New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233

Thomas C. Jorling
Commissioner

October, 1990

MEMORANDUM

TO: **Regional Water Engineers, Bureau Directors, Section Chiefs**

SUBJECT: Division of Water Technical and Operational Guidance series (1.3.5)
WASTE ASSIMILATION CAPACITY DETERMINATIONS FOR ISOLATED WASTEWATER DISCHARGES IN FRESH WATER STREAMS
(Originator: William Berner)

I. PURPOSE

The purpose of this guidance is to provide procedures and methodologies for determining waste assimilation capacity and allowable waste loadings from isolated wastewater discharges to fresh water streams. Such discharges are not necessarily geographically isolated; rather they do not have a cumulative interacting effect on the receiving stream with other wasteloads and consequently can be evaluated as individual 11isolated11 discharges. It provides detailed guidance for stream reaction kinetics, design parameters, waterbody characteristics, and applicable stream standards related to oxygen demanding discharges to water quality limiting stream segments. For isolated discharges, this guidance establishes the procedures to be used to meet the objectives of TOGS (1.3.1), "Waste Assimilative Capacity Analysis and Allocation for Setting Water Quality Based Effluent Limits."

II. DISCUSSION

TOGS (1.3.1) defines the criteria applicable to waste assimilative capacity analysis and allocation in order to determine allowable effluent limits for wastewater discharges to water quality limiting stream segments. Factors are presented for consideration in developing mathematical water quality (dissolved oxygen) models. In most cases, such models are calibrated and verified using physical and chemical stream survey data. However, in some cases where a small isolated discharge to a uniform stream segment is to be considered and field data is unavailable, allowable effluent limits may be able to be determined by applying a conservative "desktop: analysis based upon the physical characteristics of the receiving stream alone. The following guidelines are to be used for such simplified analyses.

III. GUIDANCE

A. Receiving Stream Consideration

1. Determine receiving stream name, waters index number, and current official classification from the Official Compilation of Codes. Rules and Regulations of the State of New York, Title 6 - Conservation, Volumes B,C,D,E,F.

2. Determine the statistical minimum average seven consecutive day streamflow occurring once in ten years (MA7CD/10). This value may be obtained from the U.S. Geological Survey, Albany, New York, or the N.Y.S. Department of Environmental Conservation, Bureau of Monitoring and Assessment, Survey Section, 50 Wolf Road, Albany, New York 12233-3503 (Mr. Richard Draper, A.C. 518-457-2672), or by extrapolation from Low Flow Frequency Analyses of Streams in New York, Bulletin 74, USGS/NYSDEC, 1979.

3. Discharges to Intermittent Streams

   An intermittent stream is defined as a stream which periodically goes dry or whose MA7CD/10 flow is less than 0.1 cfs as estimated by methods other than continuous daily flow measurements.

   The current guidance relating to discharges to intermittent streams is outlined in Division of Water Technical and Operational Guidance Series (1.3.1) - "Waste Assimilative Capacity Analysis and Allocation for Setting water Quality Based Effluent Limits".

4. Stream Standards

   a) Dissolved oxygen:

      Classifications and Standards Governing the Quality and Purity of Waters of New York State (Parts 700 through 705, Title 6, Official Compilation of Codes, Rules and Regulations) were revised July 24, 1985. Dissolved oxygen concentration standards are specified as not to be less than the values listed below:

REQUIRED D.O. CONCENTRATIONS IN MG/L

	Classification	A, A, B, C	D	SA, SB, SC	SD
For Trout Waters	Spawning minimum	7.0	n.a.	n.a.	n.a.
	Minimum daily average	6.0	n.a.	n.a.	n.a.
	Minimum, at anytime	5.0	n.a.	n.a.	n.a.
For Non-Trout Waters	Minimum daily average	5.0	-	-	-
	Minimum, at anytime	4.0	3.0	5.0	3.0

For purposes of performing waste assimilative capacity analyses using the conservative parameters presented in this paper, the "minimum at anytime" dissolved oxygen standard shall be used.

b) Ammonia or ammonium compounds:

Refer to Division of Water Technical and Operational Guidance Series (1.1.1), "Ambient Water Quality Standards and Guidance Values". The table for un-ionized and total ammonia standards from that document is included on the following page of this guideline.

c) Other stream parameters:

Refer to TOGS (1.1.1) referenced above and the "New York State Surface Water Quality Regulations" (Parts 700 through 705 of Title 6, Official Compilation of Codes, Rules and Regulations).

B. Receiving Waters Design Parameters

1) If there are no upstream discharges, and no oxygen data is available, assume D.O. to be 90% saturation (see Table 1 following).

2) Unless temperature data for summer drought flow periods is available, use the following stream temperatures:

a) Non-trout stream • • • • • • • • • • 25 C
b) Trout Stream • • • • • • • • • • • • 24 C

Date of Revision: April 1, 1987

AMMONIA STANDARDS (Continued):
FRESHWATER STANDARDS BASED ON FORMULA

Standards For All FW Classes Except D

Un-ionized Ammonia (mg/Liter NH_3)

pH	0°C	5°C	10°C	15°C	20°C	25°C	30°C
6.50	0.0018	0.0027	0.0040	0.0040	0.0040	0.0040	0.0040
6.75	0.0027	0.0041	0.0061	0.0061	0.0061	0.0061	0.0061
7.00	0.0042	0.0063	0.0094	0.0094	0.0094	0.0094	0.0094
7.25	0.0064	0.0096	0.0144	0.0144	0.0144	0.0144	0.0144
7.50	0.0098	0.0148	0.0220	0.0220	0.0220	0.0220	0.0220
7.75	0.0138	0.0208	0.0310	0.0310	0.0310	0.0310	0.0310
8.00	0.0139	0.0209	0.0310	0.0310	0.0310	0.0310	0.0310
8.25	0.0140	0.0210	0.0310	0.0310	0.0310	0.0310	0.0310
8.50	0.0142	0.0211	0.0310	0.0310	0.0310	0.0310	0.0310
8.75	0.0145	0.0214	0.0310	0.0310	0.0310	0.0310	0.0310
9.00	0.0150	0.0219	0.0310	0.0310	0.0310	0.0310	0.0310

Total Ammonia (mg/Liter NH_3)

pH	0°C	5°C	10°C	15°C	20°C	25°C	30°C
6.50	6.82	6.82	6.83	4.65	3.21	2.24	1.58
6.75	5.87	5.87	5.89	4.01	2.76	1.93	1.37
7.00	5.06	5.06	5.07	3.45	2.38	1.67	1.13
7.25	4.36	4.36	4.37	2.98	2.06	1.44	1.02
7.50	3.77	3.77	3.78	2.58	1.78	1.25	0.89
7.75	2.99	2.99	3.00	2.05	1.42	1.00	0.72
8.00	1.70	1.70	1.70	1.17	0.81	0.58	0.42
8.25	0.97	0.97	0.97	0.67	0.47	0.34	0.25
8.50	0.56	0.56	0.56	0.39	0.28	0.20	0.15
8.75	0.33	0.33	0.33	0.23	0.17	0.13	0.10
9.00	0.20	0.20	0.20	0.14	0.11	0.09	0.07

Standards for Class D

Un-ionized Ammonia (mg/Liter NH_3)

pH	0°C	5°C	10°C	15°C	20°C	25°C	30°C
6.50	0.008	0.013	0.019	0.019	0.019	0.019	0.019
6.75	0.014	0.021	0.031	0.031	0.031	0.031	0.031
7.00	0.021	0.032	0.048	0.048	0.048	0.048	0.048
7.25	0.030	0.046	0.069	0.069	0.069	0.069	0.069
7.50	0.040	0.061	0.091	0.091	0.091	0.091	0.091
7.75	0.049	0.074	0.110	0.110	0.110	0.110	0.110
8.00	0.056	0.084	0.125	0.125	0.125	0.125	0.125
8.25	0.061	0.091	0.135	0.135	0.135	0.135	0.135
8.50	0.065	0.096	0.141	0.141	0.141	0.141	0.141
8.75	0.068	0.100	0.145	0.145	0.145	0.145	0.145
9.00	0.071	0.104	0.147	0.147	0.147	0.147	0.147

Total Ammonia (mg/Liter NH_3)

pH	0°C	5°C	10°C	15°C	20°C	25°C	30°C
6.50	31.9	31.9	31.9	21.8	15.0	10.5	7.41
6.75	29.5	29.5	29.5	20.1	13.9	9.69	6.86
7.00	25.7	25.7	25.7	17.6	12.1	8.48	6.00
7.25	20.8	20.8	20.8	14.2	9.84	6.89	4.88
7.50	15.5	15.5	15.5	10.6	7.34	5.15	3.66
7.75	10.6	10.6	10.6	7.29	5.06	3.56	2.55
8.00	6.84	6.84	6.84	4.71	3.28	2.33	1.68
8.25	4.22	4.22	4.22	2.92	2.05	1.47	1.08
8.50	2.54	2.54	2.54	1.78	1.27	0.93	0.70
8.75	1.53	1.53	1.53	1.09	0.80	0.60	0.47
9.00	0.94	0.94	0.94	0.69	0.52	0.41	0.33

To convert these values to mg/Liter N, multiply by 0.822.

TABLE 1
Dissolved Oxygen Saturation Values
(mg/l)

Elevation - Feet	"B" (MM)*	100% Sat. 25 C	100% Sat. 24 C	90% Sat. 25 C	90% Sat. 24 C
0	760	8.3	8.4	7.6	7.7
500	746	8.1	8.3	7.4	7.5
1000	732	8.0	8.1	7.3	7.4
1500	718	7.8	8.0	7.1	7.2
2000	704	7.7	7.8	7.0	7.1
2500	690	75	7.7	6.8	6.9

*"B" is barometric pressure

3) If there are no upstream discharges and no quality data available, assume upstream TOD = 3.0 mg/l. (TOD = CBODu + NOD. The subscript "u" denotes ultimate BOD.)

4. Stream self purification factor "f": See Table II

5. K_1 (bottle rate), base "e" = Use 0.23 unless specific data is available.

6. K_1 (base 10) = $K_1/2.3$

7. Kp = K_1 unless otherwise specified according to available data.

8. $\mathbf{K_2 = f \times K_1}$

TABLE II
Typical Values of "f"

Nature of Receiving Waters	"f" Values
Small ponds and backwaters	0.5 - 1.0
Sluggish streams, large lakes or impoundments	1.0 - 1.5
Large streams of slow velocity	1.5 - 2.0
Large streams of moderate velocity	2.0 - 3.0
Swift streams	3.0 - 5.0
Rapids, waterfalls, etc.	5.0 - and up

If selection of the "f" factor is critical to the degree of treatment required, the more conservative value should be used unless a higher value can be justified by some other means (i.e. sampling data).

C. Wastewater Characteristics

1) $CBOD_u$ (Carbonaceous oxygen demand)

Use the largest of the following where no $CBOD_u$ data is available:

a) $CBOD_u$ (lbs/day) = 1.46 x BOD_5 for domestic wastes (normally 1.46 x 200 mg/l = 300 mg/l) x 8.34 x MGD

b) $$CBOD_u \text{ (lbs/day)} = \frac{BOD_5 \times 8.34 \times MGD}{(1-e^{-k_1 t})}$$ for other wastes

where t=5 days, K_1 = deoxygenous rate of waste (base "e")

c) $CBOD_u$ (lbs/day) = Population x Population Equivalent (P.E.).

P.E. = 0.25 lb/day $CBOD_u$

2) NOD (Nitrogenous oxygen demand)

The nitrogenous compounds NH_3 and Organic N exert an oxygen demand when they are oxidized by nitrifying bacteria to form nitrates. The NH_3 and Organic N concentrations of raw domestic sewage have been observed to be 25 mg/l and 15 mg/l respectively. One mg/l of NH_3 or organic N requires 4.57 mg/l of oxygen to be completely oxidized to nitrates.

The ultimate nitrogenous oxygen demand is determined by using the largest of the following:

a) NOD = (25 mg/l + 15 mg/l) x 4.5 = 180 mg/l for raw, domestic sewage. NOD (lb/day) = 180 mg/l x 8.34 x MGD.

b) NOD (lb/day) = 0.15 lb/day x Population

Some industrial wastes also contain NH_3 and organic Nitrogen. The concentrations should be determined from waste sampling. The nitrogenous oxygen demand would then be determined as shown above.

3) TOD Total Ultimate oxygen demand)

The total ultimate oxygen demand (TOD) is the sum of items 1 and 2 ($CBOD_u$ and NOD). The TOD of raw domestic sewage would therefore be 300 mg/l + 180 mg/l, or 480 mg/l converted into lb/day, or the largest total of the above $CBOD_u$ and NOD values. TOD is sometimes referred to synonymously as UOD (Ultimate Oxygen Demand).

Unless waste flow, Q_w, is known use 100 gpcd (gallons per capita per day).

4) Effluent Dissolved Oxygen

The effluent dissolved oxygen content is normally assumed to be as follows, however, it may be higher or lower depending upon the treatment processes used and the outfall configuration. Also in cases where a high degree of effluent polishing is required, it may prove desirable (or necessary) to provide effluent aeration devices.

Trickling filter effluents • • • • • • • 4.0 mg/l
Activated sludge processes effluent • • • 2.0 mg/l

5) Disinfection

Adequate disinfection of wastewater effluents is required to meet water quality standards for streams classified AA, A, SA, GA, B & SB (seasonal option) and may be required for lower classifications where a public health need exists. The application of disinfection to meet standards and allowable in-stream total chlorine residuals are specified in "Policy and Procedures Manual, Title 9200, Chapter 9210 - Municipal Wastewater Treatment". The period of disinfection for discharges to Class B and SB waters and the need and period applicable to other lower class streams is the responsibility of the DEC Regional Office having jurisdiction (based on Health Department determinations). The New York State Health Department is charged with the responsibility of determining disinfection needs based on protection of public health.

If chlorination is used as the method of disinfection, the discharge shall not cause the chlorine residual of the receiving water to exceed acceptable levels for fish propagation. Dechlorination facilities or alternate methods of disinfection may be required in certain instances. Allowable instream maximum total chlorine residuals for cold or warm water fisheries are 0.005 mg/l and 0.05 mg/l respectively. In addition, outfall structures must be constructed so as not to result in full channel mixing zones exceeding the 0.005 mg/l total chlorine residual.

D. Computation of Waste Assimilation Capacity and Waste Treatment Requirements

1) Compute the initial dissolved oxygen deficit D_a:

$$D_a = \frac{Q_w \times D_w + Q_s \times D_s}{Q_w + Q_s}$$

Where: Q_w = waste flow
C_s = Saturation concentration (Refer to Table 1)
D_w = Waste Deficit = Cs – D.O. waste
Q_s = Streamflow
D_s = Stream deficit = Cs – D.O. stream (usually 10% of C if there is no upstream pollution – see item B-1)

2) Determine the "f" factor to be used from Table II.

3) Compute the critical deficit D by subtracting the minimum allowable stream standard D.O. concentration from C, the saturation concentration. That is, D_c = C_s - Stream Standard.

4) Go to figures 1-7, knowing D_c, D_a, and "f" and find L_a which is the maximum allowable stream concentration of ultimate oxygen demand.

5) Compute the waste assimilation capacity from the following relationship:

Waste assimilation capacity (in terms of TOD in lbs/day) = [(Qw + Qs) x La x 8.34] - [Qs x 3.0 x 8.34]

Where: Qw = waste flow in MGD
Qs = stream flow in MGD
La = mg/l of total oxygen demand

The above assumes a relatively uncontaminated upstream $CBOD_u$ of 3.0 mg/l and no NOD load. If the upstream $CBOD_u$ is higher and/or an NOD load exists, the actual TOD Value should be substituted for the value 3.0 in the expression: [Qs x 3.0 x 8.34].

6) If the receiving stream is a regulated stream (controlled flow), 30 percent of the waste assimilation capacity (WAC) is held in reserve for safety factors or reliability factors.

Therefore, the net "WAC" = 0.70 times item 5 above. As an alternate to this step, use 0.70 x minimum release (Qs) to provide an assimilative capacity reserve for safety factor in item 5 above.

7. Compute the proposed effluent loading in terms of TOD:

$$TOD = [(1.0-E_b) \times CBOD + (1.0-E_n) \times NOD] \times Q_w \times 8.34$$

Where: TOD = Total Ultimate effluent oxygen demand in pounds per day.
E_b = BPT treatment efficiency with regard to carbonaceous BOD removal, usually 85% for municipal type discharge or BPT as defined by DEC's Bureau of Wastewater Facilities Design for industrial systems.

CBOD = raw CBOD ultimate, mg/l

E_n = treatment efficiency with regard to nitrogenous oxygen demand, usually 50% for secondary treatment discharges to water quality limiting stream segments unless stream capacity and wasteload allocation requires higher efficiency.

NOD = raw nitrogenous oxygen demand, mg/l

Q_w = waste flow, MGD

8) Compare item 7 with item 6 above. If item 7 is greater than item 6, more treatment is required. Check item 9 below.

9) Also, the NH3 standard must be met taking into account any upstream NH3 concentration which may exist. Background concentration of NH3 is typically 0.1 mg/l, if site specific background data is unavailable.

a) The allowable NH_3 discharge to the stream in terms of pounds per day = $(Q_s + Q_w) \times (NH_3$ standard in mg/l$) \times 8.34$ where Q_w and Q_s are in MGD.

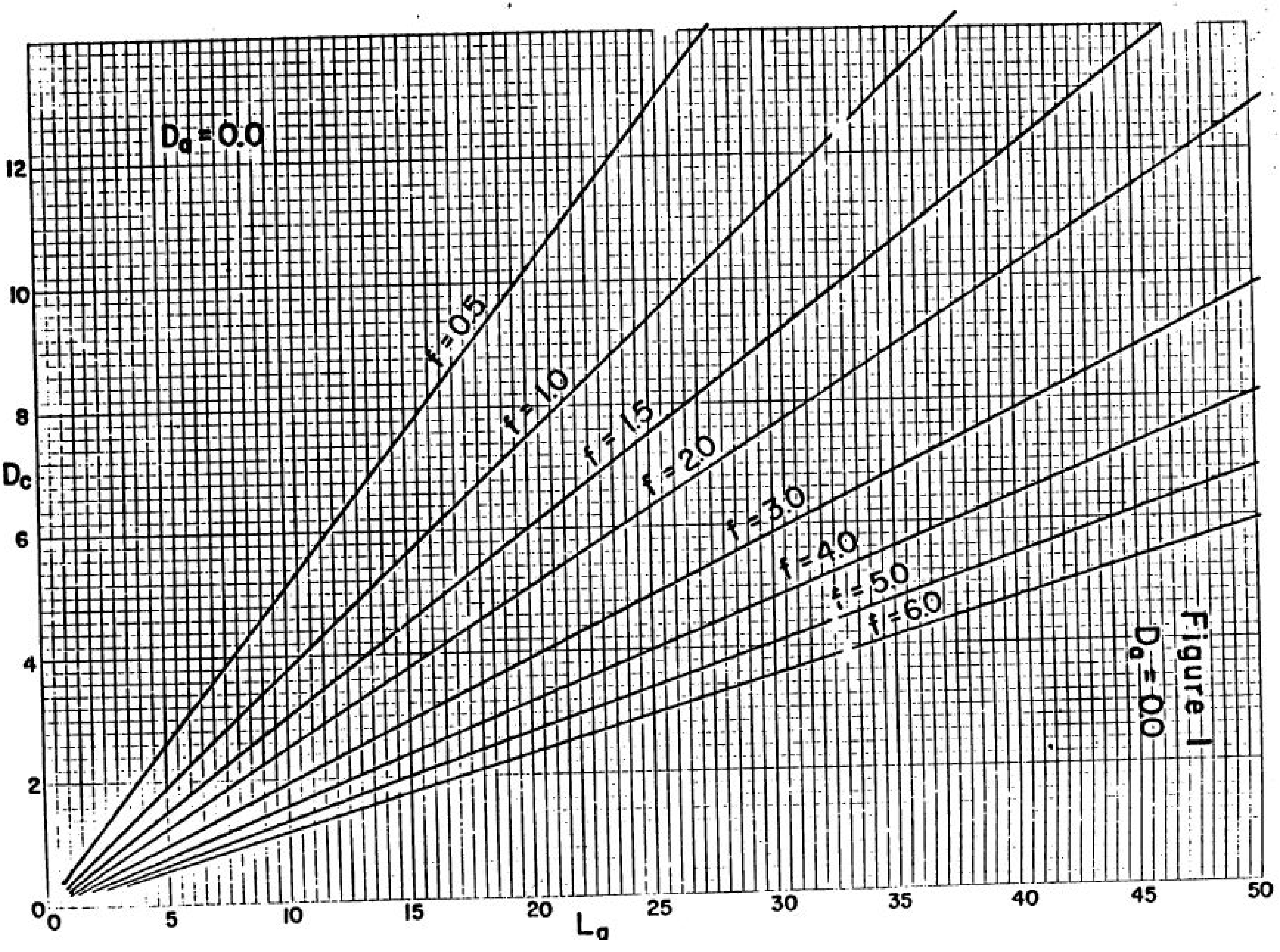
b) The amount of NH_3 in the effluent = $(1-E_n) \times 25 \times Q_w \times 8/34$. again where Q_w is in MGD.

If 9b is greater than 9a, more NH_3 must be removed in the treatment plant, even though the NOD criteria may be complied with.

Salvatore Pagano, P.E.
Director, Division of Water

cc: Dr. Banks
Mr. Campbell
Ms. Chrimes
Mr. Bruening

Regional Engineers for Environmental Quality



$D_a = 0.0$
f = 0.5
f = 1.0
f = 1.5
f = 2.0
f = 3.0
f = 4.0
f = 5.0
f = 6.0
Figure I
$D_a = 0.0$
D_c
L_a
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40
45
50

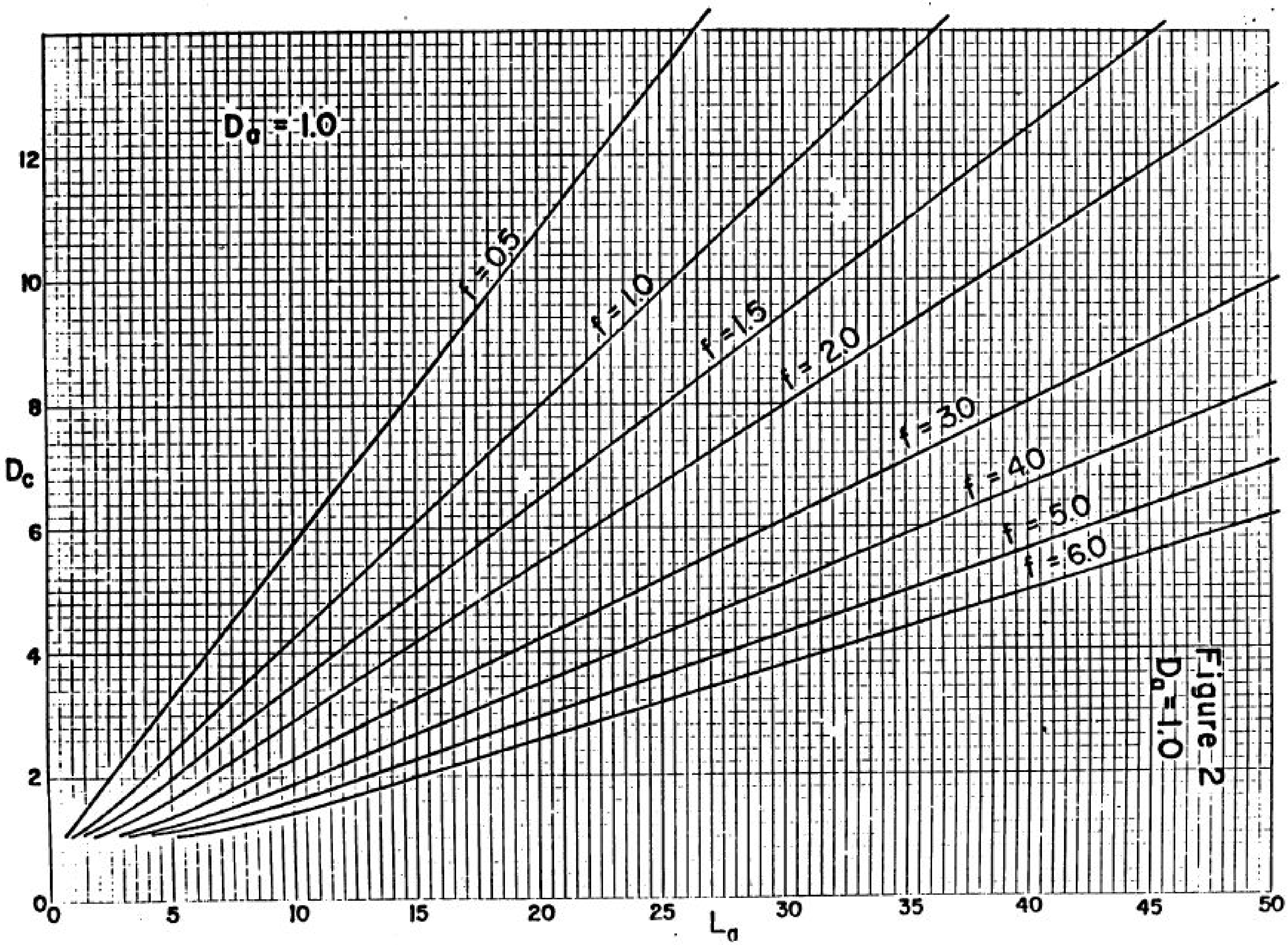


Figure 2
$D_a = 1.0$

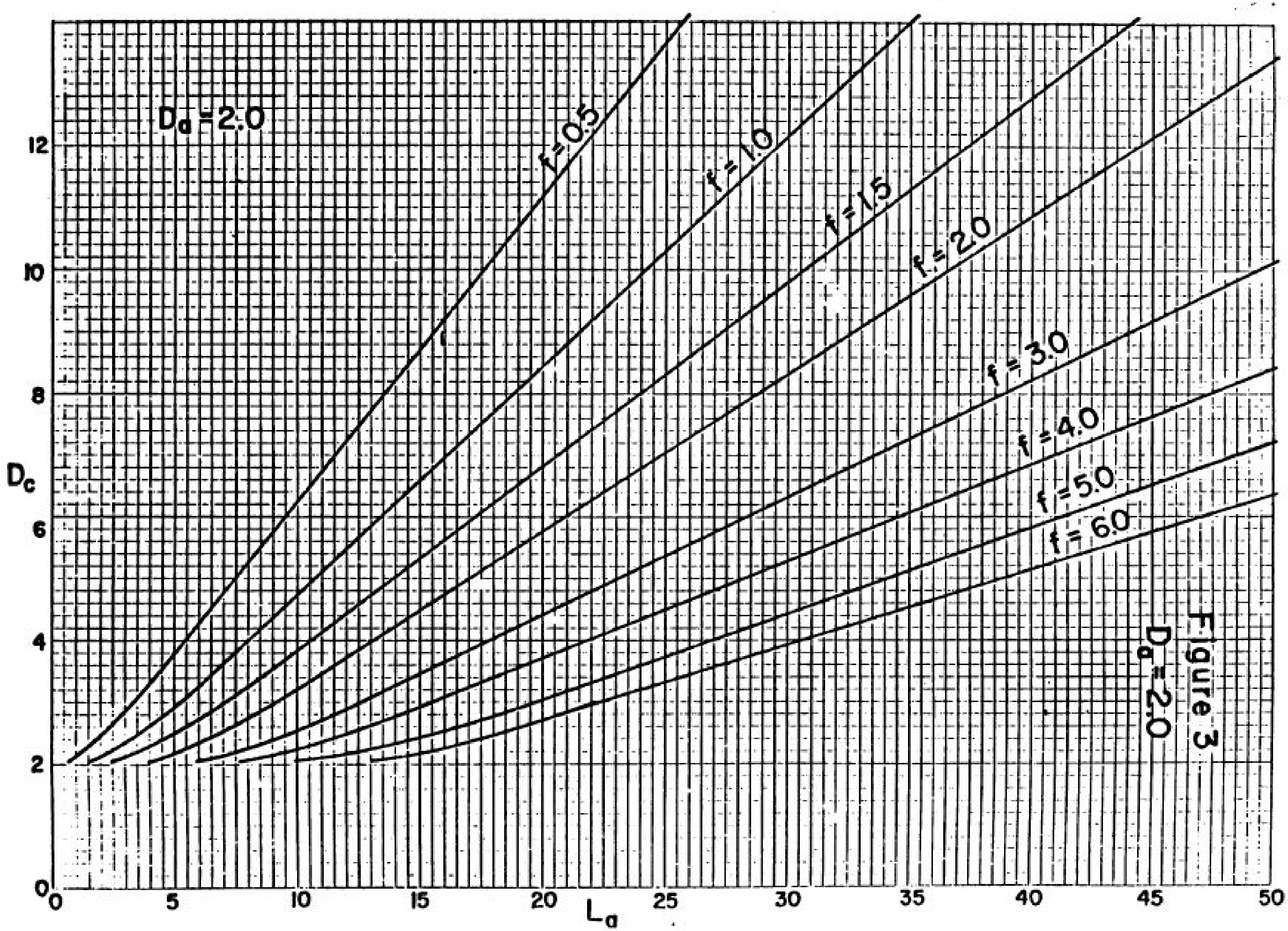


Figure 3
Da = 2.0
Da = 2.0
f = 0.5
f = 1.0
f = 1.5
f = 2.0
f = 3.0
f = 4.0
f = 5.0
f = 6.0
Dc
La
0
2
4
6
8
10
12
5
10
15
20
25
30
35
40
45
50

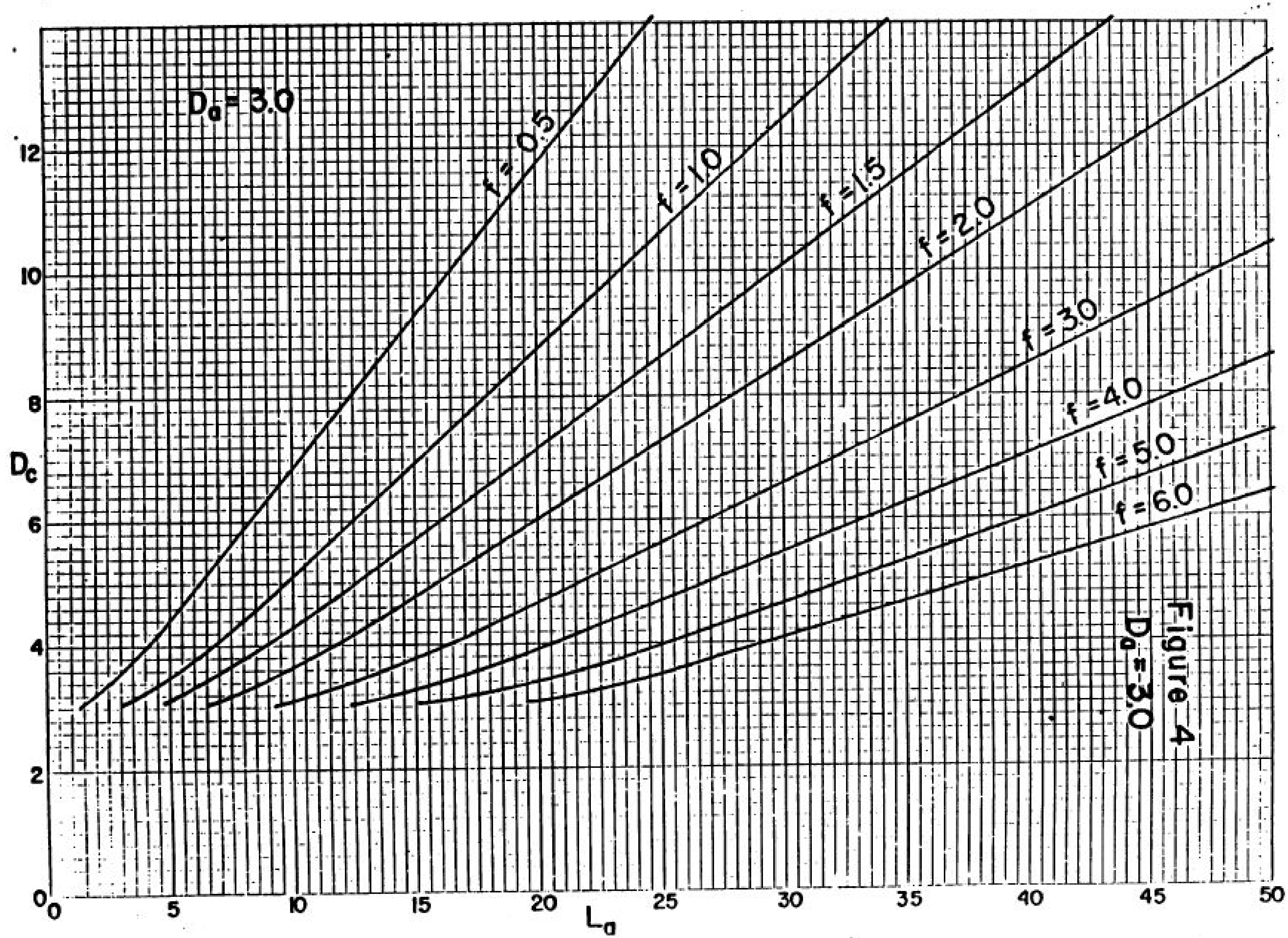


Figure 4
$D_a = 3.0$
$D_a = 3.0$
f = 0.5
f = 1.0
f = 1.5
f = 2.0
f = 3.0
f = 4.0
f = 5.0
f = 6.0
D_c
L_a
0
2
4
6
8
10
12
5
10
15
20
25
30
35
40
45
50

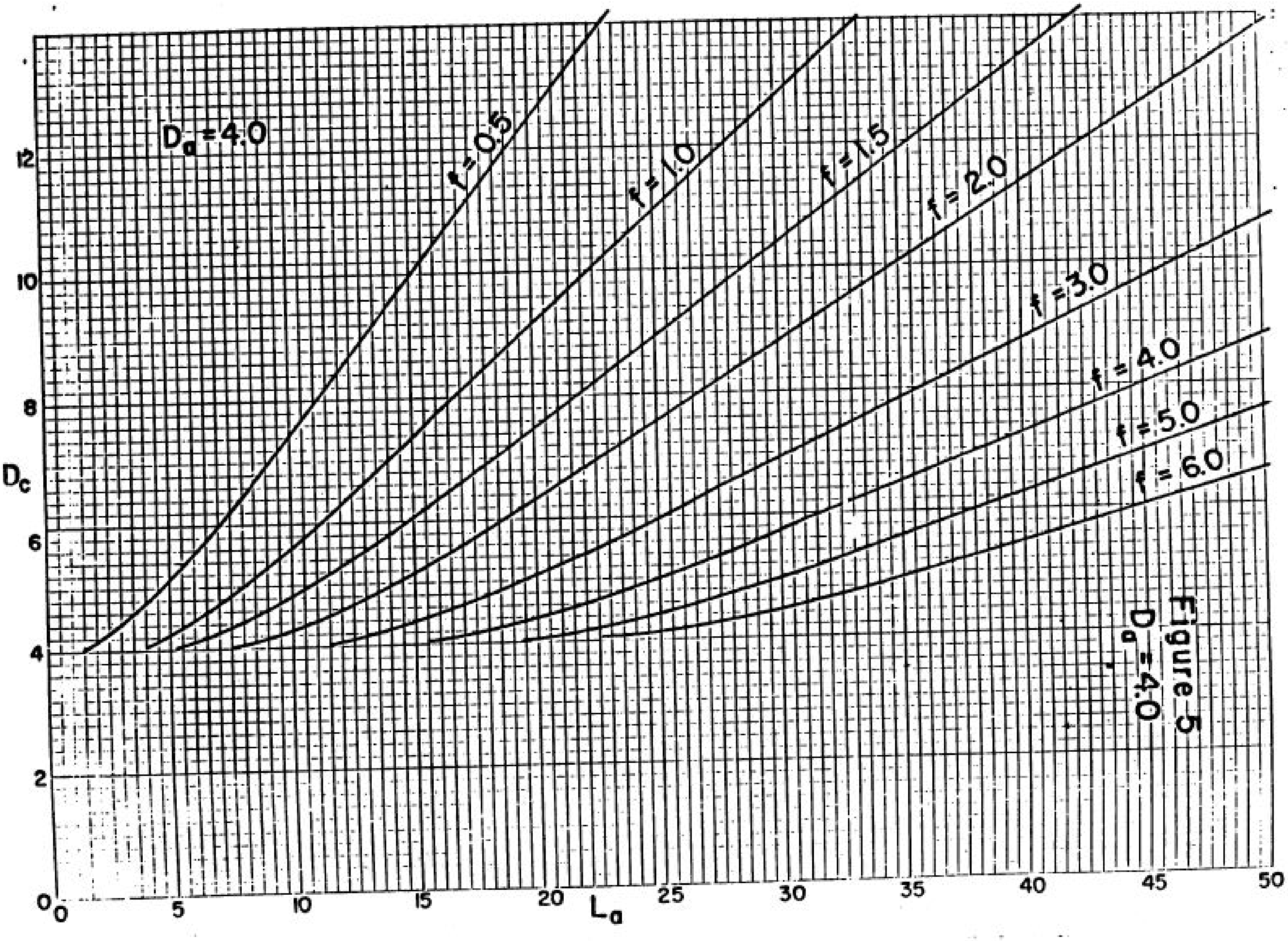
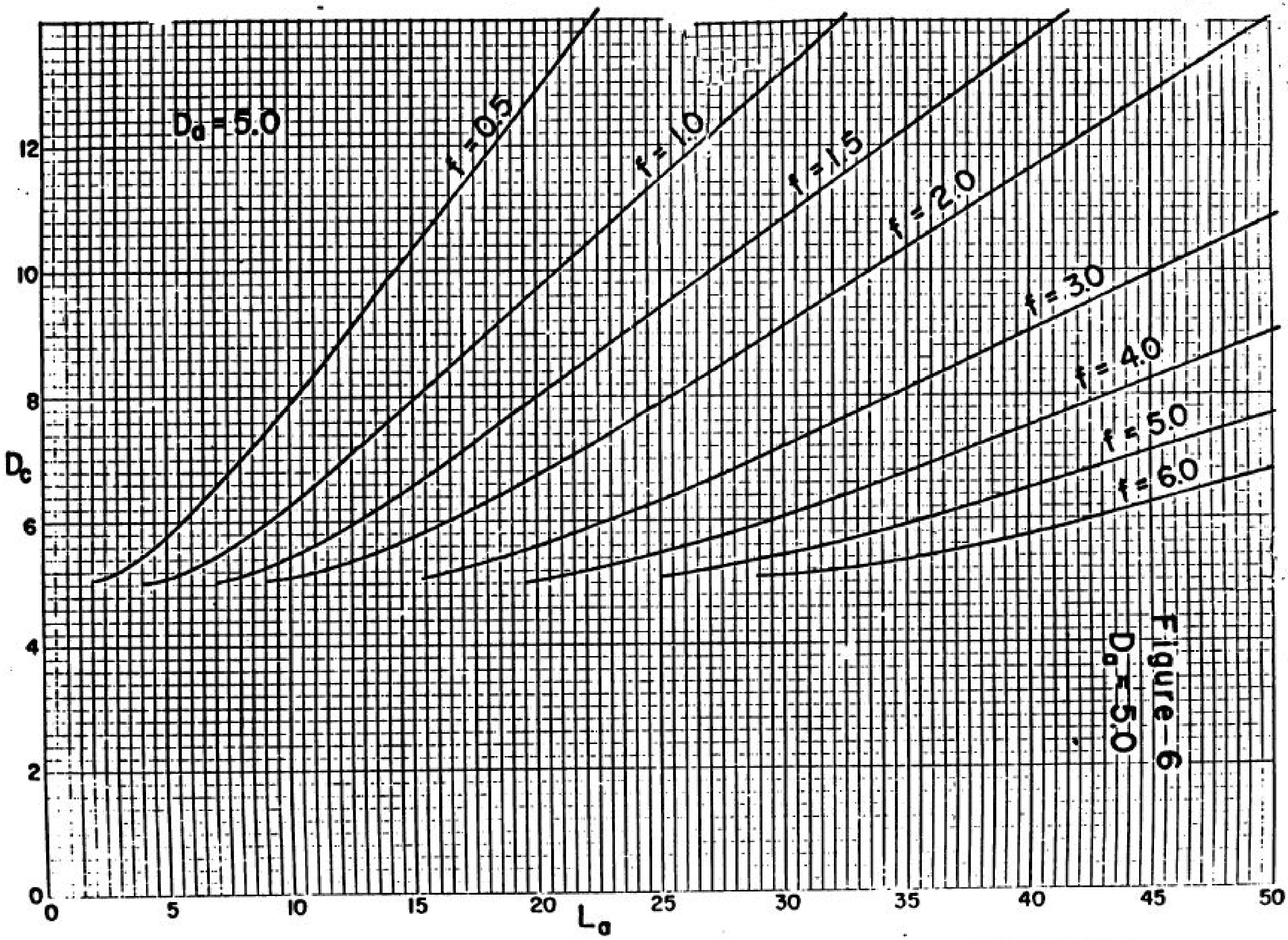


Figure 5
$D_a = 4.0$



Da = 5.0
f = 0.5
f = 1.0
f = 1.5
f = 2.0
f = 3.0
f = 4.0
f = 5.0
f = 6.0
Figure-6
Da = 5.0
Dc
La
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40
45
50

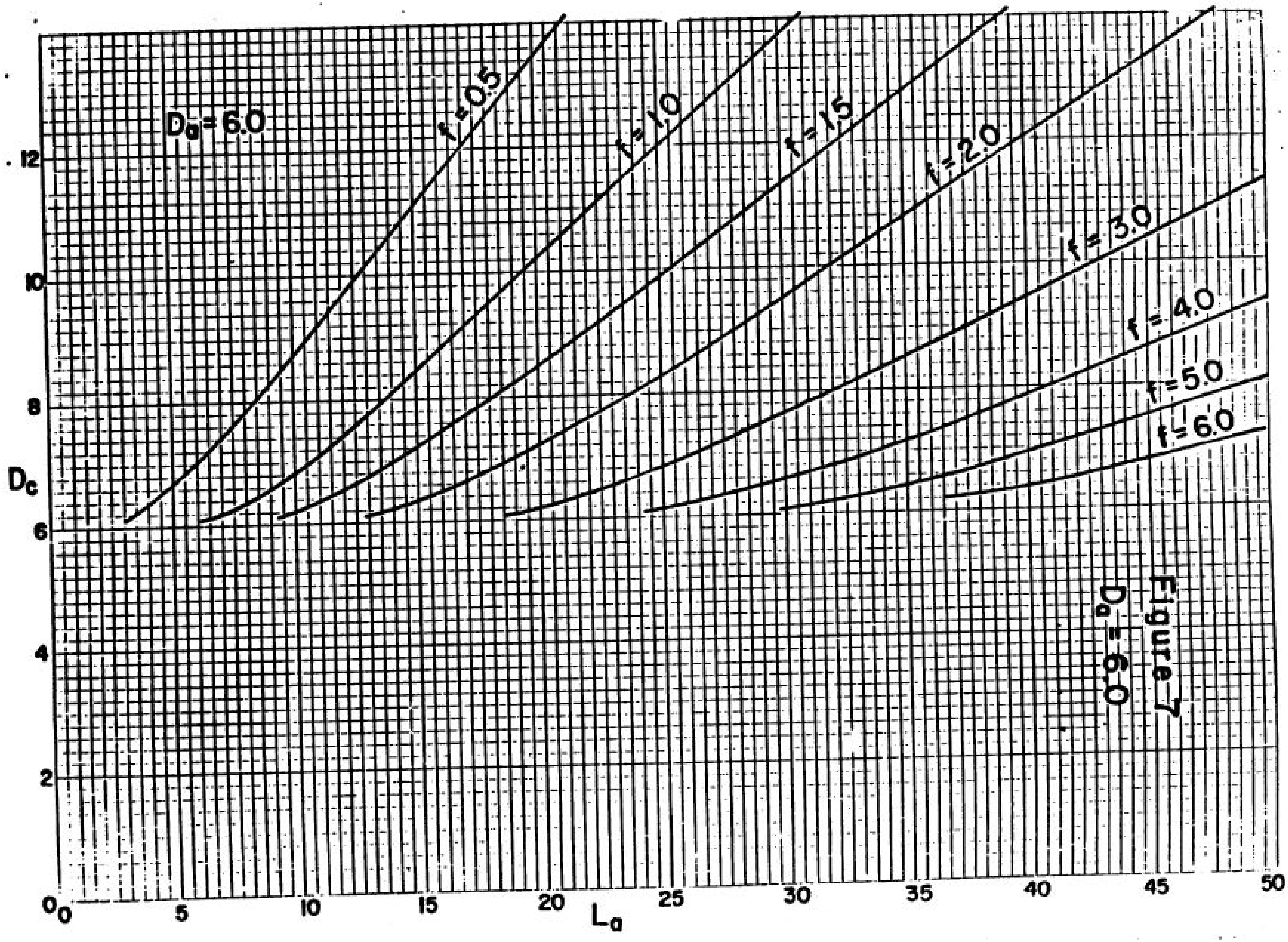


Figure 7
$D_a = 6.0$
$D_a = 6.0$
f = 0.5
f = 1.0
f = 1.5
f = 2.0
f = 3.0
f = 4.0
f = 5.0
f = 6.0
D_c
L_a
0
2
4
6
8
10
12
5
10
15
20
25
30
35
40
45
50