.4	82.1	78.2	74.9	71.6	68.4	65.9	63.3	61.0	58.7	56.7	54.8	53.2	17
18		96.6	91.6	87.1	82.9	79.4	75.8	72.6	69.8	67.0	64.8	62.6	60.3	58.3	56.4	18
19			96.7	92.0	87.7	83.6	80.2	76.7	73.9	70.9	68.4	65.9	63.7	61.4	59.5	19
20				96.9	92.3	88.3	84.4	81.1	77.6	74.9	71.9	69.5	67.0	64.8	62.9	20
21					97.1	92.8	88.7	85.1	81.9	78.5	75.8	72.9	70.5	68.1	65.9	21
22						97.2	93.2	89.3	85.8	82.4	79.4	76.7	73.9	71.6	69.1	22
23							97.3	93.3	89.6	86.2	83.1	80.2	77.3	74.9	72.6	23
24								97.4	93.6	90.1	86.7	83.6	80.8	78.2	75.4	24
25									97.6	93.8	90.5	87.3	84.1	81.3	78.8	25
26										97.6	94.1	90.8	87.7	84.8	82.1	26
27											97.7	94.3	91.1	88.1	85.3	27
28												97.8	94.5	91.3	88.5	28
29													97.9	94.7	91.6	29
30														97.9	94.8	30
31															98.0	31

References:

(1) Statistical Tables for Biological Agricultural and Medical Research, by Fisher and Yates, Hafner Pub. Co., '63, Table XX, 94-95

(2) Tables of Normal Probability Functions, U. S. Government Printing Office, '53, Table I, 2-338

(3) Pearson, E. and Hartley, H., Biometrika Tables for Statisticians Volume I, Cambridge University Press, '54, Table 28, 175, Table 1, 104-110

Ordinal No.	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Ordinal No.
1	1.92	1.88	1.83	1.74	1.70	1.66	1.62	1.58	1.54	1.50	1.46	1.43	1.39	1.36	1.32	1.32	1.29	1.25	1.22	1
2	4.9	4.3	4.6	4.6	4.5	4.3	4.2	4.1	4.0	3.9	3.8	3.7	3.6	3.5	3.4	3.4	3.3	3.2	3.2	2
3	8.1	7.3	7.6	7.4	7.2	6.9	6.8	6.7	6.4	6.3	6.2	6.1	5.8	5.7	5.6	5.5	5.4	5.3	5.2	3
4	11.1	10.9	10.6	10.2	10.0	9.7	9.4	9.2	9.0	8.7	8.5	8.4	8.1	7.9	7.8	7.6	7.5	7.4	7.2	4
5	14.2	13.8	13.3	13.1	12.7	12.3	12.1	11.7	11.5	11.1	10.9	10.6	10.4	10.2	10.0	9.7	9.5	9.3	9.2	5
6	17.4	16.9	16.4	15.9	15.4	15.2	14.7	14.2	14.0	13.6	13.3	12.9	12.7	12.3	12.1	11.9	11.7	11.3	11.1	6
7	20.6	19.8	19.2	18.7	18.1	17.9	17.4	16.9	16.4	16.1	15.6	15.4	14.9	14.7	14.2	14.0	13.8	13.3	13.1	7
8	23.6	[illegible]	22.4	21.5	20.9	20.3	19.8	19.5	18.9	18.4	18.1	17.6	17.1	16.9	16.4	16.1	15.9	15.4	15.2	8
9	26.8	[illegible]	25.1	24.5	23.6	23.3	22.7	22.1	21.5	20.9	20.3	20.0	19.5	18.9	18.7	18.1	17.9	17.4	17.1	9
10	29.8	[illegible]	28.1	27.4	26.4	25.8	25.1	24.5	23.9	23.3	22.7	22.4	21.8	21.2	20.9	20.3	20.0	19.5	19.2	10
11	33.0	[illegible]	30.9	30.2	29.5	28.4	27.8	27.1	26.4	25.8	25.1	24.5	23.9	23.6	23.0	22.4	22.1	21.5	21.2	11
12	35.9	[illegible]	34.1	33.0	31.9	31.2	30.5	29.5	28.8	28.1	27.4	26.8	26.1	25.8	25.1	24.5	24.2	23.6	23.0	12
13	39.0	[illegible]	36.7	35.9	34.8	33.7	33.0	32.3	31.2	30.5	29.8	29.1	28.4	27.8	27.4	26.7	26.1	25.5	25.1	13
14	42.1	40.9	39.7	38.6	37.4	36.7	35.6	34.8	33.7	33.0	32.3	31.6	30.9	30.2	29.5	28.8	28.1	27.8	27.1	14
15	45.2	[illegible]	42.9	41.3	40.5	39.4	38.2	37.1	36.3	35.6	34.5	33.7	33.0	32.3	31.6	30.9	30.2	29.8	29.1	15
16	48.4	[illegible]	45.6	44.4	43.3	42.1	40.9	39.7	39.0	37.8	37.1	35.9	35.2	34.5	33.7	33.0	32.3	31.6	31.2	16
17	51.6	50.0	48.4	47.2	46.0	44.4	43.6	42.5	41.3	40.1	39.4	38.6	37.4	36.7	35.9	35.2	34.5	33.7	33.0	17
18	54.8	53.2	51.6	50.0	48.8	47.2	46.0	44.8	43.6	42.9	41.7	40.9	39.7	39.0	38.2	37.4	36.7	35.9	35.2	18
19	57.9	[illegible]	54.4	52.8	51.2	50.0	48.8	47.6	46.4	45.2	44.0	43.3	42.1	41.3	40.1	39.4	38.6	37.8	37.1	19
20	61.0	[illegible]	57.1	55.6	54.0	52.8	51.2	50.0	48.8	47.6	46.4	45.2	44.4	43.3	42.5	41.7	40.5	39.7	39.0	20
21	64.1	[illegible]	60.3	58.7	56.7	55.6	54.0	52.4	51.2	50.0	48.8	47.6	46.4	45.6	44.4	43.6	42.9	41.7	40.9	21
22	67.0	[illegible]	63.3	61.4	59.5	57.9	56.4	55.2	53.6	52.4	51.2	50.0	48.8	47.6	46.8	45.6	44.8	44.0	42.9	22
23	70.2	[illegible]	65.9	64.1	62.6	60.6	59.1	57.5	56.4	54.8	53.6	52.4	51.2	50.0	48.8	48.0	46.8	46.0	44.8	23
24	73.2	[illegible]	69.1	67.0	65.2	63.3	61.8	60.3	58.7	57.1	56.0	54.8	53.6	52.4	51.2	50.0	48.8	48.0	46.8	24
25	76.4	[illegible]	71.9	69.8	68.1	66.3	64.4	62.9	61.0	59.9	58.3	56.7	55.6	54.4	53.2	52.0	51.2	50.0	48.8	25
26	79.4	77.0	74.9	72.6	70.5	68.8	67.0	65.2	63.7	62.2	60.6	59.1	57.9	56.7	55.6	54.4	53.2	52.0	51.2	26
27	82.6	80.2	77.6	75.5	73.6	71.6	69.5	67.7	66.3	64.4	62.9	61.4	60.3	58.7	57.5	56.4	55.2	54.0	53.2	27
28	85.8	83.1	80.8	78.5	76.4	74.2	72.2	70.5	68.8	67.0	65.5	64.1	62.6	61.0	59.9	58.3	57.1	56.0	55.2	28
29	88.9	86.2	83.6	81.3	79.1	76.7	74.9	72.9	71.2	69.5	67.7	66.3	64.8	63.3	61.8	60.6	59.5	58.3	57.1	29
30	91.9	89.1	86.7	84.1	81.9	79.7	77.3	75.5	73.6	71.9	70.2	68.4	67.0	65.5	64.1	62.6	61.4	60.3	59.1	30
31	95.1	92.2	89.4	86.9	84.6	82.1	80.2	77.9	76.1	74.2	72.6	70.9	69.1	67.7	66.3	64.8	63.3	62.2	61.0	31
32	98.08	95.2	92.4	89.8	87.3	84.8	82.6	80.5	78.5	76.7	74.9	73.2	71.6	69.8	68.4	67.0	65.5	64.1	62.9	32
33		98.12	95.4	92.6	90.0	87.7	85.3	83.1	81.1	79.1	77.3	75.5	73.9	72.2	70.5	69.1	67.7	66.3	64.8	33
34			98.17	95.4	92.8	90.3	87.9	85.8	83.6	81.6	79.7	77.6	76.1	74.2	72.6	71.2	69.8	68.4	67.0	34
35				98.26	95.5	93.1	90.6	88.3	86.0	83.9	81.9	80.0	78.2	76.4	74.9	73.2	71.9	70.2	68.8	35
36					98.30	95.7	93.2	90.8	88.5	86.4	84.4	82.4	80.5	78.8	77.0	75.5	73.9	72.2	70.9	36
37						98.34	95.8	93.3	91.0	88.9	86.7	84.6	82.9	81.1	79.1	77.6	75.8	74.5	72.9	37
38							98.38	95.9	93.6	91.3	89.1	87.1	85.1	83.1	81.3	79.7	77.9	76.4	74.9	38
39								98.42	96.0	93.7	91.5	89.4	87.3	85.3	83.6	81.9	80.0	78.5	77.0	39
40									98.46	96.1	93.8	91.6	89.6	87.7	85.8	83.9	82.1	80.5	78.8	40
41										98.50	96.2	93.9	91.9	89.8	87.9	86.0	84.1	82.6	80.8	41
42											98.54	96.3	94.2	92.1	90.0	88.1	86.2	84.6	82.9	42
43												98.57	96.4	94.3	92.2	90.3	88.3	86.7	84.8	43
44													98.61	96.5	94.4	92.4	90.5	88.7	86.9	44
45														98.64	96.6	94.5	92.5	90.7	88.9	45
46															98.68	96.6	94.6	92.6	90.8	46
47																98.68	96.7	94.7	92.8	47
48																	98.71	96.8	94.8	48
49																		98.75	96.8	49
																			98.78	50

For sample sizes larger than 50 plotting position is estimated as:

$$\frac{100\ (\text{ordinal number} - 0.5)}{\text{sample size}}$$

EXAMPLE:

Sample Size		Ordinal number
51		
$0.98 = \frac{100(1-0.5)}{51}$		1
$2.94 = \frac{100(2-0.5)}{51}$		2
.		.
.		.
.		.
$99.02 = \frac{100(51-0.5)}{51}$		51

BIOCHEMICAL OXYGEN DEMAND(BOD)

FUNDAMENTAL REACTION

The fraction of the total, or ultimate, carbonaceous

BOD satisfied in the 5-day BOD test (BOD_5) depends upon the rate (k_1) at which the oxygen is depleted. The following formula is the basis of most BOD (carbonaceous) calculations:

$$\text{BOD at "t" in days} = \text{ultimate BOD} \times \left[1 - 10^{-k_1 t} \right]$$

NOTE: BOD_t = amount satisfied

NOTE: $10^{-k_1 t}$ = percent remaining

$k_1 = 0.10$ - rate associated with river water

$k_1 = 0.15$ - rate presently associated with sewages

$k_1 = 0.20$ - rate for some industrial wastes

$k_1 > 0.20$ - rate for rapidly oxidized wastes like sugars, etc.

RELATIONSHIP BETWEEN 5-DAY BOD TEST TO ULTIMATE BOD

$BOD_5 = 0.44 \times$ ultimate BOD at $k_1 = 0.05$

$BOD_5 = 0.684 \times$ ultimate BOD at $k_1 = 0.10$

$BOD_5 = 0.82 \times$ ultimate BOD at $k_1 = 0.15$

$BOD_5 = 0.90 \times$ ultimate BOD at $k_1 = 0.20$

BIOCHEMICAL OXYGEN DEMAND(BOD) (contd)

EXAMPLE - of BOD satisfaction after varying periods of time at $k_1 = 0.15$ from the equation

$$BOD_t = BOD_{ult.} \left[1 - 10^{-k_1 t}\right] \text{(carbonaceous)}$$

BOD satisfied	in	1/2 day	= 0.19 x	BOD_5	= 0.16 x	$BOD_{ult.}$
BOD	" in	1 day	= 0.37 x	"	= 0.30 x	"
BOD	" in	2 days	= 0.68 x	"	= 0.50 x	"
BOD	" in	3 days	= 0.78 x	"	= 0.65 x	"
BOD	" in	4 days	= 0.91 x	"	= 0.75 x	"
BOD	" in	5 days	= 1.00 x	"	= 0.82 x	"

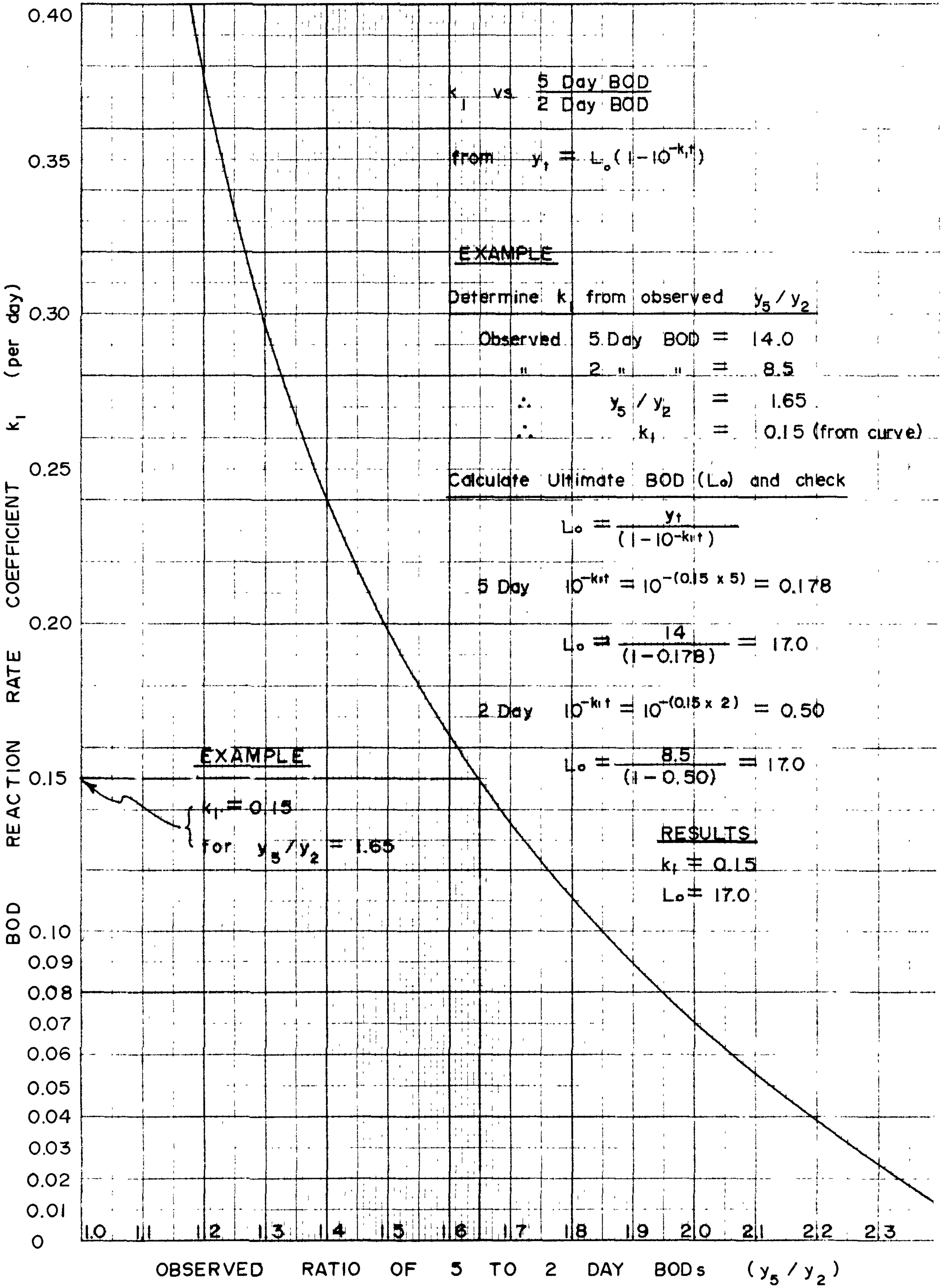
NITROGENOUS BOD:

Nitrogenous materials, such as ammonia, are also oxidized to the stable nitrate form. Some part of this reaction may occur simultaneously with the carbonaceous BOD reaction; but the major effect is exerted after the ultimate carbonaceous BOD reaction is completed. This additional nitrogenous BOD may equal the amount of the ultimate carbonaceous BOD. This concept is useful when considering BOD's some 10-30 days downstream, or in reservoirs. The nitrogenous reaction rate (k) may approximate 1/3 of the carbonaceous reaction rate (k_1).

EFFECT OF TEMPERATURE ON REACTION RATES

Laboratory measurement of k_1 rates are determined at 20° C. In streams, the actual rate increases approximately 4.7% for every 1.0°C. temperature increase (and decreases an equivalent percentage for lower temperatures) according to the following equation:

$$k_1 \text{ (T°C.)} = k_1 \text{ (20°C.)} \times 1.047^{(T-20)}$$



k1 vs 5 Day BOD / 2 Day BOD
from y_t = L_o(1-10^(-k1 t))
EXAMPLE
Determine k1 from observed y5 / y2
Observed 5 Day BOD = 14.0
" 2 " " = 8.5
∴ y5 / y2 = 1.65
∴ k1 = 0.15 (from curve)
Calculate Ultimate BOD (Lo) and check
Lo = yt / (1-10^(-k1 t))
5 Day 10^(-k1 t) = 10^(-(0.15 x 5)) = 0.178
Lo = 14 / (1-0.178) = 17.0
2 Day 10^(-k1 t) = 10^(-(0.15 x 2)) = 0.50
Lo = 8.5 / (1-0.50) = 17.0
RESULTS
k1 = 0.15
Lo = 17.0
EXAMPLE
k1 = 0.15
for y5 / y2 = 1.65
BOD REACTION RATE COEFFICIENT k1 (per day)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
OBSERVED RATIO OF 5 TO 2 DAY BODs (y5 / y2)

RIVER DISCHARGE AND TIME OF TRAVEL

RIVER VELOCITY CHARACTERISTICS

Velocity at 0.6 depth from surface approximates the MEAN velocity throughout the entire depth.

The average of velocities measured at the 0.2 and the 0.8 depth provides a slightly more precise measurement of MEAN velocity.

The MEAN vertical velocity varies from 80 to 95 percent (use 85%) of the surface velocity.

The maximum velocity occurs at 5 to 25 percent of depth; is nearer the surface in shallow streams, and farther from the surface in deep streams.

TIME-OF-TRAVEL STUDIES

Time-of-travel in rivers (also threading, mixing and diffusion characteristics) can be measured by introducing Rhodamine B dye into the river and tracing it downstream with a fluorometer.

The fluorometer can measure Rhodamine concentrations as low as 1.0 part per billion (ppb). Concentrations in excess of 3.0 parts per million (ppm) may foul the meter cell.

Therefore, adjust Rhodamine B dosage to obtain from 1.0 ppm to 10.0 ppb along the river reach to be measured.

The amount of dye to be discharged can be estimated by calculating the amount necessary to provide a theoretical 1.0 ppb average concentration throughout the entire mass of river water contained in the overall reach to be studied.

NOTE: Commercial solutions contain about 45% dye in acetic acid solutions.

Time-of-travel is determined by measuring the time required for the peak dye concentrations to reach the successive downstream sampling stations.

* SATURATION VALUES OF DISSOLVED OXYGEN IN ppm
(Under NORMAL atmosphere at 760 mm.pressure)

Temp C.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	14.62	14.58	14.54	14.50	14.46	14.42	14.39	14.35	14.31	14.27
1	14.23	14.19	14.15	14.11	14.07	14.03	14.00	13.96	13.92	13.88
2	13.84	13.80	13.77	13.73	13.70	13.66	13.62	13.59	13.55	13.52
3	13.48	13.44	13.41	13.38	13.34	13.30	13.27	13.24	13.20	13.16
4	13.13	13.10	13.06	13.03	13.00	12.97	12.93	12.90	12.87	12.83
5	12.80	12.77	12.74	12.70	12.67	12.64	12.61	12.58	12.54	12.51
6	12.48	12.45	12.42	12.39	12.36	12.32	12.29	12.26	12.23	12.20
7	12.17	12.14	12.11	12.08	12.05	12.02	11.99	11.96	11.93	11.90
8	11.87	11.84	11.81	11.79	11.76	11.73	11.70	11.67	11.65	11.62
9	11.59	11.56	11.54	11.51	11.49	11.46	11.43	11.41	11.38	11.36
10	11.33	11.31	11.28	11.25	11.23	11.21	11.18	11.15	11.13	11.11
11	11.08	11.06	11.03	11.00	10.98	10.96	10.93	10.90	10.88	10.86
12	10.83	10.81	10.78	10.76	10.74	10.71	10.69	10.67	10.65	10.62
13	10.60	10.58	10.55	10.53	10.51	10.48	10.46	10.44	10.42	10.39
14	10.37	10.35	10.33	10.30	10.28	10.26	10.24	10.22	10.19	10.17
15	10.15	10.13	10.11	10.09	10.07	10.05	10.03	10.01	9.99	9.97
16	9.95	9.93	9.91	9.89	9.87	9.85	9.82	9.80	9.78	9.76
17	9.74	9.72	9.70	9.68	9.66	9.64	9.62	9.60	9.58	9.56
18	9.54	9.52	9.50	9.48	9.46	9.44	9.43	9.41	9.39	9.37
19	9.35	9.33	9.31	9.30	9.28	9.26	9.24	9.22	9.21	9.19
20	9.17	9.15	9.13	9.12	9.10	9.08	9.06	9.04	9.03	9.01
21	8.99	8.98	8.96	8.94	8.93	8.91	8.89	8.88	8.86	8.85
22	8.83	8.81	8.80	8.78	8.77	8.75	8.74	8.72	8.71	8.69
23	8.68	8.66	8.65	8.63	8.62	8.60	8.59	8.57	8.56	8.54
24	8.53	8.51	8.50	8.48	8.47	8.45	8.44	8.42	8.41	8.39
25	8.38	8.36	8.35	8.33	8.32	8.30	8.28	8.27	8.25	8.24
26	8.22	8.20	8.19	8.17	8.16	8.14	8.13	8.11	8.10	8.08
27	8.07	8.05	8.04	8.02	8.01	7.99	7.98	7.96	7.95	7.93
28	7.92	7.90	7.89	7.87	7.86	7.84	7.83	7.81	7.80	7.78
29	7.77	7.75	7.74	7.73	7.71	7.70	7.69	7.67	7.66	7.64
30	7.63	7.61	7.60	7.59	7.57	7.56	7.55	7.54		
31	7.5									
32	7.4									
33	7.3									
34	7.2									
35	7.1									
36	7.0									
37	6.9									
38	6.8									
39	6.7									
40	6.6									
41	6.5									
42	6.4									
43	6.3									
44	6.2									
45	6.1									
46	6.0									
47	5.9									
48	5.8									
49	5.7									
50	5.6									

*(Taken from Article, "Stream Pollution," by H. W. Streeter, Sewage Works Journal, Vol. 7, p. 535; and Standard Methods, Ninth Edition)