389607

FINAL (100%) DESIGN REPORT

VOLUME 2 OF 3

PJP LANDFILL SITE
JERSEY CITY, NEW JERSEY

Prepared for:

Waste Management of New Jersey and CWM Chemical Services, LLC

Prepared by:

Golder Associates

PROJECT No. 003-6004-002

APRIL 2007

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Golder Associates

FINAL (100 PERCENT) DESIGN REPORT
PJP LANDFILL SITE
JERSEY CITY, NEW JERSEY

VOLUME 2 OF 3

Prepared for:

CWM Chemical Services, L.L.C.
and
Waste Management of New Jersey, Inc. (WMNJ)

Submitted by:

Golder Associates Inc.
200 Century Parkway, Suite C
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April 2007

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Responses to the Pre-Final (90%) Remedial Design Report (PFDR) Comments

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APPENDIX A

LANDFILL GAS MANAGEMENT CALCULATIONS

APPENDIX A-1

LANDFILL GAS GENERATION CALCULATIONS

Golder Associates	SUBJECT PJP LANDFILL GAS EMISSIONS RATES		
	Job No. 003-6004-002	Made by EMM	Date
	Ref. 10	Checked ATP	Sheet 1 of 2
		Reviewed BGE	

LANDFILL GAS MODELING USEPA LANDGEM v. 2.1

1.) REFUSE ESTIMATION

JUL 9 2001

- EXTENT OF WASTE DEFINED TO BE ~ 84 ACRES
- DEPTH OF WASTE FROM 10-30 FEET DEEP
  - USE 20 FEET DEPTH
- USING WASTE ESTIMATION TOOL, (USEPA Landgem v.2.1 PROGRAM) ESTIMATED REFUSE IN PLACE ≈ 1.32×10^6 Mg ≈ 40 lbs/ft³ (see page 2)
- PLANT REC'D WASTE FROM 1968-1974 (ANYTHING PRIOR CONSERVATIVE @ 1968)
- LACKING DISPOSAL RECORDS, ASSUMED:

$$1974-1968 = 6\text{ yrs} \quad \frac{1.32 \times 10^6 \text{ Mg}}{6 \text{ yrs.}} = \frac{2.20 \times 10^5 \text{ Mg}}{y}$$

— DISPOSAL RATE —

SET KNOWN HAP CONCENTRATIONS SOURCE: LAB DATA, AIR TOXICS, 6/14/01

CHLOROFORM — N.D. - DETECTION LIMIT = 67 ppbV (greater than detects) = 0.07 ppmV
CARBON TETRACHLORIDE — N.D. - DETECTION LIMIT - 67 ppbV = 0.07 ppmV
BENZENE - 6000 ppbV max - 6 ppmV
1,2-DICHLOROETHANE - N.D. DETECTION LIMIT = 67 ppbV = 0.07 ppmV
TRICHLOROETHENE - N.D. - DETECTION LIMIT 67 ppbV - 0.07 ppmV
TETRACHLOROETHENE - N.D. - NOT ON LIST
ETHYLENE DIBROMIDE - N.D. - DETECTION LIMIT 0.07 ppmV
1,1,2,2-PCA - N.D. - DETECTION LIMIT 0.07 ppmV
1,4-DIOXANE - N.D - WORST CASE DETECTION LIMIT 0.270 ppmV
- NOT ON LIST

ALL OTHER HAPS SET AT "CAA" (CLEAN AIR ACT) STANDARDS/DEFAULTS (MORE CONSERVATIVE THAN AP-42)

METHANE CONCENTRATIONS
HIGHEST DETECTED FROM VENT = 33%. SET TO 40% (CONSERVATIVE)

CARBON MONOXIDE - NOT DETECTED - REPT. LIMIT = $\frac{0.0017\%}{100/10^6}$ = 17 ppmV

Golder Associates	SUBJECT PJP LANDFILL GAS EMISSIONS RATES		
	Job No. 003-6004-002 Ref. 10	Made by EMM Checked ARP Reviewed	Date Sheet 2 of 2

ETHANE = $\frac{0.0017 \times 10^6}{100\%}$ = 17 ppm = RL (REPORTING LIMIT ✓ppm

PROPANE = " = 17 ppm = RL ✓ppm

ISOBUTANE (NOT LISTED)

BUTANE = 17 ppm = RL

NEOPENTANE = (NOT LISTED)

ISOPENTANE = ~~17 ppm = RL~~ (NOT LISTED)

PENTANE = 17 ppm = RL

C6+ NOT LISTED/ND

DEFAULTS:
RAN MODEL WITH AP-42, NOT CAA PER BILL CUSTER.
MORE REALISTIC, CAA PARAMETERS NOT IDEALISTIC.

Calculation addition
Date: 9/29/03
Made by: ARP
Checked by:
Reviewed by:

USEPA's Landgem V.2.1 model has an internal program which estimates the amount of waste placed in the landfill for a given volume of landfill, see attached printout of refuse estimator.

Check of waste density used by refuse estimator:

Landfill size = 84 acres Landfill depth = 20 ft

volume of land fill = 84 acres × $\frac{43,560\ ft^2}{acre}$ × 20 ft = 73,180,800 ft^3

estimated refuse placed from model = 1.3179×10^6 Mg

waste density = $\frac{\text{amount of refuse}}{\text{volume of landfill}}$ = $\frac{1.3179 \times 10^6\ Mg}{73,180,800\ ft^3} \left| \frac{1.102311\ tons}{Mg} \right| \frac{2000\ lb}{ton}$

waste density = 39.7 lb/ft^3 ≈ 40 lb/ft^3

C:\LandGEM

File Edit View Favorites Tools Help

Landfill Gas Emissions Model

File Edit Defaults Parameters Reports Utilities Window Help

Year Opened 1993 | Current Year 2003 | Capacity 0 Mg

Waste Value 0 as ◆ Refuse in Place (Mg) ◇ Acceptance Rate (Mg/Yr)

Operating Parameters: \LANDF

Year	Acceptance Rate	
1993	0.000000E+00	
1994	0.000000E+00	
1995	0.000000E+00	
1996	0.000000E+00	
1997	0.000000E+00	
1998	0.000000E+00	
1999	0.000000E+00	
2000	0.000000E+00	
2001	0.000000E+00	0.000000E+00

Refuse Estimator

Landfill Size (Acres) 84

Landfill Depth (Feet) 20

Estimated Refuse In Place (Mg) 1.317949E+06

Estimate | Ok | Help

Date Created: 9/11/1998 12:15 PM Size: 182 KB | 182 KB | My Computer

Programs

Source: G:\PROJECTS\MURPHY~1\PJP.PRM

Model Parameters

Lo : 100.00 m^3 / Mg
k : 0.0400 1/yr
NMOC : 2420.00 ppmv
Methane : 40.0000 % volume
Carbon Dioxide : 60.0000 % volume

Landfill Parameters

Landfill type : Co-Disposal
Year Opened : 1968 Current Year : 1974 Closure Year: 1974
Capacity : 1320000 Mg
Average Acceptance Rate Required from
Current Year to Closure Year : 0.00 Mg/year

Model Results

Year	Refuse In Place (Mg)	Methane Emission Rate (Mg/yr)	Methane Emission Rate (Cubic m/yr)
1969	2.200E+05	5.871E+02	8.800E+05
1970	4.400E+05	1.151E+03	1.725E+06
1971	6.600E+05	1.693E+03	2.538E+06
1972	8.800E+05	2.214E+03	3.318E+06
1973	1.100E+06	2.714E+03	4.068E+06
1974	1.320E+06	3.195E+03	4.789E+06
1975	1.320E+06	3.070E+03	4.601E+06
1976	1.320E+06	2.949E+03	4.421E+06
1977	1.320E+06	2.834E+03	4.247E+06
1978	1.320E+06	2.722E+03	4.081E+06
1979	1.320E+06	2.616E+03	3.921E+06
1980	1.320E+06	2.513E+03	3.767E+06
1981	1.320E+06	2.415E+03	3.619E+06
1982	1.320E+06	2.320E+03	3.477E+06
1983	1.320E+06	2.229E+03	3.341E+06
1984	1.320E+06	2.142E+03	3.210E+06
1985	1.320E+06	2.058E+03	3.084E+06
1986	1.320E+06	1.977E+03	2.963E+06
1987	1.320E+06	1.899E+03	2.847E+06
1988	1.320E+06	1.825E+03	2.735E+06
1989	1.320E+06	1.753E+03	2.628E+06
1990	1.320E+06	1.685E+03	2.525E+06
1991	1.320E+06	1.619E+03	2.426E+06
1992	1.320E+06	1.555E+03	2.331E+06
1993	1.320E+06	1.494E+03	2.240E+06
1994	1.320E+06	1.436E+03	2.152E+06
1995	1.320E+06	1.379E+03	2.067E+06
1996	1.320E+06	1.325E+03	1.986E+06
1997	1.320E+06	1.273E+03	1.908E+06
1998	1.320E+06	1.223E+03	1.834E+06
1999	1.320E+06	1.175E+03	1.762E+06
2000	1.320E+06	1.129E+03	1.693E+06
2001	1.320E+06	1.085E+03	1.626E+06
2002	1.320E+06	1.042E+03	1.562E+06
2003	1.320E+06	1.002E+03	1.501E+06
2004	1.320E+06	9.622E+02	1.442E+06
2005	1.320E+06	9.245E+02	1.386E+06

2006	1.320E+06	8.883E+02	1.331E+06
2007	1.320E+06	8.534E+02	1.279E+06
2008	1.320E+06	8.200E+02	1.229E+06
2009	1.320E+06	7.878E+02	1.181E+06
2010	1.320E+06	7.569E+02	1.135E+06
2011	1.320E+06	7.273E+02	1.090E+06
2012	1.320E+06	6.987E+02	1.047E+06
2013	1.320E+06	6.713E+02	1.006E+06
2014	1.320E+06	6.450E+02	9.668E+05
2015	1.320E+06	6.197E+02	9.289E+05
2016	1.320E+06	5.954E+02	8.925E+05
2017	1.320E+06	5.721E+02	8.575E+05
2018	1.320E+06	5.496E+02	8.239E+05
2019	1.320E+06	5.281E+02	7.916E+05
2020	1.320E+06	5.074E+02	7.605E+05
2021	1.320E+06	4.875E+02	7.307E+05
2022	1.320E+06	4.684E+02	7.021E+05
2023	1.320E+06	4.500E+02	6.745E+05
2024	1.320E+06	4.324E+02	6.481E+05
2025	1.320E+06	4.154E+02	6.227E+05
2026	1.320E+06	3.991E+02	5.983E+05
2027	1.320E+06	3.835E+02	5.748E+05
2028	1.320E+06	3.684E+02	5.523E+05
2029	1.320E+06	3.540E+02	5.306E+05
2030	1.320E+06	3.401E+02	5.098E+05
2031	1.320E+06	3.268E+02	4.898E+05
2032	1.320E+06	3.140E+02	4.706E+05
2033	1.320E+06	3.017E+02	4.521E+05
2034	1.320E+06	2.898E+02	4.344E+05
2035	1.320E+06	2.785E+02	4.174E+05
2036	1.320E+06	2.675E+02	4.010E+05
2037	1.320E+06	2.571E+02	3.853E+05
2038	1.320E+06	2.470E+02	3.702E+05
2039	1.320E+06	2.373E+02	3.557E+05
2040	1.320E+06	2.280E+02	3.417E+05
2041	1.320E+06	2.190E+02	3.283E+05
2042	1.320E+06	2.105E+02	3.155E+05
2043	1.320E+06	2.022E+02	3.031E+05
2044	1.320E+06	1.943E+02	2.912E+05
2045	1.320E+06	1.867E+02	2.798E+05
2046	1.320E+06	1.793E+02	2.688E+05
2047	1.320E+06	1.723E+02	2.583E+05
2048	1.320E+06	1.655E+02	2.481E+05
2049	1.320E+06	1.591E+02	2.384E+05
2050	1.320E+06	1.528E+02	2.291E+05
2051	1.320E+06	1.468E+02	2.201E+05
2052	1.320E+06	1.411E+02	2.115E+05
2053	1.320E+06	1.355E+02	2.032E+05
2054	1.320E+06	1.302E+02	1.952E+05
2055	1.320E+06	1.251E+02	1.875E+05
2056	1.320E+06	1.202E+02	1.802E+05
2057	1.320E+06	1.155E+02	1.731E+05
2058	1.320E+06	1.110E+02	1.663E+05
2059	1.320E+06	1.066E+02	1.598E+05
2060	1.320E+06	1.024E+02	1.535E+05
2061	1.320E+06	9.842E+01	1.475E+05
2062	1.320E+06	9.456E+01	1.417E+05
2063	1.320E+06	9.086E+01	1.362E+05
2064	1.320E+06	8.729E+01	1.308E+05
2065	1.320E+06	8.387E+01	1.257E+05
2066	1.320E+06	8.058E+01	1.208E+05
2067	1.320E+06	7.742E+01	1.160E+05
2068	1.320E+06	7.439E+01	1.115E+05

2069	1.320E+06	7.147E+01	1.071E+05
2070	1.320E+06	6.867E+01	1.029E+05
2071	1.320E+06	6.597E+01	9.889E+04
2072	1.320E+06	6.339E+01	9.501E+04
2073	1.320E+06	6.090E+01	9.129E+04
2074	1.320E+06	5.851E+01	8.771E+04
2075	1.320E+06	5.622E+01	8.427E+04
2076	1.320E+06	5.402E+01	8.096E+04
2077	1.320E+06	5.190E+01	7.779E+04
2078	1.320E+06	4.986E+01	7.474E+04
2079	1.320E+06	4.791E+01	7.181E+04
2080	1.320E+06	4.603E+01	6.899E+04
2081	1.320E+06	4.422E+01	6.629E+04
2082	1.320E+06	4.249E+01	6.369E+04
2083	1.320E+06	4.082E+01	6.119E+04
2084	1.320E+06	3.922E+01	5.879E+04
2085	1.320E+06	3.769E+01	5.649E+04
2086	1.320E+06	3.621E+01	5.427E+04
2087	1.320E+06	3.479E+01	5.214E+04
2088	1.320E+06	3.342E+01	5.010E+04
2089	1.320E+06	3.211E+01	4.814E+04
2090	1.320E+06	3.085E+01	4.625E+04
2091	1.320E+06	2.964E+01	4.443E+04
2092	1.320E+06	2.848E+01	4.269E+04
2093	1.320E+06	2.737E+01	4.102E+04
2094	1.320E+06	2.629E+01	3.941E+04
2095	1.320E+06	2.526E+01	3.786E+04
2096	1.320E+06	2.427E+01	3.638E+04
2097	1.320E+06	2.332E+01	3.495E+04
2098	1.320E+06	2.240E+01	3.358E+04
2099	1.320E+06	2.153E+01	3.227E+04
2100	1.320E+06	2.068E+01	3.100E+04
2101	1.320E+06	1.987E+01	2.979E+04
2102	1.320E+06	1.909E+01	2.862E+04
2103	1.320E+06	1.834E+01	2.750E+04
2104	1.320E+06	1.762E+01	2.642E+04
2105	1.320E+06	1.693E+01	2.538E+04
2106	1.320E+06	1.627E+01	2.439E+04
2107	1.320E+06	1.563E+01	2.343E+04
2108	1.320E+06	1.502E+01	2.251E+04
2109	1.320E+06	1.443E+01	2.163E+04
2110	1.320E+06	1.386E+01	2.078E+04
2111	1.320E+06	1.332E+01	1.997E+04
2112	1.320E+06	1.280E+01	1.918E+04
2113	1.320E+06	1.230E+01	1.843E+04
2114	1.320E+06	1.181E+01	1.771E+04
2115	1.320E+06	1.135E+01	1.701E+04
2116	1.320E+06	1.091E+01	1.635E+04
2117	1.320E+06	1.048E+01	1.571E+04
2118	1.320E+06	1.007E+01	1.509E+04
2119	1.320E+06	9.672E+00	1.450E+04
2120	1.320E+06	9.293E+00	1.393E+04
2121	1.320E+06	8.929E+00	1.338E+04
2122	1.320E+06	8.579E+00	1.286E+04
2123	1.320E+06	8.242E+00	1.235E+04
2124	1.320E+06	7.919E+00	1.187E+04
2125	1.320E+06	7.609E+00	1.140E+04
2126	1.320E+06	7.310E+00	1.096E+04
2127	1.320E+06	7.024E+00	1.053E+04
2128	1.320E+06	6.748E+00	1.011E+04
2129	1.320E+06	6.484E+00	9.718E+03
2130	1.320E+06	6.229E+00	9.337E+03
2131	1.320E+06	5.985E+00	8.971E+03

2132	1.320E+06	5.750E+00	8.619E+03
2133	1.320E+06	5.525E+00	8.281E+03
2134	1.320E+06	5.308E+00	7.957E+03
2135	1.320E+06	5.100E+00	7.645E+03
2136	1.320E+06	4.900E+00	7.345E+03
2137	1.320E+06	4.708E+00	7.057E+03
2138	1.320E+06	4.523E+00	6.780E+03
2139	1.320E+06	4.346E+00	6.514E+03
2140	1.320E+06	4.176E+00	6.259E+03
2141	1.320E+06	4.012E+00	6.014E+03
2142	1.320E+06	3.855E+00	5.778E+03
2143	1.320E+06	3.703E+00	5.551E+03
2144	1.320E+06	3.558E+00	5.334E+03
2145	1.320E+06	3.419E+00	5.124E+03
2146	1.320E+06	3.285E+00	4.923E+03
2147	1.320E+06	3.156E+00	4.730E+03
2148	1.320E+06	3.032E+00	4.545E+03
2149	1.320E+06	2.913E+00	4.367E+03
2150	1.320E+06	2.799E+00	4.196E+03
2151	1.320E+06	2.689E+00	4.031E+03
2152	1.320E+06	2.584E+00	3.873E+03
2153	1.320E+06	2.483E+00	3.721E+03
2154	1.320E+06	2.385E+00	3.575E+03
2155	1.320E+06	2.292E+00	3.435E+03
2156	1.320E+06	2.202E+00	3.300E+03
2157	1.320E+06	2.115E+00	3.171E+03
2158	1.320E+06	2.033E+00	3.047E+03
2159	1.320E+06	1.953E+00	2.927E+03
2160	1.320E+06	1.876E+00	2.812E+03
2161	1.320E+06	1.803E+00	2.702E+03
2162	1.320E+06	1.732E+00	2.596E+03
2163	1.320E+06	1.664E+00	2.494E+03
2164	1.320E+06	1.599E+00	2.397E+03
2165	1.320E+06	1.536E+00	2.303E+03
2166	1.320E+06	1.476E+00	2.212E+03
2167	1.320E+06	1.418E+00	2.126E+03
2168	1.320E+06	1.362E+00	2.042E+03
2169	1.320E+06	1.309E+00	1.962E+03
2170	1.320E+06	1.258E+00	1.885E+03
2171	1.320E+06	1.208E+00	1.811E+03
2172	1.320E+06	1.161E+00	1.740E+03
2173	1.320E+06	1.115E+00	1.672E+03

Source: G:\PROJECTS\MURPHY~1\PJP.PRM

Model Parameters

Lo : 100.00 m^3 / Mg
k : 0.0400 1/yr
NMOC : 2420.00 ppmv
Methane : 40.0000 % volume
Carbon Dioxide : 60.0000 % volume

Landfill Parameters

Landfill type : Co-Disposal
Year Opened : 1968 Current Year : 1974 Closure Year: 1974
Capacity : 1320000 Mg
Average Acceptance Rate Required from
Current Year to Closure Year : 0.00 Mg/year

Model Results

Year	Refuse In Place (Mg)	NMOC Emission Rate (Mg/yr)	NMOC Emission Rate (Cubic m/yr)
1969	2.200E+05	1.908E+01	5.324E+03
1970	4.400E+05	3.742E+01	1.044E+04
1971	6.600E+05	5.504E+01	1.535E+04
1972	8.800E+05	7.196E+01	2.008E+04
1973	1.100E+06	8.822E+01	2.461E+04
1974	1.320E+06	1.038E+02	2.897E+04
1975	1.320E+06	9.978E+01	2.784E+04
1976	1.320E+06	9.586E+01	2.674E+04
1977	1.320E+06	9.210E+01	2.570E+04
1978	1.320E+06	8.849E+01	2.469E+04
1979	1.320E+06	8.502E+01	2.372E+04
1980	1.320E+06	8.169E+01	2.279E+04
1981	1.320E+06	7.849E+01	2.190E+04
1982	1.320E+06	7.541E+01	2.104E+04
1983	1.320E+06	7.245E+01	2.021E+04
1984	1.320E+06	6.961E+01	1.942E+04
1985	1.320E+06	6.688E+01	1.866E+04
1986	1.320E+06	6.426E+01	1.793E+04
1987	1.320E+06	6.174E+01	1.722E+04
1988	1.320E+06	5.932E+01	1.655E+04
1989	1.320E+06	5.699E+01	1.590E+04
1990	1.320E+06	5.476E+01	1.528E+04
1991	1.320E+06	5.261E+01	1.468E+04
1992	1.320E+06	5.055E+01	1.410E+04
1993	1.320E+06	4.857E+01	1.355E+04
1994	1.320E+06	4.666E+01	1.302E+04
1995	1.320E+06	4.483E+01	1.251E+04
1996	1.320E+06	4.307E+01	1.202E+04
1997	1.320E+06	4.139E+01	1.155E+04
1998	1.320E+06	3.976E+01	1.109E+04
1999	1.320E+06	3.820E+01	1.066E+04
2000	1.320E+06	3.671E+01	1.024E+04
2001	1.320E+06	3.527E+01	9.839E+03
2002	1.320E+06	3.388E+01	9.453E+03
2003	1.320E+06	3.255E+01	9.082E+03
2004	1.320E+06	3.128E+01	8.726E+03
2005	1.320E+06	3.005E+01	8.384E+03

2006	1.320E+06	2.887E+01	8.055E+03
2007	1.320E+06	2.774E+01	7.739E+03
2008	1.320E+06	2.665E+01	7.436E+03
2009	1.320E+06	2.561E+01	7.144E+03
2010	1.320E+06	2.460E+01	6.864E+03
2011	1.320E+06	2.364E+01	6.595E+03
2012	1.320E+06	2.271E+01	6.336E+03
2013	1.320E+06	2.182E+01	6.088E+03
2014	1.320E+06	2.097E+01	5.849E+03
2015	1.320E+06	2.014E+01	5.620E+03
2016	1.320E+06	1.935E+01	5.400E+03
2017	1.320E+06	1.860E+01	5.188E+03
2018	1.320E+06	1.787E+01	4.984E+03
2019	1.320E+06	1.717E+01	4.789E+03
2020	1.320E+06	1.649E+01	4.601E+03
2021	1.320E+06	1.585E+01	4.421E+03
2022	1.320E+06	1.522E+01	4.247E+03
2023	1.320E+06	1.463E+01	4.081E+03
2024	1.320E+06	1.405E+01	3.921E+03
2025	1.320E+06	1.350E+01	3.767E+03
2026	1.320E+06	1.297E+01	3.619E+03
2027	1.320E+06	1.247E+01	3.478E+03
2028	1.320E+06	1.198E+01	3.341E+03
2029	1.320E+06	1.151E+01	3.210E+03
2030	1.320E+06	1.106E+01	3.084E+03
2031	1.320E+06	1.062E+01	2.963E+03
2032	1.320E+06	1.021E+01	2.847E+03
2033	1.320E+06	9.805E+00	2.736E+03
2034	1.320E+06	9.421E+00	2.628E+03
2035	1.320E+06	9.051E+00	2.525E+03
2036	1.320E+06	8.697E+00	2.426E+03
2037	1.320E+06	8.356E+00	2.331E+03
2038	1.320E+06	8.028E+00	2.240E+03
2039	1.320E+06	7.713E+00	2.152E+03
2040	1.320E+06	7.411E+00	2.067E+03
2041	1.320E+06	7.120E+00	1.986E+03
2042	1.320E+06	6.841E+00	1.908E+03
2043	1.320E+06	6.573E+00	1.834E+03
2044	1.320E+06	6.315E+00	1.762E+03
2045	1.320E+06	6.067E+00	1.693E+03
2046	1.320E+06	5.829E+00	1.626E+03
2047	1.320E+06	5.601E+00	1.563E+03
2048	1.320E+06	5.381E+00	1.501E+03
2049	1.320E+06	5.170E+00	1.442E+03
2050	1.320E+06	4.968E+00	1.386E+03
2051	1.320E+06	4.773E+00	1.332E+03
2052	1.320E+06	4.586E+00	1.279E+03
2053	1.320E+06	4.406E+00	1.229E+03
2054	1.320E+06	4.233E+00	1.181E+03
2055	1.320E+06	4.067E+00	1.135E+03
2056	1.320E+06	3.908E+00	1.090E+03
2057	1.320E+06	3.754E+00	1.047E+03
2058	1.320E+06	3.607E+00	1.006E+03
2059	1.320E+06	3.466E+00	9.669E+02
2060	1.320E+06	3.330E+00	9.290E+02
2061	1.320E+06	3.199E+00	8.925E+02
2062	1.320E+06	3.074E+00	8.575E+02
2063	1.320E+06	2.953E+00	8.239E+02
2064	1.320E+06	2.838E+00	7.916E+02
2065	1.320E+06	2.726E+00	7.606E+02
2066	1.320E+06	2.619E+00	7.308E+02
2067	1.320E+06	2.517E+00	7.021E+02
2068	1.320E+06	2.418E+00	6.746E+02

2069	1.320E+06	2.323E+00	6.481E+02
2070	1.320E+06	2.232E+00	6.227E+02
2071	1.320E+06	2.145E+00	5.983E+02
2072	1.320E+06	2.060E+00	5.748E+02
2073	1.320E+06	1.980E+00	5.523E+02
2074	1.320E+06	1.902E+00	5.306E+02
2075	1.320E+06	1.827E+00	5.098E+02
2076	1.320E+06	1.756E+00	4.898E+02
2077	1.320E+06	1.687E+00	4.706E+02
2078	1.320E+06	1.621E+00	4.522E+02
2079	1.320E+06	1.557E+00	4.344E+02
2080	1.320E+06	1.496E+00	4.174E+02
2081	1.320E+06	1.438E+00	4.010E+02
2082	1.320E+06	1.381E+00	3.853E+02
2083	1.320E+06	1.327E+00	3.702E+02
2084	1.320E+06	1.275E+00	3.557E+02
2085	1.320E+06	1.225E+00	3.417E+02
2086	1.320E+06	1.177E+00	3.283E+02
2087	1.320E+06	1.131E+00	3.155E+02
2088	1.320E+06	1.086E+00	3.031E+02
2089	1.320E+06	1.044E+00	2.912E+02
2090	1.320E+06	1.003E+00	2.798E+02
2091	1.320E+06	9.636E-01	2.688E+02
2092	1.320E+06	9.258E-01	2.583E+02
2093	1.320E+06	8.895E-01	2.482E+02
2094	1.320E+06	8.546E-01	2.384E+02
2095	1.320E+06	8.211E-01	2.291E+02
2096	1.320E+06	7.889E-01	2.201E+02
2097	1.320E+06	7.580E-01	2.115E+02
2098	1.320E+06	7.283E-01	2.032E+02
2099	1.320E+06	6.997E-01	1.952E+02
2100	1.320E+06	6.723E-01	1.876E+02
2101	1.320E+06	6.459E-01	1.802E+02
2102	1.320E+06	6.206E-01	1.731E+02
2103	1.320E+06	5.963E-01	1.663E+02
2104	1.320E+06	5.729E-01	1.598E+02
2105	1.320E+06	5.504E-01	1.536E+02
2106	1.320E+06	5.288E-01	1.475E+02
2107	1.320E+06	5.081E-01	1.418E+02
2108	1.320E+06	4.882E-01	1.362E+02
2109	1.320E+06	4.690E-01	1.309E+02
2110	1.320E+06	4.506E-01	1.257E+02
2111	1.320E+06	4.330E-01	1.208E+02
2112	1.320E+06	4.160E-01	1.161E+02
2113	1.320E+06	3.997E-01	1.115E+02
2114	1.320E+06	3.840E-01	1.071E+02
2115	1.320E+06	3.690E-01	1.029E+02
2116	1.320E+06	3.545E-01	9.890E+01
2117	1.320E+06	3.406E-01	9.502E+01
2118	1.320E+06	3.272E-01	9.129E+01
2119	1.320E+06	3.144E-01	8.771E+01
2120	1.320E+06	3.021E-01	8.427E+01
2121	1.320E+06	2.902E-01	8.097E+01
2122	1.320E+06	2.789E-01	7.779E+01
2123	1.320E+06	2.679E-01	7.474E+01
2124	1.320E+06	2.574E-01	7.181E+01
2125	1.320E+06	2.473E-01	6.900E+01
2126	1.320E+06	2.376E-01	6.629E+01
2127	1.320E+06	2.283E-01	6.369E+01
2128	1.320E+06	2.194E-01	6.120E+01
2129	1.320E+06	2.108E-01	5.880E+01
2130	1.320E+06	2.025E-01	5.649E+01
2131	1.320E+06	1.945E-01	5.428E+01

2132	1.320E+06	1.869E-01	5.215E+01
2133	1.320E+06	1.796E-01	5.010E+01
2134	1.320E+06	1.725E-01	4.814E+01
2135	1.320E+06	1.658E-01	4.625E+01
2136	1.320E+06	1.593E-01	4.444E+01
2137	1.320E+06	1.530E-01	4.269E+01
2138	1.320E+06	1.470E-01	4.102E+01
2139	1.320E+06	1.413E-01	3.941E+01
2140	1.320E+06	1.357E-01	3.787E+01
2141	1.320E+06	1.304E-01	3.638E+01
2142	1.320E+06	1.253E-01	3.496E+01
2143	1.320E+06	1.204E-01	3.358E+01
2144	1.320E+06	1.157E-01	3.227E+01
2145	1.320E+06	1.111E-01	3.100E+01
2146	1.320E+06	1.068E-01	2.979E+01
2147	1.320E+06	1.026E-01	2.862E+01
2148	1.320E+06	9.856E-02	2.750E+01
2149	1.320E+06	9.470E-02	2.642E+01
2150	1.320E+06	9.098E-02	2.538E+01
2151	1.320E+06	8.742E-02	2.439E+01
2152	1.320E+06	8.399E-02	2.343E+01
2153	1.320E+06	8.070E-02	2.251E+01
2154	1.320E+06	7.753E-02	2.163E+01
2155	1.320E+06	7.449E-02	2.078E+01
2156	1.320E+06	7.157E-02	1.997E+01
2157	1.320E+06	6.876E-02	1.918E+01
2158	1.320E+06	6.607E-02	1.843E+01
2159	1.320E+06	6.348E-02	1.771E+01
2160	1.320E+06	6.099E-02	1.701E+01
2161	1.320E+06	5.860E-02	1.635E+01
2162	1.320E+06	5.630E-02	1.571E+01
2163	1.320E+06	5.409E-02	1.509E+01
2164	1.320E+06	5.197E-02	1.450E+01
2165	1.320E+06	4.993E-02	1.393E+01
2166	1.320E+06	4.798E-02	1.338E+01
2167	1.320E+06	4.609E-02	1.286E+01
2168	1.320E+06	4.429E-02	1.236E+01
2169	1.320E+06	4.255E-02	1.187E+01
2170	1.320E+06	4.088E-02	1.141E+01
2171	1.320E+06	3.928E-02	1.096E+01
2172	1.320E+06	3.774E-02	1.053E+01
2173	1.320E+06	3.626E-02	1.012E+01

APPENDIX A-2

RADIUS OF INFLUENCE CALCULATIONS

Golder Associates	SUBJECT PJP - ROI Calculations		
	Job No. 003-6004-002 Ref.	Made by NK/DNB Checked BEB Reviewed JA	Date 3/6/2007 Sheet 1 of 2

$$ROI = \sqrt{\frac{Q}{\phi \times D \times GGR \times \gamma_{waste}}}$$

where,

$\phi = P_i$

D = Depth of waste = 20 feet, See gas modeling assumptions

GGR = landfill gas generation rate ($ft^3/lb/day$)

γ_{waste} = waste density = 40 lb/ft^3

Q = flow rate per vent (ft^3/day) ≈ 5 ft^3/min

$$GGR = \frac{\text{Gas generated per day in } ft^3/day}{\text{lbs of waste in landfill}}$$

From model @ 2007 = 3.20×10^6 m^3/yr @ 40% methane ✓

$$\frac{3.20 \times 10^6 m^3/yr \times 35.3\ ft^3/m^3}{365\ days/yr} = 309480\ ft^3/day \text{ as gas}$$

using 40 lb/ft^3 for waste density, Average waste at 20 feet

$$\# \text{ lbs waste} = 43560 \frac{ft^2}{acre} \times 40\ lb/ft^3 \times 20 ft \times 84\ acre$$

$$= 2.93 \times 10^9 \text{ lbs of waste} ✓$$

$$\therefore GGR = 309{,}480\ ft^3/day \,/\, 2.93 \times 10^9 \text{ lbs}$$

$$= 0.000106 \frac{ft^3}{day \cdot lb} ✓$$

Golder Associates	SUBJECT PJP – ROI Calculations		
	Job No. 003-6004-002 Ref.	Made by NK / DNB Checked BRB Reviewed	Date 3/6/2007 Sheet 2 of 2

Assuming $Q = 5\ ft^3/min$

$$ROI = \sqrt{\frac{5\ ft^3/min \times 60\ min/hr \times 24\ \frac{hr}{day}}{\phi \times 20\ ft \times 0.000106\ \frac{ft^3}{lb \cdot day} \times 40\ \frac{lb}{ft^3}}}$$

$$= 164\ ft$$ ✓

Assuming $Q = 4.1\ ft^3/min$ (Reduced proportionally to overall gas generated 2002-2007

$$ROI = \sqrt{\frac{4.1\ ft^3/min \times 60\ min/hr \times 24\ hr/day}{\phi \times 20\ ft \times 0.00016\ \frac{ft^3}{lb \cdot day} \times 40\ lb/ft^3}}$$

$$= 149\ ft$$ ✓

Note: All assumptions consistent with previous design calculations.

Reference: Pederson, T.A. and Curtis J.T., Soil Vapor Extraction Technology, Appendix E, A Practical Approach to the Design, Operation, and Monitoring of In-Situ Soil Venting Systems, Noyes Data Corporation, 1991.

APPENDIX A-3

GAS VENT SPACING CALCULATIONS

GOLDER ASSOCIATES	SUBJECT: PJP Landfill – Vent Spacing		
	Job No.: 003-6004-002	Made by: DNB	Date: 3/06/07
	Ref.: 100% Design Report	Checked: BRB	Sheet 1 of 1
		Reviewed:	

OBJECTIVE: To determine the spacing between the gas vents.

METHOD: Utilize the triangular spacing pattern by the following equation:

vent spacing = 2*ROI*cos(30°)

where: ROI = radius of influence = 164 feet

CALCULATION: Vent spacing = 2*164 feet * cos(30°) = 284 feet

CONCLUSION: For conservatism, an ROI of 150 feet will be maintained, providing a vent spacing of 260 feet.

Vent spacing = (2)(150)(cos30) = 259.8' ≈ 260'

APPENDIX B

PHOTOGRAPHIC DOCUMENTATION OF THE PDI

Site: PJP Landfill – PDI (IRM Cap Inspection)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 1

Description:

Good Stand of Vegetation on the IRM Cap

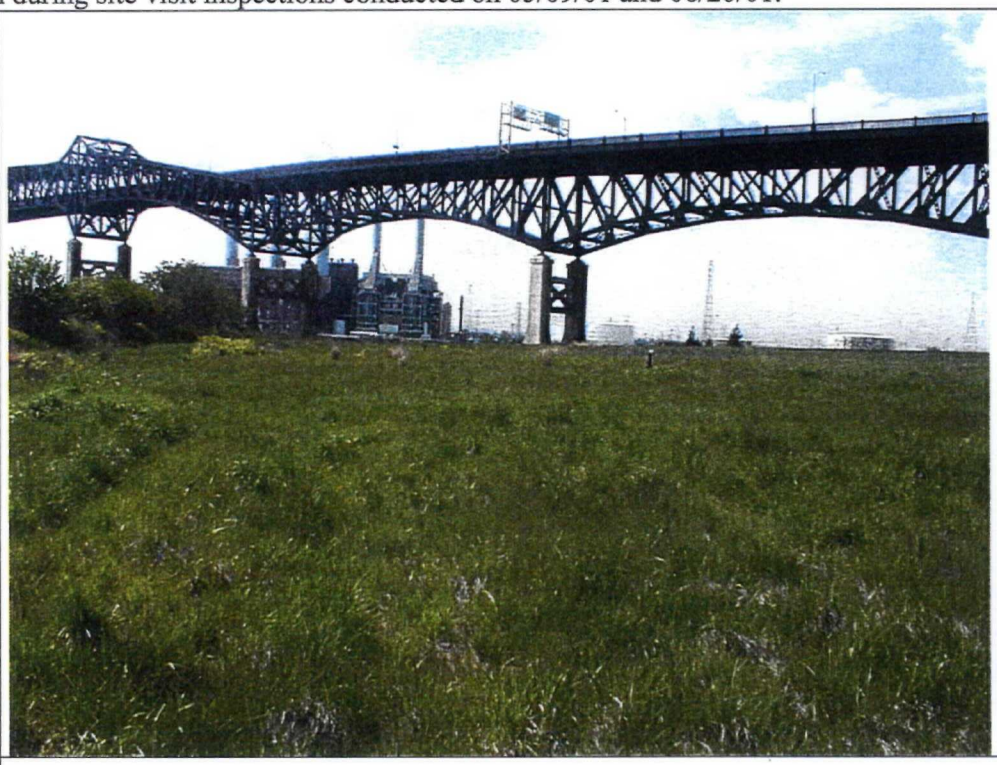


Photo 2

Description:

Good Stand of Vegetation on the IRM Cap

Site: PJP Landfill – PDI (IRM Cap Inspection)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 3

Description:

Good Stand of Vegetation on the IRM Cap

Photo 4

Description:

Good Stand of Vegetation on the IRM Cap

Site: PJP Landfill – PDI (IRM Cap Inspection)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 5

Description:

Close-up View of Vegetative Coverage on the IRM Cap

Photo 6

Description:

Poor Vegetative Coverage of IRM Cap Below the Skyway, Some Cracks

Site: PJP Landfill – PDI (Stormwater Evaluation)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 7

Description:

Coverage of the Archdiocese Property, Bare Access Road and Heavily Vegetated Portion

Photo 8

Description:

Coverage of Archdiocese Property - Ponded Water along Access Road and Heavily Vegetated Portion in Background

Site: PJP Landfill – PDI (Stormwater Evaluation)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 9

Description:

Coverage of the Northern Portion of the Archdiocese Property and Junkyard - Bare Soil Coverage with Heavy Vegetation Surrounding in the Junkyard Portion

Photo 10

Description:

Coverage of the Junkyard - Bare Soil and Vegetation Mix

Site: PJP Landfill – PDI (Stormwater Evaluation)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 11

Description:

Coverage of the Truck Stop –Bare Soil/Poorly Paved Mixed with Vegetation

Photo 12

Description:

Coverage Along the Sip Avenue Ditch Embankment within the Truck Stop – Heavy Vegetation

Site: PJP Landfill – PDI (Stormwater Evaluation)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 13

Description:

Coverage of Southern Portion of the RV Salvage Area (in background) – Heavy Vegetation along Embankments of the Sip Avenue Ditch

Photo 14

Description:

Coverage of Southern Portion of the RV Salvage Area – Heavy Vegetation along Embankments of the Sip Avenue Ditch

Site: PJP Landfill – PDI (Stormwater Evaluation)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 15

Description:

IRM Perimeter Ditch

Photo 16

Description:

IRM Perimeter Ditch

Site: PJP Landfill – PDI (Stormwater Evaluation)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 17

Description:

Rectangular Jersey City Storm Sewer Outlet to the Sip Avenue Ditch

Photo 18

Description:

Sip Avenue Ditch

Site: PJP Landfill – PDI (Stormwater Evaluation)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 19

Description:

Sip Avenue Ditch with Steep Debris Filled Embankments

Photo 20

Description:

Outlet of the Sip Avenue Ditch to the Hackensack River

Site: PJP Landfill – PDI (Stormwater Inspection)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 21

Description:

Vehicle Restricted Access to the Junk Yard - Gate damaged

Photo 22

Description:

Access Restrictions to the Junkyard

Site: PJP Landfill – PDI (Stormwater Inspection)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 23

Description:

Fence Southeast Corner of the Archdiocese Property

Photo 24

Description:

Fenceline Along the Southern Portion of the IRM

Site: PJP Landfill – PDI (Stormwater Inspection)
Photos taken during site visit inspections conducted on 05/09/01 and 06/20/01.

Photo 25

Description:

Southern Portion of the Archdiocese Property – Vegetation too Overgrown to Inspect

Photo 26

Description:

New Fence Between the Archdiocese Property and the Junkyard

APPENDIX C

STORMWATER CALCULATIONS

APPENDIX C-1

EXISTING CONDITIONS

OBJECTIVE: Determine the peak runoff from the Archdiocese Property and Junkyard, RV Salvage, and Truck Stop for the existing conditions under the 100-year, 24-hour and 500-year, 24-hour storm event.

REFERENCES:

1) Golder Associates Inc., "Pre-Final (90%) Design Report, Figure 4-18 Pre-Design Investigation Wetlands, Cap, Fence, and Stormwater Evaluation," dated June 2004.

2) USDA, Soil Conservation Service, "TR-55: Urban Hydrology for Small Watersheds" (TR-55), dated June 1986.

3) New Jersey State Soil Conservation Committee, "Standards for Soil Erosion and Sediment Control in New Jersey," dated July 1999.

4) National Oceanic & Atmospheric Administration (NOAA), U.S. Department of Commerce website for "Precipitation Frequency Estimates from NOAA Atlas 14," last modified January 2007.

METHODS & CALCULATIONS: The TR-55 computer program was used to determine the peak runoff for each area. This program requires several input parameters, such as:

- Rainfall Type – Type III (see sheet 6 of 26);
- Design Storm – 100-year, 24-hour storm (7.5 inches) (see sheet 5 of 26);
- Design Storm – 500-year, 24-hour storm (11.98 inches) (from Reference 4);
- Drainage Area (as described below);
- Curve Number (as described below); and
- Time of Concentration (as described below).

Drainage Areas

The site was separated into three drainage areas: Archdiocese Property and Junkyard, RV Salvage, and Truck Stop (see attached sheet 4 of 26). The Archdiocese Property and Junkyard were further separated into Area 1 and Area 2. Area 1 represents the portion of the properties where runoff remains within the area (does not drain outside of the Archdiocese Property and Junkyard). Area 2 represents the portion of the properties where runoff drains to a discharge point such as the Sip Avenue Ditch, or the IRM perimeter ditch.

The IRM Cap portion of the site was not included in this analysis since no modifications to that portion of the site are anticipated. However, a separate analysis of the IRM perimeter ditch has been included in Appendix C of the Final (100%) Design Report.

It should be noted that the amount of runoff from adjacent properties (e.g., south of the site), if any, is unknown.

The drainage areas were calculated using AutoCAD 2000, and are summarized as follows:

Drainage Area	Calculated Area
Archdiocese Property and Junkyard	0.0351 mi^2 (22.4 acres)
Area 1	0.0251 mi^2 (16.0 acres)
Area 2	0.0100 mi^2 (6.40 acres)

RV Salvage 0.0139 mi^2 (8.92 acres)

Truck Stop 0.0140 mi^2 (8.99 acres)

Curve Number

The Curve Number, which is based on the hydrologic soil type and surface cover, is outlined in Reference 2. The hydrologic soil type is assumed to be Type C (soils of low infiltration rates with moderately fine to fine texture, see sheet 7 of 26) based on observations made during the PDI Stormwater Evaluation. The surface coverage was categorized into four different surface coverage categories with the corresponding CN values taken from Table 2-2a and 2-2c from Reference 2 (see attached sheets 8 and 9 of 26). The four categories of coverage are:

- **Densely Vegetated Surface** **CN=70**
(from Table 2-2c – Brush of Fair Condition)

- **Bare Soil Surface** **CN=91**
(from Table 2-2a – Newly Graded Areas)

- **Mixed Bare Soil and Sparely Vegetated Surface** **CN=84**
(average between CN=91 from Table 2-2a for Newly Graded Areas and CN=77 from Table 2-2c for Brush Poor Condition)

- **Compacted Asphalt Like Surface** **CN=94**
(average between CN=98 from Table 2-2a for Impervious Areas – Paved Parking Lot and CN=89 from Table 2-2a for Impervious Areas – gravel)

- **Paved Surface** **CN=98**
(from Table 2-2a for Impervious Areas – Paved Parking Lot)

Based on observations during the PDI stormwater evaluation, the surface coverage for each drainage area was determined (See Reference 1). A weighted average curve number for each drainage area was calculated and is summarized as follows:

Archdiocese Property and Junkyard (Area 2 only)

Soil Type	% Land Coverage	Description of Land Coverage	Curve Number	Weighted Curve Number
C	23.3%	Densely Vegetated Surface	70	16.3
C	41.3%	Bare Soil Surface	91	37.6
C	35.4%	Mixed Bare Soil and Sparely Vegetated Surface	84	29.7
		Weighted Curve Number		**83.6**
			USE	**84**

RV Salvage

Soil Type	% Land Coverage	Description of Land Coverage	Curve Number	Weighted Curve Number
C	56%	Densely Vegetated Surface	70	39.2

C	44%	Bare Soil Surface	91	40.0
		Weighted Curve Number		**79.2**
			USE	**79**

Truck Stop Soil Type	% Land Coverage	Description of Land Use	Curve Number	Weighted Curve Number
C	17%	Paved Surface	98	16.7
C	61%	Compacted Asphalt Like Surface	94	57.3
C	22%	Densely Vegetated Surface	70	15.4
		Weighted Curve Number		**89.4**
			USE	**89**

(Note: % Land Coverage and Weighted Curve Numbers are rounded.)

Time of Concentration

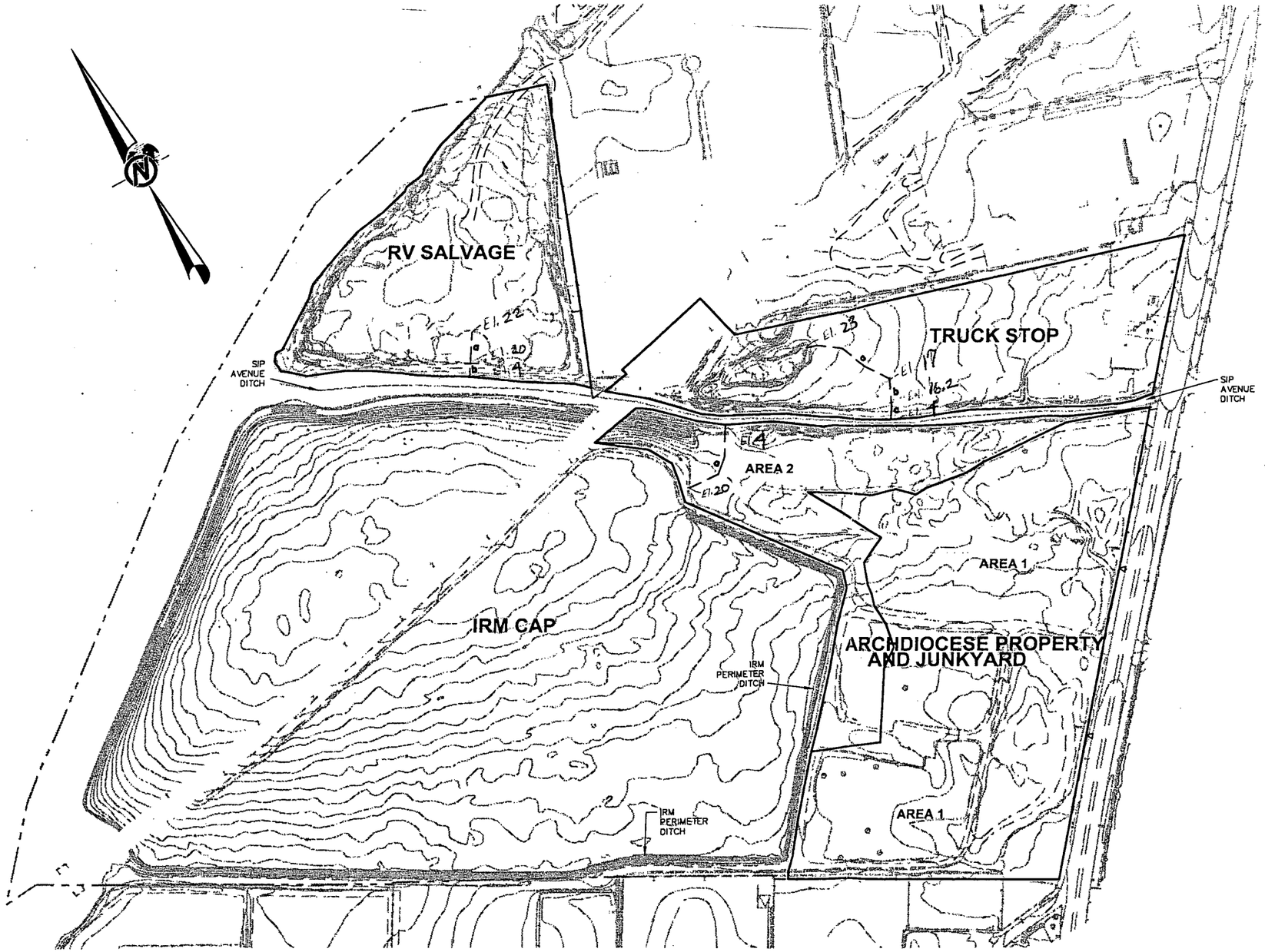
The time of concentration (T_c), the length of time for runoff to travel from the most hydrology distant point within a drainage area, was determined for each drainage area, using methods outlined in Reference 2 (see sheet 4 of 26 for locations). The following is a summary of the time of concentration for each drainage area (see sheets 10, 11, and 12 of 26 for calculation):

Drainage Area	**Time of Concentration**
Archdiocese Property and Junkyard (Area 2 only)	0.250 hours
RV Salvage	0.213 hours
Truck Stop	0.215 hours

Peak Runoff

The peak runoff for each area was determined by using the TR-55 computer program. The peak runoff for Area 1 of the Archdiocese Property is assumed to be 0 cfs since runoff does not discharge outside of the drainage area. See sheet 16 and 22 of 26, for the peak runoff calculation for the 100 year and 500 year, 24 hour storm event, respectively. The following is a summary of the peak runoff for each drainage area:

Drainage Area	Peak Runoff 100 year storm event	Peak Runoff 500 year storm event
Archdiocese Property And Junkyard	28 cfs	50 cfs
RV Salvage	40 cfs	73 cfs
Truck Stop	49 cfs	84 cfs



LEGEND

- DRAINAGE AREA BOUNDARY
- TIME OF CONCENTRATION
- SITE BOUNDARY

NOTES

1.) PLEASE REFER TO FIGURE 4–18 OF THE PRELIMINARY (30%) DESIGN REPORT FOR SURFACE COVERAGE DESCRIPTION.

REFERENCES

1.) TOPOGRAPHY PREPARED BY JAMES M. STEWARD, INC. CADD FILE No. 1886–00, DATED 11/02/98.

300 0 300
SCALE FEET

Golder Associates Philadelphia USA	SCALE	AS SHOWN	TITLE EXISTING CONDITION PEAK RUNOFF CALCULATION
	DATE	08/29/01	
	DESIGN	RAD	
	CADD	RAD	
FILE No. calcfig.dwg	CHECK	RAD/CBM	PJP LANDFILL
PROJECT No. 003–6004–002 REV. 0	REVIEW		FIGURE 1E

NEW JERSEY 24 HOUR RAINFALL

County	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Atlantic	2.8	3.5	4.5	5.5	6.2	6.8	7.6
Bergen	2.7	3.3	4.3	5.3	5.7	6.5	7.5
Burlington	2.8	3.4	4.4	5.3	6.0	6.6	7.4
Camden	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Cape May	2.9	3.5	4.6	5.6	6.3	6.9	7.7
Cumberland	2.8	3.4	4.5	5.4	6.0	6.8	7.5
Essex	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Gloucester	2.8	3.4	4.4	5.3	5.9	6.6	7.4
*Hudson	2.7	$\boxed{3.3}$	4.3	5.3	$\boxed{5.7}$	6.4	7.5*
Hunterdon	2.6	3.2	4.2	5.0	5.7	6.5	7.3
Mercer	2.7	3.3	4.3	5.2	5.8	6.4	7.5
Middlesex	2.7	3.3	4.3	5.2	5.9	6.4	7.5
Monmouth	2.8	3.4	4.4	5.3	~~6.0~~	6.5	7.5
Morris	2.6	3.3	4.3	5.2	5.7	6.5	7.5
Ocean	2.8	3.5	4.5	5.4	~~6.2~~	6.6	7.5
Passaic	2.6	3.3	4.3	5.4	5.7	6.5	7.6
Salem	2.8	3.3	4.4	5.3	5.9	6.6	7.4
Somerset	2.7	3.3	4.3	5.2	5.7	6.5	7.5
Sussex	2.6	3.2	4.2	5.0	5.7	6.6	7.5
Union	2.7	3.3	4.3	5.3	5.8	6.4	7.5
Warren	2.6	3.2	4.1	4.9	5.6	6.5	7.2

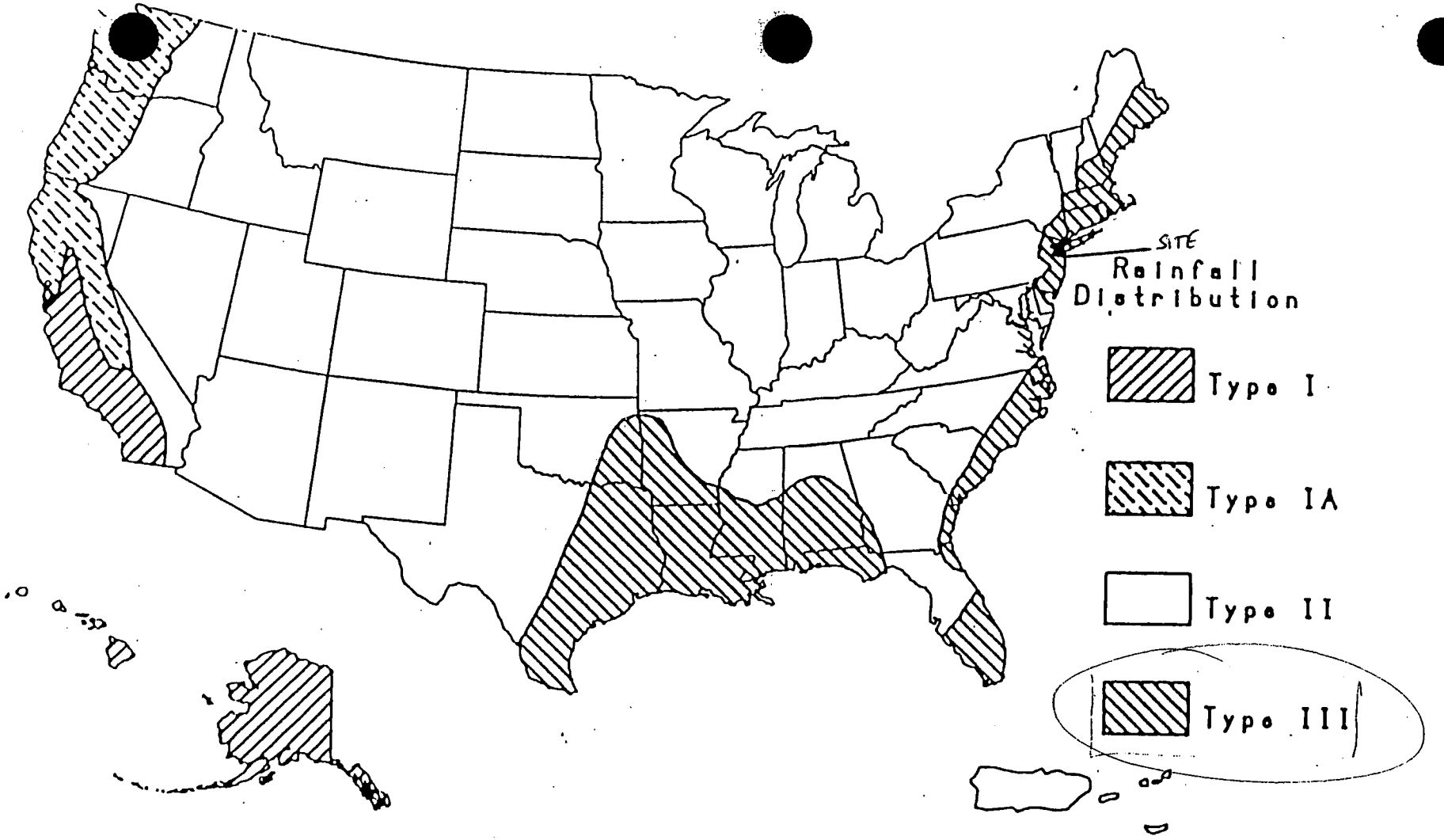


Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

(from Reference 2)

Appendix A: Hydrologic soil groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier: for example, "Abrazo: gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983):

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

(from Reference 7)

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4]Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	[4]30	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	[4]30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1]Average runoff condition, and $I_a = 0.2S$.

[2]*Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

[3]*Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4]Actual curve number is less than 30; use CN = 30 for runoff computations.

[5]CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6]*Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Project	PJP Landfill	By:	RAD	Date:	8/3/01
Location	Hudson County, Jersey City	Checked:	RAD/CBM	Date:	9/19/01
		Reviewed:	[illegible]	Date:	3/14/07
Condition	Existing				

Watershed	Archdiocese Property & Junkyard			
Segment **SHEET FLOW (Application to T_c only)**	a			
1. Surface Description	vegetative cover			
2. Manning's roughness coefficient, n	0.24 (1)			
3. Flow Length, L (total L<300ft) ft.	211			
4. Two-yr 24-hr rainfall, P_2 in.	3.3 (2)			
5. Land slope, s ft./ft $\frac{20-9}{211}$	0.076			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ hr.	**0.250**			
Segment **Shallow Concentrated Flow**				
7. Surface description (paved or unpaved)				
8. Flow Length, L ft.				
9. Watercourse slope, s ft./ft.				
10. Average velocity, V (figure 3-1) ft./s.				
11. $T_T = \frac{L}{3600V}$ hr.				
Segment **Channel Flow**				
12. Cross Sectional flow area, a $ft.^2$				
13. Wetted perimeter, p_w ft.				
14. Hydraulic radius, $r = a/p_w$ ft.				
15. Channel slope, s ft./ft.				
16. Manning's roughness coeffienct, n				
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ ft./s.				
18. Flow Length, L ft.				
19. Tt = L/3600 V hr.				
20. Total Tc from sheet, shallow, and channel flow hr.	**0.250**			

(1) See sheet 13 of ~~15~~ 26
(2) See sheet 5 of ~~15~~ 26

Project	PJP Landfill	By:	RAD	Date:	8/3/01
Location	Hudson County, Jersey City	Checked:	RAD/CBM	Date:	9/14/01
		Reviewed:	[signature]	Date:	3/14/07
Condition	Existing				

Watershed	RV Salvage Area			
Segment **SHEET FLOW (Application to T_c only)**	a	b		
1. Surface Description	vegetated	vegetated		
2. Manning's roughness coefficient, n	0.24 (1)	0.24 (1)		
3. Flow Length, L (total L<300ft) ft. $\frac{2}{80}$, $\frac{16}{90}$	80	40		
4. Two-yr 24-hr rainfall, P_2 in.	3.3 (2)	3.3 (2)		
5. Land slope, s ft./ft	0.025	0.4		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ hr.	**0.179**	**0.034**		
Segment **Shallow Concentrated Flow**				
7. Surface description (paved or unpaved)				
8. Flow Length, L ft.				
9. Watercourse slope, s ft./ft.				
10. Average velocity, V (figure 3-1) ft./s.				
11. $T_T = \frac{L}{3600V}$ hr.				
Segment **Channel Flow**				
12. Cross Sectional flow area, a ft.^{2}				
13. Wetted perimeter, p_w ft.				
14. Hydraulic radius, $r = a/p_w$ ft.				
15. Channel slope, s ft./ft.				
16. Manning's roughness coeffienct, n				
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ ft./s.				
18. Flow Length, L ft.				
19. Tt = L/3600 V hr.				
20. Total Tc from sheet, shallow, and channel flow hr.	**0.213**			

(1) See sheet 13 of ~~15~~ 26

(2) See sheet 5 of ~~15~~ 26

Project	PJP Landfill	By:	RAD	Date:	8/3/01
Location	Hudson County, Jersey City	Checked:	RAD/ CBM	Date:	9/14/01
		Reviewed:		Date:	3/14/07
Condition	Existing				

Watershed	Truck Stop			
Segment **SHEET FLOW (Application to T_c only)**	a	b		
1. Surface Description	bare soil	vegetative cover		
2. Manning's roughness coefficient, n	0.011 (1)	0.24 (1)		
3. Flow Length, L (total L<300ft) ft.	241	59		
4. Two-yr 24-hr rainfall, P_2 in.	3.3 (2)	3.3 (2)		
5. Land slope, s ft./ft $\frac{23-17}{241}$, $\frac{17-16.2}{59}$	0.025	0.014		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ hr.	**0.037**	**0.177**		
Segment **Shallow Concentrated Flow**	c			
7. Surface description (paved or unpaved)	unpaved			
8. Flow Length, L ft.	41			
9. Watercourse slope, s ft./ft. $\frac{16.2-9}{41}$	0.298			
10. Average velocity, V (figure 3-1) ft./s.	9.00 (3)			
11. $T_T = \frac{L}{3600V}$ hr.	**0.0013**			
Segment **Channel Flow**				
12. Cross Sectional flow area, a $ft.^2$				
13. Wetted perimeter, p_w ft.				
14. Hydraulic radius, $r = a/p_w$ ft.				
15. Channel slope, s ft./ft.				
16. Manning's roughness coeffienct, n				
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ ft./s.				
18. Flow Length, L ft.				
19. Tt = L/3600 V hr.				
20. Total Tc from sheet, shallow, and channel flow hr.	**0.215**			

(1) See sheet 13 of ~~19~~ 26

(2) See sheet 5 of ~~19~~ 26

(3) See sheet 14 of ~~19~~ 26

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] n values are a composite of information compiled by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

(from Reference 2)

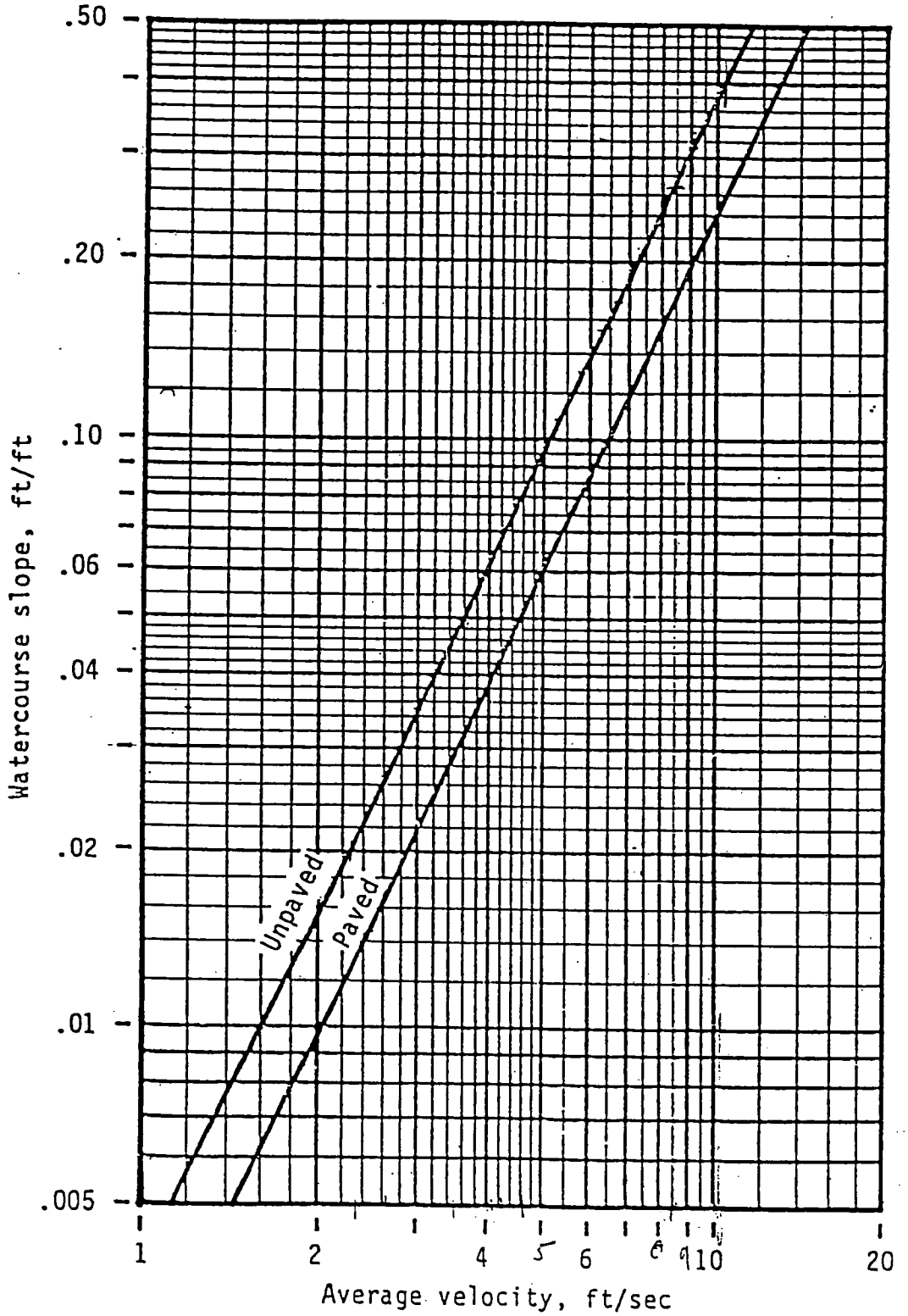


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

(from Reference 2)

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:50:30
Watershed file: --> c:\pondpack\PJPEX .WSD
Hydrograph file: --> c:\pondpack\PJPEX .HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
100 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used	
ARCH	6.40	84.0	0.30	0.00	7.50	5.62	.05	.10
RV	8.92	79.0	0.20	0.00	7.50	5.04	.07	.10
TS	8.99	89.0	0.20	0.00	7.50	6.20	.03	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 24.31 acres or 0.03798 sq.mi
Peak discharge = 114 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
ARCH	0.25	0.00	0.30	0.00	No	Computed Ia/p < .1
RV	0.21	0.00	0.20	0.00	No	Computed Ia/p < .1
TS	0.22	0.00	0.20	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:50:30
Watershed file: --> c:\pondpack\PJPEX .WSD
Hydrograph file: --> c:\pondpack\PJPEX .HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
100 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
ARCH	28	12.4
RV	40	12.3
TS	49	12.3
Composite Watershed	114	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:50:30
Watershed file: --> c:\pondpack\PJPEX .WSD
Hydrograph file: --> c:\pondpack\PJPEX .HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
ARCH	1	2	2	5	7	10	16	25	28
RV	2	2	4	8	12	18	31	40	34
TS	2	3	4	10	15	22	39	49	42
Total (cfs)	5	7	10	23	34	50	86	114	104

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
ARCH	25	20	16	11	7	5	4	4	3
RV	25	19	14	10	7	5	5	4	4
TS	31	24	17	12	8	7	6	5	5
Total (cfs)	81	63	47	33	22	17	15	13	12

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:50:30
Watershed file: --> c:\pondpack\PJPEX .WSD
Hydrograph file: --> c:\pondpack\PJPEX .HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
ARCH	3	3	2	2	2	2	1	1	1
RV	4	3	3	3	2	2	2	1	1
TS	5	4	4	3	3	2	2	2	2
Total (cfs)	12	10	9	8	7	6	5	4	4

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
ARCH	1	1	1	1	0
RV	1	1	1	1	0
TS	1	1	1	1	0
Total (cfs)	3	3	3	3	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)
Executed: 03-08-2007 11:50:30
Watershed file: --> c:\pondpack\PJPEX .WSD
Hydrograph file: --> c:\pondpack\PJPEX .HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	5	14.8	8
11.1	6	14.9	8
11.2	6	15.0	8
11.3	7	15.1	8
11.4	8	15.2	8
11.5	9	15.3	7
11.6	10	15.4	7
11.7	14	15.5	7
11.8	19	15.6	7
11.9	23	15.7	7
12.0	34	15.8	6
12.1	50	15.9	6
12.2	86	16.0	6
12.3	114	16.1	6
12.4	104	16.2	6
12.5	81	16.3	5
12.6	63	16.4	5
12.7	47	16.5	5
12.8	33	16.6	5
12.9	27	16.7	5
13.0	22	16.8	4
13.1	20	16.9	4
13.2	17	17.0	4
13.3	16	17.1	4
13.4	15	17.2	4
13.5	14	17.3	4
13.6	13	17.4	4
13.7	12	17.5	4
13.8	12	17.6	4
13.9	12	17.7	4
14.0	12	17.8	3
14.1	11	17.9	3
14.2	11	18.0	3
14.3	10	18.1	3
14.4	10	18.2	3
14.5	9	18.3	3
14.6	9	18.4	3
14.7	9	18.5	3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:50:30
Watershed file: --> c:\pondpack\PJPEX .WSD
Hydrograph file: --> c:\pondpack\PJPEX .HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	3	22.4	3
18.7	3	22.5	3
18.8	3	22.6	3
18.9	3	22.7	2
19.0	3	22.8	2
19.1	3	22.9	2
19.2	3	23.0	2
19.3	3	23.1	2
19.4	3	23.2	2
19.5	3	23.3	2
19.6	3	23.4	2
19.7	3	23.5	2
19.8	3	23.6	2
19.9	3	23.7	2
20.0	3	23.8	2
20.1	3	23.9	2
20.2	3	24.0	2
20.3	3	24.1	1
20.4	3	24.2	1
20.5	3	24.3	1
20.6	3	24.4	1
20.7	3	24.5	1
20.8	3	24.6	1
20.9	3	24.7	1
21.0	3	24.8	1
21.1	3	24.9	1
21.2	3	25.0	1
21.3	3	25.1	1
21.4	3	25.2	1
21.5	3	25.3	1
21.6	3	25.4	0
21.7	3	25.5	0
21.8	3	25.6	0
21.9	3	25.7	0
22.0	3	25.8	0
22.1	3	25.9	0
22.2	3		
22.3	3		

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:51:53
Watershed file: --> c:\pondpack\PJPEX500.WSD
Hydrograph file: --> c:\pondpack\PJPEX500.HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
500 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
ARCH	6.40	84.0	0.30	0.00	11.98	9.96	.03	.10
RV	8.92	79.0	0.20	0.00	11.98	9.29	.04	.10
TS	8.99	89.0	0.20	0.00	11.98	10.60	.02	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 24.31 acres or 0.03798 sq.mi
Peak discharge = 201 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
ARCH	0.25	0.00	0.30	0.00	No	Computed Ia/p < .1
RV	0.21	0.00	0.20	0.00	No	Computed Ia/p < .1
TS	0.22	0.00	0.20	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:51:53
Watershed file: --> c:\pondpack\PJPEX500.WSD
Hydrograph file: --> c:\pondpack\PJPEX500.HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
500 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
ARCH	50	12.4
RV	73	12.3
TS	84	12.3
Composite Watershed	201	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:51:53
Watershed file: --> c:\pondpack\PJPEX500.WSD
Hydrograph file: --> c:\pondpack\PJPEX500.HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
ARCH	2	3	4	8	12	18	29	44	50
RV	3	4	6	15	23	33	58	73	63
TS	4	5	7	18	26	38	67	84	72
Total (cfs)	9	12	17	41	61	89	154	201	185

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
ARCH	45	36	27	20	12	9	7	6	6
RV	46	35	25	18	12	10	8	8	7
TS	53	40	29	20	14	11	10	9	8
Total (cfs)	144	111	81	58	38	30	25	23	21

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:51:53
Watershed file: --> c:\pondpack\PJPEX500.WSD
Hydrograph file: --> c:\pondpack\PJPEX500.HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
ARCH	5	5	4	4	3	3	2	2	2
RV	7	6	5	5	4	4	3	3	2
TS	8	7	6	6	5	4	4	3	3
Total (cfs)	20	18	15	15	12	11	9	8	7

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
ARCH	2	1	1	1	0
RV	2	2	2	1	0
TS	3	2	2	2	0
Total (cfs)	7	5	5	4	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:51:53
Watershed file: --> c:\pondpack\PJPEX500.WSD
Hydrograph file: --> c:\pondpack\PJPEX500.HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	9	14.8	15
11.1	10	14.9	15
11.2	11	15.0	15
11.3	12	15.1	14
11.4	14	15.2	14
11.5	15	15.3	13
11.6	17	15.4	13
11.7	25	15.5	12
11.8	33	15.6	12
11.9	41	15.7	12
12.0	61	15.8	11
12.1	89	15.9	11
12.2	154	16.0	11
12.3	201	16.1	11
12.4	185	16.2	10
12.5	144	16.3	10
12.6	111	16.4	9
12.7	81	16.5	9
12.8	58	16.6	9
12.9	48	16.7	9
13.0	38	16.8	8
13.1	34	16.9	8
13.2	30	17.0	8
13.3	28	17.1	8
13.4	25	17.2	8
13.5	24	17.3	7
13.6	23	17.4	7
13.7	22	17.5	7
13.8	21	17.6	7
13.9	20	17.7	7
14.0	20	17.8	7
14.1	19	17.9	7
14.2	19	18.0	7
14.3	18	18.1	7
14.4	17	18.2	7
14.5	16	18.3	6
14.6	15	18.4	6
14.7	15	18.5	6

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 11:51:53
Watershed file: --> c:\pondpack\PJPEX500.WSD
Hydrograph file: --> c:\pondpack\PJPEX500.HYD

PJP LANDFILL-EXISTING PEAK RUNOFF
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	6	22.4	4
18.7	6	22.5	4
18.8	5	22.6	3
18.9	5	22.7	3
19.0	5	22.8	3
19.1	5	22.9	3
19.2	5	23.0	3
19.3	5	23.1	3
19.4	5	23.2	3
19.5	5	23.3	3
19.6	5	23.4	3
19.7	5	23.5	2
19.8	5	23.6	2
19.9	5	23.7	2
20.0	5	23.8	2
20.1	5	23.9	2
20.2	5	24.0	2
20.3	5	24.1	2
20.4	5	24.2	2
20.5	5	24.3	2
20.6	5	24.4	2
20.7	5	24.5	2
20.8	5	24.6	1
20.9	5	24.7	1
21.0	4	24.8	1
21.1	4	24.9	1
21.2	4	25.0	1
21.3	4	25.1	1
21.4	4	25.2	1
21.5	4	25.3	1
21.6	4	25.4	1
21.7	4	25.5	0
21.8	4	25.6	0
21.9	4	25.7	0
22.0	4	25.8	0
22.1	4	25.9	0
22.2	4		
22.3	4		

OBJECTIVE: Determine the depth of flow and available freeboard for the existing IRM Perimeter Ditch under both the 100-year and 500-year, 24-hour storm event conditions.

REFERENCES:

1) Golder Associates, Inc., "Pre-Final (90%) Design Report, Figures 4-1 through 4-4, Topographic Base Map", dated June 2004.

2) USDA, Soil Conservation Service, "TR-55: Urban Hydrology for Small Watersheds" (TR-55), dated June 1986.

3) New Jersey State Soil Conservation Committee, "Standards for Soil Erosion and Sediment Control in New Jersey," dated July 1999.

4) National Oceanic & Atmospheric Administration (NOAA), U.S. Department of Commerce website for "Precipitation Frequency Estimates from NOAA Atlas 14," last modified January 2007.

METHODS In determining the depth of the flow and available freeboard for the IRM Perimeter Ditch, the following parameters are required:

- Rainfall Type – Type III (see sheet 5 of 21);
- Design Storm - 100-year, 24-hour storm (7.5 inches) (see sheet 4 of 21);
- Design Storm - 500-year, 24-hour storm (11.98 inches) (Reference 4);
- Contributing Drainage Area (as described below);
- Curve Number (as described);
- Time of Concentration (as described);
- Peak Runoff (as described within); and
- Ditch Characteristics (as described within);

Following the calculation of the parameters described above, the depth of flow and available freeboard will be calculated by using the Manning's Equations.

CALCULATIONS:

Contributing Drainage Areas

Based on the site map (see reference 1) the area that drains to the IRM perimeter ditch was determined (see sheet 3 of 21). The contributing drainage area was calculated using AutoCAD 2000 and is determined to be approximately 0.047 mi^2 (30 acres).

It should be noted that the amount of runoff from adjacent properties (e.g., south of the site), if any, is unknown.

Curve Number

The Curve Number (CN), which is based on the hydrologic soil type and surface cover, is outlined in Reference 2. The hydrologic soil type is assumed to be Type C (soils of low infiltration rates with moderately fine to fine texture) (see sheet 6 of 21), based on observations made during the PDI Stormwater

Evaluation and site history. The surface coverage could be described as Open space (lawns, parks, golf courses, cemeteries, etc.) in good condition, therefore the CN is 74 (see sheet 7 of 21 from reference 2, Table 2-2a).

Time of Concentration

The time of concentration (T_c), the length of time for runoff to travel from the most hydrology distant point within the contributing drainage area, was determined using methods outlined in Reference 2 (see sheet 3 of 21 for locations). The Tc for the contributing drainage area was determined to be 0.648 (see sheet 8 of 21 for calculation).

Peak Runoff

The TR-55 computer program was used to determine the peak runoff for the contributing drainage area. The peak runoff collected by the IRM Perimeter Ditch under the 100-year, 24-hour storm is determined to be 72 cfs (see sheet 11 of 21 for calculation), and under the 500-year, 24 hour storm is determined to be 138 cfs (see sheet 16 of 21).

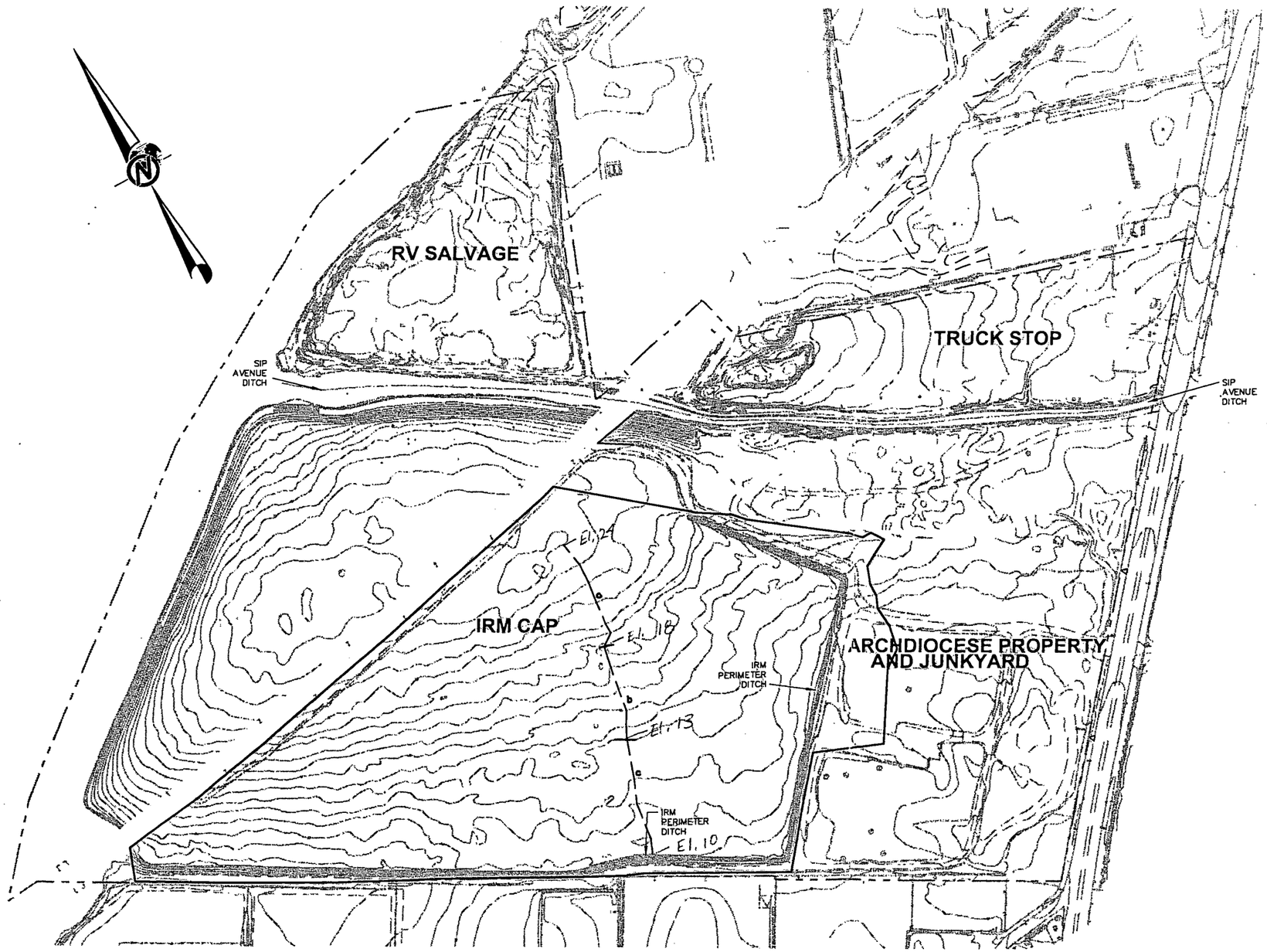
Ditch Characteristics

The IRM Perimeter Ditch is v-shaped and lined with riprap. Based on Reference 1, the dimensions of the channel changes slightly throughout the length of the ditch, varying from just over 2 feet deep to approximately 3 feet deep, with slope of 1.6% and 0.5%, respectively. The side slopes of the channel are approximately 2.5 foot horizontal to 1 foot vertical.

Depth of Flow and Available Freeboard

The Manning's Equation for open channel flow was used to determine the depth of flow and available freeboard in the existing IRM Perimeter Ditch. As described in the ditch characteristics section above, the exact dimensions of the ditch vary, and therefore two cases were calculated. For the 100-year, 24 hour storm event the depth of flow was 2.23 feet in the portion of the ditch that is 2.5 feet deep (1.6% slope); and the depth of flow was 2.77 feet in the portion of the ditch that is 3.0 feet deep (0.5% slope). In both cases, the available freeboard is approximately 0.25 feet. However in the 500-year, 24 hour storm event the channel would be overtopped in both portions of the ditch. See sheet 21 of 21 for calculation spreadsheet.

FIGURE 1



LEGEND

CONTRIBUTING DRAINAGE AREA BOUNDARY

TIME OF CONCENTRATION

SITE BOUNDARY

NOTES

1.) PLEASE REFER TO FIGURES 4–1 THROUGH 4–4 OF THE PRELIMINARY (30%) DESIGN REPORT FOR LARGER SCALED DRAWING.

REFERENCES

1.) TOPOGRAPHY PREPARED BY JAMES M. STEWARD, INC. CADD FILE No. 1886–00, DATED 11/02/98.

300 0 300
SCALE FEET

Golder Associates Philadelphia USA		SCALE	AS SHOWN
		DATE	08/29/01
		DESIGN	RAD
		CADD	RAD
FILE No.	calcfig.dwg	CHECK	CJM
PROJECT No. 003–6004–002	REV. 0	REVIEW	

TITLE

EXISTING CONDITION IRM PERIMETER DITCH

PJP LANDFILL

FIGURE **1E**

NEW JERSEY 24 HOUR RAINFALL

County	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Atlantic	2.8	3.5	4.5	5.5	6.2	6.8	7.6
Bergen	2.7	3.3	4.3	5.3	5.7	6.5	7.5
Burlington	2.8	3.4	4.4	5.3	6.0	6.6	7.4
Camden	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Cape May	2.9	3.5	4.6	5.6	6.3	6.9	7.7
Cumberland	2.8	3.4	4.5	5.4	6.0	6.8	7.5
Essex	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Gloucester	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Hudson	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Hunterdon	2.6	3.2	4.2	5.0	5.7	6.5	7.3
Mercer	2.7	3.3	4.3	5.2	5.8	6.4	7.5
Middlesex	2.7	3.3	4.3	5.2	5.9	6.4	7.5
Monmouth	2.8	3.4	4.4	5.3	6.0	6.5	7.5
Morris	2.6	3.3	4.3	5.2	5.7	6.5	7.5
Ocean	2.8	3.5	4.5	5.4	6.2	6.6	7.5
Passaic	2.6	3.3	4.3	5.4	5.7	6.5	7.6
Salem	2.8	3.3	4.4	5.3	5.9	6.6	7.4
Somerset	2.7	3.3	4.3	5.2	5.7	6.5	7.5
Sussex	2.6	3.2	4.2	5.0	5.7	6.6	7.5
Union	2.7	3.3	4.3	5.3	5.8	6.4	7.5
Warren	2.6	3.2	4.1	4.9	5.6	6.5	7.2

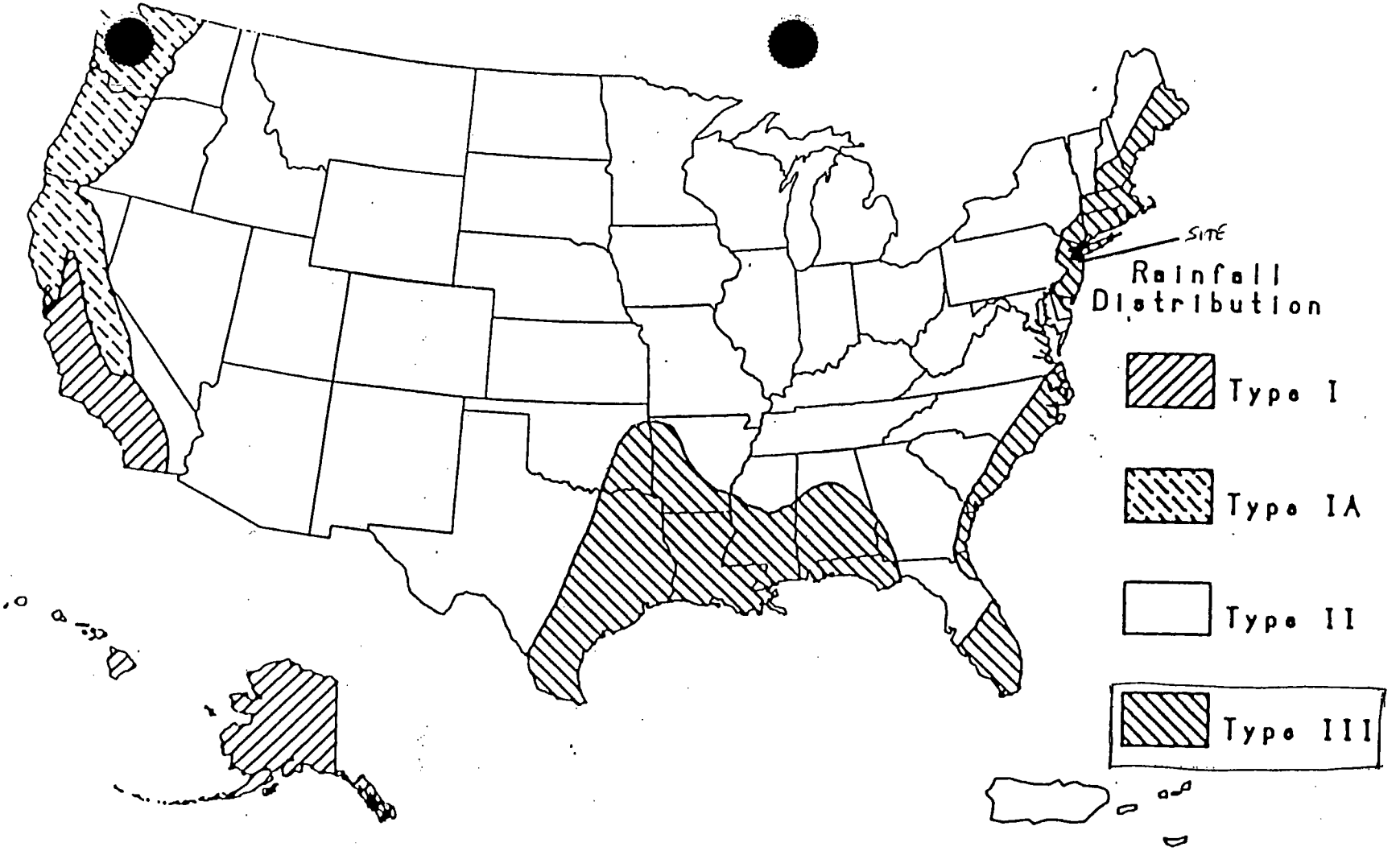


Figure II-2.—Approximate geographic boundaries for SCS rainfall distributions.

(from Reference 2)

Appendix A: Hydrologic soil groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier: for example, "Abrazo: gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983):

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

(from Reference 2)

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80 *
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4]Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

(from Reference 2)

Project	PJP Landfill	By:	RAD	Date:	8/3/01
Location	Hudson County, Jersey City	Checked:	CBM	Date:	9/14/01
		Reviewed:	[illegible]	Date:	3/14/07
Condition	Existing				

Watershed	IRM Perimeter Ditch			
Segment **SHEET FLOW (Application to T_c only)**	a			
1. Surface Description	vegetated			
2. Manning's roughness coefficient, n	0.24 (1)			
3. Flow Length, L (total L<300ft) ft.	300			
4. Two-yr 24-hr rainfall, P_2 in.	3.3 (2)			
5. Land slope, s ft./ft	0.02			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ hr.	**0.564**			
Segment **Shallow Concentrated Flow**	b	c		
7. Surface description (paved or unpaved)	unpaved	unpaved		
8. Flow Length, L ft.	248	306		
9. Watercourse slope, s ft./ft.	0.02	0.01		
10. Average velocity, V (figure 3-1) ft./s.	2.24 (3)	1.60 (3)		
11. $T_T = \frac{L}{3600V}$ hr.	**0.031**	**0.053**		
Segment **Channel Flow**				
12. Cross Sectional flow area, a $ft.^2$				
13. Wetted perimeter, p_w ft.				
14. Hydraulic radius, $r = a/p_w$ ft.				
15. Channel slope, s ft./ft.				
16. Manning's roughness coeffienct, n				
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ ft./s.				
18. Flow Length, L ft.				
19. Tt = L/3600 V hr.				
20. Total Tc from sheet, shallow, and channel flow hr.	**0.648**			

(1) See sheet 9 of 21

(2) See sheet 4 of 21

(3) See sheet 10 of 21

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

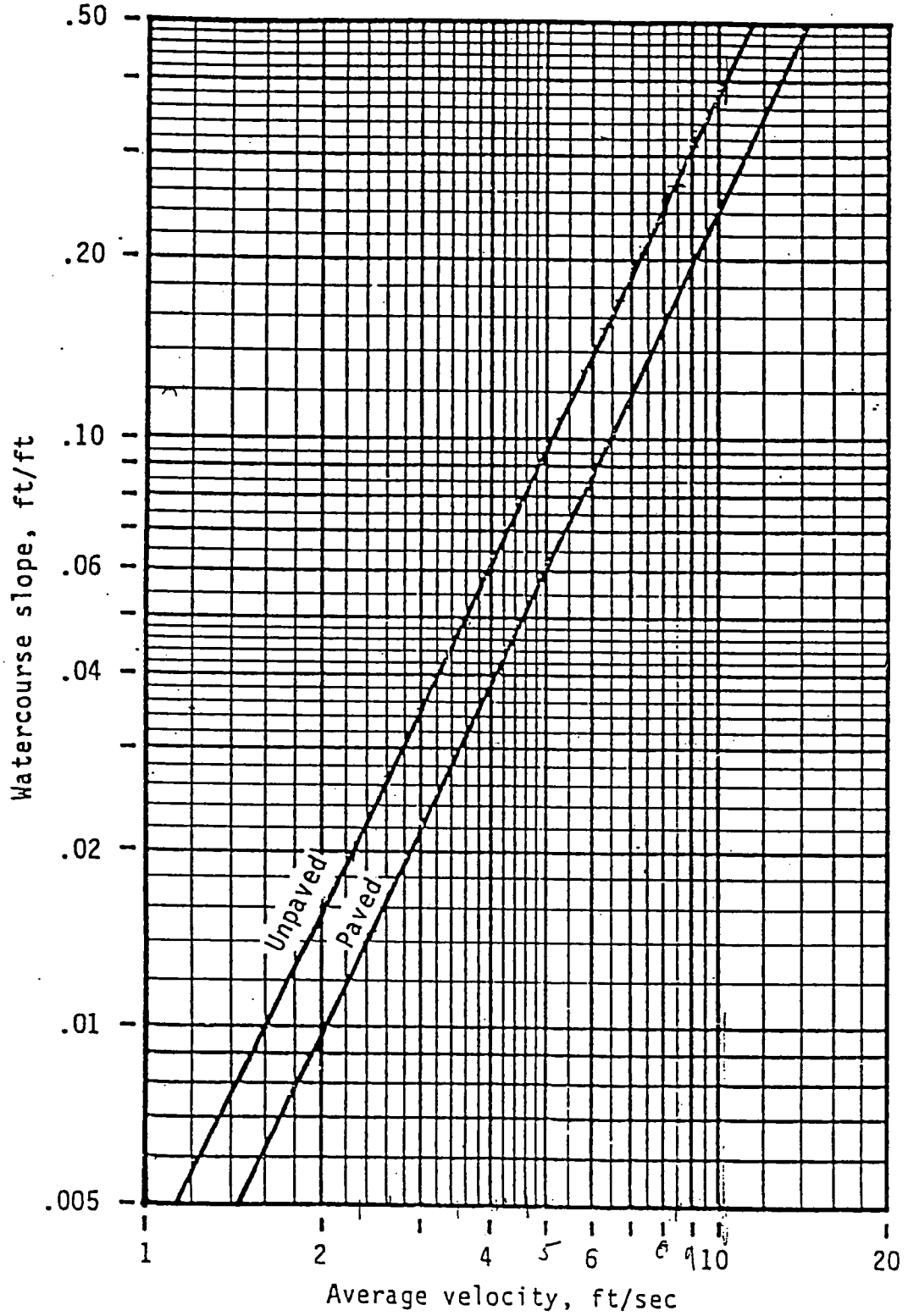


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 12:17:58
Watershed file: --> c:\pondpack\IRMEX .WSD
Hydrograph file: --> c:\pondpack\IRMEX .HYD

PJP LANDFILL-IRM DITCH EXISTING CONDITIONS
100 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used
A	30.00	74.0	0.75	0.00	7.50	4.48	.09 .10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 30.00 acres or 0.04688 sq.mi
Peak discharge = 72 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	* Tt (hr)	Rounded Values Tc (hr)	* Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	0.65	0.00	0.75	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 12:17:58
Watershed file: --> c:\pondpack\IRMEX .WSD
Hydrograph file: --> c:\pondpack\IRMEX .HYD

PJP LANDFILL-IRM DITCH EXISTING CONDITIONS
100 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	72	12.8
Composite Watershed	72	12.8

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 12:17:58
Watershed file: --> c:\pondpack\IRMEX .WSD
Hydrograph file: --> c:\pondpack\IRMEX .HYD

PJP LANDFILL-IRM DITCH EXISTING CONDITIONS
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	4	5	6	8	9	12	15	22	32
Total (cfs)	4	5	6	8	9	12	15	22	32

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	45	59	69	72	65	48	34	25	20
Total (cfs)	45	59	69	72	65	48	34	25	20

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	16	13	11	9	8	7	6	5	5
Total (cfs)	16	13	11	9	8	7	6	5	5

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	4	3	3	2	0
Total (cfs)	4	3	3	2	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 12:17:58
Watershed file: --> c:\pondpack\IRMEX .WSD
Hydrograph file: --> c:\pondpack\IRMEX .HYD

PJP LANDFILL-IRM DITCH EXISTING CONDITIONS
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	4	14.8	10
11.1	4	14.9	9
11.2	5	15.0	9
11.3	5	15.1	9
11.4	5	15.2	9
11.5	6	15.3	8
11.6	6	15.4	8
11.7	7	15.5	8
11.8	7	15.6	8
11.9	8	15.7	8
12.0	9	15.8	7
12.1	12	15.9	7
12.2	15	16.0	7
12.3	22	16.1	7
12.4	32	16.2	7
12.5	45	16.3	6
12.6	59	16.4	6
12.7	69	16.5	6
12.8	72	16.6	6
12.9	68	16.7	6
13.0	65	16.8	5
13.1	56	16.9	5
13.2	48	17.0	5
13.3	41	17.1	5
13.4	34	17.2	5
13.5	30	17.3	5
13.6	25	17.4	5
13.7	22	17.5	5
13.8	20	17.6	5
13.9	18	17.7	5
14.0	16	17.8	4
14.1	15	17.9	4
14.2	14	18.0	4
14.3	13	18.1	4
14.4	12	18.2	4
14.5	12	18.3	4
14.6	11	18.4	4
14.7	10	18.5	4

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 12:17:58
Watershed file: --> c:\pondpack\IRMEX .WSD
Hydrograph file: --> c:\pondpack\IRMEX .HYD

PJP LANDFILL-IRM DITCH EXISTING CONDITIONS
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	3	22.4	2
18.7	3	22.5	2
18.8	3	22.6	2
18.9	3	22.7	2
19.0	3	22.8	2
19.1	3	22.9	2
19.2	3	23.0	2
19.3	3	23.1	1
19.4	3	23.2	1
19.5	3	23.3	1
19.6	3	23.4	1
19.7	3	23.5	1
19.8	3	23.6	1
19.9	3	23.7	1
20.0	3	23.8	1
20.1	3	23.9	1
20.2	3	24.0	1
20.3	3	24.1	1
20.4	3	24.2	1
20.5	3	24.3	1
20.6	3	24.4	1
20.7	3	24.5	1
20.8	3	24.6	1
20.9	3	24.7	1
21.0	2	24.8	1
21.1	2	24.9	1
21.2	2	25.0	0
21.3	2	25.1	0
21.4	2	25.2	0
21.5	2	25.3	0
21.6	2	25.4	0
21.7	2	25.5	0
21.8	2	25.6	0
21.9	2	25.7	0
22.0	2	25.8	0
22.1	2	25.9	0
22.2	2		
22.3	2		

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 12:18:10
Watershed file: --> c:\pondpack\IRMEX500.WSD
Hydrograph file: --> c:\pondpack\IRMEX500.HYD

PJP LANDFILL-IRM DITCH EXISTING CONDITIONS
500 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used	
A	30.00	74.0	0.75	0.00	11.98	8.60	.06	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 30.00 acres or 0.04688 sq.mi
Peak discharge = 138 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	0.65	0.00	0.75	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 12:18:10
Watershed file: --> c:\pondpack\IRMEX500.WSD
Hydrograph file: --> c:\pondpack\IRMEX500.HYD

PJP LANDFILL-IRM DITCH EXISTING CONDITIONS
500 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	138	12.8
Composite Watershed	138	12.8

SHEET 18 OF 2

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 12:18:10
Watershed file: --> c:\pondpack\IRMEX500.WSD
Hydrograph file: --> c:\pondpack\IRMEX500.HYD

PJP LANDFILL-IRM DITCH EXISTING CONDITIONS
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	7	9	11	16	18	23	29	42	61
Total (cfs)	7	9	11	16	18	23	29	42	61

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	87	113	132	138	125	92	66	49	38
Total (cfs)	87	113	132	138	125	92	66	49	38

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	31	25	21	18	16	14	12	10	9
Total (cfs)	31	25	21	18	16	14	12	10	9

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	8	6	6	4	0
Total (cfs)	8	6	6	4	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 12:18:10
Watershed file: --> c:\pondpack\IRMEX500.WSD
Hydrograph file: --> c:\pondpack\IRMEX500.HYD

PJP LANDFILL-IRM DITCH EXISTING CONDITIONS
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	7	14.8	20
11.1	8	14.9	19
11.2	8	15.0	18
11.3	9	15.1	18
11.4	10	15.2	17
11.5	10	15.3	17
11.6	11	15.4	16
11.7	13	15.5	16
11.8	14	15.6	16
11.9	16	15.7	15
12.0	18	15.8	15
12.1	23	15.9	14
12.2	29	16.0	14
12.3	42	16.1	14
12.4	61	16.2	13
12.5	87	16.3	13
12.6	113	16.4	12
12.7	132	16.5	12
12.8	138	16.6	12
12.9	132	16.7	11
13.0	125	16.8	11
13.1	108	16.9	10
13.2	92	17.0	10
13.3	79	17.1	10
13.4	66	17.2	10
13.5	58	17.3	9
13.6	49	17.4	9
13.7	44	17.5	9
13.8	38	17.6	9
13.9	34	17.7	9
14.0	31	17.8	8
14.1	29	17.9	8
14.2	27	18.0	8
14.3	25	18.1	8
14.4	24	18.2	8
14.5	22	18.3	7
14.6	21	18.4	7
14.7	20	18.5	7

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-08-2007 12:18:10
Watershed file: --> c:\pondpack\IRMEX500.WSD
Hydrograph file: --> c:\pondpack\IRMEX500.HYD

PJP LANDFILL-IRM DITCH EXISTING CONDITIONS
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	7	22.4	4
18.7	7	22.5	4
18.8	6	22.6	3
18.9	6	22.7	3
19.0	6	22.8	3
19.1	6	22.9	3
19.2	6	23.0	3
19.3	6	23.1	3
19.4	6	23.2	3
19.5	6	23.3	3
19.6	6	23.4	3
19.7	6	23.5	2
19.8	6	23.6	2
19.9	6	23.7	2
20.0	6	23.8	2
20.1	6	23.9	2
20.2	6	24.0	2
20.3	6	24.1	2
20.4	6	24.2	2
20.5	6	24.3	2
20.6	5	24.4	2
20.7	5	24.5	2
20.8	5	24.6	1
20.9	5	24.7	1
21.0	5	24.8	1
21.1	5	24.9	1
21.2	5	25.0	1
21.3	5	25.1	1
21.4	5	25.2	1
21.5	4	25.3	1
21.6	4	25.4	1
21.7	4	25.5	0
21.8	4	25.6	0
21.9	4	25.7	0
22.0	4	25.8	0
22.1	4	25.9	0
22.2	4		
22.3	4		

PJP Landfill Site
Jersey City, New Jersey
Existing IRM Ditch

Rev's JCA 3/14/07

Channel Name	Contributing Watersheds	Design Storm (years)	Curve Number Number	Peak Discharge (cfs)	Channel Bed Slope (ft/ft)	Free-board (ft)	Channel Lining	Manning Coeff.	Channel Bottom Width (ft)	Left Side Slopes Inclintion	Right Side Slopes Inclintion	Flow Area (sq.ft.)	Flow Depth (ft)	Top Flow Width (ft.)	Flow Velocity (ft/s)	Available Q with Freeboard (cfs)	Channel Depth (ft)	Top Channel Width (ft)	Available Q without Freeboard (cfs)
IRM Ditch	portions of the IRM	100	74	72	0.016	0.28	Riprap	0.033	0.00	2.50	2.50	15.63	2.23	12.50	5.82	72.0	2.50	12.5	98.3
IRM Ditch	portions of the IRM	100	74	72	0.005	0.23	Riprap	0.033	0.00	2.50	2.50	22.50	2.77	15.00	3.76	72.0	3.00	15.0	89.3
IRM DITCH	portions of the IRM	500	74	138	0.016	-0.34	Riprap	0.033	0.00	2.50	2.50	15.63	2.84	12.50	6.85	138.0	2.50	12.5	98.3
IRM DITCH	portions of the IRM	500	74	138	0.005	-0.53	Riprap	0.033	0.00	2.50	2.50	22.50	3.53	15.00	4.43	138.0	3.00	15.0	89.3

SHEET 21 OF 21

OBJECTIVE: To evaluate the peak flow of storm water entering the Sip Avenue Ditch from the Jersey City upland drainage area, for the both 100-year and 500-year, 24-hour storm event.

REFERENCES:

1) Telephone Memorandums based on telephone conversations with the Jersey City Engineers Office, dated 8/29/03 and 9/5/03.

2) USDA, Soil Conservation Service, "Technical Release No. 55: Urban Hydrology for Small Watersheds" (TR-55), June, 1986.

3) Hydrology, Viessman, Jr., Warren and Lewis, Gary L., Harper Collins College Publishers, 1996.

4) New Jersey State Soil Conservation Committee, "Standards for Soil Erosion and Sediment Control in New Jersey, " dated July, 1999.

5) New Jersey Department of Transportation Design Manual-Roadway, "Rainfall Intensity-Duration-Frequency Curves", dated 2001.

6) National Oceanic & Atmospheric Administration (NOAA), U.S. Department of Commerce website for "Precipitation Frequency Estimates from NOAA Atlas 14," last modified January 2007.

METHOD & CALCULATIONS: In general the methods and calculations will include two separate methods:

1) Rational Method; and,
2) TR-55 computer program.

The following describes the two methods in detail.

1) Rational Method

METHOD: Per Reference 1 and 3, use the Rational Formula to estimate the peak runoff rates.

Rational Formula is $Q = CIA$

Where,
Q = peak runoff rate (cfs)
C = runoff coefficient (dimensionless)
I = average rainfall intensity (in/hr)
A = size of the drainage area (ac)

* The intensity is determined for a rainfall duration that equals the time of concentration (t_c).

CALCULATIONS: 1) The following constants have been used for all calculations:

Q = CIA

Where,
CI = 1.8 for 100-year storm event, and 2.1 for 500-year storm event;
A = 219 acres (Ref. 1);
C = 0.59 (equivalent for a neighborhood setting); and,
I = 3.0 in/hr based on the 100-year, 1-hour storm event; and equals 3.5 in/hr based on the 500-year, 1-hour storm event (from Ref. 6)

The value of (Q) is being solved for to determine the peak flow entering the Sip Avenue Ditch through the conduit located at the end of the Sip Avenue Ditch where it intersects Routes 1 and 9. Based on the information provided by the Jersey City Engineers Office, the peak flow of stormwater runoff was calculated as:

100-Year Storm Event	500-Year Storm Event
Q = (1.8)(219)	Q = (2.1)(219)
Q = 394 cfs	Q = 460 cfs

2) ***TR-55 Method***

METHOD: Per Reference 2, the TR-55 computer program was used to determine the peak runoff for Jersey City upland drainage area. This program requires several input parameters such as:

- Drainage Area (as described below);
- Time of Concentration (as described below);
- Curve Number (as described below);
- Rainfall Type – Type III (see sheet 4 of 13);
- Design Storm – 100-year, 24-hour storm (7.5 inches) (see sheet 5 of 13); and,
- Design Storm – 500-year, 24-hour storm (11.98) (from Reference 6).

Drainage Areas

The drainage area within Jersey City that contributes storm water flow to the Sip Avenue Ditch was provided by the Jersey City Engineers Office as 219 acres.

Time of Concentration

The time of concentration (Tc), the length of time for runoff to travel from the most hydrology distant point within a drainage area, was provided by the Jersey City Engineers Office as 1 hour.

Curve Number

The Curve Number, which is based on the hydrologic soil type and surface cover, is outlined in Reference 2. The hydrologic soil type is assumed to be Type C (soils of low infiltration rates with moderately fine to fine texture) (Reference 2). The proposed surface cover varies throughout the drainage area, so a weighted CN value was calculated, and determined to be 93. (See sheet 8 of 18)

Peak Runoff

The peak runoff for the drainage area was determined by using TR-55 computer program. The drainage areas, time of concentrations, curve number, rainfall type, and design storm information was inputted in to the TR-55 program. The peak runoff for the drainage area was determined to be 678 cfs and 1128 cfs, for the 100-year, 24-hour storm event and the 500-year, 24-hour storm event, respectively.

RESULTS: Based on the two methods used in the calculation of the peak flow entering the Sip Avenue Ditch, the Rational Method provided a flow rate of 394 cfs and 460 cfs, for the 100-year and 500-year storm events, respectively; and the TR-55 computer method provided a flow rate of 678 cfs and 1128 cfs, for the 100-year and 500-year storm events, respectively.

CONCLUSION: The calculations provide a range of peak flow rates entering the Sip Avenue Ditch from the upland Jersey City drainage area. For conservative measures, the higher peak values will be used in the calculations for the design of the Sip Avenue Ditch.

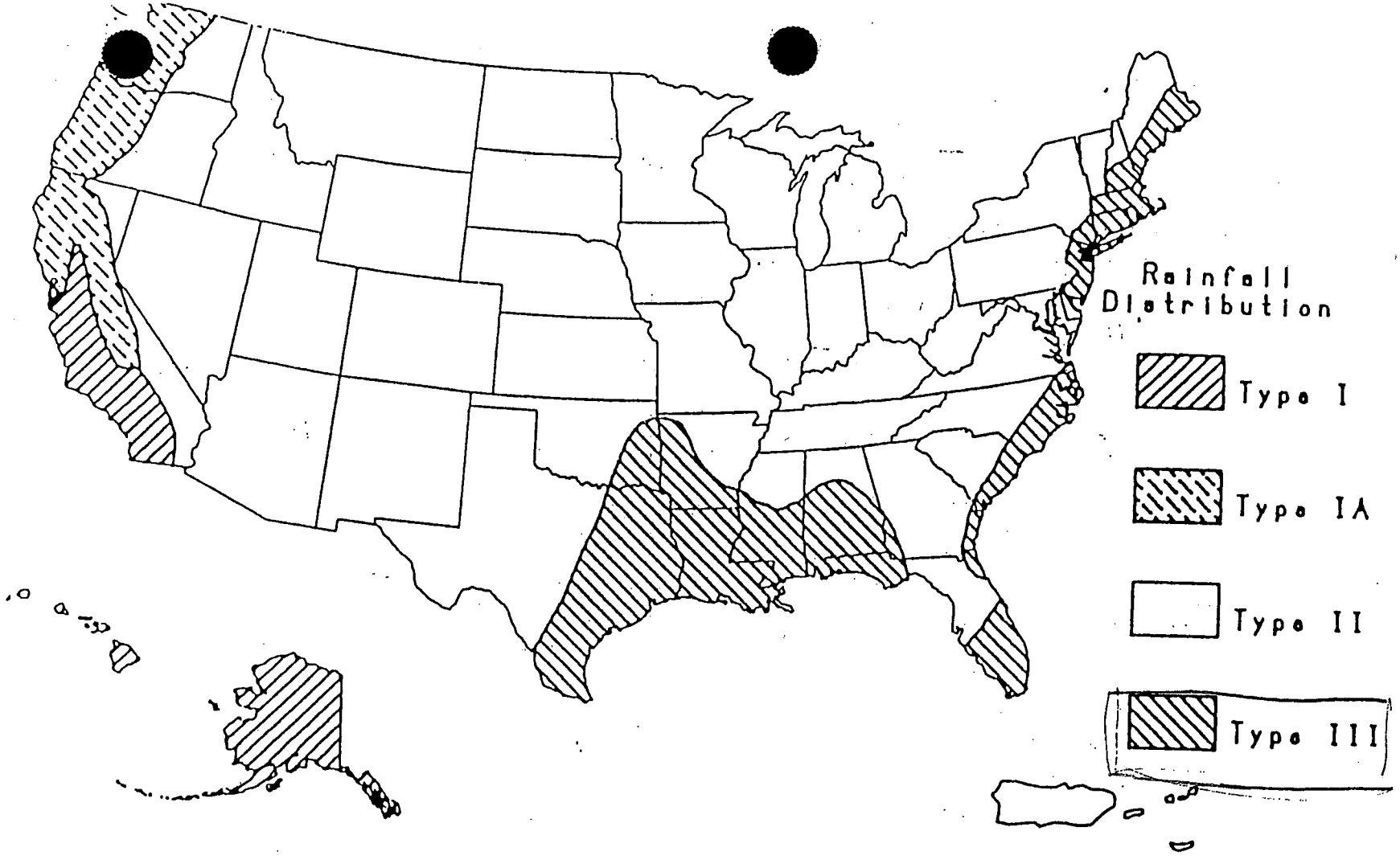


Figure II-2.—Approximate geographic boundaries for SCS rainfall distributions.

(from Reference 2)

NEW JERSEY 24 HOUR RAINFALL

County	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Atlantic	2.8	3.5	4.5	5.5	6.2	6.8	7.6
Bergen	2.7	3.3	4.3	5.3	5.7	6.5	7.5
Burlington	2.8	3.4	4.4	5.3	6.0	6.6	7.4
Camden	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Cape May	2.9	3.5	4.6	5.6	6.3	6.9	7.7
Cumberland	2.8	3.4	4.5	5.4	6.0	6.8	7.5
Essex	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Gloucester	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Hudson	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Hunterdon	2.6	3.2	4.2	5.0	5.7	6.5	7.3
Mercer	2.7	3.3	4.3	5.2	5.8	6.4	7.5
Middlesex	2.7	3.3	4.3	5.2	5.9	6.4	7.5
Monmouth	2.8	3.4	4.4	5.3	6.0	6.5	7.5
Morris	2.6	3.3	4.3	5.2	5.7	6.5	7.5
Ocean	2.8	3.5	4.5	5.4	6.2	6.6	7.5
Passaic	2.6	3.3	4.3	5.4	5.7	6.5	7.6
Salem	2.8	3.3	4.4	5.3	5.9	6.6	7.4
Somerset	2.7	3.3	4.3	5.2	5.7	6.5	7.5
Sussex	2.6	3.2	4.2	5.0	5.7	6.6	7.5
Union	2.7	3.3	4.3	5.3	5.8	6.4	7.5
Warren	2.6	3.2	4.1	4.9	5.6	6.5	7.2

Appendix A: Hydrologic soil groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier: for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983):

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4]Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Golder Associates

SUBJECT SIP AVENUE DITCH (JERSEY CITY)		
Job No. 003-6004-002 Ref.	Made by CBM Checked RAD Reviewed	Date 9/24/03 Sheet 8 of 18

AREA = 219 ACRES — PER JERSEY CITY ENGINEERS OFFICE
= 0.34 m^2

59% RESIDENTIAL (80% OF THAT IS IMPERVIOUS)
41% COMMERCIAL, INDUSTRIAL + ROADWAY

RESIDENTIAL

(219)(0.59) = 129.21 AC — TOTAL RESIDENTIAL

(129.21)(.80) = 103.37 AC — IMPERVIOUS RESIDENTIAL
129.21 − 103.37 = 25.84 AC — RESIDENTIAL HOUSING

$\frac{103.37}{219} = 0.47$ $\frac{25.84}{219} = 0.12$ AC

SOIL TYPE	% LAND COVERAGE	DESCRIPTION OF LAND	CN	WEIGHTED CN
C	47%	IMPERVIOUS	98	46.06 ✓
C	12%	RESIDENTIAL *1	80	9.60 ✓
C	41%	INDUSTRIAL/COMMERCIAL *2	91	37.31 ✓
				92.97 ≈ 93 ✓

*1 VARIES PER JERSEY CITY ENGINEERS OFFICE, SO USE CN = 80
*2 VARIES BETWEEN COMMERCIAL AND INDUSTRIAL, SO USE CN = 91

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-12-2007 14:57:45
Watershed file: --> c:\pondpack\SIPJC .WSD
Hydrograph file: --> c:\pondpack\SIPJC .HYD

PEAK FLOW INTO SIP AVENUE DITCH (JERSEY CITY)
100-YEAR, 24-HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used
A	219.00	93.0	1.00	0.00	7.50	6.67	.02 .10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 219.00 acres or 0.3422 sq.mi
Peak discharge = 678 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	1.00	0.00	**	**	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-12-2007 14:57:45
Watershed file: --> c:\pondpack\SIPJC .WSD
Hydrograph file: --> c:\pondpack\SIPJC .HYD

PEAK FLOW INTO SIP AVENUE DITCH (JERSEY CITY)
100-YEAR, 24-HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	678	13.0
Composite Watershed	678	13.0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-12-2007 14:57:45
Watershed file: --> c:\pondpack\SIPJC .WSD
Hydrograph file: --> c:\pondpack\SIPJC .HYD

PEAK FLOW INTO SIP AVENUE DITCH (JERSEY CITY)
100-YEAR, 24-HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	34	43	55	73	84	100	123	162	224
Total (cfs)	34	43	55	73	84	100	123	162	224

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	310	413	518	603	678	616	491	374	292
Total (cfs)	310	413	518	603	678	616	491	374	292

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	235	178	146	119	98	82	71	59	52
Total (cfs)	235	178	146	119	98	82	71	59	52

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	48	37	32	27	0
Total (cfs)	48	37	32	27	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-12-2007 14:57:45
Watershed file: --> c:\pondpack\SIPJC .WSD
Hydrograph file: --> c:\pondpack\SIPJC .HYD

PEAK FLOW INTO SIP AVENUE DITCH (JERSEY CITY)
100-YEAR, 24-HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	34	14.8	132
11.1	37	14.9	126
11.2	40	15.0	119
11.3	43	15.1	115
11.4	47	15.2	111
11.5	51	15.3	106
11.6	55	15.4	102
11.7	61	15.5	98
11.8	67	15.6	95
11.9	73	15.7	92
12.0	84	15.8	88
12.1	100	15.9	85
12.2	123	16.0	82
12.3	162	16.1	80
12.4	224	16.2	78
12.5	310	16.3	75
12.6	413	16.4	73
12.7	518	16.5	71
12.8	603	16.6	69
12.9	641	16.7	66
13.0	678	16.8	64
13.1	647	16.9	61
13.2	616	17.0	59
13.3	553	17.1	58
13.4	491	17.2	56
13.5	433	17.3	55
13.6	374	17.4	53
13.7	333	17.5	52
13.8	292	17.6	51
13.9	264	17.7	50
14.0	235	17.8	50
14.1	216	17.9	49
14.2	197	18.0	48
14.3	178	18.1	47
14.4	167	18.2	46
14.5	157	18.3	45
14.6	146	18.4	44
14.7	139	18.5	42

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-12-2007 14:57:45
Watershed file: --> c:\pondpack\SIPJC .WSD
Hydrograph file: --> c:\pondpack\SIPJC .HYD

PEAK FLOW INTO SIP AVENUE DITCH (JERSEY CITY)
100-YEAR, 24-HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	41	22.4	24
18.7	40	22.5	24
18.8	39	22.6	23
18.9	38	22.7	22
19.0	37	22.8	22
19.1	36	22.9	21
19.2	36	23.0	20
19.3	36	23.1	20
19.4	35	23.2	19
19.5	34	23.3	18
19.6	34	23.4	18
19.7	34	23.5	17
19.8	33	23.6	16
19.9	32	23.7	16
20.0	32	23.8	15
20.1	32	23.9	14
20.2	32	24.0	14
20.3	31	24.1	13
20.4	31	24.2	12
20.5	31	24.3	11
20.6	30	24.4	11
20.7	30	24.5	10
20.8	30	24.6	9
20.9	30	24.7	9
21.0	30	24.8	8
21.1	29	24.9	7
21.2	29	25.0	7
21.3	29	25.1	6
21.4	28	25.2	5
21.5	28	25.3	5
21.6	28	25.4	4
21.7	28	25.5	3
21.8	28	25.6	3
21.9	27	25.7	2
22.0	27	25.8	1
22.1	26	25.9	1
22.2	26		
22.3	25		

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-12-2007 15:02:15
Watershed file: --> c:\pondpack\SIPJC500.WSD
Hydrograph file: --> c:\pondpack\SIPJC500.HYD

PEAK FLOW INTO SIP AVENUE DITCH (JERSEY CITY)
500-YEAR, 24-HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used
A	219.00	93.0	1.00	0.00	11.98	11.10	.01 .10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 219.00 acres or 0.3422 sq.mi
Peak discharge = 1128 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	* Tt (hr)	Rounded Values Tc (hr)	* Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	1.00	0.00	**	**	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-12-2007 15:02:15
Watershed file: --> c:\pondpack\SIPJC500.WSD
Hydrograph file: --> c:\pondpack\SIPJC500.HYD

PEAK FLOW INTO SIP AVENUE DITCH (JERSEY CITY)
500-YEAR, 24-HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	1128	13.0
Composite Watershed	1128	13.0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-12-2007 15:02:15
Watershed file: --> c:\pondpack\SIPJC500.WSD
Hydrograph file: --> c:\pondpack\SIPJC500.HYD

PEAK FLOW INTO SIP AVENUE DITCH (JERSEY CITY)
500-YEAR, 24-HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	57	72	91	122	141	167	205	270	372
Total (cfs)	57	72	91	122	141	167	205	270	372

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	517	687	862	1003	1128	1026	817	623	486
Total (cfs)	517	687	862	1003	1128	1026	817	623	486

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	391	296	243	198	163	137	118	99	87
Total (cfs)	391	296	243	198	163	137	118	99	87

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	80	61	53	46	0
Total (cfs)	80	61	53	46	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-12-2007 15:02:15
Watershed file: --> c:\pondpack\SIPJC500.WSD
Hydrograph file: --> c:\pondpack\SIPJC500.HYD

PEAK FLOW INTO SIP AVENUE DITCH (JERSEY CITY)
500-YEAR, 24-HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	57	14.8	220
11.1	62	14.9	209
11.2	67	15.0	198
11.3	72	15.1	191
11.4	78	15.2	184
11.5	85	15.3	177
11.6	91	15.4	170
11.7	101	15.5	163
11.8	112	15.6	158
11.9	122	15.7	153
12.0	141	15.8	147
12.1	167	15.9	142
12.2	205	16.0	137
12.3	270	16.1	133
12.4	372	16.2	129
12.5	517	16.3	126
12.6	687	16.4	122
12.7	862	16.5	118
12.8	1003	16.6	114
12.9	1066	16.7	110
13.0	1128	16.8	107
13.1	1077	16.9	103
13.2	1026	17.0	99
13.3	921	17.1	97
13.4	817	17.2	94
13.5	720	17.3	92
13.6	623	17.4	89
13.7	554	17.5	87
13.8	486	17.6	86
13.9	438	17.7	84
14.0	391	17.8	83
14.1	359	17.9	81
14.2	328	18.0	80
14.3	296	18.1	78
14.4	278	18.2	76
14.5	261	18.3	74
14.6	243	18.4	72
14.7	232	18.5	70

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-12-2007 15:02:15
Watershed file: --> c:\pondpack\SIPJC500.WSD
Hydrograph file: --> c:\pondpack\SIPJC500.HYD

PEAK FLOW INTO SIP AVENUE DITCH (JERSEY CITY)
500-YEAR, 24-HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	69	22.4	41
18.7	67	22.5	40
18.8	65	22.6	39
18.9	63	22.7	38
19.0	61	22.8	37
19.1	60	22.9	36
19.2	59	23.0	34
19.3	59	23.1	33
19.4	58	23.2	32
19.5	57	23.3	31
19.6	56	23.4	30
19.7	55	23.5	29
19.8	55	23.6	28
19.9	54	23.7	26
20.0	53	23.8	25
20.1	53	23.9	24
20.2	52	24.0	23
20.3	52	24.1	22
20.4	52	24.2	21
20.5	51	24.3	20
20.6	51	24.4	18
20.7	51	24.5	17
20.8	50	24.6	16
20.9	50	24.7	15
21.0	50	24.8	14
21.1	49	24.9	13
21.2	49	25.0	12
21.3	48	25.1	10
21.4	48	25.2	9
21.5	48	25.3	8
21.6	47	25.4	7
21.7	47	25.5	6
21.8	47	25.6	5
21.9	46	25.7	3
22.0	46	25.8	2
22.1	45	25.9	1
22.2	44		
22.3	43		

APPENDIX C-2

PROPOSED IRM PERIMETER DITCH

Figure 6-2 presents a conceptual design for modification of the IRM Perimeter Ditch. As an alternative, if adjacent property access is possible, the IRM Perimeter Ditch may be relined with riprap or equivalent. The attached calculations provide details for modification if riprap or equivalent lining is possible

OBJECTIVE: Design the IRM Perimeter ditch to accommodate the increased flow capacity from the peak flow of both the 100-year and 500-year, 24-hour storm event.

REFERENCES:

1) Golder Associates Inc., Calculations entitled "IRM Perimeter Ditch – Existing Conditions", dated 3/08/07.

2) Golder Associates Inc., "Final (90%) Design Report, Figure 5-1, Existing Conditions", dated 9/22/03.

3) Golder Associates Inc., "Design for Culverts", dated 3/26/07.

4) New Jersey State Soil Conservation Committee, "Standards for Soil Erosion and Sediment Control in New Jersey," dated July 1999.

5) National Oceanic & Atmospheric Administration (NOAA), U.S. Department of Commerce website for "Precipitation Frequency Estimates from NOAA Atlas 14," last modified January 2007.

METHOD:

1) Cut-sections along the existing ditch to determine its cross-section throughout its length. (Figure 1) The length of the ditch was evenly sectioned and a cross-section was developed. Along the southerly line of the IRM property, the cross-sections were every 300 feet, except between cross-section R and S, the distance was 100 feet. Along the roadway between the IRM property and the Archdiocese property, the cross-sections were every 100 feet.

2) Provide several variations and alterations to the existing IRM Perimeter Ditch to determine which configuration provided the greatest flow area possible. (Table 1)

CALCULATION: To determine the amount of flow that is available in the resized channel, the Manning's equation for open channel flow was used. An Excel Spreadsheet was utilized to run the calculations. The Manning's equation is as follows:

$$Q = (1.49 \times R_h^{2/3} \times A \times S^{1/2})/n, \text{ where:}$$

Q = channel flow rate (cfs)
R_h = hydrualic radius of channel = A/P (ft)
A = cross-sectional area of flow (ft^2)
P = wetted perimeter of flow (ft)
S = channel slope (ft/ft)
n = Manning's coefficient

Channel Flow Rate

The existing peak flow contributing to the IRM ditch between cross-sections A through L is approximately 72 cfs, based on calculations completed in Reference 1 for the 100-year, 24-hour storm event, and 138 cfs for the 500-year, 24 hour storm event. An additional amount of 13 cfs and 25 cfs is calculated to be carried by the southerly section of the IRM ditch based on calculations completed in Reference 3 for the 100-year and 500-year, 24-hour storm events, respectively. Thus, the existing peak

flow contributing to the IRM ditch between cross-sections M through S is approximately 85 cfs and 163 cfs, for the 100-year and 500-year, 24 hour storm events, respectively.

Hydraulic Radius, Cross Sectional Area, and Wetted Perimeter

Hydraulic radius, cross sectional area, and wetted perimeter of flow are dependent on the channel dimension and depth of flow. These parameters are determined by the shape of the channel, channel side slopes, and flow depth. Various dimensions were used to resize the channel. One of the goals of resizing the channel is to limit the amount of disturbance to the existing channel, therefore it has been envisioned that varying the depth and side slope by addition of material along the sides of the channel would cause the least amount of disturbance. When determining the placement of additional material to build up the depth of the channel, site constraints such of distance to the property boundary were taken into consideration.

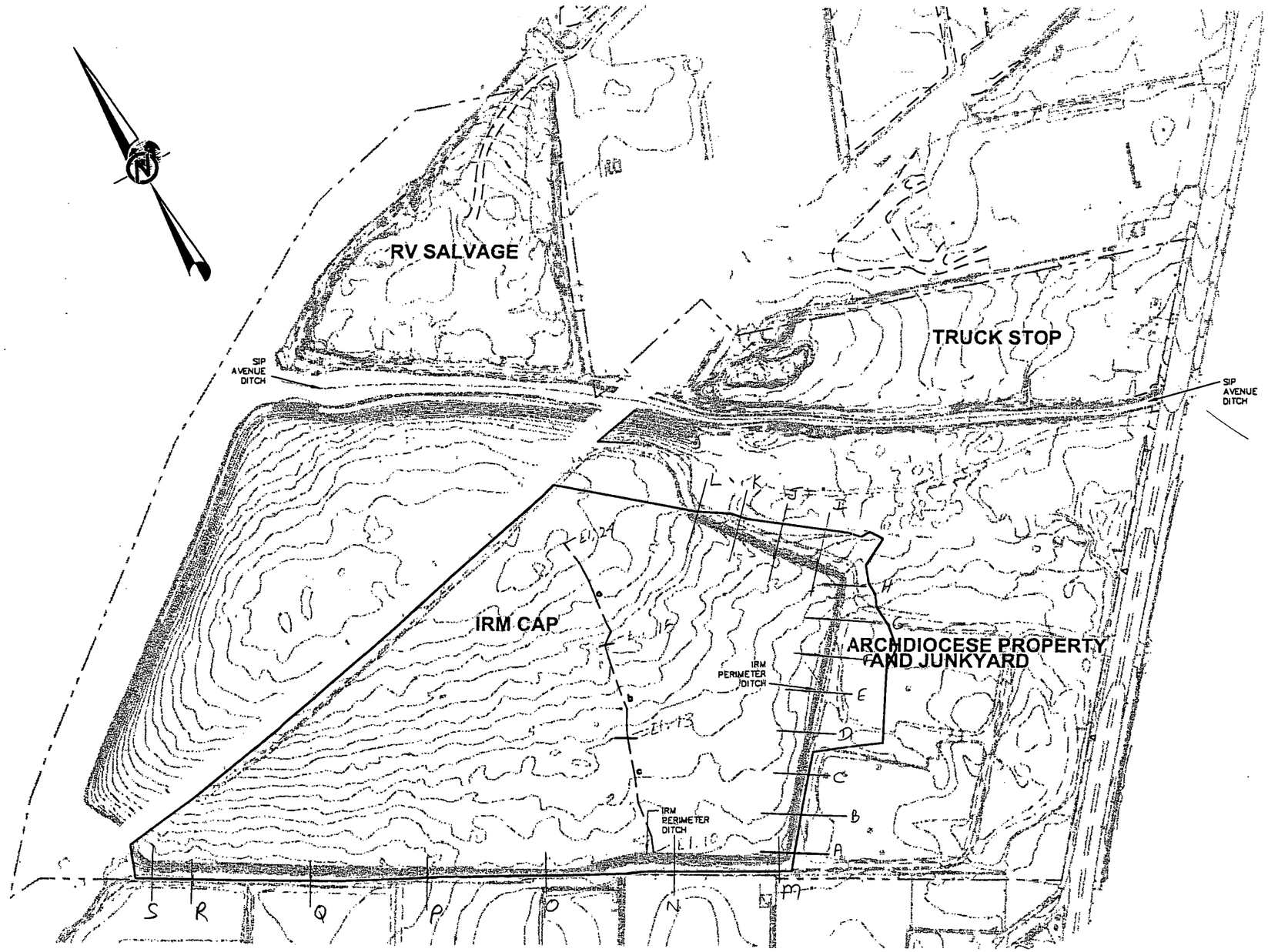
Channel Slope

The existing channel slope varies throughout the IRM ditch. Retrofitting the IRM ditch will not allow for adjustment of the channel slope since the channel elevations are fixed. A slope of 0.001 was used in the calculations, which will produce conservative peak flows.

Manning's Coefficient

The Manning's coefficient ("n") is a resistance factor related to surface roughness, channel irregularity, obstructions in the channel, and channel alignment. Since the proposed drainage channels are engineered and not naturally occurring, the main factor in determining the Manning's coefficient is surface roughness. Using guideline in Reference 4, the Manning's coefficient for channels with riprap lined is determined to be 0.033.

CONCLUSION: To provide the required amount of flow in the IRM Perimeter Ditch to accommodate both the 100-year and 500-year, 24-hour storm events, the ditch will need to be resized to establish a 6" riprap lined, trapezoidal ditch cross-section, with a varying base width, and side slopes ranging from 2H:1V to 3H:1V. The depth of the ditch will be a minimum 3.0 feet and go to 4.0 feet, in several areas, which incorporates a minimum 0.25 feet of freeboard and will prevent overtopping from the 500-year, 24 hour storm event. There will be minimal impact on the side of the ditch that borders the existing IRM cap. Most of the modifications will include building up the side slope of the channel to provide the minimum depth of channel of 3.0 feet. Cross-sectional areas are provided to show the estimated locations of the cut/fill that would be necessary to adequately resize the IRM perimeter ditch.



LEGEND

CONTRIBUTING DRAINAGE AREA BOUNDARY

TIME OF CONCENTRATION

SITE BOUNDARY

NOTES

1.) PLEASE REFER TO FIGURES 4–1 THROUGH 4–4 OF THE PRELIMINARY (30%) DESIGN REPORT FOR LARGER SCALED DRAWING.

REFERENCES

1.) TOPOGRAPHY PREPARED BY JAMES M. STEWARD, INC. CADD FILE No. 1886–00, DATED 11/02/98.

300 0 300
SCALE FEET

Golder Associates
Philadelphia USA

FILE No.	calcfig.dwg		
PROJECT No.	003–6004–002	REV.	0

SCALE	AS SHOWN
DATE	08/29/01
DESIGN	RAD
CADD	RAD
CHECK	
REVIEW	RAD

TITLE

EXISTING CONDITION IRM PERIMETER DITCH

PJP LANDFILL

FIGURE 1

TABLE 1
PROPOSED CONDITIONS FOR THE IRM PERIMETER DITCH
100-YEAR AND 500-YEAR, 24-HOUR STORM EVENT
PJP Landfill Site
Jersey City, New Jersey

Channel Name	Channel Type	Contributing Watersheds	Design Storm (years)	Curve Number Number	Peak Discharge (cfs) (1)	Channel Bed Slope (ft/ft)	Free-board (ft)	Channel Lining	Manning Coeff.	Channel Bottom Width (ft) (2)	Left Side Slopes Inclintion	Right Side Slopes Inclintion	Flow Area (sq.ft.)	Flow Depth (ft)	Top Flow Width (ft.)	Flow Velocity (ft/s)	Actual Q (cfs)	With Freeboard: Channel Depth (ft) (3)	With Freeboard: Top Channel Width (ft)	With Freeboard: Q Available (cfs)
A	Trapezoidal	IRM	100	74	72	0.001	0.45	rip-rap	0.033	8.62	2.00	2.00	34.99	2.55	18.82	2.07	72.3	3.00	20.6	98.8
B	Trapezoidal	IRM	100	74	72	0.010	1.60	rip-rap	0.033	7.26	3.00	3.00	16.04	1.40	15.66	4.49	72.0	3.00	25.3	332.2
C	Trapezoidal	IRM	100	74	72	0.001	0.34	rip-rap	0.033	5.80	3.00	3.00	36.65	2.66	21.76	1.96	72.0	3.00	23.8	93.3
D	Trapezoidal	IRM	100	74	72	0.001	0.25	rip-rap	0.033	5.06	3.00	3.00	36.60	2.75	21.56	1.97	72.2	3.00	23.1	87.4
E	Trapezoidal	IRM	100	74	72	0.001	0.33	rip-rap	0.033	6.68	3.00	2.00	35.66	2.67	20.03	2.02	72.1	3.00	21.7	91.6
F	Trapezoidal	IRM	100	74	72	0.001	0.36	rip-rap	0.033	6.95	3.00	2.00	35.77	2.64	20.15	2.02	72.2	3.00	22.0	93.8
G	Trapezoidal	IRM	100	74	72	0.010	1.28	rip-rap	0.033	5.12	2.00	2.00	14.72	1.72	12.00	4.94	72.7	3.00	17.1	222.3
H	Trapezoidal	IRM	100	74	72	0.020	1.82	rip-rap	0.033	7.82	2.00	2.00	12.01	1.18	12.54	6.01	72.2	3.00	19.8	412.4
I	Trapezoidal	IRM	100	74	72	0.001	0.57	rip-rap	0.033	9.69	2.00	2.00	35.36	2.43	19.41	2.04	72.3	3.00	21.7	107.7
J	Trapezoidal	IRM	100	74	72	0.020	1.79	rip-rap	0.033	7.43	2.00	2.00	11.92	1.21	12.27	6.06	72.2	3.00	19.4	398.1
K	Trapezoidal	IRM	100	74	72	0.010	1.15	rip-rap	0.033	4.15	2.00	2.00	14.52	1.85	11.55	5.00	72.6	3.00	16.2	197.9
L	Trapezoidal	IRM	100	74	72	0.020	1.54	rip-rap	0.033	4.89	2.00	2.00	11.40	1.46	10.73	6.36	72.5	3.00	16.9	306.1
M	Trapezoidal	IRM	100	74	85	0.003	0.48	rip-rap	0.033	5.11	2.00	2.00	25.61	2.52	15.20	3.32	85.0	3.00	17.1	121.6
N	Trapezoidal	IRM	100	74	85	0.001	1.06	rip-rap	0.033	5.75	3.00	2.50	40.74	2.94	21.94	2.09	85.0	4.00	27.8	166.1
O	Trapezoidal	IRM	100	74	85	0.003	0.54	rip-rap	0.033	5.50	2.00	2.00	25.68	2.46	15.35	3.31	85.0	3.00	17.5	127.0
P	Trapezoidal	IRM	100	74	85	0.003	0.83	rip-rap	0.033	7.75	2.00	2.00	26.25	2.17	16.43	3.24	85.0	3.00	19.8	158.7
Q	Trapezoidal	IRM	100	74	85	0.001	1.16	rip-rap	0.033	8.14	2.00	2.00	39.17	2.84	19.48	2.17	85.0	4.00	24.1	168.5
R	Trapezoidal	IRM	100	74	85	0.001	0.51	rip-rap	0.033	11.23	2.00	2.00	40.30	2.49	21.18	2.11	85.0	3.00	23.2	120.6
S	Trapezoidal	IRM	100	74	85	0.001	0.32	rip-rap	0.033	9.42	2.00	2.00	39.61	2.68	20.14	2.15	85.0	3.00	21.4	105.5
A	Trapezoidal	IRM	500	74	138	0.001	0.44	rip-rap	0.033	8.62	2.00	2.00	56.03	3.56	22.86	2.47	138.4	4.00	24.6	174.7
B	Trapezoidal	IRM	500	74	138	0.010	1.04	rip-rap	0.033	7.26	3.00	3.00	25.68	1.96	19.00	5.39	138.3	3.00	25.3	332.2
C	Trapezoidal	IRM	500	74	138	0.001	0.41	rip-rap	0.033	5.80	3.00	3.00	59.49	3.59	27.34	2.33	138.3	4.00	29.8	176.1
D	Trapezoidal	IRM	500	74	138	0.001	0.32	rip-rap	0.033	5.06	3.00	3.00	59.25	3.68	27.14	2.33	138.0	4.00	29.1	166.7
E	Trapezoidal	IRM	500	74	138	0.001	0.35	rip-rap	0.033	6.68	3.00	2.00	57.69	3.65	24.93	2.40	138.4	4.00	26.7	168.4
F	Trapezoidal	IRM	500	74	138	0.001	0.38	rip-rap	0.033	6.95	3.00	2.00	57.92	3.62	25.05	2.40	138.9	4.00	27.0	171.9
G	Trapezoidal	IRM	500	74	138	0.010	0.62	rip-rap	0.033	5.12	2.00	2.00	23.51	2.38	14.64	5.88	138.2	3.00	17.1	222.3
H	Trapezoidal	IRM	500	74	138	0.020	1.31	rip-rap	0.033	7.82	2.00	2.00	18.93	1.69	14.58	7.31	138.4	3.00	19.8	412.4
I	Trapezoidal	IRM	500	74	138	0.001	0.58	rip-rap	0.033	9.69	2.00	2.00	56.53	3.42	23.37	2.45	138.7	4.00	25.7	188.8
J	Trapezoidal	IRM	500	74	138	0.020	1.27	rip-rap	0.033	7.43	2.00	2.00	18.84	1.73	14.35	7.36	138.6	3.00	19.4	398.1
K	Trapezoidal	IRM	500	74	138	0.010	0.46	rip-rap	0.033	4.15	2.00	2.00	23.44	2.54	14.31	5.93	139.0	3.00	16.2	197.9
L	Trapezoidal	IRM	500	74	138	0.020	0.96	rip-rap	0.033	4.89	2.00	2.00	18.30	2.04	13.05	7.61	139.2	3.00	16.9	306.1
M	Trapezoidal	IRM	500	74	163	0.003	0.55	rip-rap	0.033	5.11	2.00	2.00	41.40	3.45	18.90	3.94	163.0	4.00	21.1	224.1
N	Trapezoidal	IRM	500	74	163	0.001	0.03	rip-rap	0.033	5.75	3.00	2.50	66.06	3.97	27.56	2.47	163.0	4.00	27.8	166.1
O	Trapezoidal	IRM	500	74	163	0.003	0.62	rip-rap	0.033	5.50	2.00	2.00	41.48	3.38	19.03	3.93	163.0	4.00	21.5	232.7
P	Trapezoidal	IRM	500	74	163	0.003	0.96	rip-rap	0.033	7.75	2.00	2.00	42.06	3.04	19.91	3.88	163.0	4.00	23.8	282.9
Q	Trapezoidal	IRM	500	74	163	0.001	0.06	rip-rap	0.033	8.14	2.00	2.00	63.02	3.94	23.88	2.59	163.0	4.00	24.1	168.5
R	Trapezoidal	IRM	500	74	163	0.001	0.49	rip-rap	0.033	11.23	2.00	2.00	64.18	3.52	25.29	2.54	163.0	4.00	27.2	209.3
S	Trapezoidal	IRM	500	74	163	0.001	0.25	rip-rap	0.033	9.42	2.00	2.00	63.45	3.75	24.42	2.57	163.0	4.00	25.4	185.3

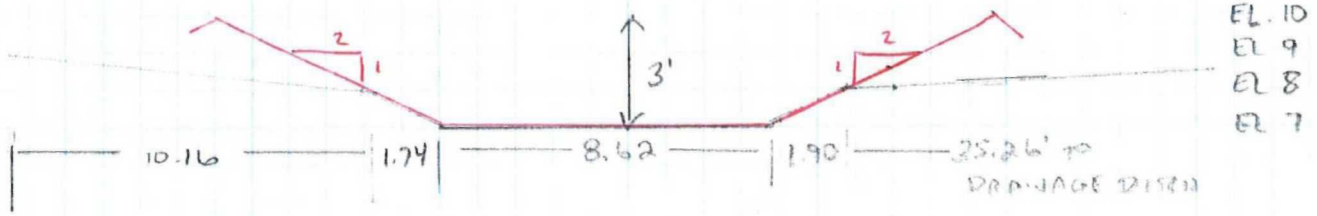
NOTES:

1) Peak Discharge for the IRM ditch was obtained from calculations entitled, "IRM Perimeter Ditch - Existing Conditionns", dated 3/08/07. An additional flow amount of 13 cfs (for the 100 year storm event) and 25 cfs (for the 500 year storm event) is introduced into the IRM ditch from Culvert A located on the Southerliy side of the Archdiocese Property as contained in calculations entitled, "Design for Culverts", dated 3/06/07.
2) The Channel Bottom Width maintains the existing bottom width of the IRM Ditch within all cross-sections except for cross-section O. Due to the close proximity of the IRM Ditch to the southerly boundary line in the area of cross-section O, the IRM Ditch will be realigned in this portion of the drainage ditch to accommodate the required bottom width and depth of channel to effectively manage the flow of both the 100-year and 500-year, 24-hour storm events.
3) The Channel Depth will be increased to four (4) feet in sections A, C, D, E, F, I, M, O, P, R and S to prevent overtopping of the channel from a 24-hour, 500-year storm event.

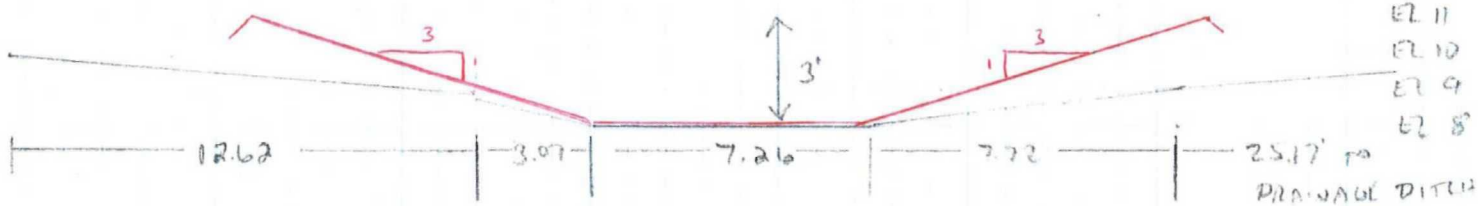
IRM CAP SIDE
(LEFT SIDE)

- EXISTING
- PROPOSED

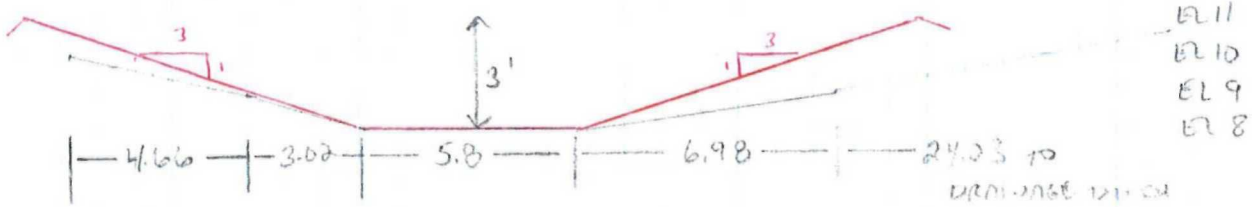
CROSS-SECTION A



CROSS-SECTION B



CROSS-SECTION C



* THE CHANNEL DEPTH IN CROSS-SECTIONS A & C WILL BE INCREASED TO FOUR FEET TO PREVENT OVERTOPPING FROM THE 500-YEAR 24-HOUR STORM EVENT.

Golder Associates

SUBJECT IRM PERIMETER DITCH - DESIGN

Job No. 003-6004.002
Ref.

Made by CRM
Checked RGG
Reviewed

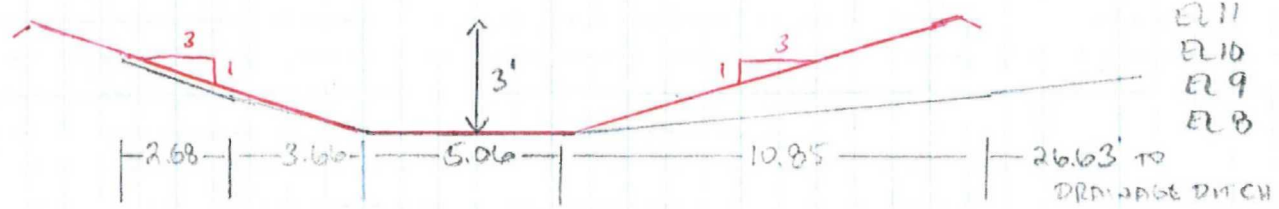
Date 2/19/07
Sheet 1 of 7

SHEET 5 OF 11

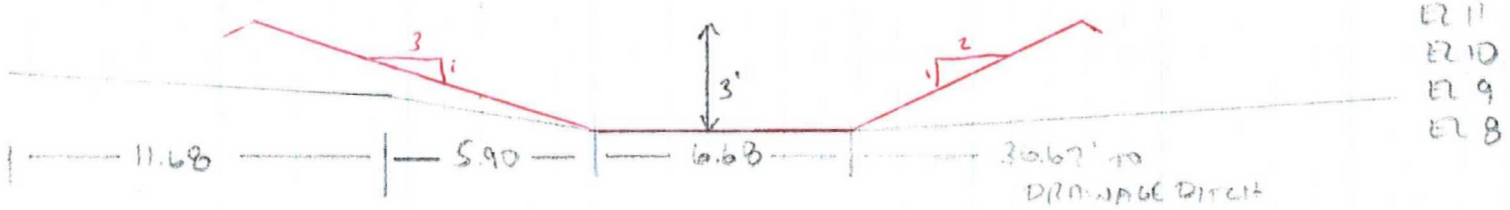
IRM CAP SIDE
(LEFT SIDE)

• EXISTING
• PROPOSED

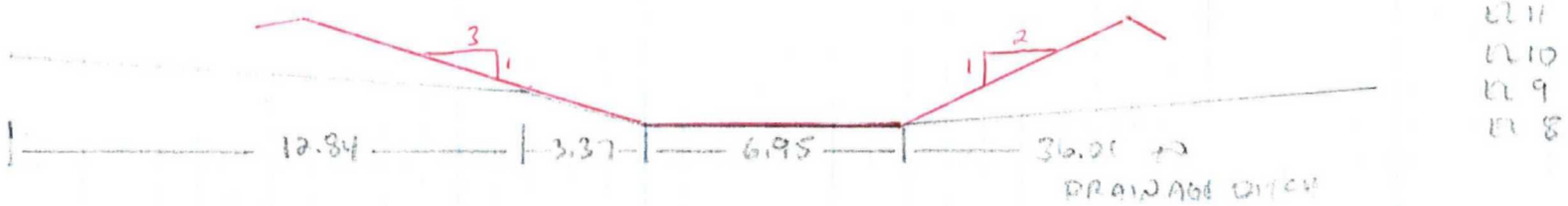
CROSS-SECTION D



CROSS-SECTION E



CROSS-SECTION F



* THE CHANNEL DEPTH IN CROSS-SECTIONS D, E, & F WILL BE INCREASED TO FOUR FEET TO PREVENT OVERTOPPING FROM THE 500 YEAR, 24-HOUR STORM EVENT.

Golder Associates

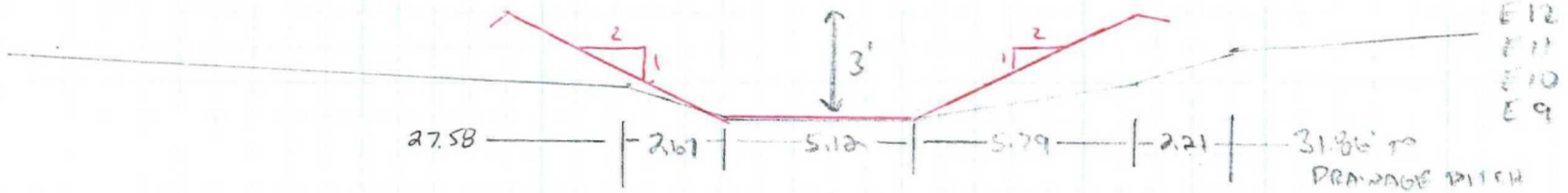
SUBJECT IRM PERIMETER DITCH - DESIGN			
Job No. 003-6004-002 Ref.	Made by CBM	Date 2/19/07	Sheet 2 of 7
	Checked RK		
	Reviewed		

SHEET 6 OF 11

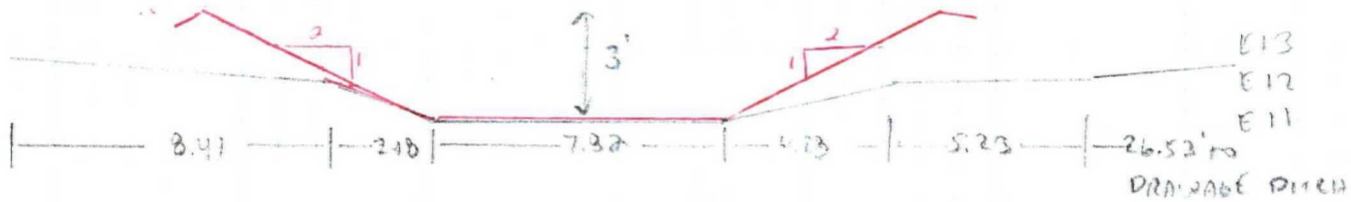
IRM CAPSIDE
(LEFT SIDE)

• EXISTING
• PROPOSED

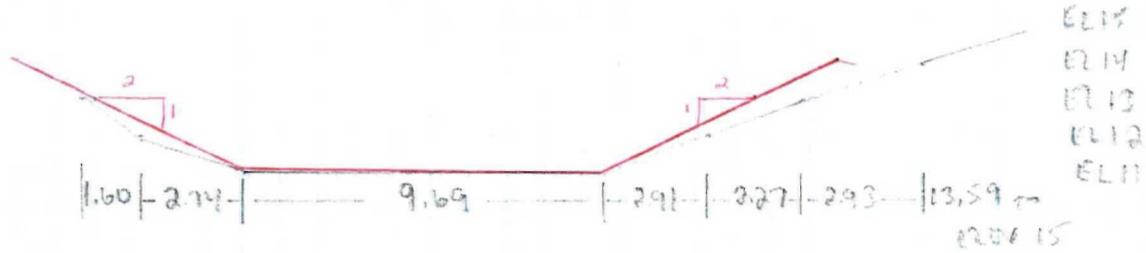
CROSS-SECTION G



CROSS-SECTION H



CROSS-SECTION I



* THE CHANNEL DEPTH IN CROSS-SECTION I WILL BE INCREASED TO FOUR FEET TO PREVENT OVERTOPPING FROM THE 500-YEAR, 24-HOUR STORM EVENT.

Golder Associates

SUBJECT IRM PERIMETER DITCH

Job No. 003-6004-002

Ref.

Made by CBM

Checked RBG

Reviewed

Date 2/19/07

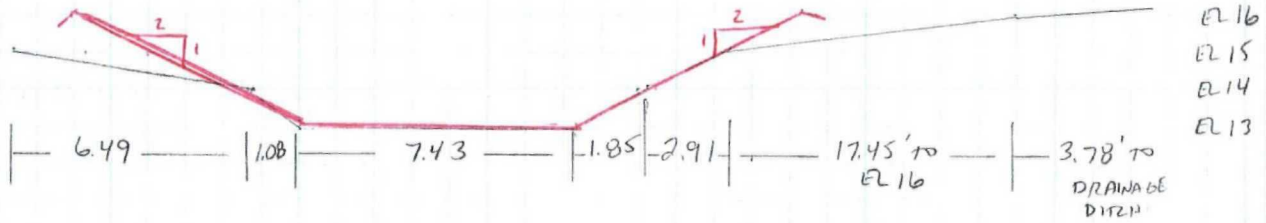
Sheet 3 of 7

SHEET 7 OF 11

IRM CAP SIDE
(LEFT SIDE)

- EXISTING
- PROPOSED

CROSS-SECTION J



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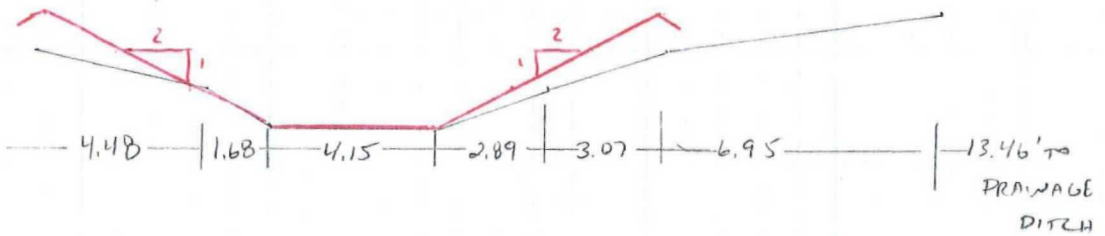

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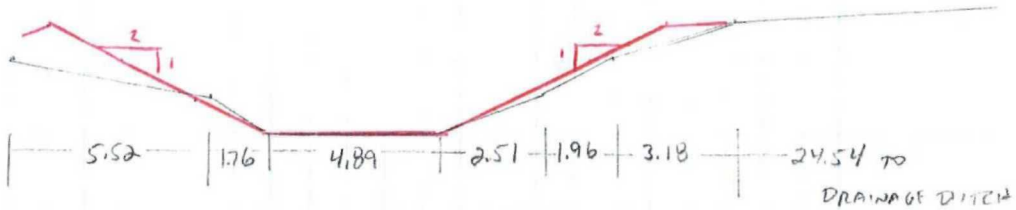


Golder Associates

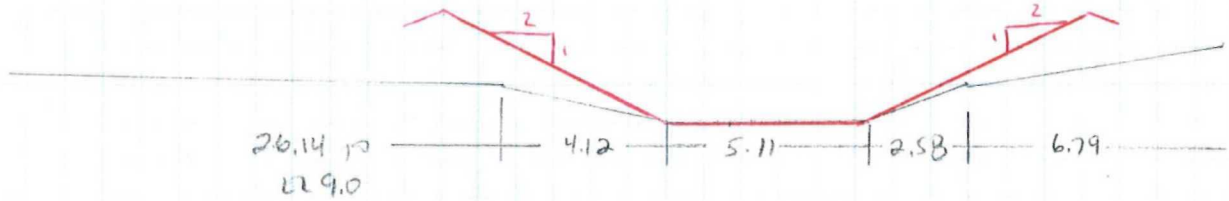
SUBJECT IRM PERIMETER DITCH			
Job No. 03-6004-002 Ref.	Made by CBM	Date 2/19/07	
	Checked RBG	Sheet 1 of 7	
	Reviewed		

SHEET 8 OF 11

TRM CAP SIDE
(LEFT SIDE)

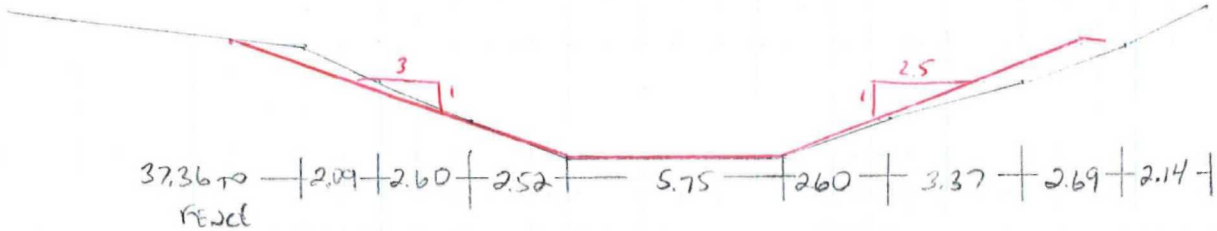
- EXISTING
- PROPOSED

CROSS SECTION M



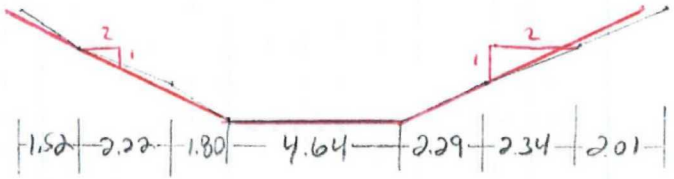
El 9
El 8
El 7

CROSS SECTION N



El 10
El 9
El 8
El 7
El 6

CROSS SECTION O



El 9
El 8
El 7
El 6

* THE CHANNEL DEPTH IN CROSS-SECTIONS M & O WILL BE INCREASED TO FOUR FEET TO PREVENT OVERTOPPING FROM THE 500-YEAR, 24-HOUR STORM EVENT.

Golder Associates

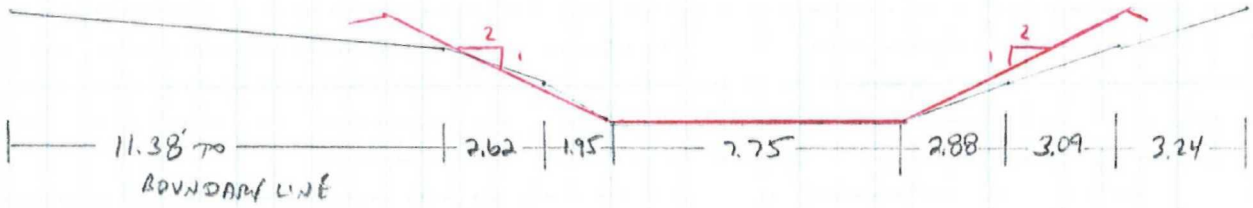
SUBJECT IRM PERIMETER DITCH - DESIGN			
Job No. 003-6004-002	Made by CSM	Date 2/26/07	
Ref.	Checked RDS	Sheet 5 of 7	
	Reviewed		

SHEET 9 OF 11

IRM CAP SIDE
(LEFT SIDE)

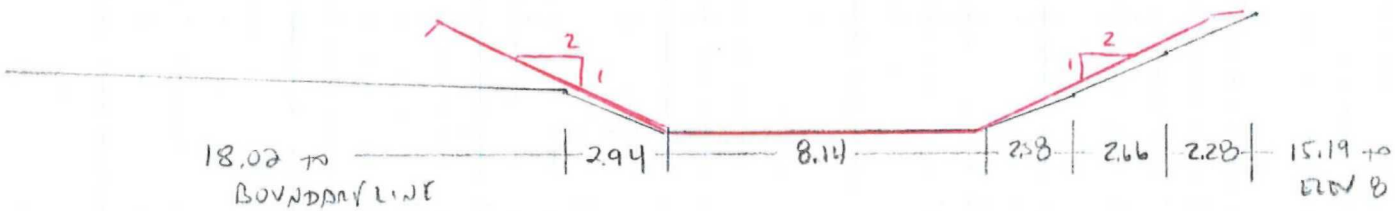
• EXISTING
∘ PROPOSED

CROSS SECTION P



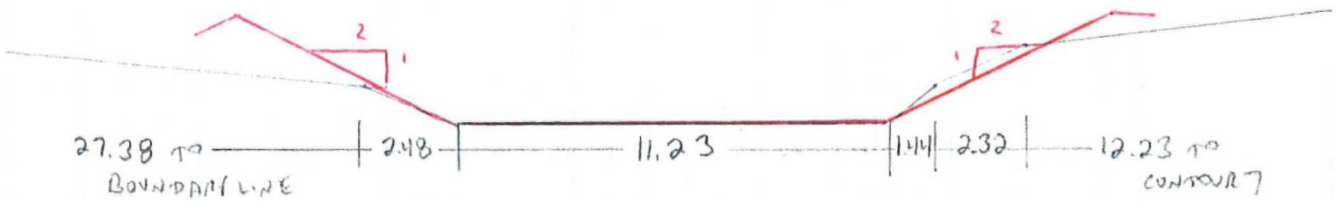
EL 8
EL 7
EL 6
EL 5

CROSS SECTION Q



EL 8
EL 7
EL 6
EL 5
EL 4

CROSS SECTION R



EL 7
EL 6
EL 5
EL 4

* THE CHANNEL DEPTH IN CROSS-SECTIONS P & R WILL BE INCREASED TO FOUR FEET TO PREVENT OVERTOPPING FROM THE 500-YEAR, 24-HOUR STORM EVENT.

Golder Associates

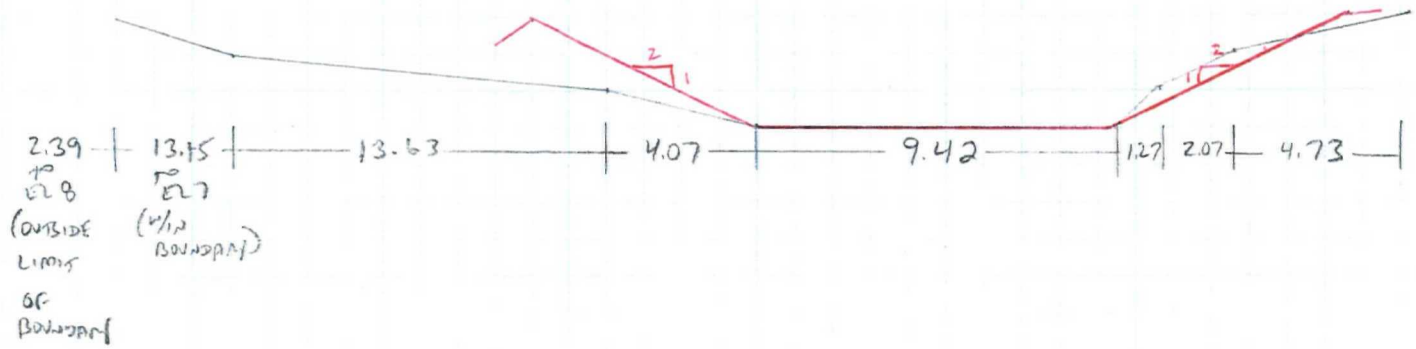
SUBJECT IRM PERIMETER DITCH	
Job No. 003-6004-002	Date 2/26/07
Ref.	Sheet 6 of 7
Made by CBM	
Checked RBK	
Reviewed	

SHEET 10 of 11

IRM CAPSIDE
(LEFT SIDE)

CROSS SECTION S

- EXISTING
- PROPOSED



* THE CHANNEL DEPTH IN CROSS-SECTION S WILL BE INCREASED TO FOUR FEET TO PREVENT OVERTOPPING FROM THE 500-YEAR, 24-HOUR STORM EVENT.

Golder Associates

SUBJECT IRM PERIMETER DITCH			
Job No. 003-6004.002 Ref.	Made by CBM	Date 2/26/07	
	Checked RBK	Sheet 7 of 7	
	Reviewed		

SHEET 11 OF 11

OBJECTIVE: To determine the peak runoff of stormwater entering the Sip Avenue Ditch from the IRM capped area for the existing conditions under the 100-year, 24-hour storm and the 500-year, 24-hour storm events.

REFERENCES:

1) Golder Associates Inc., "Pre-Final (90%) Design Report, Figure 6-1, Proposed Surface Water Management System," dated June 2004.

2) USDA, Soil Conservation Service, "Technical Release No. 55: Urban Hydrology for Small Watersheds" (TR-55), June, 1986.

3) New Jersey State Soil Conservation Committee, "Standards for Soil Erosion and Sediment Control in New Jersey," dated July 1999.

4) National Oceanic & Atmospheric Administration (NOAA), U.S. Department of Commerce website for "Precipitation Frequency Estimates from NOAA Atlas 14," last modified January 2007.

METHOD: The TR-55 computer program was used to determine the peak runoff of stormwater flow entering the Sip Avenue Ditch from the IRM Area. This computer program requires several input parameters, such as:

- Contributing Drainage Area (as described below);
- Rainfall Type – Type III (see sheet 5 of 20);
- Design Storm - 100-year, 24-hour storm (7.5 inches) (see sheet 4 of 20);
- Design Storm - 500-year, 24-hour storm (11.98 inches) (from Reference 4);
- Time of Concentration (as described below);
- Curve Number (as described below).

Drainage Areas

The drainage area of the IRM capped area that contributes flow to the Sip Avenue Ditch was determined by using topographic features of the existing IRM area as presented in Reference 1. The size of the drainage area was calculated by tracing the limits of the contributing drainage area with a planimeter. The area of the drainage area was determined to be 5.76 acres. Figure 1 (attached) shows the limits of the drainage area.

Time of Concentration

The time of concentration (Tc), the length of time for runoff to travel from the most hydrology distant point within a drainage area, was determined, using methods outlined in Reference 2 (see Figure 1 for Tc travel paths). The precipitation depth associated with the 2-year, 24-hour storm event near the site (3.30 inches from Ref. 3) is required for the time of concentration calculation. In addition, a Manning's roughness coefficient for sheet flow of 0.24 for dense grasses was used (see sheet 9 of 20).

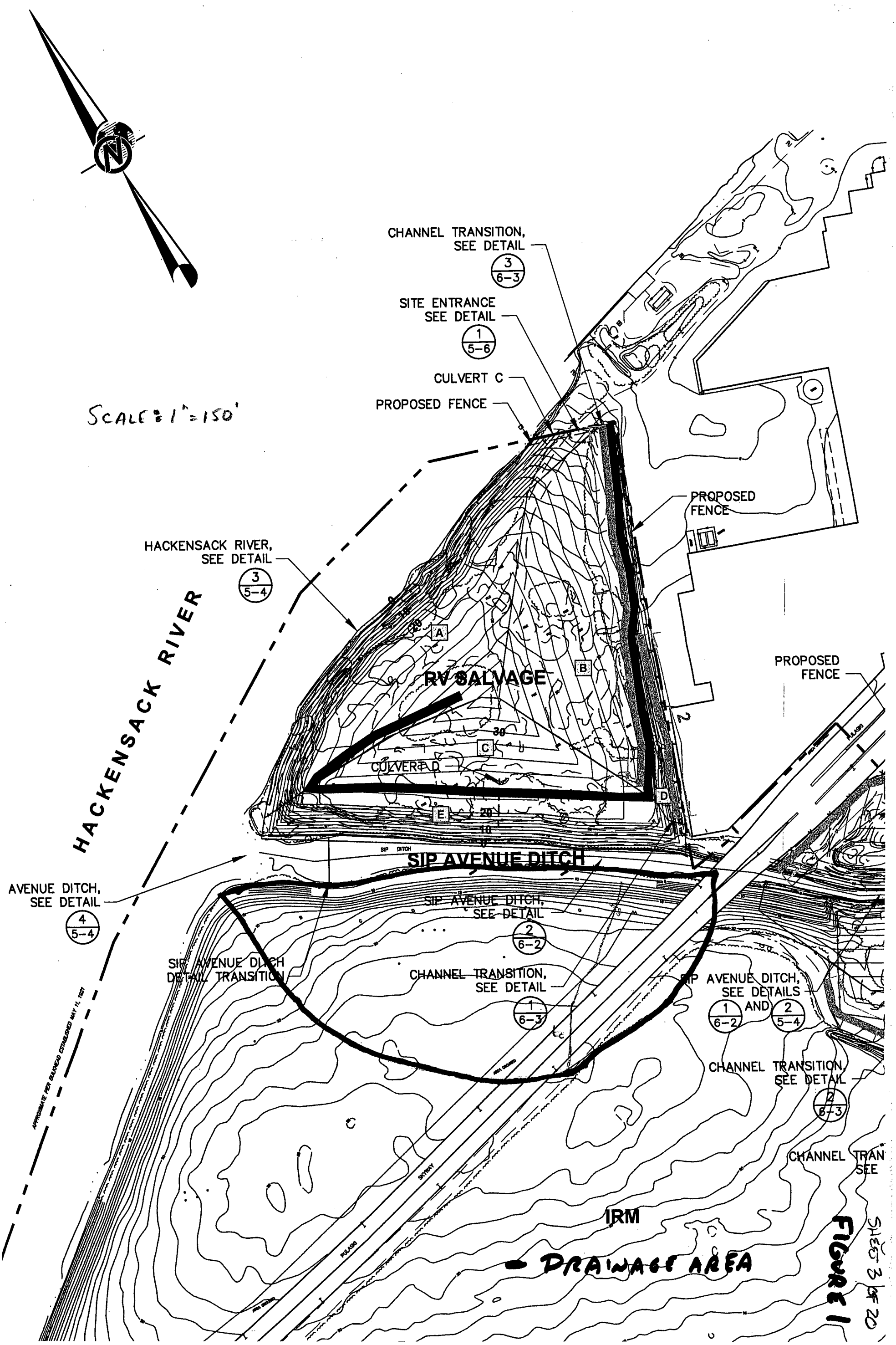
Curve Number

The Curve Number (CN), which is based on the hydrologic soil type and surface cover, is outlined in Reference 2. The hydrologic soil type is assumed to be Type C (soils of low infiltration rates with moderately fine to fine texture) (see sheet 6 of 20), based on observations made during the PDI

Stormwater Evaluation and site history. The surface coverage could be described as Open space (lawns, parks, golf courses, cemeteries, etc.) in good condition, therefore the CN is 74 (see sheet 7 of 20 from reference 2, Table 2-2a).

Peak Runoff

The peak runoff for the drainage area was determined by using TR-55 computer program. The drainage area, time of concentration, curve number, rainfall type, and design storm information were inputted in to the TR-55 program. The peak runoff for the drainage area for the 100-year, 24-hour storm event and the 500-year, 24-hour storm event is 18 cfs and 35 cfs, respectively.


SCALE = 1" = 150'
CHANNEL TRANSITION, SEE DETAIL 3/6-3
SITE ENTRANCE SEE DETAIL 1/5-6
CULVERT C
PROPOSED FENCE
PROPOSED FENCE
HACKENSACK RIVER, SEE DETAIL 3/5-4
HACKENSACK RIVER
A
B
RV SALVAGE
C
CULVERT D
D
E
PROPOSED FENCE
SIP AVENUE DITCH
AVENUE DITCH, SEE DETAIL 4/5-4
SIP AVENUE DITCH, SEE DETAIL 2/6-2
SIP AVENUE DITCH DETAIL TRANSITION
CHANNEL TRANSITION, SEE DETAIL 1/6-3
SIP AVENUE DITCH, SEE DETAILS 1/6-2 AND 2/5-4
CHANNEL TRANSITION, SEE DETAIL 2/6-3
CHANNEL TRAN SEE
APPROXIMATE PER RAILROAD ESTABLISHED MAY 11, 1921
SKYWAY
PULASKI
IRM
DRAINAGE AREA
FIGURE 1
SHEET 3 OF 20

2-30.3

NEW JERSEY 24 HOUR RAINFALL

County	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Atlantic	2.8	3.5	4.5	5.5	6.2	6.8	7.6
Bergen	2.7	3.3	4.3	5.3	5.7	6.5	7.5
Burlington	2.8	3.4	4.4	5.3	6.0	6.6	7.4
Camden	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Cape May	2.9	3.5	4.6	5.6	6.3	6.9	7.7
Cumberland	2.8	3.4	4.5	5.4	6.0	6.8	7.5
Essex	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Gloucester	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Hudson	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Hunterdon	2.6	3.2	4.2	5.0	5.7	6.5	7.3
Mercer	2.7	3.3	4.3	5.2	5.8	6.4	7.5
Middlesex	2.7	3.3	4.3	5.2	5.9	6.4	7.5
Monmouth	2.8	3.4	4.4	5.3	6.0	6.5	7.5
Morris	2.6	3.3	4.3	5.2	5.7	6.5	7.5
Ocean	2.8	3.5	4.5	5.4	6.2	6.6	7.5
Passaic	2.6	3.3	4.3	5.4	5.7	6.5	7.6
Salem	2.8	3.3	4.4	5.3	5.9	6.6	7.4
Somerset	2.7	3.3	4.3	5.2	5.7	6.5	7.5
Sussex	2.6	3.2	4.2	5.0	5.7	6.6	7.5
Union	2.7	3.3	4.3	5.3	5.8	6.4	7.5
Warren	2.6	3.2	4.1	4.9	5.6	6.5	7.2

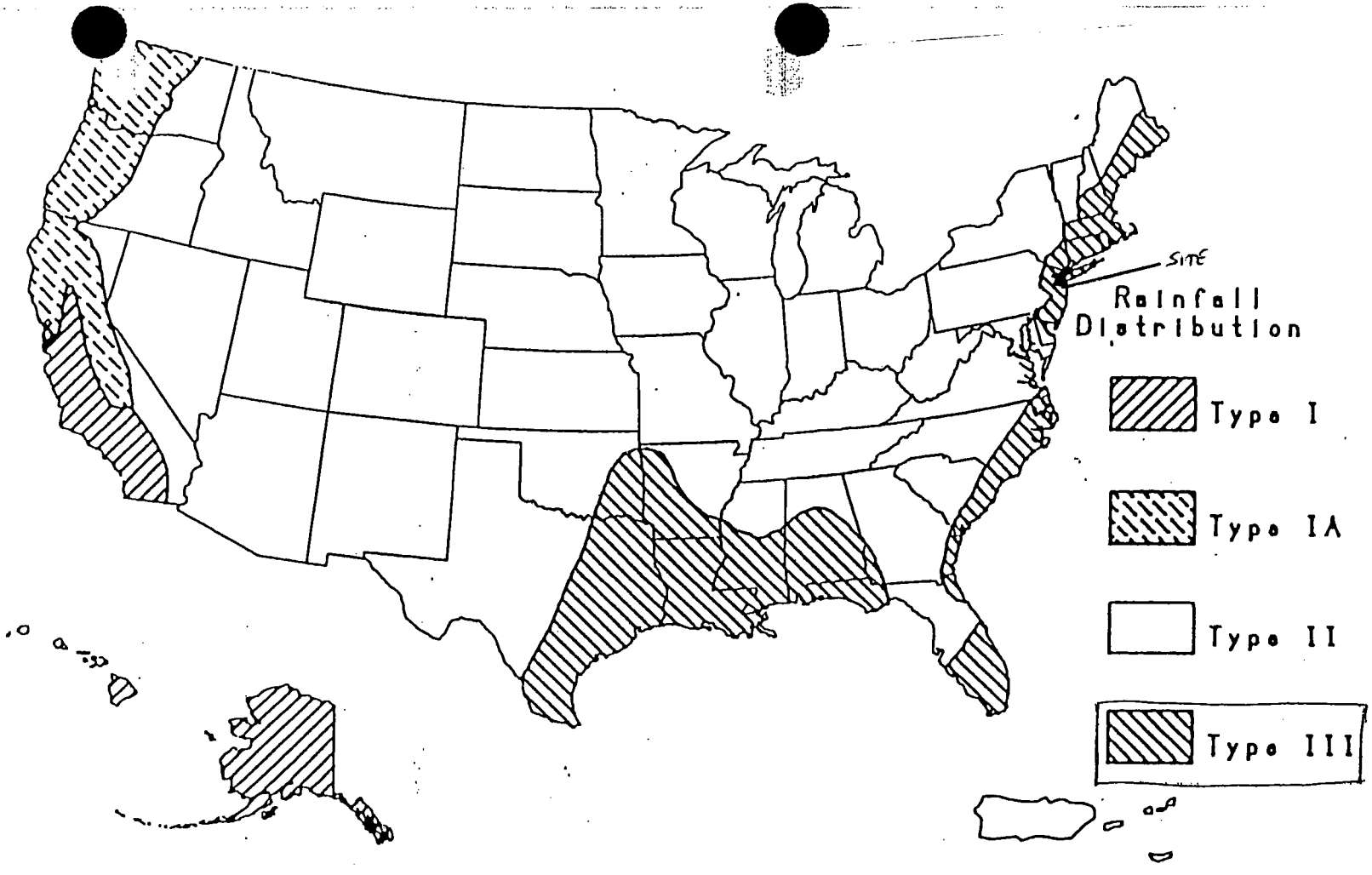


Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

(from Reference 2)

Appendix A: Hydrologic soil groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier: for example, "Abrazo: gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983):

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

(from Reference 2)

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80 *
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4]Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

(from Reference 2)

Project	PJP Landfill	By:	BRB	Date:	3/11/2007
Location	Hudson County, Jersey City	Checked:	CRM	Date:	3/12/07
		Reviewed:	[illegible]	Date:	3/14/07
Condition	Existing				

Watershed	IRM Perimeter Ditch			
SHEET FLOW (Application to T_c only)	a			
1. Surface Description	vegetated			
2. Manning's roughness coefficient, n	0.24			
3. Flow Length, L (total L<300ft) ft.	300			
4. Two-yr 24-hr rainfall, P_2 in.	3.3			
5. Land slope, s ft./ft	0.04			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ hr.	**0.427**			
Shallow Concentrated Flow	b			
7. Surface description (paved or unpaved)	unpaved			
8. Flow Length, L ft.	50			
9. Watercourse slope, s ft./ft.	0.2			
10. Average velocity, V (figure 3-1) ft./s.	7.20			
11. $T_T = \frac{L}{3600V}$ hr.	**0.002**			
Segment **Channel Flow**				
12. Cross Sectional flow area, a $ft.^2$				
13. Wetted perimeter, p_w ft.				
14. Hydraulic radius, $r = a/p_w$ ft.				
15. Channel slope, s ft./ft.				
16. Manning's roughness coeffienct, n				
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ ft./s.				
18. Flow Length, L ft.				
19. Tt = L/3600 V hr.				
20. Total Tc from sheet, shallow, and channel flow hr.	**0.429**			

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).

[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

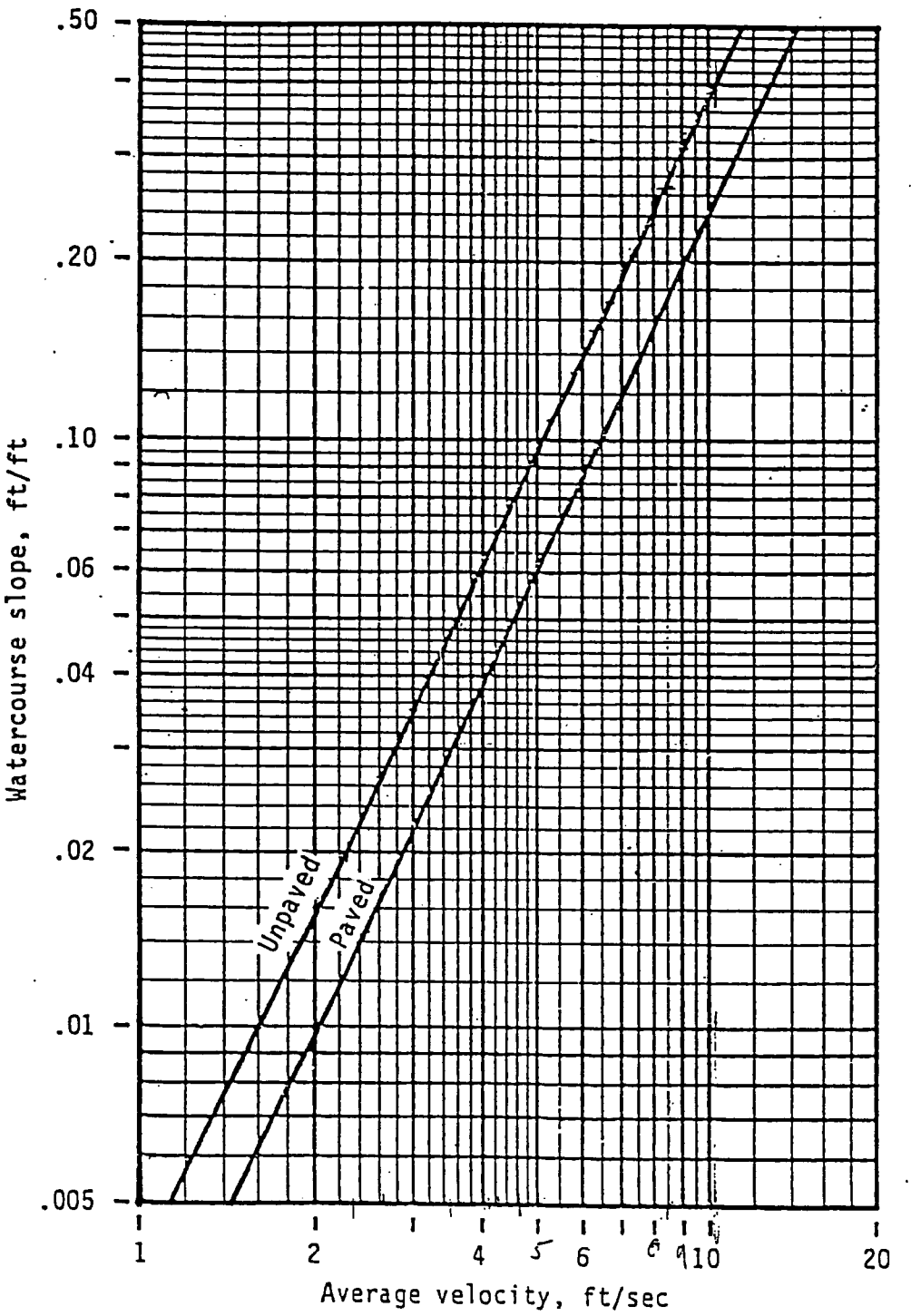


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 13:37:11
Watershed file: --> c:\pondpack\IRMSIP .WSD
Hydrograph file: --> c:\pondpack\IRMSIP .HYD

PEAK FLOW INTO SIP AVENUE DITCH FROM THE IRM AREA
100 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used
A	5.76	74.0	0.40	0.00	7.50	4.48	.09 .10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 5.76 acres or 0.00900 sq.mi
Peak discharge = 18 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	0.43	0.00	0.40	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

SHEET 12 OF 20

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

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Hydrograph file: --> c:\pondpack\IRMSIP .HYD

PEAK FLOW INTO SIP AVENUE DITCH FROM THE IRM AREA
100 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	18	12.5
Composite Watershed	18	12.5

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 13:37:11
Watershed file: --> c:\pondpack\IRMSIP .WSD
Hydrograph file: --> c:\pondpack\IRMSIP .HYD

PEAK FLOW INTO SIP AVENUE DITCH FROM THE IRM AREA
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	1	1	2	3	4	5	8	12	17
Total (cfs)	1	1	2	3	4	5	8	12	17

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	18	17	14	11	7	4	3	3	2
Total (cfs)	18	17	14	11	7	4	3	3	2

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	2	2	2	2	1	1	1	1	1
Total (cfs)	2	2	2	2	1	1	1	1	1

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	1	1	1	0	0
Total (cfs)	1	1	1	0	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 13:37:11
Watershed file: --> c:\pondpack\IRMSIP .WSD
Hydrograph file: --> c:\pondpack\IRMSIP .HYD

PEAK FLOW INTO SIP AVENUE DITCH FROM THE IRM AREA
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	1	14.8	2
11.1	1	14.9	2
11.2	1	15.0	2
11.3	1	15.1	2
11.4	1	15.2	2
11.5	2	15.3	1
11.6	2	15.4	1
11.7	2	15.5	1
11.8	3	15.6	1
11.9	3	15.7	1
12.0	4	15.8	1
12.1	5	15.9	1
12.2	8	16.0	1
12.3	12	16.1	1
12.4	17	16.2	1
12.5	18	16.3	1
12.6	17	16.4	1
12.7	14	16.5	1
12.8	11	16.6	1
12.9	9	16.7	1
13.0	7	16.8	1
13.1	5	16.9	1
13.2	4	17.0	1
13.3	4	17.1	1
13.4	3	17.2	1
13.5	3	17.3	1
13.6	3	17.4	1
13.7	2	17.5	1
13.8	2	17.6	1
13.9	2	17.7	1
14.0	2	17.8	1
14.1	2	17.9	1
14.2	2	18.0	1
14.3	2	18.1	1
14.4	2	18.2	1
14.5	2	18.3	1
14.6	2	18.4	1
14.7	2	18.5	1

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 13:37:11
Watershed file: --> c:\pondpack\IRMSIP .WSD
Hydrograph file: --> c:\pondpack\IRMSIP .HYD

PEAK FLOW INTO SIP AVENUE DITCH FROM THE IRM AREA
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	1	22.4	0
18.7	1	22.5	0
18.8	1	22.6	0
18.9	1	22.7	0
19.0	1	22.8	0
19.1	1	22.9	0
19.2	1	23.0	0
19.3	1	23.1	0
19.4	1	23.2	0
19.5	1	23.3	0
19.6	1	23.4	0
19.7	1	23.5	0
19.8	1	23.6	0
19.9	1	23.7	0
20.0	1	23.8	0
20.1	1	23.9	0
20.2	1	24.0	0
20.3	1	24.1	0
20.4	1	24.2	0
20.5	1	24.3	0
20.6	1	24.4	0
20.7	1	24.5	0
20.8	1	24.6	0
20.9	1	24.7	0
21.0	0	24.8	0
21.1	0	24.9	0
21.2	0	25.0	0
21.3	0	25.1	0
21.4	0	25.2	0
21.5	0	25.3	0
21.6	0	25.4	0
21.7	0	25.5	0
21.8	0	25.6	0
21.9	0	25.7	0
22.0	0	25.8	0
22.1	0	25.9	0
22.2	0		
22.3	0		

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 13:37:24
Watershed file: --> c:\pondpack\IRMSIP5 .WSD
Hydrograph file: --> c:\pondpack\IRMSIP5 .HYD

PEAK FLOW INTO SIP AVENUE DITCH FROM THE IRM AREA
500 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used
A	5.76	74.0	0.40	0.00	11.98	8.60	.06 .10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 5.76 acres or 0.00900 sq.mi
Peak discharge = 35 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	0.43	0.00	0.40	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

SHEET 17 of 20

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 13:37:24
Watershed file: --> c:\pondpack\IRMSIP5 .WSD
Hydrograph file: --> c:\pondpack\IRMSIP5 .HYD

PEAK FLOW INTO SIP AVENUE DITCH FROM THE IRM AREA
500 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	35	12.5
Composite Watershed	35	12.5

SHEET 18 OF 20

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 13:37:24
Watershed file: --> c:\pondpack\IRMSIP5 .WSD
Hydrograph file: --> c:\pondpack\IRMSIP5 .HYD

PEAK FLOW INTO SIP AVENUE DITCH FROM THE IRM AREA
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	2	2	3	5	7	10	15	24	33
Total (cfs)	2	2	3	5	7	10	15	24	33

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	35	32	27	21	13	8	6	5	5
Total (cfs)	35	32	27	21	13	8	6	5	5

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	4	4	3	3	3	2	2	2	2
Total (cfs)	4	4	3	3	3	2	2	2	2

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	1	1	1	1	0
Total (cfs)	1	1	1	1	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 13:37:24
Watershed file: --> c:\pondpack\IRMSIP5 .WSD
Hydrograph file: --> c:\pondpack\IRMSIP5 .HYD

PEAK FLOW INTO SIP AVENUE DITCH FROM THE IRM AREA
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	2	14.8	3
11.1	2	14.9	3
11.2	2	15.0	3
11.3	2	15.1	3
11.4	2	15.2	3
11.5	3	15.3	3
11.6	3	15.4	3
11.7	4	15.5	3
11.8	4	15.6	3
11.9	5	15.7	3
12.0	7	15.8	2
12.1	10	15.9	2
12.2	15	16.0	2
12.3	24	16.1	2
12.4	33	16.2	2
12.5	35	16.3	2
12.6	32	16.4	2
12.7	27	16.5	2
12.8	21	16.6	2
12.9	17	16.7	2
13.0	13	16.8	2
13.1	10	16.9	2
13.2	8	17.0	2
13.3	7	17.1	2
13.4	6	17.2	2
13.5	6	17.3	2
13.6	5	17.4	2
13.7	5	17.5	2
13.8	5	17.6	2
13.9	4	17.7	2
14.0	4	17.8	1
14.1	4	17.9	1
14.2	4	18.0	1
14.3	4	18.1	1
14.4	4	18.2	1
14.5	3	18.3	1
14.6	3	18.4	1
14.7	3	18.5	1

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 13:37:24
Watershed file: --> c:\pondpack\IRMSIP5 .WSD
Hydrograph file: --> c:\pondpack\IRMSIP5 .HYD

PEAK FLOW INTO SIP AVENUE DITCH FROM THE IRM AREA
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	1	22.4	1
18.7	1	22.5	1
18.8	1	22.6	1
18.9	1	22.7	1
19.0	1	22.8	1
19.1	1	22.9	1
19.2	1	23.0	1
19.3	1	23.1	1
19.4	1	23.2	1
19.5	1	23.3	1
19.6	1	23.4	1
19.7	1	23.5	1
19.8	1	23.6	1
19.9	1	23.7	1
20.0	1	23.8	1
20.1	1	23.9	1
20.2	1	24.0	0
20.3	1	24.1	0
20.4	1	24.2	0
20.5	1	24.3	0
20.6	1	24.4	0
20.7	1	24.5	0
20.8	1	24.6	0
20.9	1	24.7	0
21.0	1	24.8	0
21.1	1	24.9	0
21.2	1	25.0	0
21.3	1	25.1	0
21.4	1	25.2	0
21.5	1	25.3	0
21.6	1	25.4	0
21.7	1	25.5	0
21.8	1	25.6	0
21.9	1	25.7	0
22.0	1	25.8	0
22.1	1	25.9	0
22.2	1		
22.3	1		

APPENDIX C-3

PROPOSED STORMWATER DRAINAGE DITCH
ARCHDIOCESE PROPERTY

OBJECTIVE: Determine the peak runoff on a 100-year, 24-hour storm event on proposed conditions of the Archdiocese Property, and design the surface water channels based on the calculated peak runoff. Check that the surface water channels are not overtopped by the peak flow from the 500-year, 24-hour storm event.

REFERENCES:

1) Golder Associates Inc., "Final (100%) Design Report, Figure 6-1, Proposed Surface Water Management System," dated March 2007.

2) USDA, Soil Conservation Service, "Technical Release No. 55: Urban Hydrology for Small Watersheds" (TR-55), June, 1986.

3) New Jersey State Soil Conservation Committee, "Standards for Soil Erosion and Sediment Control in New Jersey," dated July 1999.

4) National Oceanic & Atmospheric Administration (NOAA), U.S. Department of Commerce website for "Precipitation Frequency Estimates from NOAA Atlas 14," last modified January 2007.

METHOD & CALCULATIONS: In general the method and calculations are twofold:

1) Determine the peak runoff; and,
2) Design the channels based on the peak runoff.

The following describes the two steps in detail.

1) Peak Runoff Determination

The TR-55 computer program was used to determine the peak runoff for each drainage area. This program requires several input parameters, such as:

- Drainage Area (as described below);
- Time of Concentration (as described below);
- Curve Number (as described below);
- Rainfall Type – Type III (see sheet 9 of 36);
- Design Storm – 100-year, 24-hour storm (7.5 inches) (see sheet 8 of 36); and,
- Design Storm - 500-year, 24-hour storm (11.98 inches) (from Reference 4).

Drainage Areas

The Archdiocese Property and Junkyard was separated into drainage areas based on the proposed layout of the channels. Each channel was given a channel designation number. Using topographic features of the proposed grading plan, drainage areas were delineated. The size of each drainage area was determined by tracing the limits of the drainage area in AutoCAD, and requesting the areas from the computer program. Figure 1 (attached) shows the limits of each drainage area. The following table summarizes the drainage areas:

Drainage Area	Area (ft^2)	Area (ac.)
A	179,032	4.11
B	71,003	1.63
C	61,420	1.41
D	74,052	1.70
E	59,677	1.37
F	25,700	0.59
G	20,909	0.48
H	64,469	1.48
I	34,848	0.80
J	140,263	3.22
K	132,858	3.05
L	67,954	1.56

Time of Concentration

The time of concentration (Tc), the length of time for runoff to travel from the most hydrology distant point within a drainage area, was determined for each drainage area, using methods outlined in Reference 2 (see Figure 1 for Tc travel paths). The precipitation depth associated with the 2-year, 24-hour storm event near the site (3.30 inches from Ref. 3) is required for the time of concentration calculation. In addition, a Manning's roughness coefficient for sheet flow of 0.24 for dense grasses was used (see sheet 11 of 36). The following is a summary of the time of concentration for each drainage area (see sheet 15 of 36 for calculations):

Drainage Area	Tc (hours)
A	0.296
B	0.235
C	0.226
D	0.280
E	0.228
F	0.097
G	0.087
H	0.261
I	0.151
J	0.247
K	0.271
L	0.228

A time of concentration of 0.100 was used for Drainage Areas F and G because that is the lowest time of concentration allowed in the TR-55 computer program.

Curve Number

The Curve Number, which is based on the hydrologic soil type and surface cover, is outlined in Reference 2. The hydrologic soil type is assumed to be Type C (soils of low infiltration rates with moderately fine to fine texture) (Reference 2). The proposed surface cover is considered open space in fair condition with a resulting curve number of 79.

Peak Runoff

The peak runoff for each area for the 100-year and 500-year, 24-hour storm events was determined by using TR-55 computer program. The drainage areas, times of concentration, curve numbers, rainfall type, and design storm information were inputted in to the TR-55 program. The peak runoff for each drainage area is summarized as follows:

Drainage Area	100-Year, 24-Hour Storm Event	500-Year, 24-Hour Storm Event
A	16	30
B	7	13
C	6	12
D	7	12
E	6	11
F	3	6
G	3	5
H	6	11
I	4	7
J	14	26
K	12	22
L	7	13

2) Channel Design

Manning's Equation for open channel flow was utilized to design the channels. An Excel spreadsheet was used to vary channel dimension to determine the most appropriate channel design (see sheet 34 of 36). Manning's Equation is as follows:

$$Q = (1.49 \times R_h^{2/3} \times A \times S^{1/2})/n$$

Q = channel flow rate (cfs)
R_h = hydraulic radius of channel = A/P (ft)
A = cross-sectional area of flow (ft^2)
P = wetted perimeter of flow (ft)
S = channel slope (ft/ft)
n = Manning's coefficient

Channel Flow Rate

The channel flow rate is equivalent to the peak runoff discharging to each of the channels and is summarized as follows:

Channel Designation	Channel Shape	Contributing Drainage Area	Total Peak Flow, 100-year storm	Total Peak Flow, 500-year storm
1	Triangular	A	16	30
2	Triangular	B	7	13
3	Triangular	C	6	12
4	Triangular	D, G and H	16	28
5	Triangular	D	7	12
6	Triangular	F	3	6
7	Trapezoidal	D, E, F, G and H	25	45

Hydraulic Radius, Cross Sectional Area, and Wetted Perimeter

Hydraulic radius, cross sectional area, and wetted perimeter of flow are dependent on the channel dimensions and depth of flow. These parameters are determined by the shape of the channel, channel side slopes, and flow depth. Two channel cross-sections have been selected: triangular and trapezoidal.

Channel Slope

The triangular channel slopes on average are approximately 1.2 percent. Due to the relatively flat nature of the existing conditions, steep channel slopes (2H:1V or steeper) would be difficult to achieve. However, slopes at 1.2% will allow for lower velocities of flow. The trapezoidal channel slope is approximately 2.1 percent.

Manning's Coefficient

The Manning's coefficient ("n") is a resistance factor related to surface roughness, channel irregularity, obstructions in the channel, and channel alignment. Since the proposed drainage channels are engineered and not naturally occurring, the main factor in determining the Manning's coefficient is surface roughness of the selected channel lining. Using the guidelines in Reference 3, the Manning's coefficient for riprap lined channels is determined to be 0.033. The Manning's coefficient for grass-lined channels is calculated using the Soil Conservation Service (SCS) method (as described in Reference 3) which includes determining a basic n-value and adding in modification factors for surface irregularity, variation in channel cross section, obstructions, vegetation, and meander. The basic n-value was assumed to be 0.02 based on a channel in earth. The vegetation modification factor is 0.019, which assumes a turf grass. Therefore, the n-value for a vegetation lined channel is 0.039.

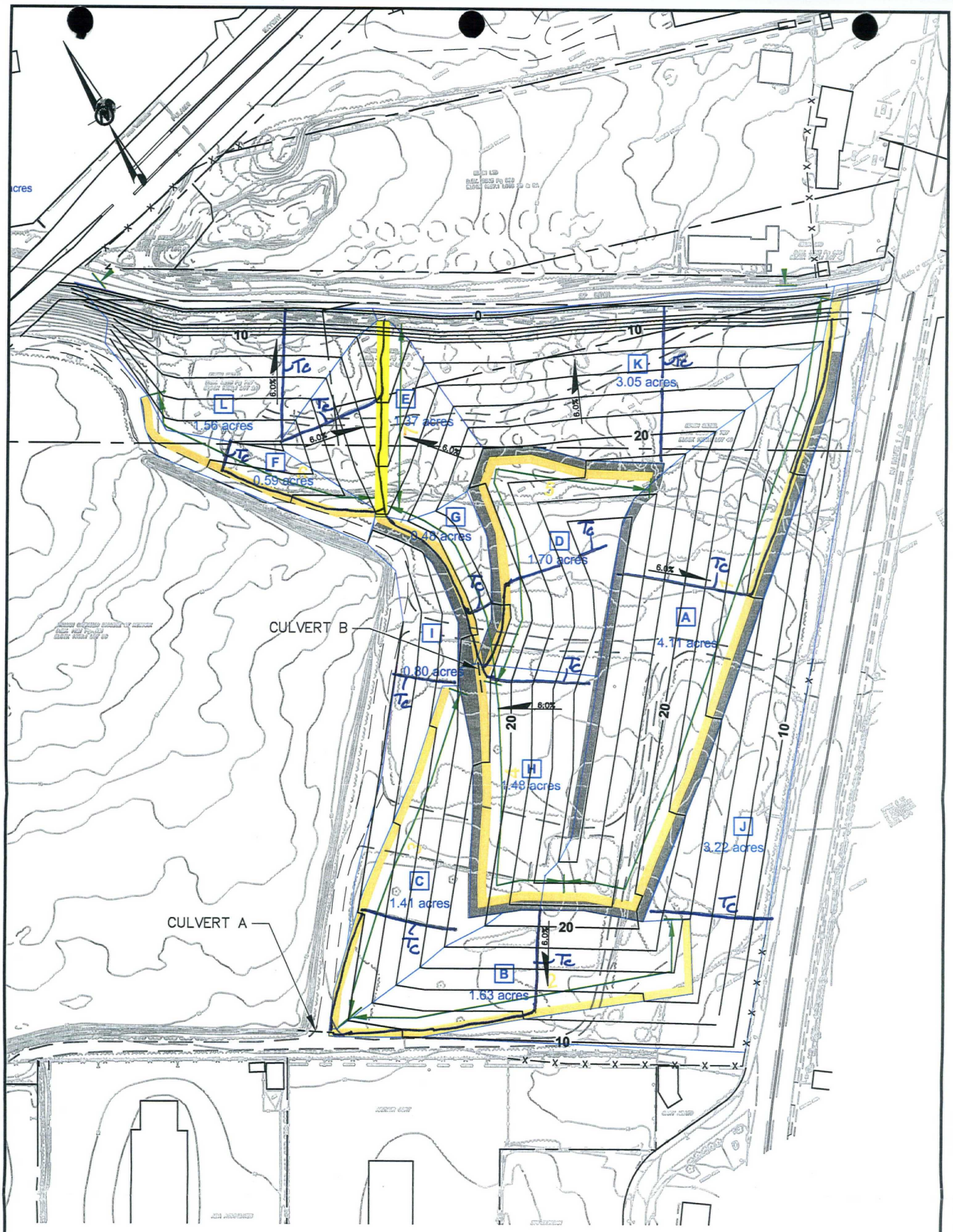
CONCLUSION: Based on the peak flow calculations, a series of drainage channels were designed for the Archdiocese Property and Junkyard area. The designed channels allowed a minimum of 0.25 feet of freeboard for a 100-year, 24-hour storm event and prevented overtopping of the channel for a 500-year, 24-hour storm event. The

drainage channel system consists of triangular-shaped channels and a trapezoidal-shaped channel, which are described in more detail as follows:

- Triangular shaped channels will be grass-lined with side slopes of 3H:1V, a channel depth of 2.0 ft, and an average longitudinal slope of 1.2 percent. The peak discharge is 16 cfs. From the attached table, the flow depth required to attain the design flow rate is 1.27 feet, which will provide at least 0.25 ft of freeboard. The maximum velocity is 2.85 ft/s. Based on Reference 3, a grass-lined channel with permanent erosion control matting is sufficient.

- For the channel conveying flow to the Sip Avenue ditch, use a riprap-lined, trapezoidal channel cross-section, with a base width of 6 feet, side slopes of 3H:1V, a channel depth of 2.0 ft, and a longitudinal slope of approximately 2.1 percent. The peak discharge is 25 cfs. From the attached table, the flow depth required to attain the design flow rate is 0.71, which will provide at least 0.25 ft of freeboard. The maximum velocity is 4.36 ft/s, therefore based on Reference 3, a riprap-lined channel is sufficient.

In addition, two culverts will be required below the existing and proposed access roads. The design calculations for the culverts are provided under separate cover.



LEGEND

- PROPOSED TRIANGULAR CHANNEL
- PROPOSED ACCESS ROAD
- WATERSHED BOUNDARY
- A — WATERSHED ZONES
- —x—x—x— PROPOSED FENCE
- CEA BOUNDARY

150 0 150
SCALE FEET

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT
PJP LANDFILL
[redacted]
JERSEY CITY, HUDSON COUNTY, NEW JERSEY

TITLE
ARCHDIOCESE AREA GRADING PLAN

NJ Authorization #24GA28029100
Golder Associates
Philadelphia USA

PROJECT No.		003-6004	FILE No.	0036004R053
DESIGN	CBM	03/08/07	SCALE AS SHOWN	REV. 0
CADD	GLS	03/08/07		
CHECK			FIGURE 1	
REVIEW				

Drawing file: 0036004R053.dwg Mar 09, 2007 - 12:51pm

SHEET 6 of 36

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4]Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

NEW JERSEY 24 HOUR RAINFALL

County	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Atlantic	2.8	3.5	4.5	5.5	6.2	6.8	7.6
Bergen	2.7	3.3	4.3	5.3	5.7	6.5	7.5
Burlington	2.8	3.4	4.4	5.3	6.0	6.6	7.4
Camden	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Cape May	2.9	3.5	4.6	5.6	6.3	6.9	7.7
Cumberland	2.8	3.4	4.5	5.4	6.0	6.8	7.5
Essex	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Gloucester	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Hudson	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Hunterdon	2.6	3.2	4.2	5.0	5.7	6.5	7.3
Mercer	2.7	3.3	4.3	5.2	5.8	6.4	7.5
Middlesex	2.7	3.3	4.3	5.2	5.9	6.4	7.5
Monmouth	2.8	3.4	4.4	5.3	6.0	6.5	7.5
Morris	2.6	3.3	4.3	5.2	5.7	6.5	7.5
Ocean	2.8	3.5	4.5	5.4	6.2	6.6	7.5
Passaic	2.6	3.3	4.3	5.4	5.7	6.5	7.6
Salem	2.8	3.3	4.4	5.3	5.9	6.6	7.4
Somerset	2.7	3.3	4.3	5.2	5.7	6.5	7.5
Sussex	2.6	3.2	4.2	5.0	5.7	6.6	7.5
Union	2.7	3.3	4.3	5.3	5.8	6.4	7.5
Warren	2.6	3.2	4.1	4.9	5.6	6.5	7.2

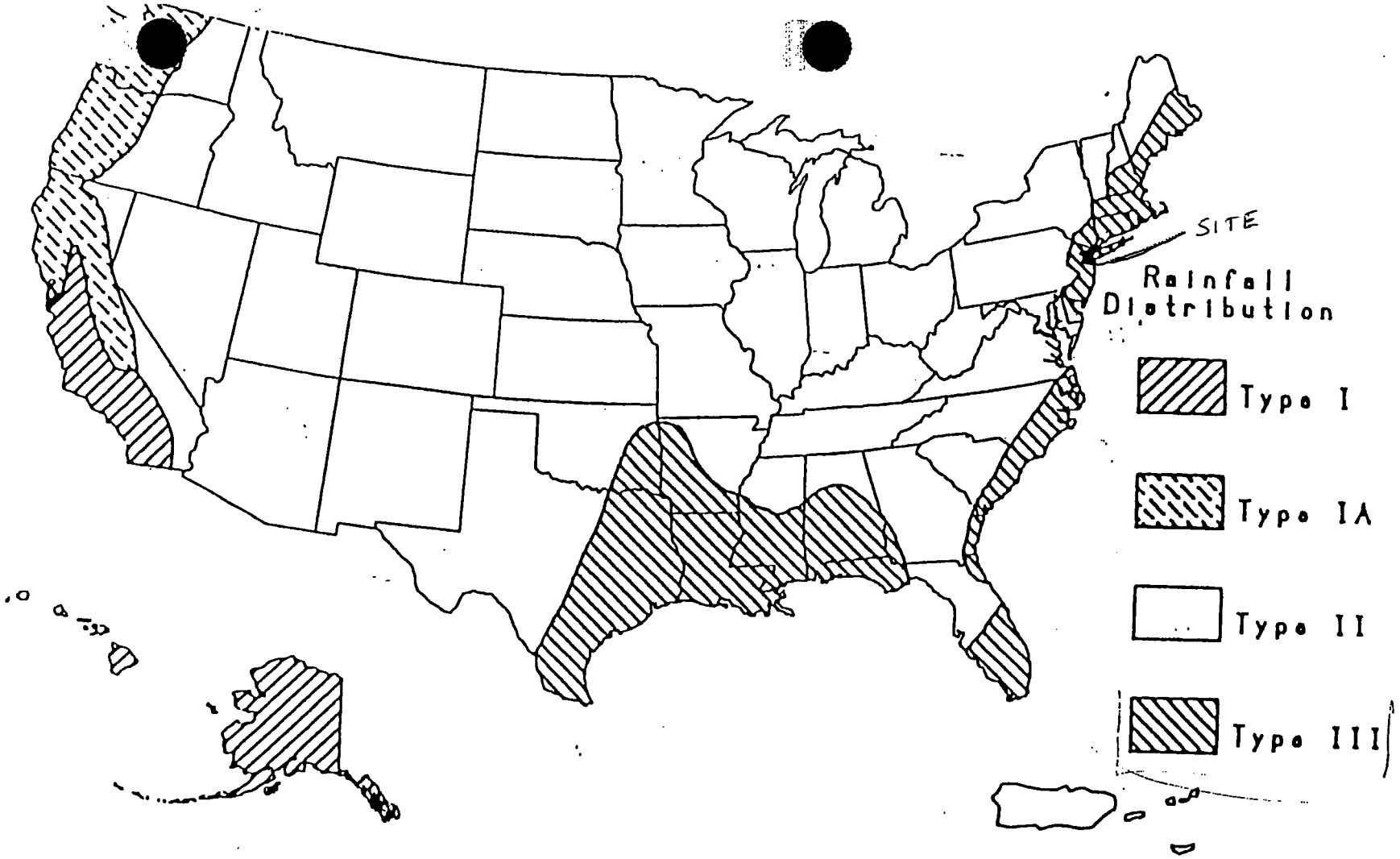


Figure II-2.—Approximate geographic boundaries for SCS rainfall distributions.

(from Reference 2)

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Chapter 3: Time of concentration and travel time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600\ V} \qquad \text{[Eq. 3-1]}$$

where

T_t = travel time (hr),
L = flow length (ft),
V = average velocity (ft/s), and
3600 = conversion factor from seconds to hours.

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \dots T_{t_m} \qquad \text{[Eq. 3-2]}$$

where

T_c = time of concentration (hr) and
m = number of flow segments.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1]The n values are a composite of information compiled by Engman (1986).
[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Manning's equation is

$$V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n} \qquad \text{[Eq. 3-4]}$$

where

- V = average velocity (ft/s),
- r = hydraulic radius (ft) and is equal to a/p_w,
- a = cross sectional flow area (ft^2),
- p_w = wetted perimeter (ft),
- s = slope of the hydraulic grade line (channel slope, ft/ft), and
- n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, T_t for the channel segment can be estimated using equation 3-1.

Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.

  In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.

The minimum T_c used in TR-55 is 0.1 hour.

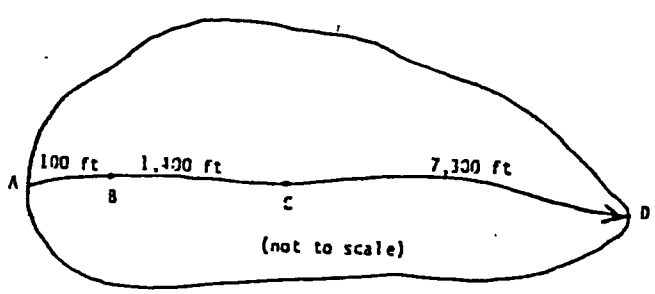
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

Example 3-1

The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute T_c at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment from the following information:

Segment AB:	Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft.
Segment BC:	Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1400 ft.
Segment CD:	Channel flow; Manning's n = .05; flow area (a) = 27 ft^2; wetted perimeter (p_w) = 28.2 ft; s = 0.005 ft/ft; and L = 7300 ft.

See figure 3-2 for the computations made on worksheet 3.



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Oceanic and Atmospheric Administration.

East of 105th meridian

Hershfield, D. M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 115 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I, Montana; Vol. II, Wyoming; Vol. III, Colorado; Vol. IV, New Mexico; Vol. V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dep. Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 p.

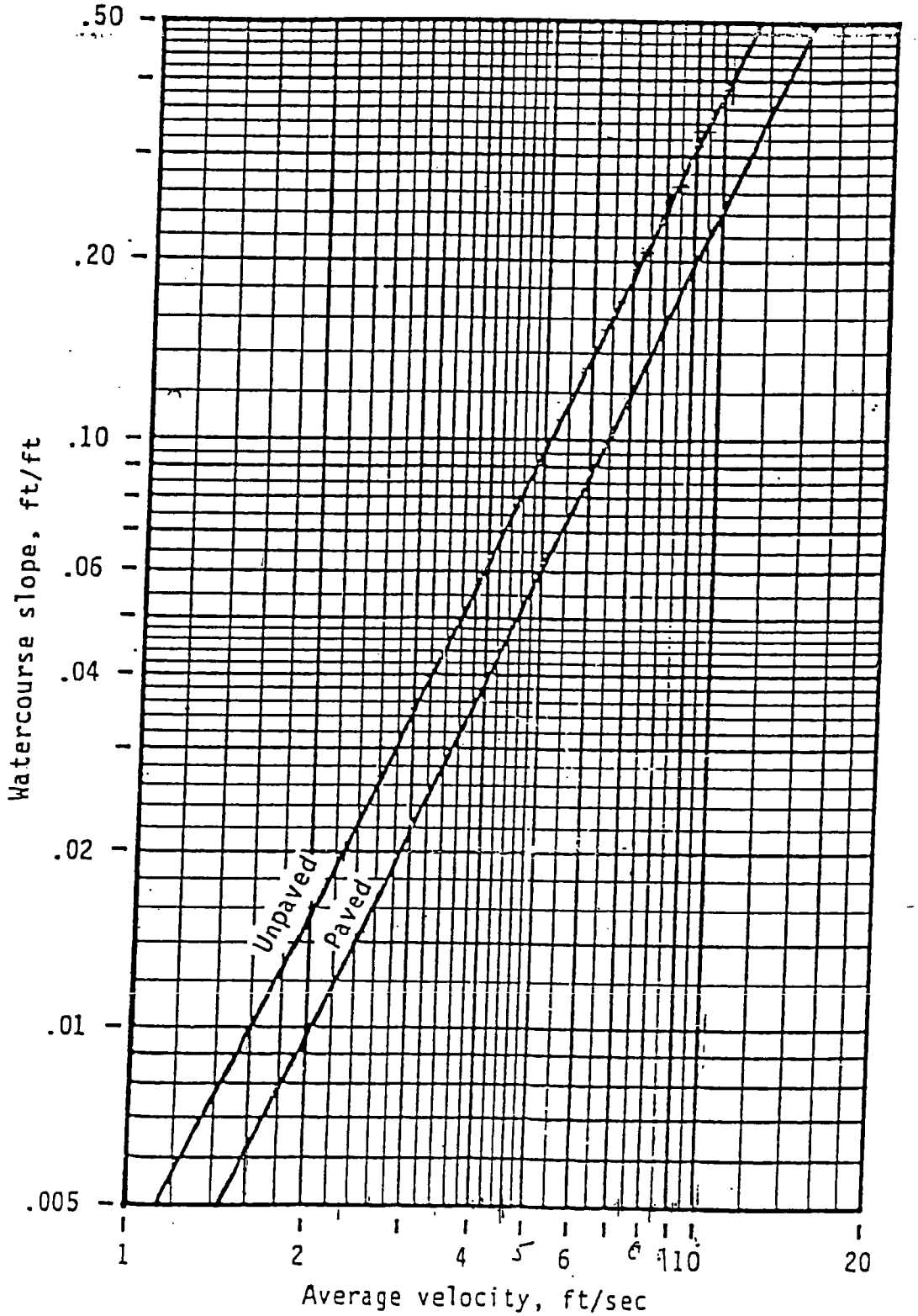


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

PJP Landfill Site
Jersey City, New Jersey
Time of Concentration
Archdiocese Property and Junkyard

Project: PJP Landfill | By: BRB | Date: 3/8/2007
Location: Jersey City, New Jersey | Checked: CBM | Date: 3/9/2007
Leo- RA 3/14/07
Condition: Construction
Site: Archdiocese Property and Junkyard

Watershed	A	B	C	D	E	F	G	H	I	J	K	L
SHEET FLOW (Application to T_c only)												
1. Surface Description	vegetated	vegetated	vegetated	vegetated	vegetated	vegetated	vegetated	vegetated	vegetated	vegetated	vegetated	vegetated
2. Manning's roughness coefficient, n	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
3. Flow Length, L (total L<300ft) ft.	200	154	153	170	165	40	33	170	100	185	206	166
4. Two-yr 24-hr rainfall, P_2 in.	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
5. Land slope, s ft./ft	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ hr.	**0.263**	**0.213**	**0.212**	**0.231**	**0.225**	**0.073**	**0.062**	**0.231**	**0.151**	**0.247**	**0.269**	**0.226**
Shallow Concentrated Flow												
7. Surface description (paved or unpaved)											vegetated	vegetated
8. Flow Length, L ft.											38.8	39
9. Watercourse slope, s ft./ft.											0.206	0.205
10. Average velocity, V (figure 3-1) ft./s.											7.4	7.4
11. $T_T = \frac{L}{3600V}$ hr.											**0.0015**	**0.0015**
Channel Flow												
12. Cross Sectional flow area, a $ft.^2$	12	12	12	12	24	12	12	12				
13. Wetted perimeter, p_w ft.	12.65	12.65	12.65	12.65	18.65	12.65	12.65	12.65				
14. Hydraulic radius, $r = a/p_w$ ft.	0.949	0.949	0.949	0.949	1.287	0.949	0.949	0.949				
15. Channel slope, s ft./ft.	0.010	0.012	0.011	0.013	0.057	0.018	0.016	0.016				
16. Manning's roughness coeffienct, n	0.039	0.039	0.039	0.039	0.033	0.033	0.033	0.033				
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ ft./s.	3.76	4.04	3.78	4.26	12.75	5.85	5.51	5.51				
18. Flow Length, L ft.	450	321	191	750	139	526	500	610				
19. Tt = L/3600 V hr.	**0.0332**	**0.0221**	**0.0140**	**0.0489**	**0.0030**	**0.0250**	**0.0252**	**0.0307**				
20. Total Tc from sheet, shallow, and channel flow hr.	**0.296**	**0.235**	**0.226**	**0.280**	**0.228**	**0.097**	**0.087**	**0.261**	**0.151**	**0.247**	**0.271**	**0.228**

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:15:55
Watershed file: --> c:\pondpack\ARCH .WSD
Hydrograph file: --> c:\pondpack\ARCH .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
100 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used	
A	4.11	79.0	0.30	0.00	7.50	5.04	.07	.10
B	1.63	79.0	0.20	0.00	7.50	5.04	.07	.10
C	1.41	79.0	0.20	0.00	7.50	5.04	.07	.10
D	1.70	79.0	0.30	0.00	7.50	5.04	.07	.10
E	1.37	79.0	0.20	0.00	7.50	5.04	.07	.10
F	0.59	79.0	0.10	0.00	7.50	5.04	.07	.10
G	0.48	79.0	0.10	0.00	7.50	5.04	.07	.10
H	1.48	79.0	0.30	0.00	7.50	5.04	.07	.10
I	0.80	79.0	0.20	0.00	7.50	5.04	.07	.10
J	3.22	79.0	0.20	0.00	7.50	5.04	.07	.10
K	3.05	79.0	0.30	0.00	7.50	5.04	.07	.10
L	1.56	79.0	0.20	0.00	7.50	5.04	.07	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 21.40 acres or 0.03344 sq.mi
Peak discharge = 84 cfs

WARNING: Drainage areas of two or more subareas
differ by a factor of 5 or greater.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:15:55
Watershed file: --> c:\pondpack\ARCH .WSD
Hydrograph file: --> c:\pondpack\ARCH .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
100 YEAR, 24 HOUR STORM EVENT

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	* Tt (hr)	Rounded Values Tc (hr)	* Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	0.30	0.00	0.30	0.00	No	Computed Ia/p < .1
B	0.23	0.00	0.20	0.00	No	Computed Ia/p < .1
C	0.23	0.00	0.20	0.00	No	Computed Ia/p < .1
D	0.28	0.00	0.30	0.00	No	Computed Ia/p < .1
E	0.23	0.00	0.20	0.00	No	Computed Ia/p < .1
F	0.10	0.00	**	**	No	Computed Ia/p < .1
G	0.10	0.00	**	**	No	Computed Ia/p < .1
H	0.26	0.00	0.30	0.00	No	Computed Ia/p < .1
I	0.15	0.00	0.20	0.00	No	Computed Ia/p < .1
J	0.25	0.00	0.20	0.00	No	Computed Ia/p < .1
K	0.27	0.00	0.30	0.00	No	Computed Ia/p < .1
L	0.23	0.00	0.20	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:15:55
Watershed file: --> c:\pondpack\ARCH .WSD
Hydrograph file: --> c:\pondpack\ARCH .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
100 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	16	12.4
B	7	12.3
C	6	12.3
D	7	12.4
E	6	12.3
F	3	12.2
G	3	12.2
H	6	12.4
I	4	12.3
J	14	12.3
K	12	12.4
L	7	12.3
Composite Watershed	84	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:15:55
Watershed file: --> c:\pondpack\ARCH .WSD
Hydrograph file: --> c:\pondpack\ARCH .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	1	1	1	3	4	6	9	14	16
B	0	0	1	2	2	3	6	7	6
C	0	0	1	1	2	3	5	6	5
D	0	0	1	1	2	2	4	6	7
E	0	0	1	1	2	3	5	6	5
F	0	0	0	1	1	2	3	2	2
G	0	0	0	1	1	2	3	2	1
H	0	0	1	1	1	2	3	5	6
I	0	0	0	1	1	2	3	4	3
J	1	1	1	3	4	7	11	14	12
K	1	1	1	2	3	4	7	11	12
L	0	0	1	1	2	3	6	7	6
Total (cfs)	3	3	9	18	25	39	65	84	81

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:15:55
Watershed file: --> c:\pondpack\ARCH .WSD
Hydrograph file: --> c:\pondpack\ARCH .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	15	12	9	7	4	3	2	2	2
B	5	3	2	2	1	1	1	1	1
C	4	3	2	2	1	1	1	1	1
D	6	5	4	3	2	1	1	1	1
E	4	3	2	1	1	1	1	1	1
F	1	1	1	0	0	0	0	0	0
G	1	1	0	0	0	0	0	0	0
H	5	4	3	2	1	1	1	1	1
I	2	2	1	1	1	0	0	0	0
J	9	7	5	3	2	2	2	2	1
K	11	9	7	5	3	2	2	2	1
L	4	3	2	2	1	1	1	1	1
Total (cfs)	67	53	38	28	17	13	12	12	10

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:15:55
Watershed file: --> c:\pondpack\ARCH .WSD
Hydrograph file: --> c:\pondpack\ARCH .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	2	2	1	1	1	1	1	1	1
B	1	1	1	0	0	0	0	0	0
C	1	1	0	0	0	0	0	0	0
D	1	1	1	1	0	0	0	0	0
E	1	0	0	0	0	0	0	0	0
F	0	0	0	0	0	0	0	0	0
G	0	0	0	0	0	0	0	0	0
H	1	1	1	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0
J	1	1	1	1	1	1	1	1	0
K	1	1	1	1	1	1	1	1	0
L	1	1	1	0	0	0	0	0	0
Total (cfs)	10	9	7	4	3	3	3	3	1

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:15:55
Watershed file: --> c:\pondpack\ARCH .WSD
Hydrograph file: --> c:\pondpack\ARCH .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	1	0	0	0	0
B	0	0	0	0	0
C	0	0	0	0	0
D	0	0	0	0	0
E	0	0	0	0	0
F	0	0	0	0	0
G	0	0	0	0	0
H	0	0	0	0	0
I	0	0	0	0	0
J	0	0	0	0	0
K	0	0	0	0	0
L	0	0	0	0	0
Total (cfs)	1	0	0	0	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:15:55
Watershed file: --> c:\pondpack\ARCH .WSD
Hydrograph file: --> c:\pondpack\ARCH .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	3	14.8	5
11.1	3	14.9	5
11.2	3	15.0	4
11.3	3	15.1	4
11.4	5	15.2	4
11.5	7	15.3	3
11.6	9	15.4	3
11.7	12	15.5	3
11.8	15	15.6	3
11.9	18	15.7	3
12.0	25	15.8	3
12.1	39	15.9	3
12.2	65	16.0	3
12.3	84	16.1	3
12.4	81	16.2	3
12.5	67	16.3	3
12.6	53	16.4	3
12.7	38	16.5	3
12.8	28	16.6	3
12.9	22	16.7	3
13.0	17	16.8	3
13.1	15	16.9	3
13.2	13	17.0	3
13.3	12	17.1	3
13.4	12	17.2	2
13.5	12	17.3	2
13.6	12	17.4	1
13.7	11	17.5	1
13.8	10	17.6	1
13.9	10	17.7	1
14.0	10	17.8	1
14.1	10	17.9	1
14.2	9	18.0	1
14.3	9	18.1	1
14.4	8	18.2	1
14.5	8	18.3	1
14.6	7	18.4	1
14.7	6	18.5	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:15:55
Watershed file: --> c:\pondpack\ARCH .WSD
Hydrograph file: --> c:\pondpack\ARCH .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	0	22.4	0
18.7	0	22.5	0
18.8	0	22.6	0
18.9	0	22.7	0
19.0	0	22.8	0
19.1	0	22.9	0
19.2	0	23.0	0
19.3	0	23.1	0
19.4	0	23.2	0
19.5	0	23.3	0
19.6	0	23.4	0
19.7	0	23.5	0
19.8	0	23.6	0
19.9	0	23.7	0
20.0	0	23.8	0
20.1	0	23.9	0
20.2	0	24.0	0
20.3	0	24.1	0
20.4	0	24.2	0
20.5	0	24.3	0
20.6	0	24.4	0
20.7	0	24.5	0
20.8	0	24.6	0
20.9	0	24.7	0
21.0	0	24.8	0
21.1	0	24.9	0
21.2	0	25.0	0
21.3	0	25.1	0
21.4	0	25.2	0
21.5	0	25.3	0
21.6	0	25.4	0
21.7	0	25.5	0
21.8	0	25.6	0
21.9	0	25.7	0
22.0	0	25.8	0
22.1	0	25.9	0
22.2	0		
22.3	0		

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:16:03
Watershed file: --> c:\pondpack\ARCH500 .WSD
Hydrograph file: --> c:\pondpack\ARCH500 .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
500 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used	
A	4.11	79.0	0.30	0.00	11.98	9.29	.04	.10
B	1.63	79.0	0.20	0.00	11.98	9.29	.04	.10
C	1.41	79.0	0.20	0.00	11.98	9.29	.04	.10
D	1.70	79.0	0.30	0.00	11.98	9.29	.04	.10
E	1.37	79.0	0.20	0.00	11.98	9.29	.04	.10
F	0.59	79.0	0.10	0.00	11.98	9.29	.04	.10
G	0.48	79.0	0.10	0.00	11.98	9.29	.04	.10
H	1.48	79.0	0.30	0.00	11.98	9.29	.04	.10
I	0.80	79.0	0.20	0.00	11.98	9.29	.04	.10
J	3.22	79.0	0.20	0.00	11.98	9.29	.04	.10
K	3.05	79.0	0.30	0.00	11.98	9.29	.04	.10
L	1.56	79.0	0.20	0.00	11.98	9.29	.04	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 21.40 acres or 0.03344 sq.mi
Peak discharge = 157 cfs

WARNING: Drainage areas of two or more subareas
differ by a factor of 5 or greater.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:16:03
Watershed file: --> c:\pondpack\ARCH500 .WSD
Hydrograph file: --> c:\pondpack\ARCH500 .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
500 YEAR, 24 HOUR STORM EVENT

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	* Tt (hr)	Rounded Values Tc (hr)	* Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	0.30	0.00	0.30	0.00	No	Computed Ia/p < .1
B	0.23	0.00	0.20	0.00	No	Computed Ia/p < .1
C	0.23	0.00	0.20	0.00	No	Computed Ia/p < .1
D	0.28	0.00	0.30	0.00	No	Computed Ia/p < .1
E	0.23	0.00	0.20	0.00	No	Computed Ia/p < .1
F	0.10	0.00	**	**	No	Computed Ia/p < .1
G	0.10	0.00	**	**	No	Computed Ia/p < .1
H	0.26	0.00	0.30	0.00	No	Computed Ia/p < .1
I	0.15	0.00	0.20	0.00	No	Computed Ia/p < .1
J	0.25	0.00	0.20	0.00	No	Computed Ia/p < .1
K	0.27	0.00	0.30	0.00	No	Computed Ia/p < .1
L	0.23	0.00	0.20	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:16:03
Watershed file: --> c:\pondpack\ARCH500 .WSD
Hydrograph file: --> c:\pondpack\ARCH500 .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
500 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	30	12.4
B	13	12.3
C	12	12.3
D	12	12.4
E	11	12.3
F	6	12.2
G	5	12.2
H	11	12.4
I	7	12.3
J	26	12.3
K	22	12.4
L	13	12.3
Composite Watershed	157	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:16:03
Watershed file: --> c:\pondpack\ARCH500 .WSD
Hydrograph file: --> c:\pondpack\ARCH500 .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	1	2	3	5	7	11	17	26	30
B	1	1	1	3	4	6	11	13	11
C	1	1	1	2	4	5	9	12	10
D	1	1	1	2	3	4	7	11	12
E	1	1	1	2	4	5	9	11	10
F	0	0	0	1	2	4	6	5	3
G	0	0	0	1	2	3	5	4	2
H	1	1	1	2	3	4	6	9	11
I	0	0	1	1	2	3	5	7	6
J	1	2	2	6	8	12	21	26	23
K	1	1	2	4	5	8	13	20	22
L	1	1	1	3	4	6	10	13	11
Total (cfs)	9	11	14	32	48	71	119	157	151

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:16:03
Watershed file: --> c:\pondpack\ARCH500 .WSD
Hydrograph file: --> c:\pondpack\ARCH500 .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	27	21	16	12	7	5	4	4	3
B	8	6	5	3	2	2	2	1	1
C	7	6	4	3	2	2	1	1	1
D	11	9	7	5	3	2	2	2	1
E	7	5	4	3	2	1	1	1	1
F	2	2	1	1	1	1	1	0	0
G	2	1	1	1	1	0	0	0	0
H	10	8	6	4	3	2	2	1	1
I	4	3	2	2	1	1	1	1	1
J	17	13	9	6	4	4	3	3	3
K	20	16	12	9	5	4	3	3	3
L	8	6	4	3	2	2	1	1	1
Total (cfs)	123	96	71	52	33	26	21	18	16

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:16:03
Watershed file: --> c:\pondpack\ARCH500 .WSD
Hydrograph file: --> c:\pondpack\ARCH500 .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	3	3	3	2	2	2	1	1	1
B	1	1	1	1	1	1	1	0	0
C	1	1	1	1	1	1	0	0	0
D	1	1	1	1	1	1	1	1	0
E	1	1	1	1	1	1	0	0	0
F	0	0	0	0	0	0	0	0	0
G	0	0	0	0	0	0	0	0	0
H	1	1	1	1	1	1	1	0	0
I	1	1	0	0	0	0	0	0	0
J	2	2	2	2	2	1	1	1	1
K	2	2	2	2	2	1	1	1	1
L	1	1	1	1	1	1	1	0	0
Total (cfs)	14	14	13	12	12	10	7	4	3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:16:03
Watershed file: --> c:\pondpack\ARCH500 .WSD
Hydrograph file: --> c:\pondpack\ARCH500 .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	1	1	1	1	0
B	0	0	0	0	0
C	0	0	0	0	0
D	0	0	0	0	0
E	0	0	0	0	0
F	0	0	0	0	0
G	0	0	0	0	0
H	0	0	0	0	0
I	0	0	0	0	0
J	1	1	1	1	0
K	1	1	1	0	0
L	0	0	0	0	0
Total (cfs)	3	3	3	2	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:16:03
Watershed file: --> c:\pondpack\ARCH500 .WSD
Hydrograph file: --> c:\pondpack\ARCH500 .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	9	14.8	12
11.1	10	14.9	12
11.2	10	15.0	12
11.3	11	15.1	12
11.4	12	15.2	12
11.5	13	15.3	12
11.6	14	15.4	12
11.7	20	15.5	12
11.8	26	15.6	12
11.9	32	15.7	11
12.0	48	15.8	11
12.1	71	15.9	10
12.2	119	16.0	10
12.3	157	16.1	9
12.4	151	16.2	9
12.5	123	16.3	8
12.6	96	16.4	8
12.7	71	16.5	7
12.8	52	16.6	6
12.9	42	16.7	6
13.0	33	16.8	5
13.1	30	16.9	5
13.2	26	17.0	4
13.3	24	17.1	4
13.4	21	17.2	4
13.5	20	17.3	3
13.6	18	17.4	3
13.7	17	17.5	3
13.8	16	17.6	3
13.9	15	17.7	3
14.0	14	17.8	3
14.1	14	17.9	3
14.2	14	18.0	3
14.3	14	18.1	3
14.4	14	18.2	3
14.5	13	18.3	3
14.6	13	18.4	3
14.7	13	18.5	3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-11-2007 12:16:03
Watershed file: --> c:\pondpack\ARCH500 .WSD
Hydrograph file: --> c:\pondpack\ARCH500 .HYD

PJP LANDFILL-ARCHDIOCESE/JUNKYARD
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	3	22.4	2
18.7	3	22.5	2
18.8	3	22.6	2
18.9	3	22.7	2
19.0	3	22.8	2
19.1	3	22.9	2
19.2	3	23.0	2
19.3	3	23.1	1
19.4	3	23.2	1
19.5	3	23.3	1
19.6	3	23.4	1
19.7	3	23.5	1
19.8	3	23.6	1
19.9	3	23.7	1
20.0	3	23.8	1
20.1	3	23.9	1
20.2	3	24.0	1
20.3	3	24.1	1
20.4	3	24.2	1
20.5	3	24.3	1
20.6	3	24.4	1
20.7	3	24.5	1
20.8	3	24.6	1
20.9	3	24.7	1
21.0	2	24.8	1
21.1	2	24.9	1
21.2	2	25.0	0
21.3	2	25.1	0
21.4	2	25.2	0
21.5	2	25.3	0
21.6	2	25.4	0
21.7	2	25.5	0
21.8	2	25.6	0
21.9	2	25.7	0
22.0	2	25.8	0
22.1	2	25.9	0
22.2	2		
22.3	2		

PJP Landfill Site
Jersey City, New Jersey
Stormwater Drainage Ditches

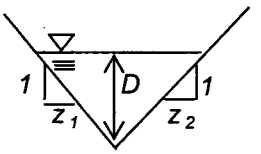
Rev. 3/14/07

Channel Name	Channel Type	Contributing Watersheds	Design Storm (years)	Curve Number Number	Peak Discharge (cfs)	Channel Bed Slope (ft/ft)	Free-board (ft)	Channel Lining	Manning Coeff.	Channel Bottom Width (ft)	Left Side Slopes Inclintion	Right Side Slopes Inclintion	Flow Area (sq.ft.)	Flow Depth (ft)	Top Flow Width (ft.)	Flow Velocity (ft/s)	Available Q with Freeboard (cfs)	Channel Depth (ft)	Top Channel Width (ft)	Available Q without Freeboard (cfs)
1	Triangular	A	100	79	16	0.011	0.73	grass	0.039	0.00	3.00	3.00	12.00	1.27	12.00	2.85	13.7	2.00	12.0	46.3
2	Triangular	B	100	79	7	0.012	1.07	grass	0.039	0.00	3.00	3.00	12.00	0.93	12.00	2.42	6.3	2.00	12.0	48.4
3	Triangular	C	100	79	6	0.013	1.12	grass	0.039	0.00	3.00	3.00	12.00	0.88	12.00	2.42	5.6	2.00	12.0	50.3
4	Triangular	D, G, and H	100	79	16	0.012	0.73	grass	0.039	0.00	3.00	3.00	12.00	1.27	12.00	2.71	13.1	2.00	12.0	44.1
5	Triangular	D	100	79	7	0.010	1.07	grass	0.039	0.00	3.00	3.00	12.00	0.93	12.00	2.52	6.5	2.00	12.0	50.3
6	Triangular	F	100	79	3	0.013	1.32	grass	0.039	0.00	3.00	3.00	12.00	0.68	12.00	2.04	2.8	2.00	12.0	50.3
7	Trapezoidal	D, E, F, G, and H	100	79	25	0.021	1.30	riprap	0.033	6.00	3.00	3.00	24.00	0.71	18.00	4.36	25.0	2.00	18.0	185.3
1	Triangular	A	500	79	30	0.011	0.40	grass	0.039	0.00	3.00	3.00	12.00	1.60	12.00	3.33	25.7	2.00	12.0	46.3
2	Triangular	B	500	79	13	0.012	0.83	grass	0.039	0.00	3.00	3.00	12.00	1.17	12.00	2.82	11.6	2.00	12.0	48.4
3	Triangular	C	500	79	12	0.013	0.86	grass	0.039	0.00	3.00	3.00	12.00	1.14	12.00	2.88	11.1	2.00	12.0	50.3
4	Triangular	D, G, and H	500	79	28	0.012	0.50	grass	0.039	0.00	3.00	3.00	12.00	1.50	12.00	3.03	20.4	2.00	12.0	44.1
5	Triangular	D	500	79	12	0.010	0.86	grass	0.039	0.00	3.00	3.00	12.00	1.14	12.00	2.88	11.1	2.00	12.0	50.3
6	Triangular	F	500	79	6	0.013	1.13	grass	0.039	0.00	3.00	3.00	12.00	0.88	12.00	2.42	5.6	2.00	12.0	50.3
7	Trapezoidal	D, E, F, G, and H	500	79	45	0.021	1.09	riprap	0.033	6.00	3.00	3.00	24.00	0.91	18.00	5.03	40.0	2.00	18.0	185.3

SHEET 3 of 3

EXAMPLE CALCULATION
FLOW VELOCITY

Rev: JGA 3/14/07



$$Q = \frac{1.486}{n} A R_h^{2/3} S^{1/2}$$

$$V = Q / A$$

where:

Q = Flow in cfs
n = Manning roughness coefficient
A = Flow area (ft^2)
R_h = Hydraulic radius = A/Pw (ft)
P_w = Wetted Perimeter
S = Slope (ft/ft)
V = Velocity (ft/s)

Inputs:

Q=	16 cfs
n =	0.039
bottom width (B) =	0 ft
side slope (Z_1) =	3.00 :1
side slope (Z_2) =	3.00 :1
Channel Depth =	2.00 ft
S =	0.012 ft/ft

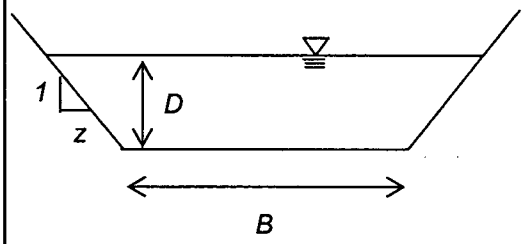
Results:

flow depth (D) =	1.27 ft
A =	4.84 ft^2
P_W =	8.03 ft
R_h =	0.60 ft
V =	3.31 fps
Available Freeboard =	0.73 fps

3/12/2007

EXAMPLE CALCULATION
FLOW VELOCITY
PJP Landfill

Rev: 3/14/07



$$Q = \frac{1.486}{n} A R_h^{2/3} S^{1/2}$$

$$V = Q / A$$

where:

Q = Flow in cfs
n = Manning roughness coefficient
A = Flow area (ft^2)
R_h = Hydraulic radius = A/Pw (ft)
P_w = Wetted Perimeter
S = Slope (ft/ft)
V = Velocity (ft/s)

Inputs:

Q=	25 cfs
n =	0.033
bottom width (B) =	6 ft
side slope =	3.00 :1
S =	0.021 ft/ft

Results:

flow depth (D) =	0.71 ft
A =	5.77 ft^2
P_W =	11.68 ft
R_h =	0.49 ft
V =	4.33 fps

APPENDIX C-4

PROPOSED STORMWATER DRAINAGE DITCH - TRUCKSTOP

OBJECTIVE: Determine the peak runoff on a 100-year, 24-hour storm event on proposed conditions of the Truckstop area, and design the surface water channels based on the calculated peak runoff. Check that the surface water channels are not overtopped by the peak flow from the 500-year, 24-hour storm event.

REFERENCES:

1) Golder Associates Inc., "Final (100%) Design Report, Figure 6-1, Proposed Surface Water Management System," dated March 2007.

2) USDA, Soil Conservation Service, "Technical Release No. 55: Urban Hydrology for Small Watersheds" (TR-55), June, 1986.

3) New Jersey State Soil Conservation Committee, "Standards for Soil Erosion and Sediment Control in New Jersey," dated July 1999.

4) National Oceanic & Atmospheric Administration (NOAA), U.S. Department of Commerce website for "Precipitation Frequency Estimates from NOAA Atlas 14," last modified January 2007.

CALCULATIONS: The calculations will include:

1) Determine the peak runoff; and,
2) Design the channels based on the peak runoff.

The following describes the two calculations in detail.

1) Peak Runoff Determination

The TR-55 computer program was used to determine the peak runoff for each drainage area. This program requires several input parameters, such as:

- Drainage Area (as described below);
- Time of Concentration (as described below);
- Curve Number (as described below);
- Rainfall Type – Type III (see sheet 8 of 28);
- Design Storm – 100-year, 24-hour storm (7.5 inches) (see sheet 7 of 28); and,
- Design Storm - 500-year, 24-hour storm (11.98 inches) (from Reference 4).

Drainage Areas

The Truckstop area was separated into drainage areas based on the proposed layout of the channels. Each channel was given a channel designation number. Using topographic features of the proposed grading plan, drainage areas were delineated. The size of each drainage area was determined by tracing the limits of the drainage area in AutoCAD, and requesting the areas from the computer program. Figure 1 (sheet 5 of 28) shows the limits of each drainage area and the following table summarizes the drainage areas:

Drainage Area	Area (ft^2)	Area (ac.)
A	37,462	0.86
B	108,465	2.49
C	138,956	3.19

Time of Concentration

The time of concentration (Tc), the length of time for runoff to travel from the most hydrology distant point within a drainage area, was determined for each drainage area, using methods outlined in Reference 2 (see Figure 1 for Tc travel paths). The precipitation depth associated with the 2 year, 24 hour storm event near the site (3.30 inches from Ref. 3) is required for the time of concentration calculation. In addition, a Manning's roughness coefficient for sheet flow of 0.24 for dense grasses was used (see sheet 10 of 28). The following is a summary of the time of concentration for each drainage area (see sheet 14 of 28 for calculations):

Drainage Area	Tc (hours)
A	0.127
B	0.312
C	0.190

Curve Number

The Curve Number, which is based on the hydrologic soil type and surface cover, is outlined in Reference 2. The hydrologic soil type is assumed to be Type C (soils of low infiltration rates with moderately fine to fine texture) (Reference 2). The proposed surface cover is considered open space in fair condition with a resulting curve number of 79.

Peak Runoff

The peak runoff for each area for the 100-year and 500-year, 24-hour storm events was determined by using TR-55 computer program. The drainage areas, times of concentrations, curve numbers, rainfall type, and design storm information were inputted into the TR-55 program. The peak runoff for each drainage area is summarized as follows:

Drainage Area	100-Year, 24-Hour Storm Event	500-Year, 24-Hour Storm Event
A	4	8
B	10	18
C	14	26

2) Channel Design

Manning's Equation for open channel flow was utilized to design the channels. An Excel spreadsheet was used to vary channel dimension to determine the most appropriate channel design. (see Sheet 27 of 28). The Manning's Equation is as follows:

$$Q = (1.49 \times R_h^{2/3} \times A \times S^{1/2})/n$$

Q = channel flow rate (cfs)
R_h = hydraulic radius of channel = A/P (ft)
A = cross-sectional area of flow (ft^2)
P = wetted perimeter of flow (ft)

S = channel slope (ft/ft)
n = Manning's coefficient

Channel Flow Rate

The channel flow rate is equivalent to the peak runoff discharging to each of the channels and is summarized as follows:

Channel Designation	Channel Shape	Contributing Drainage Area	Total Peak Flow 100 yr storm	Total Peak Flow 500 yr storm
1	Triangular	B	10	18
2	Triangular	A	4	8

Hydraulic Radius, Cross-Sectional Area, and Wetted Perimeter

Hydraulic radius, cross-sectional area, and wetted perimeter of flow are dependent on the channel dimensions and depth of flow. These parameters are determined by the shape of the channel, channel side slopes, and flow depth. A triangular cross-section was selected for design.

Channel Slope

The channel slope for Channel 1 is on average approximately 1.5 percent, and the slope for Channel 2 is approximately 4.0 percent. Due to the relatively flat nature of the existing conditions steeper channel slopes for Channel 1, would be difficult to achieve. However, slopes at 1.5% will allow for lower velocities of flow.

Manning's Coefficient

The Manning's coefficient ("n") is a resistance factor related to surface roughness, channel irregularity, obstructions in the channel, and channel alignment. Since the proposed drainage channels are engineered and not naturally occurring, the main factor in determining the Manning's coefficient is surface roughness of the selected channel lining. Using the guidelines in Reference 3, the Manning's coefficient for riprap-lined channels is determined to be 0.033. The Manning's coefficient for grass-lined channels is calculated using the Soil Conservation Service (SCS) method (as described in Reference 3) which includes determining a basic n-value and adding in modification factors for surface irregularity, variation in channel cross-section, obstructions, vegetation, and meander. The basic n-value was assumed to be 0.02 based on a channel in earth. The vegetation modification factor is 0.019, which assumes a turf grass. Therefore the n-value for a vegetation-lined channel is 0.039.

CONCLUSION: Based on the peak flow calculations, a series of drainage channels were designed for the Truckstop Property. The designed channels allowed a minimum of 0.25 feet of freeboard for both the 100-year, and 500-year 24-hour storm events. The drainage channel system consists of triangular-shaped channels, which are described in more detail as follows:

- Triangular shaped channels will be grass-lined with side slopes of 3H:1V, a channel depth of 2.0 ft, and a longitudinal slope of 1.5 percent. The peak discharge is 10 cfs. From the attached table, the flow depth required to attain the design flow rate is 1.06 feet, which will maintain at least 0.25 ft of freeboard. The maximum velocity is 2.96 ft/s. Based on Reference 3, a grass-lined channel with permanent erosion control matting is sufficient. The channel will not be overtopped in a 500-year, 24-hour storm event.

120 0 120
SCALE FEET

LEGEND

- PROPOSED TRIANGULAR CHANNEL
- PROPOSED ACCESS ROAD
- WATERSHED BOUNDARY
- A — WATERSHED ZONES
- —X—X—X— PROPOSED FENCE

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT
PJP LANDFILL
[redacted]
JERSEY CITY, HUDSON COUNTY, NEW JERSEY

TITLE
TRUCKSTOP AREA GRADING PLAN

NJ Authorization #24GA28029100
Golder Associates
Philadelphia USA

PROJECT No.		003-6004	FILE No.	0036004R052
DESIGN	CBM	03/08/07	SCALE AS SHOWN	REV. 0
CADD	MJS	03/08/07	FIGURE 1	
CHECK				
REVIEW				

Drawing file: 0036004R052.dwg Mar 26, 2007 - 1:41pm

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4]Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

2-30.3

NEW JERSEY 24 HOUR RAINFALL

County	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Atlantic	2.8	3.5	4.5	5.5	6.2	6.8	7.6
Bergen	2.7	3.3	4.3	5.3	5.7	6.5	7.5
Burlington	2.8	3.4	4.4	5.3	6.0	6.6	7.4
Camden	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Cape May	2.9	3.5	4.6	5.6	6.3	6.9	7.7
Cumberland	2.8	3.4	4.5	5.4	6.0	6.8	7.5
Essex	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Gloucester	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Hudson	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Hunterdon	2.6	3.2	4.2	5.0	5.7	6.5	7.3
Mercer	2.7	3.3	4.3	5.2	5.8	6.4	7.5
Middlesex	2.7	3.3	4.3	5.2	5.9	6.4	7.5
Monmouth	2.8	3.4	4.4	5.3	6.0	6.5	7.5
Morris	2.6	3.3	4.3	5.2	5.7	6.5	7.5
Ocean	2.8	3.5	4.5	5.4	6.2	6.6	7.5
Passaic	2.6	3.3	4.3	5.4	5.7	6.5	7.6
Salem	2.8	3.3	4.4	5.3	5.9	6.6	7.4
Somerset	2.7	3.3	4.3	5.2	5.7	6.5	7.5
Sussex	2.6	3.2	4.2	5.0	5.7	6.6	7.5
Union	2.7	3.3	4.3	5.3	5.8	6.4	7.5
Warren	2.6	3.2	4.1	4.9	5.6	6.5	7.2

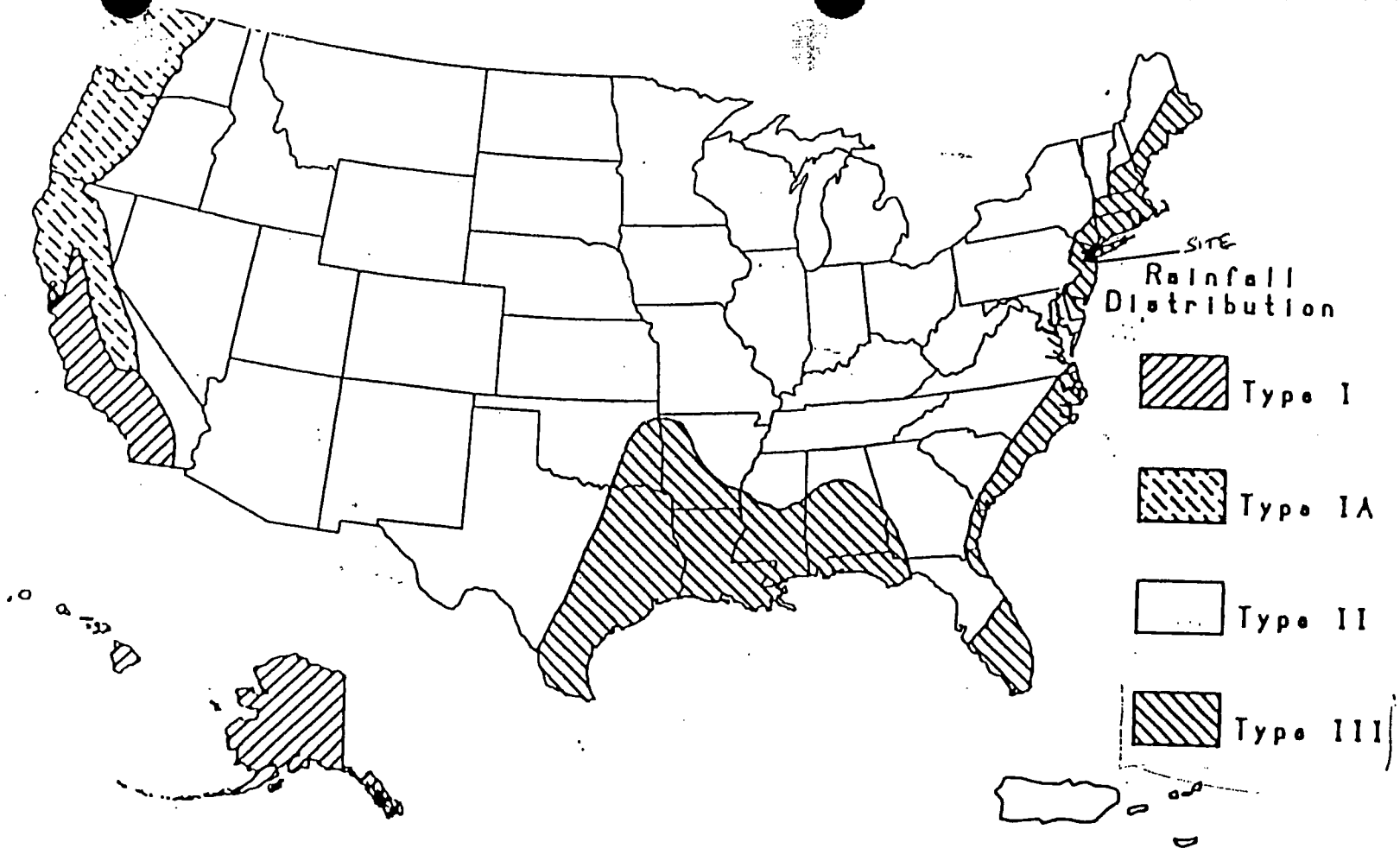


Figure II-2.—Approximate geographic boundaries for SCS rainfall distributions.

(from Reference 2)

Chapter 3: Time of concentration and travel time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600\ V} \qquad \text{[Eq. 3-1]}$$

where

T_t = travel time (hr),
L = flow length (ft),
V = average velocity (ft/s), and
3600 = conversion factor from seconds to hours.

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[Eq. 3-2]}$$

where

T_c = time of concentration (hr) and
m = number of flow segments.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1]The n values are a composite of information compiled by Engman (1986).

[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Manning's equation is

$$V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n} \qquad \text{[Eq. 3-4]}$$

where

- V = average velocity (ft/s),
- r = hydraulic radius (ft) and is equal to a/p_w,
- a = cross sectional flow area (ft^2),
- p_w = wetted perimeter (ft),
- s = slope of the hydraulic grade line (channel slope, ft/ft), and
- n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, T_t for the channel segment can be estimated using equation 3-1.

Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.

  In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.

  The minimum T_c used in TR-55 is 0.1 hour.

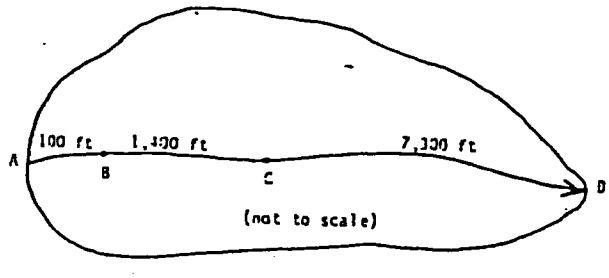
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

Example 3-1

The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute T_c at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment from the following information:

Segment AB:	Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft.
Segment BC:	Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1400 ft.
Segment CD:	Channel flow; Manning's n = .05; flow area (a) = 27 ft^2; wetted perimeter (p_w) = 28.2 ft; s = 0.005 ft/ft; and L = 7300 ft.

See figure 3-2 for the computations made on worksheet 3.



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Oceanic and Atmospheric Administration.

East of 105th meridian

Hershfield, D. M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 115 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I, Montana; Vol. II, Wyoming; Vol. III, Colorado; Vol. IV, New Mexico; Vol. V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dep. Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 p.

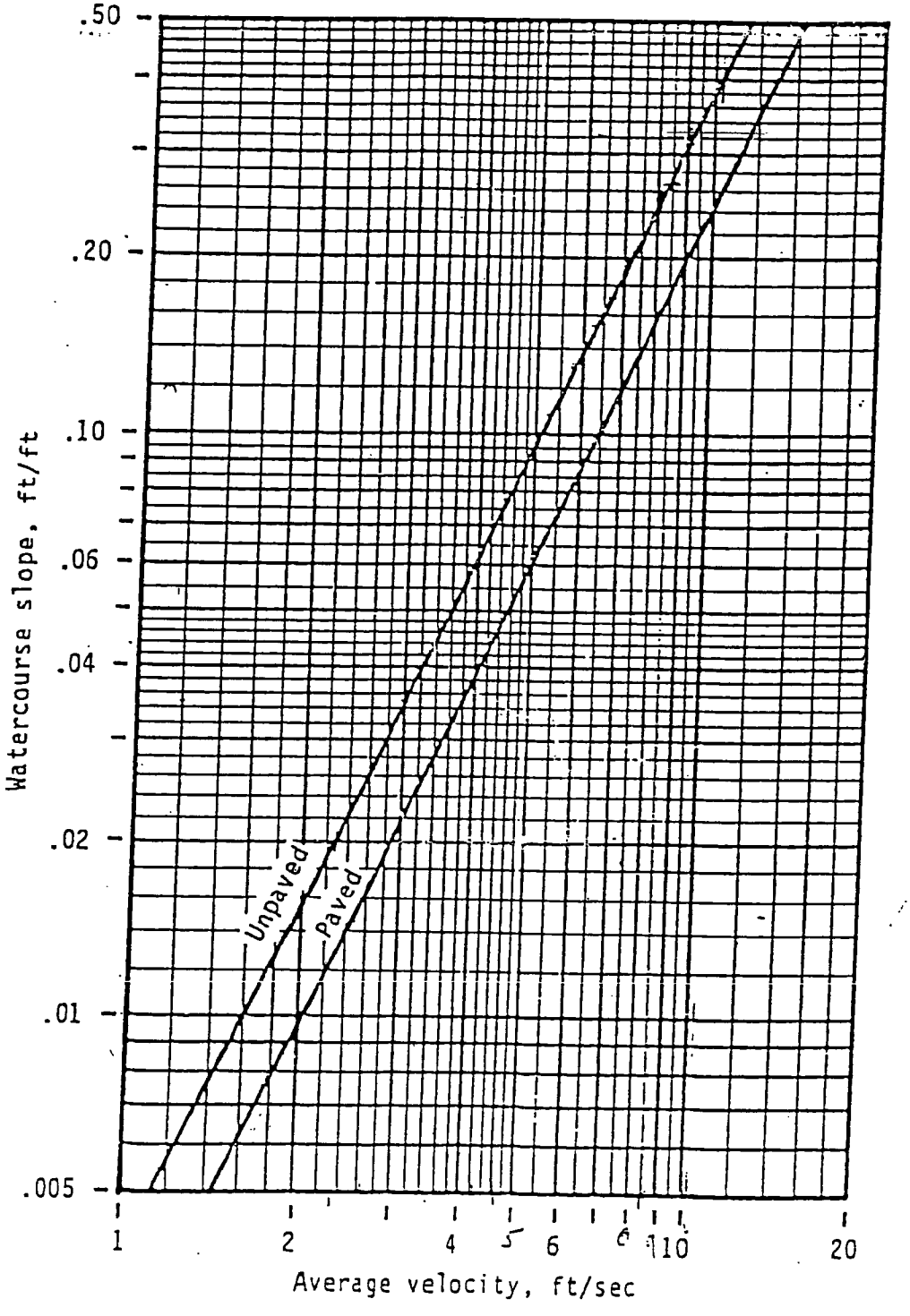


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

PJP Landfill Site
Jersey City, New Jersey
Time of Concentration
Truckstop Area

Project PJP Landfill By: BRB Date: 3/26/2007
Location Jersey City, New Jersey Checked: CBM Date: 3/26/2007
Rev: JA 3/28/07
Condition Construction
Site Truckstop

Watershed	A	B	C
SHEET FLOW (Application to T_c only)			
1. Surface Description	vegetated	vegetated	vegetated
2. Manning's roughness coefficient, n	0.24	0.24	0.24
3. Flow Length, L (total L<300ft) ft.	71	243	132
4. Two-yr 24-hr rainfall, P_2 in.	3.3	3.3	3.3
5. Land slope, s ft./ft	0.06	0.06	0.06
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ hr.	**0.115**	**0.307**	**0.188**
Shallow Concentrated Flow			
7. Surface description (paved or unpaved)			upaved
8. Flow Length, L ft.			51
9. Watercourse slope, s ft./ft.			0.33
10. Average velocity, V (figure 3-1) ft./s.			9.5
11. $T_T = \frac{L}{3600V}$ hr.			**0.0015**
Channel Flow			
12. Cross Sectional flow area, a $ft.^2$	12	12	
13. Wetted perimeter, p_w ft.	12.65	12.65	
14. Hydraulic radius, $r = a/p_w$ ft.	0.949	0.949	
15. Channel slope, s ft./ft.	0.035	0.015	
16. Manning's roughness coeffienct, n	0.033	0.033	
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ ft./s.	8.16	5.34	
18. Flow Length, L ft.	360	96	
19. Tt = L/3600 V hr.	**0.0123**	**0.0050**	
20. Total Tc from sheet, shallow, and channel flow hr.	**0.127**	**0.312**	**0.190**

SHEET 14 OF 28

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:37
Watershed file: --> c:\pondpack\TS .WSD
Hydrograph file: --> c:\pondpack\TS .HYD

PJP LANDFILL-TRUCK STOP
100 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used	
A	0.86	79.0	0.10	0.00	7.50	5.04	.07	.10
B	2.49	79.0	0.30	0.00	7.50	5.04	.07	.10
C	3.19	79.0	0.20	0.00	7.50	5.04	.07	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 6.54 acres or 0.01022 sq.mi
Peak discharge = 27 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	0.13	0.00	0.10	0.00	No	Computed Ia/p < .1
B	0.31	0.00	0.30	0.00	No	Computed Ia/p < .1
C	0.19	0.00	0.20	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:37
Watershed file: --> c:\pondpack\TS .WSD
Hydrograph file: --> c:\pondpack\TS .HYD

PJP LANDFILL-TRUCK STOP
100 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	4	12.2
B	10	12.4
C	14	12.3
Composite Watershed	27	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:37
Watershed file: --> c:\pondpack\TS .WSD
Hydrograph file: --> c:\pondpack\TS .HYD

PJP LANDFILL-TRUCK STOP
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	0	0	0	1	2	3	4	4	2
B	0	1	1	2	2	4	6	9	10
C	1	1	1	3	4	6	11	14	12
Total (cfs)	1	2	2	6	8	13	21	27	24

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	2	1	1	1	1	0	0	0	0
B	9	7	5	4	2	2	1	1	1
C	9	7	5	3	2	2	2	2	1
Total (cfs)	20	15	11	8	5	4	3	3	2

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:37
Watershed file: --> c:\pondpack\TS .WSD
Hydrograph file: --> c:\pondpack\TS .HYD

PJP LANDFILL-TRUCK STOP
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	0	0	0	0	0	0	0	0	0
B	1	1	1	1	1	1	0	0	0
C	1	1	1	1	1	1	1	1	0
Total (cfs)	2	2	2	2	2	2	1	1	0

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	0	0	0	0	0
B	0	0	0	0	0
C	0	0	0	0	0
Total (cfs)	0	0	0	0	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:37
Watershed file: --> c:\pondpack\TS .WSD
Hydrograph file: --> c:\pondpack\TS .HYD

PJP LANDFILL-TRUCK STOP
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	1	14.8	2
11.1	1	14.9	2
11.2	2	15.0	2
11.3	2	15.1	2
11.4	2	15.2	2
11.5	2	15.3	2
11.6	2	15.4	2
11.7	3	15.5	2
11.8	5	15.6	2
11.9	6	15.7	2
12.0	8	15.8	2
12.1	13	15.9	2
12.2	21	16.0	2
12.3	27	16.1	2
12.4	24	16.2	2
12.5	20	16.3	1
12.6	15	16.4	1
12.7	11	16.5	1
12.8	8	16.6	1
12.9	6	16.7	1
13.0	5	16.8	1
13.1	4	16.9	1
13.2	4	17.0	1
13.3	4	17.1	1
13.4	3	17.2	1
13.5	3	17.3	0
13.6	3	17.4	0
13.7	2	17.5	0
13.8	2	17.6	0
13.9	2	17.7	0
14.0	2	17.8	0
14.1	2	17.9	0
14.2	2	18.0	0
14.3	2	18.1	0
14.4	2	18.2	0
14.5	2	18.3	0
14.6	2	18.4	0
14.7	2	18.5	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:37
Watershed file: --> c:\pondpack\TS .WSD
Hydrograph file: --> c:\pondpack\TS .HYD

PJP LANDFILL-TRUCK STOP
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	0	22.4	0
18.7	0	22.5	0
18.8	0	22.6	0
18.9	0	22.7	0
19.0	0	22.8	0
19.1	0	22.9	0
19.2	0	23.0	0
19.3	0	23.1	0
19.4	0	23.2	0
19.5	0	23.3	0
19.6	0	23.4	0
19.7	0	23.5	0
19.8	0	23.6	0
19.9	0	23.7	0
20.0	0	23.8	0
20.1	0	23.9	0
20.2	0	24.0	0
20.3	0	24.1	0
20.4	0	24.2	0
20.5	0	24.3	0
20.6	0	24.4	0
20.7	0	24.5	0
20.8	0	24.6	0
20.9	0	24.7	0
21.0	0	24.8	0
21.1	0	24.9	0
21.2	0	25.0	0
21.3	0	25.1	0
21.4	0	25.2	0
21.5	0	25.3	0
21.6	0	25.4	0
21.7	0	25.5	0
21.8	0	25.6	0
21.9	0	25.7	0
22.0	0	25.8	0
22.1	0	25.9	0
22.2	0		
22.3	0		

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:44
Watershed file: --> c:\pondpack\TS500 .WSD
Hydrograph file: --> c:\pondpack\TS500 .HYD

PJP LANDFILL-TRUCK STOP
500 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used	
A	0.86	79.0	0.10	0.00	11.98	9.29	.04	.10
B	2.49	79.0	0.30	0.00	11.98	9.29	.04	.10
C	3.19	79.0	0.20	0.00	11.98	9.29	.04	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 6.54 acres or 0.01022 sq.mi
Peak discharge = 49 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	0.13	0.00	0.10	0.00	No	Computed Ia/p < .1
B	0.31	0.00	0.30	0.00	No	Computed Ia/p < .1
C	0.19	0.00	0.20	0.00	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:44
Watershed file: --> c:\pondpack\TS500 .WSD
Hydrograph file: --> c:\pondpack\TS500 .HYD

PJP LANDFILL-TRUCK STOP
500 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	8	12.2
B	18	12.4
C	26	12.3
Composite Watershed	49	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:44
Watershed file: --> c:\pondpack\TS500 .WSD
Hydrograph file: --> c:\pondpack\TS500 .HYD

PJP LANDFILL-TRUCK STOP
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	0	0	1	2	3	5	8	7	4
B	1	1	2	3	4	7	10	16	18
C	1	2	2	6	8	12	21	26	22
Total (cfs)	2	3	5	11	15	24	39	49	44

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	3	2	2	1	1	1	1	1	1
B	16	13	10	7	4	3	3	2	2
C	17	13	9	6	4	3	3	3	3
Total (cfs)	36	28	21	14	9	7	7	6	6

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:44
Watershed file: --> c:\pondpack\TS500 .WSD
Hydrograph file: --> c:\pondpack\TS500 .HYD

PJP LANDFILL-TRUCK STOP
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	1	1	1	0	0	0	0	0	0
B	2	2	2	1	1	1	1	1	1
C	2	2	2	2	2	1	1	1	1
Total (cfs)	5	5	5	3	3	2	2	2	2

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	0	0	0	0	0
B	1	1	0	0	0
C	1	1	1	1	0
Total (cfs)	2	2	1	1	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:44
Watershed file: --> c:\pondpack\TS500 .WSD
Hydrograph file: --> c:\pondpack\TS500 .HYD

PJP LANDFILL-TRUCK STOP
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	2	14.8	4
11.1	2	14.9	3
11.2	3	15.0	3
11.3	3	15.1	3
11.4	4	15.2	3
11.5	4	15.3	3
11.6	5	15.4	3
11.7	7	15.5	3
11.8	9	15.6	3
11.9	11	15.7	3
12.0	15	15.8	2
12.1	24	15.9	2
12.2	39	16.0	2
12.3	49	16.1	2
12.4	44	16.2	2
12.5	36	16.3	2
12.6	28	16.4	2
12.7	21	16.5	2
12.8	14	16.6	2
12.9	12	16.7	2
13.0	9	16.8	2
13.1	8	16.9	2
13.2	7	17.0	2
13.3	7	17.1	2
13.4	7	17.2	2
13.5	7	17.3	2
13.6	6	17.4	2
13.7	6	17.5	2
13.8	6	17.6	2
13.9	6	17.7	2
14.0	5	17.8	2
14.1	5	17.9	2
14.2	5	18.0	2
14.3	5	18.1	2
14.4	5	18.2	2
14.5	5	18.3	2
14.6	5	18.4	2
14.7	4	18.5	2

SHEET 26 & 28

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 14:44:44
Watershed file: --> c:\pondpack\TS500 .WSD
Hydrograph file: --> c:\pondpack\TS500 .HYD

PJP LANDFILL-TRUCK STOP
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	2	22.4	1
18.7	2	22.5	1
18.8	2	22.6	1
18.9	2	22.7	1
19.0	2	22.8	1
19.1	2	22.9	1
19.2	2	23.0	1
19.3	2	23.1	1
19.4	2	23.2	1
19.5	2	23.3	1
19.6	1	23.4	1
19.7	1	23.5	1
19.8	1	23.6	1
19.9	1	23.7	1
20.0	1	23.8	1
20.1	1	23.9	1
20.2	1	24.0	0
20.3	1	24.1	0
20.4	1	24.2	0
20.5	1	24.3	0
20.6	1	24.4	0
20.7	1	24.5	0
20.8	1	24.6	0
20.9	1	24.7	0
21.0	1	24.8	0
21.1	1	24.9	0
21.2	1	25.0	0
21.3	1	25.1	0
21.4	1	25.2	0
21.5	1	25.3	0
21.6	1	25.4	0
21.7	1	25.5	0
21.8	1	25.6	0
21.9	1	25.7	0
22.0	1	25.8	0
22.1	1	25.9	0
22.2	1		
22.3	1		

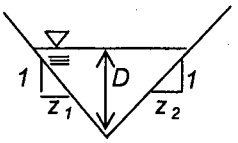
PJP Landfill Site
Jersey City, New Jersey
Stormwater Drainage Ditches
Truckstop Area

Channel Name	Channel Type	Contributing Watersheds	Design Storm (years)	Curve Number Number	Peak Discharge (cfs)	Channel Bed Slope (ft/ft)	Free-board (ft)	Channel Lining	Manning Coeff. n	Channel Bottom Width (ft)	Left Side Slopes Inclintion	Right Side Slopes Inclintion	Flow Area (sq.ft.)	Flow Depth (ft)	Top Flow Width (ft.)	Flow Velocity (ft/s)	Available Q with Freeboard (cfs)	Channel Depth (ft)	Top Channel Width (ft)	Available Q without Freeboard (cfs)
1	Triangular	B	100	79	10	0.015	0.94	grass	0.039	0.00	3.00	3.00	12.00	1.06	12.00	2.96	10.0	2.00	12.0	54.1
1	Triangular	B	500	79	18	0.015	0.68	grass	0.039	0.00	3.00	3.00	12.00	1.32	12.00	3.42	18.0	2.00	12.0	54.1
2	Triangular	A	100	79	4	0.035	1.36	grass	0.039	0.00	3.00	3.00	12.00	0.64	12.00	3.22	4.0	2.00	12.0	82.6
2	Triangular	A	500	79	8	0.035	1.17	grass	0.039	0.00	3.00	3.00	12.00	0.83	12.00	3.84	8.0	2.00	12.0	82.6

SHEET 27 OF 28

3/26/2007

EXAMPLE CALCULATION
FLOW VELOCITY



$$Q = \frac{1.486}{n} A R_h^{2/3} S^{1/2}$$

$$V = Q / A$$

where:

Q = Flow in cfs
n = Manning roughness coefficient
A = Flow area (ft^2)
R_h = Hydraulic radius = A/Pw (ft)
P_w = Wetted Perimeter
S = Slope (ft/ft)
V = Velocity (ft/s)

Inputs:	
Q=	10 cfs
n =	0.039
bottom width (B) =	0 ft
side slope (Z_1) =	3.00 :1
side slope (Z_2) =	3.00 :1
Channel Depth =	2.00 ft
S =	0.015 ft/ft

Results:	
flow depth (D) =	1.06 ft
A =	3.37 ft^2
P_W =	6.70 ft
R_h =	0.50 ft
V =	2.97 fps
Available Freeboard =	0.94 fps

APPENDIX C-5

PROPOSED STORMWATER DRAINAGE DITCH – RV SALVAGE

OBJECTIVE: Determine the peak runoff on a 100-year, 24-hour storm event on proposed conditions of the RV Salvage area, and design the surface water channels based on the calculated peak runoff. Check that the surface water channels are not overtopped by the peak flow from the 500-year, 24-hour storm event.

REFERENCES:

1) Golder Associates Inc., "Final (100%) Design Report, Figure 6-1, Proposed Surface Water Management System," dated March 2007.

2) USDA, Soil Conservation Service, "Technical Release No. 55: Urban Hydrology for Small Watersheds" (TR-55), June, 1986.

3) New Jersey State Soil Conservation Committee, "Standards for Soil Erosion and Sediment Control in New Jersey," dated July 1999.

4) National Oceanic & Atmospheric Administration (NOAA), U.S. Department of Commerce website for "Precipitation Frequency Estimates from NOAA Atlas 14," last modified January 2007.

METHOD & CALCULATIONS: The calculations will include:

1) Determine the peak runoff; and,
2) Design the channels based on the peak runoff.

The following describes the two calculations in detail.

1) Peak Runoff Determination

The TR-55 computer program was used to determine the peak runoff for each drainage area. This program requires several input parameters, such as:

- Drainage Area (as described below);
- Time of Concentration (as described below);
- Curve Number (as described below);
- Rainfall Type – Type III (see sheet 8 of 28);
- Design Storm – 100-year, 24-hour storm (7.5 inches) (see sheet 7 of 28); and,
- Design Storm - 500-year, 24-hour storm (11.98 inches) (from Reference 4).

Drainage Areas

The RV Salvage area was separated into drainage areas based on the proposed layout of the channels. Each channel was given a channel designation number. Using topographic features of the proposed grading plan, drainage areas were delineated. The size of each drainage area was determined by tracing the limits of the drainage area in AutoCAD, and requesting the areas from the computer program. Figure 1 (sheet 5 of 28) shows the limits of each drainage area. The following table summarizes the drainage areas:

Drainage Area	Area (ft^2)	Area (ac.)
A	105,415	2.42
B	155,945	3.58
C	37,026	0.85
D	16,117	0.37
E	76,666	1.76

Time of Concentration

The time of concentration (Tc), the length of time for runoff to travel from the most hydrology distant point within a drainage area, was determined for each drainage area, using methods outlined in Reference 2 (see Figure 1 for Tc travel paths). The precipitation depth associated with the 2-year, 24-hour storm event near the site (3.30 inches from Ref. 3) is required for the time of concentration calculation. In addition, a Manning's roughness coefficient for sheet flow of 0.24 for dense grasses was used (see sheet 10 of 28). The following is a summary of the time of concentration for each drainage area (see sheet 14 of 28 for calculations):

Drainage Area	Tc (hours)
A	0.218
B	0.388
C	0.209
D	0.043
E	0.062

A time of concentration of 0.100 was used for Drainage Areas D and E because that is the lowest time of concentration allowed in the TR-55 computer program.

Curve Number

The Curve Number, which is based on the hydrologic soil type and surface cover, is outlined in Reference 2. The hydrologic soil type is assumed to be Type C (soils of low infiltration rates with moderately fine to fine texture) (Reference 2). The proposed surface cover is considered open space in fair condition with a resulting curve number of 79.

Peak Runoff

The peak runoff for each area for the 100-year and 500-year, 24-hour storm events was determined by using TR-55 computer program. The drainage areas, times of concentrations, curve numbers, rainfall type, and design storm information were inputted into the TR-55 program. The peak runoff for each drainage area is summarized as follows:

Drainage Area	100-Year, 24-Hour Storm Event	500-Year, 24-Hour Storm Event
A	11	20
B	13	23
C	4	7
D	2	4
E	9	17

2) *Channel Design*

Manning's Equation for open channel flow was utilized to design the channels. An Excel spreadsheet was used to vary channel dimensions to determine the most appropriate channel design. (See Sheet 27 of 28). The Manning's Equation is as follows:

$$Q = (1.49 \times R_h^{2/3} \times A \times S^{1/2})/n$$

Q = channel flow rate (cfs)
R_h = hydraulic radius of channel = A/P (ft)
A = cross-sectional area of flow (ft^2)
P = wetted perimeter of flow (ft)
S = channel slope (ft/ft)
n = Manning's coefficient

Channel Flow Rate

The channel flow rate is equivalent to the peak runoff discharging to each of the channels and is summarized as follows:

Channel Designation	Channel Shape	Contributing Drainage Area	Total Peak Flow 100 yr storm	Total Peak Flow 500 yr storm
1	Triangular	B	13	23
2	Triangular	D	2	4

Hydraulic Radius, Cross-Sectional Area, and Wetted Perimeter

Hydraulic radius, cross-sectional area, and wetted perimeter of flow are dependent on the channel dimensions and depth of flow. These parameters are determined by the shape of the channel, channel side slopes, and flow depth. A triangular cross-section was selected for design.

Channel Slope

The channel slopes on average are approximately 1.5 percent. Due to the relatively flat nature of the existing conditions steeper channel slopes would be difficult to achieve. However, slopes at 1.5% will allow for lower velocities of flow.

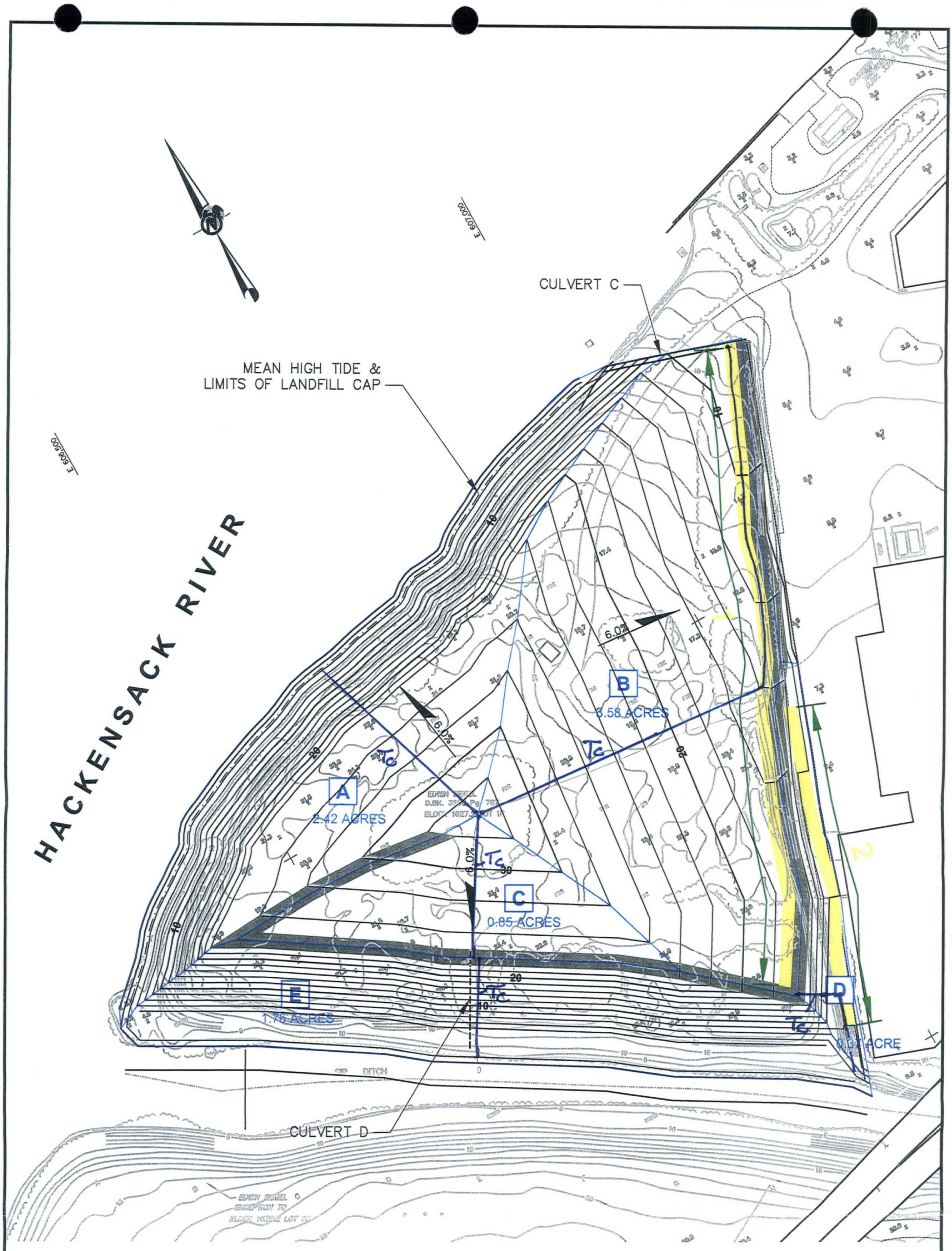
Manning's Coefficient

The Manning's coefficient ("n") is a resistance factor related to surface roughness, channel irregularity, obstructions in the channel, and channel alignment. Since the proposed drainage channels are engineered and not naturally occurring the main factors in determining the Manning's coefficient is surface roughness of the selected channel lining. Using the guidelines in Reference 3, the Manning's coefficient for riprap-lined channels is determined to be 0.033. The Manning's coefficient for grass-lined channels is calculated using the Soil Conservation Service (SCS) method (as described in Reference 3) which includes determining a basic n-value and adding modification factors for surface irregularity, variation in channel cross section, obstructions, vegetation, and meander. The basic n-value was assumed to be 0.02 based on a channel in earth. The vegetation modification factor is 0.019, which assumes a turf grass. Therefore, the n-value for vegetation lined channel is 0.039.

CONCLUSION: Based on the peak flow calculations, a series of drainage channels were designed for the RV Salvage area. The designed channels allowed a minimum of 0.25 feet of freeboard for a 100-year, 24-hour storm event and prevented overtopping of the channel for a 500-year, 24-hour storm event. The drainage channel system consists of triangular-shaped channels, which are described in more detail as follows:

- Triangular-shaped channels will be grass-lined with side slopes of 3H:1V, a channel depth of 2.0 ft, and a longitudinal slope of 1.5 percent. The peak discharge is 13 cfs. From the attached table (sheet 27 of 28), the flow depth required to attain the design flow rate is 1.17 feet, which will maintain at least 0.25 ft of freeboard. The maximum velocity is 3.16 ft/s. Based on Reference 3, a grass-lined channel with permanent erosion control matting is sufficient.

In addition, two culverts will be required below the existing and proposed access roads. The relevant calculations for the culverts are provided under separate cover.



LEGEND

PROPOSED TRIANGULAR CHANNEL

PROPOSED ACCESS ROAD

EDGE OF 30' WIDE WETLANDS BENCH

MEAN HIGH TIDE & LIMITS OF LANDFILL CAP

100 0 100
SCALE FEET

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT
PJP LANDFILL
[redacted]
JERSEY CITY, HUDSON COUNTY, NEW JERSEY

TITLE
RV SALVAGE AREA GRADING PLAN

NJ Authorization #24GA28029100
Golder Associates
Philadelphia USA

PROJECT No.		003-6004	FILE No.	0036004R051
DESIGN	CBM	03/06/07	SCALE AS SHOWN	REV. 0
CADD	GLS	03/06/07		
CHECK			FIGURE 1	
REVIEW				

Drawing file: 0036004R051.dwg Mar 23, 2007 – 1:43pm

SHEET 5 OF 28

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4]Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

2-30.3

NEW JERSEY 24 HOUR RAINFALL

County	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Atlantic	2.8	3.5	4.5	5.5	6.2	6.8	7.6
Bergen	2.7	3.3	4.3	5.3	5.7	6.5	7.5
Burlington	2.8	3.4	4.4	5.3	6.0	6.6	7.4
Camden	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Cape May	2.9	3.5	4.6	5.6	6.3	6.9	7.7
Cumberland	2.8	3.4	4.5	5.4	6.0	6.8	7.5
Essex	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Gloucester	2.8	3.4	4.4	5.3	5.9	6.6	7.4
Hudson	2.7	3.3	4.3	5.3	5.7	6.4	7.5
Hunterdon	2.6	3.2	4.2	5.0	5.7	6.5	7.3
Mercer	2.7	3.3	4.3	5.2	5.8	6.4	7.5
Middlesex	2.7	3.3	4.3	5.2	5.9	6.4	7.5
Monmouth	2.8	3.4	4.4	5.3	6.0	6.5	7.5
Morris	2.6	3.3	4.3	5.2	5.7	6.5	7.5
Ocean	2.8	3.5	4.5	5.4	6.2	6.6	7.5
Passaic	2.6	3.3	4.3	5.4	5.7	6.5	7.6
Salem	2.8	3.3	4.4	5.3	5.9	6.6	7.4
Somerset	2.7	3.3	4.3	5.2	5.7	6.5	7.5
Sussex	2.6	3.2	4.2	5.0	5.7	6.6	7.5
Union	2.7	3.3	4.3	5.3	5.8	6.4	7.5
Warren	2.6	3.2	4.1	4.9	5.6	6.5	7.2

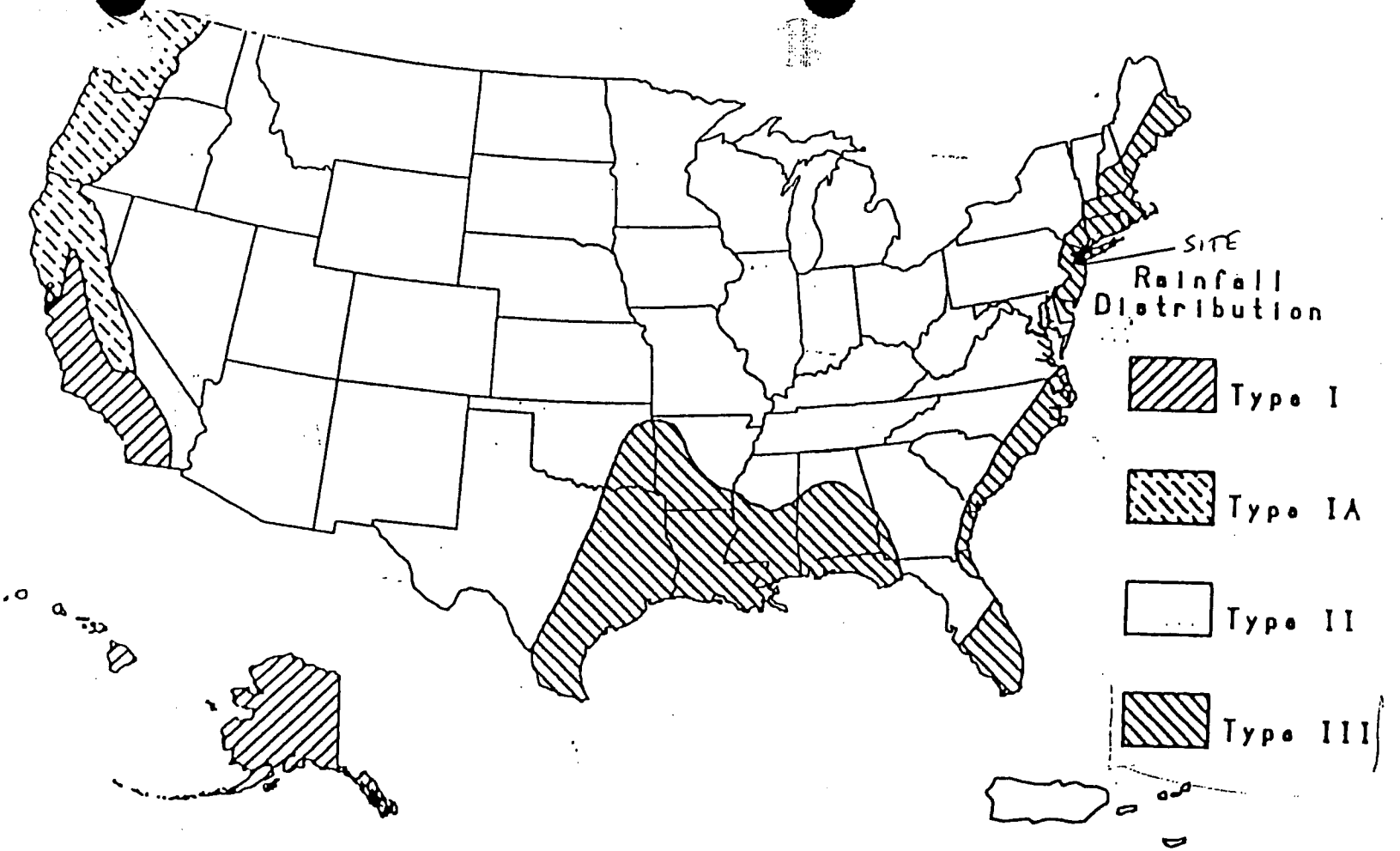


Figure II-2.—Approximate geographic boundaries for SCS rainfall distributions.

(from Reference 2)

Chapter 3: Time of concentration and travel time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600\ V} \qquad \text{[Eq. 3-1]}$$

where

T_t = travel time (hr),
L = flow length (ft),
V = average velocity (ft/s), and
3600 = conversion factor from seconds to hours.

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \dots T_{t_m} \qquad \text{[Eq. 3-2]}$$

where

T_c = time of concentration (hr) and
m = number of flow segments.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1]The n values are a composite of information compiled by Engman (1986).

[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Manning's equation is

$$V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n} \qquad \text{[Eq. 3-4]}$$

where

- V = average velocity (ft/s),
- r = hydraulic radius (ft) and is equal to a/p_w,
- a = cross sectional flow area (ft^2),
- p_w = wetted perimeter (ft),
- s = slope of the hydraulic grade line (channel slope, ft/ft), and
- n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, T_t for the channel segment can be estimated using equation 3-1.

Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.

  In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.

The minimum T_c used in TR-55 is 0.1 hour.

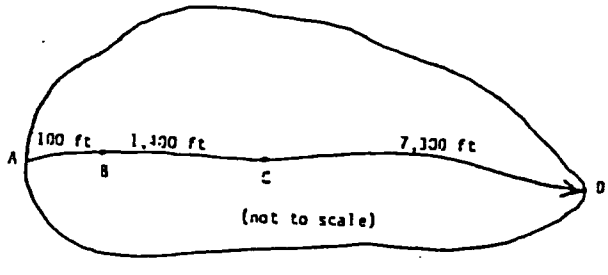
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

Example 3-1

The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute T_c at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment from the following information:

Segment AB:	Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft.
Segment BC:	Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1400 ft.
Segment CD:	Channel flow; Manning's n = .05; flow area (a) = 27 ft^2; wetted perimeter (p_w) = 28.2 ft; s = 0.005 ft/ft; and L = 7300 ft.

See figure 3-2 for the computations made on worksheet 3.



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Oceanic and Atmospheric Administration.

East of 105th meridian

Hershfield, D. M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 115 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I, Montana; Vol. II, Wyoming; Vol. III, Colorado; Vol. IV, New Mexico; Vol. V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dep. Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 p.

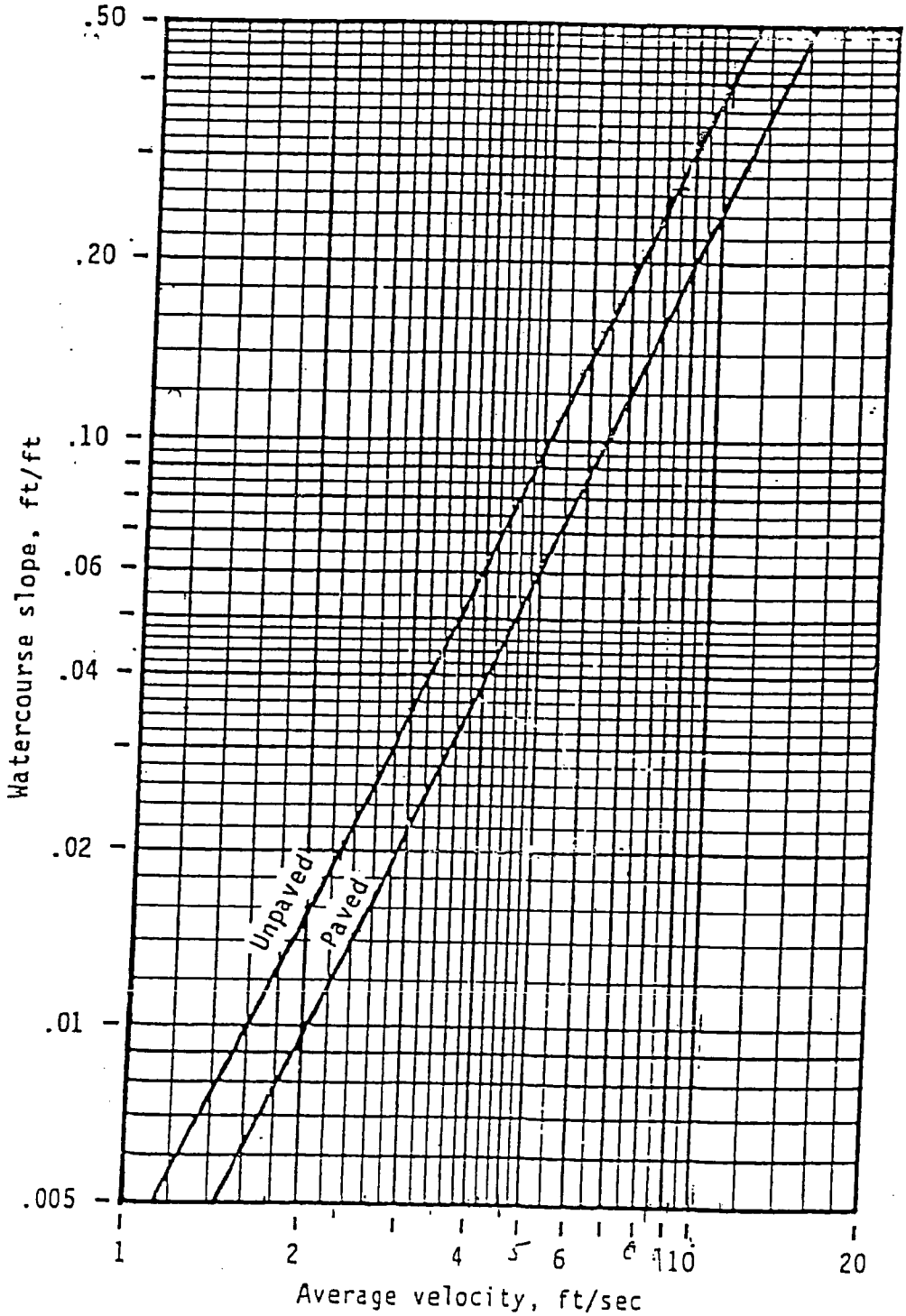


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

PJP Landfill Site
Jersey City, New Jersey
Time of Concentration
RV Salvage

Project	PJP Landfill	By:	BRB	Date:	3/23/2007
Location	Jersey City, New Jersey	Checked:	CBM	Date:	3/26/2007
Condition	Construction	Rev:	JCA 3/28/07		
Site	RV Salvage				

Watershed	A	B	C	D	E
SHEET FLOW (Application to T_c only)					
1. Surface Description	vegetated	vegetated	vegetated	vegetated	vegetated
2. Manning's roughness coefficient, n	0.24	0.24	0.24	0.24	0.24
3. Flow Length, L (total L<300ft) ft.	156	300	150	45	73
4. Two-yr 24-hr rainfall, P_2 in.	3.3	3.3	3.3	3.3	3.3
5. Land slope, s ft./ft	0.06	0.06	0.06	0.33	0.33
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ hr.	**0.215**	**0.363**	**0.209**	**0.040**	**0.059**
Shallow Concentrated Flow					
7. Surface description (paved or unpaved)	vegetated	vegetated			vegetated
8. Flow Length, L ft.	80	25			35
9. Watercourse slope, s ft./ft.	0.33	0.06			0.057
10. Average velocity, V (figure 3-1) ft./s.	9.5	4			3.8
11. $T_T = \frac{L}{3600V}$ hr.	**0.0023**	**0.0017**			**0.0026**
Channel Flow					
12. Cross Sectional flow area, a $ft.^2$		12		12	
13. Wetted perimeter, p_w ft.		12.65		12.65	
14. Hydraulic radius, $r = a/p_w$ ft.		0.949		0.949	
15. Channel slope, s ft./ft.		0.015		0.05	
16. Manning's roughness coeffienct, n		0.039		0.039	
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ ft./s.		4.52		8.25	
18. Flow Length, L ft.		375		86	
19. Tt = L/3600 V hr.		**0.0231**		**0.0029**	
20. Total Tc from sheet, shallow, and channel flow hr.	**0.218**	**0.388**	**0.209**	**0.043**	**0.062**

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:02:53
Watershed file: --> c:\pondpack\RVS .WSD
Hydrograph file: --> c:\pondpack\RVS .HYD

PJP LANDFILL-RV SALVAGE
100 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used	
A	2.42	79.0	0.20	0.00	7.50	5.04	.07	.10
B	3.58	79.0	0.40	0.00	7.50	5.04	.07	.10
C	0.85	79.0	0.20	0.00	7.50	5.04	.07	.10
D	0.37	79.0	0.10	0.00	7.50	5.04	.07	.10
E	1.76	79.0	0.10	0.00	7.50	5.04	.07	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 8.98 acres or 0.01403 sq.mi
Peak discharge = 33 cfs

WARNING: Drainage areas of two or more subareas differ by a factor of 5 or greater.

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	0.22	0.00	0.20	0.00	No	Computed Ia/p < .1
B	0.39	0.00	0.40	0.00	No	Computed Ia/p < .1
C	0.21	0.00	0.20	0.00	No	Computed Ia/p < .1
D	0.10	0.00	**	**	No	Computed Ia/p < .1
E	0.10	0.00	**	**	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:02:53
Watershed file: --> c:\pondpack\RVS .WSD
Hydrograph file: --> c:\pondpack\RVS .HYD

PJP LANDFILL-RV SALVAGE
100 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	11	12.3
B	13	12.5
C	4	12.3
D	2	12.2
E	9	12.2
Composite Watershed	33	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:02:53
Watershed file: --> c:\pondpack\RVS .WSD
Hydrograph file: --> c:\pondpack\RVS .HYD

PJP LANDFILL-RV SALVAGE
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	1	1	1	2	3	5	9	11	9
B	1	1	1	2	3	4	6	9	12
C	0	0	0	1	1	2	3	4	3
D	0	0	0	1	1	1	2	2	1
E	0	1	1	2	3	6	9	7	5
Total (cfs)	2	3	3	8	11	18	29	33	30

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	7	5	4	3	2	1	1	1	1
B	13	12	10	8	5	3	2	2	2
C	2	2	1	1	1	1	0	0	0
D	1	1	0	0	0	0	0	0	0
E	4	3	2	1	1	1	1	1	1
Total (cfs)	27	23	17	13	9	6	4	4	4

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:02:53
Watershed file: --> c:\pondpack\RVS .WSD
Hydrograph file: --> c:\pondpack\RVS .HYD

PJP LANDFILL-RV SALVAGE
100 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	1	1	1	1	1	1	0	0	0
B	2	1	1	1	1	1	1	1	1
C	0	0	0	0	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0
E	1	1	1	1	0	0	0	0	0
Total (cfs)	4	3	3	3	2	2	1	1	1

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	0	0	0	0	0
B	1	0	0	0	0
C	0	0	0	0	0
D	0	0	0	0	0
E	0	0	0	0	0
Total (cfs)	1	0	0	0	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:02:53
Watershed file: --> c:\pondpack\RVS .WSD
Hydrograph file: --> c:\pondpack\RVS .HYD

PJP LANDFILL-RV SALVAGE
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	2	14.8	3
11.1	2	14.9	3
11.2	3	15.0	3
11.3	3	15.1	3
11.4	3	15.2	3
11.5	3	15.3	2
11.6	3	15.4	2
11.7	5	15.5	2
11.8	6	15.6	2
11.9	8	15.7	2
12.0	11	15.8	2
12.1	18	15.9	2
12.2	29	16.0	2
12.3	33	16.1	2
12.4	30	16.2	2
12.5	27	16.3	1
12.6	23	16.4	1
12.7	17	16.5	1
12.8	13	16.6	1
12.9	11	16.7	1
13.0	9	16.8	1
13.1	7	16.9	1
13.2	6	17.0	1
13.3	5	17.1	1
13.4	4	17.2	1
13.5	4	17.3	1
13.6	4	17.4	1
13.7	4	17.5	1
13.8	4	17.6	1
13.9	4	17.7	1
14.0	4	17.8	1
14.1	4	17.9	1
14.2	3	18.0	1
14.3	3	18.1	1
14.4	3	18.2	1
14.5	3	18.3	1
14.6	3	18.4	1
14.7	3	18.5	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:02:53
Watershed file: --> c:\pondpack\RVS .WSD
Hydrograph file: --> c:\pondpack\RVS .HYD

PJP LANDFILL-RV SALVAGE
100 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	0	22.4	0
18.7	0	22.5	0
18.8	0	22.6	0
18.9	0	22.7	0
19.0	0	22.8	0
19.1	0	22.9	0
19.2	0	23.0	0
19.3	0	23.1	0
19.4	0	23.2	0
19.5	0	23.3	0
19.6	0	23.4	0
19.7	0	23.5	0
19.8	0	23.6	0
19.9	0	23.7	0
20.0	0	23.8	0
20.1	0	23.9	0
20.2	0	24.0	0
20.3	0	24.1	0
20.4	0	24.2	0
20.5	0	24.3	0
20.6	0	24.4	0
20.7	0	24.5	0
20.8	0	24.6	0
20.9	0	24.7	0
21.0	0	24.8	0
21.1	0	24.9	0
21.2	0	25.0	0
21.3	0	25.1	0
21.4	0	25.2	0
21.5	0	25.3	0
21.6	0	25.4	0
21.7	0	25.5	0
21.8	0	25.6	0
21.9	0	25.7	0
22.0	0	25.8	0
22.1	0	25.9	0
22.2	0		
22.3	0		

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:03:07
Watershed file: --> c:\pondpack\RVS500 .WSD
Hydrograph file: --> c:\pondpack\RVS500 .HYD

PJP LANDFILL-RV SALVAGE
500 YEAR, 24 HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
A	2.42	79.0	0.20	0.00	11.98	9.29	.04	.10
B	3.58	79.0	0.40	0.00	11.98	9.29	.04	.10
C	0.85	79.0	0.20	0.00	11.98	9.29	.04	.10
D	0.37	79.0	0.10	0.00	11.98	9.29	.04	.10
E	1.76	79.0	0.10	0.00	11.98	9.29	.04	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 8.98 acres or 0.01403 sq.mi
Peak discharge = 60 cfs

WARNING: Drainage areas of two or more subareas differ by a factor of 5 or greater.

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
A	0.22	0.00	0.20	0.00	No	Computed Ia/p < .1
B	0.39	0.00	0.40	0.00	No	Computed Ia/p < .1
C	0.21	0.00	0.20	0.00	No	Computed Ia/p < .1
D	0.10	0.00	**	**	No	Computed Ia/p < .1
E	0.10	0.00	**	**	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:03:07
Watershed file: --> c:\pondpack\RVS500 .WSD
Hydrograph file: --> c:\pondpack\RVS500 .HYD

PJP LANDFILL-RV SALVAGE
500 YEAR, 24 HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
A	20	12.3
B	23	12.5
C	7	12.3
D	4	12.2
E	17	12.2
Composite Watershed	60	12.3

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:03:07
Watershed file: --> c:\pondpack\RVS500 .WSD
Hydrograph file: --> c:\pondpack\RVS500 .HYD

PJP LANDFILL-RV SALVAGE
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
A	1	1	2	4	6	9	16	20	17
B	1	2	2	3	5	7	10	16	22
C	0	0	1	1	2	3	6	7	6
D	0	0	0	1	1	2	4	3	2
E	1	1	1	4	6	11	17	14	9
Total (cfs)	3	4	6	13	20	32	53	60	56

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
A	13	9	7	5	3	3	2	2	2
B	23	22	18	14	8	6	4	4	3
C	4	3	2	2	1	1	1	1	1
D	1	1	1	1	0	0	0	0	0
E	7	5	3	3	2	2	2	1	1
Total (cfs)	48	40	31	25	14	12	9	8	7

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:03:07
Watershed file: --> c:\pondpack\RVS500 .WSD
Hydrograph file: --> c:\pondpack\RVS500 .HYD

PJP LANDFILL-RV SALVAGE
500 YEAR, 24 HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
A	2	2	1	1	1	1	1	1	1
B	3	3	2	2	2	2	1	1	1
C	1	1	1	0	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0
E	1	1	1	1	1	1	1	1	0
Total (cfs)	7	7	5	4	4	4	3	3	2

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
A	1	0	0	0	0
B	1	1	1	1	0
C	0	0	0	0	0
D	0	0	0	0	0
E	0	0	0	0	0
Total (cfs)	2	1	1	1	0

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:03:07
Watershed file: --> c:\pondpack\RVS500 .WSD
Hydrograph file: --> c:\pondpack\RVS500 .HYD

PJP LANDFILL-RV SALVAGE
500 YEAR, 24 HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	3	14.8	4
11.1	3	14.9	4
11.2	4	15.0	4
11.3	4	15.1	4
11.4	5	15.2	4
11.5	5	15.3	4
11.6	6	15.4	4
11.7	8	15.5	4
11.8	11	15.6	4
11.9	13	15.7	4
12.0	20	15.8	4
12.1	32	15.9	4
12.2	53	16.0	4
12.3	60	16.1	4
12.4	56	16.2	4
12.5	48	16.3	3
12.6	40	16.4	3
12.7	31	16.5	3
12.8	25	16.6	3
12.9	19	16.7	3
13.0	14	16.8	3
13.1	13	16.9	3
13.2	12	17.0	3
13.3	10	17.1	3
13.4	9	17.2	3
13.5	9	17.3	2
13.6	8	17.4	2
13.7	8	17.5	2
13.8	7	17.6	2
13.9	7	17.7	2
14.0	7	17.8	2
14.1	7	17.9	2
14.2	7	18.0	2
14.3	7	18.1	2
14.4	6	18.2	2
14.5	6	18.3	2
14.6	5	18.4	2
14.7	5	18.5	2

TR-55 TABULAR HYDROGRAPH METHOD
Type III Distribution
(24 hr. Duration Storm)

Executed: 03-26-2007 10:03:07
Watershed file: --> c:\pondpack\RVS500 .WSD
Hydrograph file: --> c:\pondpack\RVS500 .HYD

PJP LANDFILL-RV SALVAGE
500 YEAR, 24 HOUR STORM EVENT

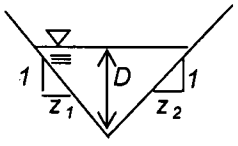
Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	1	22.4	1
18.7	1	22.5	1
18.8	1	22.6	1
18.9	1	22.7	1
19.0	1	22.8	1
19.1	1	22.9	1
19.2	1	23.0	1
19.3	1	23.1	1
19.4	1	23.2	1
19.5	1	23.3	1
19.6	1	23.4	1
19.7	1	23.5	1
19.8	1	23.6	1
19.9	1	23.7	1
20.0	1	23.8	1
20.1	1	23.9	1
20.2	1	24.0	0
20.3	1	24.1	0
20.4	1	24.2	0
20.5	1	24.3	0
20.6	1	24.4	0
20.7	1	24.5	0
20.8	1	24.6	0
20.9	1	24.7	0
21.0	1	24.8	0
21.1	1	24.9	0
21.2	1	25.0	0
21.3	1	25.1	0
21.4	1	25.2	0
21.5	1	25.3	0
21.6	1	25.4	0
21.7	1	25.5	0
21.8	1	25.6	0
21.9	1	25.7	0
22.0	1	25.8	0
22.1	1	25.9	0
22.2	1		
22.3	1		

PJP Landfill Site
Jersey City, New Jersey
Stormwater Drainage Ditches
RV Salvage Area

Channel Name	Channel Type	Contributing Watersheds	Design Storm (years)	Curve Number	Peak Discharge (cfs)	Channel Bed Slope (ft/ft)	Free-board (ft)	Channel Lining	Manning Coeff.	Channel Bottom Width (ft)	Left Side Slopes Inclintion	Right Side Slopes Inclintion	Flow Area (sq.ft.)	Flow Depth (ft)	Top Flow Width (ft.)	Flow Velocity (ft/s)	Available Q with Freeboard (cfs)	Channel Depth (ft)	Top Channel Width (ft)	Available Q without Freeboard (cfs)
1	Triangular	B	100	79	13	0.015	0.83	grass	0.039	0.00	3.00	3.00	12.00	1.17	12.00	3.16	13.0	2.00	12.0	54.1
1	Triangular	B	500	79	23	0.015	0.55	grass	0.039	0.00	3.00	3.00	12.00	1.45	12.00	3.64	23.0	2.00	12.0	54.1
2	Triangular	D	100	79	2	0.015	1.42	grass	0.039	0.00	3.00	3.00	12.00	0.59	12.00	1.99	2.0	2.00	12.0	54.1
2	Triangular	D	500	79	4	0.015	1.25	grass	0.039	0.00	3.00	3.00	12.00	0.75	12.00	2.34	4.0	2.00	12.0	54.1

3/26/2007

EXAMPLE CALCULATION
FLOW VELOCITY



$$Q = \frac{1.486}{n} A R_h^{2/3} S^{1/2}$$

$$V = Q / A$$

where:

Q = Flow in cfs
n = Manning roughness coefficient
A = Flow area (ft^2)
R_h = Hydraulic radius = A/Pw (ft)
P_w = Wetted Perimeter
S = Slope (ft/ft)
V = Velocity (ft/s)

Inputs:	
Q=	13 cfs
n =	0.039
bottom width (B) =	0 ft
side slope (Z_1) =	3.00 :1
side slope (Z_2) =	3.00 :1
Channel Depth =	2.00 ft
S =	0.015 ft/ft

Results:	
flow depth (D) =	1.17 ft
A =	4.11 ft^2
P_W =	7.40 ft
R_h =	0.55 ft
V =	3.17 fps
Available Freeboard =	0.83 fps

APPENDIX C-6

PROPOSED CULVERT DESIGN

OBJECTIVE: Determine the pipe diameter (D) for four proposed culverts located at the PJP site. One culvert is located in the southwesterly portion of the site leading to the existing IRM ditch from the Archdiocese property (Culvert A). The second culvert is located in the westerly section of the cap (Culvert B). The third culvert is located in the easterly portion of the RV Salvage site leading to the Hackensack River (Culvert C). The fourth culvert is located in the southerly section of the RV Salvage site leading to the Sip Avenue Ditch (Culvert D).

METHOD:

1) Using the nomograph (Figure 33, Reference 1), determine the required headwater (HW) by aligning a straight edge through alternate pipe diameters and calculated flow rate (from References 2 and 3) to intersect scale 1, (HW/diameter (D) of the pipe for square edge). Since a flared end section (comparable to a groove end with headwall) will be used, use scale 2. To find the HW/D value for the design condition, draw a horizontal line to scale 2, from the point on scale 1. This will provide the required HW/D. To obtain the HW, multiply the value determined from scale 2 by the diameter (in feet). Several diameters will be considered. The maximum HW for each culvert is determined by height of the embankment minus 0.25 feet (freeboard). The height of the embankment is considered the depth of the associated storm water channel (2 feet). Any calculated HW greater than the embankment height minus freeboard is too large and therefore the pipe is determined to be too small.

REFERENCES:

1) American Concrete Pipe Association, "Concrete Pipe Design Manual," dated 1985.

2) Golder Associates Inc., Calculations entitled "Stormwater Drainage Channel Design-RV Salvage," dated 3/06/07.

3) Golder Associates Inc., Calculations entitled "Stormwater Drainage Channel Design-Archdiocese Property," dated 3/11/07.

CALCULATIONS: The flow in each culvert is summarized in the table below:

Culvert ID	Contributing Drainage Area	Discharge - 100 yr storm (cfs)	Discharge - 500 yr storm (cfs)
A	Archdiocese – B,C	13	25
B	Archdiocese – D,H	13	23
C	RV Salvage – B	13	23
D	RV Salvage - C	4	7

The attached sheets 4 through 11 (Reference 1), provide the design nomographs for each culvert. From the nomograph, the HW/D is obtained, and then HW is calculated, as previously described. Single and multiple culvert pipes were considered.

RESULTS:

The headwater depths for each of the pipe diameters are summarized in the charts below. N.A. represents not applicable, due to scale limitations on Reference 1.

For Culvert A:

Pipe Diameter (inches)	Discharge Value 100 yr storm (cfs)	H.W.	Discharge Value 500 yr storm (cfs)	H.W.
15	13	3.6	25	NA
18	13	2.4	25	NA
24	13	1.8	25	3.4
15 (2)	6.5	1.7	12.5	3.5
18 (2)	6.5	1.4	12.5	2.4
15 (3)	4.3	1.2	8.3	2.3
18 (3)	4.3	1.1	8.3	1.7

Culvert A maintained HW of 1.75 for all pipe diameters, except for the 15-inch, 18-inch and 24-inch diameter pipes, in the 100 year storm event; however only the three-18-inch diameter pipes were able to handle the peak flow from the 500 year storm event.

For Culvert B:

Pipe Diameter (inches)	Discharge Value 100 yr storm (cfs)	H.W.	Discharge Value 500 yr storm (cfs)	H.W.
15	13	3.6	23	NA
18	13	2.4	23	6.2
24	13	1.8	23	3.1
15 (2)	6.5	1.7	11.5	3.5
18 (2)	6.5	1.4	11.5	2.4
15 (3)	4.3	1.2	7.7	2.1
18 (3)	4.3	1.1	7.7	1.6

Culvert B maintained HW of 1.75 for all pipe diameters, except for the 15-inch, 18-inch, and 24-inch diameter pipes, in the 100 year storm event; however only the three-18-inch diameter pipes were able to handle the peak flow from the 500 year storm event.

For Culvert C:

Pipe Diameter (inches)	Discharge Value 100 yr storm (cfs)	H.W.	Discharge Value 500 yr storm (cfs)	H.W.
15	13	3.6	23	NA
18	13	2.4	23	6.2
24	13	1.8	23	3.1
15 (2)	6.5	1.7	11.5	3.5
18 (2)	6.5	1.4	11.5	2.4
15 (3)	4.3	1.2	7.7	2.1
18 (3)	4.3	1.1	7.7	1.6

Culvert C maintained HW of 1.75 for all pipe diameters, except for the 15-inch, 18-inch, and 24-inch diameter pipes, in the 100 year storm event; however only the three-18-inch diameter pipes were able to handle the peak flow from the 500 year storm event.

For Culvert D:

Pipe Diameter (inches)	Discharge Value 100 yr storm (cfs)	H.W.	Discharge Value 500 yr storm (cfs)	H.W.
15	4	1.1	7	1.9
18	4	1.4	7	1.5
24	4	N.A.	7	1.3

Culvert D maintained HW equal to or less than 1.75 for all pipe diameters for the 100 year storm event; however for constructability, an 18-inch diameter pipe will be installed to handle the peak flow from the 500 year storm event.

CONCLUSION: The following culvert sizes are recommended:

Culverts	Number & Diameter
A	3 – 18-inch diameter
B	3 – 18-inch diameter
C	3 – 18-inch diameter
D	1 – 18-inch diameter

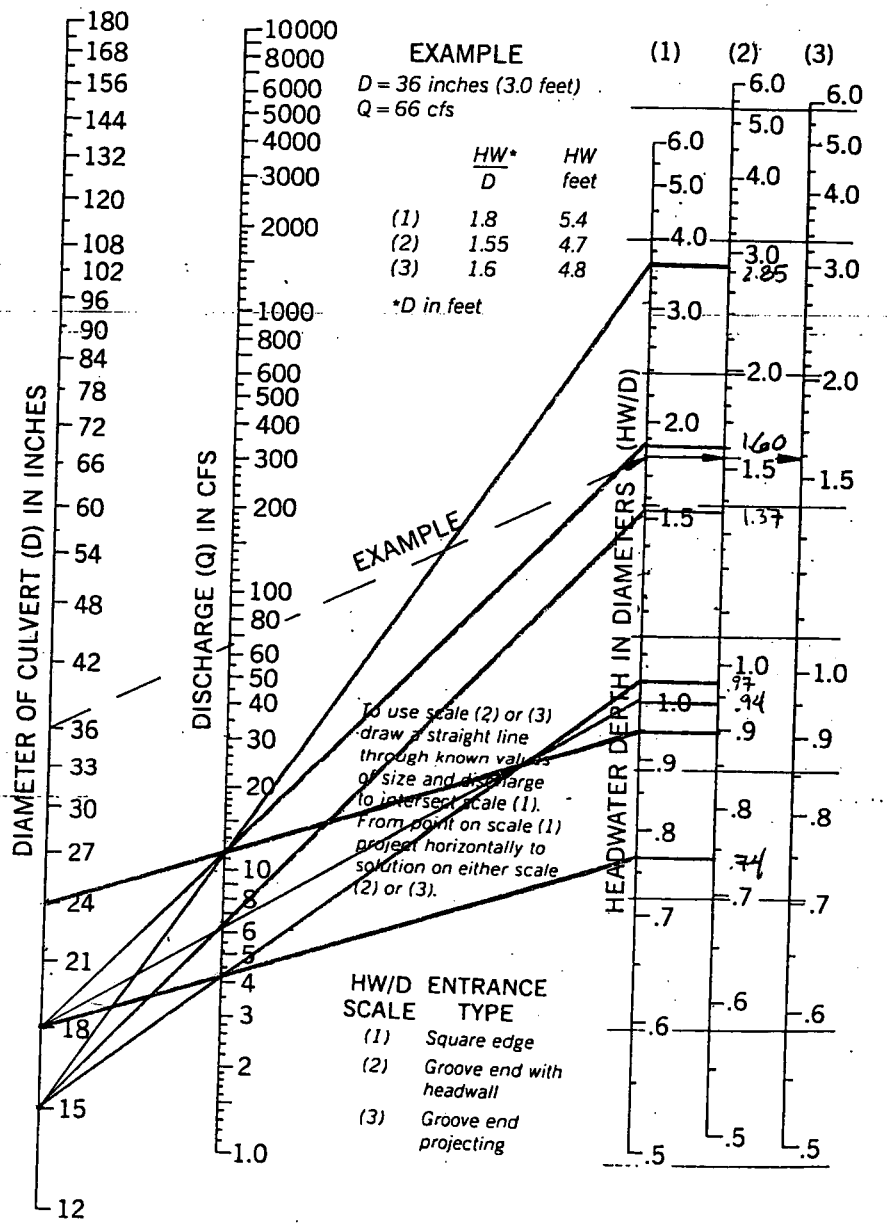
CULVERT A
IRM DITCH
100 YR STORM EVENT

SHEET 4 OF 11

Q = 13 CFS FOR 1 PIPE
Q = 6.5 CFS FOR 2 PIPES
Q = 4.3 CFS FOR 3 PIPES

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

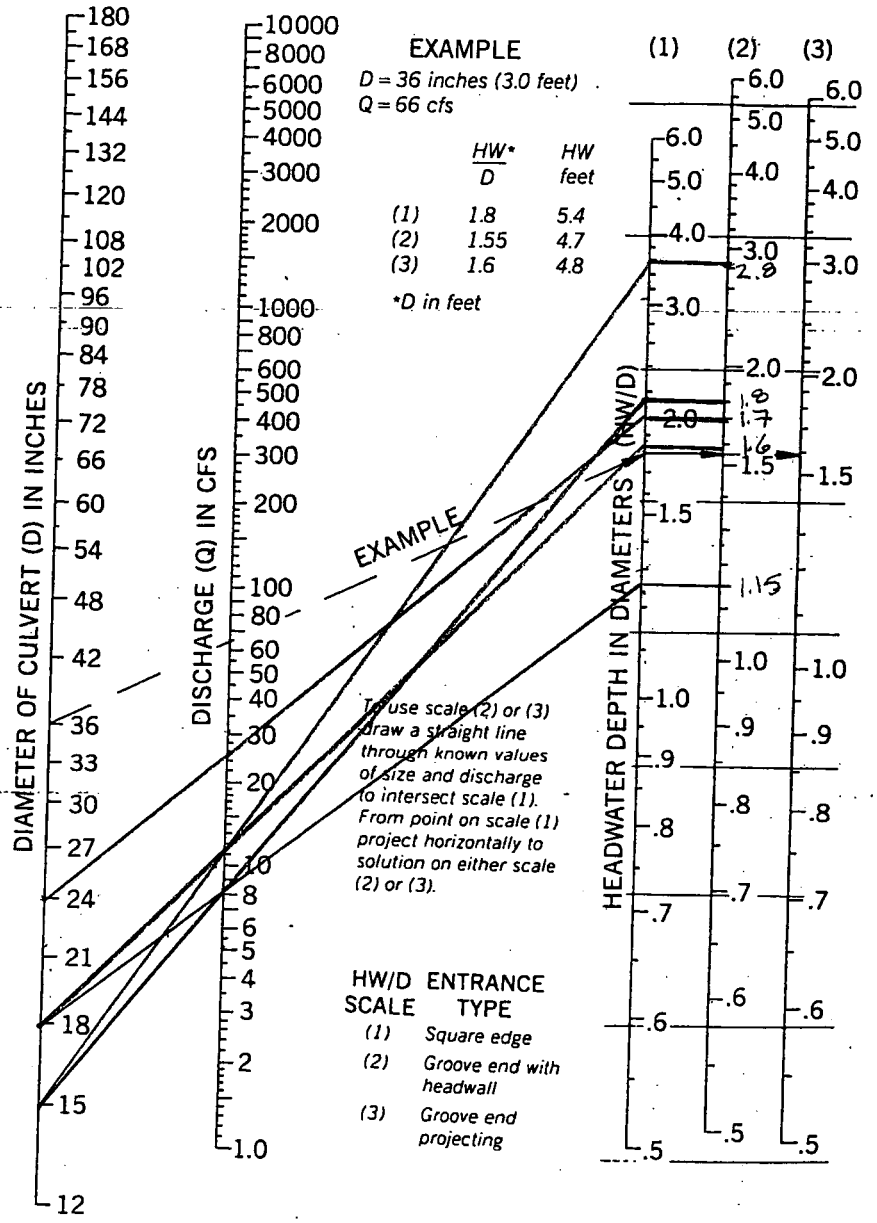
SHEET 5 OF 11

CULVERT A
IRM DITCH
500 YR STORM EVENT

Q = 25 CFS FOR 1 PIPE
Q = 12.5 CFS FOR 2 PIPES
Q = 8.3 CFS FOR 3 PIPES

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

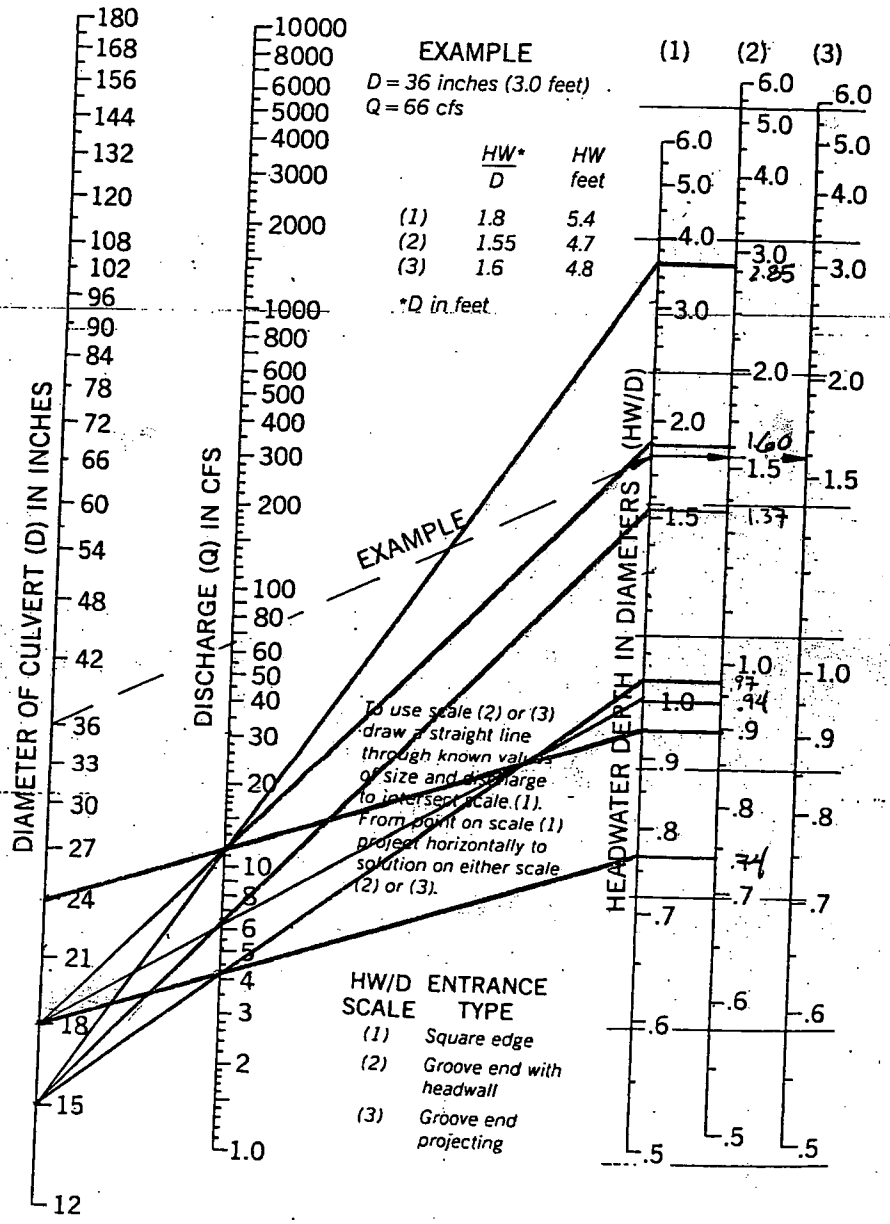
CULVERT 6
ARCHDIOCESE
100 YR STORM EVENT

SHEET 6 OF 11

Q = 13 CFS FOR 1 PIPE
Q = 6.5 CFS FOR 2 PIPES
Q = 4.3 CFS FOR 3 PIPES

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

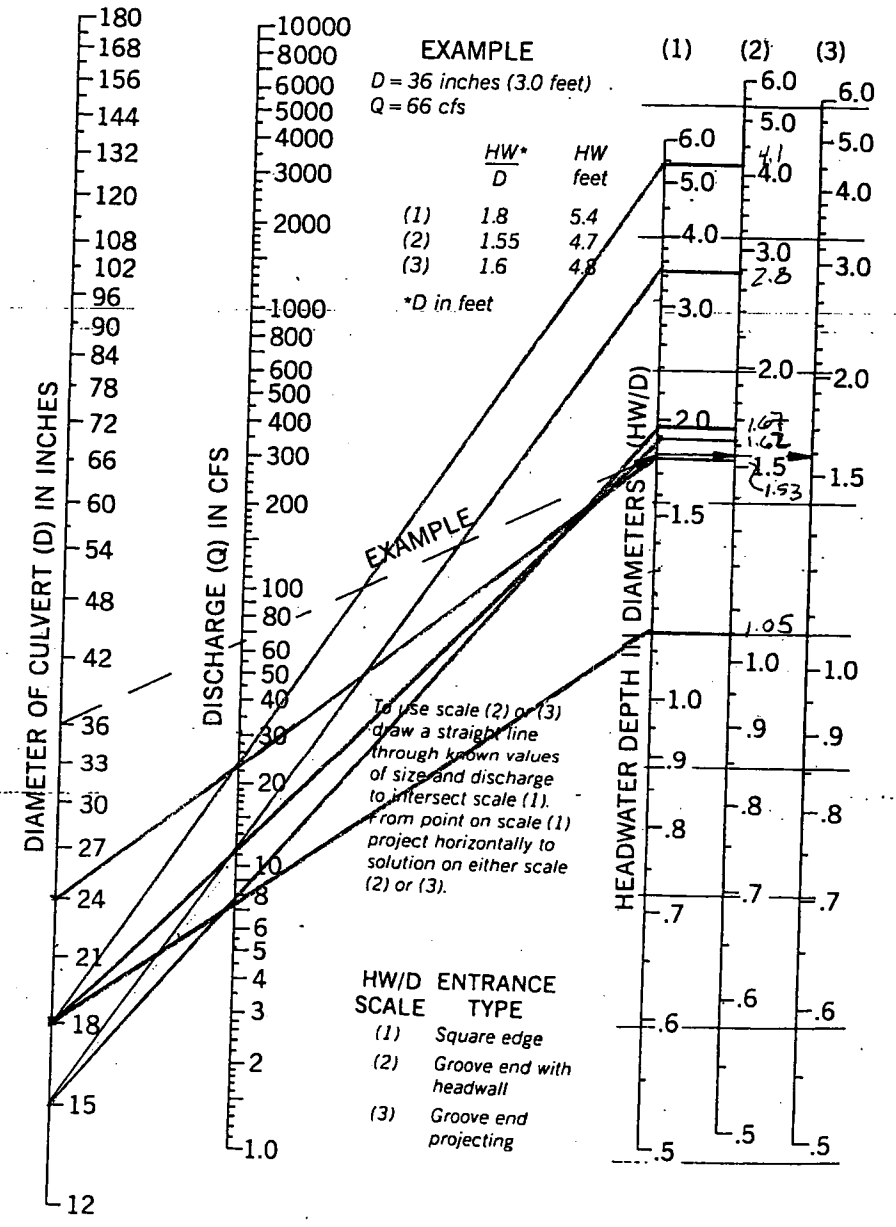
SHEET 7 OF 11

CULVERT B
ARCHDIOCESE
500 YR STORM EVENT

Q = 23 CFS FOR 1 PIPE
Q = 11.5 CFS FOR 2 PIPES
Q = 7.7 CFS FOR 3 PIPES

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

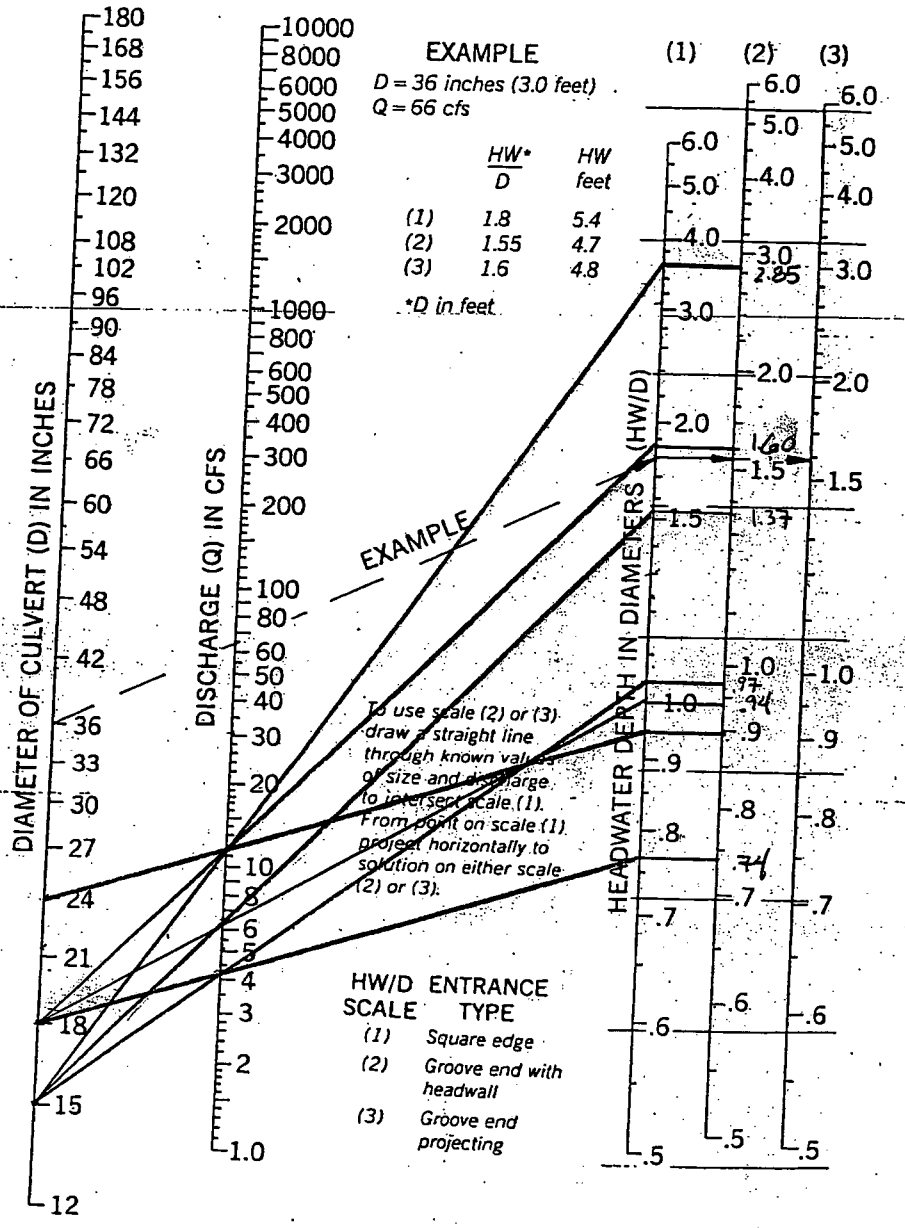
CULVERT C
RV SALVAGE
100 YR STORM EVENT

SHEET 8 OF 11

Q = 13 CFS FOR 1 PIPE
Q = 6.5 CFS FOR 2 PIPES
Q = 4.3 CFS FOR 3 PIPES

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

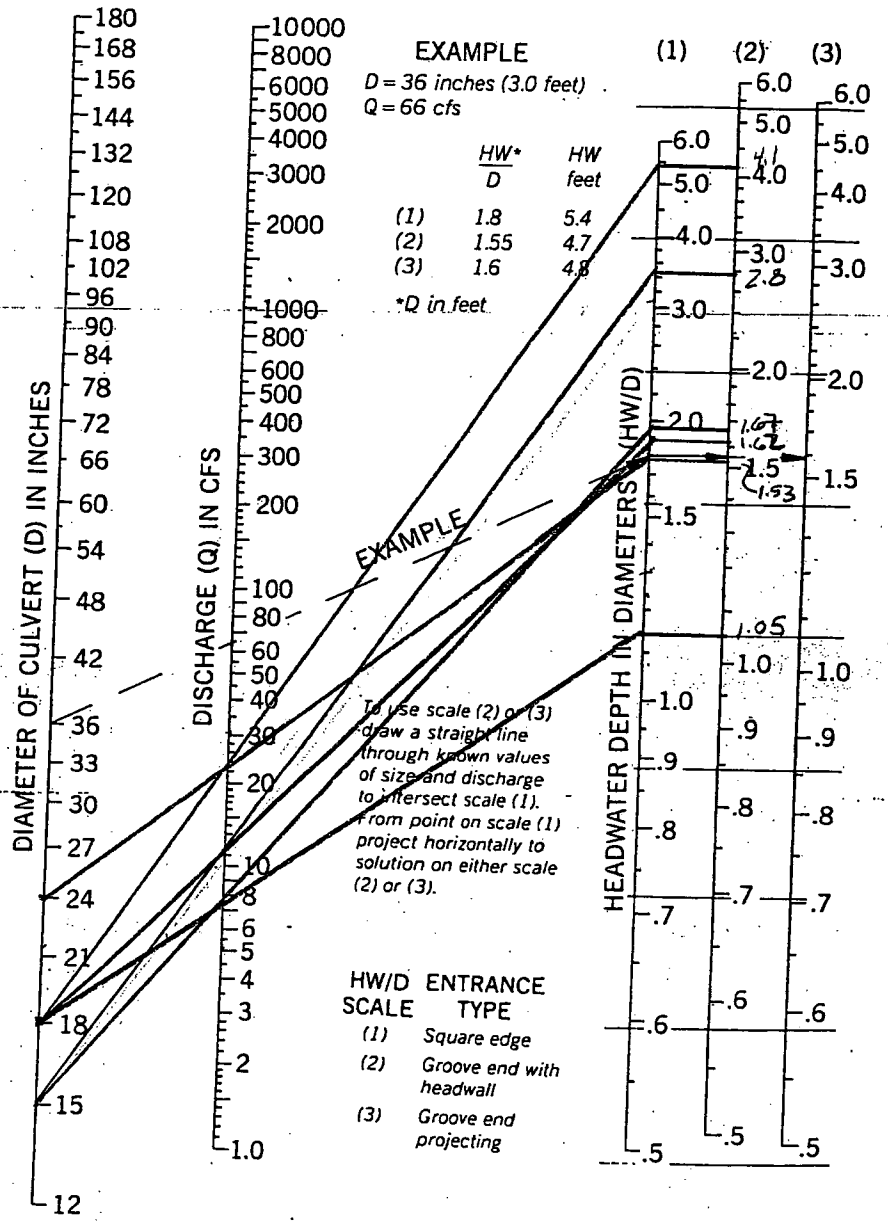
SHEET 9 OF 11

CULVERT C
RV SALVAGE
500 YR STORM EVENT

Q = 23 CFS FOR 1 PIPE
Q = 11.5 CFS FOR 2 PIPES
Q = 7.7 CFS FOR 3 PIPES

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER SCALES 2&3
REVISED MAY 1964

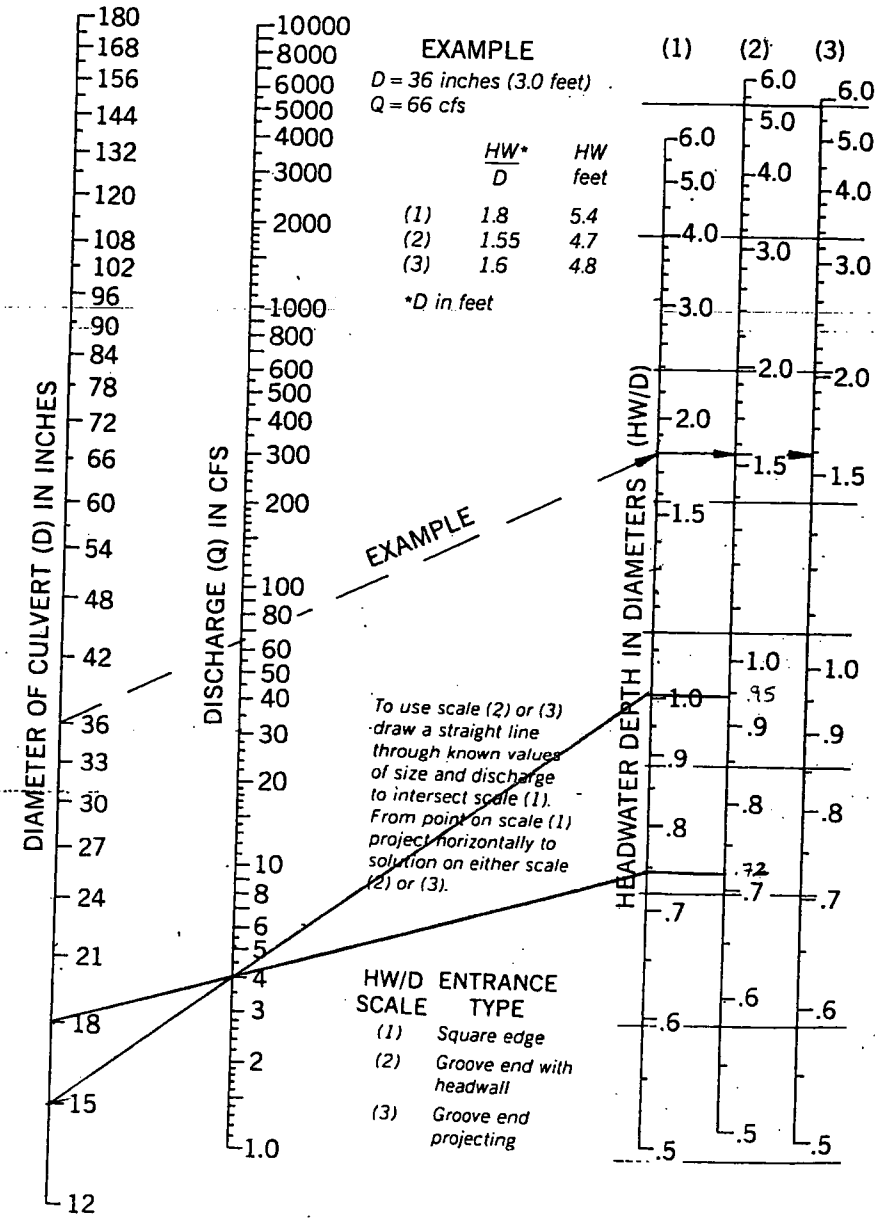
SHEET 10 OF 11

CULVERT D
RV SALVAGE
100 YR STORM EVENT

Q= 4 CFS FOR 1 PIPE

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



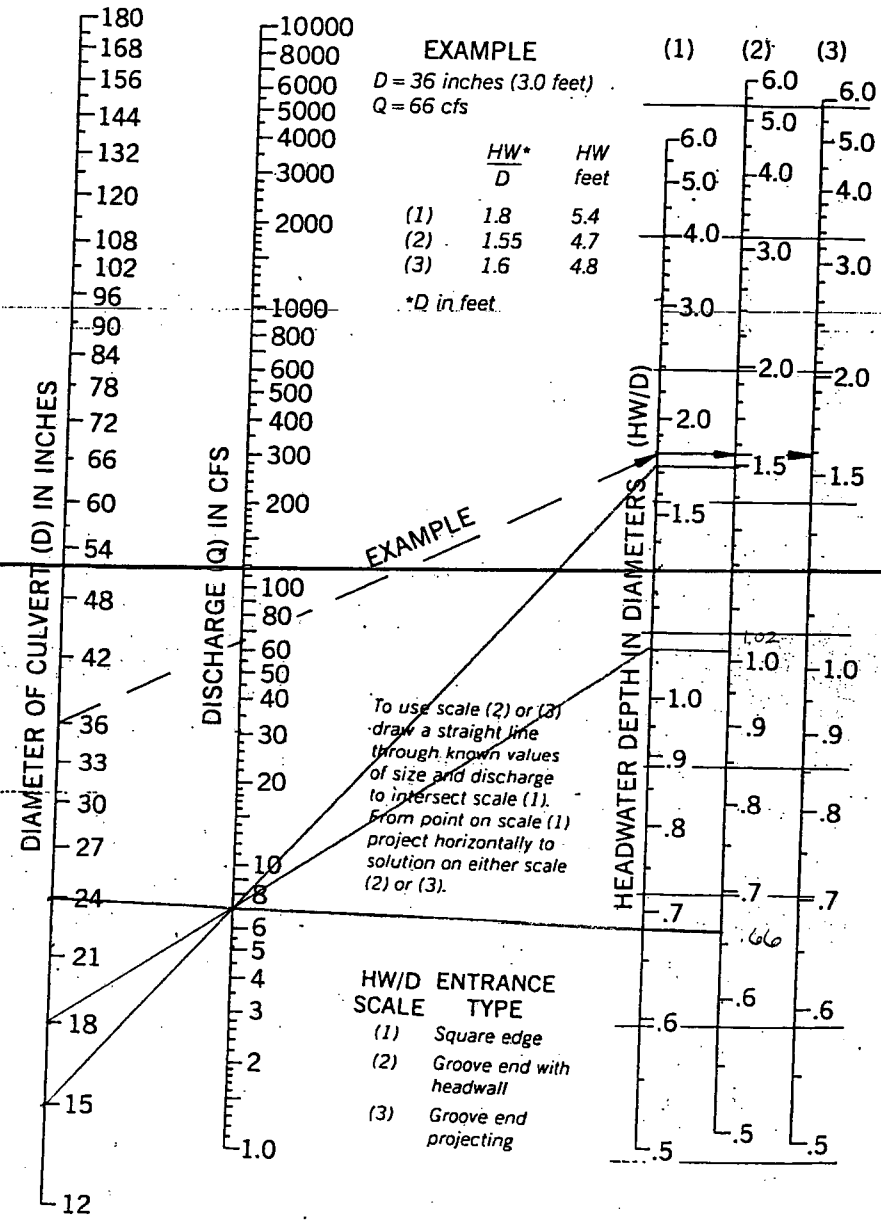
SHEET 11 OF 11

CULVERT D
RV SALVAGE
500 YR. STORM

Q = 7 CFS FOR 1 PIPE

FIGURE 33

HEADWATER DEPTH FOR CIRCULAR CONCRETE PIPE CULVERTS WITH INLET CONTROL



APPENDIX C-7

PROPOSED SIP AVENUE DITCH DESIGN

OBJECTIVE: To determine the peak runoff of stormwater entering the Sip Avenue Ditch and design the Sip Avenue Ditch to accommodate the calculated peak flows for the 100-year, 24 hour storm event, with consideration for the 500-year, 24-hour storm event.

REFERENCES:

1) Golder Associates Inc., "Final (100%) Design Report, Figures 4-1, 4-2, 4-3 and 4-4 of the Proposed Surface Water Management System," dated March 2007.

2) Golder Associates Inc., Calculations entitled "Stormwater Drainage Channel Design-Archdiocese Property", dated 3/11/07.

3) Golder Associates Inc., Calculations entitled "Stormwater Drainage Channel Design-Truckstop", dated 3/26/07.

4) Golder Associates Inc., Calculations entitled "Stormwater Drainage Channel Design-RV Salvage", dated 3/26/07.

5) Golder Associates Inc., Calculations entitled "Stormwater Drainage – IRM to Sip Avenue Ditch", dated 3/11/07.

6) Golder Associates Inc., Calculations entitled "Peak Flow – Sip Avenue Culvert (Jersey City)", dated 01/18/07.

METHOD:

1) Based upon the peak runoff rates developed for the proposed conditions of the Archdiocese Property and Junkyard, RV Salvage Area, and Truck Stop, the flow entering the Sip Avenue Ditch from the Jersey City culvert and the existing IRM capped area (Ref. 2, 3, 4, 5 and 6 and Tables 1 and 2), determine the existing flow capacity of the ditch.

2) Various cut-sections along the existing ditch were established in Figure 4-1, 4-2, 4-3 and 4-4 of the Final (100%) Design Report (Ref. 1) to determine its cross-section throughout its length. The length of the ditch was evenly sectioned.

3) Based on the established cut-sections and the location of flow entering the Sip Avenue Ditch, the ditch was further divided into Sections or Reaches.

4) Provide several variations and alterations to the existing Sip Avenue Ditch within each Reach to determine which configuration provided the greatest flow area possible.

CALCULATION: The maximum flow rate for the 100-year, 24-hour storm event was used to redesign the Sip Avenue Ditch, with the consideration of the 500-year, 24-hour storm event. To determine a conceptual amount of flow that was available in the redesigned channel, the Manning's equation was used. This equation does not address tidal influences by the Hackensack River. An Excel Spreadsheet was

implemented to run the calculations in this equation. The Manning's equation is as follows:

$$Q = (1.49 \times R_h^{2/3} \times A \times S^{1/2})/n, \text{ such that}$$

Q = channel flow rate (cfs)
R_h = hydrualic radius of channel = A/P (ft)
A = cross-sectional area of flow (ft^2)
P = wetted perimeter of flow (ft)
S = channel slope (ft/ft)
n = Manning's coefficient

The lining of the ditch consists of 12" of structural fill material within a cellular confinement above a 12" lift of compacted structural fill or some other type of rigid erosion control system. This type of channel lining in the design calculation produces a Mannings coefficient (n) of 0.030, and for conservatism, a general slope (S) of 0.001 was used throughout the length of the ditch. The depth of flow in the ditch was maintained to provide the minimum required freeboard of 0.25 feet. The design of the side slopes were altered to comply with the requirement that slopes that will be carrying a geomembrane material must provide a side slope inclination of no greater than 2H:1V. In locations along the Sip Avenue Ditch that will be providing wetlands restoration, a side slope of 3H:1V was established.

The amount of flow entering the Sip Avenue Ditch varies as flow travels from the Jersey City Culvert located at Route 1 and 9 to the Hackensack River. The varying flow is based on the proposed stormwater management systems to be constructed. Due to the varying flows entering the Sip Avenue Ditch, the ditch was divided into three (3) Sections or Reaches (see Figure 1) to provide a more accurate method of design within the Sip Avenue Ditch. The total cumulative flow entering the Sip Avenue Ditch within each Reach is presented on Tables 1 and 2 attached, and summarized below:

Section	Total Amount of Flow (cfs), 100 year storm event	Total Amount of Flow (cfs), 500 year storm event
Reach 1	730	1224
Reach 2	766	1290
Reach 3	799	1353

Based on the total flow estimation entering the Sip Avenue Ditch, various design alternatives were considered to determine the available flow that would be available upon the redesigning of the Sip Avenue Ditch.

CONCLUSION:

To provide the maximum amount of flow in the Sip Avenue Ditch, the ditch will need to be redesigned to establish a trapezoidal ditch cross-section, with a varying base width, and minimum side slopes of 2H:1V. The actual side slopes

will vary between 2H:1V and 3H:1V depending on the location of the Reach and proposed wetlands within the Sip Avenue Ditch. The channel will be lined with 12" of structural fill material within a cellular confinement above a 12" lift of compacted structural fill to elevation 2.0 (low marsh wetland line) underlain by a permeable geotextile, or a comparable erosion control system placed above the lining. The depth of the ditch will range from 8.0 feet to 9.0 feet, allowing a flow depth between 5.40 and 5.72 feet and providing a minimum 0.25 feet of freeboard. Cross-sectional areas were provided for the three (3) Reaches of the ditch to show the estimated locations of the cut/fill that would be necessary to adequately construct the Sip Avenue ditch. (Figure 2).

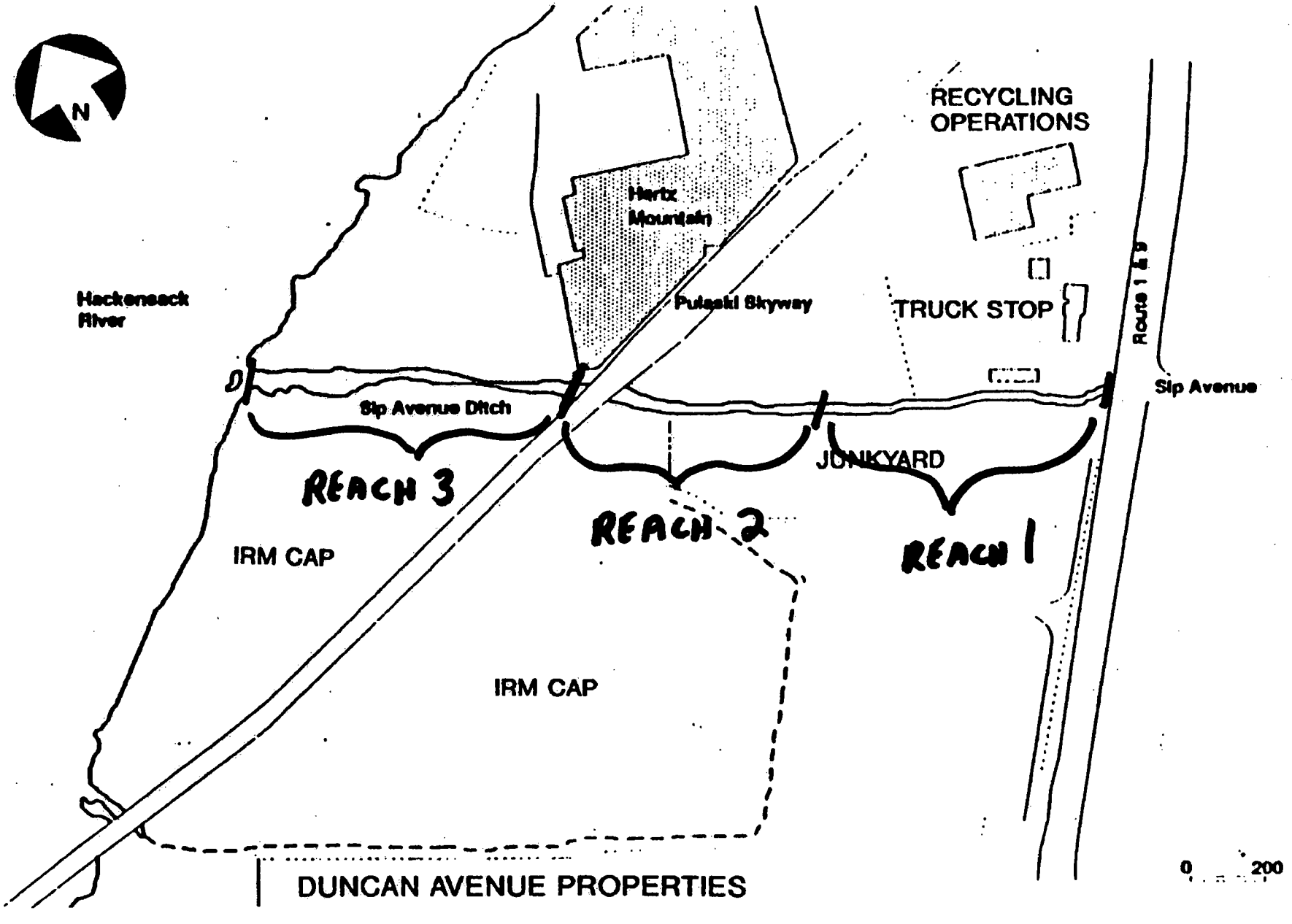


FIGURE 1

SHEET 4 of 8

TABLE 1
SIP AVENUE DITCH DESIGN
TOTAL PEAK FLOW FROM CONTRIBUTING DRAINAGE AREAS

100 Year, 24 hour Storm Event

Jersey City Storm Water		
	Conduit	**678** cfs
Archdiocese Property and Junkyard		
	Channel 1	16 cfs
	Channel 7	25 cfs
	Area K	12 cfs
	Area L	7 cfs
	Total	**60** cfs
Truck Stop		
	Channel 1	10 cfs
	Channel 2	4 cfs
	Area C	14 cfs
	Total	**28** cfs
RV Salvage		
	Channel 2	2 cfs
	Area C	4 cfs
	Area E	9 cfs
	Total	**15** cfs
IRM Area		
	Sheet Flow	**18** cfs
Over All Totals		**799** cfs

500 year, 24 hour Storm Event

Jersey City Storm Water		
	Conduit	**1128** cfs
Archdiocese Property and Junkyard		
	Channel 1	30 cfs
	Channel 7	45 cfs
	Area K	22 cfs
	Area L	13 cfs
	Total	**110** cfs
Truck Stop		
	Channel 1	18 cfs
	Channel 2	8 cfs
	Area C	26 cfs
	Total	**52** cfs
RV Salvage		
	Channel 2	4 cfs
	Area C	7 cfs
	Area E	17 cfs
	Total	**28** cfs
IRM Area		
	Sheet Flow	**35** cfs
Over All Totals		**1353** cfs

Notes: 1) See References 1 through 4 for supporting calculations.

TABLE 2
SIP AVENUE DITCH DESIGN
TOTAL PEAK FLOW ENTERING AT EACH REACH

100 Year, 24 hour Storm Event

REACH 1		
Jersey City		
	Conduit	678 cfs
Archdiocese Property and Junkyard		
	Channel 1	16 cfs
	Area K	12 cfs
Truck Stop		
	Channel 1	10 cfs
	Area C	14 cfs
	Total	**730** cfs
REACH 2		
Reach 1		730 cfs
Archdiocese Property and Junkyard		
	Channel 7	25 cfs
	Area L	7 cfs
Truck Stop		
	Channel 2	4 cfs
	Total	**766** cfs
REACH 3		
Reach 2		766 cfs
RV Salvage		
	Channel 2	2 cfs
	Area C	4 cfs
	Area E	9 cfs
IRM Area		18 cfs
	Total	**799** cfs

500 year, 24 hour Storm Event

REACH 1		
Jersey City		
	Conduit	1128 cfs
Archdiocese Property and Junkyard		
	Channel 1	30 cfs
	Area K	22 cfs
Truck Stop		
	Channel 1	18 cfs
	Area C	26 cfs
	Total	**1224** cfs
REACH 2		
Reach 1		1224 cfs
Archdiocese Property and Junkyard		
	Channel 7	45 cfs
	Area L	13 cfs
Truck Stop		
	Channel 2	8 cfs
	Total	**1290** cfs
REACH 3		
Reach 2		1290 cfs
RV Salvage		
	Channel 2	4 cfs
	Area C	7 cfs
	Area E	17 cfs
IRM Area		35 cfs
	Total	**1353** cfs

TABLE 3
PROPOSED DESIGN
SIP AVENUE DITCH
PJP Landfill Site
Jersey City, New Jersey

003-6004-002

Flow Calculations For a Cellular Confinment Lined Channel

Based on a 24-hour 100 year storm event

Channel Name	Channel Type	Contributing Watersheds	Design Storm (years)	Peak Discharge (cfs)	Channel Bed Slope (ft/ft)	Free-board (ft)	Channel Lining	Manning Coeff.	Channel Bottom Width (ft)	Left Side Slopes Inclintion	Right Side Slopes Inclintion	Flow Area (sq.ft.)	Flow Depth (ft)	Top Flow Width (ft.)	Flow Velocity (ft/s)	Actual Q (cfs)	With Freeboard		
																	Channel Depth (ft)	Top Channel Width (ft)	Q Available (cfs)
Reach 1	Trapezoidal	Various	100	730	0.001	3.28	Cellular Confinement	0.030	19.00	3.00	2.00	190.69	5.72	47.62	3.83	730.0	9.00	64.0	1828.7
Reach 2	Trapezoidal	Various	100	766	0.001	2.43	Cellular Confinement	0.030	20.00	3.00	3.00	204.37	5.57	53.41	3.75	766.0	8.00	68.0	1609.2
Reach 3	Trapezoidal	Various	100	799	0.001	2.60	Cellular Confinement	0.030	25.00	2.00	3.00	208.00	5.40	52.01	3.84	799.0	8.00	65.0	1709.8

Based on a 24-hour 500 year storm event

Channel Name	Channel Type	Contributing Watersheds	Design Storm (years)	Peak Discharge (cfs)	Channel Bed Slope (ft/ft)	Free-board (ft)	Channel Lining	Manning Coeff.	Channel Bottom Width (ft)	Left Side Slopes Inclintion	Right Side Slopes Inclintion	Flow Area (sq.ft.)	Flow Depth (ft)	Top Flow Width (ft.)	Flow Velocity (ft/s)	Actual Q (cfs)	With Freeboard		
																	Channel Depth (ft)	Top Channel Width (ft)	Q Available (cfs)
Reach 1	Trapezoidal	Various	500	1224	0.001	1.59	Cellular Confinement	0.030	19.00	3.00	2.00	278.00	7.41	56.05	4.40	1224.0	9.00	64.0	1828.7
Reach 2	Trapezoidal	Various	500	1290	0.001	0.81	Cellular Confinement	0.030	20.00	3.00	3.00	299.17	7.19	63.17	4.31	1290.0	8.00	68.0	1609.2
Reach 3	Trapezoidal	Various	500	1353	0.001	0.90	Cellular Confinement	0.030	25.00	2.00	3.00	303.77	7.10	60.52	4.45	1353.0	8.00	65.0	1709.8

SHEET 7 of 8

Golder Associates

SUBJECT SIP AVENUE DITCH CROSS-SECTIONS

Job No. 003-6004-002

Ref.

Made by CBM

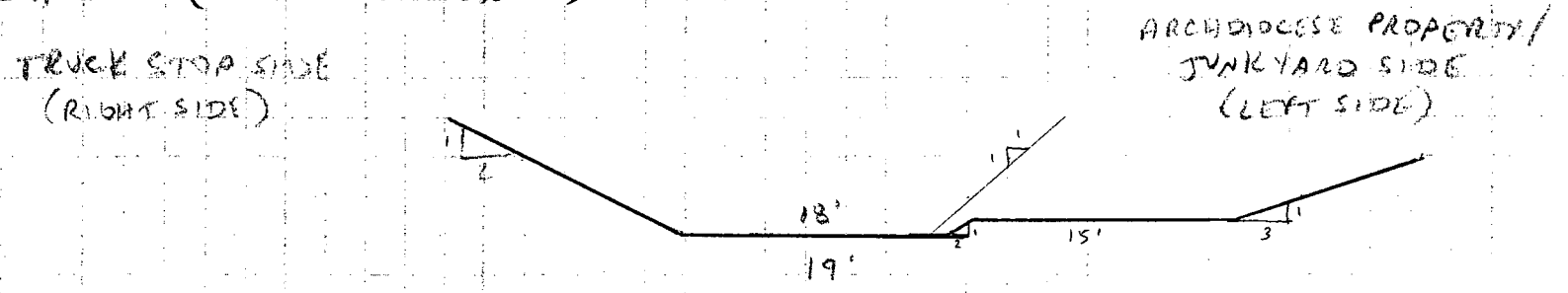
Checked

Reviewed

Date 02/23/07

Sheet 1 of 1

REACH 1 (CROSS-SECTION S)



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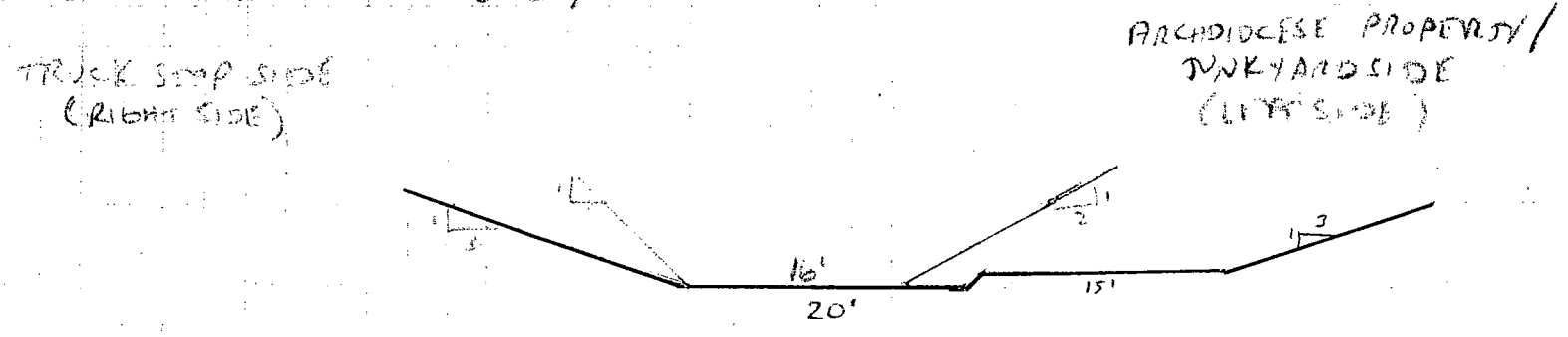

REACH 3 (CROSS-SECTION F)

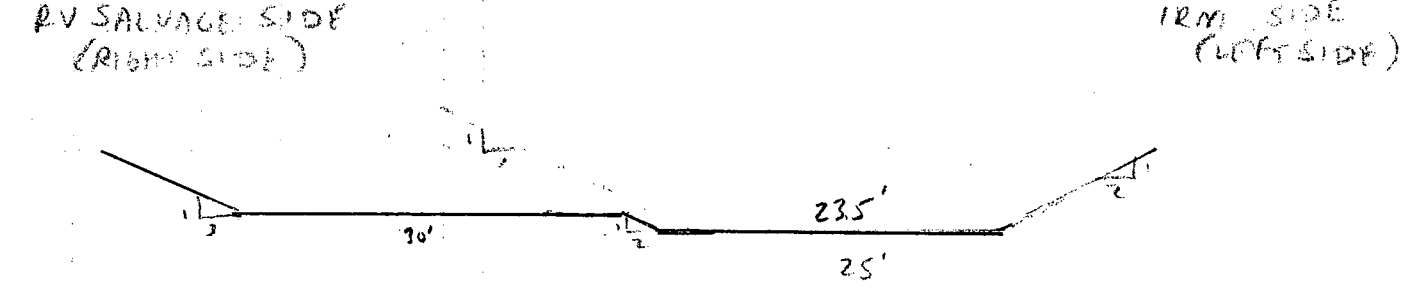

FIGURE 2

NOT TO SCALE

FIGURE 2

APPENDIX D

OPERATION AND MAINTENANCE PLAN

Golder Associates Inc.

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PRELIMINARY
OPERATION & MAINTENANCE PLAN
PJP LANDFILL SITE
HUDSON COUNTY, NEW JERSEY

Prepared for:

CWM Chemical Services, L.L.C.
and
Waste Management of New Jersey, Inc. (WMNJ)
"Collectively referred to as CCS"

Prepared by:

Golder Associates Inc.
200 Century Parkway, Suite C
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APPROVED:

CCS

Authorized Representative Date

CITY OF JERSEY CITY

Authorized Representative Date

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April 2007

Project No.: 003-6004-002

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ACRONYMS

CWM Chemical Services, L.L.C.	CCSL
CWM Chemical Services, L.L.C. and Waste Management of New Jersey, Inc.	CCS
Construction Quality Assurance	CQA
Construction Quality Assurance Plan	CQAP
Erosion & Sedimentation Control	E&S
Final (100%) Design Report	FDR
Golder Associates Inc.	Golder
Hazardous Air Pollutant	HAP
Health and Safety Contingency Plan	HASCP
High Density Polyethylene	HDPE
Hydrologic Evaluation of Landfill Performance	HELP
Intermediate (65%) Design Report	IDR
Lower Explosive Limit	LEL
Landfill Gas	LFG
Non-Methane Organic Compound	NMOC
Operation and Maintenance	O&M
Operation, Monitoring and Maintenance	OM&M
National Priorities List	NPL
New Jersey Department of Environmental Protection	NJDEP
Personal Protection Equipment	PPE
Photoionization Detector	PID
PJP Landfill Site	Site
Pre-Design Investigation	PDI
Pre-Final (90%) Design Report	PFDR
Preliminary Design Report	PDR
Poly Vinyl Chloride	PVC
Radius of Influence	ROI
Record of Decision	ROD
Remedial Action	RA
Remedial Action Contractor	RAC
Remedial Design Work Plan	RDWP
Self-Contained Breathing Apparatus	SCBA
Statement of Work	SOW
Tons Per Year	TPY
United States Environmental Protection Agency	USEPA
Universal Soil Loss Equation	USLE
Volatile Organic Compounds	VOCs
Waste Management of New Jersey, Inc.	WMNJ/CCS

1.0 INTRODUCTION

This Preliminary Operation and Maintenance Plan (O&M Plan) for the PJP Landfill Site (Site) in Hudson County, New Jersey has been prepared in accordance with Section VII.D of the Statement of Work (SOW) and Section 5.6.2 of the Remedial Design Work Plan (RDWP). This O&M Plan has been prepared by Golder Associates Inc. (Golder) on behalf of CWM Chemical Services, L.L.C. (CCSL) and Waste Management of New Jersey, Inc. (WMNJ/CCS), collectively referred to herein as CCS, and defines the O&M responsibilities of CCS during the post-closure care period for the remedy.

The SOW requires that the O&M Plan be submitted within ninety (90) calendar days of the completion of the Remedial Action construction.

This O&M Plan has been prepared assuming that Remedial Action construction is complete. It will be amended as necessary based upon edits to the FDR and upon any as-built modifications during Remedial Action construction.

This O&M Plan is composed of the following major elements:

- A Site Management Plan (SMP), including O&M management structure, reporting, recordkeeping, and safety;
- O&M Inspection Activities;
- O&M Environmental Monitoring Activities; and,
- O&M Emergency Response Procedures.

This O&M Plan is intended to be flexible to allow for modifications based on conditions encountered during operation and maintenance activities. The following subsections briefly describe the Site background and existing conditions.

2.0 SITE BACKGROUND

2.1 Background/Site Description

The Site description and history presented herein is based on information presented in the Record of Decision (ROD) (USEPA, September 28, 1995).

The PJP Landfill Site is an inactive landfill located at 400 Sip Avenue, Jersey City, in Hudson County, New Jersey, as shown on Figure 1. The Site is bounded on the north and west by the Hackensack River and on the southeast by Truck Routes 1 and 9. A recycling facility and warehouse border the northeast side of the Site, and the southwest side of the Site is boarded by several commercial trucking terminals. The landfill Site occupies approximately 87 acres, of which 45 acres were previously remediated and capped in May 1986. This capped area is known as the IRM area. The Pulaski Skyway, an elevated highway, passes over the Site. The Sip Avenue Ditch bisects the Site and transports runoff from the Site and Jersey City storm water/sewer into the Hackensack River.

The Site was originally a salt meadow. In 1932, part of the Site was used in the construction of the Pulaski Skyway. In 1968, the Site began operations as a commercial landfill that accepted chemical and industrial wastes. Although there were allegations of illegal dumping until 1984, the Site is believed to have been inactive as a solid waste disposal facility since 1974 (ICF, 1990).

In July 1973, the New Jersey Department of Transportation (NJDOT) uncovered steel and plastic drums containing chemicals under the Pulaski Skyway. From 1970 to 1985, frequent occurrences of fires in a 45-acre area (now capped and termed the "IRM Area") were reported. These fires were attributed to spontaneous combustion of buried wastes and decomposition of landfill materials. In December 1982, the Site was placed on the EPA's National Priorities List (NPL). The completion of the remediation of the IRM area was in May 1986.

A remedial investigation and feasibility study (RI/FS) was conducted over the entire 87-acre site for the New Jersey Department of Environmental Protection (NJDEP) from 1988 to 1993. Additional groundwater and surface water investigations, including toxicity testing, were completed in 1993. Based on the results of the RI/FS, the risk assessment, and the 1993 monitoring event, the NJDEP selected a remedy as presented in the ROD dated September 28, 1995. CCS entered into an ACO

and ACO Amendment with the NJDEP, effective June 27, 2000, to implement the remedy selected in the ROD. Major components of the selected remedy include the following components:

- Removal of all known and suspected buried drums and visibly contaminated soils;
- Capping the remaining landfill area of Site with a multi-layer, modified solid waste type cap;
- Extend the existing gravel lined ditch around the perimeter of the Site to collect the surface water runoff;;
- Install a passive gas venting system;
- Site fencing and institutional controls;
- Periodic inspections of the IRM cover;
- Replace the Sip Avenue ditch with an alternate form of drainage;
- Quarterly ground water and surface water monitoring; and,
- Implementation of a wetlands assessment and restoration plan.

Several of the remedy components listed in the NJDEP Record of Decision (NJDEP, 1995) have been completed to date.

2.2 Remedial Systems

The primary remedial systems include:

- Landfill Cover System;
- Surface Water Drainage Control System;
- Lining of the Sip Avenue Ditch;
- River Bank Erosion Protection; and,
- Landfill Gas Venting System.

The following sections briefly describe each system:

Landfill Cover System

Areas of the landfill outside the IRM were capped as required in the ROD. The cap system consisted of a multi-layer, modified solid waste cap that consisted of the following components from top to bottom:

Vegetative Layer: a minimum 6-inch thick layer of soil capable of sustaining vegetation to be placed over the cover layer, seeded and fertilized to establish a vegetative cover that will help reduce erosion of the cap;

Cover Layer: as required to provide a minimum soil thickness of 12 inches above the geomembrane;

Drainage Layer: the drainage layer will consist of a geocomposite drainage layer, consisting of geonet embedded between two non-woven geotextiles, which may be heat-bonded to the geonet. The geocomposite will provide filtration and lateral drainage for infiltration;

Geomembrane Layer: a 40-mil thick geomembrane will be used. The geomembrane will function as an impermeable cap layer; and,

Cushion Layer: a minimum 6-inch thick layer of cap cushion material will be placed to attain the required slope and provide for a stable base for subsequent cap system components.

Surface Water Drainage Control System

A surface water drainage control system was constructed in the newly covered portions of the landfill. It consists of several grass and riprap lined ditches within and around the cap to collect and transport surface water runoff and discharge into the existing stormwater drainage ditches, including the IRM Perimeter Ditch, Sip Avenue Ditch, and the Hackensack River.

Sip Avenue Ditch

Existing sediments in the Sip Avenue Ditch were removed to a depth of approximately two feet. The entire length of the Sip Avenue Ditch was lined with a compacted structural fill subgrade below a cellular confinement system filled with soil up to the 100-year, 24-hour storm line (elevation 10). In addition, the Sip Avenue Ditch will be regraded to serve as a replacement ARPA for wetlands presently located on the Archdiocese property.

River Bank Erosion Protection

Erosion protection measures were constructed where river bank slopes and slopes along waterways required stabilization. The placement of the cellular confinement system and

bioengineered stability systems was provided to reduce erosion and promote the stability of the cap slopes.

Landfill Gas Venting System

A passive gas venting system was also constructed within the capped area to prevent the accumulation of LFG beneath the geomembrane cap. The LFG that will be vented from beneath the cap will dissipate to the atmosphere through these vents preventing pressure development under the geomembrane cap and maintaining cap integrity. The production of gas generation is expected to be low.

Site Security System

A site security system was also constructed within the capped area to prevent trespassing and encroachment of potential violators. The site security system consists of a 6-foot high chain link fence placed around the perimeter of the Site. Fence gates with locks are located at entrance roads entering the Site.

2.3 Remedial Design

The Final (100%) Remedial Design (FDR) for the Site was submitted to the NJDEP in March 2007. Volumes 1 and 2 of the FDR contained the design rationale and the proposed construction figures, along with the supporting appendices, technical specifications, and permit equivalency information.

3.0 POST-CLOSURE MANAGEMENT STRUCTURE

The responsibilities and authority of the parties involved during post-closure activities are presented in Section 3.1. Additional training requirements for those individuals directly participating in the inspection, maintenance and monitoring activities are discussed in Section 3.2.

3.1 Responsibilities

The CCS Project Manager will be responsible for ensuring the O&M Plan is properly implemented and the results are communicated directly to the NJDEP. The responsibilities of the CCS Representative include:

1. Coordination of inspection, maintenance and monitoring activities;
2. Review and submittal of required reports and maintaining Site records;
3. Coordination and supervision of specialty contractors;
4. Preparation of O&M budgets;
5. Ensuring properly trained staff are employed at the Site;
6. Acting as the Emergency Coordinator or appointing an Emergency Coordinator; and
7. Coordination with public agency personnel as required.

The NJDEP will be notified in writing of any change to the designated CCS Project Manager. CCS may choose to utilize the services of various contractors to implement aspects of this O&M Plan. Contractor(s) responsibilities may include:

1. Conducting routine inspections and maintenance;
2. Performing repair maintenance and corrective actions as necessary;
3. Environmental monitoring;
4. Report preparation; and,
5. Emergency response.

3.2 Training

All personnel on the Site performing inspection, operation, maintenance or monitoring activities must be properly trained for these activities. The CCS Project Manager and any subcontractors will be responsible for implementing and adhering to proper health and safety measures associated with

these tasks. The site-specific Health and Safety requirements included as Appendix OMB to this O&M Plan will be implemented by the CCS. The CCS Project Manager shall be experienced in the management and implementation of operations and maintenance procedures at landfills, including safety and emergency response procedures. The CCS Project Manager is responsible for ensuring that properly trained staff are employed to work at the Site and for the selection of any contractor(s).

Personnel performing intrusive work activities (e.g., excavations below the cap/cover for maintenance or repairs, well development, etc.) must be 40-hour OSHA Health and Safety trained and have proper regular re-training and medical monitoring in accordance with 29 CFR 1910 and 1926 and other applicable laws and regulations. Personnel performing routine inspections, operations, or maintenance in which exposures to potentially hazardous materials is unlikely (e.g., groundwater and surface water monitoring, etc.) will require 24-hour OSHA Health and Safety training and annual 8-hour refresher training. At a minimum, all personnel working on-site will be briefed regarding existing Site conditions. Personnel entering confined spaces must possess, at a minimum, the required 8-hour confined space training in addition to any other training requirements.

It will be the respective responsibility of CCS and subcontractors to ensure that all employees and agents adhere to applicable training, laws, regulations, and policies while on-site.

4.0 INSPECTION AND MAINTENANCE PLAN

The Inspection Plan will be used for routine inspections of the following components of the remedy in order to identify components requiring maintenance or repair:

1. Landfill cover system;
2. Surface water control system;
3. Sip Avenue Ditch;
4. Hackensack River bank;
5. Passive gas venting system;
6. Site security system; and,
7. Environmental monitoring system.

Guidelines for inspection of each of these components are presented in the following subsections. For each component, the following is described:

1. Purpose of the inspection;
2. Reasonably anticipated inspection items; and,
3. Inspection schedule.

The Maintenance Plan will be used for scheduled maintenance of components of the remedy to ensure the continued effectiveness of the remedial systems. Repair maintenance will be performed in a manner and with materials as close as possible to those used during initial construction of the component under repair, unless otherwise approved by NJDEP. Repairs will be carried out as soon as practical following discovery of the damage. If the repairs are significant such that the as-built drawings need to be modified, the maintenance report will include as-built drawings of the repairs certified by a Professional Engineer registered in the State of New Jersey.

4.1 Landfill Cover System

4.1.1 Inspection Plan

A multi-layer, modified solid waste cap cover system was constructed over the landfill as described in Section 2.2. Reasonably anticipated items which could impact the effectiveness of the cover system include the following:

1. Insufficient vegetation resulting in erosion of the cover material by storm water runoff and/or wind;
2. Animal burrows;
3. Cracks or fissures in the cover resulting from excessive differential settlement;
4. Unauthorized damage or disturbances by personnel and/or equipment;
5. Large weeds or woody species whose roots may penetrate the cover material; and,
6. Erosion of cover soil along the Sip Avenue Ditch or the Hackensack River due to storm events.

The inspection will involve a Site walkover to search for the occurrence of the above items, with special emphasis as described below.

Integrity of the Cover System:

The landfill cover will be inspected for erosion, such as gullies, particularly on slopes and other places where erosion is most likely to occur. The cover will also be inspected for breaks in the soil due to differential settlement or animal burrows. Other damage to the cover system will also be noted.

Vegetative Cover:

The vegetation will be inspected for density, type, and damage caused by animals, personnel, equipment, erosion, seepage, or gas migration. Areas with insufficient vegetation to prevent erosion (defined as having less than 80% coverage or having bare patches larger than one square yard) will be noted. Damaged, bare, or sparsely covered areas (as defined above) will be noted. Undesirable vegetation such as large weeds or woody species will be noted for removal.

Information gathered during the inspection of the cover system will be documented on the field inspection form shown on Table 3. The cover system will be inspected annually in the spring in

order to assess damages from the freeze-thaw cycle and stormwater runoff, including snowmelt. Additional inspections will be performed as deemed appropriate by the CCS Project Manager.

Gravel access roads were installed throughout the Site to allow future access to river bank erosion protection areas and to facilitate operation and maintenance and monitoring of the groundwater and passive gas systems. The access roads must be maintained in order to allow inspection and maintenance of other constructed landfill features. Access roads are constructed with a 9-inch thick layer of either dense graded aggregate (DGA) or AASHTO No. 57 stone underlain by a woven geotextile.

4.1.2 Maintenance Plan

In order to ensure the continued effectiveness of the cover system, the following scheduled maintenance tasks will be performed:

1. Mowing of the vegetative cover annually, in the early summer; and,
2. Annual removal of any debris, large weeds, and woody plant species from the cover.

Anticipated repair maintenance tasks identified by the inspection which may be necessary to ensure the continued effectiveness of the cover system are listed below:

1. Reseeding areas having insufficient vegetation;
2. Regrading, reseeding, and stabilizing areas damaged by erosion of the cover material by storm water runoff and/or wind;
3. Filling animal burrows;
4. Replacement of stone or riprap;
5. Regrading, reseeding and stabilizing cracks or fissures of the cover material resulting from excessive differential settlement; and,
6. Repair of any unauthorized damage or disturbances by personnel and/or equipment.

All scheduled maintenance and repair maintenance tasks performed for the cover system will be documented on the field maintenance form as shown on Table 6.

4.2 Surface Water Control System

4.2.1 Inspection Plan

The surface water control system provides for collection and discharge of surface water that runs onto and off the Site. The system consists of drainage channels which collect runoff from the landfill cover, and perimeter drainage channels. Surface water from most of the landfill cover discharges to the Sip Avenue Ditch, the IRM ditch, or the Hackensack River. There are several culverts located throughout the Site to convey the surface water to these discharge points.

Reasonably anticipated items which could impact the effectiveness of the surface water drainage system include:

1. Erosion;
2. Animal burrows;
3. Differential settlement;
4. Excessive accumulation of leaves, silt, and sediment;
5. Damage to culverts;
6. Encroachment of vegetation; and,
7. Unauthorized blockage, damage or disturbances by personnel and/or equipment.

The inspection will involve a Site walk-over to search for occurrence of the above items. The drainage channels will be inspected for blockages caused by leaves, grass clippings, silt deposits, or excessive vegetative growth which could impede or change the course of flow and cause erosion along the edges of the channel lining or ponding of the water. Excessive encroachment of vegetation in riprap-lined areas which could modify the flow capacity of the channel will be recorded. Other damage from vandalism or disturbances by on-site personnel or trespassers could decrease the effectiveness of the drainage channels.

Information collected during the inspection of the surface water control system will be documented in the field inspection form shown on Table 3. The surface water control system will be inspected annually in the spring in order to assess any damages from the freeze-thaw cycle or storm events. Additional inspections will be performed as deemed appropriate by the Group Project Manager.

4.2.2 Maintenance Plan

Scheduled maintenance of the surface water control system will include removal of leaves, grass clippings, excessive silt deposits, excessive vegetative growth, or any other debris from drainage channels during the Spring inspection. The following common repair maintenance tasks are reasonably anticipated to be necessary to ensure the continued effectiveness of the surface water control systems:

1. Regrading, addition, and/or replacement of rip rap or desirable vegetation in the channels as a result of erosion, settlement or unauthorized damage; and,
2. Replacement of Site security equipment to prevent unauthorized entry and usage of IRM Perimeter Ditch or other drainage channels.

Repair maintenance tasks performed for the surface water control system will be documented on the field maintenance form as shown on Table 6.

4.3 Sip Avenue Ditch

4.3.1 Inspection Plan

The Sip Avenue Ditch is a drainage channel that runs in an east-west direction from Route 1 and 9 to the Hackensack River. Overflow from the Jersey City stormwater and sewer water system is carried under Route 1 and 9 and drains into the Sip Avenue Ditch. The Sip Avenue Ditch also receives surface water runoff from the Site. The Sip Avenue Ditch is lined with a cellular confinement system filled with soil, above a compacted structural fill subgrade.

Reasonably anticipated items which could impact the effectiveness of the surface water drainage system include:

1. Erosion;
2. Differential settlement;
3. Excessive accumulation of leaves, silt, and sediment;
4. Damage to culverts and drainage channels entering the Sip Avenue Ditch;
5. Unauthorized use of the Sip Avenue Ditch; and,
6. Unauthorized blockage, damage or disturbances by personnel and/or equipment.

The inspection will involve a Site walk-along the Sip Avenue Ditch or access roads to search for occurrence of the above items along the entire length of the Sip Avenue Ditch. The drainage channels will be inspected for blockages caused by leaves, grass clippings, silt deposits, debris or excessive vegetative growth which could impede or change the course of flow and cause erosion along the edges of the ditch lining or ponding of the water. Excessive encroachment of vegetation in riprap-lined areas which could modify the flow capacity of the ditch will be recorded. Other damage from vandalism or disturbances by on-site personnel or trespassers could decrease the effectiveness of the Sip Avenue Ditch.

Information collected during the inspection of the Sip Avenue will be documented in the field inspection form shown on Table 3. The Sip Avenue Ditch will be inspected annually in the spring in order to assess any damages from the freeze-thaw cycle or storm events. Additional inspections will be performed after significant storms equal to or greater than the magnitude of a 2-year storm event (3.3 inches of rain in a 24-hour period), or when the Project Manager, or CCS Representative warrant an inspection.

4.3.2 Maintenance Plan

Routine inspection and maintenance of the Sip Avenue Ditch will be conducted on an annual basis and will include the following focus:

- Erosion or loss of riprap;
- Animal burrows;
- Differential settlement;
- Continuous flow without disruption or blockages;
- Undermining of the ditch lining due to water (mainly in the Jersey City culvert area);
- Scouring;
- Structural integrity of the cellular confinement system side slope; and,
- Damage or disturbances by personnel or equipment.

The riprap protection, and access roads will be inspected for structural integrity. Erosion or potential areas of erosion, animal burrows, differential settlement, or signs of instability of any areas that would result in erosion, should be identified and evaluated.

Repair maintenance tasks performed for the surface water control system will be documented on the field maintenance form as shown on Table 6.

4.4 Hackensack River Bank Erosion

4.4.1 Inspection Plan

The erosion control measures included the placement of a cellular confinement system along the banks of the Hackensack River. Other erosion measures included excavation and regrading of the existing materials to flatten steep slopes and provide access in areas of steep slope where previous slopes required additional stability. The excavation and fill were constructed to facilitate the construction of permanent erosion protection on the side slopes of the Hackensack River and to accommodate the placement of wetland vegetation.

The inspection will involve a Site walk along the river banks and/or access roadways to inspect the Hackensack Riverbank along the RV Salvage area. The riprap protection, and access roads will be inspected for structural integrity. Erosion or potential areas of erosion, animal burrows, differential settlement, vandalism or signs of instability of any areas that would result in erosion, should be identified and evaluated.

4.4.2 Maintenance Plan

Scheduled maintenance of the Hackensack River Bank erosion control system will be on an annual basis, during the Spring Site inspection. Routine maintenance items that could impact the effectiveness of the river bank erosion protection system include:

- Erosion or loss of cellular confinement system;
- Animal burrows;
- Differential settlement;
- Undermining of the riverbank stabilization due to water;

- Scouring;
- Loss of vegetation and/or bioengineering stabilization systems;
- Structural integrity of the cellular confinement system side slope; and,
- Damage or disturbances by personnel or equipment.

The river bank erosion protection measures will be inspected by the CCS Project Manager or O&M subcontractor on an annual basis. Additional inspections may be performed after significant storms equal to or greater than the magnitude of a 2-year storm event (3.3 inches of rain in a 24-hour period).

Information collected during the inspection of the river bank erosion protection system will be documented on field inspection forms shown in Table 6. Photographs will be taken as appropriate.

4.5 Passive Gas Venting System

4.5.1 Inspection Plan

The gas collection system consists of thirty-three (33) passive gas vents (6-inch diameter HDPE pipes) installed into a gas collection layer. The gas system functions to control the potential migration of residual landfill gas which might be generated by the decomposition of waste.

Items that could influence the effectiveness of the passive gas venting system include:

1. Blockages as a result of debris in the vents;
2. Birds or other animals nesting in the vents; and,
3. Unauthorized damage to the vents.

The inspection of the passive gas vents will involve visual observation of the external integrity of the vent and the bird screen on the end of the vent. Physical damage to the vent such as kinks or bends which may impede gas flow will be noted. Evidence of blockages as a result of debris or nesting of animals within the gas vents which may restrict flow will also be noted.

Information collected during the inspection of the passive gas venting system will be documented on the field inspection form shown on Table 3. The inspection of the passive gas venting system will be performed as part of the annual inspection.

4.5.2 Maintenance Plan

There are no scheduled maintenance requirements for the passive gas venting system. The anticipated repair maintenance tasks which may be necessary to ensure the continued effectiveness of the passive gas venting system are the following:

1. Repair or replacement of the passive gas vents or portions of the pipes if physical damage is noted which can decrease their effectiveness;
2. Removal of blockages such as grass clippings, leaves, birds or animals nests in the vents;
3. Replacement of bird screen at the end of the vent, if damaged; and,
4. Regrading around vent to prevent ponding of storm water.

Repair tasks performed for the gas vents will be documented on the field maintenance form as shown on Table 6.

4.6 Site Security System

4.6.1 Inspection Plan

Site security is provided by the Site security system as described in Section 2.2. The purpose of the security system is to prevent unauthorized access of vehicles onto the cover system. Periodic inspection of the Site security system is necessary to document and ensure the continued security of the Site.

Reasonably anticipated items which could reduce the effectiveness of the Site security system include:

1. Unauthorized damage or disturbances by personnel and/or equipment;
2. Excessive wear to the fence gate and/or lock;
3. Improper function of the fence gate and/or lock; and,
4. Vandalism.

Inspection of the Site security system will consist of visual observations. The security fence will be inspected for damage such as holes or breaks. The gates and locks will be inspected for damage or excessive wear. The results of the inspection will be documented on the field inspection form shown on Table 3. The integrity of the Site security system will be evaluated annually during the Spring inspection.

4.6.2 Maintenance Plan

There are no scheduled maintenance requirements for the Site security system. The anticipated repair maintenance tasks which may be necessary to ensure the continued effectiveness of the Site security system are listed below:

1. Repairing of any holes, breaks or other unauthorized damage or disturbances by personnel and/or equipment to the security fence, gate or lock;
2. Replacement of the gate and/or lock if excessive wear prohibits proper functioning; and,
3. Replacement of areas or sections of the security fence which have rusted significantly in order to prevent holes or breaks from developing in the fence.

All repair tasks performed for the Site security system will be documented on the field maintenance form as shown on Table 6.

4.7 Monitoring System

4.7.1 Inspection Plan

The purpose of the monitoring system is to monitor groundwater, surface water, and landfill gas in the vicinity of the Site. A total of 10 shallow groundwater monitoring wells are located on and around the Site as part of the long-term monitoring system. All monitoring wells at the Site included as part of the monitoring system will be inspected. Monitoring well locations are illustrated on Figure 2. The periodic inspection of the groundwater monitoring wells is necessary to document and ensure their continued effectiveness as valid monitoring points.

The following are those reasonably anticipated items which may impact the effectiveness of the groundwater monitoring wells:

1. Damage to the protective casing or lock;

2. Damage to the surface seal;
3. Evidence of vandalism;
4. Damage to the internal casing;
5. Blockages resulting from objects fallen into the well or bent casing; and,
6. Damage to the dedicated sampling equipment.

The inspection of the groundwater monitoring wells will involve visual observation of the external integrity of the well. The protective casing will be inspected for excessive rust and any damage as a result of vandalism. The lock will be checked to verify that it is in good working condition. The surface seal shall be inspected for cracks and damage as a result of freeze/thaw. The internal casing/protective casing annulus will be checked for blockages as a result of kinks or bends. The area should be free of debris and animals. The internal casing should also be inspected for blockages at depth during well sampling. The area around the monitoring well shall be inspected for drainage and accessibility.

Information gathered during the inspection of the groundwater monitoring wells will be documented on the field inspection form as shown on Table 5. The groundwater monitoring wells will be inspected during each monitoring event.

4.7.2 Maintenance Plan

There are no scheduled maintenance requirements for the monitoring system. Anticipated repair maintenance tasks which may be necessary in order to ensure the continued effectiveness of the groundwater monitoring wells include:

1. Replacement or repair of surface seal;
2. Replacement or repair of protective casing;
3. Replacement of the well;
4. Removal of vegetation to maintain access;
5. Replacement of the lock; and,
6. Replacement or repair of dedicated sampling equipment.

Repair tasks performed for the groundwater monitoring wells will be documented in the field maintenance form as shown on Table 6.

5.0 ENVIRONMENTAL MONITORING PLAN

In accordance with the ROD, groundwater and surface water monitoring will be performed to evaluate the concentration of contaminants. The monitoring program will be performed quarterly to evaluate the reduction of contaminant concentrations in groundwater and surface water. After sufficient post-closure monitoring data have been compiled, CCS might petition NJDEP to reduce the monitoring parameters and/or frequency. Such changes would not be implemented without prior NJDEP approval.

Routine monitoring of the passive gas vents and perimeter barhole or monitoring probe locations will also be conducted for the concentration of explosive gases. These data will confirm that the passive venting system is operating properly. Approximately 7 of the 33 total gas vents will be monitored. Monitoring of the gas vents will continue for a period of five (5) years, and then reviewed by the NJDEP.

Any modifications to the groundwater, surface water and gas vent monitoring program for the remainder of the O&M period will be submitted to NJDEP for approval prior to implementation.

5.1 Purpose

Specific objectives for the environmental monitoring plan are as follows:

- to assess the concentration of contaminants and trend(s) at groundwater wells and surface water collection points;
- to determine the presence of explosive landfill gases; and,
- to assess the effectiveness of the Remedial Action for controlling potential off-site migration.

5.2 Groundwater Monitoring

Groundwater samples will be collected from ten (10) shallow monitoring wells at the Site to monitor groundwater quality changes resulting from implementation of the Remedial Action. The ten monitoring wells include MW-1S, MW-4S, MW-5S, MW-6S, MW-7S, MW-8S, MW-9S, MW-10S, MW-11S, and MW-12S. The locations of these wells are shown on Figure 2.

Some of these monitoring wells are located within the newly capped area, and some are located on the IRM capped area or offsite.

5.2.1 Groundwater Sampling Procedures

The monitoring wells will be purged and sampled using existing dedicated Well Wizard® sampling pumps in accordance with the USEPA Region II low-flow sampling Procedure (USEPA, 1998). If the pumps are inoperative or otherwise not useable (e.g., water level is below the pump intake), a disposable decontaminated Teflon bailer attached to Teflon coated stainless steel leader wire and new, dedicated polypropylene rope will be used for purging and sampling. Groundwater sampling procedures are presented in detail in Attachment OMA and are summarized below.

Initially, the depth to the static water surface will be measured with an electronic water level indicator to the nearest 0.01 foot. The well will then be purged until field measurements (i.e., pH, temperature, specific conductance, oxidation-reduction potential (ORP), dissolved oxygen, and turbidity) have stabilized to within 10% for two successive well volumes or until the well is dry. The 10% stability criteria does not apply to turbidity measurements less than 50 NTUs. A well volume is defined as the standing water column in the well casing. The volume of water evacuated, as well as the field measurements will be recorded for each successive well volume purged.

Once the well has been purged, samples will be collected within three (3) hours using the Well Wizard® sampling pump (or a Teflon bailer if necessary). If the well is pumped dry and is slow to recover, the well will be sampled as soon as it has recovered enough to fill the sample bottles, or within 24 hours, whichever occurs first.

Groundwater samples will be analyzed for the following:

- field measurements (pH, temperature, specific conductance, dissolved oxygen, ORP, and turbidity);
- VOCs;
- SVOCs (semi-annual only);
- metals; and,
- general water quality parameters (total suspended solids, total dissolved solids, and chloride).

If inadequate water is available to fill all sample bottles, VOC and SVOC samples should be given priority, in that order, followed by metals and general water quality parameters.

Pre-preserved sample bottles will not be used. Care will be taken while obtaining VOC samples to minimize aeration and loss of VOCs. The pump flow rate will be reduced to less than 100 milliliters per minute during collection of samples for VOCs. There will be no head space or air bubbles in the VOC vials, and the vials will be inverted and tapped lightly to check for air bubbles.

QA/QC samples will include one field duplicate and two VOC trip blanks (or one per day, whichever is greater). Equipment rinsate blanks are not necessary, as all monitoring wells have dedicated sampling pumps. However, if a bailer is used in lieu of an inoperative/not useable sampling pump, an equipment rinsate blank may be collected.

5.2.2 Groundwater Level Measurements

The depth to groundwater will be measured in all 10 existing groundwater monitoring wells at or near the Site. The locations of the wells are shown on Figure 2. The water levels of all 10 monitoring wells will be measured within a two hour period during the same day, and prior to any purging or sampling. The water level meter used for recording water levels will have the depth graduations checked with an independent measuring tape for calibration before field use.

Prior to each water level measurement, the well identification number, measuring device type and serial number, date, and time will be recorded. The water level meter will be rinsed with distilled water prior to each use. The water level meter probe will be lowered into the monitoring well and stopped at the depth where the meter indicates a completed circuit. The depth to water will be then be recorded to the nearest 0.01 foot relative to the top of the inner casing.

5.3 Surface Water Monitoring

A total of five (5) surface water samples will be collected. Samples will be collected from locations along the Sip Avenue Ditch and the Hackensack River. These locations are shown on Figure 2.

Surface water samples will be collected by direct immersion of sample bottles if possible. If not, a smaller sample bottle supplied by the laboratory and constructed of the same material (i.e.,

polyethylene or glass) will be used as a transfer vessel to distribute the sample into the various sample bottles. If the water is too shallow to allow the sample bottles to be immersed, a hole will be dug with a properly cleaned scoop or shovel to allow for complete immersion of the sample bottle. Samples will be collected after any visually-identified turbidity due to digging has dissipated.

Surface water sampling will be performed at the downstream locations first, then proceed to the more upstream locations. During sampling, the sample bottle will be held with the opening pointing upriver and the sampler will stand downriver of the bottle.

Surface water samples will be analyzed for the following parameters:

- VOCs;
- SVOCs (semi-annual only);
- metals; and
- total suspended solids (TSS); and
- hardness.

QA/QC samples will include one field duplicate and one VOC trip blank per day.

5.4 Field Measurements

Field measurements of temperature, pH, specific conductance, ORP, dissolved oxygen, and turbidity will be completed at the time of groundwater and surface water sample collection, as appropriate. The procedures to be used are included in Attachment OMA.

5.5 Schedule

Groundwater and surface water monitoring will initially be performed on a quarterly basis as required by the ROD. Once sufficient data have been compiled, CCS might petition NJDEP to reduce the monitoring parameters and/or frequency. Such changes will not be implemented without prior approval by NJDEP.

5.6 Gas Monitoring

The waste in the landfill is not expected to generate large amounts of methane because the waste is approximately 30 years old, and the release of explosive gases were not a concern during construction of the IRM cap area. Therefore, potential migration of landfill gas will be monitored on an annual basis during the O&M period. Explosive gases will be monitored at a depth of 3 feet below ground surface using soil gas barhole probes along the perimeter of the landfill in the selected passive gas vents located on Site. If the concentration of explosive gases is less than 25% of the lower explosive limit (LEL) for methane, and are not increasing during the 1-year period, then CCS might propose a more streamlined monitoring program to NJDEP for review and approval if little potential for off-site gas migration is detected.

6.0 REPORTING AND RECORDKEEPING

The following sections describe reporting procedures for inspection, operation, maintenance, and monitoring activities during the post-closure period. The results of these activities will be summarized in Annual Quarterly Reports submitted by the CCS Project Manager to the NJDEP by March of the year following the end of the reporting period.

Site records will be kept by the CCS, in care of WMNJ/CCS.

PJP Landfill Site
Waste Management, Inc.
4 Liberty Lane West
Hampton, New Hampshire 03842
(603) 929-5446

6.1 Inspection Reporting

All inspection activities described in Section 4.0 will be documented by the CCS Representative or the subcontractor(s) responsible for performing the various inspections. Inspection evaluation reports will summarize the inspection activities and any maintenance required based upon the inspections. Should repairs or corrective actions beyond routine maintenance be required, the Group will provide documentation on these activities.

6.2 Maintenance Reporting

All repair and maintenance activities described in Section 4.0 of this O&M Plan will be documented by the Group Project Manager or contractor(s) responsible for performing the various maintenance activities. Should repairs or corrective actions beyond routine maintenance be required, the Group will provide documentation on these activities. If significant repairs require modification of the as-built drawings as approved by the NJDEP, the as-built drawings will be revised and certified by a registered Professional Engineer in the State of New Jersey. The revised as-built plans will be submitted by the CCS Project Manager to the NJDEP in the annual reports.

6.3 Monitoring Reporting

Groundwater and surface water monitoring data will be collected by the CCS Project Manager as described in Section 4.0 of this O&M Plan.

6.4 Safety Reporting

If an unsafe situation is discovered during an inspection, maintenance, or monitoring activity, the CCS Project Manager will provide verbal notification of the incident to the NJDEP within 72 hours (three days) of becoming aware of the incident. The identified situation will be corrected within 24 hours or shut down until it can be corrected. A summary of the incident will be included in the next Annual Report.

7.0 EMERGENCY PLAN

Routine post-closure activities at the Site will be covered under the Health and Safety Contingency Plan (HASCP) for the PJP Landfill Site. The HASCP shall be prepared by the O&M contractor(s) in accordance with the minimum requirements presented in Appendix OMB. All personnel on the Site performing routine inspections, maintenance or monitoring activities will be properly trained for these activities and will be made aware of the proper health and safety measures associated with these tasks. Each contractor shall have a designated site health and safety coordinator responsible for assuring the designated procedures are implemented.

All health and safety equipment will be supplied by the contractor(s) performing the work and will be available on Site during inspection, maintenance and monitoring activities as indicated for the particular work in the HASCP. Equipment will be easily accessible and located as close as practical to the work area. All equipment will be maintained in a "ready-to-use" condition. All equipment used will be properly decontaminated, cleaned, refilled, or replaced as necessary or required by the manufacturers' instructions. Personnel will be familiar with proper procedures for operating and cleaning the equipment.

Personnel performing such activities as sampling, confined space entry, or any intrusive work shall be 40-hour OSHA Health and Safety trained in accordance with 29 CFR 1910 and 1926. At a minimum, these personnel will be briefed regarding existing Site conditions. It will be the responsibility of the contractor(s) to ensure that all employees adhere to the HASCP along with all local, State and Federal regulations while on-site.

7.1 Organizational Structure and Responsibilities

The CCS Project Manager will be responsible for personnel, equipment, policies, and procedures for all inspection, maintenance, monitoring, operating, and other activities at the Site. The CCS Project Manager will serve as or appoint the Emergency Coordinator. Additional responsibilities of the CCS Project Manager include, but are not limited to, the following:

- Identification of materials or wastes handled (materials inventory);
- Identification of potential hazard sources (risk assessment);
- Establishment of emergency reporting procedures;
- Establishment of visual inspection program;

- Review of past incidents, spills, and countermeasures utilized;
- Coordination and implementation of the goals of the health and Safety Contingency Plan;
- Coordination of activities for emergency response;
- Notification of appropriate authorities;
- Establishment of employee training/educational programs;
- Periodic review and update of the Safety Plan portion of this O&M Plan; and,
- Serve as or appoint one or more emergency coordinators.

The Emergency Coordinator will be responsible for coordinating all emergency response measures to reduce or prevent harm to human health and the environment in the event of a fire, explosion, emission, and/or discharge of hazardous materials. In the event of an imminent or actual emergency situation, the Emergency Coordinator will perform the following tasks:

- Notify on-site personnel;
- Identify the problem and assess the environmental and health hazards;
- Call Emergency Response personnel (fire, police, EMS) for backup;
- Take all reasonable measures to stabilize the situation, including evacuation of the Site, if necessary;
- Document the situation and actions taken;
- Continue to monitor the situation after stabilization; and,
- Contact the CCS Project Manager, who will contact State and Federal environmental regulatory agencies.

During an emergency, the Emergency Coordinator will take reasonable measures necessary to ensure that fire, explosion, emission, or discharge do not occur, reoccur, or spread. These measures will include terminating O&M activities or operations, evacuating Site personnel, and ensuring that all access roads are kept free of obstructions during an emergency situation.

If Site operations and activities cease in response to a fire, explosion, emission, or discharge, the Emergency Coordinator will ensure that adequate monitoring is conducted for leaks, pressure build-up, gas generation, or ruptures in valves, pipes, or other equipment, where appropriate.

If response to an on-site incident requires assistance from outside emergency support agencies (police, fire department, medical emergency response teams), the Emergency Coordinator will contact the appropriate agency. The Emergency Coordinator will have immediate and full responsibility and authority to engage the services required. If conditions warrant, the Emergency Coordinator will relinquish control of the situation to the appropriate agency official upon arrival on-site.

After an emergency, the Emergency Coordinator will consult with the CCS Project Manager to determine what treatment or disposal of contaminated soils or waste is appropriate. He will ensure that all necessary cleanup procedures are completed. Reporting will be as presented in Section 6.4.

In the event of an emergency, the individual who observes the event will immediately (within 15 minutes or less) report the condition to the Emergency Coordinator, who will take the appropriate action as described above. If the Emergency Coordinator is unavailable, his/her backup, or the senior individual on-site will act as the Emergency Coordinator's designee until the Emergency Coordinator becomes available. A maintenance, operations, or design failure that does not result in personal injury or imminent harm is not considered to be an emergency situation.

External communications will be accomplished via outside telephone lines or cell phones. Direct telephone communication will be used to alert outside agencies, such as the fire and police departments, in the event of an emergency. The CCS Project Manager, not the Emergency Coordinator, shall notify the NJDEP, and USEPA if appropriate, of an on-site emergency situation.

7.2 Emergency Services

If response to an on-site incident requires assistance from outside emergency support agencies (police, fire department, medical emergency response teams), the Emergency Coordinator will contact the appropriate agency. He/she has immediate and full authority to engage the services required. The Emergency Coordinator will then relinquish control of the situation to the appropriate emergency official upon the official's arrival on-site, but continue to provide advice.

A list of contacts and emergency services is provided below in case an emergency situation arises. This list and a map showing the locations of the Site and hospital will be posted in conspicuous locations on-site. The 911 emergency system is operational in the Site's immediate area.

1.	Jersey City Police Department	201/547-5477
2.	Jersey City Fire Department	201/547-4206
3.	Jersey City Ambulance	201/451-9800
4.	Jersey City Medical Center	201/451-9800
5.	CCS Group Project Manager - David Moreira	603/929-5446
6.	NJDEP – Haiyesh Shah	609-633-0178
7.	USEPA – Renee Gelblatt	212-637-4414

The Emergency Coordinator will give the following information to the emergency agency:

1. Name and telephone of person reporting the incident;
2. Name and address of the site;
3. Time and type of incident;
4. Name, nature, and quantity of material(s) involved, to the extent known;
5. The extent of injuries, if any; and,
6. Identified hazards to human health and/or the environment.

An Emergency Response Contact List and an Emergency Notification Form are provided as Table 7.

7.3 Evacuation Plan

It is not anticipated that full evacuation of the Site or adjacent properties will be necessary. In general, evacuation will be limited to the immediate area surrounding the emergency situation. If the Emergency Coordinator determines that Site evacuation is necessary, the following evacuation procedures will be implemented:

1. Notify all on-site personnel;
2. Personnel will secure equipment and materials and place them in secure areas;
3. Personnel will evacuate via site access roads;

4. Personnel will reassemble near the Route 1 and 9 entrance gate to the Site, or an alternate location, determined by the Emergency Coordinator, away from the incident to verify all personnel have evacuated the area of concern;

5. Emergency Coordinator will account for all personnel;

6. Emergency Coordinator will notify the appropriate emergency response agency; and

7. Personnel will not re-enter the area until it is determined to be safe by the Emergency Coordinator or the appropriate emergency official in charge.

The evacuation procedures outlined above will be communicated to all personnel.

7.4 Amendments to the Safety Plan

Amendments to the Health and Safety/Contingency Plan will be submitted to NJDEP for review, as necessary.

7.4.1 Alternate Operation and Maintenance (Systems Failure)

It is unlikely that failure of the cap and cover systems would occur resulting in immediate endangerment to the public health and the environment. Instead, localized areas of the cap and cover systems may be temporarily compromised as a result of a large storm event. This O&M Plan requires the cap and cover systems to be inspected and maintained after major storms to maintain the integrity of these areas. Repairs will be carried out as soon as practical following discovery of the need for a cap repair and development of an appropriate repair procedure. Temporary controls will be established to mitigate further damage until permanent systems are established.

7.4.2 Amendments to the Emergency Plan

The Emergency Plan will be reviewed and amended, as appropriate, if one of the following occurs:

1. Emergency measures merit revision based on actual experience;

2. Changes in the system operation or activities increase the potential for an emergency;

3. The personnel or agency lists or emergency equipment requirements change; or,

4. Any safety considerations.

7.5 Plan Modification Procedures

During the 30-year post-closure period, CCS will annually evaluate the inspection, operation, maintenance, and monitoring activities described in this O&M Plan and performed during, at least, the first five years of operation. Modifications to this O&M Plan may be appropriate (e.g. reduction in monitoring frequency) based on changes in Site conditions and/or new information collected during the post-closure period. The O&M modifications will be submitted for NJDEP review. Major modifications to this O&M Plan will be implemented upon receipt of approval from NJDEP. Minor modifications will be implemented without prior NJDEP review and approval, although the NJDEP will be informed of any such changes in a timely manner. The CCS Project Manager will promptly distribute the modifications to the NJDEP, USEPA, and others, if required, so that each project team member's O&M Plan can be updated.

This O&M Plan will be reviewed in detail after one year of O&M activities and modified/updated as necessary.

8.0 REFERENCES

Golder Associates Inc., 2000. "Remedial Design Work Plan, PJP Landfill Site, Hudson County, New Jersey," Revision 3, November.

Golder Associates Inc., October 2003. "Intermediate (65%) Design Report, PJP Landfill Site, Hudson County, New Jersey."

Golder Associates Inc., June 2004. "Pre-Final (90%) Design Report, PJP Landfill Site, Hudson County, New Jersey."

Golder Associates Inc., March 2007. "Final (100%) Design Report, PJP Landfill Site, Hudson County, New Jersey."

Golder Associates Inc. "Groundwater and Surface Water Monitoring Data, PJP Landfill Site, Hudson County, New Jersey."

USEPA, September 1995. "Record of Decision for the PJP Landfill."

USEPA, 1998. Region II Groundwater Sampling Procedure Low Stress (low flow) Purging and Sampling, March 16, 1998.

TABLE 1
PROJECT PERSONNEL

O&M Contractor Project Manager:	To Be Determined
O&M Contractor Field Coordinator:	To Be Determined
O&M Contractor Quality Assurance Officer:	To Be Determined
O&M Contractor Laboratory Coordinator/ Data Validator:	To Be Determined
Laboratory Project Manager: Alternate Laboratory Project Manager:	To be determined
Laboratory Quality Assurance Director: Laboratory Quality Assurance Manager:	To be determined

NJDEP will be notified when a laboratory has been selected for this project.

TABLE 2
SUMMARY OF DATA QUALITY OBJECTIVES
PJP LANDFILL ENVIRONMENTAL MONITORING PLAN

ACTIVITY	NUMBER OF SAMPLING POINTS	PARAMETERS OF INTEREST	OBJECTIVES	DQO LEVEL
Long-Term Groundwater Monitoring	10 10 10 10	TCL Volatiles TCL Semi-Volatiles (annual) Unfiltered TAL Metals Total suspended solids	Provide water quality data to evaluate benefit of remedy implementation and constituent transport to adjacent surface water bodies.	Definitive
Long-Term Surface Water Monitoring	5	TCL Volatiles, TCL Semi-Volatiles (annual) Filtered and Unfiltered TAL Metals, Hardness	Provide water quality data to evaluate potential constituent transport from site groundwater.	Definitive
Passive Landfill Vent Gas	49 IRM + all new passive gas vents	Total Volatile Organic Compounds (PID) Explosive gases (%LEL) Gas Flow Rate	To evaluate potential offsite explosive gas migration.	Field Screening
Perimeter Landfill Gas Probe	TBD	% LEL	To evaluate subsurface gas migration after capping.	Field Screening
Wetland Mitigation Vegetation [1]	TBD	Survival	Greater than 85% desirable wetland vegetation cover	Field Screeing

TBD - To be determined
All monitoring will be on a quarterly basis except semi-volatile organics in groundwater and surface water, that will be on an semi-annual basis.
[1] Inspections will occur twice per year for the first two years then each spring for three additional years.

Table 3
POST-CLOSURE ANNUAL INSPECTION FORM
PJP LANDFILL
JERSEY CITY, NEW JERSEY

DATE _____

INSPECTOR _____

INSPECTION (Circle one): ANNUAL
OTHER _____

ITEM	ADEQUATE	NEEDS ATTENTION	COMMENTS (NOTE IF REPAIR MAINTENANCE REQUIRED)
I. PROTECTIVE COVER SYSTEMS			
A. General condition of cover material			
B. Settlement control			
C. Erosion control			
D. Animal burrows			
E. Large weeds or woody species			
F. Vegetation			
G. General conditions of access roads			
II. SURFACE WATER DRAINAGE SYSTEMS			
A. General condition of channels			
B. Settlement control			
C. Erosion control			
D. Animal burrowing			
E. Flow capability			
F. Rip rap protection			
G. Vegetation control			
H. Structural integrity of culverts			
III. PASSIVE GAS VENTING SYSTEM			
A. General condition of each vent			
B. Vent visibility			
C. Drainage and accessibility			
D. Venting capability			
IV. SITE SECURITY			
A. Security Fence			
B. Gate and lock			

Clearly Identify Areas Needing Attention (Reference Item No.) on the Site Plan.

TABLE 4
INSPECTION FORM
RIVER BANK EROSION PROTECTION
OPERATION AND MAINTENANCE PLAN
PJP LANDFILL, HUDSON COUNTY, NEW JERSEY

AREA _____

DATE _____

INSPECTOR _____

INSPECTION (Circle one): ANNUAL
OTHER _____

ITEM	ADEQUATE	NEEDS ATTENTION	COMMENTS (NOTE IF REPAIR MAINTENANCE REQUIRED)
I. RIVER BANK EROSION PROTECTION SYSTEM			
A. General condition of erosion protection	_____	_____	_____
B. Erosion or loss of rip rap	_____	_____	_____
C. Animal Burrows	_____	_____	_____
D. Differential Settlement	_____	_____	_____
E. Excessive accumulation of sediment	_____	_____	_____
F. Sideslope stability	_____	_____	_____
G. Damage or disturbances by equipment and/or personnel	_____	_____	_____

Additional Notes:

1. Clearly identify areas needing attention (Reference Item No.) and illustrate on the attached Site Plans.
2. Take photographs as appropriate.

TABLE 5
MONITORING WELL
POST-CLOSURE INSPECTION FORM
PJP LANDFILL
JERSEY CITY, NEW JERSEY

DATE _____

INSPECTOR _____ MONITORING WELL NO.:_____

	YES	NO	ACTION REQUIRED
A. Location/Identification			
1. Is well readily accessible?	_____	_____	_____
2. Is well in a protected area or in a vulnerable traffic area?	_____	_____	_____
3. Is well situated outside a low point or ponded water?	_____	_____	_____
4. Is well head area free of waste, stored chemicals, etc.?	_____	_____	_____
5. Is well flagged or painted?	_____	_____	_____
6. Is well labeled inside and outside?	_____	_____	_____
B. Surface Seal			
1. Is concrete surface seal in good condition (i.e., no cracks)?	_____	_____	_____
2. Is the seal secure against the casing and ground surface?	_____	_____	_____
3. Is the seal sloped away from the well head?	_____	_____	_____
C. External Casing			
1. Does well have external casing in good condition (i.e., no cracks)?	_____	_____	_____
2. Is external casing locked?	_____	_____	_____
3. Is lock in good condition (i.e., no severe rust)?	_____	_____	_____
4. Is casing/annulus in good condition and free of water/animals/debris?	_____	_____	_____
D. Internal Casing			
1. Is internal casing at least 1 foot above ground?	_____	_____	_____
2. Is casing tight horizontally/vertically/rotationally?	_____	_____	_____
3. Is casing free of animals/debris/kinks or bends?	_____	_____	_____

TABLE 6
POST CLOSURE MAINTENANCE/REPAIR FORM
PJP LANDFILL
JERSEY CITY, NEW JERSEY

DESCRIPTION OF MAINTENANCE/PROBLEM: _____

_____

_____

DATE PROBLEM IDENTIFIED: _____

MAINTENANCE/REPAIR TAKEN TO RESOLVE PROBLEM (Identify Locations of Maintenance on Site Plan):

_____

_____

_____

_____

_____

_____

DATE COMPLETED: _____

INSPECTOR: _____

TABLE 7
EMERGENCY NOTIFICATION RECORD
PJP LANDFILL
JERSEY CITY, NEW JERSEY

Inspector identifying emergency: _____

Date of identification of emergency: _____

Description of emergency: _____
_____
_____
_____
_____

Person(s) notified: _____

Date of notification: _____

Signature of inspector and date: _____

List of persons to be notified:

1. CCS Group representative: _____

   Address: _____

   Telephone number: _____

2. Emergency Agency representative: _____

   Address: _____

   Telephone number: _____

TABLE 8
TARGET ANALYTES, ANALYTICAL METHODS, AND QUALITY ASSURANCE SAMPLES
PJP LANDFILL ENVIRONMENTAL MONITORING PLAN

Long-Term Groundwater Monitoring Program

Parameters	Methodology	Number of Samples	Types of Samples
TCL Volatiles	SW846 8260B	10 (1) 2 (2) 2 (2) 2 (2) 1 per day (2)	Primary Field Duplicates MS MSD Trip Blanks
TCL Semi-volatiles (semi-annual basis only)	SW846 8270C	10 (1) 2 (2) 2 (2) 2 (2)	Primary Field Duplicates MS MSD
TAL Metals (unfiltered)	SW-846 6010 and 7000 series	10 (1) 2 (2) 2 (2) 2 (2)	Primary Field Duplicates MS Laboratory Duplicate
Total Suspended Solids	USEPA 160.2 (3)	10 (1) 2 (2) 2	Primary Field Duplicates Laboratory Control Sample

Long-Term Surface Water Monitoring Program

Parameters	Methodology	Number of Samples	Types of Samples
TCL Volatiles	SW846 8260B	5 (1) 1 (2) 1 (2) 1 (2) 1 per day (2)	Primary Field Duplicates MS MSD Trip Blanks
TCL Semi-volatiles (semi-annual basis only)	SW846 8270C	5 (1) 1 (2) 1 (2) 1 (2)	Primary Field Duplicates MS MSD
TAL Metals (filtered and unfiltered)	SW-846 6010 and 7000 series	10 (1) 2 (2) 2 (2) 2 (2) 1 (2)	Primary Field Duplicates MS Laboratory Duplicate Field Rinsate Blanks (filtered sample only)
Hardness	6010 (calculated)	5 (1) 1 (2)	Primary Field Duplicates

Notes:

(1) Represents the number of primary samples including background samples.

(2) The number of MS/MSD samples are dependent upon the sampling schedule which may be impacted by weather, field conditions or access issues.
Each type of QA/QC sample will be collected at a rate of one per twenty primary samples or two per monitoring event, whichever is greater.

(3) See Table 9.

TABLE 9
PARCC DATA FOR AQUEOUS SAMPLES
PJP LANDFILL ENVIRONMENTAL MONITORING PLAN

MEASUREMENT PARAMETER	METHOD REFERENCE	LABORATORY PRECISION	FIELD & LABORATORY PRECISION	ACCURACY	COMPLETENESS [b]
Volatile Organics-TCL	SW846 8260B	see Table D-5	+/- 50%	see Table D-5	85%
Semi-Volatile Organics-TCL	SW846 8270C	see Table D-5	+/- 50%	see Table D-5	85%
Total Metals-TAL	SW846 6010 and 7000 series	see Table D-5	+/- 50%	see Table D-5	85%
Total Suspended Solids	EPA 160.2	+/- 20%	+/- 50%	75% - 125%	85%
Hardness	6010 (calculated)	+/- 20%	+/- 50%	75% - 125%	85%
Specific Conductance	Electrode	NA	+/- 50%	NA [a]	85%
pH	Electrode	NA	+/- 0.5 std pH units	NA [a]	85%
Turbidity	Electrode	NA	+/- 10% or 5 NTU	NA [a]	85%
Dissolved Oxygen	Electrode	NA	+/- 50 % or 0.5 mg/l	NA [a]	85%
Temperature	Electrode	NA	+/- 0.5 deg C	screening	85%
Redox Potential	Electrode	NA	+/- 100 mV	NA [a]	85%

NOTES:

NA = Not applicable
TCL = Target Compound List defined by CLP Statement of Work OLM03.2
TAL = Target Analyte List defined by CLP Statement of Work ILM03.1
SM = Standard Methods for the Examination of Water and Waste, 18th edition, 1992.
SW846 = Test Methods for Evaluating Solid Waste-Physical/Chemical Methods, SW-846, 3rd Edition, Update III, December 1996
EPA = Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, 1979 revised March, 1983.
Precision expressed as either percent relative standard deviation (%RSD) or relative percent difference (%RPD).

Accuracy expressed as percent recovery of matrix spike or laboratory control sample.
Representativeness and Comparability are non-quantitative parameters.
Reporting limits for each analyte which may be tested will be determined by the end use of the data, the analytical methodology employed and the analytical laboratory retained to perform the work.
Field and Laboratory precision based upon Region II validation guidelines.
[a] Accuracy goals that can not be defined as matrix spikes will not be performed on field parameters. Field meters will be standardized/calibrated at the beginning of each day.
[b] The goal for completeness of laboratory measurements is 90%, the goal for total completeness (sampling and analytical) is 85%.

TABLE 10
LABORATORY ACCURACY AND PRECISION* CRITERIA
FOR AQUEOUS SAMPLES

VOLATILE ORGANICS:	QC LIMITS	
Target Compound	**% Recovery**	**% RPD**
1,1-Dichloroethene	61%-145%	0%-14%
Trichloroethene	71%-120%	0%-24%
Benzene	76%-127%	0%-22%
Toluene	76%-125%	0%-13%
Chlorobenzene	75%-130%	0%-13%
Surrogate Compound		
Toluene-d8	88%-110%	Not Applicable
4-Bromofluorobenzene	86%-115%	Not Applicable
1,2-Dichloroethane-d4	80%-120%	Not Applicable
SEMIVOLATILE ORGANICS:	**QC LIMITS**	
Target Compound	**% Recovery**	**% RPD**
Phenol	12%-110%	0%-42%
2-Chlorophenol	27%-123%	0%-40%
1,4-Dichlorobenzene	36%-97%	0%-28%
N-Nitroso-di-n-propylamine	41%-116%	0%-38%
1,2,4-Trichlorobenzene	39%-98%	0%-28%
4-Chloro-3-methylphenol	23%-97%	0%-42%
Acenaphthene	46%-118%	0%-31%
4-Nitrophenol	10%-80%	0%-50%
2,4-Dinitrotoluene	24%-96%	0%-38%
Pentachlorophenol	9%-103%	0%-50%
Pyrene	26%-127%	0%-31%
Surrogate Compound		
Nitrobenzene-d5	35%-114%	Not Applicable
2-Fluorobiphenyl	43%-116%	Not Applicable
Terphenyl-d14	33%-141%	Not Applicable
Phenol-d5	10%-110%	Not Applicable
2-Fluorophenol	21%-110%	Not Applicable
2,4,6-Tribromophenol	10%-123%	Not Applicable
INORGANICS:	**QC LIMITS**	
Target Analyte	**% Recovery**	**% RPD**
Metals	75%-125%	0%-50% [a]

NOTES:

* - Accuracy and Precision Criteria based upon SW846 methodologies as well as NJDEP data validation guidelines.

[a] - Maximum % RPD is 50% if concentration is greater than five times the practical quantitation limit (PQL). If the concentration is less than five times the PQL, the precision limit is +/- 2 times the PQL.

TABLE 11
ANALYTICAL METHODS, SAMPLE CONTAINERS, PRESERVATION AND ANALYTICAL HOLD TIMES FOR AQUEOUS SAMPLES
PJP LANDFILL REMEDIAL DESIGN WORK PLAN

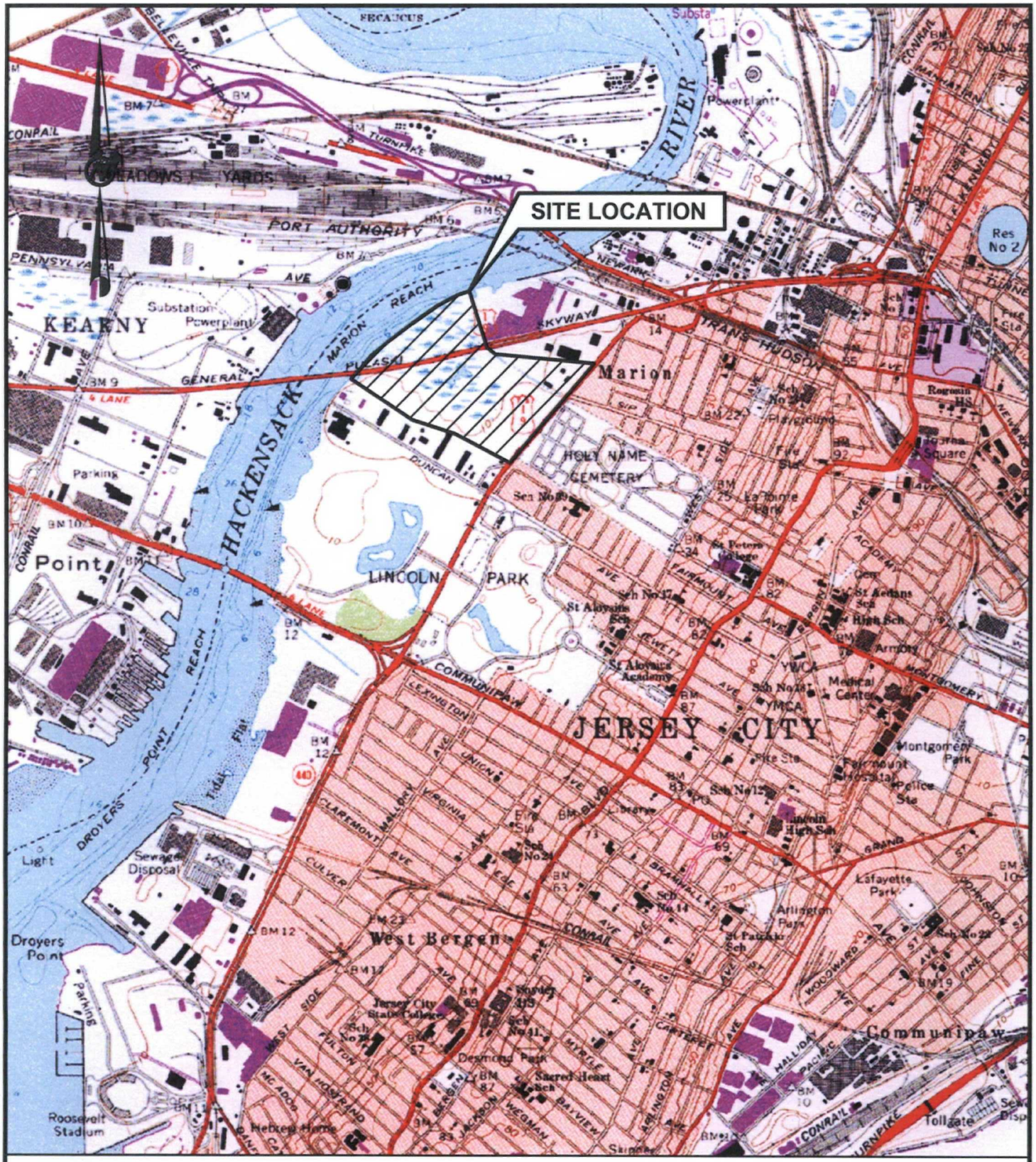
PARAMETER	CONTAINER	MINIMUM SAMPLE	PRESERVATION[d]	FIELD FILTERED	HOLD TIME[e]
Volatile Organics-TCL	3-40 ml G	3 - 40 ml		No	14 days[a]
Semi-Volatile Organics-TCL	2-1000 ml Amber G	1000 ml	Cool 4 deg C	No	7 days[b]
Metals-TAL (unfiltered)	1-500 ml P	250 ml	Cool 4 deg C;HNO_3,pH<2	No	180 days[c]
Total Suspended Solids	1-200 ml P or G	200 ml	Cool 4 deg C	No	7 days
Specific Conductance	flow-through cell	NA	None	No	Field Measurement
pH	flow-through cell	NA	None	No	Field Measurement
Turbidity	flow-through cell	NA	None	No	Field Measurement
Dissolved Oxygen	flow-through cell	NA	None	No	Field Measurement
Redox	flow-through cell	NA	screening	No	Field Measurement
Temperature	flow-through cell	NA	None	No	Field Measurement

NOTES:

[a] If preservation is not possible due to foaming, both preserved and unpreserved sample will be collected if possible. The hold time will be 7 days for unpreserved sample.
[b] 7 days for extraction, 40 days for analysis after commencement date of extraction.
[c] Hold time for Mercury is 28 days.
[d] Sample preservation is performed by sampler immediately upon sample collection.
[e] Hold time based upon day of sample collection not verified time of sample receipt.

1. EPA "Methods for Chemical Analysis of Water and Waste", 1979, revised 3/83.
2. SW846 is Test Methods for Evaluating Solid Waste, 3rd edition, Update III, December 1996.
3. SM "Standard Methods for the Examination of Water and Waste", 18th Edition, 1992.

TCL = Target Compound List defined by CLP Statement of Work OLM03.2
TAL = Target Analyte List List defined by CLP Statement of Work OLM03.1
P = Polyethylene
G = Glass



REFERENCES

1.) BASE MAP TAKEN FROM U.S.G.S. 7.5 MINUTE QUADRANGLE OF JERSEY CITY, NJ–NY DATED 1967, PHOTOREVISED 1981.

2000 0 2000
SCALE FEET

Golder Associates
Philadelphia USA

SCALE	AS SHOWN	TITLE	SITE LOCATION MAP
DATE	03/28/07		
DESIGN	CBM		
CADD	GLS		
CHECK	CBM		
REVIEW	MEC		
FILE No.	0036004R001		
PROJECT No.	003–6004 REV. 0	PJP LANDFILL	FIGURE OM-1

Drawing file: 0036004R001 FIG 2–1.dwg Mar 28, 2007 – 2:11pm

APPENDIX OMA

SAMPLING AND ANALYSIS PLAN

OPERATIONS AND MAINTENANCE (O&M) PLAN
PJP LANDFILL SITE
HUDSON COUNTY, NEW JERSEY

APPENDIX OMA

The Sampling and Analysis Plan will follow the same protocol and procedures that were followed in the Remedial Design Work Plan (RDWP), which were previously presented and approved.

APPENDIX OMB

HEALTH AND SAFETY/CONTINGENCY REQUIREMENTS FOR OPERATIONS AND MAINTENANCE ACTIVITIES

TO BE PROVIDED UPON COMPLETION OF THE REMEDIAL DESIGN

ATTACHMENT 01564-1

REMEDIAL DESIGN
HEALTH AND SAFETY CONTIGENCY PLAN

SECTION 01564

HEALTH AND SAFETY SPECIFICATIONS FOR CONSTRUCTION

PART 1 - GENERAL

1.01 PURPOSE

A. The purpose of Section is to establish minimum health and safety requirements for the CONTRACTOR to satisfy in the preparation of the CONTRACTOR's Site-specific Health and Safety Plan.

1.02 APPLICABILITY

A. These requirements shall be used by the Remedial Action CONTRACTOR's Health and Safety Officer (HSO) to assist in preparation of the CONTRACTOR's Site-specific Health and Safety Plan. These requirements shall not relieve the CONTRACTOR from compliance with any applicable State, Federal, or other health and safety requirements and safe construction practices even if not specifically identified in these requirements. These requirements shall not relieve the CONTRACTOR's complete responsibility for the Site's safety and security, including Health and Safety.

B. If, at any time, the REMEDIAL DESIGNER or GROUP'S REPRESENTATIVE is apprised of a safety hazard which demands immediate attention because of its high potential for harm to public travel, persons on or about the Work, or public or private property, the REMEDIAL DESIGNER or the GROUP'S REPRESENTATIVE shall have the right to order such safeguards to be erected and such precautions to be taken as necessary and the CONTRACTOR shall comply with such orders. In particular, the CONTRACTOR should take appropriate measures to protect workers from direct or indirect contact with solid waste, landfill gas and/or leachate from the landfill areas. Furthermore, the CONTRACTOR should take appropriate measures to protect workers from oxygen-deficient or explosive atmospheres that may be present in a confined-space entry.

If, under such circumstances, the CONTRACTOR does not or cannot immediately put the Work into proper and approved condition, or if the CONTRACTOR or his representative is not on the Site so that he can be notified immediately of the insufficiency of safety precautions, then the GROUP'S REPRESENTATIVE may put the Work into such a condition that it shall be, in his opinion, in all respects safe, and the CONTRACTOR shall pay all costs of such labor and materials. The fact that the REMEDIAL DESIGNER or the GROUP'S REPRESENTATIVE does not observe a safety hazard or does not order the CONTRACTOR to take remedial measures shall in no way relieve the CONTRACTOR of the entire responsibility for any costs, loss, or damage by any party sustained on account of the insufficiency of the safety precautions taken by the CONTRACTOR or by the REMEDIAL DESIGNER or the GROUP'S REPRESENTATIVE acting under authority of this Section.

C. It is the responsibility of the CONTRACTOR to take appropriate safety precautions to meet whatever conditions of hazard may be present during the performance of the Work, whether the hazard may or may not be reasonably foreseeable. The CONTRACTOR is alerted to the fact that it shall be his responsibility to anticipate and provide such additional safety precautions, facilities, personnel, and equipment as shall be necessary to protect life and property from whatsoever conditions of hazard are present or may be present.

1.03 RELATED SECTIONS

A. 01540 - Job Site Security

B. 01550 - Site Access and Traffic Control

C 01562 - Dust Control

D 01563 - VOC, Odor, and Vector Control

1.04 MINIMUM REQUIREMENTS

A. The CONTRACTOR shall prepare and implement a Site-specific Health and Safety Plan. The Health and Safety Plan shall conform with applicable State and Federal requirements, including, but not limited to:

1. Safety and Health Regulations promulgated by the U.S. Department of Labor: 29 CFR Part 1904 - Recording and Reporting Occupational Injuries and Illness, 29 CFR Part 1910 - Occupational Safety and Health Standards, and 29 CFR Part 1926 - Safety and Health Regulations for Construction.
2. U.S. Environmental Protection Agency Interim Standard Operating Safety Guides - Office of Emergency and Remedial Response - Hazardous Response Support Division, Rev. September 1982.
3. U.S. Environmental Protection Agency Medical Monitoring Program Guidelines.

B. The CONTRACTOR's Site-Specific Health and Safety Plan shall be prepared by the HSO. The HSO shall have experience with establishing and implementing Health and Safety Plans for hazardous waste site remediation projects and be a Certified Industrial Hygienist. The resume of the HSO shall be included in the Health and Safety Plan. The HSO shall be responsible for:

- Preparing and implementing the Health and Safety Plan;
- Updating the Health and Safety Plan as needed based on site conditions;
- Overall health and safety of the CONTRACTOR's and Subcontractor's personnel;
- Monitoring site health and safety conditions;
- Protecting surrounding community;
- Coordinating with area residents and other on-site CONTRACTOR's and subcontractors;

- Maintaining health and safety records; and,
- Identifying and providing a qualified Site Health and Safety Coordinator (SHSC) whom will implement the Site-specific Health and Safety Plan at the project site.

C. The CONTRACTOR's Health and Safety Plan shall incorporate the requirements contained herein and shall describe all actions to be taken to protect the health and safety of workers and the surrounding community. The plan shall identify all tasks to be undertaken by the CONTRACTOR and shall establish Health and Safety procedures for each task. The CONTRACTOR's Site-specific Health and Safety Plan shall be approved in writing by the HSO and shall be submitted to the GROUP'S REPRESENTATIVE, the REMEDIAL DESIGNER, the USEPA Region II, and NJDEP prior to the initiation of any fieldwork. Any modifications to the Plan shall be submitted to the REMEDIAL DESIGNER prior to construction. The GROUP'S REPRESENTATIVE, the USEPA, and/or NJDEP may comment on the CONTRACTOR's Site-specific Health and Safety Plan and any modifications thereto in addition to the REMEDIAL DESIGNER, but will not provide approval of the Site-specific Health and Safety Plan. The CONTRACTOR shall not mobilize to the Site until the plan has been received and addressed review comments on it from the GROUP'S REPRESENTATIVE, REMEDIAL DESIGNER, the USEPA, and NJDEP, unless otherwise approved by the GROUP'S REPRESENTATIVE.

D. Training requirements of all field personnel shall be specified in the Site-specific Health and Safety Plan. As a minimum, training in accordance with 29 CFR 1910.120 will be required for all personnel involved in intrusive activities (i.e., all below grade work and all grading and handling of soil or waste materials) and until all waste material is satisfactorily covered with 12 inches of soil or equivalent. Such training will also be required, at a minimum, for all crews who could be exposed to potentially hazardous materials during tie-ins, connections, and testing. Non-hazardous above-grade work (e.g., paving, seeding, signage) may not require 40-hour hazardous waste operations training, dependant upon proximity to exposed wastes.

E. To assist in preparation of the Site-specific Health and Safety Plan, the CONTRACTOR is encouraged to review existing Site documents including, but not limited to, the PJP Landfill Record of Decision (1995) and Statement of Work (1997) available from the GROUP'S REPRESENTATIVE or Public Repositories, for the CONTRACTOR's inspection.

F. The Site-specific Health and Safety Plan shall, at a minimum, include the following:

1. Identification of the HSO and the SHSC.
2. Monitoring of the worker's breathing zone and upwind and downwind of the work area for organic vapors and respirable dust.
3. Action levels for upgrading personal protective equipment (PPE) or implementing engineering controls shall be determined by the CONTRACTOR and explained in the Site-specific Health and Safety

Plan consistent with assuring health and safety of construction workers and potential on-site and off-site receptors.

4. The Work to be performed at the Site may, on occasion, need to be conducted in Level C or B PPE. The CONTRACTOR shall provide PPE for all personnel, who demonstrate they have the proper updated training for use of such equipment. The CONTRACTOR shall provide decontamination stations and shall maintain the stations daily during the Contract period. The CONTRACTOR shall provide receptacles for and disposal of all PPE used on-Site. PPE may be disposed of in accordance with the requirements for debris and waste soil disposal described in the Contract Documents. Used PPE shall be placed in appropriate containers or drums for off-site disposal.
5. A requirement that the CONTRACTOR always maintain at least one (1) person on-site trained in first aid and CPR.
6. Emergency phone numbers for the local hospital, ambulance service, police, and fire company shall be posted in conspicuous locations on-Site. A map showing the location of the nearest hospital and the most direct route to the hospital shall also be posted in conspicuous locations on-site.
7. Names and telephone numbers of emergency contacts for the CONTRACTOR and the GROUP'S REPRESENTATIVE shall be provided.
8. Contingency Plan describing medical emergency response, fire and explosion response, chemical exposure first aid, unforeseen circumstances, accident and incident reporting and emergency contacts.
9. An evaluation of potential site hazards.
10. Applicable material safety data sheets.
11. The Health and Safety Plan shall follow the general outline as provided in Attachment 01564-1 herein that contains the minimum elements for the Health and Safety Plan.
12. A Decontamination Plan, developed in conjunction with the Health and Safety Plan in accordance with Section 01300 – Submittals, of these Specifications. The Decontamination Plan shall include:
    a) Description of the procedures and materials used for the decontamination of all equipment that will be in contact with hazardous materials or media containing hazardous materials (i.e., soil, groundwater). Equipment would include such items as drill rigs, trucks, sampling equipment, field instruments, and hand-tools;
    b) No decontamination pad is currently available on-site. The Plan shall include a description and Site map showing the location of a temporary decontamination pad. The decontamination pad shall be constructed to collect all decontamination water for subsequent testing and disposal and be maintained throughout the construction period. Water supply must be provided, transported, and stored by the CONTRACTOR to the decontamination pad location.
    c) Description of the procedures used to characterize, contain, store, and dispose of wash water and personal protective equipment used during decontamination procedures.
13. Listing of Local, State, and Federal agencies and nearby residents that will be contacted in the event an accident occurs that could potentially

harm or threaten the health and safety of the CONTRACTOR's personnel, the general public, or the environment. The list should note which, if any, residents who may require special physical assistance in the event of an evacuation.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 RECORDKEEPING

A. All parties engaged in on-site activities shall read the CONTRACTOR's Site-specific Health and Safety Plan for the relevant tasks. The CONTRACTOR shall maintain documentation demonstrating compliance with this requirement on-Site. Written evidence of compliance with 29 CFR 1910.120 and applicable State and Federal requirements, for all parties engaged in on-Site activities, shall be maintained on-Site in the CONTRACTOR's files. Copies of such documentation shall be provided to the REMEDIAL DESIGNER and the GROUP'S REPRESENTATIVE.

*****END OF SECTION*****

APPENDIX E

TECHNICAL SPECIFICATIONS

SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. This Contract includes the provision of all personnel, supervision, services, materials, equipment, bonds, insurance, taxes, and all other incidentals and appurtenances necessary for the successful execution of the PJP Landfill Remedial Action Construction.

B. The Remedial Action Construction includes, but is not necessarily limited, the following activities:

- Mobilization and demobilization, including preparation of work plans, including but not limited to, a Health and Safety Plan;
- Provision and maintenance of all temporary service contracts, access roads, dust, VOC, odor and vector control, health and safety measures, site security, record documents, construction photographs, project management, home office support, and all field engineering and temporary facilities, including design thereof, required to perform the Work;
- Implementation and maintenance of all erosion and sedimentation control devices as described in, or required by, the Contract Documents;
- Dewatering, water diversion, excavation, relocation, placement, regrading, and compaction of solid waste (if necessary) and associated soils within the landfill and drainage ditches;
- Rehabilitation of river bank areas adjacent to the Sip Avenue Ditch;
- Excavation of existing material and placement on-site;
- Placement of grading fill on the landfill as required to meet the grades as shown on the Contract Drawings;
- Construction of approximately forty (40) acres of a multi-layer, modified solid waste cap, including associated gas and stormwater management systems;
- Modification of existing stormwater management system, as shown on the Contract Documents;
- Installation of thirty-three (33) passive gas vents;
- Revegetation of all disturbed areas outside of the multi-layer, modified solid waste cap area, and restoration of the Site to pre-construction conditions;
- Monitoring well installation;

- All health and safety equipment/monitoring, as well a monitoring and control of nuisances such as noise, dust and odor for site workers and the surrounding community;

- Preparation of progress reports, submittals, and Contract Record Documents.

C. All Work described above shall be performed in strict accordance with the Contract Documents, the CONTRACTOR's Health and Safety Plan, and the Remedial Design/Remedial Action Administrative Consent Order/Amendment. Guidance on Site hazards which must, at a minimum, be addressed in the CONTRACTOR's Health and Safety Plan is provided in the Health and Safety Specifications for Construction (Section 01564).

1.02 QUANTITIES

A. The OWNER reserves the right to alter, increase or decrease the quantities of Work to be performed at any time when and as found necessary, and the CONTRACTOR shall perform the Work as altered, increased or decreased. Payment for such increased or decreased quantity will be made in accordance with the Contract. No allowance will be made for any change in anticipated profits nor shall such changes be considered as waiving or invalidating any conditions or provisions of the Contract.

1.03 NOISE LIMITS AND WORK PERIOD

A. Noise must be curtailed between 7:00 p.m. and 7:00 a.m. Activities between those hours may be undertaken only with the prior approval of the GROUP's REPRESENTATIVE.

1.04 PRELIMINARY CONSTRUCTION SCHEDULE

A. Each Bidder shall prepare and submit its anticipated construction schedule with its bid.

1.05 STOCKPILE AND STAGING AREAS

A. Possible areas designated for the CONTRACTOR's staging and stockpile area are identified in the Construction Drawings. Other areas proposed by the CONTRACTOR will be considered but must be approved by the GROUP's REPRESENTATIVE.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

A. In case of conflicts between various parts of the Contract Documents, the GROUP's REPRESENTATIVE shall be notified to initiate resolution.

B. "Related Sections" which are contained in the individual Specifications of the Contract Documents are not comprehensive and all inclusive. It is the CONTRACTOR's responsibility to become familiar with the Contract Documents and interrelationships. Any inconsistencies in the Contract Documents identified by the CONTRACTOR shall be brought to the GROUP's REPRESNTATIVE to resolve.

*****END OF SECTION*****

SECTION 01015

DEFINITIONS

PART 1 - GENERAL

1.01 PARTICIPANTS

A. NJDEP: The word "NJDEP" means the New Jersey Department of Environmental Protection, 401 East State Street, P.O. Box 413, Trenton, New Jersey 08625.

B. USEPA: The word "USEPA" means the US Environmental Protection Agency, Region 2, Waste Management Division, 290 Broadway, 19th Floor, New York, New York 10007.

C. GROUP: The word "GROUP" means Waste Management of New Jersey, Inc. and CWM Chemical Services, L.L.C.. The GROUP is also collectively known as CCS.

D. GROUP's REPRESENTATIVE: The words "GROUP's REPRESENTATIVE" mean a representative of CCS, identified in the Contract Agreement.

E. CONTRACTOR: The word "CONTRACTOR" means the individual, partnership, firm, corporation or any combination thereof, including SUBCONTRACTORs, contracting with the GROUP for work covered by these Specifications.

F. REMEDIAL DESIGNER: The words "REMEDIAL DESIGNER" means Golder Associates Inc., 200 Century Parkway, Suite C, Mount Laurel, NJ 08054. The REMEDIAL DESIGNER will be responsible for monitoring the CONTRACTOR's work in relation to the schedule and for conformance with the Contract Documents. The REMEDIAL DESIGNER will receive and review Shop Drawings and other material submittals from the CONTRACTOR and submit them to the GROUP's REPRESENTATIVE, if required, for review. The REMEDIAL DESIGNER will also coordinate monitoring activities with the QUALITY ASSURANCE OFFICIAL, review all design and/or Specification change requests, and will provide clarifications to the Contract Documents.

G. QUALITY ASSURANCE OFFICIAL (QAO): To be determined. The QUALITY ASSURANCE OFFICIAL will be responsible for overseeing and implementing the Construction Quality Assurance Plan to document that the Remedial Action construction has been completed in general conformance with the Contract Documents. The QUALITY ASSURANCE OFFICIAL is responsible for reviewing each stage of construction activities and may reject materials and/or workmanship provided by the CONTRACTOR that are not in compliance with the Contract Documents.

H. SUBCONTRACTOR: The word "SUBCONTRACTOR" means the individual, partnership, firm, corporation or any combination thereof, contracting with the CONTRACTOR for work covered by these Specifications.

I. MANUFACTURER: The word "MANUFACTURER" means the individual, partnership, firm, corporation or any combination thereof, which produces or supplies materials used to by the CONTRACTOR to complete the Work.

1.02 CONTRACT DEFINITIONS

A. ADDENDA: Written or graphic instruments issued prior to the opening of Bids which clarify, correct or change the Bidding Documents or the Contract Documents.

B. APPLICATION FOR PAYMENT: The form accepted by the GROUP's REPRESENTATIVE which is to be used by the CONTACTOR in requesting progress or final payments and which is to include such supporting documentation as required by the Contract Documents.

C. BIDDING DOCUMENTS: Includes the Advertisement for Proposals, Information for Proposers, Form of Proposal, Form of Contract, Specifications, and the "Contract Documents" (including all Addenda issued prior to receipt of Bids).

D. BID PROPOSAL: A document submitted by an interested party in response to the GROUP's request for proposal which includes the proposed methods, schedule, and costs for the interested party to perform the Work.

E. BONDS: Bid, performance and payment bonds and other instruments of security.

F. CHANGE ORDER: A document recommended by the GROUP's REPRESENTATIVE, which is signed by the CONTRACTOR and the GROUP authorizing an addition, deletion or revision in the Work, and/or an adjustment in the Contract Price or the Contract Time, issued on or after the Effective Date of the Agreement.

G. COMPETENT PERSON: The words "Competent Person" mean an individual provided by the CONTRACTOR who is qualified and experienced to implement, supervise, and inspect the Work.

H. CONTRACT DOCUMENTS: The Contract Documents include Specifications, all Addenda, the Form of Agreement, General and Supplemental Conditions, Bid Proposal documents and Contract Drawings.

I. CONTRACT PRICE: The moneys payable by the GROUP to the CONTRACTOR under the Contract Documents. Minor changes to the Contract Price ($10,000 or less) may be approved by the GROUP's REPRESENTATIVE.

J. CONTRACT TIME: The number of days or the date stated in the Form of Agreement for completion of the Work. The GROUP's REPRESENTATIVE may approve minor changes to the Contract Time (fourteen (14) days or less), as long as the total number of days beyond the contact does not exceed thirty (30) days. Major schedule changes; i.e., greater than fourteen (14) days for a single task and greater than thirty (30) days for all tasks, must be approved by the GROUP.

K. DEFECTIVE: An adjective which when modifying the word Work refers to Work that is unsatisfactory, faulty or deficient, or does not conform to the Contract Documents, or does not meet the requirements of any inspection, reference standard, test or approval referred to in the Contract Documents, or has been damaged prior to the GROUP's REPRESENTATIVE's recommendation of final payment (unless responsibility for the protection thereof has been assumed by GROUP at Substantial Completion).

L. DEFICIENCY: An element of completed work which has been identified as Defective.

M. DRAWINGS/CONTRACT DRAWINGS: The final design drawings which show the character and scope of the Work to be performed and which have been prepared or approved by the REMEDIAL DESIGNER and are included in the Contract Documents.

N. FIELD ORDER: A written order issued by the REMEDIAL DESIGNER that orders minor changes in the Work but does not involve change in the Contract Price or the Contract Time and does not require approval by the GROUP's REPRESENTATIVE.

O. FORM OF AGREEMENT: A legal contract between the CONTRACTOR and the GROUP which includes, but is not limited to the Contract Price and Contact Time for the Work.

P. GENERAL SPECIFICATIONS: Sections contained in Division 1 of the Specifications.

Q. Install: Provide and install, unless otherwise noted.

R. INSTALLER: The word "Installer" means the individual, partnership, firm, corporation or any combination thereof, contracting with the CONTRACTOR for work covered by these Specifications.

S. LAWS AND REGULATIONS/LAWS OR REGULATIONS: Laws, rules, regulations, ordinances, codes, and/or orders of any governmental entity having jurisdiction over the Work. The State of New Jersey shall be the jurisdiction for any and all disputes.

T. NOTICE OF AWARD: The written notice by the GROUP to the apparent successful Bidder stating that, upon compliance by the apparent successful Bidder with the conditions precedent enumerated therein and, within the time specified, the GROUP will sign and deliver the Agreement.

U. NOTICE TO PROCEED: A written notice given by the GROUP's REPRESENTATIVE to the CONTRACTOR fixing the date on which the Contract Time will commence to run and on which the CONTRACTOR shall start to perform the CONTRACTOR's obligations under the Contract Documents.

V. PRODUCTS: The term "material" or "products" shall include products, equipment, assembly methods, manufacturer, brand, trade name, or other description. References to "equal," "approved equal," or similar terms mean that approval from the REMEDIAL DESIGNER is required. All materials shall be

new and specifically purchased for the Work under this Contract, unless as otherwise accepted by the GROUP's REPRESENTATIVE or specified in the Contract Documents. Do not use materials and equipment removed from existing premises, except as specifically permitted by the Contract Documents.

W. PROVIDE OR PROVIDED: Means "furnish and install" to the satisfaction of the GROUP's REPRESENTATIVE.

X. QUALITY ASSURANCE: Means measures taken by the GROUP's REPRESENTATIVE through the QAO to independently assess if the Contractor is in compliance with the plans and specifications for the project.

Y. QUALITY CONTROL: Means measures taken by the CONTRACTOR to determine compliance with the requirements for materials and workmanship as stated in the Contract Documents.

Z. RECORD DOCUMENTS: Includes a complete set of Contract Documents marked such that any field changes are readily identified. These Record Documents shall be maintained by the CONTRACTOR on-site, and upon Contract completion, shall be sealed and provided to the GROUP.

AA. REFERENCED STANDARD: A recognized standard which is identified in a Specification and incorporated by reference.

AB. SCHEDULE OF VALUES: The CONTRACTOR's itemized listing of activities of the Work, set forth, in a form acceptable to the GROUP's REPRESENTATIVE, the CONTRACTOR's allocation of the Contract Price by activity. These same activities shall be incorporated into the CONTRACTOR's progress schedule.

AC. SHOP DRAWINGS: All drawings, diagrams, illustrations, schedules, and other data which are specifically prepared by or for the CONTRACTOR to illustrate some portion of the Work; and all illustrations, brochures, standard schedules, performance charts, instructions, diagrams and other information prepared by a Supplier and submitted by the CONTRACTOR to illustrate material or equipment for some portion of the Work, and that must be maintained on-site.

AD. SUBSTANTIAL COMPLETION: The Work (or a specified part thereof) has progressed to the point where, in the opinion of the GROUP's REPRESENTATIVE as evidenced by the GROUP's definitive certificate of Substantial Completion, it is sufficiently complete, in accordance with the Contract Documents, so that final payment is due. The terms "substantially complete" and "substantially completed" as applied to any Work refer to Substantial Completion thereof.

AE. SUCCESSFUL BIDDER: In the event the GROUP makes an award, "Successful Bidder" means the Bidder to whom the GROUP makes an award.

AF. SUPPLIER: A manufacturer, fabricator, distributor, material man, or vendor.

AG. TECHNICAL SPECIFICATIONS/SPECIFICATIONS: Those portions of the Bidding Documents consisting of written technical descriptions of materials, equipment, construction systems, standards and workmanship as applied to the Work and certain administrative details applicable thereto. In particular,

Technical Specifications/Specifications includes Divisions 1 through 3, inclusive, of the Contract Documents.

AH. TRANSPORTATION AND HANDLING: All material shall be shipped, delivered, and stored in the manufacturer's undamaged crating and packaging, except as otherwise approved by the REMEDIAL DESIGNER. All materials shall be protected and stored off the ground on blocking or pallets and covered as appropriate. All material shall be protected from damage due to weather, vandalism, etc.

AI. UNIT PRICE: The price of a unit of Work as shown in the CONTRACTOR's Schedule of Values.

AJ. WORK: The entire completed construction, or the various separately identifiable parts thereof, required to be furnished under the Contract Documents. Work is the result of performing services, furnishing labor and furnishing and incorporating materials and equipment into the construction, all as required by the Contract Documents.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 01041

PROJECT COORDINATION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Management of the Project (Work) shall be through the use of a logical method of construction planning, inspection, scheduling and cost value documentation.

B. The Work under this Section includes all inspections and coordination by the CONTRACTOR necessary for the proper and complete performance of the Work.

C. This Section applies to the Work of every Division and every Section of these Specifications.

1.02 SUBMITTALS

The CONTRACTOR shall submit a construction schedule in accordance with Section 01300 of these Specifications, and Article 1.06 herein.

1.03 SITE CONDITIONS

A. Inspection

1. Prior to performing any Work under a Section, the CONTRACTOR shall carefully inspect the installed Work of other trades and verify that all such Work is complete to the point where the Work under that Section may properly commence.
2. The CONTRACTOR shall verify that all materials, equipment and products to be installed under a Section will be installed in accordance with the Contract Documents and pertinent reviewed Shop Drawings.

B. Discrepancies

1. In the event of a discrepancy, immediately notify the GROUP'S REPRESENTATIVE.
2. Do not proceed with the installation in areas of discrepancy until all such discrepancies have been fully resolved.

C. Mobilization

1. Cooperate with the GROUP'S REPRESENTATIVE in allocation of mobilization areas, field offices, sheds, access, traffic and parking facilities.
2. During construction, coordinate use of Site and facilities through the GROUP'S REPRESENTATIVE.
3. Comply with the Contract Documents and coordinate with the GROUP'S REPRESENTATIVE for intra-project communications,

submittals, reports and records, schedules, coordination, drawings, and resolution of ambiguities and conflicts.

4. Comply with the instructions of the GROUP'S REPRESENTATIVE for use of temporary utilities and construction facilities.

5. The CONTRACTOR shall provide field engineering, including surveying, and layout in accordance with Section 01050, and shall coordinate such activities with the GROUP'S REPRESENTATIVE.

1.04 COORDINATION

A. Carefully schedule and coordinate the Work with all suppliers, utility companies, SUBCONTRACTORs, and other trades to ensure proper and adequate interface of the Work of other trades and SUBCONTRACTORs with the Work of every Section of these Specifications.

B. The CONTRACTOR shall coordinate operations with all utility companies in or adjacent to the area of the CONTRACTOR's Work. The CONTRACTOR shall require said utility companies to identify in the field their property and provide drawings as necessary to locate them.

C. The CONTRACTOR shall coordinate the Work with the requirements for quality control or quality assurance testing by the QUALITY ASSURANCE OFFICIAL. The CONTRACTOR shall provide access to the Work for inspection and shall stop portions of the Work as necessary to allow for inspection.

D. Prior to initiating Work and during performance of Work (as required) CONTRACTOR shall coordinate as necessary with appropriate local officials including: local police, fire and health departments, hospital, township government, local POTW and New Jersey Department of Transportation so that the Work is performed without interruptions and in compliance with federal, state, and local requirements.

1.05 OTHER COORDINATION

A. Submit requests for clarification of the Contract Documents and obtain clarification through the GROUP'S REPRESENTATIVE. The GROUP's REPRESENTATIVE may provide further coordination with the REMEDIAL DESIGNER.

B. Process requests for substitutions and change orders through the GROUP'S REPRESENTATIVE a minimum of 30 calendar days prior to commencement of Work in affected areas.

C. Deliver closeout submittals for review, and preliminary inspection reports for transmittal, to the GROUP'S REPRESENTATIVE.

D. Notify the GROUP'S REPRESENTATIVE when the Work is considered substantially complete, in accordance with Section 01700 of these Specifications. Accompany the GROUP'S REPRESENTATIVE, REMEDIAL

DESIGNER, and QUALITY ASSURANCE OFFICIAL on a preliminary final inspection.

E. Comply with the instructions of the GROUP'S REPRESENTATIVE for completion of any items of the Work determined not to be substantially complete by the preliminary final inspection.

F. Provide Record Documents in accordance with Section 01720 – Record Documents of these Specifications.

1.06 SCHEDULES

A. The CONTRACTOR shall submit the initial Construction Schedule to the GROUP'S REPRESENTATIVE for review in accordance with Section 01300 - Submittals of these Specifications. After review, revise and resubmit the Construction Schedule to the GROUP'S REPRESENTATIVE for approval.

B. During the progress of the Work, the CONTRACTOR shall revise and resubmit the Construction Schedule as requested by the GROUP'S REPRESENTATIVE, and in any case, at least monthly. Submit a revised Construction Schedule with each Application for Payment.

C. The CONTRACTOR shall prepare all schedules using Microsoft Project or equivalent software program, as favorably reviewed by the GROUP's REPRESENTATIVE. The CONTRACTOR's schedule shall be resource (labor and equipment) loaded, show critical path, start and end dates, and float time of various stages of the work. Copies shall be provided in hard copy and electronically (i.e., via e-mail and/or computer file) to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL, as requested by the GROUP'S REPRESENTATIVE.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 01050

FIELD ENGINEERING/SURVEYING

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall be responsible for providing surveying services for accurate location of all features of the Work and for establishing all proposed grades. The CONTRACTOR shall be responsible for all surveys and calculations for layout of the Work, measurements for payment quantities, verification of grades, verification of the thickness of layers/lifts, and the preparation and maintenance of project Record Documents.

B. The CONTRACTOR shall employ a New Jersey Registered Land Surveyor who is acceptable to the REMEDIAL DESIGNER.

C. The CONTRACTOR shall submit evidence of the Surveyor's errors and omissions insurance coverage in the form of an Insurance Certificate acceptable to the GROUP with limits and additional insureds as specified in the Contract Documents.

D. The CONTRACTOR shall make all measurements and check all dimensions necessary for the proper performance of the Work in accordance with the Contract Documents. During the execution of the Work, the CONTRACTOR shall make all necessary measurements to ensure the accurate performance of the Work.

E. The CONTRACTOR shall be responsible for submitting survey information to be used by the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER in verifying payment quantities.

F. The GROUP'S REPRESENTATIVE may retain another New Jersey Registered Land Surveyor to independently verify survey lines and grades and payment quantities. In the event of a discrepancy, the surveyor retained by the GROUP's REPRESENTATIVE will govern. The CONTRACTOR and the CONTRACTOR's surveyor shall be responsible for cooperating with the surveyor retained by the GROUP'S REPRESENTATIVE and for submitting copies of any survey calculations and data, if required by the REMEDIAL DESIGNER. No separate payment shall be made for cooperating with the surveyor or providing copies of survey calculations.

1.02 QUALITY CONTROL

A. The CONTRACTOR's surveyor shall be a qualified and Professional Land Surveyor, licensed in the State of New Jersey. This surveyor shall have a minimum of five (5) years experience in construction surveying layout and

maintenance of as-built construction drawings with a record of performing horizontal and vertical control requirements as stated in the Contract.

B. All surveying personnel who may come in contact with refuse and/or may work within excavations must have, at a minimum, training in accordance with 29 CFR 1910.120.

1.03 SUBMITTALS

A. The CONTRACTOR shall submit for approval by the REMEDIAL DESIGNER the name, address, telephone number, and qualifications of the Surveyor prior to initiation of any survey work.

B. The CONTRACTOR shall submit documentation verifying the accuracy of the survey and the Work to REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL upon request.

C. The CONTRACTOR's Surveyor shall submit sealed and signed Record Documents and survey notes, which state that the elevations and locations of Site-constructed features are in conformance with the Contract Documents, to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL at the completion of each phase of the Work requiring the services of the Surveyor.

D. No Work shall be covered until the as-built surveying has been performed. If the Work has been covered before the survey has been completed, that portion of the Work will be uncovered, surveyed, and reconstructed at the CONTRACTOR's expense.

E. Submit the above items in accordance with Section 01300 – Submittals, of these Specifications.

1.04 RECORD DOCUMENTS

A. The CONTRACTOR shall prepare and submit Record Documents to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL in accordance Section 01300 – Submittals of these Specifications.

B. A complete, accurate log of control and survey work, as it progresses, shall be maintained at the Site by the CONTRACTOR and submitted to the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL upon request.

C. Upon completion of the Work, a complete set of Record Documents must be submitted by the CONTRACTOR to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL for review and acceptance under the provisions of Section 01720 – Record Documents of these Specifications. Copies of all required survey data, calculations, and summary tables, sealed and signed by the Surveyor, shall be submitted.

1.05 SURVEY REQUIREMENTS

A. Provide field-engineering services using recognized engineering survey practices.

B. Establish line and grade as required to complete the Work. Identify, locate and/or layout the following:

1. Existing underground pipes and/or structures to be regraded, modified, or connected to; or, are located in such manner as to affect any portion of the Work. Include depths to pipe to assist with the progression of excavation.
2. Line and grade for measurement and payment purposes (i.e., determination of in-place quantities). The CONTRACTOR shall provide sufficient survey to verify the quantities included in Applications for Payment.
3. As-Built survey information shall include, but not be limited to, the following:
   a. Alignment and profile of all underground features;
   b. Delineation of the Sip Avenue Ditch, Hackensack River Bank, and surface water management system;
   c. The areas of multi-layer, modified solid waste cap placement;
   d. Location of fences and gates;
   e. Subgrade elevations;
   f. Vertical and horizontal locations of the groundwater monitoring wells and landfill passive gas vents and associated piping and appurtenances;
   g. The finished grade elevations for waste cap surfaces, piping, waterways and wells at a contour interval of one (1) foot, to an accuracy of ± 0.01 feet;
   h. The finished grade elevations for grassed areas at a contour interval of one (1) foot to an accuracy of ± 0.1 feet;
   i. Other visible features in the construction area;
   j. Regrading activities to verify fill grades, fill thickness, and fill extent; and,
   k. Any additional requirements of Section 01720 – Record Documents of these Specifications.

C. Verify layouts by same means prior to backfilling.

1.06 SURVEYS FOR MEASUREMENT FOR PAYMENT

A. The CONTRACTOR shall perform surveys, where required, to determine the quantities of Work performed/conducted, including control surveys to establish appropriate surveying references. Notify the REMEDIAL DESIGNER at least one (1) week prior to the start of any survey Work.

1. At a minimum, surveys shall be performed both prior to and following the completion of regrading, but prior to backfilling. The CONTRACTOR may also perform interim surveys to support an Application for Payment.

2. Perform surveys to locate all wells. The horizontal locations shall be tied into the existing Site coordinate system to an accuracy of 0.1 feet. Elevations shall be surveyed to an accuracy of 0.01 feet.
3. The CONTRACTOR will sign the Surveyor's field notes to designate CONTRACTOR's review and approval thereof, or keep independent field notes, and shall calculate and certify quantities for payment purposes.
4. Copies of all original survey data, calculations, and summary tables shall be submitted with all Applications for Payment and with the Project Record Documents.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 INSPECTION

A. All surveys for this Contract must use, and be referenced to, the Site's existing coordinate system (Northing, Easting, and elevation), which is shown in the Contract Documents.

B. The CONTRACTOR shall verify the locations of the Site reference and survey control points prior to starting the Work. The REMEDIAL DESIGNER must be promptly notified of any discrepancies discovered by the CONTRACTOR.

C. Survey control points are as shown on the Contract Drawings.

3.02 SURVEY REFERENCE POINTS

A. The CONTRACTOR shall take measures to protect Site reference and survey control points prior to starting the Work, and must preserve permanent reference points throughout construction. Site reference and survey control points may not be relocated without prior written notice by the REMEDIAL DESIGNER and GROUP'S REPRESENTATIVE.

B. The REMEDIAL DESIGNER and GROUP'S REPRESENTATIVE shall be immediately notified of loss, damage or destruction of any reference point, or relocation required because of changes in grades or other reasons. The CONTRACTOR shall replace disturbed survey control points based on original survey control at the CONTRACTOR's own expense.

C. All horizontal and vertical control coordinates (i.e., Northings, Eastings, and elevations) of benchmarks and survey control points shall be determined (and recorded) with a maximum permissible error of ±0.10 foot in any horizontal coordinate and ±0.01 foot in any vertical coordinate.

D. All horizontal and vertical control coordinates are to be referred to the local coordinate system.

E. Survey and clearly mark the limits of all Work areas.

3.03 SURVEY REQUIREMENTS

A. The CONTRACTOR shall reference all survey and data reference points to permanent benchmarks and record the locations of survey control points, with horizontal and vertical data, on the Project Record Documents.

B. The CONTRACTOR shall re-verify layouts periodically during construction by the same means as the original layout.

C. Prior to construction, CONTRACTOR shall locate and clearly mark all areas of proposed construction.

D. Pre-construction surveys shall be performed in the construction area to establish baseline grade elevations. Surveys shall be performed prior to the staging of materials or equipment, and grade stakes shall be used to control excavating and filling. No payment will be made for the excavation of materials placed on-Site by the CONTRACTOR.

*****END OF SECTION*****

SECTION 01200

PROJECT MEETINGS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The Work under this Section includes all scheduling and administering of Pre-Construction and Progress Meetings, as specified herein, and necessary for the proper and complete performance of the Work.

B. Scheduling and administration by the REMEDIAL DESIGNER shall include the following:

1. Prepare an agenda for each meeting;
2. Make time arrangements for the meetings;
3. Preside at the meetings;
4. Record minutes and include significant proceedings and decisions; and,
5. Distribute copies of the minutes to participants within five (5) working days after each meeting.

C. The CONTRACTOR shall make physical arrangements for meetings. Representatives of the CONTRACTOR, SUBCONTRACTORs, Installers, and suppliers attending the meetings shall be qualified and authorized to act on behalf of the entity each represents. The GROUP'S REPRESENTATIVE will ascertain that the Work is expedited consistent with the Contract Documents and the Construction Schedule.

1.02 PRE-CONSTRUCTION MEETING

A. The GROUP'S REPRESENTATIVE shall schedule the Pre-construction meeting following issuance of the Notice to Proceed.

B. Representatives of the following parties are to be in attendance at the meeting:

1. GROUP'S REPRESENTATIVE, if appropriate;
2. CONTRACTOR and Superintendent;
3. Major SUBCONTRACTORs;
4. Representatives of governmental or regulatory agencies, if appropriate;
5. REMEDIAL DESIGNER; and,
6. QUALITY ASSURANCE OFFICIAL.

C. The agenda for the Pre-construction meeting shall include, at a minimum, the following:

1. Distribute and discuss a list of major SUBCONTRACTORs/suppliers and a tentative Construction Schedule;
2. Identification of critical path work sequencing;
3. Designation of responsible personnel and emergency telephone numbers;

4. Processing of Field Change Orders;
5. Schedule for submittal of Shop Drawings, product data and samples;
6. Format for Application for Payment, submittal cutoff date, paydate and retainage;
7. Procedures for maintaining Record Documents;
8. Use of premises, including office and storage areas, and the requirements of the GROUP'S REPRESENTATIVE and regulatory agencies;
9. Major equipment deliveries and priorities;
10. Site-specific Health and Safety Plan requirements;
11. Security procedures;
12. Housekeeping procedures;
13. Work hours;
14. Coordination with Landowners/Tenants; and,
15. Site access, traffic maintenance and control, and laydown/storage areas.

1.03 PROGRESS MEETINGS

A. The GROUP'S REPRESENTATIVE will schedule regular weekly (or other appropriate frequency) meetings to be held on-site.

B. Hold meetings as the progress of the Work dictates.

C. The meetings shall be held at the Site in offices provided by the CONTRACTOR.

D. Representatives of the following parties are to be in attendance at the progress meetings:

1. GROUP'S REPRESENTATIVE;
2. CONTRACTOR and Superintendent;
3. Major SUBCONTRACTORs as pertinent to the agenda;
4. REMEDIAL DESIGNER;
5. QUALITY ASSURANCE OFFICIAL;
6. Representatives of governmental or other regulatory agencies, as appropriate; and
7. Landowner representative, as appropriate.

E. The minimum agenda for Progress Meetings shall include the following:

1. Review and approve minutes of previous meetings;
2. Review Work progress since last meeting;
3. Discuss field observations, problems and decisions;
4. Identify problems which impede Construction Schedule;
5. Review off-Site fabrication problems and product delivery schedule;
6. Review the CONTRACTOR's corrective measures and procedures to regain planned Construction Schedule, if applicable;
7. Review submittal schedule; expedite as required to maintain Construction Schedule;
8. Maintenance of quality and work standards;
9. Review construction safety issues;

10. Review proposed changes for their effect on the Construction Schedule and completion date; and,
11. Complete other current business.

1.04 APPLICATION FOR PAYMENT MEETINGS

A. Schedule meeting for Applications for Payment as required by the Contract Documents or as requested.

B. Representatives of the following parties are to be in attendance at the meetings:

1. GROUP'S REPRESENTATIVE;
2. REMEDIAL DESIGNER;
3. CONTRACTOR; and,
4. QUALITY ASSURANCE OFFICIAL, as appropriate.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Wherever submittals are required hereunder and elsewhere in the Contract Documents, all such submittals by the CONTRACTOR shall be submitted to the REMEDIAL DESIGNER, unless otherwise noted..

B. Prior to mobilization onto the Site and (except where noted otherwise below) within ten (10) days after the date of commencement as stated in the Notice to Proceed, the CONTRACTOR shall submit to the REMEDIAL DESIGNER:

1. Detailed Site-specific Health and Safety Plan developed in accordance with all applicable laws and regulations, OSHA 29 CFR 1910 and 1926, and Section 01564 – Health and Safety Specifications for Construction, of these Specifications.
2. Construction Schedule that indicates the starting and completion dates of the various stages of the Work, resource (labor and equipment) loading, float time, and critical path analysis using Microsoft Project or equivalent software program.
3. A preliminary schedule of submittals. The schedule should include Shop Drawing, sample, and proposed substitute or "or equal" submittals. The CONTRACTOR shall thoroughly read each section of the Specifications and carefully review the Contract Drawings and reference the appropriate section of the Specifications for each submittal. The submittals comprising the schedule shall be numbered in a systematic and logical fashion that allows for future additions or deletions. This schedule shall be a prerequisite to the first Application for Payment.
4. List of potential applicable permits, permit equivalencies and approvals, which may be required to perform the Work.
5. Erosion and Sedimentation Control Plan in accordance with Section 02125 – Erosion and Sedimentation Control of these Specifications.
6. Site Access and Traffic Control Plan in accordance with Section 01550 Site Access and Traffic Control, of these Specifications.
7. Site Security Plan in accordance with Section 01540 – Job Site Security, of the Specifications.
8. Excavation Support Plan in accordance with Section 02220 - Excavation of the Specifications.
9. Site Decontamination/Off-Site Disposal Plan.
10. Qualifications of all SUBCONTRACTORS and Materials Testing Laboratories.
11. Qualifications as the Remedial Action CONTRACTOR, in accordance with the requirements of the ACO/Amendment, for submittal to USEPA.

C. Any details deemed by the CONTRACTOR to be required for the Work, but not indicated in the Contract Documents, shall be submitted by the CONTRACTOR for review by the REMEDIAL DESIGNER at least twenty-five (25) calendar days prior to the construction of that portion of the Work. Identifying any such details is the responsibility of the CONTRACTOR.

1.02 GENERAL SUBMITTALS

A. Normally, a separate transmittal form shall be used for each specific item or class of material or equipment for which a submittal is required. Transmittal of a submittal of various items using a single transmittal form will be permitted only when the items taken together constitute a manufacturer's "package" or are so functionally related that expediency indicates review of the group or package as a whole. A multiple-page submittal shall be collated into sets, and each set shall be stapled or bound, as appropriate, prior to transmittal to the REMEDIAL DESIGNER.

B. Submittals must be clearly legible. When only a particular portion of a standard-issue material, such as a manufacturer's catalog or data sheet, is relevant to a submittal, the relevant portion(s) must be clearly indicated on all copies and all non-relevant portion(s) must be struck through on all copies.

C. Except as may otherwise be provided herein, the REMEDIAL DESIGNER will return each submittal to the CONTRACTOR with its comments noted thereon, within fifteen (15) calendar days following their receipt by the REMEDIAL DESIGNER. One (1) copy will be returned to the CONTRACTOR, plus any extra copies submitted as described in Article 1.02A above. It is considered reasonable that the CONTRACTOR shall make a complete and acceptable submittal to the REMEDIAL DESIGNER by either the first or second submission of a submittal item. The GROUP reserves the right to withhold monies otherwise due the CONTRACTOR to cover additional costs of the review beyond the second submittal. Any consequences or delays due to unacceptable submittals will not be cause for extensions in schedule or additional cost.

D. If the submittal is returned to the CONTRACTOR marked "NO EXCEPTIONS TAKEN," formal revision and resubmission of said submittal will not be required.

E. If the submittal is returned to the CONTRACTOR marked "MAKE CORRECTIONS NOTED," formal revision and resubmission of said submittal will not be required. Record Documents must reflect corrections.

F. If the submittal is returned to the CONTRACTOR marked "AMEND-RESUBMIT," the CONTRACTOR shall revise said submittal and shall resubmit the required number of copies of said revised submittal to the REMEDIAL DESIGNER.

G. If the submittal is returned to the CONTRACTOR marked "REJECTED-RESUBMIT," the CONTRACTOR shall revise said submittal and shall resubmit the required number of copies of said revised submittal to the REMEDIAL DESIGNER.

H. Fabrication of an item may begin only after the REMEDIAL DESIGNER has favorably reviewed the pertinent submittals and returned the said submittals to the CONTRACTOR marked either "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED." Corrections indicated on submittals shall be considered as changes necessary to meet the requirements of the Contract Documents and shall not be taken as the basis of claims for extra work or payment. Items fabricated without prior favorable review will not qualify for payment.

I. All CONTRACTOR submittals shall be carefully reviewed by an authorized representative of the CONTRACTOR, prior to submission to the REMEDIAL DESIGNER. Each submittal shall be dated, signed, and certified by the CONTRACTOR, as being correct and in strict conformance with the Contract Documents. In the case of Shop Drawings, each copy shall be so dated, signed, and certified. The REMEDIAL DESIGNER will not review any CONTRACTOR submittals, which have not been so certified by the CONTRACTOR, or are incomplete, or not well-organized or indexed. All non-certified, incomplete, or unorganized submittals will be returned to the CONTRACTOR without action taken by the REMEDIAL DESIGNER, and any delays caused thereby shall be the total responsibility of the CONTRACTOR.

J. The REMEDIAL DESIGNER's favorable review of CONTRACTOR's Shop Drawing submittals shall not relieve the CONTRACTOR of the entire responsibility for the correctness of details and dimensions and the overall adequacy of the submitted design, product, method, process, appurtenance, or similar. The CONTRACTOR shall assume all responsibility and risk for any misfits due to any errors in the CONTRACTOR's submittals. The CONTRACTOR shall be responsible for the dimensions and the design of adequate connections and details and for provision of all items and appurtenances necessary for complete and satisfactory Work.

1.03 SHOP DRAWING SUBMITTALS

A. Furnish at least five (5) copies for each set of Shop Drawings submitted. The REMEDIAL DESIGNER will require four copies, leaving one (1) copy of marked-up reviewed Shop Drawings for return to the CONTRACTOR. The words "Shop Drawing(s)," as used herein, shall be understood to include detailed signed calculations; fabrication, installation, and erection drawings; lists; graphs; operating instructions; catalog sheets; data sheets; and all other similar items. If the CONTRACTOR wishes to receive more than one (1) copy of marked-up reviewed Shop Drawings, submit additional copies beyond the minimum five (5) copies, up to a maximum of eight (8) copies.

B. All Shop Drawing submittals shall be accompanied by the REMEDIAL DESIGNER's standard submittal transmittal form, or a similar form from the

CONTRACTOR. Any submittal not accompanied by such a form, or where all applicable items on the form are not completed, will be returned for revision and resubmittal.

1.04 CONTRACTOR'S PROGRESS SCHEDULE SUBMITTALS

A. All Construction Schedule submittals by the CONTRACTOR in accordance with Section 01041 – Project Coordination, of these Specifications shall include both electronic and paper plots for use in schedule analysis by the GROUP'S REPRESENTATIVE, and REMEDIAL DESIGNER.

B. The CONTRACTOR shall revise the Construction Schedule, as required, and resubmit the schedule with each Application for Payment. Any Application for Payment submitted without an up-to-date Construction Schedule will not be processed.

C. The CONTRACTOR shall show the complete sequence of construction by activity, identifying the Work of separate stages and other logically grouped activities. Indicate the early and late start, early and late finish, float dates, critical path, and duration.

D. The CONTRACTOR shall indicate the estimated percentage of completion for each activity with each Application for Payment.

E. The CONTRACTOR shall indicate the submittal dates required for Shop Drawings, product data, samples, and product delivery dates, including those furnished by the GROUP, if any.

1.04 PROPOSED SUBSTITUTES OF "OR EQUAL" ITEMS

A. Whenever materials or equipment are specified or described in the Contract Documents by using the name of a proprietary item, or the name of a particular supplier, the naming of the item is intended to establish the type, function, and quality required. If the words "or equal" or "or equivalent" are not present, no substitutes will be allowed, whether or not such disallowance is specifically stated. If the name is followed by the words "or equal" or "or equivalent" indicating that consideration of a substitution is permitted, materials or equipment of other suppliers may be accepted by the REMEDIAL DESIGNER if sufficient information is submitted by the CONTRACTOR to allow the REMEDIAL DESIGNER to determine that the material or equipment proposed is equivalent, or equal to, that named, subject to the following requirements:

1. The burden of proof as to the type, function, and quality of any such substitute material or equipment shall be upon the CONTRACTOR.
2. The REMEDIAL DESIGNER will be the sole judge as to the type, function, and quality of any such substitute material or equipment and the REMEDIAL DESIGNER's decision shall be final. The REMEDIAL DESIGNER will provide input on the proposed substitute from the GROUP's REPRESENTATIVE, as appropriate.

3. The REMEDIAL DESIGNER may require the CONTRACTOR to furnish, at the CONTRACTOR's expense, additional data about the proposed substitute.
4. The GROUP's REPRESENTATIVE may require the CONTRACTOR to furnish, at the CONTRACTOR's expense, a special performance guarantee or other surety with respect to any substitution.
5. Acceptance by the REMEDIAL DESIGNER of a substitute item proposed by the CONTRACTOR shall not relieve the CONTRACTOR of the responsibility for full compliance with the Contract Documents and for adequacy of the substitute item.
6. The CONTRACTOR shall be responsible for any resultant changes and all additional costs which the accepted substitution requires in the CONTRACTOR's work, the work of its SUBCONTRACTORs and of others, and shall effect such changes at the CONTRACTOR's expense. Such changes include, but are not limited to, changes in dimensions, locations, piping, fittings, clearances, electrical connections, sizing of equipment and appurtenant items, controls, alarms, and instrumentation.
7. All proposed substitutions shall be listed at the time of bidding and as called for in Article 1.01B herein above.

B. The procedure for review by the REMEDIAL DESIGNER will consist of the following:

1. If the CONTRACTOR wishes to furnish or use a substitute item of material or equipment, the CONTRACTOR shall make written application to the REMEDIAL DESIGNER.
2. Unless otherwise provided by law or authorized in writing by the REMEDIAL DESIGNER, the substitution request shall be submitted with the Bid Proposal and again within the ten (10) day period after receiving Notice to Proceed.
3. Wherever a proposed substitute material or equipment has not been submitted within said period, or wherever the submission of a proposed substitute material or equipment has been judged to be unacceptable by the REMEDIAL DESIGNER, the CONTRACTOR shall provide the material or equipment named in the Contract Documents.
4. The CONTRACTOR shall certify that the proposed substitute will adequately perform the functions and achieve the results called for by the general design, be similar and of equal substance to that specified, and be suited to the same use as that specified.
5. The REMEDIAL DESIGNER will be allowed a reasonable time within which to evaluate each proposed substitute, which can be longer than the time period set forth in Article 1.01 herein above without providing any basis for an extension of time or additional costs. In any event, the REMEDIAL DESIGNER will endeavor to complete his review in no more than twenty-five (25) calendar days from receipt of submittal.
6. As applicable, no Shop Drawing submittals will be made for a substitute item nor shall any substitute item be ordered, installed, or utilized without the REMEDIAL DESIGNER's prior written favorable review of the CONTRACTOR's substitution request.

7. The REMEDIAL DESIGNER will record the time and expenses required by the REMEDIAL DESIGNER to evaluate substitutions proposed by the CONTRACTOR and to make changes in the Contract Documents occasioned thereby. Whether or not the REMEDIAL DESIGNER favorably reviews a proposed substitute, the CONTRACTOR shall reimburse the REMEDIAL DESIGNER for the charges of the REMEDIAL DESIGNER for evaluating each proposed substitute, except to the extent that there is a net savings in cost following adoption of the substitution.

C. The CONTRACTOR's application for a proposed substitute shall contain the following statements and/or information that will be considered by the REMEDIAL DESIGNER in evaluating the proposed substitution:

1. The evaluation and acceptance of the proposed substitute will not prejudice the CONTRACTOR's achievement of substantial completion on time.
2. Whether acceptance of the substitution for use in the Work will require a change in any of the Contract Documents to adapt the design to the proposed substitute.
3. Whether incorporation or use of the substitute in connection with the Work is subject to payment of any license fee or royalty.
4. All variations of the proposed substitute from that specified shall be identified.
5. Available maintenance, repair, and replacement service shall be indicated.
6. Itemized list of all costs that will result directly or indirectly from acceptance of such substitute, including cost of redesign and claims of other contractors affected by the resulting change.

D. Any tests performed by the REMEDIAL DESIGNER or the QUALITY ASSURANCE OFFICIAL to verify acceptability of substitutes shall be at the CONTRACTOR's sole expense.

1.05 SAMPLES SUBMITTAL

A. Whenever in the Contract Documents samples are required, the CONTRACTOR shall submit, at his expense, not fewer than five (5) samples of each such item or material to the REMEDIAL DESIGNER.

B. Samples, as required herein, shall be submitted for acceptance a minimum of twenty-one (21) days prior to ordering such material, and shall be submitted in an orderly sequence so that dependent materials or equipment can be assembled and reviewed without causing delays in the Work.

C. All samples shall be individually, legibly, and indelibly labeled or tagged, indicating thereon all specified physical characteristics and Supplier's name. Upon receiving acceptance of the REMEDIAL DESIGNER, one (1) set of the samples will be stamped and dated by the REMEDIAL DESIGNER and returned to the CONTRACTOR and the remaining two (2) sets will be retained by the

REMEDIAL DESIGNER with one (1) set retained at the Site until completion of the Work.

D. Unless otherwise specified, all colors and textures of specified items will be selected by the GROUP'S REPRESENTATIVE and/or REMEDIAL DESIGNER from the manufacturer's standard colors and standard materials, products, or equipment lines.

1.06 RECORD DOCUMENTS SUBMITTAL

A. The CONTRACTOR shall keep and maintain at the Site, one set of Record Documents. On these, the CONTRACTOR shall mark all project conditions, locations, configurations, and any other changes or deviations which may vary from the details represented in the Contract Documents, including buried or concealed construction and utility features which are revealed during the course of construction. Special attention shall be given to recording the horizontal and vertical location of all buried utilities that differ from the locations indicated, or which were not indicated in the Contract Documents. Said Record Documents shall be supplemented by any detailed sketches, as necessary, or directed to fully indicate the Work as actually constructed. Include all survey data obtained from potholing and exposing of existing buried piping. These master Record Documents of the CONTRACTOR's representation of as-built conditions, including all revisions made necessary by Addenda, Change Orders, and the like, shall be maintained up-to-date during the progress of the Work. One set of Record Documents shall be submitted to the REMEDIAL DESIGNER with each Application for Payment. All as-built survey documentation shall meet the requirements of Section 01050 – Field Engineering/Surveying of these Specifications.

B. Record Documents shall be accessible to the REMEDIAL DESIGNER at all times during the construction period and shall be delivered to the REMEDIAL DESIGNER upon completion of the Work.

C. Upon substantial completion of the Work, and prior to final acceptance, the CONTRACTOR shall complete and deliver twelve (12) complete sets and one (1) reproducible set of Record Documents to the REMEDIAL DESIGNER. Record Documents shall conform to the construction records of the CONTRACTOR. The Record Documents shall consist of Contract Documents showing relevant corrections, modifications, and/or amendments, which accurately and fully report the location of the Work as constructed. The information submitted by the CONTRACTOR will be assumed to be reliable, and the REMEDIAL DESIGNER will not be responsible for the accuracy of such information, nor for any errors or omissions, which may appear on the Record Documents as a result.

D. Record Documents submitted by the CONTRACTOR shall be sealed and signed by a professional (civil) engineer licensed in the State of New Jersey. Final survey locations, elevations, and grades shall be sealed and signed by a New Jersey licensed Professional Land Surveyor.

1.07 MANUFACTURER'S INSTRUCTIONS

A. For all equipment, special items, and materials as specified in individual Sections of these Specifications, submit five (5) copies of the MANUFACTURER's printed warranties, instructions for delivery, storage, assembly, installation, start-up, adjusting, finishing, and spare parts list. All warranties shall be in the GROUP's name, where applicable.

B. Identify conflicts between manufacturer's instructions and the Contract Documents.

1.08 MANUFACTURER'S CERTIFICATES

A. When specified in individual Section of these Specifications, submit five (5) copies of MANUFACTURER's certificates to the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER for review.

B. Indicate that the material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.

C. Certificates may be recent or previous test results on material or product, if acceptable to REMEDIAL DESIGNER, unless current test results are called for in the Contract Documents.

D. For all equipment and specialist materials, submit manufacturer's Warranties and Certifications together with vendor confirmation of assignment of all warranty rights to the GROUP, including full warranty period commencing from the date of final completion and acceptance of the Work by the GROUP.

1.09 TECHNICAL MANUAL SUBMITTAL

A. The CONTRACTOR shall furnish the REMEDIAL DESIGNER with ten (10) identical sets of Technical Manuals, also referred to as O&M Manuals, for any mechanical, electrical, and instrumentation equipment. Each set shall consist of one or more volumes, each of which shall be bound in a standard size, 3-ring, loose leaf, and vinyl plastic hard cover binder suitable for bookshelf storage. A binder's ring size shall not exceed 3-inches. The contents of the Technical Manual(s) shall be well organized to REMEDIAL DESIGNER's satisfaction and subsections shall be separated with dividers. A table of contents shall be provided which indicates all equipment and related information bound in the Technical Manuals. An electronic copy shall be provided in the latest version of Microsoft Word.

B. For each item requiring submittal of a Technical Manual, the CONTRACTOR shall include the following:

1. Complete operating instructions, including location of controls, special tools or other equipment required, related instrumentation, and other equipment needed for operation.
2. Lubrication schedules, including the lubricant SAE grade and type, temperature range of lubricants, and including frequency of required lubrication.
3. Preventative maintenance procedures and schedules.
4. Parts lists, by generic title and identification number, complete, with exploded views of each assembly.
5. Instruction for disassembling and reassembling.
6. Name and location of nearest supplier and spare parts warehouse.
7. Recommended troubleshooting procedures.
8. Reproducible prints of the Record Drawings, including diagrams and schematics.

C. All Technical Manuals shall be submitted in final form to the REMEDIAL DESIGNER not later than the 75 percent construction completion date. All discrepancies or deficiencies found by the REMEDIAL DESIGNER in the Technical Manuals shall be corrected by the CONTRACTOR within twenty-eight (28) days from the date of written notification of the deficiencies.

1.10 SPARE PARTS LIST SUBMITTALS

A. The CONTRACTOR shall furnish the REMEDIAL DESIGNER with ten (10) identical sets of Spare Parts Lists for all mechanical, electrical, and instrumentation equipment, if applicable. The Spare Parts Lists shall include the current list price of each spare part. Each manufacturer or supplier shall indicate the name, address, and telephone number of its nearest outlet of spare parts. The CONTRACTOR shall cross-reference all spare parts list to the equipment numbers designated in the Contract Documents. The spare parts lists shall be bound in standard size, 3-ring, loose leaf, and vinyl plastic hard cover binders suitable for bookshelf storage. A binder's ring size shall not exceed 3-inches. An electronic copy shall be provided in the latest version of Microsoft Word.

1.11 CONSTRUCTION PHOTOGRAPHIC DOCUMENTATION REPORT

A. The CONTRACTOR shall submit the monthly construction photographs in the form of a bound report. Each report shall consist of one (1) volume bound in a standard size, 3-ring, loose-leaf, and vinyl plastic hard cover binder suitable for bookshelf storage. A binder's ring size shall not exceed 3-inches. Each copy of the Report shall include the requirements outlined in Section 01380 – Construction Photographs, of these Specifications.

1.12 EXCAVATION SUPPORT PLAN SUBMITTAL

A. Prior to commencement of any Work requiring excavation to a depth in excess of the threshold limits of the OSHA regulations, the CONTRACTOR shall submit a detailed Excavation Support Plan to the REMEDIAL DESIGNER for review. This plan shall be designed and sealed by a Professional Engineer licensed in the State of New Jersey. The plan should include the design of any sheeting,

shoring, bracing, sloping, or equivalent support method and in accordance with the requirements of Section 02220 – Excavation, of these Specifications. If so required, the plan shall include appropriate measures to provide dewatering in accordance with Section 02140 – Construction Dewatering and 02402 – Liquids Handling and Disposal, of these Specifications. The CONTRACTOR shall be in receipt of the REMEDIAL DESIGNER's written acknowledgement of receipt of the plan prior to initiation of any excavation.

1.13 DECONTAMINATION/OFF-SITE DISPOSAL

A. Prior to performing any excavation activities, which will result in the decontamination and off-site disposal of any above or below ground structures, utilities, or waste, the CONTRACTOR shall submit a detailed schedule of proposed activities to the REMEDIAL DESIGNER and GROUP'S REPRESENTATIVE for review. This schedule shall include the means and methods of decontamination and the off-Site facility where the materials will be shipped. After disposal, the CONTRACTOR shall submit a copy of the disposal manifest to the REMEDIAL DESIGNER and the GROUP's REPRESENTATIVE.

1.14 LIST OF EQUIPMENT AND PERSONNEL

A. The CONTRACTOR shall provide the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with a listing of all construction equipment and construction personnel tabulated by day.

1. The list of construction equipment shall include the manufacturer, model number, hours used, and component of the Work performed for all equipment on-site. The initial submittal shall include hourly and weekly rental rates for each piece of equipment, as well as the hourly operating costs thereof.
2. The list of construction personnel shall include employee name, job classification, hours worked, and component of the Work performed for all of the CONTRACTOR's employees and SUBCONTRACTORS not otherwise considered Site overhead.
3. Health and Safety training certifications in accordance with the requirements of Section 01564 – Health and Safety Specifications for Construction, of these Specifications.

B. The listing of construction equipment and construction personnel shall be submitted with each Application for Payment or submitted to the REMEDIAL DESIGNER for review prior to mutual agreement regarding the Application for Payment. Any Applications for Payment without a complete listing of equipment and personnel will not be processed.

1.15 DAILY REPORTS

A. The CONTRACTOR shall prepare daily reports summarizing on-site activities.

B. Daily reports shall include as a minimum the following information:

1. Weather conditions;
2. Active work area;
3. Crew description;
4. SUBCONTRACTOR activity;
5. Equipment operating;
6. Hours worked;
7. Work performed;
8. Problems;
9. Health and safety issues;
10. Visitors;
11. Photographs taken;
12. Sampling/testing performed; and,
13. Air monitoring data.

C. Daily reports shall be submitted to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL the working day following the report day.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 01380

CONSTRUCTION PHOTOGRAPHS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Work under this Section includes photographic documentation of the Work specified herein. This Section includes photography, prints, negatives, technique and submittals.

B. The CONTRACTOR shall provide, at the CONTRACTOR's own expense, all labor, equipment, materials, processing, and associated appurtenances to complete the Work associated with providing construction photographs and videos.

1.02 SUBMITTALS

A. Provide qualifications of CONTRACTOR's photographer.

B. Deliver construction photographs with each Application for Payment, but at least monthly regardless of payment application status, during performance of the Work.

1.03 PHOTOGRAPHY

A. Provide photographs of Site and activities described below throughout progress of Work. Photographs shall be produced by an experienced photographer.

B. Take photographs of, at a minimum, the following activities:

1. Condition of Site prior to work activities;
2. Regrading (cut and fill) operations throughout the Site;
3. Laydown and material staging area (s);
4. Clearing and excavation of sediments of the Sip Avenue Ditch;
5. Placement of geotextile liner and erosion protection system in the Sip Avenue Ditch;
6. Waste excavation and relocation;
7. Placement of grading fill, geomembrane, geocomposite drainage layer, cap cover soil, and vegetative layer;
8. Construction of the surface water conveyance channels;
9. Construction of the toe drain;
10. Construction of the access roads;
11. Construction of erosion control system along the Hackensack River;
12. Construction of the passive gas vents;
13. Fence locations; and,
14. Hydroseeding operations.

1.04 PRINTS

A. Full color; three prints of each view.

B. Finish: Matte.

C. Size: 4 x 6 inch.

D. Mount photographs in standard photo album, or as approved by REMEDIAL DESIGNER. Identify each print on back and below mounted photograph. Identify name of Project, orientation of view, date and time of view, name of photographer, and photographer's numbered identification of exposure.

E. Photographs shall be chronologically numbered by month/day/year and numerically for that day (i.e., Photograph No. 10/08/02-3).

F. Alternately, three digital copies of the photographs may be provided in CD-R or CD-RW format.

1.05 NEGATIVES

A. Deliver negatives to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with Project Record Documents. Catalog and index negatives in chronological sequence with a typed table of contents.

1.06 TECHNIQUE

A. Provide factual presentation.

B. Provide correct exposure and focus, high resolution and sharpness, maximum depth of field, and minimum distortion.

1.07 VIEWS

A. Provide non-aerial photographs from three views a minimum of twice during each activity, as listed in Article 1.03 of this Section, and other pertinent activities, if necessary or requested by the REMEDIAL DESIGNER.

B. Consult with REMEDIAL DESIGNER for instructions on additional views required.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 PRE-CONSTRUCTION PHOTOS AND VIDEOS

A. Prior to commencement of the Work, the CONTRACTOR shall photograph and videotape the existing Site conditions. Pre-construction photos and videos shall include, but are not necessarily limited to, the following items:

1. Areas of future construction or special interest;
2. Areas designated as temporary and permanent easements;
3. Locations of temporary Site facilities;
4. Laydown, staging, and storage areas;
5. Equipment decontamination pad areas;
6. Contaminant reduction zones;
7. Fence locations;
8. Utilities, including overhead lines;
9. Site access locations; and,
10. Existing riverbank areas.

B. Immediately prior to commencing any construction activities, an aerial photograph depicting pre-construction conditions shall be taken and submitted in accordance with the requirements of this Section.

3.02 POST-CONSTRUCTION PHOTOS

A. Upon completion of the Work, the CONTRACTOR shall photograph and videotape the Site from the same locations, and include the same features, as the photographs and videos used to document the existing, pre-Work Site conditions as outlined in Article 3.01 herein.

B. Upon completion of the Work, an aerial photograph depicting post-construction conditions shall be taken and submitted in accordance with the requirements of this Section.

*****END OF SECTION*****

SECTION 01400

QUALITY CONTROL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The Work under this Section includes the CONTRACTOR's responsibility for providing all Quality Control testing and inspection as necessary for the proper and complete performance of the Work.

B. The CONTRACTOR shall comply with the Quality Control testing and inspection requirements herein and as otherwise specified in individual Sections of these Specifications.

1.02 RELATED SECTIONS

A. 01300 - Submittals

B. 01410 - Materials Testing Laboratory

C. 02125 - Erosion and Sedimentation Control

D. 02223 - Fill Materials

E. 02225 - Vegetative Layer

F. 02233 - Aggregate Materials

G. 02274 - Stone Riprap

H. 02590 - HDPE geomembrane

I. 02595 - Geotextile

J. 02598 - Geocomposite

K. 02625 - Passive Gas Vent Construction

L. 02650 - HDPE Pipe

M. 02675 - Monitoring Wells

N. 03100 - Concrete Formwork

O. 03200 - Concrete Reinforcement

P. 03300 - Concrete

1.03 QUALITY ASSURANCE/CONTROL OF INSTALLATION

A. The CONTRACTOR shall monitor quality control over products, services, Site conditions, and workmanship for conformance with the Contract Documents.

B. The CONTRACTOR shall comply fully with MANUFACTURER's instructions, including each step in any prescribed sequence.

C. Should the MANUFACTURERS' instructions conflict with the Contract Documents, the CONTRACTOR shall request clarification from the REMEDIAL DESIGNER before proceeding.

D. The CONTRACTOR shall comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

E. The CONTRACTOR shall perform Work with persons qualified to produce workmanship of specified quality.

1.04 REFERENCES

A. Conform to the referenced standards that are in effect as of the date for receiving bids.

B. Obtain copies of referenced standards when required by the Contract Documents.

C. Should specified referenced standards conflict with the Contract Documents, request clarification from the REMEDIAL DESIGNER before proceeding.

D. The contractual relationship of the parties to the Contract shall not be altered from the Contract Documents by either mention or inference in any referenced standard.

1.05 INSPECTION AND TESTING LABORATORY SERVICES

A. The CONTRACTOR is responsible for performing and documenting all quality control tests. The GROUP will appoint, employ, and pay for services of a QUALITY ASSURANCE OFFICIAL to perform quality assurance inspection and testing.

B. The QUALITY ASSURANCE OFFICIAL and the CONTRACTOR will perform inspections, tests, and services as required by these Specifications.

C. Reports will be submitted by the QUALITY ASSURANCE OFFICIAL and the CONTRACTOR to the REMEDIAL DESIGNER, indicating observations and results of tests and indicating compliance or non-compliance with the Contract Documents.

D. The CONTRACTOR, when required, shall cooperate with the QUALITY ASSURANCE OFFICIAL to furnish samples of materials, design mixes, equipment, tools, storage and assistance as requested.

1. Notify the QUALITY ASSURANCE OFFICIAL twenty-four (24) hours prior to the expected time for operations requiring Quality Assurance services.
2. Make arrangements with the Quality Assurance Official and pay for additional samples and tests required for the CONTRACTOR's use.

E. Re-testing or re-inspection required because of deficiencies to the specified requirements shall be performed by the CONTRACTOR on instructions by the GROUP'S REPRESENTATIVE or REMEDIAL DESIGNER. Payment for re-testing or re-inspection will be charged to the CONTRACTOR by deducting inspection or testing charges from the Contract Price.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 01410

MATERIAL TESTING LABORATORY

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. This Section provides the certifications and approvals required by material testing laboratories to be utilized by the CONTRACTOR, and all SUBCONTRACTORs performing material testing during the Work.

B. Material testing includes earthen materials and other materials requiring engineering property testing as described in the Contract Documents, and as required herein.

C. Engineering property testing includes testing of materials and other necessary testing described within individual Sections of the Contract Documents, and as required herein.

D. The laboratories utilized during the Work for engineering property testing, including geotechnical testing, shall be approved by the GROUP'S REPRESENTATIVE.

E. The CONTRACTOR shall provide a "Competent Person" to implement, supervise and inspect all Work.

1.02 RELATED SECTIONS

A. 01400 – Quality Control

B. 02223 – Fill Materials

C. 02225 – Vegetative Layer

D. 02233 – Aggregate Materials

E. 02274 – Stone Riprap

F. 02590 – HDPE Geomembrane

G. 02595 – Geotextile

H. 02598 – Geocomposite

I. 02612 – Reinforced Concrete Culvert Pipe

J. 02613 – Corrugated Metal Pipe

K. 02650 – HDPE Pipe

L. 02831 – Chain Link Fences and Gates

M. 03100 – Concrete Formwork

N. 03200 – Concrete Reinforcement

O. 03300 – Concrete

1.03 TESTING LABORATORY RESPONSIBILITIES

A. Laboratories utilized during the Work for engineering property testing, including geotechnical testing, shall be approved by the REMEDIAL DESIGNER.

B. Cooperate with the REMEDIAL DESIGNER and the CONTRACTOR.

C. Provide qualified personnel promptly on notice.

D. Perform specified inspections, sampling and testing of materials and methods of construction.

1. Comply with specified standards, the American Society of Testing and Materials (ASTM), or other recognized authorities and accepted standards, and as specified.
2. Ascertain compliance with requirements of Contract Documents.

E. Promptly notify the REMEDIAL DESIGNER and the CONTRACTOR of any irregularities or deficiencies in the Work, which are observed during the performance of testing services.

F. Submit five (5) copies (four (4) copies to the REMEDIAL DESIGNER and one (1) copy to the CONTRACTOR) of reports of inspections and tests in addition to those additional copies required by the CONTRACTOR with the following information included:

1. Date issued;
2. Project title and number;
3. Location of Project;
4. Testing laboratory name and address;
5. Name and signature of inspector or analyst;
6. Date of inspection or sampling and testing;
7. Climatic data (temperature, humidity, etc.);
8. Date the test was executed;
9. Identification of product and relevant Specification Section;
10. Type of inspection or test;
11. Results of test; and,
12. Observations regarding compliance with Contract Documents.

Reports of inspections and tests shall be promptly processed and distributed (within two (2) days after their completion unless otherwise noted) to the CONTRACTOR and REMEDIAL DESIGNER to ensure all necessary re-testing or replacement of materials with the least possible delay in progress of the Work.

G. Perform additional services as required.

H. Not be authorized to:

1. Release, revoke, alter, or enlarge on the requirements of Contract Documents.
2. Approve or accept any portion of the Work.

1.04 CONTRACTOR RESPONSIBILITIES

A. Cooperate with laboratory personnel; provide access to the Work and furnish the laboratory with the MANUFACTURER's requirements/specifications for items to be tested as required.

B. Provide representative samples of materials to be tested to the laboratory in sufficient/required quantities.

C. Furnish copies of manufacturer test reports/certifications to the laboratory and as required by the REMEDIAL DESIGNER.

D. Furnish required labor and facilities to provide the laboratory with:

1. Access to the Work to be tested;
2. Assistance in obtaining and handling samples at the Site, as required;
3. The means to facilitate inspections and testing; and,
4. Sampling holding and storage boxes as needed.

E. Notify the laboratory in advance of any construction activities requiring inspection, sample collection, and testing to allow the laboratory sufficient time for assignment of personnel and scheduling of testing programs.

F. Where testing is to be conducted by an independent laboratory, the sample or samples shall be selected by such laboratory, or the REMEDIAL DESIGNER, and shipped to the laboratory by the CONTRACTOR at the CONTRACTOR's expense.

G. Copies of all correspondence between the CONTRACTOR and laboratory shall be provided to the REMEDIAL DESIGNER.

1.05 QUALITY ASSURANCE

A. Testing will be in accordance with all pertinent codes and regulations and with procedures and requirements of the ASTM, or other recognized authorities.

1.06 TESTING/RE-TESTING SERVICES

A. When initial tests performed by the laboratory indicate nonconformance with the Contract Documents, all subsequent re-testing occasioned by the nonconformance shall be performed by the same testing laboratory. The costs associated with any re-testing, including the costs for the initial tests, shall be at the CONTRACTOR's own expense.

B. Inspections and tests required by codes or ordinances or by a plan approval authority, and made by a legally constituted authority, shall be the responsibility of the CONTRACTOR and at the CONTRACTOR's own expense, unless otherwise provided in the Contract Documents.

C. Inspection or testing performed exclusively for the CONTRACTOR's convenience shall be the sole responsibility of the CONTRACTOR and at the CONTRACTOR's own expense.

1.07 SCHEDULES FOR TESTING

A. Establishing Schedule

1. The CONTRACTOR shall, by advance discussion with the selected testing laboratory, determine the time required for the laboratory to perform its tests and to issue each of its findings.
2. The CONTRACTOR is responsible for making all arrangements to have the testing laboratory on-Site to provide the required testing as construction activities require.
3. The CONTRACTOR's Construction Schedule shall include the required time for testing services.

B. When changes to the Construction Schedule are necessary during construction, coordinate all such changes of schedule with the testing laboratory.

C. If incompleteness of the Work prevents the laboratory from performing scheduled testing or sampling, all extra costs attributing to the delay shall be back-charged to the CONTRACTOR and shall not be borne by the GROUP.

1.08 SAMPLE/SPECIMEN COLLECTION AND TRANSPORT

A. All specimens and samples for testing will be collected by the CONTRACTOR, unless otherwise specified in the Contract Documents.

B. The CONTRACTOR shall be responsible for the protection and transportation of all collected specimens and samples, except those taken by the testing laboratory personnel, to the testing laboratory.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 01540

JOB SITE SECURITY

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall be responsible for all job Site security. Whenever evidence is found of damage to the Work, the CONTRACTOR shall immediately remove the damaged portion and replace it with satisfactory Work at the CONTRACTOR's expense. A copy of all accident reports shall be submitted to the REMEDIAL DESIGNER and GROUP's REPRESENTATIVE within twenty-four (24) hours or the next business day.

B. The CONTRACTOR shall keep a daily record of personnel and visitors on-Site including arrival and departure times. Provide records to the REMEDIAL DESIGNER on a weekly basis.

C. The CONTRACTOR's responsibility for the maintenance of job Site security shall not cease until the Work has been accepted by the GROUP.

1.02 RELATED SECTIONS

A. 01041 - Project Coordination

B. 01200 - Project Meetings

C. 01550 - Site Access and Traffic Control

1.02 BARRICADES, LIGHTS, AND SIGNALS

A. The CONTRACTOR shall furnish and erect such barricades, fences, flagmen, watch guards, lights, and danger signals, and shall provide such other precautionary measures to protect persons, property, and the Work as necessary to comply with Federal, State, and local regulations. Barricades shall be painted in a color, or utilize other measures, to ensure visibility at night. From sunset to sunrise, the CONTRACTOR shall furnish and maintain at least one operable light at each barricade, and sufficient numbers of barricades shall be erected to keep vehicles from being driven on, and persons from walking under or into, construction areas.

B. Damage to the Work due to failure of barricades, signs, and lights is the sole responsibility of the CONTRACTOR, and whenever evidence is found of such damage to the Work, the CONTRACTOR shall immediately remove the damaged portion and replace it at CONTRACTOR's expense. The CONTRACTOR's responsibility for the maintenance of barricades, signs, and lights shall not cease until the Work has been accepted by the GROUP.

C. The CONTRACTOR shall control vehicle access, in accordance with Section 01550 – Site Access and Traffic Control, of these Specifications, to the Site at all times when the Work is in progress. At the end of each workday, the CONTRACTOR shall secure access to the Site and provide security as specified herein.

1.03 SITE ACCESS, SECURITY, AND RESTRICTIONS

A. Immediately following issuance of the Notice to Proceed, the CONTRACTOR shall assume the responsibility and cost of Site security through the completion of the Work, including periods of no construction activity. This includes, but is not limited to, access control, installation of temporary protective fencing and gates (as required), fence inspection and repair, barricades around excavated areas, and other necessary measures to restrict public access to these designated areas until the Work is completed.

B. The CONTRACTOR shall coordinate with the REMEDIAL DESIGNER to establish guidelines for personnel access to the Site.

C. The CONTRACTOR shall be herein aware that private access areas currently exist in the vicinity of the Truck Stop Area adjacent to Truck Route 1 and 9. Additional precautions may be necessary due to the public's ready access to this area. In addition, the area directly beneath the Pulaski Skyway must be available for New Jersey Department of Transportation access at all times.

1.04 SUBMITTALS

A. The CONTRACTOR shall submit, in accordance with Section 01300 - Submittals of these Specifications, a Site Security Plan to the REMEDIAL DESIGNER for review within ten (10) days after the Notice to Proceed, and prior to mobilization onto the Site.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 01550

SITE ACCESS AND TRAFFIC CONTROL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all materials, labor, equipment, tools, and appurtenances required to maintain site access and traffic control. Traffic congestion around the Site shall be minimized to maintain public safety, and to avoid the potential for complaints from the public. The CONTRACTOR will be responsible for any direct or consequential damages arising from inadequate traffic control at off-site areas nearby the Site which are used as transportation routes for the Work.

B. The CONTRACTOR shall comply will all applicable codes, ordinances, rules, regulations and laws of local, municipal, State, and Federal authorities having jurisdiction. This includes, but is not limited to, compliance with all traffic laws and with vehicular weight and axle-loading limitations.

C. The CONTRACTOR's responsibility for the maintenance of site access and traffic control shall not cease until the Work has been accepted by the GROUP.

D. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect all Work.

1.02 RELATED SECTIONS

A. 01041 - Project Coordination

B. 01300 - Submittals

C. 01540 - Job Site Security

1.03 SUBMITTALS

A. Within ten (10) days after the Notice to Proceed, and prior to mobilization onto the Site, the CONTRACTOR shall develop and submit to the REMEDIAL DESIGNER a Site Access and Traffic Control Plan in accordance with the requirements of Section 01300 – Submittals, of these Specifications, and as specified herein.

B. The Site Access and Traffic Control Plan shall include, but not be limited to, proposed traffic patterns and layouts, required traffic control devices (i.e., signs, barricades, cones, etc.) and utilization, hours of operation, and other associated details for the proper maintenance and protection of traffic.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 SITE ACCESS

A. The CONTRACTOR shall coordinate Site access with the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER. This includes, but is not limited to, scheduling of deliveries and available working hours.

3.02 OFF-LOADING

A. Coordinate with the GROUP'S REPRESENTATIVE and/or REMEDIAL DESIGNER to select the areas to be used for off-loading and temporary storage of materials. Clearly delineate the boundary of all storage and laydown areas.

B. To reduce tracking of soils back on to the roads, dumping of soils should be done in a manner that minimizes wheel contact with the soils. Off-loading of materials on the Site shall be coordinated with construction of temporary access roads to minimize tracking of landfill soils. If tracking of soil onto public roads from the CONTRACTOR's operations is severe in the opinion of the REMEDIAL DESIGNER, the CONTRACTOR shall take action such as constructing a wheel-washing station or installation of gravel tracking pads, as required.

3.03 COVERING OF MATERIALS

A. The CONTRACTOR shall take such steps as necessary to prevent spillage, wind blown deposits on the roads, and damage to other vehicles. All trucks used for transport of soils shall be covered with a well-secured tarp before transportation on public roads.

B. After dumping the load at the Site, the CONTRACTOR shall inspect the truck bed for residual materials and shall remove or cover residual material before allowing the truck to leave the Site and entering public roads.

3.04 STREET CLEANING

A. Remove all soils, dirt, rock, asphalt and other deposits that accumulate on the public roads, except the on-site access roads, that are a result of the CONTRACTOR's hauling operation. This includes windblown deposits, spillage, and materials tracked onto the roads. Removal shall be accomplished by sweeping and washing as required.

B. Inspection of the roads is to be performed by the CONTRACTOR at least daily during hauling operations. When the inspection determines that cleaning is

required, or as directed by the REMEDIAL DESIGNER, the CONTRACTOR shall immediately perform such cleaning.

3.05 TRAFFIC CONTROL

A. The CONTRACTOR shall not impair traffic on public or private roads.

B. The CONTRACTOR shall maintain the current level-of-service on public roads in proximity to the Site. Provide flagmen or other means of traffic control when and where necessary, or when requested by the REMEDIAL DESIGNER, to avoid interruptions to the current level-of-service and adverse impacts or delays to the Work.

3.06 ON-SITE TRANSPORTATION

A. The control of on-site traffic is the CONTRACTOR's sole responsibility and shall be performed in a safe and orderly manner. A speed limit of 15 MPH shall be enforced by the CONTRACTOR on all vehicles and equipment on the Site.

B. Access roads shall be constructed and maintained by the CONTRACTOR to prevent adverse impacts or delays to the Work. The CONTRACTOR is responsible for maintaining the current level-of-service and condition of the on-Site access roads to prevent adverse impacts or delays to the Work.

C. On-site traffic shall be limited to the existing and proposed access roads. Damage to, or deterioration of, the Site's access roads, or any other damages to existing on-site features caused by unauthorized deviation from these pathways, shall be restored and/or replaced to the satisfaction of the GROUP'S REPRESENTATIVE and/or REMEDIAL DESIGNER at the CONTRACTOR's expense to an "as-was or better condition."

*****END OF SECTION*****

SECTION 01562

DUST CONTROL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall employ means and methods that keep airborne particulates to the minimum and shall provide all labor, equipment, machinery, and materials for the application of water or other appropriate preventative means or methods to maintain dust control and avoid nuisance dust complaints from the surrounding community, subject to favorable review by the REMEDIAL DESIGNER.

B. The CONTRACTOR shall comply will all applicable codes, ordinances, rules, regulations and laws of local, municipal, State, and Federal authorities having jurisdiction.

C. The CONTRACTOR shall provide a Competent Person to implement, supervise, and inspect all Work. The REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL shall monitor satisfactory implementation of the Work.

1.02 HEALTH AND SAFETY

A. Site workers shall not be exposed to respirable particulates caused by the performance of the Work in excess of applicable Federal and State standards.

B. Airborne particulates shall be monitored in accordance with the Site-specific Health and Safety Plan and the requirements of Section 01564 – Health and Safety Specifications for Construction, of these Specifications.

1.03 RELATED SECTIONS

A. 01550 - Site Access and Traffic Control

B. 01563 - VOC, Odor, and Vector Control

C. 01564 - Health and Safety Specifications for Construction

D. 02100 - Site Preparation

E. 02110 - Site Clearing and Grubbing

F. 02125 - Erosion and Sedimentation Control

G. 02210 - Site Grading

H. 02220 – Excavation

I. 02221 - Waste Excavation and Relocation

J. 02223 - Fill Materials

PART 2 - PRODUCTS

2.01 GENERAL

A. The use of calcium chloride for dust control is not permitted on the Site.

PART 3 - EXECUTION

3.01 GENERAL

A. Watering equipment shall be used to minimize airborne particulate concentrations and shall consist of pipelines, tank trucks, or other devices acceptable to the REMEDIAL DESIGNER, which are capable of applying a uniform spread of water over the ground surface. A suitable device for a positive shut-off and for regulating the flow rate of water shall be located so as to permit positive operator control.

B. Potable water shall be used for dust control. The CONTRACTOR shall provide the name and location of the water source, and evidence that the water is potable, to the REMEDIAL DESIGNER.

C. Dust control shall be applied immediately when conditions warrant. A sufficient quantity of potable water shall be maintained on-site for immediate dust control use.

*****END OF SECTION*****

SECTION 01563

VOC, ODOR AND VECTOR CONTROL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall provide all labor, equipment, machinery, and materials to apply volatile organic compound (VOC), odor, and vector control media to exposed soils or waste releasing odors noticeable above background or pre-Work conditions or with the potential to cause nuisance complaints from the surrounding community, or to violate limits in the HASCP, or at the direction of the GROUP'S REPRESENTATIVE or REMEDIAL DESIGNER.

B. Control of odors and vectors is important. The CONTRACTOR shall minimize the extent and duration of open excavations to minimize the chance of releasing odors and VOCs. The CONTRACTOR shall be fully responsible for the proper and timely implementation of VOC, odor, and vector control measures. The CONTRACTOR shall also control vectors during the Work in accordance with applicable local, State, and Federal regulations.

C. Odor control shall include application and maintenance of suitable soil cover and/or plastic cover as a first course of action. If the soil or plastic is insufficient, then the CONTRACTOR shall furnish and apply foam control agents. The CONTRACTOR shall maintain VOC, odor, and vector control media at the Site for immediate use, as required.

D. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect all Work. The REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL shall monitor satisfactory implementation of the Work.

E. VOCs, odors and vectors shall be controlled according to applicable local, State, and Federal regulations.

1.02 RELATED SECTIONS

A. 01564 - Health and Safety Specifications for Construction

B. 02100 - Site Preparation

C. 02110 - Site Clearing and Grubbing

D. 02125 - Erosion and Sedimentation Control

E. 02210 - Site Grading

F. 02220 – Excavation

G. 02221 - Waste Excavation and Relocation

H. 02223 – Fill Materials

I. 02402 - Liquids Handling and Disposal

J. 02625 – Passive Gas Vent Construction

PART 2 - PRODUCTS

2.01 VOC, ODOR AND VECTOR CONTROL MEDIA

A. Soil cover shall be in accordance with Section 02223 – Fill Materials, of these Specifications.

B. VOC and odor control foam shall consist of Rusmar AC-900, or equivalent as favorably reviewed by the REMEDIAL DESIGNER, applied in accordance with the MANUFACTURER's recommendations for odor control.

PART 3 - EXECUTION

3.01 PLACEMENT OF VOC, ODOR AND VECTOR CONTROL MEDIA

A. Soils or waste disturbed during the course of construction activities, and found to give off VOCs or odors or attract vectors, shall be covered with control measures until such time as the excavation is complete. The CONTRACTOR shall maintain the integrity of the temporary control measures during the Work to the satisfaction of the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL.

B. VOC, odor, and vector control media shall be placed over disturbed areas by the CONTRACTOR immediately upon notice of malodors above background, or at the sole direction of the REMEDIAL DESIGNER.

C. The REMEDIAL DESIGNER, with USEPA's approval where appropriate, shall make the final determination in deciding if VOC, odor, and vector control is adequate. If the CONTRACTOR is unable to adequately control VOCs, odors, and vectors in the opinion of the REMEDIAL DESIGNER, the Work may be stopped at the discretion of the REMEDIAL DESIGNER until adequate control measures can be deployed. The CONTRACTOR shall bear all costs associated with such work and shall apply the necessary resources at no additional costs to the GROUP in order to maintain the project schedule.

*****END OF SECTION*****

SECTION 01564

HEALTH AND SAFETY SPECIFICATIONS FOR CONSTRUCTION

PART 1 - GENERAL

1.01 PURPOSE

A. The purpose of Section is to establish minimum health and safety requirements for the CONTRACTOR to satisfy in the preparation of the CONTRACTOR's Site-specific Health and Safety Plan.

1.02 APPLICABILITY

A. These requirements shall be used by the Remedial Action CONTRACTOR's Health and Safety Officer (HSO) to assist in preparation of the CONTRACTOR's Site-specific Health and Safety Plan. These requirements shall not relieve the CONTRACTOR from compliance with any applicable State, Federal, or other health and safety requirements and safe construction practices even if not specifically identified in these requirements. These requirements shall not relieve the CONTRACTOR's complete responsibility for the Site's safety and security, including Health and Safety.

B. If, at any time, the REMEDIAL DESIGNER or GROUP'S REPRESENTATIVE is apprised of a safety hazard which demands immediate attention because of its high potential for harm to public travel, persons on or about the Work, or public or private property, the REMEDIAL DESIGNER or the GROUP'S REPRESENTATIVE shall have the right to order such safeguards to be erected and such precautions to be taken as necessary and the CONTRACTOR shall comply with such orders. In particular, the CONTRACTOR should take appropriate measures to protect workers from direct or indirect contact with solid waste, landfill gas and/or leachate from the landfill areas. Furthermore, the CONTRACTOR should take appropriate measures to protect workers from oxygen-deficient or explosive atmospheres that may be present in a confined-space entry.

If, under such circumstances, the CONTRACTOR does not or cannot immediately put the Work into proper and approved condition, or if the CONTRACTOR or his representative is not on the Site so that he can be notified immediately of the insufficiency of safety precautions, then the GROUP'S REPRESENTATIVE may put the Work into such a condition that it shall be, in his opinion, in all respects safe, and the CONTRACTOR shall pay all costs of such labor and materials. The fact that the REMEDIAL DESIGNER or the GROUP'S REPRESENTATIVE does not observe a safety hazard or does not order the CONTRACTOR to take remedial measures shall in no way relieve the CONTRACTOR of the entire responsibility for any costs, loss, or damage by any party sustained on account of the insufficiency of the safety precautions taken by the CONTRACTOR or by the REMEDIAL DESIGNER or the GROUP'S REPRESENTATIVE acting under authority of this Section.

C. It is the responsibility of the CONTRACTOR to take appropriate safety precautions to meet whatever conditions of hazard may be present during the performance of the Work, whether the hazard may or may not be reasonably foreseeable. The CONTRACTOR is alerted to the fact that it shall be his responsibility to anticipate and provide such additional safety precautions, facilities, personnel, and equipment as shall be necessary to protect life and property from whatsoever conditions of hazard are present or may be present.

1.03 RELATED SECTIONS

A. 01540 - Job Site Security

B. 01550 - Site Access and Traffic Control

C 01562 - Dust Control

D 01563 - VOC, Odor, and Vector Control

1.04 MINIMUM REQUIREMENTS

A. The CONTRACTOR shall prepare and implement a Site-specific Health and Safety Plan. The Health and Safety Plan shall conform with applicable State and Federal requirements, including, but not limited to:

1. Safety and Health Regulations promulgated by the U.S. Department of Labor: 29 CFR Part 1904 - Recording and Reporting Occupational Injuries and Illness, 29 CFR Part 1910 - Occupational Safety and Health Standards, and 29 CFR Part 1926 - Safety and Health Regulations for Construction.
2. U.S. Environmental Protection Agency Interim Standard Operating Safety Guides - Office of Emergency and Remedial Response - Hazardous Response Support Division, Rev. September 1982.
3. U.S. Environmental Protection Agency Medical Monitoring Program Guidelines.

B. The CONTRACTOR's Site-Specific Health and Safety Plan shall be prepared by the HSO. The HSO shall have experience with establishing and implementing Health and Safety Plans for hazardous waste site remediation projects and be a Certified Industrial Hygienist. The resume of the HSO shall be included in the Health and Safety Plan. The HSO shall be responsible for:

- Preparing and implementing the Health and Safety Plan;
- Updating the Health and Safety Plan as needed based on site conditions;
- Overall health and safety of the CONTRACTOR's and Subcontractor's personnel;
- Monitoring site health and safety conditions;
- Protecting surrounding community;
- Coordinating with area residents and other on-site CONTRACTOR's and subcontractors;

- Maintaining health and safety records; and,
- Identifying and providing a qualified Site Health and Safety Coordinator (SHSC) whom will implement the Site-specific Health and Safety Plan at the project site.

C. The CONTRACTOR's Health and Safety Plan shall incorporate the requirements contained herein and shall describe all actions to be taken to protect the health and safety of workers and the surrounding community. The plan shall identify all tasks to be undertaken by the CONTRACTOR and shall establish Health and Safety procedures for each task. The CONTRACTOR's Site-specific Health and Safety Plan shall be approved in writing by the HSO and shall be submitted to the GROUP'S REPRESENTATIVE, the REMEDIAL DESIGNER, the USEPA Region II, and NJDEP prior to the initiation of any fieldwork. Any modifications to the Plan shall be submitted to the REMEDIAL DESIGNER prior to construction. The GROUP'S REPRESENTATIVE, the USEPA, and/or NJDEP may comment on the CONTRACTOR's Site-specific Health and Safety Plan and any modifications thereto in addition to the REMEDIAL DESIGNER, but will not provide approval of the Site-specific Health and Safety Plan. The CONTRACTOR shall not mobilize to the Site until the plan has been received and addressed review comments on it from the GROUP'S REPRESENTATIVE, REMEDIAL DESIGNER, the USEPA, and NJDEP, unless otherwise approved by the GROUP'S REPRESENTATIVE.

D. Training requirements of all field personnel shall be specified in the Site-specific Health and Safety Plan. As a minimum, training in accordance with 29 CFR 1910.120 will be required for all personnel involved in intrusive activities (i.e., all below grade work and all grading and handling of soil or waste materials) and until all waste material is satisfactorily covered with 12 inches of soil or equivalent. Such training will also be required, at a minimum, for all crews who could be exposed to potentially hazardous materials during tie-ins, connections, and testing. Non-hazardous above-grade work (e.g., paving, seeding, signage) may not require 40-hour hazardous waste operations training, dependant upon proximity to exposed wastes.

E. To assist in preparation of the Site-specific Health and Safety Plan, the CONTRACTOR is encouraged to review existing Site documents including, but not limited to, the PJP Landfill Record of Decision (1995) and Statement of Work (1997) available from the GROUP'S REPRESENTATIVE or Public Repositories, for the CONTRACTOR's inspection.

F. The Site-specific Health and Safety Plan shall, at a minimum, include the following:

1. Identification of the HSO and the SHSC.
2. Monitoring of the worker's breathing zone and upwind and downwind of the work area for organic vapors and respirable dust.
3. Action levels for upgrading personal protective equipment (PPE) or implementing engineering controls shall be determined by the CONTRACTOR and explained in the Site-specific Health and Safety

Plan consistent with assuring health and safety of construction workers and potential on-site and off-site receptors.

4. The Work to be performed at the Site may, on occasion, need to be conducted in Level C or B PPE. The CONTRACTOR shall provide PPE for all personnel, who demonstrate they have the proper updated training for use of such equipment. The CONTRACTOR shall provide decontamination stations and shall maintain the stations daily during the Contract period. The CONTRACTOR shall provide receptacles for and disposal of all PPE used on-Site. PPE may be disposed of in accordance with the requirements for debris and waste soil disposal described in the Contract Documents. Used PPE shall be placed in appropriate containers or drums for off-site disposal.
5. A requirement that the CONTRACTOR always maintain at least one (1) person on-site trained in first aid and CPR.
6. Emergency phone numbers for the local hospital, ambulance service, police, and fire company shall be posted in conspicuous locations on-Site. A map showing the location of the nearest hospital and the most direct route to the hospital shall also be posted in conspicuous locations on-site.
7. Names and telephone numbers of emergency contacts for the CONTRACTOR and the GROUP'S REPRESENTATIVE shall be provided.
8. Contingency Plan describing medical emergency response, fire and explosion response, chemical exposure first aid, unforeseen circumstances, accident and incident reporting and emergency contacts.
9. An evaluation of potential site hazards.
10. Applicable material safety data sheets.
11. The Health and Safety Plan shall follow the general outline as provided in Attachment 01564-1 herein that contains the minimum elements for the Health and Safety Plan.
12. A Decontamination Plan, developed in conjunction with the Health and Safety Plan in accordance with Section 01300 – Submittals, of these Specifications. The Decontamination Plan shall include:
    a) Description of the procedures and materials used for the decontamination of all equipment that will be in contact with hazardous materials or media containing hazardous materials (i.e., soil, groundwater). Equipment would include such items as drill rigs, trucks, sampling equipment, field instruments, and hand-tools;
    b) No decontamination pad is currently available on-site. The Plan shall include a description and Site map showing the location of a temporary decontamination pad. The decontamination pad shall be constructed to collect all decontamination water for subsequent testing and disposal and be maintained throughout the construction period. Water supply must be provided, transported, and stored by the CONTRACTOR to the decontamination pad location.
    c) Description of the procedures used to characterize, contain, store, and dispose of wash water and personal protective equipment used during decontamination procedures.
13. Listing of Local, State, and Federal agencies and nearby residents that will be contacted in the event an accident occurs that could potentially

harm or threaten the health and safety of the CONTRACTOR's personnel, the general public, or the environment. The list should note which, if any, residents who may require special physical assistance in the event of an evacuation.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 RECORDKEEPING

A. All parties engaged in on-site activities shall read the CONTRACTOR's Site-specific Health and Safety Plan for the relevant tasks. The CONTRACTOR shall maintain documentation demonstrating compliance with this requirement on-Site. Written evidence of compliance with 29 CFR 1910.120 and applicable State and Federal requirements, for all parties engaged in on-Site activities, shall be maintained on-Site in the CONTRACTOR's files. Copies of such documentation shall be provided to the REMEDIAL DESIGNER and the GROUP'S REPRESENTATIVE.

*****END OF SECTION*****

SECTION 01590

FIELD OFFICES AND STORAGE SPACE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall provide a trailer with a field office for the CONTRACTOR's own needs, a separate trailer for use by the Agency (USEPA, USACE, and NJDEP), and a separate trailer for the GROUP's REPRESENTATIVE, QUALITY ASSURANCE OFFICIAL, and the REMEDIAL DESIGNER. The CONTRACTOR shall also provide secured storage space for the CONTRACTOR's needs. Alternatively, the CONTRACTOR may provide field offices in two or more large portable structures subject to the approval of the REMEDIAL DESIGNER.

B. The size of the CONTRACTOR's field offices and capacity of the storage areas shall be the responsibility of the CONTRACTOR and shall be such that daily operations can be conducted without restrictions. Office space shall provide adequate space for Project Meetings. Storage areas shall allow for access and orderly provision for maintenance and for inspection of products. The CONTRACTOR administrative, staging, and laydown areas shall be coordinated in the field by the REMEDIAL DESIGNER.

C. All field offices shall be kept clean and maintained weekly by the CONTRACTOR. The office space shall be kept free from obstructions. The CONTRACTOR shall maintain the area immediately around field offices to provide safe approach, entry, and exit. Stockpiles, debris, and equipment shall be located away from the field office.

D. The CONTRACTOR shall be responsible for all costs to permit, install and maintain, and remove the field office trailers and all temporary utilities for the duration of the Work. The CONTRACTOR shall pay for the electricity, telephone, bottled water, cleaning, and trash removal bills. Office furnishings, equipment (i.e., copiers, facsimile machines, telephones and answering machines) and appliances (i.e., microwave ovens, bottled water dispensers, and refrigerators) to be provided by the CONTRACTOR.

PART 2 - PRODUCTS

2.01 GENERAL

A. All equipment, building materials, furnishings, and fixtures must be adequate for the required purposes.

PART 3 - EXECUTION

3.01 PREPARATION

A. Field offices shall be placed at locations approved by the REMEDIAL DESIGNER and/or GROUP's REPRESENTATIVE.

B. Prior to the placement or construction of the field offices, the areas shall be graded to promote positive drainage away from the area and in a manner favorably reviewed by the REMEDIAL DESIGNER. Provide a minimum twelve (12) inch thick crushed stone mat for each field office.

3.02 INSTALLATION

A. Field offices shall be installed on adequate foundations and shall be level. Portable trailers shall be adequately anchored to prevent uplift.

B. Office space shall be ready for occupancy three (3) working days prior to initiating the Work.

C. A parking area shall be located adjacent to the field office with adequate parking space for at least ten (10) vehicles.

3.03 REQUIREMENTS

A. Portable or mobile buildings with raised floors shall be equipped with steps and landings at entrance doors including steps and handrails constructed in accordance with applicable Federal, State and local regulations.

B. Each office shall contain a minimum of two rooms (offices) and shall be minimum of 300 square feet. Heating, air conditioning, and operable windows with expanded metal protection shall be provided for each trailer. Equip each office trailer with an appropriate fire extinguisher.

C. Each office trailer shall contain an office area with three (3) desks with chairs, a conference area with a long table and chairs, and include bookcases, file cabinets, and a drafting table with stool. Furnish each trailer with a small microwave oven and a refrigerator.

D. Each office trailer shall be supplied with a bottled water dispenser and regularly supplied with bottled potable drinking water.

E. A minimum of two (2) portable restrooms, one shall be designated for use by women. Portable restrooms shall be supplied and maintained on at least a weekly basis.

F. Provide five (5) separate telephone lines to each office trailer, three (3) voice lines and two (2) data lines (facsimile and computer modem). The CONTRACTOR shall likewise provide for three (3) telephones with individual answering machines and one (1) facsimile machine. Provide each office trailer

with one (1) copier with document feeder and capable of collating up to ten (10) copies.

G. Provide one or more dumpsters for trash and arrange for emptying/hauling and off-Site disposal of trash on at least a weekly basis. The CONTRACTOR shall pick-up accumulated trash and debris daily and deposit them into a dumpster.

3.04 REMOVAL

A. At the completion of the Work, remove all buildings, utility services, trailers, and debris and restore areas to their original condition. Apply vegetative layer and seeding as required by the Contract Documents, in accordance with Section 02225 – Vegetative Layer, and Section 02936 – Seeding, of the Specifications.

*****END OF SECTION*****

SECTION 01700

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The Work under this Section includes, but is not limited to, the maintenance, recording, and submittal of appropriate documents for closeout of the Work.

1.02 SUBSTANTIAL COMPLETION

A. The CONTRACTOR shall submit written notice to the REMEDIAL DESIGNER and the GROUP's REPRESENTATIVE that the Work, or designated portion of the Work, is substantially complete.

B. The CONTRACTOR shall submit a list of major items to be completed or corrected.

C. The REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL will review the Work after receipt of notice, together with the CONTRACTOR.

D. Should the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL consider the Work tentatively substantially complete:

1. The CONTRACTOR shall prepare and submit to the REMEDIAL DESIGNER and the GROUP's REPRESENTATIVE, a list of items to be completed or corrected, as determined by the review.
2. The CONTRACTOR shall complete aspects of the Work listed for completion or correction, within designated time.

E. Should the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL consider the Work <u>not</u> substantially complete:

1. The REMEDIAL DESIGNER shall notify the CONTRACTOR within two (2) working days, in writing, stating the reasons why the Work is not considered substantially complete.
2. The CONTRACTOR shall complete the Work, and send second written notice to the REMEDIAL DESIGNER, certifying that the Work, or designated portion of the Work, is substantially complete.
3. The REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL will again review the Work.

1.03 FINAL CLEANING

A. Execute final cleaning prior to the final inspection.

B. Clean any debris from the Work areas.

C. Clean the remainder of the Site of any deleterious material as directed by the REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL.

D. Remove waste and surplus materials, rubbish, and construction facilities and offices from the Site.

E. Restore all disturbed areas to "as-was" or "better" conditions to the satisfaction of the REMEDIAL DESIGNER.

1.04 FINAL REVIEW

A. The CONTRACTOR shall submit written certification that:

1. The Work has been completed in accordance with the Contract Documents.
2. Equipment and systems have been tested in the presence of the REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL and are operational.
3. All inspections by local or regional agencies have been satisfactorily completed.
4. The Work is complete and ready for final review.
5. The Project Record Documents have been maintained in accordance with Section 01720 of these Specifications and accurately describe the completed Work.

B. The REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL shall verify the information contained in Article 1.04A herein for accuracy.

C. Should the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL consider the Work <u>not</u> finally complete:

1. The REMEDIAL DESIGNER shall notify the CONTRACTOR within five (5) working days, in writing, stating the reasons why the Work is not considered finally complete.
2. The CONTRACTOR shall take immediate steps to remedy the stated deficiencies and send second written notice to the REMEDIAL DESIGNER certifying that the Work is complete.
3. The REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL will again review the Work.

1.05 CLOSEOUT SUBMITTALS

Contractor shall submit to the REMEDIAL DESIGNER for review and acceptance:

A. Approved final Technical Manual(s) (i.e., O&M Manuals) in accordance with requirements of Section 01300, Article 1.09, of these Specifications.

B. Deliver evidence of compliance with requirements of governing authorities:

1. Certificates of Acceptance, if required.
2. Certificate of Occupancy, if required.

C. Deliver Certificate of Insurance for Products and Completed Operations.

D. Applicable requirements of Federal, State, and local agencies having jurisdiction.

E. Written warranties and/or guaranties from manufacturers for components, materials, and equipment that constitute the Work.

F. Project Record Documents in accordance with Section 01720 of these Specifications within thirty (30) days of substantial completion.

1.06 EVIDENCE OF PAYMENTS AND RELEASE OF LIENS

A. The CONTRACTOR's Affidavit of Payment of Debts and Claims.

B. The CONTRACTOR's Affidavit of Release of Liens; with:

1. Consent of Surety to Final Payment.
2. The CONTRACTOR's release or waiver of liens (to be reviewed by the REMEDIAL DESIGNER and GROUP's REPRESENTATIVE prior to final Payment Certification).

C. Separate releases or waivers of liens for SUBCONTRACTORs, suppliers, and others with lien rights against property of OPERATOR, together with list of those parties.

D. All submittals shall be duly executed before delivery to the GROUP's REPRESENTATIVE.

1.07 FINAL ADJUSTMENT OF ACCOUNTS

A. Submit the final Application for Payment to the REMEDIAL DESIGNER for verification and acceptance of the information provided. The REMEDIAL DESIGNER will submit the Application for Payment to the GROUP's REPRESENTATIVE.

B. Final application for Payment shall reflect all adjustments, including:

1. Original Contract Price.
2. Additions and deductions resulting from:
   a. Previous Change Orders;
   b. Unit Prices;
   c. Other adjustments;
   d. Deductions for uncorrected work; and,
   e. Deductions for Re-review/Re-inspect payments.
3. Total Contract Price, as adjusted.
4. Previous payments.
5. Amount remaining due.

1.08 POST-CONSTRUCTION REVIEW

A. Prior to expiration of one (1) year from the Date of Substantial Completion, the REMEDIAL DESIGNER and GROUP's REPRESENTATIVE will make visual review of the Work, in the company of the CONTRACTOR, to determine whether correction of the Work is required, in accordance with provisions of Section 01740 of these Specifications. The CONTRACTOR shall correct the deficiencies in a timely manner.

B. The REMEDIAL DESIGNER and/or GROUP's REPRESENTATIVE will promptly notify the CONTRACTOR, in writing, of any observed deficiencies.

PART 2- PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 01720

RECORD DOCUMENTS

PART I - GENERAL

1.01 DESCRIPTION OF WORK

A. The Work under this Section includes, but is not necessarily limited to, the maintenance, recording, and submittal of Record Documents as herein specified.

B. The CONTRACTOR shall maintain in designated locations at the Site for the REMEDIAL DESIGNER one (1) record copy of each of the following items as Record Documents:

1. Contract Drawings and Addenda;
2. Contract Specifications and Addenda;
3. Change Orders and other modifications to the Contract;
4. Field Orders or written instructions;
5. Reviewed submittals Shop Drawings, product data, and samples;
6. Field test records;
7. Manufacturer's certificates;
8. Monthly Construction Photographic Reports; and,
9. Daily work activity reports, including, if existing:
   a. Field test records;
   b. Photographs;
   c. Reports on emergency response actions;
   d. Records of all Site work;
   e. Chain-of-custody documents;
   f. Laboratory test records;
   g. Meteorological records;
   h. Daily inspection records;
   i. Reports on all safety and accident incidents;
   j. Reports on all spill incidents;
   k. Air monitoring reports and data;
   l. Manifest documents, truckload tickets, and shipping papers;
   m. Security records;
   n. Other items that may be required by GROUP'S REPRESENTATIVE or REMEDIAL DESIGNER, and
   o. Log of control and survey work.

C. Other Documents: Manufacturer's certifications, inspection certifications, and field-test records required by individual Sections of these Specifications.

D. The REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL shall verify the Items listed in Article 1.01 (Parts A, B, and C herein) for accuracy during the course of the Work.

1.02 MAINTENANCE OF DOCUMENTS AND SAMPLES

A. Storage

1. Store documents and samples in the CONTRACTOR's field office apart from documents used for construction.
2. Provide files and racks for storage of documents.
3. Provide locked cabinet or secure storage space for storage of samples.

B. File documents and samples in accordance with the format of these Specifications.

C. Maintenance

1. Maintain documents in a clean, dry, legible condition, and in good order.
2. Do not use the Record Documents for construction purposes.

D. Make documents and samples available at all times for inspection by the GROUP'S REPRESENTATIVE, QUALITY ASSURANCE OFFICIAL, and/or the REMEDIAL DESIGNER.

1.03 RECORDING

A. Label each document "PROJECT RECORD" in neat, large-printed letters.

B. Recording

1. Record information concurrently with construction progress.
2. Do not conceal any work until required information is recorded.

C. Drawings: Record Drawings shall be reproducible (vellum or mylar), shall have a title block indicating that the drawings are Record Drawings, the name of the company preparing the Record Drawings and the date the Record Drawings were prepared. If drawings are produced using computer software (e.g., AutoCAD), electronic copy on diskette shall also be submitted. The CONTRACTOR will be provided paper sepias of the Record Drawings, at the cost of reproduction, or he may elect to provide reproducible drawings via another method. Legibly mark drawings to record actual construction:

1. Field changes of dimension and detail.
2. Changes made by request for clarification of the Contract Documents, Field Order, or by Change Order.
3. Details not on the original Contract Drawings.
4. Horizontal and vertical locations of underground utilities and appurtenances.

D. Specifications: Legibly mark each Section to record:

1. Manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually installed.
2. Changes made by request for clarification of the Contract Documents, Field Order, or by Change Order.

E. Additional Record Documents shall be prepared as required by individual Sections of these Specifications or the Contract Documents.

1.04 SUBMITTALS

A. At Contract closeout, the CONTRACTOR shall deliver six (6) sets of the Record Documents in the form of a Final Construction Report to the QUALITY ASSURANCE OFFICIAL for review and acceptance.

B. Record Drawings shall be certified and stamped by a Professional Engineer licensed in the State of New Jersey. Survey data and plans shall be certified by a Professional Land Surveyor licensed in the State of New Jersey.

C. Each Final Construction Report shall include a Final Construction Photographic Report, consisting of a compilation of the individual monthly reports, prepared in accordance with Section 01380 – Construction Photographs, of these Specifications. The final report shall meet the requirements of Section 01380, of these Specifications. Photographic negatives shall be mounted in clear plastic, loose-leaf, negative mounts, bound in a separate binder which includes copies of the photographic logs as descried in Section 01380 of these Specifications, and submitted to the REMEDIAL DESIGNER. Clearly label the negatives with identifications corresponding to the entries in the photographic logs (e.g., film and exposure number, description, date, etc.).

D. Accompany the submittal with transmittal letter, in duplicate, containing:

1. Date;
2. Project title and number;
3. The CONTRACTOR's name, address, and telephone number;
4. Title and number of each record document; and,
5. Signature of the CONTRACTOR's authorized representative.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 01740

WARRANTIES

PART 1 - GENERAL

1.01 PROJECT MAINTENANCE AND WARRANTY

A. Maintain and keep in good repair the Work covered by this Contract until acceptance by the REMEDIAL DESIGNER.

B. The CONTRACTOR shall warrant for a period of one (1) year from the date of the written final acceptance of the Work as defined in the Contract Documents, that the completed Work is free from all defects due to faulty products or workmanship and the CONTRACTOR shall promptly make such corrections as may be necessary by reason of such defects. The REMEDIAL DESIGNER and/or GROUP'S REPRESENTATIVE will give notice of observed defects with reasonable promptness. In the event that the CONTRACTOR should fail to make such repairs, adjustments, or other work that may be made necessary by such defects, the GROUP may do so and charge the CONTRACTOR the cost thereby incurred.

C. The CONTRACTOR shall not be obligated to make replacements, which become necessary because of improper operation or maintenance, or as a result of improper work or damage by another CONTRACTOR, or to perform any work that is normally performed by a maintenance crew during operation.

D. The CONTRACTOR, at the CONTRACTOR's own expense, shall furnish all labor, materials, tools, and equipment required; and, shall make such repairs, removals, and perform such work or reconstruction as may be made necessary by any structural or functional defect or failure resulting from neglect, faulty workmanship or faulty materials, in any part of the Work performed by the CONTRACTOR. Such repair shall also include regrading of the cover system as a result of settlement or erosion due solely to the activities performed for this Work, or placement and reseeding areas disturbed by the Work to meet the cover requirements as outlined in Section 02936 – Seeding, of these Specifications, if necessary.

E. Except as noted on the Contract Drawings or as specified, all structures shall be returned to their original condition prior to the completion of the Contract. The CONTRACTOR, at the CONTRACTOR's own expense, shall promptly repair any and all damage to any facility not designated for removal and damaged from the CONTRACTOR's operations.

F. In the event CONTRACTOR fails to proceed to remedy the defects upon notification within fifteen (15) days of the date of such notice, the GROUP reserves the right to cause the required materials to be procured and the Work to be done, as described in the Contract Documents, and to hold the CONTRACTOR and the sureties on the CONTRACTOR's bond liable for the cost and expense thereof.

G. Notice to the CONTRACTOR for repairs and reconstruction will be made in the form of a registered letter addressed to the CONTRACTOR at the CONTRACTOR's home office.

H. Neither the foregoing paragraphs, nor any provision in the Contract Documents, nor any special guarantee time limit implies any limitation of the CONTRACTOR's liability within the law of the place of construction.

1.02 INDIVIDUAL EQUIPMENT AND MATERIAL WARRANTY

A. The CONTRACTOR shall provide the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER with warranties and guarantees supplied by manufacturers whose equipment or materials become part of the finished Work. The warranties and guarantees shall name the GROUP as warrantee or guarantee. Warranties or guarantees listing the CONTRACTOR as such shall not be transferable or acceptable.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 02100

SITE PREPARATION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all permits, materials, labor, equipment, tools and appurtenances required to complete the Work as described herein. The CONTRACTOR shall provide a "Competent Person" to implement, supervise and inspect all Work.

B. This Section describes materials and equipment to be utilized and requirements for their use in preparing the Site for construction.

C. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of Local, State or Federal authorities having jurisdiction.

D. The CONTRACTOR shall remove, transport, and dispose of cleared and grubbed materials at on-site areas designated by the GROUP'S REPRESENTATIVE. The CONTRACTOR shall provide all equipment, materials, and personnel necessary to remove and transport these materials to the designated areas.

E. Protect and maintain benchmarks, monuments and other reference points. Re-establish, at no cost to the GROUP, any such reference points if disturbed or destroyed. The CONTRACTOR's surveyor shall conduct a survey of all monuments and property markers within proposed Work areas prior to any disturbance so that they can be re-established after completion by the CONTRACTOR as part of this Contract.

F. Protect and maintain any existing groundwater monitoring wells, piezometers, landfill gas wells utility poles, fences and all other facilities to remain in place.

G. Protect any existing facilities, utilities, and structures from damage due to construction.

1.02 RELATED SECTIONS

A. 01540 - Job Site Security

B. 01550 - Site Access and Traffic Control

C. 01562 - Dust Control

D. 01564 - Health and Safety Specifications for Construction

E. 02110 - Site Clearing and Grubbing

F. 02220 - Excavation

PART 2 – PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

*****END OF SECTION*****

SECTION 02110

SITE CLEARING AND GRUBBING

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all materials, labor, equipment, tools and appurtenances required to complete the work as described below. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect all Work.

B. Site clearing includes, but is not limited to, removing from the construction area, hauling to disposal areas approved by the REMEDIAL DESIGNER, and disposing of trees, stumps, roots, brush, structures, abandoned utilities, trash, debris and all other materials found on or near the surface of the ground within construction areas. Precautionary measures that prevent damage to existing features to remain are part of the Work.

C. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, State, or Federal authorities having jurisdiction.

D. No clearing and grubbing shall be allowed without adequate erosion and sedimentation control measures in-place to the satisfaction of the REMEDIAL DESIGNER and as described in the Contract Documents.

E. In areas where waste is exposed by clearing and grubbing, odor and/or vector controls, as outlined in Section 01563 - VOC, Odor and Vector Control, of these Specifications, shall be implemented as necessary.

1.02 RELATED SECTIONS

A. 01562 - Dust Control

B. 01563 - VOC, Odor and Vector Control

C. 01564 - Health and Safety Specifications for Construction

D. 02125 - Erosion and Sedimentation Control

E. 02220 - Excavation

1.03 JOB CONDITIONS

A. Location of Work: Areas to be cleared and grubbed include all areas designated for the multi-layer, modified solid waste cap placement, laydown area(s), designated access roads, stormwater system upgrades, Sip Avenue Ditch, Hackensack River bank, fence relocation, and all areas identified in the Contract Documents associated with the Remedial Action.

PART 2 - PRODUCTS

A. The CONTRACTOR shall furnish equipment of the type normally used in clearing and grubbing operations including, but not limited to, dozers, shears, skidders, loaders, root rakes, chipping equipment and stump grinders.

PART 3 - EXECUTION

3.01 SCHEDULING OF CLEARING

A. The CONTRACTOR shall clear at each construction area only that area which can be completed within two weeks work. This area shall be determined based on the CONTRACTOR's Construction Schedule.

B. The GROUP'S REPRESENTATIVE may permit clearing of additional areas provided that temporary erosion and sedimentation controls are in place in accordance with Section 02125 - Erosion and Sedimentation Control, of these Specifications.

3.02 CLEARING AND GRUBBING PROCEDURES

A. Materials to be cleared, grubbed and removed from the construction areas include, but are not limited to, the following: all trees, stumps, roots, brush, trash, organic matter, and debris.

B. Grubbing shall consist of completely removing roots, stumps, trash and other debris from all graded areas so that surface material is free of roots and debris. Surface material is to be left sufficiently clean so that further picking and raking will not be required.

C. Stumps, roots, foundations and planking embedded in the ground shall be removed and properly disposed at designated on-site waste relocation areas approved by the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER.

D. Surface rocks and boulders greater than 8-inches in diameter shall be grubbed from the soil and removed to designated on-site waste relocation areas approved by the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER.

E. Where tree limbs interfere with utility wires, or where trees to be felled are in proximity to utility wires, these trees shall be taken down in sections to eliminate the possibility of damage to the utility wires. The CONTRACTOR shall be responsible for damages to utilities and consequential damages to the GROUP and third parties and shall replace or repair damaged utilities at no cost to the GROUP.

F. Any Work pertaining to utility poles and guy wires shall comply with the requirements of the appropriate utility owner.

G. Stumps and roots shall be grubbed and removed to a depth not less than 2-feet below grade. All holes or cavities which extend below the subgrade elevation of the proposed work shall be filled with crushed rock or other suitable material, compacted to a similar density as the surrounding material. Roots ½-inch in diameter and greater shall be removed to a depth not less than 6-inches below grade.

H. The CONTRACTOR shall be held liable for any direct or consequential damage to property outside of the designated Work area(s).

I. The CONTRACTOR shall be responsible for all damages to existing structures and/or improvements resulting from the Work.

J. The CONTRACTOR shall protect existing wells and fencing, and any other facilities or structures to remain from damage due to construction activities. Damaged items shall be repaired or replaced at no cost to the GROUP.

3.03 DISPOSAL OF DEBRIS

A. Debris (i.e., stumps, roots, branches, leaves etc.) resulting from the Site clearing and grubbing operations shall be removed to the approved on-site waste relocation area(s) designated by the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER.

B. All trees and shrubs from the clearing operation shall be chipped on-site. Chipped material and other organics resulting from clear and grub operations will be used on-site in on-site waste relocation areas designated by the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER. Chipped material from portions of trees and shrubs above grade (trunks, branches) will be stockpiled for later use as mulch for landscaping purposes.

*****END OF SECTION*****

SECTION 02125

EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall provide all materials and promptly take all actions necessary to achieve effective erosion and sedimentation control in accordance with all applicable Federal, State, and local enforcing agency guidelines and these Specifications. Some of the contents of this Section may not be directly applicable to this Work, but are included as a contingency if unanticipated circumstances occur.

B. The Contract Documents shall be considered minimum requirements for erosion and sedimentation control and shall not relieve the CONTRACTOR of the responsibility to actively take all steps necessary to control soil erosion and sedimentation in all areas associated with the Work. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect all erosion and sediment control work. The QUALITY ASSURANCE OFFICIAL will monitor the CONTRACTOR for satisfactory implementation of the Work.

C. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction. The CONTRACTOR must provide his site-specific Erosion and Sediment (E&S) Control Plan to the REMEDIAL DESIGNER for review prior to submitting it to the local authorities for approval. The CONTRACTOR and the REMEDIAL DESIGNER shall work together with local authorities, and other experts as directed by the REMEDIAL DESIGNER, attend meetings as necessary, and answer all questions/comments to the satisfaction of the local authorities. The CONTRACTOR is responsible for obtaining all other necessary State and local permits required for the Work.

D. The CONTRACTOR shall not proceed with construction until the site-specific Erosion and Sediment Control Plan is approved by REMEDIAL DESIGNER and submitted to the Hudson County Soil Conservation District for information purposes.

E. The CONTRACTOR shall repair and/or replace any materials damaged by erosion or covered with sedimentation, at no additional cost to the GROUP.

F. Temporary erosion and sedimentation control features installed by the CONTRACTOR shall be maintained by the CONTRACTOR until no longer needed and as determined by the REMEDIAL DESIGNER, or permanent erosion and sedimentation control methods are installed and/or established.

G. It shall be the sole responsibility of the CONTRACTOR to properly schedule and coordinate all necessary labor, equipment, and materials such that the specified Work is performed in accordance with the Construction Schedule and the Contract requirements. The GROUP'S REPRESENTATIVE and/or REMEDIAL DESIGNER may reject or direct the CONTRACTOR to repair, at the CONTRACTOR's own expense, those items which are detrimental to the Work or not in compliance with the Contract Documents. Such direction or rejection shall not relieve the CONTRACTOR of his obligation to properly schedule and perform other specified Work items in conformance with the Contract Documents.

1.02 RELATED SECTIONS

A. 02100 - Site Preparation

B. 02110 - Site Clearing and Grubbing

C. 02210 - Site Grading

D. 02220 – Excavation

E. 02221 - Waste Excavation and Relocation

F. 02223 - Fill Materials

G. 02936 - Seeding

1.03 SUBMITTALS

A. The CONTRACTOR shall submit MANUFACTURER's material data sheets and guidelines for installation of silt fence and other manufactured erosion and sediment control devices as necessary for the Work.

B. The GROUP has prepared and submitted a general Erosion and Sediment Control Plan to the Hudson County Soil Conservation District as part of the final design. The CONTRACTOR's Site-Specific Erosion and Sediment Control Plan shall incorporate the GROUP's general Erosion and Sediment Control Plan, and include specifics on the CONTRACTOR's proposed means and methods of construction and proposed sequencing. The CONTRACTOR shall submit a Site-specific Erosion and Sediment Control Plan to the REMEDIAL DESIGNER for approval a minimum of 30-days prior to the commencement of construction activities. The plan shall meet the minimum requirements outlined in the GROUP'S general plan (see Article 1.01C above). Upon approval from the REMEDIAL DESIGNER, a copy of the CONTRACTOR's Plan must be provided to the Hudson County Soil Conservation District before any Site activities commence. The CONTRACTOR shall incorporate any comments from the Hudson County Soil Conservation District until approval is achieved.

1.04 QUALITY ASSURANCE

A. All temporary erosion and sedimentation control features installed by the CONTRACTOR shall be maintained by the CONTRACTOR until no longer needed or permanent erosion and sedimentation control methods are installed or established. The QUALITY ASSURANCE OFFICIAL will monitor satisfactory completion of the Work.

1.05 COMPLIANCE WITH REGULATIONS

A. All soil erosion and sediment control measures shall be constructed and maintained in accordance with NJDEP's "Erosion and Sediment Pollution Control Program Manual," (Manual) dated March 2000. Where the Manual and these Specifications differ, the more stringent requirement shall apply.

PART 2 - PRODUCTS

2.01 SILT FENCE

A. Silt fences shall be a woven geotextile attached to wooden or steel posts as detailed on the Contract Drawings.

2.02 BALES

A. Straw bales shall be clean, seed-free oat or wheat types.

2.03 SEEDING

A. In accordance with Section 02936 - Seeding of these Specifications.

2.04 FERTILIZER

A. In accordance with Section 02936 – Seeding, of these Specifications.

2.05 MULCH

A. Straw mulch shall be oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable. Straw mulch shall be properly anchored.

B. Wood fiber mulch shall consist of wood fiber produced from clean, whole-uncooked wood, formed into resilient bundles having a high degree of internal friction, and shall be dry when delivered to the Site.

C. Mulch shall be applied at a rate of 2-tons per acre.

2.06 WATER

A. In accordance with Section 02936 – Seeding, of these Specifications.

2.07 LIME

A. In accordance with Section 02936 - Seeding, of these Specifications.

2.08 TEMPORARY EROSION CONTROL MAT

A. Temporary Erosion Control Mat shall be Erosion Control Systems Inc.'s High Impact Excelsior Mat, or approved equal.

2.09 PERMANENT EROSION CONTROL MAT

A. Permanent Erosion Control Mat shall be Enkamat, or approved equal.

2.10 STONE RIPRAP

A. Stone riprap shall be as defined in Section 02274 – Stone Riprap, of these Specifications.

PART 3 - EXECUTION

3.01 GENERAL

A. Conduct earthwork and excavation activities in such a manner to fit the topography, soil type, and condition.

B. Minimize the area being disturbed and the duration of exposure to erosion elements, such that only two weeks work is exposed at any given time.

C. Stabilize disturbed areas immediately.

D. Retain on-site, sediment that was generated on-site.

E. Prevent silt and sediment from entering any watercourse if soil erosion cannot be prevented.

F. Prevent silt and sediment from migrating downstream in the event it cannot be prevented from entering the watercourse.

G. Where provisions of pertinent rules and regulations conflict with these Specifications, the more stringent provisions shall govern.

H. The REMEDIAL DESIGNER has the authority to limit the surface area of erodible material exposed by clearing and grubbing, and to direct the CONTRACTOR to provide immediate temporary or permanent control measures to prevent sediment impacts on nearby watercourses.

I. Where erosion is likely to be a problem, clearing and grubbing operations should be scheduled and performed such that grading operations and permanent erosion

control features can follow immediately thereafter, if the Work conditions permit; otherwise, erosion control measures may be required between successive construction stages.

J. In the event that additional temporary erosion and sedimentation control measures are required due to the CONTRACTOR's negligence, carelessness or failure to install permanent controls as a part of the Work schedule, or are ordered by the GROUP'S REPRESENTATIVE, REMEDIAL DESIGNER, USEPA, NJDEP, or Hudson County Soil Conservation District, such Work shall be performed by the CONTRACTOR, at no additional cost to the GROUP, and no time extensions shall be granted.

3.02 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Temporary erosion and sedimentation control measures shall be used to correct conditions that develop during construction and lead to soil erosion or deposition of waterborne sediments; that are needed prior to installation of permanent erosion and sedimentation control features; or that are needed temporarily to control erosion and/or sedimentation that develops during normal construction practices, but are not associated with permanent control features for the Work.

B. Temporary erosion and sedimentation control devices shall be installed and maintained prior to initial land disturbance activities and until satisfactory completion or establishment of permanent erosion control measures. At that time, temporary measures shall be removed upon approval by the REMEDIAL DESIGNER.

C. The CONTRACTOR shall coordinate the installation of temporary erosion and sedimentation control provisions contained herein with the permanent erosion control features, to ensure economical, effective and continuous erosion control throughout the construction and post-construction period.

D. Silt fences, barriers, turbidity curtains, temporary sedimentation basins, and other temporary measures shown on the CONTRACTOR's approved site-specific Erosion and Sediment Control Plan shall be installed as indicated and shall be maintained until no longer needed or as determined by the REMEDIAL DESIGNER. At that time, the items shall be removed by the CONTRACTOR. All temporary items and devices must be removed with the approval of the REMEDIAL DESIGNER prior to final demobilization from the Site.

E. Where permanent vegetation is not appropriate and where the CONTRACTOR's temporary erosion and sedimentation control practices are inadequate, the CONTRACTOR shall provide a temporary vegetative cover.

F. All erosion and sedimentation control devices shall be inspected by the CONTRACTOR at least weekly, after each rainfall occurrence, and cleaned out, and repaired by the CONTRACTOR, as necessary.

3.03 TEMPORARY EROSION AND SEDIMENT CONTROL TECHNIQUES

A. Temporary Diversion Berms

1. A temporary diversion berm is constructed of compacted soil, with or without a shallow ditch, at the top of fill slopes.
2. These diversion berms are used temporarily at the top of newly constructed slopes to prevent excessive erosion until permanent controls are installed or slopes stabilized.
3. A temporary diversion berm shall be constructed of compacted soil, with a minimum width of 24-inches at the top and a minimum height of 12-inches with or without a shallow ditch. Side slopes shall be three (3) horizontal to one (1) vertical (3H:1V) or less. The minimum longitudinal (crest) slope is 1 percent; while the maximum is 5 percent.
4. The maximum contributing drainage area for a temporary diversion berm is 3-acres.

B. Temporary Slope Drains

1. A temporary slope drain may consist of stone downchutes, fiber mats, plastic sheets, half-round pipe, metal pipe, plastic pipe, sod or other material acceptable to the REMEDIAL DESIGNER that may be used to carry water down slopes to reduce erosion prior to installation of permanent facilities or growth of adequate ground cover on slopes.
2. Fiber matting and plastic sheeting shall not be used on slopes steeper than 25 percent except for short downslope distances of 20-feet or less.
3. All temporary slope drains shall be adequately anchored to the slope to prevent disruption by the force of the water flowing in the drains. The base of temporary slope drains shall be compacted and concavely formed to channel water or hold the slope drain in place. The inlet end shall be properly constructed to channel water into the temporary slope drain.
4. Energy dissipaters, sediment control structures, or other approved devices shall be constructed at the outlet end of the slope drains to reduce erosion downstream.

C. Sediment Control Structures

1. Sediment basins, ponds, and traps are prepared storage areas constructed to trap and store sediment from erodible areas in order to protect stream channels below the construction areas from excessive siltation.
2. Sediment structures shall be utilized to control sediment where slope drains outlet. All sediment structures shall be at least twice as long as they are wide.
3. When use of temporary sediment structures is to be discontinued, all sediment accumulation shall be removed, excavation backfilled, and properly compacted. The existing ground shall be restored to its natural or intended condition.

D. Stone Riprap

1. Unless otherwise indicated on the Contract Drawings, or otherwise directed by the REMEDIAL DESIGNER, stone riprap, or an alternate

and equal erosion control system shall be placed where directed by the REMEDIAL DESIGNER and at all points where banks of drainage ditches are disturbed by excavation. Temporary erosion control mat may be used in these areas with the approval of the REMEDIAL DESIGNER. The subgrade shall be carefully compacted and stone riprap placed to prevent subsequent settlement and erosion. This requirement applies equally to construction alongside a drainage ditch as well as crossing a drainage ditch.

E. Straw Bales

1. Straw bales are temporary measures to control erosion and retain the suspended silt particles in the runoff water leaving disturbed areas. Bales shall contain 5 cubic feet (cf) or more of material.
2. Straw bales shall be embedded in the ground 4- to 6-inches to prevent water flowing under them. The bales shall also be anchored securely to the ground by stakes or rods driven through the bales into the ground, as indicated on the Contract Drawings. Bales shall be removed after they have served their purpose, as determined by the REMEDIAL DESIGNER.
3. The CONTRACTOR shall keep the bales in good condition by replacing broken or damaged bales immediately after damage occurs. Normal debris clean out will be considered routine maintenance.
4. Straw bales shall be used at the toe of fill slopes, in ditches, or other areas where siltation, erosion, or water run-off is a problem.
5. Bales shall be placed so that the predominant direction of the straw stalk is oriented perpendicular to the surface water flow direction.

F. Silt Fences

1. Silt fences are temporary measures utilizing woven wire or other approved materials attached to posts with a woven geotextile attached to the upstream side of the fence to retain the suspended silt particles in the runoff water.
2. Temporary silt fences shall be placed on the natural ground, at the toe of fill slopes, in ditches around soil stockpiles or other areas where siltation, erosion, or water run-off is a potential problem. Temporary silt fences shall be anchored as indicated on Contract Drawings.
3. The CONTRACTOR shall be required to maintain silt fences in a satisfactory condition for the duration of the Work or until its removal is requested by the REMEDIAL DESIGNER. The silt accumulation at the fence shall be removed and placed on-Site as directed by the REMEDIAL DESIGNER.
4. On disturbed slopes steeper than 15 percent, silt fence shall be placed every 40–feet, measured perpendicularly to the slope. On slopes flatter than 15 percent, silt fence shall be placed every 80-feet, measured perpendicular to the slope.
5. A grassed strip 5-feet wide (minimum) shall remain in-place immediately downgradient of each silt fence.

G. Temporary Vegetation

1. Temporary vegetation measures consist of seeding, mulching, fertilizing, and matting utilized to reduce erosion. All cut and fill slopes shall be seeded when and where necessary to eliminate erosion. Disturbed or bare soil areas shall not be left without stabilization for more than 30-days.
2. Seeding, fertilizing, and mulching shall be performed in accordance with Articles 2.03 to 2.05 of this Section.
3. If late Fall completion prevents germination, disturbed areas shall be protected by installing a long-term erosion control mat (Bon Terra CS2, Erosion Control System Inc.'s High Impact Excelsior Mat, or approved equal).

H. Temporary Erosion Control Matting

1. Temporary erosion control mat shall be installed immediately after seeding, if appropriate.
2. Any area disturbed and inactive for more than 15-days shall receive temporary seeding (unless permanent seeding is more appropriate) and temporary erosion control matting, if appropriate.

3.04 PERMANENT EROSION AND SEDIMENT CONTROL

A. The CONTRACTOR shall incorporate all permanent erosion control features into the Work at the earliest practicable time, as outlined in the CONTRACTOR's accepted Construction Schedule or as land disturbance for each segment of the Work has been completed.

B. Restore the Site to its original contours, unless otherwise shown on the Contract Drawings, or as directed by the REMEDIAL DESIGNER.

C. When final grades have been established, all bare soil, unless otherwise required by the Contract Documents, shall be seeded, fertilized, and mulched in an effort to restore the area to a protected condition. Areas that are not successfully stabilized with seed and mulch within 30-days of seeding shall be reseeded at the CONTRACTOR's own expense to the satisfaction of the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL.

D. Specified permanent vegetation shall be established at the first appropriate season following establishment of final grading in each section of the Site.

E. Permanent vegetative cover activities shall comply with local soil and water conservation guidelines.

F. Where permanent vegetative cover cannot be immediately established (due to season or other circumstances) the CONTRACTOR shall provide temporary vegetative cover.

3.05 PERMANENT EROSION AND SEDIMENT CONTROL TECHNIQUES

A. Permanent Vegetation: All references to permanent vegetation, unless noted otherwise, shall relate to establishing permanent vegetative cover and be in accordance with Articles 2.03 to 2.10, inclusive, of this Section. Initial seeding of permanent vegetation shall occur within 15-days of final grading. Permanent vegetation will require a stand of growth of at least 80 percent areal coverage and no spots greater than 1 square yard (s.y.) in area, within 1-year of the initial seeding, or the CONTRACTOR shall re-seed at no cost to the GROUP. The CONTRACTOR, at the direction of the REMEDIAL DESIGNER, shall selectively cut the established first growth after 1-year.

*****END OF SECTION*****

SECTION 02140

CONSTRUCTION DEWATERING

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. This Section specifies the requirements for handling and management of dewatering activities.

B. The CONTRACTOR shall design, construct and maintain all dikes, sumps, and diversion and drainage channels as necessary to complete the construction and to protect the areas to be occupied by permanent Work from water damage. The CONTRACTOR shall remove all temporary works after they have served their purpose.

C. The CONTRACTOR shall be responsible for the stability of all temporary and permanent slopes, grades, foundations, materials and structures during the course of the Work. Repair and replace all slopes, grades, foundations, materials and structures damaged by water, both surface and subsurface, to the lines, grades and conditions existing prior to the damage, at the CONTRACTOR's own expense.

D. The CONTRACTOR shall provide a "Competent Person" to implement, supervise and inspect all Work.

E. The CONTRACTOR shall provide measures to minimize accumulation of surface water in Work areas.

F. The CONTRACTOR will segregate all surface runoff that does not contact solid waste from surface water that does contact solid waste and groundwater that may be encountered by the CONTRACTOR during excavation operations. Surface water that contacts solid waste and groundwater encountered by the CONTRACTOR will be collected, pumped, transferred and temporarily stored for disposal in accordance with Section 02402 – Liquids Handling and Disposal, of these Specifications.

1.02 RELATED SECTIONS

A. 01563 - VOC, Odor and Vector Control

B. 01564 - Health and Safety Specifications for Construction

C. 02110 - Site Clearing and Grubbing

D. 02125 - Erosion and Sedimentation Control

E. 02210 - Site Grading

F. 02220 - Excavation

G. 02221 - Waste Excavation and Relocation

H. 02402 - Liquids Handling and Disposal

1.03 SUBMITTALS

A. At least 30-days prior to the proposed commencement date for construction dewatering, the CONTRACTOR shall submit a description of the proposed methods for accomplishing construction dewatering to the REMEDIAL DESIGNER for review. This description shall describe, in detail, the CONTRACTOR's proposed Dewatering Plan. The plan shall include detailed information about the CONTRACTOR's proposed dewatering measures (wells, wellpoints, sumps, diversion berms, dikes, and other means of providing/controlling construction dewatering), supporting calculations, layout and construction drawings, and any other relevant information required for a complete Dewatering Plan.

PART 2 - PRODUCTS

2.01 EQUIPMENT

A. Piping, pumping equipment, and all other equipment and materials required for dewatering shall be suitable for the intended purpose. Standby pumping units shall be maintained at the Site to be used in case of failure of the primary pumping units.

PART 3 - EXECUTION

3.01 HANDLING OF WATER

A. Design, furnish, install, maintain, monitor, operate and remove necessary pumping and other equipment for dewatering the various parts of the Work and for maintaining the Work areas free from water as required for constructing each part of Work.

B. Install all drainage ditches, sumps, and pumps to control excessive seepage into excavations and to drain impervious surfaces at final excavation elevation.

C. Dewater by means that will enable completion of the Work and preserve final lines and grades. Do not disturb or displace adjacent soil and/or waste material without prior approval form the REMEDIAL DESIGNER.

D. All pumping and drainage shall be done with no damage to property or structures and without interference with the rights of the public, owners of private property, pedestrians, vehicular traffic or the work of other contractors, and in accordance with all Federal, State, and local laws, ordinances and regulations.

E. The CONTRACTOR shall obtain all necessary dewatering permits (equivalencies) for discharge to surface waters or the ground surface. All groundwater encountered shall be handled in accordance with Section 02402 - Liquids Handling and Disposal, of these Specifications.

F. Do not overload or obstruct existing drainage facilities.

G. Separate all surface runoff water that does not contact solid waste, and segregate and collect all surface water that does contact solid waste, as well as groundwater that may be encountered during excavation or site grading. Collect, segregate, hold, and dispose of surface water that has contacted solid waste and groundwater separately from surface runoff that does not contact solid waste.

H. After they have served their purpose, remove all temporary protective measures at a time and in a manner approved by the GROUP'S REPRESENTATIVE or REMEDIAL DESIGNER. All temporary diversion channels and other temporary excavations in areas where the compacted fill or other structures will be constructed shall be cleaned out, backfilled and processed as indicated in Section 02223 – Fill Materials, of these Specifications.

I. Water that is pumped from dewatering activities shall be handled and disposed of in accordance with Section 02402 – Liquids Handling and Disposal, of these Specifications.

3.02 DEWATERING

A. By the use of pumps, tile drains or other approved methods, the CONTRACTOR shall control the flow and accumulation of water in excavated areas to prevent excessive softening, flotation of structures, damage to foundations, and disturbance of exposed soils in excavations as necessary for completion of the Work.

B. Upon commencement of dewatering operations, any noticeable settlement, visual or measured, of any structures in proximity of the dewatering zone shall be reason for termination of dewatering operations. The CONTRACTOR shall complete the Work by the use of other dewatering methods that will not endanger adjacent structures; all such Work shall be done at the CONTRACTOR's expense.

*****END OF SECTION*****

SECTION 02210

SITE GRADING

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the Work of rough and finish site grading for areas to receive river bank erosion protection, geomembrane capping and/or soil cover, embankments, site drainage, and general landscaping necessary for restoration of utility areas, trenches, and the overall Site. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

1.02 RELATED SECTIONS

A. 01050 - Field Engineering/Surveying

B. 01562 - Dust Control

C. 01563 - VOC, Odor and Vector Control

D. 02100 - Site Preparation

E. 02110 - Site Clearing and Grubbing

F. 02220 - Excavation

G. 02221 - Waste Excavation and Relocation

H. 02223 - Fill Materials

I. 02225 - Vegetative Layer

J. 02233 - Aggregate Materials

1.03 QUALITY ASSURANCE

A. Testing shall be provided by the CONTRACTOR in accordance with applicable Sections of these Specifications as outlined in Article 1.02 herein.

B. Tolerances in accordance with those specified in individual Sections of these Specifications, as outlined in Article 1.02 herein.

1.04 GENERAL

A. Notify corporations, companies, individuals or authorities owning above- or below-ground conduits, wires, pipes or other utilities running to the property prior to the start of the Work.

B. Cap or remove and relocate utility services in accordance with instructions by the GROUP'S REPRESENTATIVE, REMEDIAL DESIGNER and/or utility company.

C. Protect, support, and maintain conduits, wires, pipes or other utilities that are to remain in accordance with the requirements of the Contract Documents, and/or as required by the REMEDIAL DESIGNER, and/or utility company.

1.05 SUBMITTALS

A. In accordance with Section 01300 - Submittals and other applicable Sections of these Specifications, as outlined in Article 1.02 herein.

PART 2 - PRODUCTS

2.01 MATERIALS

A. In accordance with applicable Sections of these Specifications, as outlined in Article 1.02 herein.

PART 3 - EXECUTION

3.01 PREPARATION

A. Examine surfaces to receive fill to determine existence of areas loosened by frost action, softened by flooding or weather, or of unsuitable materials.

B. Fill settled areas that were previously filled and where excavations or trenches were backfilled and holes made by demolition, tree removal, and other Site preparation work.

C. Natural soils or compacted fill softened by frost, flooding or weather shall be removed, replaced with soils of similar characteristics, and compacted.

D. Remove unsuitable material from under access roads and driveway areas.

E. Maintain adequate drainage of the Site. Remove standing/ponding water prior to grading.

F. Grading within the influence zones of existing or future structures or piping and electrical conduits shall be in accordance with Sections 02220 - Excavation and 02223 – Fill Materials, of these Specifications.

3.02 FILLING AND GRADING

A. Perform in accordance with Sections 02221 – Waste Excavation and Relocation, and 02223 – Fill Materials, of these Specifications.

B. Stockpile material suitable for backfill where indicated on the Contract Drawings or designated by the REMEDIAL DESIGNER. Place no fill where trenches for sewers, water lines, or other utilities will be located.

C. Place and grade materials not suitable for backfilling or grading and unsuitable materials in designated relocation areas or as directed by the REMEDIAL DESIGNER.

D. Grade to the elevations specified by the Contract Documents.

3.03 CLEANING

A. Excess materials shall be removed, stockpiled, or otherwise disposed of by the CONTRACTOR at the direction of the REMEDIAL DESIGNER.

***** END OF SECTION *****

SECTION 02220

EXCAVATION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete all excavation related activities, including, but not limited to, excavations, disposal of excess and/or unsuitable materials, relocation of excavated soils to designated areas, and other related and incidental work within the designated areas and as required for the construction of other aspects of the Work, as shown, specified or required by the Contract Documents. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

B. The Work of this Section includes, but is not limited to, excavation associated with the construction of the surface water management system, ditches, installation of culverts/pipes, remediation of the Sip Avenue Ditch, and construction of the Hackensack river bank erosion protection, and other work as shown on the Contract Drawings. Excavations within the limits of waste materials shall comply with Section 02221 – Waste Excavation and Relocation, of these Specifications.

C. The CONTRACTOR shall locate all existing active and abandoned utilities and structures in designated Work areas prior to commencing any excavation activities. The CONTRACTOR shall also protect from damage those utilities and structures which are to remain in place.

D. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State, or Federal authorities having jurisdiction. Comply with Section 02221 – Waste Excavation and Relocation, of these Specifications, for excavation of waste, as applicable.

1.02 RELATED SECTIONS

A. 01050 – Field Engineering/Surveying

B. 01562 - Dust Control

C. 01563 - VOC, Odor, and Vector Control

D. 01564 - Health and Safety Specifications for Construction

E. 02110 - Site Clearing and Grubbing

F. 02125 - Erosion and Sedimentation Control

G. 02140 - Construction Dewatering

H. 02221 - Waste Excavation and Relocation

I. 02223 - Fill Materials

J. 02233 - Aggregate Materials

K. 02402 - Liquids Handling and Disposal

L. 02612 - Reinforced Culvert Pipe (RCP)

1.03 DEFINITIONS

A. Excavation shall mean the removal from place of all materials and shall include soil, facilities, structures above and below ground, rock, pavements, topsoil, demolition waste material, boggy waste, rubbish, tree stumps, boulders, logs, ashes, cinders or organic material such as peat, humus or organic silt.

B. Mucking or mucking-out shall mean excavation, as defined herein before, without prior dewatering.

1.04 PROTECTION OF PEOPLE AND PROPERTY

A. The CONTRACTOR shall be responsible for stability and safety of all of the CONTRACTOR's excavations at all times regardless of the requirements of this subsection.

B. The CONTRACTOR shall plan and conduct his operations so as to prevent damage to existing structures, safeguard people and property, minimize traffic inconvenience, protect structures to be installed, and provide safe working conditions.

C. Excavations shall be adequately covered with temporary measures or adequately barricaded to prevent unwanted or inadvertent intrusion.

D. Minimize stockpiling of excavated material. Place stockpiles back from the excavation area and provide dust, VOC and odor control measures in accordance with Sections 01562 – Dust Control, and 01563 – VOC, Odor and Vector Control, of these Specifications, respectively, as appropriate. The CONTRACTOR shall remove all excess excavated materials to designated on-site relocation areas, or as directed by the GROUP'S REPRESENTATIVE or REMEDIAL DESIGNER.

E. Prior to exposing subgrades, Work areas shall be surrounded by soil berms, or other approved measures, to contain surface water runoff accumulation within the Work areas and to exclude surface water run-on from adjacent areas. The CONTRACTOR shall employ excavation methods that minimize the need to remove accumulated water from excavations. However, if unavoidable, accumulated water shall be disposed of by methods specified in Section 02402 – Liquids Handling and Disposal, of these Specifications. Control of surface

water shall be by methods referenced in Section 02125 – Erosion and Sedimentation Control, of these Specifications.

F. Excavations may be made without shoring and bracing within the limitations and requirements of applicable governmental agencies having jurisdiction, provided that:

1. Hazards, such as described herein, do not exist in proximity of the excavation;
2. Excavation work is not in streets or other paved, landscaped or improved areas;
3. Excavation work can be restricted to the designated construction areas provided for the CONTRACTOR's use;
4. Shoring and bracing systems are not specifically required by Contract Documents; and,
5. The CONTRACTOR shall submit an excavation support plan, prepared by a Professional Engineer licensed in the State of New Jersey, indicating that the maximum excavation side slopes proposed, and that said side slopes will remain stable under all weather and working conditions over the entire period that the excavation will be exposed. This plan shall be based on the CONTRACTOR's own subsurface exploration and consideration of available options such as dewatering, construction equipment, and proximity of disposal areas. Any review and/or comments provided to the CONTRACTOR by REMEDIAL DESIGNER shall not relieve the CONTRACTOR of the responsibility arising from excavation operations.

G. In cases where excavations without shoring and bracing are not permissible solely because of worker safety, appropriate trench boxes may be used by the CONTRACTOR.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 LIMITS OF EXCAVATION

A. Excavation Classifications:

1. Earth excavation includes excavation of pavements and other obstructions visible on ground surface; underground facilities, utilities and other items indicated to be demolished and removed; together with earth and other materials encountered that are not classified as rock or unauthorized excavation.
2. Rock excavation:
   a. Rock excavation in trenches and channels includes removal and disposal of materials and obstructions encountered which cannot

be excavated with a 1.0 cubic yard (heaped) capacity (3/4 cubic yard backhoe for smaller work), 42-inch wide bucket on track-mounted power excavator equivalent to Caterpiller Model 215, rated at not less than 90 HP flywheel power and 30,000 lb. drawbar pull. Trenches and channels in excess of 10-feet in width and are classified as open excavations.

b. Rock excavation in open excavations includes removal and disposal of materials and obstructions encountered which cannot be dislodged and excavated with modern track-mounted heavy-duty excavating equipment without drilling, or ripping. Rock excavation equipment is defined as Caterpillar Model No. 973 or No. 977K, or equivalent track-mounted loader, rated at not less than 170HP flywheel power and developing 40,000 lb. breakout force (measured in accordance with SAE J732C). Typical materials classified as rock are boulders 1/2 cubic yard or more in volume, solid rock, rock in ledges, and rock-hard cementitious aggregate deposits.

c. Intermittent drilling, or ripping if performed to increase production and not necessary to permit excavation of material encountered will be classified as earth excavation.

B. Unauthorized excavations consist of removal of materials beyond subgrade elevations indicated on Contract Documents or dimensions without specific direction by the GROUP'S REPRESENTATIVE or REMEDIAL DESIGNER. Unauthorized excavations shall be at the CONTRACTOR's sole expense. The contractor shall backfill and compact unauthorized excavations in the same manner as specified for authorized excavations of same classification at the CONTRACTOR's sole expense, unless otherwise directed by the GROUP'S REPRESENTATIVE or REMEDIAL DESIGNER.

C. Additional Excavation: When excavation has reached required subgrade elevations, notify the REMEDIAL DESIGNER who will make a review of conditions.

1. If unsuitable bearing materials are encountered at required subgrade elevations, continue excavations to develop suitable bearing and replace excavated material as directed by the REMEDIAL DESIGNER.
2. Removal of unsuitable materials and its replacement as directed will be paid on basis of Contract conditions relative to changes in Work.

3.02 STORAGE

A. Stockpile satisfactory excavated materials where directed by the REMEDIAL DESIGNER, until required for backfill and fill placement. Place, grade and shape stockpiles to provide proper drainage. Install appropriate erosion and sediment control devices around stockpiles.

B. Locate and retain stockpiled soil materials away from edge of excavations, in such a location that the weight of the stockpiled materials could create surcharge loading conditions on the excavation edges.

C. Dispose of excess material and waste materials in accordance with Section 02223 – Fill Materials, of these Specifications for materials meeting the requirements of fill, and Section 02221 – Waste Excavation and Relocation, of these Specifications for material not meeting the requirements of fill.

3.03 EXCAVATION INSTRUCTIONS

A. Excavation for Structures: Conform to elevations and dimensions required within a tolerance of plus or minus 0.10 feet, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.

B. Excavation for Trenches: Excavate trenches and channels to the uniform widths and depths required for particular designs as shown on Contract Drawings. Trenches shall be sufficiently wide to provide ample working room and as otherwise required for proper installations. All trench excavations shall be sufficiently wide to accommodate mechanical compaction equipment (minimum 6-inches).

1. All excavated materials shall be removed and hauled from the Work areas at the time of excavation, and stockpiled for reuse as backfill at designated on-site areas or disposed of, at the CONTRACTOR's expense, as directed by the GROUP'S REPRESENTATIVE.
2. Barricades and signs warning of open trench excavations shall be erected to protect personnel working in the area.
3. Excavate trenches to the depths indicated on the Contract Documents or as required. Where rock is encountered, carry excavation 6-inches below required elevation and backfill with a 6-inch layer of compacted structural backfill as defined in Section 02223 – Fill Materials, of these Specifications.
4. Bedding and backfilling shall be in accordance with Section 02223 – Fill Materials, of these Specifications.
5. Do not backfill trenches until tests and inspections have been made, as-built surveying has been performed, and backfilling authorized by the QUALITY ASSURANCE OFFICIAL. The CONTRACTOR shall use care in backfilling to avoid damage or displacement.
6. Excavated trenches with depths greater than 4'-0" shall be considered confined spaces and shall be excavated in conformance with the requirements of the CONTRACTOR's Site-specific Health and Safety Plan prepared in accordance with Section 01564 of these Specifications.

C. Following excavation for swales, channels, concrete structures, outlets, outfalls, aprons, etc., the CONTRACTOR shall re-grade and add compacted backfill as needed to achieve the required surface for placement of materials as shown on the Contract Drawings or as otherwise required by the Contract Documents.

*****END OF SECTION*****

SECTION 02221

WASTE EXCAVATION AND RELOCATION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the Work of this Section. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

B. Comply with all applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction. Comply with Section 02220 of these Specifications for excavations as applicable.

C. The Work includes, but is not limited to,

1. Excavation of existing waste (if necessary) and existing cover materials in the landfill areas which require cut, trenching, or drilling, to establish subgrade elevations, minimum or maximum grades, or the installation of landfill gas extraction system, or stormwater management systems prior to the placement of the multi-layer, modified solid waste cover system.
2. Placement of excavated waste and cover materials removed from the excavation areas in waste relocation areas on the landfill designated by the REMEDIAL DESIGNER or hauled to a permitted waste disposal facility approved the by GROUP'S REPRESENTATIVE.
3. Compaction of waste and soils in the waste relocation areas.
4. Placement of temporary and permanent cover in the waste relocation areas, as applicable.

1.02 RELATED SECTIONS

A. 01562 - Dust Control

B. 01563 - VOC, Odor and Vector Control

C. 01564 - Health and Safety Specifications for Construction

D. 02100 - Site Preparation

E. 02110 - Site Clearing and Grubbing

F. 02125 - Erosion and Sedimentation Control

G. 02140 - Construction Dewatering

H. 02210 - Site Grading

I. 02220 - Excavation

J. 02223 - Fill Materials

K. 02233 - Aggregate Materials

L. 02402 - Liquids Handling and Disposal

M. 02625 - Passive Gas Vent Construction

1.02 DEFINITIONS

A. Waste: Solid waste, debris and existing cover materials are the end product of past landfilling operations that took place in the area and soils used for daily and intermediate cover. It is imperative that all personnel associated with this activity be trained and familiar with the CONTRACTOR's Site-Specific Health and Safety Plan prepared in accordance with Section 01564 – Health and Safety Specifications for Construction, of these Specifications.

B. Waste relocation areas: Areas of the landfill where filling is required to achieve design grades, and/or other areas approved by the REMEDIAL DESIGNER.

C. Excavated waste will not be utilized for components of the Work requiring cap cushion soil, cap cover soil, vegetative layer, cellular confinement soil, or structural fill, as defined in Section 02223 – Fill Materials, or as any materials defined in Section 02233 – Aggregate Materials, of these Specifications.

1.03 SUBMITTALS

A. Waste Excavation Plan: The CONTRACTOR shall provide a plan in conjunction with the CONTRACTOR's required Site-specific Health and Safety Plan. Indicate the sequence proposed for excavating waste, proposed equipment, approximate quantities, operation procedures, and surface water and contact water control procedures, odor, VOC and dust control procedures, and health and safety protocols.

1.04 HEALTH AND SAFETY REQUIREMENTS

A. Work shall be performed in compliance with all applicable health and safety regulations and in accordance with the CONTRACTOR's Site-specific Health and Safety Plan.

1.05 FIELD MEASUREMENTS

A. Verify that survey benchmarks and intended elevations for the Work are as indicated.

PART 2 - PRODUCTS

2.01 TEMPORARY COVER

A. Temporary cover is material used for covering of the waste and soils placed in waste relocation areas and in areas of newly exposed intact waste. This material must meet the requirements for Temporary Cover Material in accordance with Section 02223 – Fill Materials, of these Specifications.

PART 3 - EXECUTION

3.01 PREPARATION OF WASTE EXCAVATION AREAS

A. Identify required lines, grades, contours, and datum.

B. Protect benchmarks and existing structures from excavation equipment and vehicular traffic.

C. The CONTRACTOR shall designate an Exclusion Zone (area containing solid waste), Decontamination Zone, and Support Zone (clean area) prior to the commencement of the excavation of areas in waste. An Exclusion Zone delineated by a tape barrier or equivalent marker shall be established in a minimum 25-foot radius around the areas to be excavated. All personnel entering the Exclusion Zone shall wear the required PPE and shall decontaminate immediately upon leaving the Exclusion Zone as described in the CONTRACTOR's Site-specific Health and Safety Plan.

3.02 PREPARATION OF WASTE RELOCATION AREAS

A. Identify required lines, grades, contours, and datum.

B. Protect benchmarks and existing structures from equipment and vehicular traffic.

C. Compact subgrade by proof-rolling in accordance with Section 02223 – Fill Materials, of the Specifications. Waste placement shall not be performed on a subgrade that has not been proof-rolled.

3.03 EXCAVATION

A. Maintain excavation area dry. Grade or berm top perimeter of excavation to prevent surface water from draining into the excavation.

B. In all areas requiring trenching or excavation of waste for installation of remedy components, the CONTRACTOR is responsible for following all applicable health and safety precautions.

C. In areas requiring cut for the multi-layer, modified solid waste cover placement, excavate to subgrade elevation of the multi-layer cover section or 24 inches lower if waste materials are encountered to allow placement of grading layer consisting of clean fill or aggregate subbase.

D. Notify the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL in advance so that the excavated area can be closely observed.

E. Notify the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL of unexpected subsurface conditions and discontinue affected Work in the area until notified to resume by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL

F. Keep all transportation equipment, roads, and traffic areas free of debris and/or waste.

3.04 PLACEMENT OF EXCAVATED WASTE AND SOILS IN WASTE RELOCATION AREAS

A. Place excavated waste and soils in areas as designated by the Contract Documents or otherwise specified by the REMEDIAL DESIGNER.

B. Excavated waste and soils shall not be placed until the subgrade has been inspected in place and favorably reviewed by the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL.

C. Mix debris and waste, as necessary, with other on-site soil requiring disposal or clean off-site borrow soils to achieve a consistency to achieve the compaction described in Article 3.05 herein.

D. Large debris and waste materials shall be cut, shredded, or crushed into pieces no greater than 12 inches in any dimension, and, as necessary, mixed with other on-site soil requiring disposal or clean off-site borrow soils to achieve the compaction described in Article 3.05 herein. Large incompressible debris may be taken off-site for disposal with proper characterization by the CONTRACTOR and the approval of the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER.

E. Employ a placement method that does not disturb or damage existing structures/ systems, other portions of the Work or work by others.

F. Make gradual grade changes blending slopes into surrounding areas.

G. Minimize areal extent of waste relocation area.

H. Surface water run-on and run-off and erosion and sedimentation control shall be in accordance with Section 02125 – Erosion and Sedimentation Control of these Specifications.

I. Tires shall be chipped or shredded into pieces no greater than 9 inches in any dimension and mixed with soil and placed and compacted in accordance with this Section.

3.05 COMPACTION OF EXCAVATED WASTE AND SOILS

A. Excavated waste and debris shall be blended with on-site soils or off-Site soils and shall be placed in loose lifts not exceeding 18-inches in thickness. Compaction shall be performed by a minimum 20-ton roller. The CONTRACTOR shall make a minimum of two passes per lift over all areas. The compacted surface shall appear smooth and stable. Areas which exhibit an unstable condition such as excessive pumping, movement, or sloughing during compaction shall be excavated, moisture conditioned, reworked and compacted at the CONTRACTOR's expense. The compacted surface shall be favorably reviewed by the QUALITY ASSURANCE OFFICIAL prior to placement of additional materials.

3.06 PROTECTION OF FINISHED WORK IN THE WASTE RELOCATION AREAS

A. Place a temporary soil cover a minimum of 12-inches in thickness over all relocated and exposed waste material.

B. The area shall be graded to promote positive drainage. The minimum slope shall be as shown on the Contract Documents.

3.07 WASTE EXCAVATION SURVEY CONTROL

A. The completed excavation surface shall be as-built surveyed, as necessary, to ensure that actual depths and grades are in accordance with the Contract Drawings.

B. In areas on the landfill where cut is required to achieve subgrade elevations for cover placement, a minimum of one cross-section for every 50 linear feet (lf) of excavation shall be surveyed. At a minimum, survey points shall be established at the top, mid-point, and bottom of each cross-section in the excavation.

C. Acceptable tolerances shall be ± 0.1 feet on survey elevations and ± 0.01 feet on survey coordinates.

D. The survey results shall be certified by a New Jersey Professional Land Surveyor.

E. The CONTRACTOR shall certify that any excavation meets the requirements of the Contract Documents and submit documentation of such to the REMEDIAL DESIGNER.

3.08 WASTE RELOCATION AREAS – SURVEY CONTROL

A. The completed surface shall be surveyed to ensure that the actual depths and grades are in accordance with the Contract Drawings.

B. A minimum of 1 cross-section for every 50 lf shall be provided. Include, at a minimum, survey points established at the top, mid-point, and bottom of each cross-section in the waste relocation areas.

C. Acceptable tolerances shall be ± 0.1 feet on survey elevations and ± 0.01 feet on survey coordinates.

D. The survey results shall be certified by a New Jersey Professional Land Surveyor in the employ of, or contracted to, the CONTRACTOR and meet the requirement of Section 01050 – Field Engineering/Surveying of these Specifications.

3.10 DECONTAMINATION

A. All equipment used for the excavation, stockpiling, and/or conveyance of solid waste materials or identified leachate seeps shall undergo decontamination in accordance with the CONTRACTOR's Site-specific Health and Safety Plan.

3.11 OFF-SITE DISPOSAL

A. Alternatively, the CONTRACTOR may elect to remove waste from the Site and haul to a permitted off-site disposal facility approved by the GROUP'S REPRESENTATIVE.

B. CONTRACTOR shall follow all rules and regulations and obtain required permits for hauling of waste materials on public roads including proper manifests and other required documentation.

C. CONTRACTOR shall supply GROUP'S REPRESENTATIVE with copy of current permit from the off-site disposal facility, as well as copies of all manifests and weigh-in tickets for each truck load of waste hauled from the Site.

*****END OF SECTION*****

SECTION 02223

FILL MATERIALS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete portions of the Work requiring backfill and fill. The work of this Section includes the acquisition, placement, grading, and compaction of soil fill materials, and other related and incidental Work within the designated areas, and as required, for the construction of other Work, as shown, specified, or required by the Contract Documents.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State, or Federal authorities having jurisdiction. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

C. The CONTRACTOR is responsible for following all health and safety precautions applicable to trenches during backfilling of trenches, backfill work along the Sip Avenue Ditch, and other Work as shown on the Contract Drawings.

D. CCS may provide all, some or none of the grading fill and cushion layer and will coordinate delivery schedule with CONTRACTOR.

1.02 PROTECTION OF PEOPLE AND PROPERTY

A. The CONTRACTOR shall plan and execute the Work so as to prevent damage to existing structures, safeguard people and property, minimize traffic inconvenience, protect structures to be installed, and provide safe working conditions.

B. Work shall be performed in accordance with all applicable health and safety and OSHA regulations and in accordance with the CONTRACTOR's site-specific Health and Safety Plan.

1.03 RELATED SECTIONS

A. 01050 - Field Engineering/Surveying

B. 01410 - Material Testing Laboratory Testing

C. 02100 - Site Preparation

D. 02110 - Site Clearing and Grubbing

E. 02125 - Erosion and Sedimentation Control

F. 02140 - Construction Dewatering

G. 02210 - Site Grading

H. 02220 - Excavation

I. 02221 - Waste Excavation and Relocation

J. 02599 – Cellular Confinement System

PART 2 - PRODUCTS

2.01 GENERAL

A. All imported materials from off-site borrow areas shall be favorably reviewed by the REMEDIAL DESIGNER prior to use. The REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL may visit the proposed borrow areas prior to, during or after approval.

B. No frozen or thawing fill material shall be placed, spread, or compacted.

C. No fill material shall be placed, spread, or compacted while the lower material is frozen or thawing, during unfavorable weather conditions, or during periods of precipitation.

D. All imported fill materials shall be free from organic materials, wood, trash, and all deleterious and objectionable materials which may be degradable or which cannot be properly compacted, unless as otherwise noted. Imported materials shall not contain rock fragments, broken concrete, masonry rubble greater than the maximum dimensions specified in Part 2 herein, unless as otherwise noted. It shall have physical properties such that it can be readily spread and compacted. Snow, ice, and frozen soil shall be removed from fill material prior to placement.

E. Spoils from trench excavation will only be acceptable as fill based on requirements of Article 2.01D above. No spoils from waste excavation, as outlined in Section 02221 – Waste Excavation and Relocation, of these Specifications, will be permitted as structural fill.

F. Material may be required for raising the landfill to required subgrade elevation. This material may be obtained from off-site borrow or may be material available on-site from the Work of other Sections. On-site and/or off-site materials proposed for this use shall be favorably reviewed by the REMEDIAL DESIGNER prior to use, and shall meet the requirements of Grading Fill below.

G. The entire fill surface shall be left in a manner to promote surface water run-off at the end of each workday.

2.02 STRUCTURAL FILL

A. Structural Fill shall be composed of non-organic, hard, durable soil or gravel material. Material to be used as Structural Fill must also meet the analytical requirements in Article 2.08 below. Structural Fill shall meet the following gradation requirements:

U.S. Standard Sieve Size	Percent Passing by Weight
1-inch	100%
No. 4	85-100%
No. 200	0-10%

2.03 CAP COVER SOIL

A. Cap cover soil material shall be environmentally clean borrow material from an off-site borrow source approved by the REMEDIAL DESIGNER and the GROUP's REPRESENTATIVE. Borrow material proposed for use as cap cover soil shall meet the analytical requirements of Article 2.08 below, and be free of deleterious and organic matter, be non-plastic, and conform to the gradation requirements below:

U.S. Standard Sieve Size	Percent Passing by Weight
3/4 inch	100%
No. 4	85-100%
No. 10	50-100%
No. 200	5-30%

B. Cap cover soil material shall also possess sufficient shear strength to maintain adequate stability on the proposed slopes where a geomembrane cap will be constructed. The minimum requirements are as follows:

Minimum Angle of Internal Friction*	Minimum Soil Cohesion
28 degrees	0 psf

* For a confining pressure of 50 psf under saturated conditions at a density equal to 90% of the maximum Standard Proctor dry density.

C. Cap cover soil shall range in hydraulic conductivity between 5.6×10^{-6} m^2/sec (minimum) and 5.6×10^{-5} m^2/sec (maximum).

2.04 CAP CUSHION LAYER

A. Cap cushion layer material shall be environmentally clean borrow material from an off-site borrow source approved by the REMEDIAL DESIGNER and the GROUP's REPRESENTATIVE. Borrow material proposed for use as cap

cushion layer shall meet the analytical requirements of Article 2.08 below, and be free of deleterious and organic matter, be non-plastic, and conform to the gradation requirements as specified below:

U.S. Standard Sieve Size	Percent Passing by Weight
3/4 inch	100%
No. 4	85-100%
No. 10	50-100%
No. 200	5-30%

B. Cap cushion layer material shall also possess sufficient shear strength to maintain adequate stability on the proposed slopes where a geomembrane cap will be constructed. The minimum requirements are as follows:

Minimum Angle of Internal Friction*	Minimum Soil Cohesion
28 degrees	0 psf

* For a confining pressure of 250 psf under saturated conditions at a density equal to 90% of the maximum Standard Proctor dry density.

2.05 TEMPORARY COVER MATERIAL

A. Temporary cover material shall meet the requirements of Grading Fill listed below.

2.06 GRADING FILL

A. Grading fill materials shall be utilized to attain subgrade elevations in geomembrane cap areas. Grading fill materials shall be placed and compacted similar to material regraded per Section 02221 – Waste Excavation and Relocation, of these Specifications.

B. No frozen, sharp, organic, deleterious or objectionable materials shall be used as a beneficial reuse material, or material, which may be degradable or which cannot be properly compacted. Materials that have been previously approved as beneficial reuse materials may be utilized as Grading Fill.

C. Proposed grading fill materials must meet the analytical requirements of Article 2.08G herein.

2.07 CELLULAR CONFINEMENT SOIL

A. Cellular confinement soil material shall be environmentally clean borrow material from an off-site borrow source approved by the REMEDIAL DESIGNER and the GROUP's REPRESENTATIVE. Borrow material proposed for use as cellular confinement soil shall meet the analytical requirements of Article 2.08 below, and be free of deleterious and organic matter, be non-plastic, and conform to the gradation requirements below:

U.S. Standard Sieve Size	Percent Passing by Weight
3/4 inch	100%
No. 4	85-100%
No. 10	50-100%

B. Cellular confinement soil material shall be capable of sustaining vegetation as specified in Section 02936, as demonstrated by pH (greater than or equal to 6.0). Organic content shall be between 6 and 8%, if it is less than 6%, an organic amendment such as leaf compost shall be incorporated into the material, prior to placement, and soil fertility testing shall be performed.

2.08 TESTING

A. The CONTRACTOR shall, 21 days prior to use of proposed materials, submit certification to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL that the proposed fill materials comply with the Specifications for the various components of construction. This certification shall include the following tests for each type of material and each material source:

1. Particle Size — ASTM D422
2. Atterberg Limits — ASTM D4318
3. Standard Proctor — ASTM D698
4. Moisture Content — ASTM D2216 or D4643
5. Permeability (Cap Cover Soil only) — ASTM D4318
6. Specific Gravity — ASTM D854
7. Coefficient of Friction* — ASTM D5321
   * Coefficient of friction testing shall be conducted for actual project specific materials as described in Section 02590.
8. Angle of Internal Friction (min) (Cap Cover Soil and Cap Cushion Layer only) — ASTM D3080
9. pH (Cellular Confinement Soil only) — ASTM D4972
10. Organic Content (Cellular Confinement Soil only) — ASTM D2974
11. Soil Fertility (Cellular Confinement Soil only) — Baker or LaMotte Test

B. The CONTRACTOR shall be responsible for quality control testing. Testing shall be performed by a specialized laboratory that has been favorably reviewed by the REMEDIAL DESIGNER. The frequency of testing shall be once per every 10,000 cubic yards of each material delivered or once per each material source, whichever is greater.

C. The CONTRACTOR shall submit to the REMEDIAL DESIGNER certification of compliance along with a minimum of one 5-gallon bucket of each proposed material from each source that is proposed for use.

D. The CONTRACTOR shall not proceed with use of the materials until the REMEDIAL DESIGNER has favorably reviewed the proposed materials.

E. If in the opinion of the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL, the CONTRACTOR's proposed material is unsuitable for the proposed application, the CONTRACTOR shall submit the above certification for material of another type or from another source for consideration at no additional cost to GROUP.

F. All fill materials, except for Cap Cushion Layer and Grading Fill as described in Article 2.04 and 2.08G herein, shall be analytically tested and written certification provided that the proposed fill materials are environmentally cleaned, defined as not exceeding the New Jersey Department of Environmental Protection Residential Direct Contact Soil Cleanup Criteria (N.J.A.C. 7:26D).

G. Cap Cushion Layer and Grading Fill materials shall be analytically tested and written certification provided that the proposed material does not exceed the New Jersey Department of Environmental Protection Non-Residential Direct Contact Soil Cleanup Criteria (N.J.A.C. 7:26D).

H. The GROUP'S REPRESENTATIVE, REMEDIAL DESIGNER, and/or the QUALITY ASSURANCE OFFICIAL may at any time request the collection of samples of imported materials for additional testing at the GROUP's expense. Any imported materials from off-site borrow sources found to not be in accordance with the Specifications, or found not to meet the requirements of this Specification, shall immediately be removed and replaced with suitable materials at the CONTRACTOR's expense with no time extensions to the Construction Schedule granted.

PART 3 - EXECUTION

3.01 PRECAUTIONS

A. Portions of the Work requiring the placement of fill materials shall not be performed with frozen materials or over snow, ice, and/or uncompacted subgrades.

3.02 STORAGE

A. Stockpile excavated and imported materials where directed by the GROUP'S REPRESENTATIVE or REMEDIAL DESIGNER until required for fill placement. Place, grade and shape stockpiles to provide proper drainage. Install appropriate erosion and sediment control devices around stockpiles.

B. Locate and retain stockpiled soil materials in a location where the weight of the stockpiled materials will not create surcharge loading conditions on the excavation edges.

3.03 PLACEMENT OF GRADING FILL

A. Grading Fill materials shall not be placed until the subgrade has been inspected in place, as-built surveyed, and favorably reviewed by the QUALITY ASSURANCE OFFICIAL and/or REMEDIAL DESIGNER.

B. Any uncompacted subgrade to receive fill shall be proof-rolled prior to the placement of fill materials. Proof-rolling shall be performed with compaction equipment weighing at least 20 tons, unless otherwise approved by the REMEDIAL DESIGNER.

C. Grading Fill with favorably reviewed materials conforming to the requirements of Part 2 herein.

D. Employ a placement method that does not disturb or damage other work.

E. Make gradual grade changes. Blend slope into level areas.

F. Place fill in relatively uniform lifts not exceeding 12 inches in loose thickness.

G. Grading tolerance for fill materials shall be -0.0 to +0.1 feet.

3.04 PLACEMENT OF CAP COVER SOIL AND CAP CUSHION LAYER

A. Cap cover soil materials shall not be placed until the geosynthetic components and/or prepared subgrade (cap cushion layer) has been inspected in-place and approved by the QUALITY ASSURANCE OFFICIAL and/or REMEDIAL DESIGNER.

B. Cap cover soil and cap cushion layer placement shall not exceed the elevations and/or design criteria depicted on the Contract Drawings.

C. Employ a placement method that does not disturb or damage other work. Puddling will not be permitted.

D. Make gradual grade changes. Blend slope into level areas.

E. Grading tolerance for the cap cushion layer soil and cap cover soil shall be -0.0 to +0.1 feet.

F. Placement of the cap cover soil shall be with low ground pressure equipment (5 psi contact pressure) with a minimum of 12 inches of soil material between the equipment and the geosynthetics.

G. Spread the cap cover soil over the underlying geosynthetics to cause the material to cascade over the geosynthetics rather than be pushed across the geosynthetics in a manner that may cause wrinkles, tension, or other damage of the materials. Cover soil shall be placed beginning at the toe of slope and pushed up the slope.

3.05 PLACEMENT OF STRUCTURAL FILL

A. Structural Fill is envisioned for pipe bedding and backfill material.

B. Placement of Structural Fill in pipe trenches shall not be done until such time as pipes and related Work has been favorably reviewed by QUALITY ASSURANCE OFFICIAL and/or REMEDIAL DESIGNER and as-built survey has been performed by the CONTRACTOR. The CONTRACTOR shall comply with the following pipe backfill procedures:

1. Pipes shall be bedded and backfilled as shown on the Contract Drawings or as directed by the REMEDIAL DESIGNER. Care shall be taken to place and compact bedding material under pipe haunches to ensure continuous contact with, and support of, the pipe.
2. All pipe trenches shall be backfilled to the dimensions shown on the Contract Drawings or as directed by the REMEDIAL DESIGNER, as soon as possible, after the pipes have been installed to assure protection against damage.
3. Structural Fill shall be compacted using appropriate compaction equipment and methods acceptable to the REMEDIAL DESIGNER. The compaction effort shall be applied to both the bedding and backfill around the pipes. The method of compaction shall not damage the pipes. The final compacted thickness of each lift shall not exceed 6 inches.
4. Structural Fill in pipe haunch zone shall be placed and worked around pipe by hand to the satisfaction of the QUALITY ASSURANCE OFFICIAL and/or REMEDIAL DESIGNER. Care shall be taken not to dislodge or damage the pipe. Each layer shall be compacted before the next layer is placed.
5. Pipe trenches shall be backfilled by hand to a depth of not less than 12 inches above the crown of the pipe for the full width of the trench.
6. Structural Fill shall be placed to the dimensions or subgrade elevations as shown on the Contract Drawings.

3.06 PLACEMENT OF CELLULAR CONFINEMENT SOIL

A. Cellular Confinement Soil shall not be placed until the geosynthetic components (cellular confinement system) and prepared subgrade have been inspected in-place and approved by the QUALITY ASSURANCE OFFICIAL and/or REMEDIAL DESIGNER.

B. Cellular Confinement Soil placement shall be placed in the cellular confinement system, and fill each cell completely and shall not exceed the elevations and/or design criteria depicted on the Contract Drawings.

C. Employ a placement method that does not disturb or damage other work. Puddling will not be permitted.

D. Place material in accordance with Section 02599 of these Specifications.

3.07 COMPACTION REQUIREMENTS

A. Structural Fill, Grading Fill, and Cap Cushion Layer materials shall be placed and compacted to achieve a minimum density of 95 percent of maximum dry density as determined by the Standard Proctor test, except when placed directly over existing (refuse) materials, in which case the material shall be compacted to achieve a minimum density of 90 percent of maximum dry density as determined by the Standard Proctor Test. Care shall be taken not to damage any piping or other buried utilities during compaction of the materials, or proof-rolling. The moisture content of the materials shall be such that the specified density may be obtained.

B. Compaction of the soil material above the geocomposite drainage layer, shall be achieved by repeated passes as provided by the spreading equipment or other method favorably approved by the REMEDIAL DESIGNER. Such equipment shall be tracked and not have rubber tires.

C. The moisture content of the materials shall be such that the specified density may be obtained.

D. Puddling or jetting for compaction will not be permitted.

3.08 FIELD QUALITY ASSURANCE/CONTROL

A. Testing of fill and backfill materials shall be performed for each lift by the CONTRACTOR and the results shall be submitted to the REMEDIAL DESIGNER for approval. Any areas that do not meet the requirements herein shall be reworked by providing additional compaction effort until acceptable test results are obtained. The CONTRACTOR shall not proceed with a new lift of material until the QUALITY ASSURANCE OFFICIAL has confirmed that the previous lift has attained the required density. The CONTRACTOR shall rework by wetting, drying, or recompacting fill material that is not in compliance with the compaction and moisture content requirements of this Section. At his sole expense, the CONTRACTOR may remove and replace fill materials with prior approval from the REMEDIAL DESIGNER.

B. During construction, tests on the in-place fill materials shall be made by an independent geotechnical testing laboratory employed by the CONTRACTOR, and this laboratory shall perform the following tests:

Property	ASTM Test Method	Frequency of Testing
1. Standard Proctor	D698	A minimum of one (1) test per 10,000 cubic yards per source
2. Field Density	D2922	A minimum of two (2) tests per acre per lift and one per lift per 100 linear feet of pipe trench.
3. Field Moisture	D3017	A minimum of two (2) tests per acre per lift and one per lift per 100 linear feet of pipe trench.

C. In areas where the degree of compaction is not obtained or the uniformity of materials is not maintained in the opinion of the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL, additional tests and/or compactive effort will be made as directed by the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL at no additional cost to the GROUP.

D. The CONTRACTOR shall be responsible for conducting any and all quality control testing necessary for the CONTRACTOR's purposes to satisfy the contract documents. The CONTRACTOR shall ensure that materials placed do not exceed maximum thicknesses as required by the Contract Documents.

E. Quality assurance testing shall be performed by the QUALITY ASSURANCE OFFICIAL in accordance with the Construction Quality Assurance Plan (CQAP).

*****END OF SECTION*****

SECTION 02225

VEGETATIVE LAYER

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete portions of the Work requiring the placement of a vegetative support layer. The Work of this Section includes the acquisition, placement, and grading of the vegetative layer material, material handling, and other related and incidental work within the designated areas and as required for the construction of other Work, as shown, specified, or required by the Contract Documents.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

1.02 RELATED SECTIONS

A. 01050 - Field Engineering/Surveying

B. 01410 - Material Testing Laboratory

C. 02100 - Site Preparation

D. 02125 - Erosion and Sedimentation Control

E. 02210 - Site Grading

1.03 DEFINITIONS

A. Vegetative layer is defined as the uppermost 6-inch thick soil layer component of the landfill cap and shall be capable of supporting vegetation.

1.04 PROTECTION OF PEOPLE AND PROPERTY

A. The CONTRACTOR shall plan and execute the Work so as to prevent damage to the underlying geosynthetic components of the landfill cap system. The CONTRACTOR shall protect existing structures, safeguard people and property, minimize traffic inconvenience, protect structures to be installed, and provide safe working conditions.

B. Work shall be performed in accordance with all applicable health and safety and OSHA regulations and in accordance with the CONTRACTOR's site-specific Health and Safety Plan.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Soil material used as the vegetative layer shall be loam, sandy loam, clayey loam, or silty loam as defined by the U.S. Department of Agriculture textural classification chart, with a range in hydraulic conductivity between 5.6×10^{-6} cm/sec (minimum) and 5.6×10^{-5} cm/sec (maximum), and shall be suitable to support vegetative growth.

B. The vegetative layer shall not contain stones, lumps, roots, or similar objects larger than 2-inches in any dimension.

C. The vegetative layer shall have a pH between 5.8 and 7.6.

D. Provide a material for the vegetative layer that has a minimum organic content of 2.75 percent by weight and a maximum organic content of 5 percent by weight.

E. Soil material used as the vegetative layer must be capable of sustaining vegetation as specified in Section 02936 – Seeding, of these Specifications.

F. Composted material from the clearing and grubbing operations of Section 02110 – Site Clearing and Grubbing, of these Specifications may be mixed and incorporated into the vegetative layer.

G. No imported material shall exceed 30% moisture content at the time of delivery to the Site

2.02 TESTING

A. The CONTRACTOR shall, 21 business days prior to use of proposed materials, submit certification to the QUALITY ASSURANCE OFFICIAL that the material proposed for the vegetative layer complies with the Specifications for the various components of construction. This certification shall include the following tests for the material and the material source(s):

1.	Particle Size	ASTM D422
2.	Atterberg Limits	ASTM D4318
3.	pH	ASTM D4972
4.	Organic Content	ASTM D2974
5.	Soil Fertility	Baker or LaMotte Test
6.	Permeability	ASTM D5084

B. The CONTRACTOR shall be responsible for initial pre-qualification testing. Testing shall be performed by a specialized laboratory that has been favorably reviewed by the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL.

C. The frequency of testing shall be once per every 5,000 cubic yards of material delivered or once per each material source, whichever is greater.

D. The CONTRACTOR shall submit to the QUALITY ASSURANCE OFFICIAL certification of compliance along with a minimum of one 5-gallon bucket of each proposed material from each source that is proposed for use.

E. The CONTRACTOR shall not proceed with the use of the material(s) until the REMEDIAL DESIGNER, NJDEP, if necessary, and GROUP's REPRESENTATIVE have favorably reviewed the proposed materials.

F. If in the opinion of the REMEDIAL DESIGNER, NJDEP and/or GROUP's REPRESENTATIVE, the CONTRACTOR's proposed material is unsuitable for the proposed application, the CONTRACTOR shall submit the above certification for material of another type or from another source for consideration.

G. Certify and submit evidence that off-site materials are free from chemical and organic contamination. Submit written certification (i.e., analytical test results) indicating that the proposed materials meet all NJDEP Residential Direct Contact Soil Cleanup Criteria (N.J.A.C. 7:26A). Analytical testing for virgin sources shall be one (1) per source and one (1) per 25,000 cubic yards and one (1) per 10,000 cubic yards for non-virgin sources.

H. The REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL may at any time request the collection of samples of imported materials for additional analytical and/or index property testing at the GROUP's expense. Any imported materials from off-site borrow sources found to not be in accordance with the Specifications, or found to be contaminated, shall immediately be removed and replaced with suitable materials at the CONTRACTOR's expense with no time extensions in the Construction Schedule granted.

PART 3 - EXECUTION

3.01 PRECAUTIONS

A. Vegetative layer soil shall not be placed using frozen materials. Previously placed soil that has become frozen shall be removed and replaced, or otherwise recompacted after thawing has occurred, as approved by the QUALITY ASSURANCE OFFICIAL.

B. Vegetative layer soil shall not be placed over snow, ice, standing water, or on a previous lift which is excessively moist, dry, cracked, rutted, or loose.

3.02 STORAGE

A. Stockpile satisfactory excavated and imported materials where directed by the REMEDIAL DESIGNER or GROUP's REPRESENTATIVE until required for placement. Place, grade and shape stockpiles to provide proper drainage. Install appropriate erosion and sediment control devices around stockpiles.

B. Locate and retain stockpiled soil materials in a location where the weight of the stockpiled materials will not create surcharge loading conditions on the excavation edges.

3.03 PLACEMENT

A. The vegetative layer shall be placed in all designated areas as shown on the Contract Drawings, in areas disturbed by construction activities, and as directed by the GROUP's REPRESENTATIVE or REMEDIAL DESIGNER.

B. No vegetative layer material shall be placed until the cap cover soil placement is complete and approved by the QUALITY ASSURANCE OFFICIAL.

C. The vegetative layer shall be placed in a single, 6-inch thick lift. The tolerance for the thickness of the vegetative layer is -0.0 to +0.2 feet.

D. Vegetative layer soil shall be placed beginning at the toe of slope and pushed up the slope.

E. The CONTRACTOR shall take care to ensure that underlying soil remains intact and does not become mixed with the vegetative layer during installation.

F. No vehicles shall be permitted on the geomembrane or geocomposite prior to the placement of at least a 12-inch thickness of the cap cover soil. Equipment with ground pressure less than 5 psi may travel on a minimum 12-inch thickness of cover soil. Equipment having maximum ground pressure of 25 psi will be permitted on the completed access roads and 15 psi on the completed vegetative cover. Rutting is prohibited.

3.04 FIELD QUALITY ASSURANCE/CONTROL

A. The CONTRACTOR shall be responsible for conducting any and all quality control testing necessary for CONTRACTOR's purposes to satisfy the Contract Documents. The CONTRACTOR shall ensure that materials placed do not exceed maximum thicknesses as required by the Contract Documents.

B. All Work shall be performed in accordance with the requirements of the Remedial Action Construction Quality Assurance Plan.

3.05 SURVEY CONTROL AND TOLERANCES

A. Survey the limits and elevation of the top of the vegetative layer in accordance with Section 01050 – Field Engineering/Surveying.

B. Construct the vegetative layer to maintain the minimum and maximum slopes as indicated on the Contract Drawings.

*****END OF SECTION*****

SECTION 02233

AGGREGATE MATERIALS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the work of furnishing, placing and compacting the aggregate materials as shown, specified, or required by the Contract Documents.

B. CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, state or federal authorities having jurisdiction. CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect all Work.

1.02 RELATED SECTIONS

A. 01410 – Material Testing Laboratory

B. 02274 – Stone Riprap

C. 02595 – Geotextile

PART 2 - PRODUCTS

2.01 MATERIALS

A. Aggregate materials shall be stored in designated areas approved by the GROUP'S REPRESENTATIVE. CONTRACTOR shall be responsible for maintaining the aggregate materials to be free of deleterious material, and any aggregate materials determined by GROUP'S REPRESENTATIVE to be deleterious material shall not be used for the required construction activities.

B. The materials shall be environmentally clean, sound, tough, durable, crushed stone or gravel as required by this Section, not lumpy, and free from slag, cinders, ashes, rubbish, ice, and deleterious and organic materials.

C. All aggregate materials shall be obtained from an environmentally clean off-site borrow source that is favorably reviewed by the REMEDIAL DESIGNER. Certify and submit evidence in the form of a clean source certification from the supplier that the off-site materials are free from chemical and organic contamination. The certification should list the location where the aggregate originated and the previous land use at the site of origin. The OWNER may at any time collect samples of imported materials for testing at the OWNER's expense. Any contaminated materials from off-site sources that are placed shall

be removed and replaced with suitable materials at the CONTRACTOR's expense with no time extensions in the Construction Schedule granted.

D. AASHTO No. 3 Stone

1. Coarse aggregate materials shall be washed crushed stone or gravel consisting of hard, strong, durable, non-carbonate particles conforming to New Jersey Department of Transportation (NJDOT) Standard Specifications, and free from slag, cinders, ashes, rubbish, organics, or other deleterious material.
2. Coarse aggregate materials shall meet AASHTO No. 3 stone specifications and the following grading requirements:

U.S. Standard Sieve Size	Percent Passing by Weight
2-1/2 inch	100
2 inch	90 – 100
1-1/2 inch	35 - 70
1 inch	0 - 15
1/2 inch	0 - 5

3. Non-carbonate shall be defined as less than 15 percent loss by weight of the aggregate sample when the material is tested in accordance with ASTM D3042.

E. AASHTO No. 57 Stone

1. Aggregate materials shall be washed crushed stone or gravel consisting of hard, strong, durable, non-carbonate particles conforming to New Jersey Department of Transportation (NJDOT) Standard Specifications, and free from slag, cinders, ashes, rubbish, organics, or other deleterious material.
2. Aggregate materials shall meet AASHTO No. 57 stone specifications and the following grading requirements:

U.S. Standard Sieve Size	Percent Passing by Weight
1-1/2 inch	100
1 inch	95-100
1/2 inch	25-60
No. 4	0-10
No. 8	0-5

3. Non-carbonate shall be defined as less than 15 percent loss by weight of the aggregate sample when the material is tested in accordance with ASTM D3042.

F. Dense Graded Aggregate Materials

1. Dense graded aggregates (DGA) shall consist of broken stone conforming to NJDOT Subsection 901.04, or crushed gravel conforming to NJDOT Subsection 901.05.
2. Dense graded aggregate materials shall conform to NJDOT Subsection 901.08 and the following grading requirements:

U.S. Standard Sieve Size	Percent Passing by Weight
1 1/2 inch	100
3/4 inch	55 - 90
No. 4	25 - 60
No. 50	5 - 25
No. 200	3 - 12

3. When tested, the portion of dense graded aggregate passing the No. 50 sieve shall be non-plastic.
4. Dense Graded Aggregate shall not contain any slag.

G. AASHTO No. 1 Stone

1. Coarse aggregate materials shall be washed crushed stone or gravel consisting of hard, strong, durable, non-carbonate particles conforming to New Jersey Department of Transportation (NJDOT) Standard Specifications, and free from slag, cinders, ashes, rubbish, organics, or other deleterious material.
2. Coarse aggregate materials shall meet AASHTO No. 1 stone specifications and the following grading requirements:

U.S. Standard Sieve Size	Percent Passing by Weight
4 inch	100
3-1/2 inch	90 - 100
2-1/2 inch	25 - 60
1-1/2 inch	0 - 15
3/4 inch	0 – 5

3. Non-carbonate shall be defined as less than 15 percent loss by weight of the aggregate sample when the material is tested in accordance with ASTM D3042.

2.02 TESTING

A. CONTRACTOR shall submit, twenty-one (21) days prior to use of proposed materials, to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL for approval, certification that the materials proposed for use as aggregate materials comply with the specification for the proposed application. The certification shall be project-specific, i.e., mention the project by name and

shall be notarized. The certification shall include, but not necessarily be limited to, testing provided by the material supplier including the following tests:

1.	Particle Size	ASTM C136
2.	Relative Density (DGA only)	COE EM1110-2-1906 (App. 12A)
3.	Carbonate Content	ASTM D3042
4.	Durability	ASTM C1137 (DGA only) ASTM C535 (all others)

B. Additional confirmatory testing at CONTRACTOR'S cost may be required by REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL to confirm compliance with these Specifications.

C. The CONTRACTOR shall be responsible for testing. Testing shall be performed by a specialized laboratory that has been favorably reviewed by the REMEDIAL DESIGNER and/or Quality Assurance Official. The frequency of testing shall be once per every 5,000 cubic yards of each material delivered or once per each material source, whichever is greater.

D. CONTRACTOR shall submit to REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL certifications of compliance as specified above along with a minimum 5-gallon bucket sample of each type of proposed material for each proposed borrow source.

E. No material shall be placed unless approved by the REMEDIAL DESIGNER.

F. If, in the opinion of GROUP'S REPRESENTATIVE, the aggregate material is unsuitable for the proposed application, CONTRACTOR shall submit to GROUP'S REPRESENTATIVE and QUALITY ASSURANCE OFFICIAL certifications of compliance as specified above for alternate materials from a different borrow source, at no additional cost to GROUP.

PART 3 - EXECUTION

3.01 STORAGE

A. Stockpile satisfactory excavated and imported materials where directed by the REMEDIAL DESIGNER until required for placement. Place, grade and shape stockpiles to provide proper drainage. Install appropriate erosion and sediment control devices around stockpiles.

B. Locate and retain stockpiled soil materials in a location where the weight of the stockpiled materials will not create surcharge loading conditions on the excavation edges.

3.02 PLACEMENT

A. Aggregate Materials shall be placed in uniform layers to the lines, depths, and grades as shown on the Contract Drawings or as directed by the REMEMDIAL DESIGNER.

B. Placement of aggregate materials shall be performed by CONTRACTOR in a manner such that the material is kept clean and free of deleterious materials.

C. The QUALITY ASSURANCE OFFICIAL may at any time inspect the in-place aggregate materials or aggregate material stockpiles for deleterious material, and reject all or portions of the material, if necessary.

****END OF SECTION****

SECTION 02274

STONE RIPRAP

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall provide all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing and placing stone riprap, as shown, specified or required by the Contract Documents.

B. CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, state or federal authorities having jurisdiction. CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect all Work.

1.02 RELATED SECTIONS

A. 01410 – Material Testing Laboratory

B. 02595 – Geotextile

PART 2 - PRODUCTS

2.01 MATERIAL

A. Stone riprap shall be hard, durable, subangular material. It shall be free from any considerable amount of flat, laminated or elongated particles; and shall be free from cracks, shells, clay, organic matter, or other deleterious matter.

B. The stone riprap shall have a minimum Specific Gravity of 2.50, as defined by ASTM C127 or ASTM C97.

C. The stone riprap shall be composed of an evenly distributed mixture of particle sizes. Fifty (50) percent of the mixture by weight shall be larger than the d_{50} size shown on the Contract Drawings. The largest stone size in this mixture shall be 2.0 times the d_{50} size. The diameter of the smallest stone size in this mixture shall be 0.5 times the d_{50} size.

D. The breadth or thickness of each stone shall not be less than 1/3 its length.

2.02 TESTING

A. The CONTRACTOR shall, 21 days prior to use of proposed materials, submit to the REMEDIAL DESIGNER for prior review, certification that the material proposed for use as stone riprap meets the requirements of Article 2.01 herein. This certification shall include particle size testing in accordance with ASTM D5519 for the stone riprap material and for each material source.

B. The CONTRACTOR shall be responsible for testing. Testing shall be performed by a specialized laboratory in accordance with Section 01410 – Material Testing Laboratory. The frequency of testing shall be once per every 5,000 cy of each material delivered or once per each material source, whichever is greater.

C. The CONTRACTOR shall submit to the QUALITY ASSURANCE OFFICIAL certification of compliance along with a minimum of 5-gallon bucket sample of each proposed material from each source that is proposed for use.

D. The CONTRACTOR shall not proceed with the use of the material until the QUALITY ASSURANCE OFFICIAL has favorably reviewed the proposed materials.

E. If in the opinion of the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL, the CONTRACTOR's proposed material is unsuitable for the proposed application, the CONTRACTOR shall submit the above certification for material of another type or from another source for consideration.

F. The REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL may at any time request the collection of samples of imported materials for additional analytical and/or index property testing at the GROUP's expense. Any imported materials from off-site sources found to not be in accordance with the Specifications, or found to be contaminated, shall immediately be removed and replaced with suitable materials at the CONTRACTOR's sole expense with no time extensions in the Construction Schedule granted.

G. All aggregate materials shall be obtained from an environmentally clean off-site borrow source that is favorably reviewed by the REMEDIAL DESIGNER. Certify and submit evidence in the form of a clean source certification from the supplier that the off-site materials are free from chemical and organic contamination. The certification should list the location where the aggregate originated and the previous land use at the site of origin. The OWNER may at any time collect samples of imported materials for testing at the OWNER's expense. Any contaminated materials from off-site sources that are placed shall be removed and replaced with suitable materials at the CONTRACTOR's expense with no time extensions in the Construction Schedule granted.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All vegetation shall be mechanically cleared from the ground surface, so as to minimize regrowth of vegetation through the stone riprap.

B. Stone riprap shall be placed over geotextile to the minimum thicknesses shown on the Contract Drawings.

C. The CONTRACTOR shall place stone riprap in a manner such that the material is graded to blend in with existing or proposed surrounding grades and to prevent surface water ponding or erosion.

D. Stone riprap shall be placed in a manner that will not damage utilities or other facilities. Stone riprap shall not be dropped from a height exceeding two feet. Compaction of riprap over geotextile-lined slopes, channels, etc. is prohibited.

E. The tolerance in stone riprap thickness in place shall be minus 0.0 feet to plus 0.25 feet.

F. Place without damage to underlying geotextile where applicable.

*****END OF SECTION*****

SECTION 02402

LIQUIDS HANDLING AND DISPOSAL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. This Section describes requirements and restrictions for handling and disposal of liquids generated during construction activities, including, but not limited to, water resulting from decontamination, leachate, and/or groundwater encountered during construction, and excavation dewatering. The CONTRACTOR shall furnish all materials, equipment, transportation, and labor necessary to complete the Work.

B. The CONTRACTOR will abide by all pertinent NJDEP, USEPA, OSHA, and other applicable regulations and guidelines, and the directions of the GROUP'S REPRESENTATIVE and/or REMEDIAL DESIGNER when performing all work applicable to this Section. The CONTRACTOR shall provide a "Competent Person" to implement, supervise and inspect the Work.

1.02 SUBMITTALS

A. The CONTRACTOR shall submit a description of methods for containing, collecting, and disposing of liquids generated during construction, including, but not limited to, seeps, leachate, groundwater, and decontamination water.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 ON-SITE HANDLING

A. The handling of liquids shall be done in a manner such that the liquids will be contained on the Site and not be allowed to flow onto the ground or off the Site as surface water discharge. Discharge of collected groundwater or other liquids to adjacent surface waters or ground surface will not be allowed. Any damage or pollution to adjacent soil or surface waters due to the CONTRACTOR's actions or negligence under this requirement, or any fines, penalties, costs of clean-up or reconstruction required as a result thereof, shall be at the sole expense of the CONTRACTOR. The CONTRACTOR shall immediately remedy, clean-up, and correct any conditions as a result of its pollution of surface waters.

B. The CONTRACTOR shall furnish secure, watertight temporary storage for the entire duration of liquids handling. The storage shall be accessible by tanker trucks. The handling of liquids shall be done in a manner such that the liquids

remain at acceptable suspended solids levels for the approved disposal facility. Filter or settle as necessary to minimize suspended solids.

C. Separate, segregate, and divert surface water runoff from groundwater encountered during excavation and Site grading activities. Handle groundwater separately from surface water runoff. The CONTRACTOR shall maintain all ground and surface water control measures as necessary and as directed by the GROUP'S REPRESENTATIVE and/or REMEDIAL DESIGNER.

D. Any non-aqueous liquids encountered shall be immediately brought to the attention of the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER. Non-aqueous liquids shall be collected separately in drums or other containers provided by the CONTRACTOR for temporary storage.

3.02 TRANSPORT AND DISPOSAL - AQUEOUS LIQUIDS

A. The CONTRACTOR shall collect, pump, store, handle, transfer, and dispose groundwater or other liquids intercepted, segregated, and collected during performance of the Work.

B. The GROUP'S REPRESENTATIVE shall coordinate the off-site disposal of non-aqueous liquids. The CONTRACTOR shall perform any characterization required for this off-site disposal at the request of the GROUP'S REPRESENTATIVE.

C. Any non-aqueous liquids found shall be removed by the CONTRACTOR and stored in separate drums prior to disposal. Coordinate with the GROUP'S REPRESENTATIVE to schedule additional testing.

D. Settled solids and used filter materials shall be disposed of off-site with the approval of the GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER.

3.03 MANAGEMENT OF NON-AQUEOUS LIQUIDS

A. Containerized non-aqueous or oily liquids or solvents shall be stored at a designated area of the Site satisfactory to the GROUP'S REPRESENTATIVE and/or REMEDIAL DESIGNER and provided with secondary containment by the CONTRACTOR. Disposal of non-aqueous or oily liquids or solvents will be arranged and paid for by the GROUP.

*****END OF SECTION*****

SECTION 02590

HDPE GEOMEMBRANE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all materials, labor, equipment, tools and appurtenances required to install the double-sided, textured, high-density polyethylene (HDPE) geomembrane for the landfill cap as shown on the Contract Drawings.

B. Installation of the textured HDPE geomembrane shall be completed by an experienced specialty SUBCONTRACTOR (Installer) fully qualified to complete the portions of the Work as specified in this Section. Reference to CONTRACTOR implies Installer as appropriate in this Section.

C. The CONTRACTOR shall have overall responsibility for the installation of the geomembrane. The CONTRACTOR, as assisted by the Installer, shall provide Shop Drawings and a written description detailing the proposed methods to be employed for performing the Work. All materials, equipment, and supplies to be incorporated into the Work shall be described, including seaming plans, boots/sleeves/skirts for cap penetrations, installation procedures, quality control programs, and any other information needed to show the proposed method of conforming to the Contract Documents.

D. A pre-deployment meeting shall be held between the CONTRACTOR, Installer, GROUP'S REPRESENTATIVE, REMEDIAL DESIGNER, and the QUALITY ASSURANCE OFFICIAL at least two (2) workdays prior to beginning the deployment of the HDPE geomembrane.

1.02 SUBMITTALS

A. The CONTRACTOR shall submit the following information at the times indicated for favorable review:

Prior to Shipping HDPE Geomembrane to the Work Site

1. Resumes of the Installer's supervisor, master seamer(s), and crew. The Installer shall have extensive, previous experience in the installation of HDPE materials. The supervisor will be required to provide satisfactory evidence demonstrating the successful completion of a minimum of 100 acres of smooth and textured HDPE geomembrane under the supervisor's previous supervision. The master seamer will be required to provide satisfactory evidence demonstrating the successful installation of a minimum 50 acres of smooth and textured HDPE geomembrane seamed using similar types of seaming equipment. Additionally, the Installer must also demonstrate experience completing welds around geomembrane penetrations and in forming geomembrane covers and

liners of other appurtenances. The HDPE geomembrane installation crew will be subject to favorable review by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL.

2. Shop Drawings shall include a panel layout diagram for the HDPE geomembrane; details and appurtenances related to the work specified herein, including pipe penetration/sealing procedures, anchor trench layout/design; and all welding processes and details. The HDPE panel layout diagram should be in sufficient detail to provide an accurate representation of the field seaming that will be performed. Any revision to the panel diagram shall be favorably reviewed by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL before implementation.
3. Provide the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with a written certification that all lots of the product to be delivered have been extruded from a favorably reviewed resin. This certification shall include the origin (resin supplier's name and resin production plant), identification (brand name and number), resin production date, and quality control certificates issued by the resin supplier. No material will be permitted to be stored on Site until this certification has been favorably reviewed by the REMEDIAL DESIGNER.
4. Provide Quality Control (QC) test results as described in Article 1.04 of this Section.
5. Provide the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with written certification that the welding rod meets the resin property requirements in Article 2.02 of this Section.
6. Provide the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with written certifications for the material to be used for boots, sleeves, and skirts for sealing the geomembrane around penetrations. Submit Shop Drawings for any prefabricated boots/sleeves/skirts and installation details for the boots/sleeves/skirts including proposed connections (i.e., welds, bands, etc.). No boot/sleeve/skirt shall be fabricated or shipped until the Shop Drawings are favorably reviewed by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL.

Prior to Installation

1. Provide a schedule of operations, including means and methods of installation (including deployment), to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL.
2. The CONTRACTOR and Installer shall complete subgrade acceptance forms indicating that the subgrade meets the minimum conditions described in Part 3 of this Section.
3. Provide the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with certifications stating the geomembrane roll number, base resin type, and lot from which the geomembrane was produced.

During Installation, Submitted Daily

1. Daily construction progress reports clearly showing the HDPE geomembrane panels placed by date.
2. Daily weld test records, including welder startup testing.
3. Daily records of seam testing (non-destructive) for the HDPE geomembrane. Reports on seam testing must be submitted to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL within three (3) working days of seaming, or no further seaming work will be permitted to continue. No geocomposite, geotextile, or cover soil shall be placed until satisfactory test results for the geomembrane area covered have been submitted and favorably reviewed by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL.

Upon Completion

1. As-built panel layout diagram indicating dates on which seams and repairs were performed to provide an accurate two-dimensional representation of the geomembrane panel layout. Provide five (5) signed prints and one (1) signed reproducible, prepared by a registered Professional Land Surveyor in the State of New Jersey. At a minimum, the surveyor must locate the edge of the geomembrane and any areas where the panel layout pattern changes. Locations shall be measured to a tolerance of ± 0.1 foot.
2. Summary and log of all laboratory quality control testing completed by the CONTRACTOR.
3. Summary and log of all field quality control work completed by the CONTRACTOR as described in Part 4 of this Section.
4. Certification by the CONTRACTOR and Installer that the material installation is complete and in accordance with theses Specifications.
5. Statement of warranty from the CONTRACTOR and geomembrane manufacturer that the material is free from manufacturing defects and that when properly installed and maintained will not suffer significant deterioration due to normal weather aging. Warranty shall be in effect for five (5) years from the date of shipment.

B. The above-noted requirements shall apply to all shop-fabricated materials as well as those items specified for fabrication in the field.

1.03 PRODUCT HANDLING

A. The CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work from damage from work covered by other Sections of these Specifications.

B. The CONTRACTOR shall, during all periods of shipment, off-loading, transporting and storage, protect the geomembrane from mud, dirt, dust, debris and other possible sources of damage. The geomembrane shall be stored off of the ground in a relatively dry, flat area of the Site.

C. If the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL determine that the geomembrane material is damaged, the CONTRACTOR shall

immediately make all repairs and replacements, at the CONTRACTOR's own expense.

1.04 QUALITY CONTROL (QC) AND CONFORMANCE TESTING OF GEOMEMBRANE

A. Test the resin and HDPE geomembrane prior to shipment to ensure that the properties of the furnished product are in accordance with these Specifications. Samples shall be tested by the geomembrane manufacturer at the CONTRACTOR's expense. Samples will be tested by the manufacturer at a frequency of at least one (1) sample for every 50,000 square feet of material produced for supply to the Work, and at least one (1) per resin lot to demonstrate compliance with all tests, properties, and requirements of Articles 2.02 and 2.03 herein, with the exception of the coefficient of friction.

B. Upon delivery of the geomembrane to the Site, assist the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL in obtaining representative samples of the furnished product for conformance testing to demonstrate compliance with all tests, properties, and requirements of Article 2.03 herein. Samples of the geomembrane will be tested at the OWNER's expense by a geosynthetics laboratory approved by the REMEDIAL DESIGNER. The frequency of testing shall be one (1) sample per lot, but a minimum of one (1) sample for every 100,000 square feet of material delivered. Unless otherwise directed, samples taken will be 3 feet by the roll width and will not include the first 3 feet at the end of the roll.

C. The manufacturer, CONTRACTOR, and the QUALITY ASSURANCE OFFICIAL shall visually inspect all samples to assure the material is free of holes, blisters, undispersed raw material, and foreign matter.

D. The CONTRACTOR shall provide the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with certified copies of the manufacturer's test results. No material shall be installed prior to furnishing the required test results and receiving favorable review.

E. The REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL, at their discretion, may obtain additional random samples of the geomembrane material for further confirmatory testing. This testing will be at the expense of the OWNER. This testing may also include some or all of the properties specified in Article 2.03 herein, or other test methods, as appropriate. The CONTRACTOR shall assist the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL in obtaining the samples, as required.

F. The CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, immediately replace the material with satisfactory materials without delay to the Work or additional cost to the OWNER.

G. Quality control during construction shall be performed in accordance with Part 4 of this Section.

PART 2 - PRODUCTS

2.01 ALTERNATIVE GEOMEMBRANE MATERIAL

A. The CONTRACTOR may elect to propose the use of an equivalent substitute for the textured HDPE geomembrane specified herein, e.g., polyvinyl chloride (PVC), linear low-density polyethylene (LLDPE), or very flexible polyethylene (VFPE). The burden of proof as to the type, function, and quality of any such substitute geomembrane material shall be upon the CONTRACTOR. The CONTRACTOR shall submit proposed equivalent substitutes in accordance with Section 01300, Article 1.04, of these Specifications. Proposed substitutes shall conform to the physical and mechanical properties specified in Article 2.03 herein, as applicable. Any proposed substitute submittals should also address ancillary issues, such as resin, welding type, etc.

2.02 RESIN

A. The HDPE geomembrane shall be manufactured from pure virgin, high-density polyethylene resin having a minimum density of 0.940 g/km^3 (after carbon black blending). No reclaimed polymer shall be added to the resin. Polymer recycled during the manufacturing process may be permitted if done with an appropriate cleanliness and if the recycled polymer does not exceed 2% by weight. The carbon black is to be pre-blended according to the specifications of the manufacturer.

2.03 HDPE GEOMEMBRANE

A. The manufacturer of the geomembrane shall have satisfactory experience in extruding high-quality HDPE materials. Submit the manufacturing company name, address, and employee contact with telephone number. The materials shall be formulated from the appropriate polymers and compounding ingredients to form an HDPE geomembrane material that meets all requirements for the specified end use of the product. The material shall be capable of being bonded to itself by thermal bonding in accordance with the manufacturer's recommendations and instructions and the seaming requirements of this Section.

B. Geomembrane material rolls shall be at least 10 feet in width. Each roll shall be identified by a roll number, lot number, and date of manufacture. Labels or tags used for such identification shall be durable. Any roll or portion of roll that cannot be identified shall not be used in the Work and shall be immediately removed from the Site by the CONTRACTOR.

C. TEXTURED HDPE GEOMEMBRANE: Conform to the minimum average roll value (MARV) and/or minimum requirements as outlined in Table 02590A herein.

D. Geomembrane core thickness tolerances are:

1. -10.0% any single reading
2. -0.0% average any 5 readings

Table 02590A

Property	ASTM Test Method	Specified Value**	Units
1. Core Thickness	D5994†	40 (min.)	mils
2. Density (sheet)	D1505	0.94	g/cm^3
3. Tensile Properties (each direction)	D638		
a. Tensile Strength, Yield		88	lb/in-width
b. Tensile Strength, Break		50	lb/in-width
c. Elongation at Yield		13	%
d. Elongation at Break		100	%
4. Tear Resistance	D1004 Die C	30	lbs
5. Dimensional Stability (each direction, maximum)	D1204 212°F 1 hour	±2	% change
7. Environmental Stress Crack (minimum with 0 failures) (once per lot)	D1693*	1,000	hours
8. Puncture Resistance	D4833	45	lbs
9. Carbon Black Content Allowable Range	D1603	2.0-3.0	%
10. Carbon Black Dispersion Acceptable Levels	D5596	1 or 2	
11. Coefficient of Friction (one test for the Work)	D4321‡	28 (min.)	degrees

† A needle point micrometer shall be used in the field for this test on textured HDPE geomembranes.

‡ Testing parameters as follows: A total of six tests, two each at 100, 200, and 400 psf normal stress will be performed. All materials shall be the specific materials to the Work.

** MARV values unless otherwise noted.

PART 3 - EXECUTION

3.01 FIELD INSTALLATION

A. Based on the favorably reviewed textured HDPE geomembrane panel layout and installation diagrams and material certifications, the individual panels will be numbered and seams will be identified by the Installer during deployment by using the numbers of the panels which create the seam. Any variation from the panel diagram must be favorably reviewed by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL in writing. Should a variance be obtained, the CONTRACTOR shall modify the panel diagram to show the "As-Built" configuration. All overlaps for field seams shall be shingled in a downslope direction. All overlaps shall be a nominal 4 inches (typically, 6 inches) and, in all cases, such that seams may be destructively tested in all locations.

B. During installation, pedestrian and equipment activity on the geomembrane shall be kept to a minimum and restricted to that which is necessary for cap construction. Construction workers shall take precautions not to damage the geomembrane surface, including the use of smooth-soled footwear, avoidance of dragging tools across the geomembrane surface, and the use of large tools which have smooth base plates or shoes. Construction and other Site staff shall be informed of the restricted access to areas of geomembrane placement. No tracked or rubber-tired equipment or other equipment which may pose a risk of puncturing, tearing or otherwise damaging the geomembrane, or other geosynthetic, will be permitted directly on the exposed geomembrane or overlying geosynthetics. For the avoidance of doubt, no ATVs (4-wheelers), garden type tractors, or other motorized equipment is allowed on the geomembrane. Small equipment such as vacuum pumps and generators may be operated on the geomembrane if placed on rub-sheets.

C. The QUALITY ASSURANCE OFFICIAL will provide one (1) representative to observe the installation of the geomembrane. If the CONTRACTOR wishes to concurrently perform two (2) or more activities which require observation by the QUALITY ASSURANCE OFFICIAL (i.e., pre-seaming preparation, seaming, vacuum testing, or seam testing), submit a request for additional representatives, in writing, to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL not less than three (3) full working days in advance of any such simultaneous construction activities.

D. The CONTRACTOR shall inform the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL of his planned construction activities at the commencement of each work day.

E. Prior to the textured HDPE geomembrane installation, the CONTRACTOR and Installer shall approve the soil subgrade surface prior to placement of the geotextile. No geomembrane shall be placed over unsuitable or unapproved subgrade. The CONTRACTOR shall furnish a subgrade acceptance form prior to the installation of each panel, indicating acceptance of the subgrade. The following conditions shall be minimum for the subgrade:

1. No stones or sharp objects larger than 1 inch in any dimension shall be present on the surface of the area to be covered with the geomembrane.
2. The subgrade surfaces will have a smooth, finished surface. The surface shall not be pebbly or tracked and rutted by equipment and shall be free from pockets, holes, and discontinuities which could cause bridging, or which could, in the judgment of the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL, overstress the geomembrane.
3. Surface moisture shall not be excessively wet or in any condition which will impede proper installation.
4. Meet the compaction requirements of Section 02223 of these Specifications.

The REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL also observe the completed subgrade. Do not proceed with installation of the geomembrane until the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL have favorably reviewed the subgrade.

F. The CONTRACTOR shall maintain reports and copies shall be provided to the REMEDIAL DESIGNER daily. These reports will contain, at a minimum, the following items.

1. Weather conditions;
2. Areas worked;
3. Daily production;
4. Manpower on-Site;
5. Equipment used;
6. Type and results of quality control testing completed by the CONTRACTOR;
7. Problems encountered during construction; and,
8. Resolution of problems.

G. The QUALITY ASSURANCE OFFICIAL will visually observe all field seaming and panels as installed. Any questionable areas or observed changes in physical installation characteristics will be immediately called to the attention of the CONTRACTOR. Random samples of seams representing different conditions may be taken for testing to examine the weld and its effect, if any, on the adjacent material. The CONTRACTOR will assist the QUALITY ASSURANCE OFFICIAL in obtaining samples. Areas where field samples were taken shall be repaired by the CONTRACTOR at the CONTRACTOR's expense.

H. Perform quality control tests and procedures as described in Part 4 of this Section.

I. No excessive wrinkles or creases in the geomembrane will be permitted. Creases in the geomembrane must be cut out and the area repaired. Wrinkles must be walked out ahead of the geocomposite and cover soil placement or cut out and repaired.

J. No vehicles shall be permitted on the geomembrane or geocomposite prior to the placement of at least a 12-inch thickness of cover soil. Equipment with ground pressure less than 5 psi may travel on a minimum 12-inch thickness of cover soil.

Equipment having maximum ground pressure of 25 psi will be permitted on the completed access roads and 15 psi on the completed vegetative cover. Rutting is prohibited.

K. Placement of the geomembrane shall be done such that a good fit (thermal expansion or contraction shall be considered), without bridging or excessive contraction, is provided. Excessive slack shall be avoided to minimize wrinkles during the placement of the geocomposite and cover soil.

L. The geomembrane shall not be installed when ambient temperatures are below 40°F or above 105°F maximum (as measured 18 inches above the geomembrane), during precipitation, or when winds exceed 20 mph, unless the CONTRACTOR has previously submitted acceptable evidence that the CONTRACTOR's performance standards can be maintained under these conditions. Trial seam and destructive testing frequencies may be increased at the discretion of the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL if installation occurs under these circumstances.

M. The CONTRACTOR shall use whatever methods deemed necessary to prevent water or wind from getting under partially installed geomembrane. This could include, but is not limited to, the installation of temporary dikes and sand bags along the exposed edges. Should, in the opinion of the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL, excessive moisture become trapped below the membrane, or wind damage be incurred, the CONTRACTOR will be required to re-perform the work, including the removal and replacement of as much of the in-place geomembrane as the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL directs, to assure that the integrity of the geomembrane and that the underlying subgrade has not been compromised, at the CONTRACTOR's expense.

N. All seams that cannot be subjected to quality control testing shall be capped.

O. Geomembrane panels shall be placed at lengths which avoid horizontal seams on the landfill areas. Further, should the Installer select to place geomembrane panels at lengths which do not cover the entire width of the landfill, a cap trench shall be constructed as shown on the Contract Drawings.

3.02 SEAMING METHODS

A. For the HDPE geomembrane, field seams shall be of one of the following types:

1. Double fusion or Split Hot Wedge or Knife - A seam produced by melting the two intimate surfaces by running a hot metal wedge between the surface followed immediately by pressure to form a homogeneous bond. This seam has an integral air channel for non-destructive testing of the seam. All areas which are to become seam interfaces shall be free of dust, oil, dirt, and moisture.
2. Extrusion Weld - A seam produced by extruding molten HDPE resin between, or at the edge of, two overlapped HDPE panels. A bonded seam is completed when the heated resin is extruded and melts the

adjacent sheet resin to form a homogeneous weld. All areas which are to become extrusion weld seam interfaces shall be properly ground and free of dust, dirt, oil, and moisture.

B. The HDPE geomembrane panels shall be staggered such that cross seams between panels are not continuous throughout the cover area. Panel layouts shall be such that no horizontal seams (cross seams) are constructed on slopes steeper than ten percent (10%). All field seams within an area of slope steeper than ten percent (10%) shall be made perpendicular, or near perpendicular, to the toe of the slope.

C. Prior to the geomembrane installation, the QUALITY ASSURANCE OFFICIAL will review the proposed methods for field seaming. Provide complete information with respect to proposed seaming methods to permit the QUALITY ASSURANCE OFFICIAL to evaluate the intended technique. No deviation from favorably reviewed seaming methods will be permitted.

D. The CONTRACTOR shall work closely with the QUALITY ASSURANCE OFFICIAL and assist same during performance of construction quality assurance testing and observance of testing performed by the CONTRACTOR. No consideration will be given for extra costs that may be incurred due to delays in testing being performed by the QUALITY ASSURANCE OFFICIAL or by the QUALITY ASSURANCE OFFICIAL observing and reviewing the testing being performed by the CONTRACTOR.

E. Field seams are to be minimized.

3.03 GEOMEMBRANE PENETRATIONS

A. An HDPE pipe boot and sleeve shall be installed in areas where the geomembrane caps must be penetrated by gas vents, wells, vaults, and any other feature as shown on the Contract Drawings or as directed by the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL.

B. Prior to constructing the boot or sleeve, the CONTRACTOR shall assure that the subbase material in the area of the penetration is properly compacted and that the area is clean. Take care to assure the geomembrane is not damaged.

C. Pipe boots/sleeves shall be fabricated to fit tightly around the outside diameter of the penetrating feature. If boots/sleeves are prefabricated, the Shop Drawings shall show dimensions or callouts indicating the fit. If the boots/sleeves are field constructed, the fit shall be made to the satisfaction of the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL.

D. The size of the skirt which flares away from the penetrating feature shall be adequate to provide a 12-inch minimum overlap over the geomembrane or as satisfactory to the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL.

PART 4 - QUALITY ASSURANCE/QUALITY CONTROL DURING INSTALLATION

4.01 REQUIREMENTS

A. Any changes in the proposed method of Work, SUBCONTRACTORs/Installers to be utilized, geomembrane resin, or geomembrane supplier must be favorably reviewed in advance by the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL.

B. The QUALITY ASSURANCE OFFICIAL will conduct destructive testing during the geomembrane installation as part of the Remedial Action Construction Quality Assurance Plan (CQAP).

C. The QUALITY ASSURANCE OFFICIAL and the CONTRACTOR shall visually inspect all material to be included in the Work for transportation/storage damage and uniformity, and compare roll identification numbers with those on the certification provided by the manufacturer to assure delivery of the appropriate material.

D. Trial Seams: At the start and midpoint of each work day, and after each break in seaming of 30 minutes or more, or after an equipment shutdown, a trial seam produced by each piece of seaming equipment and each operator shall be performed at or near the current work location. The trial seam shall be a minimum of 10 feet in length for self-propelled seaming devices, and a minimum of 3 feet for hand-held seaming devices. The material for the trial seam and test fixtures for making the field test shall be provided by the CONTRACTOR at no additional cost to the OWNER. Specimens 1-inch wide from the trial seams will be subject to shear and peel adhesion testing at the Site. A minimum of three (3) specimens will be tested for shear, and an additional three (3) specimens will be tested for peel. All specimens must be acceptable or the trail seams will be repeated until all specimens from a given trial seam are found acceptable. The testing shall be performed by the QUALITY ASSURANCE OFFICIAL. A trial seam will be considered a failure if:

1. In the shear test, the bonded thickness of the seam fails before the adjacent sheet material fails for one (1) or more of the three (3) test specimens tested from each trial seam.
2. In the peel adhesion test, the two sheets comprising the seam separate at the bond interface before tearing an individual sheet (not a film tearing bond) for one (1) or more of the three (3) test specimens tested from each sample.
3. Upon visual inspection, the weld shows:
   a. Excessive deformation or stepping of the bottom sheet when viewed in cross-section;
   b. Inadequate or excessively narrow or flat weld bead;
   c. Water blisters in weld bead;
   d. Misaligned weld bead (i.e., weld not reasonably centered with respect to overlap); or,
   e. Thinning of the sheet adjacent to the weld.

If a trial seam fails as described above, the entire round of testing shall be repeated. The seaming apparatus and seamer shall not be used for seaming until the deficiencies which caused the failures are corrected and two (2) consecutive successful trial seams are completed.

E. Destructive Samples: Random destructive samples shall be obtained by the CONTRACTOR at locations identified by the QUALITY ASSURANCE OFFICIAL. The samples will be taken and prioritized as follows:

1. Areas identified as suspect during seaming or non-destructive testing/monitoring;
2. A minimum of one sample for each geomembrane seamer;
3. A minimum of one sample for each representative working conditions (e.g., weather conditions); and,
4. A minimum of one sample for every 500 feet of seaming.

Each destructive sample will, at a minimum, measure 12 inches by 48 inches in length with the seam centered lengthwise. Two specimens, one from each end of the sample, will be cut and tested for peel and shear strength in the field by the CONTRACTOR using a calibrated field tensiometer, supplied by the CONTRACTOR, capable of quantitatively measuring peel and shear strengths.

Testing shall be conducted as follows:

1. The shear test shall be in accordance with ASTM D3083 with Article 9.3 of the ASTM standard modified to permit either Method A or Method B of ASTM D882. Also, a specimen 1-inch in width shall be used with a grip separation of four (4) inches plus the width of the seam. The seam is to be centered between the clamps. The rate of grip separation will be 2.0 inches per minute.
2. The peel adhesion test shall be in accordance with ASTM D413. That standard shall be modified to be: Strip specimen Type A, 90° peel, modified to utilize a specimen that is 1-inch in width and pulled at a rate of 2.0 inches per minute.

The QUALITY ASSURANCE OFFICIAL will record the test results on the geosynthetic data sheets. A total of four (4) samples will be collected. One (1) sample will be tested in the field by the QUALITY ASSURANCE OFFICIAL and the other three (3) samples will be distributed as specified below. If the specimen tested in the field fails, the CONTRACTOR will provide additional test samples 10 feet from the point of the failed test in each direction for repeat of the field test procedure. If these additional tests fail, then the procedure will be repeated until the length of the failed seam is established. Once the field tests have passed, the remainder of the sample will be divided into three (3) equal sections and distributed as follows:

1. One (1) sample to the geosynthetics laboratory for testing;
2. One (1) sample to the REMEDIAL DESIGNER for its records; and,
3. One (1) sample for Site archives.

The laboratory shear test results shall be reported in "ppi" (pounds per-inch of width); the minimum shear strength shall be 80 ppi for 40 mil textured HDPE. The shear test will be considered a failure if the average of five (5) individual tests per sample is less than the minimum bonded seam strength, as specified. Similarly, the peel adhesion tests result shall also be reported in ppi in addition to reporting the type of break. The peel test will be considered a failure if:

1. The two sheets comprising the seam separate at the bond interface before tearing an individual sheet (either sheet delaminates from the other on the weld for two (2) or more of the five (5) test specimens tested per sample).
2. The failure occurs in the weld and the break strength is less than 55 ppi for 40 mil textured HDPE for two (2) or more of the five (5) test specimens comprising a single sample.

Failed destructive tests shall be tracked in accordance with the CQAP. A log shall be maintained by the QUALITY ASSURANCE OFFICIAL and the CONTRACTOR for the purpose of recording all destructive test results. In addition, if at any time the QUALITY ASSURANCE OFFICIAL has reason to believe that seaming is not of adequate quality, additional test strips (1-inch specimens) shall be obtained. These shall be promptly obtained, at locations identified by the QUALITY ASSURANCE OFFICIAL, by the CONTRACTOR at no additional cost to the OWNER and tested in accordance with this Section. If the test strip seams fail at, the reason for the failure shall be resolved before any seaming of the geomembrane continues.

F. No geomembrane will be covered by the CONTRACTOR until such time as the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL have reviewed the test results required by these Specifications. As a minimum, the pre-delivery testing, the daily log of trial seam results, QA destructive test laboratory results, Installer's QC destructive test results (laboratory and field), as-built drawings of the completed area, and the seams in place will be reviewed. The CONTRACTOR shall be responsible for the protection of the installed geomembrane.

G. Non-Destructive Testing: The QUALITY ASSURANCE OFFICIAL and the CONTRACTOR shall visually inspect all geomembrane seams. In addition, the CONTRACTOR shall test all seams along their entire length, in a manner favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Potential test methods are as follows:

1. Pressure Testing - All field seams made by a double hot wedge welding device shall be tested by applying air pressure to a sealed length of seam and monitoring the pressure over time. After making the seam between two adjacent geomembrane panels, each end of the air channel in the weld is to be sealed. Air is to be introduced from one end of the seam into the air channel, and pressurized to a minimum of 25 psig. The channel is then to be sealed and monitored for a period of at least 5 minutes with an air pressure gauge calibrated in 1 psi increments. The seam shall be considered passing if the pressure drop in 5 minutes is less than 4 psi; and, a pressure gauge shall be inserted into the far end of the

air channel to check for continuity in the air channel. Alternately, the far end of the seam may be cut to relieve the air pressure. An audible rush of air shall serve as an indicator that the test represents the entire length of seam. Air channels that do not hold the minimum specified air pressure shall be further inspected to identify the location and nature of any unbonded sections of seam. The seam shall then be capped or removed and replaced and re-tested as appropriate.

2. Vacuum Box Testing - All field seams with the exception of double hot wedge seams shall be inspected for unbonded areas by applying a vacuum to a soaped section of seam. The vacuum shall be applied by a vacuum box equipped with a vacuum gage, a clear glass view panel in the top, and a soft rubber gasket on the periphery of the open bottom. The vacuum box shall be equivalent to the Series A 100 Straight Seam Tester as supplied by the American Parts and Service Company, 2201 West Commonwealth Avenue, P.O. Box 702, Alhambra, California 91802. A section of the seam shall be wetted thoroughly with soapy water and the vacuum box shall be placed over the soaped seam section and the gasket sealed to the membrane. A minimum vacuum of 8 inches of Mercury (Hg) shall be applied to the box by use of a gasoline or electric driven power-vacuum pump apparatus for a period of not less than 10 seconds. If no bubbles appear after 10 seconds, the vacuum box may be moved to the next adjoining area with a minimum 3-inch overlap and the process shall be repeated. The applied vacuum will cause bubbles to appear over unbonded areas. Any unbonded areas shall be marked by the CONTRACTOR for repair by the CONTRACTOR. The repair will consist of rewelding the questionable weld area.

All inadequate seams or portions thereof shall be corrected in accordance with the method favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Should differences of opinion between the CONTRACTOR and the QUALITY ASSURANCE OFFICIAL develop during the installation relevant to seam integrity, the QUALITY ASSURANCE OFFICIAL may, at his discretion, obtain samples of the seams in dispute for field or laboratory testing. The CONTRACTOR will be responsible for patching the resulting void in accordance with the previously favorably reviewed procedures.

H. All welds shall be observed for traces of deformation to the cover panels. Any welds which, in the opinion of the QUALITY ASSURANCE OFFICIAL , have caused excessive deformation or show visual signs of overheating of the cover panels shall be repaired at the CONTRACTOR's expense, regardless of the result of any destructive testing on the seam. The deficient seam shall be cut out and the cover panels again overlapped and welded or over capped.

I. Repairs: The Installer shall repair all geomembrane panels and seams that are found to be unacceptable by the QUALITY ASSURANCE OFFICIAL. Repairs shall be performed by methods favorably reviewed by the QUALITY ASSURANCE OFFICIAL. Repairs are eligible for non-destructive testing and destructive testing.

J. Geomembrane Installation and Testing Report: The CONTRACTOR shall provide a report to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL at the conclusion of the Work. Separate reports shall be prepared for each Fill area covered. The reports shall include the following:

1. Complete identification of geomembrane cap system, including type of resin, material type, source, and thickness.
2. Pre-delivery inspection forms for geomembrane rolls.
3. Complete identification of field seaming system used including material, method, temperatures, seam width, and date of fabrication of field seams.
4. The quality control tests used as specified or directed.
5. Complete description of field sampling procedure, number of test specimens, size of test specimens.
6. Type of test machine used, grip separation, and crosshead speed.
7. Method of recording load and determining average load for destructive/laboratory test methods.
8. Peel and shear load values for individual specimens in pounds per inch of width, and also the average load value for each group of specimen.
9. Type of failure in the tests, that is, within the seam, within the sheet material, clamp edge or seam edge, for each individual specimen.
10. For non-destructive testing, type of non-destructive test, and number of apparent failures and repairs of seams. The number of apparent failures and repairs should be reported on a per 100 lineal feet of seam basis.
11. Log of all quality control work.
12. As-built drawings showing locations of geomembrane sheets, seams, and repairs.

*****END OF SECTION*****

SECTION 02595

GEOTEXTILE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to install geotextile(s) for the geomembrane cushion layers; to reinforce new access road subgrades, line channels/ditches, line outlet aprons, and as otherwise shown on the Contract Drawings. The geotextile material associated with the geocomposite drainage layer is specified in Section 02598 of these Specifications.

B. Installation of the geotextile(s) shall be completed by an experienced specialty SUBCONTRACTOR (Installer) fully qualified to complete the portions of the Work as specified in this Section. Reference to CONTRACTOR implies Installer as appropriate in this Section.

C. The CONTRACTOR shall have overall responsibility for the installation of the geotextile(s). The CONTRACTOR, as assisted by the Installer, shall provide Shop Drawings and a written description detailing the proposed methods to be employed for performing the Work. All materials, equipment and supplies to be incorporated in the Work shall be described, including seaming/overlapping plans, installation procedures, quality control programs, and any other information needed to show the proposed method of conforming to the Contract Documents.

1.02 SUBMITTALS

A. The CONTRACTOR shall furnish written certification from the manufacturer of the geotextile(s) attesting that the geotextile(s) meets the manufacturing requirements specified. Any geotextile found to have defects, rips, holes, flaws, deterioration or other damage shall be replaced by the CONTRACTOR at the CONTRACTOR's expense.

B. The CONTRACTOR shall submit Shop Drawings showing proposed installation methods including overlapping, seaming, and layout details.

1.03 PRODUCT HANDLING

A. The CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work from damage from work covered by other Sections of these Specifications.

B. The CONTRACTOR shall, during all periods of shipment and storage, protect the geotextile from direct sunlight, ultraviolet light, temperatures greater than 120°F, mud, dirt, dust, debris and other possible sources of damage. Geotextile

rolls shall be wrapped in a heavy-duty protective covering until needed for installation.

C. If the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL determines that the geotextile material is damaged, or has experienced excessive sunlight exposure (more than 15 days), the CONTRACTOR shall immediately make all repairs and replacements, at the CONTRACTOR's expense.

1.04 QUALITY CONTROL (QC) AND CONFORMANCE TESTING OF GEOTEXTILE

A. Geotextiles shall be tested prior to shipment to ensure that the properties of the finished product are in accordance with the Specifications. Samples of geotextile materials shall be tested by the manufacturer at the CONTRACTOR's expense. Samples will be tested by the manufacturer at a frequency of one (1) sample for every 50,000 ft^2 of material produced for each lot and material type. The required material properties, test methods, values, and units are presented in Part 2 of this Section. In addition, one (1) sample 3 feet wide by the width of the roll, from each roll tested, will be retained by the manufacturer or CONTRACTOR for possible further testing until construction for which the geotextile is used is complete and favorably reviewed. Each sample of geotextile will have the machine direction, roll number, lot number, date of manufacture, and manufacturer name clearly marked on or attached to the sample.

B. Upon delivery of the geotextile to the Site, the CONTRACTOR shall assist the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL in obtaining representative samples of the furnished product for conformance testing at a minimum frequency of one (1) per 100,000 square feet. Unless otherwise directed, samples taken will be 3 feet by the roll width and will not include the first 3 feet at the end of the roll. Samples of the geotextile will be tested by a geosynthetics testing laboratory, selected by the REMEDIAL DESIGNER and Quality Assurance Official, and at the OWNER's expense for the following properties, as applicable:

1.	Mass/Unit Area	ASTM D5261
2.	Grab Tensile Strength and Elongation	ASTM D4632
3.	Puncture Strength	ASTM D4833
4.	Trapezoidal Tear Strength	ASTM D4533
5.	Apparent Opening Size (non-woven only)	ASTM D4751

C. The manufacturer, CONTRACTOR, and the QUALITY ASSURANCE OFFICIAL shall visually inspect all samples to assure the material is free of holes or foreign matter.

D. The CONTRACTOR shall provide the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with certified copies of the manufacturer's test results. No material shall be installed prior to furnishing the required test results and receiving favorable review.

E. The REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL, at his discretion, may request additional random samples of the geotextile for

further confirmatory testing. This testing will be at the expense of the OWNER. This testing may also include all properties specified in Part 2 of this Section and need not be limited to the testing required by the manufacturer. The CONTRACTOR shall assist the REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL in obtaining the samples, as required.

F. The CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, the CONTRACTOR will be responsible for replacing the material with satisfactory materials without delay to the Work and at CONTRACTOR's expense.

G. Quality control during construction shall be performed in accordance with Part 4 of this Section.

PART 2 - MATERIALS

2.01 10 OZ/SY NONWOVEN GEOTEXTILE

A. The nonwoven, needle-punched, polyester or polypropylene, geotextile to be used for cap, channel, apron, and ditch lining, or as otherwise shown on the Contract Drawings shall be a 10 ounce per square yard (oz/sy) geotextile, conforming to the following MARV and/or minimum requirements:

Property	Requirements*	Test Method
Mass/Unit Area	10 oz/sy	ASTM D5261
Trapezoidal Tear Strength	90 lbs	ASTM D4533
Grab Tensile Strength	230 lbs	ASTM D4632
Grab Tensile Elongation	50%	ASTM D4632
Puncture Strength	130 lbs	ASTM D4833
Apparent Opening Size	#70 sieve	ASTM D4751

* MARV values unless otherwise noted for manufacturer's quality control testing. All values minimum for field conformance testing.

2.02 WOVEN GEOTEXTILE

A. The woven polypropylene geotextile to be placed on the subgrade of new access roads shall meet the following MARV and/or minimum properties:

Property	Requirements*	Test Method
Grab Tensile Strength	300 lbs	ASTM D4632
Grab Tensile Elongation	15 %	ASTM D4632
Trapezoidal Tear Strength	120 lbs	ASTM D4533
Puncture Resistance	120 lbs	ASTM D4833

* MARV values unless otherwise noted for manufacturer's quality control testing. All values minimum for field conformance testing.

2.04 WIDTH OF GEOTEXTILE ROLLS

A. All geotextiles shall be provided in rolls not less than 12 feet in width.

PART 3 - EXECUTION

3.01 SUBBASE PREPARATION - OTHER AREAS TO RECEIVE GEOTEXTILE

A. Any subbase or subgrade surfaces to receive a geotextile shall be cleared of sharp objects, boulders, stumps, debris, or any materials that may contribute to fabric punctures, shearing, rupturing or tearing to the satisfaction of the QUALITY ASSURANCE OFFICIAL.

B. Subbase or subgrade surfaces underlying areas planned to receive a 10 oz/sy, nonwoven geotextile or woven geotextile shall be graded smooth and then compacted.

C. Subgrade areas of the site to receive woven or nonwoven geotextile shall be favorably reviewed by the QUALITY ASSURANCE OFFICIAL prior to deployment of geotextile.

D. Trench or channel excavations planned to receive geotextiles shall be visually observed and favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

3.02 INSTALLATION

A. The geotextile shall be placed in the manner and at the locations shown. Geotextile shall be laid smooth and free of tension, stress, folds, wrinkles, or creases.

B. Geotextile seams shall be overlapped a minimum of 6 inches prior to seaming. All geotextiles seams shall be joined by continuous sewing. Sewing will be performed using polymeric thread with chemical resistance properties equal to or exceeding those of the geotextile. The manufacturer shall certify, in writing, that the thread meets this requirement. Thread color shall contrast that of the geotextile.

C. Cover materials shall be placed or spread in a manner such that wrinkles, excessive tension, or other damage does not occur. Gravel surface courses and stone riprap shall not be dropped from a height exceeding 3 feet.

D. If nonwoven geotextile is damaged during any step of installation or placement of overlying materials, a piece of geotextile material shall be cut and placed over the damaged area and overlapped a minimum of 3 feet in each direction, and leistered around the edges, over undamaged material. For woven geotextile, the

overlap shall be 6 inches in each direction and sewn as indicated in Article 3.02B above.

3.03 PROTECTION

A. After installation, visually inspect the geotextile to assure that no objects are present that could potentially harm the geotextile.

B. Any geotextile damaged during installation or during placement of cover material shall be replaced by the CONTRACTOR at the CONTRACTOR's expense.

C. The Work shall be scheduled so that, in general, the covering of the geotextile is accomplished within fifteen (15) calendar days after placement of the geotextile. Failure to comply with this requirement shall require replacement of the geotextile at the CONTRACTOR's expense. Geotextile placed as a geomembrane cushion layer on the landfill cap areas shall be typically covered immediately and, at the latest, covered within five (5) calendar days.

D. No equipment shall be operated directly on the geotextiles prior to the placement of overlying materials. Provide a minimum 12 inches of separation between any geotextile and low ground pressure equipment (5 psi) or 3 feet of separation when using equipment greater than 5 psi.

PART 4 - QUALITY ASSURANCE/QUALITY CONTROL

4.01 GENERAL

A. The CONTRACTOR, before installation begins, shall appoint an experienced individual thoroughly experienced with work similar to the requirements specified herein, and who will be on-site at all times during the installation, to represent the CONTRACTOR in all matters relevant to this Work. This appointment shall be subject to favorable review by the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL.

B. Before installation begins, and at least weekly thereafter, more often if determined necessary by the REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL, project coordination meetings shall be held with the designated representative of the CONTRACTOR, Installer, REMEDIAL DESIGNER, and QUALITY ASSURANCE OFFICIAL to review the following information:

1. Progress of the work;
2. Adherence to the Specifications;
3. Adherence to the Remedial Action Construction Quality Assurance Plan, including the timely submission of the pertinent forms; and,
4. Planned work and methods for the ensuing week, including an estimate of the time remaining to completion of this Work.

This information shall be submitted to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL by the CONTRACTOR, in writing, during or before this meeting.

C. Any changes in the proposed method of work, SUBCONTRACTORs to be utilized, or manufacturing must be favorably reviewed in advance by the QUALITY ASSURANCE OFFICIAL. The CONTRACTOR assumes all responsibility relevant to providing an acceptable product and installation.

4.02 QUALITY ASSURANCE/QUALITY CONTROL DURING INSTALLATION

A. The Installer and CONTRACTOR shall visually inspect all material to be included in the Work for transport damage and uniformity and compare roll identification numbers with those on the certification provided by the manufacturer to assure delivery of the appropriate material.

B. The Installer and CONTRACTOR shall also visually inspect the material for any damage incurred as a result of handling or on-Site storage.

C. After the CONTRACTOR has completed each area of work and thoroughly inspected all installation and seaming, the QUALITY ASSURANCE OFFICIAL will visually inspect all seams for continuity and quality. Do not cover any geotextile prior to receiving favorable review from the QUALITY ASSURANCE OFFICIAL. All inadequate seams shall be repaired at the CONTRACTOR's expense.

*****END OF SECTION*****

SECTION 02598

GEOCOMPOSITE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to install the geocomposite drainage layer as shown on the Contract Drawings.

B. Installation of the geocomposite shall be completed by an experienced specialty SUBCONTRACTOR (Installer) fully qualified to complete the portions of the Work as specified in this Section. Reference to CONTRACTOR implies Installer as appropriate in this Section.

C. The CONTRACTOR shall have overall responsibility for installation of the geocomposite. The CONTRACTOR, as assisted by the Installer, shall provide Shop Drawings and a written description detailing the proposed methods to be employed for performing the Work. All materials, equipment and supplies to be incorporated in the Work shall be described, including seaming/overlapping plans, installation procedures, quality control programs, and any other information needed to show the proposed method of conforming to the Contract Documents.

1.02 SUBMITTALS

A. The CONTRACTOR shall submit to the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL all items described in subsequent sections as outlined by the following schedule:

Prior to Delivery to the Site

1. Shop Drawings including all geocomposite panel layouts and details of all work including details of all overlapping, tying, sewing repairs, penetrations, and attachments.
2. Geocomposite manufacturer's specifications.
3. Certification stating geocomposite roll numbers and base resin type and lot from which the internal geonet was produced.
4. Geocomposite roll correlation list that clearly shows geonet roll number and geotextile roll number correlated to the geocomposite roll number.
5. Provide certification from the manufacturer that the geocomposite is in conformance with the testing and material requirements of this Section.

Prior to Installation

1. Submit to REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL a schedule of operations including means and methods of installation.

During Installation Submitted Daily

1. Daily construction progress reports clearly showing geocomposite panels placed by date.
2. Summary and log of all laboratory quality control completed by the CONTRACTOR.
3. Certification from the CONTRACTOR and Installer that the geocomposite installed that day was satisfactorily completed in accordance with these Specifications.

After Installation

1. As-built record drawings.
2. Statement of warranty from the CONTRACTOR and geocomposite manufacturer that the material is free from manufacturing defects and that when properly installed and maintained will not suffer significant deterioration due to normal weather aging. Warranty shall be in effect for five (5) years from the date of shipment.

1.03 PRODUCT HANDLING

A. The CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work from damage from work covered by other Sections of these Specifications.

B. The CONTRACTOR shall, during all periods of shipment and storage, protect the geocomposite from direct sunlight, ultraviolet light, temperatures greater than 120°F, mud, dirt, dust, debris and other possible sources of damage. The geocomposite shall be wrapped in a heavy-duty protective covering until needed for installation.

C. If the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL determines that the geocomposite material is damaged or has experienced excessive sunlight exposure (more than 15 days), the CONTRACTOR shall immediately make all repairs and replacements, at the CONTRACTOR's expense.

1.04 QUALITY CONTROL (QC) AND CONFORMANCE TESTING OF GEOCOMPOSITE

A. Geocomposites shall be tested prior to shipment to ensure that the properties of the finished product are in accordance with these Specifications. Samples of the geocomposite shall be tested by the manufacturer at the CONTRACTOR's expense. Samples will be tested by the manufacturer at a frequency of one (1) sample for every 50,000 square feet for each lot of material produced for delivery to Site. The required material properties, test methods, values, and units are presented in Part 2 of this Section.

B. Upon delivery of the geocomposite to the Site, the CONTRACTOR shall assist the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL in obtaining representative samples of the furnished product for conformance testing. Testing shall be at a minimum frequency of one (1) sample per lot with

a minimum of one (1) sample (3 feet long by the roll width) per 100,000 square feet of material delivered. Samples will not include the first 3 feet at the end of the roll. Samples of the geocomposite will be tested by a geosynthetics testing laboratory, approved by the REMEDIAL DESIGNER, and at the OWNER's expense for the following properties:

1.	Thickness	ASTM D5199
2.	Adhesion Strength	ASTM F904 modified or D413
3.	Transmissivity (geocomposite)	ASTM D4716
4.	Permittivity (geotextile)	ASTM D4491

C. The manufacturer, CONTRACTOR, and the QUALITY ASSURANCE OFFICIAL shall visually inspect all samples to assure the material is free of holes or foreign matter.

D. The CONTRACTOR shall provide the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with certified copies of the manufacturer's test results. No material shall be installed prior to furnishing the required test results and receiving favorable review.

E. The REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL, at his discretion, may request additional random samples of the geocomposite for further confirmatory testing. This testing will be at the expense of the OWNER. This testing may also include some or all of the properties specified in Article 2.02 of this Section and need not be limited to the testing required by the manufacturer. The CONTRACTOR shall assist the REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL in obtaining the samples, as required.

F. The CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, the CONTRACTOR will be responsible for replacing the material with satisfactory materials without delay to the Work and at CONTRACTOR's expense.

G. Quality control during construction shall be performed in accordance with Part 4 of this Section.

PART 2 - PRODUCTS

2.01 MATERIALS

A. The geonet component of the geocomposite shall be manufactured from pure virgin high-density polyethylene resin (HDPE) satisfactory for the intended use, having a minimum density of 0.940 g/cm^3 (after carbon black blending). The pure virgin resin shall be mixed with two to three percent (2-3%) carbon black, pre-blended according to specifications of the manufacturer.

B. The geotextile portion of the geocomposite shall be a minimum 7.0 oz/sy nonwoven polyester or polypropylene needle-punched geotextile, heat bonded to

both sides of a geonet, designed and manufactured specifically for the purpose of liquid filtration and conveyance.

C. Provide the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with a written and signed certification from the manufacturers that the geonet portion of the product to be delivered has been extruded from a favorably reviewed HDPE resin satisfactory for the intended use. No material will be permitted to be shipped to Site until this certification has been delivered to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL.

2.02 MANUFACTURING

A. The manufacturer of the geocomposite shall be subject to favorable review by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL and have extensive experience in extruding geonet and bonding geotextiles with the geonet. The CONTRACTOR shall submit the manufacturing company, address, and name of contact, with telephone number, to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL. The geocomposite shall be formulated from the appropriate polymers and compounding ingredients to form a geocomposite that meets all requirements for the specified end use of the product.

B. Geocomposite rolls shall be a minimum of 6 feet in width. Each roll shall be identified by a lot number, roll number, and date of manufacture.

C. Geocomposite shall be manufactured and fabricated by companies regularly in the business of manufacturing geosynthetic drainage materials. The geocomposite and individual components (prior to fabrication) thereof shall possess the minimum average roll value (MARV) and/or minimum properties as specified in Table 02598A herein.

PART 3 - EXECUTION

3.01 GEOCOMPOSITE INSTALLATION

A. Install the geocomposite drainage layer over the favorably reviewed textured HDPE geomembrane to the lines and grades shown on the Contract Drawings in accordance with the manufacturer's recommendations. Do not cover the geomembrane until the geomembrane installation and test results for that area of work have been favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

B. Protect the geomembrane during the installation of the geocomposite layer. No equipment shall be permitted to operate directly on any geomembrane or geocomposite at any time. In no way shall any tracked equipment or any other equipment which may pose a risk of puncturing, tearing, or otherwise damaging the geomembrane or geocomposite be permitted to operate directly on these materials. Provide a minimum 12 inches of separation between the

geocomposite and cover soil placement equipment as described in Section 02223, Article 3.03F, of these Specifications.

TABLE 02598A

Property	ASTM Test Method	Specified Value**	Units
1. Flow Capacity			
a. Transmissivity[2] (Geocomposite) 720 psf & gradient of 0.08	D4716	7.0×10^{-3} (min.)	m^2/sec
b. Permittivity (Top Geotextile)	D4491	1.3 (min.)	gal/min/ft^2
2. Mechanical Properties			
a. Grab Tensile Strength (Top & Bottom Geotextile)	D4632	150	lbs
b. Apparent Opening Size (Top Geotextile)	D4751	40	U.S. Std. Sieve
c. Peak Tensile Strength (Geonet)	D5035	40	lb/in. width
d. Ply Adhesion (Geocomposite)	F904 modified or D413	1.5	lb/in.
e. Coefficient of Friction[1]	D5321	28	degrees
3. Material Properties			
a. Polyethylene Density (Geonet)	D1505	0.940	g/cm^3
b. Carbon Black Content (Geonet)	D1603	2.0-3.0	%
4. Dimensions			
Thickness (Geonet)	D5199	0.25 (min.)	inches
Mass/Area (Geotextile)	D5261	7.0 (min.)	oz/sy

(1) Coefficient of friction should be tested in conjunction with the entire proposed cap section testing as specified in Section 02590 of these Specifications.

(2) Transmissivity testing shall be performed using boundary conditions reflective of the field condition. The geocomposite shall be bounded by a cap cover soil and a 40-mil textured HDPE geomembrane. The cap cover soil shall be compacted to 85% of Standard Proctor maximum dry density at approximately the optimal moisture content.

* MARV values unless otherwise noted for manufacturer's quality control testing. All values minimum for field conformance testing.

C. The CONTRACTOR and/or Installer shall supply and use a sacrificial smooth geomembrane to aid in the deployment and positioning of geocomposite panels over the textured geomembrane unless an alternate method has been favorably reviewed by the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL, in accordance with Article 1.02 of this Section, prior to deployment.

D. The geocomposite shall be placed on sideslopes as shown on the Contract Drawings. The geocomposite shall be positioned by hand after being unrolled. Do not crease or fold over the geocomposite. The geocomposite shall not be placed in the horizontal direction (i.e., across the slope) on slopes steeper than 10 (horizontal):1 (vertical), except as part of a patch.

E. In the presence of wind, all in-place geocomposite rolls shall be weighted with sandbags or the equivalent, such sandbags shall be installed during placement and shall remain until replaced with cover material.

F. Adjacent rolls shall be overlapped a minimum of 4 inches and the geonet secured by plastic ties a minimum of every 5 feet along the roll length. Plastic ties shall be white or other bright and contrasting color for ease of inspection and shall be connected according to the manufacturer's recommendations. Metallic ties are not permitted. The upper geotextile sheets shall then be sewn along their entire length. The bottom geotextile sheets shall be overlapped without sewing. The geonet within the geocomposite, on cross-slope seams or end of panel seams, will be overlapped a minimum of 12 inches and securely fastened together with ties at maximum 12-inch intervals.

G. The geocomposite shall not be welded to the geomembrane.

H. All connections shall be inspected and favorably reviewed by the QUALITY ASSURANCE OFFICIAL. The QUALITY ASSURANCE OFFICIAL will reject any connections deemed insufficient and require those joints to be redone at the CONTRACTOR's expense.

I. Repairs shall be made in accordance with the manufacturer's procedures and recommendations at the CONTRACTOR's expense. The CONTRACTOR shall submit proposed repair procedures for the favorable review of the REMEDIAL DESIGNER and thee QUALITY ASSURANCE OFFICIAL.

3.02 PROTECTION

A. After installation, visually inspect the geocomposite to assure that no objects are present that could potentially harm the geocomposite.

B. Any geocomposite damaged during installation or during placement of cover material shall be replaced by the CONTRACTOR at the CONTRACTOR's expense.

C. The Work shall be scheduled so that the covering of the geocomposite is accomplished within fifteen (15) calendar days after placement of the geocomposite. Failure to comply with this requirement shall require replacement of the geocomposite at the CONTRACTOR's expense.

D. No equipment shall be operated directly on the geocomposite prior to the placement of overlying materials. Provide a minimum 12 inches of separation between any geocomposite and low ground pressure equipment (5 psi) or 3 feet of separation when using equipment greater than 5 psi.

PART 4 - QUALITY ASSURANCE/QUALITY CONTROL

4.01 GENERAL

A. The CONTRACTOR, before installation begins, shall appoint an experienced individual thoroughly experienced with work similar to the requirements specified herein, and who will be on-Site at all times during the installation, to represent the CONTRACTOR in all matters relevant to this Work. This appointment shall be subject to favorable review by the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL.

B. Before installation begins, and at least weekly thereafter, more often if determined necessary by the REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL, project coordination meetings shall be held with the designated representative of the CONTRACTOR, Installer, REMEDIAL DESIGNER, and QUALITY ASSURANCE OFFICIAL to review the following information:

1. Progress of the work;
2. Adherence to the Specifications;
3. Adherence to the Construction Quality Assurance Plan, including the timely submission of the pertinent forms; and,
4. Planned work and methods for the ensuing week, including estimate of time remaining to completion of the work.

This information shall be submitted to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL by the CONTRACTOR, in writing, during or before this meeting.

C. Any changes in the proposed method of work, SUBCONTRACTORs to be utilized, geocomposite, geotextile, resin or manufacturing must be favorably reviewed in advance by the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL. The CONTRACTOR assumes all responsibility relevant to providing an acceptable product and installation.

4.02 QUALITY ASSURANCE/QUALITY CONTROL DURING INSTALLATION

A. The Installer and CONTRACTOR shall visually inspect all material to be included in the Work for transport damage and uniformity and compare roll identification numbers with those on the certification provided by the manufacturer to assure delivery of the appropriate material.

B. The Installer and CONTRACTOR shall also visually inspect the material for any damage incurred as a result of handling or on-site storage.

C. After the CONTRACTOR has completed each area of work and thoroughly inspected all installation and seaming, the QUALITY ASSURANCE OFFICIAL will visually inspect all seams for continuity and quality. Do not cover any geocomposite prior to receiving favorable review from the QUALITY ASSURANCE OFFICIAL. All inadequate seams shall be repaired at the CONTRACTOR's expense.

*****END OF SECTION*****

SECTION 02599

CELLULAR CONFINMENT SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to install the geosynthetic cellular confinement system, as shown on the Contract Drawings.

B. Installation of the geosynthetic cellular confinement system shall be completed by an experienced specialty SUBCONTRACTOR (Installer) fully qualified to complete the portions of the Work as specified in this Section. Reference to CONTRACTOR implies Installer as appropriate in this Section.

C. The CONTRACTOR shall have overall responsibility for installation of the geosynthetic cellular confinement system. The CONTRACTOR, as assisted by the Installer, shall provide Shop Drawings and a written description detailing the proposed methods to be employed for performing the Work. All materials, equipment and supplies to be incorporated in the Work shall be described, including seaming/overlapping plans, installation procedures, quality control programs, anchoring, and any other information needed to show the proposed method of conforming to the Contract Documents.

D. A pre-application meeting shall be held at least (2) workdays before the start of installation of the cellular confinement system between the CONTRACTOR, Installer, GROUP'S REPRESENTATIVE, REMEDIAL DESIGNER, QUALITY ASSURANCE OFFICIAL, and the manufacturer's representative.

1.02 RELATED SECTIONS

A. 02223 – Fill Materials

1.03 SUBMITTALS

A. The CONTRACTOR shall submit to the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL all items described in subsequent sections as outlined by the following schedule:

Prior to Delivery to the Site

1. Shop Drawings including all geosynthetic cellular confinement panel layouts and details of all work including details of all overlapping, tying, sewing repairs, penetrations, and attachments.
2. Geosynthetic cellular confinement manufacturer's specifications.

3. Certification stating geosynthetic cellular confinement batch numbers and base resin type and lot from which the geosynthetic was produced.
4. Provide certification from the manufacturer that the geosynthetic cellular confinement is in conformance with the testing and material requirements of this Section.

Prior to Installation

1. Submit to REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL a schedule of operations including means and methods of installation.

During Installation Submitted Daily

1. Daily construction progress reports clearly showing geosynthetic cellular confinement panels placed by date.
2. Summary and log of all laboratory quality control completed by the CONTRACTOR.
3. Certification from the CONTRACTOR and Installer that the geosynthetic cellular confinement installed that day was satisfactorily completed in accordance with these Specifications.

After Installation

1. As-built record drawings.
2. Statement of warranty from the CONTRACTOR and geosynthetic cellular confinement manufacturer that the material is free from manufacturing defects and that when properly installed and maintained will not suffer significant deterioration due to normal weather aging. Warranty shall be in effect for five (5) years from the date of shipment.

1.04 PRODUCT DELIVERY, HANDLING, AND STORAGE

A. The CONTRACTOR shall provide the materials delivered to site in manufacturer's original, unopened containers, and packaging, with labels clearly identifying product name and manufacturer.

B. The CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work from damage from work covered by other Sections of these Specifications.

C. The CONTRACTOR shall, during all periods of shipment and storage, protect the geosynthetic cellular confinement from direct sunlight, ultraviolet light, and temperatures greater than 120°F, mud, dirt, dust, debris and other possible sources of damage, and in accordance with manufacturer's instructions..

D. If the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL determines that the geosynthetic cellular confinement material is damaged or has experienced excessive sunlight exposure (more than 30 days), the CONTRACTOR shall immediately make all repairs and replacements, at the CONTRACTOR's expense.

1.05 QUALITY CONTROL (QC) AND CONFORMANCE TESTING OF GEOCOMPOSITE

A. Geosynthetic cellular confinement materials shall be tested prior to shipment to ensure that the properties of the finished product are in accordance with these Specifications. Samples of the geosynthetic cellular confinement shall be tested by the manufacturer at the CONTRACTOR's expense. Samples will be tested by the manufacturer at a frequency of one (1) sample for every 50,000 square feet for each lot of material produced for delivery to Site. The required material properties, test methods, values, and units are presented in Part 2 of this Section.

B. Upon delivery of the geosynthetic cellular confinement to the Site, the CONTRACTOR shall assist the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL in obtaining representative samples of the furnished product for conformance testing. Testing shall be at a minimum frequency of one (1) sample per lot with a minimum of one (1) sample per 100,000 square feet of material delivered. Samples will not include the first 3 feet at the end of the material. Samples of the geosynthetic cellular confinement will be tested by a geosynthetics testing laboratory, approved by the REMEDIAL DESIGNER, and at the OWNER's expense for the following properties:

1.	Material Composition	ASTM D51505
2.	Environmental Stress Crack Resistance	ASTM D1693
3.	Thickness	ASTM D5199
4.	Short-term Seem Peel Strength	Manufacturer's recommendations
5.	Long-term Seem Peel Strength	Manufacturer's recommendations

C. The manufacturer, CONTRACTOR, and the QUALITY ASSURANCE OFFICIAL shall visually inspect all samples to assure the material is free of holes or foreign matter.

D. The CONTRACTOR shall provide the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL with certified copies of the manufacturer's test results. No material shall be installed prior to furnishing the required test results and receiving favorable review.

E. The REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL, at his discretion, may request additional random samples of the geocomposite for further confirmatory testing. This testing will be at the expense of the OWNER. This testing may also include some or all of the properties specified in Part 2 of this Section and need not be limited to the testing required by the manufacturer. The CONTRACTOR shall assist the REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL in obtaining the samples, as required.

F. The CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, the CONTRACTOR will be responsible for replacing the material with satisfactory materials without delay to the Work and at CONTRACTOR's expense.

G. Quality control during construction shall be performed in accordance with Part 4 of this Section.

PART 2 - PRODUCTS

2.01 CELLULAR CONFINEMENT SYSTEM

A. Cellular confinement system base materials shall conform to the following:

1. Density, ASTM D1505: 0.935-0.965 g/cm^3.
2. Environmental Stress Crack Resistance, ASTMD1693: 3,000 hours.
3. Ultra-Violet Light Stabilization: Carbon black.
4. Carbon Black Content: 1.5 to 2 percent by weight, through addition of a carrier with a certified carbon black content.
5. Homogeneously distributed throughout material.

B. Cellular confinement system strip properties shall conform to the following perforated textured strip/cell :

1. Strip Sheet Thickness, ASTM D5199: 50 mil, minus 5%, plus 10%. Determine thickness in the flat, before surface disruption.
2. Textured Sheet Thickness: 60 mil plus or minus 6 mil.
3. Polyethylene Strips: Textured surface with a multitude of rhomboidal (diamond shape) indentations.
4. Indentation Surface Density: 140-200 per square inch.
5. Polyethylene Strips: Perforated with horizontal rows of 0.4 inch diameter holes.
6. Perforations within each Row: 0.75 inch on-center.
7. Horizontal Rows: Staggered and separated 0.50 inch relative to hole centers.
8. Edge of Strip to Nearest Edge of Perforation: 0.30 inch minimum.
9. Centerline of Spot Weld to Nearest Edge of Perforation: 0.70 minimum.

C. Assembly of cell sections:

1. Fabricated using strips of sheet polyethylene each with a length of 142 inches and width equal to cell depth.
2. Connect strips using full-depth, ultrasonic spot-welds align perpendicular to longitudinal axis of strip.
3. Weld Spacing, individual cell properties, and cell seam strengths shall be in accordance with manufacturer's recommendations.

2.02 TENDONED SECTIONS (If applicable)

A. CONTRACTOR shall consult manufacturer in order to determine appropriate requirements.

B. Tendoned cellular confinement section shall conform to the following at a minimum:

1. Sections with a series of aligned holes through cell walls for insertion of tendons.
2. Insert tendons in field such that they pass through the section in the direction of expansion.
3. Hole Diameter: 0.375 inch.
4. Hole Position: According to requirements of tendon design.

C. Tendons shall conform to the following at a minimum:
1. Material: Bright, high-tenacity, industrial-continuous-filament, polyester yarn woven into a braided strap.
2. Elongations: 9-15% at break.

D. Load Transfer Pins: ATRA ® Clip restraint pins or approved equal.
1. Material: Molded high-strength polyethylene.
2. Load transfer pin within tendoned cellular confinement system designed to transfer load from infilled cells to tenedon.

2.03 ANCHORING COMPONENTS

A. Straight Steel Stakes:
1. Material: Mild steel or reinforcing steel rod.
2. Galvanizing: AASHTO M218.
3. Rod Diameter 0.50 inch.
4. Stake Lengths shall be as per the manufacturer's recommendations.

2.04 CELL INFILL MATERIALS

A. Cell infill material shall follow the requirements for Cellular Confinement Soil, as outlined in Section 02223 – Fill Materials, of these Specifications.

B. The cell infill material shall be seed in accordance with Section 02936 – Seeding, of these Specifications.

PART 3 - EXECUTION

3.01 CELLULAR CONFINMENT SYSTEM INSTALLATION

A. Install the cellular confinement system over the favorably reviewed subgrade as shown on the Contract Drawings in accordance with the manufacturer's recommendations. Do not cover the subgrade until the subgrade and test results for that area or work have been favorably reviewed by the QUALITY ASSURANCE OFFICIAL.

B. Protect the subgrade during the installation of the cellular confinement system. No equipment shall be permitted to operate directly on any subgrade or cellular confinement system at any time. In no way shall any tracked equipment or any other equipment which may pose a risk of puncturing, tearing, or otherwise damaging the cellular confinement system be permitted to operate directly on these materials.

C. The cellular confinement system shall be placed on sideslopes as shown on the Contract Drawings. The cellular confinement system shall be positioned by hand after being employed.

D. All connections shall be inspected and favorably reviewed by the QUALITY ASSURANCE OFFICIAL. The QUALITY ASSURANCE OFFICIAL will reject any connections deemed insufficient and require those joints to be redone at the CONTRACTOR's expense.

E. Repairs shall be made in accordance with the manufacturer's procedures and recommendations at the CONTRACTOR's expense. The CONTRACTOR shall submit proposed repair procedures for the favorable review of the REMEDIAL DESIGNER and thee QUALITY ASSURANCE OFFICIAL.

3.02 PLACEMENT AND ANCHORING

A. Anchor cellular confinement system at crest of slope. Use type of anchor and frequency of anchoring as recommended by the manufacturer.

B. Expand cellular confinement system down slope. Confirm each cellular confinement system section is expanded uniformly to required dimensions and outer cells of each layer are correctly aligned. Interleaf or overlap edges of adjacent sections in each layer, according to which side wall profiles abut. Ensure upper surfaces of adjoining cellular confinement sections are flush at joint and adjoining cells are fully anchored. Anchor with specified anchors in a prescribed pattern throughout slope surface.

3.03 PLACEMENT AND ANCHORING OF TENDONED CELLULAR CONFINEMENT CELLS

A. Feed precut lengths of tendon material through aligned holes in cell walls of the cellular confinement section before expanding individual sections into position. Tie off end of tendons with a knot that cannot pass through hole in cell walls. Tie knots to provide full tendon strength and not slip under tensioning of tendon.

B. Anchor tendons and cellular confinement section at slope crest and expand down slope surface.

C. Anchor tendoned cellular confinement section with specified anchors in prescribed pattern throughout slope surface. At each anchor location, form a loop in tendon, insert anchor, and drive into subgrade.

3.04 PLACEMENT OF INFILL

A. Place infill in expanded cells with suitable material handling equipment, such as a backhoe, front-end loader, conveyor, etc. Limit drop height to a maximum of 3 feet. Avoid displacement of cellular confinement section by infilling from crest to toe of slope. Overfill and compact infill cellular confinement soil between 1

to 2 inches and lightly tamp or roll to leave soil flush with top edge of cell walls. Apply specified surface treatment, as noted in Article 2.04 above.

3.05 PROTECTION

A. After installation, visually inspect the cellular confinement system to assure that no objects are present that could potentially harm the cellular confinement system.

B. Any cellular confinement system damaged during installation or during placement of cellular confinement system soil shall be replaced by the CONTRACTOR at the CONTRACTOR's expense.

C. The Work shall be scheduled so that the covering of the cellular confinement system is accomplished within thirty (30) calendar days after placement of the geocomposite. Failure to comply with this requirement shall require replacement of the cellular confinement system at the CONTRACTOR's expense.

D. No equipment shall be operated directly on the cellular confinement system after placement.

PART 4 - QUALITY ASSURANCE/QUALITY CONTROL

4.01 GENERAL

A. The CONTRACTOR, before installation begins, shall appoint an experienced individual thoroughly experienced with work similar to the requirements specified herein, and who will be on-Site at all times during the installation, to represent the CONTRACTOR in all matters relevant to this Work. This appointment shall be subject to favorable review by the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL.

B. Before installation begins, and at least weekly thereafter, more often if determined necessary by the REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL, project coordination meetings shall be held with the designated representative of the CONTRACTOR, Installer, REMEDIAL DESIGNER, and QUALITY ASSURANCE OFFICIAL to review the following information:

1. Progress of the work;
2. Adherence to the Specifications;
3. Adherence to the Construction Quality Assurance Plan, including the timely submission of the pertinent forms; and,
4. Planned work and methods for the ensuing week, including estimate of time remaining to completion of the work.

This information shall be submitted to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL by the CONTRACTOR, in writing, during or before this meeting.

C. Any changes in the proposed method of work, SUBCONTRACTORs to be utilized, resin or manufacturing must be favorably reviewed in advance by the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL. The CONTRACTOR assumes all responsibility relevant to providing an acceptable product and installation.

4.02 QUALITY ASSURANCE/QUALITY CONTROL DURING INSTALLATION

A. The Installer and CONTRACTOR shall visually inspect all material to be included in the Work for transport damage and uniformity and compare roll identification numbers with those on the certification provided by the manufacturer to assure delivery of the appropriate material.

B. The Installer and CONTRACTOR shall also visually inspect the material for any damage incurred as a result of handling or on-site storage.

C. After the CONTRACTOR has completed each area of work and thoroughly inspected all installation, anchoring, and infilling, the QUALITY ASSURANCE OFFICIAL will visually inspect all sections for continuity and quality. Do not cover any cellular confinement system cells prior to receiving favorable review from the QUALITY ASSURANCE OFFICIAL. All inadequate sections shall be repaired at the CONTRACTOR's expense.

*****END OF SECTION*****

SECTION 02612

REINFORCED CONCRETE CULVERT PIPE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing and installing reinforced concrete pipe (RCP) culvert as shown, specified, and as otherwise required by the Contract Documents.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State, or Federal authorities having jurisdiction. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

1.02 RELATED SECTIONS

A. 02140 – Construction Dewatering

B. 02220 – Excavation

C. 02221 – Waste Excavation and Relocation

D. 02223 – Fill Materials

1.03 SUBMITTALS

A. The CONTRACTOR shall submit Shop Drawings, catalog cuts, and MANUFACTURER's literature for all pipe and pipe fittings including information on coatings and linings, material specifications, dimensions, tolerances, and all related data. No material shall be installed prior to furnishing this required information and receiving favorable review.

B. The CONTRACTOR shall furnish the MANUFACTURER's material certificates for all pipe, fittings, and accessories supplied under this Section demonstrating that the requirements of this Section have been met.

C. Submit to the REMEDIAL DESIGNER in accordance with Section 01300 – Submittals, of these Specifications.

1.04 QUALITY ASSURANCE

A. Pipe installation shall be performed by skilled workers. Each pipe laying crew shall have a pipe laying foreman.

B. Accurately install pipe to the lines and grades shown in the Contract Documents, or as directed by REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL so that inverts are smooth.

C. A full circle shall be visible at the far end, when looking through pipes, unless bends are specified or shown in the Contract Documents.

D. Deflections at joints are not permitted without prior written consent from the REMEDIAL DESIGNER.

E. The GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER shall be notified whenever an existing pipeline location or other existing feature conflicts with the proposed locations of the Work.

F. Pipe and fittings of the same type shall be the products of a single manufacturer.

G. All piping shall be of the type and size as shown on the Contract Drawings and as described herein.

1.05 DELIVERY, STORAGE, AND HANDLING

A. All pipes and fittings shall be carefully handled when loading and unloading. Lift by hoists or lower on skidways in a manner to avoid shock. Avoid damaging the pipe and its coating or lining if present.

B. Where required, due to weight of material and for the safety and protection of workmen, materials, equipment, property, and the Work, use derricks, ropes, or other suitable equipment for lowering pipe into trenches. Take particular care to avoid damaging the pipes.

C. Store piping and related materials so as to cause the least possible interference with the Work, Site operations, streets, sidewalks, driveways, other thoroughfares, parking areas, delivery areas, and the public in general. Should the REMEDIAL DESIGNER so direct, relocate such material and/or equipment which is creating an interference or inconvenience. Relocate such material or equipment which is obstructing the Site or interfering or obstructing other operations or activities of the REMEDIAL DESIGNER or the QUALITY ASSURANCE OFFICIAL.

D. The MANUFACTURER's recommended procedures for pipe stacking shall be followed. When pipes are stacked for storage, the heaviest series of pipe shall be placed at the bottom.

E. If any defective pipes are discovered after being laid or placed, removal and replacement with a sound pipe will be required at the CONTRACTOR's sole expense.

PART 2 - PRODUCTS

2.01 REINFORCED CONCRETE PIPE

A. Reinforced concrete pipe shall conform to the requirements of American Association of State Highway Transportation Officials (AASHTO) M170 for Standard Strength Reinforced Concrete Culvert Pipe for Class V Pipe, unless otherwise designated on the plans. All pipes 24-inches in diameter or smaller shall be of the bell-and-spigot type. Pipes larger than 24-inches in diameter shall be tongue and groove or bell and spigot.

2.02 RUBBER RING GASKETS

A. Rubber ring gaskets shall conform to ASTM C443 and shall be tough, flexible, chemical-resistant material, and of such size and shape as to ensure satisfactory pipe joints when incorporated in the Work.

PART 3 - EXECUTION

3.01 INSPECTION

A. Each length of pipe and each fitting shall be carefully inspected prior to lowering into trench. All materials not meeting the requirements of these Specifications, or otherwise found defective or unsatisfactory by the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL , shall be rejected and immediately marked and removed from the Site by the CONTRACTOR. The CONTRACTOR shall provide suitable replacement materials, conforming to these Specifications, at no additional cost to the GROUP.

B. Bedding, subgrade, and other trench conditions shall be carefully inspected prior to laying pipe in each stretch of open trench. All conditions shall be made available to the QUALITY ASSURANCE OFFICIAL for inspection purposes, and the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL shall be further advised where, in the CONTRACTOR's opinion, unstable or otherwise deleterious conditions exist.

C. Each stretch of completed pipeline shall be inspected and the direction of flow and percentage of slope verified by the QUALITY ASSURANCE OFFICIAL prior to backfilling. The CONTRACTOR shall provide as-built survey data certified by a New Jersey Professional Land Surveyor for favorable review by the REMEDIAL DESIGNER for compliance with slope requirements. Backfilling operations shall not be initiated prior to inspection and favorable review of survey data by the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL .

3.02 LAYING OF PIPE

A. The laying of pipe shall begin at the downstream end of the pipeline. The lower segment of the pipe shall be in firm contact with the bedding throughout its full length. Bell or groove ends of pipe shall be placed facing upstream.

B. The pipe bedding shall meet the requirements of structural fill in Section 02223 – Fill Materials of these Specifications, and shall be placed to conform to pipe shape.

3.03 PIPE INSTALLATION

A. Pipes and fittings shall be carefully lowered into the trench.

B. Pipe and fittings shall be installed so that there will be no deviation at the joints and so that inverts present a smooth surface. Pipe and fittings which do not fit together to form a tight fitting joint are not permitted. RCP shall be joined using flexible watertight rubber gaskets conforming to ASTM C443.

C. Pipes shall be installed in the locations and to the required lines and grades as shown in the Contract Documents, using a method of control which has been favorably reviewed by the REMEDIAL DESIGNER. The REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL have the authority to order the removal or relaying of all pipe laid contrary to the Specifications.

D. Excavate, support, and dewater pipe trenches in accordance with Sections 02140 – Construction Dewatering, 02220 - Excavation, and 02221 – Waste Excavation and Relocation of these Specifications. Excavations shall be maintained free of water during the progress of the Work. All slides or cave-ins of the trenches or cuts shall be remedied to the satisfaction of the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL .

E. Maintain cleanliness of installed pipe and fittings interiors throughout the work. Plug ends when pipe installation is not in progress. Remove all plugs as required to place pipe into operation. Drainage of construction excavations through new pipes is prohibited.

F. All adjustments to the line and grade of pipe shall be done by scraping away or filling in the bedding under the barrel of the pipe and not by blocking or wedging. Where additional bedding is required, it shall be provided at the CONTRACTOR's sole expense. In all cases, the trench under the joint shall be excavated and suitably shaped to permit an even bearing for the barrel of the pipe. The minimum depth of bedding, as shown in the Contract Documents, shall be maintained at all times.

G. When unsuitable materials or conditions are encountered, excavate below grade until suitable foundation is encountered and the trench backfilled with compacted gravel or crushed stone foundation.

H. Favorable review by the REMEDIAL DESIGNER is required prior to changing the location of any of the Work due to field conditions. Changes in pipe sizes are prohibited without prior written consent from the REMEDIAL DESIGNER.

I. All installed piping shall form completely connected systems including connections to valves, equipment, structures, existing facilities, and

appurtenances specified in other sections to result in a satisfactorily operating installation.

J. Backfill pipes in accordance with Section 02223 – Fill Materials, of these Specifications.

3.04 ADJUST AND CLEAN

A. All sections of piping found defective in material, alignment, grade, joints, or otherwise, shall be corrected to the satisfaction of the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL .

B. Leave all the pipes and connections watertight.

C. Upon completion of construction of pipelines and appurtenances, all pipelines shall be thoroughly flushed out with water and all temporary plugs shall be removed. Flushing shall be executed in such manner that dirt or other material will not be discharged into existing watercourses.

*****END OF SECTION*****

SECTION 02613

CORRUGATED METAL PIPE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing and installing corrugated metal pipe (CMP) as shown, specified, and as otherwise required by the Contract Documents.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State, or Federal authorities having jurisdiction. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the work.

1.02 RELATED SECTIONS

A. 02140 – Construction Dewatering

B. 02220 – Excavation

D. 02221 – Waste Excavation and Relocation

E. 02223 – Fill Materials

1.03 SUBMITTALS

A. The CONTRACTOR shall submit Shop Drawings, catalog cuts, and MANUFACTURER's literature for all pipe and pipe fittings including information on coatings and linings, material specifications, dimensions, tolerances, and all related data. No material shall be installed prior to furnishing this required information and receiving favorable review.

B. The CONTRACTOR shall furnish the MANUFACTURER's material certificates for all pipe, fittings, and accessories supplied under this Section demonstrating that the requirements of this Section have been met.

C. Submit to the REMEDIAL DESIGNER in accordance with Section 01300 – Submittals, of these Specifications.

1.04 QUALITY ASSURANCE

A. Pipe installation shall be done by skilled workers. Each pipe laying crew shall have a pipe laying foreman.

B. Accurately install pipe to the lines and grades shown on the Contract Drawings, or as directed by the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL, so that inverts are smooth.

C. A full circle shall be visible at the far end, when looking through pipes, unless bends are specified or shown in the Contract Documents.

D. Deflections at joints are not permitted without prior written consent from the REMEDIAL DESIGNER.

E. The GROUP'S REPRESENTATIVE and REMEDIAL DESIGNER shall be notified whenever an existing pipeline location or other existing feature conflicts with the proposed locations of the Work.

F. Pipe and fittings of the same type shall be the products of a single manufacturer.

G. All piping shall be of the type and size as described in the Contract Documents.

1.05 DELIVERY, STORAGE, AND HANDLING

A. All pipes and fittings shall be carefully handled when loading and unloading. Lift by hoists or lower on skidways in a manner to avoid shock. Avoid damaging the pipe and its coating or lining if present.

B. Where required, due to weight of material and for the safety and protection of workmen, materials, equipment, property, and the Work, use derricks, ropes, or other suitable equipment for lowering pipe into trenches. Take particular care to avoid damaging the pipes.

C. Store piping and related materials so as to cause the least possible interference with the Work, Site operations, streets, sidewalks, driveways, other thoroughfares, parking areas, delivery areas, business areas, and the public in general. Should the GROUP'S REPRESENTATIVE and/or REMEDIAL DESIGNER so direct, relocate such material and/or equipment which is creating an interference or inconvenience. Relocate such material or equipment which is obstructing the Site or interfering or obstructing other operations or activities of the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL .

D. The MANUFACTURER's recommended procedures for pipe stacking shall be followed. When pipes are stacked for storage, the heaviest series of pipe shall be placed at the bottom.

E. If any defective pipes are discovered after being laid or placed, removal and replacement with a sound pipe will be required at the CONTRACTOR's sole expense.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable MANUFACTURERS of corrugated metal pipe, fittings, and appurtenances shall be members of the National Corrugated Steel Pipe Association.

2.02 MATERIALS

A. All pipe delivered to the Site shall be clearly marked at the factory with the MANUFACTURER's identification and all else as required by the codes, standards, and specifications referred to under this Section. Omission of this information will be cause for rejection of pipe.

2.03 CORRUGATED METAL PIPE

A. Pipe and Fittings: Comply with AASHTO M36 and M190, as modified herein. Helical corrugations with continuous lock or welded seams. Riveted, lap joint construction is acceptable only with the prior written approval from the REMEDIAL DESIGNER, and shall have rivets located in the inside valley of the corrugations.

B. Base Metal: Galvanized steel.

C. Metal Gauge: Pipe shall have 2-2/3 inches by 1/2-inch corrugation and be a minimum of 16 gauge.

D. Joints: Galvanized steel, 12-inch wide minimum, 16-gauge minimum, bolted coupling bands. Joints for sub-aqueous pipe shall be stainless steel rods and hardware.

PART 3 - EXECUTION

3.01 PREPARATION

A. Thoroughly clean pipe and fitting interiors, joint surfaces, and gaskets prior to installation. Maintain pipes and fittings clean.

3.02 INSPECTION

A. Each length of pipe and each fitting shall be carefully inspected prior to lowering into trench. All materials not meeting the requirements of these Specifications, or otherwise found defective or unsatisfactory by the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL , shall be rejected and immediately marked and removed from the Site by CONTRACTOR. The CONTRACTOR shall provide suitable replacement materials, conforming to these Specifications, at no additional cost to the GROUP.

B. Bedding, subgrade, and other trench conditions shall be carefully inspected prior to laying pipe in each stretch of open trench. All conditions shall be made available to the QUALITY ASSURANCE OFFICIAL for inspection purposes, and the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL shall be further advised where, in CONTRACTOR's opinion, unstable or otherwise deleterious conditions exist.

C. Pipes shall be installed in the locations and to the required lines and grades as shown on the Contract Drawings and as provided in these Specifications, using a method of control which has been favorably reviewed by the REMEDIAL DESIGNER. The REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL have the authority to order the removal or relaying of all pipe laid contrary to the Specifications.

3.03 LAYING OF PIPE

A. The laying of pipe shall begin at the downstream end of the pipeline. The lower segment of the pipe shall be in firm contact with the bedding throughout its full length.

B. The pipe bedding shall meet the requirements of fill in Section 02223 – Fill Materials, of these Specifications, and shall be placed to conform to pipe shape.

3.04 PIPE INSTALLATION

A. Pipes and fittings shall be carefully lowered into the trench.

B. Pipe and fittings shall be installed so that there will be no deviation at the joints. Pipe and fittings which do not fit together to form a tight fitting joint are not permitted.

C. Pipes shall be installed in the locations and to the required lines and grades as shown in the Contract Documents. The REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL have the authority to order the removal or relaying of all pipe laid contrary to the Specifications.

D. Excavate, support, and dewater pipe trenches in accordance with Sections 02140 – Construction Dewatering, 02220 - Excavation, and 02221 – Waste Excavation and Relocation, of these Specifications. Excavations shall be maintained free of water during the progress of the Work. All slides or cave-ins of the trenches or cuts shall be remedied to the satisfaction of the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL .

E. Maintain cleanliness of installed pipe and fittings interiors throughout the Work. Plug ends when pipe installation is not in progress. Remove all plugs as required to place pipe into operation. Drainage of construction excavations through new pipes is prohibited.

F. All adjustments to the line and grade of pipe shall be done by scraping away or filling in the bedding under the barrel of the pipe and not by blocking or wedging. Where additional bedding is required, it shall be provided at the CONTRACTOR's sole expense. In all cases, the trench under the joint shall be excavated and suitably shaped to permit an even bearing for the barrel of the pipe. The minimum depth of bedding, as shown in the Contract Documents, shall be maintained at all times.

G. When unsuitable materials or conditions are encountered, excavate below grade until suitable foundation is encountered and the trench backfilled with compacted gravel or crushed stone foundation.

H. Where required, holes and spaces to be used for joints shall be sufficiently large to leave the joint of each pipe free and not resting on the ground at any point. Every joint shall be made up in the trench.

I. Install fittings as required and in accordance with the Contract Documents, Specifications, and the manufacturer's installation instructions. The installation of fittings after the pipeline has been laid will not be permitted without the approval of the REMEDIAL DESIGNER. In such cases, complete details pertaining to the proposed type of fittings and the installation procedure shall be submitted by the CONTRACTOR to the REMEDIAL DESIGNER before approval will be considered.

J. Approval by the REMEDIAL DESIGNER is required prior to changing the location of any of the Work due to field conditions. Changes in pipe sizes are prohibited without written consent from the REMEDIAL DESIGNER.

K. All installed piping shall form completely connected systems including connections to valves, equipment, structures, existing facilities, and appurtenances specified in other Sections to result in a satisfactorily operating installation.

L. Since submergence of the empty pipeline could cause flotation, the CONTRACTOR shall conduct operations in such a manner as to prevent flooding of the trenches until the backfill has been placed. Where there is a danger of flooding prior to placing sufficient backfill, the pipe shall be adequately braced to prevent flotation. The CONTRACTOR shall be responsible for relaying all pipe damaged or moved from proper line and grade by flotation.

M. Backfill pipes in accordance with Section 02223 – Fill Materials, of these Specifications.

3.04 ADJUST AND CLEAN

A. All sections of piping found defective in material, alignment, grade, joints, or otherwise, shall be corrected to the satisfaction of the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL .

B. Leave all the pipes and connections watertight.

C. Upon completion of construction of pipelines and appurtenances, all pipelines shall be thoroughly flushed out with water and all temporary plugs shall be removed. Flushing shall be executed in such manner that dirt or other material will not be discharged into existing watercourses.

*****END OF SECTION*****

SECTION 02625

PASSIVE GAS VENT CONSTRUCTION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall provide all labor, equipment, materials, tools, and appurtenances required to complete the work of furnishing and installing the passive landfill gas (LFG) vents as shown on the Contract Drawings.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations, and laws of local, municipal, State, or Federal authorities having jurisdiction. The CONTRACTOR is responsible for identifying and obtaining all appropriate licenses, approvals, and permits to complete the work of this Section. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

C. Prior to the installation of the passive LFG vents, the CONTRACTOR shall identify and perform any necessary utility mark-outs.

D. Furnish and install HDPE pipe in accordance with Section 02650 of these Specifications, as shown on the Contract Drawings, or as directed by the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL.

E. Furnish and install HDPE pipe boots/sleeves and skirts, in accordance with Section 02590 of these Specifications, for use in areas where the geomembrane cap must be penetrated, as shown on the Contract Drawings, or as directed by the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL.

F. The CONTRACTOR and other SUBCONTRACTORs shall coordinate the work of this Section with the work of other Sections, as required.

1.02 GENERAL

A. The approximate locations and depths of the passive LFG vents are shown on the Contract Drawings. Exact locations will be determined and field verified by the CONTRACTOR and REMEDIAL DESIGNER before the installation of the passive LFG vents is initiated.

1.03 SUBMITTALS

A. Drilling methods are described in Article 3.03 herein. Describe in the Bid Proposal any recommended alternative drilling method(s) based on the reported Site conditions.

B. Submit samples for proposed backfill materials in accordance with Sections 01300 – Submittals and 02233 – Aggregate Materials of these Specifications.

C. Submit a Statement of Qualifications for the CONTRACTOR or SUBCONTRACTOR who will perform the installation. Include resumes of drilling crews and the superintendent. Submit safety records (OSHA 200 logs and Experience Modification Ratings for the last 3 years) and insurance rating.

D. Submit a complete list of all equipment to be used for portions of the Work described in this Section including proposed drill rigs and associated torque capacity. Submit an installation schedule and update it weekly during the Work.

E. No work shall be performed until the items required in Articles 1.03B, 1.03C, and 1.03D of this Section have been favorably reviewed by the REMEDIAL DESIGNER.

F. During drilling of each vent, maintain a detailed daily driller's report and submit daily to the QUALITY ASSURANCE OFFICIAL. The report shall give a complete description of all formations or material encountered, number of feet drilled, number of hours on the job, shutdowns, length (feet) of casing set, and other pertinent data.

G. Upon completion of each vent, the CONTRACTOR shall submit to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL a report including the following:

1. Total depth of the completed well;
2. Depth or location of any lost drilling materials or tools;
3. Nominal hole diameter of the well bore and total depth;
4. Volume and amount of materials (including number of bags) used to fill the annular space;
5. Depth and description of the well casing and screen;
6. Protective casing, plug, cap size, and materials used;
7. Concrete, bentonite, or grout materials used and depths;
8. Number and location of centralizers used;
9. Weather conditions during installation;
10. Name of individual who prepared the report and members of the drilling crew; and,
11. Other pertinent data requested by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL.

H. Following completion of drilling each vent, the CONTRACTOR shall submit to QUALITY ASSURANCE OFFICIAL signed copies of the driller's log book including the following information:

1. Reference point (i.e., top of casing) for all depth measurements;
2. Depth at which each change of material occurs;
3. Identification of the material of which each stratum is composed;
4. Depth interval from which sample was taken;
5. Name of individual who prepared log and members of drilling crew;
6. Water use during drilling;
7. Penetration resistance during split-spoon sampling (if any);
8. Water levels encountered during drilling;
9. Drill rig type, make, and torque capacity;

10. Split-spoon hammer weight and fall; and,
11. Other pertinent data requested by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL.

I. The CONTRACTOR shall submit vent coordinates and top-of-casing elevations certified by a Land Surveyor licensed in the State of New Jersey.

J. The CONTRACTOR shall supply written certification for the material to be used for the boots, sleeves and skirts, such as that required for the geomembrane under Section 02590 of these Specifications. Certification of these materials may be supplied as part of the requirements of Section 02590 of these Specifications.

1.05 QUALIFICATIONS

A. The CONTRACTOR responsible for the construction of the passive landfill gas vents shall be properly licensed and employ only competent workmen for the execution of this Work. All such Work shall be performed under the direct supervision of an experienced driller favorably reviewed by the REMEDIAL DESIGNER.

B. The driller shall be capable of identifying geologic formations, maintaining complete and current well logs and daily notes for the vent completion report.

C. The CONTRACTOR shall provide satisfactory evidence that all materials to be furnished in performing the Work are new and all equipment to be used is in good working order.

1.06 HANDLING OF MATERIALS

A. All parts and materials shall be properly protected so that no damage, deterioration, or contamination will occur from the time of shipment until the Work described in this Section is complete.

B. If in the opinion of the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL, parts and materials are damaged, deteriorated, or contaminated, the materials will be rejected and immediately removed from the Site. The CONTRACTOR shall replace the parts and materials at the CONTRACTOR's expense.

1.07 QUALITY ASSURANCE

A. The CONTRACTOR shall perform all testing required and supply any labor and equipment necessary for the testing of the geomembrane cap penetrations. Coordinate testing with the work of Section 02590 of these Specifications, as required.

PART 2 - PRODUCTS

2.01 HDPE PIPE BOOTS/SLEEVES AND SKIRTS

A. The pipe boot/sleeve and skirt shall be constructed from textured 40-mil high-density polyethylene (HDPE) geomembrane with the same material properties as the geomembrane for the landfill cap as specified in Section 02590 of these Specifications.

B. The HDPE geomembrane boots/sleeves and skirts shall be made by the same manufacturer as the geomembrane for the landfill caps.

2.02 GAS VENT MATERIALS

A. As described in Part 3 of this Section and as shown on the Contract Drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Inspect all materials upon delivery and before placement to document that they are in the original packaging as supplied by the manufacturer or supplier and free of any material that may alter the chemical quality of the vent.

3.02 PREPARATION

A. Protect existing structures from damage.

B. Prepare the area for staging of drill cuttings prior to relocation to designated areas on the landfills in accordance with Section 02221 – Waste Excavation and Relocation, of these Specifications.

C. The CONTRACTOR shall provide access to all passive LFG vent locations. Proposed access locations shall be reviewed with the REMEDIAL DESIGNER.

3.03 DRILLING

A. The anticipated range of depth for the passive LFG vents varies as shown on the Contract Drawings. The actual depth will be determined in the field by the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL. The end of boring shall be determined based upon actual conditions. For each gas vent, drill a stable 18-inch diameter borehole to the required depth. The CONTRACTOR may wish to use mud-rotary drilling techniques since augers may hang. No additional payment will be made for incomplete or relocated vents (due to obstruction, auger hang, etc.) or any changes in the means and methods used to complete the vents. Measure and record the final depth of the borehole. Passive LFG vent locations are shown on the Contract Drawings.

B. Prior to attempting to install the vents, ensure that the borehole does not tend to cave, blow-in, or both, is not obstructed, and is aligned plumb. Any borehole that must be abandoned shall be done so in accordance with applicable NJDEP requirements or guidelines.

C. The CONTRACTOR shall follow the CONTRACTOR's Site-specific Health and Safety Plan and adhere to all applicable local, municipal, State, and Federal regulations during drilling procedures.

3.04 WELL CONSTRUCTION

A. Passive gas vent construction details are shown on the Contract Drawings.

B. Assembly of the passive gas vents:

1. Inspect HDPE pipe prior to placement and use only clean water to clean well materials.
2. Take precautions to assure that grease, oil, or other contaminants do not contact the vent and probe construction materials.
3. Personnel shall wear clean gloves while handling the vent assemblies.
4. Passive gas vents shall be 6-inch diameter SDR-11 HDPE pipe. Passive gas vents shall be slotted to the dimensions and lengths as shown on the Contract Drawings.
5. All HDPE pipe shall be in accordance with Section 02650 of these Specifications.
6. Vents shall be placed to within 12 inches of the bottom of the boring.
7. Vents shall be aligned plumb prior to backfilling the borehole. Backfill material shall be as specified on the Contract Documents.

C. Installation of backfill:

1. Calculate the theoretical volumes of backfill required to fill the annular space between the screen and the wall of the borehole prior to placement and measure and record the actual volume used during installation.
2. Backfill shall extend around the well screen as shown on the Contract Documents. Take precautions not to bridge material. AASHTO No. 57 stone for the vents shall comply with Section 02233 of these Specifications. Sand pack shall prevent intrusion of overlying grout.
3. Backfill shall be non-carbonate.

D. Installation of bentonite seals:

1. Bentonite seal shall be Volclay Grout or PureGold Grout, both manufactured by American Colloid Company, or Benseal as manufactured by Baroid Drilling Fluids, or favorably reviewed alternate. Mix in accordance with the manufacturer's instructions. If needed, water for bentonite slurry mixing shall be provided by the CONTRACTOR. Mixing of the bentonite slurry shall continue until all lumps are removed. If used, bentonite slurry shall be tremied. Bentonite seals shall be completed in a manner that provides a complete seal without voids.

2. A bentonite seal mix shall set for at least 24 hours after sealing to assure complete set-up prior to vent or probe assembly.

E. Shepherd's Crook HDPE Elbows: Shepherd's crook HDPE elbows shall be installed atop the 6-inch HDPE gas vent pipe as shown on Contract Drawings.

F. All vents shall be as-built surveyed in accordance with Section 01050 of these Specifications.

G. The CONTRACTOR shall maintain all passive gas vents to be plumb to vertical during drilling and after construction throughout the warranty period.

3.05 DECONTAMINATION

A. The drill rig and all drilling equipment shall be steam-cleaned upon arrival on-Site and prior to leaving the Site. Steam cleaning shall also be conducted following installation of vents. Potable water for steam cleaning shall be supplied by the CONTRACTOR. Between boreholes, all soil and wastes shall be removed from the drill rig and drilling equipment at the borehole location. Drill cuttings and other solid materials shall be disposed of in accordance with Section 02221 – Waste Excavation and Relocation of these Specifications.

3.06 LIQUIDS HANDLING

A. All aqueous and non-aqueous liquids used, collected or encountered during the performance of this Work and including decontamination water shall be handled in accordance with Section 02402 – Liquids Handling and Disposal of these Specifications.

3.07 PIPE BOOT CONSTRUCTION METHODS

A. An HDPE pipe boot/sleeve and skirt shall be installed in areas where the geomembrane caps must be penetrated by the passive LFG vents and other protrusions, as shown on the Contract Drawings or as directed by the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL.

B. Prior to constructing the boot/sleeve, the CONTRACTOR shall assure that the material in the area of the penetration is properly compacted and that the area is clean. Take care to assure the geomembrane and geocomposite are not damaged.

C. Pipe boots/sleeves shall be fabricated to fit tightly around the outside diameter of the penetrating feature. If boots/sleeves are prefabricated, the Shop Drawings shall show dimensions or callouts indicating the fit. If the boots/sleeves are field constructed, the fit shall be made to the satisfaction of the QUALITY ASSURANCE OFFICIAL.

D. The size of the skirt which flares away from the penetrating feature shall be adequate to provide 12-inch minimum overlap over the geomembrane or as satisfactory to the QUALITY ASSURANCE OFFICIAL.

E. Extrusion welding shall be as shown on the Contract Drawings and performed in accordance with the requirements of Section 02590 of these Specifications.

F. Cushion material underneath band clamps shall extend 2 inches beyond each band's edges.

G. Do not allow cushion material to gather or wrinkle around boot when clamp is tightened.

3.08 PIPE BOOT INSPECTION AND TESTING

A. Test all welds to the geomembrane utilizing a non-destructive test method in accordance with Section 02590 – HDPE Geomembrane of these Specifications.

B. The CONTRACTOR is responsible for providing all necessary non-destructive test equipment. Conduct all weld-testing in the presence of the QUALITY ASSURANCE OFFICIAL.

*****END OF SECTION*****

SECTION 02650

HDPE PIPE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing, placing and cleaning the piping for the passive landfill gas (LFG) vents as shown, specified, and as otherwise required by the Contract Documents.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

C. Reference to CONTRACTOR implies manufacturer as appropriate in this Section.

1.02 SUBMITTALS

A. MANUFACTURER'S Literature:

1. The CONTRACTOR shall submit MANUFACTURER'S certification that proposed HDPE pipe material meets the requirements of Part 2 of this Section.
2. The CONTRACTOR shall submit Manufacturer's catalog cut sheets, specifications, installation instructions, and other related literature for:
   a. Pipe and pipe fittings; and,
   b. Supports, flanges, gaskets, fasteners, and other specialties.

   The submittal is to include material specifications, coatings, linings, dimensions, SDR ratings, tolerances, and all other related data.
3. The CONTRACTOR shall submit the selected manufacturer's recommended procedures for:
   a. Butt-fusion welding.

B. Samples:

1. Provide a 4-inch length of each piping type including cross-section sample of a properly prepared joint.

C. Technical Manuals (O&M Manuals):

1. Include record copies of the Shop Drawing information to be provided in accordance with Article 1.02A of this Section.

D. Submit in accordance with Section 01300 – Submittals, of these Specifications.

1.03 QUALITY ASSURANCE

A. Manufacturers:

1. Performance Pipe, a division of Chevron Phillips Chemical Company;
2. Plexco Amsted Industries; and,
3. Or equal.

B. Pipe installation shall be performed by skilled workers. Each pipe laying crew shall have a pipe laying foreman.

C. Accurately install pipe to the lines and grades shown on the Contract Drawings, or as directed by the REMEDIAL DESIGNER, so that inverts are smooth.

D. Deflections in horizontal alignment at joints are not permitted without the written consent of the REMEDIAL DESIGNER. If so approved, the deflections shall not exceed one-half of the manufacturer's recommendation.

E. The CONTRACTOR shall provide, at the CONTRACTOR's expense, the HDPE pipe manufacturer's representative service at the Site to inspect the installation, as scheduled by the REMEDIAL DESIGNER.

1. Provide five mandays for inspections of HDPE pipe (minimum three inspections), including presence at the beginning of HDPE installation for a minimum of two mandays.
2. Provide one manday for inspections of HDPE pipe during leachate tests.

F. The REMEDIAL DESIGNER shall be notified whenever an existing pipeline location or other existing feature conflicts with the proposed locations of the Work.

G. Pipe and fittings of the same type shall be the products of a single manufacturer.

H. Pipe Adapters: Join pipes of different materials with adapters specifically manufactured for that purpose and as favorably reviewed by the REMEDIAL DESIGNER.

I. All piping shall be of the type and size as shown on the Contract Drawings and described herein.

1.04 DELIVERY, STORAGE, AND HANDLING

A. All pipes and fittings shall be carefully handled when loading and unloading. Lift by hoists or lower on skidways in a manner to avoid shock.

B. Where required, due to weight of material and for the safety and protection of workmen, materials, equipment, property, and the Work, use derricks, ropes, or other suitable equipment for lowering pipe. Take particular care to avoid damaging the pipes.

C. Store piping and related materials so as to cause the least possible interference with the Work, Site operations, streets, sidewalks, driveways, other thoroughfares, parking areas, delivery areas, business areas, and the public in general. Should the REMEDIAL DESIGNER so direct, relocate such material and/or equipment which is creating an interference or inconvenience. Relocate such material or equipment that is obstructing the Site or interfering or obstructing other operations or activities of the REMEDIAL DESIGNER.

D. Pipes and fittings shall be protected against damaging ultraviolet rays from the sun, when stored for any period. Such protection shall consist of canvas covering, or other material as recommended by the manufacturer. Plastic sheets shall not be used which may allow excessive temperatures to develop where pipes are stored. All pipes that have been distorted or otherwise negatively affected by high temperatures shall be rejected, regardless of the pipe's appearance after return to ambient temperatures. Rejected pipes shall be removed from the Site and replaced with new pipes at the CONTRACTOR's expense.

E. The manufacturer's recommended procedures for pipe stacking shall be followed. When pipes are stacked for storage, the heaviest series of pipe shall be placed at the bottom.

F. Pipes and fittings shall be protected from damage by sharp objects through all phases of the Work.

G. To the best extent possible, pipes and fittings shall be protected from dirt and debris entering into the pipe interior. Pipes and fittings shall be cleaned prior to installation in accordance with Article 3.02 herein.

H. If any defective pipes are discovered after being laid or placed, removal and replacement with a sound pipe will be required at the CONTRACTOR's expense.

PART 2 - MATERIALS

2.01 PIPE AND FITTINGS

A. Piping resins shall be high performance, high molecular weight, high-density polyethylene conforming to ASTM D1248 (Type III, Class C, Category 5, Grade P34), and ASTM D3350 (Cell Classification PE345434C). The pipe and fittings shall be manufactured from pre-compounded resin manufactured with a minimum of two percent (2%) carbon black to withstand outdoor exposure without loss of properties. In-plant blending of non-compounded resins is not acceptable. All polyethylene pipe shall meet the requirements of ASTM F714 for SDR-11 and SDR-17 pipe as called out on the Contract Drawings. Each pipe length shall be marked with the manufacturer's name or trademark, size, material code, and standard dimension ratio (SDR). All fittings shall be SDR-11 or SDR-17 molded unless denoted on the Contract Drawings. No fabricated or

electrofusion connection shall be allowed without favorable review by REMEDIAL DESIGNER.

B. Pipes shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. Pipes shall be homogeneous throughout and free of visible cracks, holes (other than those manufactured), foreign inclusions, or other deleterious defects, and shall be identifiable in color, density, melt index, and other physical properties.

C. The polyethylene pipe manufacturer shall provide certification that stress regression testing has been performed on the specific product. This stress regression testing shall have been done in accordance with ASTM D2837, Class PE3408, and the manufacturer shall provide a product supplying a minimum hydrostatic design basis (HDB) of 1,600 psi at 63.4°F, as determined in accordance with ASTM D2837.

D. Each pipe shall meet the following cell classification standards:

Property	Requirement
Flexural Modulus:	110,000 to 160,000 psi
Tensile Strength:	3,000 to < 3,500 psi
Environmental Stress Crack Resistance:	Test Condition C Test Duration 192 hours Maximum % Failure = 20
Hydrostatic Design Basis (23°C)	1,600 psi
SDR 11.0 Pressure Rating (73°F)	160 psi
SDR 17.0 Pressure Rating (73°F)	100 psi

2.02 PIPING ACCESSORIES

A. Bolts, nuts and washers: Type 304 or 316 stainless steel, and not smaller than ¼-inch; bolts shall have hexagonal heads and nuts shall be hexagonal.

B. Fittings that unite dissimilar metals shall be dielectric insulating type.

C. Flanged connections to valves, equipment and other piping materials shall be made with a HDPE stub-end flange adapter and epoxy coated carbon steel backing ring unless otherwise shown on Contract Drawings.

D. Piping located inside vaults, manholes, or enclosures shall be supported as shown on the Contract Drawings or by other methods favorably reviewed by the REMEDIAL DESIGNER.

PART 3 - EXECUTION

3.01 INSPECTION - GENERAL

A. Each length of pipe and each fitting shall be carefully inspected prior to installation. All materials not meeting the requirements of these Specifications, or otherwise found defective or unsatisfactory by the REMEDIAL DESIGNER and/or the QUALITY ASSURANCE OFFICIAL, shall be rejected and immediately marked and removed from the Site by the CONTRACTOR on the same working day as so discovered. The CONTRACTOR shall provide suitable replacement materials, conforming to these Specifications, at no additional cost to the OWNER.

B. Bedding, subgrade, and other installation conditions shall be carefully inspected prior to pipe installation. All conditions shall be made available to the QUALITY ASSURANCE OFFICIAL for inspection purposes, and the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL shall be further advised where, in the CONTRACTOR's opinion, unstable or otherwise deleterious conditions exist.

C. Each stretch of completed pipeline shall be inspected and direction and percentage of slope verified by the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL prior to backfilling. Backfilling operations shall not be initiated prior to inspection and favorable review by REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL.

3.02 PREPARATION

A. Pipe and fitting interiors and joint surfaces shall be thoroughly cleaned prior to installation. Pipes and fittings shall be maintained clean.

3.03 PIPE INSTALLATION

A. Underground sections of pipes and fittings shall be carefully lowered into the boring.

B. Pipe and fittings shall be installed so that there will be no deviation at the joints and so that inverts present a smooth surface. Pipe and fittings which do not fit together to form a tight fitting joint are not permitted.

C. Unless noted on Contract Documents, all HDPE joints shall be butt-fusion welded. Butt-fusion welds shall be performed as follows, unless otherwise recommended by the pipe manufacturer:

1. Clean pipe ends inside and outside with a clean rag to remove dirt, water, grease, and other foreign materials.
2. Square cut end of each pipe section with the facing tool of the fusion machine or plastic pipe cutters. Remove cuttings and burrs from pipe ends.

3. Check lineup of pipe ends in the fusion machine to ensure that pipe ends meet squarely and completely over entire surface to be fused. Proper alignment is necessary to obtain uniform heating of the pipe ends and uniform bead at fused joint.
4. Heater Plate:
   a. Insert the heater plate between the aligned pipe ends. Bring and hold pipe ends in contact with heater plate.
   b. Maintain contact without pressure and allow pipe to heat and soften approximately:
      (1) 1/8-inch back from pipe end for 2-inch pipe.
      (2) 3/16-inch back from pipe end for 3-inch and larger pipe.
   c. Heater thermometer reading shall be between:
      (1) 500°F and 575°F on coated plates.
      (2) 475°F and 500°F on uncoated plates.
   d. Double check heater plate temperature with a tempilstik or pyrometer for correct surface temperature.
   e. Carefully move pipe ends away from heater plate and remove plate.
   f. If softened material sticks to plate, discontinue the joint. Clean heater plate, resquare pipe ends, and start over.
5. Flash Bead:
   a. Bring heated pipe ends together with firm pressure per Manufacturer's recommendation to form a uniform upset flash bead approximately 1/8 inch to 3/16 inch wide around entire circumference of pipe.
   b. Bead will have appearance of double upset flash.
   c. Pressure is necessary to cause heated material to flow together, which gives the fusion bead an appearance that is distinctive in appearance to this type of material.
   d. Maintain pressure until the joint cools.
6. Allow joint to cool (until finger can remain comfortably on bead) and solidify until bead feels hard. After joint is cool, remove from lineup clamps.
7. Inspect joint for uniform nonporous appearance.
8. If joint appears faulty, cut the joint and repeat procedure.

D. Pipes shall be installed in the locations and to the required lines and grades as shown on the Contract Drawings and provided in these Specifications, using a favorably approved method of control. The REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL has the authority to order the removal or relaying of all pipe laid contrary to the Specifications.

E. Excavate, support, and dewater pipe trenches in accordance with Sections 02140 – Construction Dewatering, 02220 – Excavation, and/or 02221 – Waste Excavation and Relocation, of these Specifications. Excavations shall be maintained free of water during the progress of the Work. All slides or cave-ins of the trenches or cuts shall be remedied to the satisfaction of the REMEDIAL DESIGNER.

F. Maintain cleanliness of installed pipe and fittings interiors throughout the work. Plug ends when pipe installation is not in progress. Remove all plugs as required to place pipe into operation. Drainage of construction excavations through new pipes is prohibited.

G. All adjustments to the line and grade of pipe shall be done by scraping away or filling in the bedding under the barrel of the pipe and not by blocking or wedging. Where additional bedding is required, it shall be provided at the CONTRACTOR's expense. In all cases, the trench under the joint shall be excavated and suitably shaped to permit an even bearing for the barrel of the pipe. The minimum depth of bedding, as shown on the Contract Drawings, shall be maintained at all times.

H. Fittings shall be installed as required and in accordance with the Contract Documents. The installation of fittings after the pipeline has been laid will not be permitted without the favorable review of the REMEDIAL DESIGNER.

I. Favorable review by the REMEDIAL DESIGNER is required prior to changing the location of any of the Work due to field conditions. Changes in pipe sizes are prohibited without prior written consent from the REMEDIAL DESIGNER.

J. All installed piping shall form completely connected systems including connections to and appurtenances specified in other Sections to result in a satisfactorily operating installation.

K. All pipe shall be so laid that after the line is completed, the interior surface thereof shall conform accurately to the established grade and alignment. No deflections shall be allowed at joints. Piping shall be laid as specified below:

1. Pipe assembly shall be lowered carefully into prepared trench.
2. Line shall not be dropped or subjected to jarring, impact, or unnecessary strain.
3. Pipe shall be handled with wide web and spreader bars.
4. Pipe shall not be handled with chains, end hooks, and cable slings.
5. Sections not carefully lowered in place shall be raised and reinspected. Damaged sections shall be replaced.
6. Excess stress or strain conditions shall be avoided during installation.
7. Maximum pulling force that can be applied to a pipe can be estimated by multiplying the maximum allowable stress by the cross sectional area of pipe. Pipe shall not be pulled by flanged end.
8. Pipe shall be inspected for cuts, gouges and knicks. Piping having visible cuts, gouges or knicks shall not be used.

L. Minimum pipe lengths of 20 feet (up to maximum pipe lengths of 40 feet) shall be utilized, except that shorter random lengths may be utilized where wyes and tees are present so that the connection can be made. The number of pipe joints shall be minimized. The CONTRACTOR shall provide proper smooth and square ends prior to assembling.

M. Maintain the specified depth and compaction of the embedment materials as shown on the Contract Documents and as specified in Section 02233 – Aggregate Materials of these Specifications.

N. Bends
   1. Joints shall not be located in pipe bends.
   2. The radius of the inner curve of such bend shall not be less than 25 times the inside diameter of the pipe.

O. Thrust Blocking:
   1. If the CONTRACTOR, REMEDIAL DESIGNER, or the HDPE pipe MANUFACTURER's engineering evaluation of soil conditions and design of installation determines thrust blocks are required, then thrust blocks shall be provided at branch connections (tees) and at changes in directions (elbows) as required to prevent movement.
   2. Thrust blocking shall be via concrete bearing surfaces set in soil. Pipes shall not be encased in concrete.
   3. Details of thrust blocking for each line size shall be furnished by the HDPE pipe manufacturer. Details shall be subject to favorable review by the REMEDIAL DESIGNER.

P. Anchor Weights:
   1. If the HDPE pipe is to be buried in boggy areas or areas susceptible to flooding (within 100-year flood plain) as shown on the Contract Drawings shall be provided with concrete anchor weights. The pipeline shall be weighted to a neutral buoyancy to prevent floating or sinking.
   2. Anchor weights shall be via concrete bearing surfaces set in soil. Pipes shall not be encased in concrete.
   3. Details of anchor weights for each line size shall be furnished by the HDPE pipe manufacturer. Details shall be subject to favorable review by the REMEDIAL DESIGNER.

Q. Supported Pipelines:
   1. Pipe that crosses bridges and other structures shall be continuously supported to prevent deflection and thermal expansion.
   2. Provide components for pipe hangers as shown on the Contract Drawings.
   3. Supported pipelines shall be installed in a warm condition (during summer or by circulating warm air through pipe) in a straight line while in an expanded state.

3.04 PIPE IDENTIFICATION

A. If applicable, all pipeline trenches shall be indicated by installing tracer wire. One tracer wire shall be provided for each trench, and marking ribbon shall be placed above each pipe in the uppermost tier of piping as shown in the trench details. The singer tracer wire will be used to locate centerline of the trench, and the marking tape will ensure that each line can be uncovered without being damaged. The tracer wires shall be electrically continuous, with their ends extended to penetrate in a watertide manner and terminated within weatherproof

terminal boxes that do not contain any other wiring. Use screw connectors or other satisfactory and weatherproof means of making wire connections.

B. Wire ends shall be pigtails or other method allowing convenient connection of utility locating and transmitting equipment. Each pigtail shall be clearly labeled with a weather-resistant label as to which pipe run the tracer wire corresponds to. Terminal boxes shall be located inside or adjacent o the extraction well enclosures and shall not project higher above finished grade than the top of the enclosure. Provide a sufficient number of terminal boxes such that the runs of tracer wire do not exceed 500 feet. Demonstrate to the satisfaction of the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL that each segment of tracer wire is electrically continuous. Submit product data sheets on tracer wire and locating procedures. Submit an as-built drawing clearly indicating the location of each terminal box and cross-referencing the pigtail label designation to a clearly indicated pipe segment.

*****END OF SECTION*****

SECTION 02675

MONITORING WELLS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall provide all labor, equipment, materials, tools, and appurtenances required to complete the work of furnishing and installing monitoring wells as shown on theContract Drawings.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations, and laws of local, municipal, State, or Federal authorities having jurisdiction. The CONTRACTOR is responsible for identifying and obtaining all appropriate licenses, approvals, and permits to complete the work of this Section. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

C. Prior to the installation of the monitoring wells, the CONTRACTOR shall identify and perform any necessary utility markouts.

D. Furnish and install HDPE pipe boots/sleeves and skirts, in accordance with Section 02590 – HDPE Geomembrane of these Specifications, for use in areas where the geomembrane cap must be penetrated, as shown on the Contract Drawings, or as directed by the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL.

E. The CONTRACTOR and other SUBCONTRACTORs shall coordinate the work of this Section with the work of other Sections, as required.

1.02 GENERAL

A. The approximate locations and depths of the monitoring wells are shown on the Contract Drawings. Exact locations will be determined and field verified by the CONTRACTOR and REMEDIAL DESIGNER before the installation of the monitoring wells is initiated.

1.03 SUBMITTALS

A. Drilling methods are described in Part 3 herein. Describe in the Bid Proposal any recommended alternative drilling method(s) based on the reported Site conditions.

B. Submit a Statement of Qualifications for the CONTRACTOR or SUBCONTRACTOR who will perform the installation. Include resumes of drilling crews and the superintendent. Submit safety records (OSHA 200 logs and Experience Modification Ratings for the last 3 years) and insurance rating.

C. Submit a complete list of all equipment to be used for portions of the Work described in this Section including proposed drill rigs and associated torque capacity. Submit an installation schedule and update it weekly during the Work.

D. No work shall be performed until the items required in Articles 1.03A, 1.03B, and 1.03C herein have been favorably reviewed by the REMEDIAL DESIGNER.

E. During drilling of each monitoring well, maintain a detailed daily driller's report and submit daily to the QUALITY ASSURANCE OFFICIAL. The report shall give a complete description of all formations or material encountered, number of feet drilled, number of hours on the job, shutdowns, feet of casing set, and other pertinent data.

F. Upon completion of each monitoring well, the CONTRACTOR shall submit to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL a report including the following:

1. Total depth of the completed well;
2. Depth or location of any lost drilling materials or tools;
3. Nominal hole diameter of the well bore and total depth;
4. Volume and amount of materials (including number of bags) used to fill the annular space;
5. Depth and description of the well casing and screen;
6. Protective casing, plug, cap size, and materials used;
7. Concrete, bentonite, or grout materials used and depths;
8. Number and location of centralizers used;
9. Weather conditions during installation;
10. Name of individual who prepared the report and members of the drilling crew; and,
11. Other pertinent data requested by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL.

G. Following completion of drilling each monitoring well, the CONTRACTOR shall submit to QUALITY ASSURANCE OFFICIAL signed copies of the driller's log book including the following information:

1. Reference point (i.e., top of casing) for all depth measurements;
2. Depth at which each change of material occurs;
3. Identification of the material of which each stratum is composed;
4. Depth interval from which any samples were taken (if applicable);
5. Name of individual who prepared log and members of drilling crew;
6. Water use during drilling;
7. Penetration resistance during splitspoon sampling (if any);
8. Water levels encountered during drilling;
9. Drill rig type, make, and torque capacity;
10. Split-spoon hammer weight and fall (if applicable); and,
11. Other pertinent data requested by the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL.

H. The CONTRACTOR shall submit the monitoring well coordinates and top-of-casing elevations certified by a Land Surveyor licensed in the State of New Jersey.

I. The CONTRACTOR shall supply written certification for the material to be used for the boots, sleeves and skirts, such as that required for the geomembrane under Section 02590 – HDPE Geomembrane of these Specifications. Certification of these materials may be supplied as part of the requirements of Section 02590 – HDPE Geomembrane of these Specifications.

J. The CONTRACTOR shall submit product data for the following:

1. Casing pipe;
2. Monitoring Well screen;
3. Drilling fluid materials and additives (if used); and,
4. Mix design of neat cement and cement grout.

K. The CONTRACTOR shall submit a completed New Jersey Department of Environmental Protection (NJDEP) Monitoring Well Construction Form for each monitoring well constructed. Submit five (5) copies to the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL immediately upon completion of each monitoring well.

1.04 QUALIFICATIONS

A. The CONTRACTOR responsible for the construction of the monitoring wells shall be properly licensed and employ only competent workmen for the execution of this Work. All such Work shall be performed under the direct supervision of an experienced driller favorably reviewed by the REMEDIAL DESIGNER.

B. The driller shall be capable of identifying geologic formations, maintaining complete and current well logs and daily notes for thewell completion report.

C. The CONTRACTOR shall provide satisfactory evidence that all materials to be furnished in performing the Work are new and all equipment to be used is in good working order.

1.05 HANDLING OF MATERIALS

A. All parts and materials shall be properly protected so that no damage, deterioration, or contamination will occur from the time of shipment until the Work described in this Section is complete.

B. If in the opinion of the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL, parts and materials are damaged, deteriorated, or contaminated, the materials will be rejected and immediately removed from the Site. The CONTRACTOR shall replace the parts and materials at the CONTRACTOR's expense.

1.06 SITE CONDITIONS

A. Coordinate access approvals with the GROUP's REPRESENTATIVE. Notify corporations, companies, individuals or authorities owning conduit wires or pipes running to property or encountered during construction. Protect, support, and maintain conduit, drains, sewers, pipes, and wires.

B. Do not excavate within influence zone of existing footings or foundations without prior approval of the GROUP's REPRESENTATIVE and REMEDIAL DESIGNER.

C. Review with and obtain prior approval from the REMEDIAL DESIGNER for location of mud or water pits or other temporary excavation for construction purposes.

D. Perform Site grading, filling, and surface stabilization, if necessary, to access the Site with drilling equipment.

1.07 QUALITY ASSURANCE

A. The CONTRACTOR shall perform all testing required and supply any labor and equipment necessary for the testing of the geomembrane cap penetrations. Coordinate testing with the work of Section 02590 – HDPE Geomembrane of these Specifications, as required.

PART 2 - PRODUCTS

2.01 HDPE PIPE BOOTS/SLEEVES AND SKIRTS

A. The pipe boot/sleeve and skirt shall be constructed from textured 40-mil high-density polyethylene (HDPE) geomembrane with the same material properties as the geomembrane for the landfill cap as specified in Section 02590 – HDPE Geomembrane of these Specifications.

B. The HDPE geomembrane boots/sleeves and skirts shall be made by the same manufacturer as the geomembrane for the landfill caps.

2.02 PERMANENT CASING PIPE

A. 2-inch I.D. PVC Pipe: Schedule 40 with flush threaded joints and "O" rings.

2.03 GROUT

A. Neat Cement:

1. Neat Cement Grout: Cement and water in proportion of 1 bag (94 lb) Portland cement to 8.3 gal clean water. Slurry weight of 13.4 to 14.5 lbs/gal. A mud balance shall be used to verify slurry weight.
2. Mix design, method of mixing, and consistency of grout shall be approved by the REMEDIAL DESIGNER.
3. Cement grout admixtures may be used to increase fluidity, reduce shrinkage or control time of set. Use of admixtures shall be approved by the REMEDIAL DESIGNER.
   a. No more than 5 lbs of bentonite may be added per bag (94 lb) of cement.

2.04 SCREEN

A. Manufacturers:

1. Howard Smith Screen Company.
2. Johnson Screen Company.
3. Or equal.

B. Schedule 40 PVC, pipe size, having minimum inside diameter of 2inches.

C. Estimated screen slot size: 0.010 inch, to be verified by the QUALITY ASSURANCE OFFICIAL during construction.

D. Close bottom with threaded plug of same material as the screen.

E. All fittings shall be flush threaded with "O" rings.

2.05 FILTER SAND

A. Manufacturers:

1. Morie Company, Inc.
2. Or equal.

B. Clean, washed, acid-resistant, well rounded, graded flint/quartz type grains. Free of foreign material.

C. Filter Sand should be Morie Company, Inc. #00 or approved equal, and approved by the Remedial Designer.

2.06 SAND PACK

A. Sand fill shall consist of an approved clean material free of refuse, debris, rocks, organics, and other deleterious material.

B. Sand Pack should be Morie Company, Inc. #1 or approved equal, and approved by the Remedial Designer.

2.07 BLADDER PUMP

A. QED stainless steel pump with Teflon® bladder and associated tubing/well cap/adaptors, or equal.

2.08 LOCKING PROTECTIVE CASING

A. Anodized aluminum locking protective casing of sufficient length to extend three feet into the ground.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Inspect all materials upon delivery and before placement to document that they are in the original packaging as supplied by the manufacturer or supplier and free of any material that may alter the chemical quality of the vent.

3.02 PREPARATION

A. Protect existing structures from damage.

B. Prepare the area for staging of drill cuttings prior to relocation to designated areas on the landfills in accordance with Section 02221 – Waste Excavation and Relocation of these Specifications.

C. The CONTRACTOR shall provide access to all monitoring wells. Proposed access locations shall be reviewed with the REMEDIAL DESIGNER.

3.03 GENERAL

A. Cross-sections of proposed monitoring wells are included in the Contract Drawings for reference purposes. Monitoring well cross-sections shall not be interpreted to indicate exact formation, thickness, and material encountered. This information will be verified during construction.

B. Drilling methods shall be approved by the REMEDIAL DESIGNER and shall conform to all state and local standards for monitoring well construction.

1. Acceptable drilling fluids are mortar and potable water. Bucket augers shall not be used.
2. Monitoring wells shall be drilled straight and plumb.

C. The CONTRACTOR shall provide water for drilling and grouting.

3.04 MONITORING WELL CONSTRUCTION

A. Drill a minimum 6-inch diameter borehole to a depth where the elevation of the meadow mat is encountered. Split spoon samples shall be taken in the waste and the soil layer beneath the waste at2-foot depth intervals.

B. Following construction of the 6-inch diameter borehole, install a 2-inch diameter pipe in accordance with Article 2.02 herein, inthe open hole. Screen lengths shall be 10 feet.

C. Terminate upper end of casing at height or depth relative to ground surface indicated on the Contract Drawings.

D. After placement of screen and casing, fill annular space outside of screen with filter pack materialto a depth of 3 feet above the top of the screen.

E. Place a 2-foot thick fine sand seal in the annular space between the 2-inch I.D. casing and the native formation directly above the filter pack, to prevent migration of grout into the filter pack.

F. Fill the annular space between 2-inch I.D. casing and the borehole wall above the fine sand seal with neat cement grout. Notify the REMEDIAL DESIGNER a minimum of 24 hours before grouting wells.

G. Grout by placing tremie pipe with "tee" fitting on the lower endto within 1 foot of fine sand seal. Grout continuously to ensure entire filling of annular space in one operation. Force grout down tremie pipe under moderate pressure with grout pump and force upward into annular space between casing and surrounding formation. Slowly remove grout tremie pipe as grouting operation progresses with bottom of pipe submerged in grout. Terminate the grout at the depth shown on the Contract Drawings.

H. After completion of well, and after the grout has set for minimum of 12 hours, develop the monitoring well by air-lift and/or submersible pumping in accordance with Article 3.05 herein.

I. Conduct a short-duration performance test, up to 1 hour, pumping monitoring wells at a rate of at least 5 gpm to verify performance. Coordinate testing procedures with the REMEDIAL DESIGNER. CONTRACTOR shall be responsible for supplying potable water for this procedure.

3.05 MONITORING WELL DEVELOPMENT BY SUBMERSIBLE PUMP

A. Perform development of monitoring well by submersible pumping after completion of the monitoring well construction.

B. Prior to development, clean out any fill from monitoring well.

C. Provide necessary appurtenances for performing monitoring well development.

D. Provide discharge tee or other apparatus to control water removed from monitoring well. Pack around tee to prevent water spray.

E. Pump monitoring well until water is clear and relatively free of sand. A surge block should be used to enhance pumping.

F. Continue development until turbidity, temperature, pH, and specific conductance, of pumped water have changed by 10% or less over 3 consecutive readings, spaced 10 minutes apart; or until development is satisfactory to the QUALITY ASSURANCE OFFICIAL and REMEDIAL DESIGNER.

G. Collect, handle and dispose of well development water in accordance with Article 3.07 herein.

3.06 DECONTAMINATION

A. The drill rig and all drilling equipment shall be steam-cleaned upon arrival on-Site and prior to leaving the Site. Steam cleaning shall also be conducted following installation of wells. Potable water for steam cleaning shall be supplied by the CONTRACTOR. Between boreholes, all soil and wastes shall be removed from the drill rig and drilling equipment at the borehole location. Drill cuttings and other solid materials shall be disposed of in accordance with Section 02221 – Waste Excavation and Relocation of these Specifications.

3.07 LIQUIDS HANDLING

A. All aqueous and non-aqueous liquids used, collected or encountered during the performance of this Work, including well development water and decontamination water, shall be collected and handled in accordance with Section 02402 – Liquids Handling and Disposal of these Specifications.

3.08 WELL PROTECTION

A. During the progress of the Work, the CONTRACTOR shall protect all wells from tampering or the entrance of foreign material.

***** END OF SECTION *****

SECTION 02831

CHAIN-LINK FENCE AND GATES

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment and appurtenances required for the installation of a complete chain-link fence system. Fencing and gates shall be installed in the locations shown on the Contract Drawings and as otherwise required by the CONTRACTOR and favorably reviewed by the REMEDIAL DESIGNER.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations, and laws of local, State, or Federal authorities having jurisdiction. The CONTRACTOR is responsible for identifying and obtaining all appropriate licenses, approvals, and permits to complete the Work of this Section. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the Work.

1.02 SUBMITTALS

A. Shop Drawings

1. The CONTRACTOR shall submit to the REMEDIAL DESIGNER, at least 20-days prior to construction, catalog cuts, MANUFACTURER's installation instructions, and dimensioned drawings for fencing, gates, and associated details for installation.
2. Submit detailed layout drawing showing the location of each fence post.

B. Submit in accordance with Section 01300 – Submittals, of these Specifications.

1.03 DELIVERY AND HANDLING

A. Deliver materials with the MANUFACTURER's tags and labels intact.

B. Handle and store materials in such a manner that will avoid damage.

1.04 QUALITY ASSURANCE

A. Comply with the standards of the Chain-Link Manufacturers Institute and these Specifications.

B. Provide fencing as a complete unit produced by a single manufacturer including the required erection accessories, fittings, and fasteners.

1.05 CODES AND STANDARDS

The latest edition of the publications listed below are included as a part of these Specifications.

A. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A53	Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless
A123/A123M	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A153/A153M	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A392	Zinc-Coated Steel Chain-Link Fence Fabric
A641/A641M,	Zinc-Coated (Galvanized) Carbon Steel Wire

PART 2 - PRODUCTS

2.01 GENERAL

A. Height for new fencing shall be 6-feet as shown on the Contract Drawings. Posts shall be set at no more than 10-foot centers, in concrete footings, poured the full size of the excavated holes. Corner posts shall have the necessary strut and tie bracing. Gates shall be provided as specified the Contract Documents.

B. Where fencing crosses ditches, steep grades, and other unusual conditions, make special provisions to insure that the security, appearance, maintainability and permanence of the standard fencing are maintained.

2.02 MATERIALS AND CONSTRUCTION

A. Fence Mesh and General Note: 9 gauge wire, woven to 2-inch squares, zinc-coated (hot-dip galvanized), galvanized after weaving, 6-foot wide roll. Continuous tension wire shall be provided at the lower and upper edges of the mesh. Fence mesh shall be of one continuous piece from top to bottom and between posts. Zinc-coated fabric shall conform to ASTM A392, Class 2.

B. Line Post: 2-1/2-inch O.D. ASTM A53 standard weight Galvanized Pipe (3.65 lbs/ft.)

C. Corner Post: 3-inch O.D. ASTM A53 standard weight Galvanized Pipe (5.79 lbs/ft.)

D. Gate Post: 4-inch O.D. ASTM A53 standard weight Galvanized Pipe (9.11 lbs/ft.)

E. Top Rail: 1-5/8-inch O.D. ASTM A53 standard weight Galvanized Pipe (2.27 lbs/ft.) with extra long pressed steel sleeves.

F. Tension Wire: No. 7 gauge steel spring coil tension wire, zinc-coated (hot-dip galvanized). Zinc-coated wire shall conform to ASTM A641, Class 3.

G. Swing Gates:

1. Frame shall be 2-inch O.D. ASTM A53 standard weight galvanized pipe with galvanized pressed steel or galvanized malleable iron corner ells riveted or bolted at corners.
2. Internal bracing shall be NPS 1 ASTM A53 standard weight galvanized pipe with 3/8-inch diameter galvanized adjustable truss rods and truss fasteners.
3. Bottom hinge shall be galvanized malleable iron pivot type.
4. Top hinge shall allow gate to swing 90° to 180°.
5. Gate shall be complete with padlocking device, center rest, and semi-automatic catch to secure gate in open position.
6. Gates shall be provided to match fence height and with the following minimum widths:
   a. Man Gates: Provide a single gate of 3 feet width.
   b. Vehicular Gates: Provide dual gates of equal width to provide an overall gate width of 16-feet.

H. Hardware, fasteners, and accessories: galvanized and compatible with other fence system components.

I. Brace rail: ASTM A53 standard weight galvanized pipe with 3/8-inch diameter galvanized steel truss rods and truss tighteners.

J. Lifting Eyes: Provide at each end of removable panels of adequate strength and attachment to allow fence panel removal. Provide galvanized steel or stainless steel. Repair damage to galvanized surfaces with Galv-Alloy or other means.

K. Extension Arms (where required):

1. Line Post arms shall be fabricated of pressed steel or malleable iron base with pressed steel extension riveted on.
2. Corner Posts arms shall be fabricated of 11-gauge (minimum) pressed steel or heavy malleable iron base with 11-gauge (minimum) pressed steel extension riveted on.
3. Arms shall be galvanized in accordance with ASTM A123.
4. Arms shall be able to withstand a minimum pull down weight of 300 pounds and of the barbed wire stretched to proper tension.
5. Arms shall be securely fastened to post.

L. Tension Bars and Bands: Tension bars for pulling fence fabric to terminal posts shall be 3/4-inch steel bars, hot-dip galvanized in accordance with ASTM A123. Bands for fastening tension bars to terminal posts shall be 11 gauge by 1-inch wide steel; hot-dip galvanized in accordance with ASTM A123.

M. Barbed Wire: Provide galvanized barbed wire with barbs spaced not more than 10-inches apart.

N. Concrete: Concrete for setting of fence posts shall have a minimum 28-day compressive strength of 3,000 psi. Concrete shall be a New Jersey Department of Transportation standard mix. CONTRACTOR may propose use of high early strength concrete (Type III) for prior approval by the REMEDIAL DESIGNER.

PART 3 - EXECUTION

3.01 GENERAL

A. Fence shall be installed to the lines and grades indicated in the Contract Documents. The area on either side of the fence line shall be cleared to the extent required for proper installation. Line post shall be spaced equidistant at intervals not exceeding 10 feet. Terminal (corner, gate, and pull) posts shall be set at abrupt changes in vertical and horizontal alignment. Fabric shall be continuous between terminal posts, however, runs between terminal posts shall not exceed 500-feet.

3.02 POSTS

A. Posts shall be set plumb and in alignment. Except where solid rock is encountered, posts shall be set in concrete to the depth of 36-inches. Where solid rock is encountered with no overburden, posts shall be set to a minimum depth of 18-inches in rock. Where solid rock is covered with an overburden of soil or loose rock, posts shall be set to a minimum depth of 36-inches unless a penetration of 18-inches in solid rock is achieved before reaching the 36-inch depth in which case depth of penetration shall terminate. All portions of posts set in rock shall be grouted. Portions of posts not set in rock shall be set in concrete from the rock to ground level. Posts set in concrete shall be set in holes not less than 16-inches in diameter for terminal post and 10-1/2 inches in diameter for line posts. Diameters of holes in solid rock shall be at least 1-inch greater than the largest cross section of the post. Concrete and grout shall be thoroughly consolidated around each post so as to be free of voids and finished to form a dome. Concrete and grout shall be allowed to cure for 72-hours prior to attachment of any item to the posts.

3.03 BRACES AND TRUSS RODS

A. Braces and truss rods shall be installed as required and in conformance with the standard practice for the fence furnished. Braces and truss rods shall extend from terminal posts to line posts. Diagonal braces shall form an angle of approximately 40 to 50 degrees with the horizontal.

3.04 TENSION WIRES

A. Tension wires shall be installed along the bottom of the fence line and attached to the terminal posts of each stretch of the fence. Top rails shall be installed as shown on the drawings. Bottom tension wire shall be installed within the bottom 6-inches of the installed fabric. Tension wire shall be pulled taut and shall be free of sag.

3.05 CHAIN-LINK FABRIC

A. Chain-link fabric shall be installed on the side of the post indicated. Install fabric on the Site side of the posts if side is not indicated. Fabric shall be attached to terminal posts with stretcher bars and tension bands. Bands shall be spaced at approximately 15-inch intervals. Fabric shall be pulled taut to provide a smooth uniform appearance free from sag. Fabric shall be fastened to line posts at approximately 15-inch intervals and fastened to tension wires at approximately 24-inch intervals. Fabric shall be cut by untwisting and removing pickets. Splicing shall be accomplished by weaving a single picket into the ends of the rolls to be joined. The bottom of the installed fabric shall be 2 inches (plus or minus ½-inch) above the ground.

3.06 BARBED WIRE SUPPORTING ARMS AND BARBED WIRE

A. Barbed wire supporting arms and barbed wire shall be installed as indicated in the Contract Documents similar to the existing fence and as recommended by the MANUFACTURER. Barbed wire shall be pulled taut and attached to the arms with clips or other means that will prevent easy removal.

3.07 GATES

A. Gates shall be installed at the locations shown in the Contract Documents. Hinged gates shall be mounted to swing as indicated in the Contract Documents. Latches, stops, and keepers shall be installed as required in the Contract Documents. Padlocks shall be attached to gates or gate posts with chains to prevent padlock removal.

3.08 GROUNDING

A. Fences crossed by power lines of 600 volts or more shall be grounded at or near the point of crossing and at distances not exceeding 150-feet on each side of crossing. Ground conductor shall consist of No. 8 AWG solid copper wire. Grounding electrodes shall be ¾-inch by 10-foot long copper-clad steel rod. Electrodes shall be driven into the earth so that the top of the electrode is at least 6-inches below the grade. Where driving is impracticable electrodes shall be buried a minimum of 12-inches deep and radial from the fence. Top of electrode shall be not less than 2-feet or more than 8-feet from the fence. Ground conductor shall be clamped to the fence and electrodes with bronze grounding clamps so as to create electrical continuity between fence posts, fence fabric, and ground rods. After installation the total resistance of fence to ground shall not be greater than 25 ohms.

3.09 REMOVAL OF EXISTING CHAIN-LINK SECURITY FENCE

A. The designated portions of the existing chain-link security fence as identified on the Contract Drawings shall be removed in a workmanlike manner to preclude unnecessary damage to the fence and gate materials. Except for tie wires, fabric bands, lock wires, and concrete foundations, all fence materials to be removed shall be salvaged to the extent possible for reinstallation. All tie wires, fabric bands, lock wires and any other existing fence materials removed and not

reinstalled shall be disposed of by the CONTRACTOR off the project site. The existing posts shall be cutoff at ground level. Post excavation shall be filled with suitable material in 6-inch layers and compacted to at least the density of the adjacent ground, except in areas where excavation is required after the removal of the fencing where the post excavation shall be filled only to the elevation of the finished grade.

3.10 REUSE OF EXISTING CHAIN-LINK FENCE

A. The removal of existing fence shall be in accordance with the requirements herein before specified. All fence materials shall be disposed of in waste relocation areas in accordance with Section 02221 – Waste Excavation and Relocation, of these Specifications. If the condition of the fabric is adequate to allow re-use of the material, the CONTRACTOR shall notify the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL of his intention to re-use fabric, stipulating the portions to be re-used. This material may be re-used with the approval of the QUALITY ASSURANCE OFFICIAL and/or REMEDIAL DESIGNER. The CONTRACTOR shall indicate to the REMEDIAL DESIGNER the cost savings that can be realized by re-using the fabric, with his request of such.

B. Vegetative matter shall be removed from fence fabric prior to reuse. All tie wires, fabric bands, lock wires, and concrete foundations used to install the fence shall be new (i.e., not re-used). The CONTRACTOR shall supply such new parts conforming to the requirements of this section as are necessary to complete the installation of the relocated fence.

C. Any fence materials to be reused which are damaged by the CONTRACTOR shall be repaired or replaced with new materials at no additional cost to the GROUP.

3.11 CLEANING

A. Perform cleaning during installation of the Work and upon completion of the Work. Remove from the Site all fence debris and equipment. Repair all damage resulting from the installation of the chain-link fence system as directed by the REMEDIAL DESIGNER or QUALITY ASSURANCE OFFICIAL, at the CONTRACTOR's sole expense.

3.12 EXISTING FENCE TO REMAIN

A. All chain link fencing designated to remain in place shall be jointly inspected by the CONTRACTOR and the QUALITY ASSURANCE OFFICIAL prior to the start of any work, and an agreement shall be signed briefly setting forth the current condition thereof. The CONTRACTOR shall repair / replace components of the existing fence to meet the requirements of the above Specifications.

*****END OF SECTION*****

SECTION 02936

SEEDING

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the seeding of all areas disturbed, regraded or receiving the soil cover during the course of construction.

B. The CONTRACTOR shall comply with all applicable codes, ordinances, rules, regulations and laws of local, municipal, State, or Federal authorities having jurisdiction. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect the work.

1.02 RELATED SECTIONS

A. 02125 – Erosion and Sedimentation Control

B. 02225 – Vegetative Layer

1.03 SUBMITTALS

A. A manufacturer's Certificate of Compliance for the seed mixture shall be submitted to the QUALITY ASSURANCE OFFICIAL by the MANUFACTURER with each shipment of each type of seed. These certificates shall include the guaranteed percentages of purity, weed content and germination of the seed, net weight, and the date of shipment. No seed may be sown until the CONTRACTOR has submitted these certificates.

B. The CONTRACTOR shall provide analysis of soil suitability to sustain vegetation. Analyze to ascertain percentage of nitrogen, phosphorus, potash, soluble salt content, organic matter content, and pH value by performing Baker or LaMotte Test.

C. Recommendations of the Hudson County Soil Conservation District (SCD).

D. Submit in accordance with Section 01300 – Submittals, of these Specifications.

1.04 QUALITY ASSURANCE

A. A satisfactory stand of grass, as determined by the REMEDIAL DESIGNER, shall be required. To be acceptable, bare spots shall be scattered, there shall be no bare spots larger than one square yard, and the stand of grass shall consist of a uniform stand of at least 80 percent established permanent grass species within one year of initial seeding.

B. Maintain erosion and sediment controls in accordance with Section 02125 – Erosion and Sedimentation Control, of these Specifications.

1.05 DEFINITIONS

A. Weeds include, but are not limited to, Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Broome Grass.

1.06 QUALITY CONTROL

A. The CONTRACTOR shall submit to the REMEDIAL DESIGNER evidence of compliance with the testing specified in Article 1.02 of this Section at least seven (7) business days prior to placement.

PART 2 - PRODUCTS

2.01 SEED MIXTURES FOR TEMPORARY AND PERMANENT COVER

A. The following seed mixtures (Formula L) shall be used for temporary and permanent cover:

Scientific Name Common Name	Percentage of Mixture	Application Rate (lbs per acre)
Poa Pratensis, Eclipse Kentucky Bluegrass	45% of Mixture	150
Festuca Rubra, var., Creeping Red Fescue	45% of Mixture	
Lolium perenne, Perennial Ryegrass	10% of Mixture	

Labels and contents shall conform to all State and Federal regulations. Seed shall be subject to the testing provision of the Association of Official Seed Analysts

B. The specified application rates are minimum values. The CONTRACTOR may elect to apply the specified seed mixtures more densely in order to meet the requirements of Article 1.03A herein.

C. The REMEDIAL DESIGNER, reserves the right to change the seed mixture and recommended seeding dates based upon the time of year in which the construction is performed (i.e., winter rye).

2.02 FERTILIZER

A. 10-20-10 fertilizer, or equivalent, shall be applied at a rate of 600 lbs/acre, unless fertility testing indicates that another fertilizer and a different application rate would be appropriate.

2.03 MULCH

A. Straw mulch shall be oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable. Straw mulch shall be properly anchored.

B. Wood fiber mulch shall consist of wood fiber produced from clean, whole uncooked wood, formed into resilient bundles having a high degree of internal friction and shall be dry when delivered to the Site.

2.04 WATER

A. Water shall be clean, fresh, potable, and free of substances or matter that could inhibit vigorous growth of grass.

2.05 LIME

A. Agricultural grade lime shall be applied at a rate indicated by fertility testing.

PART 3 - EXECUTION

3.01 INSPECTION

A. The CONTRACTOR shall notify the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL to inform him that the CONTRACTOR has verified that the prepared vegetative layer is ready to receive the work of this Section.

3.02 DELIVERY, STORAGE, AND HANDLING

A. The CONTRACTOR shall deliver grass seed mixture in sealed containers showing weight, seed mix, year of production, date of packaging, and location of packaging. Seed in damaged packaging shall not be acceptable.

B. The CONTRACTOR shall deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of MANUFACTURER. Fertilizer in damaged packaging is not acceptable.

3.03 LIMING

A. When required, ground limestone that has been protected from moisture, and is dry and free flowing, shall be evenly spread over the area to be seeded at a rate that will produce a pH value of the soil of at least 6.5.

B. The CONTRACTOR shall work lime into vegetative layer to a depth of 4-inches with a disc, spring-tooth harrow, or other suitable equipment.

3.04 FERTILIZING

A. The CONTRACTOR shall apply fertilizer in accordance with MANUFACTURER's instructions.

B. The CONTRACTOR shall apply fertilizer after smoothing of the vegetative layer and prior to roller compaction.

C. The CONTRACTOR shall not apply fertilizer at the same time or with the same machine as that will be used to apply seed unless hydroseeding.

D. The CONTRACTOR shall mix fertilizer thoroughly into upper 4-inches of the vegetative layer with a disc, spring-tooth harrow, or other suitable equipment.

E. The CONTRACTOR shall lightly water ground surface to aid the dissipation of fertilizer.

3.05 SEEDING

A. Areas to be seeded shall be made friable and receptive to seeding prior to seeding. Stockpiles to receive seeding may be seeded immediately after stockpiling is completed provided the seed bed is not muddy or hard. Under no circumstances will seeding be permitted in muddy, hard, or crusted soils.

B. The CONTRACTOR shall apply seed at the rates the shown in Article 2.01 of this Section or as recommended by the Hudson County Soil Conservation District. Seed evenly in two intersecting directions. Rake in lightly. Do not seed area in excess of that which can be mulched on same day.

C. Planting season shall be as recommended by the Hudson County Soil Conservation District.

D. The CONTRACTOR shall not sow immediately following rain, when ground is too dry, frozen, or during windy periods.

3.06 MULCHING

A. Straw mulch shall be applied at a rate of 2 tons per acre.

B. Wood fiber mulch shall be applied to seeded area at a rate of 1,500 pounds per acre. Immediately before spraying, the mulching material shall be mixed with water in the sprayer and kept uniformly suspended in the water by agitation during the spraying operation.

3.07 HYDROSEEDING

A. This method is best for steep, inaccessible areas. When applying seeds, lime, fertilizer, or mulch materials with hydroseeders, do not use more than 100 to 150 pounds of solids per 100 gallons of water. If inoculate is in a seed, fertilizer, and lime slurry, it should be used within three to four hours, or a fresh supply of inoculate should be added. It is preferable to hydroseed when the soil is moist.

B. If seeding is performed by hydromulching, then specified seed mixtures shall be increased by 10 percent.

3.08 WATERING

A. The plants shall be watered as necessary to maintain an adequate supply of moisture within the root zone. An adequate supply of moisture is estimated to be the equivalent of one inch of absorbed water per week delivered in the form of natural rain or augmented as required by periodic waterings. Run-off, puddling and wilting shall be prevented.

B. Water: Plants shall be watered as necessary to maintain an adequate supply of moisture within the root zone. Run-off, puddling and wilting shall be prevented.

C. Water shall not contain elements toxic to plant life.

3.09 RESEEDING

A. Where vegetative coverage is less than 80 percent with one year of initial seeding, the CONTRACTOR shall place additional seed in accordance with Articles 3.05 or 3.07 herein, at no additional cost to GROUP.

B. Within one (1) year of project completion, the CONTRACTOR shall cut the existing vegetative growth at the CONTRACTOR's expense.

*****END OF SECTION*****

SECTION 03100

CONCRETE FORMWORK

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish and install concrete formwork as required to form reinforced concrete working pads for the passive gas vents and as shown and indicated on the Contract Drawings, as specified herein, or as otherwise required to complete the Work.

B. The CONTRACTOR shall furnish all materials, labor, tools and appurtenances required to complete the Work as described below. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect all Work.

C. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

1.02 RELATED SECTIONS

A. 03200 - Concrete Reinforcement

B. 03300 - Concrete

1.03 RELATED REFERENCES

The latest editions of the publications listed below are included as a part of these Specifications.

A. ACI 318 Building Code Requirements for Reinforced Concrete

B. ACI 347 Recommended Practice for Concrete Formwork

C. US Department of Commerce Product Standard (PS)
PS 1 – Construction and Industrial Plywood

1.04 FORM DESIGN

A. The design of forms and their performance, as required by this Section, is the CONTRACTOR's responsibility. Formwork shall comply with ANSI A10.9 and OSHA Construction Standards, Part 1926, Subpart Q, Concrete, Concrete Forms, and Shoring.

PART 2 - PRODUCTS

2.01 FORM MATERIAL

A. Formwork for all concrete, unless otherwise specified, shall not be less than 5/8-inch, 5-ply Douglas fir plywood of exterior structural grade especially processed to resist moisture and conforming to PS 1, B-B Concrete Form Panels. Patented forms may be used, subject to approval by the REMEDIAL DESIGNER, provided they are in new, or like-new condition so as to produce a

smooth, even surface free from blemishes, defects, and depressions; this approval is for the finish these forms will leave on the contact surfaces and will not relieve the CONTRACTOR of the responsibility for the design and structural soundness of the forms.

2.02 ACCESSORIES

A. Form tie assemblies shall be form clamps with smooth tie rods, with a waterstop at the center, permitting tightening of the forms and be of such type as to leave no metal or other material within 1-1/2-inch of the surface after use. The assembly should provide cone-shaped depressions in the cast surface at least 1-inch in diameter and 1-1/2-inch deep to allow filling and patching.

B. Form releasing agent shall be a non-staining form coating compound such as "Cast-Off" by Sonneborn Products Division (Contech, Inc.), or an equal product as approved by the REMEDIAL DESIGNER.

PART 3 - EXECUTION

3.01 FORM CONSTRUCTION

A. Formwork shall be in accordance with ACI 347 and as follows:

1. Forms shall conform to shape, lines and dimensions of members required and shall be sufficiently rigid and tight to prevent leakage of the cement binder. Forms shall be properly braced or tied together so as to maintain position and shape. Construct forms so that they can be removed readily without hammering or prying against the concrete. Forms for exposed concrete shall be carefully made and accurately placed to obtain correct shape and lines.
2. Joints shall be butted tight on solid bearings. Arrangements of panels shall be orderly and symmetrical, and use of small pieces shall be avoided. Forms shall be chamfered for external corners of concrete, including top of walls, which will be exposed in the finished work.
3. The CONTRACTOR shall be fully responsible for the adequacy of formwork in its entirety. Forms shall support the anticipated loading while maintaining their dimensional and surface correctness to produce members with the required geometry.
4. Block-outs for slots, chases, recesses or other openings shall be provided by the CONTRACTOR as needed by the work of this and any other trades.
5. Install all the inserts to be supported by the formwork as required by the work of this and other trades as needed.

3.02 TOLERANCE FOR FORMED SURFACES

A. Variation from Plumb: Not more than ±1/4 inch in any 10 feet of length with a maximum for the entire length of ±1/2 inch.

B. Variation from the Level or from the Grades Specified in the Contract Drawings: Not more than ±1/4 inch in any 10 feet of length with a maximum for the entire length of ± 3/4 inch.

C. Variation in the Sizes and Location of Openings and Thickness of Walls: ±1/4-inch.

3.03 INSPECTION

A. The CONTRACTOR shall give the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL at least 48 hours notice before any concrete is to be cast. Concrete shall not be cast until the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL have observed and given approval of the work to be cast including, but not limited to, the placement of all the reinforcing, accessories, forms and the surfaces to be cast against. Such observations are in the nature of assisting the CONTRACTOR to minimize errors and in no case will they serve to relieve the CONTRACTOR of the responsibility to provide the materials and workmanship required by the Contract Documents.

3.04 APPLICATION OF FORM COATING

A. Immediately before the placing of reinforcing, faces of all forms in contact with the concrete shall receive a thorough coating of the liquid form-releasing agent specified, applied in compliance with the manufacturer's instructions.

3.05 REMOVAL OF FORMS

A. The CONTRACTOR shall assume full responsibility for removal of formwork and forms shall be removed in such a manner as to insure complete integrity and safety of the structure. Forms and shoring for mass concrete, walls, columns, and beams shall remain in place a minimum period of 7 days after casting the concrete. Forms for slabs shall remain in-place a minimum of 24 hours after casting.

B. Wood forms shall be completely removed from all concrete cast to avoid termite infestation.

3.06 SURVEYING

A. Prior to pouring concrete, accurately survey and measure the size and location of all structures to be placed in the concrete. Survey and record measurements.

C. Provide drawings showing surveyed measurements, dimensions, and locations necessary to locate accurately anchors, pipes, tanks, conduit, and other structures buried in or below concrete.

*****END OF SECTION*****

SECTION 03200

CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall size, furnish, and install concrete reinforcement for the reinforced concrete working pads for the extraction wells and passive gas vents, and, as shown, required, or indicated on the Contract Drawings, as specified in this Section, or as otherwise required to complete the Work.

B. The CONTRACTOR shall furnish all materials, labor, tools and appurtenances required to complete the Work as described below. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect all Work.

C. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

1.02 RELATED SECTIONS

A. 03100 - Concrete Formwork

B. 03300 - Concrete

1.03 REFERENCED PUBLICATIONS

The latest edition of the publications listed below are included as part of these Specifications.

A.	ACI 318	Building Code Requirements for Reinforced Concrete
B.	ACI 315	Manual of Standard Practice for Detailing Reinforced Concrete Structures
C.	ASTM A82	Specification for Cold Drawn Steel Wire for Concrete Reinforcement
D.	ASTM A185	Specification for Welded Steel Wire Fabric for Concrete Reinforcement
E.	ASTM A496	Deformed Steel Wire for Concrete Reinforcement
F.	ASTM A497	Welded Deformed Steel Wire Fabric for Concrete Reinforcement
G.	ASTM A615	Specification for Deformed and Billet-Steel Bars for Concrete Reinforcement

1.04 SUBMITTALS

A. Shop Drawings: Reproductions of Contract Drawings are not permitted. Shop drawings shall show the required bar sizes, spacing, and splice length for all reinforcement; reinforcement placing plans; and, bending details and complete bar lists. All relevant details and notes appearing on the Contract Drawings shall be shown on the shop drawings. Shop drawings will not be reviewed without such information. Reinforcement shall be shown in plan and cross-section, with wall reinforcing shown in elevation. Location and arrangement of accessories and block-outs shall be clearly indicated. Placing drawings, detail drawings and bar lists shall be checked by the fabricator and the CONTRACTOR before being submitted to the REMEDIAL DESIGNER.

B. Mill tests of reinforcing steel shall be submitted prior to use for each 15 tons or less shipped to the Site. Tests shall be conducted in conformance with ASTM A615, and methods prescribed therein.

1. Cost of testing shall be borne by the CONTRACTOR.
2. Three (3) copies of each test report stating whether the material meets the requirements of the ASTM specifications shall be submitted to the REMEDIAL DESIGNER and the QUALITY ASSURANCE OFFICIAL.
3. Certified copies of the mill tests may be considered evidence of compliance provided such tests are regularly conducted by the reinforcement supplier by experienced, competent personnel using appropriate testing equipment. In case of doubt as to the adequacy or accuracy of the mill tests, the QUALITY ASSURANCE OFFICIAL may require the CONTRACTOR to furnish, at the OWNER's expense, test results from an independent testing laboratory acceptable to the REMEDIAL DESIGNER on mill samples or delivered steel reinforcement.

C. Submit in accordance with Section 01300 – Submittals of these Specifications.

PART 2 - PRODUCTS

2.01 REINFORCING BARS

A. Bar reinforcement shall be deformed-type bars conforming to ASTM A615. Reinforcement shall be manufactured from new billet steel of American manufacture, Grade 60, yield strength 60,000 psi minimum.

2.02 WELDED WIRE FABRIC

A. Welded wire fabric shall be in flat sheets conforming to ASTM A185 (A497), with wire conforming to ASTM A82 (A496).

2.03 ACCESSORIES

A. All chairs and bolsters shall have plastic-covered or galvanized steel legs.

B. For slabs on grade, all reinforcing shall be supported on chairs and/or bolsters as required to properly position the bars. The chairs and/or bolsters shall be supported on precast concrete supports bearing on the subgrade. The concrete supports shall be at least 6-inch x 6-inch and no more than 1 inch thick. Pads shall be cast from Class "A" concrete or from mortar made up of one part cement and two parts sand, with embedded tie wires.

PART 3 - EXECUTION

3.01 STORAGE OF MATERIALS

A. Reinforcing steel delivered to the Site, not immediately placed in forms, shall be protected from mud and excessive rust-producing conditions by storing in a well-drained area and supported off the ground.

3.02 INSPECTION OF STEEL PLACEMENT

A. The CONTRACTOR shall give the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL at least 48 hours notice before any concrete is to be cast. Concrete shall not be cast until the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL have observed and given approval of the work to be cast including, but not limited to, the placement of all the reinforcing, accessories, forms and the surfaces to be cast against. Such observations are in the nature of assisting the CONTRACTOR to minimize errors and in no case will they serve to relieve the CONTRACTOR of the responsibility to provide the materials and workmanship required by the Contract Documents.

3.03 TOLERANCES

A. Allowable tolerances for fabricating steel reinforcement shall be as follows:

Item	Maximum Tolerance
Sheared length of bars	± 1-inch
Location of bends	± 1-inch

B. Allowable tolerances for placing steel reinforcement shall be as follows:

Item	Maximum Tolerance
Concrete cover from outside of bar to finished surface	+ 1/4-inch
Lateral spacing of bars in plane of reinforcement in slabs and walls	± 1-inch
Height of bottom bars in slabs	± 1/4-inch
Height of top bars in slabs	± 1/4-inch

3.04 SHOP FABRICATION

A. Reinforcing steel shall be fabricated to shapes and dimensions indicated on the Contract Drawings and in compliance with applicable provisions of ACI 315 and ACI 318.

B. Bars shall be bent cold. Bars shall be prefabricated to detail and delivered to the site plainly tagged and ready to set.

3.05 FIELD FABRICATION

A. Field fabrication of reinforcing steel will not be permitted without the approval of the REMEDIAL DESIGNER.

3.06 PLACEMENT AND ANCHORAGE

A. Space metal chairs, bolsters, spacers and hangers in accordance with ACI 315.

B. Reinforcement, at the time concrete is placed, shall be free from rust scale or other coatings that will destroy or reduce bond. Bars with kinks or bends not shown on the plans shall not be used. A thin coating of firmly attached rust shall not be cause for rejection.

C. Reinforcement shall be accurately placed in accordance with approved Shop Drawings and shall be adequately secured in position with not less than 16-gauge annealed wire or suitable clips at intersections. Reinforcement shall be held securely at the required distance from the forms. Nails shall not be driven into outside forms to support reinforcement.

D. Install welded wire fabric reinforcement for concrete as required on the Contract Drawings. Lap all joints 6-inches and wire securely. Extend mesh to within 2-inches of sides and ends of slabs. Unless otherwise specified, place welded wire fabric between the upper third-point and the mid-point of the slab. Sheets that do not lay flat when in their intended position will be rejected. Tags designating the wire size and spacing shall be left on each sheet until ready for use. Tuck ends of welded mesh well down into edge of beams or walls. Do not leave unreinforced border strips. Welded wire fabric shall not contain loose rust.

3.07 CONCRETE COVER

A. Metal reinforcement shall be protected by concrete cover in accordance with ACI 318.

3.08 SPLICING

A. Splices shall be Class "A" splice minimum. The location and type of splices desired by the CONTRACTOR must be specifically requested and must meet the approval of the REMEDIAL DESIGNER before they can be used.

B. Splices shall not be made at point of maximum stress and shall provide sufficient lap to transfer stress between bars by bond.

C. Mechanical splices may be used instead of lap splices provided that their location and type meets with the approval of the REMEDIAL DESIGNER and QUALITY ASSURANCE OFFICIAL.

D. Stagger splice locations to prevent their alignment.

*****END OF SECTION*****

SECTION 03300

CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish and install cast-in-place concrete for the fence posts, drainage linings, and as shown and indicated on the Contract Drawings, specified in this Section, and as otherwise required to complete the Work.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations, and laws of local, municipal, State or Federal authorities having jurisdiction. The CONTRACTOR shall provide a "Competent Person" to implement, supervise, and inspect all Work.

1.02 RELATED SECTIONS

A. 01410 – Materials Testing Laboratory

B. 02223 – Fill Materials

C. 03100 – Concrete Formwork

D. 03200 – Concrete Reinforcement

1.03 REFERENCED PUBLICATIONS

The latest edition of the publications listed below form a part of these Specifications:

A. American Concrete Institute (ACI) Publications

211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
301	Specifications for Structural Concrete for Buildings
302.1R	Guide for Concrete Floor and Slab Construction
304	Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete
305R	Hot Weather Concreting
306R	Cold Weather Concreting
318	Building Code Requirements for Reinforced Concrete

B. U.S. Army Corps of Engineers (COE) Waterways Experiment Station Publications

CRD-C-572	Specifications for Polyvinyl Chloride Waterstops
CRD-C-621	Handbook for Concrete and Cement, Specifications for Non-shrink Grout, Volume II

C. American Association of State Highway and Transportation Officials (AASHTO) Publication

M 182 Burlap Cloth Made From Jute or Kenaf

D. State of New Jersey; Department of Transportation

905 Specifications - 2001

E. American Society for Testing and Materials (ASTM) Publications

C 31 Making and Curing Concrete Test Specimens in the Field

C 33 Concrete Aggregates

C 39 Compressive Strength of Cylindrical Concrete Specimens

C 42 Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

C 94 Ready-Mixed Concrete

C 143 Slump of Portland Cement Concrete

C 150 Portland Cement

C 171 Sheet Materials for Curing Concrete

C 172 Sampling Freshly Mixed Concrete

C 173 Air Content of Freshly Mixed Concrete by the Volumetric Method

C 231 Air Content of Freshly Mixed Concrete by the Pressure Method

C 260 Air-Entraining Admixtures for Concrete

C 309 Liquid Membrane-Forming Compounds for Curing Concrete

C 494 Chemical Admixtures for Concrete

C 595 Blended Hydraulic Cements

C 618 Fly Ash and Raw or Calcimined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete

C 881 Epoxy-Resin-Base Bonding Systems for Concrete

D 1751 Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)

1.04 SUBMITTALS

A. Submit concrete MANUFACTURER's mix design to the REMEDIAL DESIGNER.

B. Submit Shop Drawings showing the sequence for concrete placement and the location and details of joints, block-outs, openings, and other embedded items not shown on the Contract Drawings.

C. Submit compression test results to the REMEDIAL DESIGNER.

D. Submit in accordance with Section 01300 – Submittals, of these Specifications.

PART 2 - PRODUCTS

2.01 CEMENT

A. Cement shall be standard Portland cement of American manufacture, conforming to ASTM C150, Type I. Only one brand of commercial Portland cement shall be used in the exposed concrete of the structure. Cement reclaimed by cleaning bags or from leaking containers shall not be used. Each bag shall weight approximately 94 pounds and contain one cubic foot.

2.02 CONCRETE AGGREGATES

A. Fine aggregates shall be sand having clean, hard, durable, uncoated grains and free from deleterious substances and shall conform to ASTM C33.

B. Coarse aggregates shall be crushed stone having clean, hard, durable, uncoated particles conforming to ASTM C33. Aggregate for lightweight concrete shall conform to ASTM C330.

2.03 WATER

A. Water used in mixing concrete shall from a potable water source and free from deleterious amounts of acids, alkalies or organic materials.

2.04 EXPANSION JOINT FILLER MATERIAL

A. Expansion joint materials shall be asphalt-impregnated fiber strips, 1/2-inch thick, unless otherwise shown or noted in the Contract Documents, conforming to ASTM D1751.

2.05 WATERSTOPS:

A. Where shown in the Contract Documents and/or otherwise required in expansion joints and construction joints, waterstops shall be polyvinyl chloride (PVC) and shall incorporate a galvanized steel wire along both edges which shall be used to secure the waterstop in position, by tying to reinforcement, during concrete placement. The waterstop shall be flat corrugated, 6-inches wide and 3/8-inch thick at its center. The waterstop shall extend the entire length of the joint; and, all splices shall be heat-welded and tested in accordance with the MANUFACTURER's instructions. Provide prefabricated tees, crosses, and other configurations as required for proper installation.

2.05 NON-SHRINK GROUT

A. Non-shrink grout shall be a ready-to-use non-metallic aggregate product requiring only the addition of water at the jobsite, and shall conform to COE CRD-C-621.

2.06 VAPOR BARRIER

A. Vapor barrier shall be polyethylene sheeting, minimum 6-mil thickness, conforming to ASTM C171.

2.07 ADMIXTURES

A. Water reducing admixture shall conform to ASTM C494, Type A.

B. Water reducing, retarding admixture shall conform to ASTM C494, Type D.

C. Non-Corrosive, Non-Chloride Accelerator: The admixture shall conform to ASTM C494, Type C.

D. Air entraining admixture shall conform to ASTM C260.

E. High range water reducer (HRWR) shall conform to ASTM C494, Type F or G.

F. Calcium Chloride: Calcium chloride or admixtures containing more than 0.1 percent chloride ions are <u>not</u> permitted.

2.08 CURING AND SEALING COMPOUNDS

A. Curing compound shall be acrylic based, conforming to ASTM C309.

B. Sealing-hardener compound shall conform to ASTM C309.

2.09 BONDING COMPOUNDS

A. Bonding Compound shall conform to ASTM C881.

2.10 DRILLED ANCHORS

A. Drilled anchors shall be Type 304 or Type 317 stainless steel and anchored to the concrete with and epoxy adhesive: Hilti HVA or HIT-C-100; Rawl Chem-Steed, Molly Parabond, or favorably reviewed equivalent.

PART 3 - EXECUTION

3.01 CONCRETE QUALITY

A. All mix designs shall be proportioned in accordance with ACI 211.1. The proportioning shall be based on the requirements of a well-graded high-density plastic and workable mix within the slump range and strengths required. The following classes of concrete is required:

1. Class A
   a) Compressive strength at 28 days: 3,000 psi
   b) Slump shall be a maximum slump of 3 inches.
   c) Concrete shall have a maximum water-cement ratio of 0.50.

2. Class AA
   a) Compressive strength at 28 days: 3,500 psi

b) Slump shall be a maximum slump of 3 inches.
c) Concrete shall have a maximum water-cement ratio of 0.47.

3. Class AAA
a) Compressive strength at 28 days: 4,000 psi
b) Slump shall be a maximum slump of 3 inches.
c) Concrete shall have a maximum water-cement ratio of 0.43.

B. Slump: Testing frequency shall be as specified in Article 3.16A herein.

C. Air Content: All concrete shall have an air content of 5 to 7 percent. Testing frequency shall be as specified in Article 3.16A herein.

D. Admixture Usage: All concrete shall contain a water reducing admixture or water reducing-retarding admixture, and an air entraining agent. All concrete placed at air temperatures below 50 degrees F shall contain the specified non-corrosive non-chloride accelerator. The use of admixtures allowed in this Specification is optional and subject to favorable review of the REMEDIAL DESIGNER.

3.02 MIX DESIGNS

A. The CONTRACTOR shall submit the concrete supplier's mix design and strength data for each class of concrete specified to document compliance with the specifications. The CONTRACTOR shall not use any concrete in this work without approval of the design mix by the REMEDIAL DESIGNER.

B. If the concrete production facility does not have a standard mix or test data meeting the requirements of this Specification, trial batches of the proposed mix shall be prepared by the production facility in accordance with ACI 211.1 and tested by an independent laboratory hired by the CONTRACTOR at no cost to the GROUP.

C. For concrete placed by pumping, the mix design shall be adjusted, if required, to meet the recommendations of ACI 211.1.

D. Compression test specimens made to verify the mixes shall be made in accordance with ASTM C192. Aggregates shall be tested in accordance with ASTM C33. All compression test specimens shall be tested in accordance with ASTM C39.

3.03 PLANT MIXING

A. Proportioning Concrete

1. Proportions shall be in compliance with approved design mix for each class of concrete.

2. The mixing plant shall be fitted with adequate equipment and facilities for accurate measurement and control of the quantities of material and water used in the concrete.

3. Concrete materials shall be measured by weight except for admixtures, which shall be measured by volume.

B. Batching

1. The CONTRACTOR shall provide all necessary equipment to accurately determine and control actual amount of materials entering into the concrete mix. Individual ingredients shall be weighted separately for each batch. Accumulative weighing will be allowed if equipment is in acceptable working order as determined by the testing laboratory and approved by the REMEDIAL DESIGNER. Accuracy of all weighing devices shall be such that successive quantities can be measured to within one percent of the desired amount.

2. Completely discharge contents of the mixer before each new batch is loaded. Use of retempered concrete or wash water is not permitted.

3. Ready-mixed concrete shall be mixed and delivered in accordance with requirements of ASTM C94 and the following:

a. A separate water-metering device (not truck tank) shall be used for measuring water added to the original batch.
b. Use of wash water as a portion of the mixing water is not permitted. Wash water added to empty drums after discharging shall be removed before a new batch is received.
c. Centrally mixed concrete shall be mixed for the length of time specified herein, not "shrink-mixed".
d. Mixing drums shall be watertight.
e. Concrete shall be discharged within one hour from the time concrete was mixed, if centrally mixed, or from time the original water was added, if transit-mixed.
f. Furnish a delivery ticket with each load of concrete delivered under these Specifications to the QUALITY ASSURANCE OFFICIAL. Delivery ticket shall show clearly the class and strength of concrete, size of coarse aggregate, water per cubic yard, the slump ordered, quantities of all admixtures, and the date and time of departure from the batching plant.

3.04 CONVEYING EQUIPMENT

A. If concrete is to be transported in carts or buggies, the carts or buggies shall be equipped with pneumatic tires.

B. Equipment for chuting or other methods of conveying concrete shall be of such size and design as to insure a practically continuous flow of concrete at delivery without segregation of materials.

3.05 CONVEYING

A. Concrete shall be conveyed from mixer to place of final deposit by methods that will prevent separation or loss of the material.

B. Runway supports shall not bear upon reinforcing steel or fresh concrete.

C. All conveying equipment shall be thoroughly cleaned before each run of concrete is begun.

3.06 DELIVERY AND PROTECTION OF MATERIALS

A. Deliver ready-mixed concrete in compliance with requirements set forth in ASTM C94.

3.07 SEVERE-WEATHER PROVISIONS

A. Hot-Weather Concreting

1. Provide adequate methods of lowering temperature of concrete ingredients so that the temperature of concrete when placed does not exceed 90 degrees F.

2. When the weather is such as to raise the as-placed concrete temperature consistently above 90 degrees F, Pozzolith retarder shall be used.

3. Subgrade and forms shall be wetted with water before placing of concrete. All excess water shall be removed before concrete is placed.

4. Curing shall start as soon as practicable to prevent evaporation of water. Flat work shall be protected from dry winds, direct sun and high temperatures.

B. Cold-Weather Concreting

1. Provide adequate equipment for heating concrete materials and protecting concrete during freezing or near-freezing weather. No frozen materials, or materials containing ice, shall be used.

2. All concrete materials and all reinforcement, forms, fillers and ground with which concrete is to come into contact shall be free from frost.

3. Whenever the temperature of the surrounding air is below 40 degrees F and falling, all concrete placed in the forms shall have a temperature of between 70 and 80 degrees F, and adequate means shall be provided for maintaining a temperature of not less than 70 degrees F for three days, or 50 degrees F for five days, or for as much more time as is necessary to insure proper curing of the concrete. If high early strength concrete is used, the requirement for maintenance of 50 degrees F can be reduced to three days.

4. Use only the specified non-chloride accelerator. Calcium chloride or admixtures containing more than 0.1 percent chloride ions are <u>not</u> permitted.

5. Housing, covering or other protection used in connection with curing shall remain in place and intact at least 24 hours after the artificial heat is discontinued.

3.08 CONSTRUCTION JOINTS

A. Early in the construction program, the CONTRACTOR shall review with the QUALITY ASSURANCE OFFICIAL any construction joints proposed for use which are not indicated on the Contract Drawings. The CONTRACTOR shall not use any construction joints which are not approved by the REMEDIAL DESIGNER. In all cases, construction joints shall occur at sections of minimum shear. Where construction joints are to be made, concrete surfaces shall be roughened (construction joints detailed with keyways in slabs and walls, are not required to be roughened) and thoroughly cleaned of foreign matter and laitance. In addition to the foregoing, joints shall be dampened with water and the specified bonding compound applied, or a slush coat of neat cement grout shall be applied.

3.09 INSPECTION OF WORK BEFORE PLACING

A. The CONTRACTOR shall inspect the forms to receive concrete for any deficiencies which would prevent proper placing of concrete. Do not proceed with placing concrete until such deficiencies are corrected.

B. The CONTRACTOR shall give the QUALITY ASSURANCE OFFICIAL at least 48 hours notice before any concrete is to be cast. Concrete shall not be cast until the QUALITY ASSURANCE OFFICIAL has observed and given approval of the work to be cast including, but not limited to, the placement of all the reinforcing, accessories, forms and the surfaces to be cast against. Such observations are in the nature of assisting the CONTRACTOR to minimize errors and in no case will they serve to relieve the CONTRACTOR of the responsibility to provide the materials and workmanship required by the Contract Documents.

C. The CONTRACTOR shall not place concrete on earth until the fill or excavation has been prepared as set forth under applicable Sections of the Specifications for that Work.

D. The CONTRACTOR shall not place any item in the concrete that has not been authorized by the Contract Documents and/or the QUALITY ASSURANCE OFFICIAL. The CONTRACTOR shall insert all the items as required by the other trades and properly position and secure them in their intended location. Openings other than those, which are facilitated by sleeves, shall be properly formed and positioned as required by the other trades.

E. Do not place concrete in forms until all foreign matter has been removed from forms and the reinforcing steel is in proper condition for placement of concrete.

F. Remove hardened, or partially hardened, concrete on forms or reinforcement before placing concrete.

3.10 PLACING

A. Deposit concrete as close as practicable in its final position to avoid segregation due to rehandling or flowing. Do not deposit concrete on work that has partially

hardened or been contaminated by foreign material, and do not use retempered concrete. In no case shall concrete be cast when the elapsed time after initial addition of water and cement to batch exceeds 90 minutes, unless approved by the REMEDIAL DESIGNER.

B. Concrete shall be placed to avoid the displacement of reinforcing, and coating or spattering of the reinforcing steel. The placing of concrete within forms shall be regulated so that the pressure within the forms does not exceed design pressures. In placing concrete, each layer shall be placed following the preceding layer to prevent lines of separation or "cold joints". After the concrete reaches its initial set, jarring the formwork or placing strain or vibration on the ends of projecting reinforcing bars shall be carefully avoided.

C. Concrete shall not be dropped more than four feet. For greater distances of drop, concrete shall be handled with metal chutes or tremie pipes. Greater drops shall be permitted only if approved by the REMEDIAL DESIGNER.

D. Once concreting has started, it shall be carried on as a continuous operation until placing of concrete between construction joints is completed. The top surface shall be finished to the required alignment.

E. Concrete shall be placed in layers not over 12-inches deep and each layer shall be compacted with the aid of mechanical internal-vibrating equipment supplemented by hand spading. Vibrators shall in no case be used to transport concrete. Use of form vibrators will not be permitted. Internal vibrators shall maintain a speed of not less than 5,000 impulses per minute when submerged in the concrete. At least one spare vibrator shall be maintained as a relief. Duration of vibrator use shall be limited to that necessary to produce satisfactory consolidation without causing objectionable segregation. Vibrator shall not be lowered into courses that have begun to set. Apply vibrator at uniformly spaced points not further apart than the visible effectiveness of the machine.

F. Type and use of vibrators shall be in accordance with ACI 301.

3.11 PROTECTION

A. Protect freshly placed concrete from damage or injury due to water, falling objects, persons or anything that may mar or injure finish surface on concrete. Only light use of the floor shall be permitted for the first seven (7) days after placing of concrete.

3.12 FINISHING

A. Formed Surfaces: Formed surfaces shall be finished and/or patched after curing in accordance with Articles 3.15 and 3.14, respectively, of this Section.

B. Broom Finish: Broom finish shall be applied to all exterior sidewalks, walkways, working pads, platforms and all steps and landings both interior or exterior.

1. Concrete shall be placed, consolidated, struck-off and leveled to the proper elevation. After the surface has stiffened sufficiently to permit the operation and the water sheen has disappeared, the surface shall be

wood floated, by hand or power float, at least twice, to a uniform sandy texture. Floors shall be leveled such that depressions between high spots do not exceed 1/4-inch under a 10 foot straightedge except where drains occur, in which case the floors shall be pitched to the drains as indicated on the Contract Drawings.

2. After the concrete has received a float finish, it shall be broomed with a flexible bristle broom or burlap belt drawn across the surface. Surface must be hardened sufficiently to retain the scoring or ridges. Scores or ridges shall be transverse to traffic or at right angles to the slope of the slab.

3.13 CURING

A. All Slabs. After placement and finishing, concrete shall be maintained in a moist condition for at least seven successive days during which the temperature of the concrete is 50 degrees F or above. For temperatures of 50 degrees F and below, curing period shall be 14 successive days.

1. Concrete shall be kept moist by any one, or combination, of the following methods:
   a. Ponding or Immersion: Continually immerse the concrete in water throughout the curing period. Water shall not be more than 20 degrees F less than the temperature of the concrete.
   b. Fog Spraying or Sprinkling: Provide uniform and continuous application of water throughout the curing period.
   c. Pervious Sheeting: Completely cover surface and edges of the concrete with two thicknesses of wet sheeting. Overlap sheeting 6-inches over adjacent sheeting. Sheeting shall be at least as long as the width of the surface to be cured. During application, do not drag the sheeting over the finished concrete nor over sheeting already placed. Wet sheeting thoroughly and keep continuously wet throughout the curing period.
   d. Impervious Sheeting: Wet the entire exposed surface of the concrete thoroughly with a fine spray of water and cover with impervious sheeting throughout the curing period. Lay sheeting directly on the concrete surface and overlap edges 12-inches minimum. Provide sheeting not less than 18-inches wider than the concrete surface to be cured. Secure edges and transverse laps to form closed joints. Repair torn or damaged sheeting or provide new sheeting. Inspect surface of concrete daily for wetness. The surface shall be kept continuously wet during the curing period.

B. All Other Concrete: After placement, concrete shall be maintained in a moist condition for the same periods as specified above.

1. Concrete in Formed Surfaces (Slabs, Beams, Columns and Building Walls, if applicable): Keep forms and exposed surfaces wet with water during the curing period. If forms are removed before the end of the

curing period, apply a curing compound within one hour after form removal.

3.14 PATCHING

A. Any concrete, which is not formed as required, or for any reason is out of alignment or level or shows a defective surface, or shows defects which reduce the structural adequacy of a member or members, as determined by the REMEDIAL DESIGNER and/or QUALITY ASSURANCE OFFICIAL, shall be considered as not conforming with these Specifications and shall be removed from the Project by the CONTRACTOR at the CONTRACTOR's sole expense, unless the REMEDIAL DESIGNER grants permission to patch the defective area. Permission to patch any such area shall not be considered a waiver of the QUALITY ASSURANCE OFFICIAL's right to require complete removal of the defective work if the patching does not, in the opinion of the QUALITY ASSURANCE OFFICIAL, satisfactorily restore the quality and appearance of the surface or the structural adequacy of the member or members.

B. After removing the forms, all concrete surfaces shall be inspected and any joints, voids, stone pockets or defective areas permitted by the QUALITY ASSURANCE OFFICIAL to be patched and all tie holes, shall be patched. Defective areas shall be chipped away to a depth not less than 1 inch with the edges perpendicular to the surface. Remove defective areas to sound concrete with clean, square cuts. Dampen concrete surfaces to be in contact with patching concrete and apply the specified bonding compound. Place patching concrete over the bonding compound as specified by the MANUFACTURER. Place, compact and finish to blend with adjacent finished concrete. Cure in the same manner as adjacent concrete. Surfaces prepared for patching shall be approved by the QUALITY ASSURANCE OFFICIAL prior to the application of the patching mix.

C. Patching concrete mix (or mortar) shall be subject to the approval of the QUALITY ASSURANCE OFFICIAL. The patching concrete shall be compacted into place and screened off so as to leave the patch higher than the surrounding surface. It shall then be left undisturbed for a period of one to two hours to permit initial shrinkage before being finished. The patch shall be finished to match the adjoining surface. All patches shall be cured as specified for the original concrete.

D. Tie holes left by withdrawal of rods or the holes left by removal of ends of wall ties shall be filled solid with mortar after first being wetted. For holes passing through the wall, a plunger-type grout gun shall be used to force the mortar through the wall starting at the back face. A piece of burlap or canvas shall be held over the hole on the outside and when the hole is filled, the excess mortar shall be struck off with the cloth flush with the surface. Holes not passing through the walls shall be filled using a small tool that will permit packing the hole solid with mortar. Any excess mortar at the surface of the wall shall be struck off flush with a cloth.

3.15 FINISHES ON FORMED SURFACES

Upon completion of patching, surfaces of concrete shall be finished as follows:

A. Common finish shall be produced by filling all tie holes, honeycomb and depressions, and knocking off and evening up burrs and form marks.

B. A rough finish shall be produced by filling all tie holes and honeycomb and in other respects leaving the surface as formed. All concrete surfaces which will be covered by earth or otherwise obstructed from view in the completed structure shall receive a rough finish.

3.16 TESTING LABORATORY

A. The testing laboratory shall be paid by the CONTRACTOR. The laboratory shall have access to all places where concrete materials and concretes are manufactured, stored, proportioned, mixed, placed and tested. Duties shall include, but not necessarily be limited to, the following:

1. Make, store, transport, cure and test compression specimens made during placing of concrete. Slump testing, air entrainment testing, and compression test specimens shall be tested in accordance with ASTM C39. Test reports shall show all pertinent data, such as class of concrete, exact location of pour, air temperature, date of pour, time of pour, truck number for ready-mixed concrete, date on which specimen was broken, age of specimen, compressive strength of specimen, slump test results, and air content of pour from which the specimen was made. One copy each of all tests shall be sent to the CONTRACTOR and copies of each to the QUALITY ASSURANCE OFFICIAL and REMEDIAL DESIGNER.

2. Collect four standard test cylinders from each 10 cubic yards of concrete delivered to the job Site, or once per truck, whichever is less. Two of these cylinders shall be designated for the 28-day test and shall comprise a test under the definition of these Specifications. One cylinder will be broken at seven days and will be used as an aid in determining the early strength of the concrete and the 28-day strength, and one cylinder retained in reserve for later testing if required.

3. Perform slump and air entrainment testing once per every ten (10) cubic yards of concrete delivered to the job Site, or once per truck, whichever is less.

4. Periodically inspect the batching plant and file a report with the QUALITY ASSURANCE OFFICIAL stating whether the MANUFACTURER's equipment and methods meet the requirements of these Specifications.

B. Temperature and Placing Record: Temperature record shall be made each day during the concreting operations. Records shall also include location, quantity and starting and finishing time of placement for all concrete work. Copy distribution shall be as specified above for test reports.

3.17 EVALUATION OF COMPRESSION TESTS

A. Evaluation of compression test results shall be as follows:

1. For each class of concrete, compressive-strength tests for laboratory-cured cylinders shall be considered satisfactory if the averages of the results of all sets of three consecutive compressive-strength tests equal or exceed the 28-day design compressive-strength specified; and, no individual cylinder strength test falls below the required compressive strength by more than 500 psi. Strength tests of specimens cured under field conditions may be required by the QUALITY ASSURANCE OFFICIAL to check the adequacy of curing and protecting of the concrete placed. Specimens shall be molded by the field quality-control laboratory at the same time and from the same batch as the laboratory-cured specimens.

B. Faulty Concrete: Failure to meet any of the specified conditions constitutes faulty concrete. Unless otherwise directed by the QUALITY ASSURANCE OFFICIAL, faulty concrete shall be removed and replaced with concrete as specified, at no expense to the GROUP.

C. Additional Testing: If permitted by the REMEDIAL DESIGNER, additional testing shall be subject to the approval of REMEDIAL DESIGNER at no expense to the GROUP. Load testing, if permitted by the REMEDIAL DESIGNER, shall be conducted in accordance with the loading criteria as required by the design of the structure, as determined by the REMEDIAL DESIGNER.

D. Neither the results of laboratory verification tests nor any provision in the Contract Documents shall relieve the CONTRACTOR of the obligation to furnish concrete of the class and strength specified.

*****END OF SECTION*****

APPENDIX F

LANDFILL GRADING PLAN SUPPORT CALCULATIONS

APPENDIX F-1

SLOPE STABILITY ANALYSES

OBJECTIVE:

This analysis is to evaluate the global slope stability based on final grading plan of PJP landfill mass at three chosen cross-sections, A-A' from RV SALVAGE, B-B' from JUNKYARD, and C-C' from TRUCKSTOP.

METHOD:

Analytical software SLOPE/W was used for the slope stability analysis (Reference 1). The Spencer Method, which was used in the analysis, is a limit equilibrium method that must satisfy both force and moment equilibrium. In contrast, Janbu's and Bishop's Simplified Methods are able to only satisfy either force or moment equilibrium.

Both translational (three-part wedge failure surface) and rotational (circular failure surface) failure modes were evaluated. The fill materials above the capping liner were assumed to be either light fill (γ=100 pcf) or heavy fill (γ=130 pcf); and final cap slope will be 6%.

Three cross-sections, Section A-A' from RV SALVAGE, B-B' from JUNKYARD, and C-C' from TRUCKSTOP, were analyzed. Reference 2 shows the locations of the cross-sections. Interpreted subsurface conditions at the cross-sections were based upon previous site investigations (References 3 & 4).

REFERENCES:

1. "SLOPE/W," Version 4.23, GEO-SLOPE International Ltd., 1999.
2. "Drawing 2 – Conceptual Grading Plan/Site Plan" 30% Remedial Design, PJP Landfill, Golder Associates, September 2001.
3. "Soils and Foundation Investigation Report", PJP Landfill, Joseph S. Ward Inc. 1976
4. "Geotechnical Engineering Design Parameters", Secaucus Interchange Project, Golder Associates Inc., May 2001
5. "Soil Mechanics in Engineering Practice," Terzaghi, K., Peck, R.B., and Mesri, G., 1996.
6. "Stability Analysis of a Municipal Solid Waste Landfill", Howland, J.D. and Landva, A.O., ASCE Geotechnical Special Publication No. 31, 1992.
7. "Mechanical Properties of Waste Materials," Jessberger, H.L. and Kockel, R., 1991.
8. "Geotechnical Properties of Municipal Solid Wastes and their Use in Landfill Design," J. Fassett, et al., 1994.
9. "Final Covers for Solid Waste Landfills and Abandoned Dumps," R. Koerner and D. Daniel, 1997.
10. "Stability of Lined Slopes at Landfills and Surface Impoundments," D. H. Mitchell, M. A. McLean and T. E. Gates, EPA 600/2-89/057.
11. "Foundations & Earth Structures," NAVFAC Design Manual 7.02, 1986.

ASSUMPTIONS:

1. The representative slope configurations are presented on the attached cross-sections as developed from interpretation of References 1, 2 and 3.
2. The subsurface stratigraphy is as depicted on the attached figures and is based upon data from previous site investigations.
3. Adopted strength parameters for each encountered stratum are depicted on the cross sections and shown below in Table 1. Soil properties are based on soil information collected during a geotechnical investigation performed at or near the site (Ref 3 and 4.), and a literature survey concerning geotechnical properties of waste material.
4. The landfill cap was modeled by treating the cap as part of the grading layer.
5. Groundwater is mounded at approximately EL+5 within the landfill.
6. Based on 2002 USGS seismic hazard probability map, the peak ground acceleration (PGA) on the site location (400 Sip Avenue, Jersey City, Hudson County, NJ) is approximately 0.25g considering 2% probability of exceedance in 50 years. A horizontal seismic coefficient, k_h, is found to be 0.125 using the Hynes-Griffin and Franklin method (k_h=0.5PGA/g).

DISCUSSION:

Grading Fill

The actual soil parameters are unknown and the unit weight of the soil could vary greatly. As a result, the analysis was run using the expected maximum (130 pcf) and minimum (100 pcf) values for the unit weight.

Waste Material

In general, the geotechnical properties of waste materials are not easily evaluated and have been found to vary greatly. Golder's review of the published literature regarding the geotechnical properties of waste material provided the basis for stability analyses modeling two strength ranges for the waste fill. Howland and Landva (Reference 6) indicate that cohesion of 200 psf, and an angle of internal friction equal to 23°, represents a lower bound of back-calculated shear strength parameters for landfill waste based upon multiple case studies.

Research by Jessberger and Kockel (Reference 7) offers evidence of agreement regarding an assigned cohesion of 200 psf. However, they found that an angle of internal friction of 32° may be typically more appropriate for landfill stability analyses. Therefore, Golder adopted the Jessberger and Kockel shear strength parameters to examine the variation in calculated factors of safety related to reasonable variations in assumed waste strengths.

Table 1. Adopted Soil Parameters Used in Slope Stability Analysis

Soil Stratum	Unit Weight (pcf)	Friction Angle (°)	Cohesion (psf)
Rip-Rap	145	0	0
Grading Fill (Light)	100	28	0
Grading Fill (Heavy)	130	28	0
Waste	85	32	200
Peat	80	0	200
Sand	125	30	0
Varved Clay	115	0	700
Glacial Till	120	27	100

CALCULATIONS:

Table 2 summarized the calculated factors of safety (FOS) as below. The output figures created by SLOPE/W on all three cross-sections can be found in Attachment D.

Table 2. Summary of FOS Calculated by SLOPE/W Assuming 6% Cap Slope

Grading Material	Cross section	Non-Seismic		Horizontal Seismic Coefficient = 0.125	
		Circular Failure	Wedge Failure	Circular Failure	Wedge Failure
Light Fill	A-A'	1.533	1.347	0.958	0.648
	B-B'	2.028	1.858	1.062	0.641
	C-C'	1.555	1.564	0.963	0.719
Heavy Fill	A-A'	1.548	1.327	0.958	0.639
	B-B'	1.962	1.816	1.045	0.63
	C-C'	1.519	1.517	0.95	0.708

CONCLUSIONS:

Given the methods and assumptions stated herein, under non-seismic loading condition, the FOS at Cross sections B-B', and C-C', are larger than 1.5 under both light and heavy cap fill materials. However, for Cross section A-A', FOS are 1.3 for three-part wedge failure mode. This should be addressed so that a FOS above 1.5 can be achieved. The obvious approach is to cut short the 3:1 slope or change it to a flatter slope. All the analysis under seismic loading show the FOS far below 1, which indicates that the site is possibly unable to withstand an earthquake of PGA=0.25g. Further permanent deformation analysis is required to assess the stability under seismic loading.

ATTACHMENTS

Attachment A:
USGS Seismic Hazardous Probability Map

Attachment B:
References

Attachment C:
Cross-section Location

Attachment D:
SLOPE/W Outputs on Cross Section A-A', B-B, and C-C'

Attachment A:

USGS Seismic Hazardous Probability Map

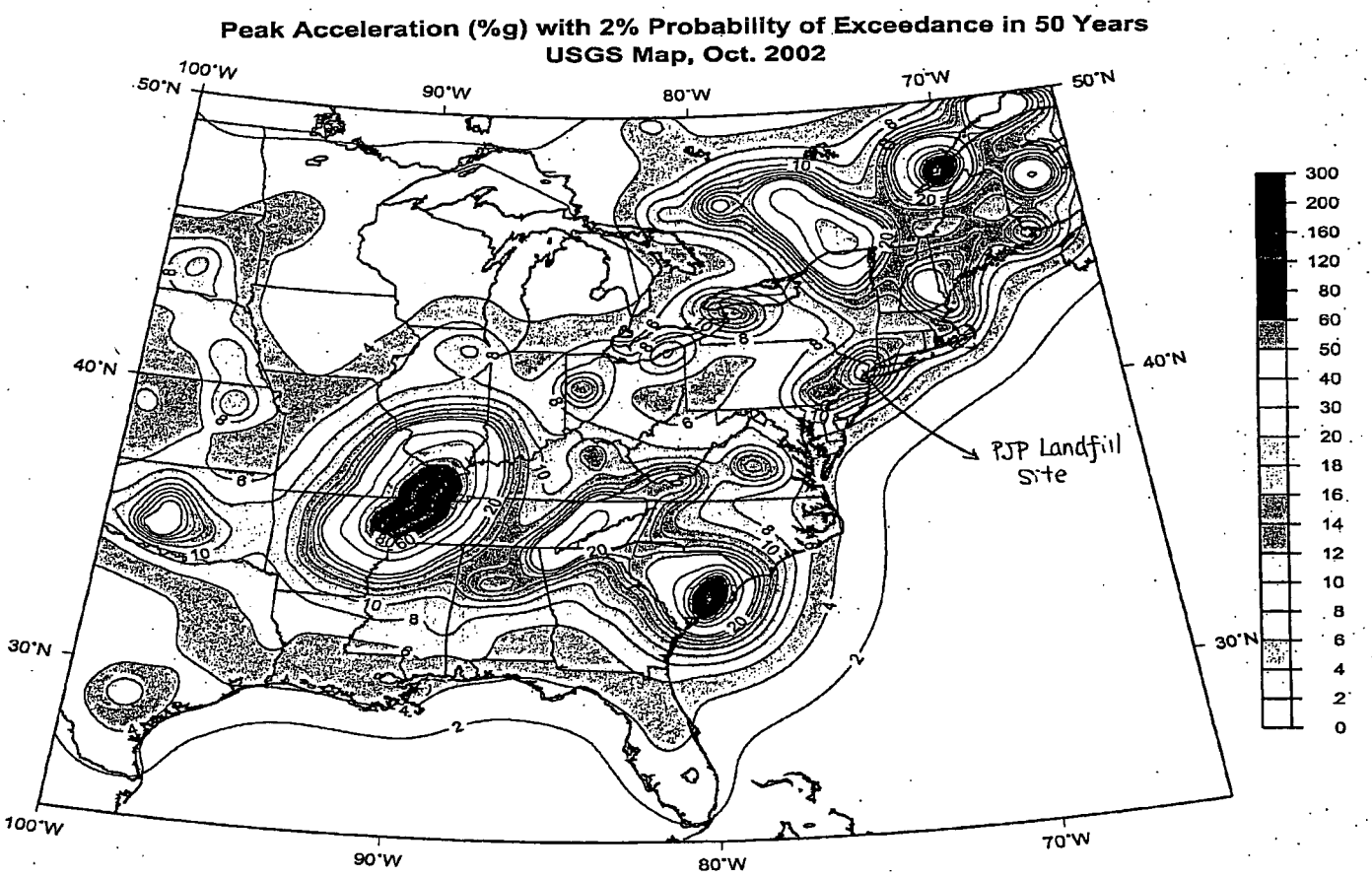


Figure A USGS Seismic Hazardous Probability Map (2002)

Attachment B:

References

Resisting moment:

Section	Length (ft)	c (lb/ft^2)	Force (kips)	Moment Arm (ft)	Moment (kip-ft/ft)
A	11.5	600	6.9	78	538.2
B	129.3	1000	129.3	78	10,085.4
					10,623.6

Factor of safety:

$$\text{Static FS} = \frac{\text{resisting moment}}{\text{static overturning moment}} = \frac{10{,}623.6}{5925.5} = 1.79$$

$$\text{Pseudostatic FS} = \frac{\text{resisting moment}}{\text{static + pseudostatic overturning moments}}$$

$$= \frac{10{,}623.6}{8281.1} = 1.28$$

Selection of Pseudostatic Coefficient. The results of pseudostatic analyses are critically dependent on the value of the seismic coefficient, k_h. Selection of an appropriate pseudostatic coefficient is the most important, and most difficult, aspect of a pseudostatic stability analysis. The seismic coefficient controls the pseudostatic force on the failure mass, so its value should be related to some measure of the amplitude of the inertial force induced in the potentially unstable material. If the slope material was rigid, the inertial force induced on a potential slide would be equal to the product of the actual horizontal acceleration and the mass of the unstable material. This inertial force would reach its maximum value when the horizontal acceleration reached its maximum value. In recognition of the fact that actual slopes are not rigid and that the peak acceleration exists for only a very short time, the pseudostatic coefficients used in practice generally correspond to acceleration values well below a_{max}. Terzaghi (1950) originally suggested the use of $k_h = 0.1$ for "severe" earthquakes (Rossi-Forel IX), $k_h = 0.2$ for "violent, destructive" earthquakes (Rossi-Forel X), and $k_h = 0.5$ for "catastrophic" earthquakes. Seed (1979) listed pseudostatic design criteria for 14 dams in 10 seismically active countries; 12 required minimum factors of safety of 1.0 to 1.5 with pseudostatic coefficients of 0.10 to 0.12. Marcuson (1981) suggested that appropriate pseudostatic coefficients for dams should correspond to one-third to one-half of the maximum acceleration, including amplification or deamplification effects, to which the dam is subjected. Using shear beam models, Seed and Martin (1966) and Dakoulas and Gazetas (1986) showed that the inertial force on a potentially unstable slope in an earth dam depends on the response of the dam and that the average seismic coefficient for a deep failure surface is substantially smaller than that of a failure surface that does not extend far below the crest. Seed (1979) also indicated that deformations of earth dams constructed of ductile soils (defined as those that do not generate high pore pressures or show more than 15% strength loss upon cyclic loading) with crest accelerations less than $0.75g$ would be acceptably small for pseudostatic factors of safety of at least 1.15 with $k_h = 0.10$ ($M = 6.5$) to $k_h = 0.15$ ($M = 8.25$). This criteria would allow the use of pseudostatic accelerations as small as 13 to 20% of the peak crest acceleration. Hynes-Griffin and Franklin (1984) applied the Newmark sliding block analysis described in the following section to over 350 accelerograms and concluded that earth dams with pseudostatic factors of safety greater than 1.0 using $k_h = 0.5a_{max}/g$ would not develop "dangerously large" deformations.

As the preceding discussion indicates, there are no hard and fast rules for selection of a pseudostatic coefficient for design. It seems clear, however, that the pseudostatic coefficient should be based on the actual anticipated level of acceleration in the failure mass (including any amplification or deamplification effects) and that it should correspond to some fraction of the anticipated peak acceleration. Although engineering judgment is required for all cases, the criteria of Hynes-Griffin and Franklin (1984) should be appropriate for most slopes.

Limitations of the Pseudostatic Approach. Representation of the complex, transient, dynamic effects of earthquake shaking by a single constant unidirectional pseudostatic acceleration is obviously quite crude. Even in its infancy, the limitations of the pseudostatic approach were clearly recognized. Terzaghi (1950) stated that "the concept it conveys of earthquake effects on slopes is very inaccurate, to say the least," and that a slope could be unstable even if the computed pseudostatic factor of safety was greater than 1. Detailed analyses of historical and recent earthquake-induced landslides (e.g., Seed et al., 1969, 1975; Marcuson et al., 1979) have illustrated significant shortcomings of the pseudostatic approach. Experience has clearly shown, for example, that pseudostatic analyses can be unreliable for soils that build up large pore pressures or show more than about 15% degradation of strength due to earthquake shaking. As illustrated in Table 10-4, pseudostatic analyses produced factors of safety well above 1 for a number of dams that later failed during earthquakes. These cases illustrate the inability of the pseudostatic method to reliably evaluate the stability of slopes susceptible to weakening instability. Nevertheless, the pseudostatic approach can provide at least a crude index of relative, if not absolute, stability.

Discussion. The pseudostatic approach has a number of attractive features. The analysis is relatively simple and straightforward; indeed, its similarity to the static limit equilibrium analyses routinely conducted by geotechnical engineers makes its computations easy to understand and perform. It produces a scalar index of stability (the factor of safety) that is analogous to that produced by static stability analyses. It must always be recognized, however, that the accuracy of the pseudostatic approach is governed by the accuracy with which the simple pseudostatic inertial forces represent the complex dynamic inertial forces that actually exist in an earthquake. Difficulty in the assignment of appropriate pseudostatic coefficients and in interpretation of pseudostatic factors of safety, coupled with the development of more realistic methods of analysis, have reduced the use of the pseudostatic approach for seismic slope stability analyses. Methods based on evaluation of permanent slope deformation, such as those described in the following sections, are being used increasingly for seismic slope stability analysis.

Table 10-4 Results of Pseudostatic Analyses of Earth Dams That Failed during Earthquakes

Dam	k_h	FS	Effect of Earthquake
Sheffield Dam	0.10	1.2	Complete failure
Lower San Fernando Dam	0.15	1.3	Upstream slope failure
Upper San Fernando Dam	0.15	~2–2.5	Downstream shell, including crest slipped about 6 ft downstream
Tailings dam (Japan)	0.20	~1.3	Failure of dam with release of tailings

Source: After Seed (1979).

Table 1 - Geotechnical Engineering Design Parameters for Design Section No. 2

Classification	Stations	Thickness (feet)	Typical N-values (blows/foot)	γ_{wet}	w_n	PI	e_o	OCR	P_c	Compression Indices C_r	C_c	C_α	C_α/C_c	Compression Ratios $C_c/(1+e_o)$	$C_r/(1+e_o)$	$C_\alpha/(1+e_o)$	C_v	C_{vr}/C_v	ϕ	c	S_{uo}	S_{uf}	S_u/P_c
Construction Materials:																							
Preload Surcharge Fill				125															33	0			
Compacted Embankment Fill				125															33	0			
Hydraulic Fill				120															30	0			
Lightweight Fill				70															33	0			
Existing Conditions:																							
West of Penhorn Creek	105+00 to 115+50																						
Fill		5 to 10	2 to 89	120																			
Meadow Mat/Peat		4 to 13	WR to 2	80	800	80	11.0	1.0	200	6.00	0.72	0.42	0.070	0.50	0.06	0.035	0.40	1	0		100	450	0.25
Organic Silt/Clay		2 to 5	2 to 4	115	150	50	2.0	1.5	900	0.90	0.09	0.06	0.067	0.30	0.03	0.020	0.05	1	0		300	900	0.23
Upper Varved Clay		4 to 8	10 to 22	120	30	15	0.8	5.0	4000	0.27	0.02	0.01	0.040	0.15	0.01	0.006	0.50	2	0		1500	1500	0.19
Lower Varved Clay		9 to 19	2 to 6	115	40	25	1.1	2.5	2500	0.42	0.04	0.02	0.040	0.20	0.02	0.008	0.30	2	0		700	950	0.21
Glacial Till		9 to 28	10 to 65	120	10	5													27	100			
Toll Plaza	116+00 to 125+50																						
Fill		5 to 10	2 to 89	120																			
Meadow Mat/Peat		4 to 13	WR to 2	80	800	80	11.0	1.0	200	6.00	0.72	0.42	0.070	0.50	0.06	0.035	0.40	1	0		100	450	0.25
Organic Silt/Clay		2 to 5	2 to 4	115	150	50	2.0	1.5	900	0.90	0.09	0.06	0.067	0.30	0.03	0.020	0.05	1	0		300	900	0.23
Upper Varved Clay		4 to 8	10 to 22	120	30	15	0.8	5.0	4000	0.27	0.02	0.01	0.040	0.15	0.01	0.006	0.50	2	0		1500	1500	0.19
Lower Varved Clay		9 to 19	2 to 6	115	40	25	1.1	2.5	2500	0.42	0.04	0.02	0.040	0.20	0.02	0.008	0.30	2	0		700	950	0.21
Glacial Till		9 to 28	10 to 65	120	10	5													27	100			
Pistol Range	125+50 to 140+00																						
Fill		5 to 10	2 to 89	120																			
Meadow Mat/Peat		4 to 13	WR to 2	80	800	80	11.0	1.0	200	6.00	0.72	0.42	0.070	0.50	0.06	0.035	0.40	1	0		100	450	0.25
Organic Silt/Clay		2 to 5	2 to 4	115	150	50	2.0	1.5	900	0.90	0.09	0.06	0.067	0.30	0.03	0.020	0.05	1	0		300	900	0.23
Upper Varved Clay		4 to 8	10 to 22	120	30	15	0.8	5.0	4000	0.27	0.02	0.01	0.040	0.15	0.01	0.006	0.50	2	0		1500	1500	0.19
Lower Varved Clay		9 to 19	2 to 6	115	40	25	1.1	2.5	2500	0.42	0.04	0.02	0.040	0.20	0.02	0.008	0.30	2	0		700	950	0.21
Glacial Till		9 to 28	10 to 65	120	10	5													27	100			

Legend:
- γ_{wet} = Unit Weight, lbs/ft³ (pcf)
- w_n = Natural Water Content, %
- PI = Plasticity Index
- e_o = Initial Void Ratio
- OCR = Over-Consolidation Ratio
- P_c = Preconsolidation Pressure, lbs/ft²(psf)
- C_c = Compressibility Index
- C_r = Recompression Index
- C_α = Secondary Compression Index
- C_v = Coefficient of Consolidation, ft²/day
- C_{vr} = Coefficient of Radial (i.e., horizontal) Consolidation, ft²/day
- ϕ = Internal Friction Angle, degrees
- c = Cohesion, lbs/ft² (psf)
- S_{uo} = Existing (i.e., pre-surcharge) Mobilized Undrained Shear Strength, lbs/ft²(psf)
- S_{uf} = Final (i.e., post-surcharge) Mobilized Undrained Shear Strength, lbs/ft²(psf)
- WR = Weight of Rod
- WH = Weight of Hammer

Notes:

a) Design values shown herein are based on laboratory testing data, published literature, experiences with similar materials, generally accepted industry standards, and professional geotechnical engineering judgment.

b) "Meadow Mat" deposits are composed of highly fibrous vegetation that is non- to partially decomposed in-nature. These materials could not be sampled in the field utilizing standard undisturbed and/or disturbed soil sampling techniques. Hence, lab tests could not be performed on said materials.

c) "Meadow Mat" deposits consist of vegetative matter within an open, saturated matrix, and its physical properties are different from soil materials (i.e. peats, organic silts/clays, varved clays, etc...). Therefore, "Meadow Mat" materials should not be mis-construed to be a soil.

d) To conform with HNTB's suggestion, a combined "Meadow Mat/Peat" deposit will be considered and utilized during requisite geotechnical engineering analyses performed for this project.

e) Intuitively, water content and compressibility parameters of "Meadow Mat" deposits will be greater than those of "Peat" deposits. Therefore, average design parameters for a combined "Meadow Mat/Peat" deposit can be extrapolated based on test data collected from peat samples.

f) C_c and C_r values vary with load, and values shown herein are based on a loading of 2 tsf.

g) S_{uf} values represent maximum strength limits, and were established assuming that proposed embankments will be surcharged. Values represent anticipated strength increases resulting from a roadway embankment height of 15 feet with an applied preload surcharge height of 10 feet.

h) S_{uf} values will only be applied to foundation strata subjected to preload surcharging. Limits of strength gain, due to surcharging, are defined by a 2:1 (V:H) plane projecting from the toe of wall or embankment.

i) Proposed roadway and preload embankments will be built utilizing staged construction techniques, and strength values will increase from S_{uo} to S_{uf} as fill stages progress to account for strength gains due to consolidation of foundation materials.

j) Hydraulic fill constitutes select, granular materials placed beneath water surfaces.

k) Fill and Meadow Mat materials do not typically co-exist together. In general, Meadow Mat material cover approximately 90%, 75% and 10% of the areas West of Penhorn Creek, Toll Plaza and Pistol Range.

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(8) *Compression Index and Water Content*

Variations in the numerous factors which influence the consolidation characteristics of peat (see Section 4.4(5)) lead to some scatter of data in Figure 4.18. The relation between the compression index (C_c) and water content varies between $C_c = 0.0075\,w$ and $C_c = 0.011\,w$, with the average being about $C_c = 0.01\,w$.

(9) *Compression Index and Void Ratio*

The observed relation between void ratio and consolidation properties is shown in Figures 4.19 and 4.20. These relations can be used for preliminary estimates in those areas represented by the references cited, but it is evident that the relation is somewhat different for the different localities. It is suggested (Cook 1967) that in any area at least two or three laboratory tests be carried out to establish the general relation.

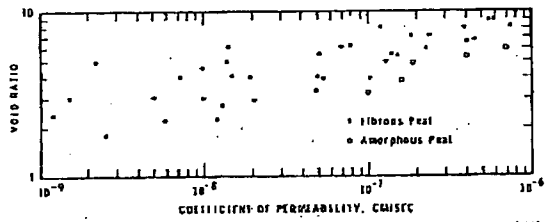

FIGURE 4.16 Void ratio (e) vs. coefficient of permeability (k) (after Lea and Brawner 1963)

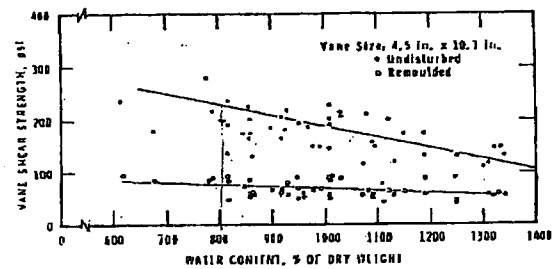

FIGURE 4.17 Shear strength vs. water content (after Anderson and Hemstock 1959)

It is evident that some relation should exist between the compression index (C_c) and void ratio. Figure 4.19 indicates a range for the various locations between $C_c = 0.45\,e$ and $C_c = 0.75\,e$.

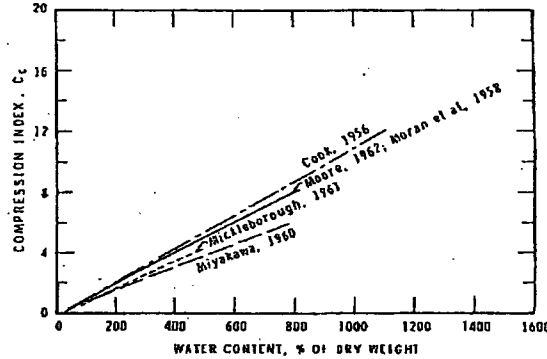

FIGURE 4.18 Compression index (C_c) vs. water content

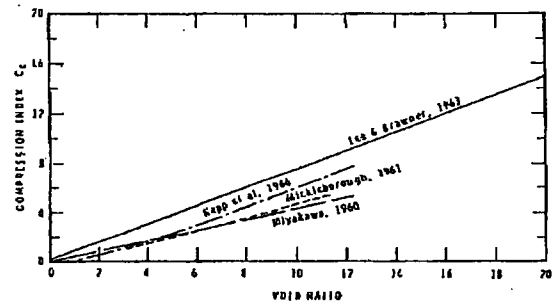

FIGURE 4.19 Compressions index (C_c) vs. void ratio

$$N'_{60} = 0.68 \times 20 \times 1.00 \times 1.0 \times 0.80 \times 1.05 = \underline{11}$$

$$N'_{70} = \frac{60}{70} \times 11 = \underline{9}$$

////

Example 3-4

Same as Example 3-2 but $E_r = 55$; $p'_o = 100$ kPa; 205 mm hollow stem auger; hole depth = 6 m

$$C_N = \left(\frac{95.76}{100}\right)^{1/2} = 0.98$$

$$\eta_1 = \frac{55}{70} = 0.79 \qquad \eta_2 = 0.95 \quad 6 < 10\,\text{m}$$

$$\eta_3 = 1.0 \quad \text{no liner} \qquad \eta_4 = 1 \quad \text{using hollow stem auger}$$

$$N'_{70} = 0.98 \times 20 \times 0.79 \times 0.95 \times 1.0 \times 1.0 = \underline{15}$$

$$N'_{60} = \frac{70}{60} \times 15 = \underline{17}$$

////

3-8 SPT CORRELATIONS

The SPT has been used in correlations for unit weight, relative density D_r, angle of internal friction ϕ, and undrained compressive strength q_u. For reasons in the preceding section these will be of questionable value—particularly since many were suggested prior to extensive study of the large number of variables affecting the N values. The data shown in Table 3-4 for D_r and ϕ relate roughly to N'_{70} and for borehole depths on the order of 4 to 6 m as for spread foundations.

TABLE 3-4 Empirical values for ϕ, D_r, and unit weight of granular soils based on the SPT at about 6 m depth and normally consolidated

Description	Very loose	Loose	Medium	Dense	Very dense
Relative density D_r	0	0.15	0.35	0.65	0.85
SPT N'_{70}: fine	1–2	3–6	7–15	16–30	7
medium	2–3	4–7	8–20	21–40	>40
coarse	3–6	5–9	10–25	26–45	>45
ϕ: fine	26–28	28–30	30–34	33–38	
medium	27–28	30–32	32–36	36–42	<50
coarse	28–30	30–34	33–40	40–50	
γ_{wet}, pcf (kN/m³)	70–100† (11–16)	90–115 (14–18)	110–130 (17–20)	110–140 (17–22)	130–150 (20–23)

† Excavated soil or material dumped from a truck will weigh 11 to 14 kN/m³ and must be quite dense to weigh much over 21 kN/m³. No existing soil has a $D_r = 0.00$ nor a value of 1.00—common ranges are from 0.3 to 0.7.

Foundation Analysis and Design, J. Bowles 1982

Attachment C:

Cross-section Location

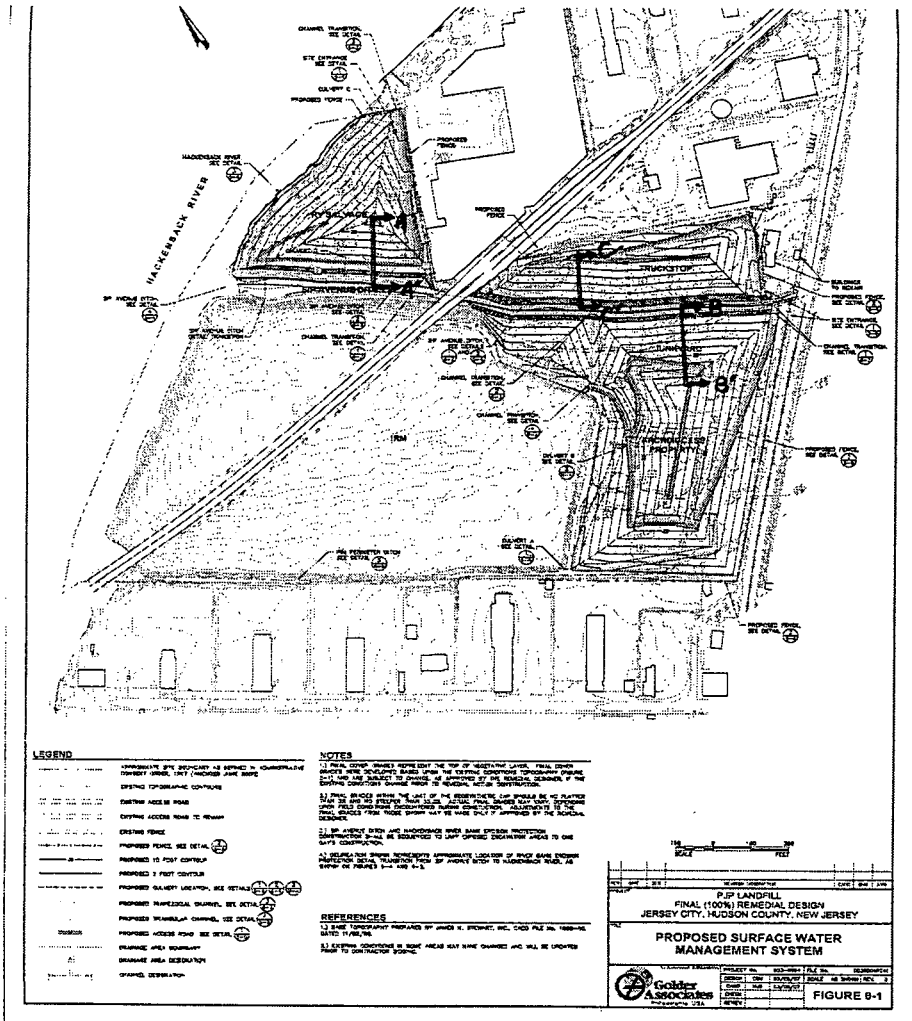

Figure C Location of Cross-section A-A', B-B', and C-C'

Attachment D:

SLOPE/W Outputs

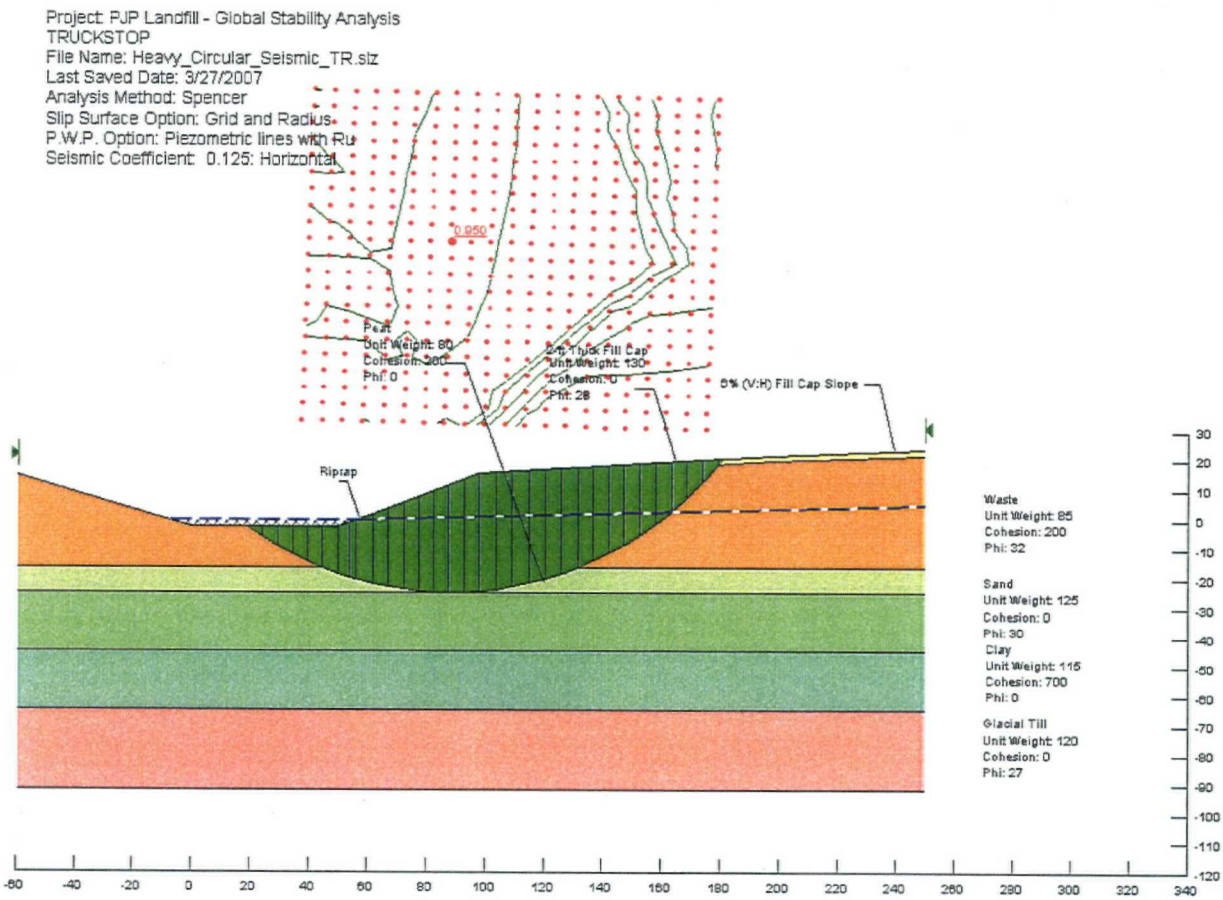

Figure D-25 Circular Failure under Seismic Load Using Heavy Fill (C-C')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 42 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
TRUCKSTOP
File Name: Heavy_Wedge_Static_TR.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: (none)

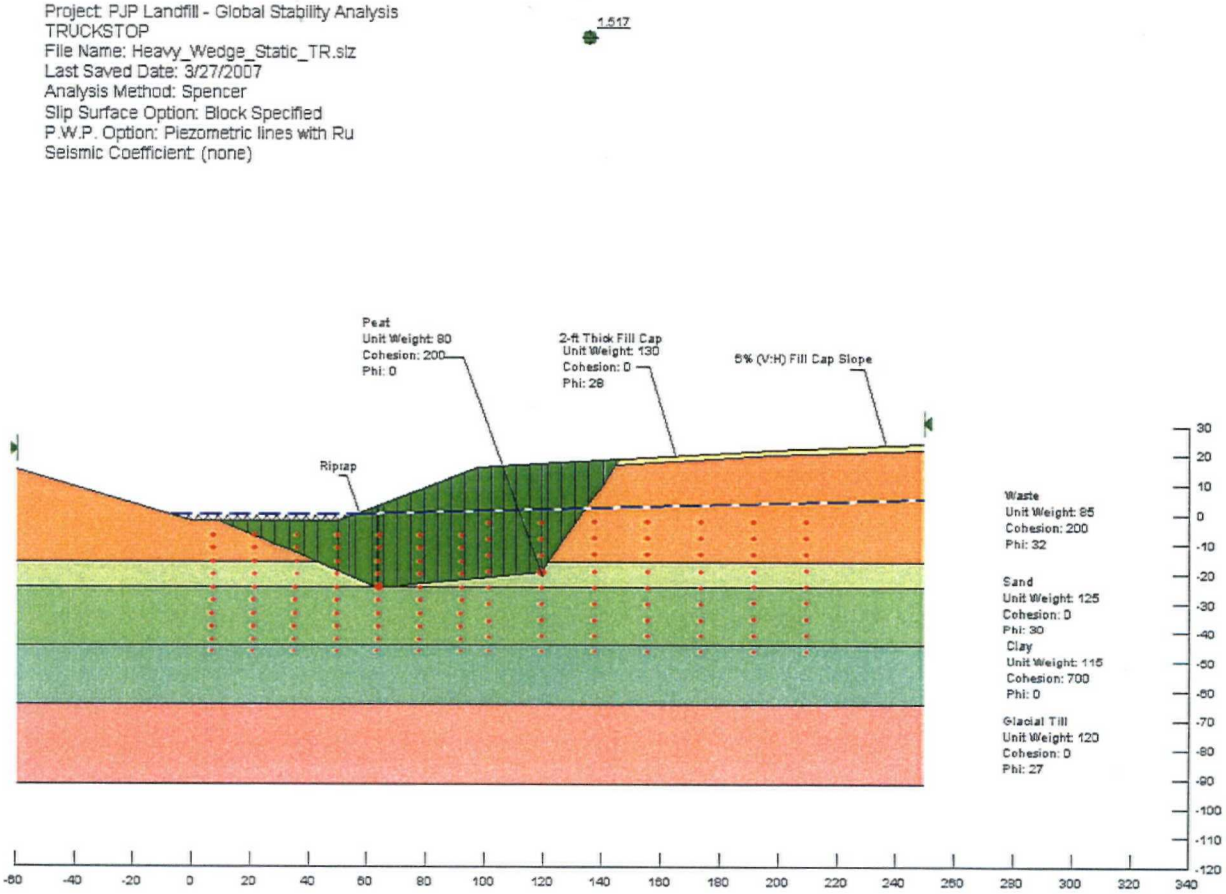

Figure D-26 Wedge Failure under Static Load Using Heavy Fill (C-C')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 43 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
TRUCKSTOP
File Name: Heavy_Wedge_Seismic_TR.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: 0.125: Horizontal

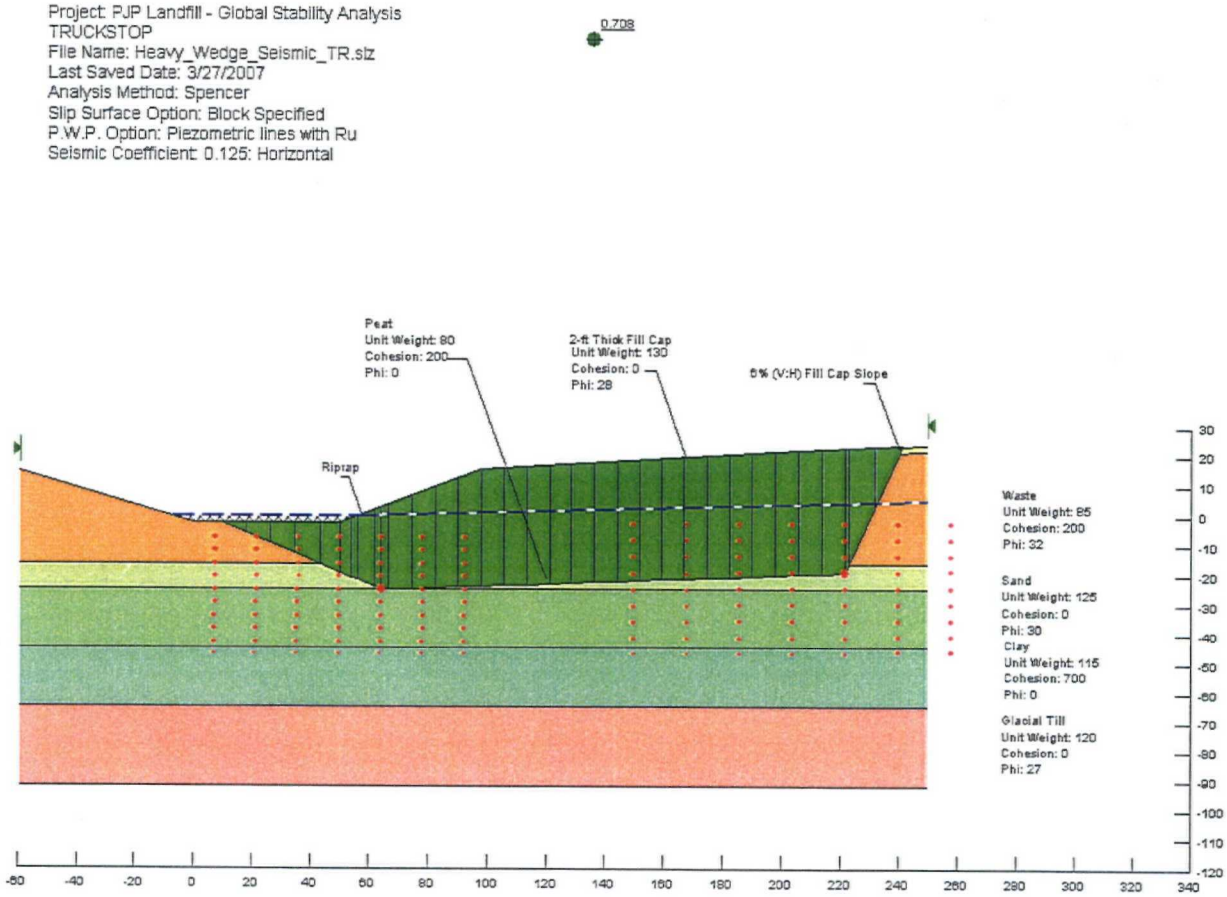

Figure D-27 Wedge Failure under Seismic Load
Using Heavy Fill (C-C')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	Made by: JZ	Date: 03/27/07
	Ref.: 100 % Design	Checked:	Sheet 17 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
Location: RV SALVAGE
Last Saved Date: 3/27/2007
Analysis Method: Spencer

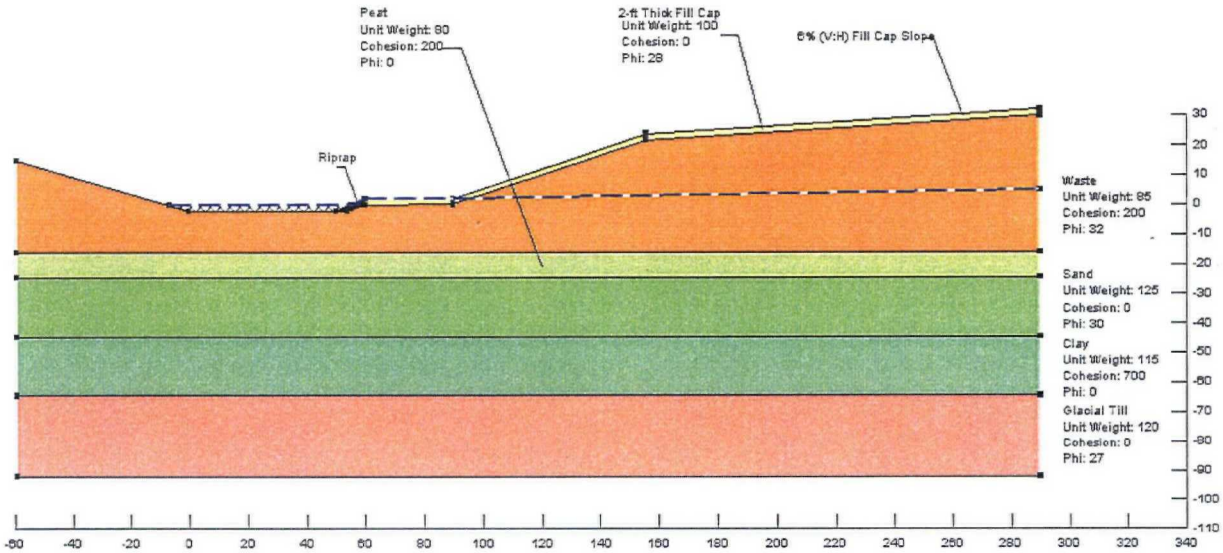

Figure D-1 Cross-section A-A'

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 18 of 43
		Reviewed:	

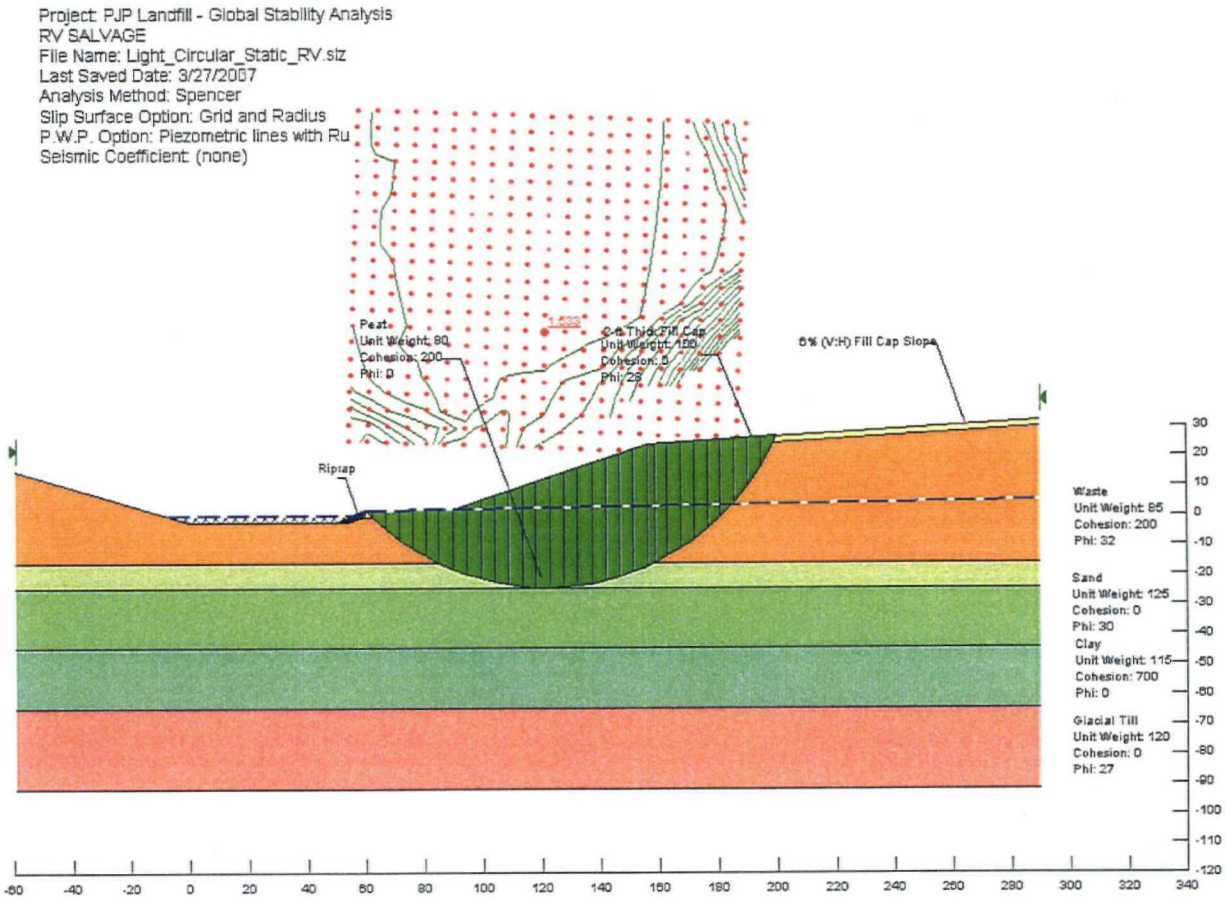

Figure D-2 Circular Failure under Static Load Using Light Fill (A-A')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	Made by: JZ	Date: 03/27/07
	Ref.: 100 % Design	Checked:	Sheet 19 of 43
		Reviewed:	

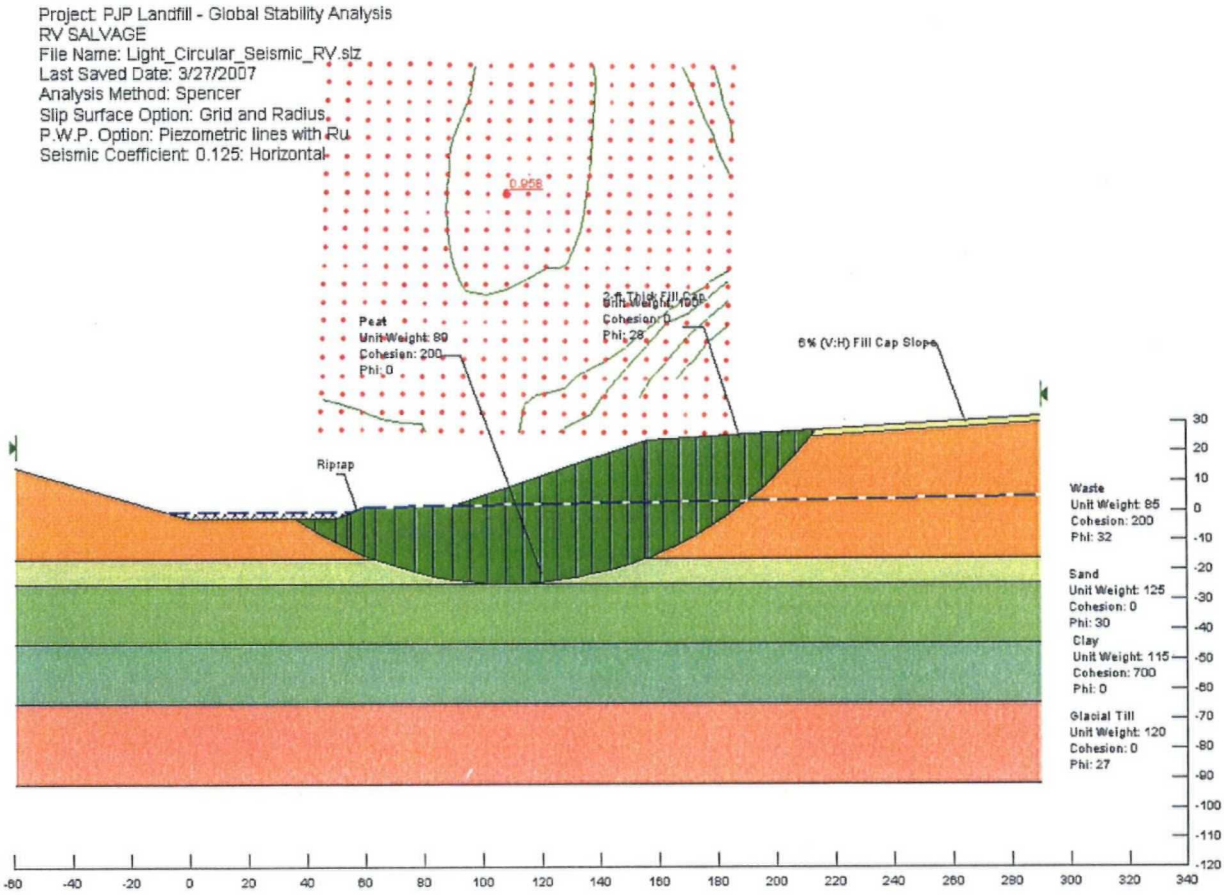

Figure D-3 Circular Failure under Seismic Load Using Light Fill (A-A')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 20 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
RV SALVAGE
File Name: Light_Wedge_Static_RV.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: (none)

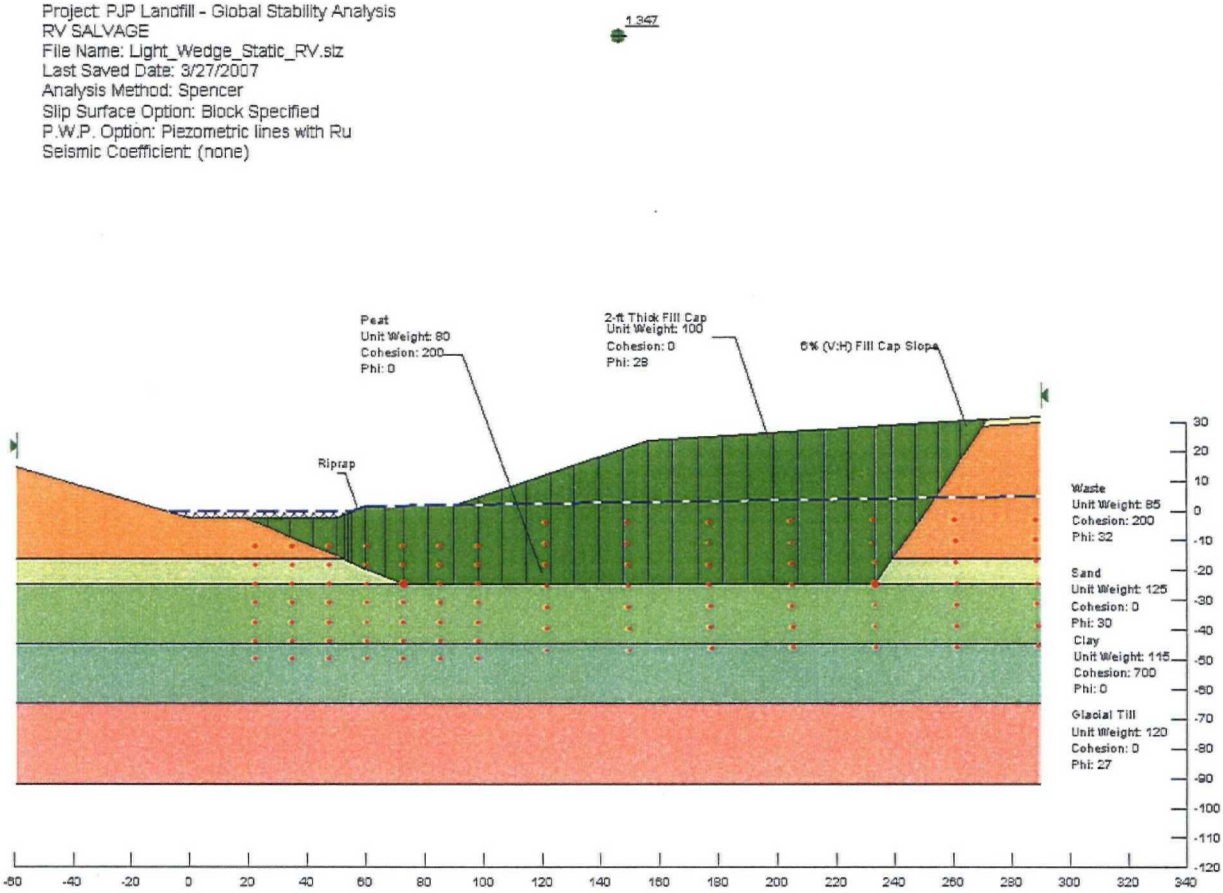

Figure D-4 Wedge Failure under Static Load Using Light Fill (A-A')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	Made by: JZ	Date: 03/27/07
	Ref.: 100 % Design	Checked:	Sheet 21 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
RV SALVAGE
File Name: Light_Wedge_Seismic_RV.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: 0.125: Horizontal

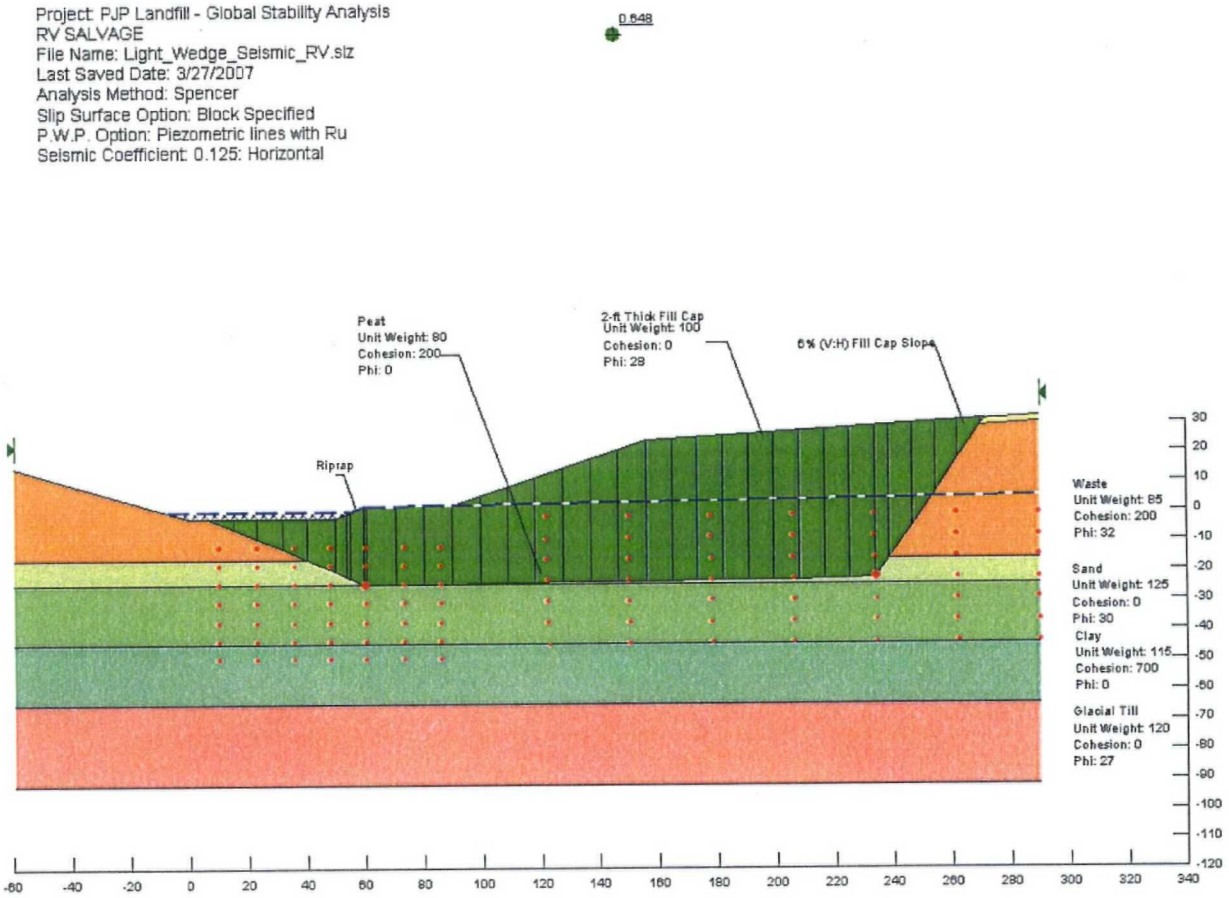

Figure D-5 Wedge Failure under Seismic Load Using Light Fill (A-A')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 22 of 43
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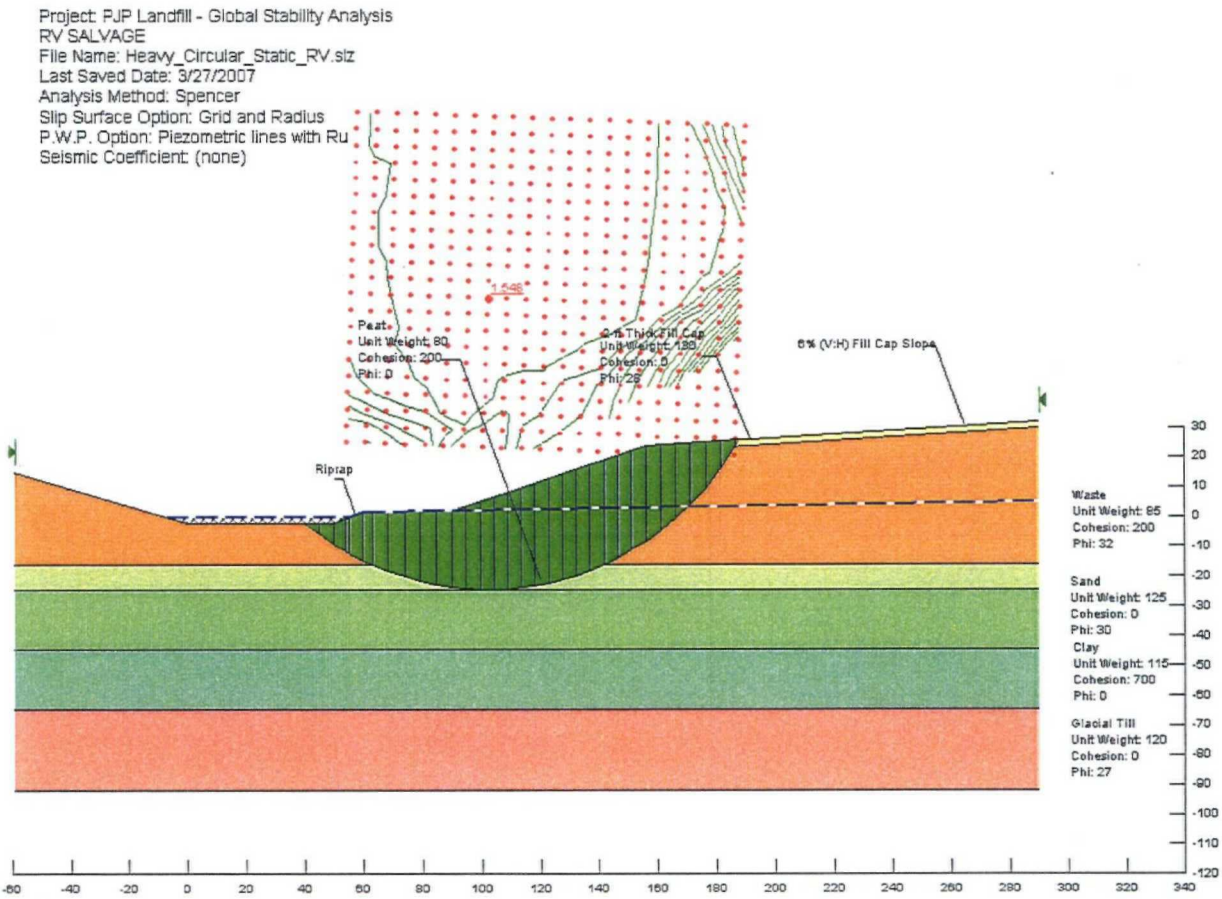

Figure D-6 Circular Failure under Static Load Using Heavy Fill (A-A')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 23 of 43
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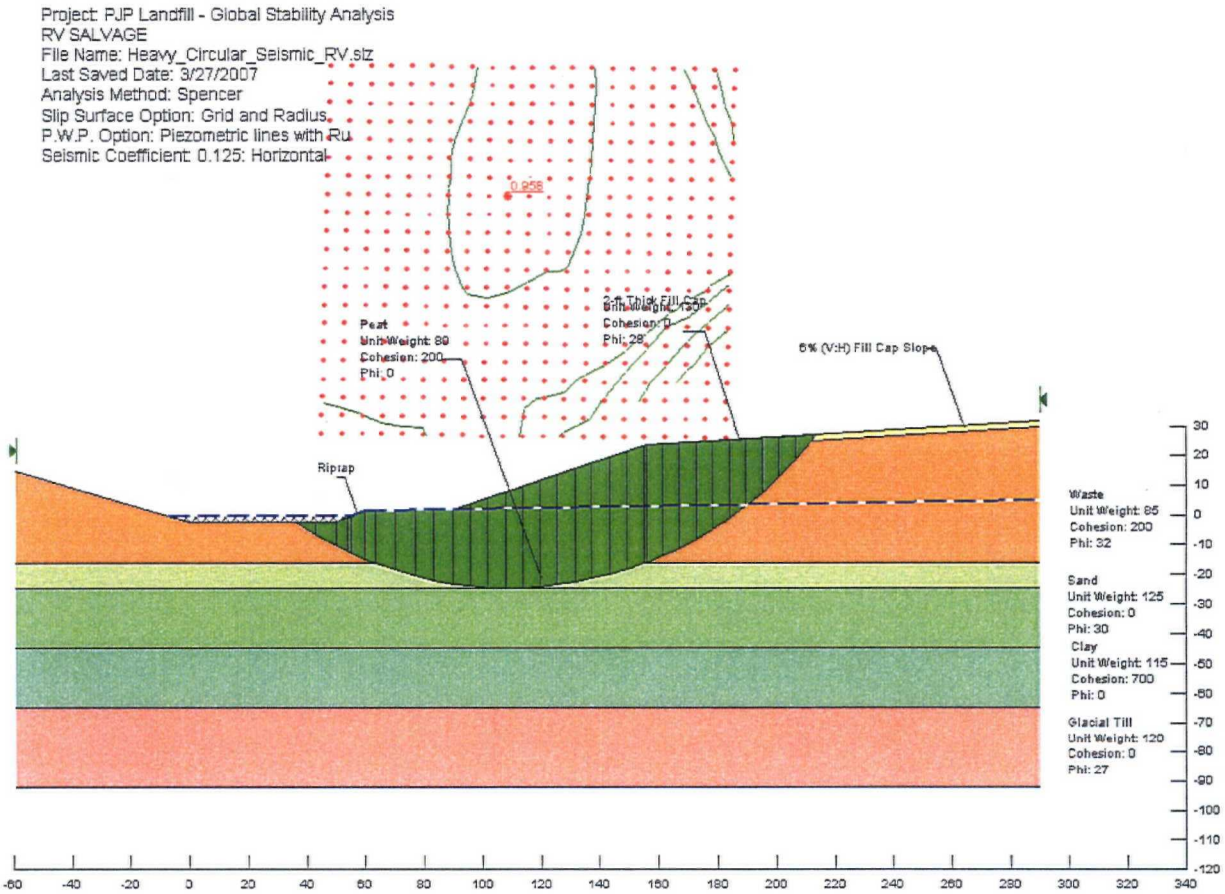

Figure D-7 Circular Failure under Seismic Load Using Heavy Fill (A-A')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 24 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
RV SALVAGE
File Name: Heavy_Wedge_Static_RV.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: (none)

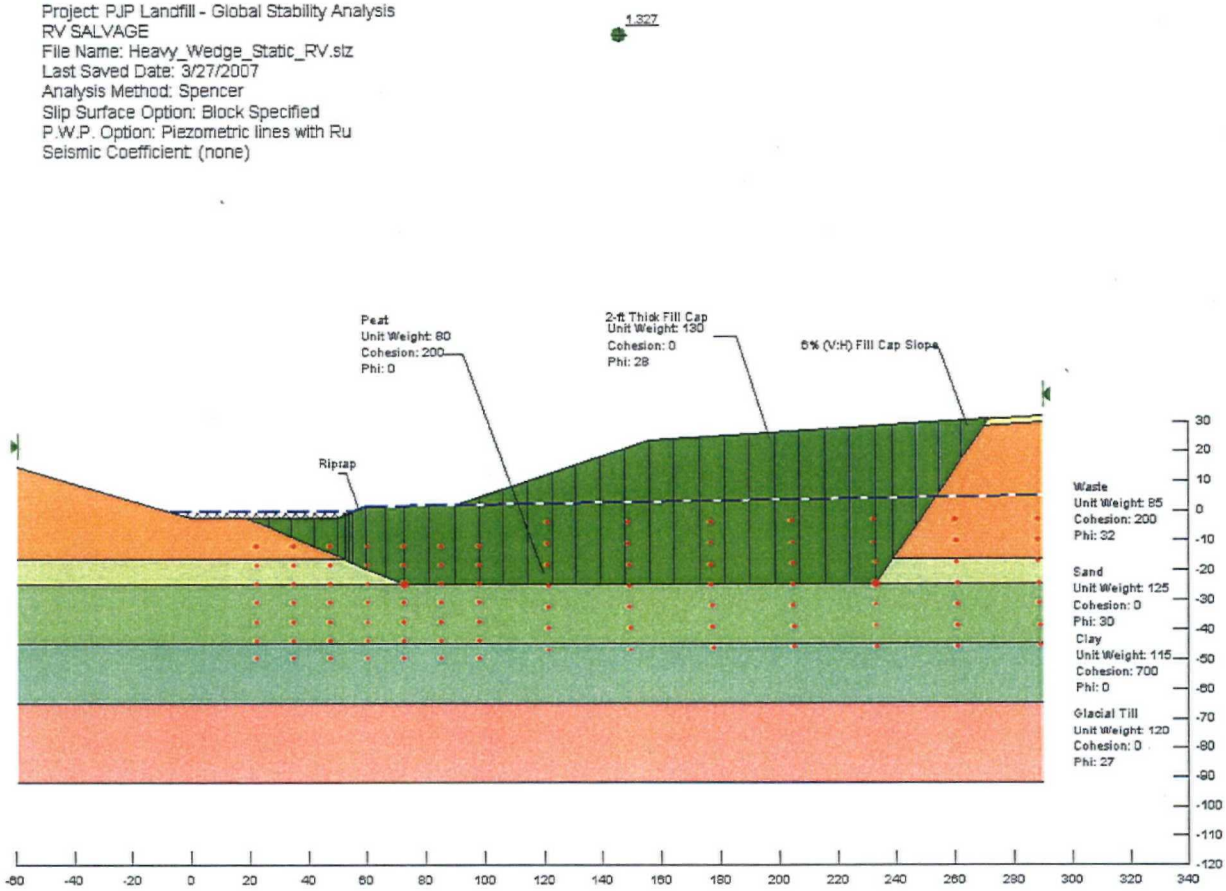

Figure D-8 Wedge Failure under Static Load Using Heavy Fill (A-A')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 25 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
RV SALVAGE
File Name: Heavy_Wedge_Seismic_RV.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: 0.125: Horizontal

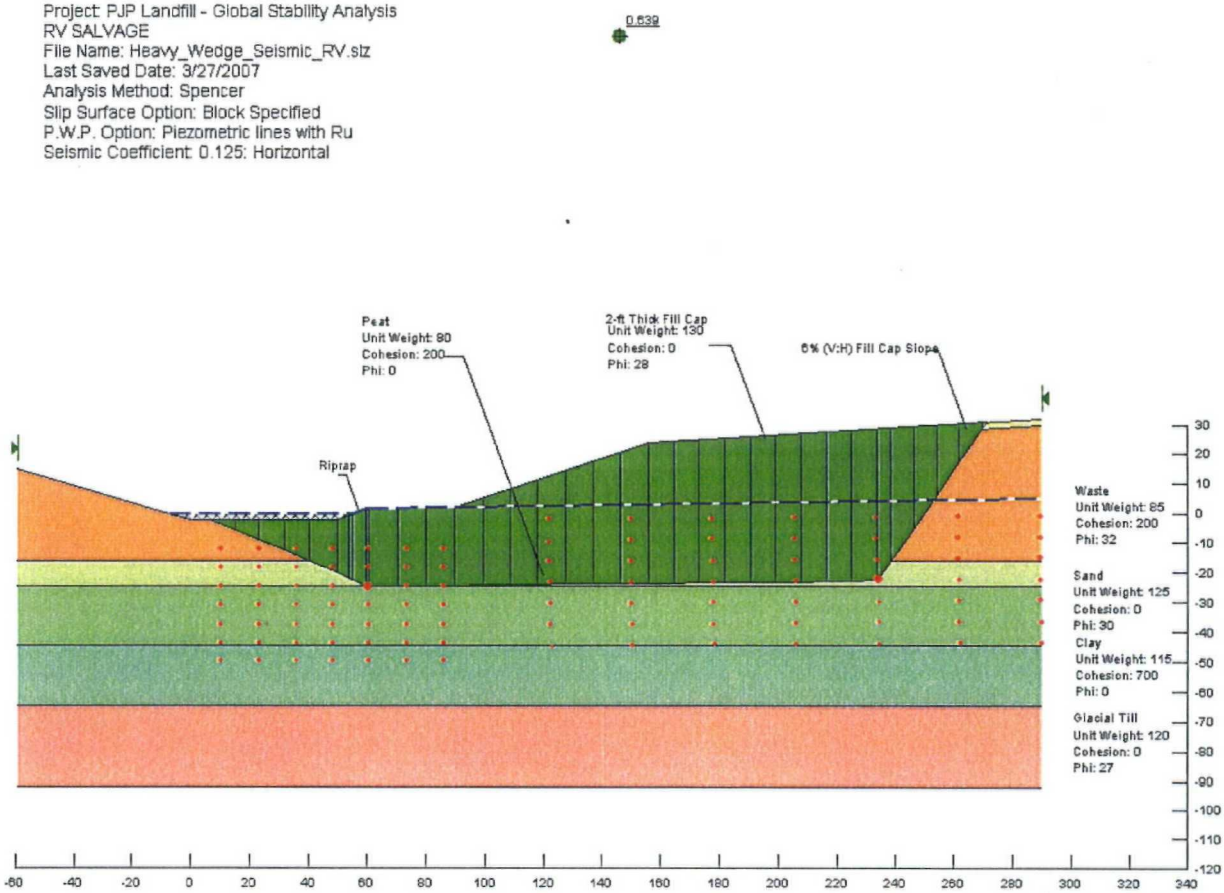

Figure D-9 Wedge Failure under Seismic Load
Using Heavy Fill (A-A')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 26 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
JUNKYARD
Last Saved Date: 3/27/2007
Analysis Method: Spencer

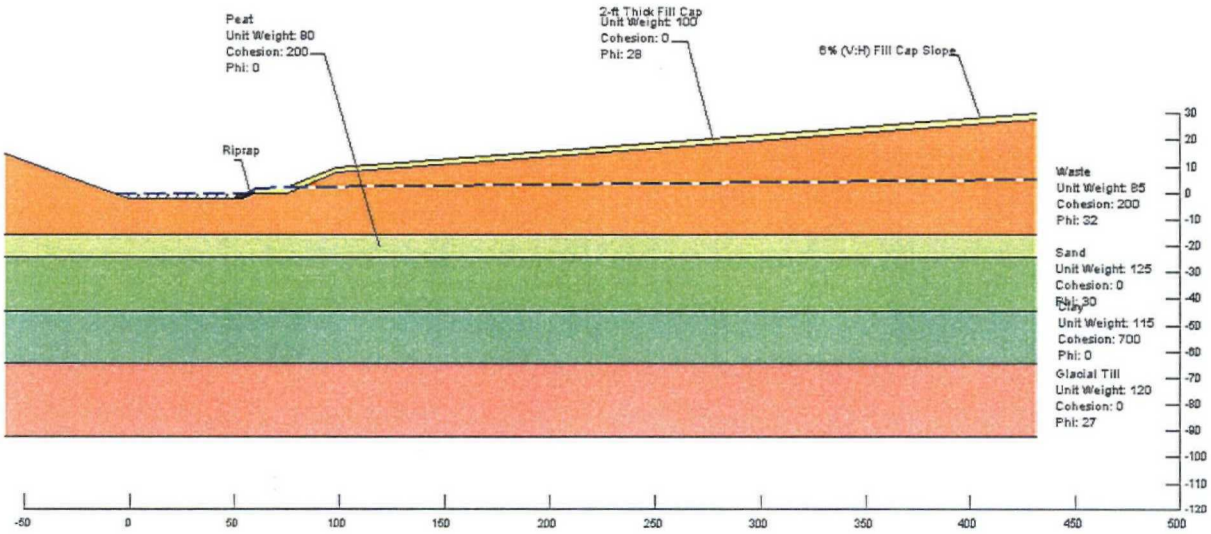

Figure D-10 Cross Section B-B'

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 27 of 43
		Reviewed:	

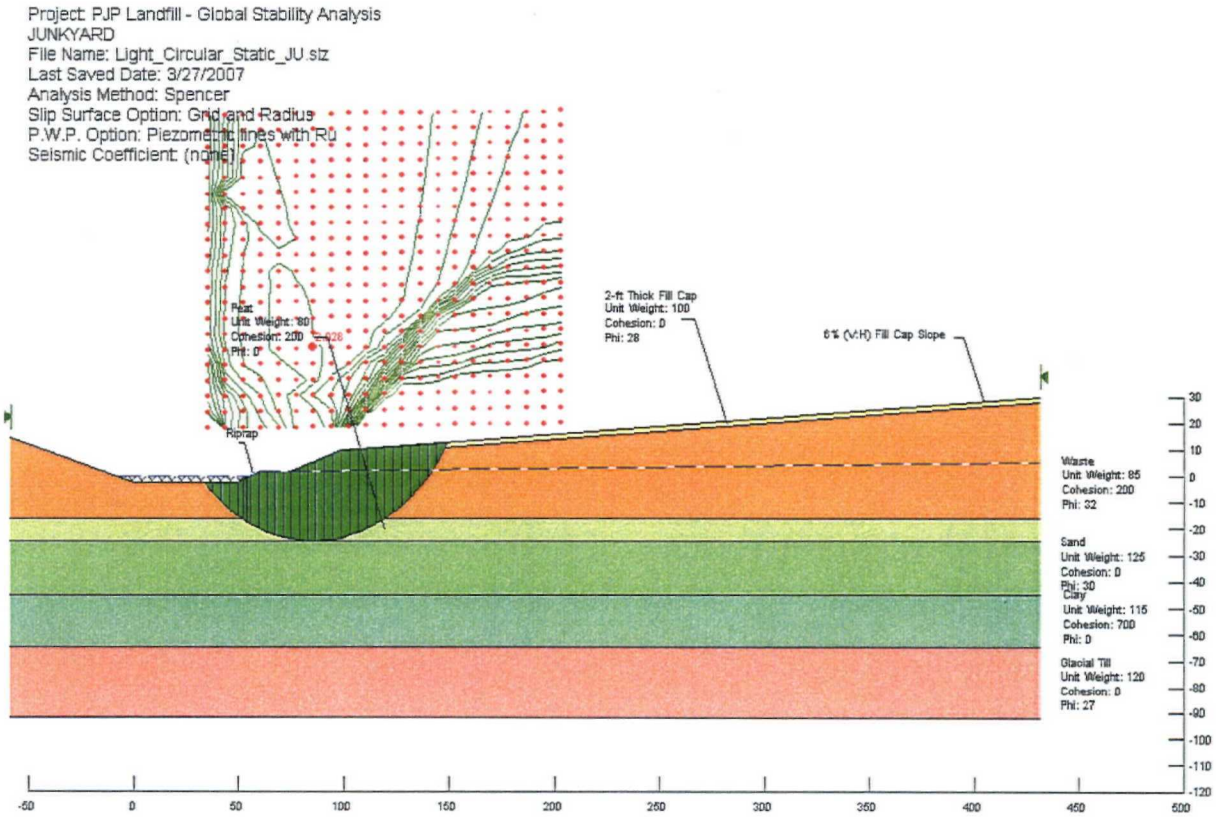

Figure D-11 Circular Failure under Static Load Using Light Fill (B-B')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 28 of 43
		Reviewed:	

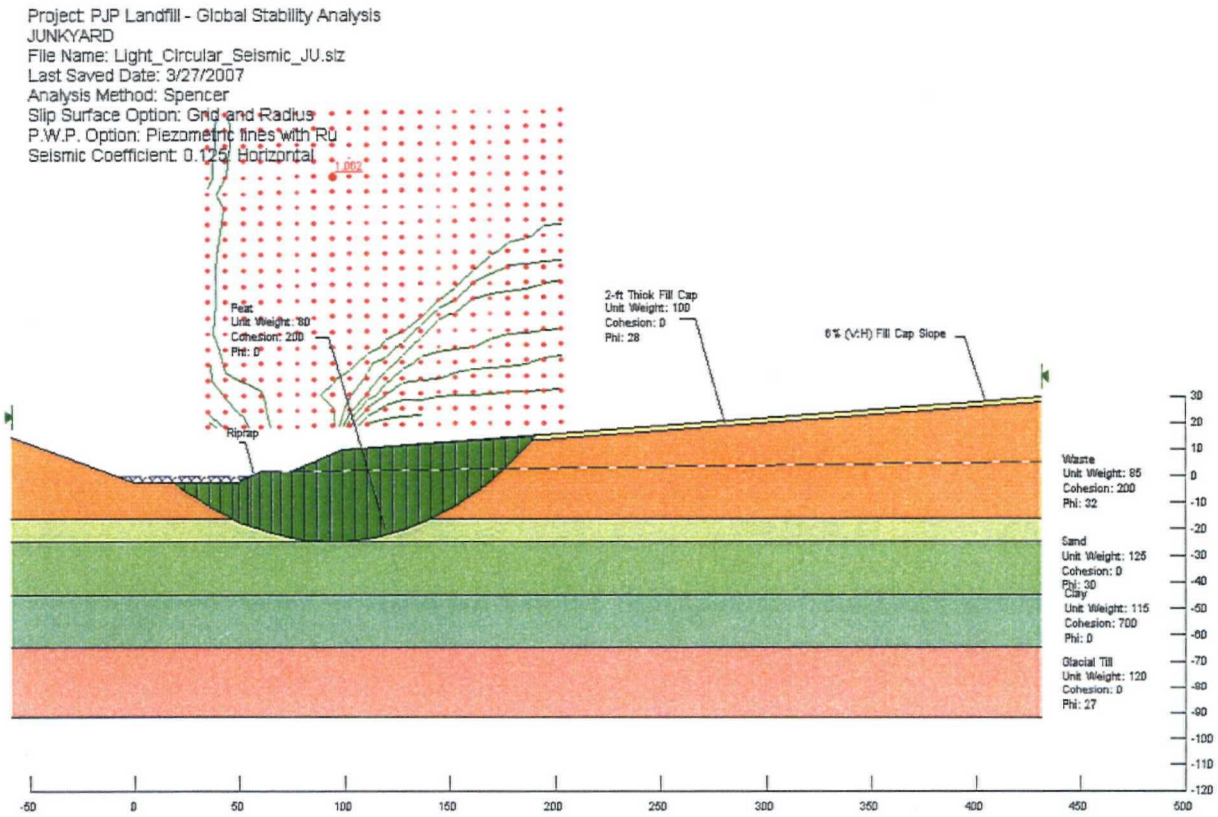

Figure D-12 Circular Failure under Seismic Load
Using Light Fill (B-B')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 29 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
JUNKYARD
File Name: Light_Wedge_Static_JU.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: (none)

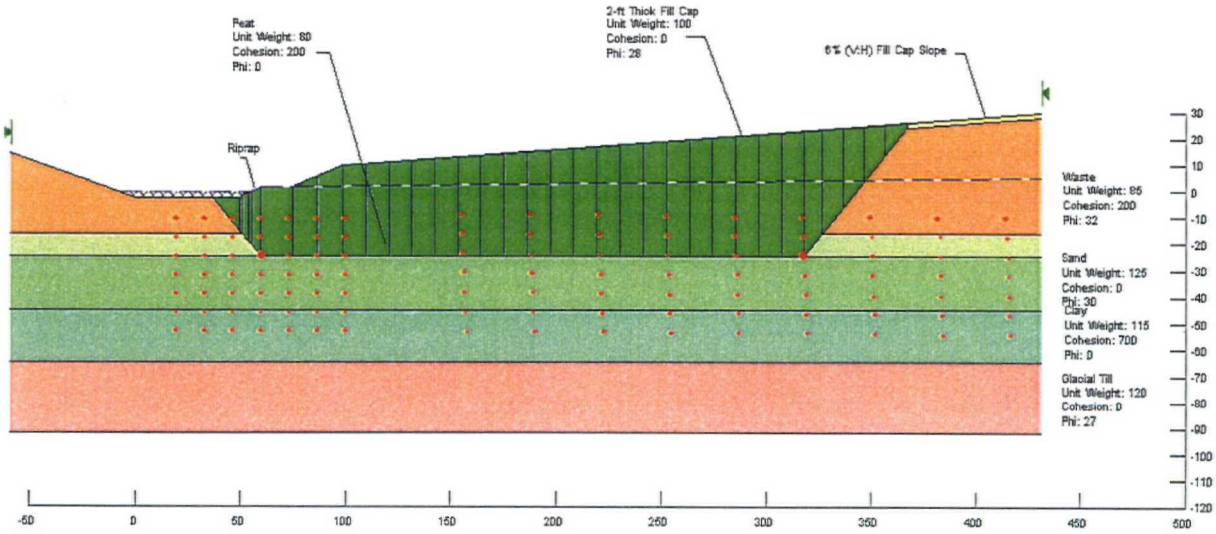

Figure D-13 Wedge Failure under Static Load Using Light Fill (B-B')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 30 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
JUNKYARD
File Name: Light_Wedge_Seismic_JU.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: 0.125: Horizontal

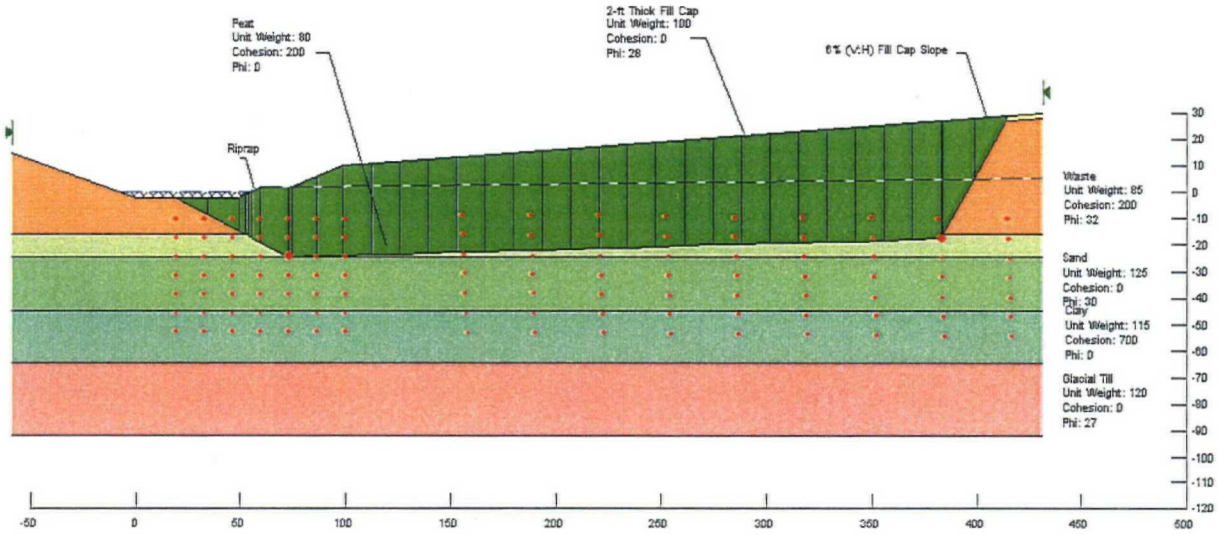

Figure D-14 Wedge Failure under Seismic Load
Using Light Fill (B-B')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 31 of 43
		Reviewed:	

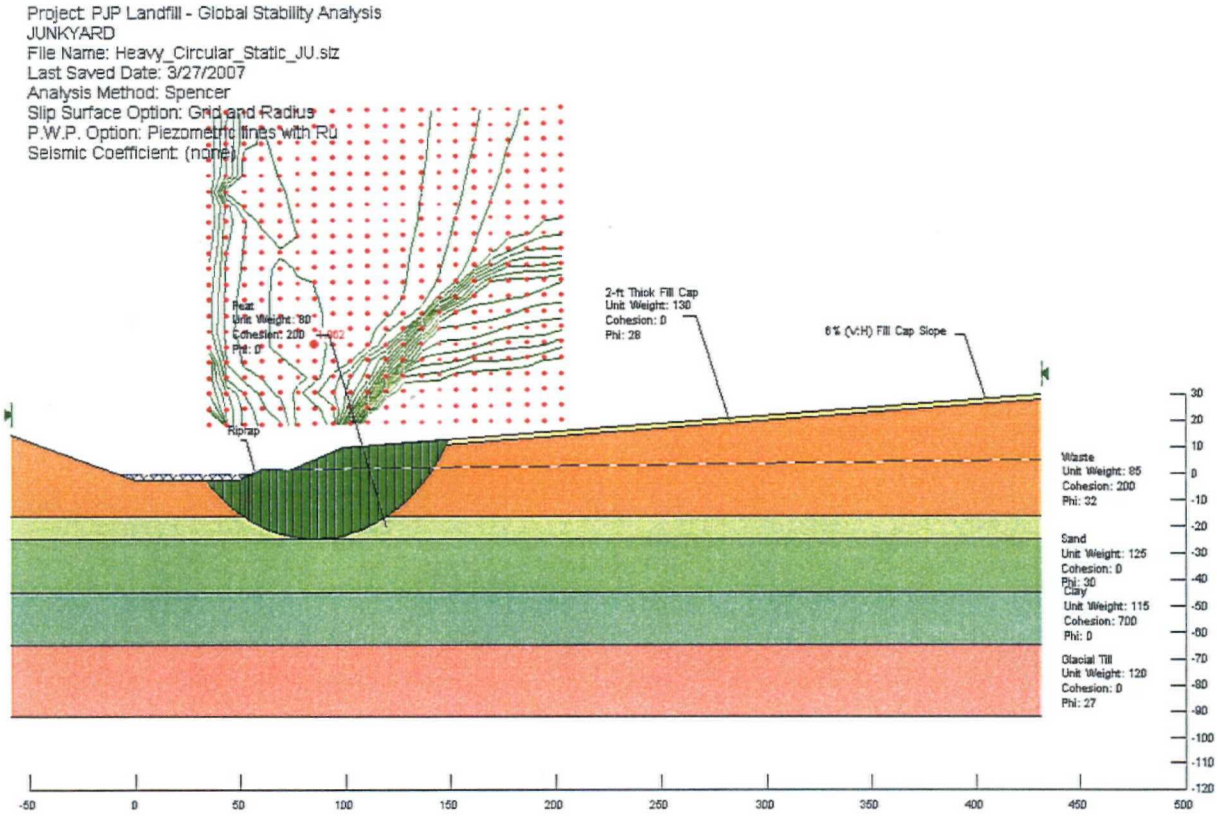

Figure D-15 Circular Failure under Static Load Using Heavy Fill (B-B')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 32 of 43
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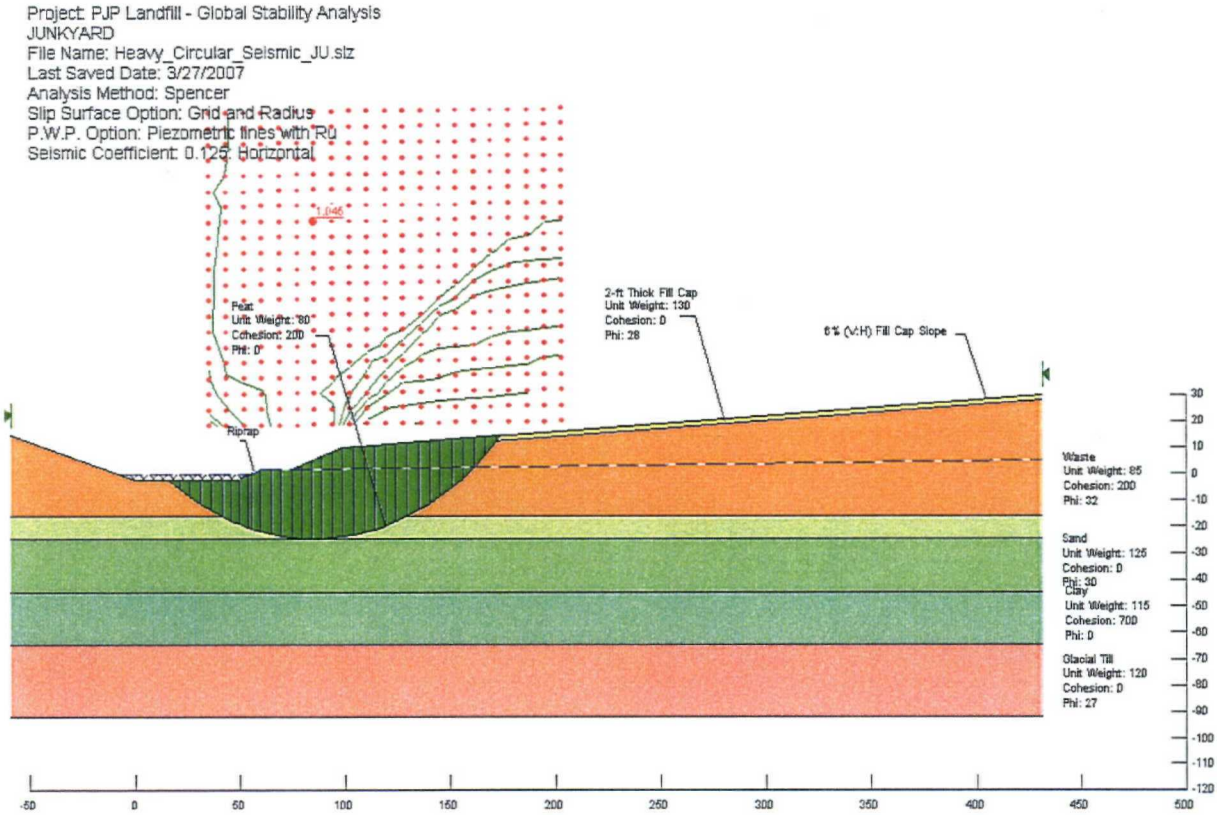

Figure D-16 Circular Failure under Seismic Load Using Heavy Fill (B-B')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 33 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
JUNKYARD
File Name: Heavy_Wedge_Static_JU.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: (none)

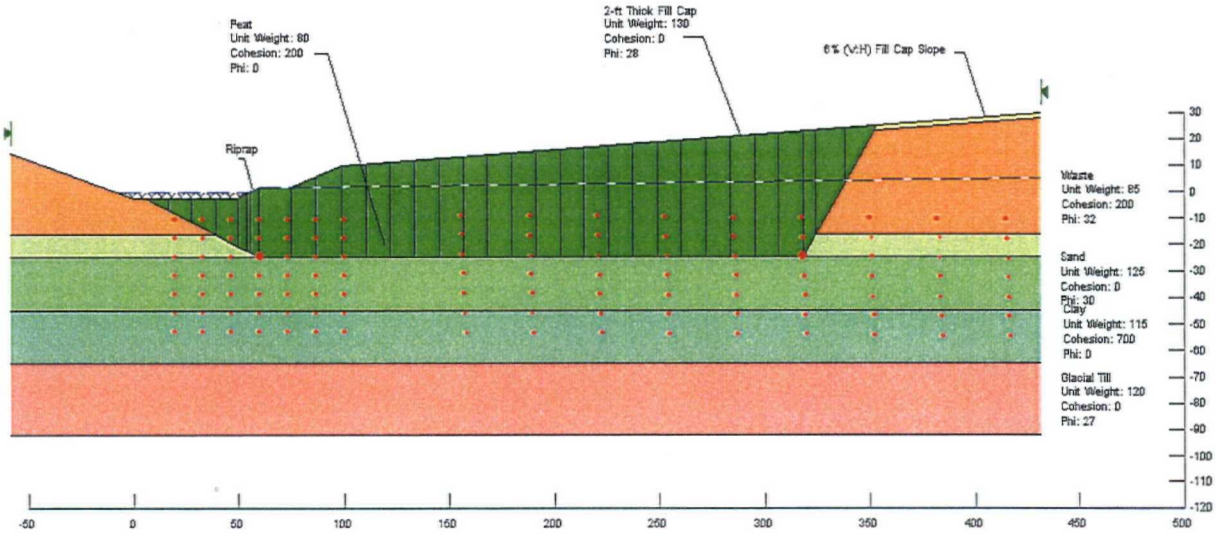

Figure D-17 Wedge Failure under Static Load Using Heavy Fill (B-B')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 34 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
JUNKYARD
File Name: Heavy_Wedge_Seismic_JU.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: 0.125: Horizontal

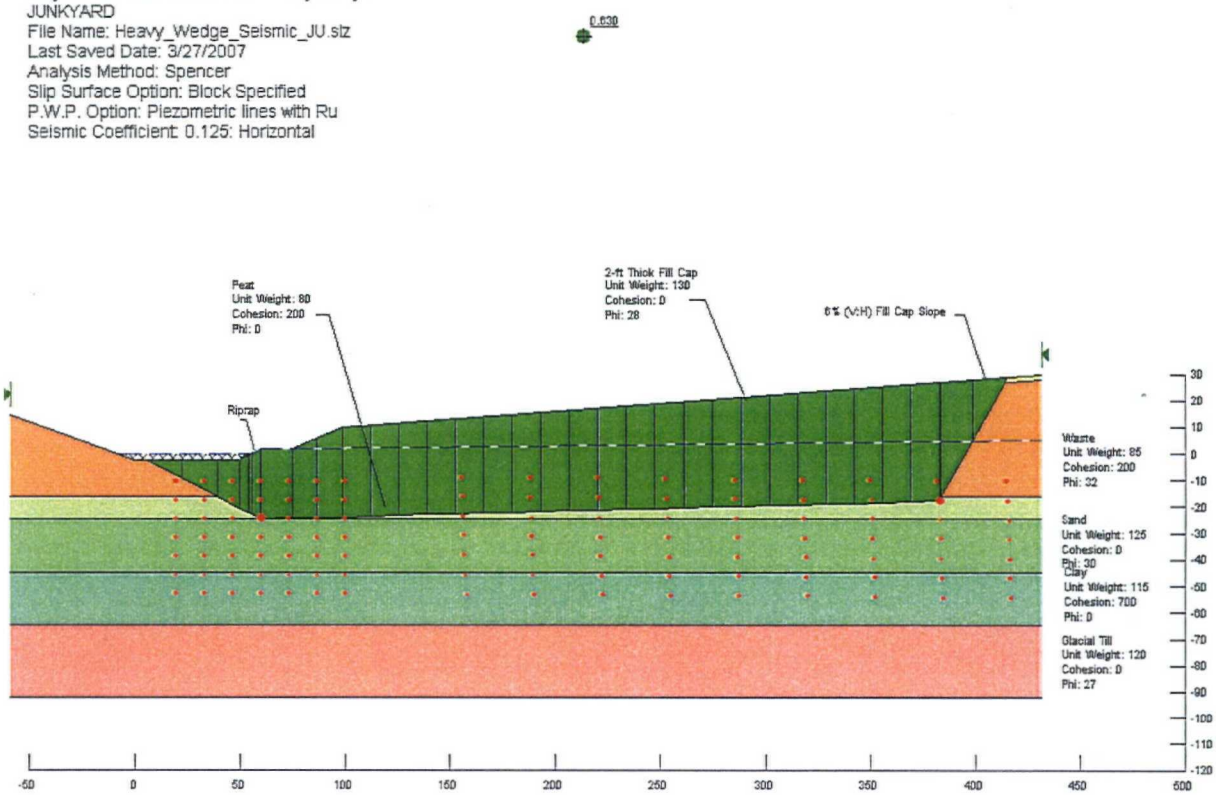

Figure D-18 Wedge Failure under Seismic Load Using Heavy Fill (B-B')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 35 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
TRUCKSTOP
Last Saved Date: 3/27/2007
Analysis Method: Spencer

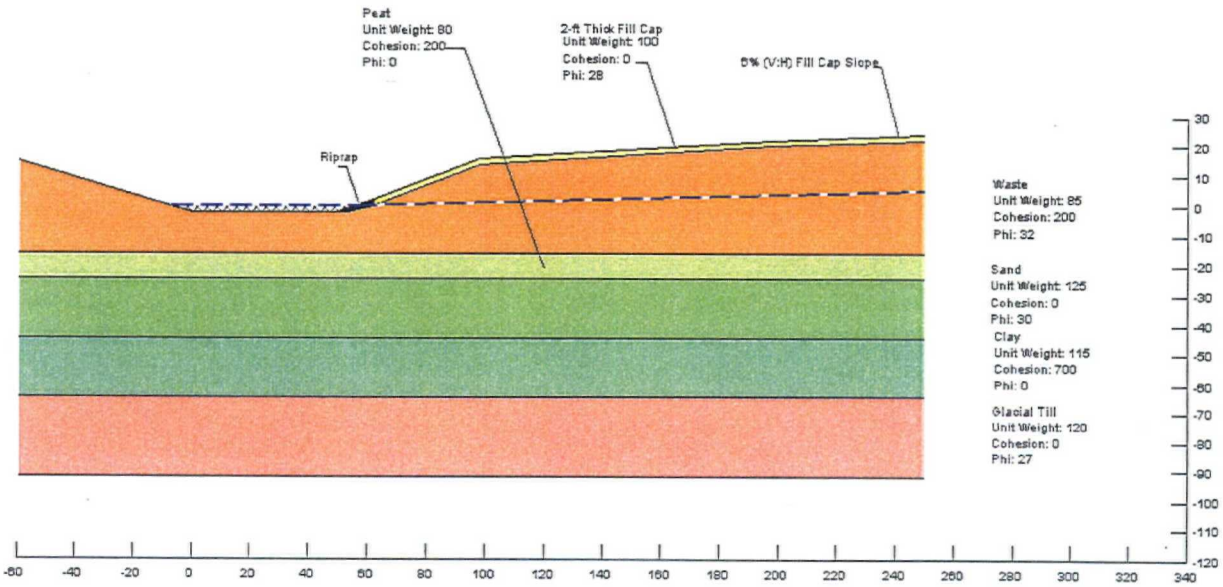

Figure D-19 Cross Section C-C'

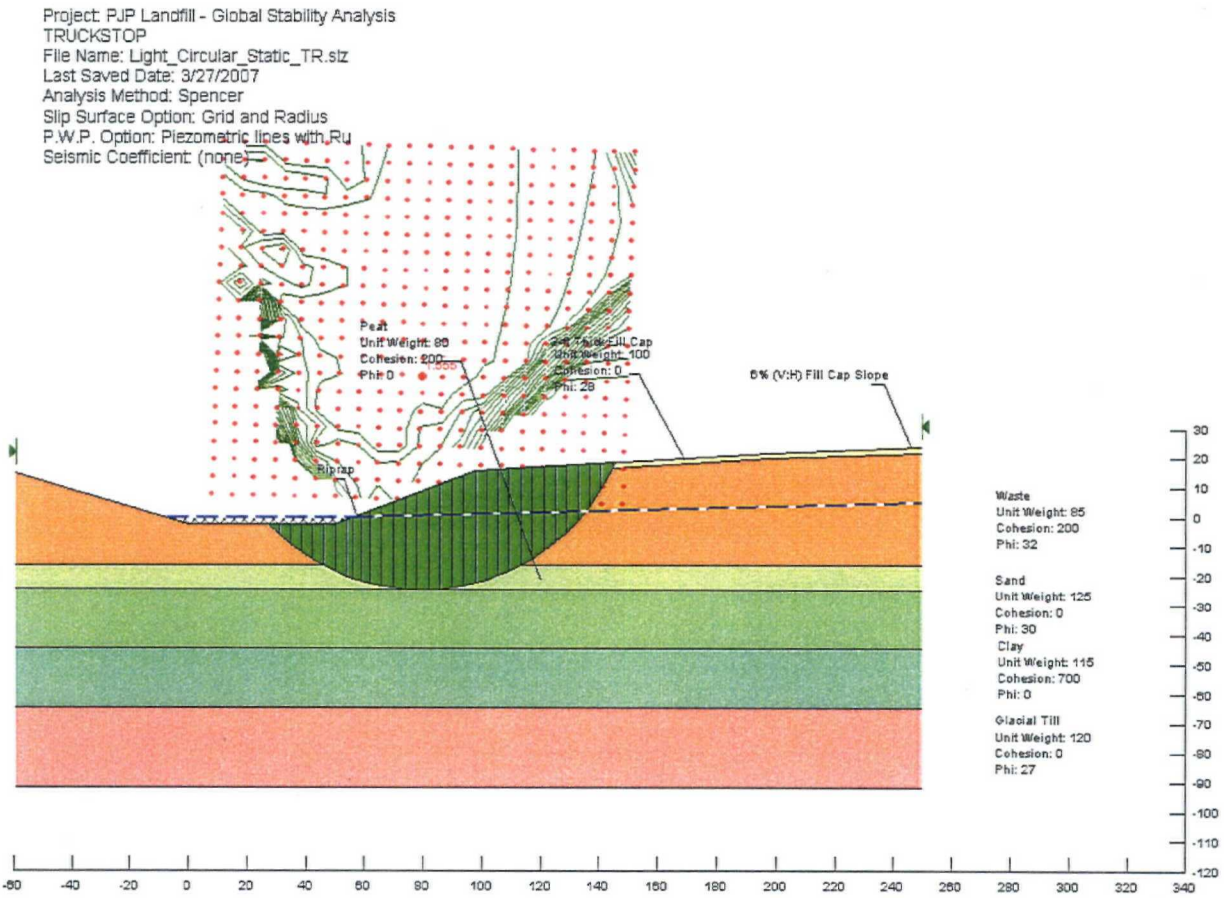

Figure D-20 Circular Failure under Static Load Using Light Fill (C-C')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	Made by: JZ	Date: 03/27/07
	Ref.: 100 % Design	Checked:	Sheet 37 of 43
		Reviewed:	

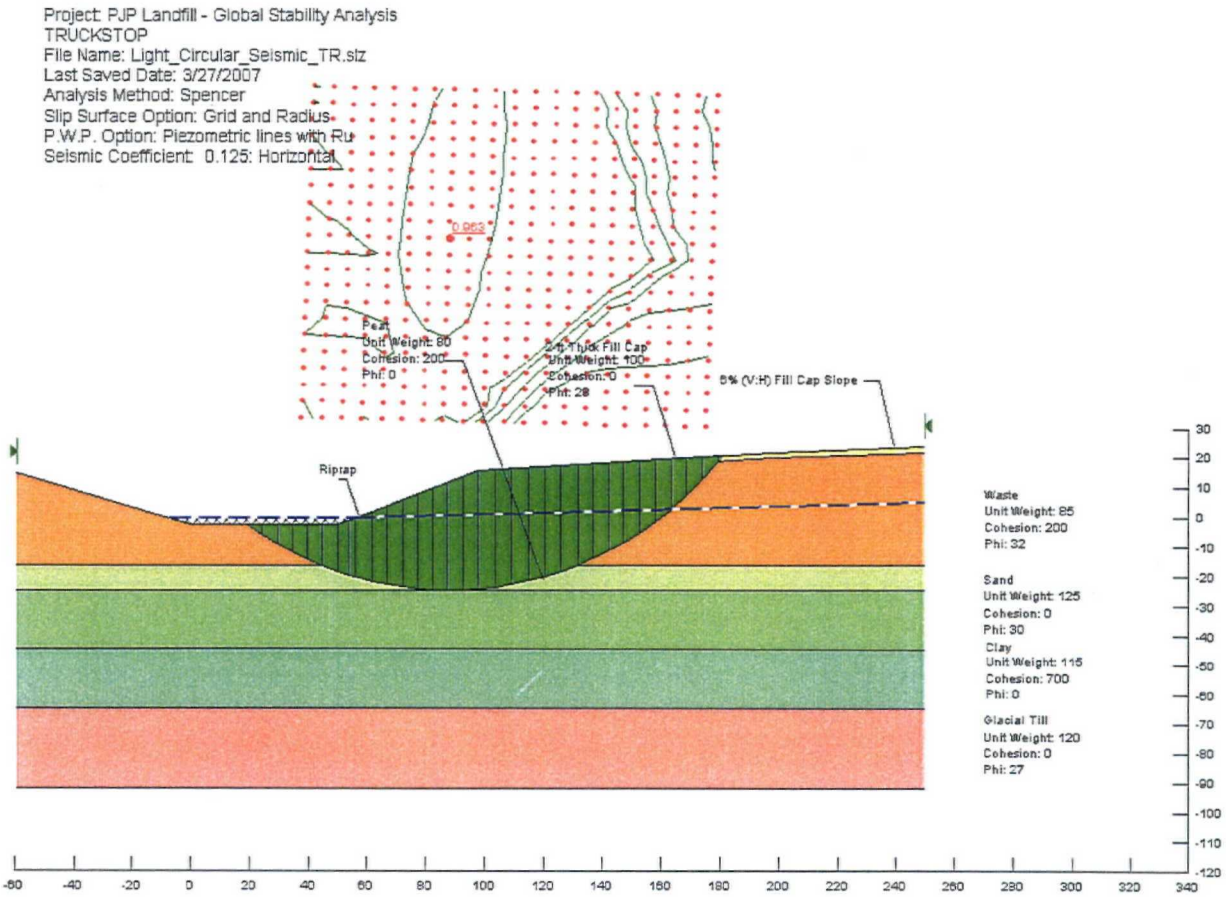

Figure D-21 Circular Failure under Seismic Load Using Light Fill (C-C')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 38 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
TRUCKSTOP
File Name: Light_Wedge_Static_TR.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: (none)

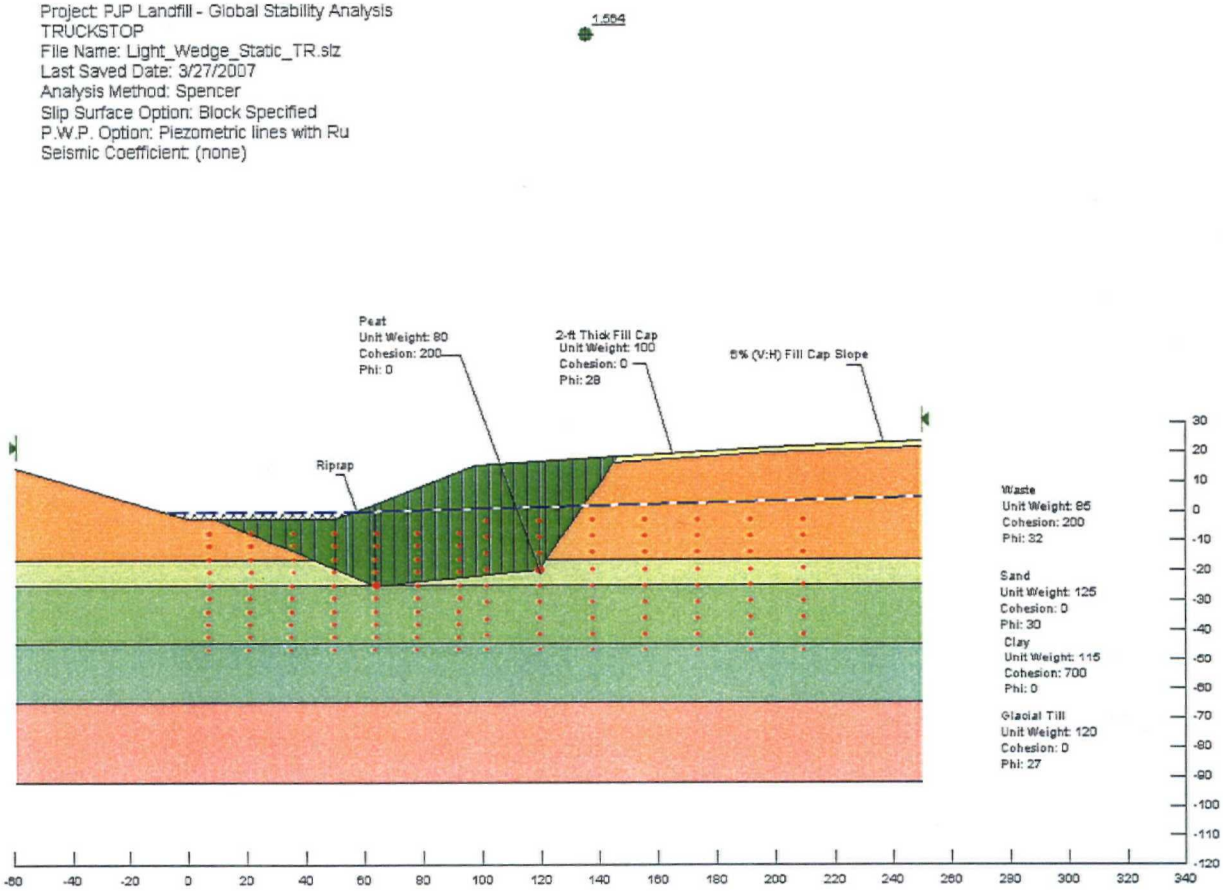

Figure D-22 Wedge Failure under Static Load Using Light Fill (C-C')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 39 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
TRUCKSTOP
File Name: Light_Wedge_Seismic_TR.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: 0.125: Horizontal

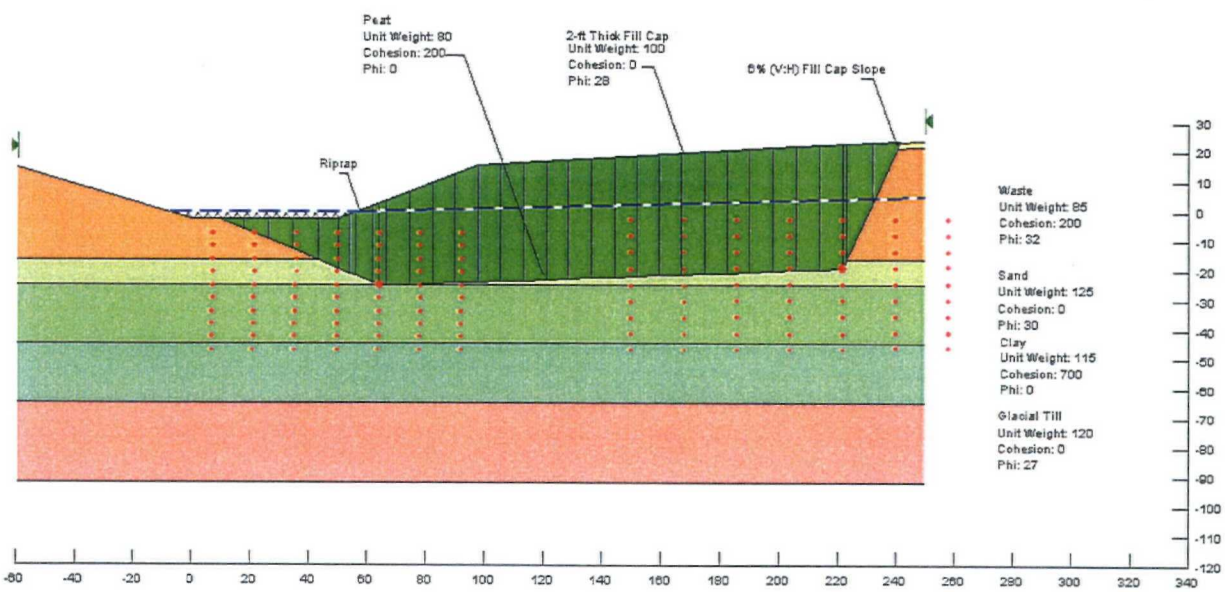

Figure D-23 Wedge Failure under Seismic Load Using Light Fill (C-C')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
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	Ref.: 100 % Design	**Checked:**	**Sheet** 40 of 43
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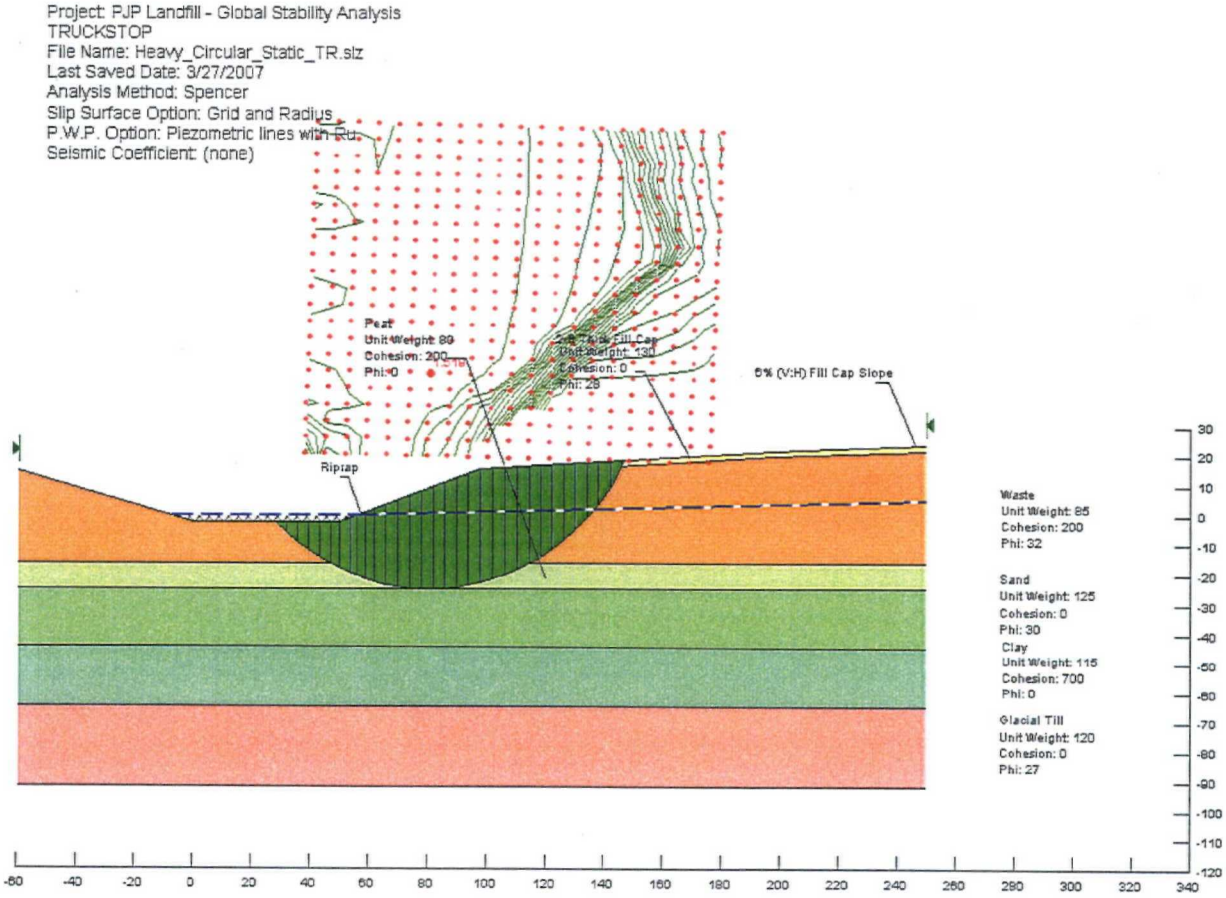

Figure D-24 Circular Failure under Static Load Using Heavy Fill (C-C')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 41 of 43
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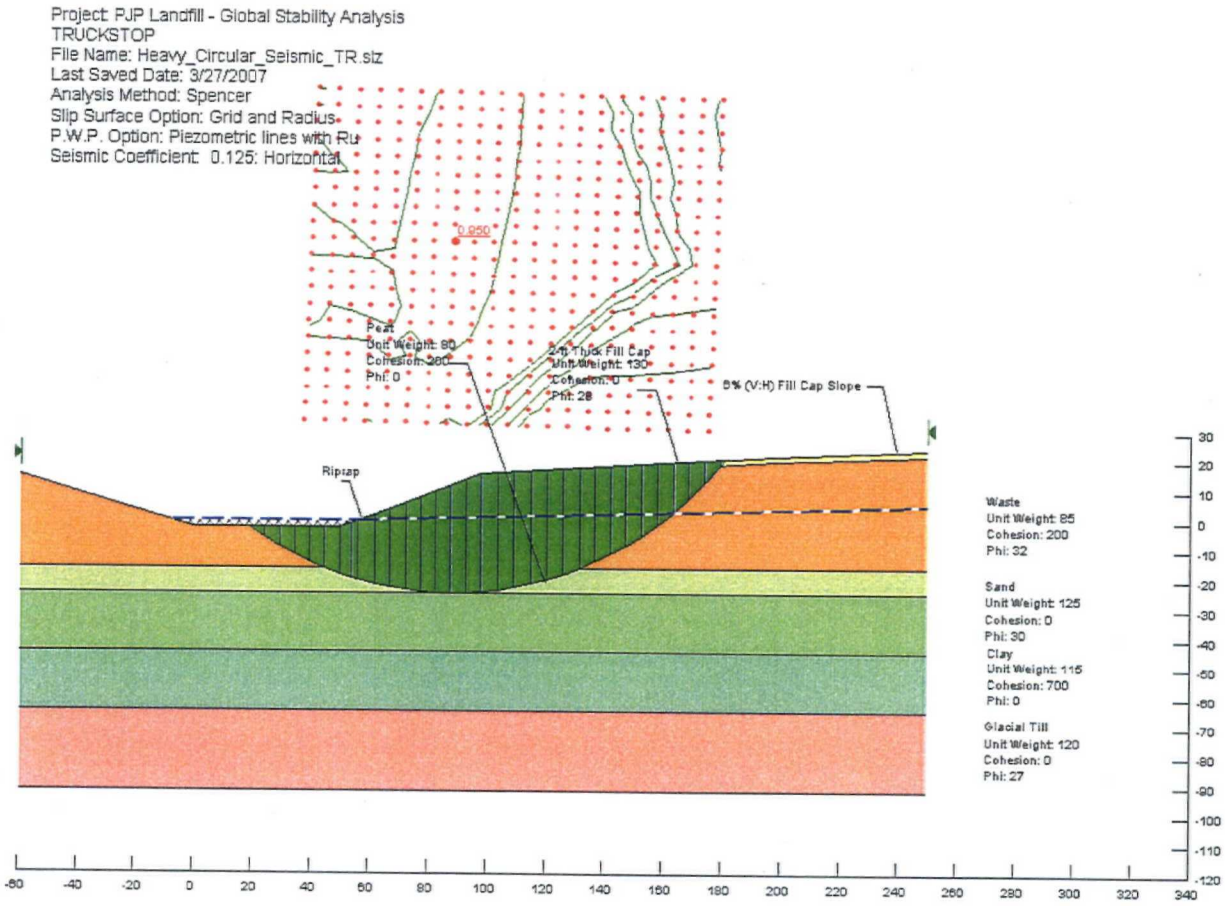


Figure D-25 Circular Failure under Seismic Load Using Heavy Fill (C-C')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 42 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
TRUCKSTOP
File Name: Heavy_Wedge_Static_TR.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: (none)

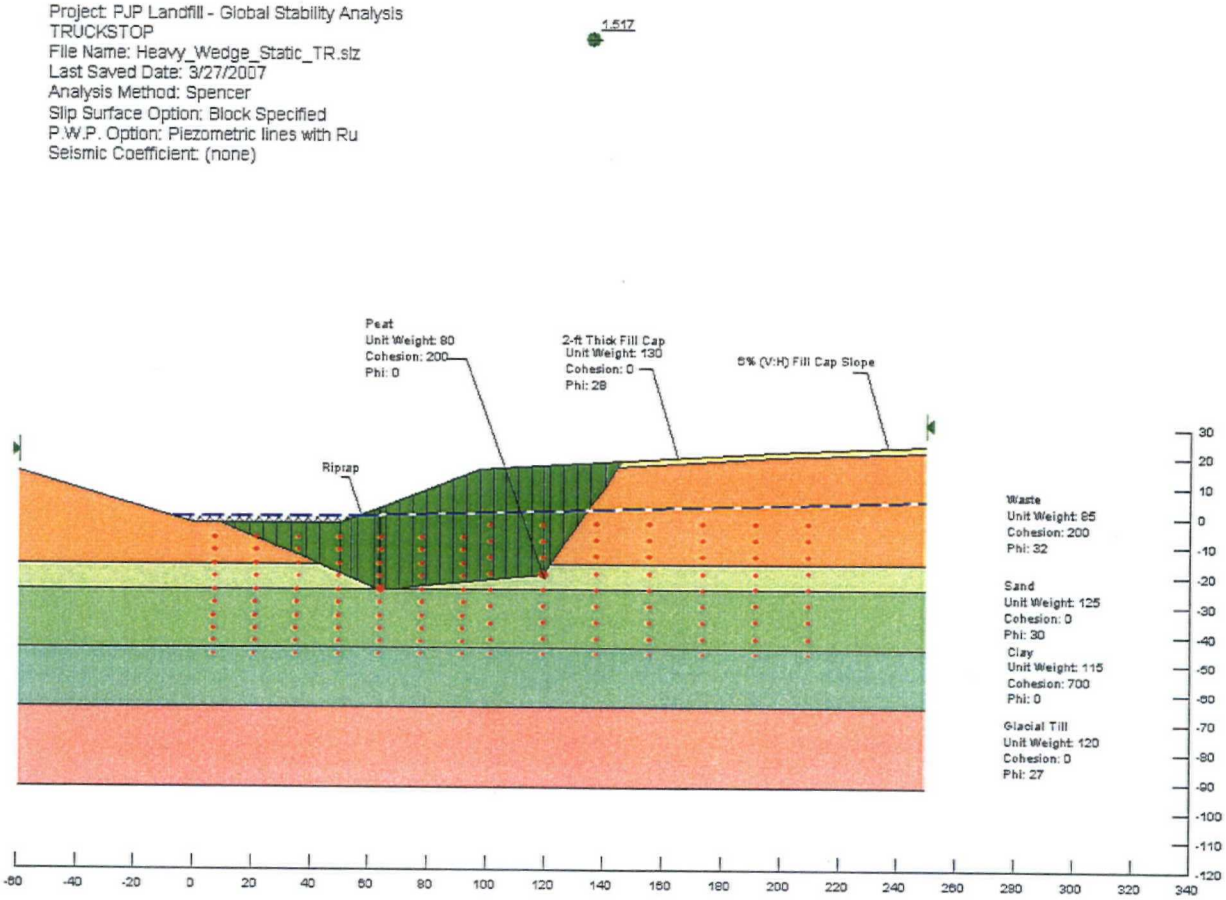


Figure D-26 Wedge Failure under Static Load Using Heavy Fill (C-C')

	SUBJECT: PJP Landfill – Global Slope Stability Analysis		
	Job No.: 003-6004.002	**Made by:** JZ	**Date:** 03/27/07
	Ref.: 100 % Design	**Checked:**	**Sheet** 43 of 43
		Reviewed:	

Project: PJP Landfill - Global Stability Analysis
TRUCKSTOP
File Name: Heavy_Wedge_Seismic_TR.slz
Last Saved Date: 3/27/2007
Analysis Method: Spencer
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Seismic Coefficient: 0.125: Horizontal

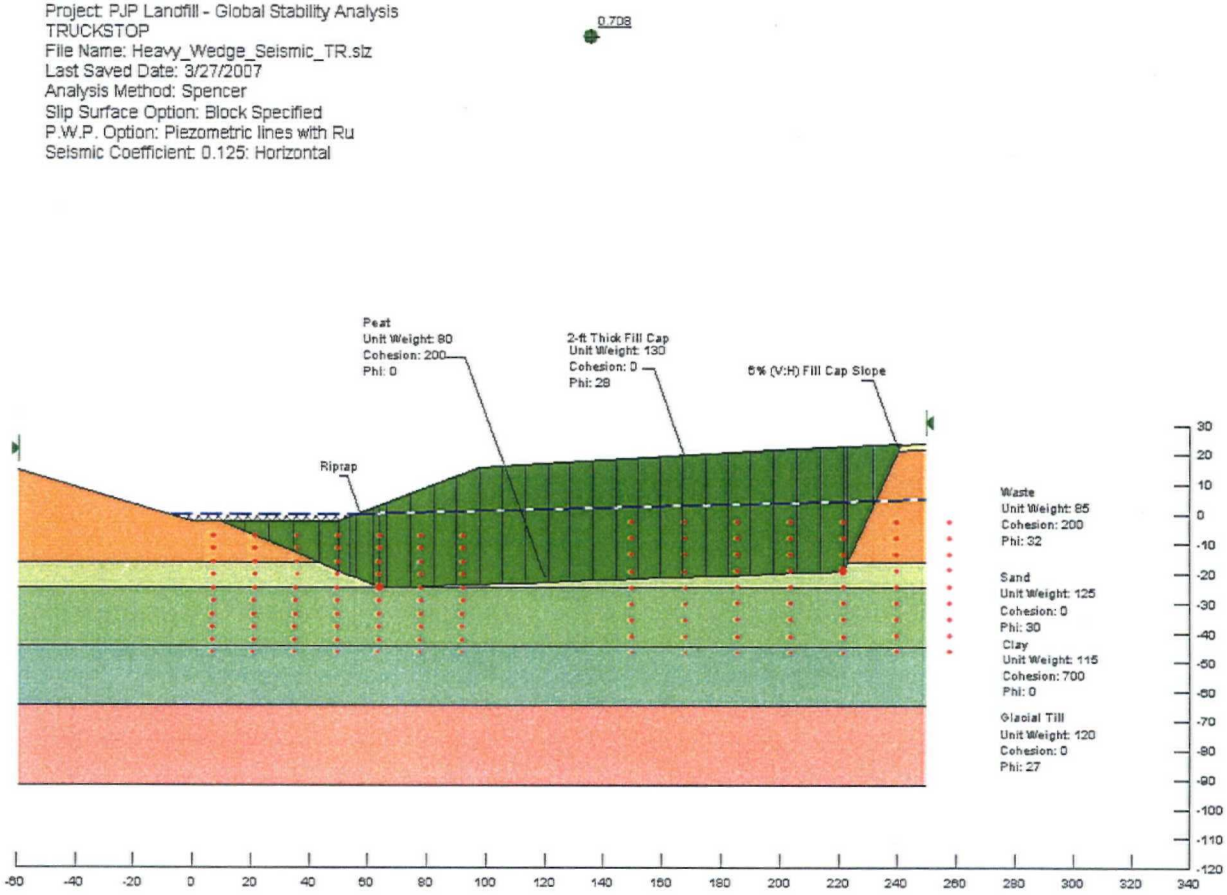


Figure D-27 Wedge Failure under Seismic Load Using Heavy Fill (C-C')

APPENDIX F-2

CAP STABILITY ANALYSES

OBJECTIVE:

To evaluate the required minimum interface friction angle to provide an acceptable factor-of-safety against veneer instability based on final landfill cap grading at Cross-section A-A'.

METHOD:

Methodology based on References 1, 2, and 3 is used to evaluate proposed geosynthetic cap slopes at Cross-section A-A' (used in Slope Stability Analysis). A-A' includes a 33% lower slope of about 25.3 ft long and 6% top slope of about 192 ft long. However, the length of 6% slope was changed to 332 ft to represent the longest length, i.e., the worst case. The veneer stability analysis considered four loading cases described as follows:

Case 1: Gravity Loading Only: Considers veneer stability without additional induced seepage forces resulting from a hydraulic head build-up upon the barrier layer.

Case 2: Gravity with Construction Equipment Loading: Considers veneer stability without hydraulic head build-up upon the barrier layer but additional load exerted by typical low ground pressure construction equipment.

Case 3: Pseudo-Static Seismic Loading: Considers veneer stability of cover soil layer with the pseudo-static load.

Case 4: Seepage Forces: Considers veneer stability with additional seepage forces resulting from hydraulic head build-up in the thickness of the soil layer.

Case 1, 2, and 3: Minimum required interface friction angle is obtained by considering only these three. The method is from Reference 1.

Case 4: The seepage force should be properly addressed. The design method is based on Reference 2.

REFERENCES:

1. "Analysis and Design of Veneer Cover Soils", R.M.Koerner, T.-Y. Soong, Geosynthetics International, 2005, 12, No.1.
2. "The Design of Drainage System Over Geosynthetically Lined Slopes", T.-Y. Soong, R.M. Koerner, GRI Report #19, June, 1997
3. "Design of Lateral Drainage Systems for Landfills", G.N. Richardson, J.P. Giroud, A. Zhao, 2000
4. "Stability of Lined Slopes at Landfills and Surface Impoundments," D. H. Mitchell, M. A. McLean and T. E. Gates, EPA 600/2-89/057.

5. "Final Covers for Solid Waste Landfills and Abandoned Dumps," R. Koerner and D. Daniel, 1997.
6. "Designing with Geosynthetics," 4th edition, R. Koerner, 1998.
7. "Soil-Mechanics in Engineering Practice," 2nd edition, K. Terzaghi and R.B. Peck, 1967.
8. "Geosynthetic Design Guidance for Hazardous Waste Landfill Cells and Surface Impoundments," R. Koerner and G. N. Richardson, 1987.
9. "Interfacial Friction Study of Cap and Liner Components for Landfill Design," M. M. Koutsourais, C. J. Sprague and R. C. Pucetas, Proceedings of the 4th GRI Seminar (December 1990).
10. Precipitation Frequency Data, NOAA
11. Laboratory Testing by Golder Associates, Inc.

ASSUMPTIONS:

1. Proposed geosynthetic cap consists of the following components (from top to bottom):
   - 6" Vegetative layer
   - 12" Cap Cover Soil
   - Geocomposite Drainage Layer
   - 40 mil Textured Geomembrane
   - 6" Cap Cushion Layer
2. Subgrade and cover soil will be a predominately granular, free-draining material. For simplicity, assuming all soils in the cap with a dry unit weight of 120 pcf, saturated unit weight of 130 pcf; friction angle of 28°,and no cohesion.
3. Soil material placement will be with low ground pressure equipment weighing 20 tons or less.
4. No distribution of equipment loading over depth (i.e., load spreading) will be made for conservatism (i.e., $W_e = W_e'$)
5. Based on the three cross sections, the largest lengths of 6% and 33% slopes are 322' (A-A') and 25.3' (B-B'), respectively.
6. Geomembrane shall be textured on both sides, very flexible/linear low-density polyethylene geomembrane.
7. Geocomposite drainage layer shall be a rigid polyethylene geonet with non-woven geotextiles thermally bonded to the upper and lower surfaces of the geonet with sufficient transmissivity such that full saturation of the cover soil will not occur.
8. Adhesion (c_a) is neglected for conservatism.
9. During the construction on the steep slope, equipment always pushes soil up.
10. The required minimum interface friction angles for veneer stability are anticipated to satisfy the following Factors of Safety (FOS):
    - Case 1: FOS = 1.5
    - Case 2: FOS = 1.3

- Case 3: FOS = 10
- Case 4: FOS = 1.5

12. Probable maximum hourly precipitation in 100 years is 2.88 in; runoff coefficient = 0.2.
13. As otherwise stated in the calculations.

DEFINITIONS:

β = slope angle
δ = interface friction angle
ϕ_{req} = minimum required interface friction angle
ϕ_c = internal shear strength of cover soil
γ_w = unit weight of water = 62.4 pcf
γ_d = dry unit weight of cover soil
γ_{sat} = saturated unit weight of cover soil
γ_S = total unit weight of cover soil
γ_B = buoyant unit weight of cover soil = $\gamma_{sat} - \gamma_w$
c_a = adhesion
c = cohesion of cover soil
i = hydraulic gradient = $\sin \beta$
W_S = weight of cover soil
W_W = weight of saturated cover soil
W_e = weight of construction equipment = equipment weight / contact area
W_e' = weight of construction equipment at interface
N_S = normal force of cover soil = $W_S \cos \beta$
N_W = normal force of saturated cover soil = $W_W \cos \beta$
N_e = normal force of construction equipment = $W_e \cos \beta$
N_e' = normal force of construction equipment at interface = $W_e' \cos \beta$
F_s = seepage force = $i\, \gamma_w\, z_W$
z_S = thickness of cover soil
z_W = saturated thickness

CALCULATIONS:

The calculation spread sheets and equations used for the calculation for Case 1 to 3 for both 33% and 6% slopes are attached.

The method addressing Case 4 is included in Cap Transmissivity Calculation. The purpose is to design appropriate vegetative soil and geocomposite system so that there is no water head above

drainage layer, i.e. no seepage force in cover soil. The geotextile used up-gradient to the geonet should be designed so that the opening of the geotextile is small enough to retain the soil particles, while big enough to avoid clogging. For this purpose, particle size gradation and plasticity tests should be performed on the soil. Generally, there is no clogging for soils having 15% or higher PI. For sandy materials to minimize clogging,

$$O_{95} > 3D_{15} \qquad \text{for } C_u > 3$$

To retain soil particles, it should have,

$$O_{95} / D_{85} < B$$

Where, O_{95} = AOS, the diameter of glass beads that 5% or less pass through geotexitle
D_{15} , D_{85} = the diameter at which 15, 85% of soil is finer
Cu = the coefficient of uniformity
B =1, when Cu<2 or >8; B= 0.5Cu, when 2<Cu<4; B=8/Cu, when 4<Cu<8

CONCLUSIONS:

Based on the methodology and assumptions stated above, minimum interface friction angles required for the 33% (66 ft long) and 6% slopes (322 ft long) are 26° and 9.5°, respectively, provided that there is no seepage force induced. It should be noted that, for the 33% (generally steep) slope, the direction of the construction equipment working on the slope may induce significant difference. Given the assumed weight and acceleration of the construction equipment, the required FOS of 1.3 can only be reached if the interface friction angle is increased to 31° if the direction is downward. Therefore, the equipment should always move up during construction of steep slopes. Another big factor that affects the veneer stability is the seepage force (i.e., Case 4). To demonstrate this, a sensitivity study was performed by assuming half of the cover soil thickness (0.75 ft) saturated during a storm. For flat slope (6% slope), interface friction angle of 9.5° is still adequate to maintain the veneer stability. However, for the 33% slope, the FOS will drop from 1.5 to 1.1. To regain the FOS to the required 1.5, friction angle needs to be increased to be at least 33°. This friction angle is much higher than assuming no seepage. The worst case is when the cover soil is fully saturated (1.5 ft water head build-up), the required friction angle will be over 41°, which is not achievable.

Zero seepage should always our target for geocomposite/cover soil system design. The seepage force should be avoided by drainage system design, (refer to Cap Transmissivity Calculation). However, to give it a safety margin, we may increase the friction angle that can stabilize the veneer when there is certain water head build-up in a probable severe storm.

For the flat slope (e.g. 6%), the critical loading condition is seismic force rather than seepage and construction equipment. An interface friction of 9° is adequate for the veneer stability.

However, due to the sensitivity of the analysis to materials used (soil and geosynthetic), infiltration and seepage, and as-placed moisture content and compaction, as appropriate, the analysis should be considered for conceptual design only. Veneer stability should be reevaluated using more specific design information upon its determination (e.g., cover soil permeability, infiltration and induced seepage) and site-specific analysis of the interfacial friction, in accordance with ASTM D5321, with actual geosynthetics, soil materials, and conditions for construction of the cap system.

Attachment A

Veneer Stability Calculations

Golder Associates	SUBJECT: PJP Landfill –Veneer Stability Analysis		
	Job No.: 003-6004.002	Made by: JZ	Date: 3/28/2007
	Ref.: 100% Design Report	Checked:	Sheet 7 of 26
		Reviewed:	

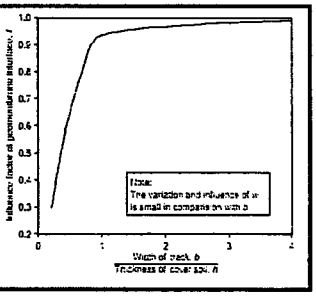
Veneer Stability Calculations_6% Slope_No Seepage

CASE 1. GRAVITY ONLY

Min. Interface Friction Angle Required, δ	**9.5**	degrees	sin β =	0.06	W_A =	53,443	lb/ft
Interface Adhesion, c_a	0	psf	tan β =	0.06	W_P =	2,263	lb/ft
Soil Friction Angle, ϕ	28	degrees	cos β =	1.00	N_A =	53,347	lb/ft
Soil Cohesion, c	0	psf	sin 2β =	0.12	C_a =	0	lb/ft
Slope	16.7	H:1V	tan ϕ' =	0.53	C =	0	lb/ft
Soil Unit Weight, γ'	120	pcf	tan δ' =	0.17			
Cover Depth, h	1.5	ft			a =	191	lb/ft
Slope Length, L	322	ft			b =	-611	lb/ft
					c =	17	lb/ft
FACTOR OF SAFETY =	**3.18**	*(Required FOS=1.5)*					

CASE 2_A. EQUIPMENT PUSHING SOIL UP

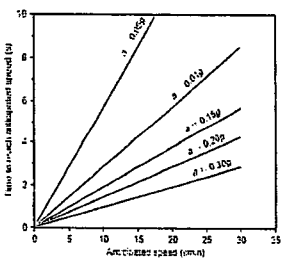
Weight of Equipment, W_b	40,000	lb	W_e =	9,645	psf
Length of Equipment Track, w	9.8	ft	N_e =	9,627	psf
Width of Equipment Track, b	1.97	ft			
Width-to-Thickness Ratio, b/h	1.3				
Influence Factor, I	0.95	(from figure to right)			
			a =	3,764	lb/ft
			b =	-11,842	lb/ft
			c =	335	lb/ft
FACTOR OF SAFETY =	**3.12**	*(Required FOS=1.3)*			



CASE 2_B. EQUIPMENT PUSHING SOIL DOWN

**a=0.01g line on figure should be a=0.1g*

Dozer-to-Gravity Acceleration Ratio, a/g	0.185	(from figure to right)			
Acceleration of Dozer, a	5.953	ft/s^2			
			F_e =	1,784	lb/ft
			a =	5,545	lb/ft
			b =	-11,899	lb/ft
			c =	335	lb/ft
FACTOR OF SAFETY =	**2.12**	*(Required FOS=1.3)*			



CASE 3. SEISMIC FORCES

Seismic Coefficient, C_S	0.125		a =	10,134	lb/ft
			b =	-10,410	lb/ft
			c =	283	lb/ft
FACTOR OF SAFETY =	**1.00**	*(Required FOS=1.0)*			

Golder Associates	SUBJECT: PJP Landfill –Veneer Stability Analysis		
	Job No.: 003-6004.002	Made by: JZ	Date: 3/28/2007
	Ref.: 100% Design Report	Checked:	Sheet 8 of 26
		Reviewed:	

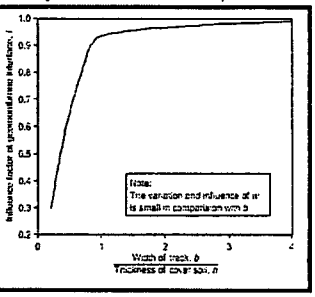
Veneer Stability Calculations_33% Slope_No Seepage

CASE 1. GRAVITY ONLY

Min. Interface Friction Angle Required, δ	**26**	degrees	sin β =	0.32	W_A =	11,025	lb/ft
Interface Adhesion, c_a	0	psf	tan β =	0.33	W_P =	450	lb/ft
Soil Friction Angle, ϕ	28	degrees	cos β =	0.95	N_A =	10,459	lb/ft
Soil Cohesion, c	0	psf	sin 2β =	0.60	C_a =	0	lb/ft
Slope	3	H:1V	tan ϕ' =	0.53	C =	0	lb/ft
Soil Unit Weight, γ	120	pcf	tan δ' =	0.49			
Cover Depth, h	1.5	ft			a =	1,046	lb/ft
Slope Length, L	66	ft			b =	-1,791	lb/ft
					c =	271	lb/ft
FACTOR OF SAFETY =	**1.54**	*(Required FOS=1.5)*					

CASE 2_A. EQUIPMENT PUSHING SOIL UP (*Note: This should be the field practice all the time)

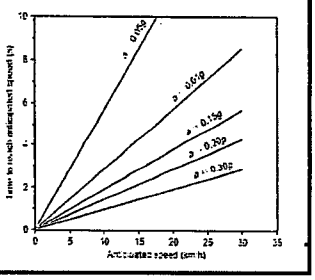
Weight of Equipment, W_b	40,000	lb	W_e =	9,645	psf
Length of Equipment Track, w	9.8	ft	N_e =	9,150	psf
Width of Equipment Track, b	1.97	ft			
Width-to-Thickness Ratio, b/h	1.3				
Influence Factor, I	0.95	(from figure to right)			
			a =	6,201	lb/ft
			b =	-10,411	lb/ft
			c =	1,608	lb/ft
FACTOR OF SAFETY =	**1.51**	*(Required FOS=1.3)*			



CASE 2_B. EQUIPMENT PUSHING SOIL DOWN (*Note: This practice should always be avoided)

**a=0.01g line on figure should be a=0.1g*

Dozer-to-Gravity Acceleration Ratio, a/g	0.185	(from figure to right)			
Acceleration of Dozer, a	5.953	ft/s^2			
			F_e =	1,784	lb/ft
			a =	7,894	lb/ft
			b =	-10,711	lb/ft
			c =	1,608	lb/ft
FACTOR OF SAFETY =	**1.19**	*(Required FOS=1.3)*			



CASE 3. SEISMIC FORCES

Seismic Coefficient, C_S	0.125		a =	4,499	lb/ft
			b =	-5,606	lb/ft
			c =	814	lb/ft
FACTOR OF SAFETY =	**1.08**	*(Required FOS=1.0)*			

Golder Associates	SUBJECT: PJP Landfill –Veneer Stability Analysis		
	Job No.: 003-6004.002	Made by: JZ	Date: 3/28/2007
	Ref.: 100% Design Report	Checked:	Sheet 9 of 26
		Reviewed:	

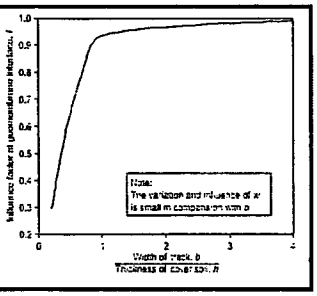
Veneer Stability Calculations_6% Slope_With Seepage

CASE 1. GRAVITY ONLY

Min. Interface Friction Angle Required, δ	**9.5**	degrees	sin β =	0.06	W_A =	53,443	lb/ft
Interface Adhesion, c_a	0	psf	tan β =	0.06	W_P =	2,263	lb/ft
Soil Friction Angle, ϕ	28	degrees	cos β =	1.00	N_A =	53,347	lb/ft
Soil Cohesion, c	0	psf	sin 2β =	0.12	C_a =	0	lb/ft
Slope	16.7	H:1V	tan ϕ' =	0.53	C =	0	lb/ft
Soil Unit Weight, γ	120	pcf	tan δ' =	0.17			
Cover Depth, h	1.5	ft			a =	191	lb/ft
Slope Length, L	322	ft			b =	-611	lb/ft
					c =	17	lb/ft
FACTOR OF SAFETY =	**3.18**	*(Required FOS =1.5)*					

CASE 2_A. EQUIPMENT PUSHING SOIL UP

Weight of Equipment, W_b	40,000	lb	W_e = 9,645	psf	
Length of Equipment Track, w	9.8	ft	N_e = 9,627	psf	
Width of Equipment Track, b	1.97	ft			
Width-to-Thickness Ratio, b/h	1.3				
Influence Factor, I	0.95	(from figure to right)			
			a = 3,764	lb/ft	
			b = -11,842	lb/ft	
			c = 335	lb/ft	
FACTOR OF SAFETY =	**3.12**	*(Required FOS =1.3)*			



CASE 3. SEISMIC FORCES

Seismic Coefficient, C_S	0.125		a =	10,134	lb/ft
			b =	-10,410	lb/ft
			c =	283	lb/ft
FACTOR OF SAFETY =	**1.00**	*(Required FOS =1.0)*			

CASE 4. SEEPAGE PARALLEL TO THE SLOPE_*Half Saturated*

Soil Dry Unit Weight, γ_d	120	pcf	W_A =	55,631	lb/ft		
Saturated Zone Depth, h_w	0.75	ft	U_h =	13,627	lb/ft		
Height from Toe to Water head, Hw	17.7	ft	U_h =	18	lb/ft		
Saturated Soil Unit Weight, γ_{sat}	130	pcf	W_P =	2,310	lb/ft	a =	3,319 lb/ft
Parallel Submergence Ratio	0.50		U_V =	294	lb/ft	b =	-8,177 lb/ft
			N_A =	41,905	lb/ft	c =	223 lb/ft
FACTOR OF SAFETY =	**2.44**	*(Required FOS =1.5)*					

Golder Associates	SUBJECT: PJP Landfill –Veneer Stability Analysis		
	Job No.: 003-6004.002	Made by: JZ	Date: 3/28/2007
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		Reviewed:	

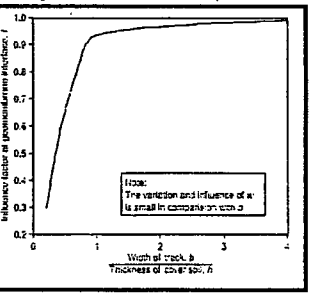
Veneer Stability Calculations_33% Slope_With Seepage

CASE 1. GRAVITY ONLY

Min. Interface Friction Angle Required, δ	**33**	degrees	sin β =	0.32	W_A =	11,025	lb/ft
Interface Adhesion, c_a	0	psf	tan β =	0.33	W_P =	450	lb/ft
Soil Friction Angle, ϕ	28	degrees	cos β =	0.95	N_A =	10,459	lb/ft
Soil Cohesion, c	0	psf	sin 2β =	0.60	C_a =	0	lb/ft
Slope	3	H:1V	tan ϕ' =	0.53	C =	0	lb/ft
Soil Unit Weight, γ	120	pcf	tan δ' =	0.65			
Cover Depth, h	1.5	ft			a =	1,046	lb/ft
Slope Length, L	66	ft			b =	-2,299	lb/ft
					c =	361	lb/ft
FACTOR OF SAFETY =	**2.03**	*(Required FOS =1.5)*					

CASE 2_A. EQUIPMENT PUSHING SOIL UP (*Note: This should be the field practice all the time)

Weight of Equipment, W_b	40,000	lb	W_e =	9,645	psf
Length of Equipment Track, w	9.8	ft	N_e =	9,150	psf
Width of Equipment Track, b	1.97	ft			
Width-to-Thickness Ratio, b/h	1.3				
Influence Factor, I	0.95	(from figure to right)			
			a =	6,201	lb/ft
			b =	-13,419	lb/ft
			c =	2,141	lb/ft
FACTOR OF SAFETY =	**1.99**	*(Required FOS =1.3)*			



CASE 3. SEISMIC FORCES

Seismic Coefficient, C_S	0.125		a =	4,499	lb/ft
			b =	-7,128	lb/ft
			c =	1,083	lb/ft
FACTOR OF SAFETY =	**1.41**	*(Required FOS =1.0)*			

CASE 4. SEEPAGE PARALLEL TO THE SLOPE_*Half Saturated*

Soil Dry Unit Weight, γ_d	120	pcf	W_A =	11,522	lb/ft			
Saturated Zone Depth, h_w	0.75	ft	U_n =	2,972	lb/ft			
Height from Toe to Water head, Hw	19.4	ft	U_h =	20	lb/ft			
Saturated Soil Unit Weight, γ_{sat}	130	pcf	W_P =	459	lb/ft	a =	3,459	lb/ft
Parallel Submergence Ratio	0.50		U_V =	59	lb/ft	b =	-5,729	lb/ft
			N_A =	7,965	lb/ft	c =	870	lb/ft
FACTOR OF SAFETY =	**1.49**	*(Required FOS =1.5)*						

Equations Used For Veneer Stability Calculations

GRAVITY ONLY

$$W_A = \gamma_{moist} \cdot h^2 \cdot \left[\frac{L}{h} - \frac{1}{\cos\beta \cdot \sin\beta} + \frac{\tan\beta}{2}\right]$$

$$W_P = \frac{h^2 \cdot \gamma_{moist}}{\sin 2\beta}$$

$$N_A = W_A \cdot \cos\beta$$

$$C_a = c_a \cdot \left(L - \frac{h}{\tan\beta}\right)$$

$$C = \frac{c \cdot h}{\sin\beta}$$

$$a = (W_A - N_A \cdot \cos\beta) \cdot \cos\beta$$

$$b = -[(W_A - N_A \cdot \cos\beta) \cdot \sin\beta \cdot \tan\phi + (N_A \cdot \tan\delta + C_a) \cdot \sin\beta \cdot \cos\beta + \sin\beta \cdot (C + W_P \cdot \tan\phi)]$$

$$c = (N_A \cdot \tan\delta + C_a) \cdot \sin^2\beta \cdot \tan\phi$$

$$FS = \frac{-b + \sqrt{b^2 - 4a \cdot c}}{2a}$$

EQUIPMENT PUSHING SOIL UP COVER SLOPE

$$q = \frac{W_b}{(2 \cdot w \cdot b)}$$

$$W_e = q \cdot w \cdot I$$

$$N_e = W_e \cdot \cos\beta$$

$$a = [(W_A + W_e) \cdot \sin\beta] \cdot \cos\beta$$

$$b = -\{[(N_e + N_A) \cdot \tan\delta + C_a] \cdot \cos\beta + [(W_A + W_e) \cdot \sin\beta] \cdot \sin\beta \cdot \tan\phi + (C + W_P \cdot \tan\phi)\}$$

$$c = [(N_e + N_A) \cdot \tan\delta + C_a] \cdot \sin\beta \cdot \tan\phi$$

- Wa, Wp, Na, Ca, C, and FS same as gravity only

EQUIPMENT PUSHING SOIL DOWN COVER SLOPE

$$F_e = W_e \cdot \left(\frac{a}{g}\right)$$

$$a = [(W_A + W_e) \cdot \sin\beta + F_e] \cdot \cos\beta$$

$$b = -\{[(N_e + N_A) \cdot \tan\delta + C_a] \cdot \cos\beta + [(W_A + W_e) \cdot \sin\beta + F_e] \cdot \sin\beta \cdot \tan\phi + (C + W_P \cdot \tan\phi)\}$$

$$c = [(N_e + N_A) \cdot \tan\delta + C_a] \cdot \sin\beta \cdot \tan\phi$$

- Wa, Wp, Na, Ca, C, and FS same as gravity only
- We, q, and Ne same as equipment pushing soil up cover slope

HORIZONTAL SEEPAGE BUILD-UP

$$W_A = \gamma_{moist} \cdot \left[h \cdot \left(\frac{H - Hw}{\sin\beta} \right) - \left(\frac{h^2}{2 \cdot \tan\beta} \right) \right] + \gamma_{sat} \cdot \left[h \cdot \left(\frac{2 \cdot Hw \cdot \cos\beta - h}{\sin 2\beta} \right) \right]$$

$$W_P = \frac{h^2 \cdot \gamma_{sat}}{\sin 2\beta}$$

$$U_v = \frac{h^2 \cdot \gamma_w}{\sin 2\beta}$$

$$U_h = \frac{h^2 \cdot \gamma_w}{2 \cdot \cos^2 \beta}$$

$$U_N = \gamma_w \cdot h \cdot \left(\frac{2 \cdot Hw \cdot \cos\beta - h}{\sin 2\beta \cdot \cos\beta} \right)$$

$$N_A = W_A \cdot \cos\beta + U_h \cdot \sin\beta - U_N$$

$$E_A = W_A \cdot \sin\beta - U_h \cdot \cos\beta - \frac{N_A \cdot \tan\delta + C_a}{FS}$$

$$E_P = \frac{U_h \cdot FS - (W_P - U_v) \cdot \tan\phi - C}{\sin\beta \cdot \tan\phi - \cos\beta \cdot FS}$$

$$a = U_h + W_A \cdot \sin\beta \cdot \cos\beta - U_h \cdot \cos^2 b$$

$$b = -W_A \cdot \sin^2 b \cdot \tan\phi + U_h \cdot \cos\beta \cdot \sin\beta \cdot \tan\phi - (N_A \cdot \tan\delta + C_a) \cdot \cos\beta - [(W_P - U_v) \cdot \tan\phi - C]$$

$$c = (N_A \cdot \tan\delta + C_a) \cdot \sin\beta \cdot \tan\phi$$

- Ca, C, and FS same as gravity only

SEEPAGE PARALLEL TO THE SLOPE

$$W_P = \frac{\gamma_{moist} \cdot (h^2 - h_w^2) + h_w^2 \cdot \gamma_{sat}}{\sin 2\beta}$$

$$W_A = \gamma_{moist} \cdot \left[L \cdot h - \frac{h^2}{\cos\beta \cdot \sin\beta} + \frac{h^2 \cdot \tan\beta}{2} \right] + \gamma_{sat} t \cdot \left[\left(h_w \cdot \frac{2H \cdot \cos\beta - 2h}{\sin 2\beta} \right) + \left((h - h_w) \cdot h_w + \frac{h_w^2}{2} \right) \cdot \tan\beta \right]$$
$$- \gamma_{moist} \cdot \left[\left(h_w \cdot \frac{2H \cdot \cos\beta - 2h}{\sin 2\beta} \right) + \left((h - h_w) \cdot h_w + \frac{h_w^2}{2} \right) \cdot \tan\beta \right]$$

$$U_N = \gamma_w \cdot h \cdot \left(\frac{2 \cdot Hw \cdot \cos\beta - h}{\sin 2\beta \cdot \cos\beta} \right)$$

$$U_h = \frac{\gamma_w \cdot h_w^2}{2 \cos^2 \beta}$$

- Ca, C, and FS same as gravity only
- a, b, c, NA, EA, and EP same as horizontal seepage

SEISMIC FORCES

$$a = (C_s \cdot W_A + N_A \cdot \sin\beta) \cdot \cos\beta + C_s \cdot W_P \cdot \cos\beta$$

$$b = -[(C_s \cdot W_A + N_A \cdot \sin\beta) \cdot \sin\beta \cdot \tan\phi + (N_A \cdot \tan\delta + C_a) \cdot \cos^2 b + (C + W_P \cdot \tan\phi) \cdot \cos\beta]$$

$$c = (N_A \cdot \tan\delta + C_a) \cdot \cos\beta \cdot \sin\beta \cdot \tan\phi$$

- Wa, Wp, Na, Ca, C, and FS same as gravity only

Attachment B

References

Geosynthetics International, 2005, 12, No. 1

Analysis and design of veneer cover soils

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ABSTRACT: Cover soil sliding on slopes underlain by geosynthetics is obviously an unacceptable situation and, if the number of occurrences becomes excessive, can eventually reflect poorly on the entire technology. Steeply sloped leachate collection layers and final covers of landfills are situations where incidents of such sliding have occurred. Paradoxically, the analytic formulation of the situation is quite straightforward. This paper presents an analysis of the common problem of a veneer of cover soil (0.3 to 1.0 m thick) on a geosynthetic material at a given slope angle and length. The paper then presents different scenarios that create lower FS (factor of safety) -values than the gravitational stresses of the above situation, e.g. equipment loads, seepage forces and seismic loads. As a counterpoint, different scenarios that create higher FS-values also are presented, e.g. toe berms, tapered thicknesses and veneer reinforcement. In this latter category, a subdivision is made into intentional reinforcement (using geogrids or high-strength geotextiles) and non-intentional reinforcement (cases where geosynthetics overlay a weak interface within a multilined slope). A standard numeric example is used in each of the above situations to illustrate the various influences on the resulting FS-value. In many cases, design curves are also formulated. Suggested minimum FS-values are presented for final closures of landfills, waste piles, leach pads, etc., which are the situations where veneer slides of this type are the most serious. Hopefully, the paper will serve as a vehicle to bring a greater awareness to this situation so as to avert such slides from occurring in the future. Note: This paper was initially published as the Giroud Lecture in the *Proceedings of the Sixth International Geosynthetics Conference* held in Atlanta, USA, in 1998.

KEYWORDS: Geosynthetics, Analysis, Design, Limit equilibrium methods, Steep slopes, Veneer stability

REFERENCE: Koerner, R. M. & Soong, T-Y. (2005). Analysis and design of veneer cover soils. *Geosynthetics International*, Special Issue on the Giroud Lectures, 12, No. 1, 28–49

1. INTRODUCTION

There have been numerous cover soil stability problems in the past, resulting in slides that range from being relatively small (which can be easily repaired), to very large (involving litigation and financial judgments against the parties involved). Furthermore, the number of occurrences appears to have increased over the past few years. Soong and Koerner (1996) report on eight cover soil failures resulting from seepage-induced stresses alone. While such slides can occur in transportation and geotechnical applications, it is in the environmental applications area where they are most frequent. Specifically, the sliding of relatively thin cover soil layers (called 'veneer') above both geosynthetic and natural soil liners, i.e. geomembranes (GM), geosynthetic clay liners (GCL) and compacted clay liners (CCL), are the particular materials of concern. These situations represent a major challenge due (in part) to the following reasons:

- The underlying barrier materials generally represent a low interface shear strength boundary with respect to the soil placed above them.
- The liner system is oriented precisely in the direction of potential sliding.
- The potential shear planes are usually linear and are essentially uninterrupted along the slope.
- Liquid (water or leachate) cannot continue to percolate downward through the cross-section owing to the presence of the barrier material.

When such slopes are relatively steep and uninterrupted in

their length (which is the design goal for landfills, waste piles and surface impoundments so as to maximize containment space and minimize land area), the situation is exacerbated.

There are two specific applications in which cover soil stability has been difficult to achieve in light of this discussion;

- leachate collection soil placed above a GM, GCL and/or CCL along the sides of a landfill before waste is placed and stability achieved accordingly;
- final cover soil placed above a GM, GCL and/or CCL in the cap or closure of a landfill or waste pile after the waste has been placed to its permitted height.

For the leachate collection soil situation the time frame is generally short (from months to a few years), and the implications of a slide may be minor in that repairs can sometimes be done by on-site personnel. For the final cover soil situation the time frame is invariably long (from decades to centuries), and the implications of a slide can be serious in that repairs often call for a forensic analysis, engineering redesign, separately engaged contractors and quite high remediation costs. These latter cases sometime involve litigation, insurance carriers, and invariably technical experts, thus becoming quite contentious.

Since both situations (leachate collection and final covers) present the same technical issues, the paper will address them simultaneously. It should be realized, however, that the final cover situation is of significantly greater concern.

In the sections to follow, geotechnical engineering considerations will be presented leading to the goal of establishing a suitable factor of safety against slope instability. A number of common situations will then be analyzed, all of which have the tendency to decrease stability. A number of design options will follow, all of which have the objective of increasing stability. A summary and conclusions section will counterpoint the various situations which tend to either create slope instability or aid in slope stability. It is hoped that an increased awareness of the analysis and design details offered herein, and elsewhere, will lead to a significant decrease in the number of veneer cover soil slides that have occurred.

2. GEOTECHNICAL ENGINEERING CONSIDERATIONS

As just mentioned, the potential failure surface for veneer cover soils is usually linear with cover soil sliding with respect to the lowest interface friction layer in the underlying cross-section. The potential failure plane being linear allows for a straightforward stability calculation without the need for trial center locations and different radii, as with soil stability problems analyzed by rotational failure surfaces. Furthermore, full static equilibrium can be achieved without solving simultaneous equations or making simplified design assumptions.

2.1. Limit equilibrium concepts

The free body diagram of an infinitely long slope with uniformly thick cohesionless cover soil on an incipient planar shear surface, like the upper surface of a geomembrane, is shown in Figure 1. The situation can be treated quite simply. By taking force summation parallel to the slope and comparing the resisting force with the driving or mobilizing force, a global factor of safety (FS) results:

$$\mathrm{FS} = \frac{\sum \text{Resisting forces}}{\sum \text{Driving forces}} \tag{1a}$$

$$= \frac{N \tan\delta}{W \sin\beta} = \frac{W \cos\beta \tan\delta}{W \sin\beta}$$

Hence:

$$\mathrm{FS} = \frac{\tan\delta}{\tan\beta} \tag{1b}$$

Here it is seen that the FS-value is the ratio of tangents of the interface friction angle of the cover soil against the upper surface of the geomembrane (δ), and the slope angle of the soil beneath the geomembrane (β). As simple as this analysis is, its teachings are very significant. For example:

- To obtain an accurate FS-value, an accurately determined laboratory δ-value is absolutely critical. The accuracy of the final analysis is only as good as the accuracy of the laboratory-obtained δ-value.
- For low δ-values, the resulting soil slope angle will be proportionately low. For example, for a δ-value of 20°, and a required FS-value of 1.5, the maximum slope angle is 14°. This is equivalent to a 4(H) on 1(V) slope, which is relatively low. Furthermore, many geomembranes have even lower δ-values than 20°.
- This simple formula has driven geosynthetic manufacturers to develop products with high δ-values, e.g. textured geomembranes, thermally bonded drainage geocomposites, internally reinforced GCLs, etc.

Unfortunately, the above analysis is too simplistic to use in most realistic situations. For example, the following situations cannot be accommodated:

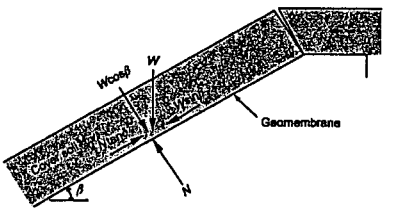

Figure 1. Limit equilibrium forces involved in an infinite slope analysis for a uniformly thick cohesionless cover soil

- a finite-length slope with the incorporation of a passive soil wedge at the toe of the slope;
- the incorporation of equipment loads on the slope;
- consideration of seepage forces within the cover soil;
- consideration of seismic forces acting on the cover soil;
- the use of soil masses acting as toe berms;
- the use of tapered covered soil thicknesses;
- reinforcement of the cover soil using geogrids or high-strength geotextiles.

These specific situations will be treated in subsequent sections. For each situation, the essence of the theory will be presented, followed by the necessary design equations. This will be followed, in each case, with a design graph and a numeric example. First, however, the important issue of interface shear testing will be discussed.

2.2. Interface shear testing

The interface shear strength of a cover soil with respect to the underlying material (often a geomembrane) is critical to properly analyze the stability of the cover soil. This value of interface shear strength is obtained by laboratory testing of the project-specific materials at the site-specific conditions. By project-specific materials, we mean sampling of the candidate geosynthetics to be used at the site, as well as the cover soil at its targeted density and moisture conditions. By site-specific conditions we mean normal stresses, strain rates, peak or residual shear strengths and temperature extremes (high and/or low). Note that it is completely inappropriate to use values of interface shear strengths from the literature for final cover soil design.

While the above list of items is formidable, at least the type of test is established. It is the direct shear test which has been utilized in geotechnical engineering testing for many years. The test has been adapted to evaluate geosynthetics and is designated as ASTM D5321 or ISO 12957.

In conducting a direct shear test on a specific interface, one typically performs three replicate tests, with the only variable being different values of normal stress. The middle value is usually targeted to the site-specific condition, with a lower and higher value of normal stress covering the range of possible values. These three tests result in a set of shear displacement against shear stress curves: see Figure 2a. From each curve, a peak shear strength (τ_p) and a residual shear strength (τ_r) is obtained. As a next step, these shear strength values, together with their respective normal stress values, are plotted in Mohr–Coulomb stress space to obtain the shear strength parameters of friction and adhesion: see Figure 2b.

The points are then connected (usually with a straight line), and the two fundamental shear strength parameters are obtained. These shear strength parameters are: δ, the angle of shearing resistance, peak and/or residual, of the two opposing surfaces (often called the interface friction angle); and c_a, the adhesion of the two opposing surfaces, peak and/or residual (synonymous with cohesion when testing fine-grained soils).

Each set of parameters constitutes the equation of a

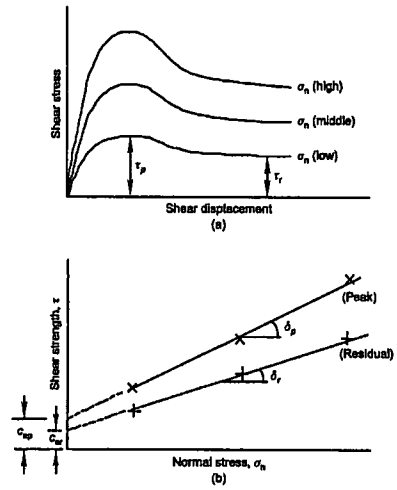

Figure 2. Direct shear test results and method of analysis to obtain shear strength parameters: (a) direct shear test data; (b) Mohr–Coulomb stress space

straight line, which is the Mohr–Coulomb failure criterion common to geotechnical engineering. The concept is readily adaptable to geosynthetic materials in the following form:

$$\tau_p = c_{sp} + \sigma_n \tan\delta_p \quad (2a)$$

$$\tau_r = c_{sr} + \sigma_n \tan\delta_r \quad (2b)$$

The upper limit of δ when soil is involved as one of the interfaces is ϕ, the angle of shearing resistance of the soil component. The upper limit of the c_a value is c, the cohesion of the soil component. In the slope stability analyses to follow, the c_a term will be included for the sake of completeness, but then it will be neglected (as being a conservative assumption) in the design graphs and numeric examples. To utilize an adhesion value, there must be a clear physical justification for the use of such values when geosynthetics are involved. Only unique situations such as textured geomembranes with physical interlocking of soils having cohesion, or the bentonite component of a GCL, are valid reasons for including such a term.

Note that residual strengths are equal to, or lower, than peak strengths. The amount of difference is very dependent on the material, and no general guidelines can be given. Clearly, material-specific and site-specific direct shear tests must be performed to determine the appropriate values. Further, each direct shear test must be conducted to a relatively large displacement to determine the residual behavior (Stark and Poeppel 1994). The decision as to the use of peak or residual strengths in the subsequent analy-

sis is a very subjective one. It is both a materials-specific and site-specific issue, which is left up to the designer and/or regulator. Even further, the use of peak values at the crest of a slope and residual values at the toe may be justified. As such, the analyses to follow will use an interface δ-value with no subscript, thereby concentrating on the computational procedures rather than this particular detail. However, the importance of an appropriate and accurate δ-value should not be minimized.

Owing to the physical structure of many geosynthetics, the size of the recommended shear box is quite large. It must be at least 300 mm by 300 mm, unless it can be shown that data generated by a smaller device contain no scale or edge effects, i.e. that no bias exists with a smaller shear box. The implications of such a large shear box should not be taken lightly. Some issues which should receive particular attention are the following:

- Unless it can be justified otherwise, the interface will usually be tested in a saturated state. Thus complete and uniform saturation over the entire specimen area must be achieved. This is particularly necessary for CCLs and GCLs (Daniel *et al.* 1993). Hydration takes relatively long in comparison with soils in conventional (smaller) testing shear boxes.
- Consolidation of soils (including CCLs and GCLs) in larger shear boxes is similarly affected.
- Uniformity of normal stress over the entire area must be maintained during consolidation and shearing so as to avoid stress concentrations from occurring.
- The application of relatively low normal stresses, e.g. 10 to 30 kPa simulating typical cover soil thicknesses, challenges the accuracy of some commercially available shear box setups and monitoring systems, particularly the accuracy of pressure gages.
- Shear rates necessary to attain drained conditions (if this is the desired situation) are extremely slow, requiring long testing times.
- Deformations necessary to attain residual strengths require large relative movement of the two respective halves of the shear box. So as not to travel over the edges of the opposing shear box sections, devices should have the lower shear box significantly longer than 300 mm. However, with a lower shear box longer than the upper traveling section, new surface is constantly being added to the shearing plane. This influence is not clear in the material's response or in the subsequent behavior.
- The attainment of a true residual strength is difficult to achieve. ASTM D5321 states that one should 'run the test until the applied shear force remains constant with increasing displacement'. Many commercially available shear boxes have insufficient travel to reach this condition.
- The ring torsion shearing apparatus is an alternative device to determine true residual strength values, but is not without its own problems. See Stark and Poeppel (1994) for information and data using this alternative test method.

2.3. Various types of loading

There are a large variety of slope stability problems that may be encountered in analyzing and/or designing final covers of engineered landfills, abandoned dumps and remediation sites as well as leachate collection soils covering geomembranes beneath the waste. Perhaps the most common situation is a uniformly thick cover soil on a geomembrane placed over the subgrade at a given and constant slope angle. This 'standard' problem will be analyzed in the next section. A variation of this problem will include equipment loads used during placement of cover soil on the geomembrane. This problem will be solved with equipment moving up the slope and then moving down the slope.

Unfortunately, cover soil slides have occurred, and it is felt that the majority of the slides have been associated with seepage forces. Indeed, drainage above a geomembrane (or other barrier material) in the cover soil cross-section must be accommodated to avoid the possibility of seepage forces. A section will be devoted to this class of slope stability problems.

Lastly, the possibility of seismic forces exists in earthquake-prone locations. If an earthquake occurs in the vicinity of an engineered landfill, abandoned dump or remediation site, the seismic wave travels through the solid waste mass, reaching the upper surface of the cover. It then decouples from the cover soil materials, producing a horizontal force, which must be appropriately analyzed. A section will be devoted to the seismic aspects of cover soil slope analysis as well.

All of the above actions are destabilizing forces tending to cause slope instability. Fortunately, there are a number of actions that can be taken to increase the stability of slopes.

Other than geometrically redesigning the slope with a flatter slope angle or shorter slope length, a designer can always use geogrids or high-strength geotextiles within the cover soil acting as reinforcement materials. This technique is usually referred to as 'veneer reinforcement'. Additionally, the designer can add soil mass at the toe of the slope, thereby enhancing stability. Both toe berms and tapered soil slopes are available options and will be analyzed accordingly.

Thus it is seen that a number of strategies influence slope stability. Each will be described in the sections to follow. First, the basic gravitational problem will be presented, followed by those additional loading situations which tend to decrease slope stability. Second, various actions that can be taken by the designer to increase slope stability will be presented. The summary will contrast the FS-values obtained in the similarly crafted numeric examples.

3. SITUATIONS CAUSING DESTABILIZATION OF SLOPES

This section treats the standard slope stability problem and then superimposes upon it a number of situations, all of which tend to destabilize slopes. Included are gravita-

tional, construction equipment, seepage and seismic forces. Each will be illustrated by a design graph and a numeric example.

3.1. Cover soil (gravitational) forces

Figure 3 illustrates the common situation of a finite length, uniformly thick cover soil placed over a liner material at a slope angle β. It includes a passive wedge at the toe and has a tension crack of the crest. The analysis that follows is after Koerner and Hwu (1991), but comparable analyses are available from Giroud and Beech (1989), McKelvey and Deutsch (1991) and others.

The symbols used in Figure 3 are defined as: W_A = total weight of the active wedge; W_P = total weight of the passive wedge; N_A = effective force normal to the failure plane of the active wedge; N_P = effective force normal to the failure plane of the passive wedge; γ = unit weight of the cover soil; h = thickness of the cover soil; L = length of slope measured along the geomembrane; β = soil slope angle beneath the geomembrane; ϕ = friction angle of the cover soil; δ = interface friction angle between cover soil and geomembrane; C_a = adhesive force between cover soil of the active wedge and the geomembrane; c_a = adhesion between cover soil of the active wedge and the geomembrane; C = cohesive force along the failure plane of the passive wedge; c = cohesion of the cover soil; E_A = interwedge force acting on the active wedge from the passive wedge; E_P = interwedge force acting on the passive wedge from the active wedge; and FS = factor of safety against cover soil sliding on the geomembrane.

The expression for determining the factor of safety can be derived as follows. Considering the active wedge:

$$W_A = \gamma h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) \quad (3)$$

$$N_A = W_A \cos\beta \quad (4)$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) \quad (5)$$

By balancing the forces in the vertical direction, the following formulation results:

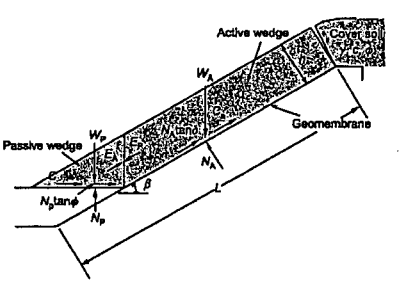

Figure 3. Limit equilibrium forces involved in a finite length slope analysis for a uniformly thick cover soil

$$E_A \sin\beta = W_A - N_A\cos\beta - \frac{N_A\tan\delta + C_a}{\mathrm{FS}}\sin\beta \quad (6)$$

Hence the interwedge force acting on the active wedge is

$$E_A = \frac{(\mathrm{FS})(W_A - N_A\cos\beta) - (N_A\tan\delta + C_a)\sin\beta}{\sin\beta(\mathrm{FS})} \quad (7)$$

The passive wedge can be considered in a similar manner:

$$W_P = \frac{\gamma h^2}{\sin 2\beta} \quad (8)$$

$$N_p = W_P + E_P\sin\beta \quad (9)$$

$$C = \frac{ch}{\sin\beta} \quad (10)$$

By balancing the forces in the horizontal direction, the following formulation results:

$$E_P\cos\beta = \frac{C + N_P\tan\phi}{\mathrm{FS}} \quad (11)$$

Hence the interwedge force acting on the passive wedge is

$$E_P = \frac{C + W_P\tan\phi}{\cos\beta(\mathrm{FS}) - \sin\beta\tan\phi} \quad (12)$$

By setting $E_A = E_P$, the resulting equation can be arranged in the form of the quadratic equation $ax^2 + bx + c = 0$, which in our case, using FS-values, is

$$a(\mathrm{FS})^2 + b(\mathrm{FS}) + c = 0 \quad (13)$$

where

$$\begin{aligned} a &= (W_A - N_A\cos\beta)\cos\beta \\ b &= -[(W_A - N_A\cos\beta)\sin\beta\tan\phi \\ &\quad + (N_A\tan\delta + C_a)\sin\beta\cos\beta \\ &\quad + \sin\beta(C + W_P\tan\phi)] \\ c &= (N_A\tan\delta + C_a)\sin^2\beta\tan\phi \end{aligned} \quad (14)$$

The resulting FS-value is then obtained from the solution of the quadratic equation:

$$\mathrm{FS} = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \quad (15)$$

When the calculated FS-value falls below 1.0, sliding of the cover soil on the geomembrane is to be anticipated. Thus a value of greater than 1.0 must be targeted as being the minimum factor of safety. How much greater than 1.0 the FS-value should be, is a design and/or regulatory issue. The issue of minimum allowable FS-values under different conditions will be assessed at the end of the paper. In order to better illustrate the implications of Equations 13, 14 and 15, typical design curves for various FS-values as a function of slope angle and interface friction angle are given in Figure 4. Note that the curves

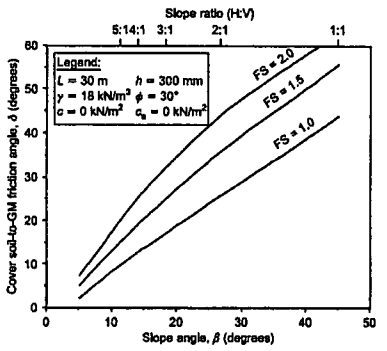

Figure 4. Design curves for stability of uniform-thickness cohesionless cover soils on linear failure planes for various global factors of safety

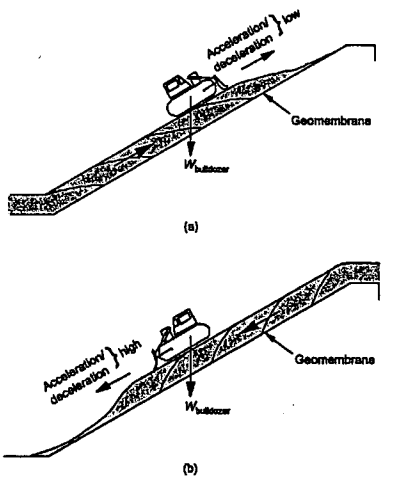

Figure 5. Construction equipment placing cover soil on slopes containing geosynthetics: (a) equipment backfilling up slope (the recommended method); (b) equipment backfilling down slope (method not recommended)

are developed specifically for the variables stated in the legend of the figure. Example 1 illustrates the use of the curves in what will be the standard example to which other examples will be compared.

Example 1

Given a 30 m long slope with a uniformly thick 300 mm cover soil at a unit weight of 18 kN/m^3. The soil has a friction angle of 30° and zero cohesion, i.e. it is a sand. The cover soil is placed directly on a geomembrane as shown in Figure 3. Direct shear testing has resulted in an interface friction angle between the cover soil and geomembrane of 22° with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e. 18.4°?

Substituting Equation 14 into Equation 15 and solving for the FS-value results in the following, which is seen to be in agreement with the curves of Figure 4:

$$\left.\begin{aligned} a &= 14.7\,\text{kN/m} \\ b &= -21.3\,\text{kN/m} \\ c &= 3.5\,\text{kN/m} \end{aligned}\right\} \text{FS} = 1.25$$

In general, this is too low a value for a final cover soil factor of safety, and a redesign is necessary. While there are many possible options for changing the geometry of the situation, the example will be revisited later in this section using toe berms, tapered cover soil thickness and veneer reinforcement. Furthermore, this general problem will be used throughout the main body of this paper for comparison purposes to other cover soil slope stability situations.

3.2. Construction equipment forces

The placement of cover soil on a slope with a relatively low shear strength inclusion (like a geomembrane) should always be from the toe upward to the crest. Figure 5a shows the recommended method. In so doing, the gravitational forces of the cover soil and live load of the construction equipment are compacting previously placed soil and working with an ever-present passive wedge and stable lower portion beneath the active wedge. While it is necessary to specify low ground pressure equipment to place the soil, the reduction of the FS-value for this situation of equipment working up the slope will be seen to be relatively small.

For soil placement down the slope, however, a stability analysis cannot rely on toe buttressing, and a dynamic stress should also be included in the calculation. These conditions decrease the FS-value, in some cases to a great extent. Figure 5b shows this procedure. Unless absolutely necessary, it is not recommended to place cover soil on a slope in this manner. If it is necessary, the design must consider the unsupported soil mass and the dynamic force of the specific type of construction equipment and its manner of operation.

For the first case of a bulldozer pushing cover soil up from the toe of the slope to the crest, the analysis uses the free body diagram of Figure 6a. The analysis uses a specific piece of construction equipment (like a bulldozer characterized by its ground contact pressure) and dissipates this force or stress through the cover soil thickness to the surface of the geomembrane. A Boussinesq analysis is used (Poulos and Davis 1974). This results in an equipment force per unit width as follows:

$$W_e = qwI \tag{16}$$

where W_e = equivalent equipment force per unit width at the geomembrane interface; $q = W_b/(2 \times w \times b)$; W_b = actual weight of equipment (e.g. a bulldozer); w = length of equipment track; b = width of equipment track; and

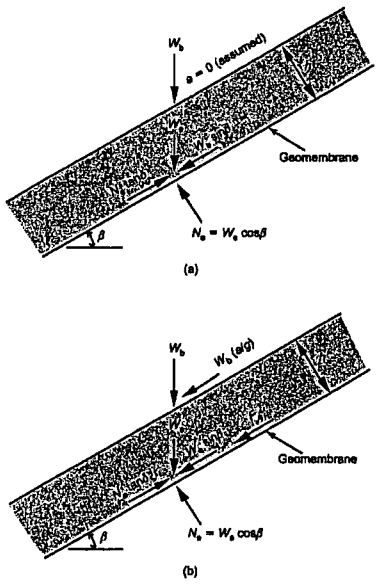

Figure 6. Additional (to gravitational forces) limit equilibrium forces due to construction equipment moving on cover soil (see Figure 3 for the gravitational soil force to which the above forces are added): (a) equipment moving up slope (load with no acceleration); (b) equipment moving down slope (load plus acceleration)

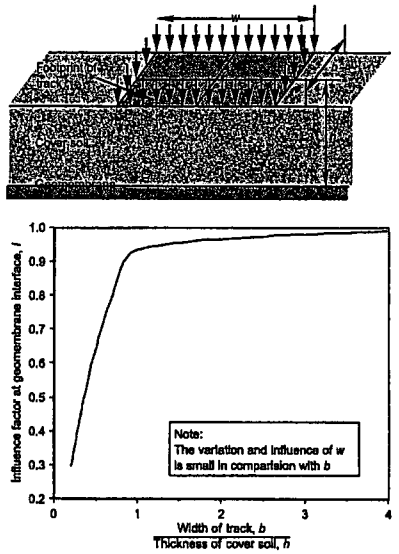

Figure 7. Values of influence factor I for use in Equation 16 to dissipate surface force through cover soil to geomembrane interface (after Poulos and Davis 1974)

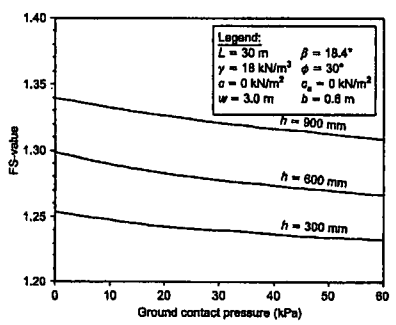

Figure 8. Design curves for stability of different thickness of cover soil for various construction equipment ground contact pressures

I = influence factor at the geomembrane interface (see Figure 7).

Upon determining the additional equipment force at the interface between cover soil and geomembrane, the analysis proceeds as described in Section 3.1 for gravitational forces only. In essence, the equipment moving up the slope adds an additional term, W_a, to the W_A-force in Equation 3. Note, however, that this involves the generation of a resisting force as well. Thus the net effect of increasing the driving force as well as the resisting force is somewhat neutralized insofar as the resulting FS-value is concerned. It should also be noted that no acceleration/deceleration forces are included in this analysis, which is somewhat optimistic. Using these concepts (the same equations as used in Section 3.1 are used here), typical design curves for various FS-values as a function of equivalent ground contact equipment pressures and cover soil thicknesses are given in Figure 8. Note that the curves are developed specifically for the variables stated in the legend. Example 2a illustrates the use of the formulation.

Example 2a

Given a 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m³. The soil has a friction angle of 30° and zero cohesion, i.e. it is a sand. It is placed on the slope using a bulldozer moving from the toe of the slope up to the crest. The bulldozer has a ground pressure of 30 kN/m² and tracks that are 3.0 m long and 0.6 m wide. The cover soil to geomembrane friction angle is 22° with zero adhesion. What is the FS-value at a slope angle 3(H)-to-1(V), i.e. 18.4°?

This problem follows Example 1 exactly except for the addition of the bulldozer moving up the slope. Using the additional equipment load, Equation 16 substituted into Equations 14 and 15 results in the following:

$$\left.\begin{aligned} a &= 73.1\,\text{kN/m} \\ b &= -104.3\,\text{kN/m} \\ c &= 17.0\,\text{kN/m} \end{aligned}\right\} \text{FS} = 1.24$$

While the resulting FS-value is low, the result is best assessed by comparing it with Example 1, i.e. the same problem but without the bulldozer. It is seen that the FS-value has only decreased from 1.25 to 1.24. Thus, in general, a low ground contact pressure bulldozer placing cover soil up the slope with negligible acceleration/deceleration forces does not significantly decrease the factor of safety.

For the second case of a bulldozer pushing cover soil down from the crest of the slope to the toe, as shown in Figure 5b, the analysis uses the force diagram of Figure 6b. While the weight of the equipment is treated as just described, the lack of a passive wedge along with an additional force due to acceleration (or deceleration) of the equipment significantly modifies the resulting FS-values. This analysis again uses a specific piece of construction equipment operated in a specific manner. It produces a force parallel to the slope equivalent to W_b (a/g), where W_b = the weight of the bulldozer, a = the acceleration of the bulldozer, and g = the acceleration due to gravity. Its magnitude is equipment operator dependent and related to both the equipment speed and the time to reach such a speed; see Figure 9.

The acceleration of the bulldozer, coupled with an influence factor I from Figure 7, results in the dynamic force per unit width at the interface between cover soil and geomembrane, F_e. The relationship is as follows:

$$F_e = W_e\left(\frac{a}{g}\right) \tag{17}$$

where F_e = dynamic force per unit width parallel to the slope at the geomembrane interface; W_e = equivalent equipment (bulldozer) force per unit width at geomembrane interface (recall Equation 16); β = soil slope angle beneath geomembrane; a = acceleration of the bulldozer; and g = acceleration due to gravity.

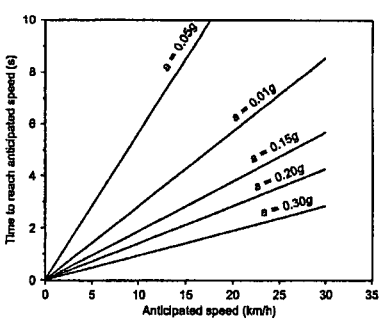

Figure 9. Graphic relationship of construction equipment speed and rise time to obtain equipment acceleration

Using these concepts, the new force parallel to the cover soil surface is dissipated through the thickness of the cover soil to the interface of the geomembrane. Again, a Boussinesq analysis is used (Poulos and Davis 1974). The expression for determining the FS-value can now be derived as follows.

Considering the active wedge, and balancing the forces in the direction parallel to the slope, the following formulation results:

$$E_A + \frac{(N_e + N_A)\tan\delta + C_a}{\text{FS}} = (W_A + W_e)\sin\beta + F_e \tag{18}$$

where N_e = effective equipment force normal to the failure plane of the active wedge according to

$$N_e = W_e\cos\beta \tag{19}$$

Note that all the other symbols have been previously defined.

The interwedge force acting on the active wedge can now be expressed as

$$E_A = (W_A + W_e)\sin\beta + F_e - \frac{(N_e + N_A)\tan\delta + C_a}{\text{FS}} \tag{20}$$

The passive wedge can be treated in a similar manner. The following formulation of the interwedge force acting on the passive wedge results:

$$E_P = \frac{C + W_P\tan\phi}{\cos\beta(\text{FS}) - \sin\beta\tan\phi} \tag{21}$$

By setting $E_A = E_P$, the following terms can be arranged in the form of Equation 13, in which the a, b and c terms are defined as follows:

$$\begin{aligned} a &= [(W_A + W_e)\sin\beta + F_e]\cos\beta \\ b &= -\{[(N_e + N_A)\tan\delta + C_a]\cos\beta \\ &\quad + [(W_A + W_e)\sin\beta + F_e]\sin\beta\tan\phi \\ &\quad + (C + W_P\tan\phi)\} \\ c &= [(N_e + N_A)\tan\delta + C_a]\sin\beta\tan\phi \end{aligned} \tag{22}$$

Finally, the resulting FS-value can be obtained using Equation 15. Using these concepts, typical design curves for various FS-values as a function of equipment ground contact pressure and equipment acceleration can be developed; see Figure 10. Note that the curves are developed specifically for the variables stated in the legend. Example 2b illustrates the use of the formulation.

Example 2b

Given a 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m^3. The soil has a friction angle of 30° and zero cohesion, i.e. it is a

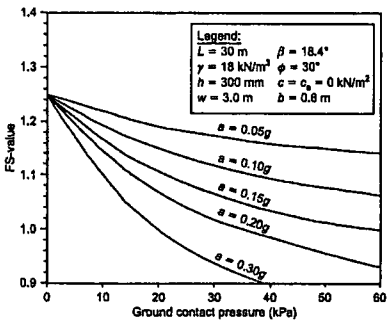

Figure 10. Design curves for stability of different construction equipment ground contact pressure for various equipment accelerations

sand. It is placed on the slope using a bulldozer moving from the crest of the slope down to the toe. The bulldozer has a ground contact pressure of 30 kN/m^2 and tracks that are 3.0 m long and 0.6 m wide. The estimated equipment speed is 20 km/h and the time to reach this speed is 3.0 s. The cover soil to geomembrane friction angle is 22° with zero adhesion. What is the FS-value at a slope angle of 3(H)-1(V), i.e. 18.4°?

First, using the design curves of Figure 10 along with Equations 22 substituted into Equation 15 the solution can be obtained:

- From Figure 9 at 20 km/h and 3.0 s the bulldozer's acceleration is 0.19g.
- From Equations 22 substituted into Equation 15 we obtain

$$\left.\begin{aligned} a &= 88.8\,\text{kN/m} \\ b &= -107.3\,\text{kN/m} \\ c &= 17.0\,\text{kN/m} \end{aligned}\right\} \text{FS} = 1.03$$

This problem solution can now be compared with the previous two examples:

Example 1: cover soil with no bulldozer loading FS = 1.25
Example 2a: cover soil plus bulldozer moving up slope FS = 1.24
Example 2b: cover soil plus bulldozer moving down slope FS = 1.03

The inherent danger of a bulldozer moving down the slope is readily apparent. Note that the same result comes about by the bulldozer decelerating instead of accelerating. The sharp braking action of the bulldozer is arguably the more severe condition owing to the extremely short times involved when stopping forward motion. Clearly, only in unavoidable situations should the cover soil placement equipment be allowed to work down the slope. If it is unavoidable, an analysis should be made of the specific stability situation, and the construction specifications should reflect the exact conditions made in the design. The maximum weight and ground contact pressure of the equipment should be stated, along with suggested operator movement of the cover soil placement operations. Truck traffic on the slopes can also give as high, or even higher, stresses, and should be avoided in all circumstances.

3.3. Consideration of seepage forces

The previous sections presented the general problem of slope stability analysis of cover soils placed on slopes under different conditions. The tacit assumption throughout was that either permeable soil or a drainage layer was placed above the barrier layer with adequate flow capacity to efficiently remove permeating water safely away from the cross-section. The amount of water to be removed is obviously a site-specific situation. Note that in extremely arid areas, or with very low-permeability cover soils, drainage may not be required, although this is generally the exception.

Unfortunately, adequate drainage of final covers has sometimes not been available, and seepage-induced slope stability problems have occurred. The following situations have resulted in seepage-induced slides:

- drainage soils with hydraulic conductivity (permeability) too low for site-specific conditions;
- inadequate drainage capacity at the toe of long slopes where seepage quantities accumulate and are at their maximum;
- fines from quarried drainage stone either clogging the drainage layer or accumulating at the toe of the slope, thereby decreasing the as-constructed permeability over time;
- fine, cohesionless, cover soil particles migrating through the filter (if one is present) either clogging the drainage layer or accumulating at the toe of the slope, thereby decreasing the as-constructed outlet permeability over time;
- freezing of the drainage layer at the toe of the slope, while the top of the slope thaws, thereby mobilizing seepage forces against the ice wedge at the toe.

If seepage forces of the types described occur, a variation in slope stability design methodology is required. Such an analysis is the focus of this subsection. Additional discussion is given by Thiel and Stewart (1993) and Soong and Koerner (1996).

Consider a cover soil of uniform thickness placed directly above a geomembrane at a slope angle β as shown in Figure 11. Different from the previous examples, however, is that within the cover soil there exists a saturated soil zone for part or all of the thickness. The saturated boundary is shown as two possibly different phreatic surface orientations. This is because seepage can be built up in the cover soil in two different ways: a horizontal build-up from the toe upward, or a parallel-to-slope build-up outward. These two hypotheses are defined and

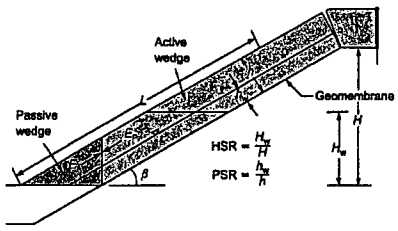

Figure 11. Cross-section of uniform thickness cover soil on geomembrane illustrating different submergence assumptions and related definitions (Soong and Koerner 1996)

quantified as a horizontal submergence ratio (HSR) and a parallel submergence ratio (PSR). The dimensional definitions of both ratios are given in Figure 11.

When analyzing the stability of slopes using the limit equilibrium method, free body diagrams of the passive and active wedges are taken with the appropriate forces (now including porewater pressures) being applied. Note that the two interwedge forces, E_A and E_P, are also shown in Figure 11. The formulation for the resulting factor of safety, for horizontal seepage build-up and then for parallel-to-slope seepage build-up, follows.

3.3.1. *Horizontal seepage build-up*

Figure 12 shows the free body diagram of both the active and passive wedge assuming horizontal seepage building. All symbols used in Figure 12 were previously defined except the following: $\gamma_{sat'd}$ = saturated unit weight of the cover soil; γ_{dry} = dry unit weight of the cover soil; γ_w = unit weight of water; H = vertical height of the slope measured from the toe; H_w = vertical height of the free water surface measured from the toe; U_h = resultant of the pore pressures acting on the interwedge surfaces; U_n = resultant of the pore pressures acting perpendicular to the slope; and U_v = resultant of the vertical pore pressures acting on the passive wedge.

The expression for finding the factor of safety can be derived as follows. Considering the active wedge:

$$W_A = \frac{\gamma_{sat'd}(h)(2H_w\cos\beta - h)}{\sin 2\beta} + \frac{\gamma_{dry}(h)(H - H_w)}{\sin\beta} \tag{23}$$

$$U_n = \frac{\gamma_w(h)(\cos\beta)(2H_w\cos\beta - h)}{\sin 2\beta} \tag{24}$$

$$U_h = \frac{\gamma_w h^2}{2} \tag{25}$$

$$N_A = W_A\cos\beta + U_h\sin\beta - U_n \tag{26}$$

The interwedge force acting on the active wedge can then be expressed as

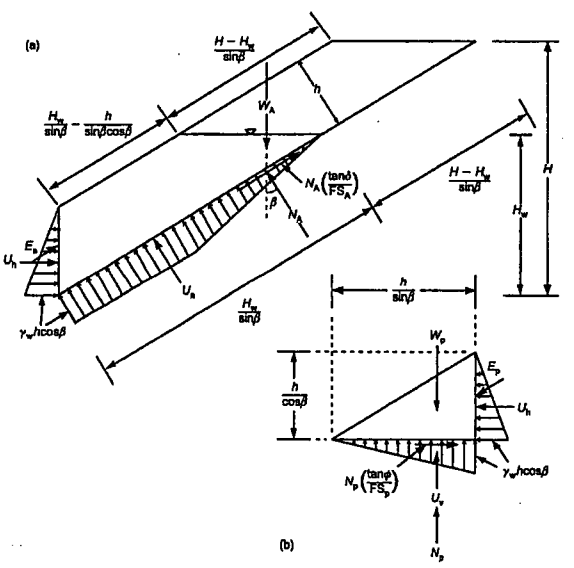

Figure 12. Limit equilibrium forces involved in finite-length slope of uniform cover soil with horizontal seepage build-up: (a) active wedge; (b) passive wedge

$$E_A = W_A \sin\beta - U_h \cos\beta - \frac{N_A \tan\delta}{FS} \quad (27)$$

The passive wedge can be considered in a similar manner, and the following expressions result:

$$W_P = \frac{\gamma_{sat'd} h^2}{\sin 2\beta} \quad (28)$$

$$U_V = U_h \cot\beta \quad (29)$$

The interwedge force acting on the passive wedge can then be expressed as

$$E_P = \frac{U_h(FS) - (W_P - U_V)\tan\phi}{\sin\beta\tan\phi - \cos\beta(FS)} \quad (30)$$

By setting $E_A = E_P$, the following terms can be arranged in the form $ax^2 + bx + c = 0$, which in this case is given by Equation 13, where:

$$\left.\begin{aligned} a &= W_A \sin\beta\cos\beta - U_h\cos^2\beta + U_h \\ b &= -W_A \sin^2\beta\tan\phi + U_h \sin\beta\cos\beta\tan\phi \\ &\quad - N_A\cos\beta\tan\delta - (W_P - U_V)\tan\phi \\ c &= N_A \sin\beta\tan\delta\tan\phi \end{aligned}\right\} \quad (31)$$

As with the previous solution, the resulting FS-value is obtained using Equation 15.

3.3.2. *Parallel-to-slope seepage build-up*

Figure 13 shows the free body diagrams of both the active and passive wedges with seepage build-up in the direction parallel to the slope. Identical symbols as defined in the previous cases are used here, with an additional definition of h_w equal to the height of free water surface measured in the direction perpendicular to the slope.

Note that the general expression of factor of safety shown in Equation 15 is still valid. However, the a, b and c terms shown in Equation 31 have different definitions in this case owing to the new definitions of the following terms:

$$W_A = \frac{\gamma_{dry}(h - h_w)[2H\cos\beta - (h + h_w)]}{\sin 2\beta} + \frac{\gamma_{sat'd} h_w (2H\cos\beta - h_w)}{\sin 2\beta} \quad (32)$$

$$U_n = \frac{\gamma_w h_w \cos\beta(2H\cos\beta - h_w)}{\sin 2\beta} \quad (33)$$

$$U_h = \frac{\gamma_w h_w^2}{2} \quad (34)$$

$$W_P = \frac{\gamma_{dry}(h^2 - h_w^2) + \gamma_{sat'd} h_w^2}{\sin 2\beta} \quad (35)$$

In order to illustrate the behavior of these equations, the design curves of Figure 14 have been developed. They show the decrease in FS-value with increasing submer-

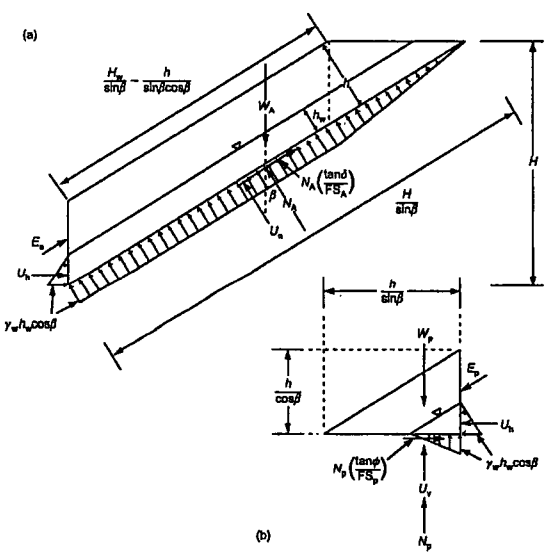

Figure 13. Limit equilibrium forces involved in finite-length slope of uniform cover soil with parallel-to-slope seepage build-up: (a) active wedge; (b) passive wedge

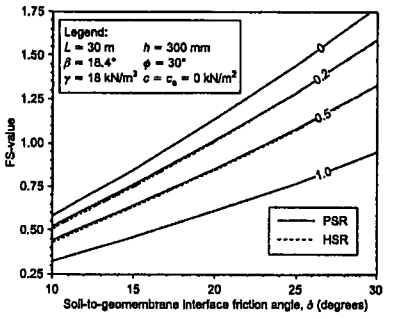

Figure 14. Design curves for stability of cohesionless, uniform thickness cover soils for different submergence ratios

gence ratio for all values of interface friction. Furthermore, the differences in response curves for the parallel and horizontal submergence ratio assumptions are seen to be very small. Note that the curves are developed specifically for variables stated in the legend. Example 3 illustrates the use of the design curves.

Example 3

Given a 30 m long slope with a uniform thickness cover soil of 300 mm at a dry unit weight of 18 kN/m^3. The soil has a friction angle of 30° and zero cohesion, i.e. it is a sand. The soil becomes saturated through 50% of its thickness, i.e. it is a parallel seepage problem with PSR = 0.5, and its saturated unit weight increases to 21 kN/m^3. Direct shear testing has resulted in an interface friction angle of 22° with zero adhesion. What is the factor of safety at a slope of 3(H)-to-1(V), i.e. 18.4°?

Solving Equations 31 with the values of Equations 32 to 35 for the a, b and c terms and substituting them into Equation 15 results in the following:

$$\left.\begin{aligned} a &= 51.7\,\text{kN/m} \\ b &= -57.8\,\text{kN/m} \\ c &= 9.0\,\text{kN/m} \end{aligned}\right\} \text{FS} = 0.93$$

The seriousness of seepage forces in a slope of this type is immediately obvious. Had the saturation been 100% of the drainage layer thickness, the FS-value would have been even lower. Furthermore, the result using a horizontal assumption of saturated cover soil with the same saturation ratio will give identically low FS-values. Clearly, the teaching of this example problem is that adequate *long-term* drainage above the barrier layer in cover soil slopes must be provided to avoid seepage forces from occurring.

3.4. Consideration of seismic forces

In areas of anticipated earthquake activity, the slope stability analysis of a final cover soil over an engineered landfill, abandoned dump or remediated site must consider seismic forces. In the United States, the Environmental Protection Agency (EPA) regulations require such an analysis for sites that have a probability of ≥ 10% of experiencing a 0.10g peak horizontal acceleration within 250 years. For the continental USA this includes not only the western states, but major sections of the midwest and northeast states, as well. If practiced worldwide, such a criterion would have huge implications.

The seismic analysis of cover soils of the type under consideration in this report is a two-part process:

- An FS-value is calculated using a pseudo-static analysis via the addition of a horizontal force acting at the centroid of the cover soil cross-section.
- If the FS-value in the above calculation is less than 1.0, a permanent deformation analysis is required. The calculated deformation is then assessed in light of the potential damage to the cover soil section, and either it is accepted, or the slope requires an appropriate redesign. The redesign is then analyzed until the situation becomes acceptable.

The first part of the analysis is a pseudo-static approach which follows the previous examples except for the addition of a horizontal force at the centroid of the cover soil in proportion to the anticipated seismic activity. It is first necessary to obtain an average seismic coefficient (C_s) from a seismic zone map (e.g. Algermissen 1969). Such maps are available on a worldwide basis. The value of C_s is non-dimensional and is a ratio of the bedrock acceleration to gravitational acceleration. This value of C_s is modified using available computer codes such as SHAKE (Schnabel *et al.* 1972), for propagation to the site and then to the landfill cover as shown in Figure 15. The computational process within such programs is quite intricate. For detailed discussion see Seed and Idriss (1982) and Idriss (1990). The analysis is then similar to those previously presented.

Using Figure 15, the additional seismic force is C_3W_A acting horizontally on the active wedge. All additional symbols used in Figure 15 have been previously defined, and the expression for finding the FS-value can be derived as follows.

Considering the active wedge, by balancing the forces

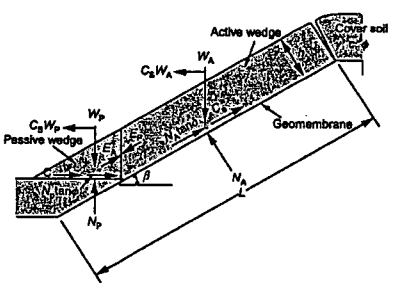

Figure 15. Limit equilibrium forces involved in pseudo-static analysis using average seismic coefficient

Golder Associates	SUBJECT: PJP Landfill –Veneer Stability Analysis		
	Job No.: 003-6004.002	Made by: JZ	Date: 3/28/2007
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		Reviewed:	

in the horizontal direction, the following formulation results:

$$E_A \cos\beta + \frac{(N_A \tan\delta + C_a)\cos\beta}{\text{FS}} = C_S W_A + N_A \sin\beta \tag{36}$$

Hence the interwedge force acting on the active wedge results:

$$E_A = \frac{(\text{FS})(C_S W_A + N_A \sin\beta)}{(\text{FS})\cos\beta} - \frac{(N_A \tan\delta + C_a)\cos\beta}{(\text{FS})\cos\beta} \tag{37}$$

The passive wedge can be considered in a similar manner, and the following formulation results:

$$E_P \cos\beta + C_S W_P = \frac{C + N_P \tan\phi}{\text{FS}} \tag{38}$$

Hence the interwedge force acting on the passive wedge is

$$E_P = \frac{C + W_P \tan\phi - C_S W_P(\text{FS})}{(\text{FS})\cos\beta - \sin\beta\tan\phi} \tag{39}$$

Again, by setting $E_A = E_P$, the following equation can be arranged in the form $ax^2 + bx + c = 0$, which in this case is given by Equation 13 where:

$$\begin{aligned} a &= (C_S W_A + N_A \sin\beta)\cos\beta + C_S W_P \beta \\ b &= -[(C_S W_A + N_A \sin\beta)\sin\beta\tan\phi \\ &\quad + (N_A \tan\delta + C_a)\cos^2\beta + (C + W_P \tan\phi)\cos\beta] \\ c &= (N_A \tan\delta + C_a)\cos\beta\sin\beta\tan\phi \end{aligned} \tag{40}$$

The resulting FS-value is then obtained from Equation 15.

Using these concepts, a design curve for the general problem under consideration as a function of seismic coefficient can be developed; see Figure 16. Note that the curve is developed specifically for the variables stated in the legend. Example 4a illustrates the use of the curve.

Example 4a

Given a 30 m long slope with uniform thickness cover soil of 300 mm at a unit weight of 18 kN/m³. The soil has a friction angle of 30° and zero cohesion, i.e. it is a sand. The cover soil is on a geomembrane, as shown in Figure 15. Direct shear testing has resulted in an interface friction angle of 22° with zero adhesion. The slope angle is 3(H)-to-1(V), i.e. 18.4°. A design earthquake appropriately transferred to the site's cover soil results in an average seismic coefficient of 0.10. What is the FS-value?

Solving Equations 40 for the values given in the example and substituting into Equation 15 results in the following FS-value:

$$\left.\begin{aligned} a &= 59.6\,\text{kN/m} \\ b &= -66.9\,\text{kN/m} \\ c &= 10.4\,\text{kN/m} \end{aligned}\right\} \text{FS} = 0.94$$

Note that the value of FS = 0.94 agrees with the design curve of Figure 16 at a seismic coefficient of 0.10.

Had the above FS-value been greater than 1.0, the analysis would be complete, the assumption being that cover soil stability can withstand the short-term excitation of an earthquake and still not slide. However, since the value in this example is less than 1.0, a second part of the analysis is required.

The second part of the analysis is directed toward calculating the estimated deformation of the lowest shear strength interface in the cross-section under consideration. The deformation is then assessed in light of the potential damage that may be imposed on the system.

To begin the permanent deformation analysis, a yield acceleration, C_{sy}, is obtained from a pseudo-static analysis under an assumed FS = 1.0. Figure 16 illustrates this procedure for the assumptions stated in the legend. It results in a value of $C_{sy} = 0.075$. Coupling this value with the time history response obtained for the actual site location and cross-section results in a comparison as shown in Figure 17a. If the earthquake time history response never exceeds the value of C_{sy}, there is no anticipated permanent deformation. However, whenever any part of the time history exceeds the value of C_{sy}, permanent deformation is expected. By double integration of the acceleration time history curve, to velocity (Figure 17b) and then to displacement (Figure 17c), the anticipated value of deformation can be obtained. It is usually based on residual stresses of the interface involved, but this may be excessively conservative (Matasovic *et al.* 1997). This value is considered to be permanent deformation and is then assessed based on the site-specific implications of damage to the final cover system. Example

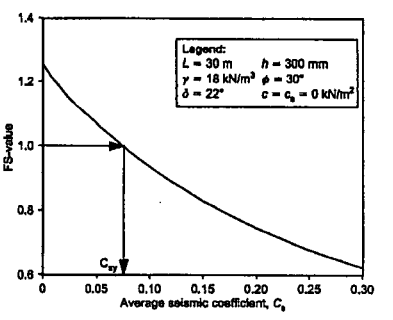


Figure 16. Design curve for a uniformly thick cover soil pseudo-static seismic analysis with varying average seismic coefficients

APPENDIX F-3

SETTLEMENT ANALYSES

Golder Associates	SUBJECT: PJP Landfill – Localized Subsidence		
	Job No.: 003-6004.002	Made by: JCA	Date: 3/12/07
	Ref.:	Checked: JE	Sheet 1 of 6
		Reviewed:	

OBJECTIVE: Evaluate the affect localized subsidence will have on the geomembrane cap.

METHOD:

1. Stress Analysis: Use the method presented in Reference 1 to calculate the factor of safety with respect to the yield stress of the geomembrane.

2. Strain Analysis: Use the method as presented in Reference 2, Section 11.5, to evaluate the amount of distortion the geomembrane can withstand before exceeding yield strain.

REFERENCES:

1. "Stability and Tension Considerations Regarding Cover Soils on Geomembrane Lined Slopes," Koerner and Hwu, Design and Construction of RCRA/CERCLA Final Covers/EPA/625/4-91/025, USEPA, May 1991.
2. "Geotechnical Aspects of Landfill Design and Construction"; Qian, Koerner, and Gray; Prentice Hall, Inc., 2002.
3. GSE published product data.

ASSUMPTIONS: As stated in the calculations.

CALCULATIONS:

1. Stress Analysis:

From Reference 1, the required strength of geomembrane is:

$$\sigma reqd = \frac{2*D*L^2*\gamma cs*Hcs}{3*t*(D^2+L^2)}$$

Where:

D = 1.0 ft;
L = 3.0 ft;
γcs = 120 pcf;
Hcs = 1.5 ft; and,
t = 40-mil = 0.04 in.

$$\sigma reqd = \frac{2\cdot 1\cdot 3^2\cdot 120\cdot 1.5}{3\cdot(0.04/12)\cdot(1^2+3^2)} = 32{,}400 \text{ psf} = 225 \text{ psi}$$

For a 40-mil textured High Density Polyethylene (HDPE) geomembrane (i.e., GSE 40-mil textured HDPE), the strength at yield (σy) is 84 lb/in-width (2,100 psi).

Assuming a reduction factor (RF) of 3 to determine the allowable stress:

$$\sigma all = (\sigma y / RF) = (2{,}100 / 3) = 700 \text{ psi.}$$

Calculate the factor of safety (FS):

$$FS = (\sigma all) / (\sigma reqd) = (700)/(225) = 3.1.$$

2. Strain Analysis

From Reference 2, Section 11.5, the strain analysis consists of defining a Distortion factor (Ψ) as the settlement (Y) divided by a length (L1). The allowable distortion value is calculated based on the strain at yield (12%) for the 40-mil textured HD geomembrane. The maximum Distortion the geomembrane can withstand before yielding is calculated to be 50.44%. The specific condition address in the Stress Analysis indicates a Distortion of 33.3%.

The Distortion calculations also indicate that the maximum distortion is a constant value for a given yield strain.

CONCLUSIONS: The typical 40-mil textured geomembrane should provide adequate stress and strain qualities to perform under the assumed design conditions.

The use of a Distortion value will allow maintenance personnel to measure any combination of actual settlement and actual length to evaluate if the geomembrane is at risk of damage due to yielding.

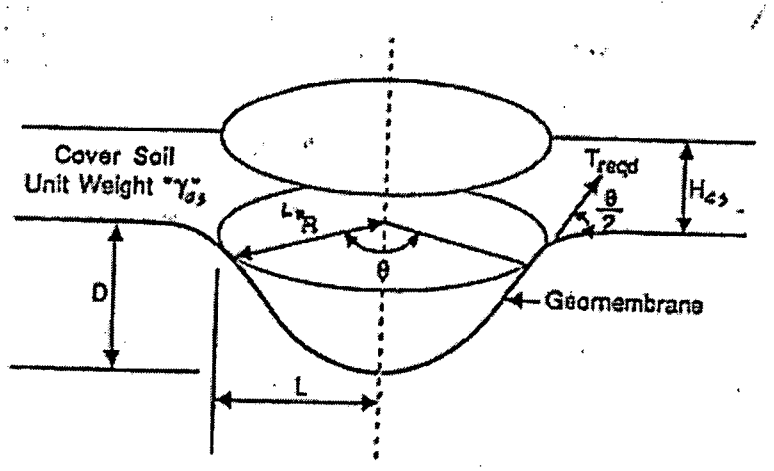
From Reference 1

Model #4: Geomembrane Tension Stresses Due to Subsidence

Whenever subsidence occurs beneath a geomembrane and it is supporting a cover soil some induced tensile stresses will occur due to out-of-plane forces from the overburden. Such subsidence is actually to be expected in closure situations above completed or abandoned landfills where the underlying waste is generally poorly compacted. The magnitude of the induced tensile stresses in the geomembrane depends upon the dimensions of the subsidence zone and on the cover soil properties.

The general scheme is shown in Figure 7 where the critical assumption is the shape of the deformed geomembrane. In the analysis which is provided in Appendix "D", the deformed shape is that of a spheroid of gradually decreasing center point along the symmetric axis of the deformed geomembrane.[9] As a worst case assumption, the geomembrane is assumed to be fixed at the circumference of the subsidence zone. The required tensile force in the geomembrane can be solved in terms of a force per unit width "T_{reqd}", or as a stress, i.e. "σ_{reqd}". The latter will be used in this analysis since it will be compared to a laboratory test method resulting in the compatible term. The necessary design equation is as follows where the specific terms are given in Figure 7.

$$\sigma_{reqd} = \frac{2\,DL^2\,\gamma_{cs}\,H_{cs}}{3\,t\,(D^2+L^2)} \qquad (8)$$



From Reference 1 (cont.)

Upon calculating the value of σ_{reqd} for the site specific situation under consideration, it is compared to an appropriate laboratory simulation test. Recommended at this time is a three-dimensional, out-of-plane, tension test of the same configuration as Figure 6. It is available as GRI Test Method GM-4.[10] Thus the formulation for the final factor-of-safety becomes the following:

$$FS = \sigma_{allow}/\sigma_{reqd} \qquad (7)$$

Since the value of σ_{allow} is used directly from the test method without any reduction in the form of partial factors-of-safety, relatively conservative values should be required. An example problem follows:

Example Problem: Given the same cover soil situation as in the previous example, except now a local subsidence occurs which is estimated to be 1.0 ft deep by 3.0 ft radius. The geomembrane is 40 mils thick has a σ_{allow} of 1000 lb/in^2. Determine the factor-of-safety of the geomembrane against the mobilized tensile stresses.

Solution:

$$\sigma_{reqd} = \frac{2\,DL^2\,\gamma_{cs}\,H_{cs}}{3\,t\,(D^2+L^2)}$$

$$= \frac{2\,(1.0)\,(3.0)^2\,(120)\,(3.0)}{3\,(0.040/12)\,[(1.0)^2+(3.0)^2]}$$

$$= 64{,}800 \text{ lb/ft}^2$$

$$\sigma_{reqd} = 450 \text{ lb/in}^2$$

$$FS = \sigma_{allow}/\sigma_{reqd}$$

$$= 1000/450$$

$$= 2.2, \text{ which is acceptable}$$

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GSE®

GSE STANDARD PRODUCTS

Product Data Sheet

GSE HD Textured

GSE HD Textured is the textured version of GSE HD. It is a high quality, high density polyethylene (HDPE) geomembrane with one or two coextruded, textured surfaces, and consisting of approximately 97.5% polyethylene, 2.5% carbon black and trace amounts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. The resin used is specially formulated, virgin polyethylene and is designed specifically for flexible geomembrane applications. GSE HD Textured has excellent resistance to UV radiation and is suitable for exposed conditions. This product allows projects with greater slopes to be designed since frictional characteristics are enhanced. *These product specifications meet or exceed GRI GM13.*

Product Specifications

40-mil values

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM VALUE				
Product Code			HDT 030G000	HDT 040G000	HDT 060G000	HDT 080G000	HDT 100G000
Thickness, (minimum average) mil (mm)	ASTM D 5994	every roll	29 (0.73)	38 (0.96)	57 (1.45)	76 (1.93)	95 (2.41)
Lowest individual for 8 out of 10 values			27 (0.69)	36 (0.91)	54 (1.40)	72 (1.80)	90 (2.30)
Lowest individual for any of the 10 values			26 (0.66)	34 (0.86)	51 (1.30)	68 (1.73)	85 (2.16)
Density, g/cm³	ASTM D 1505	200,000 lb	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)[1]	ASTM D 6693, Type IV	20,000 lb					
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm		45 (8)	60 (11)	90 (16)	120(21)	150 (27)
Strength at Yield, lb/in-width (N/mm)			63 (11)	84 (15)	126 (22)	168 (29)	210 (37)
Elongation at Break, %	G.L. = 2.0 in (51 mm)		100	100	100	100	100
Elongation at Yield, %	G.L. = 1.3 in (33 mm)		12	12	12	12	12
Tear Resistance, lb (N)	ASTM D 1004	45,000 lb	21 (93)	28 (125)	42 (187)	56 (249)	70 (311)
Puncture Resistance, lb (N)	ASTM D 4833	45,000 lb	45 (200)	60 (267)	90 (400)	120 (534)	150 (667)
Carbon Black Content, %	ASTM D 1603	20,000 lb	2.0	2.0	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1
Asperity Height	GRI GM 12	second roll	+Note 2	+Note 2	+Note 2	+Note 2	+Note 2
Notched Constant Tensile Load[2], hr	ASTM D 5397, Appendix	200,000 lb	300	300	300	300	300
REFERENCE PROPERTY	**TEST METHOD**	**FREQUENCY**	**NOMINAL VALUE**				
Oxidative Induction Time, min	ASTM D 3895, 200° C; O_2, 1 atm	200,000 lb	>100	>100	>100	>100	>100
Roll Length[3] (approximate), ft (m)	Standard Textured		830 (253)	700 (213)	520 (158)	400 (122)	330 (101)
Roll Width[3], ft (m)			22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)
Roll Area, ft² (m²)			18,674 (1,735)	15,750 (1,463)	11,700 (1,087)	9,000 (836)	7,425 (690)

NOTES:

- +Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- +Note 2: 10 mil average. 8 of 10 readings ≥7 mils. Lowest individual ≥ 5 mils.
- GSE HD Standard Textured is available in rolls weighing about 4,000 lb (1,800 kg).
- [1]The combination of stress concentrations due to coextrusion texture geometry and the small specimen size results in large variation of test results. Therefore, these tensile properties are minimum average values.
- [2]NCTL for HD Textured is conducted on representative smooth membrane samples.
- All GSE geomembranes have dimensional stability of ±2% when tested with ASTM D 1204 and LTB of <-77° C when tested with ASTM D 746.
- [3]Roll lengths and widths have a tolerance of ± 1%.

DS006 HDtext R03/09/06

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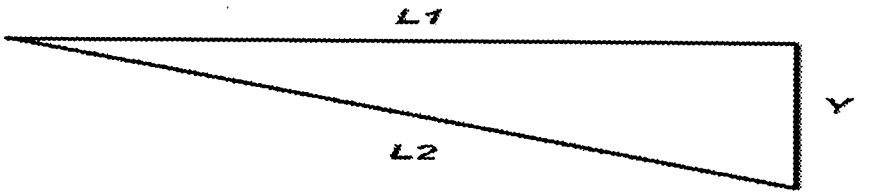
Subject:	Localized Cap Settlement		

Localized Differential Settlement

Maximum Geomembrane Tensile Strain (Є) = 12 % at break
= 0.12 unit/unit



Pythagorean Theorm $L2^2 = L1^2 + Y^2$

Strain Equation $\varepsilon = \frac{L2 - L1}{L1}$

Therefore, $Y = \sqrt{L1^2(2\varepsilon + \varepsilon^2)}$

For a given maximum geomembrane strain value, Y and L1 will vary.
Therefore, define a constant distortion term as: Distortion (ψ) = (Y / L1)

Check Distortion (ψ):

a. Case 1	*L1 (ft) =*	5			
	Y (ft) =	2.5219	=	30.26	in
	ψ =	0.5044	=	50.44	%
b. Case 2	*L1 (ft) =*	10			
	Y (ft) =	5.0438	=	60.53	in
	ψ =	0.5044	=	50.44	%
c. Case 3	*L1 (ft) =*	50			
	Y (ft) =	25.2190	=	302.63	in
	ψ =	0.5044	=	50.44	%
d. Case 4	*L1 (ft) =*	100			
	Y (ft) =	50.4381	=	605.26	in
	ψ =	0.5044	=	50.44	%
e. Stress Analysis Case	*L1 (ft) =*	3.0			
	Y (ft) =	1.0000	=	12.00	in
	ψ =	0.3333	=	33.33	%

Conclusion:

The soil cap can withstand localized differential settlement to a distortion value of ***0.5044*** *ft/ft*
or a distortion percentage of ***50.44*** *%*

References:

1. *"Geotechnical Aspects of Landfill Design and Construction"; Qian, Koerner, and Gray; Prentice Hall, Inc., 2002.*

APPENDIX F-4

CAP TRANSMISSIVITY CALCULATION

Golder Associates	SUBJECT: Cap Transmissivity Calculation PJP Landfill		
Project No.: 003-6004.002	By: JCA	Date: 03/12/07	
Phase: 012	Checked: JZ	Date: 03/13/07	Sheet 1 of 6
Ref:	Reviewed:	Date: 4/4/07	

OBJECTIVE

The objective of this calculation is to determine the maximum allowable permeability of the soil layer on top of the geocomposite drainage layer in the closure cap system. A sensitivity analysis is also provided.

METHOD

From Reference 1, *"The greatest uncertainty in the design of the lateral drainage system is accurately predicting the maximum rate of water infiltration. The extreme weather generated by 'El Nino' type of phenomena allows us to assume that the vegetative layer will be saturated at least once during the service life of the final cover."*

Consequently, the calculation method used is that first presented by Theil and Stewart at the *Geosynthetics '93* conference in Vancouver, B.C. (see Reference 1, page 36). This method, since it assumes the cap layer is saturated, allows the rate of water infiltration into the geocomposite to be readily calculated under a unit gradient (the infiltration velocity is equal to the permeability of the cap soil layer). This design method results in the calculated design flow to occur entirely within the thickness of the geocomposite drainage layer.

This calculation method has been adapted to a spreadsheet type of format that allows the designer to change various design input variables (slope, soil layer permeability, and drainage length) to determine the maximum allowable permeability of the cap soil layer.

ATTACHMENTS

1. Tenax Tenflow 770-2 Double-Sided Geocomposite product specification.
2. Design calculation in spreadsheet format.
3. Design sensitivity calculation in spreadsheet format.

REFERENCES

1. "Design of Lateral Drainage Systems for Landfills"; Richardson, Giroud, Zhao; 2000.
2. Tenax Tenflow 770-2 Double-Sided Geocomposite product specification.

CALCULATIONS

The initial input data consists of:

1. Slope - This has been set at 6% by the design.
2. Slope Length Between cap Drains – This is estimated to be approximately 322 feet, based on site conditions.
3. Flow Gradient – Generally, the flow gradient is calculated to be the sine of the slope angle. However, from Reference 1, pg 36, the flow gradient for a saturated cap layer is 1.0
4. Permeability of Cover Soils – This value is determined based on all other input variables and a minimum design factor of safety of 2.0

5. Ultimate Transmissivity of the Geocomposite Drainage Layer – This value is taken from either manufacturer's data or from laboratory testing using site-specific materials. In this case, manufacturer's data is used.

6. Reduction Factor for Intrusion – This reduction factor allows for consideration of the extent of intrusion of the non-woven geotextile into the geocomposite drainage structure. The values of this reduction factor ranges from 1.3 to 1.5. Since manufacturer's transmissivity data is used, the maximum recommended reduction factor of 1.5 is used.

7. Reduction Factor for Creep – This reduction factor allows for consideration of the extent of creep (structural collapse) of the geocomposite drainage structure. The values of this reduction factor ranges from 1.1 to 1.4. Since manufacturer's transmissivity data is used, the maximum recommended reduction factor of 1.4 is used.

8. Reduction Factor for Chemical Clogging – This reduction factor allows for consideration of the extent of chemical clogging and/or precipitation of chemicals in the geocomposite drainage structure. The values of this reduction factor ranges from 1.0 to 1.2. Since manufacturer's transmissivity data is used, the maximum recommended reduction factor of 1.2 is used.

9. Reduction Factor for Biological Clogging – This reduction factor allows for consideration of the extent of biological clogging in the geocomposite drainage structure (such as growth of bacteria or fungi). The values of this reduction factor ranges from 1.2 to 1.5. Since manufacturer's transmissivity data is used, the maximum recommended reduction factor of 1.5 is used.

Other design criteria consist of:

1. Minimum Drainage Factor of Safety – The recommended Minimum Drainage Factor of Safety is 2.0.

2. Minimum Total Factor of Safety – This value is the product of all Reduction Factors and the Drainage Factor of Safety. The recommended Minimum Total Factor of Safety is 6.0.

While these Reduction Factors and Factors of Safety may seem conservative, Reference 1 (pg 23) indicates the physical occurrence of root intrusion into the geocomposite drainage structure may be a long term serviceability concern. However, at this point, the design industry does not have adequate case studies to prescribe an appropriate reduction factor for root intrusion. Consequently, Reference 1 recommends the use of a high-flow geocomposite drainage structure to provide for the quick removal of water from the drainage layer to minimize the attraction of roots into the geocomposite drainage structure. This design considers the use of the high-flow geocomposite drainage structure "TENFLOW", by Tenax Corporation.

Attachment 1 provides manufacturer's data for the TENFLOW product. It is noted the transmissivity values reported by the manufacturer's data are for slope gradients of 0.33 and 0.1. The transmissivity values reported are 4.0×10^{-3} m^2/sec, and 7.0×10^{-3} m^2/sec, respectively. The design slope of 6% corresponds to a slope gradient of 0.06. Based on the trend of transmissivity values reported, the transmissivity for a slope gradient of 0.06 should be greater than that for a slope gradient of 0.1. For this design, the transmissivity value of 7.0×10^{-3} m^2/sec, corresponding to a slope gradient of 0.1, was used.

Based on the design parameters described, the maximum soil permeability should be 5.6×10^{-5} cm/sec.

A sensitivity analysis was performed to evaluate the how much of an increase in the soil permeability could occur before the Drainage Factor of Safety is reduced to less than 1.0. This analysis suggests an increase in the soil permeability to 1.1×10^{-4} cm/sec, will result in a Drainage Factor of Safety of 1.0.

CONCLUSIONS/RECOMMENDATIONS

As indicated previously, the slope gradient, slope length, and geocomposite transmissivity are, in effect, established prior to performing this design calculation. Consequently, the final design parameter to determine is the permeability of the soil layer in the cap system. Based on the calculation summary (Attachment 2), the soil layer on top of the geocomposite drainage layer should have a maximum permeability of 5.6×10^{-5} cm/sec. or less. Greater permeability values will result in a greater infiltration rate, thus reducing the drainage and total factors of safety.

Permeability values less than the maximum value will result in lesser infiltration rates, thus increasing the drainage and total factors of safety. However, too little permeability will hinder root growth of the vegetative cover. Therefore, the permeability of the soil on top of the geocomposite drainage layer should be further defined by a minimum permeability of 5.6×10^{-6} cm/sec.

The sensitivity analysis indicates that, based on the other design parameters, an increase in the soil permeability of approximately one-half order will reduce the Drainage Factor of Safety to less than 1.0. Therefore, construction quality assurance and quality control requirements should be developed to assure the characteristics of the constructed closure cap system are consistent with the design parameters.

The use of low ground pressure construction equipment should be considered essential in order to reduce the risk of damage to the geocomposite drainage layer, as well as other cap geosynthetic layers, during placement of the final cover soils.

product specifications

ATTACHMENT 1
3/12/07
033-6003,002/p12

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TENFLOW 770-2 Double-Sided Geocomposite

The drainage geocomposite is comprised of a tri-axial geonet structure with thermally bonded nonwoven geotextiles on both sides. The product is capable of providing high Transmissivity in a soil environment under sustained normal loads typical on landfill caps and will have properties conforming to the values and test methods listed below.

PROPERTY	TEST METHODS	UNITS	VALUE	QUALIFIER	TEST FREQUENCY
Resin					
• Density	ASTM D 1505	g/cm³	0.94	MAV	lot
• Melt Flow Index	ASTM D 1238	g/10min	1.0	MAX	lot
Geonet Core[1]					
Structure		Tri-axial			
• Tensile Strength – MD	ASTM D 4595	lb/ft (kN/m)	425 (6.2)	MAV	50,000 sf
• Creep Reduction Factor[2] @ 1,000 psf, 20 °C	GRI-GC8	-	1.1		
• Thickness[2]	ASTM D 5199	mil (mm)	340 (8.62)	MAV	50,000 sf
• Carbon Black	ASTM D 4218	%	2-3	range	50,000 sf
Geotextile[1]					
• U.V. Resistance (500 hrs)	ASTM D 4355	%	70		Per formula
• Serviceability Class	AASHTO M-288		Class 2		
• Grab Tensile	ASTM D 4632	lbs (N)	160 (712)	MARV	100,000 sf
• Grab Elongation	ASTM D 4632	%	50	MARV	100,000 sf
• Tear Strength	ASTM D 4533	lbs (N)	60 (267)	MARV	100,000 sf
• Puncture Resistance	ASTM D 4833	lbs (N)	90 (400)	MARV	100,000 sf
• AOS[3]	ASTM D 4751	US Sieve (mm)	70 (0.212)	MaxARV	500,000 sf
• Permittivity[3]	ASTM D 4491	Sec^{-1}	1.1	MARV	500,000 sf
Geocomposite					
• Peel Adhesion – MD	ASTM D7005	lb/in (g/in)	0.5 (227)	MAV	100,000 sf
• Labeling	Product code, geotextile type, roll dimensions, finished product lot and roll number.				
Hydraulic Behavior of Geocomposite					
•Transmissivity[4] - MD					
Gradient / Load	ASTM D 4716	m²/sec	1,000 psf (48 kPa)	MAV	200,000 sf
0.33			$4.0*10^{-3}$		
0.1			$7.0*10^{-3}$		

Qualifiers: MARV=Minimum Average Roll Value (MARV), MAV=Minimum Average Value, MAX=Maximum Value, MaxARV=Maximum average roll value.

NOTES: **1.** Geotextile and geonet properties listed are prior to lamination. **2.** Creep Reduction Factor is based on long term compressive creep test, extrapolated to 30 years, under the corresponding compressive load and temperature. **3.** Hydraulic properties: AOS and permittivity are only applicable to the top filter geotextile. **4.** Geocomposite transmissivity measured by manufacturer per ASTM D4716 with testing boundary conditions as follows: steel plate / Ottawa sand / geocomposite / 40 mil LLDPE geomembrane / steel plate, and seating period of 100 hours according to GRI-GC8, with the flat side of the geocomposite facing the soft boundary condition as indicated with top (soil) /bottom (liner) label on the rolls . Digital indicator of hydraulic gradient is required during the transmissivity measurement at low gradients.

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10/05/2006

ATTACHMENT 2
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Golder Associates

Project:	PJP Landfill		
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By:	JCA	**Date:**	12-Mar-07
Checked:		**Date:**	
Reviewed:		**Date:**	
Subject:	Cap Design		

Cap Drainage Layer - Geocomposite Drainage Net

General Data

Elevation Difference Between Drains =	19.32	ft			
Slope, X to 1 =	16.7	to 1			
Slope Angle, B =	3.43	degrees	=	6.0	%
Slope Length Between Drains, L =	322.0	ft	=	98.1	m
Qin Flow Gradient, i-in =	1.0				
Permeability of Cover Soils, Kveg =	5.60E-05	cm/sec			
Qin = (Kveg)(L) =	5.50E-05	m2/sec			
Qout Flow Gradient, i-out = sinB =	0.060				

Qin = Qout

Qout = (θr)(i-out)

θr = (Qin)/(i-out)

Required Transmissivity, θr (Qin)/(i-out) =	9.18E-04	m2/sec		
Ultimate Transmissivity, θu =	7.00E-03	m2/sec		
Reduction Factors				
Intrusion; Rfin =	1.5		>>>>	Range: 1.3 to 1.5
Creep; RFcr =	1.4		>>>>	Range: 1.1 to 1.4
Chemical Clogging; RFcc =	1.2		>>>>	Range: 1.0 to 1.2
Biological Clogging; RFbc =	1.5		>>>>	Range: 1.2 to 1.5
Product of Reduction Factors, PRF =	3.78			
Allowable Transmissivity, θa (θu/PRF) =	1.85E-03	m2/sec		
Drainage Factor of Safety, DFS (θa/θr) =	2.02			
Minimum Drainage Factor of Safety, MDFS MDFS =	2.0			
Total Factor of Safety, TFS (DFS x PRF) =	7.6			
Minimum Total Factor of Safety, MTFS MTFS min =	6.0			

[ ] = input data

References:

1 "Design Manual of Lateral Drainage Layers for Landfills"; Gregory N. Richardson, Ph.D., P.E. Jean-Pierre Giroud, E.C.P., Ph.D., Aigen Zhao, Ph.D., P.E.; 2000.

2 Manufacturer's data, various.

ATTACHMENT 3
3/12/07
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Golder Associates

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By:	JCA	**Date:**	12-Mar-07
Checked:		**Date:**	
Reviewed:		**Date:**	
Subject:	Cap Design - Sensitivity Analysis		

Cap Drainage Layer - Geocomposite Drainage Net

General Data

Elevation Difference Between Drains =	19.32	ft			
Slope, X to 1 =	16.7	to 1			
Slope Angle, B =	3.43	degrees	=	6.0	%
Slope Length Between Drains, L =	322.0	ft	=	98.1	m
Qin Flow Gradient, i-in =	1.0				
Permeability of Cover Soils, Kveg =	1.10E-04	cm/sec			
Qin = (Kveg)(L) =	1.08E-04	m2/sec			
Qout Flow Gradient, i-out = sinB =	0.060				

Qin = Qout

Qout = (θr)(i-out)

θr = (Qin)/(i-out)

Required Transmissivity, θr (Qin)/(i-out) =	1.80E-03	m2/sec		
Ultimate Transmissivity, θu =	7.00E-03	m2/sec		
Reduction Factors				
Intrusion; Rfin =	1.5	>>>>	*Range: 1.3 to 1.5*	
Creep; RFcr =	1.4	>>>>	*Range: 1.1 to 1.4*	
Chemical Clogging; RFcc =	1.2	>>>>	*Range: 1.0 to 1.2*	
Biological Clogging; RFbc =	1.5	>>>>	*Range: 1.2 to 1.5*	
Product of Reduction Factors, PRF =	3.78			
Allowable Transmissivity, θa (θu/PRF) =	1.85E-03	m2/sec		
Drainage Factor of Safety, DFS (θa/θr) =	1.03			
Minimum Drainage Factor of Safety, MDFS MDFS =	2.0			
Total Factor of Safety, TFS (DFS x PRF) =	3.9			
Minimum Total Factor of Safety, MTFS MTFS min =	6.0			

[ ] = *input data*

References:

1 *"Design Manual of Lateral Drainage Layers for Landfills"; Gregory N. Richardson, Ph.D., P.E. Jean-Pierre Giroud, E.C.P., Ph.D., Aigen Zhao, Ph.D., P.E.; 2000.*

2 *Manufacturer's data, various.*

APPENDIX F-5

EROSION POTENTIAL ANALYSES

OBJECTIVE: To evaluate soil erosion potential for the three areas of PJP Landfill that can be anticipated for the proposed final cover grading plan:

1) RV Salvage
2) Truck Stop
3) Archdiocese Property and Junkyard

METHOD: Per Reference 2, use the Universal Soil Loss Equation (USLE) to estimate the average annual soil loss.

USLE is A = R K (LS) C P

Where,
A = average annual soil loss (tons/acre/year)
R = rainfall and runoff erosivity index
K = soil erodibility factor (tons/acre)
L = slope-length factor
S = slope-steepness factor
C = cover management practice
P = crop pratice factor

REFERENCES:

1) USEPA, "Evaluating Cover Systems for Solid and Hazardous Waste," dated September 2002.

2) Golder Associates Inc., "Proposed Final Cover Grading Plan, Figure 5-2," dated 03/09/07.

3) Standards for Soil Erosion and Sediment Control in New Jersey, 1999.

CALCULATIONS:

1) The following constants have been used for all calculations:

A = R K (LS) C P

Where,
R = 170 (Ref. 1, Figure 20)
K = 0.24 (Ref. 1, Table 5, sandy loam, k=2%)
C = 0.004 (Ref. 1, Table 7, meadow – grass & legume mix)
P = 1.0 (Ref. 1, Table 8, no support practice)

Calculations were run on three separate areas with three separate (LS) values to determine the maximum amount of soil loss on site. The length, slope and LS values are shown as follows:

	Length (ft)	Slope (%)	(LS) Value
Trial 1	133	6	0.78
Trial 2	322	6	1.24
Trial 3	66	33.3	7.62

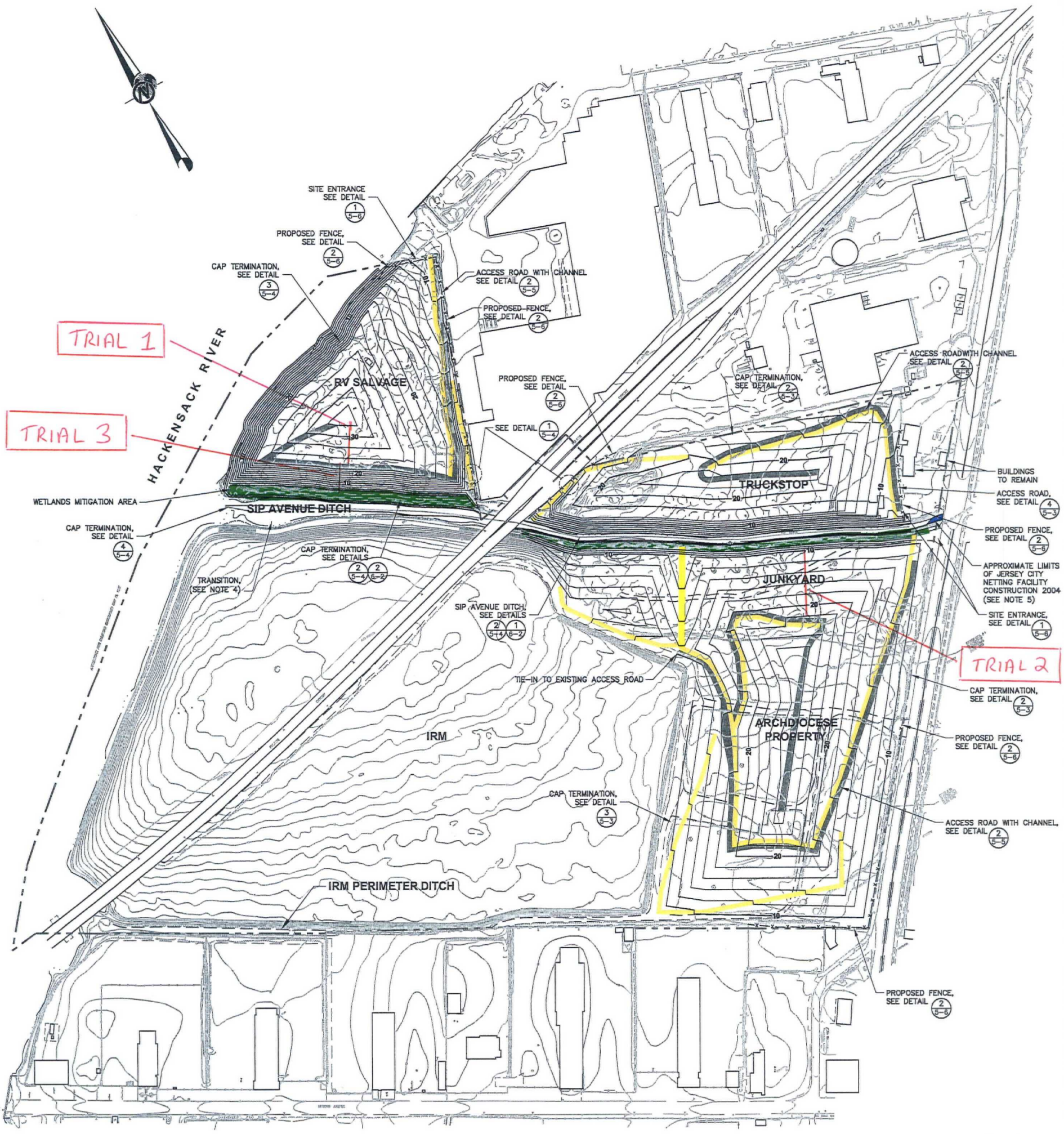
The value of (A) is being solved for to determine the average soil loss (tons/acre/year) before a bench ditch is to be placed on the side slope. Based on the highest (LS) value, the maximum amount of soil loss was calculated as:

A = (170)(0. 24)(7.62)(0.004)(1.0)
A = 1.24 tons/acre/year

CONCLUSION:

This calculation indicates that the design meets the criteria that the amount of soil loss from erosion is less than the allowable maximum amount of 2 tons/acre/year.

Drawing file: 0036004R035 FIG 5-2.dwg Mar 28, 2007 - 12:46pm



LEGEND

- APPROXIMATE SITE BOUNDARY AS DEFINED IN ADMINISTRATIVE CONSENT ORDER, 1997 (AMENDED JUNE 2000)
- EXISTING TOPOGRAPHIC CONTOURS
- EXISTING ACCESS ROAD
- EXISTING ACCESS ROAD TO REMAIN
- EXISTING FENCE
- PROPOSED FENCE, SEE DETAIL 2/5-6
- 20 — PROPOSED 10 FOOT CONTOUR
- PROPOSED 2 FOOT CONTOUR
- PROPOSED TRAPEZOIDAL CHANNEL, SEE DETAIL 3/6-2
- PROPOSED TRIANGULAR CHANNEL, SEE DETAIL 4/6-2
- PROPOSED ACCESS ROAD, SEE DETAIL 1/5-5
- WETLANDS MITIGATION (RECONSTRUCTION / ENHANCEMENT AREA)
- JERSEY CITY NETTING FACILITY

NOTES

1.) FINAL COVER GRADES REPRESENT THE TOP OF VEGETATIVE LAYER. FINAL COVER GRADES WERE DEVELOPED BASED UPON THE EXISTING CONDITIONS TOPOGRAPHY (FIGURE 5-1) AND ARE SUBJECT TO CHANGE, AS APPROVED BY THE REMEDIAL DESIGNER, IF THE EXISTING CONDITIONS CHANGE PRIOR TO REMEDIAL ACTION CONSTRUCTION.

2.) FINAL GRADES WITHIN THE LIMIT OF THE GEOSYNTHETIC CAP SHOULD BE NO FLATTER THAN 3% AND NO STEEPER THAN 33.3%. ACTUAL FINAL GRADES MAY VARY, DEPENDING UPON FIELD CONDITIONS ENCOUNTERED DURING CONSTRUCTION. ADJUSTMENTS TO THE FINAL GRADES FROM THOSE SHOWN MAY BE MADE ONLY IF APPROVED BY THE REMEDIAL DESIGNER.

3.) SIP AVENUE DITCH AND HACKENSACK RIVER BANK EROSION PROTECTION CONSTRUCTION SHALL BE SEQUENCED TO LIMIT EXPOSED EXCAVATION AREAS TO ONE DAY'S CONSTRUCTION.

4.) DELINEATION SHOWN REPRESENTS APPROXIMATE LOCATION OF RIVER BANK EROSION PROTECTION DETAIL TRANSITION FROM SIP AVENUE DITCH TO HACKENSACK RIVER, AS SHOWN ON FIGURES 5-4 AND 6-2.

5.) THE TRANSITION OF THE CAP SECTION TO THE JERSEY CITY NETTING FACILITY WILL BE FINALIZED IN THE FIELD AT TIME OF CONSTRUCTION.

REFERENCES

1.) BASE TOPOGRAPHY PREPARED BY JAMES M. STEWART, INC., CADD FILE No. 1886-00, DATED 11/02/98.

2.) EXISTING CONDITIONS IN SOME AREAS MAY HAVE CHANGED AND WILL BE UPDATED PRIOR TO CONTRACTOR BIDDING.

150 0 150 300
SCALE FEET

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT
PJP LANDFILL
FINAL (100%) REMEDIAL DESIGN
JERSEY CITY, HUDSON COUNTY, NEW JERSEY

TITLE
PROPOSED FINAL COVER GRADING PLAN

NJ Authorization #24GA28029100
Golder Associates
Philadelphia USA

PROJECT No.		003-6004	FILE No.	0036004R035
DESIGN	CBM	03/27/07	SCALE AS SHOWN	REV. 0
CADD	GLS	03/27/07	FIGURE 5-2	
CHECK				
REVIEW				

SHEET 3 of 8

Not only is erosion objectionable in itself but erosion can degrade the cover and seriously reduce its effectiveness.

Evaluate Erosion Potential — Step 19

The USDA universal soil loss equation (USLE) is a convenient tool for use in evaluating erosion potential. The USLE predicts average annual soil loss as the product of six quantifiable factors. The equation is:

$$A = R\ K\ L\ S\ C\ P$$

where A = average annual soil loss, in tons/acre
R = rainfall and runoff erosivity index
K = soil erodibility factor, tons/acre
L = slope-length factor
S = slope-steepness factor
C = cover-management factor
P = practice factor

The data necessary as input to this equation are available to the evaluator in a figure and tables included below. Note that the evaluations in Step 8 on soil composition and Steps 25-32 on vegetation all impact on the evaluation of erosion also.

Factor R in the USLE can be calculated empirically from climatological data. For average annual soil loss determinations, however, R can be obtained directly from Figure 20. Factor K, the average soil loss for a given

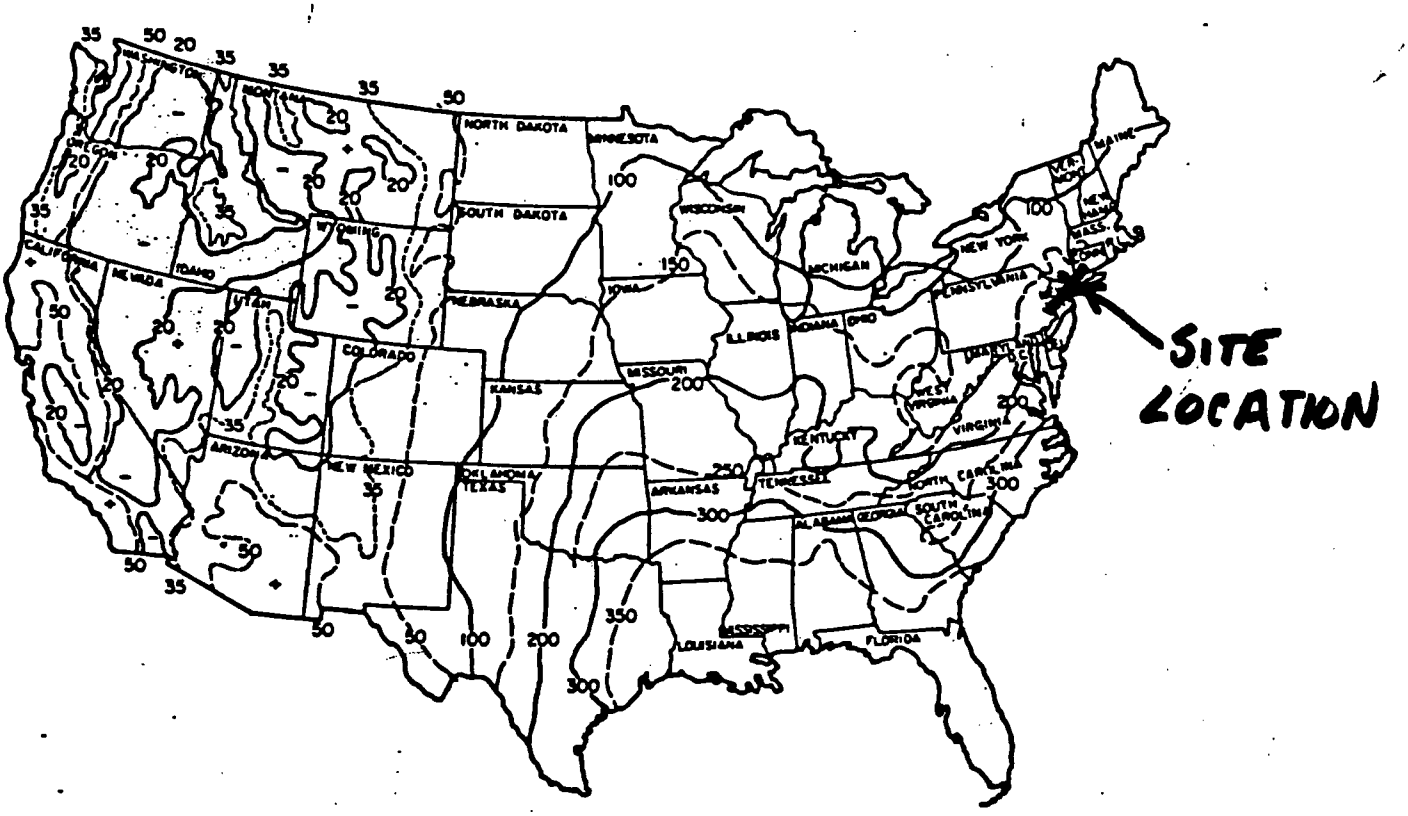


Figure 20. Average annual values of rainfall-erosivity factor R.[11]

soil in a unit plot, pinpoints differences in erosion according to differences in soil type. Long-term plot studies under natural rainfall have produced K values generalized in Table 5 for the USDA soil types.

TABLE 5. APPROXIMATE VALUES OF FACTOR K FOR USDA TEXTURAL CLASSES[11]

Texture class	Organic matter content <0.5% K	2% K	4% K
Sand	0.05	0.03	0.02
Fine sand	.16	.14	.10
Very fine sand	.42	.36	.28
Loamy sand	.12	.10	.08
Loamy fine sand	.24	.20	.16
Loamy very fine sand	.44	.38	.30
Sandy loam	.27	.24	.19
Fine sandy loam	.35	.30	.24
Very fine sandy loam	.47	.41	.33
Loam	.38	.34	.29
Silt loam	.48	.42	.33
Silt	.60	.52	.42
Sandy clay loam	.27	.25	.21
Clay loam	.28	.25	.21
Silty clay loam	.37	.32	.26
Sandy clay	.14	.13	.12
Silty clay	.25	.23	.19
Clay		0.13–0.29	

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

The evaluator must next consider the shape of the slope in terms of length and inclination. The appropriate LS factor is obtained from Table 6. A nonlinear slope may have to be evaluated as a series of segments, each with uniform gradient. Two or three segments should be sufficient for most engineered landfills, provided the segments are selected so that they are also of equal length (Table 6 can be used, with certain adjustments). Enter Table 6 with the total slope length and read LS values corresponding to the percent slope of each segment. For three segments, multiply the chart LS values for the upper, middle, and lower segments by 0.58, 1.06, and 1.37, respectively. The average of the three products is a good estimate of the

TABLE 7. GENERALIZED VALUES OF FACTOR C FOR STATES EAST OF THE ROCKY MOUNTAINS[11]

Crop, rotation, and management	Productivity level	
	High	Mod.
	C value	
Base value: continuous fallow, tilled up and down slope	1.00	1.00
CORN		
C, RdR, fall TP, conv	0.54	0.62
C, RdR, spring TP, conv	.50	.59
C, RdL, fall TP, conv	.42	.52
C, RdR, wc seeding, spring TP, conv	.40	.49
C, RdL, standing, spring TP, conv	.38	.48
C-W-M-M, RdL, TP for C, disk for W	.039	.074
C-W-M-M-M, RdL, TP for C, disk for W	.032	.061
C, no-till pl in c-k sod, 95-80% rc	.017	.053
COTTON		
Cot, conv (Western Plains)	0.42	0.49
Cot, conv (South)	.34	.40
MEADOW		
Grass & Legume mix	0.004	0.01
Alfalfa, lespedeza or Sericia	.020	
Sweet clover	.025	
SORGHUM, GRAIN (Western Plains)		
RdL, spring TP, conv	0.43	0.53
No-till pl in shredded 70-50% rc	.11	.18
SOYBEANS		
B, RdL, spring TP, conv	0.48	0.54
C-B, TP annually, conv	.43	.51
B, no-till pl	.22	.28
C-B, no-till pl, fall shred C stalks	.18	.22
WHEAT		
W-F, fall TP after W	0.38	
W-F, stubble mulch, 500 lbs rc	.32	
W-F, stubble mulch, 1000 lbs rc	.21	

Abbreviations defined:

B - soybeans
C - corn
c-k - chemically killed
conv - conventional
cot - cotton
F - fallow
M - grass & legume hay
pl - plant
W - wheat
wc - winter cover

lbs rc - pounds of crop residue per acre remaining on surface after new crop seeding
% rc - percentage of soil surface covered by residue mulch after new crop seeding
70-50% rc - 70% cover for C values in first column; 50% for second column
RdR - residues (corn stover, straw, etc.) removed or burned
RdL - all residues left on field (on surface or incorporated)
TP - turn plowed (upper 5 or more inches of soil inverted, covering residues)

are listed in Table 8. These values are based on rather limited field data, but P has a narrower range of possible values than the other five factors.

TABLE 8. VALUES OF FACTOR P[11]

Practice	Land slope (percent)				
	1.1-2	2.1-7	7.1-12	12.1-18	18.1-24
	(Factor P)				
Contouring (P_c)	0.60	0.50	0.60	0.80	0.90
Contour strip cropping (P_{sc})					
R-R-M-M[1]	0.30	0.25	0.30	0.40	0.45
R-W-M-M	0.30	0.25	0.30	0.40	0.45
R-R-W-M	0.45	0.38	0.45	0.60	0.68
R-W	0.52	0.44	0.52	0.70	0.90
R-O	0.60	0.50	0.60	0.80	0.90
Contour listing or ridge planting (P_{cl})	0.30	0.25	0.30	0.40	0.45
Contour terracing (P_t)[2]	[3] $0.6/\sqrt{n}$	$0.5/\sqrt{n}$	$0.6/\sqrt{n}$	$0.8/\sqrt{n}$	$0.9/\sqrt{n}$
No support practice	1.0	1.0	1.0	1.0	1.0

[1] R = rowcrop, W = fall-seeded grain, O = spring-seeded grain, M = meadow. The crops are grown in rotation and so arranged on the field that rowcrop strips are always separated by a meadow or winter-grain strip.

[2] These P_t values estimate the amount of soil eroded to the terrace channels and are used for conservation planning. For prediction of off-field sediment, the P_t values are multiplied by 0.2.

[3] n = number of approximately equal-length intervals into which the field slope is divided by the terraces. Tillage operations must be parallel to the terraces.

Example: An owner/operator proposes to close one section of his small landfill with a sandy clay subsoil cover having the surface configuration shown in Figure 21. The factor R has been established as 200 for this locality. The evaluator questions anticipated erosion along the steep side and assigns the following values to the other factors in the USLE after inspecting Tables 5 through 8:

$$K = 0.14 \quad LS = 8.3 \quad C = 1.00 \quad P = 0.90$$

The rate of erosion for the steep slope of the landfill is calculated as follows:

$$A = 200\ (0.14\ \text{tons/acre})\ (8.3)\ (1.00)\ (0.90) = 209\ \text{tons/acre}$$

This erosion not only exceeds a limit recommended by the permitting authority but also indicates a potential

TABLE A1-3

VALUES OF THE TOPOGRAPHIC FACTOR "LS"

Length of Slope (L) Ft.	Percent Slope (S) 0.2	0.3	0.4	0.5	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0	30.0	33.3	40.0	50.0	60.0
20	.05	.05	.06	.06	.08	.12	.18	.21	.24	.30	.44	.61	.81	1.0	1.3	1.6	1.8	2.6	4		6	8	10
40	.06	.07	.07	.08	.10	.15	.22	.28	.34	.43	.63	.87	1.2	1.4	1.8	2.2	2.6	3.5	5		8	11	15
60	.07	.08	.08	.08	.11	.17	.25	.33	.41	.52	.77	1.0	1.4	1.8	2.2	2.6	3.0	4.5	6	7.32	10	14	18
80	.08	.08	.09	.09	.12	.19	.27	.37	.48	.60	.89	1.2	1.6	2.1	2.6	3.0	3.6	5.5	7	8.32	11	16	21
100	.08	.09	.09	.10	.13	.20	.29	.40	.54	.67	.99	1.4	1.8	2.4	2.9	3.5	4.2	6.0	8		13	18	23
110	.08	.09	.10	.10	.13	.21	.30	.42	.56	.71	1.0	1.5	2.0	2.5	3.0	3.7	4.5	6	9		14	19	25
120	.09	.09	.10	.10	.14	.21	.30	.43	.59	.74	1.0	1.6	2.1	2.6	3.3	4.0	4.6	7	9		14	20	26
130	.09	.09	.10	.11	.14	.22	.31	.44	.61	.77	1.2	1.6	2.2	2.8	3.4	4.1	4.9	7	9		15	20	27
140	.09	.10	.10	.11	.14	.22	.32	.46	.63	.80	1.2	1.7	2.3	2.9	3.6	4.3	5.1	7	10		15	21	29
150	.09	.10	.11	.11	.15	.23	.32	.47	.66	.82	1.2	1.8	2.4	3.0	3.7	4.5	5.3	8	10		16	23	30
160	.09	.10	.11	.11	.15	.23	.33	.48	.68	.85	1.2	1.9	2.5	3.1	3.9	4.7	5.5	8	10		17	24	31
180	.10	.10	.11	.12	.15	.24	.34	.51	.72	.93	1.4	1.9	2.6	3.3	4.1	5.0	6.0	9	12		18	26	33
200	.10	.11	.11	.12	.16	.25	.35	.53	.76	.95	1.4	2.1	2.8	3.6	4.4	5.3	6.3	9	12		18	27	35
300	.11	.12	.13	.14	.18	.28	.40	.62	.93	1.2	1.8	2.7	3.6	4.5	5.6	6.8	8	12	16		25	35	45
400	.12	.13	.14	.15	.20	.31	.44	.70	1.0	1.4	2.0	3.2	4.2	5.4	6.7	8.0	10	14	19		30	42	54
500	.13	.14	.15	.16	.21	.33	.47	.76	1.2	1.6	2.2	3.7	4.9	6.2	7.6	9.2	11	16	21		34	47	61
600	.14	.15	.16	.17	.22	.34	.49	.82	1.4	1.6	2.4	4.1	5.4	6.9	8.5	10.3	12	16	24		38	53	68
700	.15	.16	.17	.18	.23	.36	.52	.87	1.4	1.8	2.6	4.5	5.0	7.5	9.3	11.3	13	18	26		41	58	75
800	.15	.16	.17	.18	.24	.38	.54	.92	1.6	2.0	2.8	4.9	6.4	8.2	10.1	12.2	14	20	28		45	58	81
900	.16	.17	.18	.19	.25	.39	.56	.96	1.6	2.0	3.0	5.2	6.9	8.8	10.8	13.1	16	22	30		48	67	87
1000	.16	.18	.19	.20	.26	.40	.57	1.0	1.6	2.2	3.0	5.6	7.4	9.3	11.6	14.0	17	24	32		51	72	93

When the length of slope exceeds 400 feet and (or) percent of slope exceeds 24 percent, soil loss estimates are speculative as these values are beyond the range of research data.

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