INCREMENT 1 BUILDOUT

July 16, 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).

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

These calculations estimate the minimum slope required for the flow in the leachate collection pipe.

5. Estimate of the Landfill Base Slope with Settlement

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 will still have a minimum 1% cross slope and a minimum leachate collection pipe trench slope of 0.3%. 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% and a slope along the leachate collection trench of 0.3% after settlement.

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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\SEP.D4
TEMPERATURE DATA FILE:       C:\HELP3\SET.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\SES.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\SEE.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\SESOIL.D10
OUTPUT DATA FILE:            C:\HELP3\SEHELP.OUT


TIME:   0:30     DATE:   5/10/2010


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     TITLE:  SEMINOLE ELECTRIC LANDILL BUILDOUT

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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
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                       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  =     0.2044 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.499999987000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
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              TYPE 2 - LATERAL DRAINAGE LAYER
                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  =       0.0687 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  =       0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =    33.0000000000     CM/SEC
SLOPE                       =       2.00    PERCENT
DRAINAGE LENGTH             =     200.0     FEET


                        LAYER  4
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              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       =   2 - EXCELLENT


                        LAYER  5
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              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  =       0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =    33.0000000000     CM/SEC
SLOPE                       =       2.00    PERCENT
DRAINAGE LENGTH             =     200.0     FEET
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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	=	2 - EXCELLENT	

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 COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	96.90	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.001	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	5.410	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.470	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	26.365	INCHES
TOTAL INITIAL WATER	=	26.365	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM

SEHELP.OUT

JACKSONVILLE FLORIDA

STATION LATITUDE	=	30.50 DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00
START OF GROWING SEASON (JULIAN DATE)	=	0
END OF GROWING SEASON (JULIAN DATE)	=	367
EVAPORATIVE ZONE DEPTH	=	10.0 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

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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	1.28	3.47	1.53	4.14	5.53
	9.83	11.23	8.13	0.34	1.03	1.73
RUNOFF	0.002	0.178	1.816	0.299	1.732	1.938
	4.556	6.908	4.258	0.016	0.240	0.495
EVAPOTRANSPIRATION	0.518	0.759	1.104	1.445	2.046	3.157
	3.646	4.750	3.313	0.690	0.180	0.679
LATERAL DRAINAGE COLLECTED	0.0002	0.0001	0.0002	0.0001	0.0002	0.0002
FROM LAYER 3	0.0002	0.0002	0.0002	0.0003	0.0001	0.0001
PERCOLATION/LEAKAGE THROUGH	0.0003	0.0002	0.0004	0.0003	0.0003	0.0003
LAYER 4	0.0004	0.0003	0.0004	0.0005	0.0001	0.0001

LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.0003	0.0002	0.0004	0.0003	0.0003	0.0003
	0.0004	0.0003	0.0004	0.0005	0.0001	0.0001
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	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 4	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE 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
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 1974

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.52	176127.578	100.00
RUNOFF	22.436	81442.156	46.24
EVAPOTRANSPIRATION	22.288	80904.945	45.94
DRAINAGE COLLECTED FROM LAYER 3	0.0020	7.292	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.003455	12.540	0.01
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 5	0.0035	12.539	0.01
PERC./LEAKAGE THROUGH LAYER 7	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0000		
CHANGE IN WATER STORAGE	3.791	13760.701	7.81
SOIL WATER AT START OF YEAR	26.368	95714.461	
SOIL WATER AT END OF YEAR	30.158	109475.164	
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	-0.058	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	1.174	0.735	0.493	3.699	4.791	1.290
	2.193	2.569	2.475	1.154	0.000	0.237
EVAPOTRANSPIRATION	0.971	2.259	2.845	1.888	1.666	3.355
	3.805	2.932	2.903	2.065	0.526	0.578
LATERAL DRAINAGE COLLECTED	0.0008	0.0009	0.0003	0.0015	0.0038	0.0055
FROM LAYER 3	0.0034	0.0167	0.0889	0.1440	0.1213	0.1142
PERCOLATION/LEAKAGE THROUGH	0.0010	0.0010	0.0004	0.0008	0.0019	0.0023
LAYER 4	0.0010	0.0042	0.0118	0.0162	0.0144	0.0137
LATERAL DRAINAGE COLLECTED	0.0010	0.0010	0.0004	0.0008	0.0019	0.0023
FROM LAYER 5	0.0010	0.0042	0.0118	0.0162	0.0144	0.0137
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	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 4	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 4	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	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

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ANNUAL TOTALS FOR YEAR 1975

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.15	182044.469	100.00
RUNOFF	20.809	75536.320	41.49
EVAPOTRANSPIRATION	25.793	93628.078	51.43
DRAINAGE COLLECTED FROM LAYER 3	0.5013	1819.615	1.00
PERC./LEAKAGE THROUGH LAYER 4	0.068691	249.348	0.14
AVG. HEAD ON TOP OF LAYER 4	0.0001		
DRAINAGE COLLECTED FROM LAYER 5	0.0687	249.347	0.14
PERC./LEAKAGE THROUGH LAYER 7	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0000		
CHANGE IN WATER STORAGE	2.978	10811.194	5.94
SOIL WATER AT START OF YEAR	30.158	109475.164	
SOIL WATER AT END OF YEAR	33.137	120286.359	
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	-0.086	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	0.905	0.287	1.210	0.037	5.224	1.303
	2.089	2.964	5.421	0.239	0.763	1.766
EVAPOTRANSPIRATION	0.865	1.627	1.976	0.460	4.030	2.651
	2.925	2.780	3.194	1.123	0.833	0.862
LATERAL DRAINAGE COLLECTED	0.1265	0.3252	0.3004	0.2421	0.2863	0.2598
FROM LAYER 3	0.2885	0.2233	0.1731	0.1745	0.1436	0.2444
PERCOLATION/LEAKAGE THROUGH	0.0134	0.0248	0.0247	0.0217	0.0235	0.0212
LAYER 4	0.0241	0.0205	0.0177	0.0174	0.0152	0.0213

LATERAL DRAINAGE COLLECTED	0.0134	0.0248	0.0247	0.0217	0.0235	0.0212
FROM LAYER 5	0.0241	0.0205	0.0177	0.0174	0.0152	0.0213
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	0.000	0.001	0.001	0.000	0.000	0.000
TOP OF LAYER 4	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 4	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	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

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ANNUAL TOTALS FOR YEAR 1976

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.14	182008.172	100.00
RUNOFF	22.209	80618.531	44.29
EVAPOTRANSPIRATION	23.324	84667.359	46.52
DRAINAGE COLLECTED FROM LAYER 3	2.7877	10119.417	5.56
PERC./LEAKAGE THROUGH LAYER 4	0.245556	891.369	0.49
AVG. HEAD ON TOP OF LAYER 4	0.0004		
DRAINAGE COLLECTED FROM LAYER 5	0.2456	891.368	0.49
PERC./LEAKAGE THROUGH LAYER 7	0.00000000	0.002	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0001		
CHANGE IN WATER STORAGE	1.573	5711.520	3.14
SOIL WATER AT START OF YEAR	33.137	120286.359	
SOIL WATER AT END OF YEAR	34.710	125997.875	
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	-0.023	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 2.44	3.43 7.47	1.03 7.35	1.76 2.03	3.07 1.97	1.72 4.48
RUNOFF	1.467 0.599	1.940 3.814	0.177 3.201	0.502 0.472	0.711 0.865	0.239 1.719
EVAPOTRANSPIRATION	1.150 1.228	2.227 3.557	1.443 3.793	1.017 1.087	1.657 1.120	1.669 1.156
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.3039 0.4316	0.2772 0.3134	0.3320 0.3515	0.1608 0.2579	0.1488 0.3046	0.4303 0.3381
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0234 0.0298	0.0223 0.0246	0.0260 0.0266	0.0173 0.0227	0.0156 0.0246	0.0290 0.0264
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.0234 0.0298	0.0223 0.0246	0.0260 0.0266	0.0173 0.0227	0.0156 0.0246	0.0290 0.0264
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	0.001 0.001	0.001 0.001	0.001 0.001	0.000 0.000	0.000 0.001	0.001 0.001
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 4	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
AVERAGE 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
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	15.706	57010.980	39.02
EVAPOTRANSPIRATION	21.103	76605.187	52.43
DRAINAGE COLLECTED FROM LAYER 3	3.6502	13250.101	9.07
PERC./LEAKAGE THROUGH LAYER 4	0.288371	1046.786	0.72
AVG. HEAD ON TOP OF LAYER 4	0.0005		
DRAINAGE COLLECTED FROM LAYER 5	0.2884	1046.785	0.72
PERC./LEAKAGE THROUGH LAYER 7	0.000000	0.002	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0001		
CHANGE IN WATER STORAGE	-0.497	-1805.556	-1.24
SOIL WATER AT START OF YEAR	34.710	125997.875	
SOIL WATER AT END OF YEAR	34.213	124192.320	
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	-0.026	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	2.854	1.064	1.290	1.103	5.123	0.597
	2.786	0.569	1.663	0.325	0.001	0.721
EVAPOTRANSPIRATION	1.777	2.939	2.891	1.042	3.459	1.893
	3.325	1.191	1.976	1.450	0.157	0.492
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.3258	0.3244	0.3854	0.2166	0.1527	0.2656
	0.2828	0.1979	0.2364	0.2208	0.1642	0.1122
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0249	0.0245	0.0284	0.0207	0.0160	0.0219
	0.0236	0.0179	0.0209	0.0211	0.0180	0.0129
LATERAL DRAINAGE COLLECTED	0.0249	0.0245	0.0284	0.0207	0.0160	0.0219

FROM LAYER 5	0.0236	0.0179	0.0209	0.0211	0.0180	0.0129
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	0.001	0.001	0.001	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 4	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE 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
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 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.08	156380.391	100.00
RUNOFF	18.096	65689.094	42.01
EVAPOTRANSPIRATION	22.592	82008.039	52.44
DRAINAGE COLLECTED FROM LAYER 3	2.8849	10472.351	6.70
PERC./LEAKAGE THROUGH LAYER 4	0.250849	910.583	0.58
AVG. HEAD ON TOP OF LAYER 4	0.0004		
DRAINAGE COLLECTED FROM LAYER 5	0.2508	910.581	0.58
PERC./LEAKAGE THROUGH LAYER 7	0.000000	0.002	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0001		
CHANGE IN WATER STORAGE	-0.744	-2699.693	-1.73
SOIL WATER AT START OF YEAR	34.213	124192.320	
SOIL WATER AT END OF YEAR	33.469	121492.625	
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	0.025	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	6.74	6.73	1.78	1.21	2.90
STD. DEVIATIONS	1.66	1.12	1.10	1.98	3.02	1.63
	2.65	3.16	1.83	1.21	0.97	1.30
RUNOFF						
TOTALS	1.280	0.841	0.997	1.128	3.516	1.073
	2.444	3.365	3.404	0.441	0.374	0.988
STD. DEVIATIONS	1.036	0.710	0.657	1.490	2.132	0.665
	1.429	2.311	1.478	0.431	0.415	0.710
EVAPOTRANSPIRATION						
TOTALS	1.056	1.962	2.052	1.170	2.571	2.545
	2.986	3.042	3.036	1.283	0.563	0.753
STD. DEVIATIONS	0.464	0.817	0.807	0.533	1.101	0.747
	1.039	1.293	0.674	0.513	0.417	0.264
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.1514	0.1856	0.2037	0.1242	0.1184	0.1923
	0.2013	0.1503	0.1700	0.1595	0.1468	0.1618
STD. DEVIATIONS	0.1580	0.1701	0.1882	0.1164	0.1198	0.1860
	0.1916	0.1365	0.1349	0.0990	0.1089	0.1311
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0126	0.0146	0.0160	0.0122	0.0115	0.0149
	0.0158	0.0135	0.0155	0.0156	0.0144	0.0149
STD. DEVIATIONS	0.0118	0.0128	0.0143	0.0107	0.0099	0.0128
	0.0140	0.0106	0.0100	0.0088	0.0090	0.0100
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	0.0126	0.0146	0.0160	0.0122	0.0115	0.0149
	0.0158	0.0135	0.0155	0.0156	0.0144	0.0149
STD. DEVIATIONS	0.0118	0.0128	0.0143	0.0107	0.0099	0.0128
	0.0140	0.0106	0.0100	0.0088	0.0090	0.0100

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	0.0003	0.0004	0.0004	0.0002	0.0002	0.0003
	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
STD. DEVIATIONS	0.0003	0.0003	0.0003	0.0002	0.0002	0.0003
	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001
	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	46.43	(4.511)	168533.6	100.00
RUNOFF	19.851	(2.8907)	72059.41	42.757
EVAPOTRANSPIRATION	23.020	(1.7446)	83562.71	49.582
LATERAL DRAINAGE COLLECTED FROM LAYER 3	1.96522	(1.60925)	7133.755	4.23284
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.17138	(0.12674)	622.125	0.36914
AVERAGE HEAD ON TOP OF LAYER 4	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.17138	(0.12674)	622.124	0.36914
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.001	0.00000
AVERAGE HEAD ON TOP OF LAYER 6	0.000	(0.000)		

CHANGE IN WATER STORAGE	1.420	(2.0267)	5155.63	3.059

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□
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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	5.40	19602.000
RUNOFF	4.553	16527.8633
DRAINAGE COLLECTED FROM LAYER 3	0.02209	80.19481
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001226	4.45219
AVERAGE HEAD ON TOP OF LAYER 4	0.001	
MAXIMUM HEAD ON TOP OF LAYER 4	0.005	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 5	0.00123	4.45218
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 6	0.000	
MAXIMUM HEAD ON TOP OF LAYER 6	0.005	
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)	0.3105
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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□
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FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	30.1027	0.2509
2	3.1791	0.1325
3	0.0025	0.0105
4	0.0000	0.0000
5	0.0024	0.0100
6	0.0000	0.0000
7	0.1800	0.7500
SNOW WATER	0.000	

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PBS&J	Subject: Leak Detection System		
	Comp by: JLM Check by: RGC	Date: 02/16/2010 Job Number: 100013496	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 $= 1 \times 10^{-3}\ m^2/sec.$

Thickness $=$ 200 mil. $= 0.2'' = 0.51cm$

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

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

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

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

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

Design by Wall Crushing

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

$P_S = 11{,}070$ 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

Check Design by Wall Buckling

Ref. page 37 of Driscopipe Design

$P_t = 77 psi$

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

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

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

$P_c = 15.6$

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

$P_{cb} = 173$

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

Design by Ring Deflection

Allowable Ring Deflection for SDR 17 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.

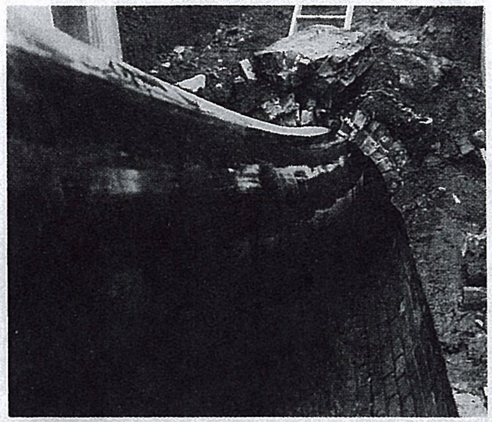
$$\% \text{ Soil Strain} = \frac{P_t}{E_{min.}} \times 100$$

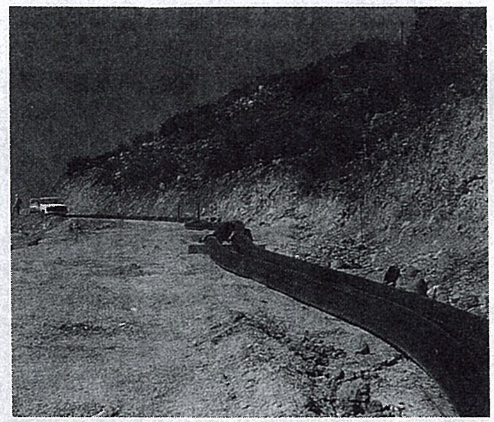
$$\% \text{ Soil Strain} = \frac{77 psi}{3000 psi} \times 100 = 2.6\%$$

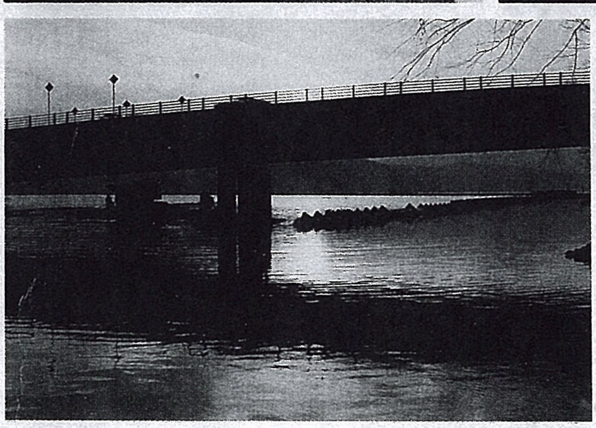
$$F.S. = \frac{4.2\%}{2.6\%} = \underline{\underline{1.6 \text{ OK}}}$$

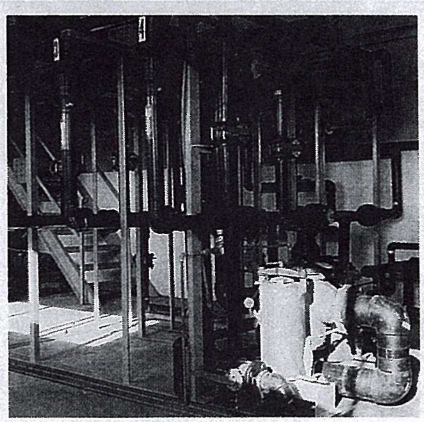
DRISCOPIPE®

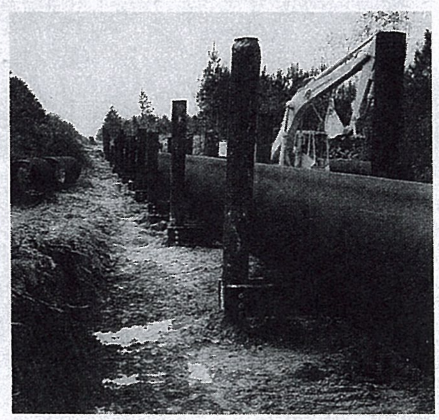
Systems Design











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 $P_t < P_{cb}$.

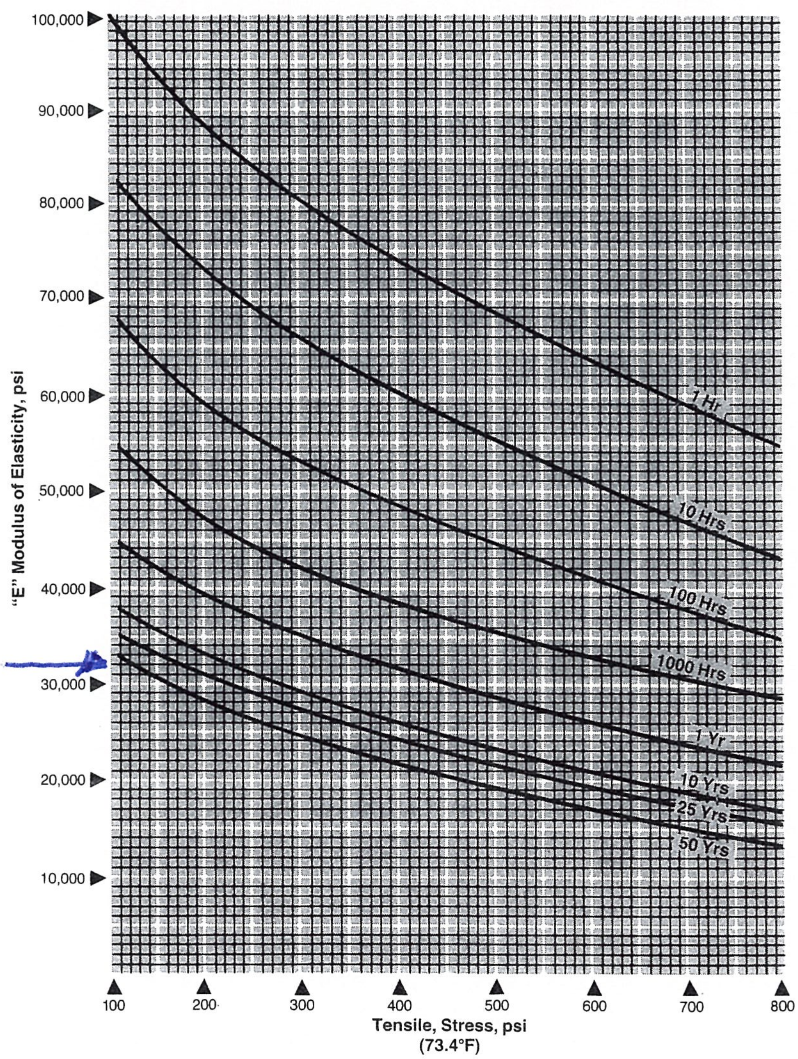
1. Calculate or estimate the total soil pressure, P_t, at the top of the pipe.
2. Calculate the stress "S_A" in the pipe wall according to the formula:

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

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.

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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:

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

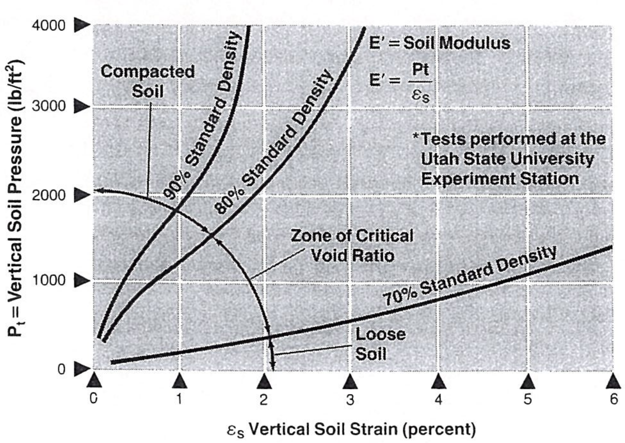
5. Calculate the soil modulus, E′, by plotting the total external soil pressure, P_t, against a specified soil density to derive the soil strain as shown in the example problem on Chart 26.
6. Calculate the critical buckling pressure at the top of the pipe by the formula:

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

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

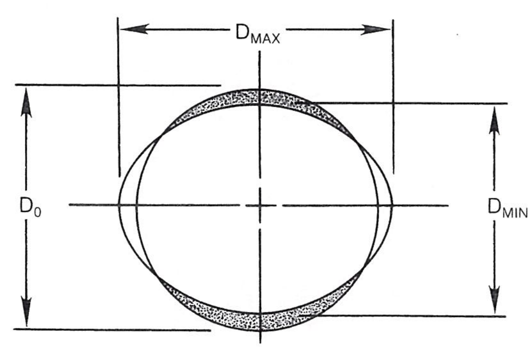
Note: The curves shown on this chart are sample curves for a granular soil. If other types of soil are used for backfill, such as clay or clay loam, curves should be developed from laboratory test data for the material used. Soil pressures greater than 4000 psf may be examined by extrapolating the slope 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 SDRs 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:

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

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

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

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.

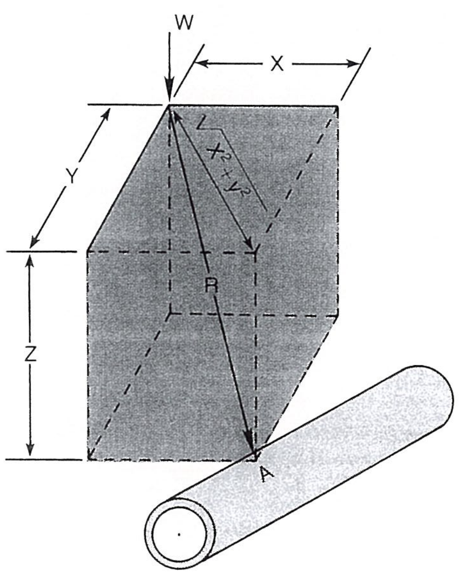
R = Straight line distance from point of load to the top of the pipe, feet.

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

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

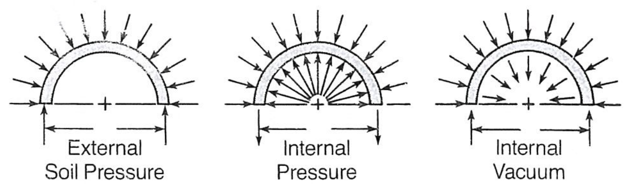
Unit underground pressures caused by a 1000 pound superimposed dynamic load is shown in Chart 28. Unit pressures for superimposed live loads can be obtained by multiplying the chart value by 1½ times the load ratio. Alternately, for heavy truck or railroad traffic, Charts 30 and 31 summarize the total 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.

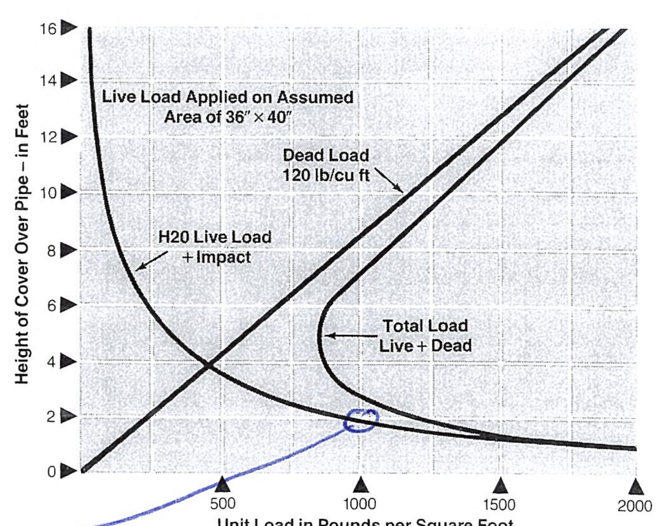
P_i: Apparent External Pressure Due to Internal Vacuum:
Positive pressure generates a tensile hoop stress in the pipe wall. Under its influence the pipe will be trying to expand. The pressure of the soil around the pipe will be trying to crush the pipe as shown in this illustration.



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.

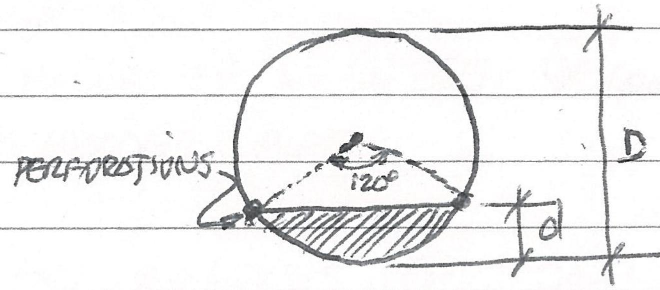
1000 PSF/144 = 7 psi

HEADER PIPE FLOW / SLOPE CALCULATIONS

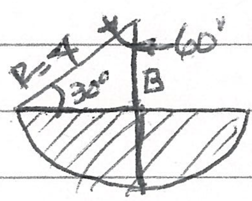
PERFORMANCE PIPE

$$Q = 98.3 \times A \times R_h^{2/3} \times S^{1/2}$$

WHERE Q = 14 CFS



8" PARTIALLY FILLED HDPE PIPE



$\cos 60° = 4/B \Rightarrow B = 4\cos 60°$

$B = 2"$

$$\frac{d}{D} = \frac{2}{8} = 0.25$$

FROM TABLE:

$$\frac{A}{D^2} = 0.1535 \Longrightarrow A = 0.1535 \times 64 = 9.824$$

FROM TABLE:

$$\frac{R_h}{D} = 0.1466 \longrightarrow R_h = 0.1466 \times 8 = 1.1728$$

FROM EQUATION ABOVE

$$\therefore S = \left[\frac{Q}{98.3 \times A \times R^{2/3}}\right]^2 = \left[\frac{14 \times 7.48}{98.3 \times 9.824 \times (1.1728)^{2/3}}\right]^2$$

$S = 0.0095$ OR 0.95%