TECHNICAL NOTES

U. S. DEPARTMENT OF AGRICULTURE
MINNESOTA STATE OFFICE

SOIL CONSERVATION SERVICE
ST. PAUL, MINNESOTA

ADMINISTRATIVE MATERIAL - FOR USE ONLY WITHIN THE SOIL CONSERVATION SERVICE

ENGINEERING No. 1

June 27, 1961

DESIGN OF EARTH SPILLWAYS

These tables and graphs provide a rapid method of determining the size earth spillway required for a specific discharge for various differences of elevation of the reservoir level above the bottom of the earth spillway. This information was developed primarily for CO-1 and ACP work.

Reference

The following tables have been developed from information given in Supplement A of Technical Release No. 2 dated May 13, 1957 and issued by the Washington Design Section. Additional information on definitions, use, layout, site investigation and hudraulic design is available in Technical Release No. 2 on file in the Area Office.

Assumptions made for development of tables

To make these tables as easy as possible to use, it was necessary to assume some values as being constant. A 3:1 side slope for the earth spillway channel is common and is used in the tables. The values given in the table will not be exactly correct for a different side slope, and an engineer should be consulted to see if a correction is necessary.

The tables are based on an inlet channel length of 100 feet. If the inlet channel length is closer to 50 feet or 150 feet, corrections are given below the table when necessary. An engineer should be consulted whenever the inlet channel exceeds the limits set forth in the tables.

The bottom slope of the inlet channel must fit the conditions given for the particular table used.

The slopes of the exit channel must fall between the minimum and maximum values given in the table to keep exit velocities within safe limits. These slope requirements must be met to the intersection of the spillway with the valley floor when the earth spillway is to be used as an auxiliary spillway. For strictly an emergency spillway, the maximum slope may be exceeded as soon as the water is conducted safely beyond the toe of the earth fill.

The maximum slope of the exit channel (S_o max) was computed on the basis of a velocity 10.5 feet per second not to exceed a 10% slope. If it is not practical to stay with the 10% maximum slope, a steeper slope may be justified. This would depend on the duration of flow through the earth spillway, frequency of use, length of exit channel, and bulk of material (soil) that is in place at the control section elevation. Any jobs of an Engineering Job Classification of C or over designed with an exit channel slope of more than 10% must have the approval of the State Conservation Engineer.

A roughness factor was selected assuming a good stand of vegetation.

Definition of nomenclature

L - Length of inlet channel. The inlet channel is defined as that part of the spillway upstream from the control section to a point where the spillway bottom grade joins natural ground.

H_p - Height of Pool. The difference in elevation between the crest at the control section and the water surface in the reservoir for a particular discharge through the earth spillway. This H_p value will not normally include freeboard, and freeboard must still be added except where the H_p value pertains to a freeboard hydrograph discharge.

n - Manning's roughness coefficient

q_c - The discharge per foot of width in cfs.

v_c - Velocity at control section in feet per second. The maximum allowed would depend on soil conditions, vegetation expected and frequency of use.

S_o min - The minimum slope allowable in the exit channel which is defined as that part of the spillway channel below the control section.

S_o max - The maximum slope allowable in the exit channel.

Example

Design earth spillway for a farm pond which must have a capacity of 75 cfs. From visual observations at the site and preliminary design, it appears that the inlet channel will be approximately 100 feet long and the width limited to 100 feet. To simplify construction, we would like to use a level inlet channel, and it would be desirable to have the top of the earth fill not more than 2 feet higher than the control section of the earth spillway.

One foot is needed for freeboard so that leaves only one foot for H_p. The above criteria fit Table 1. In the column headed by "H_p = 1.0 ft." we find by interpolation that a 65 foot bottom width gives a discharge of 76 cfs. The side slopes would be 3:1. In the upper part of the H_p = 1.0 ft. column, we read that the exit channel slope must be between 7 and 10%.

The only thing left to do is to draw it on the plan (see Layout #1) and check to see that it appears to be a practical solution.

Layouts 2 and 3 are for different inlet conditions. They will give a higher discharge for the same H_p value because of lower inlet losses. Where a more efficient spillway is required and the site characteristics are favorable, it would be advantageous to use Layout 2 or 3 in preference to Layout 1.

Ross A. St. John

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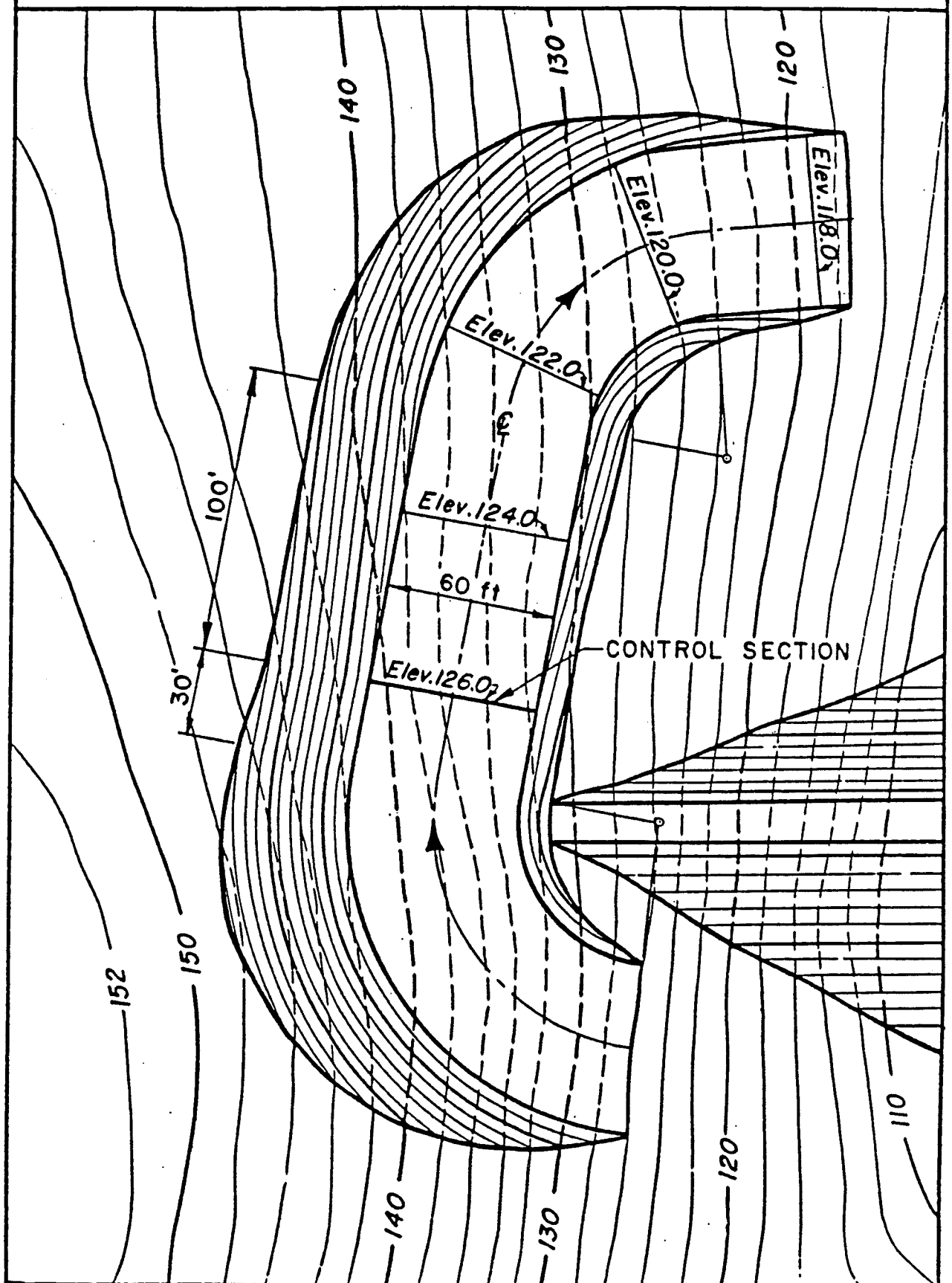
State Conservation Engineer

Attachment

EARTH SPILLWAYS : Typical layout and grading plans. No.1

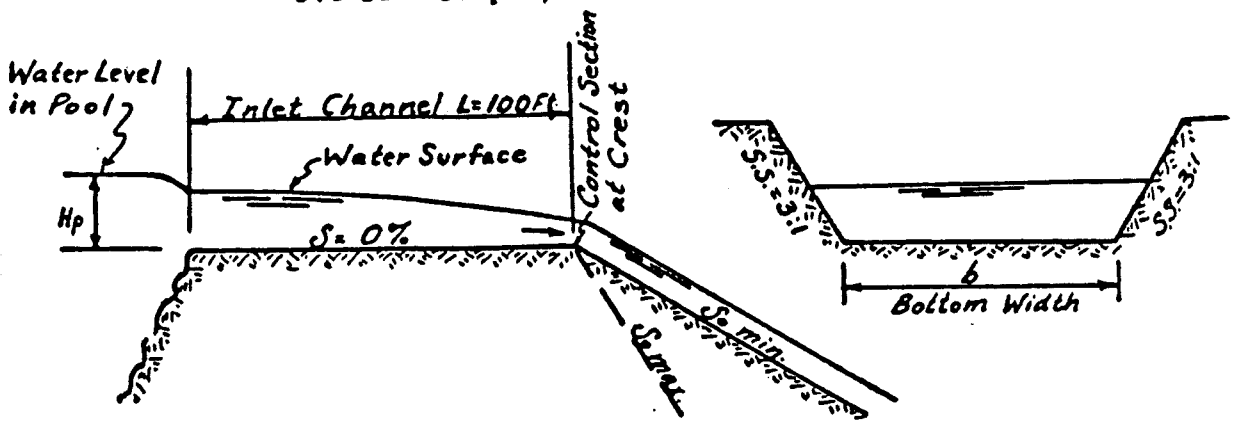


REFERENCE	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION-DESIGN SECTION	STANDARD DWG. NO ES-99 SHEET 4 OF 5 DATE 4-13-55

(MN-EFH Notice 1, Nov. 1992)

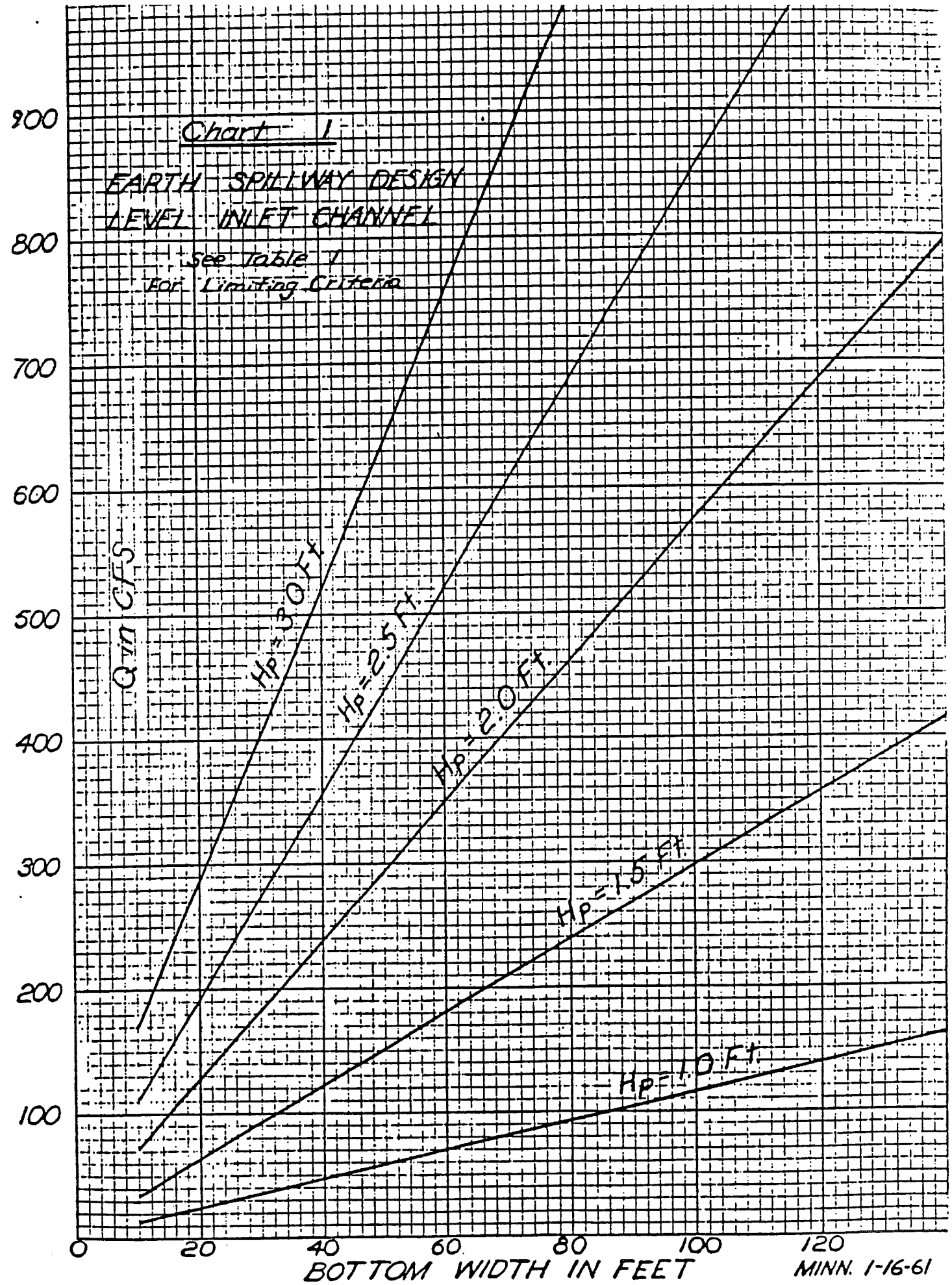
TABLE 1

EARTH SPILLWAY DESIGN - LEVEL INLET CHANNEL
3:1 Side Slopes, Based on Tech. Rel. #2, Suppl. A



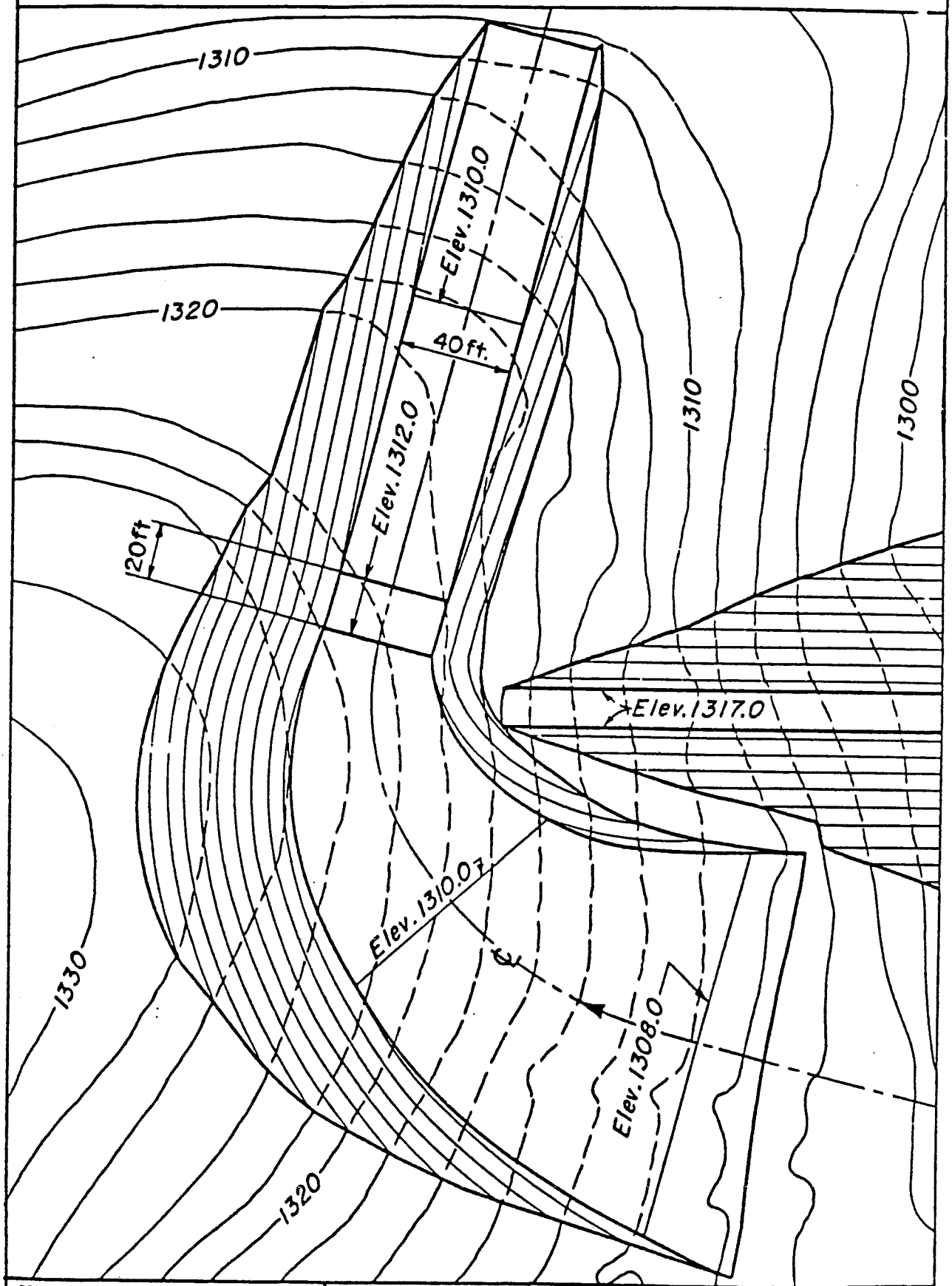
L=100 Ft.	Hp=1.0 Ft.	Hp=1.5 Ft.	Hp=2.0 Ft.	Hp=2.5 Ft.	Hp=3.0 Ft.*
"n" value	0.050	0.045	0.040	0.040	0.040
q_c in c.f.s.	1.15	2.92	5.55	8.20	11.6
v_c in ft/sec.	3.35	4.55	5.6	6.4	7.2
s_o min.	7%	5%	4%	3%	3%
s_o max.	10%	10%	10%	10%	7%
Bottom Width in Feet	Q in C.F.S.				
10	13	35	72	113	172
20	24	64	128	195	288
30	36	93	183	278	404
40	47	122	238	360	520
50	59	152	294	442	637
60	70	181	350	524	753
70	82	210	405	606	870
80	93	239	461	688	985
90	105	268	517	770	1100
100	116	298	571	850	1215

Note: Hp value does not include freeboard, except where it pertains to freeboard hydrograph discharge.
If L=50' instead of 100', subtract 0.1' from Hp value.
If L=150' instead of 100', add 0.2' to Hp value.
Minimum slope of exit channel based on 25% of Q value and "n" value given in table.
Maximum slope of exit channel based on an "n" value of 0.040 and a velocity of 10.5 ft/sec. not to exceed a 10% slope.
If dikes are needed along exit channel to contain flow, a height equal to Hp would be adequate.
Exit channel should be kept straight for 100 ft. if possible.
Curves showing above discharges versus bottom are given in Chart 1.
* This column must be used with caution because of high V_c.



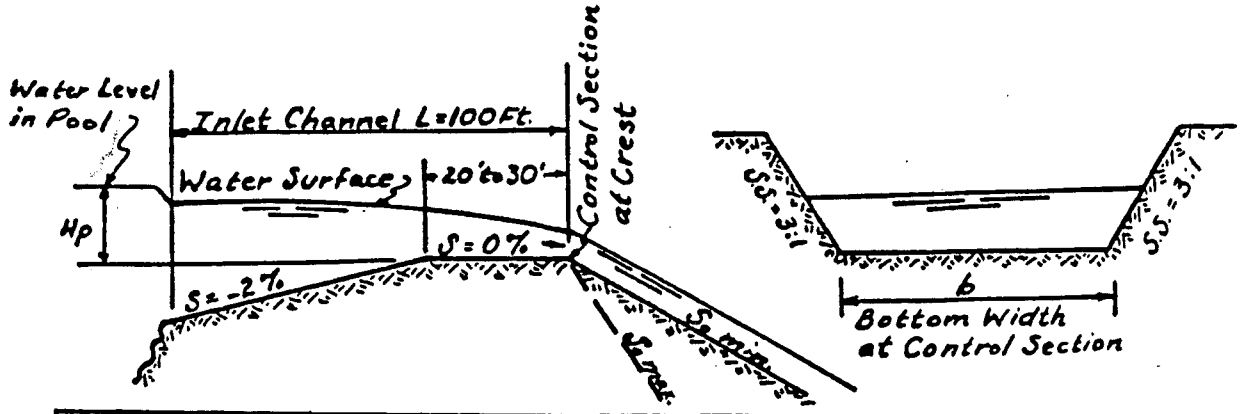
(MN-EFH Notice 1, Nov. 1992)

EARTH SPILLWAYS: Typical layout and grading plans. No. 2



REFERENCE	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION · DESIGN SECTION	STANDARD DWG. NO. ES-99 SHEET 5 OF 5 DATE 10-1-56

EARTH SPILLWAY DESIGN - SLOPING INLET CHANNEL
3:1 Side Slopes, Based on Tech. Rel. #2, Suppl. A



L=100 Ft.	Hp=1.0 Ft.	Hp=1.5 Ft.	Hp=2.0 Ft.	Hp=2.5 Ft.	Hp=3.0 Ft.*
"n" value	0.0475	0.0425	0.040	0.040	0.040
q_c in c.f.s.	1.65	3.7	6.3	9.1	12.7
v_c in ft/sec.	3.75	4.95	5.85	6.6	7.4
s_o min.	6%	4%	3%	3%	3%
s_o max.	10%	10%	10%	10%	6%
Bottom Width in Feet	Q in C.F.S.				
10	19	45	83	128	192
20	35	82	146	220	318
30	52	119	209	310	446
40	68	156	272	402	572
50	85	193	335	492	700
60	101	230	398	583	827
70	118	267	461	674	954
80	134	304	524	765	1080
90	151	341	587	856	1210
100	167	378	650	946	1334

Note: Hp value does not include freeboard unless it pertains to freeboard hydrograph discharge.
Table based on L=100 ft. Change in Hp insignificant for range of L=50 to 150 ft.
If inlet channel slope is more than 2%, c.f.s. in above table are conservative.
If inlet channel slope is less than 2%, use Table 1.
Minimum slope of exit channel based on 25% of Q value and "n" value given in table.
Maximum slope of exit channel based on an "n" value of 0.040 and a velocity of 10.5 ft/sec. not to exceed a 10% slope.
If dikes are needed along exit channel to contain flow, a height equal to Hp would be adequate.
Exit channel should be kept straight for 100 ft. if possible.
Curves showing above discharges versus bottom width are given in Chart 2.
*This column must be used with caution because of the high V_c.

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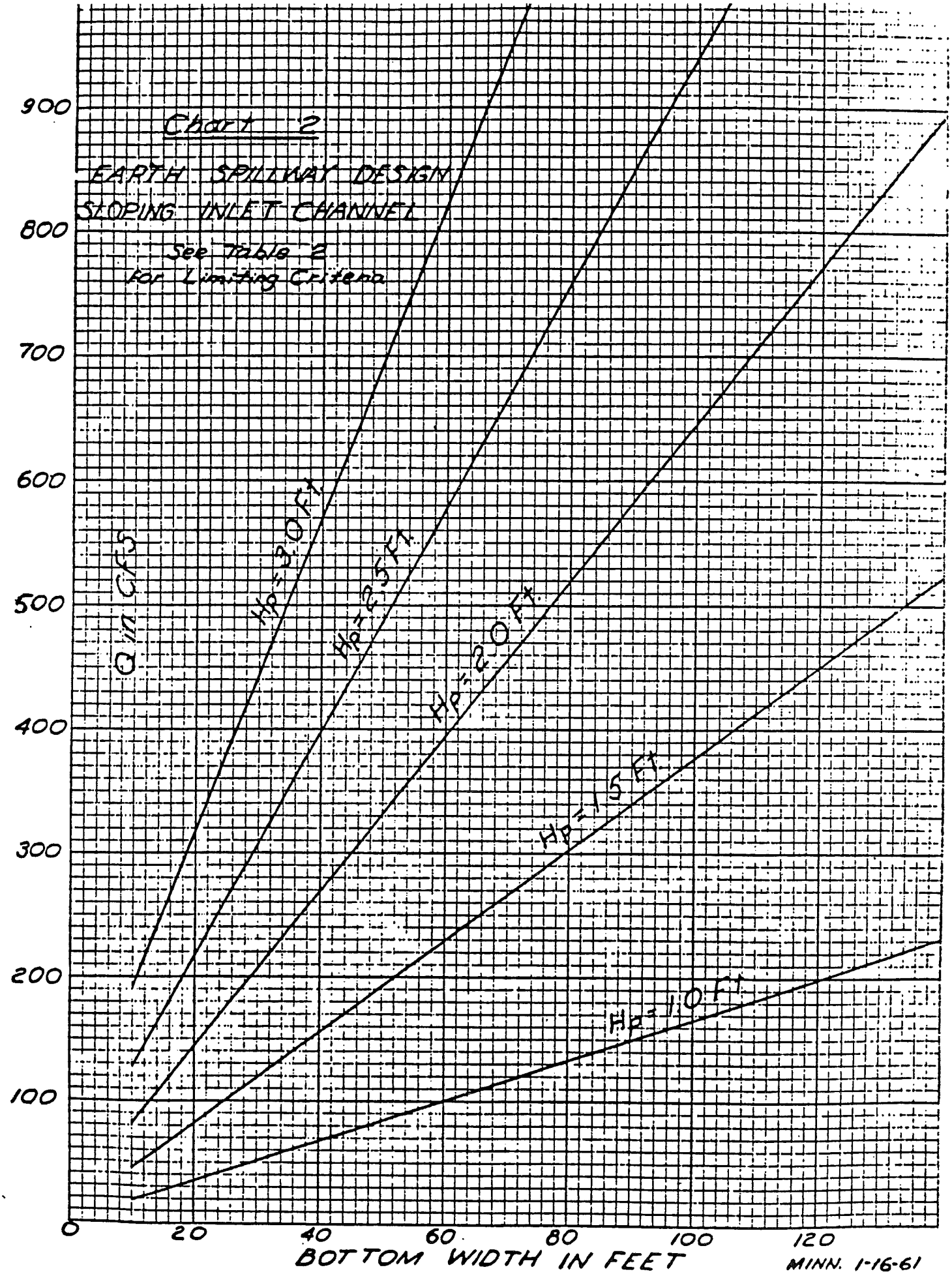

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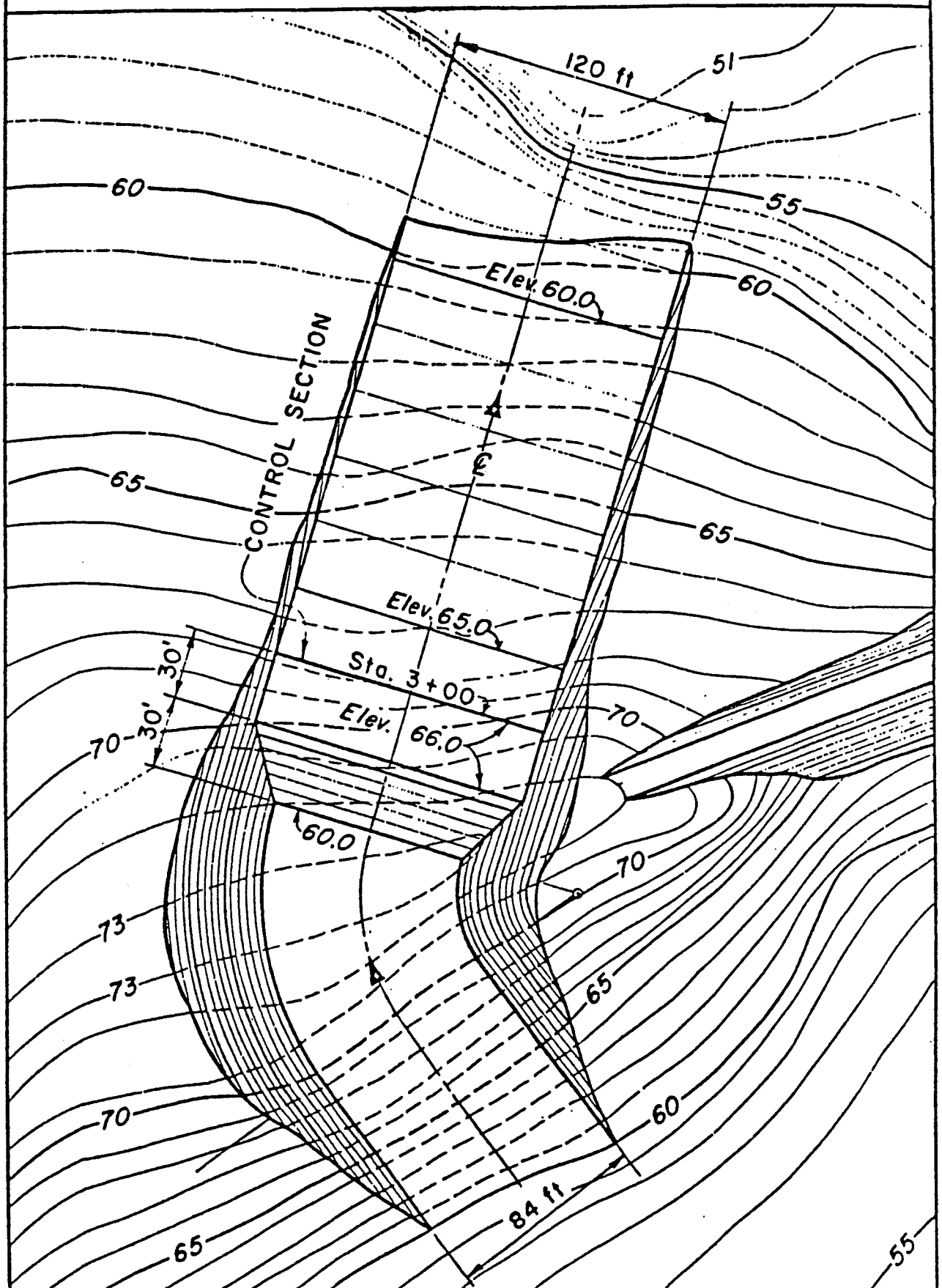
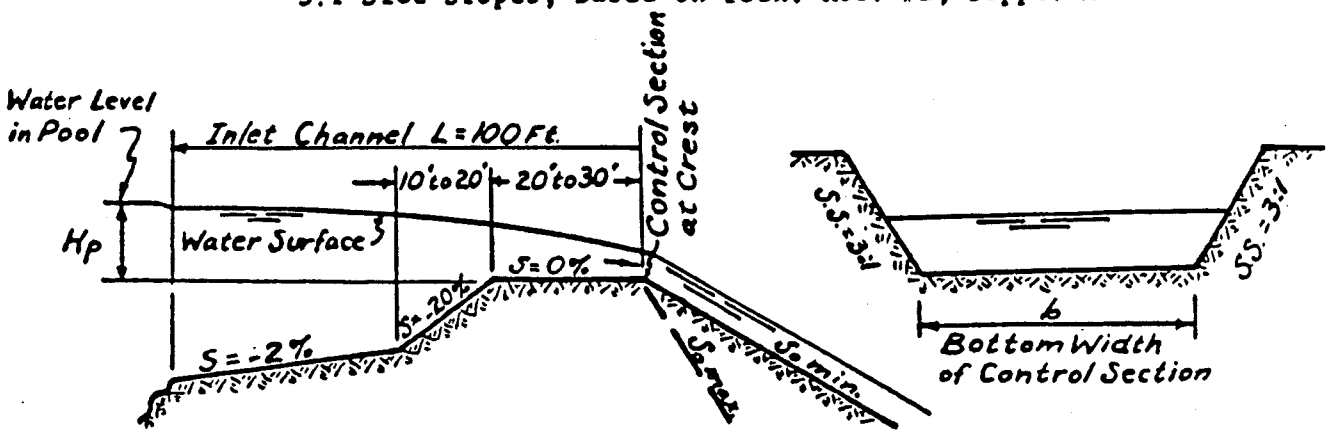
EARTH SPILLWAYS : Typical layout and grading plans. No. 3



REFERENCE	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION-DESIGN SECTION	STANDARD DWG. NO. ES-99 SHEET 1 OF 5 DATE 4-12-55

TABLE 3

EARTH SPILLWAY DESIGN — INLET CHANNEL NO. 3
3:1 Side Slopes, Based on Tech. Rel. #2, Suppl. A



L=100 Ft.	Hp=1.0 Ft.	Hp=1.5 Ft.	Hp=2.0 Ft.	Hp=2.5 Ft.	Hp=3.0 Ft.*
"n" value	0.045	0.040	0.040	0.040	0.040
q_c in c.f.s.	2.0	4.25	6.8	9.8	13.5
v_c in ft/sec.	4.0	5.1	6.0	6.8	7.6
s_o min.	5%	4%	3%	3%	3%
s_o max.	10%	10%	10%	9%	6%
Bottom Width in Feet	Q in C. F. S.				
10	23	53	91	140	208
20	43	95	159	239	343
30	63	138	230	337	478
40	83	180	295	435	613
50	103	223	364	534	748
60	123	266	432	632	884
70	143	308	500	730	1020
80	163	351	568	828	1153
90	183	393	635	925	1290
100	203	435	703	1023	1422

Note: Hp value does not include freeboard unless it pertains to freeboard hydrograph discharge.

Table based on L=100 ft. Change in Hp insignificant for range of L=50 to 200 ft.

Minimum slope of exit channel based on 25% of Q value and "n" value given in table.

Maximum slope of exit channel based on an "n" value of 0.040 and a velocity of 10.5 ft./sec. not to exceed a 10% slope.

If dikes are needed along exit channel to contain flow, a height equal to Hp would be adequate.

Exit channel should be kept straight for 100 ft. if possible.

Curves showing above discharge versus bottom width are given in Chart 3.

*This column must be used with caution because of the high V_c.

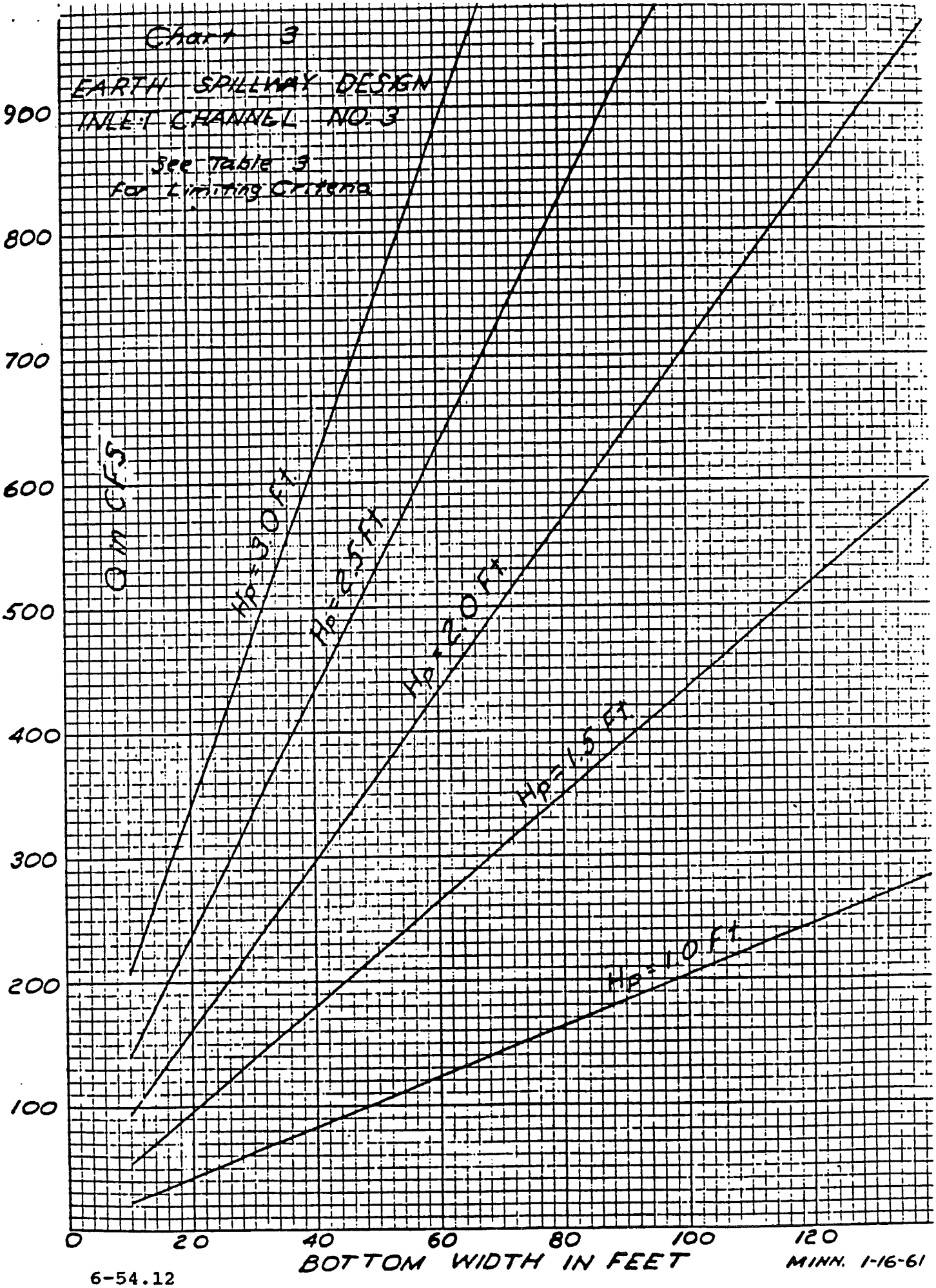


Chart 3
EARTH SPILLWAY DESIGN
INLET CHANNEL NO. 3
See Table 3
for Limiting Criteria
Q in CFS
900
800
700
600
500
400
300
200
100
0
20
40
60
80
100
120
BOTTOM WIDTH IN FEET
HP = 3.0 Ft.
HP = 2.5 Ft.
HP = 2.0 Ft.
HP = 1.5 Ft.
HP = 1.0 Ft.
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