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AVERY
RECYCLED PAPER MADE FROM 20% POST CONSUMER CONTENT

F

GROUNDWATER REVISED MODEL

MONTGOMERY WATSON

By CAM Date 8/14/00 Client US STEEL Sheet 1 of 5

Chkd. By TJK Description CALCULATION OF DEWATERING VOLUME WITHIN A BARRIER WALL AT THE US STEEL GARY WORKS CAMU Job No. 1242330.01160101

PROBLEM: CALCULATE THE VOLUME OF WATER THAT MUST BE REMOVED TO DEWATER THE INTERIOR OF A BARRIER WALL AROUND THE CAMU FROM STATIC LEVELS TO THE TARGET GROUNDWATER ELEVATION FOR CONSTRUCTION. ALSO CALCULATE THE MAINTENANCE PUMPING RATE WITHIN THE WALL THAT WILL BE REQUIRED DUE TO LEAKAGE THROUGH THE BARRIER WALL.

EQUATIONS:

① VOLUME OF WATER WITHIN THE BARRIER WALL TO BE REMOVED:

$$V_{rem} = A_W (E_1 - E_2)\Theta$$

② SEEPAGE RATE INTO THE CAMU AFTER REACHING TARGET ELEVATION (= MAINTENANCE PUMPING RATE):

$$Q_W = K_W \left(\frac{E_1 - E_2}{T_W}\right) L_W H_W$$

$$Q_B = K_B \left(\frac{E_1 - E_2}{T_B}\right) A_{CAMU}$$

$$Q_T = Q_W + Q_B$$

WHERE:

V_{rem} = VOLUME OF WATER WITHIN THE BARRIER WALL TO BE REMOVED
A_W = AREA WITHIN THE WALL
E_1 = STATIC WATER ELEVATION (HIGH WATER TABLE ≅ 590 FT MSL)
E_2 = TARGET WATER ELEVATION (= 568 FT. MSL)
* Θ = POROSITY (= 0.25 - 0.45)
Q_W = SEEPAGE RATE THROUGH THE BARRIER WALL
Q_B = SEEPAGE RATE
Q_T = TOTAL SEEPAGE RATE INTO THE CAMU AREA (= MAINTENANCE PUMPING RATE)
* K_W = PERMEABILITY OF BARRIER WALL (1×10^{-7} cm/sec ≅ 2.83×10^{-2} FT/DAY) (= 1×10^{-5} cm/sec = 2.83×10^{-2} FT/DAY)
K_B = PERMEABILITY OF CLAY BASE (= 9.88×10^{-7} cm/sec = 2.80×10^{-3} FT/DAY)
T_W = THICKNESS OF BARRIER WALL (= 2 FT)
T_B = THICKNESS OF BASAL CLAY (= 115 FT)
L_W = LINEAR FOOTAGE OF BARRIER WALL (= 5,315 FT)
H_W = HEIGHT OF WALL WITHIN SATURATED ZONE (= 590' - 545' = 45 FT)
A_{CAMU} = AREA INSIDE BARRIER WALL (= 1,816,254 FT²)

* A RANGE OF VALUES ARE TESTED FOR POROSITY AND BARRIER WALL PERMEABILITY TO ACCOUNT FOR UNCERTAINTIES IN AQUIFER PROPERTIES AND BARRIER WALL PROPERTIES, RESPECTIVELY.

SOLUTIONS:

① VOLUME OF WATER WITHIN BARRIER WALL TO BE REMOVED

A) GIVEN $n = 0.25$

$$V_{rem} = A_w (E_1 - E_2) n$$
$$= (1,816,254 \text{ FT}^2)(590 - 568 \text{ FT})(0.25)$$
$$= 9,989,397 \text{ FT}^3$$
OR 74,720,690 gal ✓

B) GIVEN $n = 0.45$

$$V_{rem} = (1,816,254 \text{ FT}^2)(590 - 568)(0.45)$$
$$= 17,980,915 \text{ FT}^3$$
OR 134,497,241 gal ✓

* NOTE: THE ACTUAL VOLUME TO PUMP TO ACHIEVE THE TARGET GROUNDWATER ELEVATION OF 568 FT MSL WILL BE THE VOLUM OF WATER WITHIN THE BARRIER WALL PLUS THE SEEPAGE RATE INTO THE CAMU AREA MULTIPLIED BY THE DAYS NEEDED FOR DEWATERING.

② SEEPAGE RATE INTO THE CAMU AREA AFTER REACHING THE TARGET GROUNDWATER ELEVATION.

$$Q_B = K_B \left(\frac{E_1 - E_2}{T_B}\right) A_{CAMU}$$
$$= (2.80 \times 10^{-3} \text{ FT/DAY})\left(\frac{590 - 568 \text{ FT}}{115 \text{ FT}}\right)(1,816,254 \text{ FT}^2)$$
$$= 973 \text{ FT}^3/\text{DAY}$$ ✓

$$Q_W = K_W \left(\frac{E_1 - E_2}{T_W}\right) L_W H_W$$

A) GIVEN $K_W = 2.83 \times 10^{-4}$ FT/DAY $(1 \times 10^{-7}$ cm/s$)$

$$Q_W = (2.83 \times 10^{-4} \text{ FT/DAY})\left(\frac{590 - 568 \text{ FT}}{2 \text{ FT}}\right)(5315 \text{ FT})(45 \text{ FT})$$
$$= 745 \text{ FT}^3/\text{DAY}$$ ✓

B) GIVEN $K_W = 2.83 \times 10^{-2}$ FT/DAY $(1 \times 10^{-5}$ cm/s$)$

$$Q_W = (2.83 \times 10^{-2} \text{ FT/DAY})\left(\frac{590 - 568 \text{ FT}}{2 \text{ FT}}\right)(5315 \text{ FT})(45 \text{ FT})$$
$$= 74,455 \text{ FT}^3/\text{DAY}$$ ✓

SOLUTIONS (CONT.)

$Q_T = Q_W + Q_B$

A) @ $K_W = 2.83 \times 10^{-4}$ FT/DAY

$Q_T = 745 \text{ FT}^3/\text{DAY} + 973 \text{ FT}^3/\text{DAY}$

$= \underline{1{,}718 \text{ FT}^3/\text{DAY}}$ OR 12,851 gal/day ✓

B) @ $K_W = 2.83 \times 10^{-2}$ FT/DAY

$Q_T = 74{,}455 \text{ FT}^3/\text{DAY} + 973 \text{ FT}^3/\text{DAY}$

$= \underline{75{,}428 \text{ FT}^3/\text{DAY}}$ OR 564,201 gal/day ✓

→ ASSUMING IT TAKES 60 DAYS TO INSTALL THE BARRIER WALL AND DEWATERING SYSTEM AND 110 DAYS TO DEWATER, CALCULATE THE PUMP RATE TO REACH TARGET GROUNDWATER ELEVATION AND THE MAINTENANCE PUMPING RATE.

- TOTAL VOLUME OF WATER TO BE REMOVED TO REACH THE TARGET GROUNDWATER ELEVATION:

$V_{TOTAL} = V_{rem} + 110 \text{ DAYS } (Q_T)$

A) @ $n = 0.25$ AND $K_W = 2.83 \times 10^{-4}$ FT/DAY

$V_{TOTAL} = 74{,}720{,}680 \text{ gal} + 110 \text{ DAY } (12{,}851 \text{ gal/day})$

$= \underline{76{,}134{,}300 \text{ gal}}$ ✓

B) @ $n = 0.25$ AND $K_W = 2.83 \times 10^{-2}$ FT/DAY

$V_{TOTAL} = 74{,}720{,}680 \text{ gal} + 110 \text{ DAY } (564{,}201 \text{ gal/day})$

$= \underline{136{,}783{,}800 \text{ gal}}$ ✓

SOLUTIONS (CONT.):

C) @ $n = 0.45$ AND $K_D = 2.83 \times 10^{-4}$ FT/DAY

$V_{TOTAL} = 134,497,241$ gal + 110 DAY (12,851 gal/day)

$= \underline{135,910,851 \text{ gal}}$ ✓

D) @ $n = 0.45$ AND $K_D = 2.83 \times 10^{-2}$ FT/DAY

$V_{TOTAL} = 134,497,241$ gal + 110 DAY (564,201 gal/day)

$= \underline{196,559,351 \text{ gal}}$ ✓

- THE AVERAGE PUMPING RATE REQUIRED TO REACH THE TARGET GROUNDWATER ELEVATION:

AVG. RATE = V_{TOTAL} / 110 DAYS

A) @ $n = 0.25$ AND $K_D = 2.83 \times 10^{-4}$ FT/DAY

AVG. RATE = 76,134,300 gal / 110 day = 692,130 gal/day = 481 gpm

B) @ $n = 0.25$ AND $K_D = 2.83 \times 10^{-2}$ FT/DAY

AVG RATE = 136,782,800 gal / 110 DAY = 1,243,480 gal/day = 864 gpm

C) @ $n = 0.45$ AND $K_D = 2.83 \times 10^{-4}$ FT/DAY

AVG RATE = 135,910,851 gal / 110 DAYS = 1,235,553 gal/day 858 gpm

D) @ $n = 0.45$ AND $K_D = 2.83 \times 10^{-2}$ FT/DAY

AVG. RATE = 196,559,351 gal / 110 DAY = 1,786,903 gal/day = 1241 gpm

* RANGES FROM 481 - 1241 gpm

SOLUTIONS (CONT.)

- THE AVERAGE PUMPING RATE REQUIRED TO MAINTAIN THE TARGET ELEVATION IS EQUAL TO Q_T PREVIOUSLY CALCULATED.

A) @ $K_H = 2.83 \times 10^{-4}$ FT/DAY

$Q_T = 12,851$ gal/day = 9 gpm

B) @ $K_H = 2.83 \times 10^{-2}$ FT/DAY

$Q_T = 564,201$ gal/day = 392 gpm

* RANGES FROM 9-392 gpm

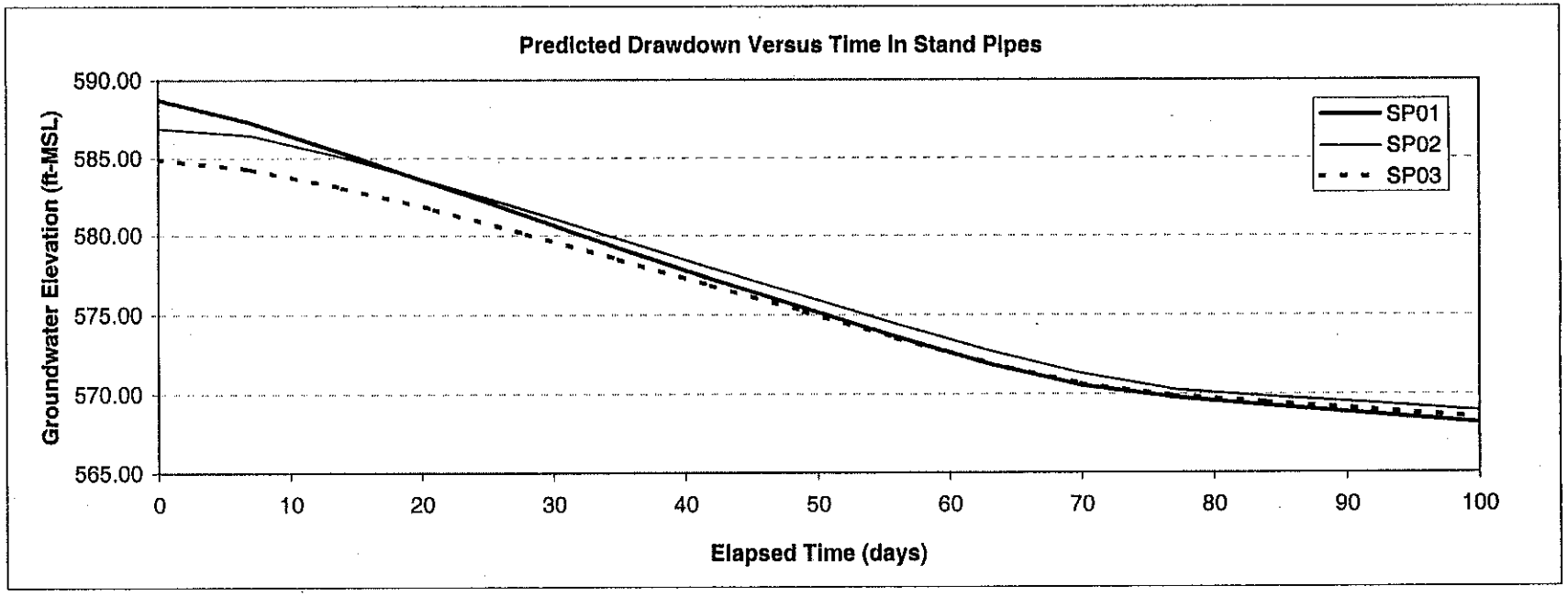
→ ASSUMING EIGHT (8) DEWATERING WELLS ARE USED AND GIVEN THE RANGE IN PUMPING RATES (481-7241 gpm) REQUIRED TO REACH THE TARGET GROUNDWATER ELEVATION, EACH WELL MUST BE CAPABLE OF PUMPING, ON AVERAGE, BETWEEN 60-155 gpm.

ASSUMING EIGHT (8) DEWATERING WELLS ARE USED AND GIVEN THE RANGE IN PUMPING RATES (9-392 gpm) REQUIRED TO MAINTAIN THE TARGET GROUNDWATER ELEVATION, EACH WELL MUST BE CAPABLE OF PUMPING, ON AVERAGE, BETWEEN 1-49 gpm.

Table F-1

Predicted Drawdown in Stand Pipes During Dewatering ($K_{wall} = 1 \times 10^{-7}$ cm/sec)

Time	SP-1			SP-2			SP-3		
(days)	GW Elev. (ft-MSL)	Drawdown (ft)	% of Target Drawdown	GW Elev. (ft-MSL)	Drawdown (ft)	% of Target Drawdown	GW Elev. (ft-MSL)	Drawdown (ft)	% of Target Drawdown
0	588.74	0.00	0%	586.91	0.00	0%	584.87	0.00	0%
7	587.28	-1.46	7%	586.46	-0.45	2%	584.27	-0.60	4%
14	585.33	-1.96	17%	585.05	-1.41	10%	583.05	-1.22	11%
21	583.29	-2.04	27%	583.38	-1.67	20%	581.62	-1.43	20%
28	581.22	-2.07	37%	581.59	-1.79	30%	580.08	-1.54	29%
35	579.21	-2.01	46%	579.78	-1.81	40%	578.49	-1.59	39%
42	577.27	-1.93	56%	577.97	-1.82	50%	576.84	-1.64	49%
49	575.41	-1.86	65%	576.18	-1.79	60%	575.18	-1.66	59%
56	573.61	-1.81	74%	574.41	-1.76	70%	573.52	-1.67	69%
63	571.91	-1.70	82%	572.74	-1.68	79%	571.93	-1.59	79%
70	570.54	-1.37	88%	571.30	-1.44	87%	570.62	-1.31	87%
77	569.78	-0.76	92%	570.27	-1.02	93%	569.89	-0.74	92%
84	569.28	-0.50	95%	569.84	-0.43	95%	569.49	-0.40	94%
92	568.73	-0.55	97%	569.42	-0.42	97%	569.01	-0.47	97%
100	568.16	-0.57	100%	568.93	-0.49	100%	568.50	-0.51	100%
Total Drawdown (ft):		-20.58			-17.98			-16.37	



Notes:
1. Predicted drawdown in stand pipes are based on a groundwater model simulation.
2. Initial groundwater elevations (at T = 0) are based on recent high water table conditions.
3. Actual groundwater elevations at the time of dewatering system start-up may reduce the total change in elevation required to reach the target groundwater elevation.

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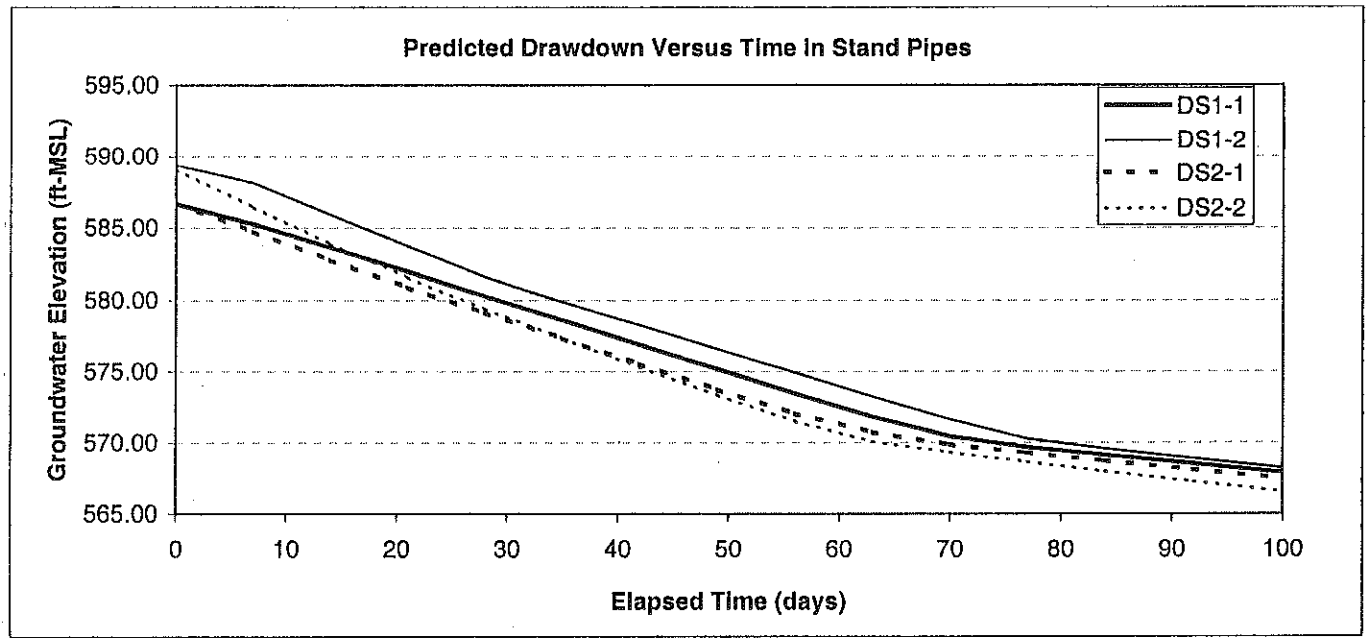
Table F-2

Predicted Drawdown at Leak Detection Sump Locations During Dewatering ($K_{wall} = 1 \times 10^{-7}$ cm/sec)

Time	DS1-1		DS1-2		DS2-1		DS2-2	
(days)	GW Elev. (ft-MSL)	Drawdown (ft)	GW Elev. (ft-MSL)	Drawdown (ft)	GW Elev. (ft-MSL)	Drawdown (ft)	GW Elev. (ft-MSL)	Drawdown (ft)
0	586.66	0.00	589.37	0.00	586.72	0.00	589.04	0.00
7	585.28	-1.37	588.10	-1.28	584.74	-1.98	586.45	-2.59
14	583.61	-1.68	585.94	-2.16	582.75	-1.99	583.90	-2.55
21	581.97	-1.64	583.73	-2.20	580.90	-1.84	581.58	-2.32
28	580.29	-1.68	581.62	-2.11	579.09	-1.81	579.39	-2.18
35	578.59	-1.70	579.89	-1.73	577.30	-1.80	577.30	-2.09
42	576.86	-1.73	578.22	-1.67	575.50	-1.80	575.28	-2.03
49	575.15	-1.71	576.57	-1.65	573.73	-1.77	573.34	-1.94
56	573.45	-1.70	574.90	-1.67	572.04	-1.70	571.50	-1.84
63	571.81	-1.64	573.25	-1.65	570.73	-1.30	570.07	-1.42
70	570.43	-1.38	571.62	-1.62	569.86	-0.87	569.32	-0.76
77	569.68	-0.75	570.28	-1.34	569.26	-0.60	568.62	-0.69
84	569.10	-0.58	569.57	-0.71	568.68	-0.58	567.95	-0.67
92	568.47	-0.63	568.87	-0.70	568.04	-0.63	567.22	-0.73
100	567.86	-0.61	568.18	-0.69	567.43	-0.62	566.52	-0.71
Total Drawdown (ft):		-18.80		-21.19		-19.29		-22.52



Notes:
1. Predicted drawdown at Leak Detection Sump locations are based on a groundwater model simulation.
2. Initial groundwater elevations (at T = 0) are based on recent high water table conditions.
3. Actual groundwater elevations at the time of dewatering system start-up may reduce the total change in elevation required to reach the target groundwater elevation.

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Table F-3

Estimated Well Loss for Dewatering Well with Greatest Drawdown ($K_{wall} = 1 \times 10^{-7}$)

USS WELL LOSS CALCULATIONS - $K_{wall} = 1 \times 10^{-7}$ cm/sec

Qwt(@ 100 days)	14439	ft3/day	=	75 gpm
Qwt(@>100 days)	1925	ft3/day	=	10 gpm
K	38	ft/day		
re	7.28	ft		
rw	0.5	ft		

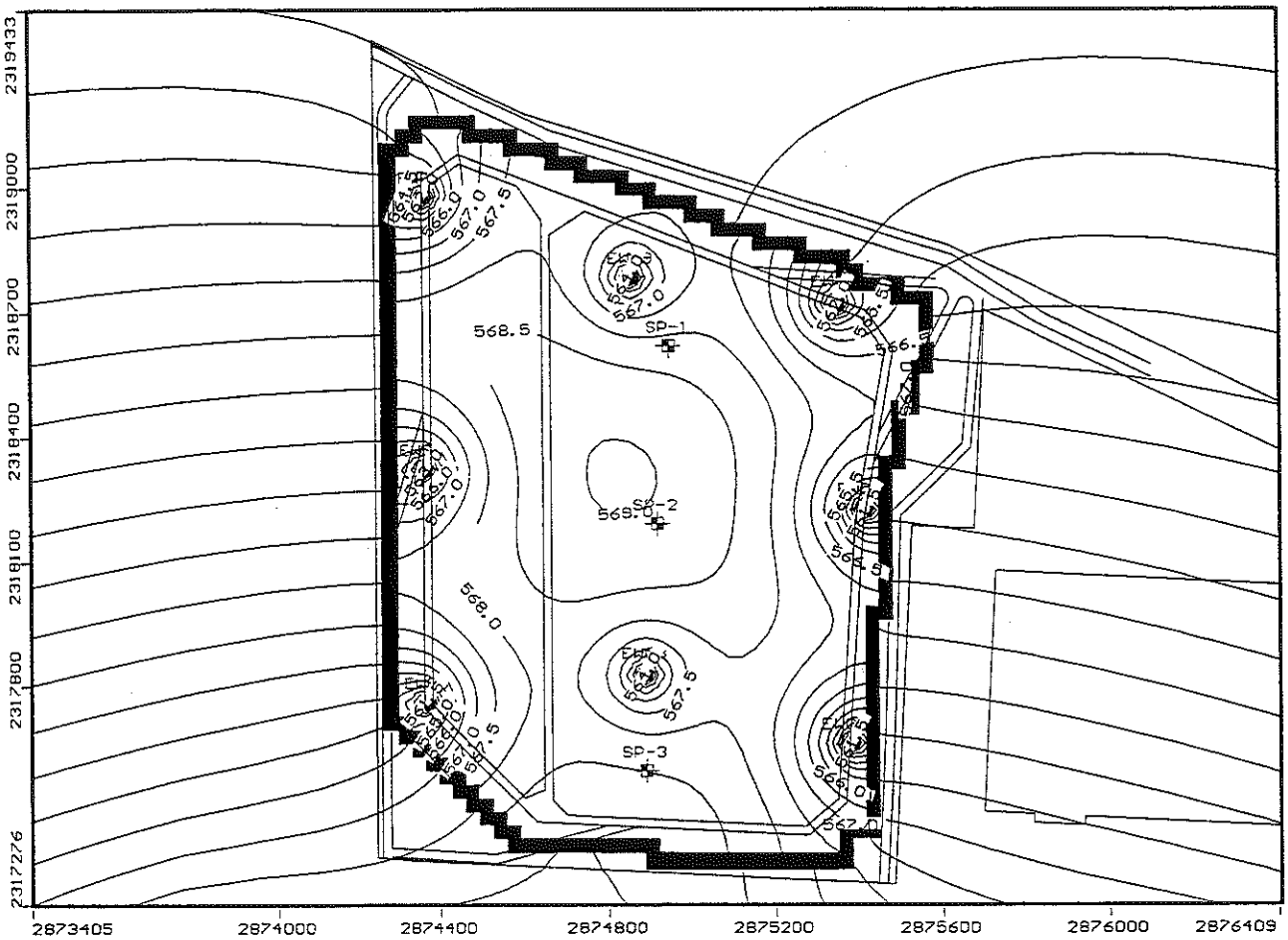
hij = simulated head in cell containing pumping well
hw = (hij^2 - (Qwt/(PI*K))*LN(re/rw))^(1/2)
(hw is the correction required to determine the head in the well from the head in the model cell)
h (50% eff) = ho - (ho-hw)/0.5
h (80% eff) = ho - (ho-hw)/0.8 where ho = initial head at time of dewatering system start-up.

Lowest Model Head Value Occurs in Cell Associated w/ Well:
EW04

T	hij	hw	ho	h (50% eff)	h (80% eff)
100	561.14	560.85	585.57	536.13	554.67

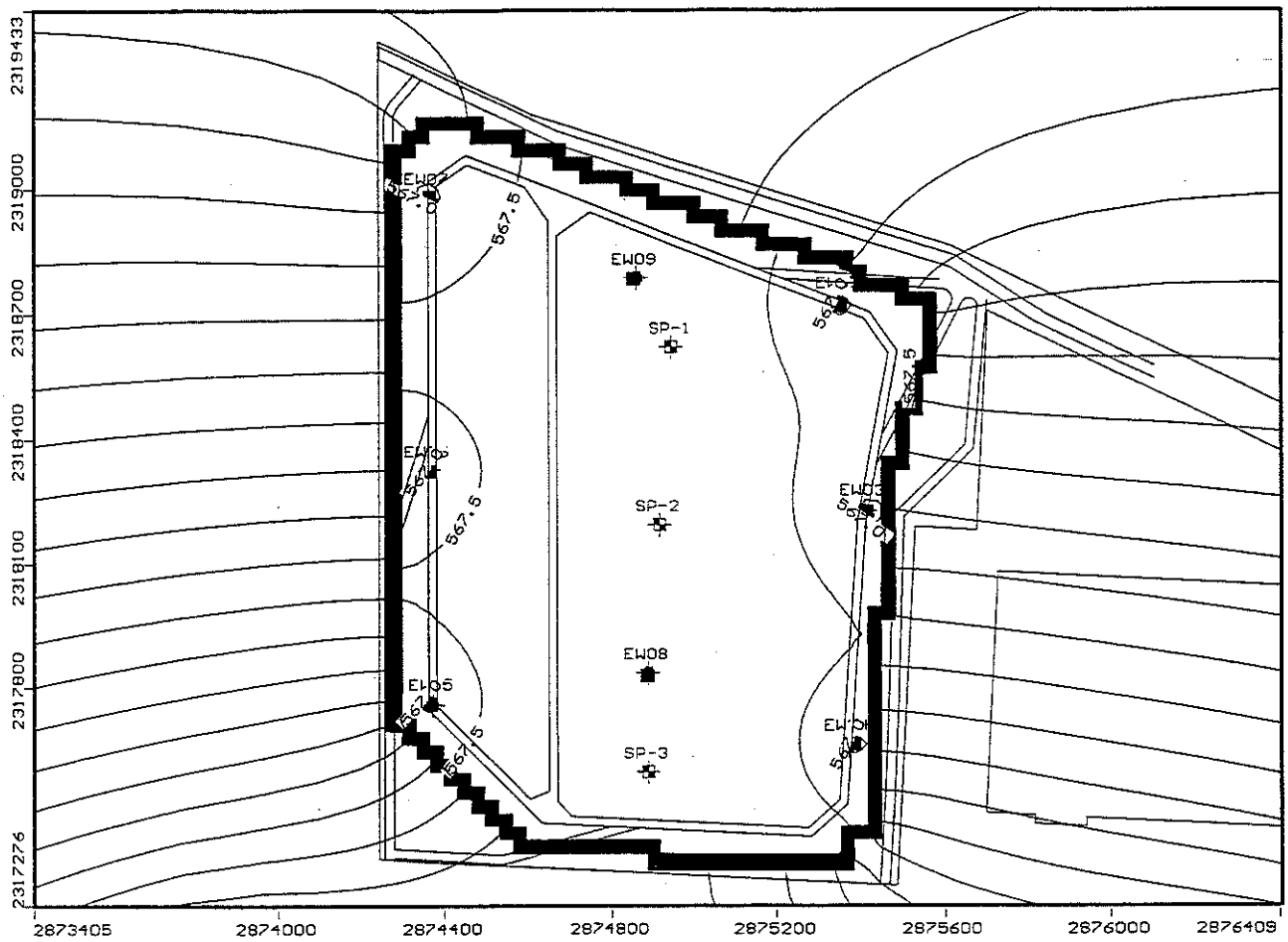
Note:
Maximum drawdown within dewatering wells occurs at T = 100 days, at which time target groundwater elevations are met.

$K_{WALL} = 1 \times 10^{-7}$ cm/sec (T= 100 days)



MW Project: US Steel CAMU Design Description: Dewatering: camu29,t100 Modeller: CAU 19 Oct 00	Visual MODFLOW v.2.8.2, (C) 1995–1999 Waterloo Hydrogeologic, Inc. NC: 71 NR: 91 NL: 5 Current Layer: 5

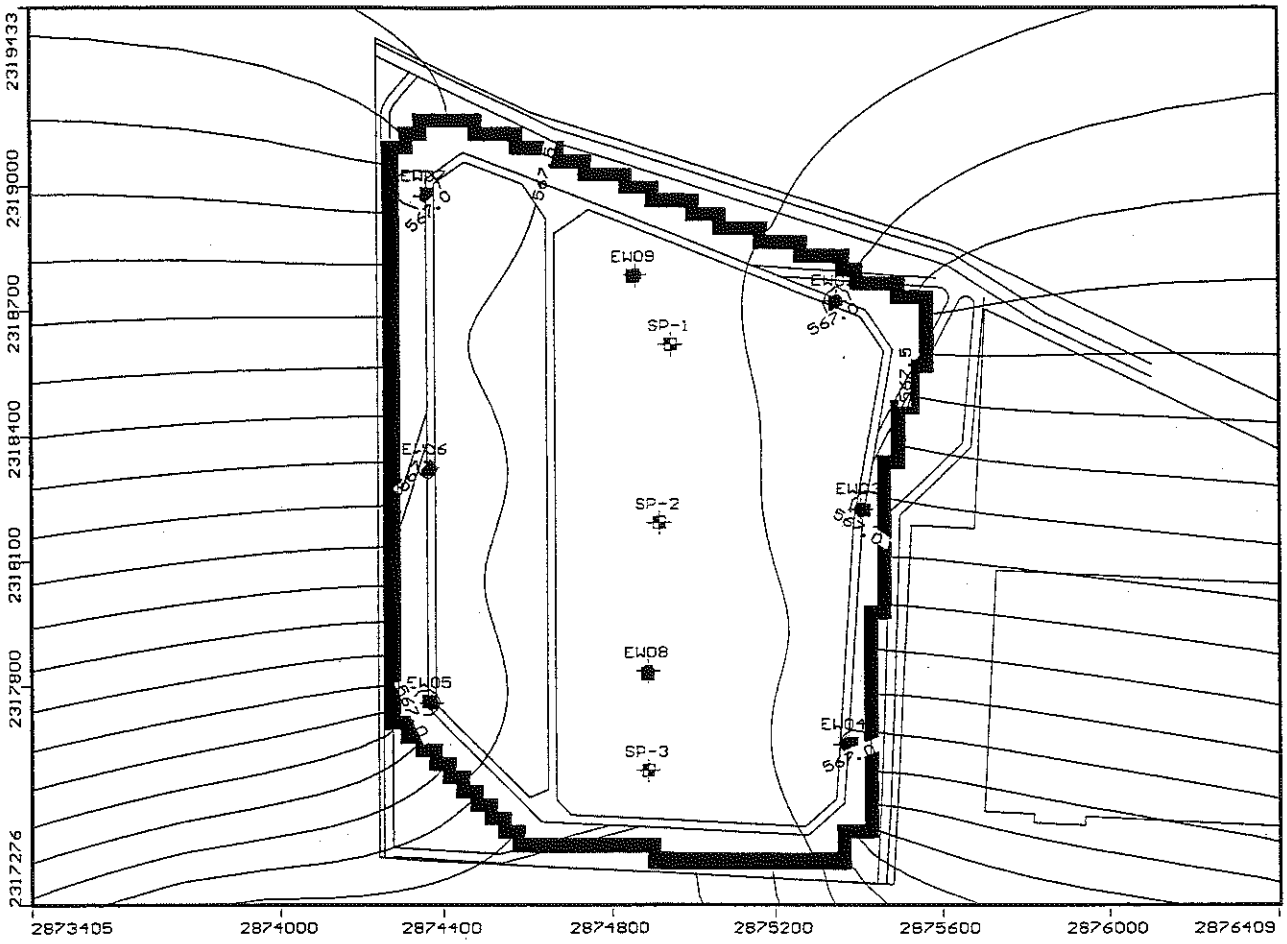
$K_{WALL} = 1 \times 10^{-7}$ cm/sec (T = 365 DAYS)



MW
Project: US Steel CAMU Design
Description: Dewatering: camu29,t365
Modeller: CAU
19 Oct 00

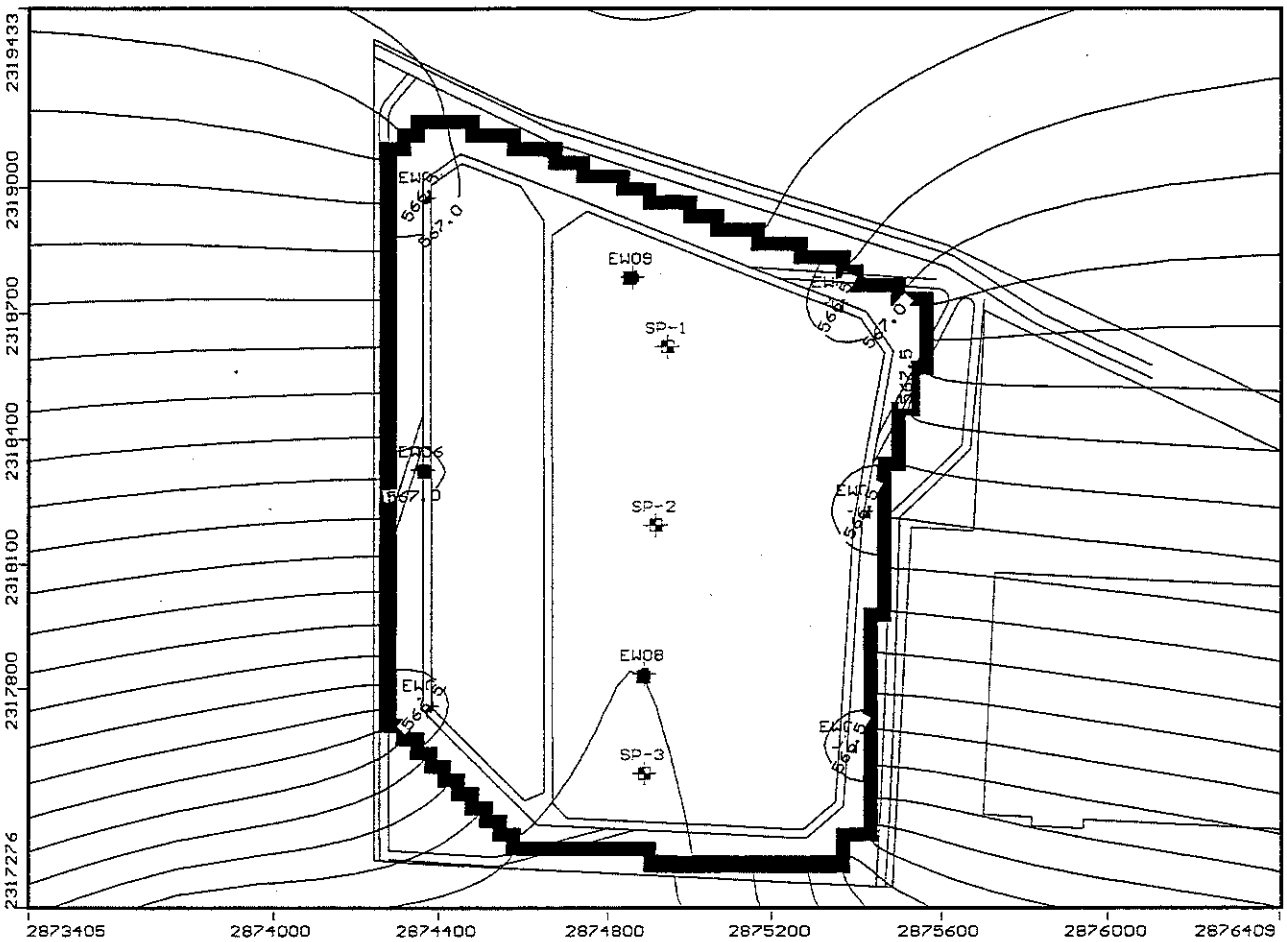
Visual MODFLOW v.2.8.2, (C) 1995–1999
Waterloo Hydrogeologic, Inc.
NC: 71 NR: 91 NL: 5
Current Layer: 5

$K_{WALL} = 1 \times 10^{-7}$ cm/sec (T = 730 DAYS)



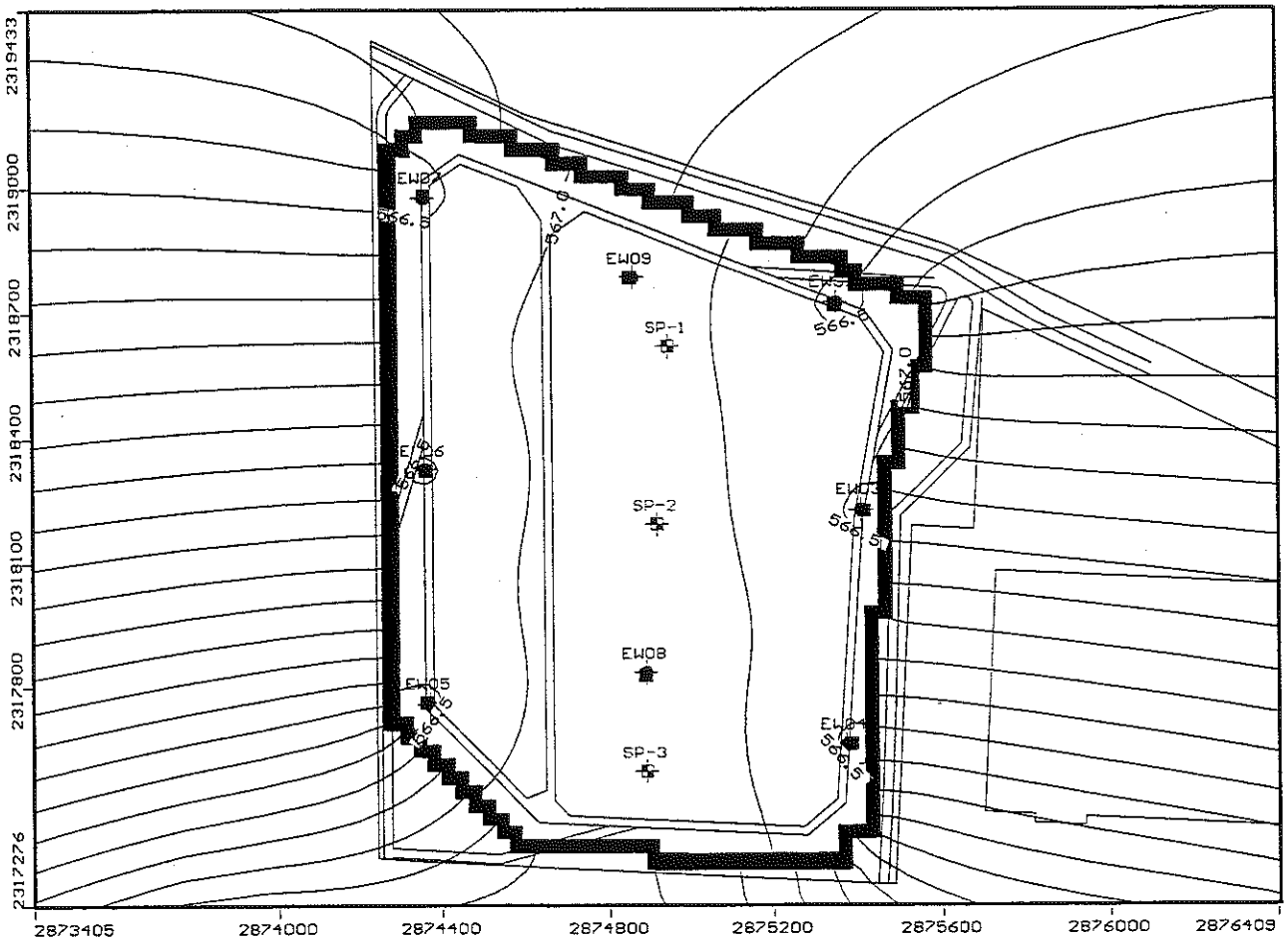
MW Project: US Steel CAMU Design Description: Dewatering: camu29,t730 Modeller: CAU 19 Oct 00	Visual MODFLOW v.2.8.2, (C) 1995-1999 Waterloo Hydrogeologic, Inc. NC: 71 NR: 91 NL: 5 Current Layer: 5

K_{WALL} = 1×10^{-7} cm/sec (T = 1825 days)



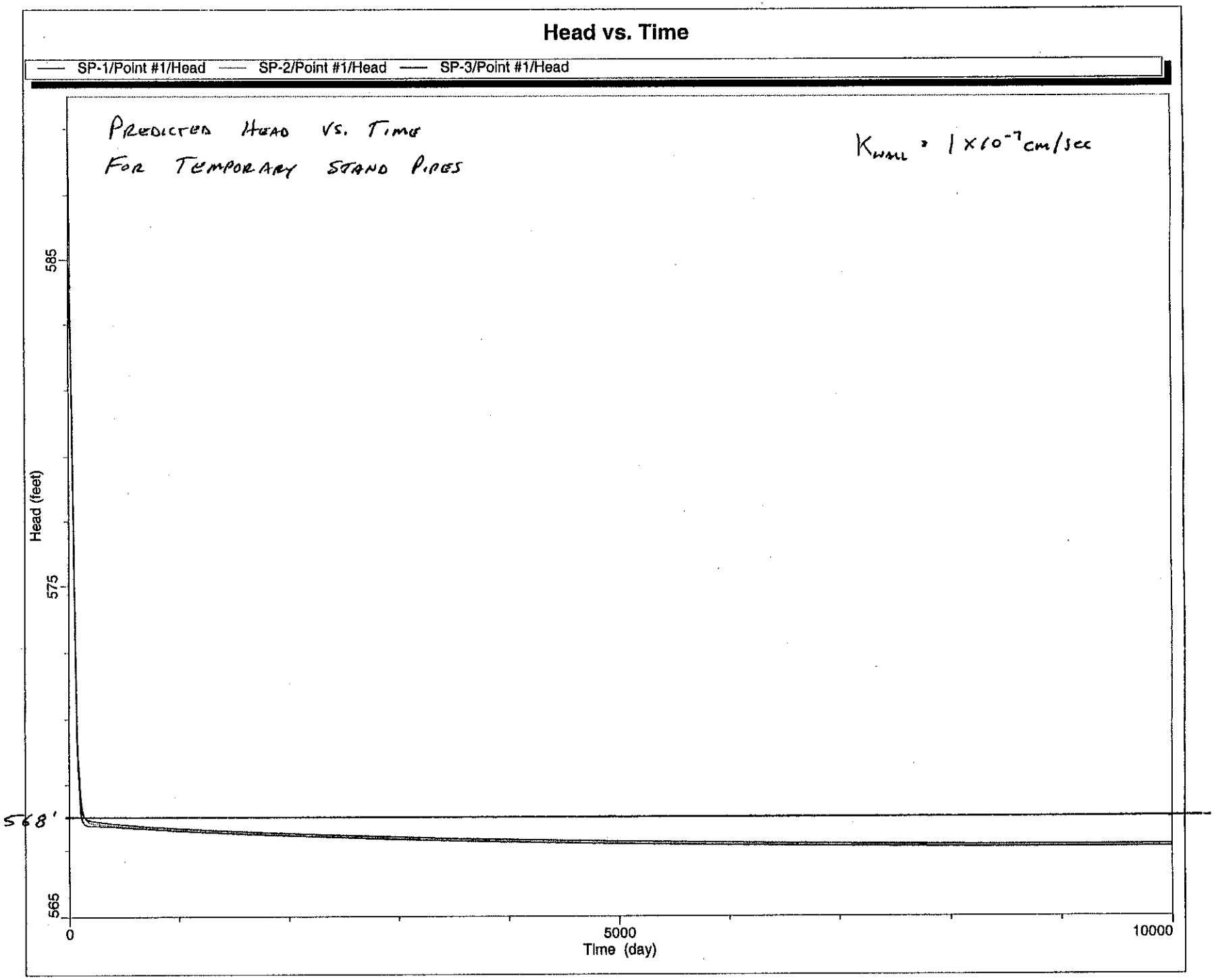
MW Project: US Steel CAMU Design Description: Dewatering: camu29,t1825 Modeller: CAU 19 Oct 00	Visual MODFLOW v.2.8.2, (C) 1995–1999 Waterloo Hydrogeologic, Inc. NC: 71 NR: 91 NL: 5 Current Layer: 5

$K_{WALL} = 1 \times 10^{-7}$ cm/sec (T = 10,000 days)



MW
Project: US Steel CAMU Design
Description: Dewatering: camu29,t10000
Modeller: CAU
19 Oct 00

Visual MODFLOW v.2.8.2, (C) 1995-1999
Waterloo Hydrogeologic, Inc.
NC: 71 NR: 91 NL: 5
Current Layer: 5


Head vs. Time
SP-1/Point #1/Head
SP-2/Point #1/Head
SP-3/Point #1/Head
PREDICTED HEAD VS. TIME
FOR TEMPORARY STAND PIPES
K_{WALL} = 1 x 10^-7 cm/sec
Head (feet)
585
575
565
568'
0
5000
10000
Time (day)

G

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G

STORM WATER DRAINAGE CALCULATIONS

G1 Infiltration Basin Calculations
G2 Surface Water Calculations

G1

Infiltration Basin Calculations

MONTGOMERY WATSON

By AAG Date 9-9-00 Client U.S. Steel - CAMU Design Sheet 1 of 7

Chkd. By L. BUSSE 9.20.00 Description Design of Infiltration Basins Job No. 1242330.01160101

Problem: Size infiltration basins for runoff from CAMU. Refer to drawing D160

Method: Use methods described in "Erosion and Sediment Control Handbook" Ref. Goldman, S.J. 1986

Assumptions: Size to settle particles 0.015mm ($V_s = 0.0005$ ft/s)
Size basins for the 25-year 6-hour storm event instead of peak flow (tc)

Given: Basin Surface Area $= \frac{1.2Q}{V_s}$

V_s = Setting Velocity 0.0005 ft/s Sheet __ of __

Q = Runoff (25-yr. 6-hr)

$Q = CiA$

C = 0.20 - Facilities Development Manual, July 2, 1979

A) Calculate Q (flow into basins) for the 25-yr, 6-hr storm event.

i = 0.64 in/hr. (Sheet __ of __)

A = Surface Area contributing to basins

A_1 = 13 Acres (Digitized)

A_2 = 19.05 Acres (Digitized)

Basin #1

$Q_1 = CiA_1 \Rightarrow (0.20)(0.64\ in/hr)(13\ A)$

$Q_1 = 1.66$ cfs

BASIN #2

$Q_2 = CiA_2 \Rightarrow (0.20)(0.64\ in/hr)(19.05\ A)$

$Q_2 = 2.44$ cfs

B) Calculate Area of Basin for this flow to settle

Basin #1

$$A_{S1} = \frac{1.2Q_1}{V_s} = \frac{1.2(1.66\ cfs)}{0.0005\ ft/s} = 3984\ ft^2$$

Basin #2

$$A_{S2} = \frac{1.2Q_2}{V_s} = \frac{1.2(2.44\ cfs)}{0.0005\ ft/s} = 5856\ ft^2$$

C.) Surface Area (as designed)

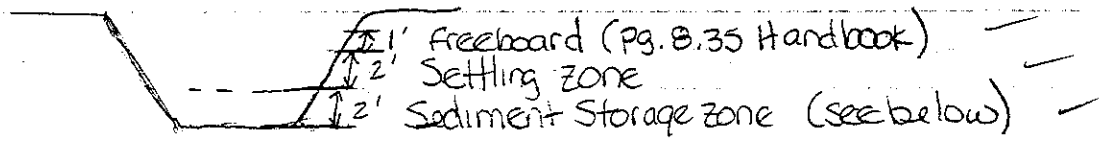
Basin #1

A_1 design = 60 x 110 = 6600 ft^2 > 3984 ft^2 OK ✓

Basin #2

A_2 design = 110 x 110 = 12,100 ft^2 > 5856 ft^2 OK ✓

D.) Settling Depth of basins → use minimum 2' (pg 8.19 Handbook) ✓



E.) Sediment Storage Depth

Assume erosion rate = 5 tons/acre/yr ✓

Basin #1

5 tons/acre/yr * 13 Acre
= 65 tons/yr * 2000 lbs/ton
@ 70 lbs/CF

= 1857 CF/yr

over actual basin area

$\frac{1857\ CF/yr}{6600\ ft^2} = 0.28\ ft/yr$ ✓

Basin #2

5 tons/acre/yr * 19.05 Acre
= 95 tons/yr * 2000 lbs/ton
@ 70 lbs/CF

= 2714 CF/yr

over actual basin Area

$\frac{2714\ CF/yr}{12,100\ ft^2} = 0.22\ ft/yr$ ✓

Therefore, in four years approximately 1' of sediment will build up so use a 2' storage depth to be conservative.

F.) Infiltration Basin Outlet Design

Use standpipe with dewatering orifice A_o

$$A_o = \frac{A_s \sqrt{2H}}{3600 \cdot T \cdot Cd \cdot \sqrt{g}}$$

A_o = Area of Dewatering orifice
H = head of water above orifice = 3
A_s = Area of Sedimentation Basin
T = Dewatering Time Assume 3 days minimum
Cd = Coefficient of contraction for orifice = 0.6
g = gravity = 32.2 ft/s²

Basin #1

$$A_{o1} = \frac{6600\ ft^2 \sqrt{2(6)}}{3600 * 72 * 0.6 \sqrt{32.2}}$$

$A_{o1} = 0.03\ ft^2 = 4.3\ in^2$

use a 2" x 2" hole

Check flow:

$Q = cd * A_o * \sqrt{2gh}$

$= 0.6 * 0.03 * \sqrt{2(32.2)(6)}$

$Q = 0.35\ ft^3/s$

flow is minimal

Basin #2

$$A_{o2} = \frac{12{,}100\ ft^2 \sqrt{2(6)}}{3600 * 72 * 0.6 \sqrt{32.2}}$$

$A_{o2} = 0.05\ ft^2 = 7.2\ in^2$

use a 2" x 4" hole

Check flow

$Q = cd * A_o * \sqrt{2gh}$

$= 0.6 * 0.05 * \sqrt{2(32.2)(6)}$

$Q = 0.58\ ft^3/s$

flow is minimal

G) Find maximum flow Infiltration basins can handle with current design.

Basin #1

$$A_{s1max} = \frac{1.2 Q_{max}}{V_s}$$

$$Q_{1max} = \frac{A_{smax} V_s}{1.2}$$

$$Q_{1max} = \frac{(6000 sf)(0.0005 ft/s)}{1.2}$$

$$Q_{1max} = 2.75 \text{ cfs}$$

Basin #2

$$A_{s2max} = \frac{1.2 Q_{2max}}{V_s}$$

$$Q_{2max} = \frac{A_{s2max} V_s}{1.2}$$

$$Q_{2max} = \frac{(12100 ft^2)(0.0005 ft/s)}{1.2}$$

$$Q_{2max} = 5.04 \text{ cfs}$$

H) Find maximum intensity rainfall

Basin #1

$$Q_{1max} = C i_{1max} A_{1max}$$

$$i_{1max} = \frac{Q_{1max}}{C A_{1max}}$$

$$i_{1max} = \frac{2.75 ft^3/s}{(0.20)(13 acres)}$$

$$i_{1max} = 1.05 \text{ in/hr}$$

maximum intensity rainfall of 1.05 in/hr corresponds to a 100-year, 4-hr storm event.

Basin #2

$$Q_{2max} = C i_{2max} A_{2max}$$

$$i_{2max} = \frac{Q_{2max}}{C A_{2max}}$$

$$i_{2max} = \frac{5.04 cfs}{(0.2)(19.05 Acres)}$$

$$i_{2max} = 1.32 \text{ in/hr}$$

maximum intensity rainfall of 1.32 in/hr corresponds to a 100-year, 3-hr storm event.

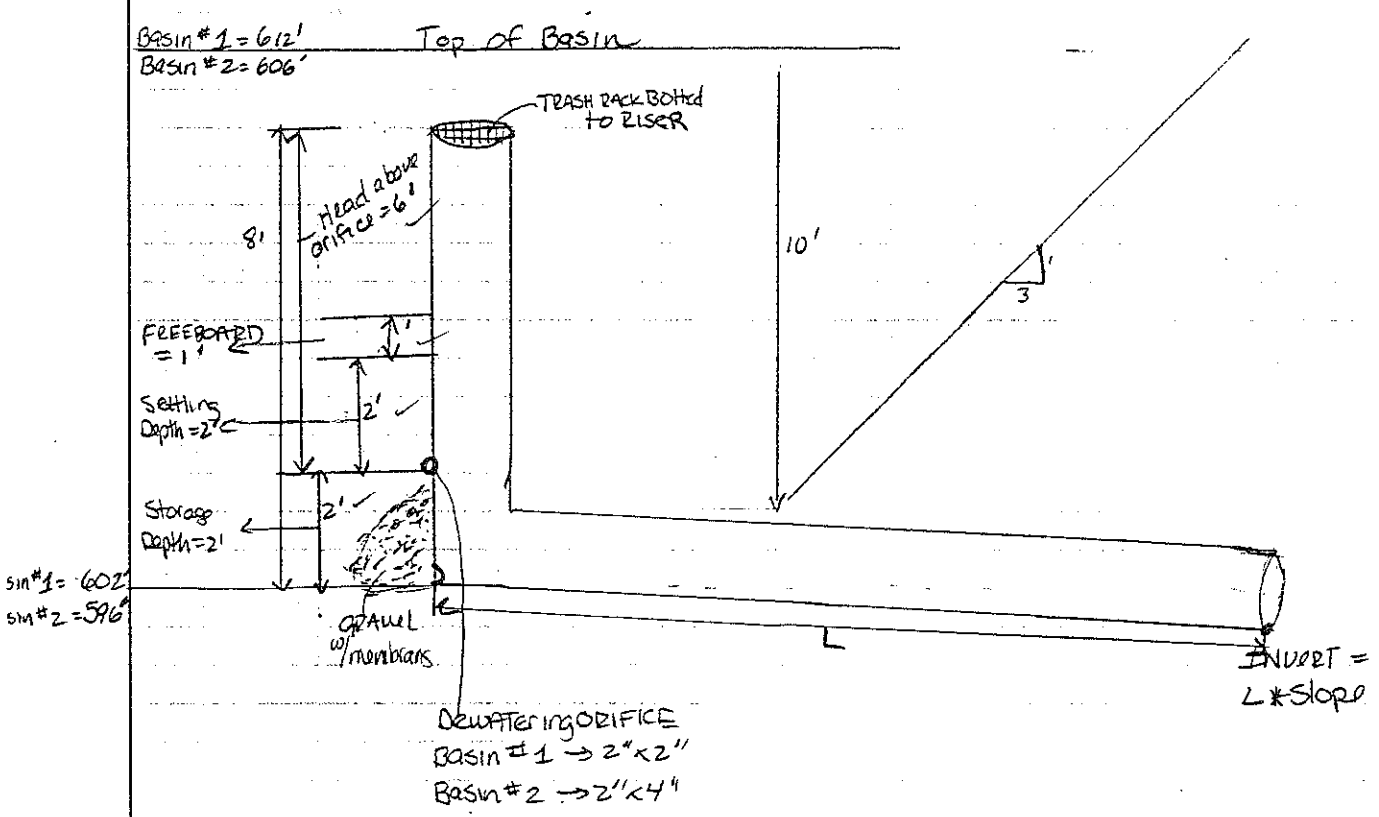
MONTGOMERY WATSON

By AAG Date 9-9-00 Client U.S. Steel - CAMU Design Sheet 5 of 7

Chkd. By Busse 9-20-00 Description Design of Infiltration Basins Job No 1242330.01160101

I.) Infiltration Basin outlet Schematic

The over flow structure will be designed with a 24" corrugated pipe diameter for both basins



DETAIL A

RUNOFF COEFFICIENTS (C), RATIONAL FORMULA

Land Use	Percent Impervious Area	Hydrologic Soil Group A			B			C			D		
		Slope Range (Percent)			Slope Range (Percent)			Slope Range (Percent)			Slope Range (Percent)		
		0-2	2-6	6 & Over	0-2	2-6	6 & Over	0-2	2-6	6 & Over	0-2	2-6	6 & Over
Industrial	90	0.67 0.85	0.68 0.85	0.68 0.86	0.68 0.85	0.68 0.86	0.69 0.86	0.68 0.86	0.69 0.86	0.69 0.87	0.69 0.86	0.69 0.86	0.70 0.88
Commercial	95	0.71 0.88	0.71 0.89	0.72 0.89	0.71 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.90	0.72 0.89	0.72 0.89	0.72 0.90
High-Density Residential	60	0.47 0.58	0.49 0.60	0.50 0.61	0.48 0.59	0.50 0.61	0.52 0.64	0.49 0.60	0.51 0.62	0.54 0.66	0.51 0.62	0.53 0.64	0.56 0.69
Medium-Density Residential	30	0.25 0.33	0.28 0.37	0.31 0.40	0.27 0.35	0.30 0.39	0.35 0.44	0.30 0.38	0.33 0.42	0.38 0.49	0.33 0.41	0.36 0.45	0.42 0.54
Low-Density Residential	15	0.14 0.22	0.19 0.26	0.22 0.29	0.17 0.24	0.21 0.28	0.26 0.34	0.20 0.28	0.25 0.32	0.31 0.40	0.24 0.31	0.28 0.35	0.35 0.46
Agriculture	5	0.08 0.14	0.13 0.18	0.16 0.22	0.11 0.16	0.15 0.21	0.21 0.28	0.14 0.20	0.19 0.25	0.26 0.34	0.18 0.24	0.23 0.29	0.31 0.41
Open Space	2	0.05 0.11	0.10 0.16	0.14 0.20	0.08 0.14	0.13 0.19	0.19 0.26	0.12 0.18	0.17 0.23	0.24 0.32	0.16 0.22	0.21 0.27	0.28 0.39
Freeways and Expressways	70	0.57 0.70	0.59 0.71	0.60 0.72	0.58 0.71	0.60 0.72	0.61 0.74	0.59 0.72	0.61 0.73	0.63 0.76	0.60 0.73	0.62 0.75	0.64 0.78

Source SEWRPC.

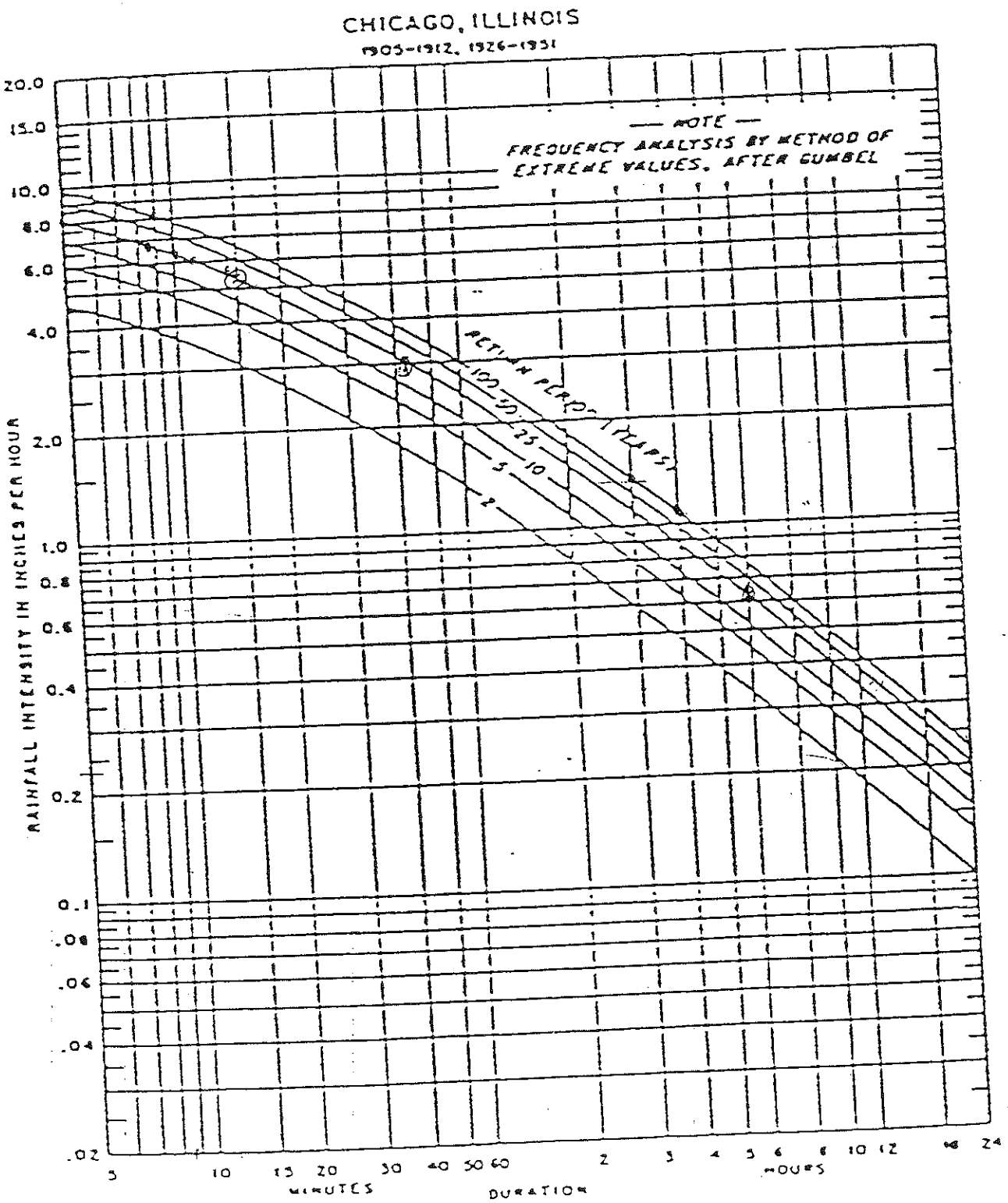
DETAIL B

RUNOFF COEFFICIENTS FOR SPECIFIC LAND USE

	Hydrologic Soil Group A			B			C			D		
	Slope Range (Percent)			Slope Range (Percent)			Slope Range (Percent)			Slope Range (Percent)		
LAND USE:	0-2	2-6	6 & Over	0-2	2-6	6 & Over	0-2	2-6	6 & Over	0-2	2-6	6 & Over
Row crops	.08 .22	.16 .30	.22 .38	.12 .26	.20 .34	.27 .44	.15 .30	.24 .37	.33 .50	.19 .34	.28 .41	.38 .56
Median strip-turf	.19 .24	.20 .26	.24 .30	.19 .25	.22 .28	.26 .33	.20 .26	.23 .30	.30 .37	.20 .27	.25 .32	.30 .40
Side slope-turf			.25 .32			.27 .34			.28 .36			.30 .38
PAVEMENT:												
Asphalt	.70 - .95											
Concrete	.80 - .95											
Brick	.70 - .80											
Drives, Walks	.75 - .85											
Roofs	.75 - .95											
Gravel Roads Shoulders	.40 - .60											

NOTE: The lower C values in each range should be used with the relatively low intensities associated with 2-to 10-year design recurrence intervals whereas the higher C values should be used for intensities associated with the longer 25-to 100-year design recurrence intervals.

Sheet 1 of 1


CHICAGO, ILLINOIS
1905-1912, 1926-1951
— NOTE —
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
RETURN PERIOD (YEARS)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
.08
.06
.04
.02
5
10
15
20
30
40
50
60
2
3
4
5
6
8
10
12
18
24
MINUTES
HOURS
DURATION

G2

Surface Water Calculations

MONTGOMERY WATSON

By AAG Date 9-7-00 Client [illegible] Design Sheet 1 of 17

Chkd. By Busse 9/14/00 Description Surface Water [illegible] for Swales and Diversion Design Job No. [illegible]

Size RCP Pipes in Perimeter Swale based on peak flow.

Given: Final grade plan showing 3H:1V slopes from berm at an elevation of 620 ft. to a high elevation at 700 ft. An intermediate swale divides the flow on the site and at approximately 700 ft. flow is directed to Perimeter swales placed next to berm at 620 ft. which flows to the stormwater manholes at 620' and ultimately discharges into the sedimentation basins.

Basin #1 - Area A

Area A-1 = (610' + 140')/2 * 500' = 4.3 ac ✓

t_c = 500'/V=2 (V for 33% O.F) + 200'/V=1.5 (V for 1% G.W)
= 6.39 min. ✓

i_{A-1} = 7.5 in/hr ✓

Q_{A-1} = (0.2)(7.5 in/hr)(4.3 Ac)

Q_{A-1} = 6.45 ft^3/s ✓

Area A-2 = (540' + 170')/2 * 500' = 4.1 ac. ✓

t_c = 600'/V=2 (33% O.F) + 350'/V=1.5 (1% G.W)
= 8.9 min ✓

i_{A-2} = 6.7 in/hr ✓

Q_{A-2} = (0.2)(6.7 in/hr)(4.1 Ac) ✓

Q_{A-2} = 5.5 ft^3/s ✓

Area A-3 = (600' + 90')/2 * 480' = 3.8 ac ✓

t_c = 600/V=2 (V for 33% O.F) + 360/V=1.5 (V for 1% G.W)
= 9.0 min ✓

i_{A-3} = 6.6 in/hr ✓

Q_{A-3} = (0.2)(6.6 in/hr)(3.8 Ac) = 5.0 ft^3/s ✓

MONTGOMERY WATSON

By AAG Date 9-9-00 Client U.S. Steel - Gary Sheet 2 of 17

Chkd. By Busse 9/14/00 Description Surface Water Calculations Job No. 1242330 01160

Basin #1

Sizing Pipes for manholes on berm at 620'

Refer to Drawing D100

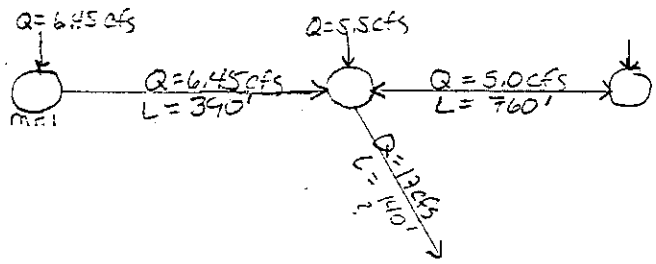
flow from SM1 to SM2 = 6.45 ft³/s ✓

flow from SM3 to SM2 = 5.0 ft³/s ✓

flow into SM2 = 5.5 ft³/s ✓

Pipe leading out of SM2 into Sedimentation basin 1 will need to handle flow from all three manholes

$Q = 5.0\ ft^3/s + 6.45\ ft^3/s + 5.5\ ft^3/s = 17\ ft^3/s$ ✓



Size Pipes using mannings equation

$$Q = \frac{0.463}{n} d^{8/3} s^{1/2}$$

$$D = \left(\frac{2.159 Qn}{s^{1/2}}\right)^{3/8}$$

$n = 0.011$ ✓
$S = 0.5\%$ (0.005 slope) ✓

$$D = \frac{2.159(0.011)Q}{(0.005)^{1/2}} = \frac{0.02375Q}{0.07071}$$ ✓

$$D = (0.336Q)^{3/8}$$ ✓

*NOTE: FOR PLASTIC PIPE n = 0.016 CHECK TO SEE IF PLASTIC WILL WORK

$D = (0.4885Q)^{3/8}$ for plastic

D for plastic is circled

1st Segment SM1 to SM2, Q = 6.5 cfs D = 1.34' (1.54') = 16 in (18.5") use 18" (USE 21")

2nd Segment SM3 to SM2 Q = 5.0 cfs D = 1.21' (1.39') = 15 in use 18" (USE 18") ✓

3rd Segment SM2 to Basin Q = 17 cfs D = 1.92' (2.2') = 23 in (26.5") use 24" ✓

USE 21" PE on 1st & 18" on 2nd BUT USE CONC FOR 3rd Seg

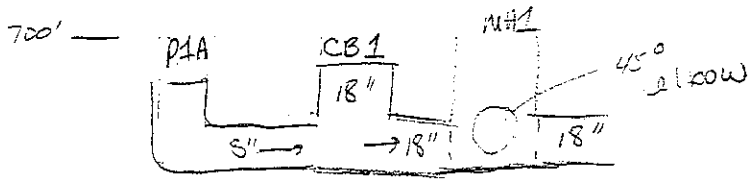
LAB 10/18/00

Basin #1

Sizing of catch basins for intermediate swale at 700' elevation to perimeter swale located alongside berm at 620'

Area A-1

piping from P1a → CB1b → MH1



Size downslope pipe (downslope pipe) to CB1

Area A-1a = $\left(\frac{140' + 400'}{2}\right) 260' = 1.6\ ac$ ✓

t_c = 260'/v=2 (v for 33% O.F) + 170'/v=1.5 (v for 1% & w)

t_c = 4.1 min. ✓

i_{a-1a} = 8 in/hr ✓ (Reference Sh 18)

$Q_{A-1a} = (0.2)(8.0\ in/hr)(1.6\ ac)$

Q_{A-1a} = 2.6 cfs ✓

Using Mannings equation to determine downslope pipe size

$D = \left(\frac{2.159 Qn}{S^{1/2}}\right)^{3/8}$ n = 0.011, S = 0.33

$D = \left(\frac{(2.159)(2.6)(0.011)}{0.33^{1/2}}\right)^{3/8}$

D = 0.43 ft ✓ => 5.2 in ✓ use 8 in pipe ✓

* $D = (0.06\ Q)^{3/8}$ for plastic pipe n = 0.016

D = 0.498 = 5.9

PE 8" pipe OK

Check D = 8 in

$V = \frac{1.486 r^{2/3} S^{1/2}}{n}$ n = 0.011, S = .33, r = D/4 = 0.67/4

$V = \frac{1.486 (0.67)^{2/3} (0.33)^{1/2}}{0.011}$ = 24 ft/s

$\pi r^2 = A$

$\frac{3.14}{4}(0.67)^2 = A$

A = 0.35

Q = V * A = 24 * 0.35 = 8.47

$Q_{act} = \frac{2.6\ cfs}{0.5} = 5.2$ 5.2 < 8.4 OK

MONTGOMERY WATSON

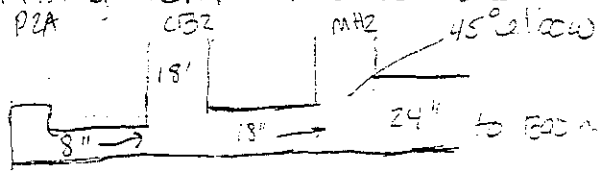
By [illegible] Date 9-9-00 Client U.S. Steel CAMU Design Sheet 4 of 17

Chkd. By L. BUSSE 9-20-00 Description Surface water calculations for downslope piping from interceptor swale to perimeter swale Job No. 1242350.0160101

Basin #1

Area A-2a

Piping from P2a to CB2 (Downslope Pipe)



Size Downslope Pipe P2a in Area A-2a

Area A-2a $= \left(\frac{390' + 160'}{2}\right) 260' = 1.64\ ac$ ✓

$t_c = 260'/v=2$ (v for 35% O.F) + $240'/v=1.5$ (v for 1% G.W)

$t_c = 4.8$ min ✓

$i = 8$ in/hr - peak flow for 25-yr storm ✓

$Q = (0.2)(8\ in/hr)(1.64\ ac)$

$Q_{A-2a} = 2.62$ cfs ✓

using mannings equation to determine downslope pipe size

$D = \left(\frac{2.159 Qn}{S^{1/2}}\right)^{3/8}$ $n = 0.011$, $Q = 2.6$ cfs, $S = 0.33$

$D = \left(\frac{(2.159)(2.6)(0.011)}{0.33^{1/2}}\right)^{3/8} = 0.43$ in = 6 in from previous area A-1a use 8 in pipe ✓

For $n = 0.016$ PE pipe
$D = (0.060\ Q)^{3/8}$
$D = .5$ ∴ 8" PE pipe OK

Area A-3a $= \frac{1}{2}(80' \times 90') = 0.082\ AC + (340' + 90')/2 * 260' = 1.4\ ac$

$t_c = 240/v=2$ (v for 35% O.F) + $120'/v=1.5$ (v for 1% G.W) =
$t_c = 3.3$ min.
$i = 8$ in/hr - peak flow for 25-year storm

$Q_{A-3a} = (0.2)(8\ in/hr)(1.4\ ac) = 2.24$ cfs ✓

Size downslope pipe to be 8" → same as areas A-1a and A-2a

8" PE PIPE OK

MONTGOMERY WATSON

By AFG Date 9-9-00 Client U.S. Steel - CAMU Design Sheet 5 of 17

Chkd. By L. Busse 9.20.00 Description Surface water calculations for piping to sedimentation basin Job No. 1242332.01160101

Basin #1

Check swale Depths by using a computer program
Perimeter swale + Intermediate swale

Inputs: B = 2' (bottom width) PERIMETER SWALE
Rip.Swale SS = 3 ✓ Flow Depth = 1.2' < 2.0' - OK ✓
Channel slope = 0.01 ✓
Maximum flow = 6.5 cfs ✓ See Sheet 6 of 19
retardance curve C

Intermediate Swale B = 0' ✓ Max. Flow = 1.9 cfs Flow Depth = 1.2' < 2.0' OK
Inputs: SS = 3 ✓ retardance curve C
Channel slope = 0.01 ✓ See sheet 7 of 17

Check Scouring velocity on downslope Pipes.

Downslope pipe diameter = 8" $A = \pi r^2 = 0.349\ ft^2$

Q = 2.6, 2.6, and 2.2 cfs

$Vel = Q/A \quad \frac{2.6\ ft^3/s}{0.349\ ft^2} = 7.5\ ft/s$

Vel will be > 2 ft/s ✓

U.S. Steel
Perimeter Swale Depth for Area A

Swale Sizing Using Vegetative Retardance Curves

Set Design Data

Bottom Width (B) (ft)	2
Sideslope (Z:1)	3
Channel slope (S) (ft/ft)	0.01
Maximum Flow (Q) (cfs)	6.5
Retardance Curve	C
Solve for Flow Depth (Y) (ft)	**1.15**

V1 must be equal to or close to V2

Result **Try Smaller Y**

Calculations

Area (A)	6.2675
Hydraulic Radius (R)	0.67587
Velocity (V1)	1.0371
Product (V1 * R)	0.70094
Velocity (V2)	1.10339
Manning's N	0.104

D ≤ 1.15'

Proposed swale design D = 2'

AAG/aag/
M:\1242\330\01\PerswaleDepthA.xls
1242330.01160101-MD

U.S. Steel
Intermediate Swale Depth for Area A

Swale Sizing Using Vegetative Retardance Curves
Set Design Data

Bottom Width (B) (ft)	0
Sideslope (Z:1)	3
Channel slope (S) (ft/ft)	0.01
Maximum Flow (Q) (cfs)	1.9
Retardance Curve	c
Solve for Flow Depth (Y) (ft)	**1.21**

V1 must be equal to or close to V2

Result	**Try Larger Y**
Calculations	
Area (A)	4.3923
Hydraulic Radius (R)	0.57395
Velocity (V1)	0.43258
Product (V1 * R)	0.24828
Velocity (V2)	0.42877
Manning's N	0.24

D ≤ 1.21 Proposed Swale Design D=2

AAG/aag /L B
J:\1242\330\01\IntswalesDepthA.xls
9/27/00

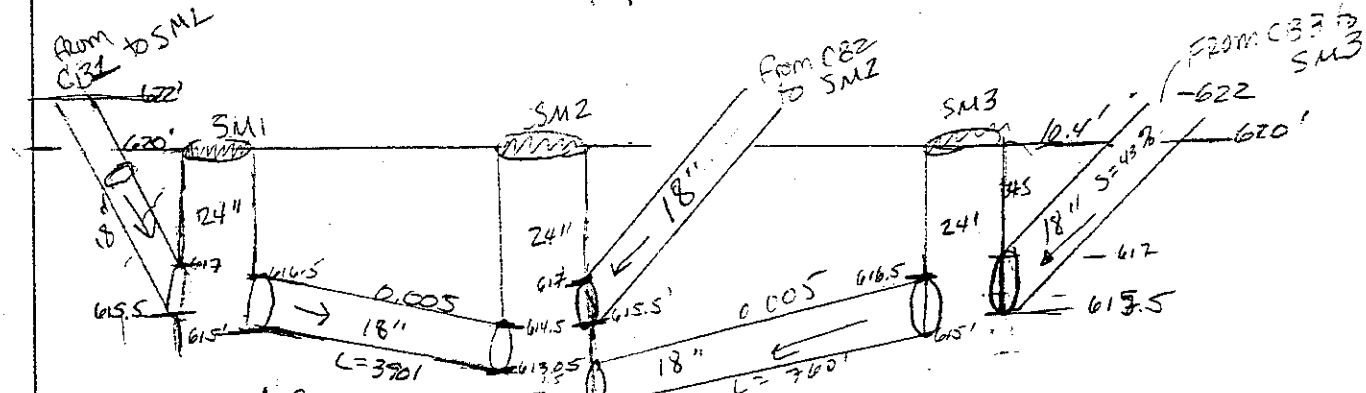
MONTGOMERY WATSON

By AAG Date 9-9-00 Client U.S. Steel-CAMU Design Sheet 8 of 17

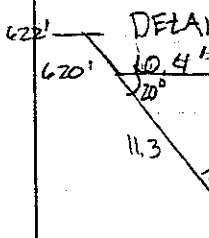
Chkd. By _____ Description Surface Water calculations for swales and piping design Job No. 1242330.0116010

Basin #1

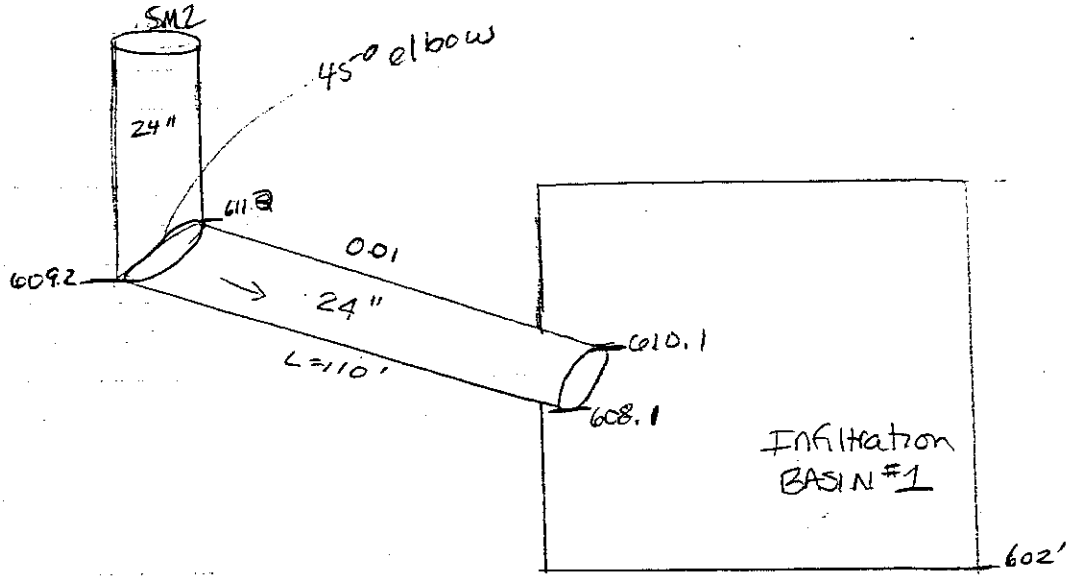
SM 1 = 18" pipe
SM 2 = 18" pipe
SM 3 = 24" pipe



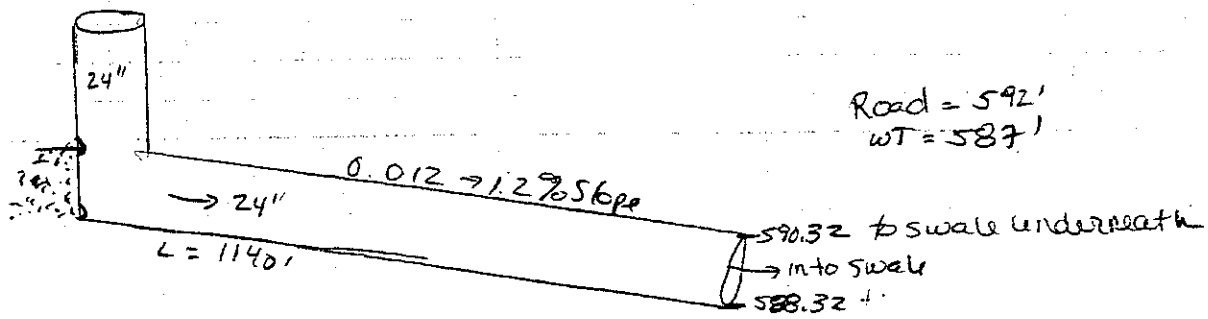
DETAILED for catch basins CB1, CB2, + CB3



Slope = 43% = 2.3:1



ORIFICE - EMERGENCY OVERFILL



Road = 592'
WT = 587'

Basin #2 - Area B

To keep manhole numbering consistent around perimeter roadway Area B starts with Area B-4

Size RCP pipes in Perimeter berm based on Peak flow

Area B-4 = 1/2[420 * 720'] + 1/2[490 * 620'] = 7.0 Acres

t_c = 600'/v=2 (v for 33% O.F) + 680'/v=1.5 (v for 1% G.W)
t_c = 12.6 min
i_{B-4} = 6.0 in/hr (Reference Sheet 18)

Q_{B-4} = (0.2)(6.0 in/hr)(7.0 Acres)

Q_{B-4} = 8.4 cfs

Area 2-5 = $\left(\frac{570+285}{2}\right)$ 470' = 4.6 Acres

t_c = 570'/v=2 (v for 33% O.F) + 350'/v=1.5 (v for 1% G.W)
t_c = 8.6 min
i_{B-5} = 6.8 in/hr (Reference Sh 18)

Q_{B-5} = (0.2)(6.8 in/hr)(4.8 Acres)

Q_{B-5} = 6.3 cfs

Area B-6 = $\left(\frac{335+130'}{2}\right)$ 510' + $\frac{320 * 520'}{2}$ = 4.6 Acres

t_c = 500'/v=2 (v for 33% O.F) + 340'/v=1.5 (v for 1% O.F)
t_c = 7.9 min
i_{B-6} = 7.0 in/hr (Sheet 18)

Q_{B-6} = (0.2)(7.0 in/hr)(4.6 Acres)

Q_{B-6} = 6.4 cfs

Basin #2

AREA B-7 = $\left(\frac{230' + 70'}{2}\right) 510' + \frac{1}{2}[720' \times 330'] = 4.5$ Acres

$t_c = 550'/V=2$ (V for 33% O.F) + $250'/V=1.5$ (V for 1% S.W)
$t_c = 7.7$ min
$i_{B-7} = 7.0$ in/hr (Sheet 13)

$Q_{B-7} = (0.2)(7.0 \text{ in/hr})(4.5 \text{ Acres})$

$Q_{B-7} = 6.3$ cfs

Sizing Pipes for Area B manholes on berm at 620'

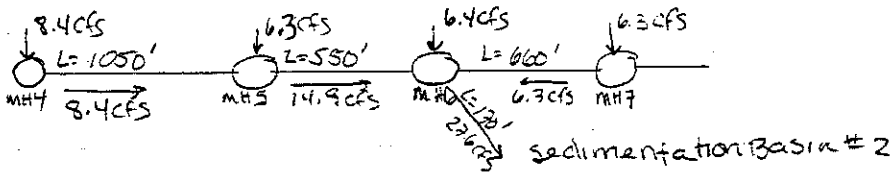
at a 1% slope CBs will be entering SHS at appoximately 616.6' elevation beneath the road

manholes are at an elevation of a 0.5% slope ≈ 618'

Flow from SM 4 to SM 5 = 8.4 cfs
Flow from SM 5 to SM 6 = 6.3 + 8.4 cfs = 14.7 cfs
flow from SM 7 to SM 6 = 6.3 cfs
flow into SM 6 = 6.4 cfs

Pipe leading out of SM 6 into Infiltration, Basin #2 will need to handle flows from all 4 manhous.

Qout = 8.4 + 6.3 + 6.3 + 6.4 = 27.4 cfs



Size Pipes using Mannings equation for Area B

$$Q = \frac{0.463\, d^{8/3} s^{1/2}}{n} \qquad n = 0.011,\ s = 0.5\%$$

$$D = \left(\frac{2.159(0.011)Q}{(0.005)^{1/2}}\right)^{3/8}$$

$$D = (0.336\,Q)^{3/8}$$

IF PE PIPE $n = 0.016$
$D = (0.4885\,Q)^{3/8}$
D_{PE} circled below

1st segment SM4 to SH5, Q = 8.4 cfs, D = 1.5' (=1.69) = 18" use 20" (PE needs 20")

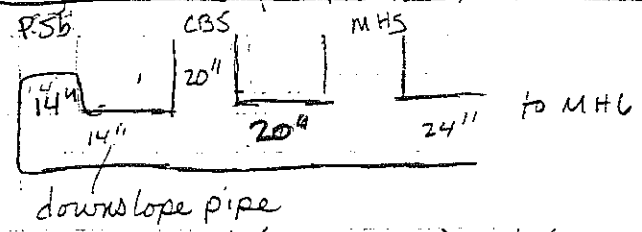
2nd Segment SM5 to SH6, Q = 15 cfs, D = 1.83' (2.11) = 22" use 24" (Needs 27')

3rd Segment SM7 to SH6, Q = 6.3 cfs, D = 1.32' (1.52) = 16" use 18" (18 OK)

4th Segment SM6 to Basin, Q = 27.6 cfs, D = 2.31' (2.65) = 28" (31.8) use 30" (PE USE 36" OR USE CONC.)

Sizing of Downslope Pipes for intermediate swale at 700' elevation to perimeter swale located alongside berm at 620'

Sizing downslope pipes P.4b, 5b, 6b, 7b for worst case



Area B-4b = 1/2 (280' * 330') + 1/2 (220' * 310') = 1.8 Acres

Area B-5b = $\frac{(420 + 270)}{2} * 270'$ = 2.13 Acres

Area B-6b = (250' + 90') 250' + 1/2 (150 * 280) = 1.5 Acres

Area B-7b = 1/2 (400' * 260') = 1.2 Acres

worst CASE = 2.13 Acres → Area B-5b

t_c = 310/v = 2 (v for 33% O.F) + 210'/v = 1.5 (v for 1% G.W)
= 4.9 min
i = 8.0 in/hr

Q_{B-5b} = (0.2)(8.0 in/hr)(2.13 Ac) = 3.4 cfs

Basin #2

Size downslope pipe from P5b by using mannings equation

$D = \left(\frac{2.159\,Qn}{S^{1/2}}\right)^{3/8}$ $n = 0.011$, $S = 0.33$

$D = \frac{(2.159)(0.011)Q}{0.574} = 0.0414\,Q$

$D = (0.0414\,Q)^{3/8}$ ✓

$D = [(0.0414)(3.4\,cfs)]^{3/8}$

$D = 0.479 = 6''$ ∴ use 8"

PE PIPE $D = (0.060\,Q)^{3/8}$

$D = 0.55 = 6.61'$

8" OK

Check D = 14" → $n = 0.011$, $S = 0.33$, $r = D/4$

$V = 1.486\,r^{2/3}S^{1/2}/n$

$V = 1.486\left(\frac{0.67}{4}\right)^{2/3}(0.33)^{1/2}/0.011$

$V = 24\ ft/s$

$A = \pi r^2 \Rightarrow \frac{3.14}{4}[0.67]^2 = 0.35\,ft^2$

$Q = 24 * 0.35\,ft^2 = 8.5\ cfs$

$Q_{act} = \frac{3.4\,cfs}{0.5} = 6.8\,cfs < 8.5$ OK

use 8" Downslope pipes for P5b, P6b, P7b, P8b

use 20" catchbasins for CB4, CB5, CB6, and CB7

SH4 = 20"
SH5 = 24"
SH6 = 30"
SH7 = 18"

SH6 to Sedimentation Basin #2 use 30" pipe

Check Swale Depths by using computer program

Perimeter Swale

inputs: B = 2 ✓ Q = 8.4 ✓
SS = 3 ✓
CS = 0.01 – retardance curve = C ✓

Depth = 1.2' < 2.0' OK (Sheet 14 of _) ✓

Interceptor Swale

inputs: B = 0 ✓ retardance curve = C
SS = 3 ✓
CS = 0.1 ✓
Q = 3.4 ✓

Depth = 1.25 < 2.0 → OK ✓
(Sheet 15 of _)

Check scour velocity for downslope pipes

$Q = VA$ $V = \frac{Q}{A} \Rightarrow \frac{3.4\,cfs}{0.35\,ft^2} = 9.7\,ft/s > 2.0$ OK ✓

U.S. Steel
Perimeter Swale Depth for Area B

Swale Sizing Using Vegetative Retardance Curves
Set Design Data

Bottom Width (B) (ft)	2
Sideslope (Z:1)	3
Channel slope (S) (ft/ft)	0.01
Maximum Flow (Q) (cfs)	8.4
Retardance Curve	C
Solve for Flow Depth (Y) (ft)	**1.2**

V1 must be equal to or close to V2

Result	**Try Larger Y**
Calculations	
Area (A)	6.72
Hydraulic Radius (R)	0.70077
Velocity (V1)	1.25
Product (V1 * R)	0.87596
Velocity (V2)	1.23741
Manning's N	0.095

D = 1.2 < proposed d = 2 ✓

AAG/aag/
M:\1242\330\01\PerswaleDepthB.xls
1242330.01160101-MD

U.S. Steel
Intermediate Swale Depth for Area B

Swale Sizing Using Vegetative Retardance Curves
Set Design Data

Bottom Width (B) (ft)	0
Sideslope (Z:1)	3
Channel slope (S) (ft/ft)	0.01
Maximum Flow (Q) (cfs)	3.4
Retardance Curve	c
Solve for Flow Depth (Y) (ft)	**1.25**

V1 must be equal to or close to V2

Result **Try Larger Y**

Calculations

Area (A)	4.6875
Hydraulic Radius (R)	0.59293
Velocity (V1)	0.72533
Product (V1 * R)	0.43007
Velocity (V2)	0.70107
Manning's N	0.15

D = 1.25 < proposed ok ✓

AAG/aag / L B
J:\1242\330\01\IntswalesDepthB.xls
9/27/00

MONTGOMERY WATSON

By AAG Date AAG Client U.S Steel - CAM Design Sheet 15 of 17

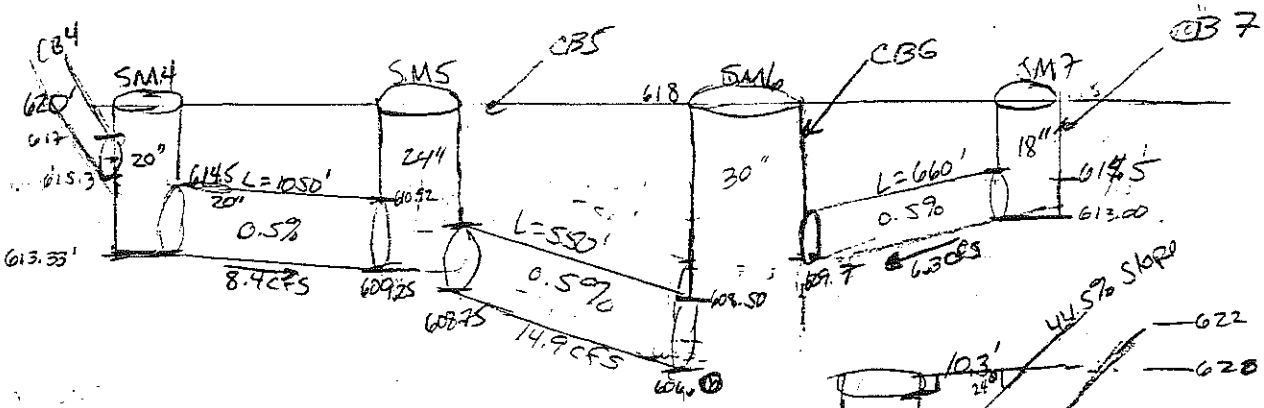
Chkd. By _____ Description Surface water calculations for swales + piping Design Job No. 1242330.01.6010

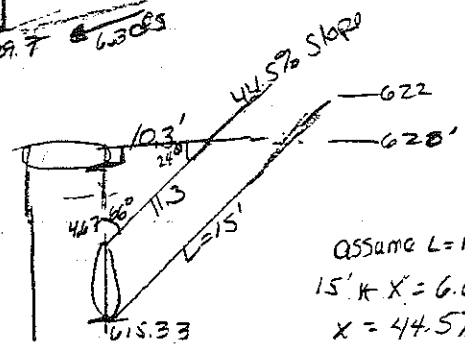
BASIN #2

H4 = 20"
H5 = 24"
H6 = 30"
H7 = 18"

Make all storm manholes - (SM) worst case = 30"

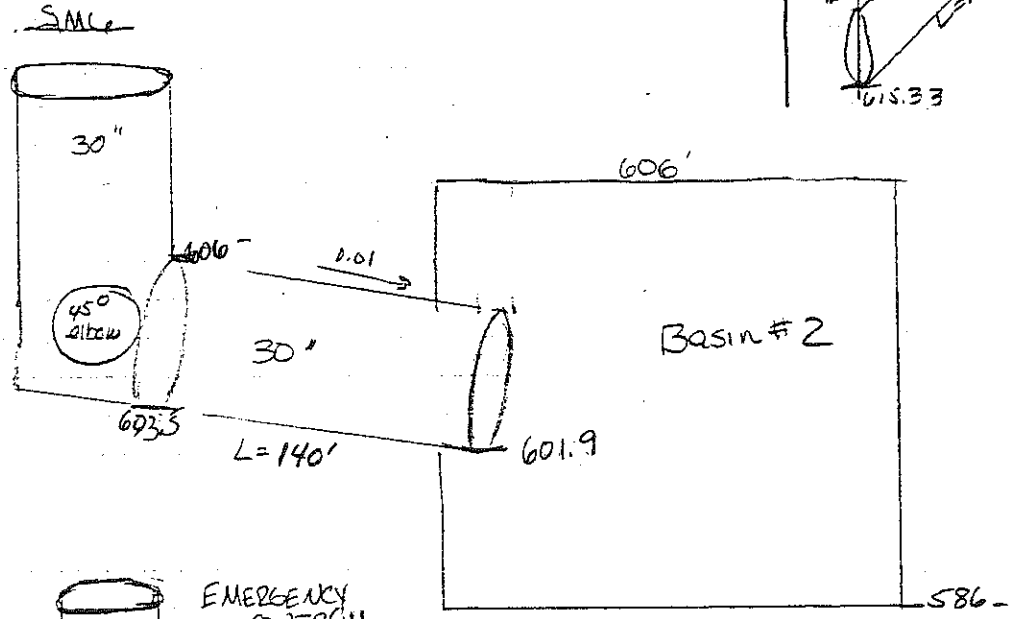
Make all catchbasins coming into storm manholes → 20"

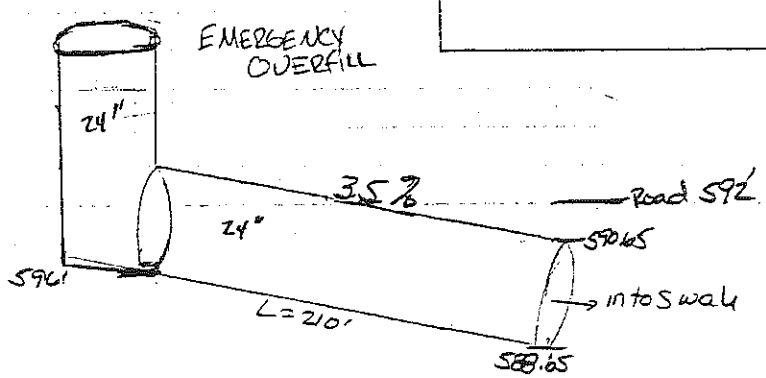




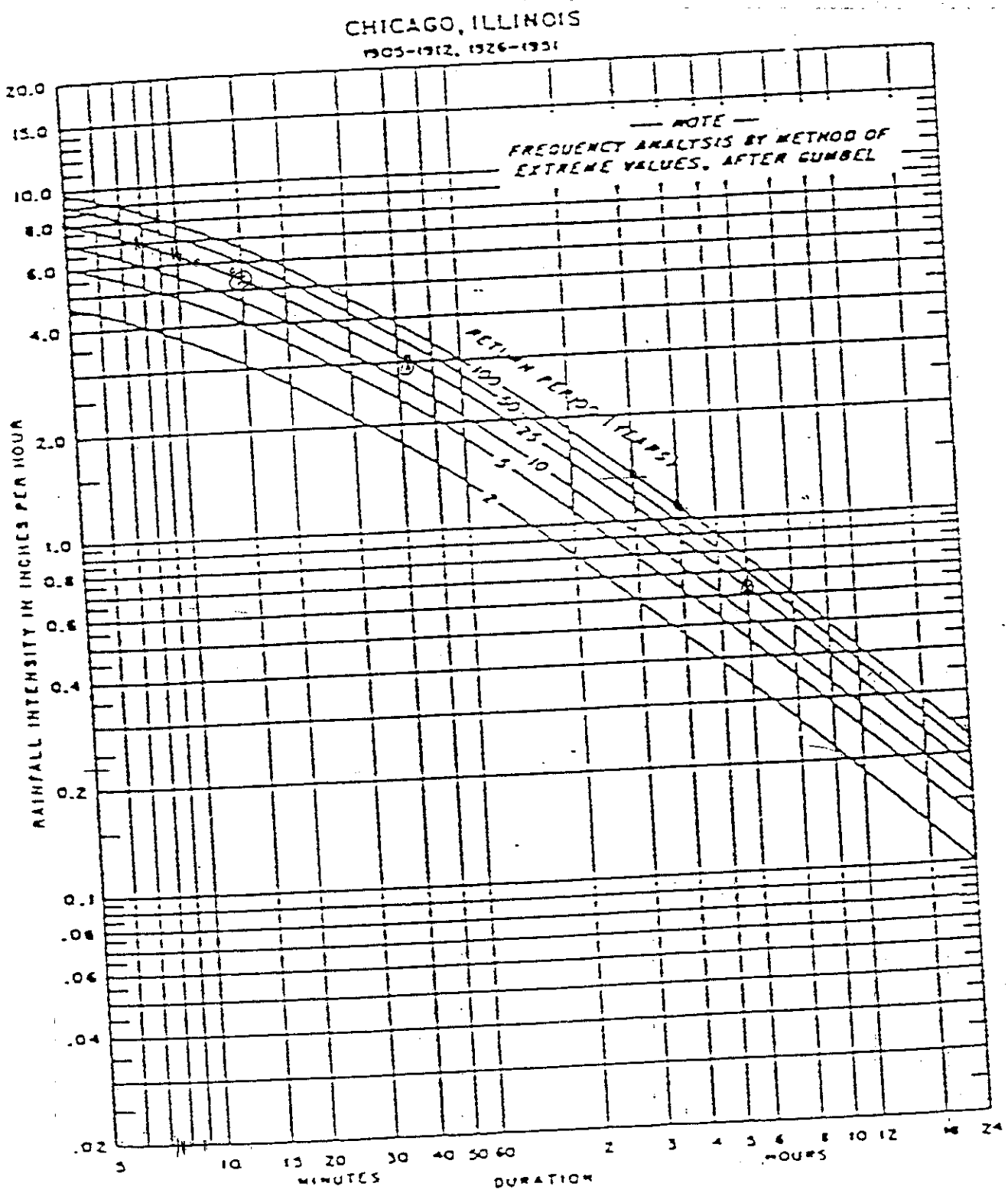
assume L=15'
15' * X = 6.67
X = 44.5% slope

$0.445 = \frac{1}{X}$ X=22

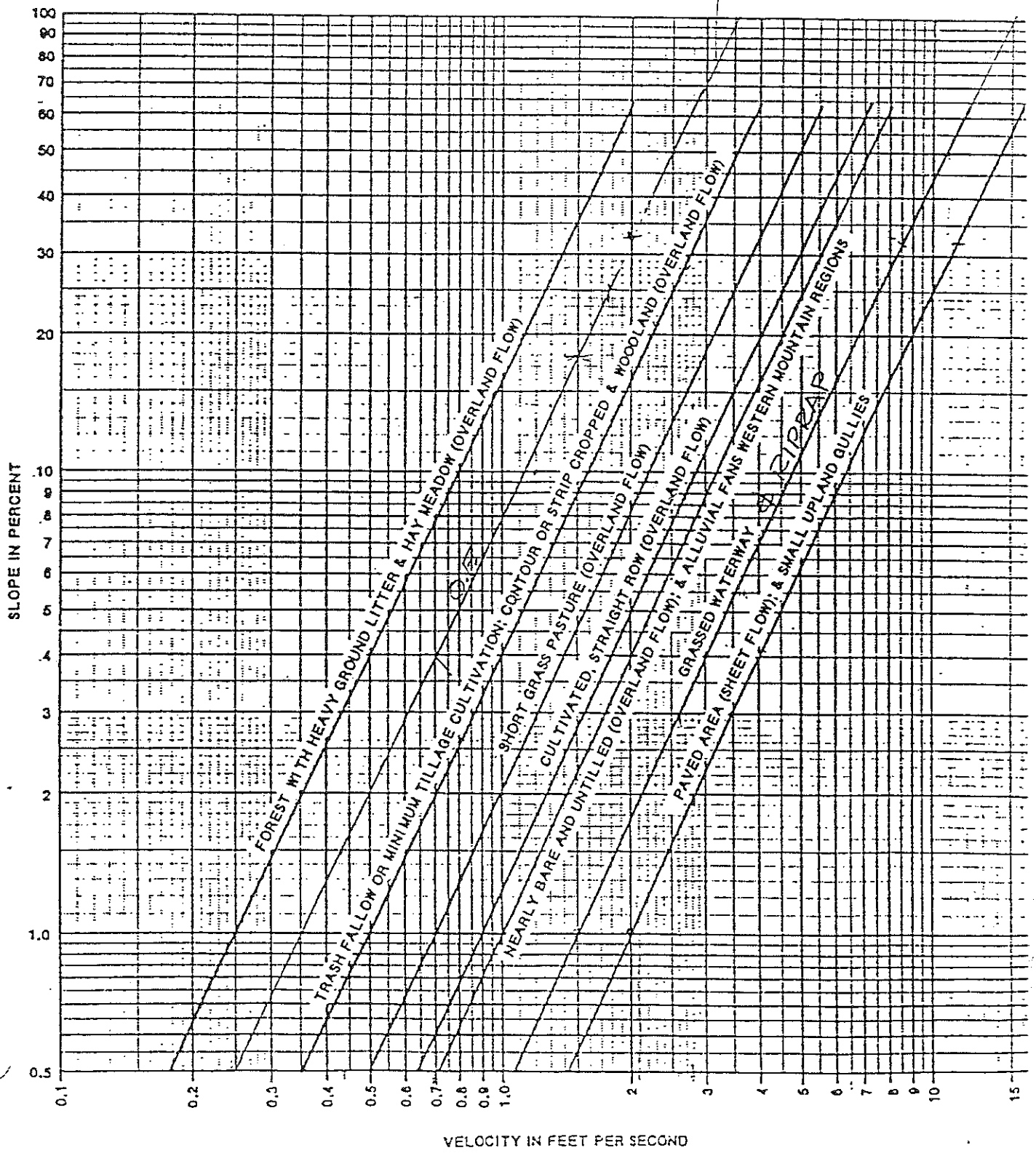




Road elevation = 592'
WATERTABLE = 587'


CHICAGO, ILLINOIS
1905-1912, 1926-1951
— NOTE —
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
RETURN PERIOD (YEARS)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
.08
.06
.04
.02
5
10
15
20
30
40
50
60
2
3
4
5
6
8
10
12
18
24
MINUTES
HOURS
DURATION

-8


SLOPE IN PERCENT
VELOCITY IN FEET PER SECOND
FOREST WITH HEAVY GROUND LITTER & HAY MEADOW (OVERLAND FLOW)
TRASH FALLOW OR MINIMUM TILLAGE CULTIVATION; CONTOUR OR STRIP CROPPED & WOODLAND (OVERLAND FLOW)
SHORT GRASS PASTURE (OVERLAND FLOW)
CULTIVATED, STRAIGHT ROW (OVERLAND FLOW)
NEARLY BARE AND UNTILLED (OVERLAND FLOW); & ALLUVIAL FANS WESTERN MOUNTAIN REGIONS
GRASSED WATERWAY
PAVED AREA (SHEET FLOW); & SMALL UPLAND GULLIES
RIPRAP

H

AVERY RECYCLED PAPER MADE FROM 20% POST CONSUMER CONTENT

H

GEOSYNTHETIC LABORATORY TEST RESULTS

H1 Geomembrane EPA 9090 and GCL Compatability Laboratory Test Results (December 1997)

H2 Geomembrane EPA 9090 Laboratory Test Results (February 1998)

H3 Geotextile Biological Clogging Laboratory Test Results (September 1999)

MEMORANDUM

MONTGOMERY WATSON

One Science Court
P.O. Box 5385
Madison, Wisconsin 53705-0385
Tel: (608)231-4747
Fax: (608)231-4777

To: File 1272035.01090090 **Date:** November 8, 1999

From: Val Ranguette

Subject: Geosynthetic Laboratory Results
Grand Calumet River Sediment Remediation Project
CAMU Design
U.S. Steel - Gary Works

Geosynthetic laboratory compatibility testing was performed on proposed, typical geosynthetic materials that are proposed for the liner system for the Grand Calumet River Passive Dewatering Facility (PDF) for U.S. Steel - Gary Works. Testing was performed by J&L Testing Company, Inc. of Canonsburg, Pennsylvania. Geosynthetic compatibility testing consisted of the following tests:

- EPA 9090/ASTM D5747 - Geomembrane Compatibility Testing
- ASTM D5084 - GCL Compatibility Permeability
- ASTM D1987 - Geotextile Biological Clogging

Each of these compatibility tests were performed with the synthetic leachate that was developed based on testing previously performed with the river sediments. Refer to the synthetic leachate testing program in the *Permit Level Design Report, Passive Dewatering Facility, Grand Calumet River Sediment Remediation Project U.S. Steel - Gary works, Gary, Indiana* (December 1997).

EPA 9090/ASTM D5747 - GEOMEMBRANE COMPATIBILITY TESTING

A typical 60-mil HDPE geomembrane sample manufactured by National Seal Company (NSC) was tested in accordance with EPA 9090/ASTM D5747. This test exposes the geomembrane to the synthetic leachate by immersion for 120 days at elevated temperatures. At specified durations (30, 60, 90, and 120 days) the geomembrane is tested for physical and chemical properties to determine if a change in the geomembrane has occurred due to

exposure to the synthetic leachate. Three test groups were used and the geomembrane coupons were prepared for testing. These three groups consisted of the following:

- Baseline - These samples were tested from the geomembrane as it was delivered to the laboratory and were not exposed to the synthetic leachate.

- Group 1 - These samples were exposed to the synthetic leachate maintained at 23° C (73° F).

- Group 2 - These samples were exposed to the synthetic leachate maintained at 50° C (122° F).

At 30 day intervals, up to 120 days, the geomembrane samples were removed from the synthetic leachate and tested for the following measurements and tests:

- Thickness
- Density
- Tensile Properties
- Tear Resistance
- Puncture Resistance
- Hardness
- Volatiles
- Extractables
- Secant Modulus (2%)

A summary of the laboratory test results are included in Table 1 for Group 1 samples (23° C), and Table 2 for Group 2 (50° C) samples. The percent change in the test results compared to the baseline results were reviewed and compared to the suggested limits of different test values for incubated geomembranes as presented in Table 5.9(b) of *Designing With Geosynthetics*, by R. M. Koerner (1994) (see attached). Based on the values in Table 5.9, the typical 60-mil HDPE geomembrane sample was resistant to the synthetic leachate.

As a result of the EPA 9090/ASTM D5747 geomembrane compatibility testing, it was concluded that a typical 60-mil HDPE geomembrane is resistant to the chemicals that are anticipated to be in the leachate that will be generated in the PDF. A typical 60-mil HDPE geomembrane can be used in the liner system and is expected to maintain its integrity in providing a relatively impermeable layer even if exposed to the leachate over a long period of time.

ASTM D5084 - GCL COMPATIBILITY PERMEABILITY

A typical geosynthetic clay liner (GCL) sample, Bentofix NW, manufactured by NSC was tested in accordance with ASTM D5084. This permeability test allowed the synthetic leachate to permeate through the GCL to determine if the anticipated leachate generated in

the PDF had an effect on the GCL's permeability. To simulate actual field conditions, the GCL was first permeated with water to saturate the GCL, since the GCL, below the HDPE liner, will first be exposed to moisture in the soils that will hydrate the bentonite. After the GCL was saturated, the synthetic leachate was used as the permeant liquid. Two samples were used for testing the effect that the synthetic leachate had on the permeability of the GCL. These two samples consisted of the following:

- Baseline - This sample used well water for the permeant fluid for the entire test. The well water was obtained from J&L Testing's well located in Canonsburg Pennsylvania.

- Sample 1 - This sample was saturated with well water and then the permeant fluid was switched to the synthetic leachate.

Both samples were monitored for a minimum of 90 days from the date that the permeant was switched to the synthetic leachate.

The results of the hydraulic conductivity verses time are shown on the attached graphs. Graph 1 is for the baseline sample. It shows that the long-term hydraulic conductivity of the baseline sample is 2.0×10^{-9} cm/sec. Graph 2 is for Sample 1. This graph shows that the long-term hydraulic conductivity of Sample 1, with the synthetic leachate, is 1.8×10^{-9} cm/sec. This result is nearly equal to the baseline sample.

Based on these results, it is concluded that a typical GCL is resistant, based on its permeability, to the chemicals that are anticipated to be in the leachate that will be generated in the PDF. A typical GCL can be used in the liner system and is expected to maintain its integrity in providing secondary containment even if exposed to the leachate over a long period of time.

ASTM D1987 - GEOTEXTILE BIOLOGICAL CLOGGING

One geotextile, consisting of a non-woven, needle-punched polypropylene supplied by Geosynthetic Inc., was tested for biological clogging in accordance with ASTM D1987. Only a polypropylene geotextile was tested, rather than both a polypropylene and a polyester geotextile because only one manufacturer is currently producing the polyester geotextile.

This test was performed under anaerobic conditions with no soil column above the geotextile, so that if biological growth occurred it was readily known that the synthetic leachate caused the growth and not organisms in the soil. This test allowed the synthetic leachate to permeate through the geotextile to determine if the leachate that will be generated in the PDF will generate biological growth in the geotextile and have an effect on its permeability.

The test was performed for a period of 90 days. For the first six days of the test, the flow through the sample was continuous. For subsequent readings, through the 90 days, the flow was initiated and allowed to stabilize for 30 minutes each time the data was collected. For each reading period the flow measurements were taken at three head differentials; 2 inches, 4 inches, and 8 inches. The attached Figure 1 shows the relation between the elapsed time and the flow rate during the 90 days, for each of the three gradients.

Based on the Figure 1, it can be noted that the flow rates decreased significantly after the first 6 days when the flow was terminated between each reading (as is recommended by ASTM D1987). At the end of 90 days the flow rates ranged from 3 to 11 gpm/sf for the different gradients. The permittivity of the material was approximately 0.01/sec. It was noted when the test was disassembled that the up gradient side of the geotextile had a thin coating of a dark gray gelacious matter on the fabric surface. This thin veneer, which coated the fibers, is likely responsible for the deduction in flow rate over time.

Based on these results, it is concluded that a typical geotextile may be susceptible to clogging based on its flow rate when exposed to the chemicals that are anticipated to be in the leachate that will be generated in the PDF. Therefore this consideration must be taken into consideration during the final design of the liner system.

VJR/vjr/DTL/RHW
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1272035.01090090

TABLE 1
EPA 9090 Laboratory Test Results - 23 deg C
Construction/Operation Level Design Report
GCR - PDF
U.S. Steel - Gary Works

Test Specimen	Test Parameter																	
	Thickness (mils)	Density	Yield (MD) Strength (lb/in.)	Yield (MD) Elongation (%)	Break (MD) Strength (lb/in.)	Break (MD) Elongation (%)	Yield (CD) Strength (lb/in.)	Yield (CD) Elongation (%)	Break (CD) Strength (lb/in.)	Break (CD) Elongation (%)	Tear Resistance (MD) (lb)	Tear Resistance (CD) (lb)	Puncture Resistance (lb)	Hardness (Duro D)	Volatiles (%)	Extractables (%)	2% Secant Modulus (MD) (psi)	2% Secant Modulus (CD) (psi)
Baseline	60.5	0.9535	157.18	20.62	263.87	777.15	175.73	21.69	263.79	811.34	54.78	53.85	131.04	60.30	0.10	0.66	50,993	54,172
30 day	60.8	0.9543	156.26	19.23	303.65	888.91	165.48	18.92	295.59	907.83	54.66	54.84	133.90	58.60	0.10	0.66	51,391	52,715
60 day	60.8	0.9533	158.65	19.69	290.27	845.39	161.86	18.77	285.25	890.79	55.82	55.78	134.07	57.00	0.05	0.33	52,111	54,305
90 day	60.2	0.9601	155.53	19.85	264.17	777.27	158.85	18.62	265.41	835.33	56.54	56.38	132.71	60.20	0.03	0.32	54,845	60,976
120 day	60.7	0.9624	156.73	19.54	279.50	815.58	158.59	18.62	273.48	872.76	52.41	51.19	131.42	60.60	0.06	0.35	51,446	53,645
Percent Change From Baseline	0.0	-0.9%	0.3%	5.2%	-5.9%	-4.9%	9.8%	14.2%	-3.7%	-7.6%	4.3%	4.9%	-0.3%	-0.5%	40.0%	47.0%	-0.9%	1.0%

VJR/vjr/DRF
nadf\m:\jobs\1272\035\01\vjr\subs\9090compare.xls-23C comparison
4/30/1998&11/8/99

4

TABLE 2
EPA 9090 Laboratory Test Results - 50 deg C
Construction/Operation Level Design Report
GCR - PDF
U.S. Steel - Gary Works

Test Specimen	Test Parameter																	
	Thickness (mils)	Density	Yield (MD) Strength (lb/in.)	Yield (MD) Elongation (%)	Break (MD) Strength (lb/in.)	Break (MD) Elongation (%)	Yield (CD) Strength (lb/in.)	Yield (CD) Elongation (%)	Break (CD) Strength (lb/in.)	Break (CD) Elongation (%)	Tear Resistance (MD) (lb)	Tear Resistance (CD) (lb)	Puncture Resistance (lb)	Hardness (Duro D)	Volatiles (%)	Extractables (%)	2% Secant Modulus (MD) (psi)	2% Secant Modulus (CD) (psi)
Baseline	60.5	0.9535	157.18	20.62	263.87	777.15	175.73	21.69	263.79	811.34	54.78	53.85	131.04	60.30	0.10	0.66	50,993	54,172
30 day	60.5	0.9542	162.09	19.69	313.94	903.98	161.20	19.54	307.49	952.83	56.20	53.73	137.14	59.40	0.13	0.56	50,993	50,993
60 day	60.9	0.9542	161.32	19.69	297.74	868.99	156.50	19.38	294.02	907.78	56.94	55.04	138.74	56.80	0.05	0.29	53,311	53,503
90 day	61.2	0.9602	159.31	19.85	263.42	782.87	162.43	18.92	272.47	845.56	57.50	55.62	134.78	60.40	0.06	0.19	56,511	56,844
120 day	60.6	0.9627	159.41	19.85	276.35	814.96	162.50	19.23	277.85	870.39	52.75	52.21	131.42	59.40	0.06	0.22	48,379	52,379
Percent Change From Baseline	0.0	-1.0%	-1.4%	3.7%	-4.7%	-4.9%	7.5%	11.3%	-5.3%	-7.3%	3.7%	3.0%	-0.3%	1.5%	40.0%	66.7%	5.1%	3.3%

VJR/vjr/DRF
mad1\m:\jobs\1272\035\01\vjr\subs\9090compare.xls-50C comparison
4/30/1998&11/8/99

6

Table 5.9 Suggested limits of different test values for incubated geomembranes

(a) For flexible thermoplastic polymers, e.g., CSPE, PVC, etc., after Little [23]

Property	*Resistant*	*Not Resistant*
Permeation rate	<0.9 g/m²/hr.	>0.9 g/m²/hr.
Change in weight (%)	<10	>10
Change in volume (%)	<10	>10
Change in tensile strength (%)	<20	>20
Change in elongation at break (%)	<30	>30
Change in 100% or 200% modulus (%)	<30	>30
Change in hardness	<10 points	>10 points

(b) For semicrystalline polymers, e.g., HDPE

	O'Toole [24]		*Little [23]*		*Koerner*	
Property	*Resistant*	*Not Resistant*	*Resistant*	*Not Resistant*	*Resistant*	*Not Resistant*
Permeation rate (g/m²-hr.)	—	—	<0.9	≥0.9	<0.9	≥0.9
Change in weight (%)	<0.5	>1.0	<3	≥3	<2	≥2
Change in volume (%)	<0.2	>0.5	<1	≥1	<1	≥1
Change in yield strength (%)	<10	>20	<20	≥20	<20	≥20
Change in yield elongation (%)	—	—	<20	≥20	<30	≥30
Change in modulus (%)	—	—	—	—	<30	≥30
Change in tear strength (%)	—	—	—	—	<20	≥20
Change in puncture strength (%)	—	—	—	—	<30	≥30

(c) For low crystallinity polymers, e.g., VLDPE, LLDPE, etc.

Properties to be considered should be the same as in Table (a) and values for resistance should be slightly more restrictive. No specific recommendations are available.

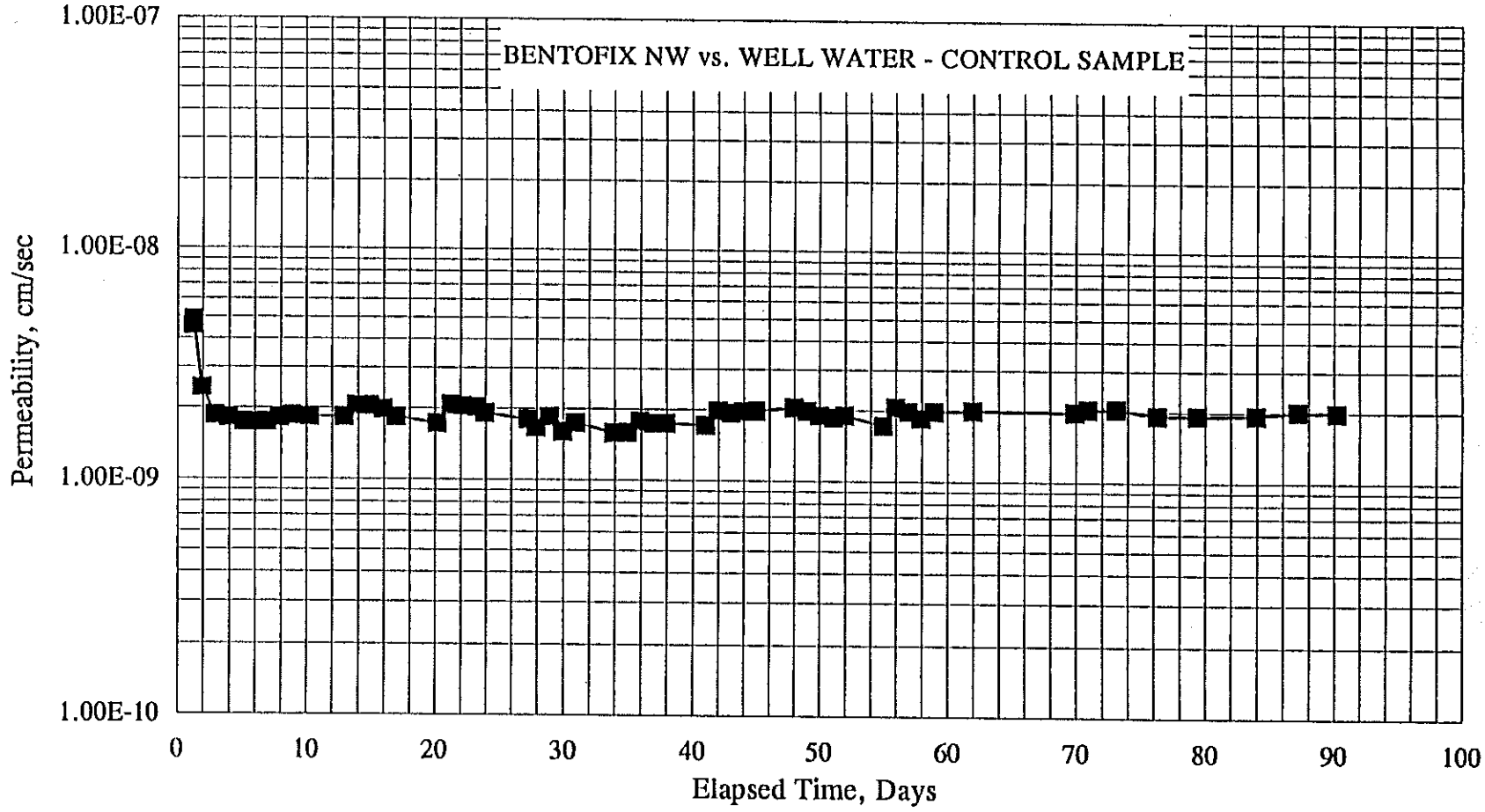
is no longer acceptable for the service in question." This statement, which is of a qualitative nature, seems to suggest comparison testing of candidate geomembranes for critical situations or using new samples for each incubation time and performing tensile tests for comparison purposes.

5.1.4.5.2 Cold Temperature Behavior. Testing to evaluate the effect of cold on geomembranes follows along the same general lines as the effects of heat, but the behavior of the material is, of course, completely different. Cold will generally not degrade the geomembrane in any appreciable way, at least under temperatures normally encountered. Geomembranes have been successfully installed in the arctic and have served properly [25]. (Problems of ice leading to puncturing and tearing problems were discussed earlier.) The only meaningful effect that cold has on the constructability of the system is that flexibility is decreased and seams are more

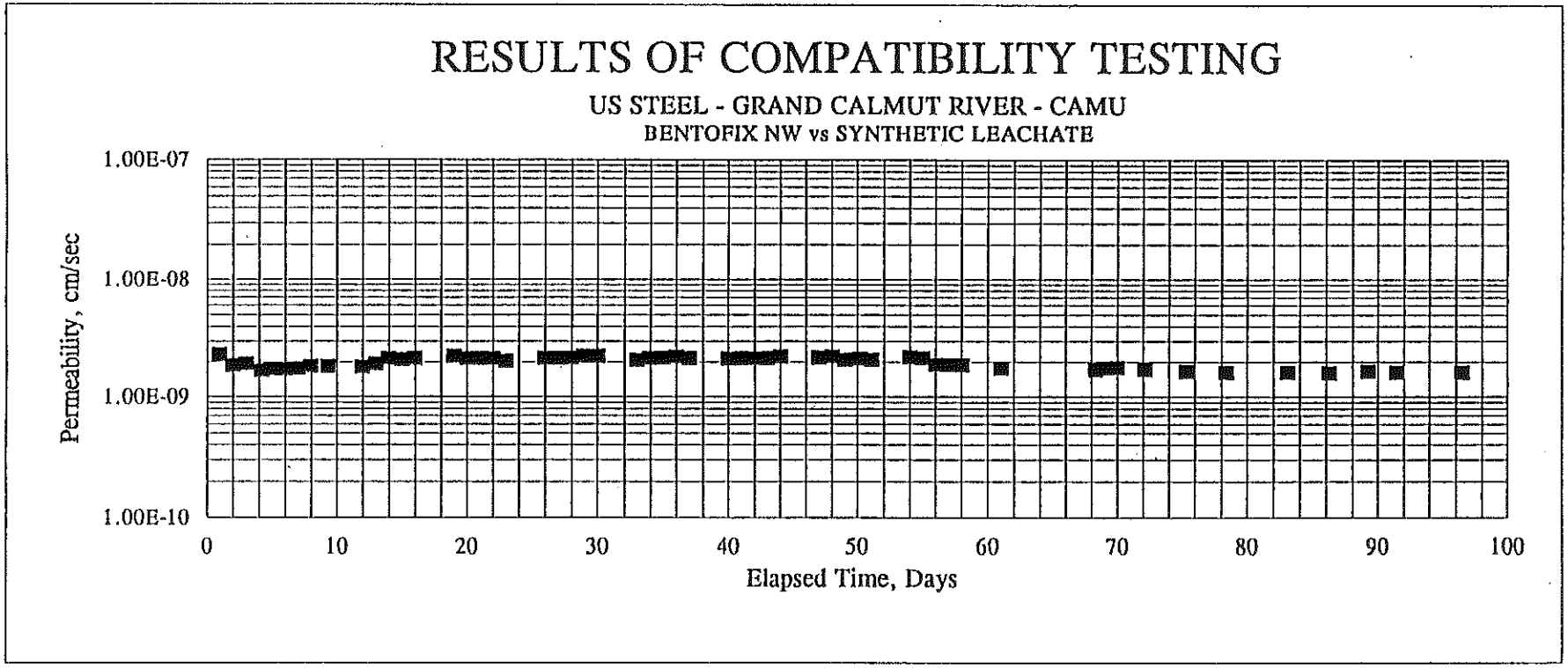
GRAPH 1

RESULTS OF COMPATIBILITY TESTING

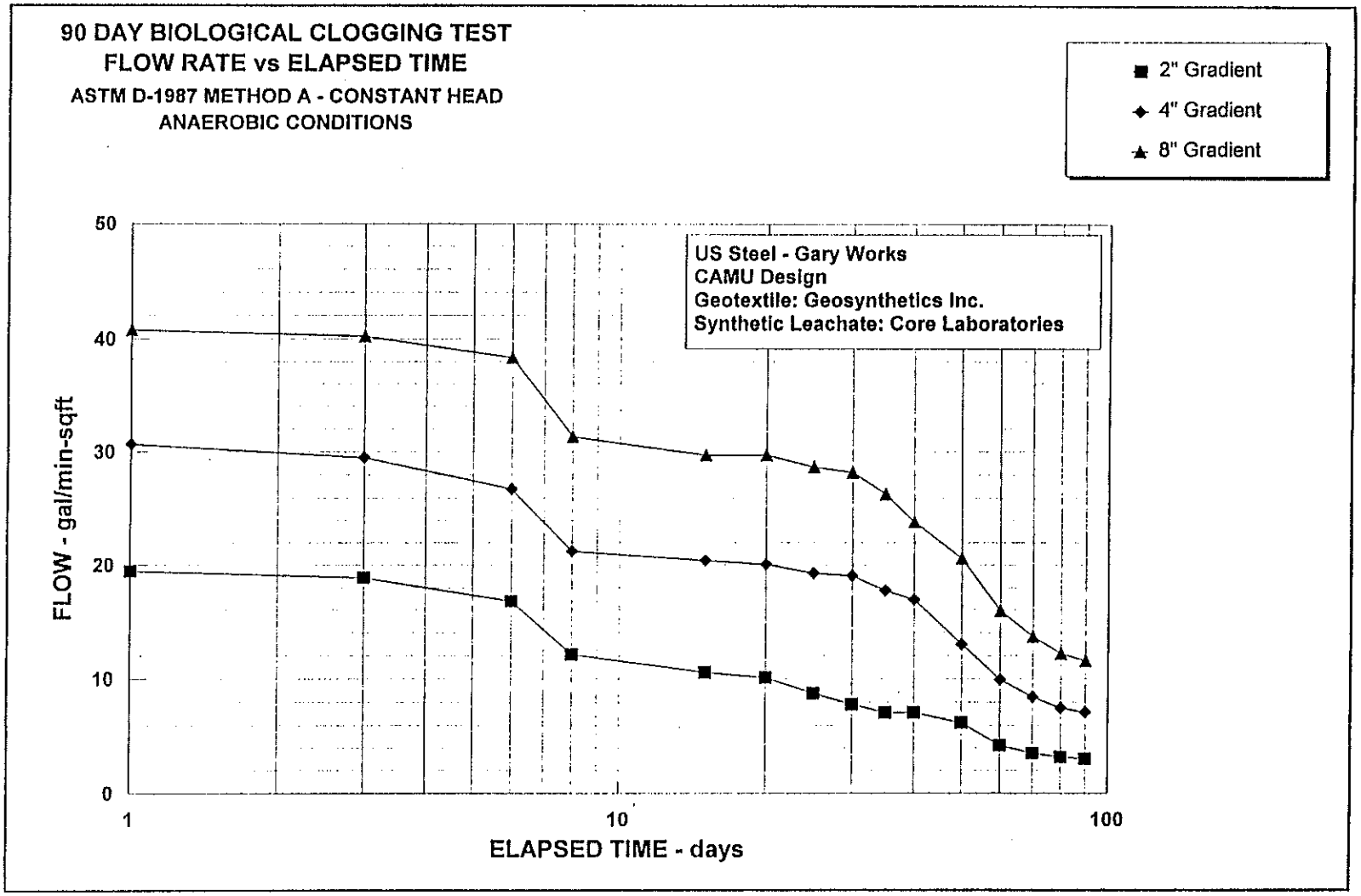
U.S. STEEL - GRAND CALMUT RIVER CAMU



GRAPH 2


RESULTS OF COMPATIBILITY TESTING
US STEEL - GRAND CALMUT RIVER - CAMU
BENTOFIX NW vs SYNTHETIC LEACHATE
Permeability, cm/sec
1.00E-07
1.00E-08
1.00E-09
1.00E-10
0
10
20
30
40
50
60
70
80
90
100
Elapsed Time, Days

JLT



J & L TESTING COMPANY, Inc.

FIGURE 1

H1

Geomembrane EPA 9090 and GCL Compatability Laboratory Test Results (December 1997)

GEOSYNTHETIC LABORATORY TESTING
U.S.STEEL GRAND CALMUT RIVER CAMU

Performed For:

Montgomery Watson
One Science Court
P.O. Box 5385
Madison, WI 53705-0385

Performed By:

J&L Testing Company, Inc.
938 S. Central Avenue
Canonsburg, PA 15317

December 31, 1997

J&L TESTING COMPANY, INC.
GEOTECHNICAL AND GEOSYNTHETICS MATERIALS TESTING AND RESEARCH

December 31, 1997

Montgomery Watson
One Science Court
P.O. Box 5385
Madison, WI 53705-0385

Attn: Valerie Ranguette, P.E.

RE: GEOSYNTHETIC LABORATORY TESTING
U.S. STEEL GRAND CALMUT RIVER CAMU

Dear Ms. Ranguette:

J&L Testing Company, Inc. (JLT) is please to submit this interim report of testing being performed to evaluate the compatibility of geosynthetics materials for the above referenced project. The purpose of this report is to provide you with an update of the work in progress, allow you to review some of the data and provide any comments. The work being performed and summarized herein includes:

1) Preparation of synthetic leachate
2) Compatibility testing of geomembrane in accordance with EPA 9090A protocols using the leachate generated above
3) Compatibility testing of geosynthetic clay liner (GCL) in accordance with EPA 9100 protocols
4) Biological clogging test on two (2) geotextile and the generated leachate

The following sections describe the details of the preparation of the leachate, the compatibility testing program and interim results of tests performed to date.

1. Leachate Preparation

The synthetic leachate used for the compatibility and the biological clogging tests was prepared by mixing the required organic chemicals in well water. The required concentration recipe of each organic compound in the final solution was provided to JLT by Montgomery Watson and are as follows:

Chemical	Concentration
Toluene	100 mg/L
Naphthalene	100 mg/L
Dibenzofuran	10.0 mg/L

938 South Central Avenue • Canonsburg, Pennsylvania 15317 Tel: (412) 746-4441 Fax: (412) 745-4261

These chemicals were purchased in pure state. Three (3) batches, each sufficient to prepare 28 liters of the synthetic leachate were prepared. The following outlines further details of the leachate preparation.

- The organic compounds were weighed to the nearest 0.0001g using an analytical balance and mixed.
- To insure that the compounds would dissolve in water, the organic mix was dissolved in acetone. The resulting mix was then stored in a bottle with teflon-lined cap.
- Two (2) stainless steel 55-gallon drums were purchased and filled with 28 liters of well water each. The water used was previously tested for pH and metals (see Table 1).
- A bottle containing the proportioned mix was emptied into each of the water drums and thoroughly mixed.
- Two (2) samples were taken from each of the two (2) water-chemical drums and tested for concentration of the chemicals for confirmation. Results of the confirmatory testing are presented on Table 2.
- This prepared synthetic leachate was then used to set up the compatibility and biological clogging tests.

Table 1
Analytical Results
Well Water Used for Preparing Synthetic Leachate

Parameter	Method	Result	Units
pH	EPA 150.1	7.31	su
Barium	EPA 200.7	0.08	mg/L
Calcium	EPA 200.7	84.7	mg/L
Iron	EPA 236.1	0.56	mg/L
Magnesium	EPA 200.7	16.9	mg/L
Manganese	EPA 243.1	<0.01	mg/L
Sodium	EPA 273.1	40.7	mg/L
Zinc	EPA 289.1	0.03	mg/L

Table 2
Synthetic Leachate
Confirmatory Test Results

Parameter	Method	Sample from Drum A		Sample from Drum B	
		1	2	1	2
Toluene	SW-846- 8021A	137.0	109.0	103.2	103.2
Naphthalene	SW-846-8270C	77.2	101.0	102.6	103.7
Dibenzofuran	SW-846-8270C	14.8	11.2	11.4	11.7

2. Geomembrane Compatibility Testing

In accordance with the laboratory testing program developed by Montgomery Watson, a sample of 60 mil Smooth HDPE geomembrane is being tested for compatibility with the synthetic leachate. The geomembrane used is manufactured by National Seal Company (NSC) and was supplied to JLT at Montgomery Waston's request for the purpose of this testing. The compatibility testing is being performed in accordance with EPA 9090A protocols. The work performed is summarized below.

Three (3) groups of gemembrane coupons were prepared for testing.

- One group was tested for all the required properties to establish baseline data. The group used for the baseline testing was not exposed to the leachate.
- The second group of samples was prepared and immersed in a tank of leachate maintained at 23°C.
- The third group of samples was prepared and placed in a leachate tank maintained at 50°C.
- Both the 23°C and 50°C tanks contain sufficient coupons to test for the required properties in both the machine direction (MD) and cross direction (CD).
- Samples were drawn from each of the two (2) tanks at 30-day intervals and tested for the required properties.

- The following measurements and tests were performed on the baseline samples as well as the samples retrieved from the temperature controlled tanks:

Thickness	ASTM D-5199
Dimensions (length and width)	ASTM D-751
Weight	ASTM D-5261
Tensile Properties	ASTM D-698
Tear Resistance	ASTM D-1004
Puncture Resistance	ASTM D-4833
Hardness	ASTM D-2240
Volatiles	EPA/600/2-88/052
Extractables	EPA/600/2-88/052
Density	ASTM D-1505
Secant Modulus (2%)	ASTM D-5323

  These are the basic indicator tests required for the project in accordance with ASTM D-5747 and per EPA 9090A.

- The results of tests performed are then compared against the baseline data as well as the data from previous intervals for evaluation.

- Appendix A presents the results of the baseline testing and two (2) subsequent periods.

3. GCL Compatibility Testing

Compatibility testing was performed to evaluate the effect of the synthetic leachate on the permeability of the geosynthetic clay liner (GCL). The GCL used for the testing was Bentofix NW supplied by NSC. The following is a summary of the testing program.

- Two (2) 4-inch diameter samples were cut from the GCL and set in a triaxial cell for the permeability testing.

- Both samples were back pressure saturated with well water. Samples from the well water used for preparing the synthetic leachate was used.

- Upon saturation, the permeant fluid for one of the samples was switched to the synthetic leachate while the second sample was maintained with well water as the permeant fluid.

The sample with well water was included in the monitoring program to evaluate potential effects of other environmental conditions (e.g. temperature variation) on the permeability of the test specimens.

- Both samples were monitored for a period of at least 90 days from the date of the switch in accordance with the project requirement.

- The flow rate was periodically monitored and permeability calculated. The results of the test along with a graph of permeability vs. time are presented in Appendix B.

4. Biological Clogging Test

This test is also currently being performed and we will submit a report as soon as it becomes available.

Should you, upon review of the information presented herein, have any questions, comments or require additional information, please call. Thank you.

Sincerely,

J&L TESTING COMPANY, INC.

DRAFT

Mahiru Shettima, Ph.D., P.E.
Director

Enclosures
MS/rdg
\wpwin60\letter\97437

7-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana	DATE:	10-15-97
	EPA 9090 Testing Program (Baseline)	TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.
	1	2	3	4	5	
A	59.0	60.0	60.0	59.0	60.0	59.6
B	61.0	61.0	65.0	61.3	61.3	61.9
C	60.5	60.5	60.0	60.0	60.0	60.2
D	60.5	60.5	60.0	60.0	60.0	60.2
E	60.5	61.0	61.7	61.7	61.7	61.3
F	61.5	61.5	60.5	60.5	61.3	61.1
G	60.5	60.5	59.5	59.5	59.5	59.9
H	60.5	60.5	59.5	60.0	59.5	60.0
I	60.5	60.0	61.0	60.5	60.5	60.5
J	60.0	60.0	60.5	60.5	60.5	60.3
K	61.0	61.0	61.0	60.5	60.5	60.8
L	60.0	59.0	60.0	59.5	58.7	59.4
M	59.0	59.0	60.0	59.9	59.3	59.4
N	60.7	60.5	61.0	61.0	61.0	60.8
O	60.0	59.9	60.0	60.5	60.0	60.1
P	61.0	60.8	60.8	61.0	61.0	60.9
Q	61.5	61.3	60.5	60.4	61.0	60.9
R	61.5	61.5	61.3	61.0	60.5	61.2
S	60.7	60.7	61.5	61.8	61.8	61.3
T	60.0	60.5	61.8	61.5	61.5	61.1
U	60.0	60.0	61.0	60.5	60.5	60.4
V	59.5	60.5	60.5	60.0	60.5	60.2
W	61.0	60.0	61.0	61.5	61.0	60.9
X	60.0	60.8	60.8	60.4	60.5	60.5
AVERAGE	**60.43**	**60.46**	**60.79**	**60.52**	**60.50**	***60.54***

MASS PER UNIT AREA
ASTM D-5261

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Area	sq. cm.	100.00	100.00	100.00	100.00	100.00	100.00	0.0000
Weight	gms	14.4821	14.6665	14.4366	14.6567	14.6783	14.5840	0.1030
Mass per Unit Area	lb/sq. ft.	0.297	0.300	0.296	0.300	0.301	0.299	0.0021

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	180.65	135.08	176.21	172.18	121.77	157.18	23.9984
Elongation at Yield (MD)	%	20.00	15.38	26.92	24.62	16.15	20.62	4.5482
Break Strength (MD)	lb/in	266.53	226.61	277.42	266.13	282.66	263.87	19.6824
Elongation at Break (MD	%	750.95	768.31	788.95	767.17	810.40	777.15	20.5386
Yield Strength (CD)	lb/in	174.19	176.21	175.40	178.23	174.60	175.73	1.4290
Elongation at Yield (CD)	%	17.69	24.62	21.54	22.31	22.31	21.69	2.2506
Break Strength (CD)	lb/in	258.87	285.08	250.00	274.60	250.40	263.79	13.8827
Elongation at Break (CD)	%	799.77	880.68	765.50	833.58	777.15	811.34	41.7298

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.00	61.38	61.35	61.18	60.50	60.88	0.5425
Tear Resistance (MD)	lb	56.40	53.42	55.20	54.30	54.60	54.78	0.9913
Tear Resistance (MD)	lb/in	940.00	870.39	899.76	887.62	902.48	900.05	22.9628
Thickness (CD)	mils	60.17	60.73	60.80	61.00	60.50	60.64	0.2855
Tear Resistance (CD)	lb	55.00	54.20	55.35	51.57	53.15	53.85	1.3699
Tear Resistance (CD)	lb/in	914.13	892.43	910.36	845.41	878.51	888.17	24.9242

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	59.86	59.98	60.38	60.18	60.06	59.30	59.00	59.00	60.00	59.50	59.48	0.43
Puncture Resistance	lb	131.66	131.52	132.22	135.60	133.37	128.95	127.10	130.40	134.30	132.10	131.04	2.50
Puncture Resistance	lb/in	2199.47	2192.73	2189.80	2253.24	2220.61	2174.54	2154.24	2210.17	2238.33	2220.17	2203.01	29.13

HARDNESS
ASTM D-2240

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	60.0	61.0	60.0	60.0	60.5	60.3
2	61.0	61.0	61.0	60.0	59.0	60.4
3	61.0	61.0	60.5	61.0	60.5	60.8
4	60.5	61.0	61.0	60.5	60.5	60.7
5	61.0	60.5	60.0	59.5	60.5	60.3

TOTAL VOLATILES
MTM-1

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	BASELINE TESTING		

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.13	0.08	0.10	0.10

Reference : EPA/600/2-88/052, Appendix G

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	BASELINE TESTING		

Initial Wt.	2.3132 grams
After Extraction	2.2980 grams
%Extractables	0.66

Reference : EPA/600/2-88/052, Appendix E

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program (Baseline)	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	33.6	33.98
2	0.9494	23.2	21.84
3*	0.9560	16.2	17.18

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	20	19.6	19	17	17.4	18.60
DENSITY	0.9515	0.9520	0.9529	0.9557	0.9552	0.9535

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	54,304.60	47,682.10	47,682.10	52,317.90	52,980.10	50,993.36	2778.30
2% Secant Modulus (CD)	psi	52,980.10	52,980.10	52,980.10	57,615.90	54,304.60	54,172.16	1796.66

10-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
A (Initial)	59.0	60.0	60.0	59.0	60.0	59.6	
A (Final)	59.0	60.0	59.0	61.0	61.0	60.0	0.67
B (Initial)	61.0	61.0	65.0	61.3	61.3	61.9	
B (Final)	61.0	62.0	61.0	62.0	62.0	61.6	-0.52
C (Initial)	60.5	60.5	60.0	60.0	60.0	60.2	
C (Final)	61.0	61.0	60.0	61.0	61.0	60.8	1.00

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
A	42.1	42.1	0.01
B	43.1	43.1	0.04
C	42.4	42.5	0.02

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
A (Initial)	100.0	99.5	-0.50
A (Final)	99.9	99.5	-0.40
B (Initial)	100.0	99.5	-0.50
B (Final)	100.0	99.5	-0.50
C (Initial)	100.0	99.5	-0.50
C (Final)	99.9	99.5	-0.40

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	168.43	152.62	155.24	148.67	156.33	156.26	6.6325
Elongation at Yield (MD)	%	19.23	18.46	20.00	20.00	18.46	19.23	0.6880
Break Strength (MD)	lb/in	306.33	302.70	316.94	282.14	310.16	303.65	11.7456
Elongation at Break (MD	%	883.83	884.38	933.48	839.78	903.07	888.91	30.4845
Yield Strength (CD)	lb/in	166.01	162.90	164.40	169.76	164.31	165.48	2.3561
Elongation at Yield (CD)	%	19.23	19.23	18.46	19.23	18.46	18.92	0.3768
Break Strength (CD)	lb/in	302.50	272.66	299.60	311.57	291.61	295.59	13.1209
Elongation at Break (CD)	%	923.90	848.96	928.02	943.07	895.21	907.83	33.2636

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.50	60.00	60.00	60.50	60.00	60.20	0.2449
Tear Resistance (MD)	lb	53.17	54.42	52.90	55.42	57.40	54.66	1.6408
Tear Resistance (MD)	lb/in	878.84	907.00	881.67	916.03	956.67	908.04	28.2048
Thickness (CD)	mils	60.00	60.50	60.00	61.00	60.50	60.40	0.3742
Tear Resistance (CD)	lb	53.25	54.10	54.40	57.15	55.32	54.84	1.3293
Tear Resistance (CD)	lb/in	887.50	894.21	906.67	936.89	914.38	907.93	17.2458

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	60.50	61.00	61.00	60.50	60.50	61.80	60.20	61.00	61.50	61.00	61.00	0.54
Puncture Resistance	lb	134.49	134.39	133.44	134.96	133.49	136.09	134.41	131.16	133.66	134.61	133.90	1.49
Puncture Resistance	lb/in	2222.98	2203.11	2187.54	2230.74	2206.45	2202.10	2232.72	2150.16	2173.33	2206.72	2195.25	26.52

HARDNESS
ASTM D-2240

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	DATE:	10-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	30 DAY, 23 DEGREE CELSIUS		

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	58.0	60.0	60.0	62.0	57.0	59.4
2	59.0	61.0	58.0	61.0	58.0	59.4
3	57.0	60.0	57.0	59.0	57.0	58.0
4	59.0	58.0	59.0	57.0	59.0	58.4
5	59.0	58.0	59.0	57.0	60.0	58.6

TOTAL VOLATILES
MTM-1

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 DAY, 23 DEGREE CELSIUS		

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.10	0.13	0.08	0.10

Reference : EPA/600/2-88/052, Appendix G

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana	DATE:	10-15-97
	EPA 9090 Testing Program	TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	30 DAY, 23 DEGREE CELSIUS		

Initial Wt.	2.7090 grams
After Extraction	2.6912 grams
%Extractables	0.66

Reference : EPA/600/2-88/052, Appendix E

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 DAY, 23 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	37.8	38.11
2	0.9494	26.7	25.60
3*	0.9560	20	20.80

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	24	24	21.2	21.2	20.8	22.24
DENSITY	0.9512	0.9512	0.9550	0.9550	0.9556	0.9536

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	51,655.60	49,006.60	51,655.60	52,317.90	52,317.90	51,390.72	1228.31
2% Secant Modulus (CD)	psi	55,629.10	54,966.90	46,357.60	56,291.40	50,331.12	52,715.22	3806.65

end 11-

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
M (Initial)	59.0	59.0	60.0	59.9	59.3	59.4	
M (Final)	60.0	60.0	60.0	59.5	60.0	59.9	0.77
N (Initial)	60.7	60.5	61.0	61.0	61.0	60.8	
N (Final)	61.0	61.5	61.5	61.0	61.5	61.3	0.76
O (Initial)	60.0	59.9	60.0	60.5	60.0	60.1	
O (Final)	60.0	61.0	60.0	60.0	61.0	60.4	0.53

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
M	42.2	42.2	0.07
N	43.0	43.1	0.07
O	42.3	42.6	0.72

2

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
M (Initial)	100.0	99.5	-0.50
M (Final)	100.0	100.0	0.00
N (Initial)	100.0	99.5	-0.50
N (Final)	100.0	99.5	-0.50
O (Initial)	100.0	100.0	0.00
O (Final)	100.0	100.0	0.00

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	165.12	154.11	162.50	162.10	166.61	162.09	4.3231
Elongation at Yield (MD)	%	18.46	20.77	19.23	20.00	20.00	19.69	0.7845
Break Strength (MD)	lb/in	299.40	320.56	304.72	326.69	318.35	313.94	10.2231
Elongation at Break (MD	%	868.94	924.96	876.42	931.51	918.09	903.98	26.0181
Yield Strength (CD)	lb/in	156.85	159.35	164.52	161.49	163.79	161.20	2.8311
Elongation at Yield (CD)	%	19.23	20.00	20.00	18.46	20.00	19.54	0.6154
Break Strength (CD)	lb/in	313.71	315.00	305.65	297.18	305.93	307.49	6.4386
Elongation at Break (CD)	%	966.58	966.18	950.92	927.98	952.50	952.83	14.0609

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.00	60.00	59.00	60.00	60.50	59.90	0.4899
Tear Resistance (MD)	lb	56.67	56.47	55.37	56.80	55.70	56.20	0.5644
Tear Resistance (MD)	lb/in	944.50	941.17	938.47	946.67	920.66	938.29	9.2501
Thickness (CD)	mils	59.50	60.50	60.50	61.00	60.50	60.40	0.4899
Tear Resistance (CD)	lb	55.20	53.97	51.77	53.47	54.25	53.73	1.1312
Tear Resistance (CD)	lb/in	927.73	892.07	855.70	876.56	896.69	889.75	23.7884

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	61.00	60.50	61.00	61.00	60.50	61.20	61.50	60.00	60.00	60.00	60.53	0.61
Puncture Resistance	lb	136.50	136.43	136.23	136.35	137.35	139.40	138.65	134.53	136.70	136.23	137.14	1.60
Puncture Resistance	lb/in	2237.70	2255.04	2233.28	2235.25	2270.25	2277.78	2254.47	2242.17	2278.33	2270.50	2265.58	13.10

HARDNESS
ASTM D-2240

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 DAY, 50 DEGREE CELSIUS		

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	61.0	58.0	61.0	58.0	62.0	60.0
2	62.0	58.0	61.0	59.0	60.0	60.0
3	61.0	57.0	58.0	59.0	59.0	58.8
4	58.0	61.0	58.0	61.0	58.0	59.2
5	59.0	61.0	58.0	62.0	57.0	59.4

TOTAL VOLATILES
MTM-1

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 DAY, 50 DEGREE CELSIUS		

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.12	0.14	0.12	0.13

Reference : EPA/600/2-88/052, Appendix G

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana	DATE:	10-15-97
	EPA 9090 Testing Program	TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	30 DAY, 50 DEGREE CELSIUS		

Initial Wt.	2.5435 grams
After Extraction	2.5292 grams
%Extractables	0.56

Reference : EPA/600/2-88/052, Appendix E

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 DAY, 50 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	37.8	38.11
2	0.9494	26.7	25.60
3*	0.9560	20	20.80

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	24.5	22.5	23	20.2	21.2	22.28
DENSITY	0.9505	0.9532	0.9526	0.9564	0.9550	0.9535

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	51,655.60	51,655.60	52,980.10	51,655.60	47,019.90	50,993.36	2051.89
2% Secant Modulus (CD)	psi	49,006.60	51,655.60	50,993.40	50,331.10	52,980.10	50,993.36	1324.50

end

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
D (Initial)	60.5	60.5	60.0	60.0	60.0	60.2	
D (Final)	60.5	60.5	60.0	60.0	60.0	60.2	0.00
E (Initial)	60.5	61.0	61.7	61.7	61.0	61.2	
E (Final)	60.5	61.5	61.5	61.0	61.0	61.1	-0.13
F (Initial)	61.5	61.5	60.5	60.5	61.3	61.1	
F (Final)	61.5	61.0	60.5	61.0	61.0	61.0	-0.10

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
D	42.2	42.2	-0.00
E	43.0	43.0	-0.00
F	43.0	43.0	0.00

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
D (Initial)	99.9	99.9	0.00
D (Final)	100.0	100.0	0.00
E (Initial)	99.9	100.0	0.10
E (Final)	100.0	100.0	0.00
F (Initial)	100.0	100.0	0.00
F (Final)	100.0	100.0	0.00

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	161.69	149.88	162.50	160.08	159.07	158.65	4.5440
Elongation at Yield (MD)	%	20.00	20.00	19.23	20.00	19.23	19.69	0.3768
Break Strength (MD)	lb/in	286.90	298.27	300.81	291.81	273.59	290.27	9.6643
Elongation at Break (MD	%	831.77	864.46	873.99	846.80	809.93	845.39	22.9210
Yield Strength (CD)	lb/in	159.56	163.79	162.50	159.96	163.51	161.86	1.7759
Elongation at Yield (CD)	%	18.46	19.23	19.23	18.46	18.46	18.77	0.3768
Break Strength (CD)	lb/in	293.02	294.76	296.65	267.94	273.87	285.25	11.9153
Elongation at Break (CD)	%	913.98	915.09	913.04	850.51	861.32	890.79	28.6861

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.50	61.50	60.50	61.50	61.50	61.10	0.4899
Tear Resistance (MD)	lb	56.00	54.30	56.50	55.50	56.80	55.82	0.8795
Tear Resistance (MD)	lb/in	925.62	882.93	933.88	902.44	923.58	913.69	18.5518
Thickness (CD)	mils	60.00	61.50	60.50	61.00	61.00	60.80	0.5099
Tear Resistance (CD)	lb	55.60	55.60	55.20	56.20	56.30	55.78	0.4118
Tear Resistance (CD)	lb/in	926.67	904.07	912.40	921.31	922.95	917.48	8.1830

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	62.00	61.00	61.00	60.00	61.00	60.50	61.00	61.50	61.00	62.00	61.17	0.47
Puncture Resistance	lb	135.15	134.50	132.95	134.70	134.47	135.62	135.17	137.50	129.90	131.75	134.07	2.53
Puncture Resistance	lb/in	2179.84	2204.92	2179.51	2245.00	2204.43	2241.65	2215.90	2235.77	2129.51	2125.00	2192.04	47.44

HARDNESS
ASTM D-2240

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	11-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 DAY, 23 DEGREE CELSIUS		

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	60.0	58.0	57.0	59.0	58.0	58.4
2	60.0	59.0	57.0	58.0	58.0	58.4
3	57.0	58.0	60.0	61.0	61.0	59.4
4	58.0	57.0	57.0	58.0	60.0	58.0
5	57.0	56.0	56.0	58.0	58.0	57.0

TOTAL VOLATILES
MTM-1

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	11-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 DAY, 23 DEGREE CELSIUS		

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.05	0.05	0.04	0.05

Reference : EPA/600/2-88/052, Appendix G

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	11-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 DAY, 23 DEGREE CELSIUS		

Initial Wt.	2.4916 grams
After Extraction	2.4834 grams
%Extractables	0.33

Reference : EPA/600/2-88/052, Appendix E

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	11-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 DAY, 23 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	35.2	38.11
2	0.9494	26.5	25.60
3*	0.9560	19	20.80

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	20.5	20.5	21.0	19.8	19.8	20.3
DENSITY	0.9524	0.9524	0.9517	0.9534	0.9534	0.9527

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	50,622.25	54,966.89	46,357.60	52,980.10	55,629.14	52,111.20	3364.72
2% Secant Modulus (CD)	psi	51,655.60	54,966.90	54,966.90	54,966.90	54,966.90	54,304.64	1324.52

End

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
P (Initial)	61.0	60.8	60.8	61.0	61.0	60.9	
P (Final)	61.0	61.0	61.0	61.0	61.0	61.0	0.13
Q (Initial)	61.5	61.3	60.5	60.4	61.0	60.9	
Q (Final)	61.5	60.5	60.0	60.5	61.0	60.7	-0.39
R (Initial)	61.5	61.5	61.3	61.0	60.5	61.2	
R (Final)	60.5	61.0	61.5	61.5	61.0	61.1	-0.10

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
P	43.0	42.2	-1.86
Q	43.1	43.1	0.01
R	43.3	43.3	0.02

2

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
P (Initial)	100.0	100.0	0.00
P (Final)	100.0	100.0	0.00
Q (Initial)	100.0	100.0	0.00
Q (Final)	100.0	100.0	0.00
R (Initial)	100.0	100.0	0.00
R (Final)	100.0	100.0	0.00

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	167.22	161.69	152.42	161.09	164.19	161.32	4.9488
Elongation at Yield (MD)	%	18.46	19.23	20.00	19.23	21.54	19.69	1.0434
Break Strength (MD)	lb/in	307.06	293.75	315.32	288.31	284.27	297.74	11.6806
Elongation at Break (MD	%	889.81	871.91	896.08	858.00	829.16	868.99	24.0145
Yield Strength (CD)	lb/in	154.84	148.67	160.97	164.11	153.91	156.50	5.4534
Elongation at Yield (CD)	%	19.23	18.46	19.23	20.77	19.23	19.38	0.7537
Break Strength (CD)	lb/in	266.81	274.88	327.02	296.85	304.52	294.02	21.5103
Elongation at Break (CD)	%	838.84	859.87	989.53	903.36	947.29	907.78	55.3371

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	61.00	61.50	61.20	60.50	61.50	61.14	0.3720
Tear Resistance (MD)	lb	56.50	57.30	56.70	55.90	58.30	56.94	0.8139
Tear Resistance (MD)	lb/in	926.23	931.71	926.47	923.97	947.97	931.27	8.7267
Thickness (CD)	mils	62.00	61.50	60.00	60.00	60.00	60.70	0.8718
Tear Resistance (CD)	lb	55.30	56.20	54.20	55.20	54.30	55.04	0.7338
Tear Resistance (CD)	lb/in	891.94	913.82	903.33	920.00	905.00	906.82	9.5890

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	61.50	62.00	60.00	61.50	60.00	60.50	60.50	62.00	62.00	62.00	61.17	0.85
Puncture Resistance	lb	140.65	140.25	138.45	135.62	139.62	138.00	137.85	138.90	139.57	138.47	138.74	0.70
Puncture Resistance	lb/in	2286.99	2262.10	2307.50	2205.20	2327.00	2280.99	2278.51	2240.32	2251.13	2233.39	2268.56	31.64

HARDNESS
ASTM D-2240

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	11-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 DAY, 50 DEGREE CELSIUS		

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	56.0	58.0	58.0	58.0	57.0	57.4
2	55.0	57.0	56.0	57.0	57.0	56.4
3	60.0	59.0	60.0	60.0	59.0	59.6
4	57.0	57.0	58.0	59.0	58.0	57.8
5	57.0	56.0	58.0	57.0	56.0	56.8

TOTAL VOLATILES
MTM-1

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	11-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 DAY, 50 DEGREE CELSIUS		

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.06	0.05	0.06	0.05

Reference : EPA/600/2-88/052, Appendix G

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana	DATE:	11-15-97
	EPA 9090 Testing Program	TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	60 DAY, 50 DEGREE CELSIUS		

Initial Wt.	2.4882 grams
After Extraction	2.4810 grams
%Extractables	0.29

Reference : EPA/600/2-88/052, Appendix E

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	11-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 DAY, 50 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	35.2	38.11
2	0.9494	26.5	25.60
3*	0.9560	19	20.80

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	19.5	19.5	20.0	19.6	19.8	19.7
DENSITY	0.9538	0.9538	0.9531	0.9537	0.9534	0.9535

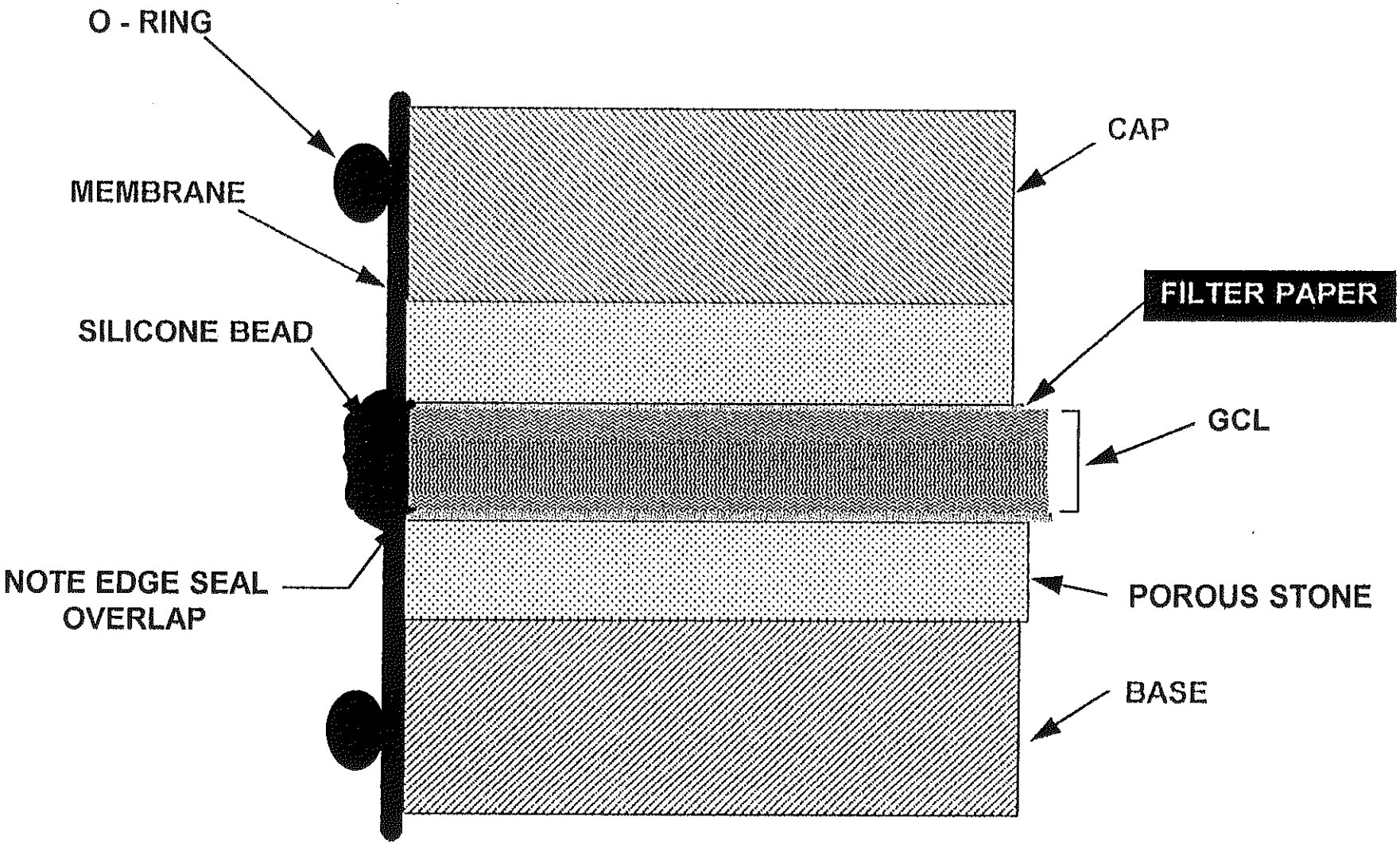
2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	53,642.40	51,655.60	54,304.60	51,986.80	54,966.90	53,311.26	1290.96
2% Secant Modulus (CD)	psi	53,973.50	56,921.40	51,655.60	52,649.00	52,317.90	53,503.48	1868.34

11-end



SYSTEM CONFIGURATION DETAIL

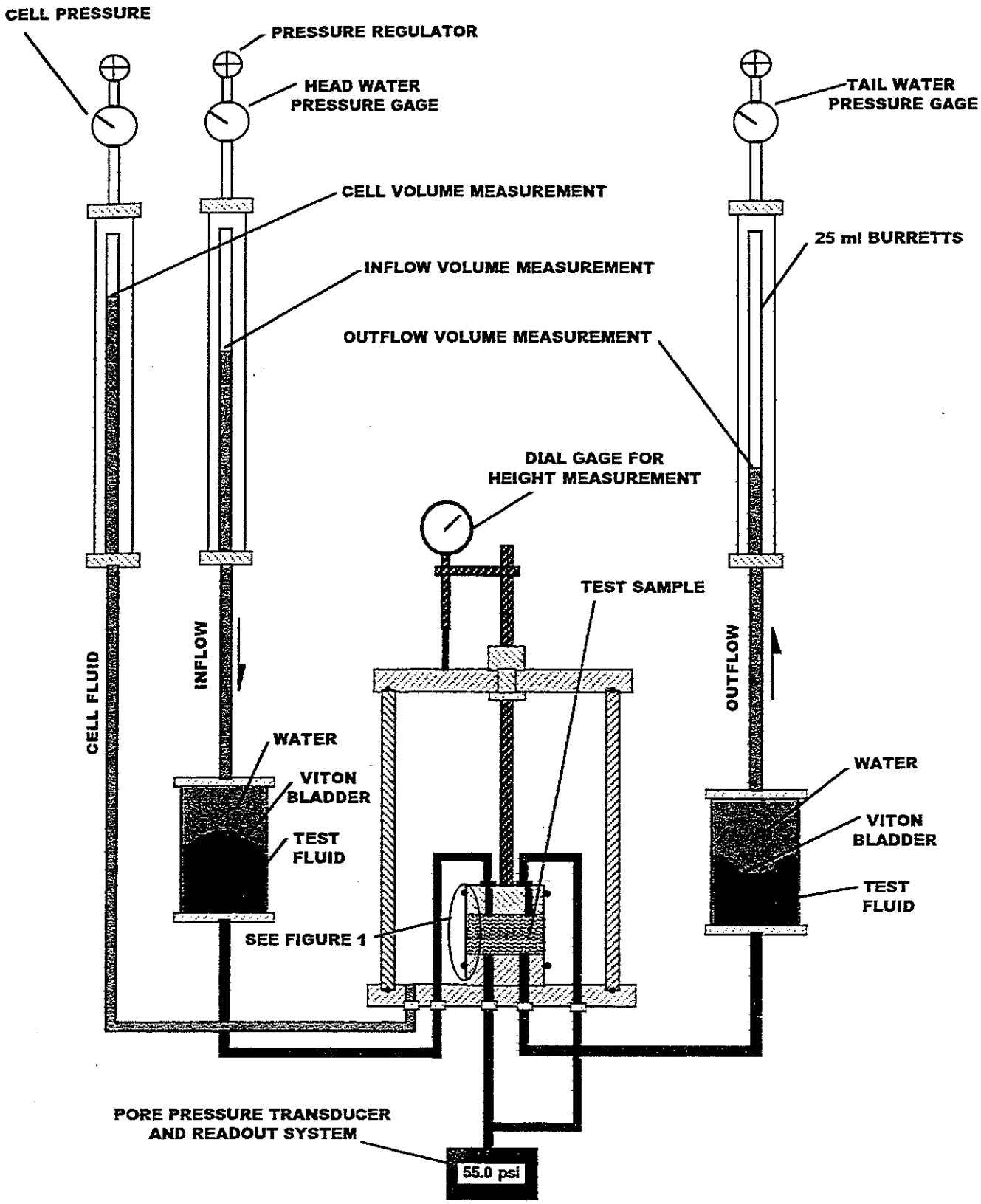
FIGURE 1

J & L Testing Company, Inc.

GCLSETUP.PPT

FLEX-WALL FLUID COMPATIBILITY TEST SCHEMATIC FOR GCL's

" EPA 9100/ASTM D-5084 TEST PROCEDURE "



J & L Testing Company, Inc

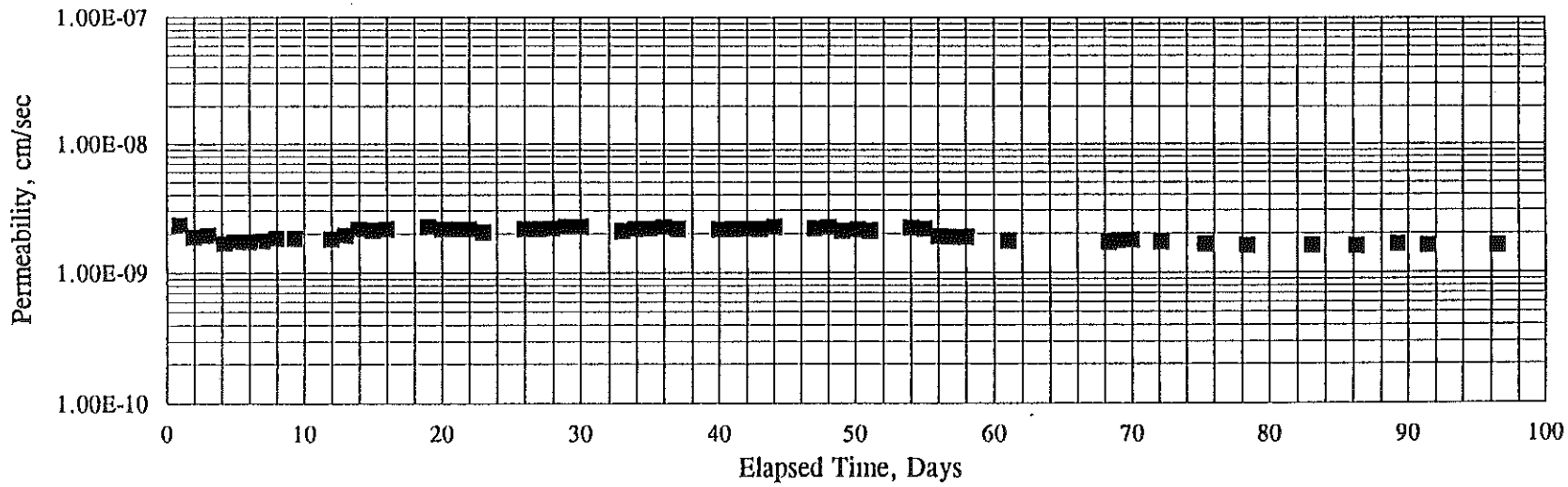
TXGCLCMP.PPT

FIGURE 2

RESULTS OF COMPATIBILITY TESTING

US STEEL - GRAND CALMUT RIVER - CAMU

BENTOFIX NW vs SYNTHETIC LEACHATE



(4) J&L TESTING COMPANY Inc. JOB No. 97S2180-02 MW-EPA1.WK4

SUMMARY OF TRIAXIAL PERMEABILITY TEST RESULTS
ASTM D-5084 (METHOD A)

Client	:	MONTGOMERY WATSON	Date	:	12/24/97
Project Location	:	U.S. STEEL GRAND CALMUT RIVER - CAMU	Job No.	:	97S2180-02
	:	GARY WORKS, INDIANA	Tested By	:	KT/MS
Sample ID	:	BENTOFIX NW GCL	Checked By	:	MS
Description	:	CHEMICAL IN TEST LIQUID			

Physical Property Data

Initial Height (in)	:	0.33	Final Height (in)	:	0.30
Initial Diameter (in)	:	4.00	Final Diameter (in)	:	3.85
Initial Volume (in^3)	:	4.15	Final Volume (in^3)	:	3.49
Initial Wet Weight (g)	:	54.80	Final Wet Weight (g)	:	68.50
Wet Density (pcf)	:	50.30	Wet Density (pcf)	:	74.65
Moisture Content %	:	47.2	Moisture Content %	:	84.1
Dry Density (pcf)	:	34.17	Dry Density (pcf)	:	40.56

Test Parameters

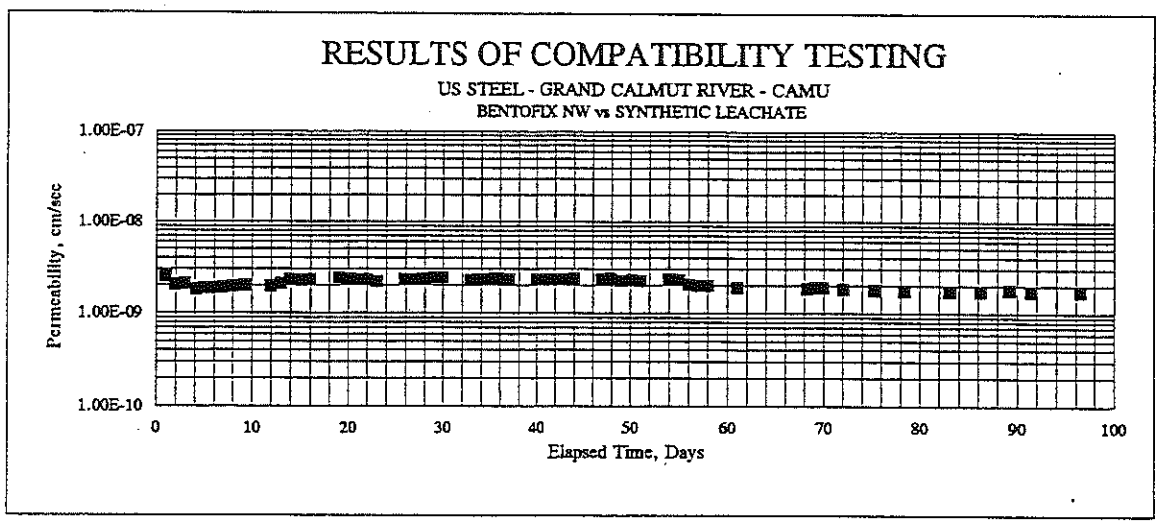
Cell Pressure	(psi)	:	50.5	Effective Stress (psi)	:	10
Head Water	(psi)	:	41.0			
Tail Water	(psi)	:	40.0	Gradient	:	92.3

DATE	TIME	El. Time		
09/04/97	16:32		SATURATION AND PERMEABILITY WITH WELL WATER	23
09/17/97	08:24	18232.00		

Permeability Data

			Inflow, cc	Outflow, cc	Out/Inflow	Ave Flow,cc	K, cm/sec	Cum Time, Day
09/17/97	09:15							
09/18/97	08:08	1373.00	1.5	1.6	1.07	1.6	2.5E-09	0.95
09/19/97	08:05	1437.00	1.3	1.3	1.00	1.3	2.0E-09	1.95
09/20/97	08:10	1445.00	1.3	1.4	1.08	1.4	2.1E-09	2.95
09/21/97	13:15	1745.00	1.6	1.25	0.78	1.4	1.8E-09	4.17
09/22/97	08:07	1132.00	1	0.9	0.90	1.0	1.9E-09	4.95
09/23/97	08:05	1438.00	1.1	1.3	1.18	1.2	1.9E-09	5.95
09/24/97	08:09	1444.00	1.3	1.15	0.88	1.2	1.9E-09	6.95
09/25/97	08:09	1440.00	1.3	1.25	0.96	1.3	2.0E-09	7.95
09/26/97	15:54	1905.00	1.6	1.8	1.12	1.7	2.0E-09	9.28
09/29/97	08:09	3855.00	3.4	3.4	1.00	3.4	2.0E-09	11.95
09/30/97	08:09	1440.00	1.4	1.3	0.93	1.4	2.1E-09	12.95
10/01/97	08:10	1441.00	1.6	1.4	0.88	1.5	2.3E-09	13.95
10/02/97	08:10	1440.00	1.45	1.5	1.03	1.5	2.3E-09	14.95
10/03/97	08:10	1440.00	1.55	1.46	0.94	1.5	2.3E-09	15.95
10/06/97	08:26	4336.00	4.7	4.7	1.00	4.7	2.4E-09	18.97
10/07/97	08:17	1431.00	1.5	1.5	1.00	1.5	2.3E-09	19.96
10/08/97	08:10	1433.00	1.5	1.5	1.00	1.5	2.3E-09	20.95
10/09/97	08:10	1440.00	1.5	1.5	1.00	1.5	2.3E-09	21.95
10/10/97	08:11	1441.00	1.45	1.4	0.97	1.4	2.2E-09	22.96
10/13/97	08:10	4319.00	4.5	4.5	1.00	4.5	2.3E-09	25.95
10/14/97	08:10	1440.00	1.5	1.5	1.00	1.5	2.3E-09	26.95
10/15/97	08:14	1444.00	1.55	1.5	0.97	1.5	2.4E-09	27.96
10/16/97	08:13	1439.00	1.6	1.55	0.97	1.6	2.5E-09	28.96
10/17/97	08:13	1440.00	1.55	1.6	1.03	1.6	2.4E-09	29.96
10/20/97	08:09	4316.00	4.45	4.3	0.97	4.4	2.3E-09	32.95
10/21/97	08:10	1441.00	1.5	1.5	1.00	1.5	2.3E-09	33.95
10/22/97	08:13	1443.00	1.46	1.6	1.10	1.5	2.4E-09	34.96
10/23/97	08:10	1437.00	1.6	1.5	0.94	1.6	2.4E-09	35.95
10/24/97	08:10	1440.00	1.5	1.5	1.00	1.5	2.3E-09	36.95
10/27/97	09:14	4384.00	4.5	4.55	1.01	4.5	2.3E-09	40.00
10/28/97	09:10	1436.00	1.5	1.5	1.00	1.5	2.3E-09	41.00

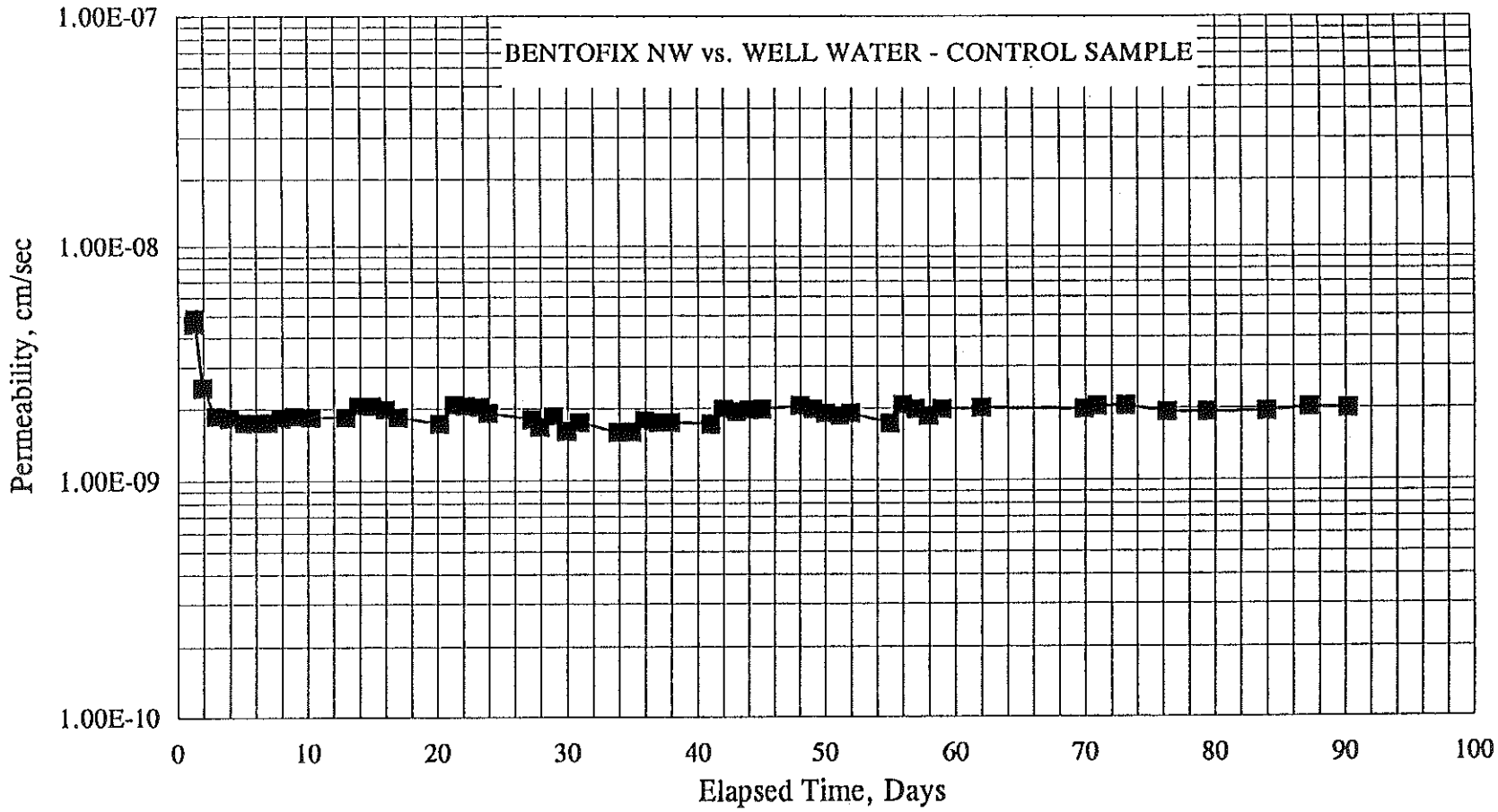
10/29/97	09:07	1437.00	1.5	1.5	1.00	1.5	2.3E-09	41.99
10/30/97	09:10	1443.00	1.5	1.5	1.00	1.5	2.3E-09	43.00
10/31/97	09:11	1441.00	1.6	1.5	0.94	1.6	2.4E-09	44.00
11/03/97	09:17	4326.00	4.5	4.6	1.02	4.6	2.4E-09	47.00
11/04/97	09:12	1435.00	1.6	1.5	0.94	1.6	2.4E-09	48.00
11/05/97	09:11	1439.00	1.4	1.5	1.07	1.5	2.3E-09	49.00
11/06/97	12:36	1645.00	1.7	1.7	1.00	1.7	2.3E-09	50.14
11/07/97	09:12	1236.00	1.3	1.2	0.92	1.3	2.3E-09	51.00
11/10/97	09:18	4326.00	4.6	4.6	1.00	4.6	2.4E-09	54.00
11/11/97	09:10	1432.00	1.5	1.5	1.00	1.5	2.3E-09	55.00
11/12/97	09:08	1438.00	1.35	1.3	0.96	1.3	2.1E-09	56.00
11/13/97	09:10	1442.00	1.3	1.3	1.00	1.3	2.0E-09	57.00
11/14/97	09:10	1440.00	1.3	1.3	1.00	1.3	2.0E-09	58.00
11/17/97	09:06	4316.00	3.75	3.6	0.96	3.7	1.9E-09	60.99
11/24/97	16:42	10536.00	8.6	8.7	1.01	8.7	1.8E-09	68.31
11/25/97	08:21	939.00	0.8	0.8	1.00	0.8	1.9E-09	68.96
11/26/97	07:39	1398.00	1.2	1.2	1.00	1.2	1.9E-09	69.93
11/28/97	12:00	3141.00	2.6	2.6	1.00	2.6	1.9E-09	72.11
12/01/97	16:42	4602.00	3.7	3.6	0.97	3.7	1.8E-09	75.31
12/04/97	18:25	4423.00	3.5	3.4	0.97	3.5	1.7E-09	78.38
12/09/97	10:55	6750.00	5.2	5.3	1.02	5.3	1.7E-09	83.07
12/12/97	14:26	4531.00	3.5	3.5	1.00	3.5	1.7E-09	86.22
12/15/97	14:26	4320.00	3.45	3.45	1.00	3.5	1.8E-09	89.22
12/17/97	20:10	3224.00	2.5	2.5	1.00	2.5	1.7E-09	91.45
12/22/97	20:30	7220.00	5.6	5.6	1.00	5.6	1.7E-09	96.47



5-end

RESULTS OF COMPATIBILITY TESTING

U.S. STEEL - GRAND CALMUT RIVER CAMU



J&L TESTING COMPANY Inc. JOB No. 97S2180-02 MW-EPA2.WK4

1 of 3

SUMMARY OF TRIAXIAL PERMEABILITY TEST RESULTS
ASTM D-5084 (METHOD A)

Client	:	MONTGOMERY WATSON	Date	:	10-3-97
Project Location	:	U.S. STEEL GRAND CALMUT RIVER - CAMU	Job No.	:	97S2180-02
	:	GARY WORKS, INDIANA	Tested By	:	KT
Sample Number	:	CONTROL SAMPLE	Checked By	:	MS
Description	:	WELL WATER ONLY			

Physical Property Data

Initial Height (in)	:	0.33	Final Height (in)	:	0.31
Initial Diameter (in)	:	4.00	Final Diameter (in)	:	3.96
Initial Volume (in^3)	:	4.15	Final Volume (in^3)	:	3.82
Initial Wet Weight (g)	:	54.80	Final Wet Weight (g)	:	71.20
Wet Density (pcf)	:	50.30	Wet Density (pcf)	:	70.98
Moisture Content %	:	28.0	Moisture Content %	:	81.2
Dry Density (pcf)	:	39.29	Dry Density (pcf)	:	39.17

Test Parameters

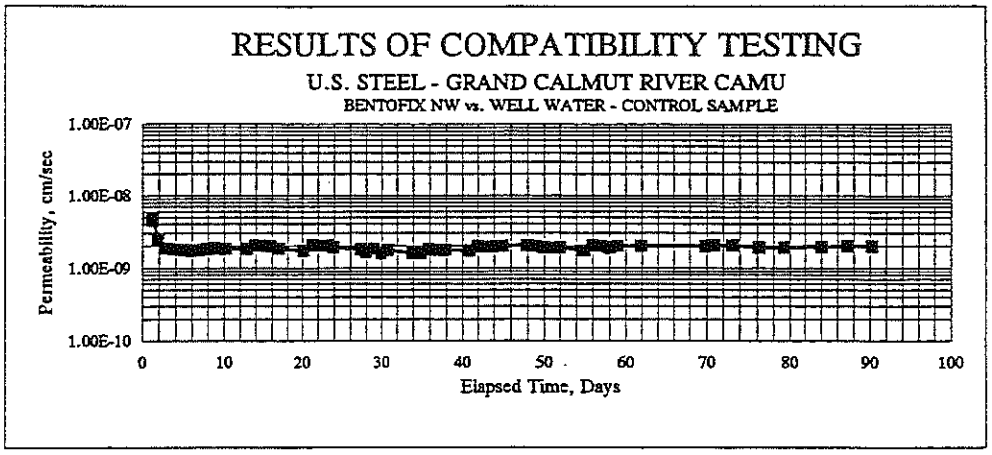
Cell Pressure	(psi)	:	54.5	Effective Stress (psi)	:	10
Head Water	(psi)	:	45.0			
Tail Water	(psi)	:	44.0	Gradient	:	89.3

DATE	TIME	El. Time			
09/04/97	16:26		SATURATION	TEST TEMP.	23
09/16/97	10:20	16914.00			

Permeability Data

			Inflow, cc	Outflow, cc	Out/Inflow	Ave Flow,cc	K, cm/sec	Cum Time, Day
09/16/97	10:25							
09/17/97	14:10	1665.00	3	3.95	1.32	3.5	4.6E-09	1.16
09/17/97	17:10	180.00	0.4	0.4	1.00	0.4	4.9E-09	1.28
09/18/97	08:08	898.00	1	1	1.00	1.0	2.4E-09	1.90
09/19/97	08:05	1437.00	1.3	1.15	0.88	1.2	1.9E-09	2.90
09/20/97	08:10	1445.00	1.25	1.15	0.92	1.2	1.8E-09	3.91
09/21/97	13:15	1745.00	1.4	1.4	1.00	1.4	1.8E-09	5.12
09/22/97	08:07	1132.00	0.9	0.9	1.00	0.9	1.7E-09	5.90
09/23/97	08:05	1438.00	1.2	1.1	0.92	1.2	1.7E-09	6.90
09/24/97	08:09	1444.00	1.2	1.2	1.00	1.2	1.8E-09	7.91
09/25/97	08:09	1440.00	1.2	1.25	1.04	1.2	1.9E-09	8.91
09/26/97	15:54	1905.00	1.6	1.6	1.00	1.6	1.8E-09	10.23
09/29/97	08:09	3855.00	3.2	3.3	1.03	3.3	1.8E-09	12.91
09/30/97	08:08	1439.00	1.3	1.4	1.08	1.4	2.1E-09	13.90
10/01/97	08:10	1442.00	1.4	1.3	0.93	1.4	2.0E-09	14.91
10/02/97	08:09	1439.00	1.2	1.4	1.17	1.3	2.0E-09	15.91
10/03/97	08:07	1438.00	1.1	1.32	1.20	1.2	1.8E-09	16.90
10/06/97	13:20	4633.00	3.6	3.7	1.03	3.7	1.7E-09	20.12
10/07/97	16:35	1635.00	1.5	1.6	1.07	1.6	2.1E-09	21.26
10/08/97	14:50	1335.00	1.3	1.2	0.92	1.3	2.0E-09	22.18
10/09/97	16:55	1565.00	1.5	1.4	0.93	1.5	2.0E-09	23.27
10/10/97	08:10	915.00	0.8	0.8	1.00	0.8	1.9E-09	23.91
10/13/97	16:53	4843.00	3.85	4.1	1.06	4.0	1.8E-09	27.27
10/14/97	08:10	917.00	0.55	0.85	1.55	0.7	1.7E-09	27.91
10/15/97	08:14	1444.00	1.39	1.05	0.76	1.2	1.8E-09	28.91
10/16/97	08:13	1439.00	1.01	1.1	1.09	1.1	1.6E-09	29.91
10/17/97	08:13	1440.00	1.1	1.2	1.09	1.2	1.7E-09	30.91
10/20/97	08:09	4316.00	3.1	3.15	1.02	3.1	1.6E-09	33.91
10/21/97	08:10	1441.00	1.1	1	0.91	1.1	1.6E-09	34.91
10/22/97	08:13	1443.00	1.15	1.2	1.04	1.2	1.8E-09	35.91
10/23/97	08:10	1437.00	1.1	1.2	1.09	1.2	1.8E-09	36.91
10/24/97	08:10	1440.00	1.2	1.1	0.92	1.2	1.7E-09	37.91

10/27/97	09:13	4383.00	3.6	3.3	0.92	3.5	1.7E-09	40.95
10/28/97	09:10	1437.00	1.3	1.3	1.00	1.3	2.0E-09	41.95
10/29/97	09:07	1437.00	1.25	1.3	1.04	1.3	1.9E-09	42.95
10/30/97	09:10	1443.00	1.3	1.3	1.00	1.3	2.0E-09	43.95
10/31/97	09:11	1441.00	1.3	1.3	1.00	1.3	2.0E-09	44.95
11/03/97	09:17	4326.00	4	4.1	1.03	4.1	2.0E-09	47.95
11/04/97	09:12	1435.00	1.25	1.35	1.08	1.3	2.0E-09	48.95
11/05/97	09:10	1438.00	1.3	1.2	0.92	1.3	1.9E-09	49.95
11/06/97	12:35	1645.00	1.4	1.4	1.00	1.4	1.9E-09	51.09
11/07/97	09:12	1237.00	1.05	1.1	1.05	1.1	1.9E-09	51.95
11/10/97	09:17	4325.00	3.45	3.4	0.99	3.4	1.7E-09	54.95
11/11/97	09:10	1433.00	1.35	1.35	1.00	1.4	2.1E-09	55.95
11/12/97	09:08	1438.00	1.3	1.3	1.00	1.3	2.0E-09	56.95
11/13/97	09:10	1442.00	1.25	1.2	0.96	1.2	1.9E-09	57.95
11/14/97	09:10	1440.00	1.3	1.3	1.00	1.3	2.0E-09	58.95
11/17/97	09:06	4316.00	4	3.9	0.98	4.0	2.0E-09	61.95
11/25/97	08:21	11475.00	10.4	10.4	1.00	10.4	2.0E-09	69.91
11/26/97	07:39	1398.00	1.3	1.3	1.00	1.3	2.0E-09	70.88
11/28/97	13:10	3211.00	3	3	1.00	3.0	2.0E-09	73.11
12/01/97	16:42	4532.00	4	4	1.00	4.0	1.9E-09	76.26
12/04/97	18:25	4423.00	3.9	3.9	1.00	3.9	1.9E-09	79.33
12/09/97	08:30	6605.00	5.8	5.9	1.02	5.9	1.9E-09	83.92
12/12/97	14:25	4675.00	4.3	4.3	1.00	4.3	2.0E-09	87.17
12/15/97	15:11	4366.00	3.95	4	1.01	4.0	2.0E-09	90.20



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Geomembrane EPA 9090 Laboratory Test Results
(February 1998)

EPA 9090 TESTING
U.S. STEEL GRAND CALMUT RIVER - CAMU
FINAL REPORT

J&L TESTING COMPANY, INC.
GEOTECHNICAL AND GEOSYNTHETICS MATERIALS TESTING AND RESEARCH

1 of 6

EPA 9090 TESTING
U.S. STEEL GRAND CALMUT RIVER - CAMU
FINAL REPORT

Performed For:

Montgomery Watson
One Science Court
P.O. Box 5385
Madison, WI 53705-0385

Performed By:

J&L Testing Company, Inc.
938 S. Central Avenue
Canonsburg, PA 15317

February 26, 1998
97S2180

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J&L TESTING COMPANY, INC.
GEOTECHNICAL AND GEOSYNTHETICS MATERIALS TESTING AND RESEARCH

February 26, 1998
97S2180-01

Montgomery Watson
One Science Court
P.O. Box 5385
Madison, WI 53705-0385

Attn: Valerie Ranguette, P.E.

RE: GEOSYNTHETIC LABORATORY TESTING
U.S. STEEL GRAND CALMUT RIVER CAMU
FINAL REPORT

Dear Ms. Ranguette:

J&L Testing Company, Inc. (JLT) is pleased to submit this final report of testing performed to evaluate the compatibility of geosynthetics materials for the above referenced project. The purpose of this report is to provide you with a copy of the data and results, allow you to review the data, and provide any comments. The work performed and summarized herein includes:

1) Preparation of synthetic leachate
2) Compatibility testing of geomembrane in accordance with EPA 9090A protocols using the leachate generated above

The following sections describe the details of the preparation of the leachate, the compatibility testing program and results of tests.

1. Leachate Preparation

The synthetic leachate used for the compatibility and the biological clogging tests was prepared by mixing the required organic chemicals with well water. The required concentration recipe of each organic compound in the final solution was provided to JLT by Montgomery Watson and are as follows:

Chemical	Concentration
Toluene	100 mg/L
Naphthalene	100 mg/L
Dibenzofuran	10.0 mg/L

These chemicals were purchased in pure state. Three (3) batches, each sufficient to prepare 28 liters of the synthetic leachate were prepared. The following outlines further details of the leachate preparation.

- The organic compounds were weighed to the nearest 0.0001g using an analytical balance and mixed.

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- To insure that the compounds would dissolve in water, the organic mix was dissolved in acetone. The resulting mix was then stored in a glass bottle with a teflon-lined cap.
- Two (2) stainless steel 55-gallon drums were purchased and filled with 28 liters of well water each. The water used was previously tested for pH and metals (see Table 1).
- A bottle containing the proportioned mix was emptied into each of the water drums and thoroughly mixed.
- Two (2) samples were taken from each of the two (2) water-chemical drums and tested for concentration of the chemicals for confirmation. Results of the confirmatory testing are presented on Table 2.
- This prepared synthetic leachate was then used to set up the compatibility and biological clogging tests.

Table 1
Analytical Results
Well Water Used for Preparing Synthetic Leachate

Parameter	Method	Result	Units
pH	EPA 150.1	7.31	su
Barium	EPA 200.7	0.08	mg/L
Calcium	EPA 200.7	84.7	mg/L
Iron	EPA 236.1	0.56	mg/L
Magnesium	EPA 200.7	16.9	mg/L
Manganese	EPA 243.1	<0.01	mg/L
Sodium	EPA 273.1	40.7	mg/L
Zinc	EPA 289.1	0.03	mg/L

Table 2
Synthetic Leachate
Confirmatory Test Results

Parameter	Method	Sample from Drum A		Sample from Drum B	
		1	2	1	2
Toluene	SW-846- 8021A	137.0	109.0	103.2	103.2
Naphthalene	SW-846-8270C	77.2	101.0	102.6	103.7
Dibenzofuran	SW-846-8270C	14.8	11.2	11.4	11.7

2. Geomembrane Compatibility Testing

In accordance with the laboratory testing program developed by Montgomery Watson, a sample of 60 mil Smooth HDPE geomembrane was tested for compatibility with the synthetic leachate. The geomembrane used was manufactured by National Seal Company (NSC) and was supplied to JLT at Montgomery Waston's request for the purpose of this testing. The compatibility testing was being performed in accordance with EPA 9090A protocols. The work performed is summarized below.

Three (3) groups of gemembrane coupons were prepared for testing.

- One group was tested for all the required properties to establish baseline data. The group used for the baseline testing was not exposed to the leachate.

- The second group of samples was prepared and immersed in a tank of leachate maintained at 23°C.

- The third group of samples was prepared and placed in a leachate tank maintained at 50°C.

- Both the 23°C and 50°C tanks contained sufficient coupons to test for the required properties in both the machine direction (MD) and cross direction (CD).

- Samples were drawn from each of the two (2) tanks at 30-day intervals and tested for the required properties.

- The following measurements and tests were performed on the baseline samples as well as the samples retrieved from the temperature controlled tanks:

Thickness	ASTM D-5199
Dimensions (length and width)	ASTM D-751
Weight	ASTM D-5261
Tensile Properties	ASTM D-698
Tear Resistance	ASTM D-1004
Puncture Resistance	ASTM D-4833
Hardness	ASTM D-2240
Volatiles	EPA/600/2-88/052
Extractables	EPA/600/2-88/052
Density	ASTM D-1505
Secant Modulus (2%)	ASTM D-5323

These were the basic indicator tests required for the project in accordance with ASTM D-5747 and per EPA 9090A.

- The results of tests performed were then compared against the baseline data as well as the data from previous intervals for evaluation.

- Appendix A presents the summary tables and graphical representations for test data obtained over the 120-day testing period.
- Appendix B presents the test results of the baseline testing.
- Appendix C presents the test results for the 30-day samples.
- Appendix D presents the test results for the 60-day samples.
- Appendix E presents the test results for the 90-day samples.
- Appendix D presents the test results for the 120-day samples.

We appreciate the opportunity to provide the above testing services to Montgomery Watson and look forward to working with you again. Should you, upon review of the information presented herein, have any questions, comments or require additional information, please call. Thank you.

Sincerely,

J&L TESTING COMPANY, INC.

Ken Urbanec, P.E.
Project Manager

Enclosures
KU/rdg
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6-end

EPA 9090 TESTING
SUMMARY TEST RESULTS
TENSILE PROPERTIES ASTM D-638

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	01-12-98
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

23 Deg C

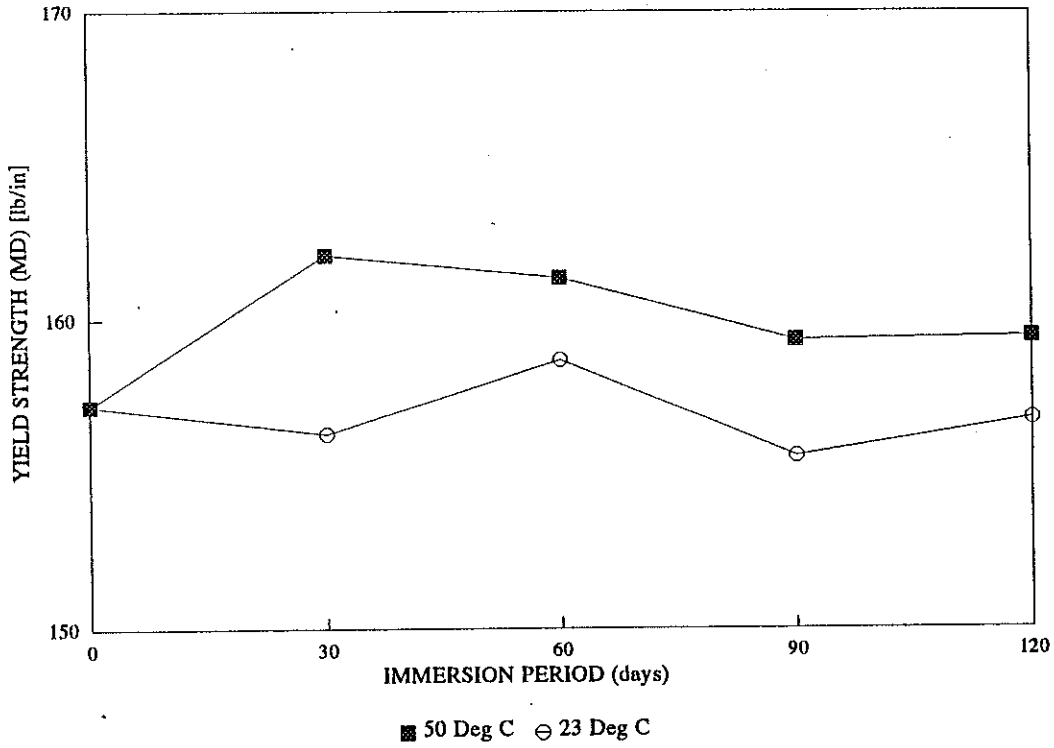
TEST	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
Yield Strength (MD) [lb/in]	157.18	156.26	-0.59	158.65	0.94	155.53	-1.05	156.73	-0.29
Elongation at Yield (MD) [%]	20.62	19.23	-6.74	19.69	-4.51	19.85	-3.73	19.54	-5.24
Break Strength (MD) [lb/in]	263.87	303.65	15.08	290.27	10.00	264.17	0.11	279.50	5.92
Elong. at Break (MD) [%]	777.15	888.91	14.38	845.39	8.78	777.27	0.02	815.58	4.94
Yield Strength (CD) [lb/in]	175.73	165.48	-5.83	161.86	-7.89	158.85	-9.61	158.59	-9.75
Elongation at Yield (CD) [%]	21.69	18.92	-12.77	18.77	-13.46	18.62	-14.15	18.62	-14.15
Break Strength (CD) [lb/in]	263.79	295.59	12.06	285.25	8.14	265.41	0.61	273.48	3.67
Elong. at Break (CD) [%]	811.34	907.83	11.89	890.79	9.79	835.33	2.96	872.76	7.57

50 Deg C

TEST	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
Yield Strength (MD) [lb/in]	157.18	162.09	3.12	161.32	2.63	159.31	1.36	159.41	1.42
Elongation at Yield (MD) [%]	20.62	19.69	-4.51	19.69	-4.51	19.85	-3.73	19.85	-3.73
Break Strength (MD) [lb/in]	263.87	313.94	18.98	297.74	12.84	263.42	-0.17	276.35	4.73
Elong. at Break (MD) [%]	777.15	903.98	16.32	868.99	11.82	782.87	0.74	814.96	4.87
Yield Strength (CD) [lb/in]	175.73	161.20	-8.27	156.50	-10.94	162.43	-7.57	162.50	-7.53
Elongation at Yield (CD) [%]	21.69	19.54	-9.91	19.38	-10.65	18.92	-12.77	19.23	-11.34
Break Strength (CD) [lb/in]	263.79	307.49	16.57	294.02	11.46	272.47	3.29	277.85	5.33
Elong. at Break (CD) [%]	811.34	952.83	17.44	907.78	11.89	845.56	4.22	870.39	7.28

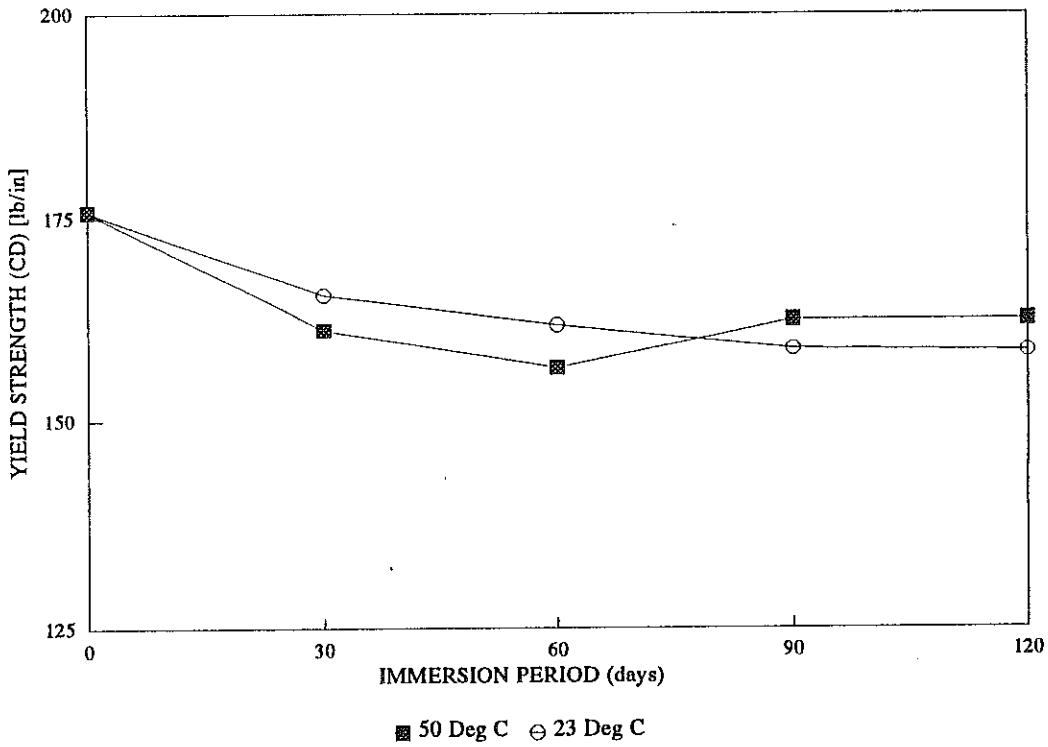
EPA 9090 TESTING
SUMMARY TEST RESULTS
TENSILE PROPERTIES ASTM D-638

Client:	Montgomery Watson	YIELD STRENGTH MACHINE DIRECTION	Job Number:	97S2180-01
Project:	Gary Works, Indiana EPA 9090 Testing Program		Date:	1-12-98
			Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE		Checked By:	K.U.



EPA 9090 TESTING
SUMMARY TEST RESULTS
TENSILE PROPERTIES ASTM D-638

Client:	Montgomery Watson	YIELD STRENGTH	Job Number:	97S2180-01
Project:	Gary Works, Indiana	CROSS DIRECTION	Date:	1-12-98
	EPA 9090 Testing Program		Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE		Checked By:	K.U.



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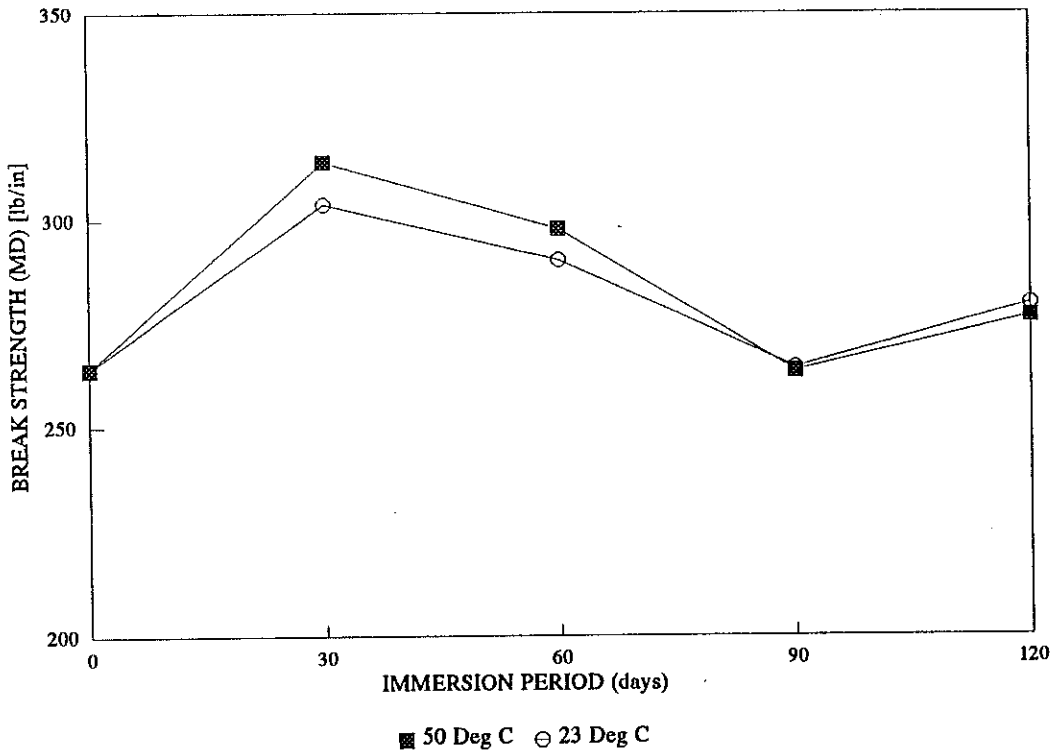
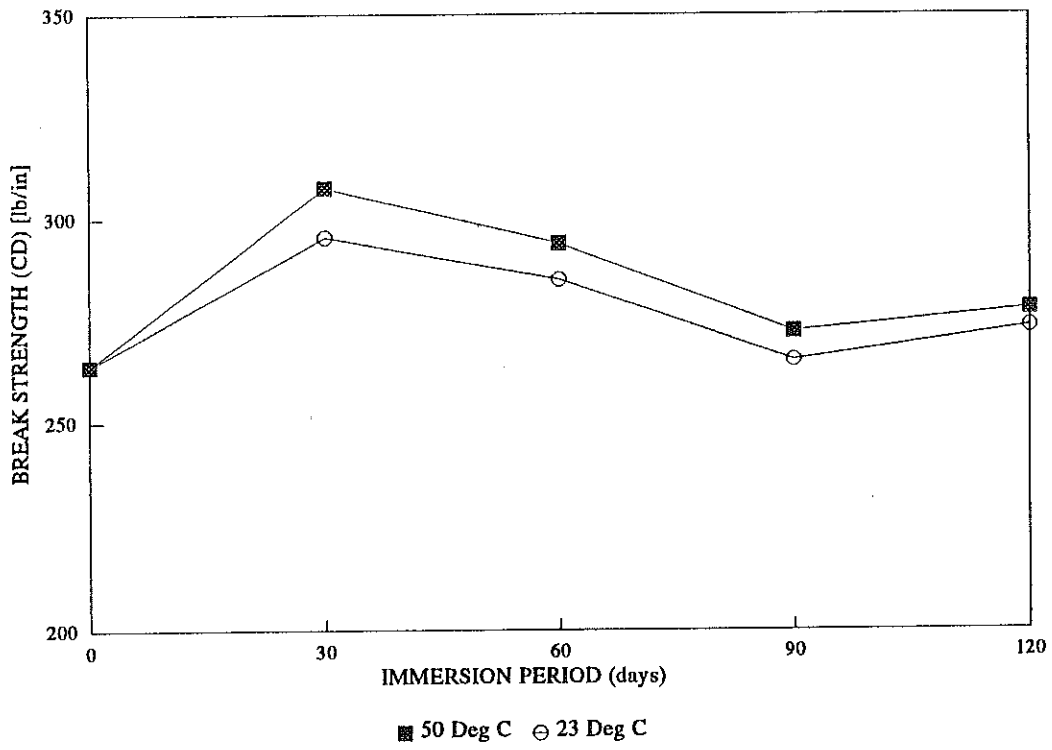
EPA 9090 TESTING
SUMMARY TEST RESULTS
TENSILE PROPERTIES ASTM D-638

Client:	Montgomery Watson	**BREAK STRENGTH**	Job Number:	97S2180-01
Project:	Gary Works, Indiana	**MACHINE DIRECTION**	Date:	1-12-98
	EPA 9090 Testing Program		Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE		Checked By:	K.U.



EPA 9090 TESTING
SUMMARY TEST RESULTS
TENSILE PROPERTIES ASTM D-638

Client:	Montgomery Watson	BREAK STRENGTH	Job Number:	97S2180-01
Project:	Gary Works, Indiana	CROSS DIRECTION	Date:	1-12-98
	EPA 9090 Testing Program		Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE		Checked By:	K.U.



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EPA 9090 TESTING
SUMMARY TEST RESULTS
TEAR RESISTANCE - ASTM D-1004

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	01-12-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

23 Deg C

TEST	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
THICKNESS [mils]	60.88	60.20	-1.12	61.10	0.36	60.60	-0.46	60.84	-0.07
RESISTANCE (MD) [lbs]	54.78	54.66	-0.22	55.82	1.90	56.54	3.21	52.41	-4.33
RESISTANCE (MD) [lb/in]	900.50	908.04	0.84	913.69	1.46	933.05	3.61	861.32	-4.35

23 Deg C

TEST	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
THICKNESS [mils]	60.64	60.40	-0.40	60.80	0.26	60.60	-0.07	60.80	0.26
RESISTANCE (CD) [lbs]	53.85	54.84	1.84	55.78	3.58	56.38	4.70	51.19	-4.94
RESISTANCE (CD) [lb/in]	888.17	907.93	2.22	917.48	3.30	930.46	4.76	841.80	-5.22

50 Deg C

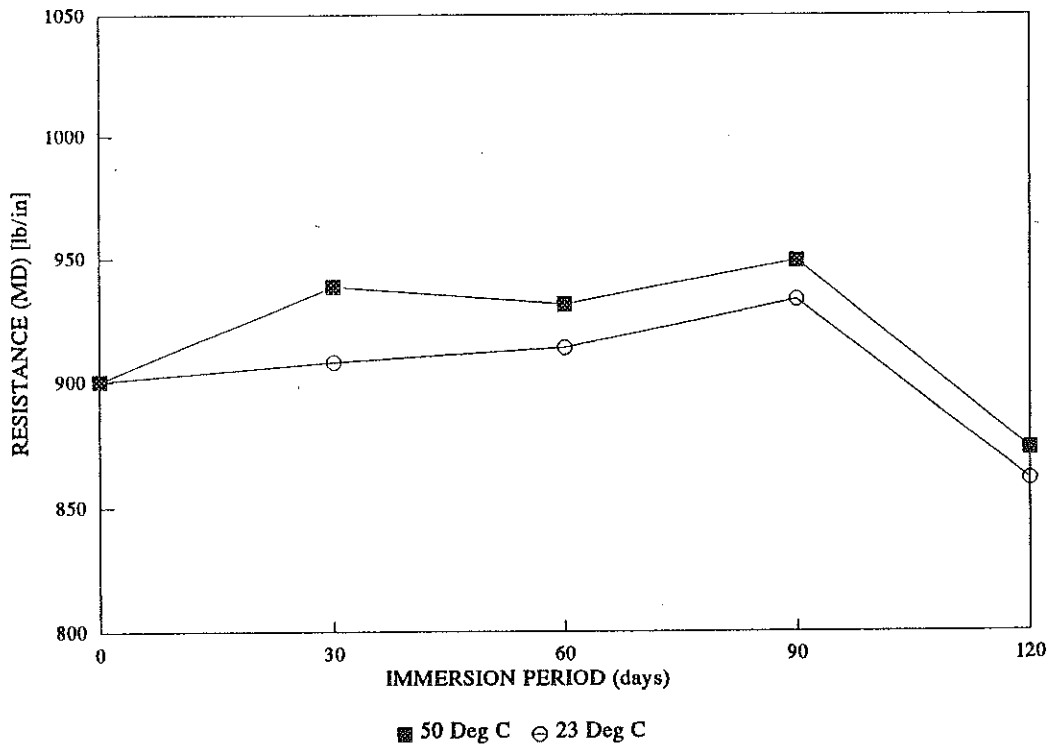
REPLICATE No.	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
THICKNESS [mils]	60.88	59.90	-1.61	61.14	0.43	60.60	-0.46	60.40	-0.79
RESISTANCE (MD) [lbs]	54.78	56.20	2.59	56.94	3.94	57.50	4.97	52.75	-3.71
RESISTANCE (MD) [lb/in]	900.50	938.29	4.20	931.27	3.42	948.90	5.37	873.33	-3.02

50 Deg C

REPLICATE No.	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
THICKNESS [mils]	60.64	60.40	-0.40	60.70	0.10	60.30	-0.56	61.14	0.82
RESISTANCE (CD) [lbs]	53.85	53.73	-0.22	55.04	2.21	55.62	3.29	52.21	-3.05
RESISTANCE (CD) [lb/in]	888.17	889.75	0.18	906.82	2.10	922.51	3.87	853.95	-3.85

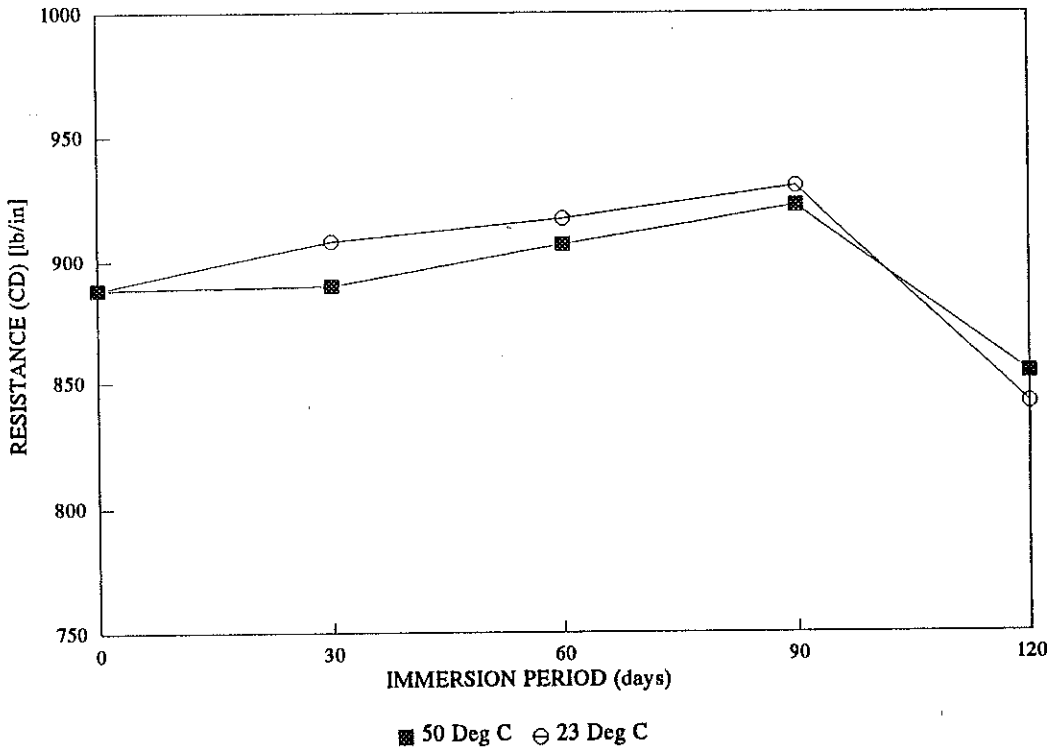
EPA 9090 TESTING
SUMMARY TEST RESULTS
TEAR RESISTANCE ASTM D-1004

Client:	Montgomery Watson		Job Number:	97S2180-01
Project:	Gary Works, Indiana		Date:	1-12-98
	EPA 9090 Testing Program	MACHINE DIRECTION	Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE		Checked By:	K.U.



EPA 9090 TESTING
SUMMARY TEST RESULTS
TEAR RESISTANCE ASTM D-1004

Client:	Montgomery Watson		Job Number:	97S2180-01
Project:	Gary Works, Indiana		Date:	1-12-98
	EPA 9090 Testing Program	CROSS DIRECTION	Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE		Checked By:	K.U.



EPA 9090 TESTING
SUMMARY TEST RESULTS
PUNCTURE RESISTANCE - ASTM D-4833

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	01-12-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

23 Deg C

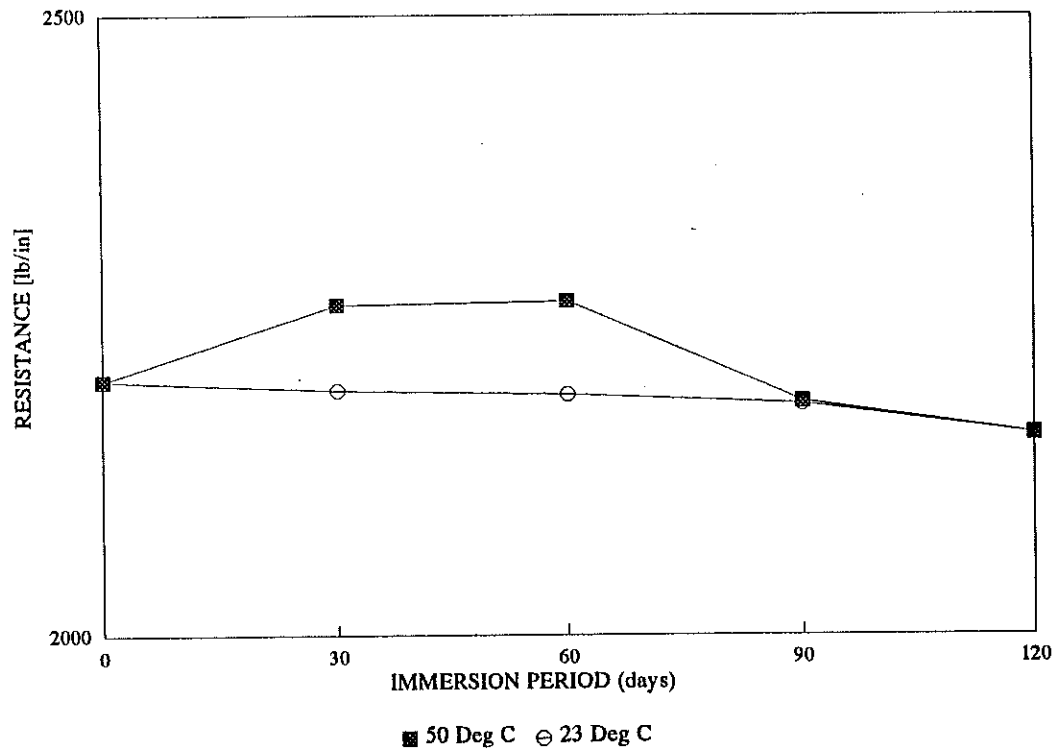
TEST	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
THICKNESS [mils]	59.48	61.00	2.56	61.17	2.84	60.75	2.14	60.83	2.27
RESISTANCE [lbs]	131.04	133.90	2.18	134.07	2.31	132.71	1.27	131.42	0.29
RESISTANCE [lb/in]	2203.01	2195.25	-0.35	2192.04	-0.50	2184.38	-0.85	2160.30	-1.94

50 Deg C

REPLICATE No.	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
THICKNESS [mils]	59.48	60.53	1.77	61.17	2.84	61.65	3.65	60.83	2.27
RESISTANCE [lbs]	131.04	137.14	4.66	138.74	5.88	134.78	2.85	131.42	0.29
RESISTANCE [lb/in]	2203.01	2265.58	2.84	2268.56	2.98	2186.25	-0.76	2160.30	-1.94

EPA 9090 TESTING
SUMMARY TEST RESULTS
PUNCTURE RESISTANCE ASTM D-4833

Client:	Montgomery Watson	Job Number:	97S2180-01
Project:	Gary Works, Indiana	Date:	1-12-98
	EPA 9090 Testing Program	Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE	Checked By:	K.U.



EPA 9090 TESTING
SUMMARY TEST RESULTS
HARDNESS - ASTM D-2240

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	01-12-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

23 Deg C

TEST	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
READING [Duro D]	60.30	58.60	-2.82	57.00	-5.47	60.20	-0.17	60.60	0.50

50 Deg C

REPLICATE No.	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
READING [Duro D]	60.30	59.40	-1.49	56.80	-5.80	60.40	0.17	59.40	-1.49

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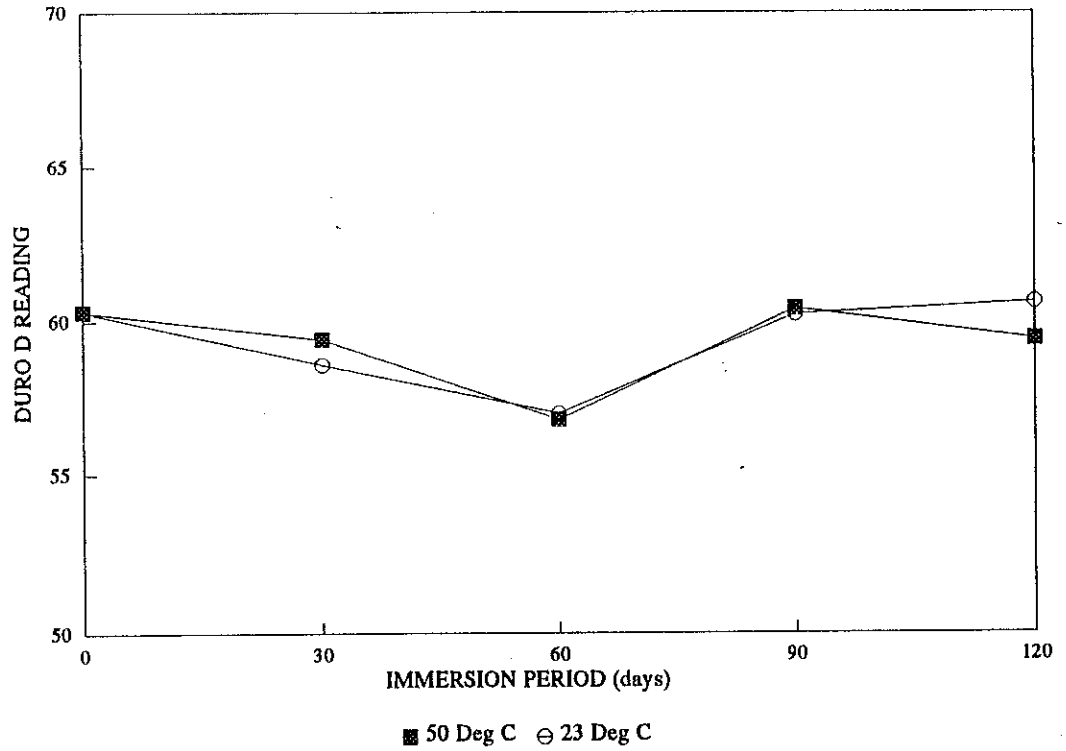
EPA 9090 TESTING
SUMMARY TEST RESULTS
HARDNESS ASTM D-2240

Client:	Montgomery Watson	Job Number:	97S2180-01
Project:	Gary Works, Indiana	Date:	1-12-98
	EPA 9090 Testing Program	Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE	Checked By:	K.U.



EPA 9090 TESTING
SUMMARY TEST RESULTS
VOLATILES

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	01-12-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

23 Deg C

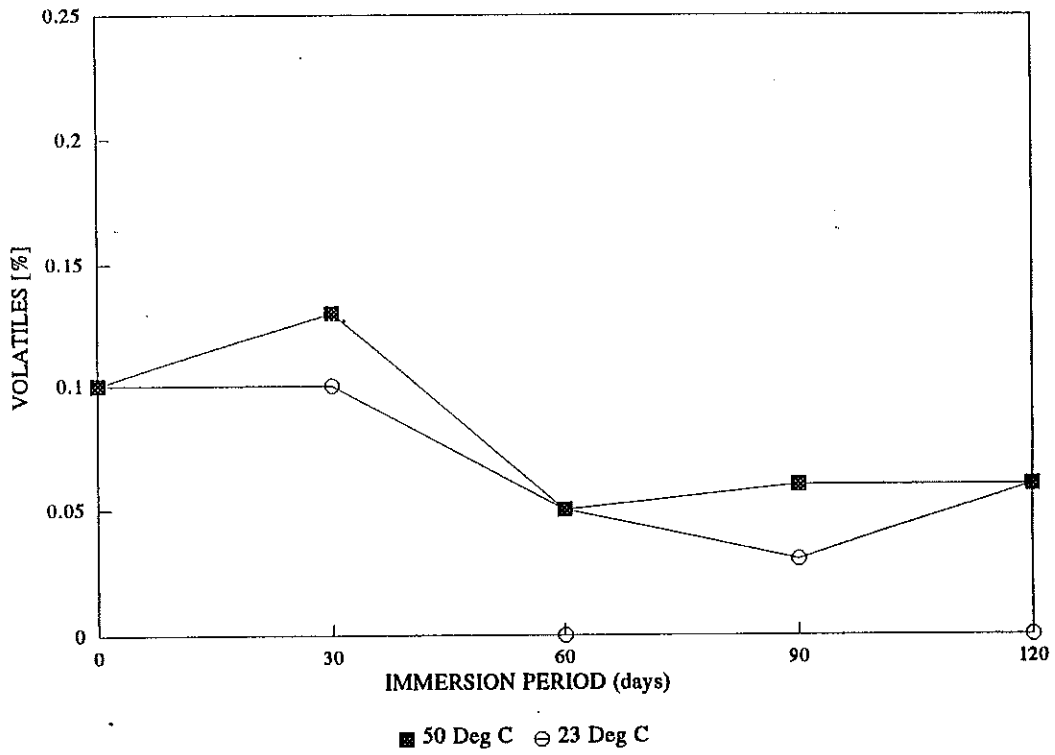
TEST	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
VOLATILES [%]	0.10	0.10	0.00	0.05	-50.00	0.03	-70.00	0.06	-40.00

50 Deg C

REPLICATE No.	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
VOLATILES [%]	0.10	0.13	30.00	0.05	-50.00	0.06	-40.00	0.06	-40.00

EPA 9090 TESTING
SUMMARY TEST RESULTS
VOLATILES

Client:	Montgomery Watson	Job Number:	97S2180-01
Project:	Gary Works, Indiana	Date:	1-12-98
	EPA 9090 Testing Program	Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE	Checked By:	K.U.



EPA 9090 TESTING
SUMMARY TEST RESULTS
EXTRACTABLES

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	01-12-98
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

23 Deg C

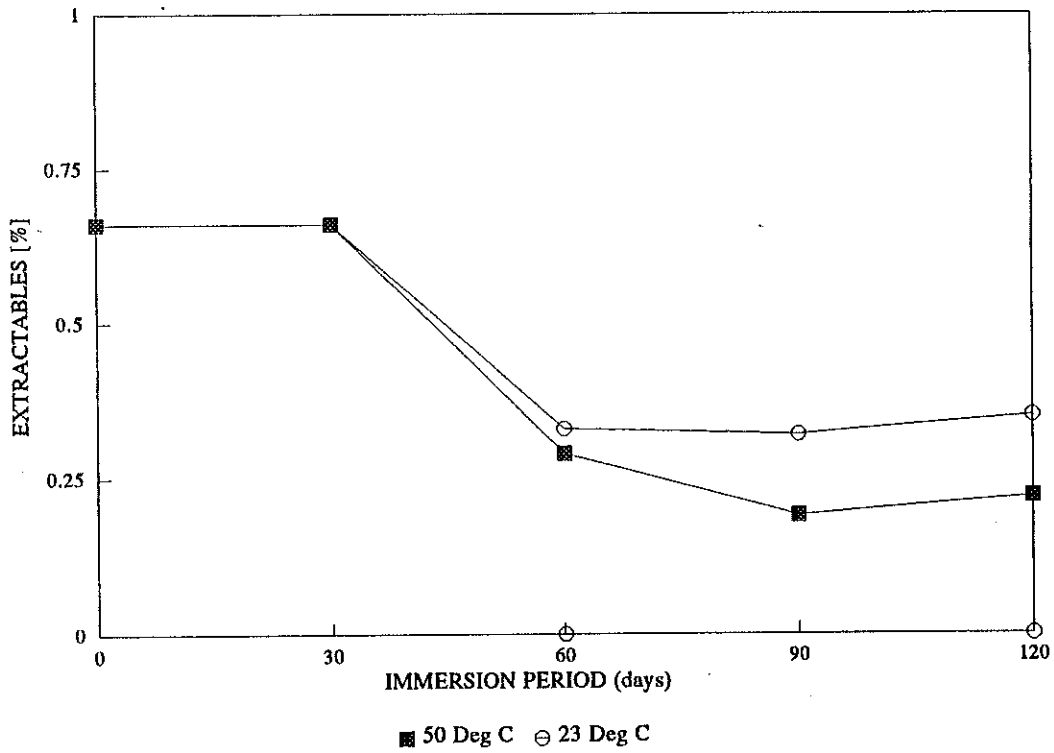
TEST	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
EXTRACTABLES [%]	0.66	0.66	0.00	0.33	-50.00	0.32	-51.52	0.35	-46.97

50 Deg C

REPLICATE No.	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
EXTRACTABLES [%]	0.66	0.56	-15.15	0.29	-56.06	0.19	-71.21	0.22	-66.67

EPA 9090 TESTING
SUMMARY TEST RESULTS
EXTRACTABLES

Client:	Montgomery Watson	Job Number:	97S2180-01
Project:	Gary Works, Indiana	Date:	1-12-98
	EPA 9090 Testing Program	Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE	Checked By:	K.U.



EPA 9090 TESTING
SUMMARY TEST RESULTS
2 % SECANT MODULUS ASTM D-5323

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	01-12-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

23 Deg C

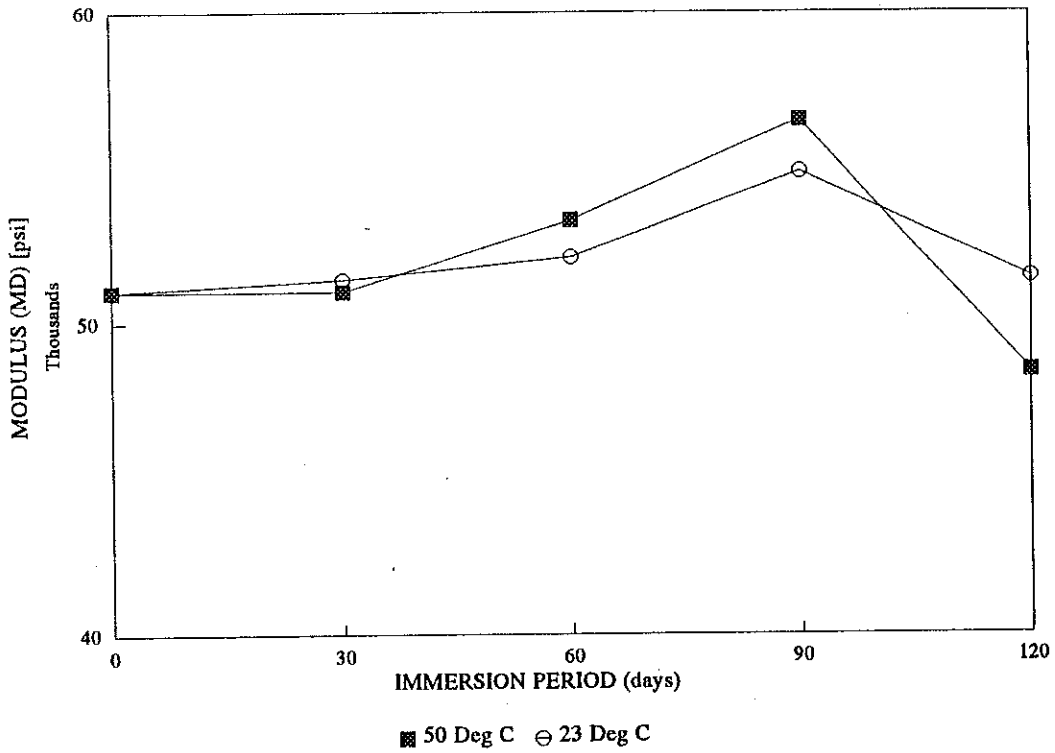
TEST	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
MODULUS (MD) [psi]	50993.36	51390.72	0.78	52111.20	2.19	54844.73	7.55	51446.09	0.89
MODULUS (CD) [psi]	54172.16	52715.22	-2.69	54304.64	0.26	60975.61	13.34	53645.29	-1.03

50 Deg C

REPLICATE No.	Baseline	30 day Immersion		60 day Immersion		90 day Immersion		120 day Immersion	
	Average	Average	Change, %	Average	Change, %	Average	Change, %	Average	Change, %
MODULUS (MD) [psi]	50993.36	50993.36	0.00	53311.26	4.55	56510.73	10.82	48379.05	-5.13
MODULUS (CD) [psi]	54172.16	50993.36	-5.87	53503.48	-1.31	56843.93	5.24	52379.05	-3.52

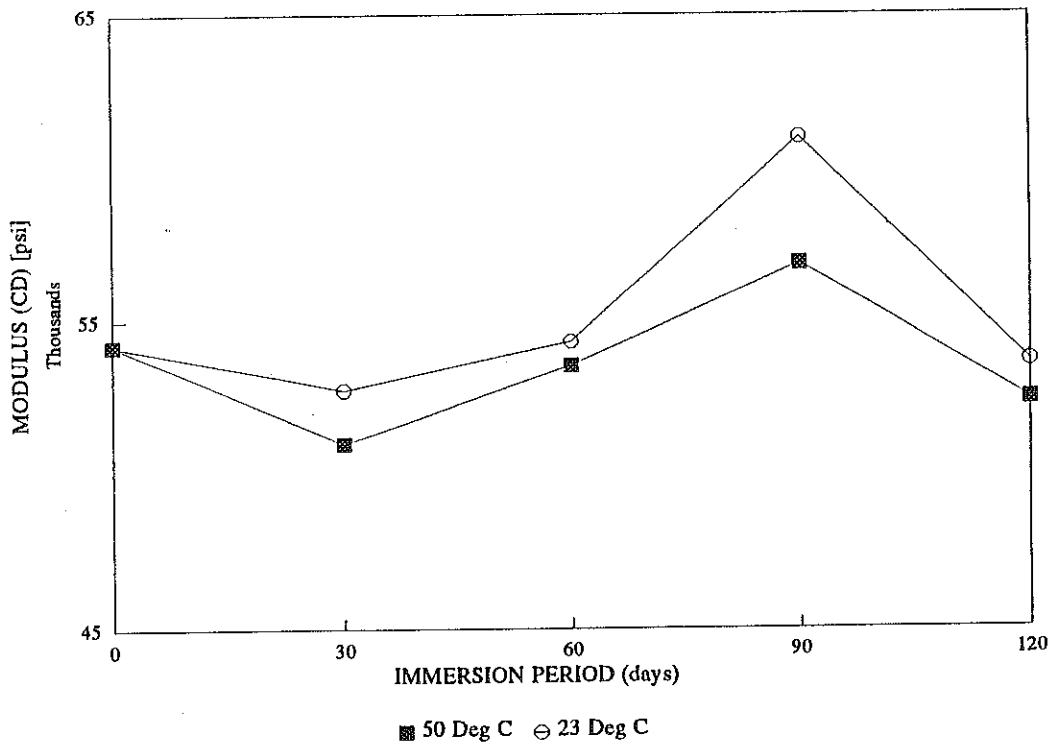
EPA 9090 TESTING
SUMMARY TEST RESULTS
2 % SECANT MODULUS ASTM D-5323

Client:	Montgomery Watson		Job Number:	97S2180-01
Project:	Gary Works, Indiana		Date:	1-12-98
	EPA 9090 Testing Program	MACHINE DIRECTION	Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE		Checked By:	K.U.



EPA 9090 TESTING
SUMMARY TEST RESULTS
2 % SECANT MODULUS ASTM D-5323

Client:	Montgomery Watson		Job Number:	97S2180-01
Project:	Gary Works, Indiana		Date:	1-12-98
	EPA 9090 Testing Program	CROSS DIRECTION	Tested By:	D.T./K.T.
Material:	60 mil Smooth HDPE		Checked By:	K.U.



19-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program (Baseline)	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.
	1	2	3	4	5	
A	59.0	60.0	60.0	59.0	60.0	59.6
B	61.0	61.0	65.0	61.3	61.3	61.9
C	60.5	60.5	60.0	60.0	60.0	60.2
D	60.5	60.5	60.0	60.0	60.0	60.2
E	60.5	61.0	61.7	61.7	61.7	61.3
F	61.5	61.5	60.5	60.5	61.3	61.1
G	60.5	60.5	59.5	59.5	59.5	59.9
H	60.5	60.5	59.5	60.0	59.5	60.0
I	60.5	60.0	61.0	60.5	60.5	60.5
J	60.0	60.0	60.5	60.5	60.5	60.3
K	61.0	61.0	61.0	60.5	60.5	60.8
L	60.0	59.0	60.0	59.5	58.7	59.4
M	59.0	59.0	60.0	59.9	59.3	59.4
N	60.7	60.5	61.0	61.0	61.0	60.8
O	60.0	59.9	60.0	60.5	60.0	60.1
P	61.0	60.8	60.8	61.0	61.0	60.9
Q	61.5	61.3	60.5	60.4	61.0	60.9
R	61.5	61.5	61.3	61.0	60.5	61.2
S	60.7	60.7	61.5	61.8	61.8	61.3
T	60.0	60.5	61.8	61.5	61.5	61.1
U	60.0	60.0	61.0	60.5	60.5	60.4
V	59.5	60.5	60.5	60.0	60.5	60.2
W	61.0	60.0	61.0	61.5	61.0	60.9
X	60.0	60.8	60.8	60.4	60.5	60.5
AVERAGE	**60.43**	**60.46**	**60.79**	**60.52**	**60.50**	***60.54***

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program (Baseline)	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	33.6	33.98
2	0.9494	23.2	21.84
3*	0.9560	16.2	17.18

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	20	19.6	19	17	17.4	18.60
DENSITY	0.9515	0.9520	0.9529	0.9557	0.9552	0.9535

MASS PER UNIT AREA
ASTM D-5261

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Area	sq. cm.	100.00	100.00	100.00	100.00	100.00	100.00	0.0000
Weight	gms	14.4821	14.6665	14.4366	14.6567	14.6783	14.5840	0.1030
Mass per Unit Area	lb/sq. ft.	0.297	0.300	0.296	0.300	0.301	0.299	0.0021

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	BASELINE TESTING		

Initial Wt.	2.3132 grams
After Extraction	2.2980 grams
%Extractables	0.66

Reference : EPA/600/2-88/052, Appendix E

HARDNESS
ASTM D-2240

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program (Baseline)	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	60.0	61.0	60.0	60.0	60.5	60.3
2	61.0	61.0	61.0	60.0	59.0	60.4
3	61.0	61.0	60.5	61.0	60.5	60.8
4	60.5	61.0	61.0	60.5	60.5	60.7
5	61.0	60.5	60.0	59.5	60.5	60.3

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	54,304.60	47,682.10	47,682.10	52,317.90	52,980.10	50,993.36	2778.30
2% Secant Modulus (CD)	psi	52,980.10	52,980.10	52,980.10	57,615.90	54,304.60	54,172.16	1796.66

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NOTCHED CONSTANT TENSILE LOAD
ASTM D-5397

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana	DATE:	10-15-97
	EPA 9090 Testing Program	TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	BASELINE TESTING		

Average Stress at Yield (lb/in) =	175.73
Applied Stress (lb/in) =	52.72
Sample thickness (mil) =	60.5
Notch depth (mil) =	12.1
Minimum required time period =	200 hrs
Results :	No failures

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	59.86	59.98	60.38	60.18	60.06	59.30	59.00	59.00	60.00	59.50	59.48	0.43
Puncture Resistance	lb	131.66	131.52	132.22	135.60	133.37	128.95	127.10	130.40	134.30	132.10	131.04	2.50
Puncture Resistance	lb/in	2199.47	2192.73	2189.80	2253.24	2220.61	2174.54	2154.24	2210.17	2238.33	2220.17	2203.01	29.13

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	180.65	135.08	176.21	172.18	121.77	157.18	23.9984
Elongation at Yield (MD)	%	20.00	15.38	26.92	24.62	16.15	20.62	4.5482
Break Strength (MD)	lb/in	266.53	226.61	277.42	266.13	282.66	263.87	19.6824
Elongation at Break (MD	%	750.95	768.31	788.95	767.17	810.40	777.15	20.5386
Yield Strength (CD)	lb/in	174.19	176.21	175.40	178.23	174.60	175.73	1.4290
Elongation at Yield (CD)	%	17.69	24.62	21.54	22.31	22.31	21.69	2.2506
Break Strength (CD)	lb/in	258.87	285.08	250.00	274.60	250.40	263.79	13.8827
Elongation at Break (CD)	%	799.77	880.68	765.50	833.58	777.15	811.34	41.7298

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program (Baseline)
MATERIAL: 60 mil Smooth HDPE

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.00	61.38	61.35	61.18	60.50	60.88	0.5425
Tear Resistance (MD)	lb	56.40	53.42	55.20	54.30	54.60	54.78	0.9913
Tear Resistance (MD)	lb/in	940.00	870.39	899.76	887.62	902.48	900.05	22.9628
Thickness (CD)	mils	60.17	60.73	60.80	61.00	60.50	60.64	0.2855
Tear Resistance (CD)	lb	55.00	54.20	55.35	51.57	53.15	53.85	1.3699
Tear Resistance (CD)	lb/in	914.13	892.43	910.36	845.41	878.51	888.17	24.9242

TOTAL VOLATILES
MTM-1

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	BASELINE TESTING		

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.13	0.08	0.10	0.10

Reference : EPA/600/2-88/052, Appendix G

11-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
A (Initial)	59.0	60.0	60.0	59.0	60.0	59.6	
A (Final)	59.0	60.0	59.0	61.0	61.0	60.0	0.67
B (Initial)	61.0	61.0	65.0	61.3	61.3	61.9	
B (Final)	61.0	62.0	61.0	62.0	62.0	61.6	-0.52
C (Initial)	60.5	60.5	60.0	60.0	60.0	60.2	
C (Final)	61.0	61.0	60.0	61.0	61.0	60.8	1.00

Average of final = 60.8

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
A (Initial)	100.0	99.5	-0.50
A (Final)	99.9	99.5	-0.40
B (Initial)	100.0	99.5	-0.50
B (Final)	100.0	99.5	-0.50
C (Initial)	100.0	99.5	-0.50
C (Final)	99.9	99.5	-0.40

2

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
A	42.1	42.1	0.01
B	43.1	43.1	0.04
C	42.4	42.5	0.02

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program (Baseline)	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 DAY, 23 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	37.8	33.98
2	0.9494	26.7	21.84
3*	0.9560	20.0	17.18

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	24.0	24.0	21.2	21.2	20.8	22.2
DENSITY	0.9518	0.9518	0.9557	0.9557	0.9563	0.9543

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana	DATE:	10-15-97
	EPA 9090 Testing Program	TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	30 DAY, 23 DEGREE CELSIUS		

Initial Wt.	2.7090 grams
After Extraction	2.6912 grams
%Extractables	0.66

Reference : EPA/600/2-88/052, Appendix E

HARDNESS
ASTM D-2240

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	58.0	60.0	60.0	62.0	57.0	59.4
2	59.0	61.0	58.0	61.0	58.0	59.4
3	57.0	60.0	57.0	59.0	57.0	58.0
4	59.0	58.0	59.0	57.0	59.0	58.4
5	59.0	58.0	59.0	57.0	60.0	58.6

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	51,655.60	49,006.60	51,655.60	52,317.90	52,317.90	51,390.72	1228.31
2% Secant Modulus (CD)	psi	55,629.10	54,966.90	46,357.60	56,291.40	50,331.12	52,715.22	3806.65

NOTCHED CONSTANT TENSILE LOAD
ASTM D-5397

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	10-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 Day, 23 DEGREE CELSIUS		

Average Stress at Yield (lb/in) =	165.48
Applied Stress (lb/in) =	49.64
Sample thickness (mil) =	60.7
Notch depth (mil) =	12.1
Minimum required time period =	200 hrs
Results :	No failures

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	60.50	61.00	61.00	60.50	60.50	61.80	60.20	61.00	61.50	61.00	61.00	0.54
Puncture Resistance	lb	134.49	134.39	133.44	134.96	133.49	136.09	134.41	131.16	133.66	134.61	133.90	1.49
Puncture Resistance	lb/in	2222.98	2203.11	2187.54	2230.74	2206.45	2202.10	2232.72	2150.16	2173.33	2206.72	2195.25	26.52

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	168.43	152.62	155.24	148.67	156.33	156.26	6.6325
Elongation at Yield (MD)	%	19.23	18.46	20.00	20.00	18.46	19.23	0.6880
Break Strength (MD)	lb/in	306.33	302.70	316.94	282.14	310.16	303.65	11.7456
Elongation at Break (MD	%	883.83	884.38	933.48	839.78	903.07	888.91	30.4845
Yield Strength (CD)	lb/in	166.01	162.90	164.40	169.76	164.31	165.48	2.3561
Elongation at Yield (CD)	%	19.23	19.23	18.46	19.23	18.46	18.92	0.3768
Break Strength (CD)	lb/in	302.50	272.66	299.60	311.57	291.61	295.59	13.1209
Elongation at Break (CD)	%	923.90	848.96	928.02	943.07	895.21	907.83	33.2636

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.50	60.00	60.00	60.50	60.00	60.20	0.2449
Tear Resistance (MD)	lb	53.17	54.42	52.90	55.42	57.40	54.66	1.6408
Tear Resistance (MD)	lb/in	878.84	907.00	881.67	916.03	956.67	908.04	28.2048
Thickness (CD)	mils	60.00	60.50	60.00	61.00	60.50	60.40	0.3742
Tear Resistance (CD)	lb	53.25	54.10	54.40	57.15	55.32	54.84	1.3293
Tear Resistance (CD)	lb/in	887.50	894.21	906.67	936.89	914.38	907.93	17.2458

TOTAL VOLATILES
MTM-1

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 DAY, 23 DEGREE CELSIUS		

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.10	0.13	0.08	0.10

Reference : EPA/600/2-88/052, Appendix G

12-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
M (Initial)	59.0	59.0	60.0	59.9	59.3	59.4	
M (Final)	60.0	60.0	60.0	59.5	60.0	59.9	0.77
N (Initial)	60.7	60.5	61.0	61.0	61.0	60.8	
N (Final)	61.0	61.5	61.5	61.0	61.5	61.3	0.76
O (Initial)	60.0	59.9	60.0	60.5	60.0	60.1	
O (Final)	60.0	61.0	60.0	60.0	61.0	60.4	0.53

Average final 60.53

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
M (Initial)	100.0	99.5	-0.50
M (Final)	100.0	100.0	0.00
N (Initial)	100.0	99.5	-0.50
N (Final)	100.0	99.5	-0.50
O (Initial)	100.0	100.0	0.00
O (Final)	100.0	100.0	0.00

2

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
M	42.2	42.2	0.07
N	43.0	43.1	0.07
O	42.3	42.6	0.72

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	10-15-97
	EPA 9090 Testing Program (Baseline)	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 DAY, 50 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	37.8	33.98
2	0.9494	26.7	21.84
3*	0.9560	20.0	17.18

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	24.5	22.5	23.0	20.2	21.2	22.3
DENSITY	0.9510	0.9539	0.9532	0.9571	0.9557	0.9542

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	10-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 DAY, 50 DEGREE CELSIUS		

Initial Wt.	2.5435 grams
After Extraction	2.5292 grams
%Extractables	0.56

Reference : EPA/600/2-88/052, Appendix E

5

HARDNESS
ASTM D-2240

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	61.0	58.0	61.0	58.0	62.0	60.0
2	62.0	58.0	61.0	59.0	60.0	60.0
3	61.0	57.0	58.0	59.0	59.0	58.8
4	58.0	61.0	58.0	61.0	58.0	59.2
5	59.0	61.0	58.0	62.0	57.0	59.4

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	51,655.60	51,655.60	52,980.10	51,655.60	47,019.90	50,993.36	2051.89
2% Secant Modulus (CD)	psi	49,006.60	51,655.60	50,993.40	50,331.10	52,980.10	50,993.36	1324.50

NOTCHED CONSTANT TENSILE LOAD
ASTM D-5397

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	10-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	30 Day, 50 DEGREE CELSIUS		

Average Stress at Yield (lb/in) =	161.2
Applied Stress (lb/in) =	48.36
Sample thickness (mil) =	60.3
Notch depth (mil) =	12.1
Minimum required time period =	200 hrs
Results :	No failures

8

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	61.00	60.50	61.00	61.00	60.50	61.20	61.50	60.00	60.00	60.00	60.53	0.61
Puncture Resistance	lb	136.50	136.43	136.23	136.35	137.35	139.40	138.65	134.53	136.70	136.23	137.14	1.60
Puncture Resistance	lb/in	2237.70	2255.04	2233.28	2235.25	2270.25	2277.78	2254.47	2242.17	2278.33	2270.50	2265.58	13.10

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	165.12	154.11	162.50	162.10	166.61	162.09	4.3231
Elongation at Yield (MD)	%	18.46	20.77	19.23	20.00	20.00	19.69	0.7845
Break Strength (MD)	lb/in	299.40	320.56	304.72	326.69	318.35	313.94	10.2231
Elongation at Break (MD	%	868.94	924.96	876.42	931.51	918.09	903.98	26.0181
Yield Strength (CD)	lb/in	156.85	159.35	164.52	161.49	163.79	161.20	2.8311
Elongation at Yield (CD)	%	19.23	20.00	20.00	18.46	20.00	19.54	0.6154
Break Strength (CD)	lb/in	313.71	315.00	305.65	297.18	305.93	307.49	6.4386
Elongation at Break (CD)	%	966.58	966.18	950.92	927.98	952.50	952.83	14.0609

10

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.00	60.00	59.00	60.00	60.50	59.90	0.4899
Tear Resistance (MD)	lb	56.67	56.47	55.37	56.80	55.70	56.20	0.5644
Tear Resistance (MD)	lb/in	944.50	941.17	938.47	946.67	920.66	938.29	9.2501
Thickness (CD)	mils	59.50	60.50	60.50	61.00	60.50	60.40	0.4899
Tear Resistance (CD)	lb	55.20	53.97	51.77	53.47	54.25	53.73	1.1312
Tear Resistance (CD)	lb/in	927.73	892.07	855.70	876.56	896.69	889.75	23.7884

TOTAL VOLATILES
MTM-1

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 30 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 10-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.12	0.14	0.12	0.13

Reference : EPA/600/2-88/052, Appendix G

12-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
D (Initial)	60.5	60.5	60.0	60.0	60.0	60.2	
D (Final)	60.5	60.5	60.0	60.0	60.0	60.2	0.00
E (Initial)	60.5	61.0	61.7	61.7	61.0	61.2	
E (Final)	60.5	61.5	61.5	61.0	61.0	61.1	-0.13
F (Initial)	61.5	61.5	60.5	60.5	61.3	61.1	
F (Final)	61.5	61.0	60.5	61.0	61.0	61.0	-0.10

Average Final : 60.76

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
D (Initial)	99.9	99.9	0.00
D (Final)	100.0	100.0	0.00
E (Initial)	99.9	100.0	0.10
E (Final)	100.0	100.0	0.00
F (Initial)	100.0	100.0	0.00
F (Final)	100.0	100.0	0.00

2

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
D	42.2	42.2	-0.00
E	43.0	43.0	-0.00
F	43.0	43.0	0.00

3

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program (Baseline)	**DATE:**	11-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 DAY, 23 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	35.2	33.98
2	0.9494	26.5	21.84
3*	0.9560	19.0	17.18

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	20.5	20.5	21.0	19.8	19.8	20.3
DENSITY	0.9530	0.9530	0.9523	0.9540	0.9540	0.9533

4

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	DATE:	11-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	60 DAY, 23 DEGREE CELSIUS		

Initial Wt.	2.4916 grams
After Extraction	2.4834 grams
%Extractables	0.33

Reference : EPA/600/2-88/052, Appendix E

5

HARDNESS
ASTM D-2240

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	60.0	58.0	57.0	59.0	58.0	58.4
2	60.0	59.0	57.0	58.0	58.0	58.4
3	57.0	58.0	60.0	61.0	61.0	59.4
4	58.0	57.0	57.0	58.0	60.0	58.0
5	57.0	56.0	56.0	58.0	58.0	57.0

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	50,622.25	54,966.89	46,357.60	52,980.10	55,629.14	52,111.20	3364.72
2% Secant Modulus (CD)	psi	51,655.60	54,966.90	54,966.90	54,966.90	54,966.90	54,304.64	1324.52

NOTCHED CONSTANT TENSILE LOAD
ASTM D-5397

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	11-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 Day, 23 DEGREE CELSIUS		

Average Stress at Yield (lb/in) =	161.86
Applied Stress (lb/in) =	48.56
Sample thickness (mil) =	60.8
Notch depth (mil) =	12.2
Minimum required time period =	200 hrs
Results :	No failures

8

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	62.00	61.00	61.00	60.00	61.00	60.50	61.00	61.50	61.00	62.00	61.17	0.47
Puncture Resistance	lb	135.15	134.50	132.95	134.70	134.47	135.62	135.17	137.50	129.90	131.75	134.07	2.53
Puncture Resistance	lb/in	2179.84	2204.92	2179.51	2245.00	2204.43	2241.65	2215.90	2235.77	2129.51	2125.00	2192.04	47.44

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	161.69	149.88	162.50	160.08	159.07	158.65	4.5440
Elongation at Yield (MD)	%	20.00	20.00	19.23	20.00	19.23	19.69	0.3768
Break Strength (MD)	lb/in	286.90	298.27	300.81	291.81	273.59	290.27	9.6643
Elongation at Break (MD	%	831.77	864.46	873.99	846.80	809.93	845.39	22.9210
Yield Strength (CD)	lb/in	159.56	163.79	162.50	159.96	163.51	161.86	1.7759
Elongation at Yield (CD)	%	18.46	19.23	19.23	18.46	18.46	18.77	0.3768
Break Strength (CD)	lb/in	293.02	294.76	296.65	267.94	273.87	285.25	11.9153
Elongation at Break (CD)	%	913.98	915.09	913.04	850.51	861.32	890.79	28.6861

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.50	61.50	60.50	61.50	61.50	61.10	0.4899
Tear Resistance (MD)	lb	56.00	54.30	56.50	55.50	56.80	55.82	0.8795
Tear Resistance (MD)	lb/in	925.62	882.93	933.88	902.44	923.58	913.69	18.5518
Thickness (CD)	mils	60.00	61.50	60.50	61.00	61.00	60.80	0.5099
Tear Resistance (CD)	lb	55.60	55.60	55.20	56.20	56.30	55.78	0.4118
Tear Resistance (CD)	lb/in	926.67	904.07	912.40	921.31	922.95	917.48	8.1830

TOTAL VOLATILES
MTM-1

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.05	0.05	0.04	0.05

Reference : EPA/600/2-88/052, Appendix G

12-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
P (Initial)	61.0	60.8	60.8	61.0	61.0	60.9	
P (Final)	61.0	61.0	61.0	61.0	61.0	61.0	0.13
Q (Initial)	61.5	61.3	60.5	60.4	61.0	60.9	
Q (Final)	61.5	60.5	60.0	60.5	61.0	60.7	-0.39
R (Initial)	61.5	61.5	61.3	61.0	60.5	61.2	
R (Final)	60.5	61.0	61.5	61.5	61.0	61.1	-0.10

Average Final 60.93

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
P (Initial)	100.0	100.0	0.00
P (Final)	100.0	100.0	0.00
Q (Initial)	100.0	100.0	0.00
Q (Final)	100.0	100.0	0.00
R (Initial)	100.0	100.0	0.00
R (Final)	100.0	100.0	0.00

2

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
P	43.0	42.2	-1.86
Q	43.1	43.1	0.01
R	43.3	43.3	0.02

3

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	11-15-97
	EPA 9090 Testing Program (Baseline)	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 DAY, 50 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	35.2	33.98
2	0.9494	26.5	21.84
3*	0.9560	19.0	17.18

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	19.5	19.5	20.0	19.6	19.8	19.7
DENSITY	0.9544	0.9544	0.9537	0.9543	0.9540	0.9542

4

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	DATE:	11-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	60 DAY, 50 DEGREE CELSIUS		

Initial Wt.	2.4882 grams
After Extraction	2.4810 grams
%Extractables	0.29

Reference : EPA/600/2-88/052, Appendix E

5

HARDNESS
ASTM D-2240

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	56.0	58.0	58.0	58.0	57.0	57.4
2	55.0	57.0	56.0	57.0	57.0	56.4
3	60.0	59.0	60.0	60.0	59.0	59.6
4	57.0	57.0	58.0	59.0	58.0	57.8
5	57.0	56.0	58.0	57.0	56.0	56.8

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	53,642.40	51,655.60	54,304.60	51,986.80	54,966.90	53,311.26	1290.96
2% Secant Modulus (CD)	psi	53,973.50	56,921.40	51,655.60	52,649.00	52,317.90	53,503.48	1868.34

NOTCHED CONSTANT TENSILE LOAD
ASTM D-5397

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	DATE:	11-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	60 Day, 50 DEGREE CELSIUS		

Average Stress at Yield (lb/in) =	156.5
Applied Stress (lb/in) =	46.95
Sample thickness (mil) =	61.0
Notch depth (mil) =	12.2
Minimum required time period =	200 hrs
Results :	No failures

8

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	61.50	62.00	60.00	61.50	60.00	60.50	60.50	62.00	62.00	62.00	61.17	0.85
Puncture Resistance	lb	140.65	140.25	138.45	135.62	139.62	138.00	137.85	138.90	139.57	138.47	138.74	0.70
Puncture Resistance	lb/in	2286.99	2262.10	2307.50	2205.20	2327.00	2280.99	2278.51	2240.32	2251.13	2233.39	2268.56	31.64

6

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	167.22	161.69	152.42	161.09	164.19	161.32	4.9488
Elongation at Yield (MD)	%	18.46	19.23	20.00	19.23	21.54	19.69	1.0434
Break Strength (MD)	lb/in	307.06	293.75	315.32	288.31	284.27	297.74	11.6806
Elongation at Break (MD	%	889.81	871.91	896.08	858.00	829.16	868.99	24.0145
Yield Strength (CD)	lb/in	154.84	148.67	160.97	164.11	153.91	156.50	5.4534
Elongation at Yield (CD)	%	19.23	18.46	19.23	20.77	19.23	19.38	0.7537
Break Strength (CD)	lb/in	266.81	274.88	327.02	296.85	304.52	294.02	21.5103
Elongation at Break (CD)	%	838.84	859.87	989.53	903.36	947.29	907.78	55.3371

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 60 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 11-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	61.00	61.50	61.20	60.50	61.50	61.14	0.3720
Tear Resistance (MD)	lb	56.50	57.30	56.70	55.90	58.30	56.94	0.8139
Tear Resistance (MD)	lb/in	926.23	931.71	926.47	923.97	947.97	931.27	8.7267
Thickness (CD)	mils	62.00	61.50	60.00	60.00	60.00	60.70	0.8718
Tear Resistance (CD)	lb	55.30	56.20	54.20	55.20	54.30	55.04	0.7338
Tear Resistance (CD)	lb/in	891.94	913.82	903.33	920.00	905.00	906.82	9.5890

TOTAL VOLATILES
MTM-1

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	11-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	60 DAY, 50 DEGREE CELSIUS		

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.06	0.05	0.06	0.05

Reference : EPA/600/2-88/052, Appendix G

12-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
G (Initial)	60.5	60.5	59.5	59.5	59.5	59.9	
G (Final)	60.0	60.0	59.5	59.5	60.0	59.8	-0.17
H (Initial)	60.5	60.5	59.5	60.0	59.5	60.0	
H (Final)	60.0	60.0	60.5	60.5	60.0	60.2	0.33
I (Initial)	60.5	60.0	61.0	60.5	60.5	60.5	
I (Final)	61.0	60.5	61.0	60.0	60.0	60.5	0.00

Average final 60.17

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
G (Initial)	100.0	100.0	-1.00
G (Final)	99.0	99.0	-1.00
H (Initial)	100.0	100.0	0.00
H (Final)	100.0	99.0	-1.00
I (Initial)	100.0	100.0	-1.00
I (Final)	99.0	99.5	-0.50

2

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
G	42.4	42.4	0.07
H	42.5	42.6	0.05
I	42.8	42.8	0.03

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	12-15-97
	EPA 9090 Testing Program (Baseline)	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	90 DAY, 23 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	36.2	33.98
2	0.9494	25.0	21.84
3*	0.9560	16.6	17.18

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	16.4	16.5	16.4	16.5	16.6	16.5
DENSITY	0.9603	0.9601	0.9603	0.9601	0.9600	0.9601

4

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	12-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	90 DAY, 23 DEGREE CELSIUS		

Initial Wt.	4.3986 grams
After Extraction	4.3847 grams
%Extractables	0.32

Reference : EPA/600/2-88/052, Appendix E

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HARDNESS
ASTM D-2240

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	61.0	60.0	60.0	62.0	62.0	61.0
2	61.0	62.0	61.0	59.0	59.0	60.4
3	59.0	58.0	62.0	62.0	59.0	60.0
4	63.0	62.0	61.0	61.0	61.0	61.6
5	62.0	62.0	58.0	60.0	59.0	60.2

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2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	54,644.81	53,978.41	54,978.00	55,311.21	55,311.21	54,844.73	498.69
2% Secant Modulus (CD)	psi	61,975.21	58,976.41	59,976.01	61,642.01	62,308.41	60,975.61	1281.85

NOTCHED CONSTANT TENSILE LOAD
ASTM D-5397

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana	**DATE:**	12-15-97
	EPA 9090 Testing Program	**TESTED BY:**	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	90 Day, 23 DEGREE CELSIUS		

Average Stress at Yield (lb/in) =	158.85
Applied Stress (lb/in) =	47.66
Sample thickness (mil) =	60.2
Notch depth (mil) =	12.0
Minimum required time period =	200 hrs
Results :	No failures

8

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	61.00	60.00	61.20	61.20	60.00	60.00	61.50	61.00	61.00	61.00	60.75	0.56
Puncture Resistance	lb	133.27	133.67	132.80	135.37	128.20	130.87	134.85	133.87	134.20	134.27	132.71	2.39
Puncture Resistance	lb/in	2184.75	2227.83	2169.93	2211.93	2136.67	2181.17	2192.68	2194.59	2200.00	2201.15	2184.38	22.31

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	166.94	149.48	150.48	151.49	159.27	155.53	6.6712
Elongation at Yield (MD)	%	19.23	20.00	20.00	20.77	19.23	19.85	0.5756
Break Strength (MD)	lb/in	265.81	259.68	267.14	264.72	263.51	264.17	2.5457
Elongation at Break (MD)	%	774.86	778.32	776.23	777.23	779.71	777.27	1.6708
Yield Strength (CD)	lb/in	164.92	150.00	155.44	162.38	161.49	158.85	5.4074
Elongation at Yield (CD)	%	18.46	18.46	18.46	18.46	19.23	18.62	0.3077
Break Strength (CD)	lb/in	270.65	262.78	275.81	260.69	257.14	265.41	6.8288
Elongation at Break (CD)	%	842.42	835.40	853.94	819.74	825.17	835.33	12.1885

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TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.50	61.00	60.50	60.50	60.50	60.60	0.2000
Tear Resistance (MD)	lb	57.20	55.30	58.30	56.20	55.70	56.54	1.0855
Tear Resistance (MD)	lb/in	945.45	906.56	963.64	928.93	920.66	933.05	19.8078
Thickness (CD)	mils	60.00	61.00	61.00	60.50	60.50	60.60	0.3742
Tear Resistance (CD)	lb	57.60	55.30	56.50	56.10	56.40	56.38	0.7414
Tear Resistance (CD)	lb/in	960.00	906.56	926.23	927.27	932.23	930.46	17.1764

TOTAL VOLATILES
MTM-1

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.00	0.05	0.04	0.03

Reference : EPA/600/2-88/052, Appendix G

12-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
S (Initial)	60.7	60.7	61.5	61.8	61.8	61.3	
S (Final)	62.0	62.0	61.0	61.5	61.0	61.5	0.33
T (Initial)	60.0	60.5	61.8	61.5	61.5	61.1	
T (Final)	62.0	61.5	61.0	61.5	61.5	61.5	0.72
U (Initial)	60.0	60.0	61.0	60.5	60.5	60.4	
U (Final)	61.0	60.5	60.0	60.5	60.5	60.5	0.17

Average final 61.17"

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
S (Initial)	100.0	100.0	-1.00
S (Final)	99.0	99.0	-1.00
T (Initial)	100.0	100.0	-1.00
T (Final)	99.0	99.0	-1.00
U (Initial)	100.0	100.0	-0.50
U (Final)	99.5	99.0	-1.00

2

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
S	43.2	43.3	0.11
T	43.2	43.2	0.21
U	42.5	42.5	0.01

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program (Baseline)	**DATE:**	12-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	90 DAY, 50 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	36.2	33.98
2	0.9494	25.0	21.84
3*	0.9560	16.6	17.18

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	16.4	16.5	16.4	16.5	16.4	16.4
DENSITY	0.9603	0.9601	0.9603	0.9601	0.9603	0.9602

4

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	12-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	90 DAY, 50 DEGREE CELSIUS		

Initial Wt.	3.5894 grams
After Extraction	3.5826 grams
%Extractables	0.19

Reference : EPA/600/2-88/052, Appendix E

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HARDNESS
ASTM D-2240

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	58.0	59.0	60.0	60.0	60.0	59.4
2	61.0	62.0	59.0	62.0	61.0	61.0
3	61.0	62.0	59.0	62.0	62.0	61.2
4	61.0	61.0	62.0	60.0	62.0	61.2
5	60.0	59.0	62.0	62.0	59.0	60.4

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	55,311.21	57,310.41	58,643.21	57,310.41	53,978.41	56,510.73	1653.96
2% Secant Modulus (CD)	psi	55,977.61	55,644.41	58,643.21	58,310.01	55,644.41	56,843.93	1342.76

NOTCHED CONSTANT TENSILE LOAD
ASTM D-5397

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	DATE:	12-15-97
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	90 Day, 50 DEGREE CELSIUS		

Average Stress at Yield (lb/in) =	158.85
Applied Stress (lb/in) =	47.66
Sample thickness (mil) =	60.2
Notch depth (mil) =	12.0
Minimum required time period =	200 hrs
Results :	No failures

8

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	61.20	61.00	63.00	60.50	61.00	61.20	63.00	61.20	62.50	61.00	61.65	0.80
Puncture Resistance	lb	136.70	135.65	136.25	134.35	136.10	135.85	137.70	131.20	135.80	132.02	134.78	2.34
Puncture Resistance	lb/in	2233.66	2223.77	2162.70	2220.66	2231.15	2219.77	2185.71	2143.79	2172.80	2164.26	2186.25	30.57

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	159.76	159.07	154.03	161.29	162.38	159.31	2.8793
Elongation at Yield (MD)	%	20.00	19.23	21.54	19.23	19.23	19.85	0.8971
Break Strength (MD)	lb/in	264.11	265.32	261.09	263.59	262.98	263.42	1.3967
Elongation at Break (MD)	%	783.54	782.93	778.59	786.24	783.07	782.87	2.4549
Yield Strength (CD)	lb/in	167.06	164.03	162.02	157.50	161.53	162.43	3.1386
Elongation at Yield (CD)	%	18.46	19.23	19.23	18.46	19.23	18.92	0.3768
Break Strength (CD)	lb/in	266.37	272.66	275.44	270.16	277.70	272.47	3.9693
Elongation at Break (CD)	%	837.63	835.36	856.36	833.62	864.83	845.56	12.6297

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.50	60.50	61.00	60.50	60.50	60.60	0.2000
Tear Resistance (MD)	lb	60.00	57.00	55.80	57.00	57.70	57.50	1.3914
Tear Resistance (MD)	lb/in	991.74	942.15	914.75	942.15	953.72	948.90	24.9608
Thickness (CD)	mils	60.50	59.50	60.50	60.50	60.50	60.30	0.4000
Tear Resistance (CD)	lb	55.80	57.00	54.30	55.60	55.40	55.62	0.8635
Tear Resistance (CD)	lb/in	922.31	957.98	897.52	919.01	915.70	922.51	19.7051

TOTAL VOLATILES
MTM-1

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 90 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 12-15-97
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.06	0.09	0.02	0.06

Reference : EPA/600/2-88/052, Appendix G

12-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
J (Initial)	60.0	60.0	60.5	60.5	60.5	60.3	
J (Final)	60.8	60.8	61.0	61.0	61.0	60.9	1.03
K (Initial)	61.0	61.0	61.0	60.5	60.5	60.8	
K (Final)	61.2	61.5	61.7	61.0	61.2	61.3	0.86
L (Initial)	60.0	59.0	60.0	59.5	58.7	59.4	
L (Final)	59.5	60.0	60.5	59.8	59.5	59.9	0.71

Average final 60.7

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
J (Initial)	100.0	100.0	-0.50
J (Final)	99.5	99.0	-1.00
K (Initial)	100.0	100.0	-0.50
K (Final)	99.5	99.0	-1.00
L (Initial)	100.0	100.0	-0.50
L (Final)	99.5	99.5	-0.50

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
J	42.9	42.9	0.00
K	43.1	43.1	-0.00
L	41.9	41.9	-0.02

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program (Baseline)	**DATE:**	01-15-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	120 DAY, 23 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	36.5	33.98
2	0.9494	24.4	21.84
3*	0.9560	15.0	17.18

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	15.0	15.2	15.4	15.2	15.2	15.2
DENSITY	0.9627	0.9624	0.9621	0.9624	0.9624	0.9624

4

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	01-15-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	120 DAY, 23 DEGREE CELSIUS		

Initial Wt.	2.9549 grams
After Extraction	2.9446 grams
%Extractables	0.35

Reference : EPA/600/2-88/052, Appendix E

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HARDNESS
ASTM D-2240

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	62.0	62.0	62.0	59.0	60.0	61.0
2	61.0	62.0	62.0	61.0	59.0	61.0
3	63.0	62.0	62.0	59.0	61.0	61.4
4	62.0	62.0	60.0	61.0	59.0	60.8
5	61.0	61.0	61.0	59.0	61.0	60.6

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	49,313.61	55,977.61	49,313.61	51,312.81	51,312.81	51,446.09	2435.78
2% Secant Modulus (CD)	psi	51,312.81	53,312.01	52,645.61	56,977.61	53,978.41	53,645.29	1885.01

NOTCHED CONSTANT TENSILE LOAD
ASTM D-5397

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	DATE:	01-20-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	120 Day, 23 DEGREE CELSIUS		

Average Stress at Yield (lb/in) =	158.59
Applied Stress (lb/in) =	47.58
Sample thickness (mil) =	60.7
Notch depth (mil) =	12.1
Minimum required time period =	200 hrs
Results :	No failures

8

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	60.50	61.00	61.00	60.00	61.00	61.00	60.00	61.00	61.00	61.00	60.83	0.37
Puncture Resistance	lb	129.92	131.00	130.00	130.35	132.80	131.87	130.85	133.72	128.25	131.00	131.42	1.73
Puncture Resistance	lb/in	2147.44	2147.54	2131.15	2172.50	2177.05	2161.80	2180.83	2192.13	2102.46	2147.54	2160.30	29.51

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	161.29	159.48	158.75	149.68	154.44	156.73	4.1814
Elongation at Yield (MD)	%	20.00	20.00	19.23	18.46	20.00	19.54	0.6154
Break Strength (MD)	lb/in	284.15	276.29	284.56	271.85	280.65	279.50	4.8432
Elongation at Break (MD)	%	807.35	792.98	827.43	824.44	825.71	815.58	13.4143
Yield Strength (CD)	lb/in	168.35	162.70	155.04	152.42	154.44	158.59	6.0006
Elongation at Yield (CD)	%	18.46	18.46	18.46	19.23	18.46	18.62	0.3077
Break Strength (CD)	lb/in	279.92	280.65	268.83	264.52	273.47	273.48	6.2414
Elongation at Break (CD)	%	880.74	883.51	878.94	861.65	858.98	872.76	10.3034

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.00	61.00	61.20	62.00	60.00	60.84	0.7632
Tear Resistance (MD)	lb	50.32	50.63	53.78	55.16	52.17	52.41	1.8457
Tear Resistance (MD)	lb/in	838.67	830.00	878.76	889.68	869.50	861.32	23.1052
Thickness (CD)	mils	61.00	61.00	61.50	61.00	59.50	60.80	0.6782
Tear Resistance (CD)	lb	51.25	52.70	52.16	50.87	48.96	51.19	1.2884
Tear Resistance (CD)	lb/in	840.16	863.93	848.13	833.93	822.86	841.80	13.8085

TOTAL VOLATILES
MTM-1

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.06	0.09	0.04	0.06

Reference : EPA/600/2-88/052, Appendix G

12-end

NOMINAL THICKNESS
ASTM D-5199

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	THICKNESS [mils]					AVG.	Percent Change
	1	2	3	4	5		
V (Initial)	59.5	60.5	60.5	60.0	60.5	60.2	
V (Final)	60.5	60.0	60.0	60.5	60.5	60.3	0.17
W (Initial)	61.0	60.0	61.0	61.5	61.0	60.9	
W (Final)	60.5	61.0	61.5	61.0	61.0	61.0	0.16
X (Initial)	60.0	60.8	60.8	60.4	60.5	60.5	
X (Final)	61.0	60.5	60.0	60.5	61.0	60.6	0.17

Average Final 60.63

DIMENSION CHANGES

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Length (MD) (mm)	Width (CD) (mm)	Percent Change
V (Initial)	100.0	100.0	-1.00
V (Final)	99.0	99.0	-1.00
W (Initial)	100.0	100.0	-1.00
W (Final)	99.0	99.0	-1.00
X (Initial)	100.0	100.0	-1.00
X (Final)	99.0	99.0	-1.00

2

WEIGHT CHANGE

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

SPECIMEN No.	Initial Mass (oz/sy)	Final Mass (oz/sy)	Percent Change
V	42.4	42.4	-0.01
W	43.0	43.0	0.00
X	42.7	42.7	-0.04

3

DENSITY
ASTM D-1505

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program (Baseline)	**DATE:**	01-15-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	120 DAY, 50 DEGREE CELSIUS		

Standard Floats			
Float No.	**ensity, g/c**	**Depth**	**Corr. Depth**
1*	0.9322	36.5	33.98
2	0.9494	24.4	21.84
3*	0.9560	15.0	17.18

c = 0.9322
s = -0.0014

Density = c + s*(specimen depth)

PARAMETER	1	2	3	4	5	AVERAGE
DEPTH	15.0	15.0	14.9	15.1	15.0	15.0
DENSITY	0.9627	0.9627	0.9628	0.9625	0.9627	0.9627

4

EXTRACTABLES CONTENT
MTM-2

CLIENT:	Montgomery Watson	JOB No.:	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	DATE:	01-15-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	CHECKED BY:	K.U.
SAMPLE:	120 DAY, 50 DEGREE CELSIUS		

Initial Wt.	3.0430 grams
After Extraction	3.0364 grams
%Extractables	0.22

Reference : EPA/600/2-88/052, Appendix E

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HARDNESS
ASTM D-2240

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

REPLICATE No.	POINT No.					AVG.
	1	2	3	4	5	
1	62.0	60.0	61.0	62.0	61.0	61.2
2	62.0	61.0	58.0	58.0	59.0	59.6
3	63.0	62.0	62.0	60.0	60.0	61.4
4	60.0	60.0	60.0	62.0	63.0	61.0
5	60.0	60.0	60.0	59.0	58.0	59.4

2 % SECANT MODULUS
ASTM D-5323

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
2% Secant Modulus (MD)	psi	47,314.41	49,980.01	51,979.21	46,640.01	45,981.61	48,379.05	2255.20
2% Secant Modulus (CD)	psi	49,980.01	49,980.01	51,312.81	54,644.81	55,977.61	52,379.05	2479.15

NOTCHED CONSTANT TENSILE LOAD
ASTM D-5397

CLIENT:	Montgomery Watson	**JOB No.:**	97S2180-01
PROJECT:	Gary Works, Indiana EPA 9090 Testing Program	**DATE:**	01-20-98
		TESTED BY:	D.T./K.T.
MATERIAL:	60 mil Smooth HDPE	**CHECKED BY:**	K.U.
SAMPLE:	120 Day, 50 DEGREE CELSIUS		

Average Stress at Yield (lb/in) =	162.5
Applied Stress (lb/in) =	48.75
Sample thickness (mil) =	60.6
Notch depth (mil) =	12.1
Minimum required time period =	200 hrs
Results :	No failures

8

PUNCTURE RESISTANCE
ASTM D-4833

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 23 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.										AVERAGE	STANDARD DEVIATION
		1	2	3	4	5	6	7	8	9	10		
Thickness	mils	60.50	61.00	61.00	60.00	61.00	61.00	60.00	61.00	61.00	61.00	60.83	0.37
Puncture Resistance	lb	129.92	131.00	130.00	130.35	132.80	131.87	130.85	133.72	128.25	131.00	131.42	1.73
Puncture Resistance	lb/in	2147.44	2147.54	2131.15	2172.50	2177.05	2161.80	2180.83	2192.13	2102.46	2147.54	2160.30	29.51

TENSILE PROPERTIES
ASTM D-638

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Yield Strength (MD)	lb/in	168.67	162.38	152.50	152.70	160.81	159.41	6.1523
Elongation at Yield (MD)	%	19.23	19.23	20.00	20.00	20.77	19.85	0.5756
Break Strength (MD)	lb/in	274.52	282.98	271.01	276.90	276.33	276.35	3.9040
Elongation at Break (MD)	%	800.73	827.53	805.84	824.30	816.42	814.96	10.3263
Yield Strength (CD)	lb/in	163.91	167.22	159.56	159.60	162.22	162.50	2.8783
Elongation at Yield (CD)	%	19.23	20.00	18.46	19.23	19.23	19.23	0.4865
Break Strength (CD)	lb/in	268.83	275.00	277.26	267.14	301.05	277.85	12.1881
Elongation at Break (CD)	%	835.21	852.04	881.95	848.70	934.08	870.39	35.3120

TEAR RESISTANCE
ASTM D-1004

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

PARAMETER	UNITS	REPLICATE No.					AVERAGE	STANDARD DEVIATION
		1	2	3	4	5		
Thickness (MD)	mils	60.00	61.00	61.00	60.00	60.00	60.40	0.4899
Tear Resistance (MD)	lb	51.98	52.81	53.42	52.86	52.67	52.75	0.4613
Tear Resistance (MD)	lb/in	866.33	865.74	875.74	881.00	877.83	873.33	6.1887
Thickness (CD)	mils	61.50	61.20	61.00	61.00	61.00	61.14	0.1960
Tear Resistance (CD)	lb	51.78	53.51	52.12	51.47	52.17	52.21	0.6975
Tear Resistance (CD)	lb/in	841.95	874.35	854.43	843.77	855.25	853.95	11.5370

TOTAL VOLATILES
MTM-1

CLIENT: Montgomery Watson
PROJECT: Gary Works, Indiana
EPA 9090 Testing Program
MATERIAL: 60 mil Smooth HDPE
SAMPLE: 120 DAY, 50 DEGREE CELSIUS

JOB No.: 97S2180-01
DATE: 01-12-98
TESTED BY: D.T./K.T.
CHECKED BY: K.U.

TEST	UNITS	REPLICATE No.			AVG.
		1	2	3	
VOLATILES	%	0.06	0.06	0.05	0.06

Reference : EPA/600/2-88/052, Appendix G

12-end

H3

Geotextile Biological Clogging Laboratory Test Results
(September 1999)

J&L TESTING COMPANY, INC.
GEOTECHNICAL AND GEOSYNTHETICS MATERIALS TESTING AND RESEARCH

September 22, 1999
99G2410-01

Montgomery Watson
One Science Court
P.O. Box 5385
Madison, WI 53705-0385

Attn: Valeri J. Ranguette, P.E.

RE: BIOLOGICAL CLOGGING TEST RESULTS
US STEEL - GARY WORKS
CAMU DESIGN
WORK ORDER No. WI1

Dear Ms. Ranguette:

J&L Testing Company, Inc. (JLT) is pleased to submit the results of the biological clogging test performed on a non-woven needle-punched polypropylene geotextile supplied by Geosynthetics, Inc. The geotextile was heat treated (calendered) on one side and had an average thickness of 83 mils. The leachate used for this test was a synthetic leachate supplied by Core Laboratories.

The test was performed per ASTM D-1987 titled *"Biological Clogging of Geotextiles or Soil/Geotextile Filters"* using Method A - Constant Head Test.

TEST SETUP

The cross sectional area of the test chamber was 81.07 cm^2 (diameter = 4 inches) and the fabric was oriented with the calendered side down gradient of the flow. The geotextile specimen had an average thickness of 83 mils and ranged from 81 to 85 mils. The fabric rested on a No. 4 stainless steel screen and the periphery sealed with a closed foam rubber compression O-ring. The entire system was sealed and the air replaced with nitrogen to insure anaerobic conditions.

TEST PROCEDURE

Flow through the system used a sealed variable speed pump that discharged the synthetic leachate into the inlet head control reservoir. The leachate flowed down through the geotextile exiting through the base into a variable head outlet overflow port. Both the inlet and outlet units were fitted with manometers which measured the head differential across the specimen.

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During the first six (6) days of testing, flow was continuous. At the end of the 6th day, the flow was terminated but the specimen was maintained in a saturated anaerobic state between readings. For subsequent readings, through 90 days, the flow was resumed and allowed to stabilize over an approximate 30-minute period before data was collected. Flow measurements were taken first at 2 inches; then 4 inches; and, finally, at 8 inches head differential. The enclosed data sheet presents the data for each reading, the elapsed time in days, the head, the flow, the time and the temperature of the test fluid.

The last three columns of data present the temperature correction factor for 20°C, the computed flow rate in gpm/sf and the permittivity based on the noted sample properties. The second data summary table presents the test points as plotted on Figure 1.

TEST RESULTS

The data on Figure 1 presents the relationship between flow rate and elapsed time over the prescribed 90-day period for each of the three (3) test gradients. It is interesting to note that flows decreased significantly after 6 days when flow was terminated between readings as recommended by ASTM D-1987, Section 19.1.13.

Upon disassembly of the unit, the up gradient side of the geotextile had a thin coating of a dark gray gelacious matter on the fabric surface. This thin veneer, which coated the fibers, clearly accounted for the reduction of flow over time.

All testing was performed in accordance with the above referenced ASTM standard and subject to JLT's internal QA/QC and data validation procedures.

We appreciate the opportunity to provide our services and look forward to working with you again. Should you have any questions, comments or require additional information, please call. Thank you.

Sincerely,

J&L TESTING COMPANY, INC.

John Boschuk, Jr., P.E., REP
Technical Consultant

Enclosures
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JLT

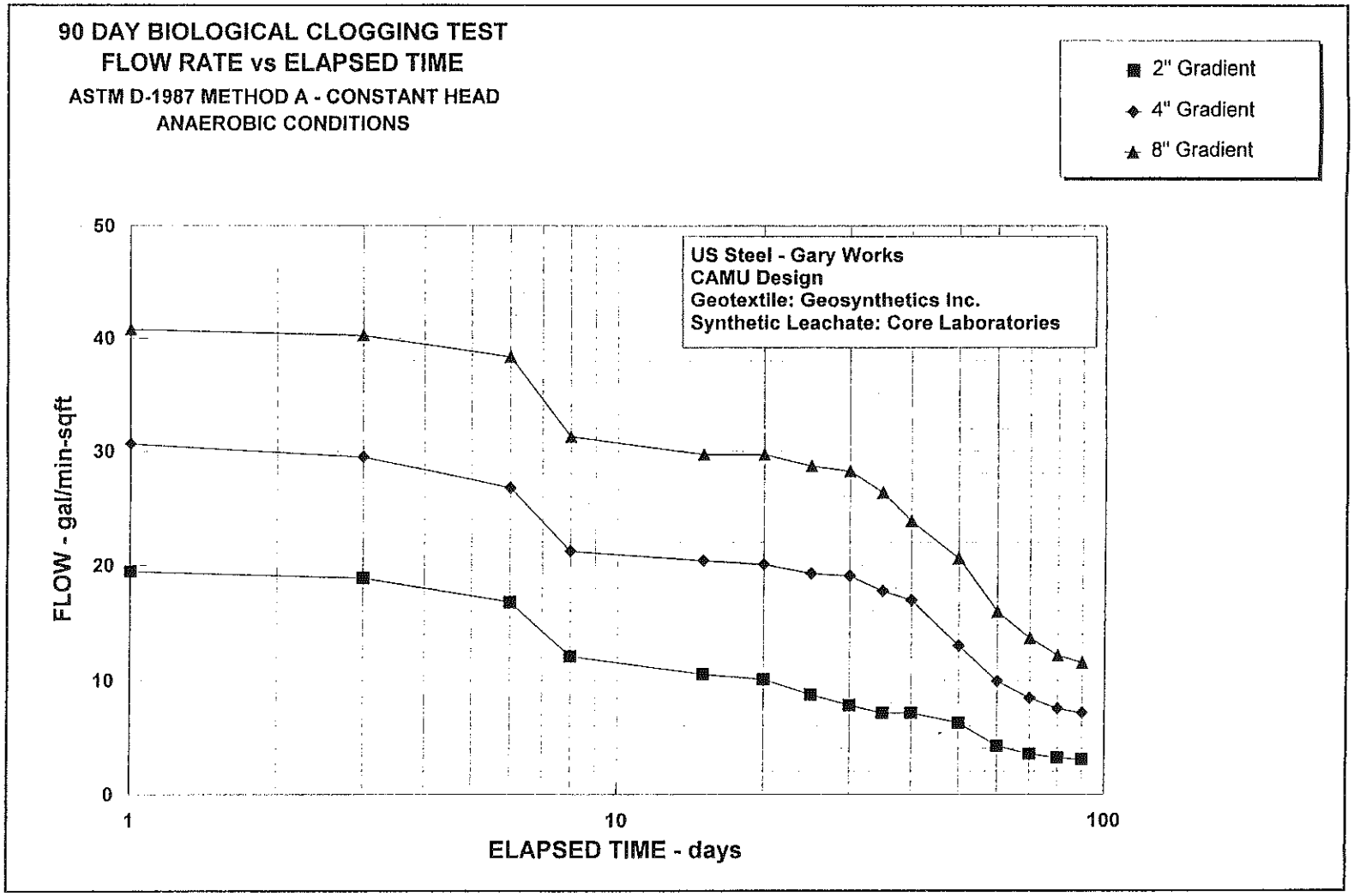

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FIGURE 1

BIOLOGICAL CLOGGING CONSTANT HEAD TEST RESULTS

GEOTEXTILE AND SYNTHETIC LEACHATE

ASTM D-1987 - Method A

TEST RESULTS OVER 90 DAYS

SAMPLE PROPERTIES			
Sample	Area	Avg Thickness of Geotextile	
0.0873	sq ft	83	mils
81.07	cm^2	0.2108	cm

DATE	Elapsed Time Days	HEAD Inches	Head cm	FLOW cc	TIME sec	TEMP Degrees C	TEMP. COR FACT	RATE gpm/sqft	PERMITTIVITY sec^-1
2-10-99	1	2	5.08	1521	14.20	14.3	1.158	19.457	0.0548
	1	4	10.16	2398	14.21	14.3	1.158	30.654	0.0432
	1	8	20.32	3264	14.55	14.3	1.158	40.750	0.0287
2-12-99	3	2	5.08	1490	14.35	18.0	1.051	18.861	0.0531
	3	4	10.16	2279	14.04	18.0	1.051	29.486	0.0415
	3	8	20.32	3122	14.09	18.0	1.051	40.249	0.0284
2-15-99	6	2	5.08	1356	14.70	14.2	1.161	16.756	0.0472
	6	4	10.16	2128	14.45	14.2	1.161	26.751	0.0377
	6	8	20.32	2995	14.20	14.2	1.161	38.313	0.0270
2-17-99	8	2	5.08	945	14.20	15.5	1.122	12.089	0.0341
	8	4	10.16	1638	14.03	15.5	1.122	21.208	0.0299
	8	8	20.32	2463	14.31	15.5	1.122	31.265	0.0220
2-24-99	15	2	5.08	821	14.14	14.3	1.158	10.547	0.0297
	15	4	10.16	1601	14.28	14.3	1.158	20.366	0.0287
	15	8	20.32	2489	14.80	14.3	1.158	30.549	0.0215
3-1-99	20	2	5.08	778	14.01	14.2	1.161	10.087	0.0284
	20	4	10.16	1561	14.15	14.2	1.161	20.039	0.0282
	20	8	20.32	2321	14.20	14.2	1.161	29.691	0.0209
3-6-99	25	2	5.08	685	14.21	14.2	1.161	8.757	0.0247
	25	4	10.16	1486	14.01	14.2	1.161	19.267	0.0271
	25	8	20.32	2242	14.21	14.2	1.161	28.660	0.0202
3-11-99	30	2	5.08	602	14.00	14.1	1.164	7.811	0.0220
	30	4	10.16	1481	14.13	14.1	1.164	19.039	0.0268
	30	8	20.32	2223	14.31	14.1	1.164	28.219	0.0199
3-16-99	35	2	5.08	566	14.45	15.8	1.113	7.115	0.0200
	35	4	10.16	1443	14.78	15.8	1.113	17.735	0.0250
	35	8	20.32	2080	14.35	15.8	1.113	26.330	0.0185
3-21-99	40	2	5.08	561	14.33	15.7	1.116	7.111	0.0200
	40	4	10.16	1344	14.43	15.7	1.116	16.919	0.0238
	40	8	20.32	1963	14.96	15.7	1.116	23.836	0.0168
3-31-99	50	2	5.08	482	14.08	16.8	1.085	6.218	0.0175
	50	4	10.16	1009	14.14	16.8	1.085	12.962	0.0183
	50	8	20.32	1578	13.94	16.8	1.085	20.563	0.0145
4-10-9	60	2	5.08	339	14.60	18.7	1.033	4.218	0.0119
	60	4	10.16	799	14.61	18.7	1.033	9.934	0.0140
	60	8	20.32	1235	14.08	18.7	1.033	15.933	0.0112
4-20-99	70	2	5.08	286	14.77	19.8	1.005	3.517	0.0099
	70	4	10.16	660	14.22	19.8	1.005	8.431	0.0119
	70	8	20.32	1094	14.58	19.8	1.005	13.630	0.0096
4-30-99	80	2	5.08	248	14.08	19.8	1.005	3.200	0.0090
	80	4	10.16	601	14.58	19.8	1.005	7.488	0.0105
	80	8	20.32	945	14.13	19.8	1.005	12.149	0.0086
5-10-99	90	2	5.08	236	14.11	19.8	1.005	3.038	0.0086
	90	4	10.16	558	14.23	19.8	1.005	7.123	0.0100
	90	8	20.32	904	14.23	19.8	1.005	11.540	0.0081

FIGURE 1 DATA POINTS

ELAP TIME DAYS	FLOW - gal/min-sqft 2"	4"	8"
1	19.457	30.654	40.750
3	18.861	29.486	40.249
6	16.756	26.751	38.313
8	12.089	21.208	31.265
15	10.547	20.366	29.690
20	10.087	20.039	29.691
25	8.757	19.267	28.660
30	7.811	19.039	28.219
35	7.115	17.735	26.330
40	7.111	16.919	23.836
50	6.218	12.962	20.563
60	4.218	9.934	15.933
70	3.517	8.431	13.630
80	3.200	7.488	12.149
90	3.038	7.123	11.540

PERMITTIVITY FOR CONSTANT HEAD TEST

$$\Psi = \frac{q}{A(\Delta h)}$$

Where :

Ψ = Permittivity (sec^{-1})

q = Flow Rate (cm^3/sec)

A = Area of Geotextile (cm^2)

Δh = Head across Specimen (cm)

US Steel - Gary Works
CAMU Design
Geotextile: Geosynthetics Inc.
Synthetic Leachate: Core Laboratories

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