Increment 1 Buildout at Seminole Generating Station

Response to August, 2010 Request for Additional Information

September 30, 2010

Enclosures

ENCLOSURE 5

REVISED

SECTION 9

ENGINEERING CALCULATIONS

Seminole Electric COOPERATIVE, INC.
IN PARTNERSHIP WITH THOSE WE SERVE

INCREMENT 1 BUILDOUT

~~July 16, 2010~~

Revised September 24, 2010

SECTION 9

ENGINEERING CALCULATIONS

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1. Hydrologic Evaluation of Landfill Performance (HELP) Model

~~The output from the HELP model is included in this section. The HELP model estimates typical leachate generation values per acre per day. Based on the hydrologic conditions in Putnam County Florida, and the characteristics of the waste, the HELP model estimated the peak daily value of leachate generated at 80.2 cubic feet per acre, or about 600 gallons per acre per day. The HELP model also estimated the maximum head on the liner at 0.005 inches which is less than the thickness of the geonet which is 200 mils (0.2 inches).~~

As requested in RFI 1, we changed the HELP Model parameters: The runoff curve (CN) was changed to 90, the Fraction of Area Allowing Runoff was changed to 20%, the Evaporation Zone Depth was changed to 1", to be conservative the surface slope was reduced to 1.0% minimum with a length of 300' and the placement of the geomembrane as good. The 25-year, 24 hour rainfall event of 8-inches was added to the precipitation data.

The output from the HELP model is included along with Table 4 "Default Soil, Waste, and Geosynthetic Characteristics." The results are on page 14 of the output. If the 25 year, 24 hour rain event occurs when there is 10 feet of waste over the liner, then the leachate collected in the drainage layer is estimated at 2,119.6 cubic feet per acre per day (15,855 gallons per acre per day). The maximum head on the primary geomembrane as estimated by the HELP model for this event is 0.183 inches. This is less than the thickness of the geonet which is 200 mils (0.2 inches). Based on a maximum landfill liner area of 27.3 acres for the Increment 1 Buildout, the peak day leachate volume is estimated at 432,841 gallons.

The maximum head on the secondary liner as estimated by the HELP Model for this event is 0.004 inches. This is less than the thickness of the geonet which is 200 mils (0.2 inches.) So even during this event, the secondary leachate collection system / leak detection system will not be saturated. This demonstrates that the design complies with 62-701.400 (3) (c) 2. "The leak detection and secondary leachate collection system shall have a minimum hydraulic conductivity of ten cm/sec, shall be designed to limit the maximum hydraulic head on the lower liner to one inch, and shall not allow leachate head to exceed the thickness of the drainage

layer. The hydraulic conductivity of the leak detection and secondary collection system material shall be derived from transmissivity and thickness measurements." The calculation to estimate the hydraulic conductivity for the leak detection system is included in section 2 of these calculations.

2. Estimate of Hydraulic Conductivity for the Leak Detection System

The calculations are based on the thickness of the geonet and the transmissivity, and show that the hydraulic conductivity of the geonet is 19.6 cm/sec which is greater than the 10 cm/sec required.

3. HDPE Leachate Collection Pipe Strength Calculations

The calculations to show that the 8 inch diameter leachate collection pipe has sufficient mechanical properties to prevent collapse under the pressure of the waste are included in this section.

4. Header Pipe Flow / Slope Calculations and Leachate Treatment and Disposal

These calculations estimate the minimum slope required for the flow in the leachate collection pipe. As estimated above in Subsection 1, the peak day leachate volume is estimated at 432,841 gallons. The leachate flows from the landfill through an 8-inch diameter gravity pipe to Pond 8. The minimum slope on this pipe is 0.6%. Based on the attached Fig. 1 "Nomograph for flow in round pipe – Manning's formula", an 8 inch pipe (8-inch diameter SDR 17 HDPE pipe has an internal diameter of 7.95-inches) has the capacity of 670,000 gallons per day. This is approximately 1.6 times the required capacity for the peak day. At Pond 8, SECI has a 50 horse power pump capable of pumping wastewater at an estimated rate of 864,000 gallons per day to Pond 9. At Pond 9 the leachate is mixed with other plant process wastewater. The wastewater from Pond 9 is treated and reused in the plant process. If there is excess treated wastewater, the wastewater is discharged per the NPDES permit. The permit has a maximum permitted discharge of 7.46 million gallons per day (MGD) with a projected annual average daily flow of 5.62 MGD to the St. Johns River through Outfall D-001. Also attached to these calculations is a summary of the storage capacities in the wastewater ponds. The pond locations are shown on Construction Drawing C-2.

5. Estimate of the Landfill Base Slope with Settlement

Four drawings were prepared to show that after the predicted settlement, the landfill liner base will still have the minimum slopes required. Included with these calculations are four drawings that show the landfill liner base elevations and slopes as shown on Construction Drawing C-4. The drawings are:

Sheet 1 of 4 Landfill Base with Settlement Estimate – West Half

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Sheet 2 of 4 Landfill Base with Settlement Estimate – East Half

Sheet 3 of 4 Landfill Base Contours After Settlement – West Half

Sheet 4 of 4 Landfill Base Contours After Settlement – East Half

Sheet 1 of 4 shows the west portion of the landfill liner sub-grade, and Sheet 2 of 4 shows the east portion of the landfill liner sub-grade. The liner sub-grade construction elevations and slopes for these drawings were taken from Construction Drawing C- 4 in Application Section 11 Construction Drawings. The estimated landfill settlement contours were overlaid on the landfill liner base. We revised these two drawings to include the construction point elevations and slopes for the leachate collection trenches and pipes as shown on Construction Drawing C-4. We also added the estimated post-construction elevations for each of these points and calculated the post settlement slope based on the settlement contours.

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Sheet 3 of 4 and Sheet 4 of 4 show the landfill base contours after settlement. It shows the calculated slope between each settlement point on a 50 foot grid. We also added the construction elevations and slopes and settled post construction elevation and slopes for the leachate collection trench/pipe to these drawings.

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Flow arrows were added to all four drawings to show the direction of flow.

The minimum post settlement slope for the leachate collection system trench/pipe is

These calculations demonstrate that the landfill design slope for the base grade is adequate such that after the estimated landfill foundation settlement occurs, the landfill liner in areas which drain to lateral collection pipes and header pipes shall be ~~will still have a~~ minimum 1.1% (with a construction and survey tolerance of +/- 0.1%) cross slope and a minimum leachate collection pipe trench slope of 0.4~~3~~% (with a construction and survey tolerance of +/-0.1%). The Geotechnical Report includes an estimate of the foundation settlement based on the weight of the waste as determined from the landfill final contours. The settlement estimates were used to generate settlement contours for the landfill base. A computer program was used to generate the amount of settlement that would occur at each point based on a 50-foot grid. Then the grid was placed over the design contours for the landfill base and the amount of settlement at each of the grid points was subtracted from the design elevation at that point. Then a new contour map was drawn showing the settled contours for the landfill base. This final drawing shows that the landfill base will still have a minimum cross slope of 1.1% (Tolerance +/- 0.1%) and a slope along the leachate collection trench of 0.4~~3~~% Tolerance (+/- 0.1%) after settlement.

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6. Liners Compatibility with the Expected Leachate

The proposed liner system for Increment 1 Buildout is compatible with the expected leachate. The proposed liner system uses the same materials tested and installed for the construction of the landfill liner system completed at the Seminole Generating Station landfill in 2009. The test results are documented in "Construction Quality Assurance Report for Installation of a Landfill System at Seminole Generating Station – Putnam County, Florida" by Ardaman & Associates, Inc., dated October 22, 2009. This Report was submitted to the Florida Department of Environmental Protection with the Certification of Construction Completion. Included with these design calculation for reference are pages 3 and 4 from that report and Appendix 1. On pages 3 and 4 is a summary of the test results of leachate on the GCL. Appendix 1 includes a table with the results of a Synthetic Precipitation Leaching Procedure (SPLP) on the various waste materials placed in the landfill. Also included is a Technical Note from GSE entitled "Chemical Resistance for Geomembrane Products". GSE manufactured the HDPE geomembrane for the landfill liner system installed in 2009 at the Seminole Generating Station. The Technical Note includes a table entitled "Chemical Resistance Chart". Comparing the analytes from the SPLP test in Appendix 1 of the Ardaman Report to those listed on the GSE Chemical Resistance Chart indicates that the polyethylene geomembrane is suitable for this project.

7. Sand/Geotextile/Gravel/Slotted Pipe Infiltration of Fines Calculation

As demonstrated by the attached calculations, the drainage sand will be retained by the geotextile so that the drainage sand will not infiltrate and clog the leachate collection system. The calculations also demonstrate that the gradation of the gravel around the slotted pipe is sized such that the gravel will not infiltrate the pipe and clog the pipe.

8. Stormwater Run-off Calculations

These calculations demonstrate that the proposed stormwater management system is more than capable of transmitting the run-off from the 25-year 24-hour event for the closure of the increment 1 Buildout.

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Joseph L. Miller

PE #39177

Septemebr 24, 2010

Seminole Electric COOPERATIVE, INC.
IN PARTNERSHIP WITH THOSE WE SERVE

LIST OF ATTACHMENTS

1. HELP MODEL

2 CALCULATION OF THE HYDRAULIC CONDUCTIVITY OF THE LEAK DETECTION SYSTEM

3 CALCULATION OF THE BUIRAL DESIGN CAPACITY OF THE LEACHATE COLLECTION PIPE

4 CALCULATION OF THE DISCHARGE CAPACITY OF THE 8-INCH DIAMETER LEACHATE COLLECTION PIPE AND THE SUMMARY OF THE STORAGE CAPACITY OF THEWASTEWATER PONDS

5. SETTLEMENT CALCULATIONS FOR THE LANDFILL BASE AND CROSS SECTIONS THOUGH THE LANDFILL THAT SHOW THE LANDFILL BASE DESIGN ELEVATIONS AND THE POST-SETTLEMENT ELEVATIONS AND THE RELATIONSHIP TO THE SEASONAL HIGH WATER TABLE

6. DOCUMENTATION THAT THE HDPE GEOMEMBRANE IS COMPATIBLE WITH THE LANDFILL LEACHATE

7. CALCULATION TO CHECK THE GRADATION OF THE DRAINAGE SAND FOR PIPING THROUGH THE GEOTEXTILE AND THE GRAVEL THROUGH THE SLOTTED LEACHATE COLLECTION PIPE

8 DRAINAGE CALCULATIONS OF THE STORMWATER RUN-OFF FOR THE INCREMENT 1 BUILDOUT FINAL GRADING PLAN

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Section 9 Engineering Calculations

ATTACHMENT 1

HELP MODEL

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:    C:\HELP3\SGSP.D4
TEMPERATURE DATA FILE:      C:\HELP3\SGST.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\SGSR.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\SGSE.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\SOIL.D10
OUTPUT DATA FILE:           C:\HELP3\SEM.OUT


TIME:  18: 1     DATE:   8/27/2010


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     TITLE:  SEMINOLE ELECTRIC LANDFILL BUILDOUT 8-25-10

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  30
          THICKNESS                    =    120.00   INCHES
          POROSITY                     =      0.5410 VOL/VOL
          FIELD CAPACITY               =      0.1870 VOL/VOL
          WILTING POINT                =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3131 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.499999987000E-04 CM/SEC



                                LAYER  2
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              TYPE 2 - LATERAL DRAINAGE LAYER
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MATERIAL TEXTURE NUMBER 2

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1498	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 34

THICKNESS	=	0.24	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0367	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	33.0000000000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 34

THICKNESS	=	0.24	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0118	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	33.0000000000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	90.00	
FRACTION OF AREA ALLOWING RUNOFF	=	20.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	1.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.047	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	0.541	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.047	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	41.364	INCHES
TOTAL INITIAL WATER	=	41.364	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
JACKSONVILLE FLORIDA

STATION LATITUDE	=	30.50 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	0

END OF GROWING SEASON (JULIAN DATE) = 367
EVAPORATIVE ZONE DEPTH = 1.0 INCHES
AVERAGE ANNUAL WIND SPEED = 8.20 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 73.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 79.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 78.00 %

NOTE: PRECIPITATION DATA FOR JACKSONVILLE FLORIDA
WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR JACKSONVILLE FLORIDA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
53.20	55.10	61.30	67.70	74.10	79.00
81.30	81.00	78.20	69.50	60.80	54.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR JACKSONVILLE FLORIDA
AND STATION LATITUDE = 30.50 DEGREES

Included in August is the 25-year, 24-hour 8" rain event.

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1974

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.28 9.83	1.28 19.08	3.47 8.13	1.53 0.34	4.14 1.03	5.53 1.73
RUNOFF	0.000 0.719	0.002 4.430	0.191 0.827	0.003 0.000	0.352 0.000	0.447 0.006
EVAPOTRANSPIRATION	0.095 3.330	0.647 4.076	0.820 2.439	1.010 0.356	1.495 0.146	2.418 0.779
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.9740 1.5673	1.3577 2.8491	0.9597 9.1088	0.9306 5.8804	0.9110 3.1685	0.7274 1.9944
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0771 0.0901	0.0881 0.1180	0.0775 0.2279	0.0741 0.1942	0.0660 0.1401	0.0620 0.1118
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.0771 0.0897	0.0882 0.1176	0.0776 0.2277	0.0742 0.1944	0.0660 0.1403	0.0622 0.1119
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.005	0.008	0.005	0.005	0.005	0.004
TOP OF LAYER 4	0.008	0.015	0.049	0.030	0.017	0.010
STD. DEVIATION OF DAILY	0.002	0.001	0.001	0.002	0.004	0.002
HEAD ON TOP OF LAYER 4	0.005	0.012	0.024	0.007	0.003	0.003
AVERAGE DAILY HEAD ON	0.000	0.001	0.000	0.000	0.000	0.000
TOP OF LAYER 6	0.000	0.001	0.001	0.001	0.001	0.001
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000

ANNUAL TOTALS FOR YEAR 1974

	INCHES	CU. FEET	PERCENT
PRECIPITATION	56.37	204623.062	100.00
RUNOFF	6.979	25332.117	12.38
EVAPOTRANSPIRATION	17.611	63929.625	31.24
DRAINAGE COLLECTED FROM LAYER 3	30.4286	110455.984	53.98
PERC./LEAKAGE THROUGH LAYER 4	1.326905	4816.665	2.35
AVG. HEAD ON TOP OF LAYER 4	0.0134		
DRAINAGE COLLECTED FROM LAYER 5	1.3269	4816.653	2.35
PERC./LEAKAGE THROUGH LAYER 7	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0006		
CHANGE IN WATER STORAGE	0.024	88.678	0.04
SOIL WATER AT START OF YEAR	41.366	150160.141	
SOIL WATER AT END OF YEAR	41.391	150248.812	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.001	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1975

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.48	2.58	2.46	5.78	7.00	5.21
	6.36	6.23	5.24	3.63	0.39	1.79
RUNOFF	0.036	0.015	0.050	0.752	1.513	0.094
	0.258	0.379	0.615	0.031	0.000	0.011
EVAPOTRANSPIRATION	1.390	1.497	1.314	1.199	1.476	3.261
	3.310	2.762	1.720	1.509	0.433	0.566
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.9905	0.8227	1.5618	1.3209	2.1861	1.8886
	2.4328	2.3075	2.8375	3.1992	3.1737	2.1307
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0731	0.0631	0.0965	0.0878	0.1075	0.1001
	0.1198	0.1151	0.1254	0.1370	0.1403	0.1166
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.0732	0.0630	0.0965	0.0879	0.1074	0.1000
	0.1199	0.1150	0.1259	0.1363	0.1404	0.1167
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 4	0.005	0.005	0.008	0.007	0.011	0.010
	0.013	0.012	0.015	0.017	0.017	0.011
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 4	0.003	0.002	0.004	0.003	0.006	0.005
	0.006	0.005	0.008	0.008	0.002	0.001
AVERAGE DAILY HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.001	0.001
	0.001	0.001	0.001	0.001	0.001	0.001
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1975

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.15	182044.469	100.00

RUNOFF	3.754	13626.425	7.49
EVAPOTRANSPIRATION	20.436	74182.750	40.75
DRAINAGE COLLECTED FROM LAYER 3	24.8520	90212.617	49.56
PERC./LEAKAGE THROUGH LAYER 4	1.282217	4654.448	2.56
AVG. HEAD ON TOP OF LAYER 4	0.0109		
DRAINAGE COLLECTED FROM LAYER 5	1.2822	4654.468	2.56
PERC./LEAKAGE THROUGH LAYER 7	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0006		
CHANGE IN WATER STORAGE	-0.174	-631.758	-0.35
SOIL WATER AT START OF YEAR	41.391	150248.812	
SOIL WATER AT END OF YEAR	41.217	149617.062	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.051	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1976

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.29	1.05	3.41	0.63	10.02	4.26
	5.41	6.37	8.56	1.63	2.43	4.08
RUNOFF	0.028	0.001	0.292	0.000	1.258	0.223
	0.430	0.361	1.076	0.030	0.043	0.184
EVAPOTRANSPIRATION	1.094	0.585	1.337	0.368	3.167	2.156
	1.894	2.266	2.339	1.095	1.025	1.302
LATERAL DRAINAGE COLLECTED FROM LAYER 3	1.4320	0.5926	1.2268	0.8575	1.4557	1.2219
	2.3782	2.5680	3.1168	4.9330	2.6025	1.4337
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0942	0.0552	0.0835	0.0689	0.0945	0.0738
	0.1150	0.1217	0.1208	0.1773	0.1263	0.0921
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.0943	0.0554	0.0833	0.0689	0.0946	0.0735
	0.1150	0.1219	0.1203	0.1776	0.1265	0.0923
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.007	0.003	0.006	0.005	0.008	0.007
TOP OF LAYER 4	0.012	0.013	0.017	0.026	0.014	0.007
STD. DEVIATION OF DAILY	0.003	0.002	0.003	0.003	0.003	0.006
HEAD ON TOP OF LAYER 4	0.006	0.006	0.014	0.006	0.002	0.003
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 6	0.001	0.001	0.001	0.001	0.001	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000

ANNUAL TOTALS FOR YEAR 1976

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.14	182008.172	100.00
RUNOFF	3.928	14257.255	7.83
EVAPOTRANSPIRATION	18.627	67617.258	37.15
DRAINAGE COLLECTED FROM LAYER 3	23.8185	86461.047	47.50
PERC./LEAKAGE THROUGH LAYER 4	1.223333	4440.698	2.44
AVG. HEAD ON TOP OF LAYER 4	0.0104		
DRAINAGE COLLECTED FROM LAYER 5	1.2234	4440.885	2.44
PERC./LEAKAGE THROUGH LAYER 7	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0005		
CHANGE IN WATER STORAGE	2.543	9231.752	5.07
SOIL WATER AT START OF YEAR	41.217	149617.062	
SOIL WATER AT END OF YEAR	43.760	158848.812	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.036	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1977

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.50	3.43	1.03	1.76	3.07	1.72
	2.44	7.47	7.35	2.03	1.97	4.48
RUNOFF	0.121	0.253	0.029	0.053	0.110	0.010
	0.011	0.904	0.984	0.008	0.058	0.132
EVAPOTRANSPIRATION	1.447	0.918	0.661	0.587	1.296	1.299
	0.753	1.947	1.677	1.053	0.658	1.355
LATERAL DRAINAGE COLLECTED FROM LAYER 3	1.1735	2.0431	2.2474	2.0588	1.2625	0.8879
	1.1029	1.3545	1.9685	3.7787	2.0532	1.9122
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0781	0.1053	0.1193	0.1127	0.0857	0.0692
	0.0810	0.0902	0.0908	0.1535	0.1097	0.1033
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.0780	0.1054	0.1192	0.1127	0.0861	0.0692
	0.0807	0.0902	0.0905	0.1535	0.1099	0.1034
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 4	0.006	0.012	0.012	0.011	0.007	0.005
	0.006	0.007	0.011	0.020	0.011	0.010
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 4	0.004	0.006	0.003	0.001	0.003	0.003
	0.003	0.003	0.012	0.006	0.005	0.006
AVERAGE DAILY HEAD ON TOP OF LAYER 6	0.000	0.001	0.001	0.001	0.000	0.000
	0.000	0.000	0.000	0.001	0.001	0.001
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	40.25	146107.469	100.00
RUNOFF	2.673	9701.487	6.64

EVAPOTRANSPIRATION	13.652	49555.977	33.92
DRAINAGE COLLECTED FROM LAYER 3	21.8432	79290.930	54.27
PERC./LEAKAGE THROUGH LAYER 4	1.198815	4351.699	2.98
AVG. HEAD ON TOP OF LAYER 4	0.0096		
DRAINAGE COLLECTED FROM LAYER 5	1.1988	4351.687	2.98
PERC./LEAKAGE THROUGH LAYER 7	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0005		
CHANGE IN WATER STORAGE	0.884	3207.393	2.20
SOIL WATER AT START OF YEAR	43.760	158848.812	
SOIL WATER AT END OF YEAR	44.644	162056.203	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.008	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	4.68	3.33	3.67	2.24	9.08	2.72
	6.65	2.41	4.38	1.28	0.21	2.43
RUNOFF	0.347	0.131	0.090	0.105	1.224	0.200
	0.523	0.007	0.134	0.005	0.000	0.012
EVAPOTRANSPIRATION	1.242	1.293	1.652	0.907	3.008	1.561
	2.607	1.118	1.657	0.504	0.211	0.728
LATERAL DRAINAGE COLLECTED FROM LAYER 3	2.3517	1.8649	2.0983	2.7935	1.7137	2.8076
	2.6121	1.7635	1.9167	1.7981	2.3506	1.9061
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.1215	0.0926	0.1073	0.1304	0.0973	0.1305
	0.1266	0.0973	0.1055	0.1010	0.1207	0.1095
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.1214	0.0925	0.1073	0.1305	0.0973	0.1304
	0.1270	0.0968	0.1056	0.1010	0.1206	0.1096
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.012	0.011	0.011	0.015	0.009	0.015
TOP OF LAYER 4	0.014	0.009	0.010	0.009	0.013	0.010
STD. DEVIATION OF DAILY	0.003	0.007	0.005	0.004	0.005	0.004
HEAD ON TOP OF LAYER 4	0.004	0.005	0.004	0.004	0.001	0.002
AVERAGE DAILY HEAD ON	0.001	0.001	0.001	0.001	0.001	0.001
TOP OF LAYER 6	0.001	0.001	0.001	0.001	0.001	0.001
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000

ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.08	156380.391	100.00
RUNOFF	2.779	10087.789	6.45
EVAPOTRANSPIRATION	16.488	59852.426	38.27
DRAINAGE COLLECTED FROM LAYER 3	25.9769	94295.969	60.30
PERC./LEAKAGE THROUGH LAYER 4	1.340152	4864.750	3.11
AVG. HEAD ON TOP OF LAYER 4	0.0114		
DRAINAGE COLLECTED FROM LAYER 5	1.3401	4864.484	3.11
PERC./LEAKAGE THROUGH LAYER 7	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0006		
CHANGE IN WATER STORAGE	-3.504	-12720.273	-8.13
SOIL WATER AT START OF YEAR	44.644	162056.203	
SOIL WATER AT END OF YEAR	41.139	149335.922	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.009	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.85	2.33	2.81	2.39	6.66	3.89
	6.14	8.31	6.73	1.78	1.21	2.90
STD. DEVIATIONS	1.66	1.12	1.10	1.98	3.02	1.63
	2.65	6.32	1.83	1.21	0.97	1.30
RUNOFF						
TOTALS	0.106	0.081	0.130	0.183	0.892	0.195
	0.388	1.216	0.727	0.015	0.020	0.069
STD. DEVIATIONS	0.142	0.111	0.110	0.321	0.619	0.165
	0.269	1.825	0.375	0.015	0.028	0.083
EVAPOTRANSPIRATION						
TOTALS	1.053	0.988	1.157	0.814	2.088	2.139
	2.379	2.434	1.966	0.903	0.495	0.946
STD. DEVIATIONS	0.553	0.398	0.407	0.334	0.917	0.771
	1.084	1.096	0.388	0.470	0.358	0.359
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	1.3843	1.3362	1.6188	1.5922	1.5058	1.5067
	2.0187	2.1685	3.7896	3.9179	2.6697	1.8754
STD. DEVIATIONS	0.5714	0.6317	0.5515	0.8234	0.4800	0.8529
	0.6510	0.6059	3.0198	1.5741	0.4973	0.2630
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0888	0.0808	0.0969	0.0948	0.0902	0.0871
	0.1065	0.1084	0.1341	0.1526	0.1274	0.1067
STD. DEVIATIONS	0.0200	0.0210	0.0171	0.0261	0.0156	0.0282
	0.0198	0.0138	0.0542	0.0362	0.0131	0.0094
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	0.0888	0.0809	0.0968	0.0949	0.0903	0.0870
	0.1065	0.1083	0.1340	0.1526	0.1275	0.1068
STD. DEVIATIONS	0.0199	0.0210	0.0171	0.0262	0.0156	0.0281
	0.0201	0.0139	0.0542	0.0364	0.0131	0.0094
PERCOLATION/LEAKAGE THROUGH LAYER 7						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0072	0.0076	0.0084	0.0085	0.0078	0.0081
	0.0104	0.0112	0.0203	0.0203	0.0143	0.0097
STD. DEVIATIONS	0.0030	0.0037	0.0029	0.0044	0.0025	0.0046
	0.0034	0.0031	0.0161	0.0081	0.0027	0.0014

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
	0.0006	0.0006	0.0007	0.0008	0.0007	0.0006
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
	0.0001	0.0001	0.0003	0.0002	0.0001	0.0000

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.00	(6.394)	174232.7	100.00
RUNOFF	4.022	(1.7456)	14601.02	8.380
EVAPOTRANSPIRATION	17.363	(2.5319)	63027.61	36.174
LATERAL DRAINAGE COLLECTED FROM LAYER 3	25.38383	(3.20433)	92143.305	52.88519
PERCOLATION/LEAKAGE THROUGH LAYER 4	1.27428	(0.06217)	4625.652	2.65487
AVERAGE HEAD ON TOP OF LAYER 4	0.011	(0.001)		
LATERAL DRAINAGE COLLECTED FROM LAYER 5	1.27428	(0.06214)	4625.635	2.65486
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.001	(0.000)		
CHANGE IN WATER STORAGE	-0.045	(2.2107)	-164.84	-0.095

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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	8.00	29040.000
RUNOFF	2.518	9140.9150
DRAINAGE COLLECTED FROM LAYER 3	0.58392	2119.64209
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.011163	40.52063
AVERAGE HEAD ON TOP OF LAYER 4	0.094	
MAXIMUM HEAD ON TOP OF LAYER 4	0.183	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	6.6 FEET	
DRAINAGE COLLECTED FROM LAYER 5	0.01106	40.14831
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.002	
MAXIMUM HEAD ON TOP OF LAYER 6	0.004	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.00	0.0000

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5410
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0470

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	37.1007	0.3092

2	3.8421	0.1601
3	0.0113	0.0472
4	0.0000	0.0000
5	0.0029	0.0119
6	0.0000	0.0000
7	0.1800	0.7500
SNOW WATER	0.000	

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THE HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP) MODEL

USER'S GUIDE FOR VERSION 3

by

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TABLE 4. DEFAULT SOIL, WASTE, AND GEOSYNTHETIC CHARACTERISTICS

Classification			Total Porosity	Field Capacity	Wilting Point	Saturated Hydraulic Conductivity
HELP	USDA	USCS	vol/vol	vol/vol	vol/vol	cm/sec
1	CoS	SP	0.417	0.045	0.018	1.0×10^{-2}
2	S	SW	0.437	0.062	0.024	5.8×10^{-3}
3	FS	SW	0.457	0.083	0.033	3.1×10^{-3}
4	LS	SM	0.437	0.105	0.047	1.7×10^{-3}
5	LFS	SM	0.457	0.131	0.058	1.0×10^{-3}
6	SL	SM	0.453	0.190	0.085	7.2×10^{-4}
7	FSL	SM	0.473	0.222	0.104	5.2×10^{-4}
8	L	ML	0.463	0.232	0.116	3.7×10^{-4}
9	SiL	ML	0.501	0.284	0.135	1.9×10^{-4}
10	SCL	SC	0.398	0.244	0.136	1.2×10^{-4}
11	CL	CL	0.464	0.310	0.187	6.4×10^{-5}
12	SiCL	CL	0.471	0.342	0.210	4.2×10^{-5}
13	SC	SC	0.430	0.321	0.221	3.3×10^{-5}
14	SiC	CH	0.479	0.371	0.251	2.5×10^{-5}
15	C	CH	0.475	0.378	0.265	1.7×10^{-5}
16	Barrier Soil		0.427	0.418	0.367	1.0×10^{-7}
17	Bentonite Mat (0.6 cm)		0.750	0.747	0.400	3.0×10^{-9}
18	Municipal Waste (900 lb/yd^3 or 312 kg/m^3)		0.671	0.292	0.077	1.0×10^{-3}
19	Municipal Waste (channeling and dead zones)		0.168	0.073	0.019	1.0×10^{-3}
20	Drainage Net (0.5 cm)		0.850	0.010	0.005	$1.0 \times 10^{+1}$
21	Gravel		0.397	0.032	0.013	3.0×10^{-1}
22	L*	ML	0.419	0.307	0.180	1.9×10^{-5}
23	SiL*	ML	0.461	0.360	0.203	9.0×10^{-6}
24	SCL*	SC	0.365	0.305	0.202	2.7×10^{-6}
25	CL*	CL	0.437	0.373	0.266	3.6×10^{-6}
26	SiCL*	CL	0.445	0.393	0.277	1.9×10^{-6}
27	SC*	SC	0.400	0.366	0.288	7.8×10^{-7}
28	SiC*	CH	0.452	0.411	0.311	1.2×10^{-6}
29	C*	CH	0.451	0.419	0.332	6.8×10^{-7}
30	Coal-Burning Electric Plant Fly Ash*		0.541	0.187	0.047	5.0×10^{-5}
31	Coal-Burning Electric Plant Bottom Ash*		0.578	0.076	0.025	4.1×10^{-3}
32	Municipal Incinerator Fly Ash*		0.450	0.116	0.049	1.0×10^{-2}
33	Fine Copper Slag*		0.375	0.055	0.020	4.1×10^{-2}
34	Drainage Net (0.6 cm)		0.850	0.010	0.005	$3.3 \times 10^{+1}$

* Moderately Compacted

(Continued)

TABLE 4 (continued). DEFAULT SOIL, WASTE, AND GEOSYNTHETIC CHARACTERISTICS

Classification		Total Porosity	Field Capacity	Wilting Point	Saturated Hydraulic Conductivity
HELP	Geomembrane Material	vol/vol	vol/vol	vol/vol	cm/sec
35	High Density Polyethylene (HDPE)				2.0×10^{-13}
36	Low Density Polyethylene (LDPE)				4.0×10^{-13}
37	Polyvinyl Chloride (PVC)				2.0×10^{-11}
38	Butyl Rubber				1.0×10^{-12}
39	Chlorinated Polyethylene (CPE)				4.0×10^{-12}
40	Hypalon or Chlorosulfonated Polyethylene (CSPE)				3.0×10^{-12}
41	Ethylene-Propylene Diene Monomer (EPDM)				2.0×10^{-12}
42	Neoprene				3.0×10^{-12}

(concluded)

user-defined soil option accepts non-default soil characteristics for layers assigned soil type numbers greater than 42. This is especially convenient for specifying characteristics of waste layers. User-specified soil characteristics can be assigned any soil type number greater than 42.

When a default soil type is used to describe the top soil layer, the program adjusts the saturated hydraulic conductivities of the soils in the top half of the evaporative zone for the effects of root channels. The saturated hydraulic conductivity value is multiplied by an empirical factor that is computed as a function of the user-specified maximum leaf area index. Example values of this factor are 1.0 for a maximum LAI of 0 (bare ground), 1.8 for a maximum LAI of 1 (poor stand of grass), 3.0 for a maximum LAI of 2 (fair stand of grass), 4.2 for a maximum LAI of 3.3 (good stand of grass) and 5.0 for a maximum LAI of 5 (excellent stand of grass).

The manual option requires values for porosity, field capacity, wilting point, and saturated hydraulic conductivity. These and related soil properties are defined below.

Soil Water Storage (Volumetric Content): the ratio of the volume of water in a soil to the total volume occupied by the soil, water and voids.

Total Porosity: the soil water storage/volumetric content at saturation (fraction of total volume).

ATTACHEMENT 2

CALCULATION OF THE HYDRAULIC CONDUCTIVITY OF THE LEAK DETECTION SYSTEM

PBS&J®

Subject: Leak Detection System

Comp by: JLM
Check by: RGC

Date: 02/16/2010
Job Number: 10001 3496

Sheet Number: 1/2

Per 62-701.400 (3)(c) 2.

2. The leak detection and secondary leachate collection system shall have a minimum hydraulic conductivity of ten cm/sec, shall be designed to limit the maximum hydraulic head on the lower liner to one inch, and shall not allow leachate head to exceed the thickness of the drainage layer. The hydraulic conductivity of the leak detection and secondary collection system material shall be derived from transmissivity and thickness measurements.

Per specifications (see attached)

Transmissivity = 1×10^{-3} m²/sec.

Thickness = 200 mil. = 0.2" = 0.51cm

$$\text{Hydraulic conductivity (H.C.)} = \frac{\text{Transmissivity}}{\text{Thickness}}$$

$$H.C. = \frac{1 \times 10^{-3} \text{ m}^2/\text{sec} \times 10{,}000 \text{ sq.cm/sq.m.}}{0.51\text{cm}}$$

H.C. = 19.6 cm/sec. > 10 cm/sec.

So OK.

7.2.1.3 Physical Properties

The HDPE geonet shall meet the following criteria:

Property	Test Method	Criterion
Carbon Black Content	ASTM D1603	•2.0% & <3.0%
Density	ASTM D1505	•0.94 g/cm^3
Thickness	ASTM D5199	•200 mil
Transmissivity	ASTM D4716	•1.0x10^{-3} m^2/sec*
Tensile Strength	ASTM D7179	•45 lb/in **
* Machine direction under a compressive load of 5,000 psf and at a gradient of 0.01. ** Machine direction.		

A complete description of the geonet proposed for use and the Manufacturer's product data sheets shall be submitted to the Engineer for approval at least 2 weeks prior to installation. Certification from the Manufacturer that the geonet complies with this Specification shall also be supplied to the Engineer 2 weeks prior to installation.

7.2.2 Geotextiles

Geotextiles for the geocomposite drainage net and where shown elsewhere on the Drawings shall be a non-woven, needle-punched fabric manufactured from 100 percent polyester or 100 percent polypropylene. The geotextiles shall be uniform and homogeneous in appearance and composition, and free from tears, cuts, thin spots, or any defects that may affect serviceability. The geotextiles shall meet the following criteria.

Property	Test Method	Criterion
Mass per Unit Area	ASTM D5261	•8 oz/yd^2
Apparent Opening Size	ASTM D4751	•80†
Grab Tensile Strength*	ASTM D4632	•200 lb
Grab Elongation*	ASTM D4632	•50 %
Trapezoidal Tear Strength*	ASTM D4533	•50 lb
Puncture Strength	ASTM D4833	•120 lb
Permeability to Water	ASTM D4491	•0.2 cm/sec
* Machine and transverse directions. † United States standard sieve number.		

A complete description of the geotextiles proposed for use and the Manufacturer's product data sheets shall be submitted to the Engineer for approval at least 2 weeks prior to installation. Certification from the Manufacturers that the geotextiles comply with this Specification shall also be supplied to the Engineer 2 weeks prior to installation.

7.2.2.1 Geocomposite

The geonet and 8-oz/yd^2 geotextile in the geocomposite shall meet the requirements in Sections 7.2.1 and 7.2.2, respectively. The single-sided geocomposite above the textured primary HDPE liner at the base of the lined disposal area shall also meet the following requirements: (i) a transmissivity equal to or greater than 2.0x10^{-3} m^2/sec, as determined in accordance with ASTM D4716 using a compressive load of 5,000 psf and a gradient of 0.01; and (ii) the bond between the geotextiles and the geonet shall exhibit an average ply adhesion of equal to or greater than

ATTACHMENT 3

CALCULATION OF THE BURIAL DESIGN CAPACITY OF THE LEACHATE COLLECTION PIPE

PBS&J®

Subject: SECI - Leachate Pipe Design

Comp by: JAM
Check by: RGC
Date: 7/16/2010
Job Number: 60013496
Sheet Number: 1

Check Leachate Collection Pipe Burial Design by:

1. Wall crushing
2. Wall Buckling
3. Ring Deflection

Assumptions

1. 8" ϕ HDPE Pipe - SDR 17
2. Pipe evelopeis gravel
   Soil type of initial Backfill embedment material is Type 1 with E'(psi) of 3000 (See page 36 of Driscopipe systems Design)

From Chart 24 on page 36

For SDR 17 pipe with Soil Modulus 3000psi
Maximum Burial Depth is 181' for soil of 100 lbs/c.f.
Maximum thickness of ash over leachate collection pipe is 135'
So OK

PBS&J®

Subject: SECI - Leachate Pipe Design

Comp by: JLM | Date: 7/16/2010 | Sheet Number: 2

Check by: RGC | Job Number: 10001346

Design by Wall Crushing

$$S_A = \frac{(SDR-1)}{2} P_T \quad \text{(page 37 Driscopipe)}$$

S_A = Actual compressive stress, psi

SDR = 17 (Standard Dimension Ratio)

P_T = External Pressure, psi

$P_T = P_S + P_L + P_i$

P_S = static load

P_L = Live load

P_i = internal pressure = 0

$P_S = 135' \times 82$ lbs/cf. (Density of Ash)

$P_S = 11{,}070$ lbs/SF / 144 in²/SF = 77 psi

$P_L = 0$ for fills over 20'

$P_L = 1000$ psf for 2' cover = 7 psi

So worse case is P_T for 135' of ash

$$S_A = \frac{(17-1)}{2} 77 \text{ psi} = 616 \text{ psi}$$

Safety Factor = 1500 psi / SA

Safety Factor = 1500 psi / 616 psi = 2.4

OK

PBS&J®

Subject: SECT - Leachate Pipe Design

Comp by: JLM | Date: 7/16/2013 | Sheet Number: 3

Check by: RGC | Job Number: 1000/3496

Check Design by Wall Buckling

Ref. page 37 of Driscopipe Design

$P_t = 77 psi$

$P_{cb} = 0.8\sqrt{E' \times P_c}$

$E' = 3000 psi$ $\quad E = 33{,}000 psi$ (Chart 25 page 32)

$P_c = \frac{2.32(E)}{(SDR)^3} = \frac{2.32(33000 psi)}{(17)^3}$

$P_c = 15.6$

$P_{cb} = 0.8\sqrt{3000 psi \times 15.6}$

$P_{cb} = 173$

$F.S. = P_{cb}/P_t = 173/77 = 2.5$ OK

PBS&J®

Subject: SECI - Leachate Pipe Design

Comp by: JLM | Check by: RGC | Date: 7/16/2010 | Job Number: 1000/3496 | Sheet Number: 4

Design by Ring Deflection

Allowable Ring Deflection for SDR17 pipe is 4.2% from Chart 27 page 38

$P_t = 77 psi$

Assume pipe deflection is based upon the principal that its deflection will be the same as the surrounding backfill.

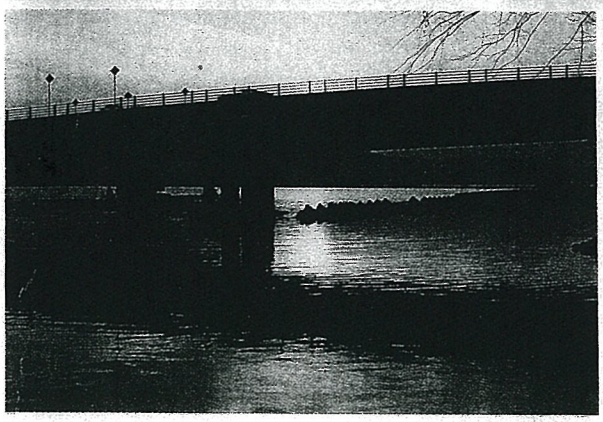
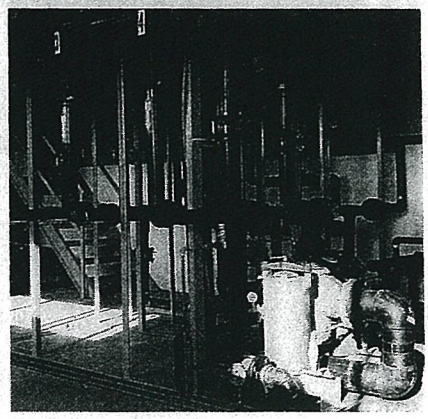
$$\% \text{ Soil Strain} = \frac{P_t}{E' \text{min.}} \times 100$$

$$\% \text{ Soil Strain} = \frac{77 psi}{3000 psi} \times 100 = 2.6\%$$

$$F.S. = \frac{4.2\%}{2.6\%} = \underline{1.6 \text{ OK}}$$

DRISCOPIPE®

Systems Design

PHILLIPS 66

Simplified Burial Design: A conservative estimate of the ability of Driscopipe pipelines to perform in a buried environment is found in Chart 24. It is based on a minimum 2:1 safety factor and 50 year design service life. A detailed burial design starts on page 37. The detailed design should be used for critical or marginal applications or whenever a more precise solution is desired.

Detailed Burial Design:
Design by Wall Crushing: Wall crushing would theoretically occur when the stress in a pipe wall, due to the external vertical pressure, exceeded the long-term compressive strength of the pipe material. To ensure that the Driscopipe wall is strong enough to endure the external pressure the following check should be made:

$$S_A = \frac{(SDR - 1)}{2} P_T$$

Values of E'

Based on Soil Type (ASTM D2321) and Degree of Compaction

Soil Type of Initial Backfill Embedment Material	Description	E' (psi) for Degree of Compaction (Proctor Density, %)			
		Loose	Slight (70-85%)	Moderate (85-95%)	High (95%)
I	Manufactured angular, granular materials (crushed stone or rock, broken coral, cinders, etc.)	1,000	3,000	3,000	3,000
II	Coarse grained soils with little or no fines	N.R.	1,000	2,000	3,000
III	Coarse grained soils with fines	N.R.	N.R.	1,000	2,000
IV	Fine-grained soils	N.R.	N.R.	N.R.	N.R.
V	Organic soils (peat, muck, clay, etc.)	N.R.	N.R.	N.R.	N.R.

N.R. = Not Recommended for use by ASTM D2321 for pipe wall support

Chart 24

SDR	Maximum Burial Depth, ft. in dry soil of 100 lbs/cu. ft. Soil Modulus, psi*			Maximum External Pressure psi Soil Modulus, psi*			Maximum Deflection, % after installation Soil Modulus, psi*		
	1000	2000	3000	1000	2000	3000	1000	2000	3000
32.5	25	32	37	17	22	26	1.7	0.9	0.6
26	33	45	52	23	31	36	2.3	1.2	0.8
21	46	61	71	32	42	49	3.2	1.6	1.1
19	52	69	81	36	48	56	3.6	1.8	1.2
17	61	121	181	42	84	126	4.2	2.1	1.4
15.5	56	112	168	39	78	117	3.9	2.0	1.3
13.5	49	98	147	34	68	102	3.4	1.7	1.1
11	39	78	117	27	54	81	2.7	1.4	0.9
9.3	33	68	101	23	47	70	2.3	1.2	0.8
8.3	30	61	89	21	42	62	2.1	1.1	0.7
7.3	26	52	79	18	36	55	1.8	0.9	0.6

*assumes no external loads

Where: S_A = Actual compressive stress, psi
SDR = Standard Dimension Ratio
P_T = External Pressure, psi

Safety Factor = 1500 psi ÷ S_A where 1500 psi is the Compressive Yield Strength of Driscopipe.

Design by Wall Buckling: Local wall buckling is a longitudinal wrinkling of the pipe wall. Tests of *non-pressurized* Driscopipe show that buckling and collapse do not occur when the soil envelope is in full contact with the pipe and is compacted to a dense state. However, it can be forced to occur over the long term in *non-pressurized* pipe if the total external soil pressure, P_t, is allowed to exceed the pipe-soil system's critical buckling pressure, P_{cb}. If $P_t > P_{cb}$, gradual collapse may occur over the long term. A calculated, conservative value for the critical buckling pressure may be obtained by the following approximate formula. All pipe diameters with the same SDR in the same burial situation have the same critical collapse and critical buckling endurance

$$P_{cb} = 0.8\sqrt{E' \times P_c}$$

Where:

P_t = Total vertical soil pressure at the top of the pipe, psi

P_{cb} = Critical buckling soil pressure at the top of the pipe, psi

E' = Soil modulus in psi calculated as the ratio of the vertical soil pressure to vertical soil strain at a specified density

P_C = Hydrostatic, critical-collapse differential pressure, psi

$$P_C = \frac{2E\,(t/D)^3\,(D_{MIN}/D_{MAX})^3}{(1-\mu^2)}$$

$$P_c = \frac{2.32\,E}{(SDR)^3}$$

Where: $(D_{MIN}/D_{MAX}) = .95$
μ = Poission's Ratio
μ = .45 for Driscopipe
E = stress and time dependent tensile modulus of elasticity, psi

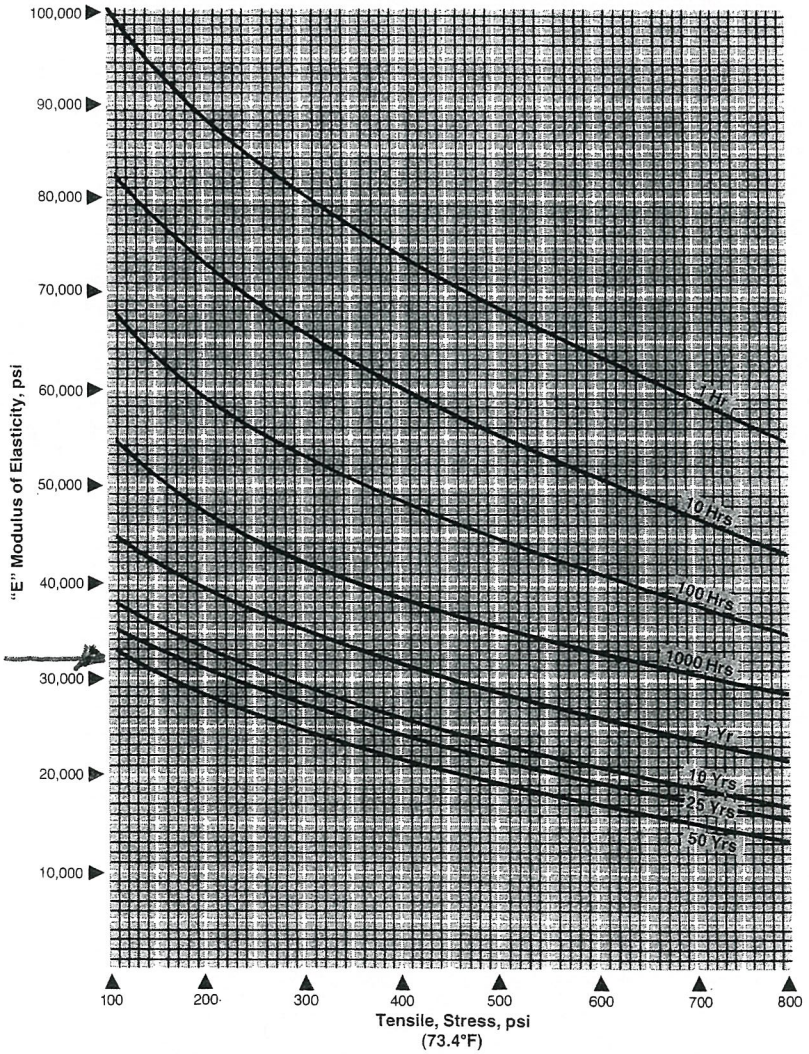
In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling should be examined.

Design by Wall Buckling Guidelines:
Although wall buckling is seldom the limiting factor in the design of a Driscopipe system, a check of non-pressurized pipelines can be made according to the following steps to insure $P_t < P_{cb}$.

1. Calculate or estimate the total soil pressure, P_t, at the top of the pipe.
2. Calculate the stress "S_A" in the pipe wall according to the formula:
$$S_A = \frac{(SDR - 1)\,P_t}{2}$$
3. Based upon the stress "S_A" and the estimated time duration of non-pressurization, use Chart 25 to find the value of the pipe's modulus of elasticity, E, in psi.

Chart 25

Time Dependent Modulus of Elasticity for Polyethylene Pipe vs. Stress Intensity (73.4°F)



NOTE: The short term modulus of elasticity of Driscopipe per ASTM D 638 is approximately 100,000 psi. Due to the cold flow (creep) characteristic of the pipe material, this modulus is dependent upon the stress intensity and the time duration of the applied stress.

4. Based upon the pipe SDR and the value of the polyethylene modulus of elasticity, E, calculate the pipe's hydrostatic, critical-collapse differential pressure, P_C:

$$P_C = \frac{2.32\,(E)}{(SDR)^3}$$

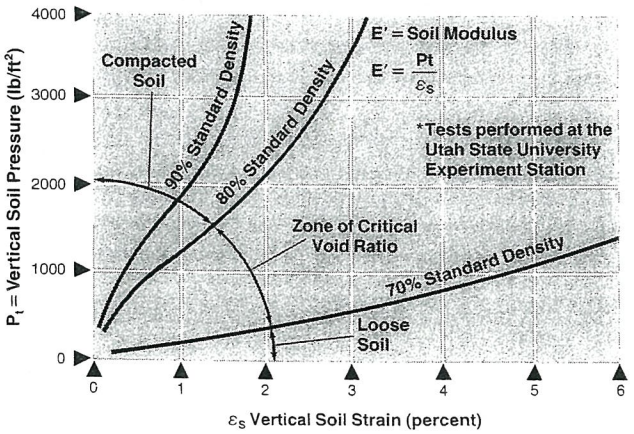
5. Calculate the soil modulus, E′, by plotting the total external soil pressure, P_t, against a specified soil density to derive the soil strain as shown in the example problem on Chart 26.
6. Calculate the critical buckling pressure at the top of the pipe by the formula:

$$P_{cb} = 0.8\sqrt{E' \times P_c}$$

7. Calculate the Safety Factor: S.F. $= P_{CB} \div P_t$
   In burial applications, a safety factor of 1.0 may be considered a minimum because of the margin of safety provided by the arching action of the soil. However, Driscopipe endorses using a more conservative value approaching or exceeding a 2.0 safety factor.
8. The above procedures could be reversed to derive the minimum pipe SDR required for a given soil pressure and an estimated soil density. However, this procedure should permit the engineer to optimize the system design quickly by examining several combinations.

Chart 26

Plot of Vertical Stress-Strain Data for Typical Trench Backfill (Except Clay) from Actual Tests*



EXAMPLE

Find: E′ @ 2000 PSF and 80% Density
Formula: $E' = P_t / \varepsilon_s$
Calculations: E′ = 2000 PSF / .018 = 111111 PSF = 771 psi

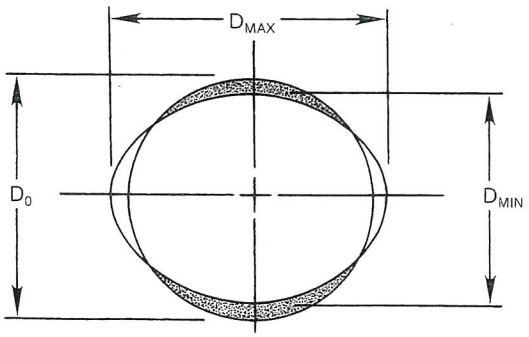
Note: The curves shown on this chart are sample curves for a granular soil. If other types of soil are used for backfill, such as clay or clay loam, curves should be developed from laboratory test data for the material used. Soil pressures greater than 4000 psf may be examined by extrapolating the slope of the curve or by generating curves by testing at those higher soil pressures. Probable error of curves is about half the distance between adjacent lines.

Design by Ring Deflection: Ring deflection is defined as the ratio of the vertical change in diameter to the original diameter. It is often expressed as a percentage. Ring deflection for buried Driscopipe is conservatively the same as (no more than) the vertical compression of the soil envelope around the pipe. Design by ring deflection matches the ability of Driscopipe to accommodate, without structural distress, the vertical compression of the soil enveloping the buried pipeline. *Design by ring deflection comprises a calculation of vertical soil strain to ensure it will be less than the allowable ring deflection of the pipe.* See Chart 27. The tabulation shows that with lower values of SDR, the allowable deflection is less. For installations which require this thicker wall to resist the external soil pressure, actual ring deflection can easily be limited to the tabular values by proper compaction of the backfill around the pipe. The recommended allowable deflection for the various SDR s are:

Chart 27

SDR	Allowable Ring Deflection
32.5	8.1%
26.0	6.5%
21.0	5.2%
19.0	4.7%
17.0	4.2%
15.5	3.9%
13.5	3.4%
11.0	2.7%

The allowable ring deflection of polyethylene pipe is a function of the allowable tangential strain in the outer surface of the pipe wall. A conservative limit of 1-1½% tangential strain in the outer surface of the pipe wall due to vertical deflection of the pipe "ring" by soil compression can be understood by comparing two pipes of the same diameter but different wall thickness.



$$\%\ \text{Ring Deflection} = \left(1 - \frac{D_{MIN}}{D_0}\right) \times 100\%$$

NOTE: 5% deflection decreases flow-area by ¼%. 10% deflection decreases flow-area by 1%.

Assume each of the pipes is equally deflected under loads required to achieve that result. The tangential surface strain developed in the thickwall pipe is much greater than the surface strain in the thinwall pipe. The tangential strain varies directly as the wall thickness (i.e.: distance from the neutral axis) and is proportional to the amount of ring deflection. For a given ring deflection, the thicker the wall, the higher the strain.

Alternately, assume that each of the pipes is subjected to loads such that the tangential surface strain in the pipe's wall surface is equal for both pipes. For equal surface strain, the degree of vertical deflection of the pipe ring is different for the two pipes. Under these circumstances, the degree of deflection would be less for the thickwall pipe and greater for the thinwall pipe.

The percentage ring deflection based upon strain for a given SDR pipe can be calculated as follows:

$$\frac{\Delta Y}{D} = (0.25)(\varepsilon)(\frac{D}{t})$$

$$\frac{\Delta Y}{D} = (0.25)(\varepsilon)(SDR)$$

$$\frac{\Delta Y}{D} = (.0025)(SDR)$$

Where: ε = Tangential strain in the surface of the pipe ring due to deflection (conservatively 0.01 for Driscopipe)
D = Pipe OD, inches
t = Pipe wall thickness, inches
SDR = Standard Dimension Ratio, D/t
ΔY = Vertical deflection, inches

Driscopipe recognizes a tangential surface strain value of 0.01 due to ring deflection as a conservative yet responsible design parameter. This value is based upon the following:

- Most of the deflection of a flexible pipe occurs within a few hours or a few days after final backfilling and increases very little thereafter. This results in the development of the soil arch over the pipe which relieves the pipe of much of the vertical soil load by the arching action of the soil envelope and by the development of soil restraint at the sides of the pipe.
- With an allowable long term stress of 800 psi and a time of approximately four days (100 hours) to reach the maximum allowable ring deflection, the tangential strain would be 2% to 2½% (See Chart 25 for time and load dependent modulus of elasticity to calculate: strain = stress ÷ modulus.) Therefore, the use of 800 psi incorporates an additional margin of safety of over 2.0.
- An allowable strain value of 0.01 will allow for reasonable additional deflection due to disturbance of the backfill by earthquake, fluctuations of the water table, etc.
- An allowable design strain value of 0.01 allows for the normal deviation of temperature encountered during installation.

In summary, a soil density can be specified for the bedding and initial backfill so that the vertical strain of the sidefill soil under the total soil pressure, P_t, at the top of the pipe will be no greater than the maximum allowable ring deflection for a given SDR pipe.

Test Performance of Direct Burial Driscopipe: The density of the bedding and soil envelope determines the performance capability of the pipe-soil system with regard to ring deflection. Tests conducted on Driscopipe at Utah State University by Dr. Reynold K. Watkins show that Driscopipe will not buckle under ordinary conditions if the soil envelope is compacted and is in full contact with the pipe. A virtual fail-safe installation can be assured if soil density is generally over 85% of Standard Proctor (AASHTO T-99) Density. With the backfill compacted to 90% of standard density, the depth of laying for Driscopipe is almost unlimited. However, in the thinner wall series, due to the flexibility of the pipe, it is difficult to achieve the desired high soil density without buckling of the pipe cross-section, particularly when using backfill material other than sand or gravel.

Soil densities less than 90% are certainly adequate if depth of soil cover is in the range of most installations. Compaction to 75% standard density is relatively easy to achieve even in poor soils. This would cover a large percentage of all installations. However, 85% Standard Proctor Density (AASHTO T-99) should be considered a conservative minimum.

wheel or axle weight should be increased by 50% to provide a pipe design with extra strength and endurance against the impact of these dynamic forces. The load at the top of the pipe caused by a superimposed dynamic load at point "A" is evaluated as:

$$P_B = \frac{3\,WZ^3}{2\pi R^5}$$

Where: W = 1½ times the superimposed dynamic load, pounds.

Z = Vertical distance from the point of load to the top of the pipe, feet.

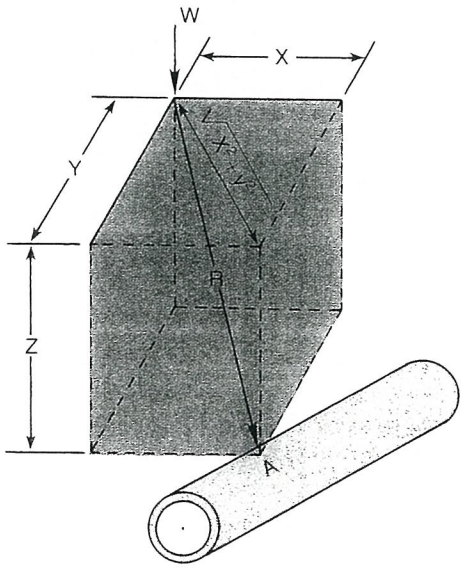
R = Straight line distance from point of load to the top of the pipe, feet.

$$R = \sqrt{X^2 + Y^2 + Z^2}$$

X and Y = Horizontal distances at 90° to each other from point of load to the top of the pipe, feet.

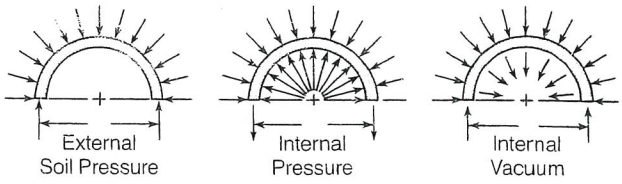
Unit underground pressures caused by a 1000 pound superimposed dynamic load is shown in Chart 28. Unit pressures for superimposed live loads can be obtained by multiplying the chart value by 1½ times the load ratio. Alternately, for heavy truck or railroad traffic, Charts 30 and 31 summarize the total pressure due to the weight of the soil alone together with the weight of the rolling vehicle. An allowance for impact is included in each of these two charts.

These graphs show that, beyond an optimum depth, the total pressure on the pipe increases due primarily to soil pressure. At shallower depths the load intensifies because it is nearer the rolling equipment and the live load is not as well distributed.



Note: If the live load pressure exceeds the capability of a specific SDR pipe for a specific traffic situation, the designer may want to consider the use of a steel or reinforced concrete casing to protect the pipeline.

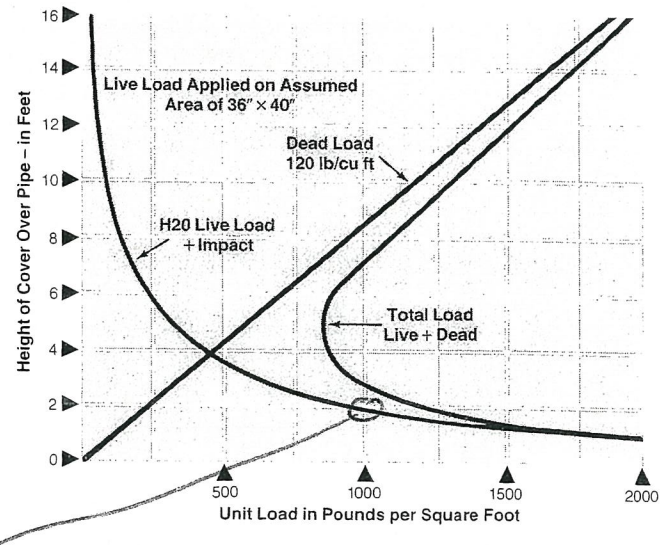
P_i: Apparent External Pressure Due to Internal Vacuum:
Positive pressure generates a tensile hoop stress in the pipe wall. Under its influence the pipe will be trying to expand. The pressure of the soil around the pipe will be trying to crush the pipe as shown in this illustration.



In a positive pressure situation, the value of P_i is negative and theoretically should be subtracted from the other two external pressure components of P_t because it is counteracting the external soil pressure. However, a pipeline should not be designed such that internal pressure is required to support the pipeline to prevent collapse from soil pressure. At some point in the system's operations, the pipeline will be shut down. The support offered by positive pressure against collapse by external soil pressure should be viewed as a means of adding additional

Chart 30

H20 Highway Loading



Note: The H20 live load assumes two 16,000 lb. concentrated loads applied to two 18" × 20" areas, one located over the point in question, and the other located at a distance of 72" away. In this manner, a truckload of 20 tons is simulated.

Source: American Iron and Steel Institute, Washington, D.C.

1000 PSF/144 = 7 psi

ATTACHMENT 4

CALCULATION OF THE DISCHAGE CAPACITY OF THE 8-INCH DIAMETER LEACHATE COLLECTION PIPE

AND

SUMMARY OF THE STORAGE CAPACITY OF THE WASTEWATER PONDS

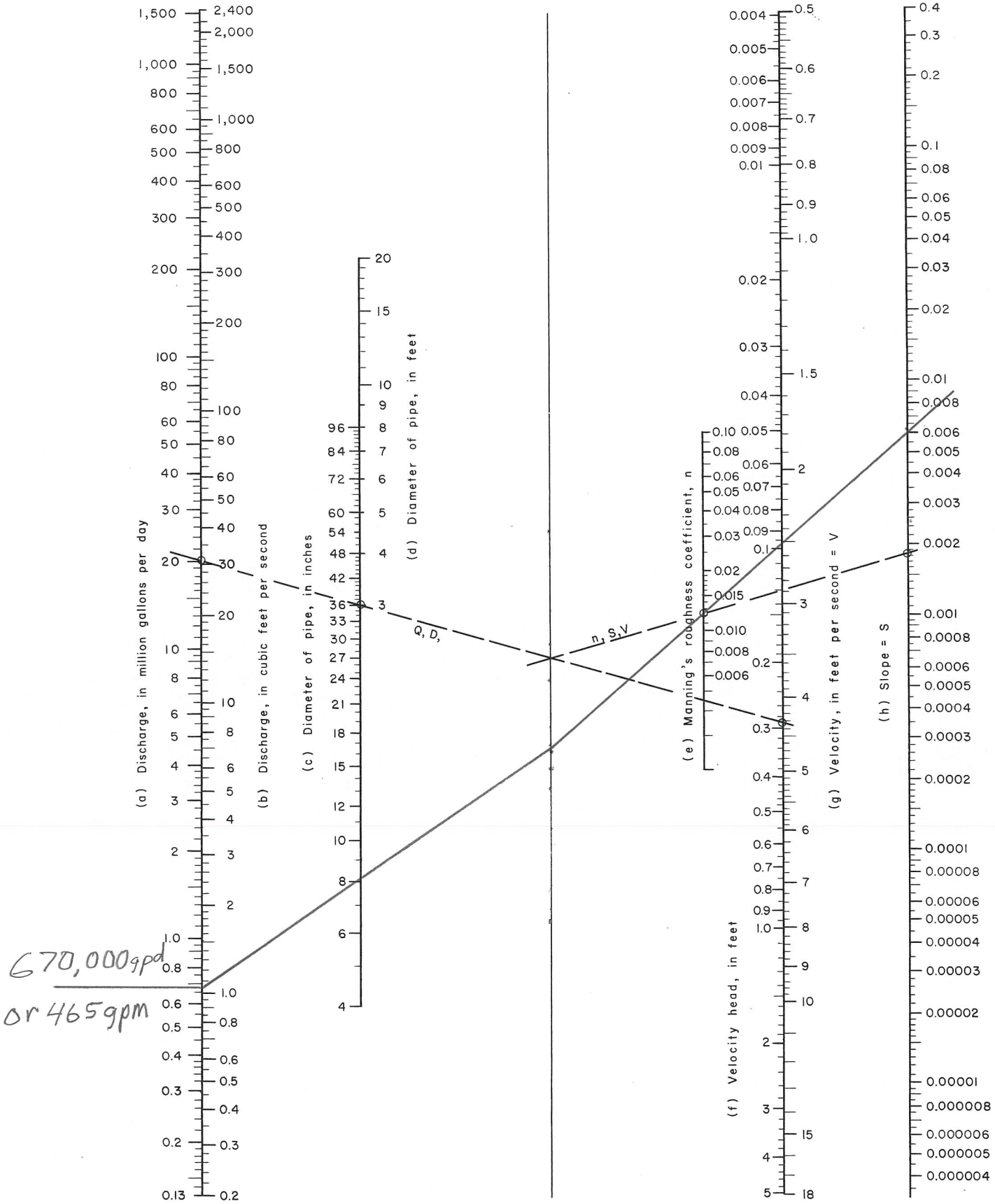


Fig. 1. Nomograph for flow in round pipe—Manning's formula

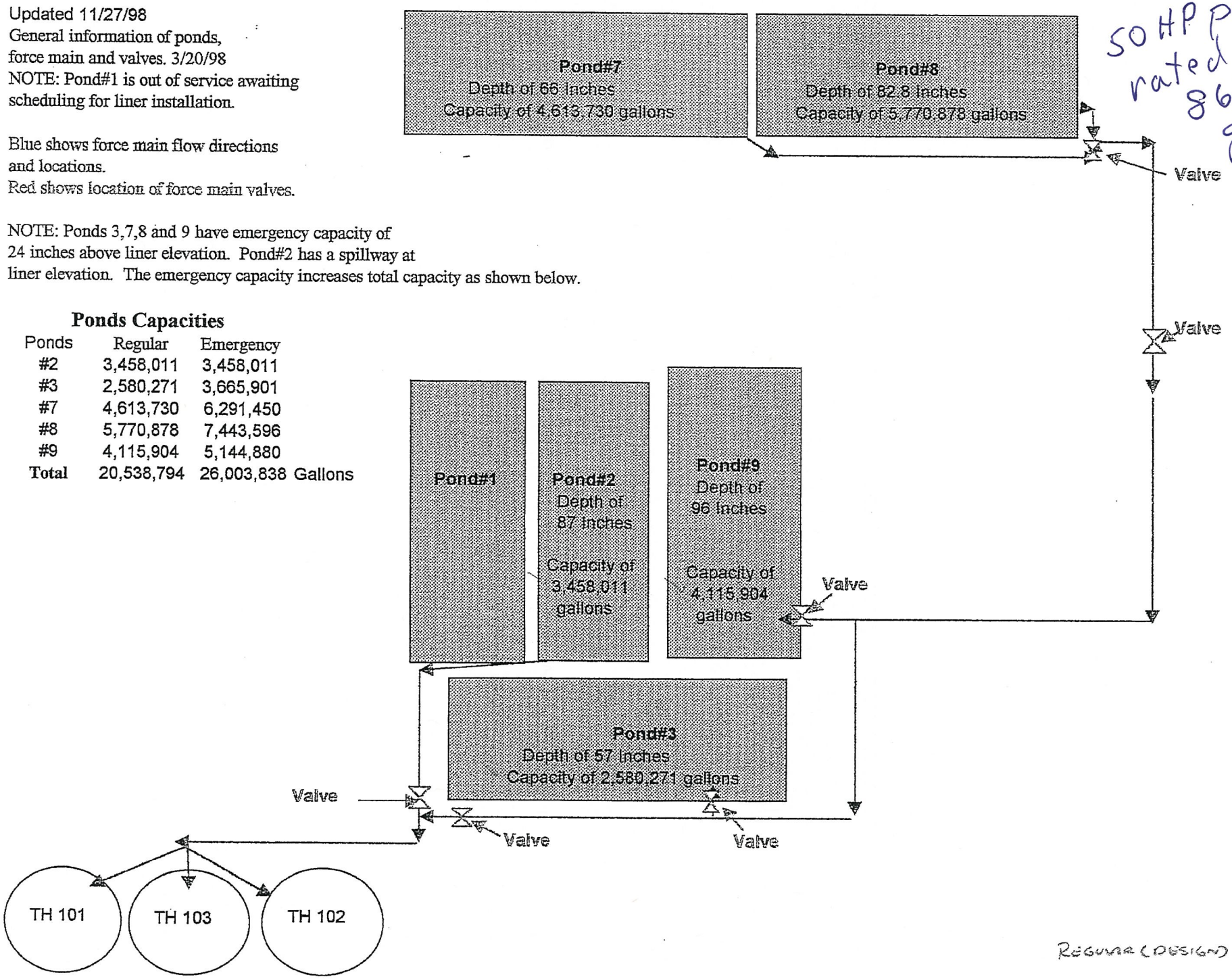
Updated 11/27/98
General information of ponds, force main and valves. 3/20/98
NOTE: Pond#1 is out of service awaiting scheduling for liner installation.

Blue shows force main flow directions and locations.
Red shows location of force main valves.

NOTE: Ponds 3,7,8 and 9 have emergency capacity of 24 inches above liner elevation. Pond#2 has a spillway at liner elevation. The emergency capacity increases total capacity as shown below.

Ponds Capacities

Ponds	Regular	Emergency
#2	3,458,011	3,458,011
#3	2,580,271	3,665,901
#7	4,613,730	6,291,450
#8	5,770,878	7,443,596
#9	4,115,904	5,144,880
Total	20,538,794	26,003,838 Gallons



50 HP pump rated at 864,000 gallons per day

REGULAR DESIGN

ATTACHMENT 5

SETTLEMENT CALCULATIONS FOR THE LANDFILL BASE

AND

CROSS SECTIONS THROUGH THE LANDFILL THAT SHOWS THE LANDFILL BASE DESIGN ELEVATIONS AND

POST-SETTLEMENT ELEVATIONS AND

THE RELATIONSHIP

TO THE SEASONAL HIGH WATER TABLE

ATTACHMENT 6

DOCUMENTATION THAT THE HDPE GEOMEMBRANE IS COMPATIBLE WITH THE LANDFILL LEACHATE

Construction Quality Assurance Report
for Installation of a
Landfill Liner System at
Seminole Generating Station
Putnam County, Florida

October 22, 2009

Ardaman & Associates, Inc.

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Florida Institute of Consulting Engineers

in the test cells, proposed onsite borrow soils including drainage sand, GCL, HDPE geomembrane liners, geonets, geocomposites, geotextiles, HDPE liner seams, and gravel. Laboratory tests performed on samples of the ash, soil and test cell materials included moisture content determinations, sieve analyses, and standard Proctor compaction tests. Laboratory conformance tests were performed on samples of the GCL, HDPE geomembrane liner, geonets and geocomposites, geotextiles, and the drainage sand/protective cover soil.

Field observations were conducted by one or two Ardaman field representatives during the construction period. Our field representatives also performed in-place field density tests and collected samples for laboratory testing, as required by the project specifications.

2.0 LABORATORY TESTING PRIOR TO CONSTRUCTION

Prior to the start of construction, Ardaman performed laboratory testing to establish:

- The compatibility of the GCL with landfill leachate.
- The compaction characteristics of the liner subgrade materials and proposed borrow soils.
- The suitability of a proposed onsite borrow material for use as the drainage sand/protective cover soil above the liner system.

2.1 Compatibility of GCL with Leachate

Ardaman performed laboratory testing to evaluate the compatibility of the GCL with the leachate that will be generated from the lined landfill. Ardaman obtained bucket samples of fly ash, fly ash conditioned with wastewater, bottom ash, and pozzocrete from the SGS for the purpose of producing leachate with chemical characteristics comparable to what can be expected from the landfill. ENCO Laboratories generated synthetic leachate from the various waste materials using the Synthetic Precipitation Leaching Procedure (SPLP), and tested the chemical properties of the SPLP extract. The results of the laboratory testing are provided in Appendix 1. ENCO also extracted additional synthetic leachate from each waste material for use by Ardaman in testing.

Ardaman performed laboratory testing of samples of bentonite and GCLs provided by CETCO Lining Technologies (CETCO) using the synthetic leachate. Swell index (ASTM D5890) testing of bentonite hydrated with synthetic leachate from fly ash showed a swell index of 31 mL/2 g versus a swell index of 28 mL/2 g with distilled water. The specifications for the GCL require a minimum bentonite swell index of 24 mL/2 g. Index flux (ASTM D5887) testing of a GCL hydrated and permeated with synthetic leachate from fly ash at a confining pressure of 25 psi measured an index flux of 1.3×10^{-7} $m^3/m^2/sec$. An equivalent hydraulic conductivity of 7.3×10^{-8} cm/sec was calculated from the index flux. The specification requirements for the GCL are hydraulic conductivity less than or equal to 5×10^{-9} cm /sec and index flux less than or equal to 1×10^{-8} $m^3/m^2/sec$ when hydrated and permeated with water and hydraulic conductivity less than or equal to 1×10^{-7} cm /sec when hydrated and permeated with leachate from fly ash. This hydraulic conductivity value also meets the requirements of 62-701, F.A.C.

Based on information provided by Mr. Chris Athanassopoulos of CETCO, the hydraulic conductivity of a GCL with a hydraulic conductivity of 5×10^{-9} cm/sec when hydrated and permeated with de-ionized water is predicted to be on the order of 1.0×10^{-8} to 2.8×10^{-8} cm/sec when hydrated and permeated with the various synthetic leachates.

The GCL provided by GSE for this project is expected to behave in a similar manner to the CETCO GCL tested when hydrated and permeated with leachate.

2.2 Compaction Characteristics of Ash and Borrow Soils

The liner system subgrade consisted of fly ash and bottom ash on top of the existing landfill. Some of the fly ash was mixed with purge water treatment (PWT) sludge at a ratio of approximately four parts of fly ash to one part of sludge by volume prior to landfilling. In order to test the compaction characteristics of materials to be used for construction of the landfill liner system, the perimeter dikes, and the subgrade, Ardaman obtained samples of fly ash, fly ash mixed with PWT sludge, bottom ash, and proposed borrow soils from two onsite locations. The potential borrow areas were located near the cooling towers and between Test Cells A and B. The borrow area located near the cooling towers was intended to be used for the drainage sand/protective cover soil. According to SECI, much of this material resulted from excavation of the stormwater management pond south of the test cell area. The potential borrow soil stockpiled between Test Cells A and B was soil cover on top of the landfill that was removed when the area was re-opened for landfilling. This borrow soil contained some topsoil, grass, and roots.

Ardaman performed index and classification testing and standard Proctor compaction tests (ASTM D698) on samples of the different materials. The result of the standard Proctor compaction tests are presented in Table 1. Based on previous work performed by Ardaman, the in-place density of pozzocrete is on the order of 72 to 91 pounds per cubic foot (pcf).

2.3 Suitability of Onsite Borrow Material for Drainage Sand Layer

Material for construction of the 24-inch thick layer of drainage sand/protective cover soil on top of the primary geocomposite was planned to be obtained from the existing onsite borrow area near the cooling towers. The drainage sand/protective cover soil is required to have a have a fines content equal to or less than 12 percent and a saturated hydraulic conductivity of no less than 1.0×10^{-3} cm/sec. Test results of this sandy material indicated a fines content of 0.6 to 5.7 percent and a hydraulic conductivity of 2.1×10^{-2} cm/sec at a dry density of 99 pcf. As shown in Table 1, this is very close to the standard Proctor maximum dry density of 99.1 pcf.

3.0 CONTRACTOR'S AND MANUFACTURER'S SUBMITTALS

Geosynthetic materials other than pipe were supplied by GSE Lining Technology, Inc. (GSE). In accordance with the project specifications, Comanco and GSE provided shop drawings, proposed liner panel layouts, product data sheets, certifications for material properties, and results of manufacturer's laboratory quality control testing. The requirements for testing of geosynthetic materials by the manufacturer, including the minimum test frequencies, are summarized in Table 2.

The number of rolls, the roll dimensions, and the total area for each geosynthetic product provided by GSE are listed in Table 3. The areas of the products provided are larger than the area of the liner system footprint to allow for anchorage, overlap, and waste. Appendix 2 contains the specific lot and roll numbers provided and the GSE data sheet for each product that was submitted by Comanco.

Ardaman reviewed Contractor's and Manufacturer's submissions and advised SECI that the materials provided conformed to the specifications.

Appendix 1

Chemical Characteristics of Synthetic Landfill Leachates

ENCO Laboratories Analytical Results for SPLP Extracts

Analyte	Fly Ash	Fly Ash Leached with Water	Conditioned Fly Ash	Pozzocrete	Bottom Ash
Calcium (mg/L)	279	279	290	625	10.5
Magnesium (mg/L)	<0.023	0	0.023	0	0.422
Potassium(mg/L)	14.3	15.9	18.8	17.1	0
Sodium (mg/L)	13.8	12.8	19.2	24.6	3.96
Sulfate (mg/L)	530	530	410	130	11
Chloride (mg/L)	1.5	1.5	160	250	1.8
pH (Std. units)	12	12	12	12	10
TDS (ppm)	1100	1000	1300	2300	92

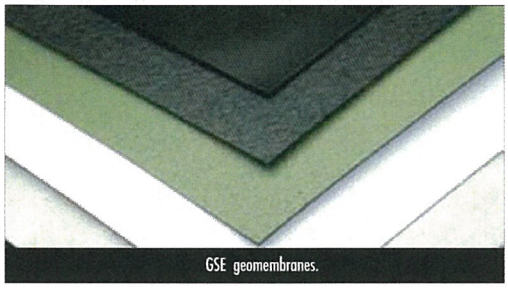
SPLP – Synthetic Precipitation Leaching Procedure
TDS – Total dissolved solids

The Pioneer Of Geosynthetics

S I N C E 1 9 7 2

Technical Note

Chemical Resistance for Geomembrane Products



GSE geomembranes.

GSE geomembranes are made of high quality, virgin polyethylene which demonstrates excellent chemical resistance. GSE polyethylene geomembranes are resistant to a great number and combinations of chemicals. It is this property of (HDPE) high density polyethylene geomembranes that makes it the lining material of choice.

In order to gauge the durability of a material in contact with a chemical mixture, testing is required in which the material is exposed to the chemical environment in question. Chemical resistance testing is a very large and complex topic because of two factors. First, the number of specific media is virtually endless and second, there are many criteria such as tensile strength, hardness, etc. that may be used to assess a material's resistance to degradation.

The chemical resistance of polyethylene has been investigated by many people over the past few decades. We are able to draw from that work when making statements about the chemical resistance of today's polyethylene geomembranes. In addition to that, many tests have been performed that specifically use geomembranes and certain chemical mixtures. Naturally, however, every mixture of chemicals cannot be tested for. As a result of these factors, GSE published a chemical resistance chart, demonstrating general guidelines.

Polyethylene is, for practical purposes, considered impermeable. Be aware, however, that all materials are permeable to some extent. Permeability varies with concentration, temperature, pressure and type of permeant. The rates of permeation are usually so low, however, that they are insignificant. As a point of reference, polyethylene is commonly used for packaging of several types of materials. These include gasoline, motor oil, household cleaners (i.e. bleach), muratic acid, pesticides, insecticides, fungicides, and other highly concentrated chemicals. Also, you should be aware that there are some chemicals which may be absorbed by the material but only when present at very high concentrations. These include halogenated and/or aromatic hydrocarbons at greater than 50%; their absorption results in swelling and slight changes in physical properties such as increased tensile elongations. This includes many types of fuels and oils. Recognize that this action, however, does not affect the liner's ability to act as a barrier for the material it is containing.

Since polyethylene is a petroleum product, it can absorb other petroleum products. Like a sponge, the material becomes slightly thicker and more flexible but does not produce a hole or void. However, unlike a sponge, this absorption is not immediate. It takes a much longer time for a polyethylene liner to swell than it does for a sponge. The exact time it takes for swelling to occur depends on the particular constituents and concentrations of the contained media. However, a hole would not be produced. Also, this absorption is reversible and the material will essentially return to it's original state when the chemical is no longer in contact with the liner.

With regard to typical municipal landfills in the United States, legally allowable levels of chemicals have been demonstrated to have no adverse affect on polyethylene geomembrane performance. The very low levels of salts, metals and organic compounds do not damage polyethylene. A double-lined containment with a leachate (leak detection) removal system effectively prevents any significant, continuous exposure of the secondary membrane to these materials and for practical purposes makes the total liner system even more impermeable.

TNS ChemicalResistance 8/01/15/10

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The Pioneer Of Geosynthetics
SINCE 1972

Chemical Resistance Chart

GSE is the world's leading supplier of high quality, polyethylene geomembranes. GSE polyethylene geomembranes are resistant to a great number and combinations of chemicals. Note that the effect of chemicals on any material is influenced by a number of variable factors such as temperature, concentration, exposed area and duration. Many tests have been performed that use geomembranes and certain specific chemical mixtures. Naturally, however, every mixture of chemicals cannot be tested for, and various criteria may be used to judge performance. Reported performance ratings may not apply to all applications of a given material in the same chemical. Therefore, these ratings are offered as a guide only.

Medium	Concentration	Resistance at: 20° C (68° F)	60° C (140° F)
A			
Acetic acid	100%	S	L
Acetic acid	10%	S	S
Acetic acid anhydride	100%	S	L
Acetone	100%	L	L
Adipic acid	sat. sol.	S	S
Allyl alcohol	96%	S	S
Aluminum chloride	sat. sol.	S	S
Aluminum fluoride	sat. sol.	S	S
Aluminum sulfate	sat. sol.	S	S
Alum	sol.	S	S
Ammonia, aqueous	dil. sol.	S	S
Ammonia, gaseous dry	100%	S	S
Ammonia, liquid	100%	S	S
Ammonium chloride	sat. sol.	S	S
Ammonium fluoride	sol.	S	S
Ammonium nitrate	sat. sol.	S	S
Ammonium sulfate	sat. sol.	S	S
Ammonium sulfide	sol.	S	S
Amyl acetate	100%	S	L
Amyl alcohol	100%	S	L
Aniline	100%	S	L
Antimony trichloride	90%	S	S
Arsenic acid	sat. sol.	S	S
Aqua regia	HCI-HNO3	U	U
B			
Barium carbonate	sat. sol.	S	S
Barium chloride	sat. sol.	S	S
Barium hydroxide	sat. sol.	S	S
Barium sulfate	sat. sol.	S	S
Barium sulfide	sol.	S	S
Benzaldehyde	100%	S	L
Benzene	—	L	L
Benzoic acid	sat. sol.	S	S
Beer	—	S	S
Borax (sodium tetraborate)	sat. sol.	S	S
Boric acid	sat. sol.	S	S
Bromine, gaseous dry	100%	U	U
Bromine, liquid	100%	U	U
Butane, gaseous	100%	S	S
1-Butanol	100%	S	S
Butyric acid	100%	S	L
C			
Calcium carbonate	sat. sol.	S	S
Calcium chlorate	sat. sol.	S	S
Calcium chloride	sat. sol.	S	S
Calcium nitrate	sat. sol.	S	S
Calcium sulfate	sat. sol.	S	S
Calcium sulfide	dil. sol.	L	L
Carbon dioxide, gaseous dry	100%	S	S
Carbon disulfide	100%	L	U
Carbon monoxide	100%	S	S
Chloracetic acid	sol.	S	S
Carbon tetrachloride	100%	L	U
Chlorine, aqueous solution	sat. sol.	L	U
Chlorine, gaseous dry	100%	L	U
Chloroform	100%	U	U
Chromic acid	20%	S	L
Chromic acid	50%	S	L
Citric acid	sat. sol.	S	S

Medium	Concentration	Resistance at: 20° C (68° F)	60° C (140° F)
Copper chloride	sat. sol.	S	S
Copper nitrate	sat. sol.	S	S
Copper sulfate	sat. sol.	S	S
Cresylic acid	sat. sol.	L	—
Cyclohexanol	100%	S	S
Cyclohexanone	100%	S	L
D			
Decahydronaphthalene	100%	S	L
Dextrine	sol.	S	S
Diethyl ether	100%	L	—
Dioctylphthalate	100%	S	L
Dioxane	100%	S	S
E			
Ethanediol	100%	S	S
Ethanol	40%	S	L
Ethyl acetate	100%	S	U
Ethylene trichloride	100%	U	U
F			
Ferric chloride	sat. sol.	S	S
Ferric nitrate	sol.	S	S
Ferric sulfate	sat. sol.	S	S
Ferrous chloride	sat. sol.	S	S
Ferrous sulfate	sat. sol.	S	S
Fluorine, gaseous	100%	U	U
Fluorosilicic acid	40%	S	S
Formaldehyde	40%	S	S
Formic acid	50%	S	S
Formic acid	98-100%	S	S
Furfuryl alcohol	100%	S	L
G			
Gasoline	—	S	L
Glacial acetic acid	96%	S	L
Glucose	sat. sol.	S	S
Glycerine	100%	S	S
Glycol	sol.	S	S
H			
Heptane	100%	S	U
Hydrobromic acid	50%	S	S
Hydrobromic acid	100%	S	S
Hydrochloric acid	10%	S	S
Hydrochloric acid	35%	S	S
Hydrocyanic acid	10%	S	S
Hydrofluoric acid	4%	S	S
Hydrofluoric acid	60%	S	L
Hydrogen	100%	S	S
Hydrogen peroxide	30%	S	L
Hydrogen peroxide	90%	S	U
Hydrogen sulfide, gaseous	100%	S	S
Lactic acid	100%	S	S
Lead acetate	sat. sol.	S	—
M			
Magnesium carbonate	sat. sol.	S	S
Magnesium chloride	sat. sol.	S	S
Magnesium hydroxide	sat. sol.	S	S
Magnesium nitrate	sat. sol.	S	S
Maleic acid	sat. sol.	S	S
Mercuric chloride	sat. sol.	S	S
Mercuric cyanide	sat. sol.	S	S
Mercuric nitrate	sol.	S	S

-Continued-

Technical Note

Medium	Concentration	Resistance at: 20° C (68° F)	60° C (140° F)
Mercury	100%	S	S
Methanol	100%	S	S
Methylene chloride	100%	L	—
Milk	—	S	S
Molasses	—	S	S
N			
Nickel chloride	sat. sol.	S	S
Nickel nitrate	sat. sol.	S	S
Nickel sulfate	sat. sol.	S	S
Nicotinic acid	dil. sol.	S	—
Nitric acid	25%	S	S
Nitric acid	50%	S	U
Nitric acid	75%	U	U
Nitric acid	100%	U	U
O			
Oils and Grease	—	S	L
Oleic acid	100%	S	L
Orthophosphoric acid	50%	S	S
Orthophosphoric acid	95%	S	L
Oxalic acid	sat. sol.	S	S
Oxygen	100%	S	L
Ozone	100%	L	U
P			
Petroleum (kerosene)	—	S	L
Phenol	sol.	S	S
Phosphorus trichloride	100%	S	L
Photographic developer	cust. conc.	S	S
Picric acid	sat. sol.	S	—
Potassium bicarbonate	sat. sol.	S	S
Potassium bisulfide	sol.	S	S
Potassium bromate	sat. sol.	S	S
Potassium bromide	sat. sol.	S	S
Potassium carbonate	sat. sol.	S	S
Potassium chlorate	sat. sol.	S	S
Potassium chloride	sat. sol.	S	S
Potassium chromate	sat. sol.	S	S
Potassium cyanide	sol.	S	S
Potassium dichromate	sat. sol.	S	S
Potassium ferricyanide	sat. sol.	S	S
Potassium ferrocyanide	sat. sol.	S	S
Potassium fluoride	sat. sol.	S	S
Potassium hydroxide	10%	S	S
Potassium hydroxide	sol.	S	S
Potassium hypochlorite	sol.	S	L
Potassium nitrate	sat. sol.	S	S
Potassium orthophosphate	sat. sol.	S	S
Potassium perchlorate	sat. sol.	S	S
Potassium permanganate	20%	S	S
Potassium persulfate	sat. sol.	S	S
Potassium sulfate	sat. sol.	S	S
Potassium sulfite	sol.	S	S
Propionic acid	50%	S	S
Propionic acid	100%	S	L
Pyridine	100%	S	L
Q			
Quinol (Hydroquinone)	sat. sol.	S	S
S			
Salicylic acid	sat. sol.	S	S

Medium	Concentration	Resistance at: 20° C (68° F)	60° C (140° F)
Silver acetate	sat. sol.	S	S
Silver cyanide	sat. sol.	S	S
Silver nitrate	sat. sol.	S	S
Sodium benzoate	sat. sol.	S	S
Sodium bicarbonate	sat. sol.	S	S
Sodium biphosphate	sat. sol.	S	S
Sodium bisulfite	sol.	S	S
Sodium bromide	sat. sol.	S	S
Sodium carbonate	sat. sol.	S	S
Sodium chlorate	sat. sol.	S	S
Sodium chloride	sat. sol.	S	S
Sodium cyanide	sat. sol.	S	S
Sodium ferricyanide	sat. sol.	S	S
Sodium ferrocyanide	sat. sol.	S	S
Sodium fluoride	sat. sol.	S	S
Sodium hydroxide	40%	S	S
Sodium hydroxide	sat. sol.	S	S
Sodium hypochlorite	15% active chlorine	S	S
Sodium nitrate	sat. sol.	S	S
Sodium nitrite	sat. sol.	S	S
Sodium orthophosphate	sat. sol.	S	S
Sodium sulfate	sat. sol.	S	S
Sodium sulfide	sat. sol.	S	S
Sulfur dioxide, dry	100%	S	S
Sulfur trioxide	100%	U	U
Sulfuric acid	10%	S	S
Sulfuric acid	50%	S	S
Sulfuric acid	98%	S	U
Sulfuric acid	fuming	U	U
Sulfurous acid	30%	S	S
T			
Tannic acid	sol.	S	S
Tartaric acid	sol.	S	S
Thionyl chloride	100%	L	U
Toluene	100%	L	U
Triethylamine	sol.	S	L
U			
Urea	sol.	S	S
Urine	—	S	S
W			
Water	—	S	S
Wine vinegar	—	S	S
Wines and liquors	—	S	S
X			
Xylenes	100%	L	U
Y			
Yeast	sol.	S	S
Z			
Zinc carbonate	sat. sol.	S	S
Zinc chloride	sat. sol.	S	S
Zinc (II) chloride	sat. sol.	S	S
Zinc (IV) chloride	sat. sol.	S	S
Zinc oxide	sat. sol.	S	S
Zinc sulfate	sat. sol.	S	S

Specific immersion testing should be undertaken to ascertain the suitability of chemicals not listed above with reference to special requirements.

NOTES:

(S) **Satisfactory**: Liner material is resistant to the given reagent at the given concentration and temperature. No mechanical or chemical degradation is observed.

(L) **Limited Application Possible**: Liner material may reflect some attack. Factors such as concentration, pressure and temperature directly affect liner performance against the given media. Application, however, is possible under less severe conditions, e.g. lower concentration, secondary containment, additional liner protections, etc.

(U) **Unsatisfactory:** Liner material is not resistant to the given reagent at the given concentration and temperature. Mechanical and/or chemical degradation is observed.

(–) **Not tested**

sat. sol. = Saturated aqueous solution, prepared at 20°C (68°F)

sol. = aqueous solution with concentration above 10% but below saturation level

dil. sol. = diluted aqueous solution with concentration below 10%

cust. conc. = customary service concentration

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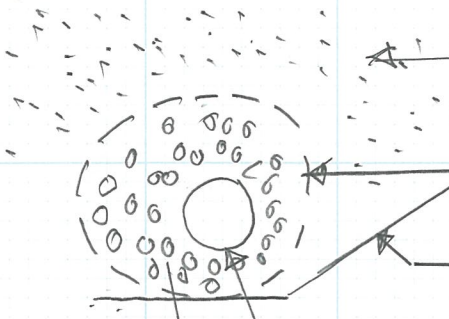
ATTACHMENT 7

CALCULATION TO CHECK THE GRADATION OF THE DRAINAGE SAND FOR PIPING THROUGH THE GEOTEXTILE AND GRAVEL THROUGH THE SLOTTED LEACHATE COLLECTION PIPE

PBS&J

Subject: SECI Increment 1 Buildout		
Comp by: JLM Check by: RGC	Date: 9/23/10 Job Number:	Sheet Number:

Check Gradation of Sand to Geotextile and Gravel to Slotted Drain Pipe For the leachate Collection System Reference Cedergren (attached)



Drainage Sand $D_{100\%} < 1/4"$ $D_{85} <$

12 oz non-woven geotextile

Geomembrane

8" ø slotted HDPE leachate collection pipe slot width >0.09" and <0.12"

Gravel - See attached Gradation D85 of Gravel 1"

For slots on pipe to Gravel Filter

$$\frac{\text{85\% size of Gravel}}{\text{slot width}} > 1.2$$

$$\frac{1"}{0.12"} = 8.3 > 1.2 \text{ so } \underline{\text{OK}} \checkmark$$

For Sand to Geotextile

$$\frac{\text{85\% pore size of Geotextile filter } (P_{85})}{\text{85\% size of soil } (D_{85})} \leq 1$$

$0.007" / 0.01 = 0.7 < 1$ OK ✓

8.2.4 Pipe Sizes

Both solid and slotted HDPE pipe shall have the nominal diameters and Standard Dimension Ratios (SDR) shown on the Drawings. Dimensions, workmanship, SDR and corresponding pressure rating shall be in accordance with ASTM F714.

8.2.5 Slotted Pipe

Where slotted pipe is specified on the Drawings, the slots shall be cleanly cut, identical in geometry, and evenly spaced. The slot length shall be located perpendicular to the longitudinal axis of the pipe. Slots shall be located in two straight rows along the length of the pipe. The rows of slots shall be spaced 180° on centers around the circumference of the pipe, and shall not be staggered. The slots shall satisfy the following criteria:

Dimension or Area	Criteria
Slot Width (inches)	>0.09 and <0.12
Slot Length Measured Along Outer Pipe Circumference (inches)	>1.50 and <2.50
Slotted Area (in^2/foot of pipe)	>2.0 (outer wall) >1.0 (inner wall)
Spacing Between Slots Along Pipe Length (c/c, inches)	>1.0 and <3.0

The Contractor shall submit a 3-foot long sample of slotted pipe for each SDR rating shown on the Drawings at least 2 weeks prior to construction. Slotted pipe shall not be delivered to the Site without first receiving approval from the Owner.

8.2.6 Fabricated Fittings

Fabricated fittings made by butt fusing cut segments of pipe shall be used where shown on the Drawings. Fabricated fittings shall be made using pipe segments meeting the base resin, physical appearance and physical property requirements specified in Sections 8.2.1, 8.2.2, and 8.2.3 of this Specification. Shop Drawings for fabricated fittings shall be submitted to the Engineer for approval at least 2 weeks prior to fabrication.

8.2.7 Approved Manufacturers

The following manufacturers and corresponding pipe series designations are approved for use:

- Chevron Phillips DriscoPlex PE 3408 Pipe Series
- Poly Pipe PE 3408 Pipe Series

Other manufacturers producing equivalent pipes may be approved provided product data sheets and resin certificates are submitted to the Engineer to confirm compliance with this Specification.

The filter fabric shall be uniform and homogeneous in appearance and composition, and free from tears, cuts, thin spots or any defects that may affect serviceability. The filter fabric shall be supplied in rolls having a minimum width of 15 feet and minimum length of 300 feet, and shall meet the following material requirements:

Property	Test Method	Criterion
Mass per Unit Area		≥12 oz/yd²
Apparent Opening Size	ASTM D5261	≥80 U.S. Standard Sieve
Grab Tensile Strength*	ASTM D4751	≥275 lb
Grab Elongation*	ASTM D4632	≥50%
Trapezoidal Tear*	ASTM D4533	≥110 lb
Puncture Resistance	ASTM D4833	≥150 lb
Permeability to Water	ASTM D4491	≥0.20 cm/sec
* Machine and transverse directions.		

← 0.007"

A complete description of the filter fabric proposed for use by the Contractor that meets or exceeds the specified requirements shall be submitted to the Engineer for approval at least 1 week prior to delivery of the material to the Job Site.

9.3.4 Gravel

The gravel used for construction of the leachate collection and leak detection systems shall consist of clean, washed, rounded, sub-rounded to sub-angular particle shape, silica classifying as a GP-type poorly graded fine gravel, as determined in accordance with ASTM D2487. Gravel consisting of predominantly angular or otherwise sharp-edged particles shall not be used.

The gravel shall be free of any trash or debris, and shall meet the following gradation requirements, as determined using ASTM D421 and D422:

U.S. Standard Sieve Size	Percent Passing (Dry Weight Basis)
2-inch	100
1½-inch	90-100
1-inch	40-60
¾-inch	15-40
⅜-inch	0-5

Say D85 ≈ 1"

A complete description of the proposed gravel material, including its chemical composition and the gradation test results, shall be submitted by the Contractor to the Engineer for approval at least 1 week prior to delivery of the material to the Job Site to confirm compliance with these Specifications.

Note slot size is 0.12" smallest gravel is 0.375" so OK!

9.3.5 Drainage Sand/Protective Cover

The sand used for construction of the drainage sand/protective cover layer shall meet the following requirements:

- The material shall have no particle retained on a U.S. ¼-inch standard sieve.
- The material shall have a plasticity index of 0 percent (ASTM D4318).
- The material shall have carbonate content no greater than 10 percent (ASTM D4373), and an organic content no greater than 5 percent (ASTM D2974).
- The material shall classify as a fine sand or slightly silty fine sand with a SP or SP-SM designation in accordance with ASTM D2487.
- The material shall have a fines content equal to or less than 12 percent, as determined by ASTM D1140.
- The material shall be relatively uniform in character and, after compaction, shall be able to achieve an in place saturated hydraulic conductivity equal to or greater than $1.0x10^{-3}$ cm/sec.

9.4 Installation of Drain System

Proper tools and equipment shall be used by the Contractor for installation of the drain system at the base of the landfill. The geocomposite drainage nets and HDPE pipes shall be installed at the locations and along the lines and grades shown on the Drawings. The geocomposite drainage net of the leachate collection system shall be installed prior to placement of the drainage sand/protective cover layer.

Prior to installation of the drain system, the Contractor shall carefully examine all geocomposites and HDPE pipe and fittings for any damage and defects. All defective materials shall be rejected and replaced. The Contractor shall also carefully inspect the base of the landfill and make sure that it is free of foreign objects or obstacles that may affect installation of the drain system. If water is present in the pipe trench or sump area, it shall be dewatered prior to placement of the filter fabric, gravel and HDPE pipes.

The filter fabric used in the gravel trench drain shall remain wrapped and protected from moisture and ultraviolet light until the time of installation. Storage at the Site shall be in a suitable area protected from sunlight and moisture. After installation, the filter fabric shall not be left exposed for more than 48 hours before being covered with drainage sand or the upper liner.

During installation, the filter fabric shall be loosely laid with the long direction of the filter fabric roll placed along the alignment of the trenches upon the liner or geocomposite surface, as shown on the Construction Drawings. The liner or geocomposite surface shall be free from debris or

Drainage Sand

TABLE 5

Summary of Grain Size Analyses
Seminole Generating Station Unit 3
Power Plant Project
Palatka, Florida

SPT	Depth (Feet)	NM (%)	Percent Passing Sieve Size						
			#10	#20	#40	#60	#100	#140	#200
B-45-07	3½-5	3.7	100	100	99.3	90.3	22.9	6.9	5.0
B-47-07	6½-7½	19.9	100	100	99.6	93.2	25.4	4.2	2.7
B-50-07	5-6	25.4	100	100	98.6	85.8	19.4	3.8	2.8
B-52-07	9½-11	24.6	100	100	99.9	96.5	18.7	1.9	1.1
B-57-07	4½-6	1.4	100	99.9	98.5	90.1	23.0	2.6	1.3

$D_{85} \approx 0.01$"

SEEPAGE, DRAINAGE, AND FLOW NETS

THIRD EDITION

HARRY R. CEDERGREN

WILEY

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ratio (D_{15} of filter/D_{85} of soil) for all projects requiring the use of dispersive clays.

While recognizing that the prevention of erosion failures by deflocculation of dispersive clays and hydraulic fracturing may require special precautions, the designers of water-retaining facilities should be just as careful when dealing with soils that are considered relatively unsusceptible to hydraulic fracturing or dispersion failures, such as cohesionless silts and silty clays. These soils are highly erodible if not protected with well designed filters and drains, constructed without segregation.

Those who have extensive experience with dispersive clay action, seem to agree that the deflocculation process does not begin unless there is a significant flow of water, such as can occur through poorly compacted or cracked layers in an impervious core; through cracks extending in the upstream-downstream direction in a core; or along inadequately bonded contacts with rock foundations, abutment, or outlet conduits extending across the impervious core.

To safeguard *all* earth dams and other water-impounding facilities from piping failures, designers should require high standards for all facets of design and construction, use relatively wide impervious cores and other features that hold seepage quantities and hydraulic gradients to the lowest practical levels, and provide well designed and constructed filters and drains wherever needed.

Although filter criteria are almost foolproof, experience and judgment will reduce the danger of mistakes being made in their application. Several examples of "normal" designs of filters to prevent piping are given in Sec. 5.3. Precautions that must be taken in designing filters to protect gap-graded soil-rock mixtures or stratified formations, and the dangers of severe segregation in filters are described in the last part of Sec. 5.3. In these examples the primary control is assumed to be criterion 1, the ratio of the largest D_{15} size of the filter to the D_{85} size of the finest protected soil.

Pipe Joints, Holes, and Slots

When pipes are embedded in filters and drains, no unplugged ends should be allowed and the filter materials in contact with pipes must be coarse enough not to enter joints, holes, or slots. The U.S. Army Corps of Engineers (1955*a*) and the U.S. Army et al. (1971) use the following criteria for gradation of filter materials in relation to slots and holes:

For slots

$$\frac{\text{85\% size of filter material}}{\text{slot width}} > 1.2 \qquad (5.4)$$

For circular holes

$$\frac{\text{85\% size of filter material}}{\text{hole diameter}} > 1.0 \qquad (5.5)$$

To prevent piping by soils when filter fabrics are used I suggest the following criterion:

$$\frac{85\% \text{ pore size of filter } (P_{85})}{85\% \text{ size of soil } (D_{85})} \leq 1 \tag{5.12}$$

The physical significance of the criterion represented by Eq. 5.12 is illustrated in Figure 5.13, which shows several pore-size distribution curves for filter fabrics in relation to several soil gradation curves. It is a little more conservative than the criteria suggested by others based on the equivalent opening size (EOS) sieve or the average pore size (Pavg).

Examples of the use of filter fabrics that give filter or separator protection appear in other chapters (Figs. 7.7, 7.11, 7.13, 7.15, 8.15, 8.22, 9.10, 9.16, 9.17, 10.1*d*, 10.3, 10.7, 10.9, and 10.15). If filter fabrics are to provide long-lasting protection to engineering works, only the right kind for a given type of construction and use must be specified and the entire design and construction must be correctly carried out. Because of the many factors that can affect the performance of filter fabrics and the drains they protect, the preparation of adequate acceptance and performance specifications is extremely important.

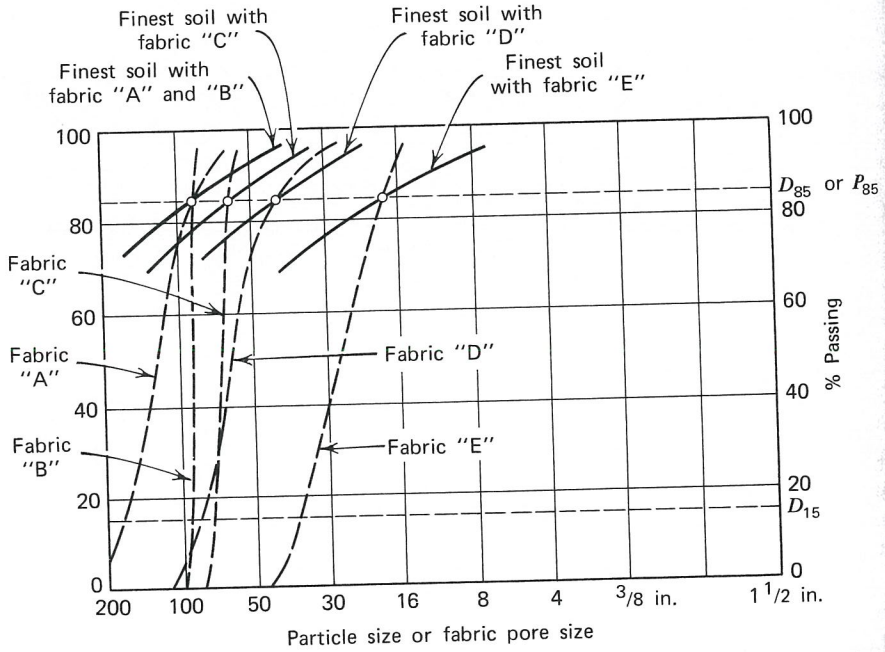


FIG. 5.13 Suggested criterion (tentative) for filter protection of soils with synthetic fabrics: D_{85} of soil $\geq$ P_{85} of fabric.

ATTACHMENT 8

DRAINAGE CALCULATIONS OF THE STORMWATER RUNOFF FOR THE INCREMENT 1 BUILDOUT FINAL GRADING PLAN

PBS&J

Subject: SECI - Stormwater

Comp by: JLM
Check by: RGC
Date: 09/24/2010
Job Number:
Sheet Number: 1/26

Summary of Stormwater Calculation for Increment 1 Buildout

Design Storm 24 hour - 25 year event
8" rainfall in 24 hours

Intensity for 8 minute Duration
8.5 inches

Total Increment 1 Buildout Area = 31 acres

Use Rational Formula

$Q = ciA$

$c = 0.95$

$i = 8.5$ inches

$A = 31$ acres

$Q = 250$ cfs maximum

Total peak Flow

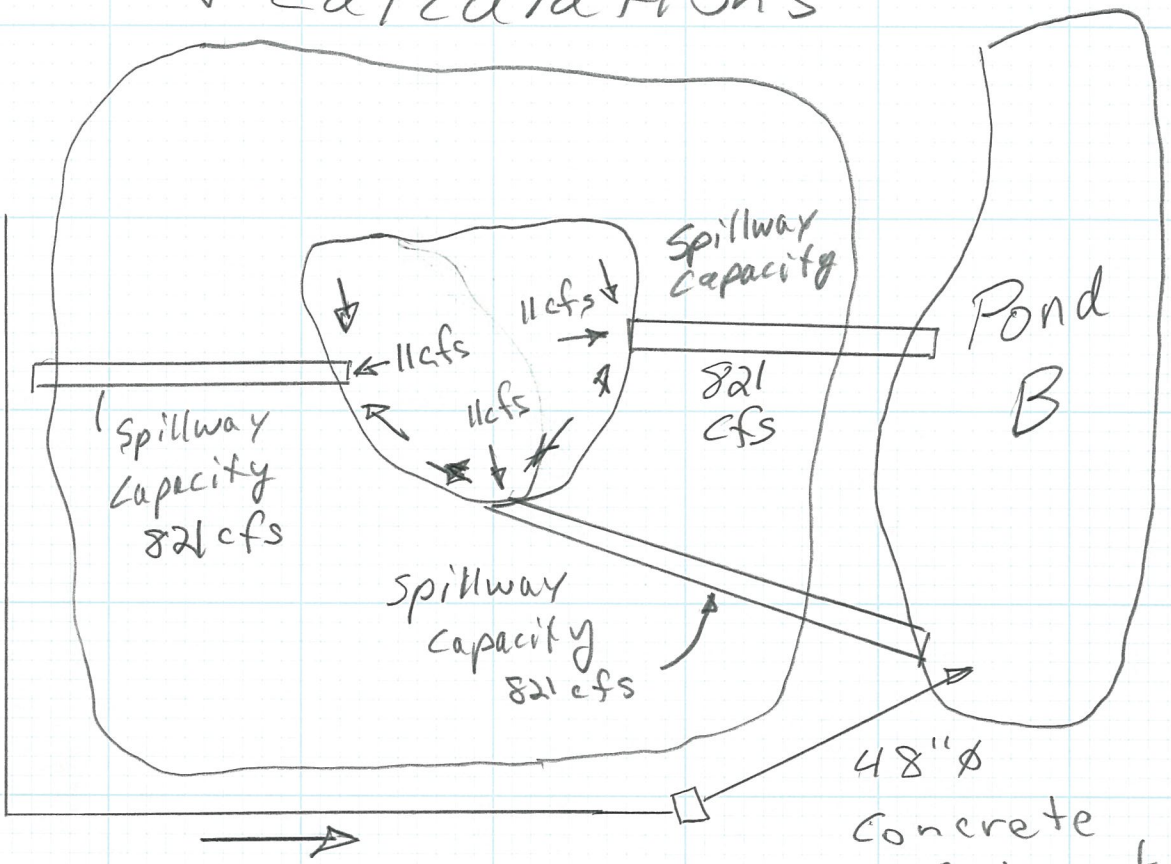
PBS&J

Subject: SECI - Stormwater

Comp by: JLM | Date: 09/24/2010 | Sheet Number: 2/26

Check by: RGC | Job Number:

Summary of Stormwater Calculations



West Ditch capacity 1,116cfs

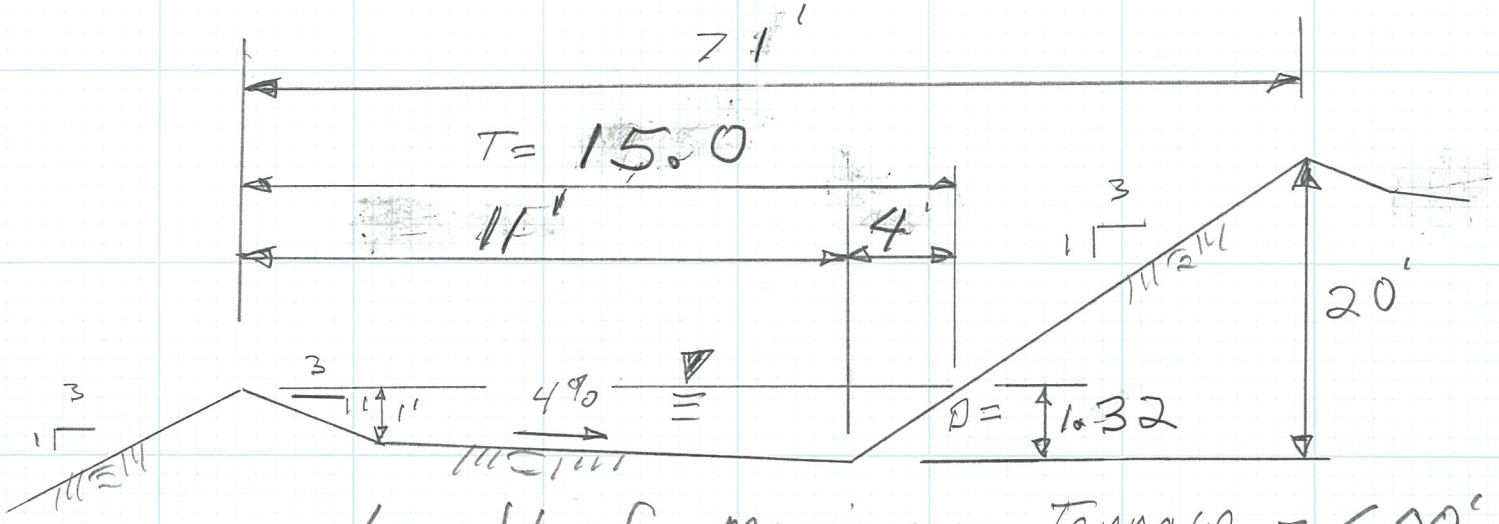
South Ditch capacity 629cfs

Since Ditchs and spillways capacity exceed total peak of 250cfs, ditches and spillways are large enough.

PBS&J®

Subject: SECI - Storm water			
Comp by: JLM	Date: 9/24/2010	Sheet Number: 3/26	
Check by: RCG	Job Number:		

Calculate Capacity of Landfill Side slope terrace to Control Stormwater Runoff



Length of maximum Terrace = 600'

Typical Terrace Design

Assumptions

1. Use Rational Formula

$$Q = C\,i\,a$$

a = Drainage area

71' x 600' / 43,560 S.F./acre

= 1 acre

C = 0.95 Runoff coefficient

i = 8.5"/hr. for 8 minute time of concentration (See attached)

PBS&J

Subject: SECI - Stormwater

Comp by: SLM | Date: 9/24/2010 | Sheet Number: 4/26

Check by: RGC | Job Number:

$Q = ciA$

$Q = 0.95 \times 8.5\text{"/hr} \times 1\text{ac}$

$Q = \underline{8\text{ cfs}}$

Use Nomograph - chart 29 attached to check capacity of terrace

$T = 15.0'$

$D = 1.32'$

$Z = T/D = 11.4$

$n = 0.08$ (See attached)

S = slope = 0.003

$Z/n = 11.4/0.08 = 142.5$

From Nomograph

Ditch Discharge is 9.5 cfs

$9.5\text{ cfs} / 8\text{ cfs} =$ Factor of Safety of 1.2 OK!

5/26

DESIGN CHARTS FOR OPEN-CHANNEL FLOW

Hydraulic Design Series No. 3

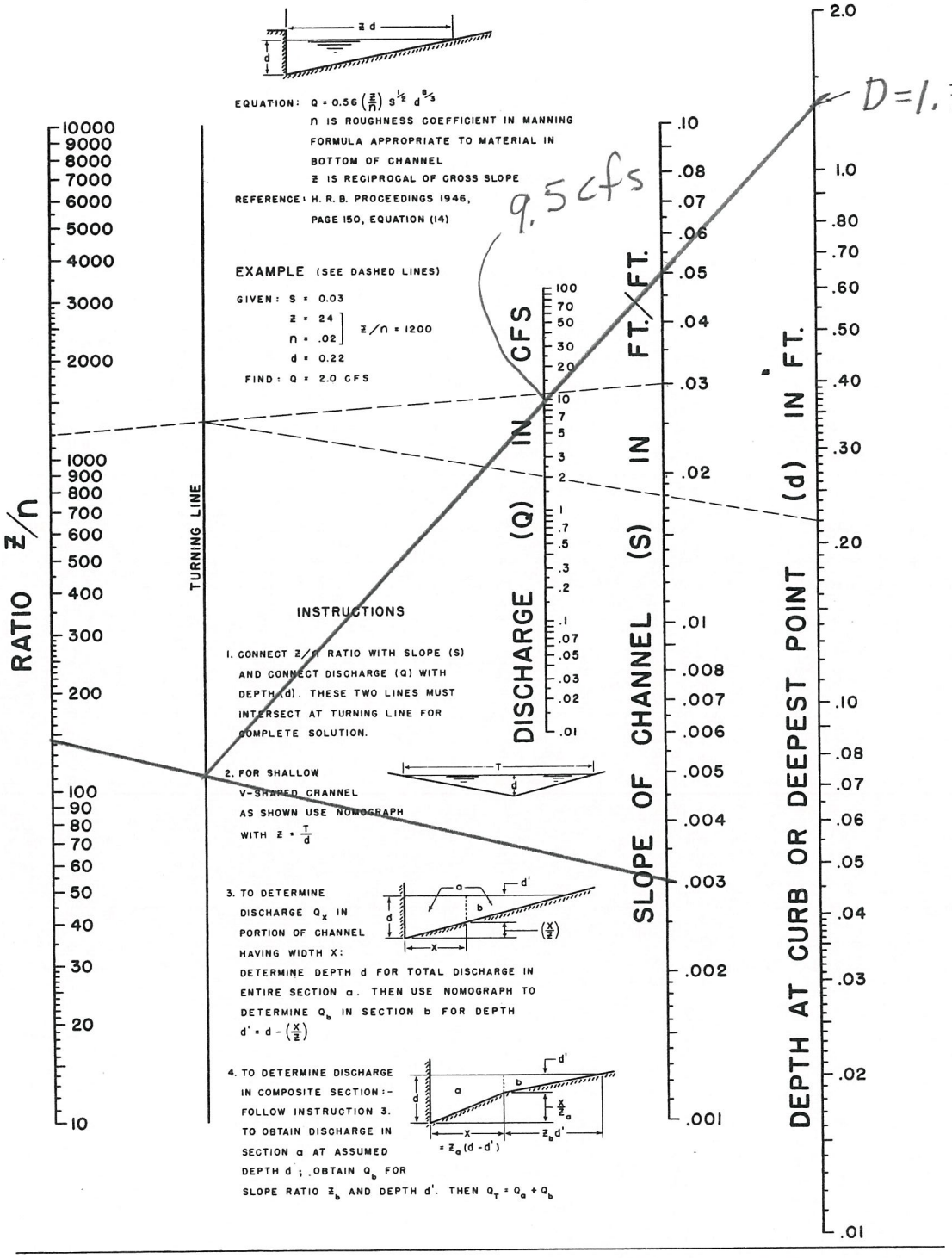
U.S. Department of Transportation
Federal Highway Administration

August 1961
Reprinted November 1977

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

6/26

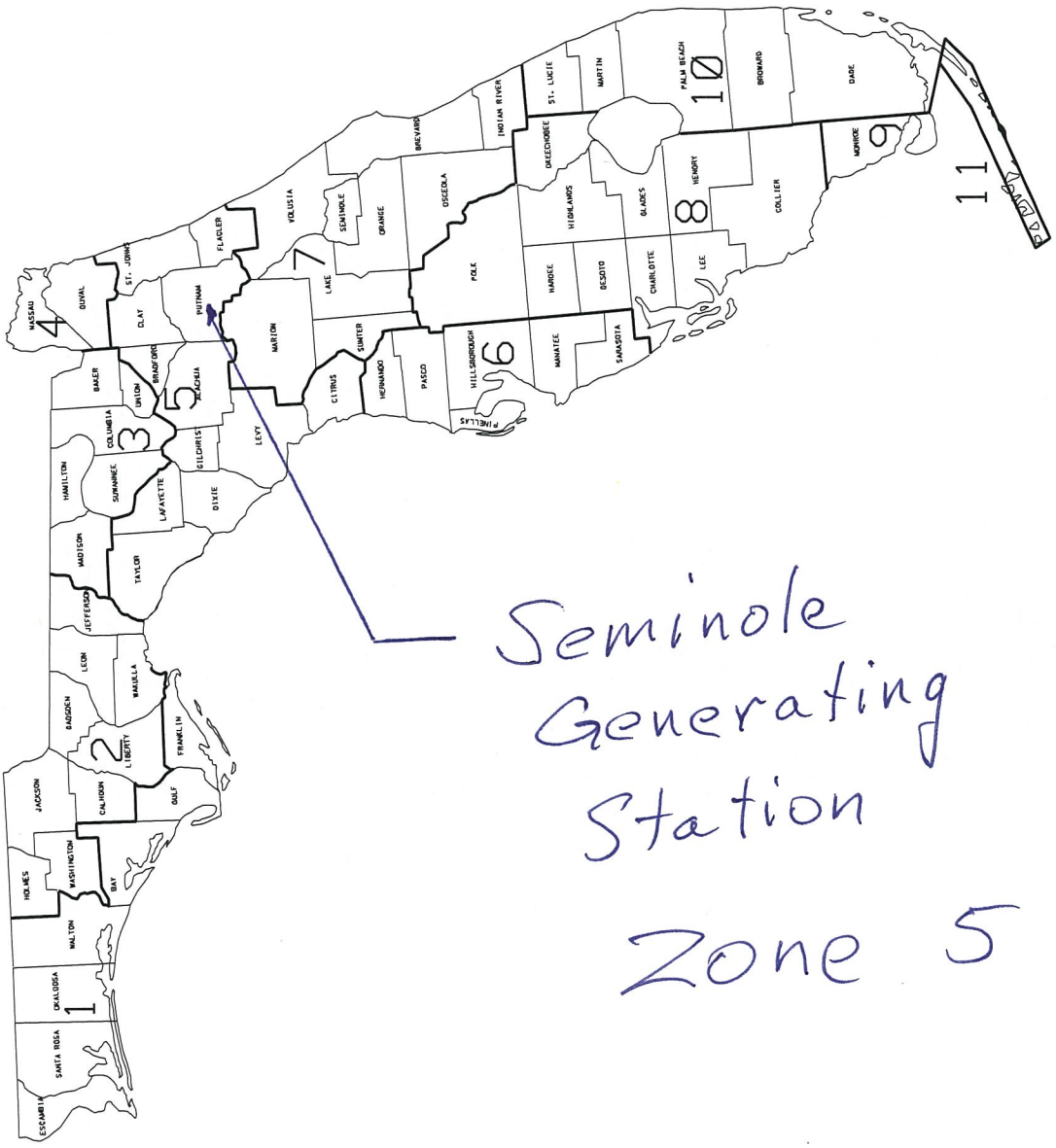
CHART 29



NOMOGRAPH FOR FLOW IN TRIANGULAR CHANNELS

7/26

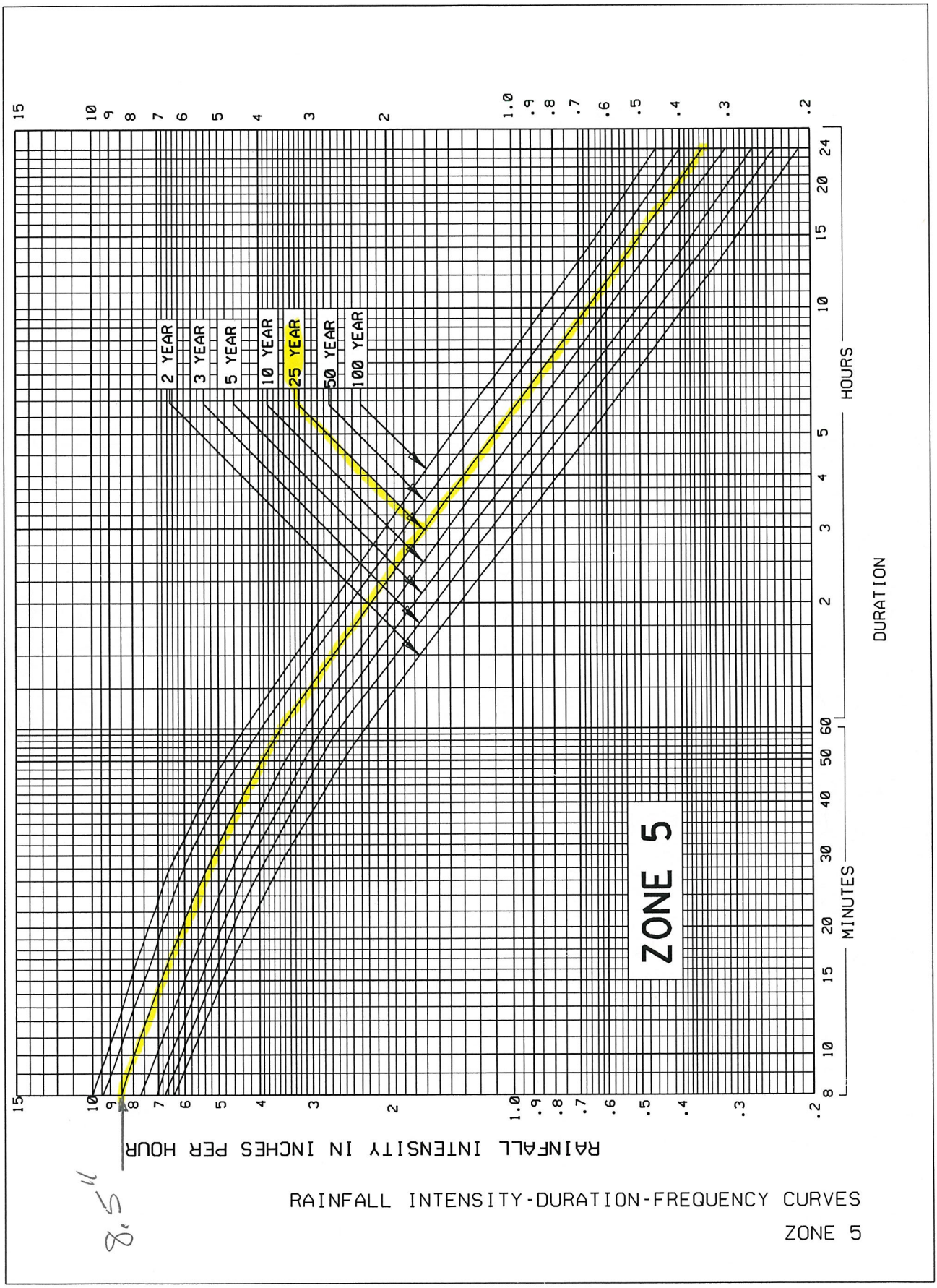
ZONES FOR PRECIPITATION IDF CURVES DEVELOPED BY THE DEPARTMENT



Seminole Generating Station

Zone 5

8/26



RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

ZONE 5

8.5"

9/24

Table 7-3
RECOMMENDED MANNING'S n VALUES FOR ARTIFICIAL CHANNELS
WITH BARE SOIL AND VEGETATIVE LININGS

Channel Lining	Description	Design Manning's n Value
Bare Earth, Fairly Uniform	Clean, recently completed	0.022
Bare Earth, Fairly Uniform	Short grass and some weeds	0.028
Dragline Excavated	No vegetation	0.030
Dragline Excavated	Light brush	0.040
Channels not Maintained	Dense weeds to flow depth	0.10
Channels not Maintained	Clear bottom, brush sides	0.08
Maintained Grass or Sodded Ditches	Good stand, well maintained 2" - 6"	0.06*
Maintained Grass or Sodded Ditches	Fair strand, length 12" - 24"	0.20*

*Decrease 30 percent for flows >0.7' depth (maximum flow depth 1.5').

Table 7-4
RECOMMENDED MANNING'S n VALUES FOR
ARTIFICIAL CHANNELS WITH RIGID LININGS

Channel Lining	Finish Description	Design Manning's n Value
Concrete Paved	Broomed*	0.016
Concrete Paved	"Roughened" - Standard	0.020
Concrete Paved	Gunite	0.020
Concrete Paved	Over rubble	0.023
Asphalt Concrete	Smooth	0.013
Asphalt Concrete	Rough	0.016

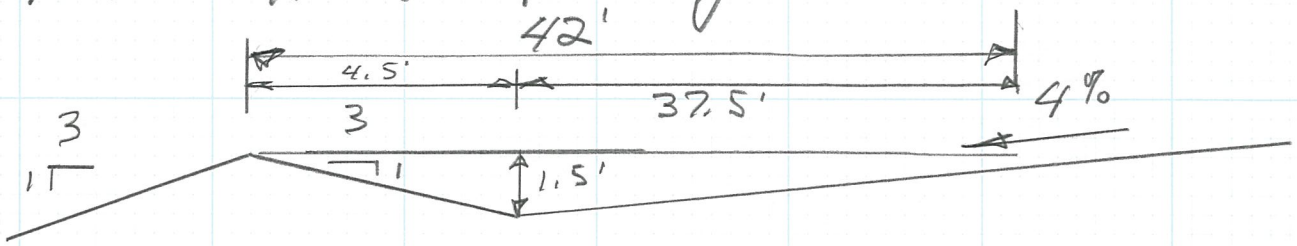
*Because this is not the standard finish, it must be specified (see Section 5.24-7 of Standard Specifications).

PBS&J

Subject: SECT - Stormwater

Comp by: JLM
Check by: RGC
Date: 9/24/2010
Job Number:
Sheet Number: 10/26

Check ditch capacity on top of Landfill



Use Nomograph - Chart 29 attached

T = 42'

D = 1.5'

Z = T/D = 42/1.5 = 28

n = 0.08 (See attached)

S = slope = 0.003

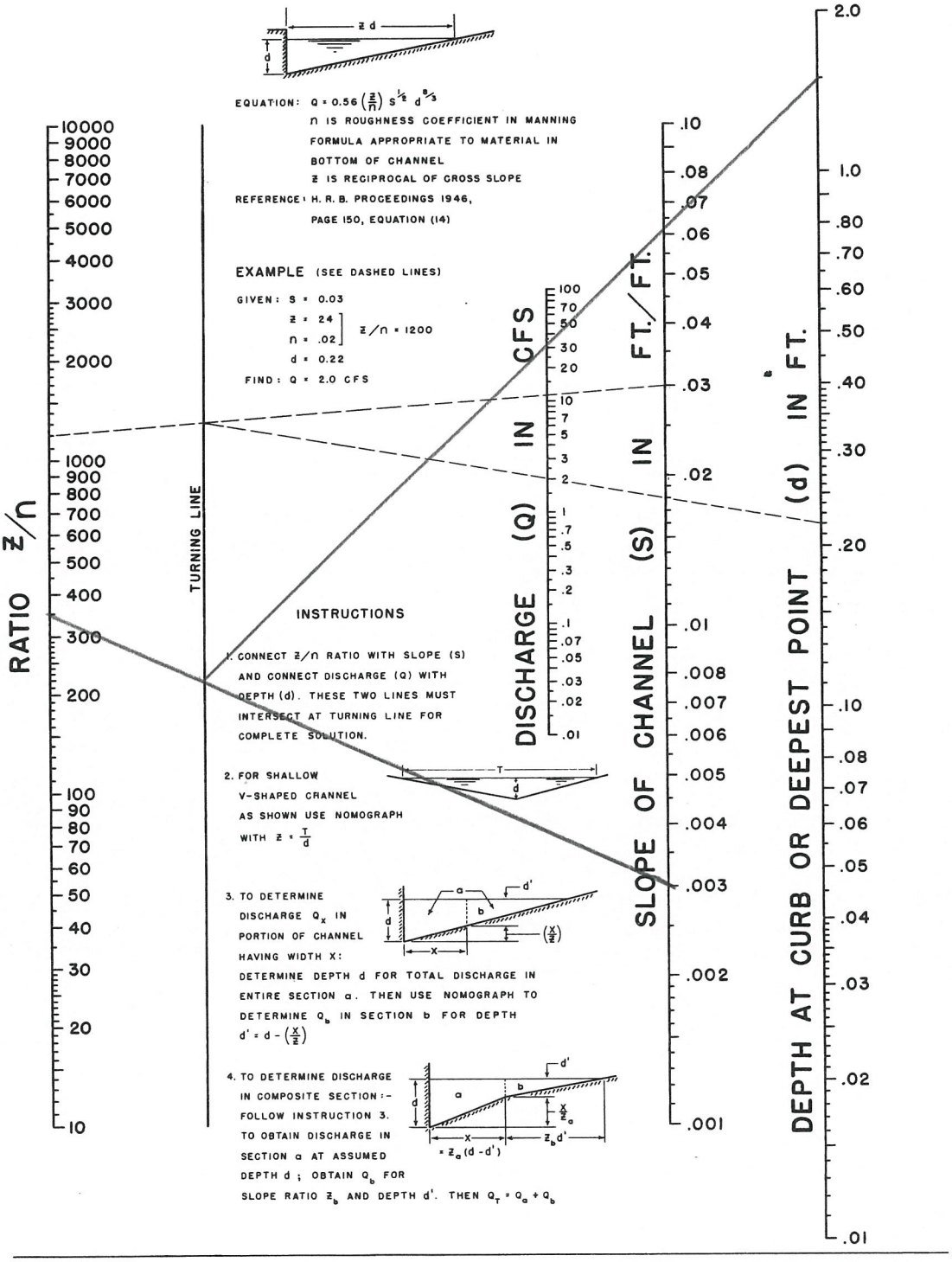
Z/n = 28/0.08 = 350

From Nomograph
Ditch Discharge is

32 cfs

11/26

CHART 29



NOMOGRAPH FOR FLOW IN TRIANGULAR CHANNELS

Table 7-3
RECOMMENDED MANNING'S n VALUES FOR ARTIFICIAL CHANNELS
WITH BARE SOIL AND VEGETATIVE LININGS

Channel Lining	Description	Design Manning's n Value
Bare Earth, Fairly Uniform	Clean, recently completed	0.022
Bare Earth, Fairly Uniform	Short grass and some weeds	0.028
Dragline Excavated	No vegetation	0.030
Dragline Excavated	Light brush	0.040
Channels not Maintained	Dense weeds to flow depth	0.10
Channels not Maintained	Clear bottom, brush sides	0.08
Maintained Grass or Sodded Ditches	Good stand, well maintained 2" - 6"	0.06*
Maintained Grass or Sodded Ditches	Fair strand, length 12" - 24"	0.20*

*Decrease 30 percent for flows >0.7' depth (maximum flow depth 1.5').

Table 7-4
RECOMMENDED MANNING'S n VALUES FOR
ARTIFICIAL CHANNELS WITH RIGID LININGS

Channel Lining	Finish Description	Design Manning's n Value
Concrete Paved	Broomed*	0.016
Concrete Paved	"Roughened" - Standard	0.020
Concrete Paved	Gunite	0.020
Concrete Paved	Over rubble	0.023
Asphalt Concrete	Smooth	0.013
Asphalt Concrete	Rough	0.016

*Because this is not the standard finish, it must be specified (see Section 5.24-7 of Standard Specifications).

PBS&J®

Subject: SECT - Stormwater

Comp by: JLM
Check by: RGC

Date: 09/24/2010
Job Number:

Sheet Number: 13/26

Determine Peak Flow from top of Landfill

$Q = ciA$

$c = 0.95$

$i = 8.5$ inches

$A = 4$ acres

$Q = 32.3$ cfs.

Perimeter Ditch capacity from previous calculation is 32 cfs.

Ditch capacity is adequate

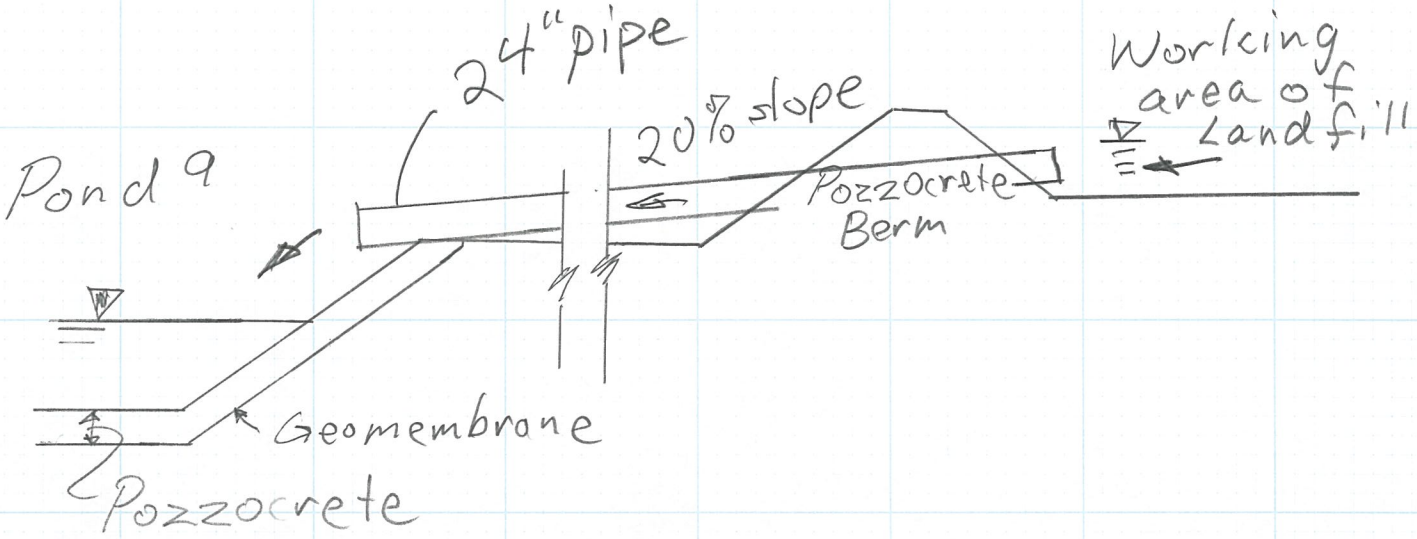
Each spillway has adequate capacity So OK

PBS&J®

Subject:

Comp by: JLM
Check by: RGC
Date: 09/24/2010
Job Number:
Sheet Number: 14/26

Check capacity of 24" ø pipe to Remove Storm water from Working Area With in the Pozzocrete Berms



Maximum area of landfill within Pozzocrete Berms is 20 acres.

Determine Runoff from 25-year 24 hour storm water event of 8"

Volume = 20 ac. x 43,560 SF/ac x 8"/12"/ft x 7.48 gal/cf

Volume = 43.4 million gallons

From attached nomograph 24" ø pipe has capacity of 80 million gallons/day

15/26

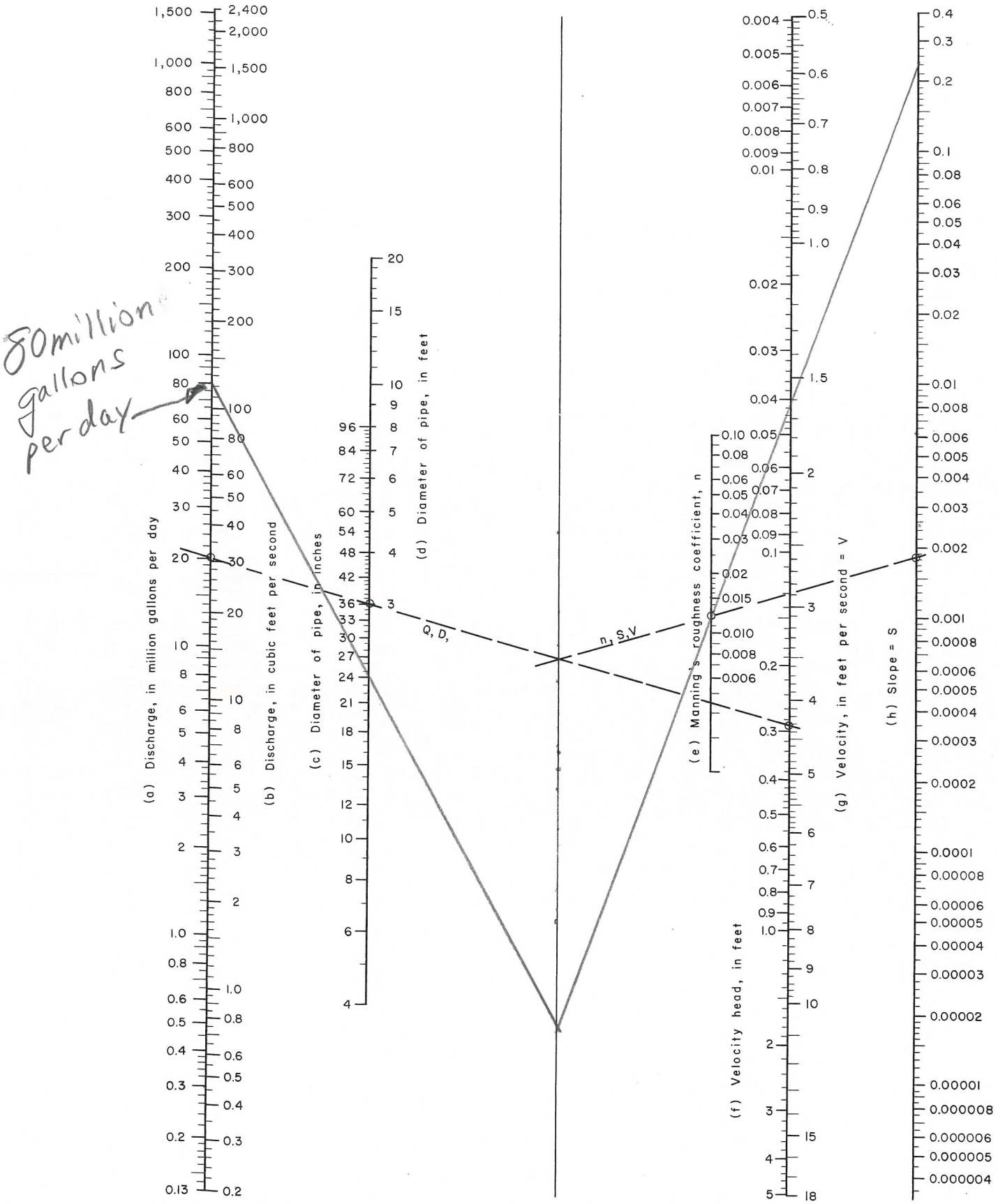


Fig. 1. Nomograph for flow in round pipe—Manning's formula

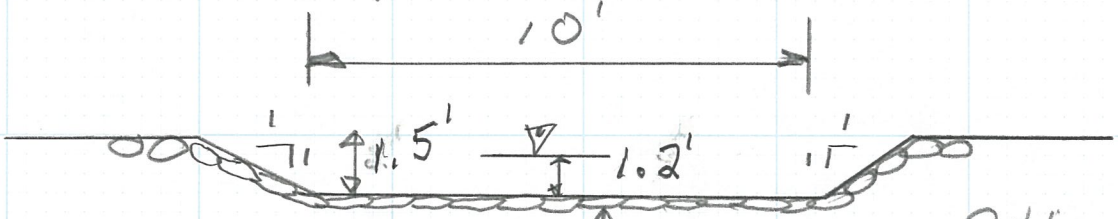
PBS&J

Subject: SECI - Stormwater

Comp by: JLM | Date: 9/24/2010 | Sheet Number: 16/26

Check by: RGC | Job Number:

Determine Size for Side slope spillways



concrete filled fabric forms

Slope – 3H:1V ≈ 0.33'/'

Area = 11.2' × 1.2' = 13.44 sf

Manning's 'n' = 0.014 for Rough Concrete

Wetted Perimeter = 13.4'

Spillway capacity

= 821 cfs

see attached

17/26

- Simple Beam - Concentrated Load
- Plastic Section Modulus
- Welded Wire Fabric
- Reinforcing Steel

$Q = a \times 1.486/n \times R^{2/3} \times S^{1/2}$					
Input Data:			**Results:**		
Area =	13.44	ft²	Hydraulic Radius =	1.00	ft
Mannings 'n' =	0.014		Flow Rate =	821.13	cfs
Wetted Perimeter =	13.4	ft	Velocity =	61.10	ft/s
Slope =	0.33	ft/ft			

MANNING'S FORMULA

$Q = A * 1.486/n * R^{2/3} * S^{1/2}$

- Q = Discharge (cu. ft./sec.)
- A = Cross-sectional Area of Flow (sq. ft.)
- n = Coefficient of Roughness
- R = Hydraulic Radius (ft.)
- S = Slope of Pipe (ft./ft.)

Hydraulic Radius

$R = A / P$

- R = Hydraulic Radius (ft.)
- A = Cross-sectional Area of Flow (sq. ft.)
- P = Wetted perimeter (ft.)

Material	Manning's n
Metals	
Brass	0.011
Cast Iron	0.013
Smooth Steel	0.012
Corrugated Metal	0.022
Non-Metals	
Glass	0.010
Clay Tile	0.014
Brickwork	0.015

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Asphalt	0.016
Masonry	0.025
Finished Concrete	0.012
Unfinished Concrete	0.014
Gravel	0.029
Earth	0.025
Planed Wood	0.012
Unplaned Wood	0.013
Corrugated Polyethylene (PE) with smooth inner walls	0.009-0.015
Corrugated Polyethylene (PE) with corrugated inner walls	0.018-0.025
Polyvinyl Chloride (PVC) with smooth inner walls	0.009-0.011
Excavated Earth Channels	
Clean	0.022
Gravelly	0.025
Weedy	0.030
Stony, Cobbles	0.035 tr
Natural Streams	
Clean and Straight	0.030
Major Rivers	0.035
Sluggish with Deep Pools	0.040
Floodplains	
Pasture, Farmland	0.035
Light Brush	0.050
Heavy Brush	0.075
Trees	0.15

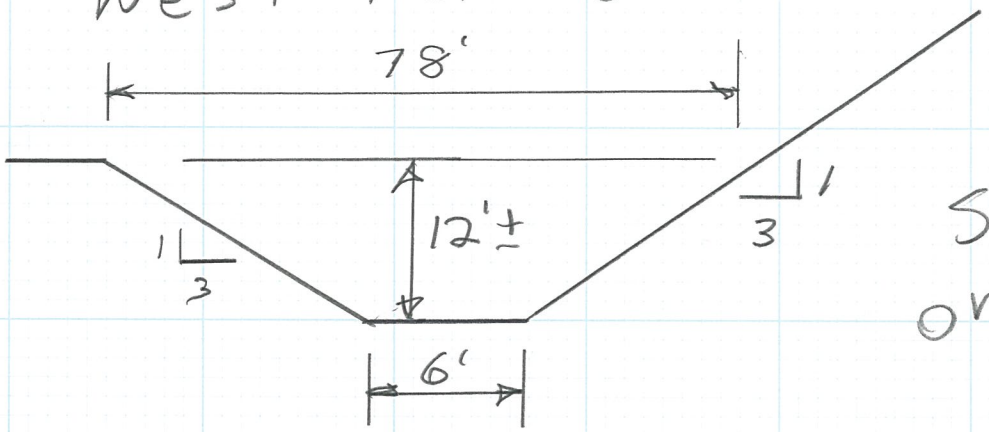
PBS&J

Subject: SECI Stormwater

Comp by: JLM | Date: 9/24/2010 | Sheet Number: 19/26

Check by: RGC | Job Number:

check Capacity of West Perimeter Ditch



See ditch on Drawing C-7 & C-8

Slope = 0.002

Area = $12' \times 6' + 2 \times (\frac{1}{2} \cdot 12 \cdot 36) = 504\ SF$

Manning "n" = 0.03

Wetted Perimeter = 81.9'

Capacity = 1,116 cfs

See attached

20/26

- Simple Beam - Concentrated Load
- Plastic Section Modulus
- Welded Wire Fabric
- Reinforcing Steel

$Q = a \times 1.486/n \times R^{2/3} \times S^{1/2}$					
Input Data:			**Results:**		
Area =	504	ft^2	Hydraulic Radius =	1.00	ft
Mannings 'n' =	0.03		Flow Rate =	1,116.46	cfs
Wetted Perimeter =	504	ft	Velocity =	2.22	ft/s
Slope =	0.002	ft/ft			

MANNING'S FORMULA

$Q = A * 1.486/n * R^{2/3} * S^{1/2}$

- Q = Discharge (cu. ft./sec.)
- A = Cross-sectional Area of Flow (sq. ft.)
- n = Coefficient of Roughness
- R = Hydraulic Radius (ft.)
- S = Slope of Pipe (ft./ft.)

Hydraulic Radius

$R = A / P$

- R = Hydraulic Radius (ft.)
- A = Cross-sectional Area of Flow (sq. ft.)
- P = Wetted perimeter (ft.)

Material	Manning's n
Metals	
Brass	0.011
Cast Iron	0.013
Smooth Steel	0.012
Corrugated Metal	0.022
Non-Metals	
Glass	0.010
Clay Tile	0.014
Brickwork	0.015

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Asphalt	0.016
Masonry	0.025
Finished Concrete	0.012
Unfinished Concrete	0.014
Gravel	0.029
Earth	0.025
Planed Wood	0.012
Unplaned Wood	0.013
Corrugated Polyethylene (PE) with smooth inner walls	0.009-0.015
Corrugated Polyethylene (PE) with corrugated inner walls	0.018-0.025
Polyvinyl Chloride (PVC) with smooth inner walls	0.009-0.011
Excavated Earth Channels	
Clean	0.022
Gravelly	0.025
Weedy	0.030
Stony, Cobbles	0.035 tr
Natural Streams	
Clean and Straight	0.030
Major Rivers	0.035
Sluggish with Deep Pools	0.040
Floodplains	
Pasture, Farmland	0.035
Light Brush	0.050
Heavy Brush	0.075
Trees	0.15

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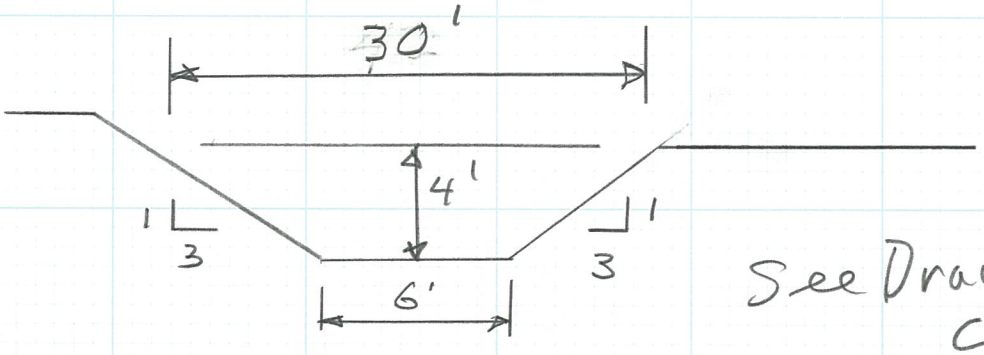
Subject: SECI - Stormwater

Comp by: JLM
Check by: RGC
Date: 9/24/2010
Job Number:
Sheet Number: 22/26

Check capacity of West Perimeter Ditch



See Drawing C-6

slope = 0.01

Area = $(\frac{1}{2} \times (30+6)) \times 4' = 72$ SF

Mannings "n" = 0.03

Wetted Perimeter = 30.7'

capacity = 629 cfs

see attached

23/26

- Simple Beam - Concentrated Load
- Plastic Section Modulus
- Welded Wire Fabric
- Reinforcing Steel

$Q = a \times 1.486/n \times R^{2/3} \times S^{1/2}$					
Input Data:			**Results:**		
Area =	72	ft^2	Hydraulic Radius =	2.35	ft
Mannings 'n' =	0.03		Flow Rate =	629.54	cfs
Wetted Perimeter =	30.7	ft	Velocity =	8.74	ft/s
Slope =	0.01	ft/ft			

MANNING'S FORMULA

$Q = A * 1.486/n * R^{2/3} * S^{1/2}$

- Q = Discharge (cu. ft./sec.)
- A = Cross-sectional Area of Flow (sq. ft.)
- n = Coefficient of Roughness
- R = Hydraulic Radius (ft.)
- S = Slope of Pipe (ft./ft.)

Hydraulic Radius

$R = A / P$

- R = Hydraulic Radius (ft.)
- A = Cross-sectional Area of Flow (sq. ft.)
- P = Wetted perimeter (ft.)

Material	Manning's n
Metals	
Brass	0.011
Cast Iron	0.013
Smooth Steel	0.012
Corrugated Metal	0.022
Non-Metals	
Glass	0.010
Clay Tile	0.014
Brickwork	0.015

24/26

Asphalt	0.016
Masonry	0.025
Finished Concrete	0.012
Unfinished Concrete	0.014
Gravel	0.029
Earth	0.025
Planed Wood	0.012
Unplaned Wood	0.013
Corrugated Polyethylene (PE) with smooth inner walls	0.009-0.015
Corrugated Polyethylene (PE) with corrugated inner walls	0.018-0.025
Polyvinyl Chloride (PVC) with smooth inner walls	0.009-0.011
Excavated Earth Channels	
Clean	0.022
Gravelly	0.025
Weedy	0.030
Stony, Cobbles	0.035 tr
Natural Streams	
Clean and Straight	0.030
Major Rivers	0.035
Sluggish with Deep Pools	0.040
Floodplains	
Pasture, Farmland	0.035
Light Brush	0.050
Heavy Brush	0.075
Trees	0.15

PBS&J®

Subject: SECI – Stormwater

Comp by: JLM | Date: 09/24/2010 | Sheet Number: 25/26

Check by: RGC | Job Number:

Determine Capacity of 48" ø Concrete culvert from ditch to Pond B

Slope = 0.033

n = 0.012 for finished concrete

From Nomograph attached

Discharge Capacity = 250 cfs

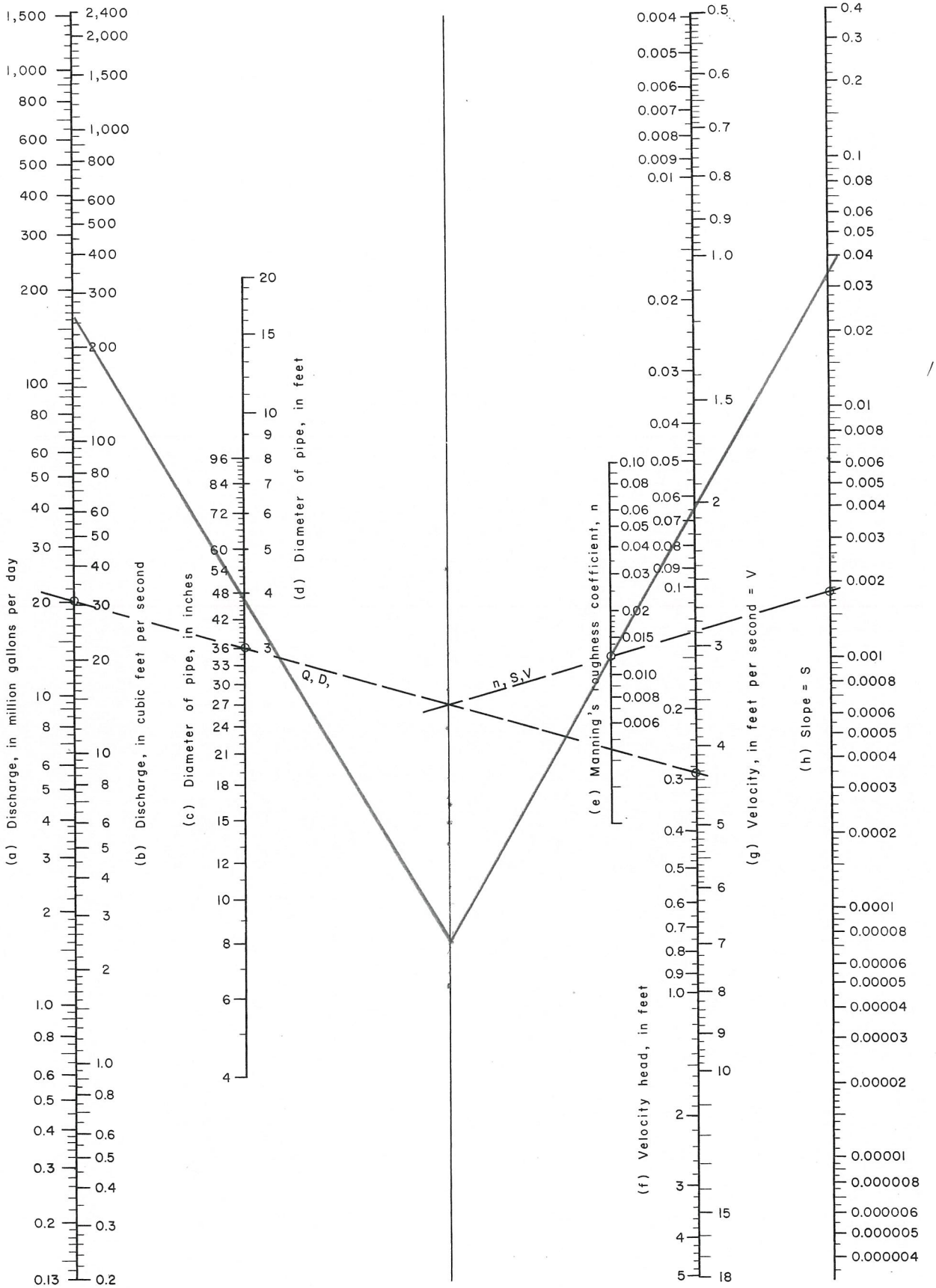


Fig. 1. Nomograph for flow in round pipe—Manning's formula